A

MANUAL

OF THE PRINCIPAL

INSTRUMENTS

USED IN

AMERICAN ENGINEERING AND SURVEYING,

MANUFACTURED BY

W. & L. E. GURLEY,
TROY, N. Y., U. S. A.

TWENTY-NINTH EDITION.

TROY, N. Y.:
PUBLISHED BY W. & L. E. GURLEY.
January, 1891.

PRICE 50 CENTS.

BENJ. D. BENSON,
Printer and Stationer,
49 John Street, N. Y.

PREFACE

TO THE TWENTY-NINTH EDITION.

WITH this issue of our MANUAL we take occasion to inform our numerous patrons of the large increase of our business over that of any previous year.

We have aimed to supply instruments of the highest quality, adding important improvements thereto, without increasing the price, and our success in pleasing our customers has exceeded our greatest expectations.

Our facilities for manufacturing have also greatly multiplied, and we now occupy about thirty thousand square feet of floors in a building constructed with special reference to our business, and equipped with a steam-engine of eighty horse-power and the best machinery of all kinds. Among which are twelve graduating engines, of which six are automatic; three engraving and figuring machines, an automatic rack and pinion machine, two automatic screw machines, six special turret-head lathes, over one hundred lathes, and other tools too numerous to be further described, and all constructed with especial reference to our business.

Our wood-working department is equipped with the most modern machinery, and supplies all the cabinet-work necessary to our business, including plain and fancy wood boxes, tripod legs, leveling rods, T squares, triangles, drawing boards, etc.

The business which has been conducted by us since 1845, has now become so widely known that our customers are found all over the civilized world.

To the ever-widening circle of our patrons and friends we now commit this description of our instruments, with the hope that it may be found of increasing value and interest.

It will be noticed that the wood-cuts are new and illustrate our latest improved instruments.

The wood-cuts of the transits show the new clamp to the horizontal limb, by which the limb is securely fastened without any possibility of springing the plates.

We supply the new tangent screw with an opposing spring (so that all lost motion is avoided) to the limb, the telescope axis and the leveling head of transits and to the leveling head of Engineers' Y Levels.

The Verniers to the limb, heretofore placed at right angles to the telescope and beyond the view of the Engineer, without a change of position, are now located in the RIGHT PLACE—at an angle of 30° with the telescope—so that they can be read at once without any movement of the observer.

Among the new instruments is the Reconnoissance Transit, which has already obtained an extensive sale and has proved itself a most desirable and a very portable instrument.

See also the following :

The split leg tripod, considered by Engineers to be a very rigid tripod.

An improved form of Plane Table movement.

We think we show here the first really practical Hand Level with telescope that has yet been made; with it better light as well as considerable magnifying power is obtained.

We show also the new method of attaching the telescopic sight to pocket compasses, dispensing with the cross-bar and making a strong and portable instrument for approximate work.

See the Wheelbarrow Odometer for use in making County or District Maps; the Positive Motion Odometer for use on a wagon wheel; Price's Current Meters for measuring the velocities of currents of harbors and rivers; and here also we show Anemometers for use in coal mines and all places where ventilation and a supply of pure air is essential.

We have constantly in stock a large assortment of the best make of Aneroid Barometers, Anemometers, Field Glasses, Opera Glasses and Telescopes.

When any articles can be sent safely by mail, we have printed the cost of postage for same, so that, by remitting with the order the cost of the article and postage, the goods can be sent by mail at small expense.

As heretofore, we have made our list prices of Engineers' and Surveyors' Instruments as low as we can put them, and furnish warranted instruments of the latest pattern.

W. & L. E. GURLEY.

TROY, N. Y., U. S. A., *January*, 1891.

PRICE LIST,

TWENTY-NINTH EDITION.

TROY, JANUARY, 1891.

ALL PRICES IN THIS WORK ARE IN U. S. CURRENCY. STATE WHAT EDITION OF MANUAL WHEN ORDERING GOODS; ALSO GIVE CATALOGUE NUMBER.

This Price List Supersedes all previous editions.

ENGINEERS' TRANSITS.

No.		PRICE
1.	—Engineers' Transit, two verniers to limb, 4-inch needle, plain telescope.*	$145 00
2.	—Engineers' Transit, two verniers to limb, 4½-inch needle, plain telescope	150 00
3.	—Engineers' Transit, two verniers to limb, 5-inch needle, plain telescope, as shown on page 32	150 00
3A.	—Engineers' Transit, two verniers to limb, 5-inch needle, but with 4½-inch vertical circle reading with vernier to single minutes, level on telescope with ground bubble and scale, and clamp and tangent movement to axis of telescope	180 00
3B.	—Engineers' Transit, two verniers to limb, 5-inch needle, with 6-inch vertical arc with vernier moved by tangent screw and reading to 30 seconds, level on telescope, gradienter combined with clamp and tangent, as shown on page 44	198 00
3C.	—Engineers' Transit, two verniers to limb, 5-inch needle, same as No. 3A, but omitting vertical circle	168 00
3D.	—Engineers' Transit, 5-inch needle, with 6-inch vertical arc, with vernier moved by tangent screw, and reading to 30 seconds, level on telescope, with clamp and tangent movement to telescope axis	186 00

---

* A "plain" telescope is one without any of the attachments or extras, as we term them, such as the clamp and tangent, vertical circle, and level.

NOTE.—All of our Transits, Nos. 1 to 25 inclusive, are furnished with a tripod, leveling screws, clamp and tangent to spindle, and shifting center to leveling head.

The limbs of all our Transits, Nos. 1 to 25, are now graduated on rolled silver and without extra charge. We also put stadia wires in the telescopes of our Transits and Y Levels, without extra charge, if requested when the instrument is ordered.

ENGINEERS' TRANSITS.—*Concluded.*

No.		Price
4.	Engineers' Transit, two verniers to limb, 5-inch needle, with Solar Attachment, vertical arc reading to 30 seconds, level on telescope, clamp and tangent to axis of telescope, and variation plate, as shown on page 55	$250 00
6.	Light Mountain Transit, 4-inch needle, magnetic variation plate, two verniers to limb, telescope of finest quality, power twenty diameters, patent extension tripod shortening to half length. The instrument is packed in a mahogany case, covered with a light sole-leather case, with straps for "packing." With plain telescope	150 00
6A.	Light Mountain Transit, but with 4½-inch vertical circle reading to one minute, level on telescope, and clamp and tangent movement to axis of telescope	180 00
6B.	Light Mountain Transit, same as No. 6A, but omitting vertical circle.	168 00
7.	Light Mountain Transit, with patent solar attachment, vertical arc reading to one minute, level on telescope, and clamp and tangent to axis of telescope, complete, as shown on page 59	245 00
7A.	Light Mountain Transit, with level, vertical arc, clamp and tangent to axis of telescope, same as No. 7, but omitting solar attachment	186 00
7B.	Light Mountain Transit, with vertical arc, level on telescope, and gradienter combined with clamp and tangent movement	198 00
8.	Light Mountain Transit, with patent solar attachment, Jones' patent latitude are complete, level on telescope, and clamp and tangent to axis of telescope, as shown on page 71	299 00

SURVEYORS' TRANSITS.

(WITH TWO VERNIERS TO LIMB.)

No.		Price
12.	Surveyors' Transit, 4-inch needle, two verniers to limb, plain telescope	$125 00
12A.	Surveyors' Transit, same as above, but with 4½-inch vertical circle reading to one minute, level on telescope, and clamp and tangent to axis of telescope	155 00
12B.	Surveyors' Transit, 4-inch needle, same as No. 12A, but omitting vertical circle	143 00
13.	Surveyors' Transit, 5-inch needle, two verniers to limb, plain telescope	130 00
14.	Surveyors' Transit, 5½-inch needle, two verniers to limb, plain telescope	130 00
15.	Surveyors' Transit, 5 or 5½-inch needle, but with 4½-inch vertical circle reading with vernier to single minutes, level on telescope with ground bubble and scale, and clamp and tangent movement to axis of telescope, as shown on page 82	160 00
15A.	Surveyors' Transit, 5 or 5½-inch needle, same as No. 15, but omitting vertical circle	148 00
15B.	Surveyors' Transit, 5 or 5½ inch needle, two verniers to limb, and with 4½-inch vertical circle reading with vernier to single minutes, level on telescope with ground bubble and scale, and gradienter combined with clamp and tangent movement to axis of telescope	172 00
16.	Surveyors' Transit, two verniers to limb, 5-inch needle, with Solar Attachment, vertical arc reading to 30 seconds, level on telescope, clamp and tangent to axis of telescope, as shown on page 93	226 00

SURVEYORS' TRANSITS.

(WITH ONE VERNIER TO LIMB.)

No.		Price
20.	Surveyors' Transit, 4-inch needle, one vernier to limb, plain telescope.	$110 00
20A.	Surveyors' Transit, same as above, but with level on telescope, and clamp and tangent to axis of telescope	128 00
21.	Surveyors' Transit, 5-inch needle, one vernier to limb, plain telescope	115 00
22.	Surveyors' Transit, 5½-inch needle, one vernier to limb, plain telescope.	115 00
23.	Surveyors' Transit, same as above, 5 or 5½-inch needle, but with level on telescope, and clamp and tangent movement to axis of telescope, as shown on page 87	133 00
23A.	Surveyors' Transit, 5 or 5½-inch needle, same as No. 23, but with addition of 4½-inch vertical circle reading to one minute	145 00
23B.	Surveyors' Transit, 5 or 5½-inch needle, one vernier to limb and with 4½-inch vertical circle reading with vernier to single minutes, level on telescope with ground bubble and scale, and gradienter combined with clamp and tangent movement to axis of telescope	157 00
24.	Surveyors' Transit, one vernier to limb, 5-inch needle, with Solar Attachment, vertical arc reading to 30 seconds, level on telescope, clamp and tangent to axis of telescope, as shown on page 93	211 00
25.	Reconnoissance Transit, 3½-inch needle, one vernier to limb, 3½-inch vertical circle reading with vernier to 5 minutes, level on telescope, and clamp and tangent to telescope axis, leveling screws and clamp and tangent to spindle, and extension tripod, as shown on page 95	115 00

VERNIER TRANSIT COMPASSES.

No.		Price
28.	Vernier Transit, 4-inch needle, compass tripod, plain telescope	$70 00
28A.	Vernier Transit, same as above, but with 3½ inch vertical circle with vernier reading to 5 minutes, level on telescope, and clamp and tangent movement to axis of telescope	96 00
29.	Vernier Transit, 5-inch needle, compass tripod, plain telescope	70 00
29A.	Vernier Transit, same us above, but with 3½-inch vertical circle with vernier reading to 5 minutes, level on telescope, and clamp and tangent movement to axis of telescope	96 00
30.	Vernier Transit, 6-inch needle, compass tripod, plain telescope	75 00
31.	Vernier Transit, same as above, but with 3½-inch vertical circle with vernier reading to 5 minutes, level on telescope, clamp and tangent movement to axis of telescope, as shown on page 97	101 00

ATTACHMENTS FOR TRANSITS.

No.		Price	Post.
35.	Patent Solar Attachment	$60 00	$ .15
36.	Variation Plate furnished with new Engineers' Transits, Nos. 1 to 3D, when ordered	4 00	
37.	Variation plate added to any Engineers' Transit sent for repairs	15 00	
38.	Plummet Lamp for Mining Engineering, see page 77	10 00	.30

ATTACHMENTS FOR TRANSITS.—*Concluded.*

No.	Price	Post.
39.—Diagonal Prism for Eye-piece, see page 75	$8 00	$ .04
40.—Reflector for illuminating cross wires, see page 75	4 00	.04
41.—Vertical Circle, 3½ inches diameter, divided on silver, vernier reading to 5 minutes	8 00	.08
42.— do do 4½ do do do reading to single minutes	12 00	.10
43.—Vertical Arc, 6 inches diameter, divided on silver, with vernier movable by tangent screw, reading to 30 seconds, or to one minute, as ordered	18 00	.10
44.—Clamp and tangent movement to axis of telescope	6 00	.08
45.—Gradienter, combined with clamp and tangent, see page 79	18 00	.15
46.—Level on telescope, with ground bubble and scale	12 00	.12
47.—Rack and pinion movement to eye-piece	5 00	
48.—Sights on telescope with folding joints	8 00	
49.—Sights on standards at right angles to telescope	8 00	
50.—Detachable telescope for vertical sighting, either style A or B, see page 76	25 00	.25
55.—Jones' Patent Latitude Arc, with reversible level bubble, as shown on page 71	72 00	
56.—Patent Latitude Level, for use with Solar Transit, as shown on page 69	6 00	.10
57.—Attached microscopes to read verniers, each	5 00	
58.—Quick-leveling attachment, see page 230	6 00	.30
59.— do do when ordered with new Transit (Nos. 1 to 24), extra	5 00	
60.—Leveling tripod head, with clamp and tangent movement, fitted to Vernier Transit Compasses (Nos. 28 to 31), extra	13 00	

SPECIAL GRADUATIONS.

	Price
52.—Graduation of limb to read to 20″ or 30″, extra	$10 00
53.— do do to read to 10″, extra	30 00
54.— do on 4½-inch vertical circle, to read to 20″ or 30″, extra	5 00

SPECIAL TRIPODS FOR TRANSITS.

61.—Patent extension tripod, furnished instead of regular tripod, with any new Transit (Nos. 1 to 5, and 12 to 24), extra	$5 00
62.— do do furnished instead of regular tripod, with any new Transit Compass (Nos. 28 to 31), extra	7 00
63A.—Patent extension tripod, for Transits (Nos. 25 to 31)	12 00
63B.— do do do for Transits (Nos. 1 to 5, and 12 to 24), see page 228	15 00
64.—Split leg tripod, for Transits (Nos. 1 to 5, and 12 to 24), see page 229	15 00
65.— do do do instead of regular tripod, extra	5 00
66.— do do instead of extension tripod, at same price.	

LEVELING INSTRUMENTS.

Y LEVELS.

	Price
70.—Fifteen-inch Telescope, with tripod, having leveling screws and clamp and tangent to spindle, as shown on page 192	$90 00
72.—Eighteen-inch, do do do	110 00
73.—Twenty-inch, do do do see page 178	110 00
74.—Twenty-two-inch, do do do	115 00
75.—Architects' Level, 11-inch telescope, and tripod, and leveling screws, see page 198	50 00

FARMERS' OR DRAINAGE LEVEL.

	Price	Post.
76.—Farmers' or Drainage Level, with jacob-staff mountings	$15 00	$1 00
77.— do do with plain tripod	20 00	1 60
78.— do do with tripod and leveling screws, as shown on page 197	25 00	1 90
79.— do do do do do and with compass attached, see pages 197 and 199	30 00	2 25

Note.—An extension tripod, instead of plain tripod, for Drainage Levels, is furnished at an extra cost of $5.00.

SPECIAL TRIPODS, &C., FOR LEVELS.

	Price
80.—Patent Extension Tripod for Y Level (Nos. 70 to 74), instead of regular tripod, extra	$5 00
81.— do do for Architects' Level instead of regular tripod, extra	7 00
82.—Extension Tripod for 15, 18, 20, or 22 inch Y Level, see page 228	15 00
83.—Split Leg Tripod for 15, 18, 20, or 22 inch Y Level, see page 229	15 00
84.—Split Leg Tripods forLevels (Nos.70 to74),instead of regular tripod, extra	5 00
85.—Quick-leveling Attachment, see page 230	6 00
86.— do do when ordered with new instrument (Nos. 70 to 75), extra	5 00

CATHETOMETER.

89.—Cathetometer, a leveling instrument to measure minute differences in height, as shown on page 232	$250 00

PLANE TABLES.

90.—Plane Table, board 24x30 inches, mounted on large tripod, with leveling socket and clamp, and with plumbing bar, plummet and clamps for paper	$45 00
Combined compass and levels, with square base	15 00
Alidade with compass sights, see page 214	15 00
Total	$75 00

PLANE TABLES.—*Concluded.*

No.		Price
91.—	Plane Table, with board, etc., as in No. 90	$45 00
	Combined compass and levels	15 00
	Alidade like No. 90, supplied with telescopic sight, No. 182, with stadia, vertical circle to 5 minutes, level, and clamp and tangent, see page 214	50 00
	Total	$110 00
92.—	Plane Table, with board, etc., like No. 90	$45 00
	Combined compass and levels	15 00
	Alidade with telescope 9 inches long, power 20 diameters, with stadia, vertical circle to 1 minute, level on telescope, and clamp and tangent, mounted on column as in Engraving, see page 209	70 00
	Total	$130 00
93.—	Plane Table, with board, etc., like No. 90	$45 00
	Combined compass and levels	15 00
	Alidade with telescope 11 inches long, with stadia, 4½-inch vertical circle on silver to 1 minute, level on telescope, and clamp and tangent, on column, power of telescope 24 diameters, see page 215	90 00
	Total	$150 00
96.—	Set of three leveling screws for any of the above-named Plane Tables, extra	$10 00
97.—	Clamp and tangent, for movement in azimuth, extra	10 00

JOHNSON'S IMPROVED PLANE TABLE.

98A.—	Johnson's Improved Plane Table Movement, mounted on large tripod, see page 212	$45 00

EXTRAS.

98B.—	Plane Table Drawing Board, 24x31 inches, fitted, and with screw sockets and clamp screws for paper	5 00
98C.—	Plumbing Bar and Plummet	4 00
98D.—	Combined Compass and Levels with square base	15 00

Note.—The Alidades as before described can be used with Johnson's Plane Table when desired.

SOLAR COMPASS.

100.—	Burt's Solar Compass, with compound tangent ball, leveling screws and clamp and tangent to spindle, and tripod, see page 101	$210 00

Note.—For Pocket Solar Compass, see No. 140, and page 162.

RAILROAD COMPASSES.

	Price
105.—5½-inch needle, one vernier to limb, jacob-staff mountings, brass cover and out-keeper	$60 00
106.—5-inch needle, two verniers to limb, do do	70 00
107.—5½-inch needle do do do see page 133	75 00

VERNIER COMPASSES.

110.—4-inch needle, jacob-staff mountings, brass cover and out-keeper	$30 00
111.—5-inch needle, do do do	35 00
112.—6-inch needle, do do do see page 141	40 00

PLAIN COMPASSES.

115.—4-inch needle, jacob-staff mountings, brass cover and out-keeper	$25 00
116.—5-inch needle, do do do	30 00
117.—6-inch needle, do do do see page 153	35 00

EXTRAS TO COMPASSES.

	Price	Post.
120.—Compass Tripod	$5 00	$1 25
121.—Patent Extension Tripod, furnished with any compass (Nos. 105 to 117)	12 00	1 50
122.—Compass Tripod, with leveling screws, and clamp and tangent movement	18 00	
123.—Compass Tripod Mountings, without legs	4 00	.50
124.—Compound Tangent Ball, see page 98	6 00	.26
126.—Leveling Adopter, large size, see page 116	7 00	.30

TELESCOPIC SIGHT.

ATTACHABLE TO COMPASS SIGHT. (*See pages 133, 154, 167.*)

Patented July 9, 1878.

130.—Nine-inch Achromatic Telescope, power about 10 diameters	$12 00	$.40
131.—Nine-inch Achromatic Telescope, larger diameter of object glass and power about 20 diameters, see page 154	17 00	.45
132.—Same Telescope as No. 131, but furnished with micrometer or stadia wires for measuring distances	20 00	.50

We add to any Telescopic Sight the following extras, at prices annexed:

133.—Vertical Circle, Vernier to 5′	5 00
134.—Level on Telescope	5 00
135.—Clamp and Tangent to Axis of Telescope	5 00

POCKET SOLAR COMPASS. (See page 162.)

No.		Price	Post.
140.	—Pocket Solar Compass, with staff mountings and mahogany box.	$100 00	$1.25
141.	—Side Telescope and counterpoise fitted to Pocket Solar Compass	25 00	.50
	Note.—When desired, we add to the side telescope, extras Nos. 133, 134, and 135, at prices named.		
142A.	—Leather case with shoulder strap for Pocket Solar Compass...	4 00	.40
142B.	—Leather case with shoulder strap for Pocket Solar Compass with telescope and extras....................................	6 00	.60
	Tripods for Pocket Solar Compass, extra, at prices quoted for Nos. 168, 169, and 170.		
148.	—Simple Dial Compass, with removable hour arc, graduated for any latitude as ordered, two levels and clinometer, see page 175..	16 00	.30
	Extra Hour Arcs, graduated for any latitude as ordered, to fit same compass, each..	5 00	.05

POCKET COMPASSES AND EXTRAS.

No.		Price	Post.
150.	—With folding sights, 2½-inch needle, very serviceable for retracing lines once surveyed....................................	$ 8 00	$ .20
151.	—Same as above, with jacob-staff mountings, see page 172........	10 00	.30
152.	—With 3½-inch needle, and jacob-staff mountings, do	12 00	.45
153.	—Same as above, and two levels..................................	13 50	.45
154.	—Same as 152, but without jacob-staff mountings..................	10 00	.35
155.	—Vernier Pocket Compass, with folding sights, staff mountings, two levels, and 3½-inch needle, see page 169..................	16 00	.50
156.	—Same as above, 4½-inch needle, see page 169....................	18 00	.80
157.	—Railroad Pocket Compass, with folding sights, staff mountings, two levels, 3½-inch needle, with limb reading to five minutes.	23 00	.65
158.	—Railroad Pocket Compass, 4½-inch needle, clamp and tangent to limb, with limb reading to one minute........................	33 00	1 00
159.	—Railroad Pocket Compass, one vernier to limb, see page 165....	40 00	1 25
159A.	—Railroad Pocket Compass, 4½-inch needle, clamp and tangent to limb, with limb reading to one minute, with clamp and tangent to the main spindle or socket, and fitted with our new telescopic sight No. 130, with the extras of level, vertical circle to 5′, and clamp and tangent to axis of telescope. Price, including tripod..	70 00	
159B.	—Same as above, but with telescopic sight No. 131............	75 00	
159C.	— do do do No. 132............	78 00	
159D.	— do do do No. 132, and with leveling adopter, see page 167..................................	88 00	
160.	—Vernier Pocket Compass, 4½-inch needle, with clamp and tangent to the main spindle or socket, and fitted with our new telescopic sight No. 130, with the extras of level, vertical circle to 5′, and clamp and tangent to axis of telescope. Price, including tripod..	55 00	

POCKET COMPASSES AND EXTRAS.—*Concluded.*

No.		Price	Post.
161.—	Same as above, but with telescopic sight No. 131	$60 00	
162.—	do do do No. 132, see page 171	63 00	
167.—	Leather case with shoulder strap for pocket compasses:		
	A.—Size fitted for compasses Nos. 150 and 151	2 00	$ .15
	B.— do do Nos. 153 to 155, and 157	3 00	.25
	C.— do do Nos. 156, 158, 159	4 00	.40
	D.— do do Nos. 159 A, B, C, D	6 00	.60
	E.— do do Nos. 160, 161, 162	6 00	.60
168.—	Tripod for pocket compasses (Nos. 140 to 162)	5 00	.85
169.—	Tripod for pocket compass, with leveling plates and clamp and tangent	15 00	1 00
170.—	Patent extension tripod for pocket compasses (Nos. 140 to 162).	10 00	1 00
171.—	Tangent movement for ball spindle of pocket compasses (Nos. 151 to 159), extra	5 00	
172.—	Rack and pinion movement to Vernier of Vernier Pocket Compass, extra	4 00	
173.—	Leveling adopter, small size, see page 172	5 00	.20

MINERS' COMPASSES OR DIPPING NEEDLES.

FOR TRACING VEINS OF MAGNETIC IRON ORE.

178.—	3-inch needle, glass on both sides, wood box, stop to needle, see page 173	$12 00	$ .20
179.—	3-inch needle, glass on both sides, brass covers, stop to needle	12 00	.25
181.—	"Norwegian Needle," glass on both sides, brass covers, 3-inch needle, superior article, see page 173	12 00	.20
182.—	Same as above, 4-inch needle	15 00	.40

NOTE.—No instrument made that will indicate the presence of gold or silver.

HAND LEVELS.

183.—	Monocular Hand Level, in case, see page 216	$12 00	$ .15
184.—	Binocular Hand Level, in case, see page 216	15 00	.30
185.—	Locke's Hand Level, Bronze, in box, see page 218	9 00	.12
186.—	do do Nickel Plated, in box, see page 218	10 00	.12

ABNEY LEVEL AND CLINOMETER.

187.—	Abney Level, 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, see page 219	$15 00	$ .15
187A.—	Ditto, and with compass and staff socket attached	18 00	.20

ABNEY LEVEL AND CLINOMETER.—*Concluded.*

No.		PRICE	POST.
188.	—Clinometer, or Slope Level, to ½ deg., 7 inches long, in walnut case	$8 00	$ .25
189.	—Ditto (Gunner's quadrant pattern), with vernier to 5 min., 18 inches long, in walnut case	15 00	

LEVELING RODS.

(See pages 200 to 208.)

		PRICE
190A.	—Architects' Rod, 5½ feet closed, sliding to 10 feet, feet, inches, and 16ths	$6 00
190B.	— do do do do feet and 10ths	6 00
191.	—Troy Rod, 6½ feet closed, sliding to 12 feet	10 00
192.	—Boston Rod, 6 feet closed, sliding to 11 feet	16 00
193.	—Philadelphia Rod, 7 3/10 feet closed, sliding to 13 feet	16 00
194.	—Philadelphia Mining Rod, 3 3/10 feet closed, sliding to 5 feet	13 00
195.	—New York Rod, in 2 parts, with improved mountings, 6 8/10 feet closed, sliding to 12 feet	16 00
196.	— do in 3 parts, either 5 feet closed, sliding to 12½ feet, or 5 8/10 feet closed, sliding to 14 feet	18 00
197.	— do in 4 parts, 5 feet closed, sliding to 16 feet	20 00
198.	—New York Mining Rod, in 2 parts, 3 3/10 feet closed, sliding to 5 3/10 feet	13 00
199.	—Telemeter, or Stadia Rod, 6 feet folded, unfolding to 12 feet	12 00
200.	—Telescopic Rod, 5 feet long, sliding to 14 feet	24 00
201.	—Cross-Section Rod, 10 feet long, with level vial at each end	10 00
202.	—Plain Leveling Rod, in one piece, without target, 10 feet long, reading to feet and 100ths	6 00

NOTE.—Any of the above Rods with Metric measure, at same price.

		PRICE	POST.
205.	—Pocket Leveling Rod, 10 feet long, self-reading to feet and 100ths, made of rubber canvas, can be coiled up and carried in pocket; in use it is fastened to a board with thumb tacks	$3 25	.15
206.	— do do 12 feet long, self-reading to feet, inches and ⅛ inch	4 00	.18
207.	— do do 3½ meters long, divided to centimeters	4 00	.18

WOOD AND IRON FLAG STAFFS, ETC.

These Staffs are divided off in feet, which are painted red and white, alternately.

		PRICE
210.	—Wood Staff, 6 feet long, with metal shoe	$2 00
211.	—Wood Staff, 8 feet long, with metal shoe	2 25
212.	—Wood Staff, 10 feet long, with metal shoe	2 50
213.	—Aligning or Ranging Pole, 6 feet long, hung in gimbals	4 00

NOTE.—This pole consists of an iron tube, 11/16 of an inch diameter, 6 feet long, and being hung in gimbals always assumes a vertical position.

		PRICE
214A.	—Iron tubular ranging pole, 6 feet long, 13/16 inch diameter	2 75
214B.	—Iron tubular ranging pole, 8 feet long, 13/16 inch diameter	3 00

NOTE.—Nos. 210 to 214 divided metrically, at same price.

		PRICE	POST.
215.	—Rod Level for plumbing a rod or flag staff	$3 00	.10

CHAINS.

No.								Price	Post.
220.—	66	feet,	100	links, with oval rings,	No.	8	refined iron wire......	$4 00	$1.40
221.—	66	do	100	do	do	10	do	3 50	1.00
222.—	33	do	50	do	do	8	do	2 50	.74
223.—	33	do	50	do	do	10	do	2 25	.55
224.—	100	do	100	do	do	8	best steel wire........	10 00	1.80
225.—	100	do	100	do	do	10	do	8 50	1.25
226.—	50	do	50	do	do	8	do	5 50	.90
227.—	50	do	50	do	do	10	do	4 75	.70
228.—	66	do	100	do	do	8	do	9 00	1.40
229.—	66	do	100	do	do	10	do	7 00	1.00
230.—	33	do	50	do	do	8	do	5 00	.74
231.—	33	do	50	do	do	10	do	4 00	.55

STEEL BRAZED CHAINS.

235.—	100	feet,	100	links, No. 12 steel, spring temper, brazed links and rings				$11 00	$ .90
236.—	66	do	100	do	do	do		10 00	.70
237.—	50	do	50	do	do	do		6 00	.56
238.—	33	do	50	do	do	do		5 50	.35

Our steel brazed chains 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.

Pennsylvania chains of 2 and 4 poles with 40 and 80 links, same price as chains of 50 and 100 links.

SPANISH VARA AND FRENCH METRE CHAINS.

FOR USE IN TEXAS, MEXICO, SOUTH AMERICA, AND CUBA.

240.—	10	varas or	10	metres,	50	links, No.	10	refined iron wire.........	$2 25	$ .48
241.—	20	do	20	do	100	do	10	do	3 50	.85
242.—	10	do	10	do	50	do	8	do	2 50	.74
243.—	20	do	20	do	100	do	8	do	4 00	1.40
244.—	10	do	10	do	50	do	10	best steel wire...........	4 00	.55
245.—	20	do	20	do	100	do	10	do	7 00	1.00
246.—	10	do	10	do	50	do	8	do	5 00	.74
247.—	20	do	20	do	100	do	8	do	9 00	1.40
248.—	10	do	10	do	50	links, brazed links and rings, No. 12 steel wire, tempered........			5 50	.35
249.—	20	do	20	do	100	do	12	do	10 00	.70

Note.—Parties ordering chains Nos. 240 to 249, must state whether vara or metre chains are wanted.

Steel snaps to make full chains into "half chains," no extra charge, if ordered with the chain.

GRUMMAN PATENT STEEL CHAINS.

No.		Price	Post.
260.—	66 feet, No. 15 tempered steel wire, 100 links, weight $1\frac{1}{4}$ lbs.... With 10 extra links.	$9 00	$ .26
261.—	33 do do 50 do 1 lb..... With 5 extra links.	5 00	.18
262.—	100 do do 200 do $2\frac{1}{4}$ lbs.... With 15 extra links.	11 00	.38
263.—	50 do do 100 do $1\frac{1}{4}$ lbs.... With 10 extra links.	6 00	.22
264.—	33 feet, No. 12 wire, 50 links, with 5 extra links, $1\frac{3}{4}$ lbs......	5 50	.33
265.—	66 do 100 do 10 do $3\frac{1}{4}$ lbs......	10 00	.58
266.—	50 do 50 do 5 do $2\frac{1}{4}$ lbs......	6 00	.40
267.—	100 do 100 do 10 do $4\frac{1}{4}$ lbs......	11 00	.75
268.—	50 feet, No. 18 tempered steel wire, 100 links, with attachments of spring-balance, level, and thermometer, for very accurate measurements; weight 14 oz.	15 00	.18
270.—	Brass Plummet, to use with light chain	2 00	.16
271.—	Spring-balance to use with chains Nos. 260 to 263	2 00	.05

MARKING PINS.

275.—	Set of 11 Pins, iron wire, No. 4	$1 50	$ .40
276.—	do steel wire, No. 6	2 00	.32
277.—	do brass wire, No. 4	3 00	.40
278.—	do steel wire, No. 6, weighted near point	3 00	1.10
279.—	do steel wire, No. 10, very light, with leather case...	2 00	.12
280.—	Timber scribes or Marking irons, each	1 25	.05

CHESTERMAN'S METALLIC TAPE MEASURES.

Made of linen thread, interwoven with fine brass wire, and in leather cases.

285.—	Metallic tape, 33 feet long, in 10ths or 12ths, and links	$2 10	$ .10
287.—	do 50 do do do	2 50	.15
288.—	do 66 do do do	3 00	.18
292.—	do 100 do do do	4 20	.25

NOTE.—We can furnish metallic tapes with metric or vara measure on reverse side, instead of links, at an extra cost of one cent per foot.

CHESTERMAN'S METALLIC TAPES WITHOUT BOXES.

295.—	Metallic tape, without box, 50 feet, 10ths or 12ths, and links...	$1 50	$ .08
296.—	do do 63 do	1 80	.12
297.—	do do 100 do	2 90	.16

CHESTERMAN'S STANDARD STEEL TAPE MEASURES.

All steel; the most accurate, durable, and portable measures, in leather case

No.						Price	Post.
302.—	Steel tape, 25 feet long,	in 10ths or 12ths,	and links			$4 50	$ .08
303.—	do	33	do	do	do	5 20	.10
305.—	do	50	do	do	do	7 00	.12
306.—	do	66	do	do	do	9 00	.14
307.—	do	75	do	do	do	10 40	.16
308.—	do	100	do	do	do	12 80	.20

EXCELSIOR STEEL TAPES.

Excelsior steel tape, ½-inch wide, on brass frame with handle, handy in rolling up or unrolling the tape, very good to be used in mines.

					Price	Post.
810.—	Steel tape, 50 feet long,	in 10ths or 12ths,	and links		$7 15	$ .20
811.—	do	100	do	do do	12 75	.28
312.—	do	50	do	in 12ths, and meters on reverse side	7 15	.20
813.—	do	100	do	do do do	12 75	.28

The brass frames have many advantages; they are stronger than leather cases, and have a convenient handle. In the open frame the tape can be wound up much safer, and also protected against moisture and dirt which destroys the tape enclosed in a case.

POCKET STEEL TAPE MEASURES.

						Price	Post.
315.—	Pocket Steel tapes, in German silver cases, with spring and stop, divided in 10th or 12ths of feet, 3 feet long					$1 35	$ .03
317.—	do	do	do	5	do	1 75	.04
318.—	do	do	do	6	do	2 00	.04
320.—	do	do	do	12	do	3 00	.06

These pocket tapes, with divisions to centimeters and millimeters on the other side, 5 cents per foot extra.

PAINE'S PATENT STANDARD STEEL TAPES.

IN LEATHER CASES, FLUSH HANDLES.

No.		Price	Post.
325.—	Steel tape, 33 feet long, 10ths or 12ths, and links	$5 50	$ .10
326.—	do 50 do do do	8 00	.15
327.—	do 66 do do do	10 00	.18
328.—	do 75 do do do	12 00	.20
329.—	do 100 do do do	15 00	.25

IN JAPANNED CASES, FOLDING HANDLES.

330.—	Steel tape, 25 feet long, 10ths or 12ths, and links	3 50	.08
331.—	do 33 do do do	4 50	.10
332.—	do 50 do do do	6 00	.15
333.—	do 66 do do do	8 00	.18
334.—	do 75 do do do	10 00	.20
335.—	do 100 do do do	12 00	.22

Tapes Nos. 325 to 335, with metric or vara measure on reverse side, instead of links, at an extra cost of three cents per foot.

EXTRAS TO PAINE'S PAT. STAND. STEEL TAPES.

340.—	Compensating handles, with graduated scale, per pair	$4 00	$ .04
341.—	Pocket thermometers	1 50	.08
342.—	Spring balance and level	4 00	.08

STEEL RIBBON CHAIN-TAPES.

(With handles and reel.)

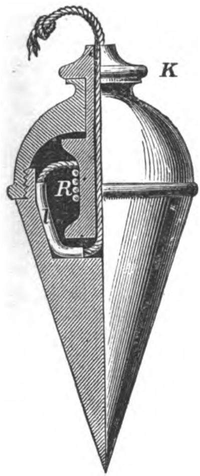
345.—	Steel Ribbon, 33 feet long, graduated each link	$3 50	$ .10
346.—	do 50 do do foot	4 00	.20
347.—	do 66 do do link	4 50	.30
348.—	do 100 do do foot	5 00	.35

Longer tapes to order. For each additional 100 feet, with an extra graduation at each 10 feet, add $2.00. Thus, a steel ribbon 500 feet long will cost $5.00 + 8.00 = $13.00.

Tape Nos. 345 to 348 are mounted on a reel which can be folded and carried in the pocket when not in use.

		Price
349A.—	Steel Ribbon, 200 feet long, with handles and substantial reel	$11 00
349B.—	do 300 do do do do	14 00
349C.—	do 500 do do do do	20 00

Tapes Nos. 349A, B, and C are graduated at each five feet the entire length, and are mounted on a mahogany reel of solid sides and swivel handles.



ADJUSTABLE PLUMB BOBS.

This plummet has a concealed reel, *R*, around which the string is wound by turning the milled head, *K*, on top. The friction upon the reel within will hold the bob at any desired point of the line.

No.	Price	Post.
350.—10 oz. adjustable	$2 50	$ .12
354.—30 oz. do	5 00	.35

BRASS PLUMB BOBS (plain).

