

CIVIL ENGINEERS'  
AND  
SURVEYORS'  
INSTRUMENTS



W. & L. E. GURLEY'S Instrument Manufactory, Established 1845.

1880.

W. & L. E. GURLEY,  
TROY, N. Y.

## A TABLE OF MEAN REFRACTIONS IN DECLINATION.

To apply on the declination arc of Solar Attachment of either  
Compasses or Transits.

Computed by EDWARD W. ARMS, C. E., for W. & L. E. GURLEY, Troy, N. Y.

HOUR ANGLE	DECLINATIONS.								
	For Latitude 30°								
	- - 20°	- - 15°	- - 10°	- - 5°	0°	— 5°	— 10°	— 15°	— 20°
0 h.	10"	15"	21"	27"	33"	40"	48"	57"	68"
2	14	19	25	31	38	46	54	1' 09"	78
3	20	26	32	39	47	55	1' 06"	1' 19"	1' 36"
4	32	39	46	52	1' 06"	1' 19"	1' 35"	1' 57"	2' 29"
5	1' 00"	1' 10"	1' 24"	1' 52"	2' 07"	2' 44"	3' 46"	5' 43"	13' 06"
For Latitude 35°									
0 h.	15"	21"	27"	33"	40"	48"	57"	1' 08"	1' 21"
2	20	25	32	38	46	55	1' 05"	1' 18"	1' 35"
3	26	33	39	47	56	1' 07"	1' 21"	1' 38"	2' 00"
4	39	47	56	1' 07"	1' 20"	1' 36"	1' 59"	2' 32"	3' 25"
5	1' 07"	1' 20"	1' 38"	2' 00"	2' 34"	3' 29"	5' 14"	10' 16"	
For Latitude 40°									
0 h.	21"	27"	33"	40"	48"	57"	1' 08"	1' 31"	1' 39"
2	25	32	39	46	52	1' 06"	1' 19"	1' 35"	1' 57"
3	33	40	48	57	1' 08"	1' 21"	1' 38"	2' 02"	2' 36"
4	47	55	1' 06"	1' 19"	1' 36"	1' 58"	2' 30"	3' 21"	4' 59"
5	1' 15"	1' 31"	1' 51"	2' 20"	3' 05"	4' 25"	7' 34"	25' 18"	
For Latitude 45°									
0 h.	27"	33"	40"	48"	57"	1' 08"	1' 31"	1' 39"	2' 02"
2	32	39	46	52	1' 06"	1' 19"	1' 35"	1' 57"	2' 29"
3	40	47	56	1' 07"	1' 21"	1' 38"	2' 00"	2' 34"	3' 29"
4	54	1' 04"	1' 16"	1' 33"	1' 54"	2' 24"	3' 11"	4' 38"	8' 15"
5	1' 23"	1' 41"	2' 05"	2' 41"	3' 40"	5' 40"	12' 02"		
For Latitude 50°									
0 h.	33"	40"	48"	57"	1' 08"	1' 31"	1' 39"	2' 02"	2' 36"
2	38	46	55	1' 06"	1' 18"	1' 35"	1' 57"	2' 28"	3' 19"
3	47	56	1' 06"	1' 19"	1' 36"	2' 29"	2' 31"	3' 23"	5' 02"
4	1' 02"	1' 14"	1' 29"	1' 48"	2' 16"	2' 58"	4' 18"	6' 59"	19' 47"
5	1' 30"	1' 51"	2' 19"	3' 04"	4' 22"	7' 28"	24' 10"		

### TO USE TABLE OF REFRACTIONS IN DECLINATION.

Instead of using the meridional refraction as explained on pages 89 and 92 of Manual, 23d edition, use the refraction as given in the table for the hour, declination and latitude, bearing in mind that refraction is positive and to be added to North or -|- declination and subtracted from South or — declination.



LIGHT MOUNTAIN TRANSIT.

Price as shown here, - - \$245.00.

See Page 14.



# ILLUSTRATED CATALOGUE

AND

## PRICE LIST

OF

CIVIL ENGINEERS' AND SURVEYORS'

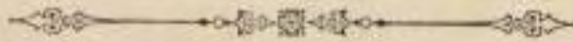
### INSTRUMENTS,

With Descriptions and Illustrations of Latest Improvements,

MADE AND SOLD BY

W. & L. E. GURLEY,

TROY, N. Y.



REDUCED PRICES.

1880.

ILLUSTRATED CATALOGUE

PRICE LIST

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1880

# PRICE LIST

OF

## Civil Engineers' and Surveyors' INSTRUMENTS,

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TROY, N. Y.

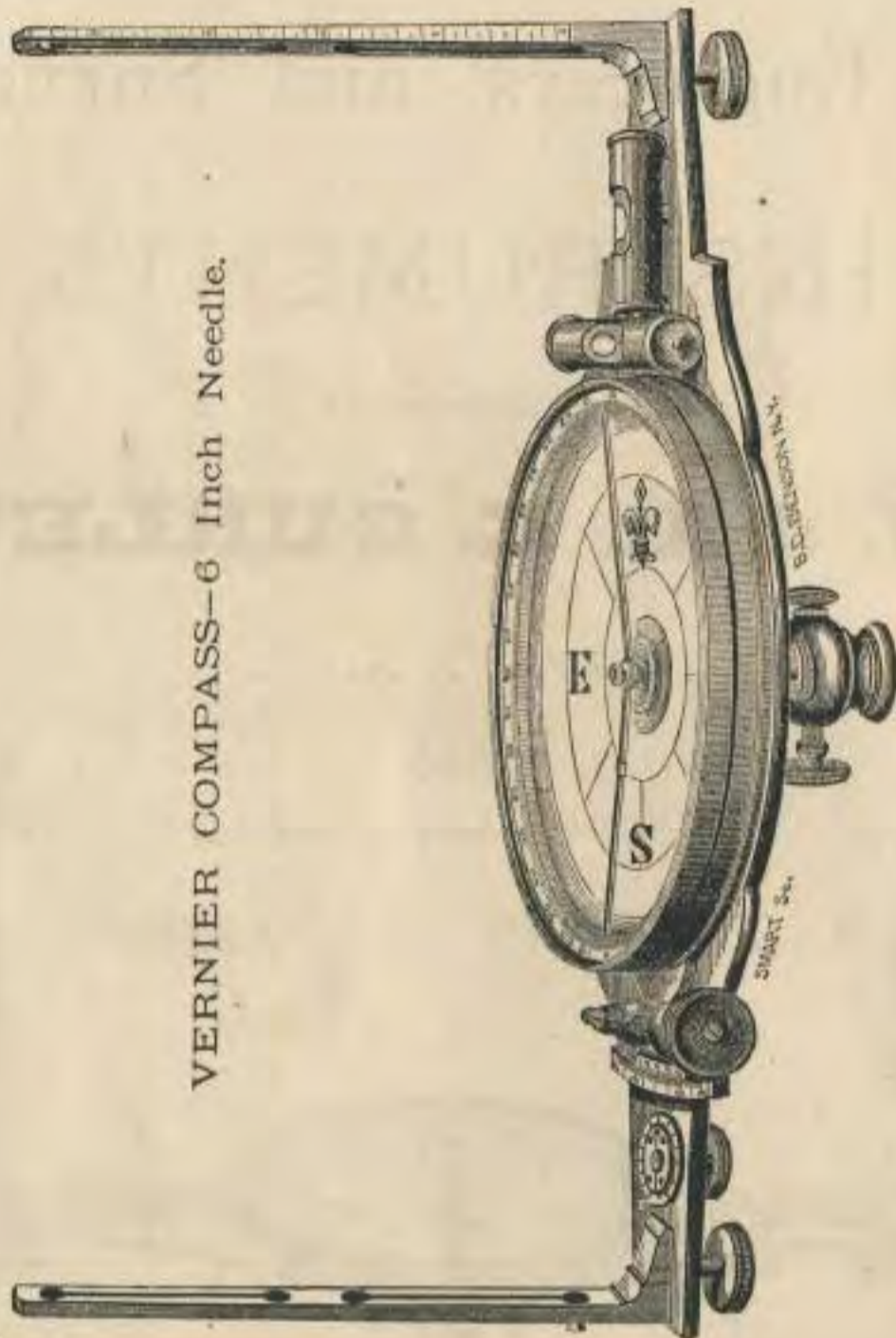
1880.

SURVEYORS' COMPASSES.



### PLAIN COMPASSES.

- |   |         |
|---|---------|
| No. 1. Surveyors' Compass, 4 inch needle, two straight levels, jacob-staff mountings, brass cover, out-keeper, sights graduated for taking angles of elevation and depression. In mahogany box with lock, and strap for carrying..... | \$25 00 |
| No. 2. Surveyors' Compass, same as above, but with 5 inch needle.....   | 30.00   |
| No. 3. Surveyors' Compass, same as above, but with 6 inch needle.....   | 35.00   |



VERNIER COMPASS—6 Inch Needle.

### VERNIER COMPASSES.

- |        |   |         |
|--------|---|---------|
| No. 4. | Surveyors' Compass, 4 inch needle, two straight levels, jacob-staff mountings, brass cover, out-keeper, vernier under the glass for adding or subtracting the magnetic variation of the needle, sights graduated for taking angles of elevation and depression. In mahogany box with lock, and strap for carrying ..... | \$30.00 |
| No. 5. | Surveyors' Compass, same as above, but with 5 inch needle.....  | 35.00   |
| No. 6. | Surveyors' Compass, same as above, but with 6 inch needle and vernier outside as shown in engraving .....   | 40.00   |

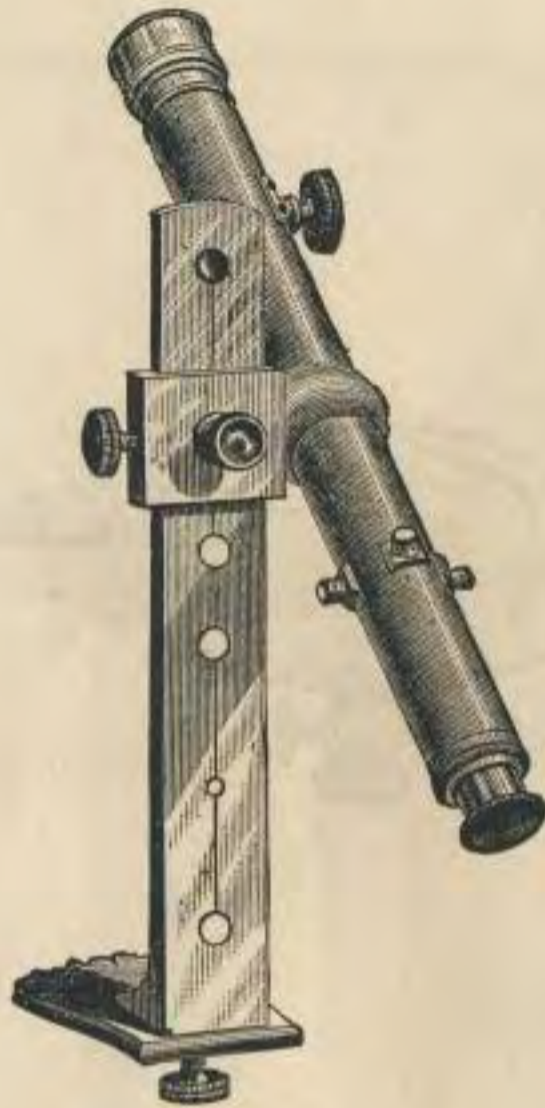


**RAILROAD COMPASSES.**

The Railroad Compass has the main plate, levels, sights and needle, jacob-staff mountings, brass cover, out-keeper, and vernier for setting off the variation of the needle of the ordinary Surveyors' Compass, but has also underneath the main plate a divided circle or limb, by which horizontal angles to single minutes can be read independently of the needle ; in mahogany box, with lock and strap.

- No. 7. Railroad Compass, 5½ inch needle, one vernier to limb .....\$60 00
- No. 8. Railroad Compass, 5 inch needle, two verniers to limb ..... 70.00
- No. 9. Railroad Compass, same as above, but with 5½ inch needle..... 75.00
- No. 11. Compass Tripod, cherry legs ..... 5.00
- No. 12. Patent Extension Tripod furnished with any compass..... 10.00
- No. 13. Compass Tripod, cherry legs, parallel plates and leveling screws, clamp and tangent movement, leveling screws passing through thickened upper plate without nuts. .... 15.00
- No. 13a. Compass Tripod, same as above, but with leveling screws having nuts and dust caps ..... 18.00





### TELESCOPIC SIGHT.

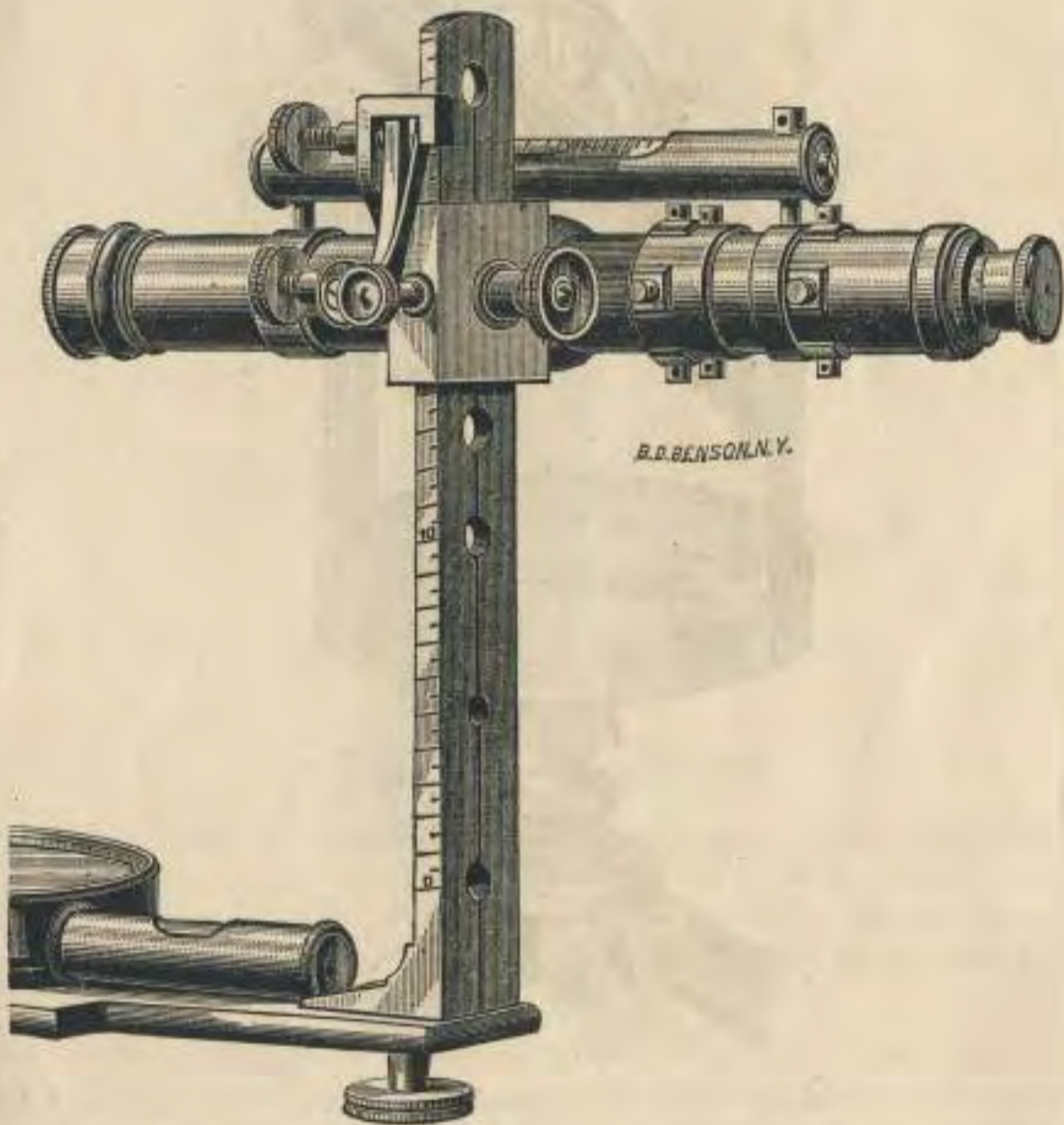
ATTACHABLE TO ANY COMPASS.

*Patented July 9, 1878.*

No. 17.	Nine-inch Achromatic Telescope of low, but sufficient power . . . . .	\$12.00
No. 18.	Nine-inch Achromatic Telescope, larger diameter of object glass and higher power . . . . .	17.00
No. 19.	Same Telescope as No. 18, but furnished with micrometer or stadia wires for measuring distances . . . . .	20.00
We add to any TELESCOPIC SIGHT the following extras, at prices annexed :		
No. 20.	Vertical Circle, Vernier to 5' . . . . .	5.00
No. 21.	Level on Telescope . . . . .	5.00
No. 22.	Clamp and Tangent to Axis of Telescope . . . . .	5.00

TELESCOPIC SIGHT.

WITH MICROMETER, LEVEL ON TELESCOPE, AND CLAMP AND TANGENT TO AXIS.



As shown above with Level and Clamp and Tangent.

No. 17a.	With Telescope No. 17, (page 6).....	\$22.00
No. 18b.	With Telescope No. 18, (page 8).....	27.00
No. 19c.	With Telescope No. 19, as shown in above engraving.....	30.00

## VERNIER POCKET COMPASS.

4½ INCH NEEDLE.

WITH TELESCOPIC SIGHT, REMOVABLE AT PLEASURE.

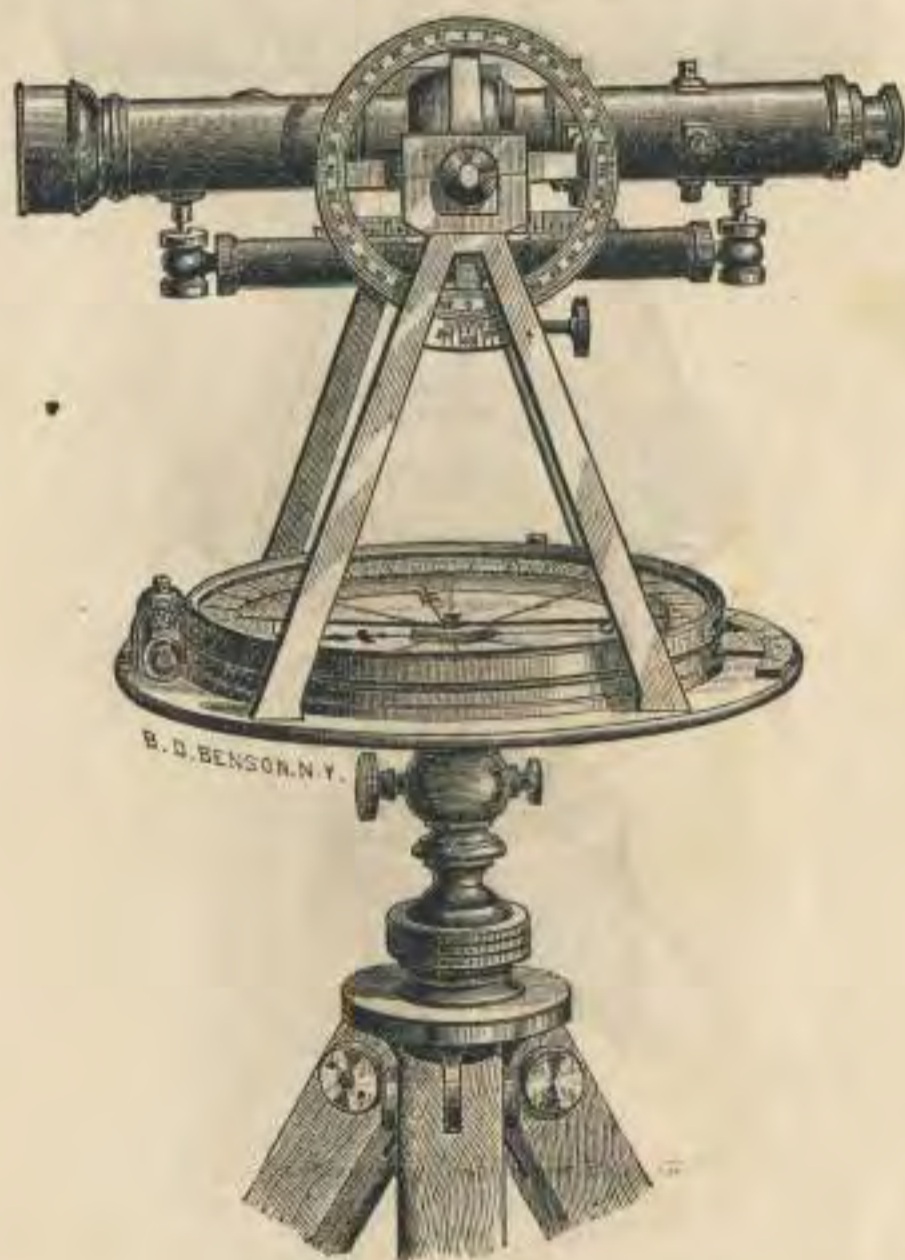


This engraving shows the attachment of our new TELESCOPIC SIGHT No. 2, with the extras of Level, Vertical circle to 5' and clamp and tangent to axis of telescope, to our 4½ inch needle Vernier Pocket Compass—which has also a clamp and tangent to the main spindle or socket.

Thus furnished, this light and popular instrument becomes a Transit Compass for ordinary land surveying or reconnoissance, with power to give levels and grades with accuracy sufficient for the common practice of the surveyor.