355.—Steel point, screw head,			3 oz	$1 00	$ .04
356.—	do	do	6 oz	1 25	.07
357.—	do	do	10 oz	1 50	.12
358.—	do	do	14 oz	2 00	.16
359.—	do	do	20 oz	2 50	.23
360.—	do	do	24 oz	3 00	.28
361.—	do	do	32 oz	3 50	.37

ODOMETERS.

FOR MEASURING DISTANCES BY THE REVOLUTION OF A CARRIAGE WHEEL.

No.		
365.—Odometer, outside dial, with bolts for attaching, complete, see page 222	$10 00	$ .90
366.— do inside dial, with leather case and straps, see page 220	15 00	.75
367.—Positive Motion Odometer, see page 223	20 00	
368A.—Wheelbarrow Odometer, complete, see page 225	120 00	
368B.— do do omitting compass	104 00	

CURRENT METERS.

(W. G. PRICE'S PATENT.)

For measuring the velocity of the current of rivers and harbors, at any depth.

	Price.
375.—Deep Water and Harbor Meter, see page 235	$100 00
376.—River and Smaller Stream Meter, see page 235	100 00
377.—Electric Register, see page 235	50 00
379.—Lead Weight, 60 lbs., and connections (to use with Harbor Meter No. 375), see page 235	15 00

CURRENT METERS.—*Concluded.*

No.		Price
380.	—Brass tubing, jointed, in 4-ft. lengths, and graduated in feet and tenths (to use with Meter No. 376 and without lead weight) per foot	$1 25
381.	—Leclanche Battery, 3 cells, in case	7 00
382.	—Insulating connecting wires for Battery, per foot	02
385.	—Boyden's Hook Gauge, see page 240	25 00

PRICES FOR PARTS OF INSTRUMENTS LIABLE TO LOSS OR INJURY.

FOR TRANSITS.

	Price	Post.
Needle and center pin	$2 50	$ .03
Ground glass level vial for plate or standard, each	35	.02
do do brass mounted complete, for plate or standard, each	2 50	.05
do do for telescope, each	1 35	.05
Cap for eye-piece or object-glass, each	75	.03
Shade for object-glass	75	.03
Clamp screws for horizontal limb, each	75	.02
Tangent screw for leveling head	1 50	.03
Clamp do do	75	.03
Leveling do do each	1 50	.05
Eye-piece complete	6 00	.05
Object-glass complete	6 00	.03
Platinum cross-wires and diaphragm	3 00	.05
" stadia do do	5 00	.05
Striding, or Adjusting Level, see page 65	8 00	.10

FOR Y LEVELS.

Ground glass level vial	1 65	.10
Cap for eye-piece or object-glass, each	75	.03
Clamp screw for leveling head	75	.03
Tangent do do	1 50	.03
Leveling do do each	1 50	.05
Eye-piece complete	6 00	.05
Object-glass complete	7 00	.04
Platinum cross-wires and diaphragm	3 00	.05
do stadia do do	5 00	.05

FOR SURVEYORS' COMPASSES.

Needle and center pin	2 50	.03
Plain glass level vials, each	12	.02
do do brass mounted complete	1 50	.05
Brass cover for compass of our make	1 00	.15
Outkeeper	1 00	.03

FOR SURVEYORS' COMPASSES.—*Concluded.*

	PRICE	POST.
Staff mountings, brass head (without spindle)	$2 50	.18
do steel point	60	.18
Ball-spindle, fitted	1 50	.10
Compass sight vanes, each	2 50	.15
Clamp screw for spindle or sight vane	75	.03
Tangent screw for moving vernier	1 50	.03
Staff mountings complete for pocket compass	2 50 to 3 50	.08

MISCELLANEOUS.

Patent Extension Tripod, for Engineers' Transit or Level	15 00	
Extension legs only, with clamps, do do per set,	10 00	
Plain Tripod, do do	10 00	
Plain tripod legs only, do do per set,	5 00	
Split leg tripod, do do	15 00	
Tripod head with bolts, do do	5 00	.40
Wooden Cap, with brass screw plate, for tripod head	75	.10
Ring for tripod legs	10	.02
Brass Bolts do each	50	.03
Metal Points do do	50	.05
Screw drivers, each	20	.03
Steel adjusting pins, each	05	.01
Brass wrench for center pin	10	.01
Glass circle for compass face	25	.15
Mahogany case with lock and key and leather strap, fitted complete for Transit or Level	6 00	
do do do do fitted complete for Compass	5 00	
Regraduating compass circle to half degrees	5 00	
do horizontal limb of Transit to read to one minute	10 00	
do vertical do do	5 00	
Reading microscope	75	.02
Plumb-bob for Transit or Level	1 50	.12
Target and springs for New York or Philadelphia Rod	5 50	.25
Clamp for New York or do	2 50	.10
Rubber hood for Transit or Level	1 00	.04
Chamois skin, best quality	65	.05
Chain handles, each	75	.08
Chain tallies, per set of nine	50	.05
Clamp screw and band for extension leg	85	.05
Leather Case and Shoulder Straps for Engineers' or Surveyors' Transits, price according to size	$8 00 to $10 00	
Leather Case and Shoulder Straps for 15 to 22-inch Y Levels	8 00 to 10 00	
Leather Case and Shoulder Straps for Architects' Level and for 4 to 6-inch Vernier Compasses	7 00 to 9 00	

INFORMATION TO PURCHASERS.

SELECTION OF INSTRUMENTS.—Where only original surveys or the bearing of lines in the preparation of County Maps are required, the Plain Compasses will answer.

The Vernier Compass, or Vernier Transit Compass, will be required where the variation of the needle is to be allowed, as in retracing the lines of an old survey, etc.

When in addition to the variation of the needle local attraction must be taken into account, and the angles taken independently of the needle, an instrument with a divided limb must be employed, and for this purpose the Railroad Compass will be sufficient.

For a mixed practice of general surveying, including farm and city work, the establishment of grades of roads, the running of levels, etc., such an instrument as the Surveyors' Transit, with its various attachments, is amply sufficient.

The various forms of the Engineers' Transit, the Mountain Transit, and the Y Leveling Instruments, are designed for engineering of the highest class.

In the U. S. public land surveys, an instrument with Solar Apparatus is required, and the Solar Transit is usually selected.

In surveys of Mining claims, especially in the high elevations of Colorado, and for the surveys of mines in general, the Mountain Transit, either with the Solar Attachment or with other extras, has proved an almost universal favorite.

The new Drainage Level is, we believe, the most simple and efficient instrument designed for the drainage of farms, etc.

The Architects' Level is employed in laying out buildings, determining the level of their floors, sills, windows, and the general work of the builder.

The various forms of the Pocket Compass, with or without Telescopic Attachments, and the Reconnoissance Transit, are very desirable for a large class of work where extreme lightness and portability are demanded.

Where iron ores are also to be traced, the Miners' or Dip Compass, the Dial Compass and the Pocket Solar Compass are often required.

We do not pretend to make any instrument by which veins of gold and silver can be traced, or the presence of those metals detected, Our instruments are *not* for sale by dealers in books and apparatus; we do not deem it advisable to add to our prices to enable us to give such dealers a large *discount*, which of course would be paid by the purchaser.

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

When purchased directly of us, 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 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 instruments in all cases an injury very much greater to us than to the customer himself.

TRIAL OF INSTRUMENTS.—It may often happen that this statement of the prices and quality of our instruments may come into the hands of those who are entirely unacquainted with us or 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: If requested to do so, 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 the charges of transportation, and hold the money on deposit, one or two weeks, as may be desired, until the purchaser shall have had 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.

This privilege of two weeks' trial applies only to our larger Transits, Levels, and Compasses, and is not given unless requested, and is only granted in the United States.

EXTENT OF OUR BUSINESS.—The manufacture of surveying instruments has been conducted by us since 1845, and thousands of our instruments have been distributed to customers in all parts of the United States, and in Canada, Mexico, Central America, Cuba, South America, Sandwich Islands and Japan.

Our facilities for manufacturing, which for many years have been far superior to those of any other similar establishment, we have now (1891) greatly increased by the introduction of new machinery and tools of the most improved construction. Our manufactory has been enlarged to nearly three times its former size, and we are better prepared than ever before to fill orders for any of our instruments with promptness and satisfaction.

LOW PRICES OF OUR INSTRUMENTS.—It is often urged by other makers and persons prejudiced in their favor, that it is impossible to make first-rate instruments at the prices charged by us, and which are so very far below those of other skillful manufacturers.

We have only to reply, in addition to what we have stated in our warranty, that a visit to our works and a comparison of our facilities with those of our competitors, would dispel all questions as to our ability to surpass them, not only in the cheapness, but also in the superior quality of our work.

PACKING, ETC.—Each of our Transits, Levels and Surveyors' Compasses is packed in a well finished mahogany case, furnished with lock and key and brass hooks, and leather straps for convenience in carrying. Each case is provided with screw-drivers, adjusting pin and wrench for center pin, and if accompanied by a tripod with a brass plumb bob. With all instruments used for taking angles without the needle, a reading microscope is also furnished.

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 inclosed 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 thousands sent out since 1845, in all seasons, by every mode of transportation, and to all parts of the Union, and Canada, Mexico, Central America, South America, and many other foreign countries, not more than three or four have sustained any serious injury.

Instruments packed for foreign shipment are hermetically sealed in tin cases.

MEANS OF TRANSPORTATION.—Instruments can be sent by express to almost every town in the United States, Canada and Mexico, 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 and 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 Transit and Leveling instruments of bronze finish, and Compasses of bright 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, or by registered mail. 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, obtained as before, and without additional cost. The customer may also send the money in advance through the express agent, or may pay the agent on receipt of the instrument in funds current in New York or Boston.

Customers ordering instruments and desiring changes in construction from our regular patterns, must make a payment in advance, when ordering, of 50 per cent. of the price.

Goods ordered for shipment to foreign countries must be paid for in advance of shipment.

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

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 repolishing and renovating.

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 then enclosed 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 heads in which they are inserted need never be sent, unless themselves in need of repairs.

When requested to do so, we will send an estimate of the cost of the repairs on any instrument sent us, before beginning the work.

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. A new pair of sights fitted costs $5; a new needle with jeweled center and pivot complete, $2.50; a new jeweled center, $1.50; regraduating compass circle, $5.

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 sent to us; a new ball spindle costs $1.50. See also page 23.

Repairs to Railroad Compasses cost from $10 to $20, and to Solar Compasses from $20 to $40 or $50.

TRANSIT INSTRUMENTS.—The repairs of the Vernier Transits cost about the same as those of the Railroad 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-bars of telescopes are often bent, and sockets or centers usually so deranged as to be entirely useless.

The cost of repairing an instrument with such injuries ranges from $10 to $30 or even $50, the new sockets alone costing from $15 to $20. See also page 23.

Variation Plate added to any Engineers' Transit sent for repairs, costs	$15 00
Regraduating horizontal limb and vernier	10 00
Regraduating vertical limb and vernier	5 00

PLATINUM CROSS-WIRES.—None but a practiced hand and provided with the best facilities can properly set the platinum wires in a cross-wire diaphragm, and it is useless, therefore, to send a parcel of wire for that purpose.

The only way in which they can be replaced without sending the telescope is to take out the ring and send it to us with its screws, washers, etc., and we will return it properly secured.

We are not responsible for wires sent in this way and broken while inserting the ring.

The price of platinum cross-wires, plain, replaced in old ring, is	$2 00
Stadia wires, replaced in old ring	3 00

If sent by mail add 15c. for postage and registry.

When it is desirable to substitute platinum for spider-web, a new ring, with screws, etc., will be required.

The price of platinum cross-wires, with diaphragm, screws, etc., plain, is	$3 00
Stadia wires, with diaphragm, etc	5 00

LEVELING INSTRUMENTS are generally much less injured by falling than Transits, the damages 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 or 20 dollars; a new level vial set in the tube costs two dollars. See also page 23.

REPOLISHING INSTRUMENTS.—The cost of repolishing an instrument, involving, of course, its complete re-adjustment, varies with the different kinds, but may be stated generally as follows:

Compasses, (Plain and Vernier), from	$5 to $7
Railroad Compasses, from	8 to 10
Solar Compasses, from	15 to 20
Transits, from	12 to 20
Levels, from	12 to 15

These prices are in addition to the cost of repairs.

No additional charge is made for bronzing or blackening an instrument when repolished.

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 instrument to us or not, as he may prefer. Whenever the freight is paid in advance, the express receipt should be mailed immediately to us.

W. & L. E. GURLEY,

Mathematical Instrument Makers,

No. 514 FULTON ST., OPPOSITE NORTH END OF UNION R. R. DEPOT, TROY, N. Y.

ENGINEERS' INSTRUMENTS.

Of all the instruments used in engineering, the American Transit, in its various modifications, is by far the most important, and we shall therefore first describe that form commonly known as

THE ENGINEERS' TRANSIT.

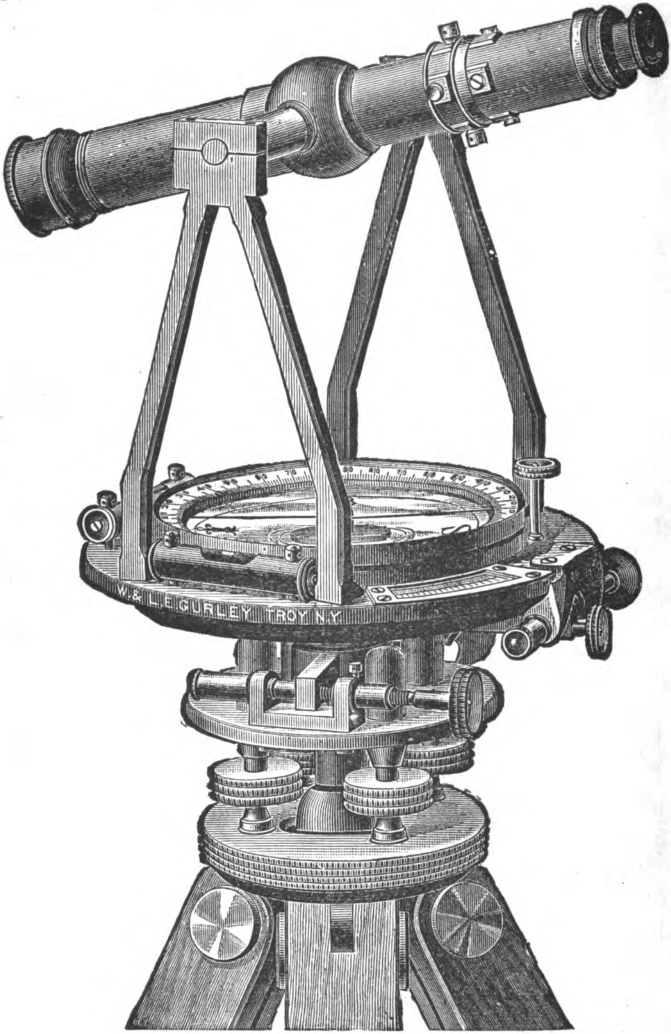
The essential parts of the Transit, as shown in the cut, are the *telescope* with its axis and two supports, the *circular plates* with their attachments, the *sockets* upon which the plates revolve, the *leveling head*, and the *tripod* on which the whole instrument stands.

The *telescope* is from ten to eleven inches long, firmly secured to an axis having its bearings nicely fitted in the standards, and thus enabling the telescope to be moved in either direction, or turned completely around if desired. The different parts of the telescope are shown on page 33.

The object-glass is composed of two lenses, so as to show objects without color or distortion, and is placed at the end of a slide having two bearings, one at the end of the outer tube, the other in the ring C C, suspended within the tube by four screws, only two of which are shown in the cut.

The object-glass is carried out or in by a pinion working in a rack attached to the slide, and thus adjusted to objects either near or remote as desired.

The eye-piece is made up of four lenses, which, beginning at the eye-end, are called respectively the eye, the field, the amplifying, and the object lenses, the whole forming a compound microscope having its focus in the plane of the cross-wire ring B B.

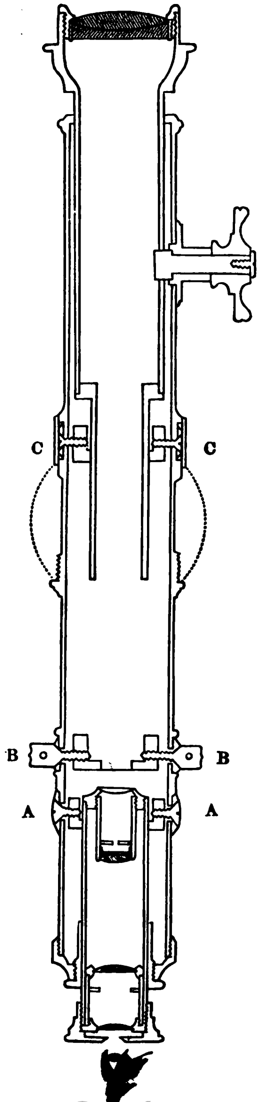


No. 3.

Engineers' Transit, with 5-inch needle, plain telescope and tripod. Price as shown, $150.00.

Inverting Eye-piece.—Sometimes, especially in English instruments, an eye-piece of two lenses is employed; but this, while it gives more light, inverts the object seen, and so has been discarded by American engineers.

Diagonal Prism.—Where it is desired to take greater vertical angles than is possible with the ordinary eye-piece, the little cap on the end of the eye-piece is unscrewed and replaced by another containing a small prism, which reflects the image of the object at right angles, and brings it to the eye of an observer from above; when used on the sun, a colored glass or darkener is interposed between the eye and prism. See page 75.



How Vision is Aided by the Telescope.—The object-glass receiving the rays of light which proceed from all the points of a visible object, converges them to a focus at the cross-wires, and there forms a minute, inverted, and very bright image, which may be seen by placing a piece of ground glass to receive it at that point.

The eye-piece acting as a compound microscope, magnifies this image, restores it to its natural position, and conveys it to the eye.

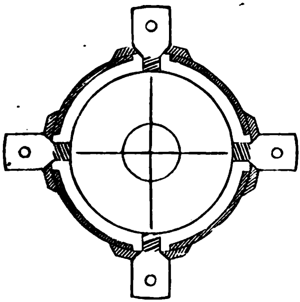
The visual angle which the image there subtends, is as many times greater than that which would be formed without the use of the telescope, as the number which expresses its magnifying power. Thus, a telescope which magnifies twenty times, increases the visual angle just as much, and therefore diminishes the apparent distance of the object twenty times—or in other words, it will show an object two hundred feet distant, with the same distinctness as if it was distant only ten feet from the naked eye.

High Powers.—It might be supposed that the greater the power of a telescope, the better ; but in practice, beyond a certain point, this is found to be incorrect. In the first place, as only a given amount of light can enter the object-glass, the more the object is magnified the less clear and bright will it appear ; and again, the higher the power the more difficult will it be to precisely focus the telescope and to complete its adjustment. We have found that a power of from twenty to twenty-four diameters in the telescopes of transits gives the best results and is amply sufficient for all ordinary practice.

The Kellner Eye-piece, the main feature of which is the use of a compound amplifying lens, as shown on page 33, in place of the single one heretofore employed, has sensibly increased the brilliancy of the object and secured a better field. This is now applied to all our transit telescopes. The eye-piece is brought to its proper focus by a rack and pinion movement, precisely like that employed in focusing the object-glass, and for this we make no additional charge.

The Cross-wires (see page 35) are two fibres of spider-web or very fine platinum wire, cemented into the cuts on the surface of a metal ring, at right angles to each other, so as to divide the open space in the center into quadrants.

To Remove the Cross-wire Ring.—Take out the eye-piece tube, together with the little ring by which it is



centered, and having removed two opposite cross-wire screws, with the others turn the ring until one of the screw holes is brought into view from the open end of the telescope tube; in this thrust a pointed splinter of wood or a small wire, so as to hold the ring when the remaining screws are withdrawn; the ring is then taken out. It may be replaced by returning it to its position in the tube, and either pair of screws being inserted, the splinter or wire is removed, and the ring is turned until the other screws can be replaced.

Care must also be taken that the same side of the ring is turned to the eye-piece as before it was removed.

When this has been done, the eye-tube is inserted, and its centering ring brought into such a position that the screws in it can be replaced, and then by screwing on the end of the telescope, the little cover into which the eye-tube is fixed, the operation will be completed.

The advantage of Platinum over Spider-web 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-web heretofore used.

Optical Axis.—The intersection of the wires forms a very minute point, which, when they are adjusted, determines the optical axis of the telescope, and enables the surveyor to fix it upon an object with the greatest precision.

The imaginary line passing through the optical axis of the telescope, is termed the "line of collimation," and the operation of bringing the intersection of the wires into the optical axis, is called the "adjustment of the line of collimation." This will be hereafter described.

The openings in the telescope tube are made considerably larger than the screws used in adjusting the cross-wires, so that, when the screws are loosened, the whole ring can be turned around for a short distance in either direction.

The object of this will be seen more plainly, when we describe the means by which the wire is made truly vertical.

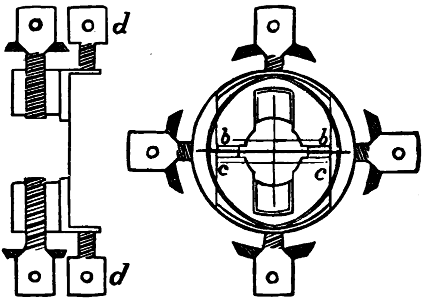
The sectional view of the telescope also shows two movable rings, one placed at A A, the other at C C, which are respectively used, to effect the centering of the eye-piece, and the adjustment of the object-glass slide.

The centering of the eye-tube is performed after the wires have been adjusted, and is effected by moving the ring, by means of the screws shown on the outside of the tube, until the intersection of the wires is brought into the center of the field of view.

The adjustment of the object-slide, which will be hereafter described, keeps the line of collimation in adjustment through the whole range of the slide, preventing at the same time what is termed the "traveling" of the wires.

This adjustment, which is peculiar to our telescopes, is always made in the process of construction, and needing no further attention at the hands of the engineer, is concealed within the ring near the ball of the telescope axis.

The Stadia, or ***Micrometer***, is a compound cross-wire ring or diaphragm, as shown, having three horizontal wires, of which the middle one is cemented to the ring as usual, while the others, *bb* and *cc*, are fastened to small slides, held apart by a slender brass spring hoop, and actuated by independent screws, *dd*, by which the distance between the two movable wires can be adjusted to include a given space, as one foot on a rod one hundred feet distant.



These wires will in the same manner include two feet on a rod two hundred feet distant, or half a foot at a distance of fifty feet, and so on in the same proportion, thus furnishing a means of measuring distances, especially over broken ground, much more easily and even more accurately than with a tape or chain.

We put stadia wires in all Transit telescopes without extra cost if requested when ordering the instrument.

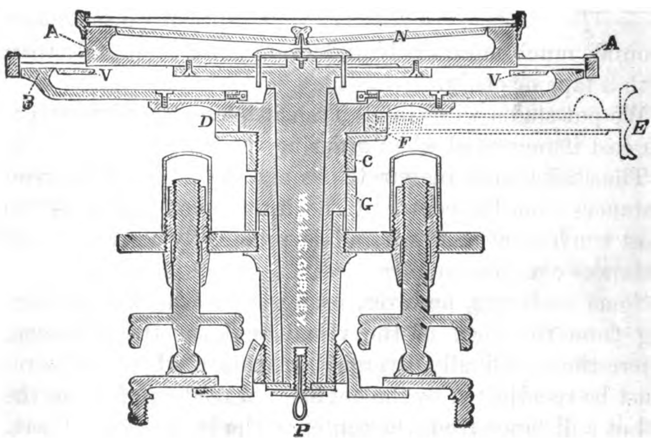
The stadia wires in our telescopes are adjusted to read distances from the center of the instrument. This is the most convenient method and is practically correct for all distances over one hundred feet.

Some engineers, however, prefer the method of measuring from the apex of the visual angle of the telescope, where the rays finally diverge. In this method the wires must be re-adjusted by the engineer to read one foot on the rod at a distance from the center of the instrument of, say, one hundred feet plus c plus f; c being the distance of the objective from the center of the instrument, and found by measuring from the center of the axis to the objective when it is focused on a mean distance of, say, two hundred feet; and f being the focal length of the objective, and found by measuring from the cross-wires to the objective.

For example, in our eleven-inch telescopes, such as are used with our larger Transits, $c = 5\frac{3}{10}$ inches and $f = 8$ inches; $c + f = 13\frac{3}{10}$ inches. In our Mountain Transit telescopes $c = 3\frac{9}{10}$ inches and $f = 5\frac{4}{10}$ inches; $c + f = 9\frac{3}{10}$ inches. In our Reconnoissance Transit telescopes $c = 4\frac{1}{2}$ inches and $f = 5\frac{3}{4}$ inches, $c + f = 10$ inches.

The Standards of the Transit are firmly attached by their expanded bases to the upper plate, one of them having near the top, as shown on page 87, a little movable box, actuated by a screw underneath, by which the telescope axis is made truly horizontal, as will be hereafter described.

THE SOCKETS AND CIRCULAR PLATES.



The circular plates, with their accompanying sockets, are shown in section on page 38; the upper plate, A A, carrying the compass circle, etc., is screwed fast to the flange of the interior spindle; the lower plate or divided limb, B, is fastened to the exterior socket C, which again is fitted to and turns in the hollow socket of the leveling head.

The compass box, containing the needle, etc., is covered by a glass to exclude the moisture and air; the circle is silvered, and is divided on its upper surface or rim into degrees and half-degrees, and figured from 0 to 90 on each side of the center or line of zero; the degree marks being also cut down on the inner edge.

The Magnetic Needle is four to five inches long in the different sizes of transits, its brass cap having inserted in it either a little socket of hardened steel or a jeweled center perfectly polished, and this resting upon the hardened and polished point of the center-pin, allows the needle to play freely in a horizontal direction, and thus take its direction in the magnetic meridian. The needle has its north end designated by a scollop or other mark, and on its south end a small coil of fine brass wire, easily moved, so as to bring both ends of the needle to the same level. The needle is lifted from the pin by a concealed spring underneath the upper plate, actuated by a screw shown above, thus raising the button so as to check the vibrations of the needle, or bring it up against the glass when not in use, to avoid the unnecessary wear of the pivot.

The forms of the needle are almost infinitely varied, according to the taste or fancy of the maker or surveyor, but may be resolved into two general classes, one having the greatest breadth in a horizontal, the other in a vertical direction.

We have usually made our needles about one-twentieth of an inch broad and one-third as thick, parallel from end to end, and find that they are generally acceptable, but whenever desired, supply other forms and without additional charge.

The test of the delicacy of a magnetic needle is the number of horizontal vibrations which it will make in a certain arc, before coming to rest—besides this most surveyors prefer also to see a sort of quivering motion in a vertical direction.

This quality, which is manifested more in a horizontal than in a vertical needle, and depends upon the near coincidence of the point of suspension with the center of gravity of the needle, serves to show merely that the cap below is unobstructed.

The Clamp and Tangent Movement, as now improved, has its tangent screw with opposing spring attached to the upper plate, as shown on page 32; the clamp is shown in section on page 38, being a strong metal ring, D F, moving easily around the solid outer socket, to which it is securely fixed at will by a clamp screw, E, impinging upon a small segment, F. By this means the plates are clamped firmly together and moved slowly around each other in either direction by the tangent screw, or loosened at will and moved by the hand, the telescope being thus easily and accurately directed to the point of sight.

The two Levels are shown placed at right angles to each other so as to level the plate in all directions, and adjusted by turning the capstan head-screws at their ends, by a small steel adjusting pin. The glass vials used in the levels of this and all our Transits are ground on their interior surface, so as to make the bubble move evenly and with great sensitiveness.

The Lower Plate or Limb B (see page 38), is divided on its upper surface—usually into degrees and half-degrees—and figured in two rows, viz., from 0 to 360, and from 0 to 90 each way; sometimes but a single series is used, and then the figures run from 0 to 360 or from 0 to 180 on each side. The figuring, which is the same upon this as the limbs of all our Transits, is varied according to the wish of the person ordering the instrument, the double series being always used unless otherwise desired.

The two verniers V V are attached to the upper plate diametrically opposite to each other, and serve to read the limb around which they revolve.

The place of the verniers, as will be observed, is now in front of the observer and at an angle of 30° from the telescope, so that they are easily read without a change of position. This improvement we have adopted in all our instruments.

The Verniers are double, having on each side of the zero mark thirty equal divisions corresponding precisely with twenty-nine half degrees of the limb; they thus read to single minutes, and the number passed over is counted in the same direction in which the vernier is moved.

The use of two opposite verniers in this and other instruments gives the means of "cross questioning" the graduations, the perfection with which they are centered and the dependence which can be placed upon the accuracy of the angles indicated.

Sometimes a finer reading than minutes is desired, and then the divisions of the limb and vernier are both made smaller, so as to give readings to 30, 20, or even 10 seconds of arc, if required. The vernier openings are covered with glass, carefully cemented to exclude the moisture and dust.

Reflectors of silver or celluloid, as in the Mountain Transit, are often used to throw more light upon the divisions, and more rarely, shades of ground glass are employed to give a clear but more subdued light.

The Graduations are made commonly on the brass surface of the limb, afterwards filled with black wax, and then finished and silvered. The limbs of all our Transits are now covered with a solid silver plate, the graduations are much finer and more distinct, and the surfaces less liable to tarnish or change color.

This improvement, which usually costs quite a large sum, we now make without additional charge.

The Sockets of the Transit, as shown on page 38, are compound; the interior spindle attached to the vernier plate, turning in the exterior socket C when an angle is taken on the limb, but when the plates are clamped together, the exterior socket itself, and with it the whole instrument, revolves in the socket of the leveling head.

The sockets are made with the greatest care, the surfaces being truly concentric with each other, and the bell metal or composition of which they are composed, of different degrees of hardness, so as to cause them to move upon each other easily and with the least possible wear.

The leveling head, also shown, consists of two plates connected together by a socket, having at its end a hemispherical nut, fitting into a corresponding cavity in the lower plate.

The plates are inclined to each other or made parallel at will by four leveling screws, of which only two are shown in the section.

The screws are of bronze or hard composition metal and fitted to long nuts of brass screwed into the upper parallel plate. They are protected from dust by brass covers as shown, screwed on the upper ends of the nuts.

The screws rest in little cups or sockets, which are secured to their ends and in which they turn without marring the surface of the lower plate, the cups also permitting the screws to be shifted from side to side, or turned around in either direction on the lower plate.

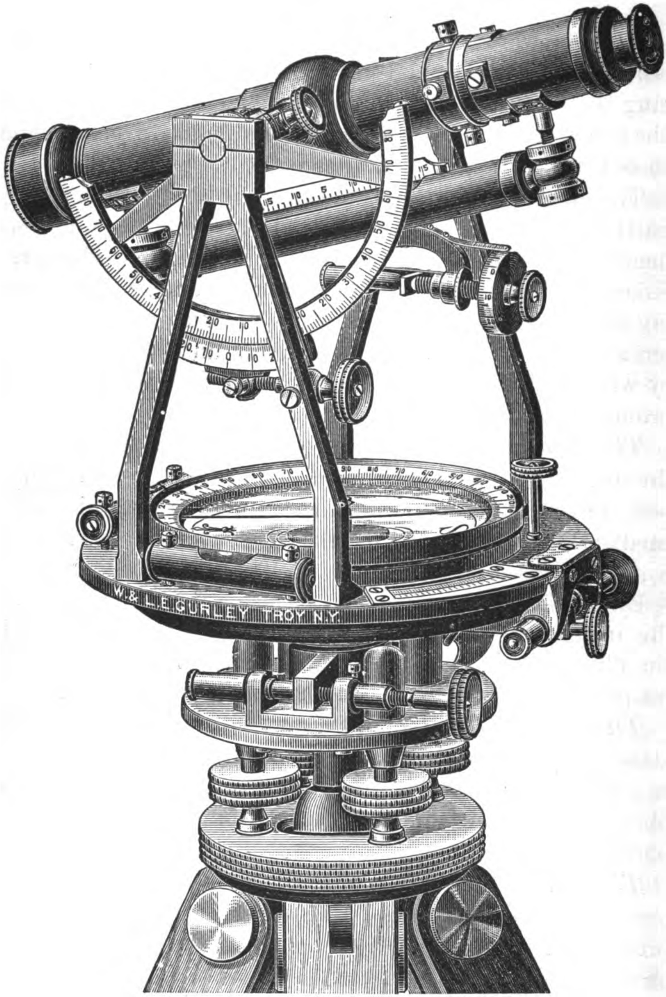
The clamp and tangent movement of the leveling head, partially shown on page 32, serves to turn the whole instrument upon its sockets, so as to fix the telescope with precision upon any given point—and when unclamped allowing it to be directed approximately by hand. The tangent screw is now single, as shown, and has an opposing spring by which all lost motion is avoided and a very fine and prompt movement secured.

The Lower Leveling-plate is made in two pieces—the upper one, which is screwed fast to the top of the tripod, having a large opening in its center, in which the smaller lower one is shifted from side to side, or turned completely around.

By this simple arrangement, termed a "shifting center," the instrument is easily moved over the upper plate, and the plummet which hangs from the center P (see page 38), set precisely over a point, without moving the tripod.

The Leveling Head of the Engineers' Transit is attached to the sockets by a screw and washer below; it can be removed for cleaning, oiling, &c., but should be in place when the instrument is in use, or packed for transportation.

The Tripod, the top of which is shown on page 32, has three mahogany legs, the upper ends of which are pressed firmly on each side of a strong tenon on the solid bronze head by a bolt and nut on opposite sides of the leg; the nut can also be screwed up at will by a wrench furnished for the purpose, and thus kept firm.



No. 3 B.

Engineers' Transit, 5-inch needle, with 6-inch vertical arc on silver, with vernier moved by tangent screw, and reading to 30 seconds, level on telescope, gradienter combined with clamp and tangent, and tripod. Price as shown, $198 00

The lower end of the leg has a brass shoe with iron point, securely fastened and riveted to the wood.

The Extension Tripod described in the article "Mountain Transit" is often used with the other larger instruments, and is then made heavier and stronger than with the one just named.

The Attachments of the Transit.—The engraving (page 44) represents some of the attachments often applied to the Engineers' Transit—viz., the vertical arc, level on telescope, and clamp and tangent to telescope axis with gradienter screw.

These and other appliances are employed where leveling, taking vertical angles, etc., are required in connection with the ordinary use of the Transit, and with their adjustments, etc., will be described hereafter.

TO ADJUST THE TRANSIT.

Every instrument should leave the hands of the maker in complete adjustment, but all are so liable to derangement by accident or careless use, that we deem it necessary to describe particularly those which are most likely to need attention.

The principal adjustments of the Transit are—

(1) *The Levels.*
(2) *The Line of Collimation.*
(3) *The Standards.*

To Adjust the Levels.—Set up the instrument upon its tripod as nearly level as may be, and having unclamped the plates, bring the two levels above and on a line with the two pairs of leveling screws; then with the thumb and first finger of each hand clasp the heads of two, opposite; and, turning both thumbs in or out, as may be needed, bring the bubble of the level directly over the screws, exactly to the center of the opening. Without moving the instrument proceed in the same manner to bring the other bubble to its center; after doing this, the level first corrected may be thrown a little out; bring it in again; and when both are in place, turn the instrument half-way around; if the bubbles both come to the center, they would need no correction, but if not, with the adjusting pin turn the small screws at the end of the levels until the bubbles are moved over half the error; then bring the bubbles again into the center by the leveling screws, and repeat the operation until the bubbles will remain in the center during a complete revolution of the instrument, and the adjustment will be complete.

To Adjust the Line of Collimation.—To make this adjustment—which is, in other words, to bring the intersection of the wires into the optical axis of the telescope, so that the instrument, when placed in the middle of a straight line, will, by the revolution of the telescope, cut its extremities—proceed as follows:

Set the instrument firmly on the ground and level it carefully; and then having brought the wires into the focus of the eye-piece, adjust the object-glass on some well-defined point, as the edge of a chimney or other object, at a distance of from two hundred to five hundred feet; determine if the vertical wire is plumb, by clamping the instrument firmly and applying the wire to the vertical edge of a building, or observing if it will move parallel to a point taken a little to one side; should any deviation be manifested, loosen the cross-wire screws, and by the pressure of the hand on the heads outside the tube, move the ring around until the error is corrected.

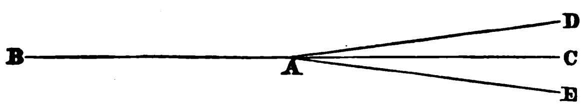
The wires being thus made respectively horizontal and vertical, fix their point of intersection on the object selected; clamp the instrument to the spindle, and having revolved the telescope, find or place some good object in the opposite direction, and at about the same distance from the instrument as the first object assumed.

Great care should always be taken in turning the telescope, that the position of the instrument upon the spindle is not in the slightest degree disturbed.

Now, having found or placed an object which the vertical wire bisects, unclamp the instrument, turn it half way around, and direct the telescope to the first object selected; having bisected this with the wires, again clamp the instrument, revolve the telescope, and note if the vertical wire bisects the second object observed.