No. 17d.	Price, complete, with Telescope Sight No. 17.....	\$55 00
No. 18e.	“ “ “ “ “ “ 18.....	60 00
No. 19f.	“ “ “ “ “ “ 19.....	63 00

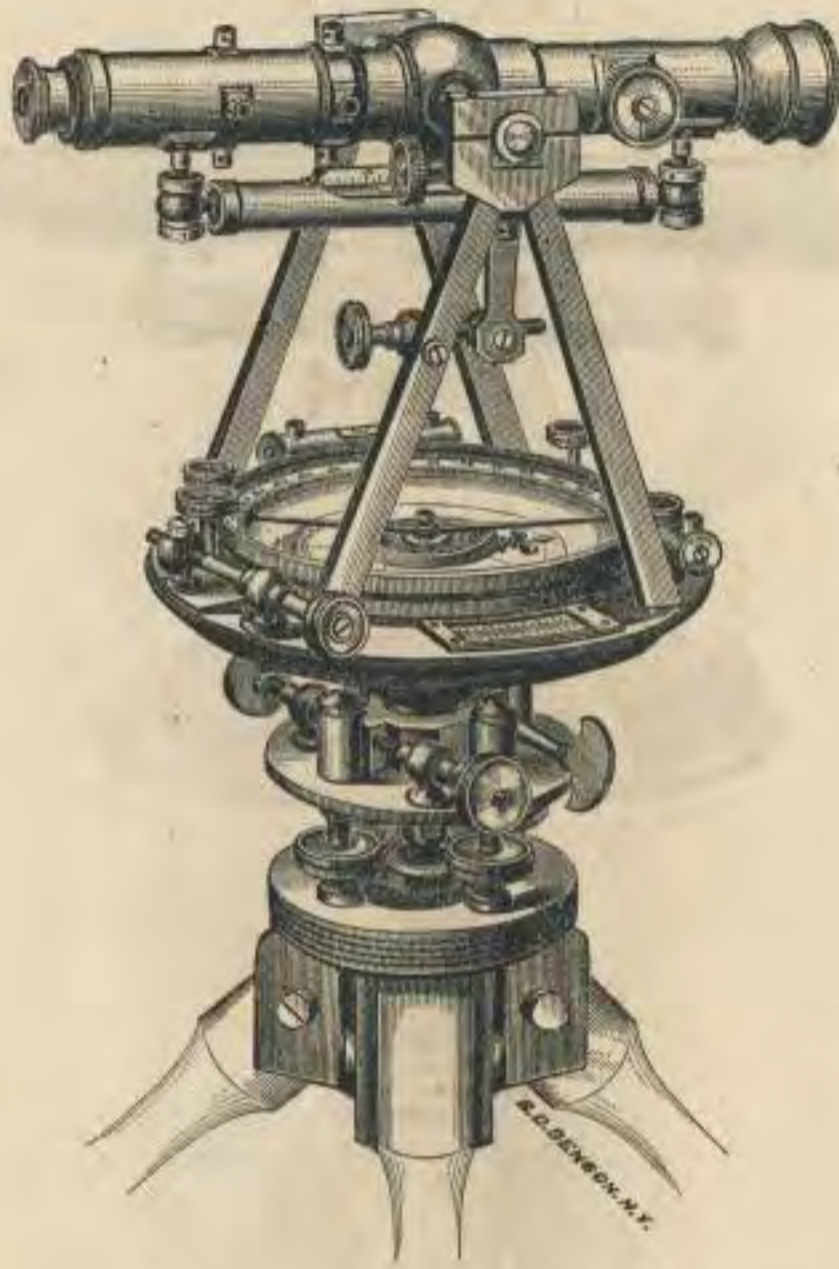
TRANSITS.



VERNIER TRANSITS.

The Vernier Transit or Transit Compass has the same general properties as the Vernier Compass, but is furnished with a telescope in place of the ordinary sights. The telescope is from ten to twelve inches long, and sufficiently powerful to see and set a flag at a distance of two miles on a clear day.

- No. 55. Vernier Transit, 4 inch needle, compass tripod, plain telescope .....\$70.00
- No. 55a. Vernier Transit, same as above, but with 3½ inch vertical circle, level on telescope, and clamp and tangent movement, to axis of telescope, as in engraving ..... 96.00
- No. 56. Vernier Transit, 5 inch needle, compass tripod, plain telescope..... 70.00
- No. 56a. Vernier Transit, same as above, but with vertical circle, level on telescope, and clamp and tangent movement, to axis of telescope, as in engraving ..... 96.00
- No. 57. Vernier Transit, 6 inch needle, compass tripod, plain telescope ..... 75.00
- No. 57a. Vernier Transit, same as above, but with vertical circle, level on telescope, and clamp and tangent movement, to axis of telescope, as in engraving.....101 00

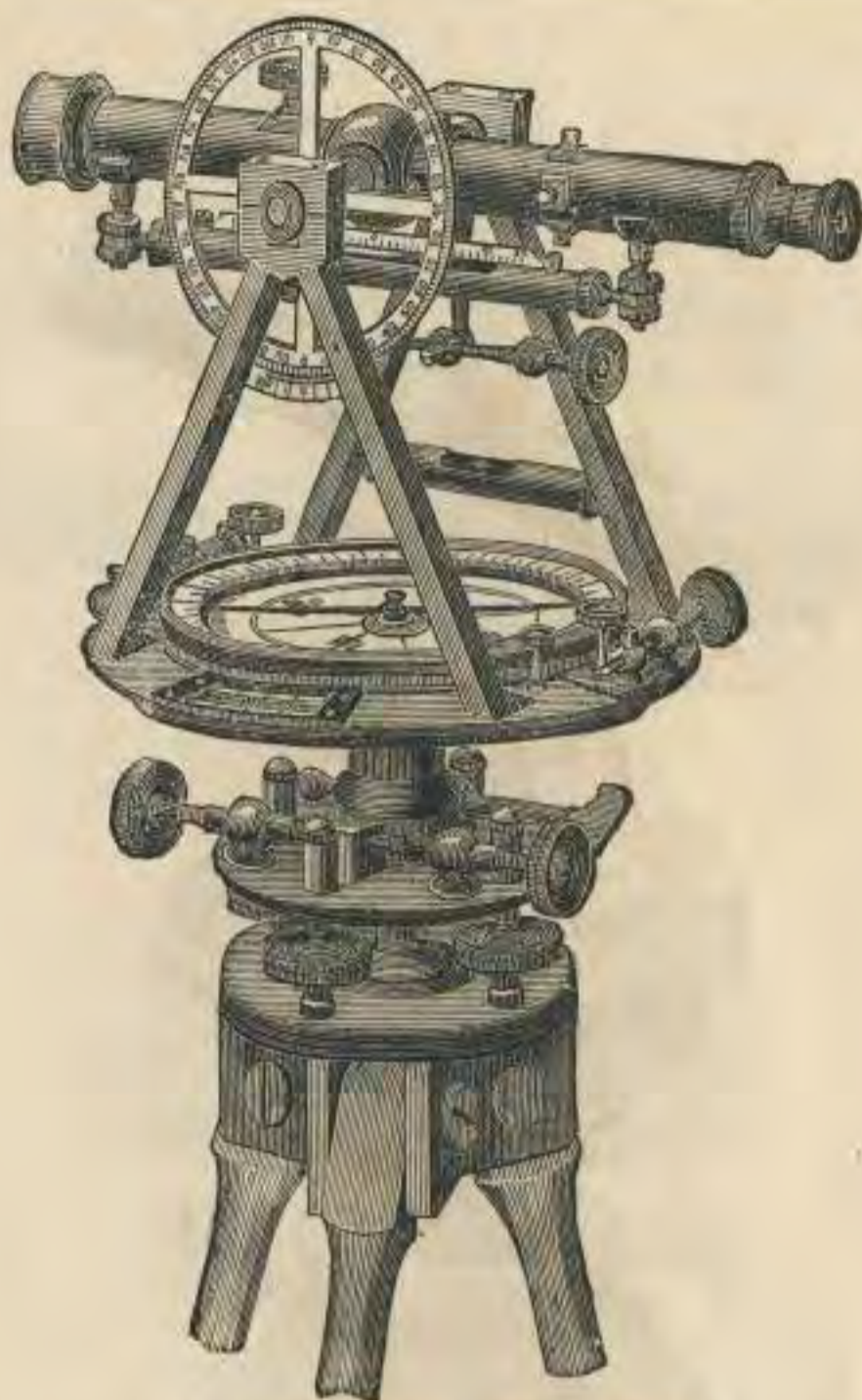


### SURVEYORS' TRANSITS.

ONE VERNIER TO LIMB.

The Surveyors' Transit has a telescope from ten to twelve inches long. The compass circle is divided to half degrees, and is provided with a vernier for adding or subtracting the magnetic variation of the needle. The tripod head is arranged with shifting centre, for setting the instrument quickly over a given point, without altering the position of the legs. The tripod legs are mahogany. The limb or divided circle outside the compass box and under the main plate, is provided with a vernier covered with glass at right angles to the telescope and reads to minutes.

- No. 58. Surveyors' Transit, 4 inch needle, one vernier to limb, plain telescope \$110.00  
 No. 58a. Surveyors' Transit, same as above, but with level on telescope, and clamp and tangent to axis of telescope, as in engraving .....128.00  
 No. 59. Surveyors' Transit, 5 or 5½ inch needle, one vernier to limb, plain telescope, or without extras ....115.00  
 No. 59a. Surveyors' Transit, same as above, but with level on telescope, and clamp and tangent movement to axis of telescope, as in engraving... ..133 00



### SURVEYORS' TRANSITS.

TWO VERNIERS TO LIMB.

The Surveyors' Transit has a telescope from ten to twelve inches long. The compass circle is divided to half degrees, and is provided with a vernier for adding or subtracting the magnetic variation of the needle. The tripod head is arranged with shifting centre, for setting the instrument quickly over a given point, without altering the position of the legs. The tripod legs are mahogany. The limb or divided circle outside the compass box and under the main plate, is provided with two opposite verniers covered with glass at right angles to the telescope and is read to single minutes.

- No. 61. Surveyors' Transit, 4 inch needle, two verniers to limb, plain telescope \$125.00
- No. 61a. Surveyors' Transit, same as above, but with vertical circle, level on telescope, and clamp and tangent to axis of telescope, as in engraving, 155.00
- No. 62. Surveyors' Transit, 5 or 5½ inch needle, two verniers to limb, plain telescope, or without extras .....130.00
- No. 62a. Surveyors' Transit, same as above, but with 4½ inch vertical circle on silver, reading with vernier to single minutes, level on telescope with ground bubble and scale, and clamp and tangent movement to axis of telescope. as in engraving ....160 00

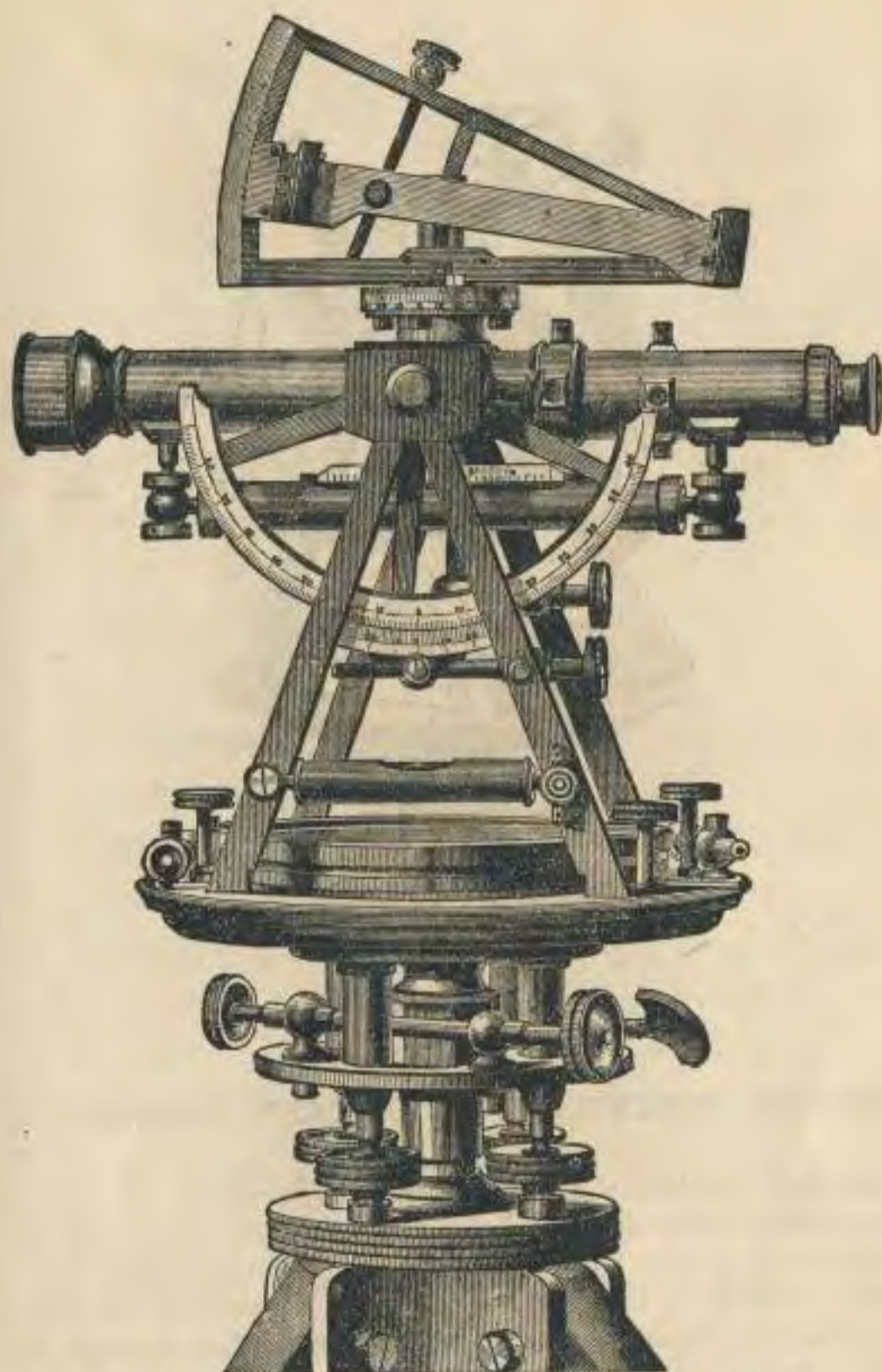


### ENGINEERS' TRANSITS.

The Engineers' Transit is like the Surveyors' Transits, except that in the former the axis or centre runs from the lower parallel plate to the centre plate of the instrument, thus giving a long socket and spindle, and there is no vernier for adding or subtracting the magnetic variation of the needle as in the Surveyors' Transit, unless it is specially ordered. The upper part of the instrument does not separate from the leveling plates as in the Surveyors' Transit, but is permanently attached to them and when put into its box is unscrewed from the tripod at the lower parallel plate.

This is the standard Railroad Transit, and is generally preferred for exclusive railroad practice.

- |  |          |
|--|----------|
| No. 64. Engineers' Transit, 4 inch needle, two verniers to limb, plain telescope ..... | \$145.00 |
| No. 66. Engineers' Transit, same as above, but with 4½ or 5 inch needle . . .          | 150.00   |



*From Gebbie & Barrie's "Masterpieces of the U. S. International Exhibition, 1876."*

### TRANSIT WITH SOLAR ATTACHMENT.

Patent Solar Attachment, with level on telescope, clamp and tangent and vertical arc, can be fitted to any of our plain transits at a cost of \$96.00, making the cost of Solar Transit as in engraving.

- No. 59b. For Surveyors' Transit, one vernier, 5 or 5½ inch needle, complete. \$211.00  
 No. 62b. Or when applied to Surveyors' Transit, two verniers to limb, 5 or 5½ in. needle . . . . .226.00  
 No. 66b. Engineers' Transit, 5 inch needle, with Solar Attachment, vertical arc, level on telescope, clamp and tangent to axis of telescope and variation plate as shown above. . . . .250 00





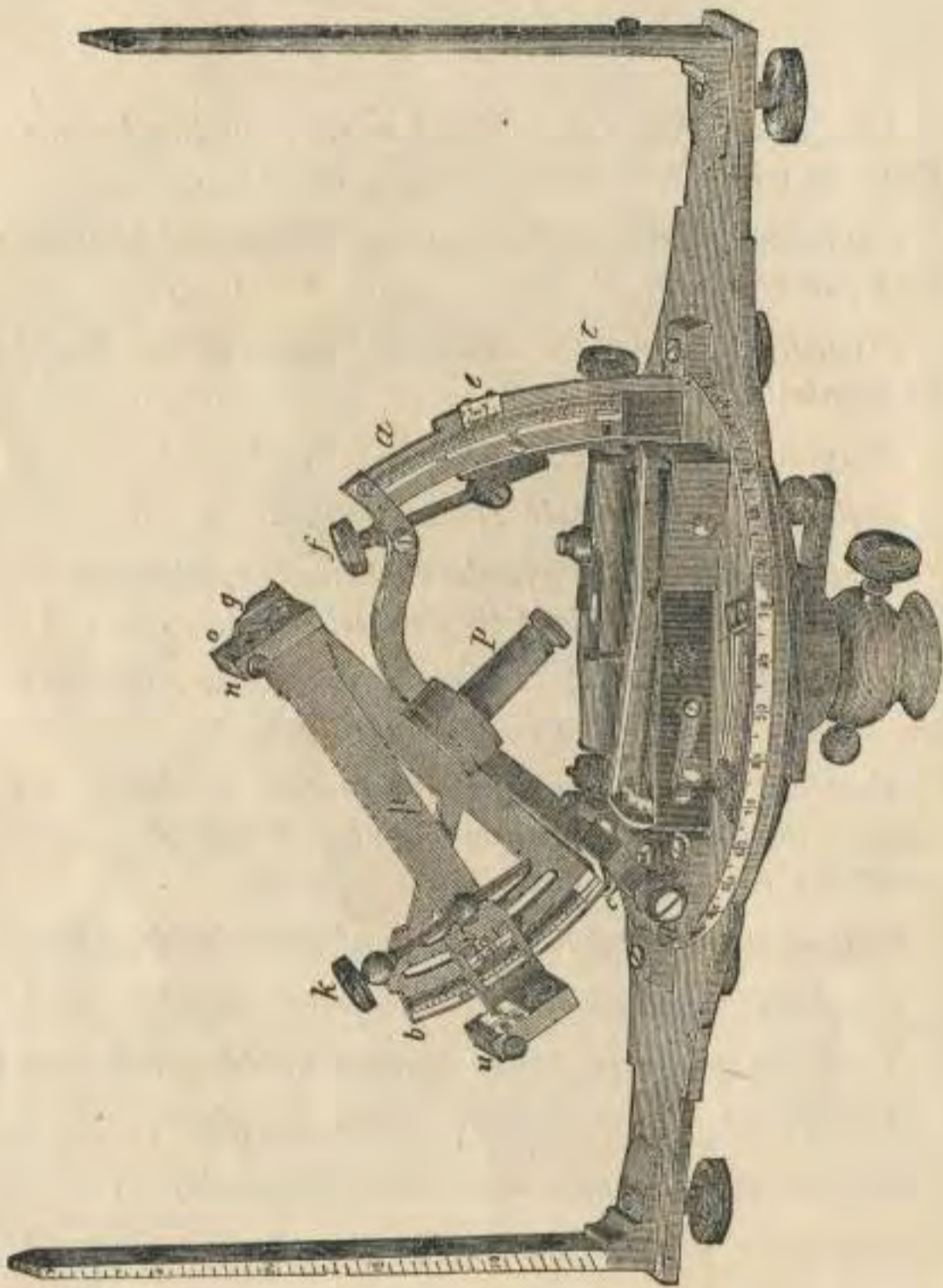
### LIGHT MINING OR MOUNTAIN TRANSITS.

This is an extra light Engineers' Transit for mine or mountain use, introduced by us in 1876 to meet a demand for a light transit of the best quality. It has met with a very large sale and been universally approved. We confidently recommend it to all our friends as a transit of the first class, capable of any work, and specially adapted for mining or rough country use where great portability is required.

- No. 68. Light Mountain Transit, with 4 inch needle, vernier for setting off the magnetic variation, two opposite verniers to the limb reading to single minutes, 8 inch achromatic telescope of the finest quality, power 20 diameters, furnished with our patent extension tripod shortening to half length for portability and low tunnel service. The instrument is packed in a light mahogany case, and this covered with a light sole leather case amply furnished with straps for "packing." With plain telescope . . . . \$150.00
- No. 69. Light Mountain Transit, same in all respects as the above, but with the addition of our patent solar attachment, vertical arc on silver, level on telescope with ground bubble and scale, and clamp and tangent to axis of telescope, complete, as shown in frontispiece. . . . . 245 00

## EXTRAS TO TRANSITS.

	PRICE.
No. 76. Variation Plate furnished with new Engineers' Transit when ordered, . . . . .	\$4 00
77. Variation Plate added to any Engineers' Transit sent for repairs, . . . . .	15 00
78. Plummet Lamp for Mining Engineering, hung in gimbals, . . . . .	10 00
79. Diagonal Eye-piece, . . . . .	8 00
80. Reflector for Transit Telescope, . . . . .	4 00
81. Vertical Circle, $3\frac{1}{2}$ inches diameter, divided on silver, vernier reading to five minutes, . . . . .	8 00
82. Vertical Circle, $4\frac{1}{2}$ inches diameter, divided on silver, reading to single minutes, . . . . .	12 00
83. Vertical Arc, 6 inches diameter, divided on silver, with vernier, movable by tangent screw, reading to 30 seconds, . . . . .	18 00
84. Clamp and tangent movement to axis of telescope, . . . . .	6 00
85. Gradienter, combined with clamp and tangent, . . . . .	18 00
86. Level on telescope, with ground bubble and scale, . . . . .	12 00
87. Rack and pinion movement to eye-piece, . . . . .	5 00
88. Sights on telescope, with folding joints, . . . . .	8 00
89. Sights on standards at right angles to telescope, . . . . .	8 00
90. Detachable telescope on end of axis, for vertical sights, with counterpoise, . . . . .	25 00
91. Graduations of limb on solid silver, . . . . .	10 00
92. " " to read to $20'$ or $30'$ . . . . .	10 00
93. " " to read to $10'$ . . . . .	30 00
94. Graduations on $4\frac{1}{2}$ inch vertical circle to read to $20'$ or $30'$ . . . . .	5 00
95. Patent Extension Tripod furnished with any new instrument, in place of the usual Tripod, extra, . . . . .	5 00



### BURT'S SOLAR COMPASS.

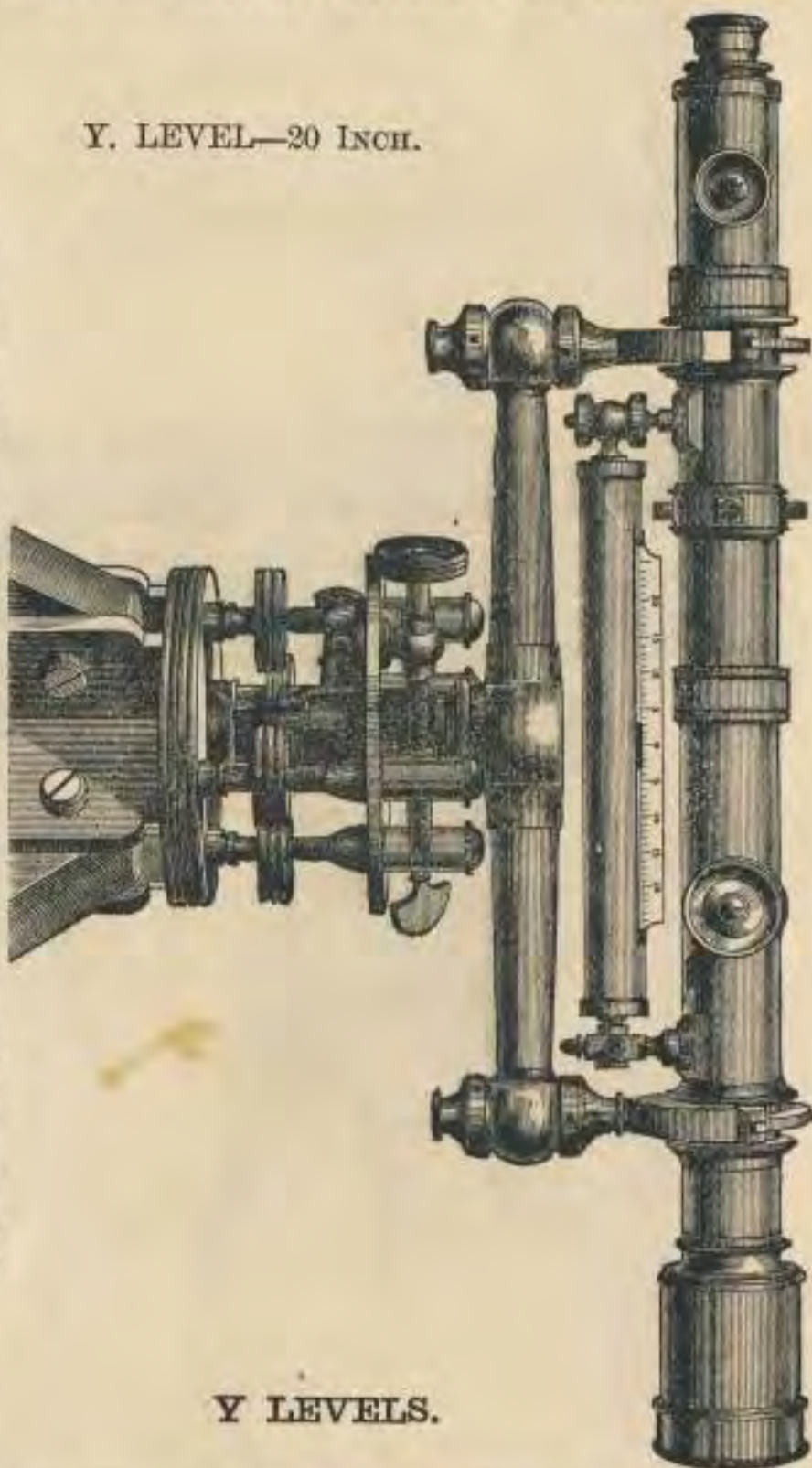
No. 10. Burt's Solar Compass, with adjusting socket and leveling tripod . . . \$210.00

Patent telescopic sight furnished with any Solar Compass. (See page 6.)

LEVELING INSTRUMENTS.

Y. LEVEL—20 INCH.

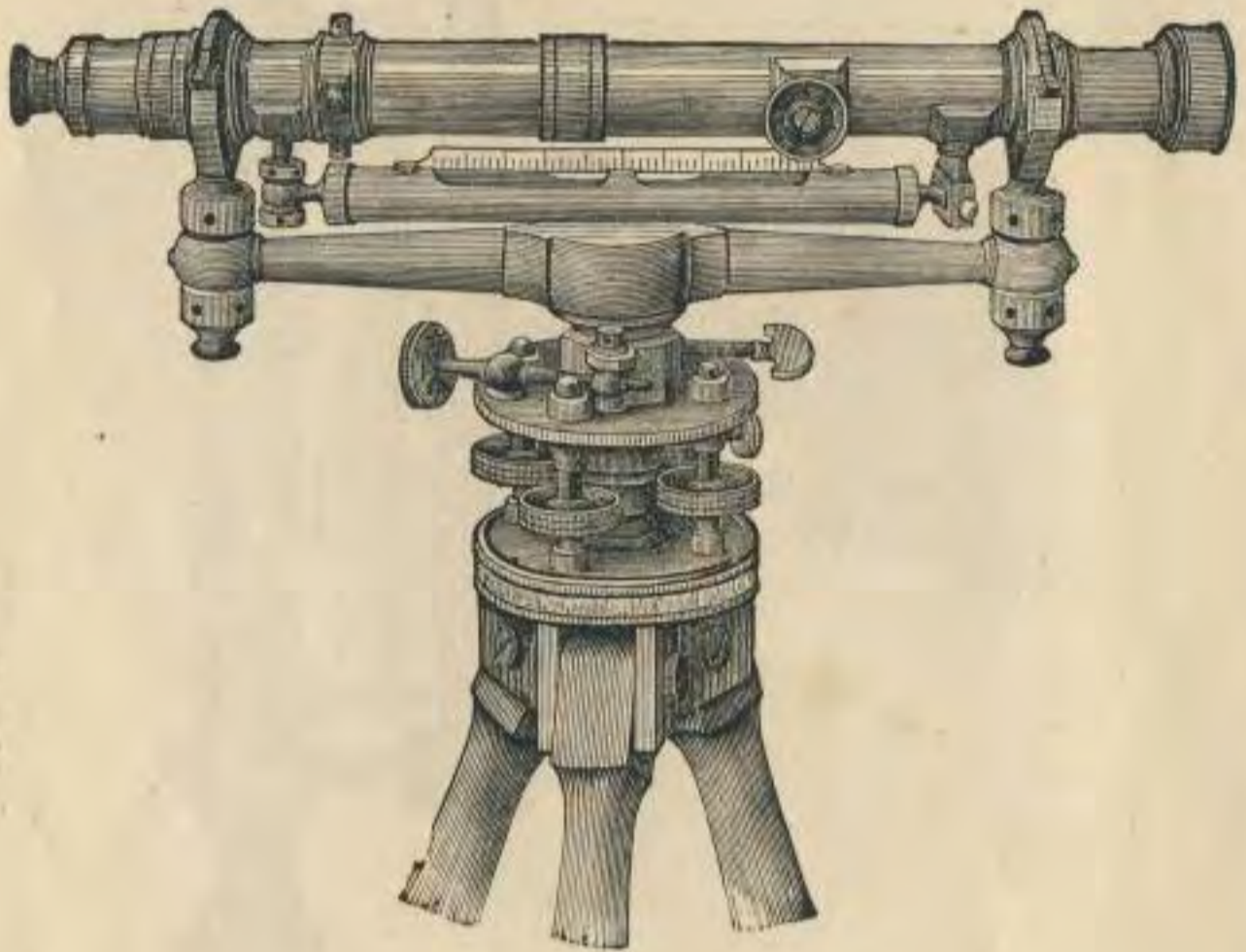
*From Cobble & Barris's "Masterpieces of the U. S. International Exhibition, 1876."*



Y LEVELS.

Y Level, of the most approved form and construction, with telescope either 16, 18, 20 or 22 inches long. In this instrument the telescope is made to revolve readily and truly in the Y's by rings of bell metal which when desired may be firmly clamped by the clips and held in any position. One Y clip is furnished with a horizontal stud fitting into a semi-cylindric cut on the flange of the ring of the telescope, insuring the accurate position of the vertical wire. It has a rack and pinion movement to both object and eye glasses, an adjustment for centering the eye-piece, and another for insuring the accurate projection of the object-glass in a straight line. Both of these are completely concealed from observation and disturbance by a thin ring which slides over them. The Y's of this level are made large and strong of the best bell metal, and each has two nuts, both being adjustable with the ordinary steel pin. The level bar is made round, of fine bronze, and shaped so as to possess the greatest strength in the parts most subject to sudden strains. The leveling plates are the same as those used with the Engineers' Transit.

- No. 105, 106 or 107. Y Level, with telescope, 16, 18 or 20 inches long .....\$110.00
- No. 108. Y Level, with telescope 22 inches long ..... 115.00

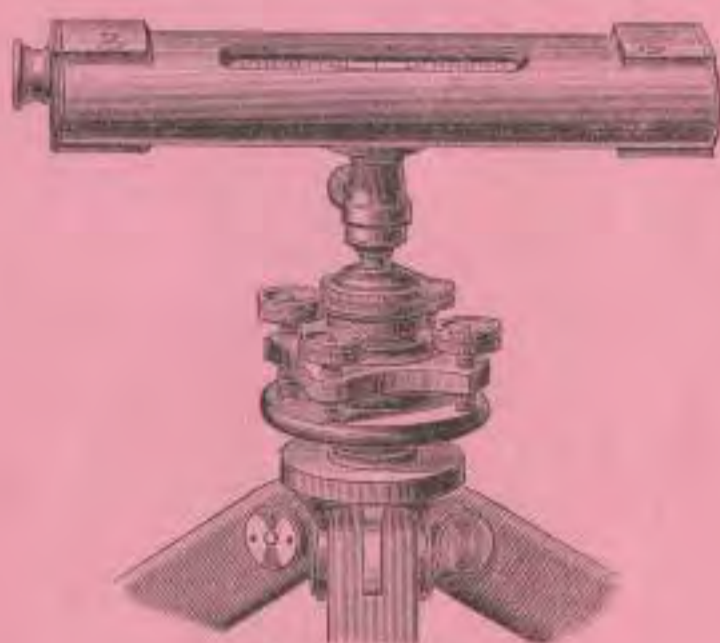


### ENGINEERS' LEVEL.

15 INCH TELESCOPE.

No. 109. Y Level, with telescope 15 inches long, with simpler construction of sockets than the 20 inch before shown, without rack to eye-piece, and with the leveling plates remaining on the body of the instrument attached to the socket, substantially as in engraving, but with the heads of the leveling screws covered by dust caps.....\$90.00

## THE DRAINAGE LEVEL.



NEW FIG. 43.

The figure represents a level just devised by us, combining the extremes of simplicity and compactness with real efficiency, and all at a very moderate cost. The level and telescope with cross-wires are both inclosed and secured in a strong outside case of brass from 8 to 9 inches long, 2 inches wide, and  $1\frac{1}{4}$  inches high, oval in form, and covered with a cloth finish.

The ends of the case are thickened, so as to be faced off and thus made parallel, each to each, on the two opposite sides.

A small socket screws into the under side of the case, and is fitted to a ball-spindle, by which it is made approximately level, and then precisely so, by the small leveling screws as shown. When desired, the leveling-head can be dispensed with, and the instrument leveled on the ball alone.

This instrument is adjusted nearly as simply as an ordinary mason's or builder's level, on a wooden block which accompanies each instrument; the spirit-level, by reversing from end to end on the lower faces of the case, and making the corrections by the two screws in the line with the level tube; the telescope, by applying the opposite faces to the same surface, and bringing the telescope cross-wire by two screws, one on each face, so as to cut the same point in both positions of the case.

When the socket is screwed to the case, and the instrument revolved upon its spindle, the level is made to remain in the centre in all positions by four screws, two on each side of the flange of the socket underneath, the pair on one side being loosened, and that on the opposite tightened, until the correction is made.

It will of course be understood that these adjustments are always made by the maker, and are not liable to derangement in the ordinary use of the level.

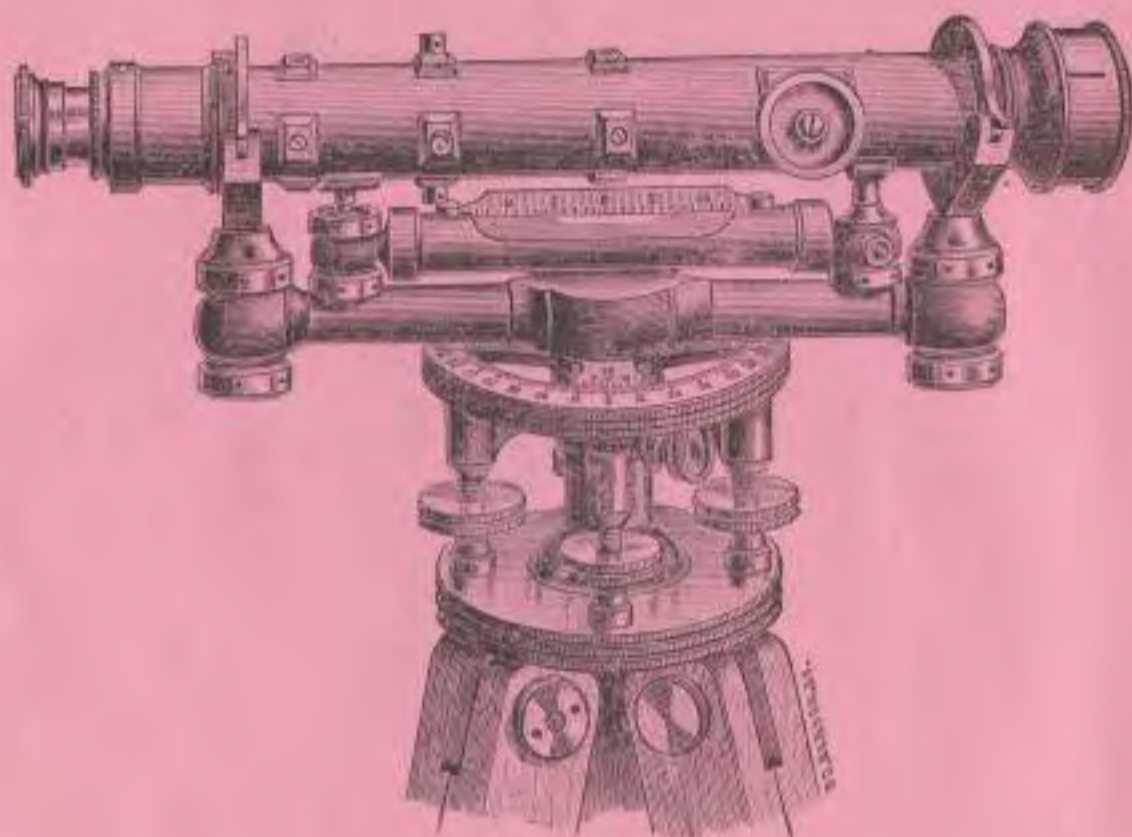
The advantages of this level in the work of the farmer, manufacturer and builder will be apparent on a simple inspection; for not only can drains be located and leveled, the height of springs ascertained, the accurate levels of lines of shafting, floor-timbers, sills, etc., be determined, but when removed from its socket it can be applied, either by itself or on a straight-edge, to the leveling of any surfaces of stone, wood or metal.

### PRICES.

Farmers' or Drainage Level, with Jacob-staff mountings .....	\$15.00
" with plain tripod .....	20.00
" " tripod and leveling screws .....	25.00

APRIL, 1883.

## THE ARCHITECTS' LEVEL.



NEW FIG. 41.

The Architects' Level, as first made by us nine years ago, had a rough iron bar on which the level was fixed. The telescope, furnished with common lenses, revolved in the Y's, resting only on the telescope tube, and the whole instrument was made to meet a demand for a cheap level suitable for architects, builders, millwrights and farmers.

We have been making constant and steady improvement in the material, the finish and the accuracy of the instrument, until now the Architects' Level, as shown (Fig. 41), has a turned bar. The level is attached to the telescope and has a carefully ground vial and scale. The lenses are selected and are equal in quality to those furnished with our transits. The telescope revolves in the Y's on carefully turned and concentric rings of bell metal. All of the adjustments are precisely like those of the larger leveling instruments; they are not liable to derangement and will require ordinarily but little attention. In fact, the instrument, as now made, is accurate enough for any leveling or grading, except the finest railroad or canal work.

On account of these improvements and the necessarily increased expense, the price of the Architects' Level has been advanced to \$45, and the instrument is, we think, cheaper at that price than the one first introduced was at \$35.

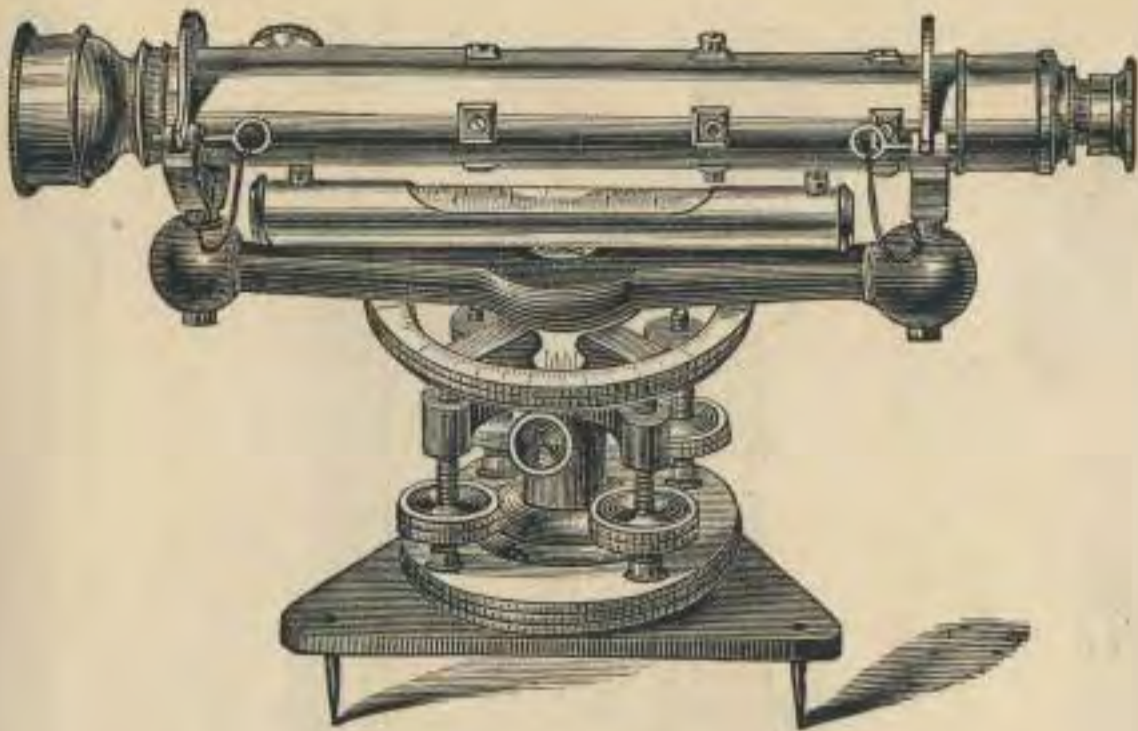
### PRICE.

Architects' Level, 11 inch Telescope, with Leveling Tripod and Trivet..... \$45.00

**We shall not make any more Architects' Levels at \$35.**

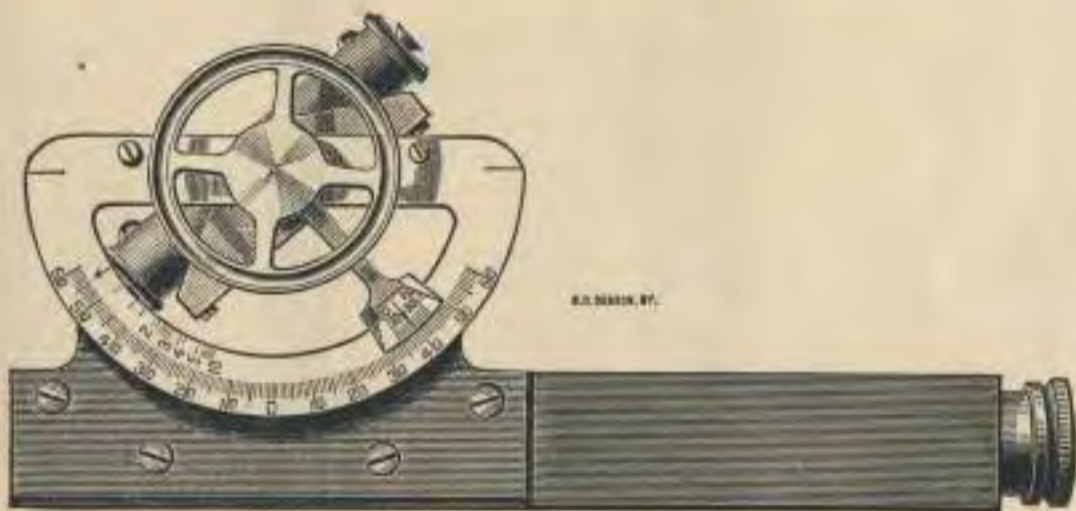
APRIL, 1883.

[See over for *Drainage Level*.



ARCHITECTS' LEVEL.

No. 110. Y Level with telescope, 11 inches long, and all the usual adjustments, having also a horizontal circle reading with vernier to 5 minutes, and arranged with clamp for laying off angles and furnished both with tripod *tenon pattern* as shown with vernier pocket compass, and with trivet as in the engraving.....\$35.00 45.00



ABNEY LEVEL AND CLINOMETER.