Should this happen, it will indicate that the wires are in adjustment, and the points bisected are with that of the center of the instrument, in the same straight line.

If not, however, the space which separates the wires from the second point observed, will be double the deviation of that point from a true straight line, which may be conceived as drawn through the first point and the center of the instrument, since the error is the result of two observations, made with the wires when they are out of the optical axis of the telescope.



For, as in the diagram, let A represent the center of the instrument, and B C the imaginary straight line, upon the extremities of which the line of collimation is to be adjusted.

B represents the object first selected, and D the point which the wires bisected, when the telescope was made to revolve.

When the instrument is turned half around, and the telescope again directed to B, and once more revolved, the wires will bisect an object, E, situated as far to one side of the true line as the point D is on the other side.

The space, D E, is therefore the sum of two deviations of the wires from a true straight line, and the error is made very apparent.

In order to correct it, use the two capstan head screws on the sides of the telescope, these being the ones which affect the position of the vertical wire.

Remember that the eye-piece inverts the position of the wires, and therefore that in loosening one of the screws and tightening the other on the opposite side, the operator must proceed as if to increase the error observed. Having in this manner moved back the vertical wire until, by estimation, one-quarter of the space, D E, has been passed over, return the instrument to the point B, revolve the telescope, and if the correction has been carefully made, the wires will now bisect a point, C, situated midway between D and E, and in the prolongation of the imaginary line, passing through the point B and the center of the instrument.

To ascertain if such is the case, turn the instrument half around, fix the telescope upon B, clamp to the spindle, and again revolve the telescope towards C. If the wires again bisect it, it will prove that they are in adjustment, and that the points, B, A, C, all lie in the same straight line.

Should the vertical wire strike to one side of C, the error must be corrected precisely as above described, until it is entirely removed.

Another method of adjusting the line of collimation often employed in situations where no good points in opposite directions can be selected upon which to reverse the wires, may here be described.

The operator sets up the instrument in some position which commands a long sight in the same direction, and having leveled his instrument, clamps to the spindle, and with the telescope locates three points which we will term A, B and C, which are distant from the instrument about one hundred, two hundred, and three hundred feet respectively.

These points, which are usually determined by driving a nail into a wooden stake set firmly into the ground, will all be in the same straight line, however much the wires are out of adjustment, since the position of the instrument remains unchanged during the whole operation.

Having fixed these points he now moves the instrument to B, and sets its center directly over the nail-head, by letting down upon it the point of a plumb-bob suspended from the tripod.

Then having leveled the instrument, he directs the wires to A, clamps to the spindle and revolves the telescope towards C. Should the wires strike the nail at that point, it would show that they were in adjustment.

Should any deviation be observed, the operator must correct it by moving the wire with the screws until, by estimation, half the error is removed.

Then bringing the telescope again upon either A or C, and revolving it, he will find that the wires will strike the point in the opposite direction if the proper correction has been applied.

If not, repeat the operation until the telescope will exactly cut the two opposite points, when the intersection of the wires will be in the optical axis, and the line of collimation in adjustment.

In our description of the previous operation, we have spoken more particularly of the vertical wire, because in a revolving telescope this occupies the most important place, the horizontal one being employed mainly to define the center of the vertical wire, so that it may be moved either up or down without materially disturbing the line of collimation.

The wires being adjusted, their intersection may now be brought into the center of the field of view by moving the screws A A, shown in the sectional view of the telescope, (page 33), which are slackened and tightened in pairs, the movement being now direct, until the wires are seen in their proper position.

It is here proper to observe, that the position of the line of collimation depends upon that of the object-glass, solely, so that the eye-piece may, as in the case just described, be moved in any direction, or even entirely removed and a new one substituted, without at all deranging the adjustment of the wires.

To Adjust the Standards.—In order that the wires may trace a vertical line as the telescope is moved up or down, it is necessary that both the standards of the telescope should be of precisely the same height.

To ascertain this and make the correction if needed, proceed as follows:

Having the line of collimation previously adjusted, set up the instrument in a position where points of observation, such as the point and base of a lofty spire, can be selected, giving a long range in a vertical direction.

Level the instrument, fix the wires on the top of the object and clamp to the spindle; then bring the telescope down, until the wires bisect some good point, either found or marked at the base; turn the instrument half around, fix the wires on the lower point, clamp to the spindle, and raise the telescope to the highest object.

If the wires bisect it, the vertical adjustment is effected; if they are thrown to either side this would prove that the standard opposite that side was the highest, the apparent error being double that actually due to this cause.

To correct it, we make one of the bearings of the axis movable, so that by turning a screw underneath this sliding piece, as well as the screws which hold on the cap of the standard, the adjustment is made with the utmost precision.

This arrangement, which is common to all our telescope instruments, is very substantial and easily managed.

Other Adjustments of the Transit.

Besides the three adjustments already described—which are all that the Surveyor will ordinarily have to make—there are those of the needle and the object-glass slide, which may sometimes be required.

The first is best given with the description of the Compass—the last will now be described.

To Adjust the Object-slide.—Having set up and leveled the instrument, the line of collimation being also adjusted for objects from three hundred to five hundred feet distant, clamp the plates securely, and fix the vertical cross-wire upon an object as distant as may be distinctly seen; then, without disturbing the instrument, throw out the object-glass, so as to bring the vertical wire upon an object as near as the range of the telescope will allow. Having this clearly in mind, unclamp the limb, turn the instrument half-way around, reverse the eye-end of the telescope, clamp the limb, and with the tangent-screw bring the vertical wire again upon the near object; then draw in the object-glass slide until the distant object first sighted upon is brought into distinct vision. If the vertical wire strikes the same line as at first, the slide is correct for both near and remote objects; and, being itself straight, for all distances.

But if there be an error, proceed as follows: first, with the thumb and forefinger twist off the thin brass tube that covers the screws C C (see page 33). Next, with the screw-driver, turn the two screws C C on the opposite *sides* of the telescope, loosening one and tightening the other, so as apparently to increase the error, making, by estimation, one-half the correction required.

Then go over the usual adjustment of the line of collimation, and having it completed, repeat the operation above described; first sighting upon the distant object, then finding a near one in line, and then reversing, making correction, &c., until the adjustment is complete.

This adjustment is always made by us before the instrument is shipped, is peculiar to our Transits, and, in our experience, furnishes the only way in which the line of collimation can be made correct for all distances.

To Use the Transit.—The instrument should be set up firmly, the tripod legs being pressed into the ground, so as to bring the plates as nearly level as convenient; the plates should then be carefully leveled and properly clamped, the zeros of the verniers and limb brought into line by the upper tangent-screw, and the telescope directed to the object by the tangent-screw of the leveling head.

The angles taken are then read off upon the limb, without subtracting from those given by the verniers, in any other position.

Before an observation is made with the telescope, the eye-piece should be moved in or out, until the wires appear distinct to the eye of the operator ; the object-glass is then adjusted by turning the pinion-head until the object is seen clear and well-defined, and the wires appear as if fastened to its surface.

The intersection of the wires, being the means by which the optical axis of the telescope is defined, should be brought precisely upon the center of the object to which the instrument is directed.

The needle is used, as in the compass, to give the bearing of lines, and as a rough check upon the angles obtained by the verniers and limb ; but its employment is only subsidiary to the general purposes of the Transit.

Different Sizes, with Weights of Each.

We make three sizes of the Engineers' Transit, having respectively 4, 4½, and 5-inch needles ; the average weight of each size, with plain telescope, excluding the tripod head and legs, is as follows :

4-inch	needle,	without tripod,	about	12½ lbs.
4½-inch	"	"	"	14 "
5-inch	"	"	"	16 "

ENGINEERS' TRANSIT WITH SOLAR ATTACHMENT.

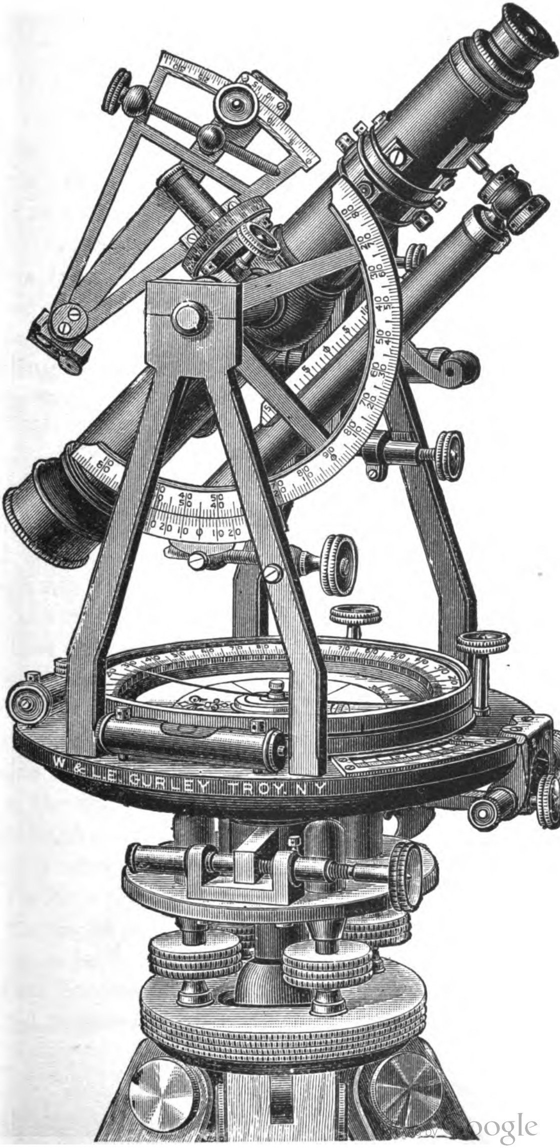
The engraving on page 55 represents our Engineers' Transit with 5-inch needle and attachments of vertical arc, 6 inches in diameter, divided on silver, reading to thirty seconds—level on telescope—clamp and tangent to axis—and solar apparatus with declination arc reading to thirty seconds.

The horizontal limb is divided on rolled silver, and reads to single minutes.

The compass circle is also made movable, with pinion and clamp, for setting off the variation of the needle.

The variation circle is also applied to engineers' transits of our make, when desired at the time of ordering the instrument, at an extra cost of $4.00.

Where the variation plate is desired in the application of the new solar attachment to any engineers' transit sent to us for the purpose, a charge of $15 will be made for the same.



No. 5.

ENGINEERS' TRANSIT, WITH SOLAR ATTACHMENT. Price as shown, $250.00.

LIGHT MOUNTAIN TRANSIT.

This instrument is a modification of the Engineers' Transit, made for Mountain and Mine Surveys, but applicable as well to all the other work of the Engineer. It is made exceedingly light and portable, its needle being 4 inches long; and its telescope 8 inches long, having a power of 20 diameters.

Its sockets are like those shown on page 38, and, with the leveling head, remain attached to the instrument; and its compass circle is movable about its center, like that of the Railroad Compass, hereafter shown, so as to lay off the variation of the needle as described in the account of that instrument.

In this instrument the limb is divided on solid silver to half degrees, with verniers reading to single minutes; sometimes the limb is divided to twenty minutes with verniers reading to half minutes.

There are also cylindrical caps above the leveling screws to exclude the dust, &c., as in our other instruments.

The cut shows the celluloid reflectors, which are placed over the two opposite verniers of the limb, and are of service especially in the surveys of mines, to throw light upon the divisions below.

Attachments of the Telescope.—Like the Engineers' Transit before described, this instrument is sometimes used with a plain telescope; but oftener with one or more of the extras, as level, clamp and tangent, and vertical circle, as shown in the cut of the Surveyors' Transit.

More frequently, however, the Mountain Transit is furnished as shown, with vertical arc, level, clamp and tangent, and the patent solar attachment, the last of which we shall now proceed to describe, referring to the article on the Solar Compass, for a more detailed account of the principles involved in its construction and use.

The Solar Attachment is essentially the solar apparatus of Burt placed upon the cross-bar of the ordinary transit, the polar axis being directed above instead of below, as in the solar compass.

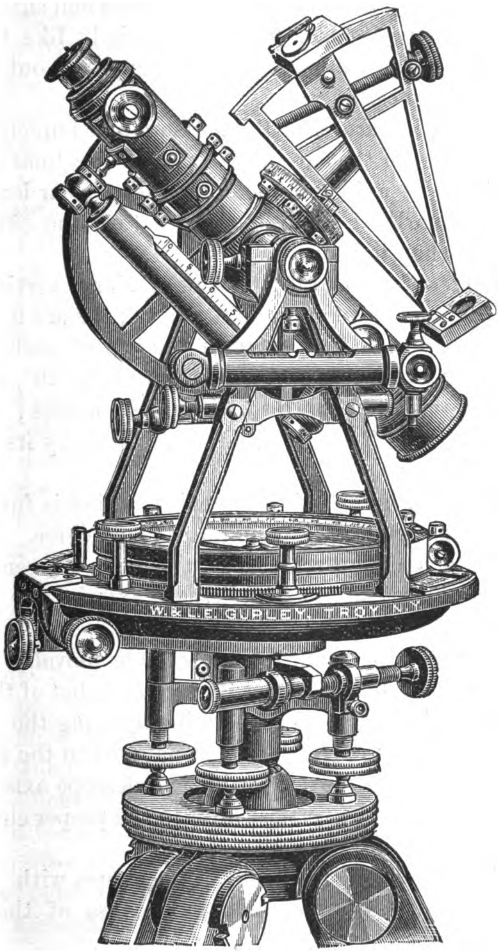
A little circular disc of an inch and a half diameter, and having a short round pivot projecting above its upper surface, is first securely screwed to the telescope axis.

Upon this pivot rests the enlarged base of the polar axis, which is also firmly connected with the disc by four capstan head screws passing from the under side of the disc into the base already named. These screws serve to adjust the polar axis, as will be explained hereafter.

The hour circle surrounding the base of the polar axis is easily movable about it, and can be fastened at any point desired by two flat-head screws above. It is divided to five minutes of time ; is figured from I. to XII., and is read by a small index fixed to the declination arc, and moving with it.

A hollow cone, or socket, fitting closely to the polar axis and made to move snugly upon it, or clamped at any point desired by a milled-head screw on top, furnishes by its two expanded arms below, a firm support for the declination arc, which is securely fastened to it by two large screws, as shown.

The declination arc is of about five inches radius, is divided to quarter degrees, and reads by its vernier to single minutes of arc, the divisions of both vernier and limb being in the same plane.



No. 7.

Light Mountain Transit, with patent solar attachment, vertical arc reading to one minute, level on telescope, and clamp and tangent to axis of telescope, and extension tripod.......................................$245 00

The declination arm has the usual lenses and silver plates on the two opposite blocks, made precisely like those of the ordinary solar compass, but its vernier is outside the block, and more easily read.

The declination arm has also a clamp and tangent movement, as shown in the cut. The arc of the declination limb is turned on its axis and one or the other solar lens used, as the sun is north or south of the equator; the cut shows its position when it is north.

The latitude is set off by means of a large vertical limb having a radius of two and a half inches; the arc is divided to thirty minutes, is figured from the center, each way, in two rows, viz. from 0 to 80°, and from 90° to 10°, the first series being intended for reading vertical angles; the last series for setting off the latitude, and is read by its vernier to single minutes.

When desired, an arc of three inches radius is furnished, reading by its vernier to half minutes of a degree.

It has also a clamp-screw inserted near its center, by which it can be set fast to the telescope axis in any desired position.

The vernier of the vertical limb is made movable by the tangent-screw attached, so that its zero and that of the limb are readily made to coincide when, in adjusting the limb to the level of the telescope, the arc is clamped to the axis.

The usual tangent movement to the telescope axis serves, of course, to bring the vertical limb to the proper elevation, as hereafter described.

A level on the under side of the telescope, with ground vial and scale, is indispensable in the use of the Solar attachment.

The divided arcs, verniers, and hour circle are all on silver plate, and are thus easily read and preserved from tarnishing.

Explanation of the Solar Apparatus.

In the engraving on page 63, suggested by Prof. L. M. Haupt, author of the "Topographer, his Methods and Instruments," we have a graphical illustration of the Solar apparatus; the circles shown being intended to represent in miniature those supposed to be drawn upon the concave surface of the heavens.

When the telescope is made horizontal by its spirit level the hour-circle will be in the plane of the horizon, the polar axis will point to the zenith and the zeros of the vertical arc and its vernier coincide.

In this position of the instrument, if the arm of the declination arc be placed at zero, and one lens directed to the sun, his image will be seen between the lines on the silver plate of the opposite block, as shown on page 102, and will indicate his position in the heavens, on an instrument placed at the north pole of the earth at the time of equinoxes, or when the equator is in the plane of the horizon.

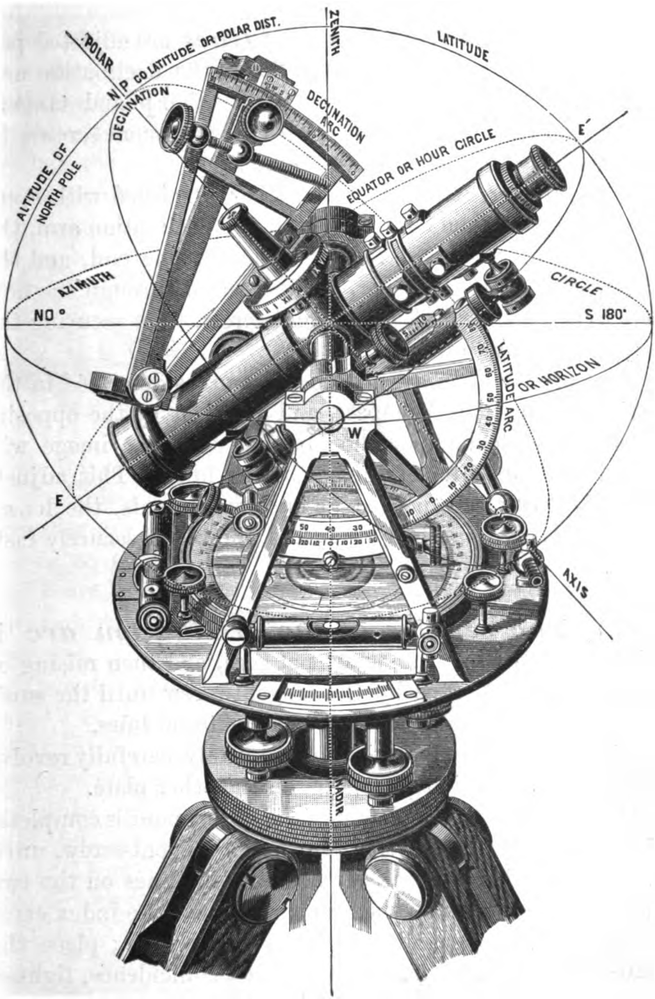
Now if we incline the telescope as shown in the cut, the polar axis will descend from the direction of the zenith. The angle through which it moves, being laid off on the vertical arc, and shown by its vernier to be 40°, will be the co-latitude of the place where the instrument is supposed to be used, the latitude itself being found by subtracting 40° from 90°, making it just 50°.

Now if the declination arm remains at zero, and the lens be again directed to the sun, his image will appear on the opposite plate as before, the instrument being used at the time of the equinox and at a latitude of 50°.

When, however, the sun passes above or below the equator, his declination or angular distance from it, as given in the Ephemeris, can be allowed for and set off upon the arc, and his image brought into position as before.

In order to do this, however, it is necessary not only that the latitude and declination shall be correctly set off upon their respective arcs, but also that the instrument should be moved in azimuth until the polar axis points to the pole of the heavens, or, in other words, is placed in the plane of the meridian, and thus the position of the sun's image will indicate not only the latitude of the place, the declination of the sun for the given hour, and the apparent time, but also determine the meridian or true north and south line, passing through the place where the observation is made.

THE SOLAR ATTACHMENT



The Adjustments of the Solar Attachment.

(1.) ***The Solar lenses and lines*** are adjusted precisely like those of the ordinary Solar, the declination arm being first detached by removing the clamp and tangent screws, and the conical center with its two small screws, by which the arm is attached to the arc.

The adjuster, which is a short bar furnished with every instrument, is then substituted for the declination arm, the conical center screwed into its place, at one end, and the clamp-screw into the other, being inserted through the hole left by the removal of the tangent-screw, thus securing the adjuster firmly to the arc.

The arm is then turned to the sun, as described in the article on the Solar Compass, and reversed by the opposite faces of the blocks upon the adjuster, until the image will remain in the center of the equatorial lines. This adjustment is very rarely needed in our instruments, the lenses being cemented in their cells, and the plates securely fastened.

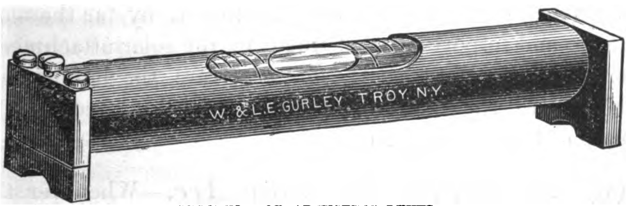
(2.) ***The vernier of the declination arc*** is adjusted by setting the vernier at zero, and then raising or lowering the telescope by the tangent-screw until the sun's image appears exactly between the equatorial lines.

Having the telescope axis clamped firmly, carefully revolve the arm until the image appears on the other plate.

If precisely between the lines, the adjustment is complete; if not, move the declination arm by its tangent-screw, until the image will come precisely between the lines on the two opposite plates; clamp the arm and remove the index error by loosening two screws that fasten the vernier; place the zeros of the vernier and limb in exact coincidence, tighten the screws, and the adjustment is finished.

(3.) ***To Adjust the Polar Axis.***—First level the instrument carefully by the long level of the telescope, using in the operation the tangent movement of the telescope axis in connection with the leveling screws of the parallel plates until the bubble will appear in the center during a complete revolution of the instrument upon its axis.

Place the solar apparatus upon the axis, and see that it moves easily around it; bring the declination arc in line



STRIDING, OR ADJUSTING LEVEL.

with the telescope, and having the vernier of the arc set at zero, place the *adjusting level* upon the top of the rectangular blocks, and bring the bubble of the level into the center, by the two capstan-head screws under the hour arc, which are in line with the declination arc, loosening one end and tightening the other with the pin until the level is centered.

Then turn the arc until it is directly over the telescope axis, or at right angles to its former position; and, if out, bring the bubble to the center by the other pair of screws directly under the arc and in line with the axis of telescope.

Return the arc to the first position, and, if necessary, repeat the operation of centering the bubble; then turn the arc half way around, bringing it again parallel with the telescope, and note the position of the level.

If in the center, the polar axis is vertical in that direction; if not, make the correction and repeat the operation as before, taking care always that the level under the telescope is kept in the center, and the capstan screws brought to a firm bearing. Pursue the same course in adjusting the arc in the second position, or over the telescope axis, and when completed, the level will remain in the center during an entire revolution of the arc, showing that the polar axis is at right angles to the level under the telescope, or truly vertical.

The adjusting level in the above described operation is supposed to be itself in adjustment ; but if not, can be easily corrected by the screws shown at one end, when reversed upon a plane surface, precisely as a mason's level is adjusted.

It should here be noted that, as this is by far the most delicate and important adjustment of the solar attachment, it should be made with the greatest care, the bubble kept perfectly in the center and frequently inspected in the course of the operation.

(4.) ***To Adjust the Hour Arc.***—Whenever the instrument is set in the meridian, as will be hereafter described, the index of the hour arc should read apparent time.

If not, loosen the two flat-head screws on the top of the hour circle, and with the hand turn the circle around until it does, fasten the screws again, and the adjustment will be complete.

To obtain mean time, of course the correction of the equation for the given day, as given in the Nautical Almanac, must always be applied.

To find the Latitude.

First level the instrument very carefully, using, as before, the level of the telescope until the bubble will remain in the center during a complete revolution of the instrument, the tangent movement of the telescope being used in connection with the leveling screws of the parallel plates, and the axis of the telescope firmly clamped.

Next clamp the vertical arc, so that its zero and that of its vernier coincide as near as may be, and then bring them into exact line by the tangent screw of the vernier.

Then, having the declination of the sun for 12 o'clock of the given day as affected by the meridional refraction carefully set off upon the declination arc, note also the equation of time and fifteen or twenty minutes before noon, the telescope being directed to the north, and the object-end lowered until, by moving the instrument upon its spindle and the declination arc from side to side, the sun's image is brought nearly into position between the equatorial lines. Now bring the declination arc directly in line with the telescope, clamp the axis firmly, and with the tangent screw bring the image precisely between the lines and keep it there with the tangent screw, raising it as long as it runs below the lower equatorial line, or, in other words, as long as the sun continues to rise in the heavens.

When the sun reaches the meridian the image will remain stationary for an instant and then begin to rise on the plate.

The moment the image ceases to run below is of course apparent noon, when the index of the hour arc should indicate XII, and the latitude be determined by the reading of the vertical arc.

It must be remembered, however, that the angle through which the polar axis has moved in the operation just described is measured from the zenith instead of the horizon as in the ordinary solar, so that the angle read on the vertical limb is the complement of the latitude.

The latitude itself is readily found by subtracting this angle from 90°; thus at Troy the reading of the limb being found as above directed to be 47° 16′, the latitude will be 90° — 47° 16′ = 42° 44′.

The latitude may also be read direct by referring to the inner row of figures on the arc, beginning with 90 in the center, and running to 10 on either side.

Patent Latitude Level.

The outline engraving, No. 56, represents an arrangement (*A*, *B*, *C*) recently patented by us, for recovering the Latitude of a Solar Transit, without referring to the vertical arc; and generally for setting the telescope at any desired angle in running grades, etc.

It consists of a level, *A*, connected by a short conical socket with the end of the telescope axis, to which it is clamped by a milled head screw at *C*, and made adjustable at *B* by a screw and spring on opposite sides of the enlarged end of the level tube. When the screw at *C* is released, the level turns vertically upon the axis, and can thus be set at any angle with the telescope, the final adjustment being made by the screw at *B*.

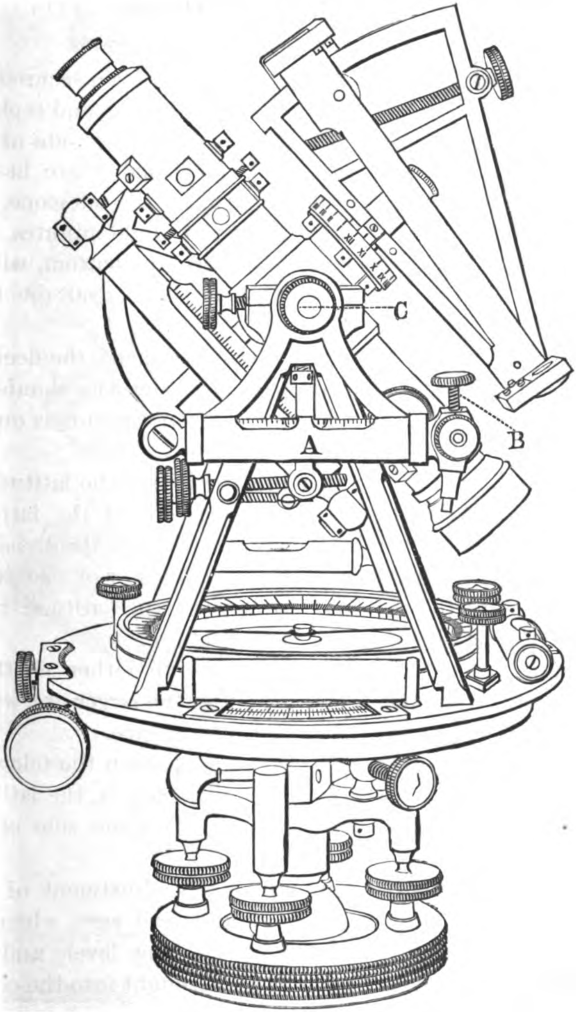
The latitude being set off upon the vertical arc, as usual, the level is clamped and brought into the center as above described.

The telescope may then be released and used in running lines, etc., until it is desired to recover the latitude again; this is easily and accurately done by the level alone without referring to the vertical arc.

Its use in running any desired grade is readily understood.

We make no additional charge for this attachment on transits with solar attachment hereafter furnished by us; and when put on our solar transits heretofore sold, the cost will be $6.

Solar Transit, showing Patent Latitude Level.



No. 53.

PATENT LATITUDE LEVEL. (*Patented Sept. 2, 1884.*)

R. M. Jones' Patent Latitude Arc.

(Patented Jan. 16, 1883.)

In this new attachment, which has now been secured exclusively to us, the usual vertical arc is omitted, and replaced by a double latitude arc attached to the under side of the telescope, as shown on page 71. The smaller arc having its center directly under the cross-bar of the telescope, has an arm with vernier reading the arc to single minutes, and carries also a level tube open both top and bottom, with a divided scale over each opening, in order to read the level accurately.

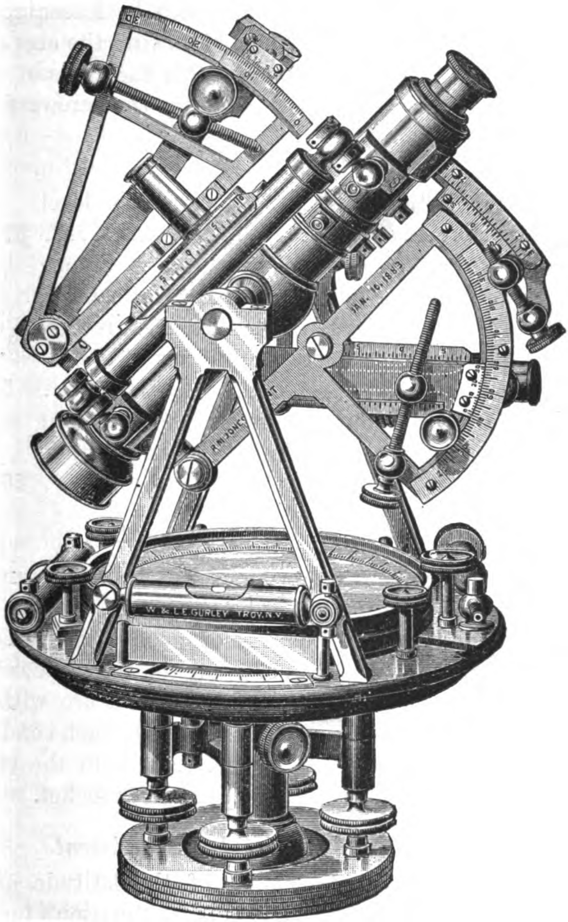
In obtaining latitudes with this attachment, the declination being set off as usual, the level bubble should be brought into the center of its scale when the sun is on the meridian.

The reading of the smaller arc then gives the latitude of the place, and in all further observations of the latitude reference is made to the level rather than to the divisions, the level being easily brought into the center of the scale, thus enabling the surveyor to recover the latitude more rapidly than with the ordinary vertical arc.

Minute changes, as long lines are run either north or south, may be computed and set off on the larger arc, which reads by its vernier to ten seconds of a degree.

The Solar apparatus can also be used when the telescope is revolved and the apparatus brought below it, the latitude being now ascertained by reference to the other side of the level with its divided scale.

There is but one test required of the adjustment of this attachment, viz. that both arcs should read zero, when the telescope is made horizontal by its long level, and the smaller level of the arc below is also brought into the center of its scale.



No. 8.

Light Mountain Solar Transit, with Jones' Patent Latitude Arc, and reversible level bubble. Price as shown, including extension tripod............$299 00

NOTE.—The standards, vernier openings and tangent movements are now made, as shown on page 59.

If not correct, they may be adjusted by loosening the screws by which each is confined, and moving the arcs until the zeros of both are in coincidence with the zeros of their verniers, care being also taken to set up the screws firmly again.

PRICES.

Jones' Patent Latitude Arc, with reversible level bubble	$72 00
When furnished with a new transit of our make in place of the ordinary vertical arc, the Jones' Patent Latitude Arc, with reversible level bubble, increases the cost of the instrument	54 00
Thus: The Light Mountain Transit, with Patent Solar Attachment and Jones' Patent Latitude Arc, costs	299 00

To use the Solar Attachment.

From the foregoing description it will be readily understood, that good results can not be obtained from the solar attachment unless the transit is of good construction—furnished with the appliances of a level on telescope, clamp and tangent movement to axis, and vertical arc with adjustable vernier, and the sockets or centers in such condition that the level of the telescope will remain in the center when the instrument is revolved upon either socket.

To run lines with the Solar Attachment.

Having set off the complement of the latitude of the place on the vertical arc, and the declination for the given day and hour as in the solar, the instrument being also carefully leveled by the telescope bubble, set the horizontal limb at zero and clamp the plates together, loosen the lower clamp so that the transit moves easily upon its lower socket, set the instrument approximately north and south, the object end of the telescope pointing to the north, turn the proper solar lens to the sun, and with one hand on the plates and the other on the revolving arm, move them from side to side until the sun's image is brought between the equatorial lines on the silver plate.

The lower clamp of the instrument should now be fastened and any further lateral movement be made by the tangent screw of the leveling head. The necessary allowance being made for refraction, the telescope will be in the true meridian, and being unclamped, may be used like the sights of the ordinary solar compass, but with far greater accuracy and satisfaction in establishing meridian lines. Of course when the upper or vernier plate is unclamped from the limb, any angle read by the verniers is an angle from the meridian, and thus parallels of latitude or any other angles from the true meridian may be established as with the solar compass.

The bearing of the needle, when the telescope is on the meridian, will also give the variation of the needle at the point of observation.

If the instrument, as in our surveyors' transits, has a movable compass circle, the variation of the needle can be set off to single minutes, the needle kept at zero, or "with the sun," and thus lines be run by the needle alone when the sun is obscured.

Advantages of the Solar Attachment.

From what has been already said the intelligent surveyor will readily understand that the more perfect horizon obtained by the use of the telescope level, and the use of a telescope in place of sights, render the new attachment more accurate than the ordinary solar compass.

It can also be put on the telescope of any good transit at comparatively small cost, and thus enable the surveyor to establish the true meridian, to determine the correct latitude, and to obtain true time very nearly.

Its adaptation to the purposes of illustration and instruction in practical astronomy in colleges and schools, will occur to every teacher; and we believe that for the government surveyor it furnishes a long-sought and much-needed instrument, superior, in many respects, to the solar compass now so commonly used.

In experiments made by us, an error of one-quarter of a minute in the direction of the true meridian, or in latitude, could be easily detected by observing the sun's image by a magnifier, and we feel confident that any one who uses the new solar will be surprised and delighted with its work. When desired it can be removed from the telescope and packed in the instrument case.

A thin sheath is put on the polar axis, and kept in its place by the screw and washer of the socket.

The weight of the new solar attachment is but little over ten ounces, and is so distributed as not to disturb the counterpoise of the instrument, thus obviating the objection which has hitherto prevented the successful application of the telescope to the solar apparatus.

It is evident that all transits to which the solar attachment is to be applied should have a horizontal limb and verniers, and be furnished with the appliances of a level on telescope, clamp and tangent movement to axis, and vertical arc and vernier.

They should also have a movable compass circle to set off the variation, and be leveled by leveling screws and parallel plates.

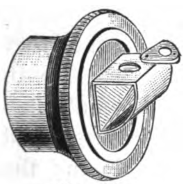
Of course it will be understood, in all cases, that where transits of any kind are to be supplied with the new solar attachment, they must be in perfect order, especially in respect to the sockets, before correct work can be done.

Other Attachments.

In the surveys of mines with this and other transits, a number of appliances are used, which may now be described.

No. 40.

The reflector, No. 40, is an elliptical piece of brass, silver-plated on the under side, and inclined at an angle of 45° to its ring, which is fitted to the object end of the telescope; the hole in the reflector admits the use of the telescope, while a light held near the under surface illuminates the cross-wires. Price of reflector is $4.00.



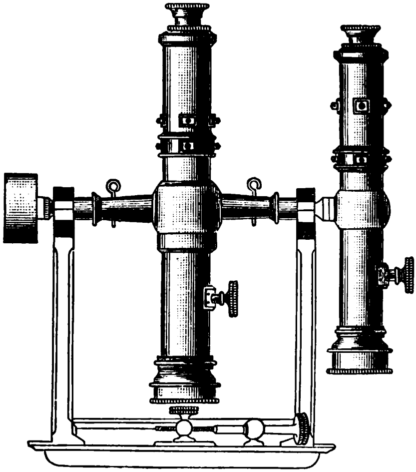
No. 39.

The diagonal prism, No. 39, used where greater vertical angles are to be taken than are possible with the ordinary telescope, consists merely of a diagonal prism attached to the cap of the eye-piece, by which the object is reflected to the eye, placed at right angles to the telescope; when directed to the sun the little slide or darkener containing colored glass is moved over the opening.

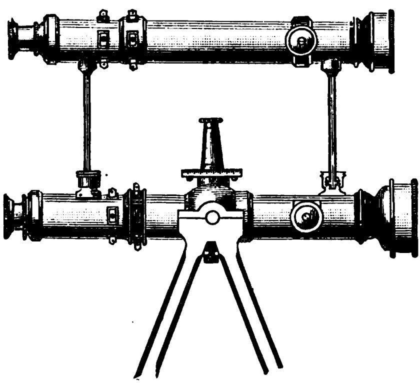
The circular plate with which the prism is connected is made to turn in the cap so that when it is substituted for the ordinary cap of the eye-piece, the opening over the prism can be easily adjusted to the position of the eye.