No. 115. This is an improved "Locke's Hand Level," giving angles of elevation, and is also divided for slopes, as 1 to 1, 2 to 1, etc., in case.....\$15.00



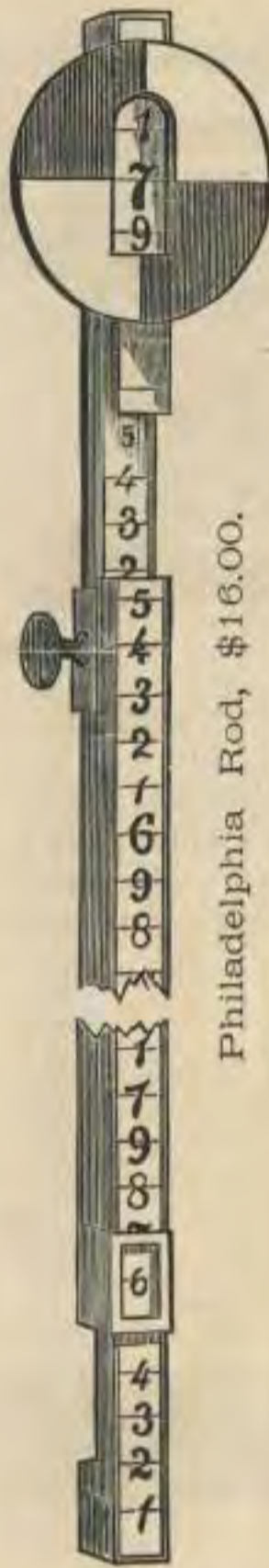
LOCKE'S HAND LEVEL.

No. 113. Nickel Plated, in box.....\$12.00  
 No. 114. Bronze, in box..... 10.00





New York Rod, with Improved Mountings, \$16.00



Philadelphia Rod, \$16.00.



Boston Rod, \$13.00.



Whitehouse Patent Rod, \$8.00.

LEVELING RODS, &c.

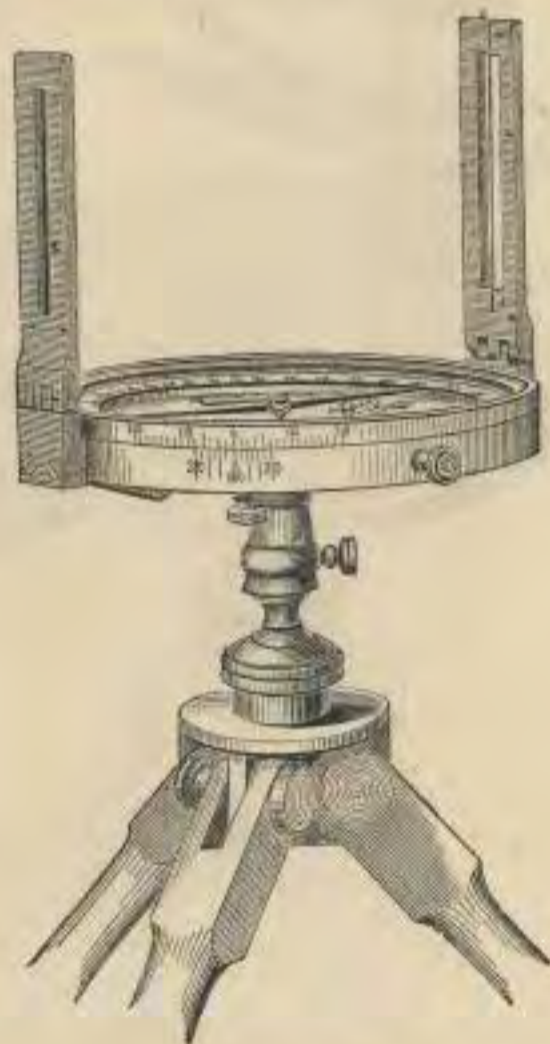
The New York Rod as supplied by us with our improved mountings, is far superior to those furnished by other makers, as the clamp does not mar the divisions and the painted face of the target is protected by a raised rim.

No. 116. Philadelphia Rod . . . . .	\$16.00	No. 121. Whitehouse Patent Rod	\$8.00
No. 117. Boston Rod . . . . .	15.00	No. 123. Flag Staff, 6 feet long, with steel pointed shoe and divided off in feet which are painted red and white alternately	2.50
No. 118. New York Rod, with im- proved mountings . . . . .	16.00	No. 124. Flag Staff, 8 ft. long, same as above . . . . .	2.75
No. 119. Target for New York Rod,	5.50	No. 125. Flag Staff, 10 ft. long, same as above . . . . .	3.00
No. 120. Clamp for New York Rod,	2.50		
No. 122. Simple Rod with target reading to 100ths of a foot, rod either 8 or 10 ft. long . . . . .	5 00		



**POCKET COMPASS.**

- |         |   |         |
|---------|---|---------|
| No. 35. | With folding sights, 2½ inch needle, very serviceable for retracing lines once surveyed ..... | \$ 8.00 |
| No. 36. | Same as above, with jacob-staff mountings .....   | 10.00   |
| No. 37. | With 3½ inch needle, and jacob-staff mountings .....  | 12.00   |
| No. 38. | Same as above, and two levels.....  | 13.50   |



**VERNIER POCKET COMPASS.**

- |          |  |         |
|----------|--|---------|
| No. 40a. | Price including tripod as in engraving, with 3½ inch needle .....  | \$21.00 |
| No. 41a. | Price including tripod as in engraving, with 4½ inch needle .....  | 23.00   |
| No. 40.  | Vernier Pocket Compass, with folding sights, staff mountings, two levels, and 3½ inch needle.....                          | 16.00   |
| No. 41.  | Same as above, 4½ inch needle.....   | 18.00   |
| No. 42.  | Railroad Pocket Compass, folding sights, staff mountings, two levels, 3½ inch needle, with limb reading to 5 minutes ..... | 23.00   |
| No. 43.  | Tripod for pocket compass, extra .....   | 5.00    |
| No. 44.  | Tripod for pocket compass, with leveling plates .....  | 13.00   |
|          | Rack and pinion for moving Vernier, extra .....  | 4.00    |
- Pocket Compasses without sights. 1 to 3 inch needle, \$1.00 to 6.00 each, varying with size and cost of case.



### NEW POCKET SOLAR COMPASS.

(FOR DESCRIPTION AND ADJUSTMENTS, SEE PAGE 41.)

With Staff, Mountings and Box, complete.....	\$70.00
With Light Tripod.....	75.00
With Light Patent Extension Tripod.....	80.00
Leather Case, With Strap, <i>extra</i> .....	3.00
<hr/>	
Simple Dial Compass, with removable hour arc, graduated for any latitude, two levels and clinometer.....	16.00
Extra Arcs for different latitudes, each.....	5.00

## THE POCKET SOLAR COMPASS.



NEW FIG. 29.

The **Pocket Solar Compass**, well shown in Fig. 29, has a needle 3 inches long, and a limb of  $4\frac{1}{2}$  inches in diameter, divided to half degrees and reading by its one double vernier, horizontal angles to single minutes.

The arrangement of the plates is similar to that of the large Solar Compass, the under plate carrying the sights revolving around the upper or compass plate, to which are attached the solar apparatus, levels, etc. There is also a clamp with tangent screw between the two plates, and another to the whole instrument about its spindle.

The distance between the sights is nearly 7 inches, the sights themselves are  $4\frac{1}{2}$  inches high, and have a slot and hair in half their height. They are hinged so as to fold down in packing.

The compass-circle is arranged with pinion and movable part so as to set off the variation of the needle to five minutes. The needle has a lifting-lever, as usual, by which it is raised against the glass.

The solar apparatus is attached to the flange of the upper plate, and consists of the usual *hour, latitude and declination arcs*, marked respectively, A, C and B in the cut, with an arm, F F, to the last named, carrying the solar lenses and lines as in the larger instruments. The latitude and declination arcs are each divided to half degrees, and read by verniers to five minutes of a degree. The hour arc is divided on its inner edge into hours and twelfths, or spaces of five minutes each, the index of the declination arc above easily enabling one to read the time to single minutes.

The hour arc is made movable upon its supporting segment to either side, its outer edge being also divided on the middle portion to spaces of five minutes of time, and read by a vernier upon the segment to single minutes. In this way the *equation of time* for any given day is set off at once, and the time given by the index of the hour arc thus made to agree with mean time or that given by the ordinary clock.

The solar lenses and lines are placed as in the larger instruments, the declination arc being also reversible, as the sun changes from north to south of the equator.

When packed in the case the declination arc with its arm is detached from the hour arc, and this itself, together with the latitude arc, folds closely to the compass-box.

The Pocket Solar is set up for use either upon a ball spindle, with staff mountings, or as in Fig. 29, upon a light tripod and often with small leveling-head with clamp and tangent screws.

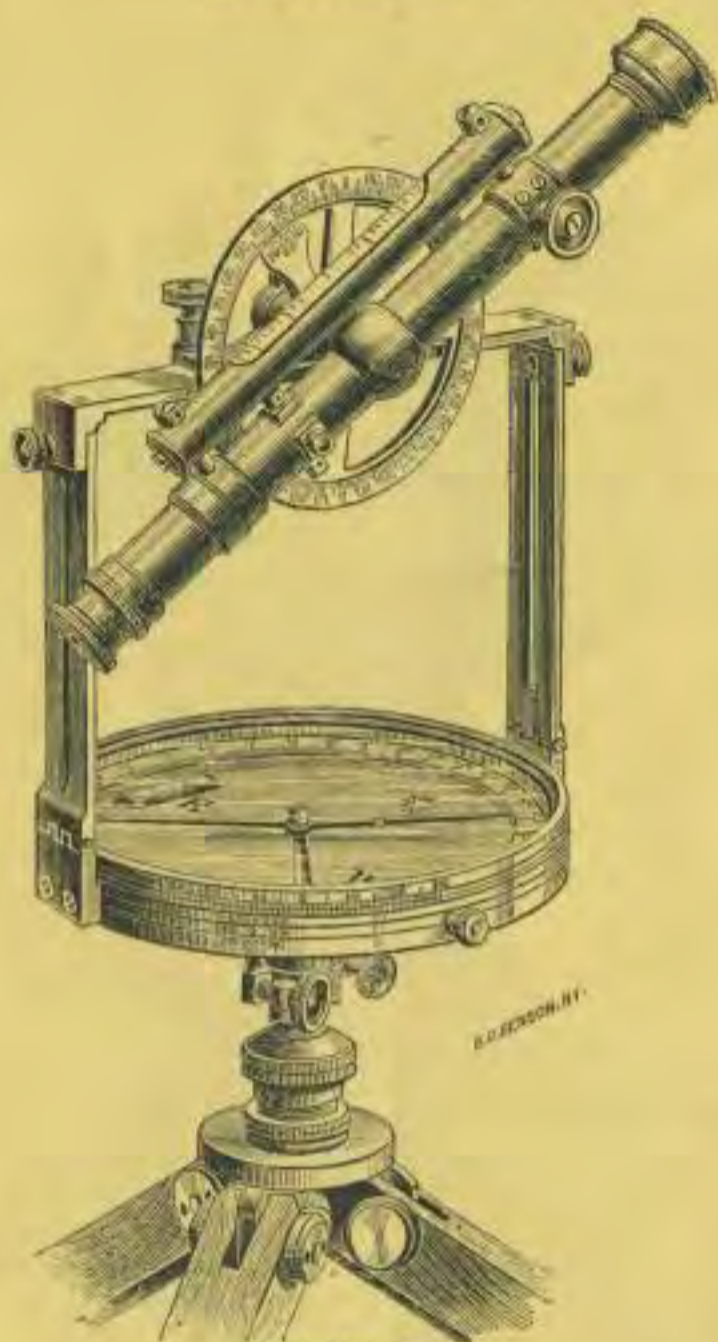
Sometimes a side telescope with counterpoise is substituted for the sight-vanes. The adjustments are the same as those of the ordinary solar compass.

### PRICES.

Price, with Staff Mountings.....	\$100.00
"    "    Light Tripod.....	105.00
"    "    Light Extension Tripod.....	110.00
"    "    "    and Leveling Plates.....	120.00
"    of Side Telescope and Counterpoise fitted to New Pocket Solar Compass.....	25.00
"    of Leather Case with Shoulder Strap for New Pocket Solar Compass.....	5.00

APRIL, 1883.

## POCKET RAILROAD COMPASS, WITH TELESCOPIC ATTACHMENT.



NEW FIG. 31.

One form of this instrument, with  $4\frac{1}{4}$  inch needle, is shown in Fig. 31, with attachments of telescope, etc.

In this style of the Pocket Railroad Compass the plates are circular, the sights being screwed to the lower one, the compass-circle above, and turning around the lower plate to set off the variation of the needle.

The limb is underneath the compass-face, but not shown in the cut, and read by one double vernier under the glass, to single minutes. It has also a clamp and tangent to limb, and a clamp and tangent movement to the spindle.

The sights are made to fold down closely to the glass for convenience in packing; they are each made half-slot and half-hair, so as to take back and fore sights without turning the instrument.

### TELESCOPIC ATTACHMENTS.

To the compasses with  $4\frac{1}{4}$  inch needles we have recently adapted a telescopic attachment as in Fig. 31. When the sights are raised upright, a cross-piece is fastened by milled-head screws to their tops, and thus a telescope placed in position, making the instrument in effect a very light Surveyor's Transit.

The attachments of a vertical circle, level, and clamp and tangent as shown in the figure, can also be added, and thus the means furnished for taking grades and running levels with accuracy sufficient for the common practice of the surveyor.

When the telescope is applied, the sights are now placed by us to one side of the line of zeros, and the telescope is then brought into that line and over the centre of the instrument.

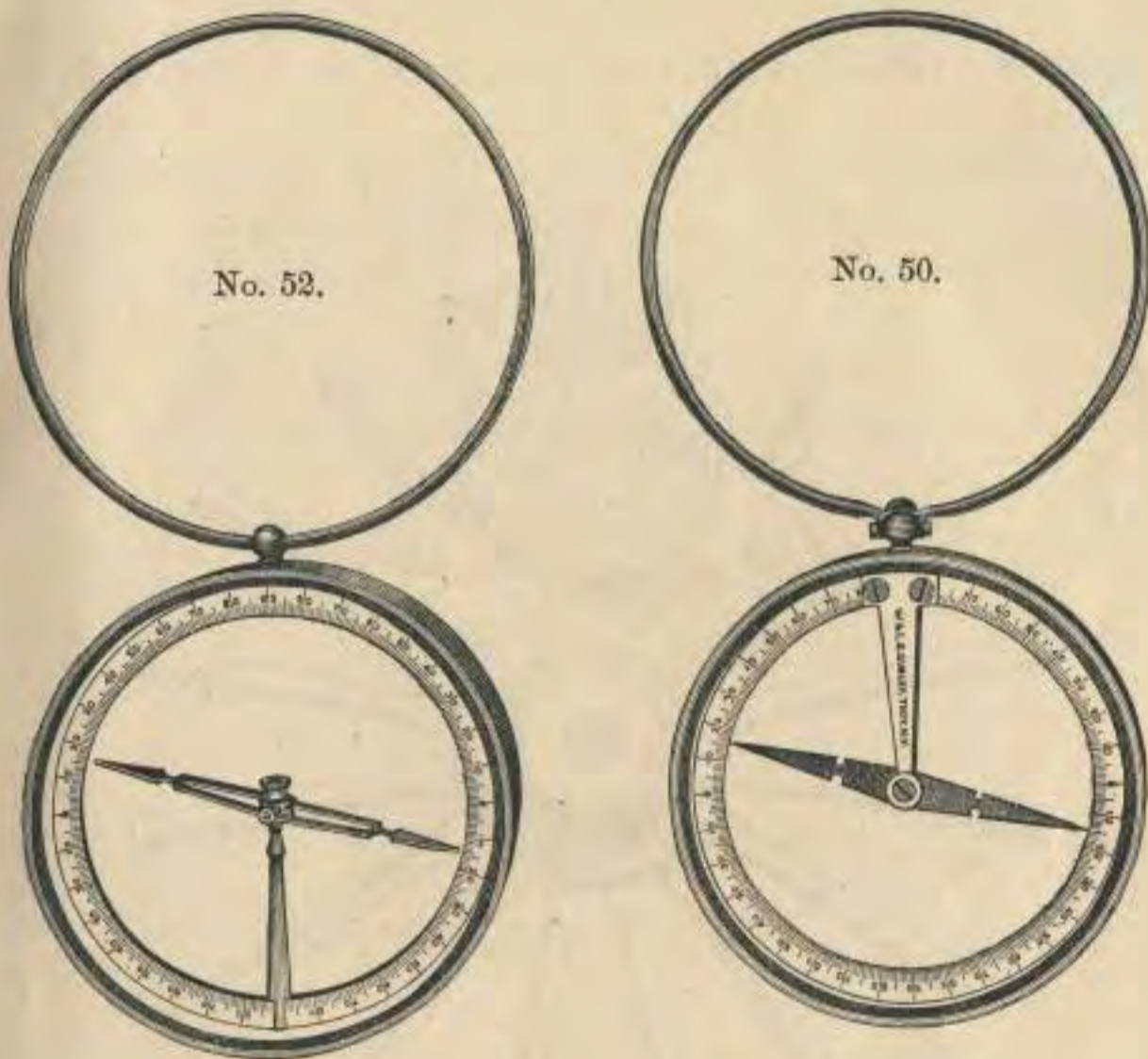
The cross-piece with telescope is detached when the Pocket Compass is put into its case, and replaced in a few moments' time, and without derangement of any adjustments.

The Pocket Railroad Compass can be used either on a jacob-staff or with small tripod, as in Fig. 31, and if desired, with small leveling head.

### PRICES.

Railroad Pocket Compass, $4\frac{1}{4}$ inch needle, clamp and tangent to limb, with limb reading to one minute, with jacob-staff mountings.....	\$28.00
Tripod for Pocket Compass.....	5.00
Clamp and Tangent Movement to ball spindle.....	5.00
Micrometer Telescope, with vertical circle, level on telescope and clamp and tangent to telescope axis.....	35.00
Or complete, as shown in Fig. 31.....	73.00

*APRIL, 1883.*



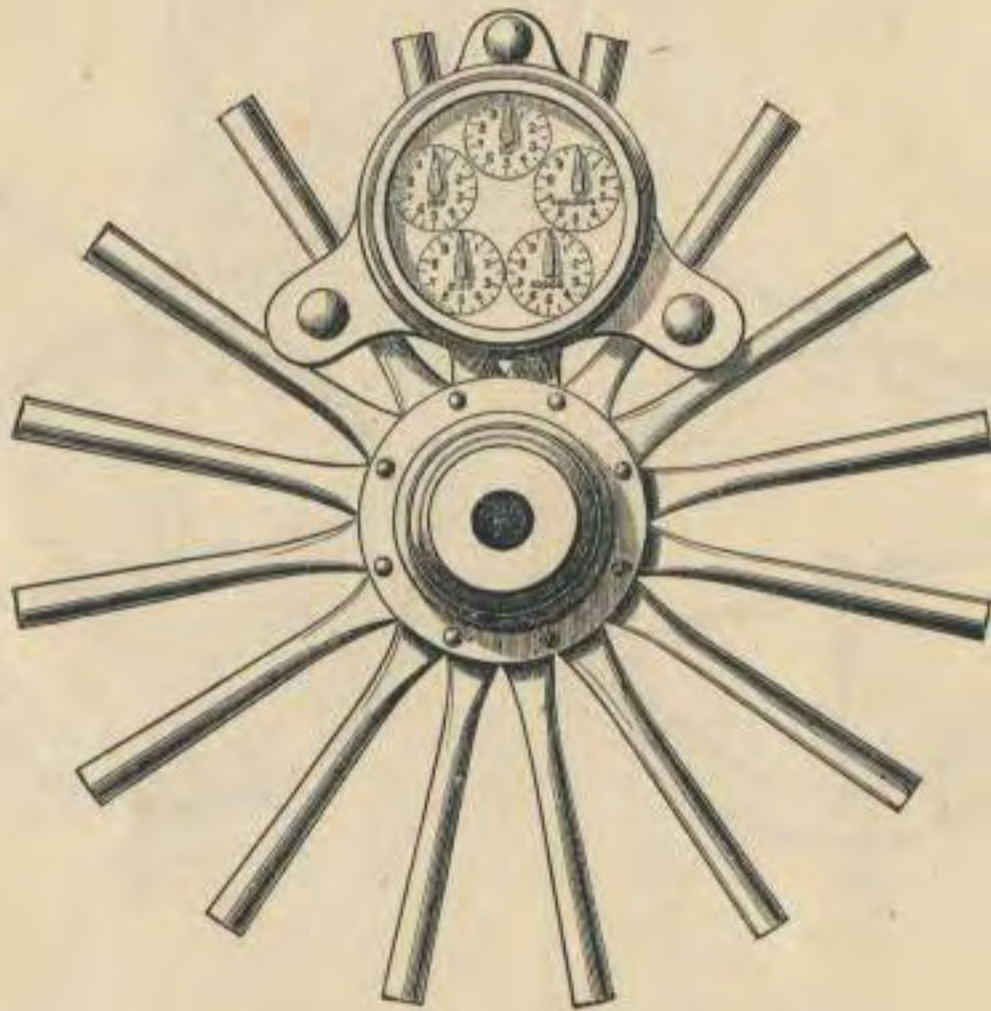
**MINERS' COMPASSES OR DIPPING NEEDLES.**

FOR TRACING VEINS OF MAGNETIC IRON ORE.

No. 49.	Glass on both sides, wood box, stop to needle.....	\$12.00
No. 50.	Glass on both sides, brass covers, stop to needle.....	12.00
No. 51.	Glass on one side, brass cover, stop to needle. ....	12.00
No. 52.	"Norwegian Needle," glass both sides, brass covers, 3 inch needle, superior article.....	12.00
No. 53.	Same as above, 4 inch needle.....	15.00
The first three of the Miners' Compasses furnished without stop (each).....		10.00

## ODOMETER.

FOR MEASURING DISTANCES BY THE REVOLUTION OF A CARRIAGE WHEEL.



REGISTERS FROM 1 TO 100,000 REVOLUTIONS.

Can be attached to any carriage without injury to the wheel and removed at pleasure.

The circumference of the wheel being given, the distance is obtained by multiplying it by the number of revolutions recorded on the dials.

No. 126. Price, with bolts for attaching, complete.....\$10.00

No. 127. We can also furnish the old pattern of Odometer, having the dial in a brass box with leather case and straps, and registering 9,900 revolutions, price..... 16.00

## CHAINS.

The sale of our Steel Brazed Chains is constantly increasing, and they displace the ordinary chains wherever they are tried, on account of superior lightness and strength. They are practically the only chains now used in Railroad construction.

No. 144.	100 feet, No. 12 steel, spring temper, brazed links and rings.....	\$11.50
No. 145.	66 " " " " " " " " .....	10.00
No. 146.	50 " " " " " " " " .....	6.00
No. 147.	33 " " " " " " " " .....	5.50
No. 128.	100 feet with oval rings, No. 5 refined iron wire ... ..	10.00
No. 130.	50 " " " No. 5 " " .....	5.50
No. 129.	100 " " " No. 6 " " .....	7.50
No. 131.	50 " " " No. 6 " " .....	4.25
No. 132.	66 " " " No. 8 " " .....	4.00
No. 133.	33 " " " No. 8 " " .....	2.50
No. 134.	66 " " " No. 10 " " .....	3.50
No. 135.	33 " " " No. 10 " " .....	2.25
No. 136.	100 feet No. 8 best steel wire.....	10.00
No. 138.	50 " No. 8 " " .....	5.50
No. 140.	66 " No. 8 " " .....	9.00
No. 142.	33 " No. 8 " " .....	5.00
No. 137.	100 " No. 10 " " .....	8.50
No. 139.	50 " No. 10 " " .....	4.75
No. 141.	66 " No. 10 " " .....	7.00
No. 143.	33 " No. 10 " " .....	4.00

## GRUMMAN PATENT CHAINS.

No. 160.	66 feet, No. 15 tempered steel wire, light with extra links.....	\$ 9.00
No. 161.	33 " " " " " " " " .. ..	5.00
No. 162.	100 " " " " " " " " .....	11.50
No. 163.	50 " " " " " " " " .....	6.00
No. 164.	33 feet, No. 12 " " " " " " .....	5.50
No. 165.	66 " " " " " " " " .....	10.00
No. 166.	50 " " " " " " " " .....	6.00
No. 167.	100 " " " " " " " " .....	11.50
No. 168.	50 feet, No. 18, with spring balance, level and thermometer, for very accurate measurements, weight $\frac{3}{4}$ lb.....	15.00



### SPANISH OR MEXICAN VARA CHAINS.

No. 148.	10 Varas No. 10 iron.....	\$ 2.25
No. 149.	20 " " .....	3.50
No. 150.	10 Varas No. 8 iron.....	2.50
No. 151.	20 " " .....	4.00
No. 152.	10 Varas No. 10 steel.....	4.00
No. 153.	20 " " .....	7.00
No. 154.	10 Varas No. 8 steel.....	5.00
No. 155.	20 " " .....	9.00
No. 156.	10 Varas No. 12 tempered steel, brazed.....	5.50
No. 157.	20 " " " " .....	10.00

Metre Chains made to order at same price as corresponding length American chains. Steel Snaps to make any of above "Half Chains" no extra charge.

No. 170.	Brass Plummet to use with light chain .....	2.00
No. 171.	Lead Plummet to use with light chain .....	1.50
No. 172.	Spring Balance.....	2.00
No. 175.	Set of 11 Marking Pins, No. 4 iron wire .....	1.50
No. 176.	Set of 11 Marking Pins, No. 6 steel.....	2.00
No. 177.	Set of 11 Marking Pins, No. 4 brass .....	3.00
No. 178.	Set of 11 Marking Pins, No. 6 steel loaded.....	3.00
No. 169.	Set of 10 Marking Pins, very light, with leather case .....	2.00

### STANDARD STEEL RIBBONS.

Our own manufacture, without joint, for testing chains or tapes, or for bridge work.

Ribbon,  $\frac{3}{8}$  to  $\frac{1}{2}$  inch wide, divided on soldered brass plates, graduated every ten feet: 50 feet long, \$4.00; 100 feet long, \$7.00; with graduations, also, at sixteen and a half feet: 33 feet long, \$3.00; 66 feet long, \$6.00. Longer tapes to order. These prices include handles and simple wood reel.

### TAPE MEASURES.

#### CHESTERMAN'S METALLIC TAPE MEASURES.

Made of linen thread, interwoven with fine brass wire, not so liable to stretch as the usual linen tape, and better calculated to withstand the effect of moisture. In substantial leather cases, to 10ths or 12ths of feet.

No. 181.	33 feet .....	2.95
No. 182.	50 feet .....	3.00
No. 183.	66 feet .....	3.30
No. 186.	100 feet .....	4.75

#### CHESTERMAN'S STEEL TAPE MEASURES.

All steel, to wind up in a box same as the metallic tapes, the most accurate, durable and portable measures.

No. 194.	33 feet .....	6.25
No. 196.	50 feet .....	8.50
No. 197.	66 feet .....	11.00
No. 199.	100 feet .....	16.00

#### STEEL POCKET TAPES.

In German silver cases, with spring and stop, divided to 10ths or 12ths of feet.

No. 200.	3 feet .....	1.75
No. 201.	4 feet .....	2.00
No. 202.	5 feet .....	2.25
No. 203.	6 feet .....	2.50

Same, with divisions to centimeters and millimeters on one side, 25 cents per tape higher.

## PAINE'S PATENT STANDARD STEEL TAPES IN JAPANNED CASES.

No. 206.	25 feet .....	\$ 3.50
No. 207.	33 feet .....	4.50
No. 208.	50 feet .....	6.00
No. 209.	66 feet .....	8.00
No. 211.	100 feet .....	12.00

## SAME TAPES IN LEATHER CASES, FLUSH HANDLES.

No. 212.	33 feet .....	\$ 5.50
No. 213.	50 feet .....	8.00
No. 214.	66 feet .....	10.00
No. 215.	75 feet .....	12.00
No. 216.	100 feet .....	15.00
No. 217.	Handles for above tapes, with graduated scale, per pair.....	3.00
No. 218.	Pocket Thermometer .....	1.50
No. 219.	Spring Balance and Level.....	4.00

Besides field instruments which we keep on hand and make to order, we have in stock and can supply at short notice all the materials and instruments needed by Civil Engineers, Surveyors and Draughtsmen, for office work. A full illustrated and priced catalogue will be sent on application.

## DRAWING INSTRUMENTS.

Fine German silver instruments, suitable for office work and plotting of all kinds of field notes.

Morocco Box ; pair of 5½-inch Dividers, with Pen and Pencil Points, pair of 5-inch Plain Dividers, Drawing Pen, Ivory Protractor Scale 6 inches long, per set..... \$5.00

Morocco Box ; pair of 5½-inch Dividers, with Pen and Pencil Points, and Lengthening Bar, pair of 5-inch plain Dividers, pair of 3-inch Dividers, with Pen and Pencil Points, Drawing Pen, German Silver Protractor, German Silver Square, Ivory Scale 6 inches long, per set ..... 9.50

Morocco Box ; pair of 5½-inch Dividers, with Pen, Pencil and Needle Points, and Lengthening Bar, pair of 5-inch plain Dividers, Spring Bow Pen, Drawing Pen, Ivory Protractor Scale 6 inches long, per set .... 9.50

Morocco Box ; pair of 5½-inch Dividers, with Pen, Pencil and Needle Points, and Lengthening Bar, pair of 5-inch plain Dividers, pair of 3-inch Dividers, with Pen, Pencil and Needle Points, two Drawing Pens, German Silver Square, German Silver Protractor, Ivory Scale 6 inches long, per set ... 11.00

Swiss Instruments, same number of pieces, of extra fine finish, and best quality ; cost about twice as much as the above.

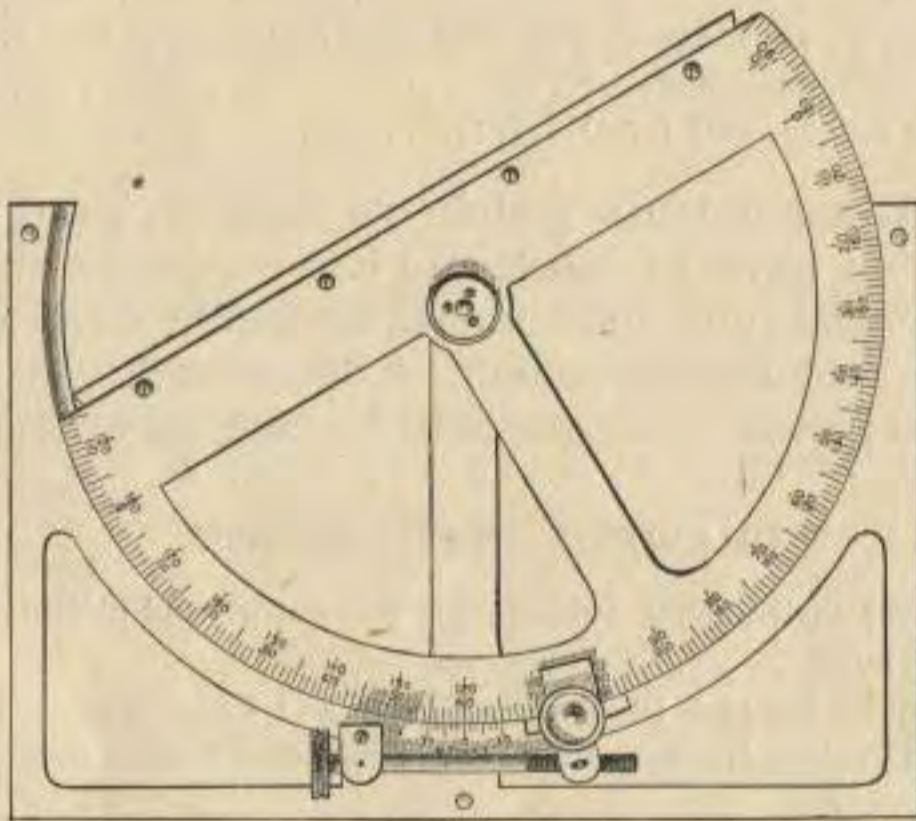
Common Brass Instruments, same number of pieces ; cost about one-third as much as the fine German Silver instruments mentioned above.

Besides the above described cases, we have loose instruments of all kinds, as well as cases containing a larger number of pieces, and costing more money.

CROZET'S PROTRACTOR.

EIGHT INCHES DIAMETER.

VERNIER READING TO 1".



GERMAN SILVER. IN CASE.

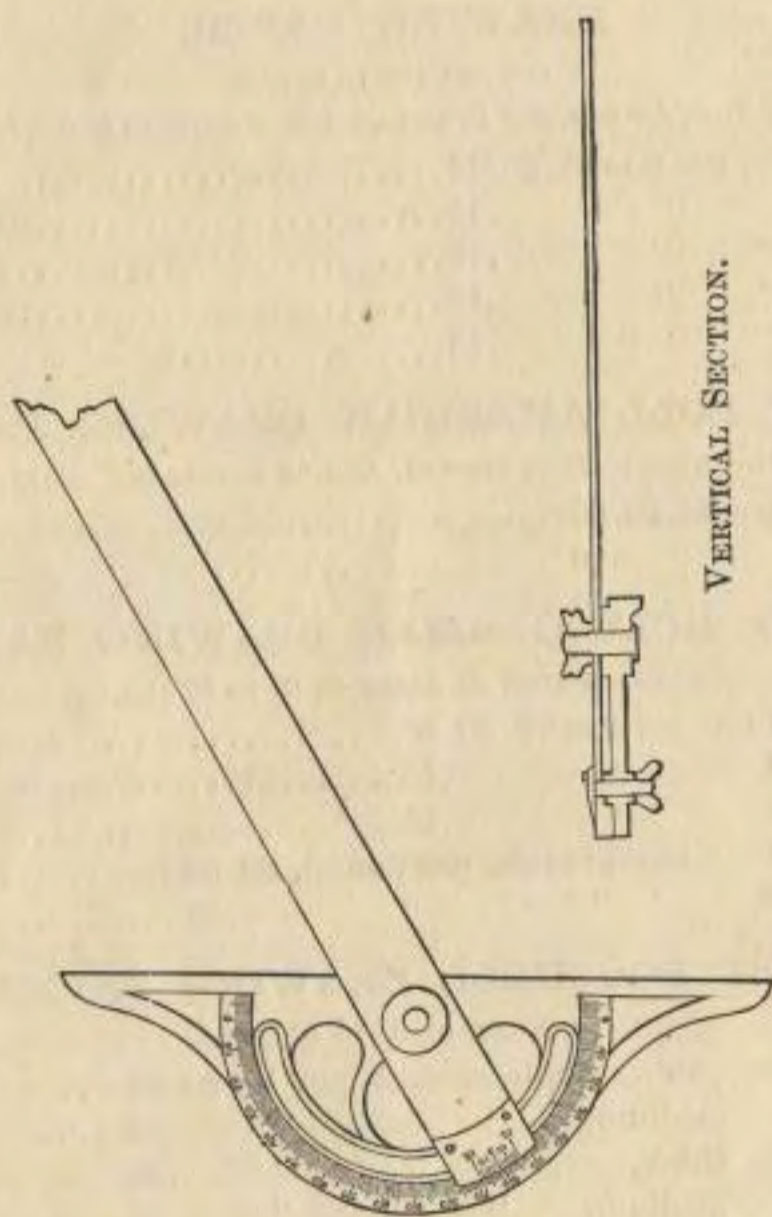
Price..... 40.00  
~~35.00~~

The Crozet Protractor, named from its inventor, an officer of the U. S. Engineer Corps, we recommend as the best among the various high grade protractors yet devised.

It may be used with the T rule or straight edge. The feather edge is always set to the starting point and the line produced without puncturing the paper.

The feather edge is the only metallic bearing upon the paper, small ivory projections on the under side of the frame keep the metal from contact with the paper and prevent soiling it.

NEW LIMB PROTRACTOR.



BRONZE HEAD. STEEL BLADE, 24 INCH. VERNIER TO 1'.

Price.....\$8.00

Add 12 cents per inch, if longer blades are ordered.

## DRAWING STATIONERY.

WHATMAN'S HOT AND COLD PRESSED DRAWING PAPERS, SELECTED, BEST QUALITY.

Demy,	15 x 20, per quire.....	\$ 1.00
Medium,	17 x 22 " .....	1.35
Royal,	19 x 24 " .....	1.80
Super Royal,	19 x 27 " .....	2.30
Imperial,	22 x 30 " .....	2.60
Atlas,	26 x 34 " .....	5.25
Double Elephant,	27 x 40 " .....	5.25
Antiquarian,	31 x 53 " .....	30.00

We only keep the best Whatman's Paper in stock, but to parties desiring it, can furnish the second quality at about 15 per cent. below the above prices.

## DRAWING PAPER.

CONTINUOUS IN ROLLS.

Bleached Manilla, Buff Tint, for working Drawings, best American make, in Rolls of 50 to 100 lbs.

36 inches wide, thick, per pound, \$0.15.....	per yard, \$0.10
40 " " " .15.....	" .12
44 " " " .15.....	" .14
48 " " " .15.....	" .16
54 " " " .15.....	" .18

## WHITE ROLL AMERICAN DRAWING PAPER.

A NEW ARTICLE, VERY STRONG, AND OF EXCELLENT QUALITY.

36 inches wide, per pound, \$0.60.....	per yard, \$0.25
42 " " " .60.....	" .30

## WHITE ROLL GERMAN DRAWING PAPER.

EXTRA WHITE, IN ROLLS OF 30 TO 50 LBS.

36 inches wide, medium, per pound, \$0.40.....	per yard, \$0.25
44 " " " .40.....	" .30
56 " " " .40.....	" .35
56 " " extra tough, per pound, \$0.55.....	" .50
56 " thick " " .55.....	" .70

## BEST EGGSHELL DRAWING PAPER.

IN ROLLS OF 30 TO 40 LBS.

Eggshell 58 inches wide, thin, rough surface, per lb. \$0.58.....	per yard, \$0.45
" 58 " medium, " " .55.....	" .55
" 58 " thick, " " .55.....	" .75
" 42 " medium, " " .55.....	" .40

Full Rolls only of continuous paper sold by the pound at above prices.

## MOUNTED DRAWING PAPER.

WHITE, MOUNTED ON MUSLIN—IN ROLLS OF 10 YARDS.

American paper, 36 inches wide, smooth surface, per roll, \$8.00.....	per yard, \$0.90
" " 42 " " " " 9.00.....	" 1.00
German " 42 " rough " " 9.00.....	" 1.00
" " 54 " " " " 12.00.....	" 1.40
" " 54 " thick, " " 14.00.....	" 1.60
Eggshell, 42 inches wide, medium, " " 12.50.....	" 1.45
" 54 " " " " 14.00.....	" 1.60
" 58 " " " " 16.00.....	" 1.80

Large Pieces for City, County or State Maps. Mounted to order.

**TRACING OR VELLUM CLOTH.**

IN ROLLS OF 24 YARDS, BOTH SIDES GLAZED, OR FACE GLAZED AND BACK DULL,  
SUITABLE FOR PENCIL MARKS.

Imperial, 18 inches wide, per roll, \$5.00.....	per yard, \$	.30
“ 30 “ “ 7.50.....	“	.40
“ 36 “ “ 9.00.....	“	.50
“ 42 “ “ 11.50.....	“	.60

**FLAXINE TRACING PAPER.**

White, in sheets 21 x 31 inches .....	\$	.12
In rolls of 25 sheets, per roll .....		2.50

**PROFILE PAPER.**

Plate A, 42 x 15 in., horizontal ruling, 4, vertical, 20 to inch, per sheet.....	\$	.40
Plate B, 42 x 13 $\frac{1}{4}$ “ 4, “ 30 “ “ .....		.40
Plate C, 42 x 15 “ 5, “ 25 “ “ .....		.40
The three above, per quire.....		8.50
Continuous Profile Paper, Plates A or B, 22 inches wide, per yard .....		.30

**MUSLIN BACKED ROLL PROFILE PAPER.**

Muslin Backed Roll Profile Paper, of either Plate A or B, 22 inches wide, in rolls of 20 yards, per yard.....	\$	.75
Muslin Backed Roll Profile Paper, Plate B, 9 inches wide, in rolls of 20 yards, per yard.....		.50

Plate B corresponds to that in sheets known as Brown's Profile Paper.

**CROSS SECTION PAPERS.**

Topographical Paper, 14 x 17 inches, ruled 400 feet to the inch, per sheet....	\$	.10
Per quire.....		1.75
Trautwine's Cross Section and Diagram, 10 feet to inch, for embankments of 14 and 24 feet, roadway, and for excavations of 18 and 28 feet, rulings 19 $\frac{3}{4}$ x 12 inches, per sheet, 25 cents.....	per quire	5.00
Cross Section Papers, rulings 22 x 16 in., 8 ft. to in., per sheet, 25c. “		5.00
“ “ 20 x 16 10 “ “ 25c. “		5.00
“ “ 20 x 16 10 “ every fifth line heavy, per sheet, 25 cents.....	per quire	5.00
Cross Section Papers, rulings 22 x 16 in., 16 ft. to in., per sheet, 25c. “		5.00

Ruled Cross Section Paper at half the above prices.

All the Profile and Cross Section Papers can be furnished, printed with red or green lines.

India Ink, Winsor and Newton's Standard Water Colors, Triangles and Curves of wood or hard rubber, Protractors of all kinds, Thumb Tacks, Pencils, Pens, India Rubber, Rules, Scales, Straight Edges, and T Squares, Steel Goods.

STANDARD WORKS  
ON  
SURVEYING AND CIVIL ENGINEERING.

*Sent post paid on receipt of price.*

Gillmore on Limes, Cements and Mortars .....	\$ 4.00
Loomis' Practical Astronomy.....	2.00
Cullum's Military Bridges.....	3.50
Haupt's Bridge Construction .....	3.50
Merrill's Iron Truss Bridges for Railways.....	5.00
Whipple's Bridge Building .....	4.00
De Volson Wood on the Construction of Bridges and Roofs.....	3.00
Boller's Iron Highway Bridges .....	2.50
Gillespie's Roads and Railroads.....	2.50
Stoney on Strains .....	12.50
Vose's Hand Book of Railroad Construction .....	12.50
De Volson Wood on the Resistance of Materials.....	2.50
Copley's Letter Book .....	3.00
Mahan's Industrial Drawing—Thompson's Revision .....	3.50
Krepp on the Sewage Question.....	5.00
Baker's Railway Engineering, with Tables.....	2.50
Fanning's Water Supply Engineering, fully illustrated .....	6.00
Burt's Key for Solar Compass.....	2.50
S. V. Clevenger Treatise on Government Surveying.....	2.50
Henck's Field Book for Civil Engineers.....	2.50
Scribner's Pocket Table Book, 10th Edition, revised .....	1.50
Scribner's Engineers' and Mechanics' Companion, 18th Edition, revised .....	1.50
Trautwine's Civil Engineer's Pocket Book.....	5.00
Gillespie's Land Surveying .....	2.60
Gillespie's Higher Surveying.....	2.20
Gillmore on Roads, Streets and Pavements.....	2.00
Hawes' System of Rectangular Surveying.....	3.00
Murray's Manual of Land Surveying. ....	2.00
Gurley's Manual of the Principal Instruments used in American Engineering and Surveying, fully illustrated .....	.50
Nautical Almanac.....	.75
Stewart on Irrigation.....	1 50
Balch's Railway Inventory .....	5.00

## SPECIAL NOTICE.

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*Many of our smaller instruments, such as pocket compasses, chains, tapes, small packages of paper and parts of large instruments can be sent by mail securely packed, and at much lower rates than are charged by express companies for packages not exceeding four pounds in weight.*

*In all cases where goods are to be sent by mail, the cash for postage as well as for the goods must accompany the order. All articles can be registered at an extra cost of ten cents besides regular postage. We are not responsible for goods sent by mail.*

*Samples of drawing paper, tracing paper, tracing cloth and profile and cross-section papers sent with prices on application.*



## Important Improvements in Instruments.

---

In presenting the preceding new price list of instruments of our manufacture, we take occasion to inform our patrons and friends, as well as the profession generally, of some important improvements principally of our own manufacture, and which we believe to be worthy of their attention.

We have carefully revised our list of prices, materially reducing them; but we assure our readers that we shall fully maintain the reputation of our instruments for careful workmanship and general excellence—a reputation which has been won by a close attention to the wants of our customers during more than thirty-five years.

Our aim has always been to improve the quality of our instruments, introducing all the appliances and making all the changes which the needs of the profession and our own long experience could suggest; and we assure our old customers, as well as those who may favor us in the future, that we shall strive to make the best and most complete instruments that can be procured.