An angle of sixty degrees elevation can thus be taken with the prism. Price of diagonal prism is $8.00.

EXTRA TELESCOPES FOR VERTICAL SIGHTING.



No. 50A.

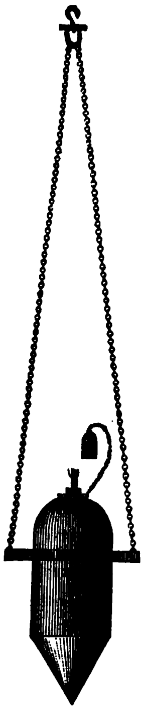


No. 50B,

A common arrangement for sighting up or down a vertical shaft is shown in No. 50 A, in which an extra telescope is fitted by a conical spindle or, as is now our practice, by a flange and disc connecting it with the axis, so as to make it precisely parallel to the center telescope; a counterpoise, as shown, is fitted to the other end, and both can be detached at pleasure, and placed in the packing-case when not in use.

In No. 50 B, the extra telescope is connected with the main one by coupling nuts, which fasten it securely directly over the center of the instrument, and allow its ready removal and replacement without disturbing its adjustments.

It will be understood that in both arrangements the extra telescopes are adjusted to the main telescopes of the transits, so that the line of collimation of both are parallel, and in the same plane, horizontal in No. 50 A, and vertical in No. 50 B; and in both, the extra telescope swings over the outside of the transit plates. The diagonal prism is often used with the extra telescope for greater convenience in sighting. Price of the extra telescopes, either style, $25.00.



No. 38.

PLUMMET LAMP.

As shown in No. 38, this is a large plummet of which the upper part is hollow, to contain oil; and has also a tube for wick covered by a screw cap.

It is hung in gimbals by a chain with hook, and so always assumes a vertical position, and when suspended from a tripod with shifting center, can be easily adjusted over a given point.

Two of these lamps are often packed in a simple wooden case, furnished with a strap to sling over the shoulders; the weight of each lamp is about one and a quarter pounds. Price of each lamp as shown, $10.00.

The Light Mountain Transit is almost always used upon our patent extension tripod (see page 228), in which all its legs can be shortened or lengthened at will. It is thus adapted for use in mountain surveys, where one or more legs must be shortened; or for mines, where in many places a short tripod is indispensable.

If desired, the sliding pieces can be easily turned end for end, the points being thus put out of the way, and the tripod more safely transported. The tripod when closed is only three feet long, and is carried by an ordinary shawl-strap.

GRADIENTER.

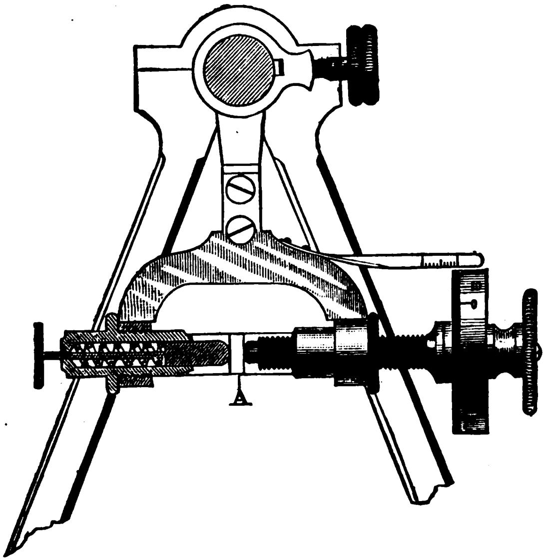
This attachment, as shown on page 79, is often used with this and other transits for fixing grades, determining distances, etc.

It consists mainly of a screw attached to the semicircular expanded arm of the ordinary clamp of the telescope axis; the screw is accurately cut to a given number of threads, and passing through a nut in one side of the arm, presses against a little stud, A, fixed to the inside surface of the right-hand standard.

In the other side of the semicircular arm is inserted a hollow cylinder containing a pin actuated by a strong spiral spring, the end of the pin pressing against the side of the stud opposite that in contact with the screw.

Near the other end of the screw, and turning with it, is a wheel, or micrometer, the rim of which is plated with silver, and divided into one hundred equal parts.

A small silver scale, attached to the arm and just above the micrometer wheel, is divided into spaces, each of which is just equal to one revolution of the screw; so that by comparing the edge of the wheel with the divisions of the



No. 45. Gradienter Attachment. Price, $18.00.

scale, the number of complete revolutions of the screw can be easily counted.

It will be seen that when the clamp is made fast to the axis by the clamp-screw, and the gradienter-screw turned, it will move the telescope vertically, precisely like the tangent-screw ordinarily used.

And as the value of the screw thread is such that a complete revolution of the screw will move the horizontal cross-wire of the telescope over a space of one foot on a rod at a distance of one hundred feet, it is clear that when the screw is turned through fifty spaces on the graduated head, the wire will pass over fifty one-hundredths, or one-half a foot on the rod, and so on in the same proportion.

In this way the Gradienter can be used in the measurement of distances, precisely like the stadia already described in the article on the Engineers' Transit.

Grades can also be established, with great facility, as follows: First, level the instrument; bring the telescope level to its center by the clamp and gradienter screw; move the graduated head until its zero is brought to the edge of the scale; and then turn off as many spaces on the head as there are hundredths of feet to the hundred in the grade to be established.

Weight of the Mountain Transit.

The weight of this instrument with plain telescope, and without tripod, is 10 pounds; with solar attachment, arc, level, and clamp, as shown in figure, 12 pounds. The extension tripod weighs about 9 pounds.

Leather Case.—Besides the light mahogany box, in which the instrument is packed as usual, there is also supplied a light sole-leather case, amply furnished with straps for "packing."

The Light Mountain Transit was introduced by us in 1876 to meet a demand for a light instrument of the finest quality.

It has met with a very large sale, and been universally approved.

We commend it with perfect confidence to all, as a transit of first quality, adapted to all kinds of work which may be required, and especially fitted for mining or mountain surveying, where great portability is desired.

THE SURVEYORS' TRANSIT.

The Surveyors' Transit has essentially the same construction as the instrument first described in the manual, but its compass-circle is movable about its center, like that of the Mountain Transit, in order that the variation of the needle may be set off in the surveys of old lines, or in running lines by the true meridian.

The arrangement of the sockets and leveling head, however, permits the Surveyors' Transit to be detached from the leveling head, packed separately in the case, and replaced, when desired, upon its spindle, without in any way disturbing its adjustments.

The sectional view, page 83, shows the interior construction of the sockets of the transit, the manner in which it is detached from the spindle, and the means by which it can be taken apart if desired.

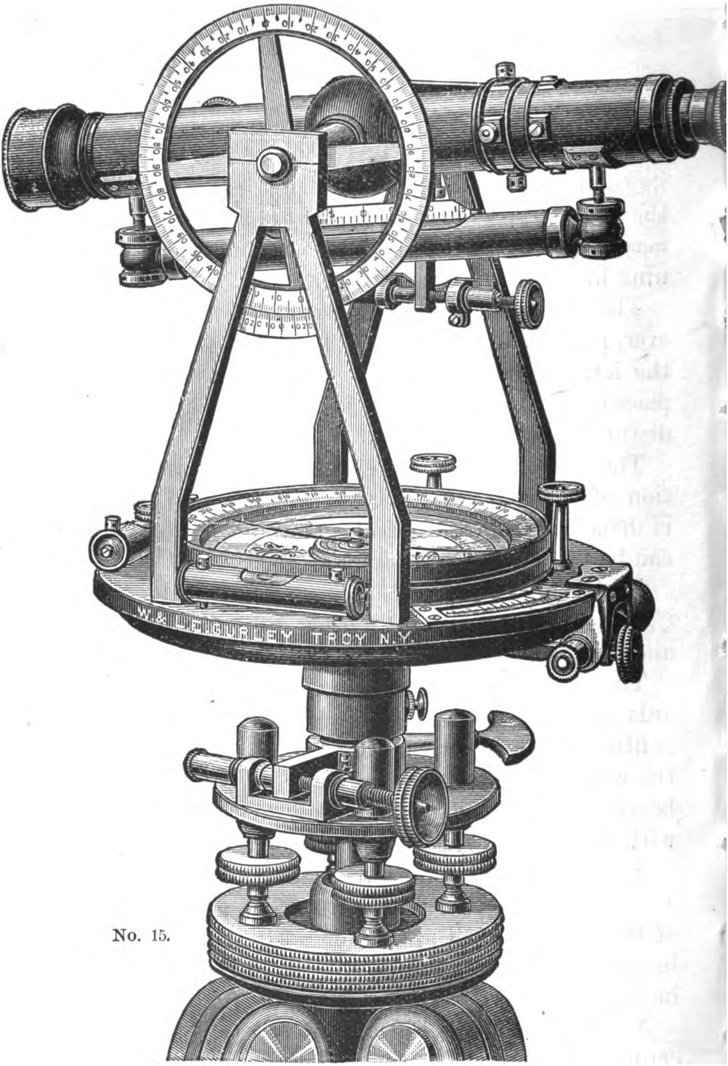
In the figure, the limb B is attached to the main socket C, which is itself carefully fitted to the conical spindle H, and held in place by the spring catch S.

The upper plate, A, carrying the compass-circle, standards, &c., is fastened to the flanges of the socket K, which is fitted to the upper conical surface of the main socket C; the weight of all the parts being supported on the small bearings of the end of the socket, as shown, so as to turn with the least possible friction.

A small conical center, in which from below is inserted a strong screw, is brought down firmly upon the upper end of the main socket C, and thus holds the two plates of the instrument securely together, while at the same time allowing them to move freely around each other in use.

A small disc above the conical center contains the steel center-pin upon which rests the needle, as shown; the disc

 SURVEYORS' TRANSIT. **With two Verniers to Limb.**



No. 15.

Surveyors' Transit, 5 or 5½-inch needle, 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, and tripod. Price..$160 00

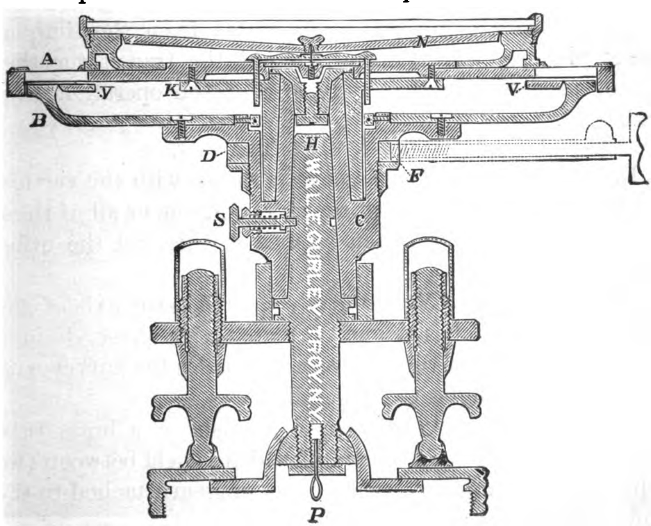
is fastened to the upper plate by two small screws, as represented.

The new clamp to limb, with clamp-screw, &c., is also shown at D F firmly attached to the main socket below.

The main socket with all its parts is of the best bell-metal and is most carefully and thoroughly made, the long bearing of the sockets insuring their firm and easy movement, while at the same time they are entirely out of the reach of dust, or other source of wear.

When desired, the whole upper part of the instrument can be taken off from the spindle by pulling out the head of the spring-catch at S, and when replaced will be secured by the self-acting spring of the catch.

The figure also shows the covers of the leveling screws, the shifting center of the lower leveling plate, and the screw and loop for the attachment of the plummet.



To take Apart the Surveyor's Transit.

When it is necessary to separate the plates of the transit proceed as follows (see page 83):

(1) Remove the clamp-screw and take off the head of the pinion, both outside the compass circle. (2) Unscrew the bezel ring containing the glass cover of the compass, remove the needle and button beneath it, and take out the two small screws so as to remove the disc. (3) Take the instrument from its spindle, and with a large screw-driver take out the screw from the underside of the conical center. (4) Drive out the center from below by a round piece of wood, holding the instrument vertical so that the center will not bruise the circle. (5) Set the instrument again upon its spindle, unscrew the milled head cap from the thimble containing the opposing spring of the tangent movement to limb, take out the three screws which fasten that movement to the upper plate, and that plate with standards, &c., can then be separated from the limb or lower plate of the transit. To put the transit together again, proceed exactly the reverse of the operation thus described.

Attachments of Transit.

In the engraving the telescope is shown with the vertical circle, level, and clamp and tangent, and one or all of these extra attachments are often applied to this and the other transits described.

The Vertical Circle firmly secured to the axis of the telescope is 4½ inches diameter, plated with silver, divided to half degrees, and with its vernier enables the surveyor to obtain vertical angles to single minutes.

The Level on Telescope consists of a brass tube about 6½ inches long, each end of which is held between two capstan-nuts connected with a screw or stem attached to the underside of the telescope tube.

The vial enclosed in the tube is a little over 5 inches long and half an inch in diameter, is ground on its upper interior surface so as to ensure an even and sensitive bubble, the length of which is measured by the divided scale above; the scale is divided into tenths of an inch, and figured from 0 at the center to 5, 10, 15, 20, on either side, and thus determines when the bubble is brought into the center of its run.

The Clamp and Tangent consists of an arm at one end encircling the telescope axis, and at the other connected with the tangent-screw; the clamp is fastened at will to the axis by a clamp-screw inserted at one side of the ring, and then by turning the tangent-screw the telescope is raised or lowered as desired.

The clamp and tangent ought always to accompany the vertical circle, and level on telescope, whenever either is applied to a transit.

The Adjustments of this instrument so far as relates to the levels, needle, line of collimation, &c., are the same as those of the Engineers' Transit, and we need to mention only those of the attachments.

To Adjust the Vertical Circle.

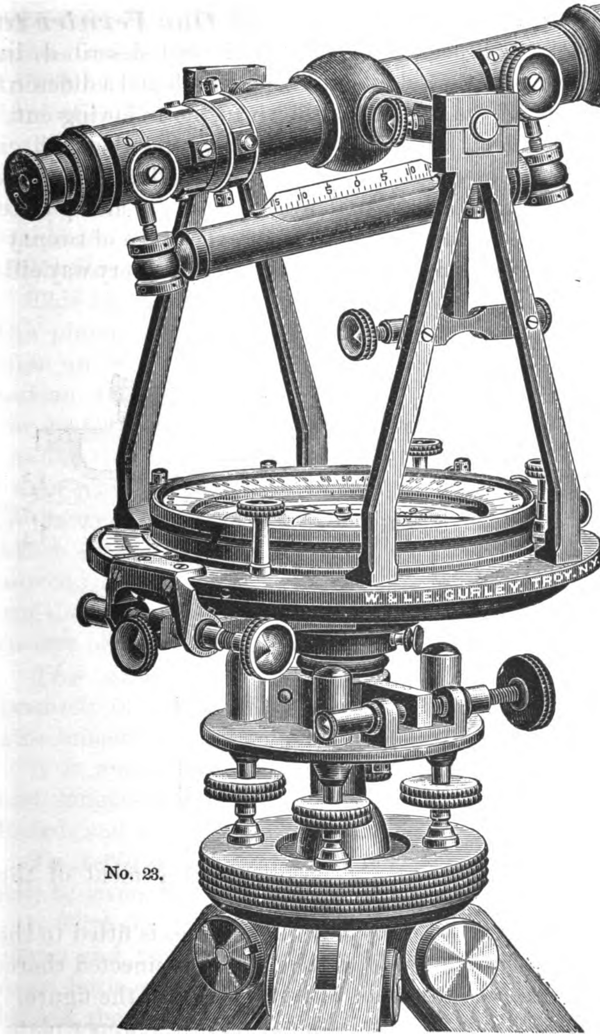
Having the instrument firmly set up and carefully leveled, bring into line the zeros of the circle and vernier, and with the telescope find or place some well-defined point or line, from one hundred to five hundred feet distant, which is cut by the horizontal wire.

Turn the instrument half-way around, revolve the telescope, and fixing the wire upon the same point as before, note if the zeros are again in line.

If not, loosen the capstan-head screws, which fasten the vernier, and move the zero of the vernier over half the error; bring the zeros again into coincidence, and proceed precisely as at first, until the error is entirely corrected, when the adjustment will be complete.

A slight error may be most readily removed by putting the zeros in line and then moving the wire itself over half the interval.

The Level is Adjusted by bringing the bubble carefully into the center by the nuts at each end; and when there is a vertical circle on the instrument, this should be done when the zeros of circle and vernier are in line, and in adjustment; when there is no vertical circle, proceed as described in the account of the next instrument.

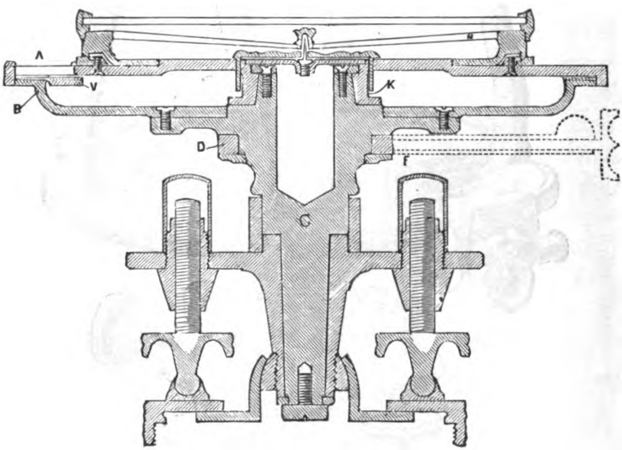


No. 23.

Surveyors' Transit, 5 or 5½-inch needle, but with level on telescope, and clamp and tangent movement to axis of telescope, and tripod. Price............$133 00

The Surveyors' Transit with One Vernier to Limb is a modification of the transit just described, in which there is but one double vernier to limb and a different arrangement of the sockets, as shown in the following cut.

The instrument is more compact and somewhat lighter than that with two verniers, and is furnished at less cost. Its graduations, telescope, and attachments are all equal to those of the best transits, and after an experience of twenty-two years the instrument has proved itself in every way efficient and satisfactory for all classes of work.



The engraving shows the peculiar arrangement of the sockets of this instrument.

The main socket C, now in a single piece, is fitted to the socket of the leveling head as shown, and connected therewith by a screw and washer underneath, as in the figure.

The socket K is formed in the metal of the upper plate, a strong washer with four screws, only two of which are seen in the cut, keeping the two plates together, but at the same time allowing them to turn freely around each other.

The new clamp to limb with clamp screw, etc., is shown in dotted lines at D F under the plates.

The vernier with the opening above is shown on the left at A. The arrangement of the center-pin, needle, etc., is precisely like that of the transit with two verniers, but the instrument remains attached to the leveling head precisely like the engineers' transit.

This instrument may be taken apart by first removing the pinion-head and clamp-screw, near the compass circle, then unscrewing the bezel ring, taking out the needle and button underneath, and next removing the disc in which the center-pin is fixed, by taking out two small screws which confine it. The four screws which hold the washer to the under-plate must then be removed, the milled head cap of the tangent opposing spring be unscrewed, the three screws which secure the tangent support to the upper plate removed; and then the plates can be separated. The replacing the several parts is done in the same manner, but in a reverse order.

The Adjustments and use of this instrument are precisely like those of the others already described, and its attachments to the telescope the same, if desired.

It is represented with a level on telescope, with clamp and tangent to axis, an arrangement very generally selected, and of which we will now give the adjustment.

To Adjust the Level on Telescope.—Two methods will be given, of which the first is to be preferred.

1. First level the instrument carefully, and with the clamp and tangent movement to the axis, make the telescope horizontal, as near as may be, with the eyes; then, having the line of collimation previously adjusted, drive a stake at a convenient distance, say from one hundred to

three hundred feet, and note the height cut by the horizontal wire, upon a staff set on the top of the stake.

Fix another stake in the opposite direction, and at the same distance from the instrument, and without disturbing the telescope, turn the instrument upon its spindle, set the staff upon the stake, and drive in the ground, until the same height is indicated as in the first observation.

The top of the two stakes will then be in the same horizontal line, however much the telescope may be out of level.

Now remove the instrument from fifty to one hundred feet to one side of either of the stakes, and in line with both; again level the instrument, clamp the telescope as nearly horizontal as may be, and note the heights indicated upon the staff placed first upon the nearest, and then upon the most distant stake.

If both agree, the telescope is level; if they do not agree, then with the tangent-screw move the wire over nearly the whole error, as shown at the distant stake, and repeat the observation as just described. Proceed thus until the horizontal wire will indicate the same height at both stakes, when the telescope will be truly horizontal.

Taking care not to disturb its position, bring the bubble into the center by the little leveling nuts at the end of the tube, when the adjustment will be completed.

2. Choose a piece of ground nearly level, and having set the instrument firmly, level the plates carefully, and bring the bubble of the telescope into the center with the tangent-screw. Measure in any direction from the instrument, from one hundred to three hundred feet, and drive a stake, and on the stake set a staff and note the height cut by the horizontal wire; then take the same distance from the instrument in an opposite direction, and drive another stake.

On that stake set the staff, and note the height cut by the wire when the telescope is turned in that direction.

The difference of the two observations is evidently the difference of level of the two stakes.

Set the instrument over the lowest stake, or that upon which the greatest height was indicated, and bring the levels on the plates and telescope into adjustment as at first.

Then, with the staff, measure the perpendicular distance from the top of the stake to the center of one of the horizontal cross-wire screw-heads: from that distance subtract the difference of level between the two stakes and mark the point on the staff thus found; place the staff on the other stake, and with the tangent-screw bring the horizontal wire to the mark just found, and the line will be level.

The telescope now being level, bring the bubble of the level into the center, by turning the little nuts at the end of the tube, and noting again if the wires cut the point on the staff; screw up the nuts firmly and the adjustment will be completed.

With such a level carefully adjusted, the engineer, by taking equal fore and back sights, can run horizontal lines with great rapidity, and a good degree of accuracy.

The Surveyors' Transit, with its peculiar construction of sockets, &c., is entirely of our own invention; it has stood the test of over twenty years use, and combining, as it does, the capabilities of a needle instrument with a fine telescope, and the accuracy of a divided limb and verniers, together with a movable compass-circle for setting off the variation of the needle, it is, for a mixed practice of accurate surveying and engineering, the best instrument ever constructed.

Sizes and Weights of the Surveyors' Transit, with plain telescope, all having two verniers to limb,

4-in. needle,	with leveling-head,	but no tripod,	about	13¾	lbs.
5	"	"	"	16½	"
5½	"	"	"	17½	"

With one vernier to limb,

4-in. needle,	with leveling-head,	but no tripod,	about	13	lbs.
5	"	"	"	16	"
5½	"	"	"	17	"

Weight of the Attachments,

Vertical circle, 4½-in., with vernier,	5½	oz.
Level on telescope, . . .	8	"
Clamp and tangent to axis, . .	4	"

SURVEYORS' TRANSIT WITH SOLAR ATTACHMENT.

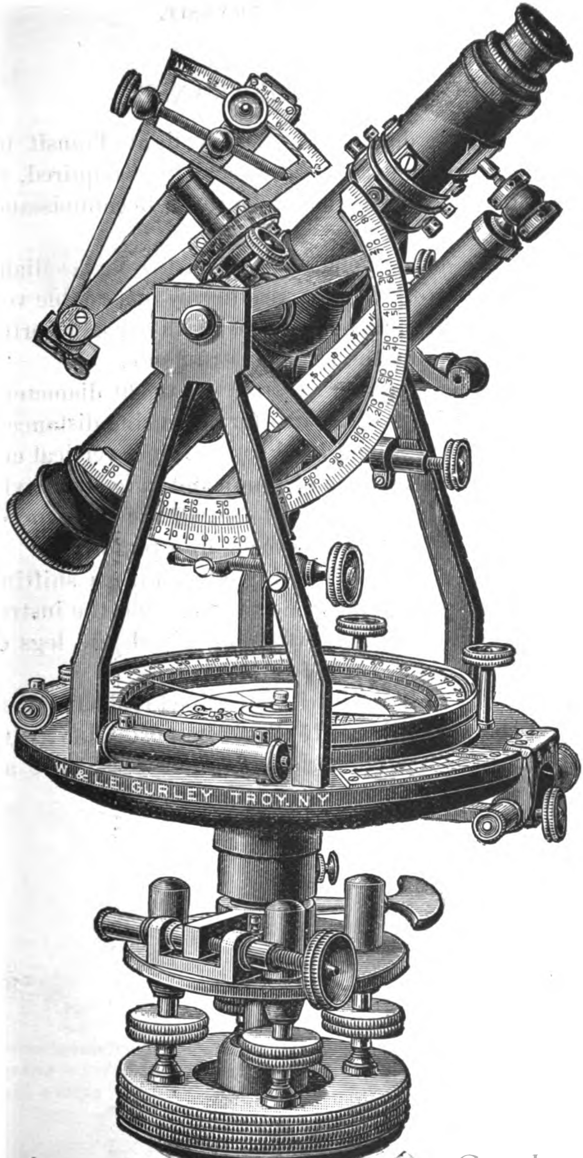
The engraving (see page 93), represents our Surveyors' Transit with 5-inch needle, to which is adapted the Solar Attachment with vertical arc, level, &c.; both the vertical arc and that of the declination arm being divided on silver, and reading by vernier to thirty seconds.

The instrument is furnished either with two verniers to limb, or with one vernier to limb, as may be desired.

Both styles have been for years in successful use in different parts of the country; both have shifting centers to leveling head.

PRICES.

No.		PRICE
16.	—Surveyors' Transit, two verniers to limb, 5-inch needle, with Solar Attachment, vertical arc, level on telescope, clamp and tangent to axis of telescope, and tripod....................................	$226 00
24.	—Surveyors' Transit, one vernier to limb, 5-inch needle, with Solar Attachment, vertical arc, level on telescope, clamp and tangent to axis of telescope, and tripod....................................	211 00



Nos. 16 and 24.

SURVEYORS' TRANSIT WITH SOLAR ATTACHMENT.

RECONNOISSANCE TRANSIT.

In response to a demand for a very light Transit for rapid work and where extreme accuracy is not required, we have recently introduced what we term a Reconnoissance Transit, shown on page 95.

It has a needle of 3½ inches—a limb of five inches diameter, graduated on rolled silver, reading by one double vernier to single minutes, and is supplied with our new spring tangent movement like the larger instruments.

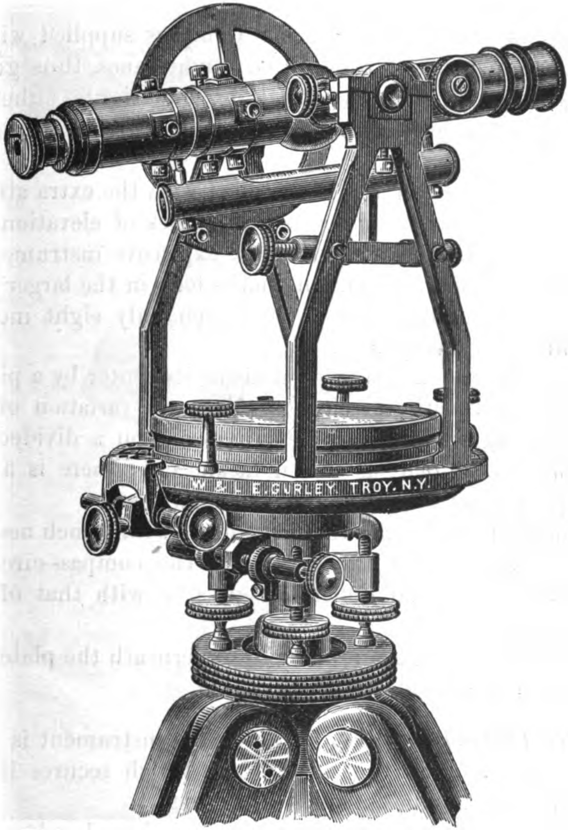
The telescope has a power of from 18 to 20 diameters, and is furnished with stadia wires for measuring distances; it has also, as shown, a long level to telescope, vertical circle reading to five minutes, and clamp and tangent to axis.

The compass circle is arranged to set off the variation of the needle, the movement being made by a pinion.

It has also, as shown, a leveling head with a shifting center, and with spring clamp and tangent, and the instrument is set upon our light extension tripod, the legs of which close up to about three feet long.

The weight of this Transit without tripod is about 7¾ lbs.; with tripod complete, about 15 lbs. Its portability, with its capabilities for a large variety of rapid work, have already made this a very popular instrument.

RECONNOISSANCE TRANSIT.



No. 25.

Reconnoissance Transit, one vernier to limb, 3½-inch needle, vertical circle, reading to five minutes, level on telescope, clamp and tangent to telescope axis, leveling tripod, with extension legs. Price........................$115 00

VERNIER TRANSIT COMPASS.

This is essentially a Vernier Compass supplied with a telescope in place of the ordinary sight-vanes, thus giving the surveyor the means of taking long sights, either on a level, or on hilly ground, with much greater ease and accuracy.

The telescope can also be supplied with the extra attachments, as shown, and levels and angles of elevation and depression taken, as with the more expensive instruments.

The telescopes are eleven inches long in the larger sizes of these instruments, but in the 4-inch, only eight incnes; but all are of fine quality.

The compass-circle is moved about its center by a pinion placed underneath the circular plate; the variation of the needle being set off to single minutes upon a divided arc attached to the plate as shown in the cut; there is also a clamp-screw by which the circle is made fast.

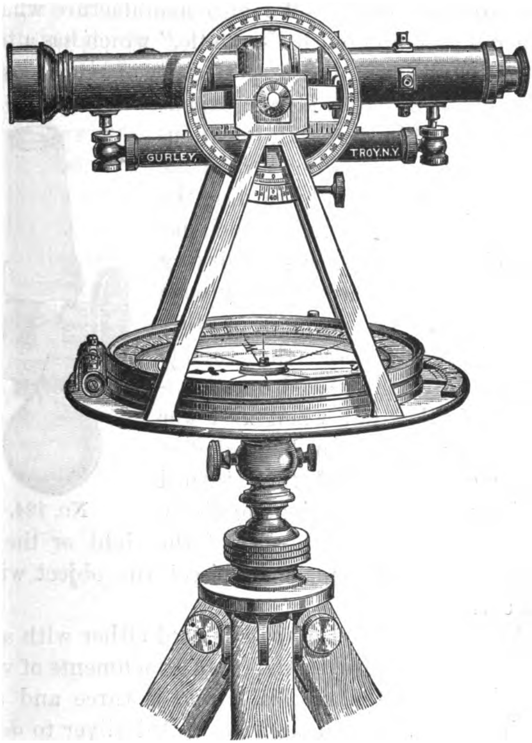
The figure represents the instrument with 6-inch needle; in the smaller sizes, the vernier of the compass-circle is within the box and under the glass, as with that of the Surveyors' Transit.

The needle lifting-screw is also underneath the plate, but concealed in the cut.

The Clamp-screw, by which the instrument is fixed to the spindle, and the spring-catch which secures it, are both shown on opposite sides of the socket.

The levels are both above the plate, and made adjustable by a capstan-head screw at either end.

The instrument is commonly used on a ball spindle placed in a compass tripod as shown on page 97, but is some-

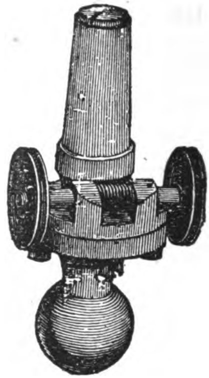


No. 31.

Vernier Transit 6-inch needle, but with 3½-inch vertical circle, reading to 5 minutes, level on telescope, clamp and tangent movement to axis of telescope, and tripod. Price $101 00

times fitted to a leveling-head like that of the Surveyors' Transit.

Compound Ball.—We also manufacture what may be termed a "compound ball-spindle," which has a tangent movement, and gives all the perfection of more costly arrangements, at a very moderate expense. (Price, $6.00.)



No. 124.

As represented in the cut, it has an interior spindle, around which an outside hollow cylinder is moved by turning the double-headed tangent-screw, which has in the middle an endless screw, working into teeth cut spirally around in a groove of the cylinder. The compass, or other instrument, revolves on the outside socket, precisely as if placed on a common ball-spindle; but when a slower movement is required, can be made fast by the clamp-screw, and then turned gradually around the interior spindle by the tangent-screw, until the slot of the sight or the intersection of the wires, is made to bisect the object with the utmost certainty.

The Vernier Transit Compass is used either with a plain telescope, or supplied with the extra attachments of vertical circle, level, &c.; the vertical circle is three and a half inches in diameter, graduated on rolled silver to degrees, and reads by the vernier to five minutes.

The adjustments of this instrument are mainly those of the transits already described.

In Surveying with this instrument the operator should keep the south end of the compass circle towards his person, read the bearings of lines from the north end of the needle, and use the telescope in place of sights, revolving it as objects are selected in opposite directions.

Before an observation is taken the eye-piece must be brought into distinct focus upon the cross-wires, and the object-glass moved by the pinion-head until the object is brought into clear view, so that the wires appear as if fastened to its surface.

The intersection of the wires being the means by which the optical axis of the telescope is defined, should be brought precisely upon the center of the object.

Sizes and Weights.

We make three sizes of this instrument, having respectively 4, 5, and 6-inch needles, the average weights of which are as follows :

4-inch	needle,	plain	telescope,	and without	tripod,	6 lbs.
5-inch	"	"	"	"	"	9 "
6-inch	"	"	"	"	"	11¾ "

THE SOLAR COMPASS.

This instrument, so ingeniously contrived for readily determining a true meridian or north and south line, was invented by WILLIAM A. BURT, of Michigan, and patented by him in 1836. It came into general use in the surveys of U. S. public lands, the principal lines of which are required to be run with reference to the true meridian.

The invention long since became public property, and for over thirty years the Solar Compass has been manufactured by us, with improvements of our own, which have made it increasingly popular and efficient.*

The arrangement of its sockets and plates is similar to that of the Surveyors' Transit, as shown on page 83, except that the sight vanes are attached to the under plate or limb, and this revolves around the upper or vernier plate on which the solar apparatus is placed.

The limb is divided to half degrees, is figured in two rows, as usual, and reads by the two opposite verniers to single minutes.

The divisions of the limb and all other arcs of the Solar Compass are made upon solid silver so as to avoid tarnishing.

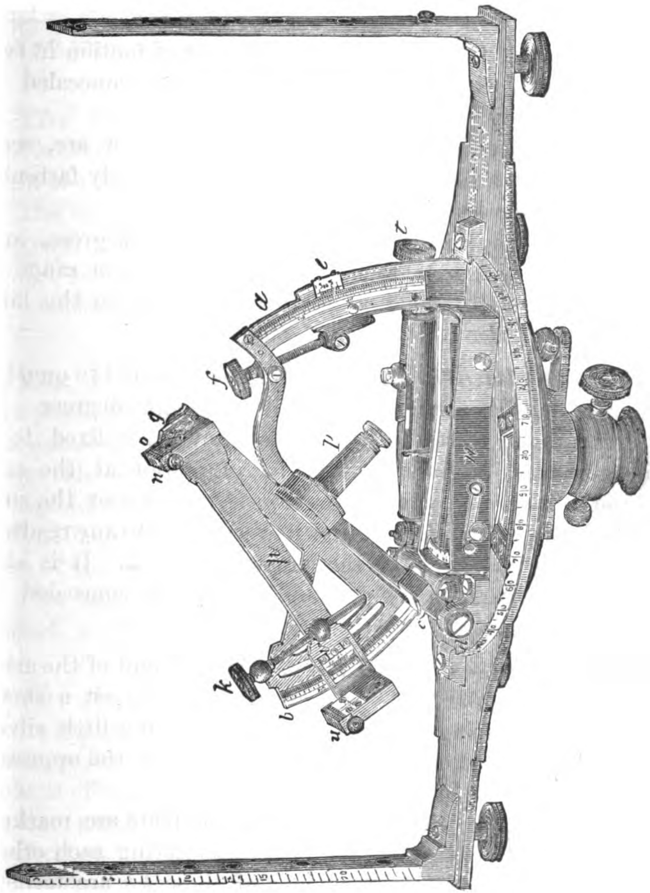
The Solar Apparatus.

The Solar Apparatus is seen in the place of the needle, and in fact operates as its substitute in the field.

It consists mainly of three arcs of circles, by which can be set off the latitude of a place, the declination of the sun, and the hour of the day.

These arcs, designated in the cut by the letters *a*, *b*, and

*For several years past the U. S. Land Office has required the principal lines of its surveys to be run with a Solar Telescope instrument, and for this purpose our Solar Transits Nos. 5, 7, 8, 16 and 24 have been very generally adopted.



No. 100.

Price as shown. including compound tangent ball, leveling screws and clamp and tangent to spindle, and tripod........ ....$210 00

c, are therefore termed the latitude, the declination, and the hour arcs respectively.

The Latitude Arc, a, has its center of motion in two pivots, one of which is seen at *d*, the other is concealed in the cut.

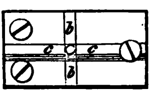
It is moved either up or down within a hollow arc, seen in the cut, by a tangent-screw at *f*, and is securely fastened in any position by a clamp-screw.

The Latitude arc is graduated to quarter degrees, and reads by its vernier, *e*, to single minutes; it has a range of about thirty-five degrees, so as to be adjustable to the latitude of any place in the United States.

The Declination Arc, b, is also graduated to quarter degrees, and has a range of about twenty-eight degrees.

Its vernier, *v*, reading to single minutes, is fixed to a movable arm, *h*, having its center of motion at the end of the declination arc at *g*; the arm is moved over the surface of the declination arc, and its vernier set to any reading by turning the head of the tangent-screw, *k*. It is also securely clamped in any position by a screw, concealed in the engraving.

Solar Lenses and Lines.—At each end of the arm, *h*, is a rectangular block of brass, in which is set a small convex lens, having its focus on the surface or a little silver plate A, fastened by screws to the inside of the opposite block.



A

On the surface of the plate are marked two sets of lines intersecting each other at right angles; of these *b b* are termed the hour lines, and *c c* the equatorial lines, as having reference respectively to the hour of the day and the position of the sun in relation to the equator.

The equatorial lines are those on the lower block, parallel to the surface of the hour arc *c*; the hour lines are of course those at right angles to the first.

The Hour Arc, *c*, is supported by the two pivots of the latitude arc, already spoken of, and is also connected with that arc by a curved arm, as shown in the figure.

The hour arc has a range of about 120°, is divided to half degrees, and figured in two series, designating both the hours and the degrees, the middle division being marked 12 and 90 on either side of the graduated lines.

The Polar Axis.—Through the center of the hour arc passes a hollow socket, *p*, containing the spindle of the declination arc, by means of which this arc can be moved from side to side over the surface of the hour arc, or turned completely round, as may be required.

The hour arc is read by the lower edge of the graduated side of the declination arc.

The axis of the declination arc, or indeed the whole socket, *p*, is appropriately termed the polar axis.

The Adjuster.—Besides the parts shown in the cut, there is also an arm used in the adjustment of the instrument as described hereafter, but laid aside in the box when that is effected.

The parts just described constitute properly the solar apparatus.

Besides these, however, are seen the needle box, *n*, with its arc and tangent-screw, *t*, and the spirit levels, for bringing the whole instrument to a horizontal position.

The Needle Box, *n*, has an arc of about 36° in extent, divided to half degrees, and figured from the center or zero mark on either side.

The needle, which is made as in other instruments, except that the arms are of unequal lengths, is raised or lowered by a lever shown in the cut.

The needle-box is attached by a projecting arm to a tangent-screw, *t*, by which it is moved about its center, and its needle set to any variation.

This variation is also read off by the vernier on the end of the projecting arm, reading to three minutes a graduated arc, attached to the plate of the compass.

The Levels seen with the solar apparatus have ground glass vials, and are adjustable at their ends like those of our other instruments.

The edge of the circular plate on which the solar work is placed, is divided and figured at intervals of ten degrees, and numbered, as shown, from 0 to 90 on each side of the line of sight.

These graduations are used in connection with a little brass pin, seen in the center of the plate, to obtain approximate bearings of lines, which are not important enough to require a close observation.

Lines of Refraction.—The inside faces of the sights are also graduated and figured, to indicate the amount of refraction to be allowed when the sun is near the horizon. These are not shown in the cut.

Definition of Astronomical Terms.

Before proceeding to describe the principles and adjustments of this instrument, a brief statement of the terms employed may here be appropriately made.

The Sun is the center of the solar system, remaining constantly fixed in its position, though, for the sake of convenience, often spoken of as in motion around the earth.

The Earth makes a complete revolution around the sun in 365 days, 6 hours, very nearly.

It also rotates about an imaginary line passing through its center, and termed its *axis*, once in twenty-four hours, turning from west to east.

The Poles are the extremities of the axis; that in our own hemisphere, known as the north pole, if produced indefinitely towards the concave surface of the heavens, would reach a point situated near the polar star, and called the north pole of the heavens.

The Equator is an imaginary line passing around the earth equi-distant from the poles, and at right angles with them.

If the plane of the equator is produced to the heavens, it forms what is termed the equator of the heavens.

The Orbit of the earth is the path in which it moves in making its yearly revolution.

If the plane of this orbit were extended to the heavens, it would form the *ecliptic*, or the sun's apparent path in the heavens.

The earth's axis is inclined to its orbit at an angle of about 23° 28′, making the angle between the earth's orbit and its equator, or between the celestial equator and the ecliptic, of the same amount.

The Equinoxes are the two points in which the ecliptic and the celestial equator intersect each other.

The Declination of the sun is its angular distance north or south of the celestial equator; when the sun is at the equinoxes, that is about the 21st of March and the 21st of September of each year, his declination is 0, or he is said to be on the equator ; from these points his declination increases from day to day, and from hour to hour, until, on the 21st of June and 21st of December, he is 23° 28′ distant from the equator.

It is the declination which causes the sun to appear so much higher in summer than in winter, his altitude in the heavens being in fact nearly 47° more on the 21st of June than it is on the 21st of December.

The Horizon of a place is the surface which is defined by a plane supposed to pass through the place at right angles to a vertical or plumb line, and to bound our vision at the surface of the earth.

The horizon or a horizontal surface is determined by the surface of any liquid when at rest, or by the spirit levels of an instrument.

The Zenith of any place is the point directly over head, at right angles to the horizon.

The Meridian of any place is a great circle passing through the zenith of a place, and the poles of the earth.

The meridian, or true north and south line of any place, is the line determined by the intersection of the plane of the meridian circle with the plane of the horizon.

The Meridian Altitude of the sun is its angular elevation above the horizon, when passing the meridian of a place.

The Latitude of a place is its distance north or south of the equator, measured on a meridian. At the equator the latitude is 0°, at the poles 90°.

The Longitude of a place is its distance in degrees or in time, east or west of a given place taken as the starting-point or first meridian ; it is measured on the equator or any parallel of latitude.

In the Nautical Almanac, which is commonly used with the Solar Compass, the longitude of the principal places in the United States is reckoned from Greenwich, England, and expressed both in degrees and hours.

The Zenith Distance of any heavenly body, is its angular distance north or south of the zenith of a place, measured when the body is on the meridian.

Suppose a person situated on the equator at the time of the equinoxes, the sun, when on the meridian, would be in the zenith of the place, and the poles of the earth would, of course, lie in the plane of his horizon.

Disregarding for the present the declination of the sun, let us suppose the person travels towards the north pole.

As he passes to the north, the sun will descend from the zenith, and the pole rise from the horizon in the same proportion, until when he arrives at the north pole of the earth, the sun will have declined to the horizon, and the pole of the heavens will have reached the zenith.

The altitude of the pole at any place, or the distance of the sun from the zenith, would, in the case supposed, give the observer the latitude of that place.

If we now take into account the sun's declination, it would increase or diminish its meridian altitude, according as it passes north or south of the equator; but the declination of the sun at any time being known, its zenith distance, and therefore the latitude of the place, can be readily ascertained by an observation made when it is on the meridian.

As we shall see hereafter, it is by this method that we obtain the latitude of any place by the Solar Compass.

Time.—A solar day is the interval of time between the departure of the sun from the meridian of a place, and its succeeding return to the same position.

The length of the solar day, by reason of the varying velocities of the earth in its orbit, and the inclination of its axis, is continually changing.

In order to have a uniform measure of time, we have recourse to what is termed a *mean solar day,* the length of which is equal to the mean or average of all the solar days in a year.

The time thus given is termed *mean time,* and is that to which clocks and watches are adjusted for the ordinary business of life.

The sun is sometimes faster, and sometimes slower than the clock, the difference being termed the *equation of time.*

The moment when the sun is on the meridian of any place is termed *apparent noon,* and this being ascertained, we can, by referring to the equation of time for the given day, and adding to, or subtracting from, apparent noon, according as the sun is slow or fast, obtain the time of *mean noon,* by which to set the watch or chronometer.

Difference of Longitude.—As the earth makes a complete rotation upon its axis once a day, every point on its surface must pass over 360° in 24 hours, or 15° in one hour, and so on in the same proportion.

And as the rotation is from west to east, the sun would come to the meridian of every place 15° west of Greenwich, just one hour later than the time given in the Almanac for apparent noon at that place.

To an observer situated at Troy, N.Y., the longitude of which is in time 4 hours 54 minutes 40 seconds, the sun would come to the meridian nearly five hours later than at Greenwich, and thus when it was 12 M. at that place, it would be but about 7 o'clock A. M. in Troy.

Refraction.—By reason of the increasing density of the atmosphere from its upper regions to the earth's surface, the rays of light from the sun are bent out of their course, so as to make his altitude appear greater than is actually the case.

The amount of refraction varies, according to the altitude of the body observed; being 0 when it is in the zenith, about one minute when midway from the horizon to the zenith, and almost 34′ when in the horizon.

Effect of Incidental Refraction.—It will be seen by referring to the instrument, that the effect of the ordinary refraction upon the position of the sun's image with reference to the equatorial lines, which, in fact, are the only ones to be regarded in running lines with the Solar Compass, is continually changing, not only with the change of latitude, but also with that of the sun's declination from hour to hour, and the motion of the revolving arm as it follows the sun in its daily revolution.

If the equatorial lines were always in the same vertical plane with the sun, as would be the case at the equator at the time of the equinoxes, it is evident that refraction would have no effect upon the position of the image between these lines, and therefore would not be of any importance to the surveyor.

But as we proceed further north, and as the sun's declination to the south increases, the refraction also increases, and must now be taken into account.

Again, the angle which the equatorial lines make with the horizon is continually changing as the arm is made to follow the motion of the sun during the course of a day.

Thus, in the morning and evening they are more or less inclined to the horizon, while at noon they are exactly parallel to it.

And thus it follows that the excess of refraction at morning and evening is in some measure balanced by the fact that the position of the sun's image with reference to the equatorial lines is then less affected by it, on account of the greater inclination of the lines to the horizon.

Allowance for Refraction.—The proper allowance to be made for refraction in setting off the declination of the sun upon the Solar Compass has long been a source of perplexity to the surveyor; we have, accordingly, given the subject a good deal of attention, and now publish a table to be found at the end of this article, by which the amount of refraction for any hour of any day of the year can be ascertained, and set off with a degree of accuracy which is all that can be desired.

The use of this table will be fully described when we come to speak of the manner of setting off the declination in the actual use of the instrument.

Principles of the Solar Compass.

The interval between two equatorial lines *c c*, (plate A, page 102), as well as between the hour lines *b b*, is just sufficient to include the circular image of the sun as formed by the solar lens on the opposite end of the revolving arm *h* (page 101). When, therefore, the instrument is made perfectly horizontal, the equatorial lines and the opposite lenses being accurately adjusted to each other by a previous operation, and the sun's image brought within the equatorial lines, his position in the heavens, with reference to the horizon, will be defined with precision.

Suppose the observation to be made at the time of one of the equinoxes; the arm *h*, set at zero on the declination arc *b*, and the polar axis *p*, placed exactly parallel to the axis of the earth.

Then the motion of the arm *h*, if revolved on the spindle of the declination arc around the hour circle *c*, will exactly correspond with the motion of the sun in the heavens, on the given day and at the place of observation; so that if the sun's image was brought between the lines *c c*, in the morning, it would continue in the same position, passing neither above nor below the lines, as the arm was made to revolve in imitation of the motion of the sun about the earth.

In the morning as the sun rises from the horizon, the arm *h* will be in a position nearly at right angles to that shown in the cut, the lens being turned towards the sun, and the silver plate on which his image is thrown directly opposite.

As the sun ascends, the arm must be moved around, until when he has reached the meridian, the graduated side of the declination arc will indicate 12 on the hour circle, and the arm *h*, the declination arc *b*, and the latitude arc *a*, will be in the same plane.

As the sun declines from the meridian the arm *h* must be moved in the same direction, until at sunset its position will be the exact reverse of that it occupied in the morning.

Allowance for Declination.—Let us now suppose the observation made when the sun has passed the equinoctial point, and when his position is affected by declination.

By referring to the Almanac, and setting off on the arc his declination for the given day and hour, we are still able to determine his position with the same certainty as if he remained on the equator.

When the sun's declination is south, that is, from the 22d of September to the 20th of March in each year, the arc *b* is turned towards the plates of the compass, as shown in the engraving, and the solar lens, *o*, with the silver plate opposite, are made use of in the surveys.

The remainder of the year, the arc is turned from the plates, and the other lens and plate employed.

When the Solar Compass is accurately adjusted, and its plates made perfectly horizontal, the latitude of the place, and the declination of the sun for the given day and hour, being also set off on the respective arcs, and the instrument set approximately north by the magnetic needle, *the image of the sun cannot be brought between the equatorial lines until the polar axis is placed in the plane of the meridian of the place, or in a position parallel to the axis of the earth.* The slightest deviation from this position will cause the image to pass above or below the lines, and thus discover the error.

We thus, from the position of the sun in the solar system, obtain a certain direction absolutely unchangeable, from which to run our lines, and measure the horizontal angles required.

This simple principle is not only the basis of the construction of the Solar Compass, but the sole cause of its superiority to the ordinary or magnetic instrument. For in a needle instrument, the accuracy of the horizontal angles indicated, and therefore of all the observations made, depends upon "the delicacy of the needle, and the constancy with which it assumes a certain direction, termed the magnetic meridian."

The principal causes of error in the needle briefly stated, are the dulling of the pivot, the loss of polarity in the needle, the influence of local attraction, and the effect of the sun's rays, producing the diurnal variation.

From all these imperfections the solar instrument is free.

The sights and the graduated limb being adjusted to the solar apparatus, and the latitude of the place and the declination of the sun also set off upon the respective arcs, we are able, not only to run the true meridian, or a due east and west course, but also to set off the horizontal angles with minuteness and accuracy from a direction which never changes, and is unaffected by attraction of any kind.

To Adjust the Solar Compass.

The adjustments of this instrument, with which the surveyor will have to do, are simple and few in number, and will now be given in order.

1st. ***To Adjust the Levels.***—Proceed precisely as directed in the account of the other instruments we have described, by bringing the bubbles into the center of the tubes by the leveling screws of the tripod, and then reversing the instrument upon its spindle, and raising or lowering the ends of the tubes, until the bubbles will remain in the center during a complete revolution of the instrument.

2d. ***To Adjust the Equatorial Lines and Solar Lenses.***—First detach the arm *h* from the declination arc by withdrawing the screws shown in the cut from the ends of the posts of the tangent-screw *k*, and also the clamp-screw, and the conical pivot with its small screws by which the arm and declination arc are connected.

The arm *h*, being thus removed, attach the adjuster in its place by replacing the conical pivot and screws, and insert the clamp-screw so as to clamp the adjuster at any point on the declination arc.

Now level the instrument, place the arm *h* on the adjuster, with the same side resting against the surface of the declination arc as before it was detached. Turn the instrument on its spindle so as to bring the solar lens to be adjusted in the direction of the sun, and raise or lower the adjuster on the declination arc, until it can be clamped in such a position as to bring the sun's image as near as may be between the equatorial lines on the opposite silver plate, and bring the image precisely into position by the tangent of the latitude arc or the leveling-screws of the tripod. Then carefully turn the arm half way over, until it rests upon the adjuster by the opposite faces of the rectangular blocks, and again observe the position of the sun's image.

If it remains between the lines as before, the lens and plate are in adjustment; if not, loosen the three screws which confine the plate to the block, and move the plate under their heads, until one half the error in the position of the sun's image is removed.

Again bring the image between the lines, and repeat the operation until it will remain in the same situation, in both positions of the arm, when the adjustment will be completed.

To adjust the other lens and plate, reverse the arm end for end on the adjuster, and proceed precisely as in the former case, until the same result is attained.

In tightening the screws over the silver plate, care must be taken not to move the plate.

This adjustment now being complete, the adjuster should be removed, and the arm *h*, with its attachments, replaced as before.

3d. ***To Adjust the Vernier of the Declination Arc.***—Having leveled the instrument, and turned its lens in the direction of the sun, clamp to the spindle, and set the vernier *v*, of the declination arc, at zero, by means of the tangent-screw at *k*, and clamp to the arc.

See that the spindle moves easily and yet truly in the socket, or polar axis, and raise or lower the latitude arc by turning the tangent-screw *f*, until the sun's image is brought between the equatorial lines on one of the plates. Clamp the latitude arc by the screw, and bring the image precisely into position by the leveling-screws of the tripod or socket, and without disturbing the instrument, carefully revolve the arm *h*, until the opposite lens and plate are brought in the direction of the sun, and note if the sun's image comes between the lines as before.

If it does, there is no index error of the declination arc; if not, with the tangent-screw *k*, move the arm until the sun's image passes over half the error; again bring the image between the lines, and repeat the operation as before, until the image will occupy the same position on both the plates.

We shall now find, however, that the zero marks on the arc and the vernier do not correspond, and to remedy this error, the little flat-head screws above the vernier must be loosened until it can be moved so as to make the zeros coincide, when the operation will be completed.

4th. ***To Adjust the Solar Apparatus to the Compass Sights.***—First level the instrument, and with the clamp and tangent-screws set the main plate at 90° by the verniers and horizontal limb. Then remove the clamp-screw, and raise the latitude arc until the polar axis is by estimation very nearly horizontal, and if necessary, tighten the screws on the pivots of the arc, so as to retain it in this position.

Fix the vernier of the declination arc at zero, and direct the equatorial sights to some distant and well marked object, and observe the same through the compass sights. If the same object is seen through both, and the verniers read to 90° on the limb, the adjustment is complete; if not, the correction must be made by moving the sights or changing the position of the verniers.

It should be remarked that as the solar work is attached permanently to the sockets, and this adjustment is made by the maker, it will need no further attention at the hands of the surveyor except in case of serious accidents.

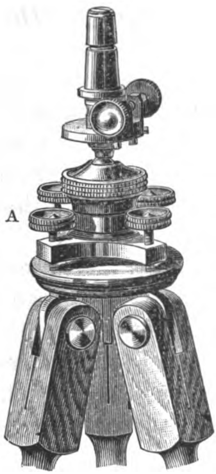
The other adjustments are of course also made in the process of finishing the instrument, and are liable to very little derangement in the ordinary use of the Solar Compass.

Tripod, &c., for Solar Compass.

This instrument should always be used on a tripod, with screws for ready and accurate leveling, and a tangent-screw for directing it to any given point.

For this purpose a leveling-head with tangent-screw, &c., similar to those shown in the cuts of the Surveyors' Transit is furnished, unless otherwise ordered, with every instrument.

Leveling Adopter.—For more rapid leveling of the Solar Compass as well as other instruments hereafter described, we have recently devised the arrangement shown at A, which is screwed into the top of the tripod like the ordinary leveling-head.



This can be used either with a simple ball-spindle, or with the compound ball with tangent screw as shown in the cut.

The instrument is leveled very nearly upon the ball, and finally made truly horizontal by the leveling screws.

It also revolves upon the spindle as upon the ordinary compass-ball, but can be clamped at pleasure to the spindle, and then by the tangent-screw directed precisely to any object.

The price of the leveling adopter, without tripod or ball spindle, is $7.00; with tripod and compound tangent ball, as shown, $18.00.

To Use the Solar Compass.

Before this instrument can be used at any given place, it is necessary to set off upon its arcs both the declination of the sun as affected by its refraction for the given day and hour, and the latitude of the place where the observation is made.

To Set off the Declination.—The declination of the sun, given in the ephemeris of the Nautical Almanac from year to year, is calculated for apparent noon at Greenwich, England.

To determine it for any other hour at a place in the U. S., reference must be had, not only to the difference of time arising from the longitude, but also to the change of declination from day to day.

The longitude of the place, and therefore its difference in time, if not given directly in the tables of the Almanac, can be ascertained very nearly by reference to that of other places given, which are situated on, or very nearly on, the same meridian.

It is the practice of surveyors in the states east of the Mississippi to allow a difference of *six* hours for the difference in longitude, calling the declination given in the Almanac for 12 M., that of 6 A. M., at the place of observation.

Beyond the meridian of Santa Fe, the allowance would be about *seven* hours, and in California, Oregon, and Washington Territory about *eight* hours.

Having thus the difference of time, we very readily obtain the declination for a certain hour in the morning, which would be earlier or later as the longitude was greater or less, and the same as that of apparent noon at Greenwich on the given day. Thus, suppose the observation made at a place, say, five hours later than Greenwich, then the declination given in the Almanac for the given day at noon, affected by the refraction, would be the declination at the place of observation for 7 o'clock, A. M.; this gives us the starting-point.

To obtain the declination for the other hours of the day, take from the Almanac the declination for apparent noon of the given day, and, as the declination is increasing or decreasing, add to or subtract from the declination of the first hour the difference for one hour as given in the ephemeris, which will give, when affected by the refraction, the declination for the succeeding hour; and proceed thus in making a table of the declination for every hour of the day.

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 15°.								
	+20°	+15°	+10°	+5°	0°	−5°	−10°	−15°	−20°
0 h.	−05″	0″	+05″	10″	15″	21″	27″	33″	40″
2	−01	+02	07	12	18	23	29	36	43
3	+01	05	11	16	22	28	34	41	49
4	08	12	19	24	30	37	44	53	1′04
5	29	34	41	49	59	1′10	1′24	1′43	2 08
	For Latitude 17° 30′.								
0 h.	−02″	+02″	08″	13″	18″	24″	30″	36″	44″
2	0	05	10	15	21	27	33	40	48
3	+02	10	15	21	27	33	40	48	57
4	13	18	23	29	35	43	51	1′01	1′13
5	34	41	49	58	1′10	1′23	1′41	2 06	2 42
	For Latitude 20°.								
0 h.	0″	05″	10″	15″	21″	27″	33″	40″	48″
2	03	07	13	18	24	30	36	44	52
3	06	13	18	24	30	36	44	52	1′02
4	17	22	28	35	42	50	1′00	1′11	1 26
5	39	47	57	1′07	1′20	1′37	2 00	2 32	3 25
	For Latitude 22° 30′.								
0 h.	02″	08″	13″	18″	24″	30″	36″	44″	52″
2	06	11	15	21	27	33	40	48	57
3	11	15	21	27	33	40	48	57	1′08
4	20	26	32	39	46	56	1′07	1′19	1 37
5	45	53	1′03	1′16	1′31	1′52	2 21	3 07	4 28
	For Latitude 25°.								
0 h.	05″	10″	15″	21″	27″	33″	40″	48″	57″
2	08	14	19	25	31	38	46	54	1′05
3	12	18	24	30	37	44	53	1′04	1 18
4	23	29	35	45	58	1′01	1′16	1 31	1 52
5	49	59	1′10	1′24	1′52	2 07	2 44	3 46	5 43

HOUR ANGLE.	DECLINATIONS.								
	For Latitude 27° 30′.								
	+20°	+15°	+10°	+5°	0°	−5°	−10°	−15°	−20°
0 h.	08″	13″	18″	24″	30″	36″	44″	52″	1′02″
2	11	16	22	28	34	41	49	1′00	1 10
3	17	22	28	35	42	50	1′00	1 11	1 26
4	28	35	42	50	1′00	1′11	1 26	1 43	2 09
5	54	1′05	1′18	1′34	1 54	2 24	3 11	4 38	8 15
	For Latitude 30°.								
0 h.	10″	15″	21″	27″	33″	40″	48″	57″	1′08″
2	14	19	25	31	38	46	54	1′05	1 18
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 32° 30′.								
0 h.	13″	18″	24″	30″	36″	44″	52″	1′02″	1′14″
2	17	22	28	35	42	50	1′00	1 11	1 26
3	23	29	35	43	51	1′01	1 13	1 28	1 47
4	35	43	51	1′01	1′13	1 27	1 46	2 13	2 54
5	1′03	1′15	1′31	1 53	2 20	3 05	4 25	7 36	
	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 37° 30′.								
0 h.	18″	24″	30″	36″	44″	52″	1′02″	1′14″	1′29″
2	22	28	35	42	50	1′00	1 12	1 26	1 45
3	29	36	43	52	1′02	1 14	1 29	1 49	2 16
4	43	51	1′01	1′13	1 27	1 49	2 14	2 54	4 05
5	1′11	1′26	1 44	2 10	2 49	3 55	6 15	14 58	
	For Latitude 40°.								
0 h.	21″	27″	33″	40″	48″	57″	1′08″	1′21″	1′3 ″
2	25	32	39	46	52	1′06	1 19	1 35	1 57
3	33	40	48	57	1′03	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 42° 30′.								
0 h.	24″	30″	36″	44″	52″	1′02″	1 14″	1′29″	1′49″
2	28	35	39	50	1′00	1 12	1 26	1 45	2 11
3	36	43	52	1′02	1 13	1 29	1 49	2 17	2 59
4	50	1′00	1′11	1 26	1 44	2 10	2 49	3 55	6 16
5	1′16	1 36	1 58	2 30	3 22	5 00	9 24		

HOUR ANGLE.	DECLINATIONS.								
	For Latitude 45°.								
	+20°	+15°	+10°	+5°	0°	−5°	−10°	−15°	−20°
0 h.	27″	33″	40″	48″	57″	1′08″	1′21″	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 47° 30′.								
0 h.	30″	36″	44″	52″	1′02″	1′14″	1′29″	1′49″	2′18″
2	35	42	50	1′00	1 12	1 26	1 45	2 01	2 51
3	43	51	1′01	1 13	1 28	1 47	2 15	2 56	4 08
4	56	1′09	1 23	1 40	2 05	2 40	3 39	5 37	11 18
5	1′27	1 46	2 12	2 52	4 01	6 30	16 19		
	For Latitude 50°.								
0 h.	33″	40″	48″	57″	1′08″	1′21″	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		
	For Latitude 52° 30′.								
0 h.	36″	44″	52″	1′02″	1′14″	1′29″	1′49″	2′18″	3′05″
2	43	50	59	1 11	1 26	1 42	2 23	2 49	3 55
3	50	1′00	1′11	1 26	1 45	2 11	2 51	2 53	6 22
4	1′05	1 18	1 35	2 10	2 28	3 19	4 53	8 42	
5	1 34	1 56	2 27	3 16	4 47	8 52			
	For Latitude 55°.								
0 h.	40″	48″	57″	1′08″	1′21″	1′39″	2′02″	2′36″	3′33″
2	46	55	1′05	1 18	1 34	1 56	2 30	3 15	4 47
3	55	1′06	1 19	1 35	1 58	2 30	3 21	4 58	9 19
4	1′10	1 23	1 42	2 06	2 43	3 44	5 49	12 41	
5	1 37	2 01	2 34	3 28	5 15	10 18			
	For Latitude 57° 30′.								
0 h.	44″	52″	1′02″	1′14″	1′29″	1′49″	2′18″	3′05″	4′37″
2	50	59	1 11	1 25	1 43	2 09	2 47	3 51	6 04
3	58	1′10	1 24	1 42	2 07	2 43	3 45	5 50	12 47
4	1′11	1 25	1 43	2 10	2 50	3 55	6 14	14 49	
5	1 41	2 06	2 42	3 42	5 46	12 26			
	For Latitude 60°.								
0 h.	48″	57″	1′08″	1′21″	1′39″	2′02″	2′36″	3′33″	5′23″
2	54	1′04	1 17	1 33	1 54	2 24	3 12	4 38	8 15
3	1′03	1 15	1 30	1 51	2 20	3 04	4 24	7 31	24 44
4	1 18	1 34	1 56	2 28	3 18	4 50	8 53		
5	1 45	2 11	2 50	3 57	6 21	15 32			

Explanation of the Table of Refractions.

The table is calculated for latitudes between 15° and 60° at intervals of 2½°, that being as near as is required.

The declination ranges from 0 to 20° both north and south, the + declinations being north, and − south, and is given for every five degrees, that being sufficiently near for all practical purposes.

The hour angle in the first column indicates the distance of the sun from the meridian in hours, the refraction given for 0 hours being that which affects the observed declination of the sun when on the meridian, commonly known as meridional refraction ; the refraction for the hours just before and after noon is so nearly that of the meridian, that it may be called and allowed as the same.

When the table is used, it must be borne in mind that when the declination is north or + in the table, the refraction is to be added; when the declination is south or —, the refraction must be subtracted.

It will be noticed that the refraction in south or — declination increases very rapidly as the sun nears the horizon, showing that observations should not be taken with the sun when south of the equator, less than one hour from the horizon.

Thus, suppose it was required to obtain the declination for the different hours of April 16, 1888, at Troy, N. Y.

The longitude in time is 4 hours 54 minutes 40 seconds, or practically 5 hours; so that the declination given in the ephemeris for apparent noon of that day at Greenwich would be that of 7 A. M. at Troy.

To obtain the declination of the given day proceed as follows:

Declination at Greenwich at noon of April 16, 1888,

N. 10° 22′ 43″ +

Declination		Refr.		Dec.	Time at Troy
N. 10° 22′ 43″ +	Refr. 5 hrs.	1′ 58″ =	10° 24′ 41″ =	Dec. at	7 A.M. Troy
add hr. dif. 53″					
10° 23′ 36″ +	" 4 "	1′ 11″ =	10° 24′ 47″ =	"	8 "
53″					
10° 24′ 29″ +	" 3 "	0′ 52″ =	10° 25′ 21″ =	"	9 "
53″					
10° 25′ 22″ +	" 2 "	0′ 39″ =	10° 26′ 01″ =	"	10 "
53″					
10° 26′ 15″ +	" 1 "	0′ 36″ =	10° 26′ 51″ =	"	11 "
53″					
10° 27′ 08″ +	" 0 "	0′ 36″ =	10° 27′ 44″ =	"	12 M.
53″					
10° 28′ 01″ +	" 1 "	0′ 36″ =	10° 28′ 37″ =	"	1 P.M.
53″					
10° 28′ 54″ +	" 2 "	0′ 39″ =	10° 29′ 33″ =	"	2 "
53″					
10° 29′ 47″ +	" 3 "	0′ 52″ =	10° 30′ 29″ =	"	3 "
53″					
10° 30′ 40″ +	" 4 "	1′ 11″ =	10° 31′ 51″ =	"	4 "
53″					
10° 31′ 33″ +	" 5 "	1′ 58″ =	10° 33′ 31″ =	"	5 "

Again, suppose it was desired to obtain the corrected declination for the different hours of Oct. 16, 1888, at Troy, N. Y.

The difference in time being nearly 5 hours, and the declination at Greenwich, noon, S. 9° 8′ 58″, that declination affected by the refraction would give the true declination for 7 A.M. at Troy; the latitude being nearly 42° 30′. The declination being now south, the refraction is to be subtracted, but the hourly difference is to be added because the declination is increasing, as in the first example: thus,

S. 9° 8′ 58″—	Refr. 5	hrs. 9′ 24″	=8° 59′ 34″	=Dec. 7	A.M. Troy
add hr. dif. 55″					
9° 9′ 53″—	" 4	" 2′ 49″	=9° 7′ 4″	= " 8	"
55″					
9° 10′ 48″—	" 3	" 1′ 49″	=9° 9′ 59″	= " 9	"
55″					
9° 11′ 43″—	" 2	" 1′ 26″	=9° 10′ 17″	= " 10	"
55″					
9° 12′ 38″—	" 1	" 1′ 14″	=9° 11′ 24″	= " 11	"
55″					
9° 13′ 33″—	" 0	" 1′ 14″	=9° 13′ 19″	= " 12	M.
55″					
9° 14′ 28″—	" 1	" 1′ 14″	=9° 13′ 14″	= " 1	P. M.
55″					
9° 15′ 23″—	" 2	" 1′ 26″	=9° 13′ 17″	= " 2	"
55″					
9° 16′ 18″—	" 3	" 1′ 49″	=9° 14′ 29″	= " 3	"
55″					
9° 17′ 13″—	" 4	" 2′ 49″	=9° 14′ 24″	= " 4	"
55″					
9° 18′ 08″—	" 5	" 9′ 24″	=9° 8′ 44″	= " 5	"

We believe it will be found that the use of the table as illustrated above, will not only relieve the surveyor of the perplexity hitherto attending the subject of refractions, but will also enable him to secure more accurate results than were possible by the methods usually given.

The calculation of the declination for the different hours of the day, should of course be made and noted before the surveyor commences his work, that he may lay off the change from hour to hour, from a table prepared as above described.

To Set Off the Latitude.—Find the declination of the sun for the given day at noon, at the place of observation as just described, and with the tangent-screw set it off upon the declination arc, and clamp the arm firmly to the arc.

Observe in the Almanac the equation of time for the given day, in order to know about the time the sun will reach the meridian.

Then, about fifteen or twenty minutes before this time, set up the instrument, level it carefully, fix the divided surface of the declination arc at 12 on the hour circle, and turn the instrument upon its spindle until the solar lens is brought into the direction of the sun.

Loosen the clamp-screw of the latitude arc, and with the tangent-screw raise or lower this arc until the image of the sun is brought precisely between the equatorial lines, and turn the instrument from time to time so as to keep the image also between the hour lines on the plate.

As the sun ascends, its image will move below the lines, and the arc must be moved to follow it. Continue thus, keeping it between the two sets of lines until its image begins to pass above the equatorial lines, which is also the moment of its passing the meridian.

Now read off the vernier of the arc, and we have the latitude of the place, which is always to be set off on the arc when the compass is used at the given place.

It is the practice of surveyors using the Solar Compass to set off, in the manner just described, the latitude of the point where the survey begins, and to repeat the observation and correction of the latitude arc every day when the weather is favorable, there being also nearly an hour at mid-day when the sun is so near the meridian as not to give the direction of lines with the certainty required.

To Run Lines with the Solar Compass.—Having set off in the manner just given the latitude and declination upon their respective arcs, the instrument being also in adjustment, the surveyor is ready to run lines by the sun.

To do this, the instrument is set over the station and carefully leveled, the plates clamped at zero on the horizontal limb, and the sights directed north and south, the direction being given, when unknown, approximately by the needle.

The solar lens is then turned to the sun, and with one hand on the instrument, and the other on the revolving arm, both are moved from side to side, until the sun's image is made, to appear on the silver plate; when by carefully continuing the operation, it may be brought precisely between the equatorial lines.

Allowance being now made for refraction, the line of sights will indicate the true meridian; the observation may now be made, and the flag-man put in position.

When a due east and west line is to be run, the verniers of the horizontal limb are set at 90°, and the sun's image kept between the lines as before.

The Solar Compass being so constructed that when the sun's image is in position the limb must be clamped at 0 in order to run a true meridian line, it will be evident that the bearing of any line from the meridian, may be read by the verniers of the limb precisely as in the ordinary magnetic compass, the bearing of lines are read from the ends of the needle.

Use of the Needle.—In running lines, the magnetic needle is always kept with the sun; that is, the point of the needle is made to indicate 0 on the arc of the compass box, by turning the tangent-screw connected with its arm on the opposite side of the plate. By this means the lines can be run by the needle alone in case of the temporary disappearance of the sun; but, of course, in such cases the surveyor must be sure that no local attraction is exerted.

The variation of the needle, which is noted at every station, is read off in degrees and minutes on the arc, by the edge of which the vernier of the needle-box moves.

Allowance for the Earth's Curvature.—When long lines are run by the Solar Compass, either by the true meridian, or due east and west, allowance must be made for the curvature of the earth.

Thus, in running north or south, the latitude changes about one minute for every distance of 92 chains 30 links, and the side of a township requires a change on the latitude arc of 5′ 12″, the township, of course, being six miles square.

This allowance is of constant use where the surveyor fails to get an observation on the sun at noon, and is a very close approximation to the truth.

In running due east and west, as in tracing the standard parallels of latitude, the sights are set at 90° on the limb, and the line is run at right angles to the meridian.

If no allowance were made for the earth's curvature, these lines would, if sufficiently produced, reach the equator, to which they are constantly tending.

Of course, in running short lines either east or west, the variation from the parallel would be so small as to be of no practical importance; but when long sights are taken, the correction should be made by taking fore and back sights at every station, noticing the error on the back sight, and setting off one half of it on the fore sight on the side towards the pole.

Time of Day by the Sun.—The time of day is best ascertained by the Solar Compass when the sun is on the meridian, as at the time of making the observation for latitude.

The time thus given is that of apparent noon, and can be reduced to mean time, by merely applying the equation of time as directed in the Almanac, and adding or subtracting as the sun is slow or fast.

The time, of course, can also be taken before or after noon, by bringing the sun's image between the hour lines, and noticing the position of the divided edge of the revolving arm, with reference to the graduations of the hour circle, allowing four minutes of time for each degree of the arc, and thus obtaining apparent time, which must be corrected by the equation of time as just described.