Among the improvements which we have recently introduced in surveying instruments we mention the following:

The Patent Solar Attachment for transits; the use of platinum cross wires; the Architect's Level; our Patent Extension Tripod, and the new Telescopic Attachment for compass sights; vertical circle, level and clamp and tangent movement applied to Patent Telescopic Sight; Abney Level; new Odometer; Whitehouse Patent Rod; Patent Quick Levelling Head; Crozet Protractor; Pocket Solar Compass.

(1.) **The Patent Solar Attachment** is essentially the solar apparatus of Burt, placed upon the crossbar of the ordinary transit telescope, the polar axis only being directed above instead of below.

In applying this attachment to any instrument, a circular disc is first securely screwed to the centre of the axis of the telescope; upon a pivot in the centre of this disc rests the enlarged base of the polar axis, firmly fastened to the disc by four capstan head-screws passing from the under side of the disc, and thus adjusting the axis in any direction.

The hour circle surrounds the base of the polar axis, is figured from I. to XII., and is read to ten minutes of time by a small index fixed to the declination circle and moving with it. A hollow socket fitted to the polar axis and moving around it furnishes by two expanded arms a firm support for the declination arc. This arc is of from four to six inches radius, and is read by its vernier to either thirty seconds or one minute of arc.

The declination arc has the usual lenses and silver plates placed on two opposite blocks like those of the ordinary solar compass ; it has also a tangent screw for accurately setting off the declination.

The latitude is set off by means of a vertical limb divided on silver, and reading to single or half minutes as desired. The vernier of the arc is furnished with a tangent screw for fine adjustment.

We have given the Solar Attachment the test of nearly four years of service ; during this time we have put it on a large number of instruments of our own and of other makers, and we can recommend it with perfect confidence to all surveyors whose practice requires them to make surveys by the true meridian.

Our own observation with this attachment has shown to us the perfection of its adjustments, and the accuracy with which it will enable a surveyor to obtain the latitude of a place, the time of day, and the true meridian, with a precision heretofore unattainable except with fixed astronomical instruments.

We are fully satisfied that this is the only successful application of the Solar Apparatus to the transit, and the numerous instruments of other makers sent to us to be fitted with this attachment assure us that surveyors in all parts of the country are of the same opinion.

*(For testimonials see end of this Circular.)*

(2.) **The advantage of platinum over spiderweb** for the cross-wires of telescopes has long been conceded, but the difficulty of procuring it of sufficient fineness has prevented its general adoption. We are now successfully drawing platinum wires of a fineness of from one eight-thousandth to one twelve-thousandth of an inch, and are using them in the telescopes of all our instruments, unless spider-lines are specially ordered.

These wires are perfectly opaque, and of course entirely unaffected by moisture, and we believe they will be universally preferred to the spider's web heretofore used.

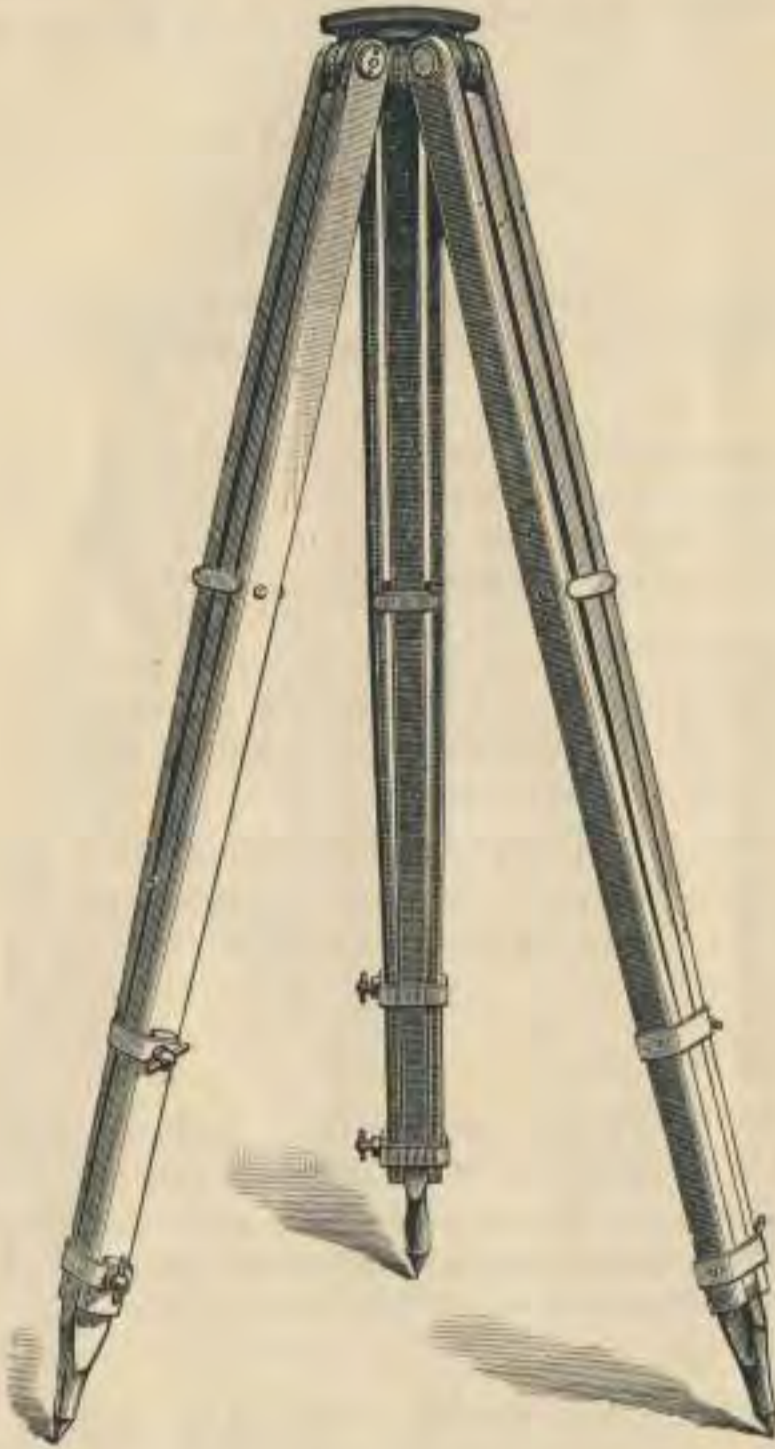
(3.) **Our new Architect's Level** supplies a want long felt by every intelligent architect, builder, millwright, and farmer, of a simple and accurate level, procurable at a reasonable price.

It has a telescope about eleven inches long, having the usual cross-wires and adjustments of the object and eye-glasses, and mounted in adjustable Y's, like those of the Engineer's Level.

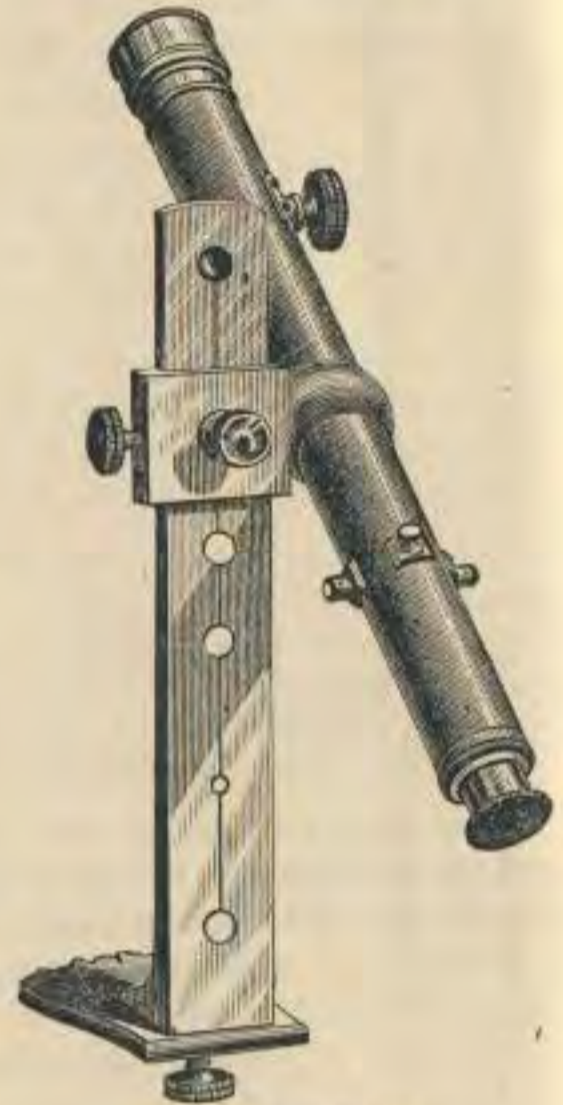
The Y's are set in the ends of a bar connected below with a spindle and socket, levelled in any direction by the ordinary leveling screws. An adjustable spirit level is placed on the upper surface of the bar. The instrument is thus supplied with all the appliances of the larger and more costly level ; and it has, in addition, a horizontal circle or limb divided to degrees, and read by a vernier to five minutes, which\* turns with the telescope, thus enabling the observer to obtain the angle between any two points, to set off right angles, &c.

(SEE PAGE 6 AND FRONTISPIECE.)

## (4.) New Patent Extension Tripod.



## (5.) New Telescopic Sight.



Patented July 9, 1878.

(4.) **Our new Patent Extension Tripod** has all of its legs so made that they can be shortened or lengthened at will. It is thus perfectly fitted for use in hilly country and is specially adapted for use in mines where a short tripod is needed. Shown in frontispiece with Light Mountain Transit.

(5.) **The new Telescopic Sight** consists of a telescope furnished with the usual cross wires, etc., and attached to a movable band; which, as shown in the engraving, can be slipped over the sight of a compass, clamped at any point desired, and put in adjustment by any person who has a screw driver and a steel adjusting pin.

To put this apparatus in place, slip the band over the south sight of the compass, having (as shown in the cut) the telescope on the right hand and the front clamp-screw on the outer surface of the sight; and place the band as low as will allow the telescope to revolve in either direction without striking the compass. This place should be marked by a line across the sight, that the band may be set at the same point in subsequent use.

To fasten the band to the sight, first bring up the clamp-screw in front with a pressure just sufficient to hold the band to its place then tighten the screw on the left until the band is brought up against the right edge of the sight, and finally touch the front clamp-screw again, when the fastening will be complete.

To put the telescope in focus, turn the end of the eye-piece either back or forth by the thumb and forefinger until by the spiral motion of the tube the cross wires are brought into distinct view; the object glass is then moved in either direction by the pinion on the side of the telescope until the object is clearly seen.

#### THE ADJUSTMENTS.

Of the Telescopic sight are as follows :

(1.) To make the telescope axis horizontal.

(2.) To bring the optical axis of telescope into a position at right angles to the axis.

(3.) To make the optical axis of telescope cut the same line as the sight vanes of compass.

To make these adjustments—and, indeed, to do any correct work with a compass—the spindle should be well fitted and the level bubbles remain in the centre when the instrument is revolved upon its spindle; the sights also should trace a plumb line when the compass is level.

To make the first adjustment :

(1.) The compass being in good order, first bring the levels into the centre; place the band in position upon the sight, as before described; bring the telescope into focus and set the vertical cross wire on the vertical edge of a building, distant from fifty to sixty feet, and at a point near the ground; clamp the compass to the spindle, and direct the telescope to the top of the building. If the wire strikes to the right of the edge, it shows that the right end of the telescope axis is lowest.

To raise it, loosen the clamp-screw on the left, and with a small screw driver turn in the little screw on the right side of the band and under the axis until the correction is made.

If the cross wire strikes to the left when the telescope is raised, proceed exactly the reverse in making the correction until the wire will follow the edge from one end to the other, when the adjustment will be complete. If the vertical cross wire is not parallel with the edge, loosen the capstan head screws, and turn the ring by the screw heads until the correction is made; and finally tighten the screws.

(2.) To make the second adjustment—that is, to bring the optical axis into a position at right angles to the axis of the telescope so that the cross wires will indicate two points in opposite directions in the same straight line—proceed as follows :

Having the instrument level, find or place two objects one on each side of the compass, and from three to four hundred feet distant from it, which the sight vanes will intersect; clamp to the spindle and sight through the telescope at either of the objects; if the vertical wire strikes to the right, loosen the clamp screw in front, and with the screw-driver turn in the little screws set in the front side of the band, one on each side of the telescope axis, until the vertical wire bisects the object—looking again through the vanes to see that the compass has not moved on its spindle, so that the same object is seen through both telescope and sights. If, however, the cross wire should strike to the left of the object, proceed in a manner exactly the reverse until the error is corrected.

Then, without disturbing the compass, revolve the telescope and sight to the object in the opposite direction; if the vertical wire strikes to either side, half the error must be removed by the cross wire screws shown on the outside of the telescope—first loosening the screw on the side towards which the wire is to be moved, and then tightening the opposite screw until one-half the error is corrected, and the remainder by the two small screws in front of the band.

Having made the correction, sight again through the vanes and telescope, repeating the operation until the error is entirely removed, when the adjustment will be complete.

It should be here remarked that the adjustment just described, and which is usually termed the adjustment of the line of collimation, is fully described in our Manual in the account of the transit instrument, and may be effected with this apparatus by the telescope alone, without reference to the sight vanes—precisely as directed in the adjustments of a transit instrument. It is always made by us before the apparatus passes out of our hands, and need not again be disturbed except in cases of accident or careless interference with the cross-wire screws; but in any event it can be easily effected by any surveyor in a few moments, and with very little practice.

(3.) If the surveyor has made the second adjustment, as just described, he has already put the optical axis of the telescope in line with the sights, and so effected the final adjustment; but if not, and especially if the telescopic sight is to be applied by himself to a compass to which the maker has not fitted it, then he will proceed as follows:

Having the compass level, direct the sights to some clearly defined object—as a post, staff, or vertical bar of a window—some three or four hundred feet distant, clamp to spindle and observe the same with the telescope.

If the vertical wire strikes to either side, remove the error by the two screws in front of the band, as already described in the previous adjustment, until the correction is made; and the telescope will then bisect the same object in either direction, as is indicated by the sight vanes.

Of course, when the telescopic sight is fitted by us, either to a new or old compass, the adjustments above described are all completed before the instrument is sent out of our hands, but we have been thus minute in our description of them in order that surveyors sending for this apparatus may be enabled to apply it to their own compasses without further trouble or expense.

When the adjustments are complete the appliance can be put in place on the sights, removed and replaced again in a moment, and without danger of derangement in any of its parts.

The stadia wires alluded to in No. 19 are two horizontal parallel cross wires, one on each side of the centre wire, and each fastened to a movable piece which is controlled by a screw on the outside of the telescope. The distance between the stadia wires can thus be adjusted so as to cover a certain vertical space on a divided rod, held at a given distance from the centre of the instrument, usually one foot or one link on the rod to one hundred feet or links in distance—as more fully described in our Manual and other works on instruments.

The optical axis of the telescopic sight is at one side of the line of sight of the sight vanes, but parallel to it. The difference between a sight taken with the sight vanes, and one taken with the telescope, is, at a distance of two hundred feet about two minutes, so small that it may be disregarded in any survey made with the magnetic needle.

If *all* lines are run with the telescopic sight, the angles measured will be accurate, as even this slight difference is entirely eliminated.

The advantages of the telescope over the ordinary sight vanes will be apparent to every one who has ever seen them compared, or who has given the matter a moment's reflection.

Much longer sights can be taken, either forward or backward, and lines run up and down steep hillsides with the same facility as on level ground, and all with more accuracy, and with inexpressible relief to the eyes of the surveyor, so often severely strained by the use of the sight vanes of the ordinary compass.

Indeed, it may be said that every compass can with this simple appliance be transformed into a transit-compass at will, and thus all the advantages of the telescope brought within the reach of every surveyor at comparatively trifling cost.

When furnished with a new instrument, it is packed in the box, like the sights, etc., or it can be safely forwarded by mail to any part of the country, securely packed in a suitable case, in which it may be kept when not in use.

We have furnished the Patent Telescopic Sight, in this, the second year since its introduction, to Surveyors in almost every State and Territory in the Union. It has been carefully tested and with entire satisfaction. The demand for it has far surpassed our highest expectations, and we feel warranted in recommending it as an addition of great value to any compass.

(6.) In compliance with the wants of some of the Surveyors who have used our Patent Telescopic Sights, we furnish them when desired with a level on the telescope with clamp and tangent movement to axis of telescope, and vertical circle with vernier reading to five minutes, for angles of elevation and depression. See pages 7 and 8.

(7.) We would call special attention to the addition of our Patent Telescopic Sight (with extras if desired) to our Vernier Pocket Compass, so largely used in exploring and reconnoitering, and we confidently recommend this Vernier Transit Compass as the lightest, strongest and cheapest instrument in use for land or mining prospectors. See page 8.

(8.) We are now manufacturing the Abney Level. It is substantially a Locke's Hand Level combined with the clinometer, giving angles of elevation as well as slopes of excavation and embankment, as 1 to 1, 2 to 1, &c. See page 19.

(9.) The Whitehouse Patent Rod, a new twelve feet sliding rod, made of black walnut and maple, of good quality and at a reasonable cost. It combines the self-reading properties of the Philadelphia Rod, with the general construction of the Yankee or Boston Rod. See page 20.

(10.) The following engravings represent a new tripod head for Engineers' and Surveyors' Instruments, greatly facilitating the leveling of an instrument, and making as we believe, the most efficient quick leveling arrangement yet devised.

**DIRECTIONS FOR USE.**—Screw the instrument on the tripod as usual; if not nearly level, unscrew the leveling head a very little, a bare loosening of the screw is sufficient. The instrument will then be free to move upon the spherical surfaces, *A. B. C.*, in any direction required to bring the plates approximately level, and will be held in this position by the friction of the same surfaces.

Now screw the head fast again firmly clamping the whole instrument to the tripod. The final adjustment of the level is then completed by the use of the leveling screws.

The friction of the spherical surfaces may be increased or diminished at will, by turning the screws "*D*" which compress the spiral springs.

FIG. 1.

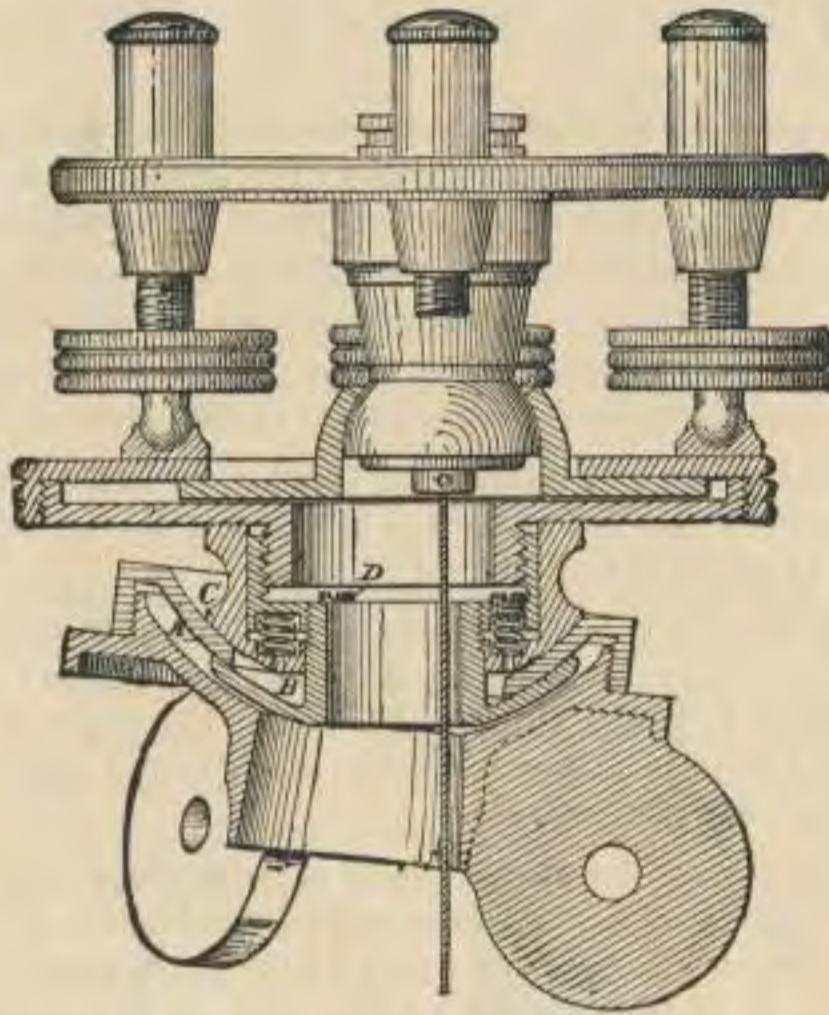


FIG. 1. Shows the quick leveling tripod with shifting plate for use with transit.

FIG. 2.

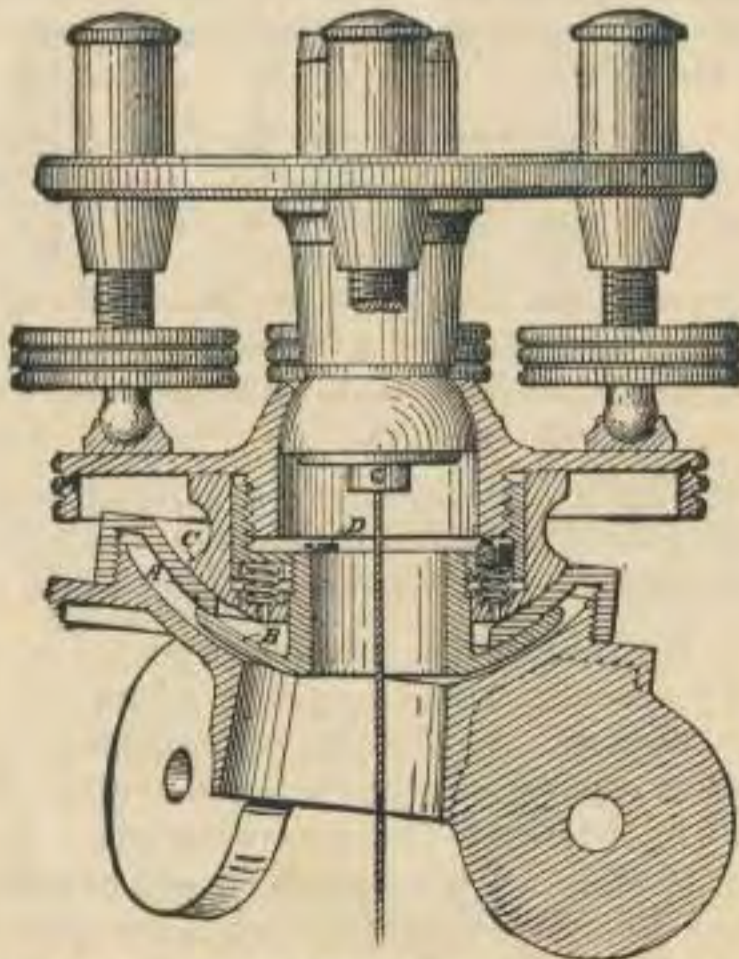


FIG. 2. Shows the quick leveling tripod head designed for level or transit, and without shifting plate.