Caution as to the False Image.—In using the compass upon the sun, if the revolving arm be turned a little one side of its proper position, a false or reflected image of the sun will appear on the silver plate in nearly the same place as that occupied by the true one. It is caused by the reflection of the true image from the surface of the arm, and is a fruitful source of error to the inexperienced surveyor. It can, however, be readly distinguished from the real image by being much less bright, and not so clearly defined.

Approximate Bearings.—When the bearings of lines, such as the course of a stream, or the boundaries of a forest, are not desired with the certainty given by the verniers and horizontal limb, a rough approximation of the angle they make with the true meridian, is obtained by the divisions on the outside of the circular plate.

In this operation, a pencil, or thin straight edge of any sort, is held perpendicularly against the circular edge of the plate, and moved around until it is in range with the eye, the brass center-pin, and the object observed.

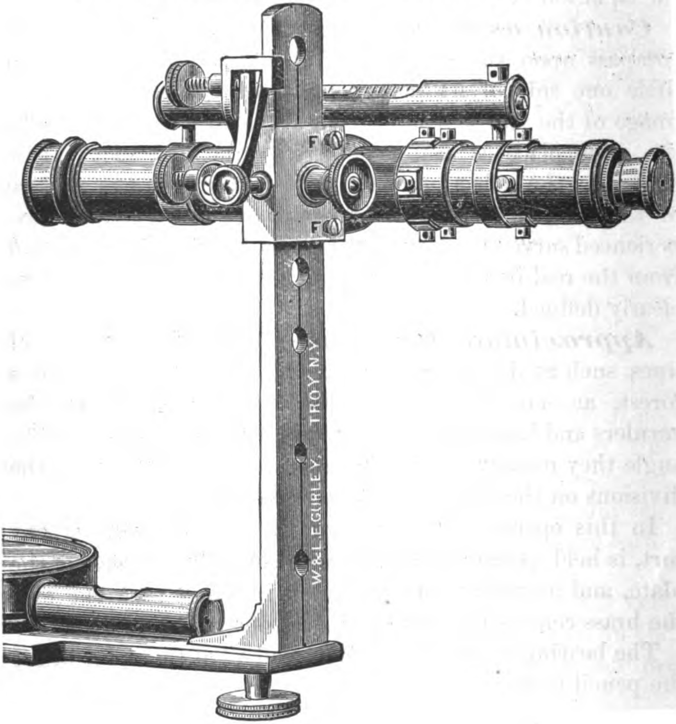
The bearing of the line is then read off at the point where the pencil is placed.

Time for Using the Solar Compass.

The Solar Compass, like the ordinary instrument, can be used at all seasons of the year, the most favorable time being, of couse, in the summer, when the declination is north, and the days are long, and more generally fair.

It is best not to take the sun at morning and evening, when it is within half-an-hour of the horizon, nor at noon, as we have before stated, for about the same interval, before and after it passes the meridian.

THE TELESCOPIC SIGHT. *(Patented July 9, 1878.)*



Telescope No. 132, with Level, and Clamp and Tangent
Price as shown, $30.00.

The figure shows the adaptation of a telescope to the sight vanes of an ordinary compass, which was invented by us in 1878, and has since come into very general use with the Solar Compass. The telescope is about 9 inches long, and has a power of 18 to 20 diameters; it is provided of course with the ordinary cross-wires, and has also the micrometer-wires or stadia for measuring distances as described in our account of the Engineers' Transit. In the cut the telescope is shown fitted with a level, and clamp and tangent, and to these can be added a vertical circle if desired for the measurement of angles of elevation and depression. For simple sighting the level and circle can of course be dispensed with, but in the use of the micrometer-wires the tangent movement is very desirable.

When measurements are to be recorded in chains and links, the wires should be made to cover a foot at a distance of 66 feet; if recorded in feet, they should cover the same interval at a distance of 100 feet.

The rod used with the micrometer should be graduated to feet and decimals of a foot, and provided with two targets, the upper one being fixed at some definite point, while the lower one can be moved as the surveyor requires, the distance between the two targets being accurately read off by the vernier of the movable one; or a self-reading rod as hereafter described may be used without target for short distances.

In using the micrometer, the upper wire is brought by the tangent-screw precisely upon the upper or stationary target, while the lower target is moved up or down until the lower wire exactly bisects its center line, when the rod is read, and the distance recorded.

Advantages of the Solar Compass in Surveying.

It will readily occur to all who have read the preceding description of the Solar Compass, that while it is indispensable in the surveys of public lands, it also possesses important advantages over the magnetic compass, when used in the ordinary surveys of farms, &c.

For not only can lines be run and angles be measured without regard to the diurnal variation, or the effect of local attraction, but the bearings being taken from the true meridian, will remain unchanged for all time.

The constant uncertainty caused by the variation of the needle, and the litigation to which it so often gives rise, may thus be entirely prevented by the use of the Solar Compass in this kind of work.

It is also said by those familiar with the use of this instrument, that, in favorable weather, surveys can be more rapidly made with it than with the ordinary needle instrument; there being no time consumed in waiting for the needle to settle, or in avoiding the errors of local attraction.

When the sun is obscured, the lines may be run by the needle alone, it being always kept with the sun, or at 0 on its arc, and thus indicating the direction of the true meridian.

The sun, however, must ever be regarded as the most reliable guide, and should, if possible, be taken at every station.

It is with the design of making the principles and use of the Solar Compass intelligible to the ordinary surveyor, that we have given a more extended account of this instrument than of the others previously mentioned.

Superiority of our Solar Compasses.

The Solar Compass as hitherto made, though planned with great ingenuity in its general arrangement, was still extremely rude in its mechanical details and adjustments. Some of these defects which are apparent on inspection of any instrument, as hitherto made by other manufacturers, and which must have frequently occurred to the surveyor, we will now enumerate.

The motion of the plates over each other was accompanied with so much friction, that in turning the verniers around the limb, the whole instrument would often be moved about its spindle.

Again, the verniers must be set, and the sights directed to an object by the hand alone, a matter of no little difficulty when single minutes of a degree were to be set off, and accurate observations were required.

The latitude and declination arcs must also be moved by hand, and the verniers set to single minutes in the same manner.

The points in which we claim the superiority of our Solar Compass over any hitherto manufactured, and by means of which the defects just enumerated are entirely removed, are partially shown in the various cuts already given, and will now be stated in detail.

1. A motion of the horizontal plates almost entirely free from friction, combined with perfect solidity.

2. A fine clamp and tangent movement to the divided limb, as shown under the plate.

3. A tangent movement with clamp, for the declination arc, as shown at *k*.

4. A tangent movement with clamp to the latitude arc, as shown at *f*.

5. A tangent motion for the whole instrument about its sockets.

6. Great facility of adjustment, and, in consequence, an important saving of time.

7. An important reduction in price, while still furnishing an article greatly improved.

Weight of the Solar Compass.

Solar Compass, including leveling head, about 15 lbs.

THE RAILROAD COMPASS.

This instrument is a compass of the highest grade, in which by the addition of a divided limb and verniers the surveyor is enabled to take angles, and run lines unaffected by the imperfections of the magnetic needle.

Imperfections of the Needle.

These may arise either from the loss of magnetic virtue in the poles, the blunting of the center-pin, or the attraction exerted upon it by bodies of iron, whose presence may be entirely unsuspected.

The first two of these errors may be easily remedied in the manner hereafter described.

Local Attraction.—The third and most frequent source of inaccuracy, may be detected by taking back sights as well as fore sights, upon every line run with the needle, and by the agreement of the bearings determining the true direction of the line.

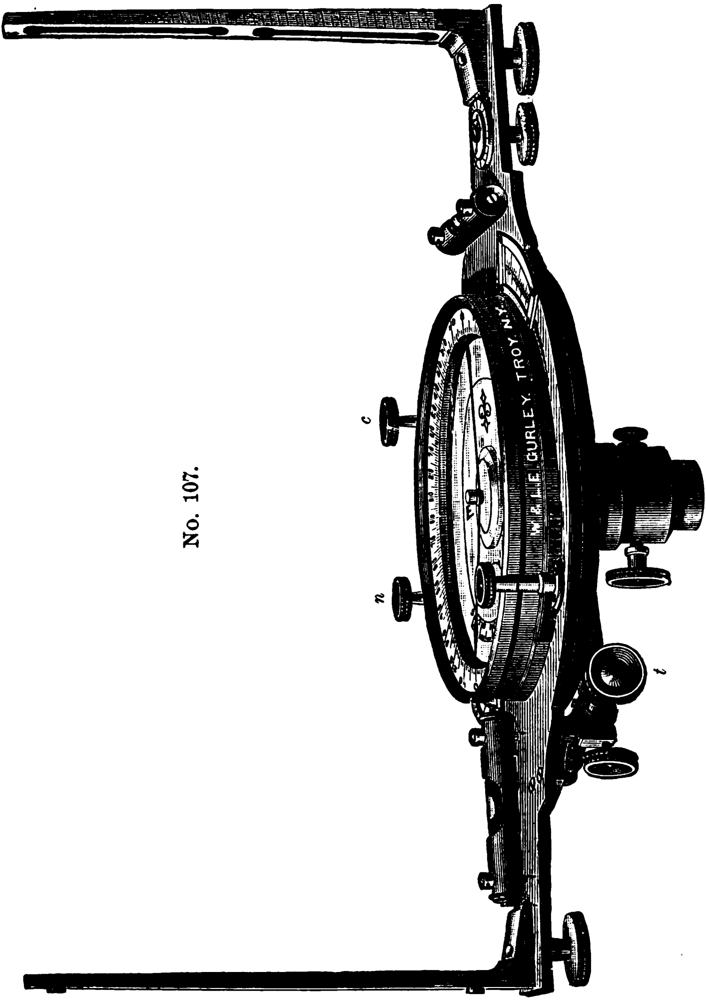
Sometimes a compass may have little particles of iron concealed within the surface of the metal circle or plates.

It is the business of the maker to examine every instrument, in search of this defect, by trying the reversion of the needle upon all points of the divided circle.

If the needle should fail to reverse, when the compass is turned half around, and the sights directed a second time upon any object, the instrument should be thrown aside and never sold.

Besides the difficulties caused by the above imperfections, the variation of the needle is a frequent source of annoyance.

What is termed the secular variation, we shall soon mention in our account of the Vernier Compass; we will now speak of the diurnal variation.



No. 107.

Railroad Compass, with two verniers to limb, 5½-inch needle and jacob-staff mountings $75 00

Diurnal Variation.—This is owing to the influence of the sun, which, in summer, will cause the needle to vary from ten to fifteen minutes in a few hours, when exposed to its fullest influence.

To guard against these causes of inaccuracy in the use of needle instruments, the surveyor will need the greatest care and attention; and yet, with all the precautions that can be suggested, the difficulty of measuring horizontal angles with certainty, and to a sufficient degree of minuteness by the needle alone, has caused a demand to be felt more and more sensibly in all parts of the country for instruments, in the use of which the surveyor may proceed with assured accuracy and precision.

Indeed, in Canada, so great is the distrust of needle instruments, that the Provincial Land Surveyors are forbidden to use an instrument in their land surveys, unless it is capable of taking angles independently of the needle.

And though, with all its imperfections, the ordinary compass, from its simplicity and convenience, is a very valuable instrument, and therefore will always be used where land is abundant and cheap, yet the demand for instruments of a higher class is constantly increasing, as more accurate work is required; and to supply this demand, at least in part, the Railroad Compass was devised.

It has, of course, as shown on page 133, the main-plate, levels, sights, and needle of the ordinary instrument, and in addition, underneath the main-plate, a divided circle or limb by which horizontal angles to single minutes can be taken independently of the needle.

The arrangement of the sockets is precisely like that of the Surveyors' Transit with two verniers to limb, and the plates can be separated and replaced in the same manner.

The verniers are attached to the under surface of the main-plate at an angle of 30° with the line of sights, the openings through which they are seen being covered with slips of glass to protect the divisions from dust and moisture.

The connection between the two plates is made by a clamp and tangent movement with opposing spring shown at *t*, by which they can be fastened together or released at will, or moved slowly around each other as may be desired in the use of the compass.

The needle lifting-screw is shown at *n*, on the left of the plate.

On the right of the compass-circle is seen the head of a pinion working into a circular rack fixed to the edge of the compass-circle, and thus enabling the surveyor to move the compass-circle about its center in setting off the variation of the needle, precisely as in the case of the vernier compass.

The variation is read to single minutes by a vernier and divided arc, partially shown in the cut.

At *c*, is shown a clamp-screw, by which the circle is securely fixed when moved to the proper position.

The sockets upon which the plates of this instrument turn are long and well fitted, and the movement of the vernier plate around the limb is almost perfectly free from friction.

The Graduated Circle or limb is divided to half degrees, and figured in two rows, viz.: from 0° to 90°, and from 0° to 360° ; sometimes but a single series is used, and then the figures run from 0° to 360°, or from 0° to 180° on each side.

The figuring, which is the same upon this as in the other angular instruments already described, is varied when desired by the surveyor. The first method is our usual practice.

The Verniers are double, having on each side of the zero mark thirty equal divisions corresponding precisely with twenty-nine half degrees of the limb; they thus read to single minutes, and the number passed over is counted in the same direction in which the vernier is moved.

The use of two opposite verniers in this and other instruments gives the means of "cross-questioning" the graduations, the perfection with which they are centered, and the dependence which can be placed upon the accuracy of the angles indicated.

The Needle of this instrument is five or five and a half inches long, and made precisely like those previously described.

The Adjustments of this instrument, with which the surveyor will have to do, as those of the sights, levels, needle, &c., will be described in the account of the Vernier Compass.

To Use the Railroad Compass.

It can be set upon the common ball-spindle, or still better, the tangent-ball already described, placed either in a jacob-staff socket, a compass tripod, or the leveling adopter and tripod, as shown on page 116.

We have also adapted to many of these instruments the leveling tripod head, with clamp and tangent movement, and this is preferable to any other support.

To Take Horizontal Angles.—First level the plate and set the limb at zero, fix the sights upon one of the objects selected, and clamping the whole instrument firmly to the spindle, unclamp the vernier plate and turn it with the hand, until the sights are brought nearly upon the second object; then clamp to the limb, and with the tangent-screw fix them precisely upon it.

The number of degrees and minutes read off by the vernier will give the angle between the two objects taken from the center of the instrument.

It will be understood that the horizontal angles can be taken in any position of the verniers, with reference to the zero point of the limb; we have given that above as being the usual method, and liable to the fewest errors.

It is advisable where great accuracy is required, in this and other instruments furnished with two verniers, to obtain the readings of the limb from both, add the two together and halve their sum; the result will be the mean of the two readings, and the true angle between the points observed.

Such a course is especially necessary when the readings of the verniers essentially disagree, as may sometimes happen when the instrument has been injured by an accident.

Use of the Needle.—In taking horizontal angles as just described, the magnetic bearings of the two objects are often noted, and thus two separate readings of the same angle, one by the limb, the other by the needle, are obtained, to be used as checks upon each other to prevent mistakes.

To Turn Off the Variation of the Needle.—Having leveled the instrument, set the limb at zero, and place the sights upon the old line, note the reading of the needle, and make it agree with that given in the field notes of the former survey, by turning the compass-circle about its center by the pinion-head.

Now, clamp the compass-circle firmly by the clamp-screw, and the number of degrees or minutes passed over by the vernier of the compass-circle will be the change of variation in the interval between the two surveys.

To Survey with this instrument, the operator should turn the south side of the compass-face towards his person, and having brought the zeros of the limb and vernier plate in contact, clamp them, and proceed as directed in our account of the Vernier Compass.

The telescopic sight as hereafter described, is often used with the Railroad Compass with very excellent results.

Of course it will be understood that lines can be run and angles measured by the divided limb and verniers, independently of the needle; and, in localities where local attraction is manifested, this is very desirable.

The accuracy and minuteness of horizontal angles indicated by this instrument, together with its perfect adaptation to all the purposes to which the Vernier Compass can be applied, have brought it into use in many localities, where the land is so valuable as to require more careful surveys than are practicable with a needle instrument.

Railroad Compass, One Vernier to Limb.

This instrument is essentially like that already described, but of somewhat simpler construction in its sockets, and having but one vernier to the limb; and, though afforded at a price materially lower than the other, it is still in every way accurate and reliable.

Size and Weight of the Railroad Compass, One Vernier.

We make but one size of this instrument, viz.: five and a half inch needle; which, including the brass head of the jacob-staff, weighs about thirteen pounds.

Size and Weight of the Railroad Compass, Two Verniers.

We make two sizes of this instrument, viz.: five, and five and a half inch needle; the largest size, including the brass head of the jacob-staff, weighing fourteen pounds, and the five-inch, about thirteen pounds.

We invite especial attention to the different styles of our Railroad compasses, believing that in many respects they are very much superior to any other compass made, having a horizontal limb, and an arrangement by which the variation of the needle can be readily set off and ascertained.

THE VERNIER COMPASS.

This instrument, represented in the engraving (page 141), has its compass-circle, to which is attached a "vernier," movable about a common center a short distance in either direction, thus enabling the surveyor to set the zeros of the circle at any required angle with the line of sights; the number of degrees contained in this angle or the "variation of the needle" being read off by the vernier.

The Compass-circle in this, as in all our instruments, is divided to half degrees on its upper surface, the whole degree marks being also cut down on the inside circumference, and is figured from 0 to 90, on each side of the center or "line of zeros." The circle and face of the compass are silvered. The movement of the circle is effected either by a slow moving or "tangent screw," as shown in the engraving, or by a concealed rack and pinion—the head of which projects from the under side of the main compass-plate. When the variation is set off as described, the circle is securely fastened in its position by a clamping-nut underneath the main-plate.

Ball-Spindle.—The compass is usually fitted to a spindle made slightly conical, and having on its lower end a ball turned perfectly spherical, and confined in a socket by a pressure so light that the ball can be moved in any direction in the operation of leveling the compass.

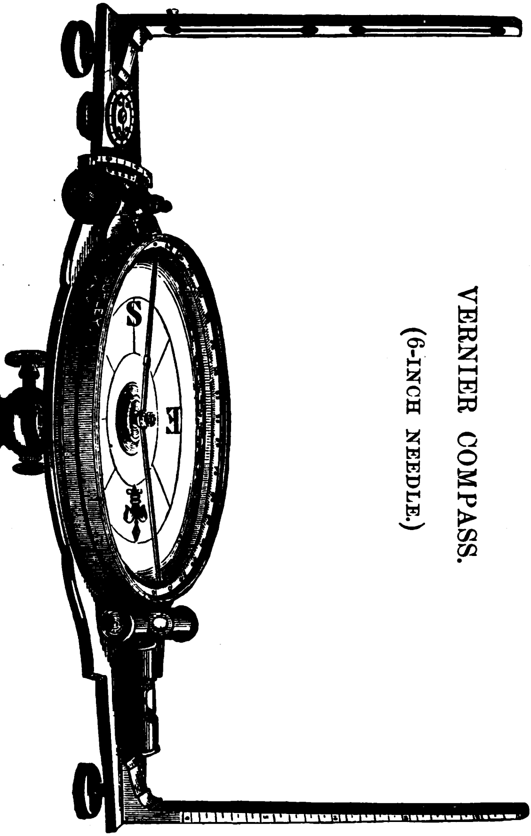
The ball is placed either in the brass head of the jacob-staff, or, still better, in the compass-tripod seen in the engraving of the Vernier Transit already described.

A leveling adopter (see page 116) is also often used for rapid leveling of the compass.

The Jacob-Staff mountings which are furnished with all our compasses, and packed in the same case, consist of

VERNIER COMPASS.

(6-INCH NEEDLE.)



No. 112.

Price, with jacob-staff mountings, $40.00.

the brass head already mentioned, and a shoe, pointed with steel, so as to be set firmly in the ground.

The staff, to which the mountings should be securely fastened, is procured from any wheelwright, or selected by the surveyor himself from a sapling of the forest.

The Spirit Levels are placed at right angles to each other so as to level the plate in all directions, and are balanced upon a pivot underneath the middle of the tube, so as to be adjustable by a common screw-driver.

The Sights, or sight-vanes, have fine slits cut through nearly their whole length, terminated at intervals by large circular apertures, through which the object sighted upon is more readily found. Sometimes a fine horse-hair or wire is substituted for one half the slit, and placed alternately with it on opposite sights.

Tangent Scale.—The right and left hand edges of the sights of our compasses, have respectively an eye-piece, and a series of divisions, by which angles of elevation and depression, for a range of about twenty degrees each way, can be taken with considerable accuracy.

Such arrangement is very properly termed a "tangent scale," the divided edges of the north sight being tangents to segments of circles having their centers at the eye-pieces, and their points of contact with the tangent lines at the zero divisions of the scale.

The cut shows the eye-piece and divisions for angles of elevation; those for angles of depression, concealed in this cut, are seen in that of the Plain Compass.

Clamp-Screw.—In the side of the hollow cylinder, or socket of the compass, which fits to the ball-spindle, is a screw by which the instrument may be clamped to the spindle in any position.

Spring-Catch.—Besides the clamp-screw, we now have fitted to the sockets of our compasses a little spring-catch, which, as soon as the instrument is set upon the spindle, slips into a groove, and thus removes all danger of falling when the instrument is carried.

Needle-Lifter.—There is also underneath the main plate a needle-lifting screw which, by moving a concealed spring, raises the needle from the pivot, and thus prevents the blunting of the point in transportation.

When the compass is not in use it is the practice of many surveyors to let down the needle upon the point of the center-pin, and let it assume its position in the magnetic meridian, so as to retain or even increase its polarity.

We would advise in addition, that after the needle has settled it should be raised against the glass, in order not to dull the point of suspension.

Outkeeper.—A small dial plate, having an index turned by a milled head underneath, is used with this and the other compasses to keep tally in chaining.

The dial is figured from 0 to 16, the index being moved one notch for every chain run.

Brass Cover.—A brass cover is fitted over the glass of the compass, and serves to protect it from accident, as well as to prevent electric disturbance.

The Telescopic Sight is often supplied with the various sizes of the Vernier Compass, and its adjustments and use will be found in our account of the Plain Compass.

Use of the Vernier.

The superiority of the vernier over the plain compass consists in its adaptation to the retracing the lines of an old survey, and to the surveys of the U. S. public lands, where the lines are based on a true meridian.

Variation of the Needle.

It is well known that the magnetic needle, in almost all parts of the United States, points more or less to the east or west of a true meridian, or north and south line.

This deviation, which is called the ***Variation or Declination*** of the needle, is not constant, but increases or decreases to a very sensible amount in a series of years.

Thus, at Troy, N. Y., a line bearing in 1871, N. 31° E., would in 1891, with the same needle, have a bearing of about N. 32° 30′ E., the needle having thus in that interval traveled a full degree to the west.

For this reason, therefore, in running over the lines of a farm from field notes of some years standing, the surveyor would be obliged to make an allowance, both perplexing and uncertain, in the bearing of every line.

To avoid this difficulty the *vernier* was devised, the arrangement of which we shall now describe.

The Vernier is divided on its edge to thirty equal parts, and figured in two series on each side of the center line.

In the same plane with the vernier is an arc or limb, fixed to the main plate of the compass, and graduated to half degrees.

The surfaces of both vernier and limb are silvered.

On the vernier are thirty equal divisions, which exactly correspond in length with thirty-one of the half degrees of the limb.

Each division of the vernier is, therefore, one-thirtieth or, in other words, one minute longer than a single division of the limb.

To Read the Vernier.—In "reading" the vernier, if it is moved to the right, count the minutes from its zero point to the left, and vice versa. Proceed thus until a division on the vernier is found exactly in line with another on the limb, and the lower row of figures on the vernier will give the number of minutes passed over. When the vernier is moved more than fifteen minutes to either side, the number of the additional minutes up to thirty or one-half degree of the limb is given by the upper row of figures on the opposite side of the vernier.

To read beyond thirty, add the minutes given by the vernier to that number, and the sum will be the correct reading.

In all cases when the zero point of the vernier passes a whole degree of the limb, this must be added to the minutes, in order to define the distance over which the vernier has been moved.

To Turn Off the Variation.—It will now be seen that the surveyor having the vernier compass, can by moving the vernier to either side, and with it of course the compass-circle attached, set the compass to any variation.

He therefore places his instrument on some well-defined line of the old survey, and turns the tangent-screw until the needle of his compass indicates the same bearing as that given in the old field-notes of the original survey.

Then screwing up the clamping nut underneath the vernier, he can run all the other lines from the old field-notes without further alteration.

The reading of the vernier on the limb in such a case would give the change of variation at the two different periods.

The variation of the needle at any place being known, a true meridian, or north and south line, may be run by moving the vernier to either side, as the variation is east or west, until the arc passed over on the limb is equal to the angle of variation; and then turning the compass until the needle is made to cut the zeros on the divided circle, when the line of the sights would give the direction of the true meridian of the place.

Such a change in the position of the vernier is necessary in surveying the U. S. public lands, which are always run from the true meridian.

The Line of No Variation, as it is called, or that upon which the needle will indicate a true north and south direction, is situated in the United States, nearly in an imaginary line drawn from the middle of Lake Erie to Cape Hatteras, on the coast of North Carolina.

A compass-needle, therefore, placed east of this line would have a variation to the west, and when placed west of the line, the variation would be to the east, and in both cases the variation would increase as the needle was carried farther from the line of no variation.

Thus, in Minnesota the variation is from 10° to 11° to the east, while in Maine it is from 14° to 16° to the west.

At Troy, in the present year, 1891, the variation is about 10° 30′ to the west, and is increasing in the same direction from three to four minutes annually.

To Read to Minutes.—A less important use of the vernier is to give a reading of the needle to single minutes, which is obtained as follows:

First be sure, as in all observations, that the zero of the vernier exactly corresponds with that of the limb; then noting the number of whole degrees given by the needle, move back the compass-circle with the tangent-screw until the nearest whole degree-mark is made to coincide with the point of the needle, read the vernier as before described, and this reading added to the whole degrees will give the bearing to minutes.

To Adjust the Compass.

The Levels.—First bring the bubbles into the center, by the pressure of the hand on different parts of the plate, and then turn the compass half-way around; should the bubbles run to the end of the tubes, it would indicate that those ends were the highest; lower them by tightening the screws immediately under, and loosening those under the lowest ends until, by estimation, the error is half removed; level the plate again, and repeat the first operation until the bubbles will remain in the center, during an entire revolution of the compass.

The Sights may next be tested by observing through the slits a fine hair or thread, made exactly vertical by a plumb. Should the hair appear on one side of the slit, the sight must be adjusted by filing off its under surface on that side which seems the highest.

The Needle is adjusted in the following manner: Having the eye nearly in the same plane with the graduated rim of the compass-circle, with a small splinter of wood or a slender iron wire, bring one end of the needle in line with any prominent division of the circle, as the zero, or ninety degree-mark, and notice if the other end corresponds with the degree on the opposite side; if it does, the needle is said to "cut" opposite degrees; if not, bend the center-pin by applying a small brass wrench, furnished with our compasses, about one-eighth of an inch below the point of the pin, until the ends of the needle are brought into line with the opposite degrees.

Then, holding the needle in the same position, turn the compass half-way around, and note whether it now cuts opposite degrees; if not, correct half the error by bending the needle, and the remainder by bending the center-pin.

The operation should be repeated until perfect reversion is secured in the first position.

This being obtained, it may be tried on another quarter of the circle; if any error is there manifested, the correction must be made in the center-pin only, the needle being already straightened by the previous operation.

When again made to cut, it should be tried on the other quarters of the circle, and corrections made in the same manner until the error is entirely removed, and the needle will reverse in every point of the divided surface.

To Use the Compass.

In using the compass, the surveyor should keep the south end towards his person, and read the bearings from the north end of the needle. He will observe that the E and W letters on the face of the compass are reversed from their natural position, in order that the direction of the line of sight may be correctly read.

The compass-circle being graduated to half-degrees, a little practice will enable the surveyor to read the bearings to quarters, or even finer—estimating with his eye the space bisected by the point of the needle, and as this is as low as the traverse table is usually calculated, it is the general practice.

Sometimes, however, a small vernier is placed upon the south end of the needle, and reads the circle to five minutes of a degree—the circle being in that case graduated to whole degrees.

This contrivance, however, is quite objectionable on account of the additional weight imposed on the center-pin, and the difficulty of reading a vernier which is in constant vibration; it is therefore but little used.

To Take Angles of Elevation.—Having first leveled the compass, bring the south end towards you, and place the eye at the little button, or eye-piece, on the right side of the south sight, and with the hand fix a card on the front surface of the north sight, so that its top edge will be at right angles to the divided edge, and coincide with the zero mark; then sighting over the top of the card, note upon a flagstaff the height cut by the line of sight; then move the staff up the elevation, and carry the card along the sight until the line of sight again cuts the same height on the staff, read off the degrees and half-degrees passed over by the card, and you will have the angle required.

For Angles of Depression.—Proceed in the same manner, using the eye-piece and divisions on the opposite sides of the sights, and reading from the top of the sights.

When the Instrument is to be used in making new surveys, the vernier should be set at zero and securely clamped by screwing up the nut beneath the plate.

In surveying old lines, the change of the variation of the needle should be ascertained by setting the compass on some one well-defined line of the tract, and making the bearing to agree with that of the old survey, by moving the circle as already described.

Then the circle can be clamped, and the old lines re-traced from the bearings given by the original surveyor.

When the variation of the needle is known, it can be set off by the vernier, and the compass used to run a true meridian by the needle.

Electricity.—A little caution is necessary in handling the compass, that the glass covering be not excited by the friction of cloth, silk, or the hand, so as to attract the needle to its under surface.

When, however, the glass becomes electric, the fluid may be removed by breathing upon it, or touching different parts of its surface with the moistened finger.

An ignorance of this apparently trifling matter has caused many errors and perplexities in the practice of the inexperienced surveyor.

Repairs of the Compass.

To enable the surveyor to make such repairs as are possible without having recourse to an instrument maker, we here add a few simple directions.

1. ***The Needle.***—It may sometimes happen that the needle has lost its polarity, and needs to be remagnetized; this is effected in the following manner:

The operator being provided with an ordinary permanent magnet,* and holding it before him, should pass with a gentle pressure each end of the needle from center to extremity over the magnetic pole, describing before each pass a circle of about six inches radius, to which the surface of the pole is tangent, drawing the needle towards him, and taking care that the north and the south ends are applied to the *opposite* poles of the magnet.

Should the needle be returned in a path near the magnetic pole, the current induced by the contact of the needle and magnet, in the pass just described, would be reversed, and thus the magnetic virtue almost entirely neutralized at each operation.

When the needle has been passed about twenty-five times in succession, in the manner just described, it may be considered as fully charged.

A fine brass wire is wound in two or three coils on the south end of the needle, and may be moved back or forth in order to counterpoise the varying weight of the north end.

2. ***The Center-Pin.***—This should occasionally be

* A magnet suitable for this purpose costs 25 to 50 cents.

examined, and if much dulled, taken out with the brass wrench, already spoken of, or with a pair of pliers, and sharpened on a hard oil-stone—the operator placing it in the end of a small stem of wood, or a pin-vise, and delicately twirling it with the fingers as he moves it back and forth at an angle of about 30 degrees to the surface of the stone.

When the point is thus made so fine and sharp as to be invisible to the eye, it should be smoothed by rubbing it on the surface of a soft and clean piece of leather.

3. ***To Put in a New Glass.***—Unscrew the "bezel ring" which holds it, and with the point of a knife-blade spring out the little brass ring above the glass, remove the old glass and scrape out the putty; then if the new glass does not fit, smooth off its edges by holding it obliquely on the surface of a grindstone until it will enter the ring easily; then put in new putty, spring in the brass ring, and the operation will be complete.

4. ***To Replace a Spirit-Level.***—Take out the screws which hold it on the plate, pull off the brass ends of the tube, and with a knife-blade scrape out the plaster from the tube; then with a stick made a little smaller than the diameter of the tube, and with its end hollowed out, so that it will bear only on the broad surface of the level vial, push out the old vial and replace it with a new one, taking care that the crowning side, which is usually marked with a file on the end of the vial, is placed on the upper side.

When the vial does not fit the tube it must be wedged up by putting under little slips of paper until it moves in snugly.

After the vial is in its place, put around its ends a little boiled plaster, mixed with water to the consistency of putty, taking care not to allow any to cover the little tip of the glass, then slip in the brass ends and the operation will be completed.

A little beeswax, melted and dropped upon the ends of the vial, is equally as good as the boiled plaster, and often more easily obtained.

We would here remark that an extra glass and level vials are always furnished, free of charge, with every new compass and transit sent out of our works.

Sizes of the Vernier Compass.

We make three sizes of this compass, having needles of four, five and six inches long respectively, the main plates of the two largest being over fifteen inches long ; and of the smallest size, thirteen inches, the sights of the last are also about an inch shorter.

In the four and five inch Vernier Compasses, the variation arc is within the compass-circle like that of the railroad compass before described, and the variation is set off to minutes by a pinion-head underneath the plate; the circle is also clamped at any variation by a screw placed opposite the pinion.

Weight of the Vernier Compasses.

The average weights of the different sizes, including the brass head of the jacob-staff, beginning with the smallest, are respectively 6¼, 8¾, and 10½ pounds.

THE PLAIN COMPASS.

No. 117.

Price, with 6-inch needle and jacob-staff mountings, $35.00.

As represented, the Plain Compass has a six-inch needle, and is furnished with levels, sight-vanes, socket, &c.

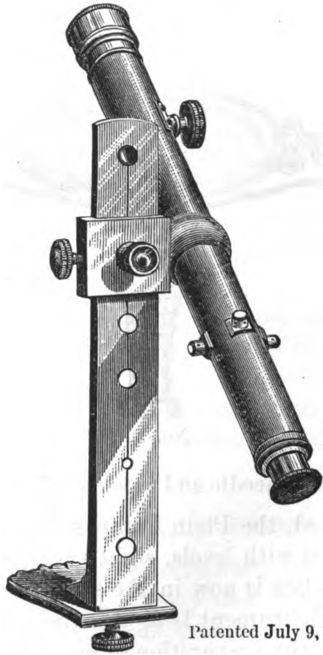
The compass-box is now in the same piece with the main plate, and the instrument is used mainly in the surveys of new lines, or in the preparation of maps, where the variation of the needle is not required.

The Adjustments and use of the Plain Compass are substantially the same as those of the instrument just described.

Telescopic Sights.

We have for years supplied for this and the other compasses a telescope fitted to the sight-vanes, which could be put on and removed at will, and it has met with very great approval, hundreds of them being now in use in different parts of the country; this attachment we will now more fully describe.

THE TELESCOPIC SIGHT.



Patented July 9, 1878.

Price of Telescope No. 131 as shown, with movable band for attaching, $17.00.

This valuable improvement of the Surveyors' Compass consists of a telescope furnished with the usual cross-wires, &c., 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 attachment 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, or, still better, a screw or pin on the inner surface of 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:

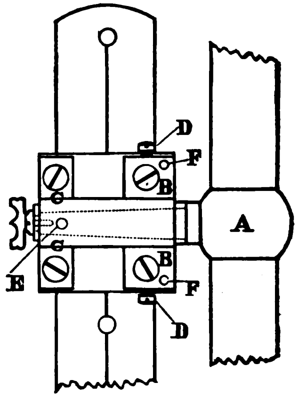
(1) To make the telescope axis horizontal.

(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 center when the instrument is revolved upon its spindle; the sights also should trace a plumb-line when the compass is level.

The means of effecting these adjustments will be understood by the engraving on page 154 and the outline cut here given, the first showing the rear, the second the front view of the band to which the telescope is attached.



(1) To make the first adjustment—The compass being in good order, first bring the levels into the center; 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 raise 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 screws B B, C C, which confine the piece which contains the spindle of the telescope, and by the screws D D, the lower of which should be unscrewed, and the upper one tightened, raise the telescope until the wire will follow the vertical line.

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 hundred 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 screws B B, and screw up those in front marked F F, the ends only of which are shown in the figure, until the vertical wire bisects the object —looking again through the vanes to see 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 screws B B and F F, as already described.

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 the account of the various transit instruments already given, and may be effected with this attachment 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 attachment 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 telescope 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 hundred 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 screws B B, F F, 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 attachment may be enabled to apply it to their own compasses without further trouble or expense.

When the adjustments are complete the attachment 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 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 fore or back, 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 attachment 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.

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.

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 make three styles of the telescopic sight; see Price List, Nos. 130, 131, 132.

The stadia wires alluded to in No. 132 are two horizontal parallel cross-wires, one on each side of the center 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 center of the instrument, usually one foot or one link on the rod to one hundred feet or one hundred links in distance—as more fully described in our account of other instruments.

Attachments to Telescopic Sights.

In the account of the Solar Compass we have already given a figure and description of telescopic sight with stadia, level, and clamp and tangent, and these with vertical circle reading to five minutes, are often applied and found to be serviceable.

Sizes and Weights of the Plain Compass.

Three different sizes of this instrument are in common use, having, respectively, four, five, and six-inch needles, and differing also in the length of the main-plate, which in the four-inch compass is twelve and a half inches long, and in the larger sizes, fifteen and a half inches.

The six-inch needle compass is generally preferred.

Weight of the Plain Compasses.