FIG. 3.

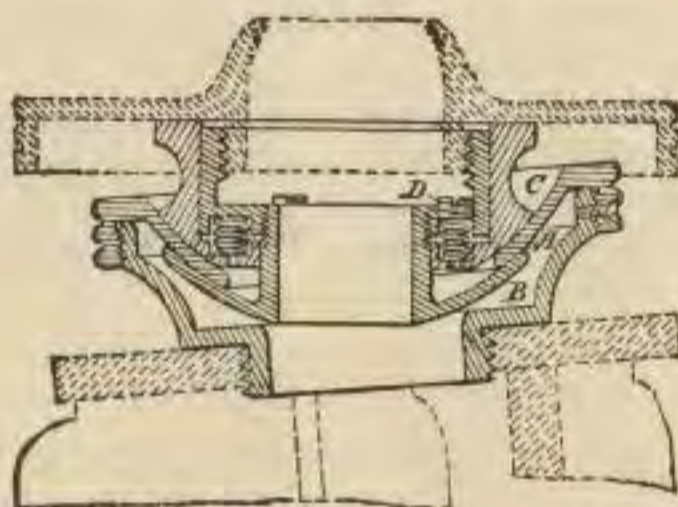


FIG. 3. Shows the quick leveling attachment as screwed fast to a tripod of any pattern now in use.

PRICES. As shown in Figs. 1 and 2, when furnished with a new instrument, \$5.00. For same, adapted to any instrument already in use, as in Fig. 3, \$6.00.

N. B.—When No. 3 is ordered for any instrument, the lower plate of the leveling head, as shown in outline of same figure, or the brass head of the tripod, the legs being removed, may be sent to us by mail or express, prepaid, with the remittance of—say \$7.00—to pay for attachment and return charges.

(11.) The Odometer of new pattern with visible register under plate glass, can be attached to any wheel without marring the varnish, and registers the number of revolutions of the wheel up to 100,000. We continue to furnish the Odometers of old pattern in leather case where the dial must be taken out of its box in order to read it, an inconvenience avoided in the one shown on page 24.

(12.) Crozet Protractor, see page 28.

### NEW POCKET SOLAR COMPASS.

(SEE ENGRAVING, PAGE 22.)

This instrument, devised by us to supply a need felt by every mining surveyor and explorer, for a simple and portable instrument, giving the true meridian with substantial accuracy, and by the comparative degree of deflection of the magnetic needle from such meridian, indicating with certainty the presence and direction of veins of magnetic iron ore; and in general for its adaptability to all accurate surveys of mining property, and all other surveys based upon the true meridian, we have named the Pocket Solar Compass.

It is provided with a needle of  $3\frac{1}{2}$  inches, and has its compass circle movable with a pinion, so as to set off the variation of the needle to single minutes.

The outside circle or limb is divided on silver to half degrees, and read by one double vernier to single minutes. The main plate carrying this vernier and sights is moved around the limb by a pinion underneath, and clamped at any point desired. There is also a clamp and tangent movement to the whole instrument about its spindle.

The solar apparatus is attached to the limb (as shown in the cut), and consists of the usual *hour*, *latitude* and *declination* arcs, with an arm to the last named, carrying the solar lenses and lines as in the larger instruments; each of the arcs is read by a simple index line.

The latitude and declination arcs are both divided to half degrees, and figured as



usual. The hour arc is divided on its inner edge into hours and twelfths, or spaces of five minutes each, the index of the declination arm above, easily enabling one to estimate the time to single minutes.

The hour arc is made movable upon its supporting segment to either side, its outer edge being also divided to five minutes of time, and read by a vernier upon the segment to single minutes; in this way the *equation of time* for any given day is set off at once, and the time given by the index of the hour arc thus made to agree with mean time or that given by the ordinary watch.

The solar lenses and lines are placed as in the larger instruments, the declination arc being also reversible, as the sun changes from north to south of the equator.

The sights have a fine hair, and slit alternately in one half their length, and are made with hinges to fold.

When packed in its case the declination arc with its arm is detached from the hour arc; and this itself, together with the latitude arc, folds closely to the compass box.

The compass is set up for use either upon a single staff or upon a very light tripod, as shown in the engraving.

#### TO USE THE POCKET SOLAR COMPASS.

The instrument is set upon its tripod or staff, and carefully leveled; the declination of the sun for the given day is obtained from the Nautical Almanac and set off upon its arc, and the hour arc is raised until its index marks the latitude of the place upon the latitude arc.

The equation of time for the day of observation is also set off, as before described, the zero of the hour circle being moved to the right when the equation is to be added, and to the left when it is to be subtracted from apparent time.

The index of the declination arc being then directed to the proper minute on the hour arc, as given by a correct watch, the whole instrument is turned upon its spindle, until the sun's image is brought between the vertical or hour lines of the silver plate on the declination arm; the vernier of the limb being set at zero, the sights will indicate the *true meridian* of the place; and this being found, the change in time will be accurately marked by the index of the hour arc, as the declination arm is made to follow the movement of the sun.

The compass circle being now turned by a pinion head placed above the outer edge of the compass circle, not shown in the engraving, until the needle points to its zero, the needle also will then be set to the true meridian, and the variation of the needle can be read off upon the outside divisions of the compass box.

#### TO OBTAIN THE CORRECT TIME.

As in this instrument, unlike the ordinary Solar Compass, the element of correct mean time is of the first importance, we here describe the manner of obtaining it by equal altitudes of the sun.

Having the instrument carefully leveled, the declination set off upon its arc, and the hour arc set to zero of the vernier on its outer edge, find by the Almanac the true time of *apparent noon*, or the moment when the sun crosses the meridian.

About 15 or 20 minutes before this time, set the index of the declination arm to XII of the hour arc, and by moving the hour segment up or down on the latitude arc, bring the sun's image as nearly as possible between the two horizontal or *equatorial lines* on the silver plate, and turning the instrument upon its spindle, bring the image into the little square formed by the two sets of lines, and with a

good magnifier—waiting until the image is precisely between the equatorial lines—note the exact moment by the watch.

As the sun rises to its highest point, its image will run below the lines and again ascend after the sun passes its culmination.

Now, turning the instrument on its spindle, so as to keep the image still within the hour lines, note by the watch the exact moment when the image comes again to its former position between the equatorial lines, and we shall have the exact times of the equal altitudes of the sun.

The mean of the two readings of the watch will give the precise time of the meridian passage of the sun, or correct time of apparent noon.

Suppose that the time of the first altitude of the sun was 11h. 42m. 14s., and the second 12h. 15m. 10s., the mean of the two being 11h. 58m. 42s., instead of 12h. 0m. 0s., would show that the watch was 1m. 18s. slow.

In this example we have supposed the sun and clock to agree, or the equation of time to be 0; but as this occurs but four times in the year, we must at all other times apply the equation of time to the mean time as given by the watch, in order to obtain the time of apparent noon, or the moment of the meridian passage of the sun.

If, for instance, the observation was made on the 23d of January, 1880, the equation being then 12m. 1s., and to be added to apparent time to obtain correct mean time, then the sun would not reach the meridian until 12m. 1s. after XII by the watch, and if the first altitude was 11h. 55m. 14s. and the second 12h. 25m. 10s., the mean being 12h. 15m. 12s. instead of 12h. 12m. 1s., would show that the watch was 1m. 49s. too slow.

When the equation is to be subtracted the sun will come to the meridian before XII by the watch, and allowance is to be made, as in the case just described.

In summer, when the sun is high and its movement in altitude most rapid, the equal altitudes are most readily taken and the time most accurately obtained. When it is low a longer time should be allowed between the two altitudes to insure the best results.

#### TO OBTAIN THE LATITUDE OF A PLACE.

Having set up and accurately leveled the instrument, the declination being carefully set off upon its arc, set the hour arc at zero and the declination arm at XII; and at 20 or 25 minutes before the time of the sun's meridian passage raise or lower the hour segment by the side of the latitude arc until the sun's image is brought between the horizontal or equatorial lines; and turning the instrument on its spindle so as to keep the image between the hour lines, follow the sun until it has ceased to run below the equatorial lines; and the index of the hour segment will indicate on the latitude arc the true latitude of the place.

After repeated trials with this little compass, we are satisfied that it will determine a true meridian, within an error of less than five minutes of a degree; that its adjustments and use are so simple as to be easily understood and applied by any intelligent observer; and that, combining as it does the accuracy of a divided limb, with a good needle, it will be found admirably adapted to the needs of mining surveyors and prospectors in all parts of the country.

It is packed in a mahogany case,  $7\frac{1}{4} \times 6 \times 2\frac{1}{4}$  inches in outside measure; and can thus be carried in a pocket or by a strap slung over the shoulder.

Its weight, including the staff, mountings and case, is less than 4 lbs., and with the small tripod a little over 7 lbs.

Besides the special improvements above named, we also make all the instruments and attachments used by either Surveyors or Engineers—such as the *shifting tripod head*, by which the whole instrument is shifted horizontally in any direction in setting the plummet precisely over a point; *the plummet and stationary lamps*; *reflector for illuminating cross-wires*; *side telescope for vertical sights*, either up or down; and *all the apparatus* used by the mining engineer, besides any special adaptations which may be required.

Our telescope glasses are made to our order, and we guarantee them fully equal to any used by other makers.

We furnish glasses of high power, when ordered, without additional cost, but we do not consider them as desirable for most purposes as those of medium power, on account of the loss of light, the difficulty of focussing, and the less sharpness of definition—objections which always accompany the use of telescopes of very great magnifying power.

Our facilities for the manufacture of Engineers' instruments are not equaled by any similar establishment in our own country or abroad, and our instruments are distributed in all parts of North and South America, in Australia, Japan, China, Egypt, the East and West Indies, and the Sandwich Islands.

Our exhibit at the Centennial, in the opinion of all who saw it, was far superior to that of any other manufacturer in the number, variety, style and finish, as well as in the price and quality of the instruments shown. On pages 48 and 49 we publish the awards of the judges in full on all exhibits in our department, and leave our customers to make their own comments.

## INFORMATION TO PURCHASERS.

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**INSTRUMENTS WANTED.**—In regard to the best kind of instruments for particular purposes, we would here say, that where only common surveying, or the bearing of lines in the surveys for county maps is required, a plain compass is all that is necessary. In cases where the variation of the needle is to be allowed, as in retracing the lines of an old survey, etc., the vernier compass or the vernier transit is required.

Where, in addition to the variation of the needle, horizontal angles are to be taken, and in cases of local attraction, the Railroad compass is preferable; and for a mixed practice of surveying and engineering, we consider the Surveyor's transit superior to any instrument made by us or any other manufacturers.

In the surveys of the U. S. public lands, the county and township lines are required to be run by such instruments as the Solar compass and Solar transit.

Where engineering is the exclusive design, the Engineer's transit and the leveling instrument are of course indispensable.

**WARRANTY.**—All our instruments are examined and tested by us in person, and are sent to the purchaser adjusted and ready for immediate use.

They are warranted correct in all their parts—we agreeing in the event of any defect appearing after reasonable use, to repair or replace with a new and perfect instrument, promptly and at our own cost, express charges included, or we will refund the money and the express charges paid by the customer.

Instances may sometimes occur, in a business as large and widely extended as ours, where, owing to careless transportation, or to defects escaping the closest scrutiny of the maker, instruments may reach our customers in bad condition. We consider the retention of such instrument in all cases an injury very much greater to us than to the purchaser himself.

**TRIAL OF INSTRUMENTS.**—It may often happen that this statement of the prices and quality of our instruments will come into the hands of those who are entirely unacquainted with us, or with the quality of our work, and who therefore feel unwilling to make a final purchase of an article, of the excellence of which they are not perfectly assured.

To such we make the following proposition: We will send the instrument to the express station nearest the person giving the order, and direct the express agent, on delivery of the same, to collect our bill, together with charges of transportation, and hold the money on deposit until the purchaser shall have had, say two weeks' actual trial of its quality.

If not found as represented, he may return the instrument before the expiration of that time, and receive the money paid, in full, including express charges, and direct the instrument to be returned to us.

**PACKING, ETC.**—Each instrument is packed in a well finished mahogany case furnished with a lock and key and brass hooks, and leather strap for convenience in carrying. Each case is provided with screw drivers, adjusting pin, and wrench for centre pin, and, if accompanied by a tripod, with a brass plumb-bob; with all instruments for taking angles, without the needle, a reading microscope is also furnished.

## REPAIR OF INSTRUMENTS.

Hundreds of instruments of our own and others' make, come to us every year for refitting and repairs, and so much correspondence arises therefrom, that we are led to believe that a brief statement in this place, of the cost of such repairs, etc., will be of service to our customers and ourselves.

Most instruments sent to us for repairs are injured by falls; many are worn and defective in parts after long use; and others are sent for re-polishing and renovation.

We advise our customers having instruments in need of repairs, etc., to send them immediately to us, as our facilities enable us to do the work much more economically and promptly than any other maker, however accessible.

They should always, when practicable, be placed in their own boxes, and these inclosed in an outside packing case, an inch larger in all its dimensions, that the interval between the two may be filled with paper wadding, hay, or fine shavings.

A note specifying the repairs needed should accompany the instrument, and a letter should also be sent by mail to us, giving not only directions as to the repairs, but also stating when the return of the instrument is required, and the precise location to which it should be forwarded. It should also be remembered that each instrument is made to fit its own spindle and no other; and therefore this part with the parallel plates and leveling screws, if it has any, should always be sent with it.

The legs and brass head in which they are inserted need never be sent, unless themselves in need of repairs.

**COMPASSES.**—These come to us with the plates sprung, the sights bent or broken, the glass or level vials fractured, and the pivot so dulled as to render the needle sluggish and unreliable. The cost of repairing the defects above named, ranges from 2 to 8 or 10 dollars. A new pair of sights fitted costs 5 dollars; a new needle, with jeweled centre and pivot complete, \$2.50; a new jeweled centre, \$1.50.

The compass should always be accompanied by the ball spindle, and if a new ball spindle is required, the whole instrument, or at least the socket in which the spindle fits, should be sent with the letter of advice to us; a new ball spindle costs \$1.50.

**TRANSIT INSTRUMENTS.**—The repairs of the Vernier Transits cost about the same as those of the compasses above stated.

The injuries sustained by the falls of Engineers' and Surveyors' Transits are usually much more serious; in these the plates, standards, and cross-bar of telescope are often bent, and the sockets or centres often so deranged as to be entirely useless.

The cost of repairing an instrument with such injuries ranges from 10 to 30, or even 50 dollars, the new sockets alone costing from 15 to 20 dollars.

**LEVELING INSTRUMENTS** are generally much less injured by falling than Transits, the damage being included usually in the bending of the cross-bar, the springing of the sockets, and the breaking of the level vial.

The cost of repairs varies from 5 to 15 dollars; a new level vial set in the tube costs 2 dollars.

**RE-POLISHING INSTRUMENTS.**—The cost of re-polishing an instrument, involving also, of course, its complete renovation and adjustment, varies with the different kinds, but may be stated generally as follows :

Compasses, from.....	\$5 to \$10
Transits,       “ .....	15 to 20
Levels,         “ .....	12 to 15

No additional charge is made for bronzing or blackening an instrument when re-polished.

**PAYMENT OF REPAIRS, ETC.,** may be made at the express office where the instrument is received, the customer paying for the first transportation of the instruments to us, or not, as he may prefer. Whenever the freight is paid in advance, the express receipt should be mailed immediately to us.

Unless the purchaser is already supplied, each instrument is accompanied by our “Manual,” giving full instructions for such adjustments and repairs as are possible to one not provided with the facilities of an instrument maker.

When sent to the purchaser, the mahogany cases are carefully enclosed in outside packing boxes, of pine, made a little larger on all sides to allow the introduction of elastic material ; and so effectually are our instruments protected by these precautions, that of many thousand sent out by us during the last thirty-five years, in all seasons, by every mode of transportation, and to all parts of the Union and the Canadas, not more than three or four have sustained any serious injury ; (with all instruments sent by sea, the mahogany boxes are enclosed in soldered tin cases as well as the pine case).

We make no charge for packing or packing cases.

**MEANS OF TRANSPORTATION.**—Instruments can be sent by express to almost every town in the United States and Canadas, regular agents being located at all the more important points, by whom they are forwarded to smaller places by stage. The charges of transportation from Troy to the purchaser are, in all cases, to be borne by him, we guaranteeing the safe arrival of our instruments to the extent of express transportation, and holding the express companies responsible to us for all losses or damages on the way.

**FINISH OF INSTRUMENTS.**—Customers ordering instruments will do us a favor by mentioning whether they prefer them of bright or bronze finish, the cost being the same in either case.

If no direction is given, we usually send instruments of bronze finish.

**TERMS OF PAYMENT** are uniformly cash, and we have but one price, whether ordered in person or by mail. Our terms are as low as we think instruments of equal quality can be made, and will not be varied from the list given on the previous pages.

Remittances may be made by a draft payable to our order at Troy, Albany, New York, Boston, or Philadelphia, which can be procured from banks or bankers in almost all the larger villages, or by post office money order.

These may be sent by mail with the order for the instrument, and, if lost or stolen on the route, can be replaced by a duplicate draft, obtained as before, and without additional cost.

The customer may also send the money in advance through the express agent, or, as it is most common, may pay the agent on receipt of the instrument in funds current in New York or Boston.

The cost of returning money on bills collected by express of amounts under \$20 will be charged to the customer.

(No. 235.)

## INTERNATIONAL EXHIBITION.

Philadelphia, 1876.

The United States Centennial Commission has examined the report of the Judges, and accepted the following reasons, and decreed an award in conformity therewith.

PHILADELPHIA, Nov. 15th, 1876.

## REPORT ON AWARDS.

*PRODUCT,*

## Transits, Levels &amp; Compasses.

Name and Address of Exhibitor,

**W. & L. E. GURLEY,**

TROY, N. Y., U. S. A.

The undersigned, having examined the product herein described, respectfully recommends the same to the United States Centennial Commission for Award, for the following reasons, viz. :

This firm exhibits a large number of the instruments used in Engineering, of various sizes and special adaptations, which all show excellent workmanship and great perfection in the mechanical as well as in the optical parts. A special claim is the successful application of a solar apparatus to the telescope of the Engineers' transit for determining the true meridian ; the form of the solar attachment possesses important advantages over other forms heretofore used, in admitting of more exact adjustment. Other claims are the introduction of means of adjustment for the slide carrying the object-glass of transit and leveling telescopes, and the first practical application of Aluminium in the manufacture of field instruments, reducing their weight about forty per cent., while on the other hand their cost is increased about one half. These claims are well founded, and, together with the general excellence of the products, entitle the exhibitors to an award.

P. F. KUPKA, Signature of the Judge.

## APPROVAL OF GROUP JUDGES.

JAMES C. WATSON,  
JOSEPH HENRY,J. E. HILGARD,  
WM. THOMPSON,E. F. PERRET,  
E. LEVASSEUR,H. K. OLIVER,  
J. SCHIEDMAYER.*A true copy of the record.*

FRANCIS A. WALKER, Chief of the Bureau of Awards.

Given by authority of the United States Centennial Commission.

A. T. GOSHORN, Director-General.

J. L. CAMPBELL, Secretary.

J. R. HAWLEY, President.

All meritorious exhibits having received the bronze medal, the only gradation in the awards is shown by the report of the judges accompanying the medal.

We append the reports of the judges on the other American exhibits of Engineers' and Surveyors' instruments which received awards.

W. & L. E. GURLEY.

W. K.—*Surveying Instruments.*

*Report*—The transit theodolite and Y level combined is an instrument of new design, of special usefulness in certain cases, and is well constructed.

W. J. Y. & S., Phila., U. S.—*Surveying and Astronomical Circle.*

*Report*—The exhibit of this firm, which has been established since 1820, sustains its well-earned reputation for good construction and workmanship, and improvements in detail of all classes of surveying instruments.

The graduation of an astronomical circle of forty inches in diameter is shown by readings to have probably no error greater than two seconds, and demonstrates that the circular dividing engine of their own construction is capable of making first-class graduations.

H. & B., Phila.—*Surveying Instruments.*

*Report*—This firm has lately become distinguished by improvements in the customary methods of constructing surveying instruments, such as the use of three leveling screws, and other improved details, and by the construction of plane tables of superior quality.

C. F. & Co., Washington, D. C.

*Report*—Commended for excellences of design and construction of the instruments exhibited consisting of an eight foot equatorial telescope, completely mounted with a six and a half inch object glass, by Alvan Clark & Sons; an altazimuth instrument with twelve inch horizontal circle read by three, and ten inch vertical circle read by two micrometer microscopes with radial illumination, and provided with a chambered level of first-class accuracy; also a transit theodolite, and a leveling instrument of lesser size.

Further than this, we have had the pleasure of receiving from Prof. P. F. Kupka, Chairman of the Board of Judges on our group of exhibits, his report to the Austrian Government on the Centennial Exhibition at Philadelphia. Prof. Kupka illustrates his report with seven wood-cuts, four of which are pictures of our standard instruments, and are taken from our manual of 1876; and a fifth is a drawing of a section of our new plumb-bob with internal reel. We consider this report a very decided expression of Prof. Kupka's opinion of our instruments and exhibit.

We here add a few extracts of letters received from correspondents who have used our instruments. This list of commendatory letters we might increase indefinitely, if it were desirable:

RENSSELAER POLYTECHNIC INSTITUTE.

TROY, N. Y., May 13, 1876.

Messrs. W. & L. E. GURLEY.