The average weights of the different sizes, with the brass mountings of the jacob-staff, are :

For the 4-inch	needle,	6	lbs.
For the 5-inch	"	$7\frac{3}{4}$	"
For the 6-inch	"	$9\frac{1}{2}$	"

POCKET INSTRUMENTS.

We manufacture a variety of small instruments so portable and yet so efficient that they are often used in preference to the larger ones, especially for preliminary or reconnoitering work, and these will now be described.

The Pocket Solar Compass, shown on page 162, has a needle 3 inches long, and a limb of 4½ inches 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, &c. There is a clamp and tangent movement to the horizontal limb, and another to the whole instrument about its spindle.

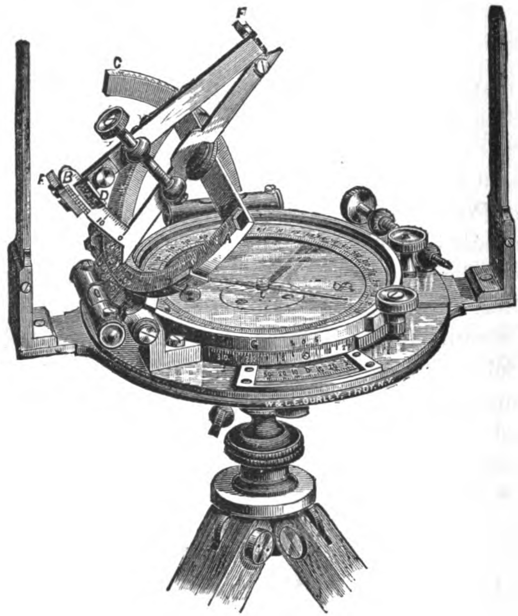
Both tangent movements are now made with an opposing spring, as shown in the cut of the Mountain Solar Transit.

The distance between the sights is nearly 7 inches, the sights themselves are 4½ inches high, and have a slot and hair in half their heights; 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 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 POCKET SOLAR COMPASS.



No. 140B.

Price as shown........................ $105 00.

PRICES.

		Post.
No. 140A.—Pocket Solar Compass, with staff mountings and mahogany box..	$100 00	$1 25
No. 140B.—Pocket Solar Compass, with Light Tripod, as shown.....	105 00	2 00
No. 140C.— " " " " " Extension Tripod...	110 00	2 25
No. 140D.— " " " " " " " and Leveling Plates.	120 00	2 50
No. 141.—Side Telescope and Counterpoise fitted to new Pocket Solar Compass	25 00	56
No. 142A.—Leather Case with Shoulder Straps for new Pocket Solar Compass.. ..	4 00	40
No. 142B.—Leather Case with Shoulder Straps for Pocket Solar Compass with Telescope and extras	6 00	60

The latitude arc is divided to half degrees, and reads by its vernier to five minutes of a degree. The declination arc is divided to quarter degrees, and reads by its vernier to single minutes of a degree. The hour arc is divided on its inner edge into hours and twelfths, or spaces of five minutes of time, the index of the declination arc above easily enabling one to read to single minutes of time.

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 shown, upon a light tripod like the other pocket compasses, and often with small leveling-head with clamp and tangent screws.

Sometimes a side telescope with counterpoise is substituted for the sight-vanes.

To Use the Pocket Solar.

The instrument is set upon its tripod or staff, and carefully leveled ; the declination of the sun for the given day and hour is obtained from the Ephemeris supplied by us with this and other solar instruments, and set off upon its arc, and the hour arc is raised until its vernier marks the latitude of the place upon the latitude arc.

The equation of time for the day 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.

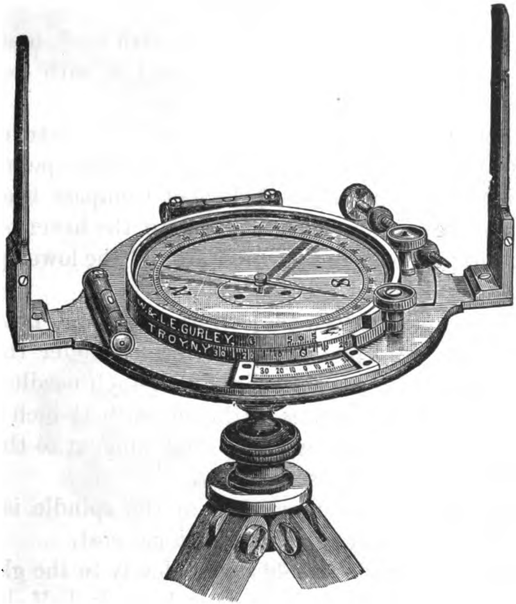
The index of the declination arc being then set to the proper division on the hour arc, and the declination arm directed to the sun, the limb being also set at zero, and the sun's image brought between the hour lines of the silver plate by turning the whole instrument upon its spindle, the sights will indicate the *true meridian* precisely as with the larger Solar Compass.

The compass-circle being now turned by the pinion until the needle points to zero, the needle also will be set to the true meridian, and the variation of the needle can be read off upon the outside divisions of the compass-box.

The Adjustments and use of this Pocket Solar are substantially the same as those of the Solar Compass already described, and its indications so accurate that after repeated trials we are satisfied that it will give the true meridian within an error of less than three minutes of a degree, which taken in connection with the deflection of the magnetic needle will indicate with certainty the presence and direction of veins of magnetic iron ore.

Indeed we have the assurance of competent surveyors that while it is much more portable it is also very nearly or quite as accurate in all its indications as the large Solar Compass; its weight, excluding box and tripod, is $4\frac{3}{4}$ lbs.

RAILROAD POCKET COMPASS.



No. 159.

This instrument is a single vernier Railroad Compass in miniature.

The variation arc, the vernier opening and the clamp and tangent movement are now made like those of the larger Railroad Compass shown on page 133.

The limb is on the lower plate, is five inches in diameter, and reads to single minutes by the vernier. The needle is $3\frac{1}{2}$ inches long, and its variation can be set off to single minutes as in the larger instruments.

The Railroad Pocket Compass can be used for a great variety of work, and with light extension tripod is especially adapted for surveys of mines, &c., where angles must be taken independently of the needle.

The price of this little instrument, with staff mountings only, is $40, with light tripod $45, and if with extension tripod $50.

Another and more common form of this instrument is shown on page 167, with attachments of telescope, etc.

In this style of the Railroad Pocket 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 five minutes of a degree in the 3½-inch needle instrument, and to single minutes in the one with 4½-inch needle; the last-named has also a clamp and tangent to the limb, the 3½-inch size a clamp-screw only.

A clamp and tangent movement to the spindle is added whenever desired, and at small additional cost.

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 4½-inch needles we have recently adapted a telescopic attachment (see page 167). When the sights are inclined to each other as shown, a short standard with two projecting arms below and supporting the telescope above, is secured by two milled-head screws to the tops of the sights, and thus a telescope placed in position, making the instrument in effect a very light Surveyors' Transit.

RAILROAD POCKET COMPASS.

(WITH TELESCOPIC ATTACHMENT, ETC.)

No. 159D.

Price, as shown................\$83 00

The attachments of a vertical circle, level, and clamp and tangent as show 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 center of the instrument.

The short standard, with two projecting arms, holding the telescope axis, and which is secured to the top of the sights when they are inclined to each other as shown in the figure, can be detached at will, and with the telescope placed in the case, or replaced in a few moments' time, and without derangement of any adjustments.

The Railroad Pocket Compass can be used either on a jacob-staff, or with small tripod, and if desired, with small leveling-head, as shown on page 167.

WEIGHT OF THE RAILROAD POCKET COMPASSES,

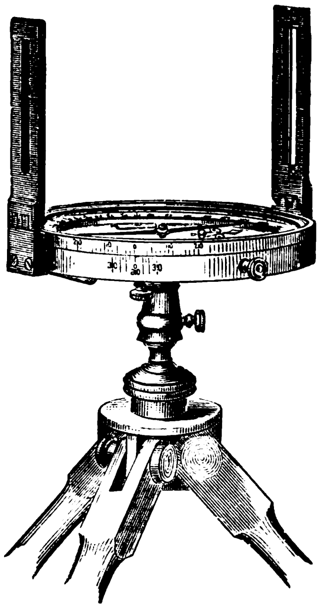
Including the brass mountings of the jacob-staff, but without tripod.

No. 157.—3½-inch compass, about	......................2¼	lbs.
" 158.—4½-inch " "	......................4½	"
" 159.—3½-inch " "	4	"
" 159A, B or C.—4½-inch compass, about	...........6½	"
" 159D.— 4½-inch " "	...........7¾	"

No. **PRICES.**

No.		
157.—	Railroad Pocket Compass, with folding sights, staff mountings, two levels 3½-inch needle, with limb reading to five minutes.............	$23 00
158.—	Railroad Pocket Compass, 4½-inch needle, clamp and tangent to limb, with limb reading to one minute..........	33 00
159A.—	Railroad Pocket Compass, 4½-inch needle, clamp and tangent to limb, with limb reading to one minute, with clamp and tangent to the main spindle or socket, and fitted with our new telescopic sight No. 130, with the extras of level, vertical circle to 5′, and clamp and tangent to axis of telescope. Price, including tripod....	70 00
159B.—	Same as above, but with telescopic sight No. 131.................	75 00
159C.—	do do do No. 132	78 00
159D.—	do do do No. 132, and with leveling adopter, as shown on page 167	83 00

THE VERNIER POCKET COMPASS.



Nos. 155 and 156.

Price as shown, $3\frac{1}{2}$-inch needle, with tripod, \$21.00.
If $4\frac{1}{2}$-inch needle, and tripod, \$23.00.

This is a most excellent and portable instrument for preliminary work, having a fine needle, and also a vernier and clamping-nut by which the sights can be placed at an angle with the line of zeros, so as to set off the variation of the needle, as with the Vernier Compass.

The sights are made with a slot in the south vane, and a hair in the north one, for readily finding the object; they also fold down to the compass, when it is packed in the case.

The compass is furnished with jacob-staff mountings; often a very light tripod is ordered for it; it has also two levels, and is neatly packed in a mahogany case.

We make two sizes of the Vernier Pocket Compass having needles of 3½ and 4½ inches respectively; both have the compass-circle divided to half degrees; in the 3½-inch size the variation vernier reads to five minutes; in the 4½-inch size the variation is set off to single minutes. When desired, a rack-movement with pinion is supplied, in order to set off the variation more readily.

The 3½-inch compass weighs about 1¾ lbs.; and the 4½-inch compass about 2¾ lbs.

VERNIER POCKET COMPASS.

(WITH TELESCOPIC ATTACHMENT, ETC.)

The arrangement for attaching a telescope and extras to the sights of the 4½-inch Vernier Pocket Compass is shown on page 171, making this little instrument a Transit Compass for ordinary land surveying and reconnoissance, with power to give levels and grades with accuracy sufficient for all ordinary practice.

The sights in such an arrangement are placed at one side, that the telescope may be directly over the center, and in such case the instrument should have a clamp and tangent movement for spindle, as shown in the figure.

When packed for transportation, the telescope and support are detached from the sights, and packed separately in the case.

Staff Mountings are always furnished with these compasses; and a light tripod, as shown, is very generally added.

The weight of compass No. 162, without tripod, is about 4½ lbs; the tripod weighs about 4 lbs.

VERNIER POCKET COMPASS.

(WITH TELESCOPIC ATTACHMENT, ETC.)

No. 162.

Price, complete as shown................$63 00

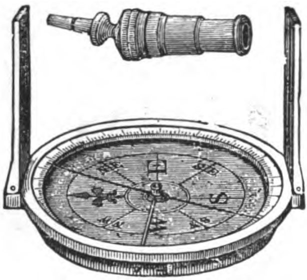
PRICES.

No. 160.—Vernier Pocket Compass, 4½-inch needle. with clamp and tangent to the main spindle or socket, and fitted with our new telescopic sight No. 130, with the extras of level, vertical circle to 5′, and clamp and tangent to axis of telescope. Price, including tripod....$55 00

No. 161.—Same as above, but with telescopic sight, No. 131... .... 60 00

No. 162.— do do do No. 132, as shown........ 63 00

PLAIN POCKET COMPASSES.



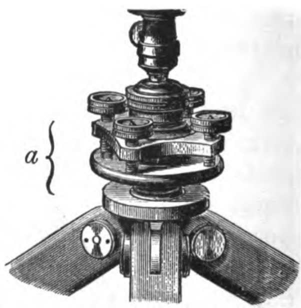
Nos. 151 and 152.

Besides the Vernier Pocket Compass we also furnish an instrument without a vernier, but often a very serviceable compass.

These are made of 2½ or 3½-inch needles in the different sizes, and supplied with levels and jacob-staff mountings as desired; they are also packed in a light mahogany case, the sights folding down close to the glass.

NOTE.—For prices of Plain Pocket Compasses see Nos. 150 to 154 on page 15.

Leveling Adopter.—We have recently introduced the appliance shown in No. 173, at *a*, for use with the Pocket Compasses (Nos. 151 to 162), giving in connection with the ball a rapid and accurate means of leveling any of the smaller instruments.

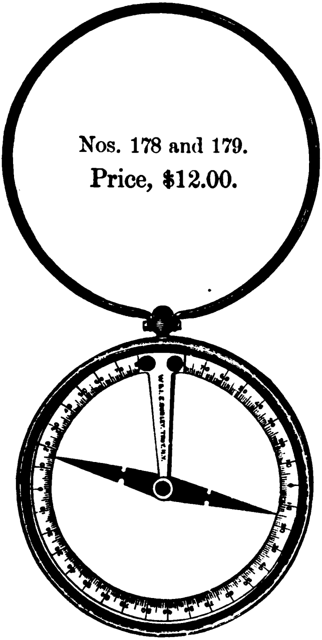


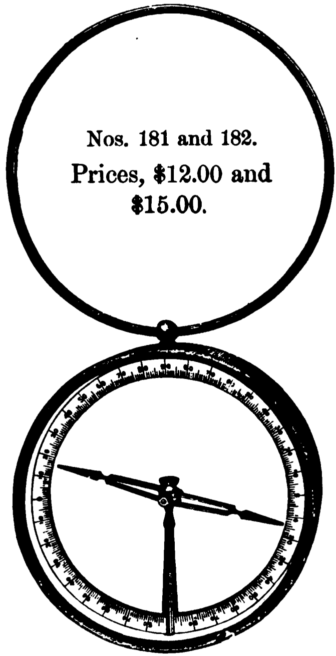
No. 173.

Its weight is less than one pound; it can be attached to the lighter tripods by merely removing the brass cap, and its value and use are apparent on inspection. Price, $5.00.

We also make a larger size of the adopter for use with our larger compasses. Price, $7.00.

MINERS' OR DIP COMPASSES.





The Dip Compasses, two forms of which are here shown, consist essentially of a magnetic-needle so suspended as to move readily in a vertical direction, the angle of inclination or "dip" being measured upon the divided rim of a small compass box.

When in use, the ring or bail is held in the hand—the compass-box by its own weight takes a vertical position—and must also be in the plane of the magnetic meridian.

In this position the needle, when unaffected by the attraction of iron, assumes a horizontal line, as shown by the zeros of the circle. When brought over any mass of iron it dips, and thus detects the presence of iron ores with certainty.

If the Miners' Compass is held horizontally it serves as an ordinary Pocket Compass, and indicates the magnetic meridian, in the plane of which it should be held when used to ascertain the dip of the place where the observation is made.

Several different styles of this instrument are made; those shown as Nos. 178 and 179, with a 3-inch needle, have the two sides of glass, and are provided with a stop for the needle, worked by the little brass knob between the ends of the ring.

The Norwegian Compass, Nos. 181 and 182, is a modification of one used in Northern Europe.

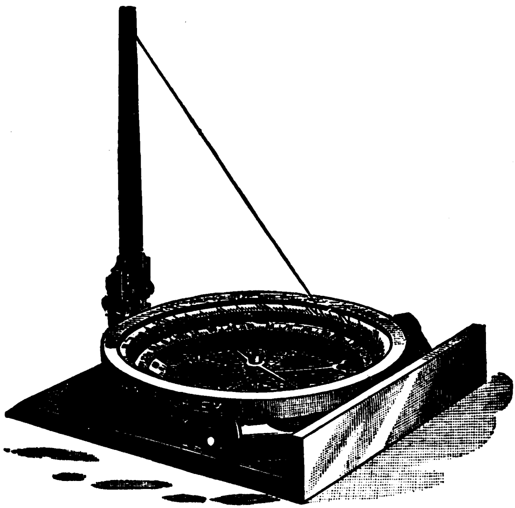
This has a needle of either 3 or 4 inches resting upon a single vertical pivot so as to move freely in a horizontal direction, and thus place itself with certainty in the magnetic meridian; while at the same time, being attached to the needle-cap by two delicate pivots, one on each side, it is free to dip—like that of the ordinary miners' compass, described above.

PRICES.

No.			Post.
178.	—3-inch needle, glass on both sides, wood box, stop to needle.....	$12 00	$ 20
179.	—3-inch needle, glass on both sides, brass covers, stop to needle..	12 00	25
181.	—"Norwegian Needle," glass on both sides, brass covers, 3-inch needle, superior article..........	12 00	30
182.	—Same as No. 181, but with 4-inch needle..........	15 00	40

NOTE.—No instrument made that will indicate the presence of gold or silver.

THE DIAL COMPASS.



No. 148. Price, $16.00.

This little instrument has a needle three inches long, and with its compass circle is inclosed in a circular box set upon a brass base four inches square, three edges of which are chamfered and divided; one on the W-side of the compass into inches and tenths, the two others into degrees and half degrees, and figured from a center on the southwest corner of the base.

The compass circle is movable in order to set off the variation of the needle, and has a vernier attached to it on the inside, reading a divided arc on the face of the compass to three minutes of a degree.

There is also on the south side of the face an arc of 180°, figured from 0 to 90 on each side of the south or zero line of the face.

A little pendulum with index point hung from the center-pin reads this arc, when the compass is set up, vertical, on the raised south edge, thus making it a clinometer or slope measurer.

The sight is hinged so as to fold in packing, but when erect, makes taut a fine silk thread attached at one end to the sight and at the other to a brass hour-circle above the compass glass, at an angle with the plane of the hour-circle equal to that of the latitude of the place where the compass is used. The hour-circle is divided for any required latitude like that of a sun-dial, the hair serving as a gnomon to give apparent time with the sun.

When it is desired to use the instrument at a latitude a degree or two either higher or lower than that for which the hour-circle is divided, the end of the thread attached to the sight may be made adjustable, so as to be either raised or lowered on the sight until the angle of the thread with the plane of the hour-circle is made equal to that of the latitude required.

Extra hour arcs, graduated for any latitude, and to fit the same compass, can be furnished when desired.

In using the Dial Compass it is first leveled carefully, the equation of time for the given day allowed for, and then by observation on the sun at midday the true meridian approximately obtained.

The needle may then be set to the meridian by laying off the variation, and any deflection of the needle from the true meridian will indicate the presence of veins of magnetic iron ore.

LEVELING INSTRUMENTS.

THE Y LEVEL.

Of the different varieties of the leveling instrument, that termed the Y Level has been almost universally preferred by American engineers, on account of the facility of its adjustment and superior accuracy.

Of these levels we manufacture four different sizes, having telescopes of fifteen, eighteen, twenty, and twenty-two inches long, respectively.

The engraving on page 178 represents our twenty-inch Y Level.

We shall consider the several parts of the instrument in detail:

The telescope has at each end a ring of bell-metal, turned very truly and both of exactly the same diameter; by these it revolves in the wyes, or can be at pleasure clamped in any position when the clips of the wyes are brought down upon the rings, by pushing in the tapering-pins.

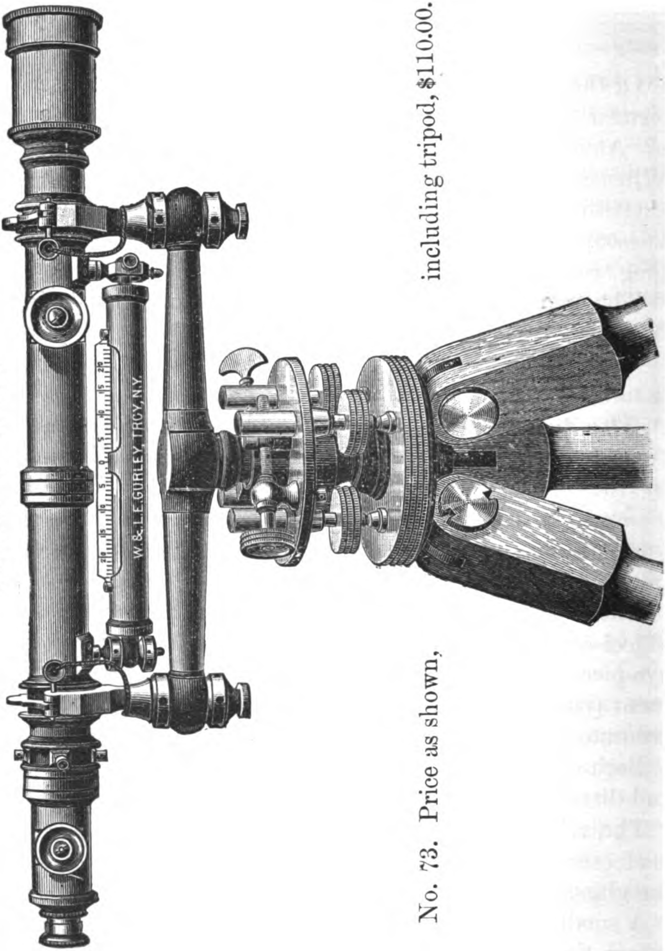
The telescope has a rack and pinion movement to both object-glass and eye-piece, an adjustment for centering the eye-piece, shown at A A, in the sectional view of the instrument (page 180), and another seen at C, for ensuring the accurate projection of the object-glass, in a straight line.

Both of these are completely concealed from observation and disturbance by thin rings which screw over them.

The telescope has also a shade over the object-glass, so made that, whilst it may be readily moved on its slide over the glass, it cannot be dropped off and lost.

A small compass, without sights and with 2½-inch needle, is sometimes attached to the telescopes of the larger leveling instruments, and used to obtain the bearing of lines when desired; its extra cost is $10.00.

20-INCH Y LEVEL.



No. 73. Price as shown, including tripod, $110.00.

NOTE.—The tangent movement of the leveling-head is now made with an opposing spring. Stadia wires are furnished with any of our Levels, free of charge, if requested when the Level is ordered.

The interior construction of the telescope will be readily understood from the sectional cut on page 180, which exhibits the adjustment which insures the accurate projection of the object-glass slide.

As this is peculiar to our instruments, and is always made by the maker so permanently as to need no further attention at the hands of the engineer, we shall here describe the means by which it is effected, somewhat in detail.

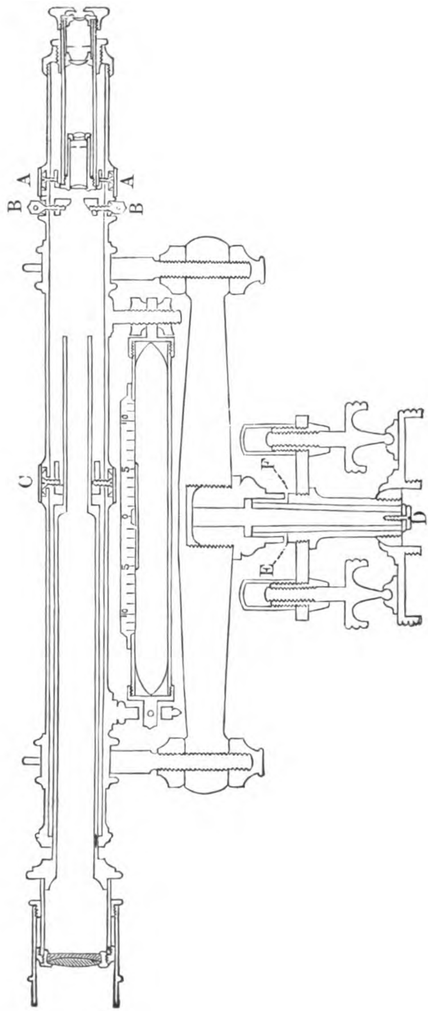
The necessity for such an adjustment will appear, when we state, that it is almost impossible to make a telescope tube perfectly straight on its interior surface.

Such being the case, it is evident that the object-glass slide which is fitted to this surface, and moves in it, must partake of its irregularity, so that the glass and the line of collimation depending upon it, though adjusted in one position of the slide, will be thrown out when the slide is moved to a different point.

To prove this, let any level be selected which is constructed in the usual manner, and the line of collimation adjustment upon an object taken as near as the range of the slide will allow; then let another be selected, as distant as may be clearly seen; upon this revolve the wires, and they will almost invariably be found out of adjustment, sometimes to an amount fatal to any confidence in the accuracy of the instrument. The arrangement adopted by us to correct this imperfection, and which so perfectly accomplishes its purpose, is shown on page 180.

Here are seen the two bearings of the object-glass slide, one being in the narrow bell-metal ring, which slightly contracts the diameter of the main tube, the other in the small adjustable ring, also of bell-metal, shown at C, and suspended by four screws in the middle of the telescope.

Advantage is here taken of the fact, that the rays of



SECTIONAL VIEW OF Y LEVEL.

light are converged by the object-glass, so that none are obstructed by the contraction of the slide, except those which diverge, and which ought always to be intercepted, and absorbed in the blackened surface of the interior of the slide.

Now, in such a telescope, the perfection of movement of the slide, depends entirely upon its exterior surfaces, at the points of the two bearings.

These surfaces are easily and accurately turned, concentric, and parallel with each other, and being fitted to the rings, it only remains necessary to adjust the position of the smaller ring, so that its center will coincide with that of the optical axis of the object-glass.

When this has been once well done, no further correction will be necessary, unless the telescope should be seriously injured.

The manner in which the adjustment of the object-glass slide is effected, will be considered when we come to speak of the other adjustments.

Rack and Pinion.—As seen in the engraving, our Level telescopes are usually furnished with the ordinary rack and pinion movement to both object and eye tubes.

The advantages of an eye-piece pinion are, that the eye-piece can be shifted without danger of disturbing the telescope, and that the wires are more certainly brought into distinct view, so as to avoid effectually any error of observation, arising from what is termed the instrumental parallax.

We usually place our object-slide pinion on the side—both of Transit telescopes, and of those of the Level. The pinion of the eye-tube is always placed on the side of the telescope.

The Level or ground bubble tube is attached to the under side of the telescope, and furnished at the different ends with the usual movements, in both horizontal and vertical directions.

The aperture of the tube, through which the glass vial appears, is about five and one-fourth inches long, being crossed at the center by a small rib or bridge, which greatly strengthens the tube.

The level scale which extends over the whole length, is graduated into tenths of an inch, and figured at every fifth division, counting from zero at the center of the bridge; the scale is set close to the glass.

The level vial is made of thick glass tube, selected so as to have an even bore from end to end, and finely ground on its upper interior surface, that the run of the air-bubble may be uniform throughout its whole range.

The sensitiveness of a ground level, is determined best by an instrument called a level-tester, having at one end two Y's to hold the tube, and at the other a micrometer wheel divided into hundredths, and attached to the top of a fine-threaded screw which raises the end of the tester very gradually.

The number of divisions passed over on the perimeter of the wheel, in carrying the bubble over a tenth of the scale, is the index of the delicacy of the level. In the tester which we use, a movement of the wheel ten divisions to one of the scale, indicates the degree of delicacy generally preferred for railroad engineering.

For canal work practice, a more sensitive bubble is often desired, as, for instance, one of seven or eight divisions of the wheel, to one of the scale.

The Wyes of our levels are made large and strong, of the best bell-metal, and each have two nuts, both being adjustable with the ordinary steel pin.

The clips are brought down on the rings of the telescope-tube by the Y pins, which are made tapering, so as to clamp the rings very firmly.

The clip of one of the wyes has a little pin projecting from it, which entering a recess filed in the edge of the ring, ensures the horizontal position of the cross-wire.

The Level-Bar is made round, of the best bell-metal, and shaped so as to possess the greatest strength in the parts most subject to sudden strains.

Connected with the level-bar is the head of the tripod-socket.

The Socket is compound; the interior spindle D (see page 180), upon which the whole instrument is supported, is made of steel, and nicely ground, so as to turn evenly and firmly in a hollow cylinder of bell-metal; this again has its exterior surface fitted and ground to the main socket E E of the leveling-head.

The bronze cylinder is held upon the spindle by a washer and screw, the head of the last having a hole in its center, through which the string of the plumb-bob is passed.

The upper part of the instrument, with the socket, may thus be detached from the leveling-head; and this also, as in the case of all our instruments, can be unscrewed from the tripod-head, so that both may be conveniently packed in the box.

A little under the upper parallel plate of the leveling-head, and in the main socket, is a screw which can be moved into a corresponding groove, turned on the outside of the hollow cylinder, and thus made to hold the instrument securely when it is carried upon the shoulders.

It will be seen from the engraving, that the arrangement just described allows long sockets, and yet brings the whole instrument down as closely as possible to the tripod-head, both objects of great importance in the construction of any instrument.

The Leveling Head has the same plates and leveling-screws as that described in the account of the Engineers' Transit; the tangent-screw has also an opposing spring as there described.

For our fifteen-inch level we make a tripod-head, similar to that used with the lighter Engineers' Transit.

The Adjustments.

Having now completed the description of the different parts of the Leveling Instrument, we are ready to proceed with their adjustments, and shall begin with that of the object-slide, which, although always made by the maker, so permanently as to need no further attention at the hands of the engineer, unless in cases of derangement by accident, is yet peculiar to our instruments, and therefore not familiar to all engineers.

To Adjust the Object-Slide.—The maker selects an object as distant as may be distinctly observed, and upon it adjusts the line of collimation, in the manner hereafter described, making the center of the wires to revolve without passing either above or below the point or line assumed.

In this position, the slide will be drawn in nearly as far as the telescope-tube will allow.

He then, with the pinion-head, moves out the slide until an object, distant about ten or fifteen feet, is brought clearly into view; again revolving the telescope in the Y's, he observes whether the wires will reverse upon this second object.

Should this happen to be the case, he will assume that, as the line of collimation is in adjustment for these two distances, it will be so for all intermediate ones, since the bearings of the slide are supposed to be true, and their planes parallel with each other.

If, however, as is most probable, either or both wires fail to reverse upon the second point, he must then, by estimation, remove half the error by the screws at C (page 180), at right angles to the hair sought to be corrected, remembering, at the same time, that on account of the inverting property of the eye-piece, he must move the slide in the direction which apparently increases the error. When both wires have thus been treated in succession, the line of collimation is adjusted on the near object, and the telescope again brought upon the most distant point; here the tube is again revolved, the reversion of the wires upon the object once more tested, and the correction, if necessary, made in precisely the same manner.

He proceeds thus, until the wires will reverse upon both objects in succession; the line of collimation will then be in adjustment at these and all intermediate points, and by bringing the screw-heads, in the course of the operation, to a firm bearing upon the washers beneath them, the adjustable ring will be fastened so as for many years to need no further adjustment.

When this has been completed, the thin brass ferule is screwed over the outside ring, concealing the screw-heads, and avoiding the danger of their disturbance by an inexperienced operator.

In effecting this adjustment, it is always best to bring the wires into the center of the field of view, by moving the little screws A A (page 180), working in the ring which embraces the eye-piece tube.

Should the engineer desire to make the adjustment of the object-slide, it will be necessary to remove the bubble-tube, in order that the small screw immediately above its scale may be operated upon with the screw-driver.

The adjustment we have now given is preparatory to those which follow, and are common to all leveling instruments of recent construction, and are all that the engineer will have to do with in using our instruments. What is still necessary then is—

1. *To adjust the line of collimation*, or in other words, to bring both wires into the optical axis, so that their point of intersection will remain on any given point, during an entire revolution of the telescope.

2. *To bring the level-bubble parallel* with the bearings of the Y rings, and with the longitudinal axis of the telescope.

3. *To adjust the wyes*, or to bring the bubble into a position at right angles to the vertical axis of the instrument.

To Adjust the Line of Collimation, set the tripod firmly, remove the Y pins from the clips, so as to allow the telescope to turn freely, clamp the instrument to the leveling-head, and, by the leveling and tangent-screws, bring either of the wires upon a clearly marked edge of some object, distant from one hundred to five hundred feet.

Then with the hand carefully turn the telescope half-way around, so that the same wire is compared with the object assumed.

Should it be found above or below, bring it half-way back by moving the capstan-head screws at right angles to it, remembering always the inverting property of the eye-piece; now bring the wire again upon the object, and repeat the first operation until it will reverse correctly.

Proceed in the same manner with the other wire until the adjustment is completed.

Should both wires be much out, it will be well to bring them nearly correct before either is entirely adjusted.

When this is effected, unscrew the covering of the eye-piece centering screws, shown in the sectional view (page 180) at A A, and move each pair in succession with a small screw-driver, until the wires are brought into the center of the field of view.

The inverting property of the eye-piece does not affect this operation, and the screws are moved direct.

To test the correctness of the centering, revolve the telescope, and observe whether it appears to shift the position of an object.

Should any movement be perceived, the centering is not perfectly effected.

It may here be repeated, that in all telescopes the position and adjustment of the line of collimation depends upon that of the object-glass; and, therefore, that the movement of the eye-piece does not affect the adjustment of the wires in any respect.

When the centering has been once effected, it remains permanent, the cover being screwed on again to conceal and protect it from derangement at the hands of the curious or inexperienced operator.

To Adjust the Level-Bubble.—Clamp the instrument over either pair of leveling-screws, and bring the bubble into the center of the tube.

Now turn the telescope in the wyes, so as to bring the level-tube on either side of the center of the bar. Should the bubble run to the end, it would show that the vertical plane, passing through the center of the bubble, was not parallel to that drawn through the axis of the telescope rings.

To correct the error, bring the bubble by estimation half-way back, with the capstan-head screws, which are set in either side of the level-holder, placed usually at the object end of the tube.

Again bring the level-tube over the center of the bar, and the bubble to the center, turn the level to either side, and, if necessary, repeat the correction until the bubble will keep its position, when the tube is turned half an inch or more, to either side of the center of the bar.

The necessity for this operation arises from the fact, that when the telescope is reversed end for end in the wyes in the other and principal adjustment of the bubble, we are not certain of placing the level-tube in the same vertical plane; and therefore it would be almost impossible to effect the adjustment without a lateral correction.

Having now, in great measure, removed the preparatory difficulties, we proceed to make the level-tube parallel with the bearings of the Y rings.

To do this, bring the bubble into the center with the leveling-screws, and then, without jarring the instrument, take the telescope out of the wyes and reverse it end for end. Should the bubble run to either end, lower that end, or what is equivalent, raise the other by turning the small adjusting nuts, on one end of the level, until by estimation half the correction is made; again bring the bubble into the center and repeat the whole operation, until the reversion can be made without causing any change in the bubble.

It would be well to test the lateral adjustment, and make such correction as may be necessary in that, before the horizontal adjustment is entirely completed.

To Adjust the Wyes.—Having effected the previous adjustments, it remains now to describe that of the wyes, or, more precisely, that which brings the level into position at right angles to the vertical axis, so that the bubble will remain in the center during an entire revolution of the instrument.

To do this, bring the level-tube directly over the center of the bar, and clamp the telescope firmly in the wyes, placing it as before, over two of the leveling-screws, unclamp the socket, level the bubble, and turn the instrument half-way around, so that the level-bar may occupy the same position with respect to the leveling-screws beneath.

Should the bubble run to either end, bring it half-way back by the Y nuts on either end of the bar; now move the telescope over the other set of leveling-screws, bring the bubble again into the center, and proceed precisely as above described, changing to each pair of screws, successively, until the adjustment is very nearly perfected, when it may be completed over a single pair.

The object of this approximate adjustment, is to bring the upper parallel plate of the tripod-head into a position as nearly horizontal as possible, in order that no essential error may arise, in case the level, when reversed, is not brought precisely to its former situation. When the level has been thus completely adjusted, if the instrument is properly made, and the sockets well fitted to each other and the tripod-head, the bubble will reverse over each pair of screws in any position.

Should the engineer be unable to make it perform correctly, he should examine the outside socket carefully to see that it sets securely in the main socket, and also notice that the clamp does not bear upon the ring which it encircles.

When these are correct, and the error is still manifested, it will, probably, be in the imperfection of the interior spindle.

After the adjustments of the level have been effected, and the bubble remains in the center, in any position of the socket, the engineer should turn the telescope in the wyes until the pin on the clip of the wye will enter the little recess in the ring to which it is fitted, and by which is ensured the vertical position of the spirit-level and cross-wire.

When the pin is in its place the horizontal wire may be applied to any level line, and in case it should not be parallel with it, two of the cross-wire screws that are at right angles to each other may be loosened, and by the screws outside, the cross-wire ring turned until the wire is horizontal; the line of collimation must then be corrected again and the adjustments of the level will be complete.

To Use the Level.