*Gentlemen*:—In a series of observations which I lately made with your Patent Solar Attachment, as fitted to the ordinary Engineers' Transit, I found that I was able to determine the true meridian, and the latitude of the place, each within about half a minute. This result I obtained repeatedly, without other previous practice with the instrument than just sufficient to make myself familiar with the manipulations. I am, therefore, able to speak with confidence of the accuracy with which work may be readily done with the Solar Attachment, and to recommend it as a most serviceable adjunct to any transit. Yours very truly,

DASCOM GREEN,

Senior Professor of Mathematics and Astronomy.



Boulder, Col., *October 12, 1874.*

Messrs. W. & L. E. GURLEY, Troy, N. Y.

*Sirs:*—I received my Transit with Solar Attachment in good order. Have thoroughly tested it and find it works charmingly.

After testing the various transit and solar adjustments, I leveled the instrument, and setting off the sun's declination for ten o'clock A.M. ; I turned the telescope into the meridian and clamped all fast. Then at two P.M. I moved the vernier of the declination arc so as to read the sun's declination for two o'clock P.M., and found that the sun's image on the silver plate could not be discerned even with a magnifier to vary from its place between the equatorial lines. \* \* \* \*

Most truly,

E. J. HALL, U. S. Deputy Mineral Land Surveyor.

LAKE CITY, Col., *April 29, 1876.*

Messrs. W. & L. E. GURLEY.

*Dear Sirs:*—My experience with the Solar Attachment to the Transit during the six months that I used it was highly satisfactory. I regard it as the most important feature of a transit for any kind of work in the West. Of the three solars you have made for me, I like the last (on the light mining transit) the best. Although weighing but about thirteen pounds, including tripod, with it I can do everything required in all ordinary surveying. It is a complete encyclopedia of engineering apparatus. It will measure an angle, run a line, determine a level, obtain the true meridian—the latitude of any place—the time of day—all these, too, within a few seconds.

Very truly yours,

JAMES W. ABBOTT, C.E., Deputy U. S. Mineral Surveyor.

#### CANADIAN PACIFIC RAILWAY.

OTTAWA, *July 7, 1877.*

Messrs. W. & L. E. GURLEY.

I have had for the last eighteen months in constant use one of your Engineers' Transits, with Solar Attachment. I wish to bear testimony to the thoroughly satisfactory working of the instrument, and would call particular attention to the accuracy of the Solar Attachment. Having tested it not only on long stretches of work, but also in a series of observations on an established meridian with most gratifying results.

J. H. GRAY,

Civil Engineer, C. P. Railway.

CENTRALIA, Pa., *September 24, 1877.*

Messrs. W. & L. E. GURLEY.

The light mountain Transit, with Solar Attachment, which you furnished me last April arrived safely, and gives me perfect satisfaction in every respect. With it I am able to do all kinds of work, and I consider it in all respects a perfect instrument.

Respectfully yours,

L. S. BALDWIN,

Mine Superintendent and Engineer.

HOLLISTER, Cal., *June 20, 1877.*

Messrs. W. &amp; L. E. GURLEY, Troy, N. Y.

*Gentlemen:*— \* \* \* I presume you are constantly receiving letters in praise of your instruments, and that long since it has got to be an old story. I will say, however, that I have had one of your Double Vernier Solar Transits for about two years. The Solar works to a charm. The line of collimation has always remained exactly true; and, to use a common expression, "it has never gone back on me," notwithstanding some very rough usage, and which is more than I can say of instruments of other makers that I have used.

Very respectfully,

F. P. McCRAY, County Surveyor,  
San Benito County, Cal.

YANKTON, *September 11, 1876.*

Messrs. W. &amp; L. E. GURLEY:

I have tried and tested the two Solar Compasses, one forwarded by Messrs. ——— of ———, and the other by you. The compasses are both good—I may say most excellent. They have both been examined critically by an efficient corps of deputy surveyors now in my employ. Some prefer one, others the other. I have decided to keep your compass, for the following reasons chiefly:

First.—Your compass and accompanying outfit will cost me about eighty dollars less than that of Messrs. ———, and your instrument will answer quite as well if not better.

Second.—Your compass is several pounds lighter, which I consider a great advantage for the use I have for it, which is testing lines and inspecting work.

Third.—Your tripod and the head or attachment thereto is lighter, handier, and better. These are the three advantages which control my decision and election in the premises.

I am very truly yours,

WM. P. DEWEY,  
U. S. Surveyor-General.

SINGLE VERNIER TRANSIT, AS SHOWN ON PAGE 10.

MADISON, Me., *February 18, 1878.*

Messrs. GURLEY:

The instrument I ordered of you came to hand a few weeks ago. Since that time I have examined and tested it, and feel perfectly satisfied with it. In fact it more than meets my anticipations. It came perfectly safe, without even a scratch.

Truly yours,

A. G. MITCHELL.

LIGHT MOUNTAIN TRANSIT, WITH SOLAR ATTACHMENT,

OURAY, Col., *July 16, 1878.*

Messrs. W. &amp; L. E. GURLEY:

I received my instrument in remarkably good condition, considering our facilities for express transportation. \* \* \* I have tried all the adjustments and found all right, except the levels on plates, which I soon adjusted. I find it perfectly satisfactory in every respect.

Yours truly,

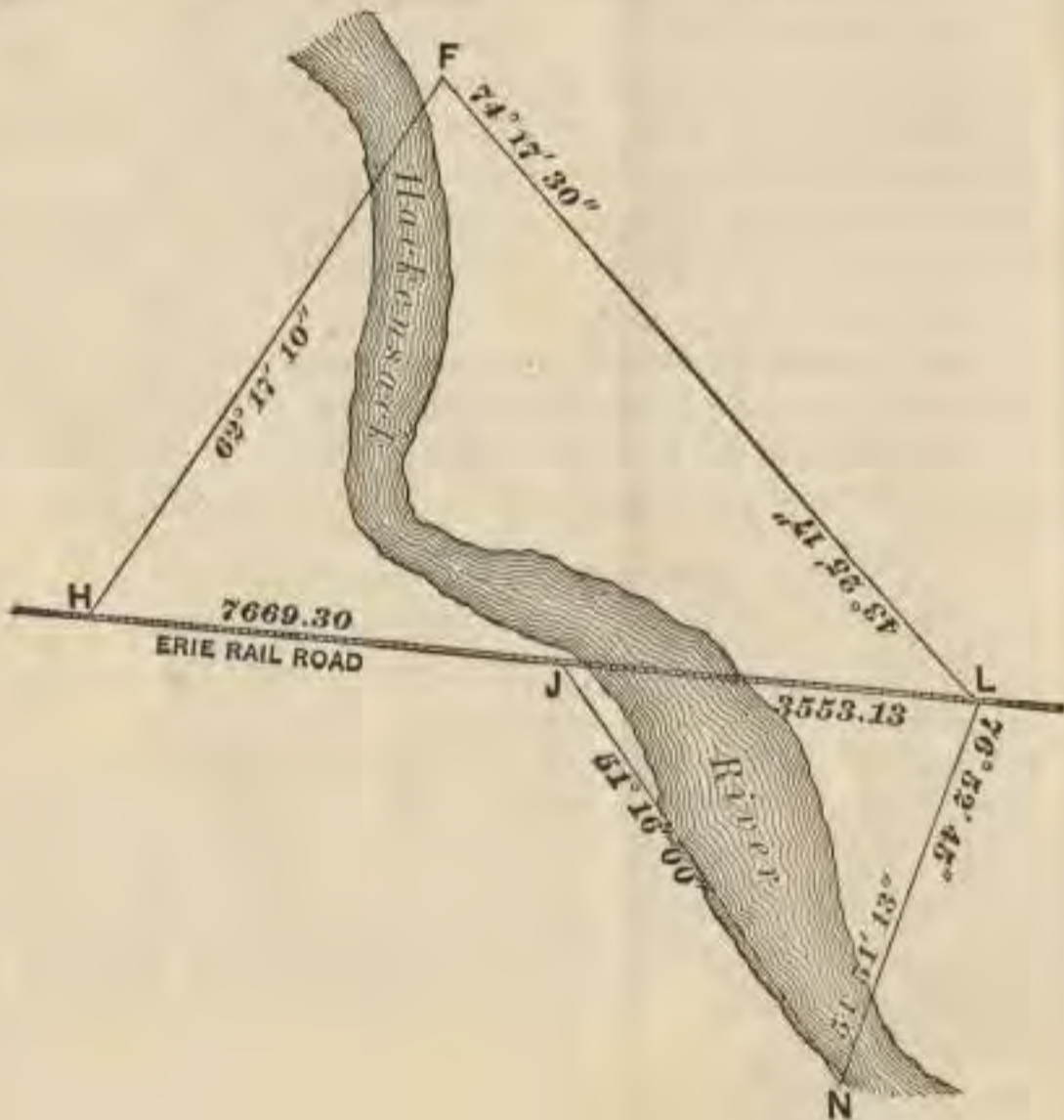
JOHN F. WANNEMAKER,  
U. S. Deputy Mineral Surveyor.

ENGLEWOOD, N. J., July 30, 1878.

Messrs. W. &amp; L. E. GURLEY.

*My Dear Sirs:*—I have tried and thoroughly tested my instrument (Engineers' Transit with Solar Attachment) and find that it works very nicely, and in some respects better than originally.

I have made, during the past four years' constant practice in surveying and engineering, a large number of observations with the Solar Transit you made for me in 1874 with great satisfaction. With it I am able to determine the true meridian, and the latitude of a place, each accurately, within ten seconds, at any time between the hours 8 and 10:30 A.M., and 1:30 and 4 P.M. I consider it the most complete instrument for surveying and engineering purposes that has yet been constructed. A portable observatory, with which the latitude of any place, the true meridian, and the time of day may be determined with a degree of accuracy that is highly satisfactory.



The graduations of my instrument are excellent, as will appear from the following data taken from my field notes in the survey of the boundary line between the counties of Bergen and Hudson, 1875. In the triangle H F L, the line H L was very carefully measured and found to be 7,669.30 feet in length, also each angle of the triangle, with three (3) to five (5) repetitions, and closed within .03". Thus, angle H =  $62^{\circ} 17' 10''$ ; angle F =  $74^{\circ} 17' 30''$ ; and the angle L =  $43^{\circ} 25' 17''$ . Sum =  $179^{\circ} 59' 57''$ ; error, .03". In the triangle J L N the line J L was carefully measured and found to be 3,553.13 feet in length, and each angle of the triangle as above with three (3) to five (5) repetitions, and closed within two (02") seconds, thus: Angle J =  $51^{\circ} 16' 00''$ ; angle L =  $76^{\circ} 52' 45''$ ; and the angle N =  $51^{\circ} 51' 13''$ . Sum =  $179^{\circ} 59' 58''$ ; error, 02". Observe that the angles were measured with only three (3) to five (5) repetitions. I might add numerous examples like the above if it were desirable, showing the accuracy with which angles may be measured with my instrument.

Yours truly,

J. H. SERVISS, C.E.

DUNDEE, N. Y., *August 30, 1878.*

Messrs. W. &amp; L. E. GURLEY.

*Sirs*:—I have put your Telescopic Sight No. 2 to quite as severe a test as will ever be required, and on two of the smokiest days I remember to have seen, and it operated perfectly. The line run was over two miles long, and I could see the stake as far as I could signal and be understood, and the relief to my eyes was very great. \* \* \*

Yours, etc.,

H. G. WOLCOTT.

CITY ENGINEER'S OFFICE,  
MINNEAPOLIS, Minn., *April 21, 1879.* }

Messrs. W. &amp; L. E. GURLEY, Troy, N. Y.

*Gents*:— \* \* \* The *tunnel* came out O. K., of course, variation about two or three inches, and I say it can't be beat. It was run over 400 feet, with three angles in tunnel and three in surface line. The surface line jumping off from a perpendicular bank forty feet high, and the telescope plunged over 60° to put the point in line. If anybody can raise a transit that will turn off six angles, and run the way I did, and come any closer, I want to see it. I have run seven (7) sand rock tunnels with the transit, varying from 150 to 700 feet in length, and five (5) inches is the *most* I have been out in any. One under Nicollet Island, 688 feet long, with an angle at each end and dug from both ways varied one and three-quarters ( $1\frac{3}{4}$ ) inches. Bring on your ———'s, ———'s, or ———'s, and I won't lie down with this Gurley. I go round a block 410 feet square, turn the four angles, and close within less than an inch regularly.

Very respectfully yours,

E. T. ABBOTT,

Assistant Engineer.

VIRGINIA CITY, Montana, *March 4, 1879.*

Messrs. W. &amp; L. E. GURLEY, Troy, N. Y.

*Gentlemen*:—In response to the inquiry in your favor of January 13th, I am pleased to say that the Solar Attachment placed upon my transit by you early in 1877 more than met my expectations. It is steady in place and adjustment, and with its use there are no corrections for instrumental error as with the old solar compass. I have but one improvement to suggest:—If an adjustable jam nut or stop was so attached to the vertical arc as to stop the arm exactly at the latitude reading when set for any locality, the instrument could be trained in less time and the liability to error be lessened.

Very truly yours,

A. B. KNIGHT,

U. S. Deputy Mineral Surveyor.

*Note*.—Since receiving the above letter from Mr. Knight, we have supplied a stop for the arm, as suggested, with our Patent Solar Attachment.

W. &amp; L. E. GURLEY.

SMITHVILLE, Lancaster Co., Pa., *June 21, 1879.*

Messrs. W. & L. E. GURLEY, Troy, N. Y.

*Sirs:*—I received my two-vernier Surveyor's Transit \* \* \* and also the other articles in good order and condition. The Transit gives me perfect satisfaction in all its parts in every respect, and I consider it a perfect instrument. \* \* \* \* \*

Very respectfully yours,

S. M. MYLIN.

LEADVILLE, Col., *July 9, 1879.*

Messrs. W. & L. E. GURLEY, Troy, N. Y.

*Gentlemen:*— \* \* \* My new Mountain Transit I am much pleased with; *portability* combined with accuracy being the prime requisites for this section.

Yours very truly,

C. W. E. REICHEL.

(*From Hon. ANSELMO B. SMITH, Ex-State Engineer of Nebraska.*)

PLATTSMOUTH, Nebraska, *June 9, 1879.*

Messrs. W. & L. E. GURLEY :

Your catalogue and price list at hand, from which I see you are up to date with all kinds of improvements in instruments, and down to bed rock prices. The latter I consider of minor importance when compared with the thorough and substantial manner in which you make your instruments.

Out of the many instruments that I have bought of you in the past twenty-two years, most of them have been made to order, I always having some peculiar notion of my own which I wanted in my instrument, and frequently quite difficult in construction, and hence in only making one much more liable to be not exactly right; yet in no instance has a defect appeared, which I think speaks well for your workmanship.

I have a Transit, seven-inch limb, graduations on solid silver reading to 30", with microscopes on each side, which you made for me seven or eight years ago, and which I have used constantly (my work extending from the Mississippi River on the east to the Rocky Mountains on the west, and from the Arkansas on the south to the Neobrara on the north), and as far as I can notice it is as good as when new. I used two of your instruments in laying out Lincoln, Neb., and it was and is to-day called a fine job of work. But this instrument beats them all. It is no trick at all to set it on an inch rod at 2,000 feet, turn half around and cut the same rod every time. I never have come across its equal for measuring an angle accurately, and I take particular pains to match it with all instruments I come in contact with. My work for the past twelve years has been almost entirely town surveying, laying out town lots, where extreme accuracy in angle is required. It is needless to say that *of course* I have taken good care of it.

Truly yours,

ANSELMO B. SMITH.

UNITED STATES SURVEYOR-GENERAL'S OFFICE, }  
 Santa Fé, New Mexico, *December, 29, 1879.* }

Messrs. W. & L. E. Gurley, Troy, N. Y.

*Gentlemen* :—Please send me one Nautical Almanac for 1880—send care of U. S. Surveyor-General, Santa Fé, New Mexico.

The Mountain solar Transit you sent gives full satisfaction. It is the finest instrument in New Mexico.

Respectfully,  
 GEO. TAYLOR.

WATERTOWN, Codington Co., Dakota, *July 25, 1879.*

Messrs. W. & L. E. Gurley, Troy, N. Y.

*Gents* :—The Light Mountain Engineers' Transit with Solar Attachment, which you made for me, came duly to hand, and arrived in good condition.

Since I received it I have laid out a town plot consisting of two hundred and eighty lots, varying greatly in size and form, which has given me an opportunity of most thoroughly testing its various graduations, and while taking with it the levels necessary to establish the different grades for streets, I have critically tested its accuracy as a leveling instrument.

With reference to the Solar Attachment, from the trials and tests already made with it, I am convinced that it is entirely reliable.

In my professional experience, extending through a period of over thirty years, I have used instruments from most of the leading manufacturers in the United States, and I am free to confess that I never before used any instrument that would so successfully overcome all of the different obstacles so constantly to be encountered in the profession, as this one does. And I consider that the members of the profession throughout the entire country are under a lasting debt of gratitude for the many devices and improvements you have made in bringing your instruments up to their present state of perfection.

Wishing you many years of health and prosperity in which to continue your business thus far so successfully conducted, I remain,

Yours respectfully,

A. S. WADSWORTH,

Civil Engineer and Land Surveyor.

SILVER CLIFF, Colorado, *Sept. 27, 1879.*

Messrs. W. & L. E. Gurley, Troy, N. Y.

*Gents* :—I have received the Light Mountain Transit ordered from you, and have used it in my work during the past ten days, have carefully tested it in my field work, and am more than pleased with it. For my work it is almost perfect—in fact, it is *the instrument*.

Everyone who is capable of judging an instrument that has examined your Solar Attachment concedes it superior to anything seen by them. I trust I have been the means of securing you at least one order from this place. \* \* \*

I am, very truly yours,

W. H. HOLMES,

U. S. Surveyor and Mining Engineer.

OHIO STATE UNIVERSITY, Columbus, Ohio, }  
January 21, 1880. }

Messrs. W. & L. E. Gurley.

In response to your inquiry concerning the "Light Mountain Transit," I say that "my copy" of it works "like a charm." It is all that you claim for it, and I shall take pleasure in continuing to recommend it to those under my charge, as also I do of all the other instruments which your house has furnished for our college.

Very respectfully,

R. W. McFARLAND,

Professor of Mathematics.

*We might increase this list of testimonials indefinitely, but think it is not necessary to add any more. We are prepared to send any of our larger Instruments, Transits, Levels, or Compasses by express, C. O. D., with the privilege of two weeks' trial IF DESIRED. See page 45.*

## TABLE OF DECLINATIONS OF SUN TO NEAREST HALF DEGREE.

FOR USE WITH THE POCKET SOLAR COMPASS.

Dec.	21	23½°	March	20	0°	June	21	-1-23½°	Sept.	22	0°
Jan.	1	23		21	-1- ½		31	23		24	- ½
	6	22½		22	1	July	7	22½		25	1
	11	22		24	1½		11	22		26	1½
	15	21½		25	2		15	21½		27	2
	18	21		26	2½		17	21		29	2½
	19	20½		27	3		20	20½		30	3
	21	20		29	3½		23	20	Oct.	1	3½
	23	19½		30	4		25	19½		3	4
	25	19		31	4½		27	19		4	4½
	27	18½	April	1	5		29	18½		5	5
	29	18		3	5½	Aug.	31	18		6	5½
Feb.	31	17½		4	6		2	17½		8	6
	2	17		6	6½		4	17		9	6½
	3	16½		7	7		6	16½		10	7
	5	16		8	7½		8	16		12	7½
	7	15½		10	8		10	15½		13	8
	8	15		11	8½		11	15		14	8½
	10	14½		12	9		13	14½		16	9
	11	14		14	9½		15	14		17	9½
	13	13½		15	10		16	13½		18	10
	14	13		17	10½		18	13		20	10½
	16	12½		18	11		19	12½		21	11
	17	12		19	11½		21	12		23	11½
	19	11½		21	12		22	11½		24	12
	20	11		22	12½		24	11		26	12½
	21	10½		24	13		25	10½		27	13
	23	10		25	13½		27	10		28	13½
	24	9½		27	14		28	9½		30	14
	25	9		29	14½	Sept.	29	9	Nov.	1	14½
	27	8½		30	15		31	8½		2	15
	28	8	May	2	15½		1	8		4	15½
March	1	7½		4	16		2	7½		6	16
	2	7		5	16½		4	7		7	16½
	3	6½		7	17		5	6½		9	17
	4	6		9	17½		7	6		11	17½
	6	5½		11	18		8	5½		13	18
	7	5		13	18½		9	5		15	18½
	8	4½		15	19		10	4½		17	19
	9	4		17	19½		12	4		19	19½
	11	3½		20	20		13	3½		21	20
	12	3		22	20½		14	3		23	20½
	13	2½		25	21		16	2½		26	21
	15	2		28	21½		17	2		29	21½
	16	1½		31	22		18	1½	Dec.	2	22
	17	1	June	4	22½		20	1		6	22½
	18	- ½°		10	-1-23°		21	-1- ½		11	-23°

## APPROXIMATE EQUATION OF TIME.

From Chambers's Astronomy.

DATE.	MINUTES.	DATE.	MINUTES.	DATE.	MINUTES.	DATE.	MINUTES.
Jan. 1	4	April 1	4	Aug. 9	5	Oct. 27	16
3	5	4	3	15	4	Nov. 15	15
5	6	7	2	20	3	20	14
7	7	11	1	24	2	24	13
9	8	15	0	28	1	27	12
12	9			31	0	30	11
15	10	19	1			Dec. 2	10
18	11	24	2	Sept. 3	1	5	9
21	12	30	3	6	2	7	8
25	13	May 13	4	9	3	9	7
31	14	29	3	12	4	11	6
Feb. 10	15	June 5	2	15	5	13	5
21	14	10	1	18	6	16	4
27	13	15	0	21	7	18	3
Mar. 4	12			24	8	20	2
8	11	20	1	27	9	22	1
12	10	25	2	30	10	24	0
15	9	29	3	Oct. 3	11		
19	8	July 5	4	6	12	26	1
22	7	11	5	10	13	28	2
25	6	28	6	14	14	30	3
28	5			19	15		

Clock faster than the Sun.

Clock slower than the Sun.

Clock faster.

Clock slower.