When using the instrument, the legs must be set firmly into the ground, and neither the hands nor person of the operator be allowed to touch them ; the bubble should then be brought over each pair of leveling-screws successively, and leveled in each position, any correction being made in the adjustments that may appear necessary.

Care should be taken to bring the wires precisely in focus, and the object distinctly in view, so that all errors of parallax may be avoided.

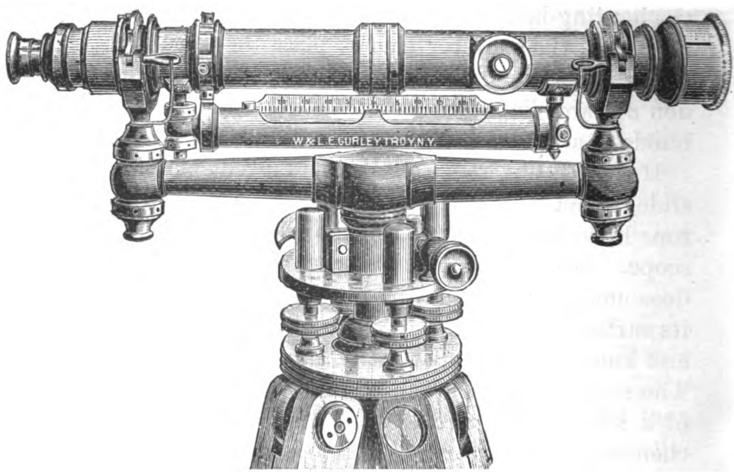
This error is seen when the eye of an observer is moved to either side of the center of the eye-piece of a telescope, in which the foci of the object and eye-glasses are not brought precisely upon the cross-wires and object ; in such a case the wires will appear to move over the surface, and the observation will be liable to inaccuracy.

In all instances the wires and object should be brought into view so perfectly, that the cross-wires will appear to be fastened to the surface, and will remain in that position however the eye is moved.

In running levels it is best wherever possible, that equal fore and back sights should be taken, so as to avoid any error arising from the curvature of the earth.

If the socket of the instrument becomes so firmly set in the leveling-head as to be difficult of removal in the ordinary way, the engineer should place the palm of his hand under the wye-nuts at each end of the bar, and give a sudden upward check to the bar, taking care also to hold his hands so as to grasp it the moment it is free.

If there is any roughness in the movement of the object-slide, it can be looked for in three places:—1. Remove the four little screws that attach the pinion strap to the telescope. See that the pinion turns free in its socket; if it does not, then there is dirt in the bearing that is cutting its surface. Remove the nut at the end of the pinion rod and knock the pinion out of its head with a block of wood. The scratched surface can be rubbed smooth with the back of a knife blade. Put a little tallow on the bearings and then replace the parts. 2. While the pinion is out, see that the slide moves freely in or out. If it scratches, rub it smooth. 3. If the pinion movement and slide are found in good order, the trouble may be found on the side of the slot opposite the rack, on the edge that bears upon the back of the pinion socket. Rub it smooth and apply a little tallow.



No. 70. 15-inch Y Level.

Price as shown, with tripod, $90.00.

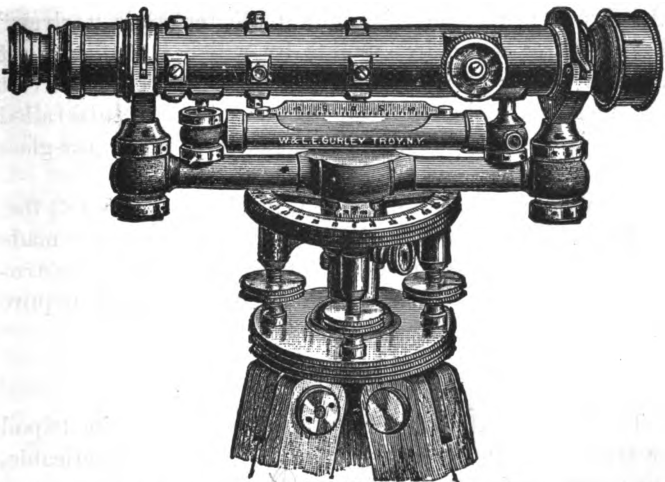
Our fifteen-inch Level as shown has the same arrangement of sockets, tripod, &c., as the larger instruments, but no pinion movement to the eye-piece. The leveling-head remains attached to the spindle, and is packed with it in the box; it has the tangent screw with an opposing spring; it is also somewhat smaller and lighter than those of the other sizes.

Weight of Leveling Instrument.

The average weights of the different sizes of this instrument, exclusive of the tripod-legs, are as follows:

15-inch telescope, with leveling head			11¼ lbs.
18-inch	"	"	13¼ "
20-inch	"	"	13½ "
22-inch	"	"	14¼ "

THE ARCHITECTS' LEVEL.



No. 75.

Price as shown, with tripod, $50.00.

The figure represents the Level introduced by us in 1874, and which has since been very largely used by architects, builders, and millwrights, as well as by engineers and surveyors, in the grading of streets, drains, sewers, &c., in all parts of the country. It has a telescope of 12 inches, now furnished with rings, wyes, &c., precisely like the larger levels, and adjusted in the same manner.

The leveling-head has the ordinary screws and a clamp to the spindle, but no tangent movement; it has also a horizontal circle of 3 inches diameter, fitted to the upper end of the socket and turning readily upon it; the circle is graduated to degrees, figured from 0 to 90 each way, and is read to five minutes by a vernier which is fixed to the spindle.

The telescope is directed to any object by hand, the spindle turning readily in its socket, but can be clamped in any position by the clamp-screw shown under the circle.

The instrument is placed either upon a light tripod as in the figure, or a small triangular plate termed a "trivet," having three sharp iron points by which it is firmly set upon any surface of wood or stone; both tripod and trivet are furnished with the level. A short piece of tube called a shade is also supplied, to be put on over the object-glass to protect it from the glare of the sun.

The weight of the level, without its tripod, is about 6¼ lbs.

The Adjustments of this little instrument are made precisely as described in our account of the larger instruments—they are not liable to derangement, and will require ordinarily but little attention.

To Use the Architects' Level.

The instrument should be set up firmly upon the tripod or trivet, and in a position as nearly level as practicable, the telescope placed over either pair of leveling-screws, and the bubble brought into the center by turning the opposite screws with the thumb and forefinger of each hand, the thumbs being both turned in or out as may be needed, and both screws brought to a bearing in the little cups underneath. Having brought the bubble into the center of the vial, turn the telescope over the other pair of screws, and repeat the same operation.

If the bubble runs to either end, bring it half-way back by the capstan-head nuts at the ends, and go over the adjustment until the bubble will stand in the center in every position, when the instrument will be ready for use.

Now, bring the object and eye-glasses into focus upon the object as before described, and the horizontal cross-wire will give any number of points required, which will all be in the same level line.

A long strip of board, held erect, will answer as a rod, and a line in pencil drawn across it at the part cut by the horizontal wire will give the height of the starting-point; and any different points on the rod, either above or below indicated by the cross-wire, will show the difference in height of the various points assumed, as compared with the starting-point.

In laying off angles with the Level, the bubble should first be brought into the center as before described, and the vertical cross-wire made to cut the object or line from which the angle is to be taken. Then the spindle being clamped by the little milled-head screw under the circle, the circle is turned around by hand, until the zero or center-points of both the circle and vernier are made to coincide—then loosen the clamp-screw, turn the telescope to the point desired, and the angle between the two points will be read off on the circle.

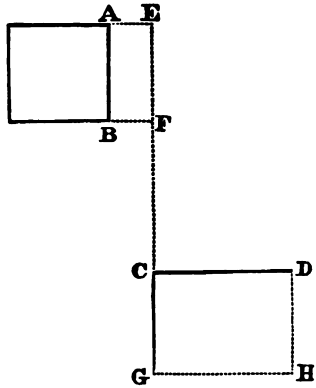
The point underneath the Level is easily indicated by the point of the plummet suspended from the tripod.

Of course it will be understood that, by the use of the vernier, angles can be read on the circle to five minutes of a degree, but ordinarily only even angles will be taken, and the center-line of the vernier will alone be used.

In many situations, after the walls of a building have been carried up to any required height, it becomes difficult to set up the tripod, and in this case the Level is screwed upon the little trivet, which can be set upon the wall, or a piece of board tacked to the building, or indeed upon any surface nearly level and not less than six inches square.

To illustrate the value of this instrument in laying out the sites of buildings, let it be supposed that it is desired to erect a building C D, (page 196), at right angles to a building A B, and at a given distance from its front.

First—Set up the level at E, and carefully center the bubble, the point of the plummet below indicating the required distance of the side of the new building from the front A B.



Next, measure off the same distance at the other corner of A B, and having erected the rod, sight upon it with the telescope, and clamp to spindle.

Now, carry the rod the required distance from B, and move it from side to side, until it is again in line with the telescope, as at C.

Remove the instrument, and having carefully set it over the point C by the plummet, and brought the bubble into the center as before, set the telescope again upon the rod placed at E or F, clamp to spindle, bring the circle to 0 with the zero of the vernier—unclamp and turn the vernier to 90 degrees—it will give a point D at any required distance from C, and C D will be the side of the proposed building. The side C G is determined by turning the telescope around until the vernier is in line with the other 0 of the circle, and thus the corner C, and the two sides C D and C G, are at once set off, and the remaining corner H easily ascertained by making D H and G H equal to C G and C D respectively.

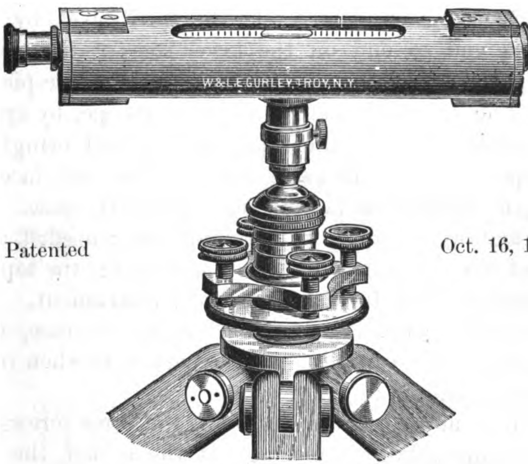
Other applications of the Level—as the setting of floor timbers, of window and door sills, the leveling of floors, etc., will readily occur to one who has been engaged in building, where it can be made of very great and increasing advantage, as he becomes familiar with its use.

To the millwright, such a level is almost indispensable in the lining and leveling of shafting, the ascertaining of the fall of water obtainable, and the overflow of land by a mill-pond, which may be determined upon.

The extensive farmer will find it of great value in laying out drains, determining their location, the heights of springs, etc.

Indeed, we believe that as this little Level shall become more widely known, its extreme cheapness, simplicity, and excellence will create for it, among all intelligent and enterprising Architects, Builders, Millwrights, and Farmers, a demand which will constantly increase in all parts of the country.

THE DRAINAGE LEVEL.



Patented Oct. 16, 1883.

No. 78.

PRICES.

No. 76.—	Farmers' or Drainage Level, with jacob-staff mountings	$15 00
No. 77.—	do do with plain tripod	20 00
No. 78.—	do do with tripod and leveling screws	25 00
No. 79.—	do do do do and with compass and clamp screws	30 00

The figure represents a level 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.

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 masons' or builders' level; the spirit-level, by reversing from end to end on the lower faces of the case, and making the corrections by the screw at the eye-piece end and in 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.

For making the above adjustments when needed, a small block of wood having a screw-thread that fits the top of the staff-mountings, is furnished with the instrument.

When the socket is screwed firmly to the case, and the instrument leveled up, it should remain level when reversed upon its spindle in any direction.

If it does not, correct the error by the three screws found on the same side of the flange of the socket, the outside ones when unscrewed carrying the flange down, while the center one draws it up.

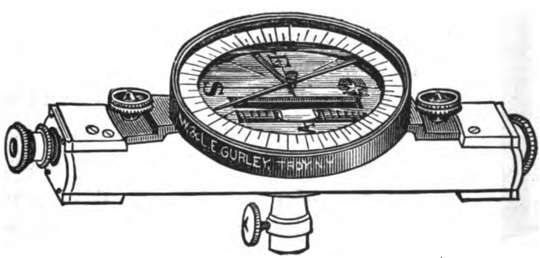
Should the cross wires be indistinct or out of focus, unscrew the cap of eye-piece, and turn the setting of the lens around in either direction until the wires are clearly seen, when the cover may be replaced, as before.

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; drains can be located and leveled, the height of springs ascertained, the accurate levels of lines of shafting, floor-timbers, sills, etc., be determined.

We add to the drainage level, when desired, a three-inch needle magnetic compass. This is fitted securely to the upper surface of the case, is removable at pleasure, and while it does not interfere in any way with the reading of the level, it furnishes a ready means of determining the bearings of lines or measuring angles by the needle.

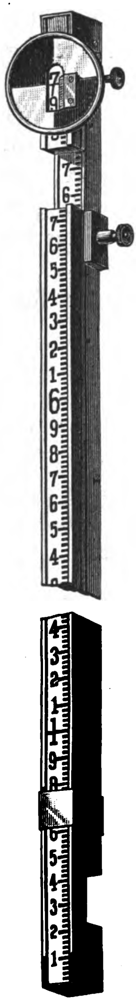
Level No. 78, without the tripod, weighs about 4 lbs.; and Level No. 79, about $4\frac{3}{4}$ lbs.



The Architects' leveling rod (No. 190) hereafter described, is intended for use with this instrument, if desired.

LEVELING RODS.

The various leveling rods used by American engineers are made in two or more parts, which slide from each other as they are extended in use.



No. 193. *Philadelphia Rod.* Price, $16.00.

THE PHILADELPHIA ROD. (No. 193.)

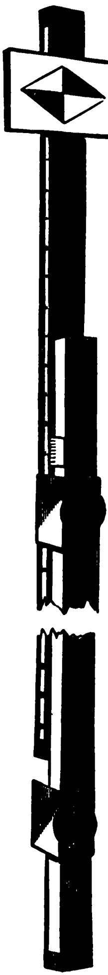
This rod is made of two strips of cherry, each about three-fourths of an inch thick by one and a half inches wide and seven feet long, connected together by two metal sleeves, the upper one of which has a clamping-screw for fastening the two parts together when the rod is raised for a higher reading than seven feet.

Both sides of the back strip and one side of the front one are planed out one-sixteenth of an inch below the edges; these depressed surfaces are painted white, divided into feet, tenths and hundredths of a foot, and the feet and tenths figured.

The front piece reads from the bottom upward to seven feet, the foot figures being red and the tenth figures black. When the rod is extended to full length the front surface of the rear half reads from seven to thirteen feet, and the whole front of the rod is figured continuously and becomes a self-reading rod thirteen feet long, reading to hundredths of a foot.

The back surface of the rear half is figured from seven to thirteen feet, reading from the top down; it has a scale also by which the rod is read to hundredths and half-hundredths of a foot as it is extended. The target is round and made of sheet-brass raised on the perimeter to increase its strength, and is painted in white and red quadrants; it has also a scale on its chamfered edge, reading to hundredths and half-hundredths of a foot.

When a level of less than seven feet is desired the target is moved up or down the front surface, the rod being closed together and clamped; but when a greater height is required the target is fixed at seven feet and the rear half extended, the scale on the back giving the readings like those of the target to hundredths and half-hundredths of a foot.



No. 192. *Boston Rod.* Price, $16.00.

THE BOSTON ROD (No. 192)

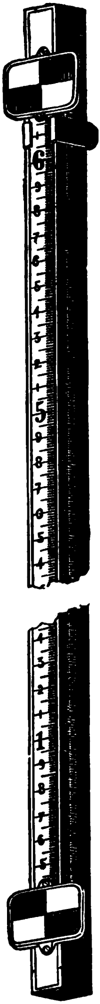
Is formed of two pieces of light mahogany or baywood, each about six feet long, and sliding easily by each other in either direction.

One side is furnished with a clamping piece and screw, and a small vernier at each end, the other or front piece carries the target and has on each side a strip of satinwood inlaid upon which divisions of feet, tenths and hundredths are marked and figured.

The target is a rectangle of wood fastened on the front half, is painted black and white and has its middle line just three-tenths above the end of the rod.

Each tenth of the rod is figured decimally in three figures or to hundredths of a foot, and by the verniers is read to thousandths.

The target being fixed, when any height



No. 191. *Troy Rod.* Price, $10.00.

is taken above six feet, the rod is changed end for end, and the divisions read by the other vernier; the height to which the rod can be extended being a little over eleven feet.

This kind of rod is very convenient from its great lightness, but the parts are made too frail to endure the rough usage of this country, and therefore American engineers have generally given the preference to others, made heavier and more substantial.

THE TROY ROD.

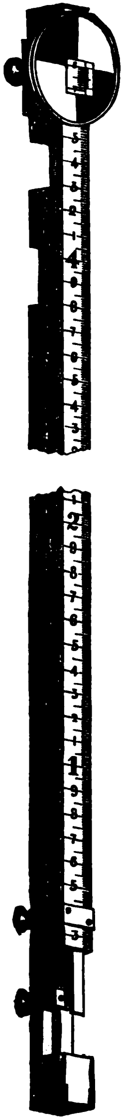
No. 191 represents another form of the sliding leveling rod, which we have ventured to name the Troy Rod; this is a self-reading rod up to six feet, or can be read by a vernier on the rear piece to thousandths of a foot as usual.

It has two targets as shown, both fastened to the front half of the rod, the lower one having its center line just three-tenths above the end, and the other target exactly six feet above the lower.

There is a clamping piece with screw on the back of the rod and below the target, by which the two parts are clamped together when desired.

The face of the front piece is recessed like that of the Philadelphia Rod, painted white, divided to feet and hundredths, and figured as represented.

The side of the front half is divided to feet and hundredths, read by a vernier on the top of the rear half to thousandths, and figured



No. 196. *New York Rod, in 3 parts.* Patented Oct. 23, 1883. Price, as shown, $18.00.
No. 195. *New York Rod, in 2 parts* (usual pattern). Price, $16.00.

from the top downwards, beginning with three-tenths, that being the height of the center line of the lower target.

When a level of less than six feet is taken on the rod the observation is made by the lower target, and the reading is direct as given on the side; but when a greater height is taken the upper target is sighted upon, and six feet added to the reading on the side in every instance, and thus a reading up to twelve feet readily obtained.

THE NEW YORK ROD. (No. 195.)

In 2, 3, or 4 Parts.

This rod, which is shown in the engraving as cut in two, so that the ends may be exhibited, is made of maple, the pieces sliding one from the other, the same end being always held on the ground, and the graduations starting from that point.

The graduations are made to tenths and hundredths of a foot, the tenth figures being black, and the feet marked with a large red figure.

The front surface, on which the target moves, reads to about six and a half feet on the two part rods; when a greater height is required, the horizontal line of the target is fixed at the highest graduation, and the upper half of the rod, carrying the target, is moved out of the lower, the reading being now obtained by a vernier on the graduated side, up to an elevation of twelve feet.

The mountings of this rod are differently made by different manufacturers. We shall give those which we have adopted.

The target is round, made of thick sheet brass, having, to strengthen it still more, a raised rim, which also protects the paint from being defaced.

The target moves easily on the rod, being kept in any position by the friction of the two flat plates of brass which are pressed against two alternate sides, by small spiral springs, working in little thimbles attached to the band which surrounds the rod.

There is also a clamp-screw on the back, by which it may be securely fastened to any part of the rod.

The face of the target is divided into quadrants, by horizontal and vertical diameters, which are also the boundaries of the alternate colors with which it is painted.

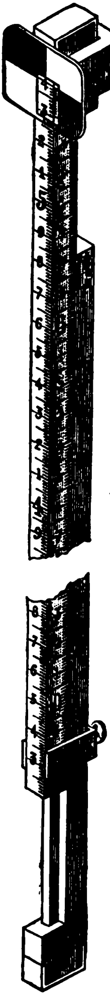
The colors usually preferred are white and red; sometimes white and black.

The opening in the face of the target is a little more than a tenth of a foot long, so that in any position a tenth, or a foot figure, can be seen on the surface of the rod.

The right edge of the opening is chamfered, and divided into ten equal spaces, corresponding with nine-hundredths on the rod; the divisions start from the horizontal line which separates the colors of the face.

The vernier, like that on the other side of the rod, reads to thousandths of a foot.

The clamp, which is screwed fast to the lower end of the upper sliding-piece, has a movable part which can be brought by the clamp-screw firmly against the front surface of the lower half of the rod, and thus the two parts immovably fastened to each other without marring the divided face of the rod. Price of New York Rod, in two parts, $16.00.



No. 190. *Architects' Rod.* Price, $6.00.

THE NEW YORK ROD.

In 3 or 4 Parts.

(Patented October 23, 1883.)

We have just introduced a modification of this favorite rod, which we believe will be generally approved.

In the new rod, as shown on page 203, a third or fourth piece is added to the two of the old rod, giving thus a rod of greater length, and at the same time making it more compact and portable.

The divisions, verniers, readings and target are the same as those of the old rod.

We make two varieties of the three-parted rod, one sliding to allow a reading of twelve and a half feet and the other extending to fourteen feet; the first when closed is only five feet long, the last but a little over five and a half feet. Price, $18.00.

Our four-parted rod is, when closed, but five feet in length, but can be extended to sixteen feet. Price, $20.00.

THE ARCHITECTS' ROD. (No. 190.)

This is a very light and simple sliding rod, made of maple, in two equal parts, each seven-eighths of an inch square, and, when closed, about five feet six inches long.

As shown, the front half is divided on two sides to feet, tenths, and hundredths, reading by verniers on the target and side to thousandths of a foot.

The target is smaller than those of the rods already described, but of sufficient size, and moves on the closed rod when levels of less than five feet and four-tenths are to be taken.

When a greater height is needed, the target is fixed at the highest division, the front half carried above the rear part, and clamped at any point desired by the clamp-screw, as shown, the height being now read off by the vernier on the lower half up to ten feet.

This rod is adapted for use with any level, and is so light and efficient that we believe it will come into general use; when it is to be used by an architect, the divisions are made in feet, inches, and sixteenths, and no verniers are then required.

THE TELEMETER ROD. (No. 199.)

We also make what is termed a Telemeter Rod, formed of two pieces of pine, each three and a half inches in width, seven-eighths of an inch thick, and six feet long.

Both sides of the rods are painted white, the inner surfaces being also recessed to protect the divided surface, with divisions in black of feet, tenths, and hundredths, and figured, the feet in red, the tenths in black.

The two pieces are connected by a strong iron hinge, and folded in transportation; when in use, they are opened, laid flat, and joined firmly in line by a wooden bar, about eighteen inches long, held to each piece by two strong brass screws, which enter into metal sockets secured in each part of the rod.

This is a self-reading rod, and is often used in connection with the micrometer wires to ascertain distances by simple observation in the same manner as the Philadelphia Rod already described. Price, $12.00.

No. 200. *Telescopic Rod.* Price, $24.00.

THE TELESCOPIC ROD. (No. 200.)

A rod is sometimes used in which the two smaller upper parts slide out of a larger and lower one which answers as a case; when closed the rod is five feet long, and extends to fourteen feet.

It is divided on a recessed face to feet, tenths, and hundredths, the divisions being painted and figured like those of the Philadelphia and Telemeter Rods.

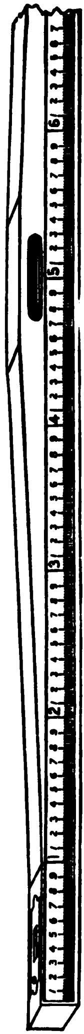
THE CROSS-SECTION ROD.

We have recently devised a Cross-Section Rod (No. 201) which has been much approved.

It is made of well seasoned pine, and is 10 feet long and 1½ inches thick; square at both ends, and about 4 inches in the middle, where is also an opening for the hand, as shown.

Both sides are graduated on a recessed white surface, the divisions being painted black like those of a leveling rod, and are figured from the same end of the rod.

There is also an adjustable spirit level at each end, one of which is shown in the cut.



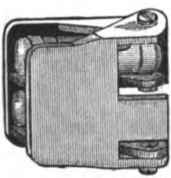
No. 201. *Cross-Section Rod.* Price, $10.00.

METRIC RODS.

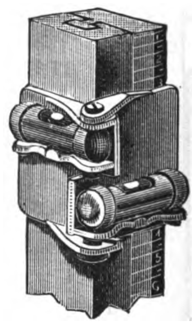
Besides the usual divisions of the leveling rods into parts of a foot, we also divide any of our rods into meters, decimeters, and centimeters. The scales on the target and sides of the rods read the centimeters to millimeters on all except the Telemeter and Telescopic Rods, which are read only to centimeters.

THE ROD LEVEL.

No. 215 represents a level recently devised by us, and patented, for the more accurate plumbing of leveling rods.



No. 215. *Rod Level.*
Price, $3.00.
(Patented Feb. 17, 1885.)



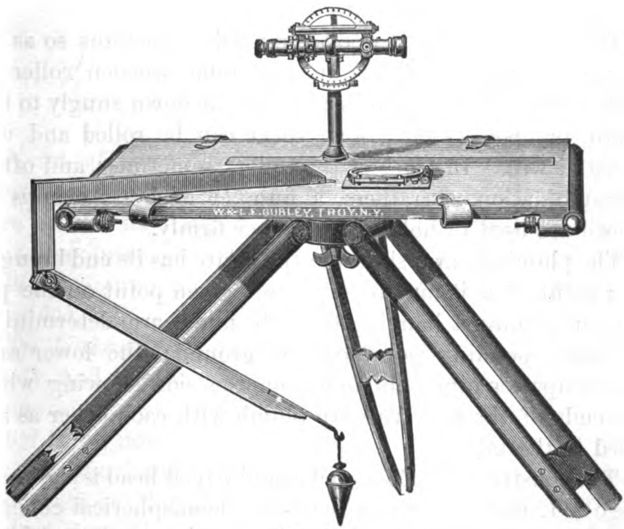
Rod Level as applied to a Rod.

The figures show it when folded, for convenience in carrying and also as applied to a rod. Its convenience and value have commended it to general favor.

THE PLANE TABLE.

This instrument, which has been so largely employed abroad in topography and map drawing, is now fast coming into use in our own country, especially in colleges and schools where the study of surveying is pursued.

To further popularize the Plane Table we have devised a number of different styles, varying mainly in the Alidades furnished with each and supplying in all the grades an excellent instrument at a very moderate cost.



No. 92.

No. 92.—Plane Table, board 24 × 30 inches, mounted on large tripod, with leveling socket and clamp, and with plumbing bar, plummet and clamps for paper	$45 00
Combined compass and levels	15 00
Alidade with telescope 9 inches long, power 20 diameters, with stadia. vertical circle to 1 minute, level on telescope, and clamp and tangent, mounted on column as in engraving	70 00
Price as shown, total	$120 00

As shown in No. 92, the Plane Table consists mainly of a drawing-board set upon a firm tripod, and having upon its upper surface a movable straight edge or *Alidade* arranged either with sight-vanes or telescope, by which it may be directed to any given point, the line being then drawn on the paper along the edge of the Alidade.

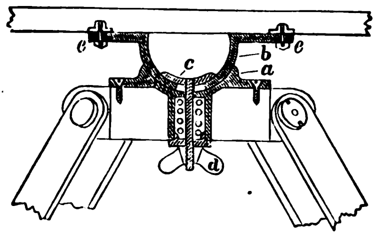
A rectangular plate of brass, to which is attached a small compass and two spirit-levels, is also shown, and serves both to level the table, and, when applied by the edges parallel to the zero points of the compass circle, to determine the magnetic bearing of the lines drawn on the paper, or the direction of the table itself.

The table is made of wood arranged in sections so as to prevent warping, and has an adjustable wooden roller at each end by which the paper is brought down snugly to the board, or upon which a long sheet can be rolled and unrolled at will. In place of the rollers, sometimes, and often in combination with them, a number of brass clamps as shown are used in holding the paper firmly.

The plumbing arm shown in the figure has its end brought to a point, that it may be set at any given point on the paper, the plummet hanging from the under arm determining the corresponding point on the ground; the lower arm moves upon a hinge, an index on the side showing when the ends of the two arms are plumb with each other as applied to the table.

The construction of the socket and tripod-head is shown on page 211, in which *a* represents the hemispherical concave metal cup fastened by six screws to the wood top of the tripod, *b* the upper or convex part fitting nicely into the cup and clamped to it at will by the clamping piece *c* and nut *d;* a strong spiral-spring in the hollow cylinder between *c* and *d*, serves to hold the two spherical surfaces of the socket together, and allow of the easy movement of the one within the other in the leveling of the table.

The flange of the socket *b* supports the table and is connected with its under surface by three segments of brass, two of which are shown at *e e*; these are brought down firmly upon the shoulder of the flange by capstan-head screws as shown, or released at will, thus allowing the Plane Table to be moved horizontally when desired.



A set of three leveling-screws is sometimes added for more accurately leveling the table, but ordinarily the pressure of the hand upon it with the socket alone will be all that is required.

When desired a tangent movement in azimuth may also be added.

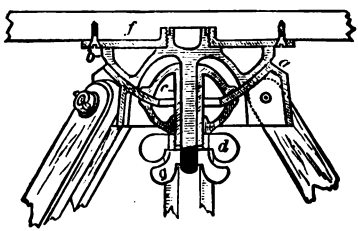
In Using the Plane Table the tripod is set up firmly, and the table covered with paper, placed upon the flange of the socket, and secured by the screws *e e*, the nut *d* being now loosened the table is moved by the pressure of the hand on different parts of the board, until the levels on the plate will come into the center on any part of the table. The nut *d* is then screwed up and the table made firm; any place on the paper can then be assumed as the starting-point, its position over a given point on the ground being determined by the plumbing-bar and plummet. From the given point on the paper, sights can then be taken to different corners of the field and lines drawn on the paper along the edge of the Alidade, and thus a miniature of the tract be traced on the paper, the bearing of any line being ascertained by applying the side of the compass-plate to the edge of the Alidade placed on that line.

The table can be moved horizontally either by hand on releasing the screws *e e*, or by a tangent-screw as before described.

The measurement of distances by the micrometer wires of the telescope, and of vertical angles by the circle, is effected as already described in our account of the Transit.

JOHNSON'S IMPROVED PLANE TABLE MOVEMENT.

(*Patented May 3, 1887*).



No. 98A.

The figure represents in section an improved Plane Table movement, for which a patent was obtained by W. D. Johnson, May 3d, 1887, and which has been approved by the Topographers of the U. S. Geological Survey.

As shown in the cut, it supplies an arrangement by which the table can be easily made horizontal and then secured at will by the winged nut *d*.

The board is attached to the flange screwed to the upper part of the main spindle as represented.

In leveling the table, the upper clamping nut *d* is released, the sockets easily brought into position and then securely clamped by the same nut.

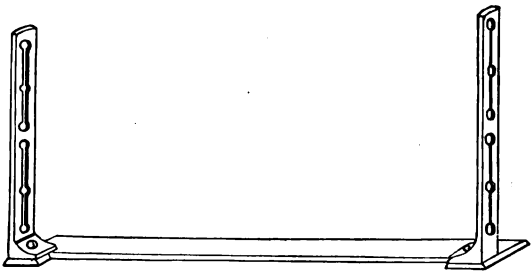
When it is desired to turn the table in azimuth, the nut *g* is loosened, leaving the hemisperical surface *b* free to move around the concave part *a* of the tripod head, and made fast at will by screwing up the same nut.

No.	PRICES.	
98A.—Johnson's Improved Plane Table movement, mounted on large tripod,		$45 00
	EXTRAS.	
98B.—Plane Table Drawing Board 24x31 inches, fitted, and with screw sockets and clamp screws for paper		5 00
98C.—Plumbing bar and plummet		4 00
98D.—Combined Compass and Levels with square base		15 00

Note.—The Alidades, hereafter described, can be used with Johnson's Plane Table when desired.

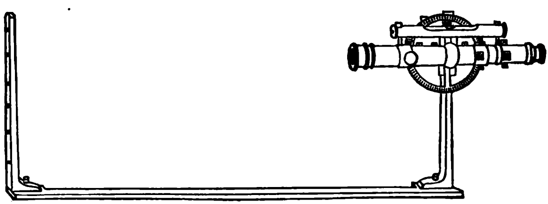
THE ALIDADES.

The different styles of our Plane Tables vary mainly in their Alidades, of which we make four kinds.



Price, $15.00. (See No. 90 in Price List.)

(1.) The first or most simple Alidade is shown above, and consists of a brass rule or straight edge, twenty inches long and two to three inches wide, at the ends of which are screwed sight-vanes, like those of the ordinary compass; the edge of the rule being chamfered and in line with the slots of the vanes.



Price, 50.00. (See No. 91 in Price List.)

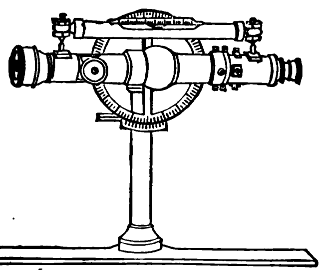
(2.) The lower figure shows the simple Alidade, to which is fitted the telescopic sight, having a level, clamp and tangent and vertical circle reading to five minutes, attached to the telescope, which is also supplied with micrometer wires.

The telescope is placed in line with the straight edge as before.

(3.) The third style of Alidade is shown in the cut of the Plane Table at the beginning of this article, the brass rule being now two inches wide, except where it is expanded one-third from the end to receive the base of the column.

The column supports the telescope with its attachments, the vertical circle now being divided on silver and reading to single minutes.

The telescope is nine inches long, of a power of 20 diameters, provided with stadia, and adjusted and used like that of the Transit; it is also in line with the chamfered edge of the rule (see page 209).



Price, $90.00. (See No. 93 in Price List.)

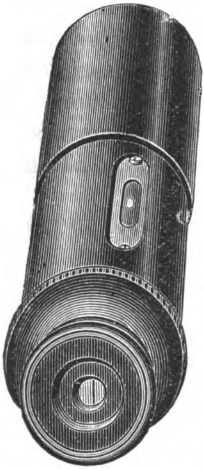
(4.) In the Alidade here shown the telescope is precisely the same as that used in our best Transits, being also supplied with level, clamp and tangent, vertical circle on silver reading to single minutes, and micrometer wires for measuring distances.

It is placed on the brass rule, precisely like that of the one last described, and is adjusted and used in the same manner.

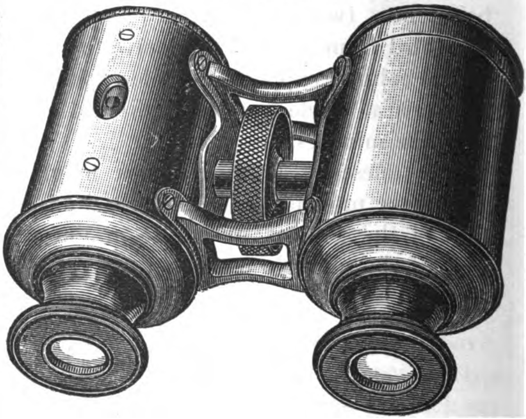
SMALLER INSTRUMENTS AND APPLIANCES.

NEW TELESCOPIC HAND LEVELS.

Patented Nov. 30, 1886.



Patented Apr. 5, 1887.



No. 183.
Price, $12.00.

No. 184.
Price, $15.00.

The figures represent an instrument devised by us to remedy the defects of the ordinary hand level, and to increase its usefulness in the work of the Engineer.

It consists of a tube to which are fitted the lenses of a single opera-glass, and containing, in addition thereto, a reflecting prism, cross-wire, and small spirit level, the last being shown in the open part of the tube (No. 183).

The eye lens, as indicated in the cut, is made up of two separate pieces, the larger one being the usual concave eye lens of the opera-glass, the smaller one a segment of a plano-convex lens, having its focus in a cross-wire under the level vial and above the reflecting prism.

The observer holds the tube horizontal with the level opening above, and with the same eye sees the object to which the instrument is directed, and at the same time observes the position of the level bubble with reference to the cross-wire on the under side of the level vial.

When the Hand Level is held truly horizontal the cross-wire will bisect the bubble, and will also determine the level of any object seen through the telescope; thus securing to the observer a clear bright view of the object, magnified also by the telescope.

In the second form of the Telescopic Hand Level shown as No. 184, the tube on the right incloses the usual lenses of the opera-glass, while that on the left contains only the prism, level vial, and cross-wire of the instrument first described.

This binocular Hand Level is used like the ordinary opera-glass, the level being above, as shown in the cut.

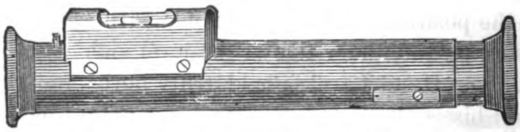
When the tubes are held truly horizontal, the engineer, using both eyes, will see the level, with cross-wire below it, bisecting the bubble as before described, and also the object observed, the level of which is determined by the position of the cross-wire upon its surface.

The use of the binocular Hand Level gives a clearer view of an object than is possible with a single tube, there being now no light lost by the interference of the prism and level vial.

The vial is first adjusted by reversing the telescope body in a small pair of Y's. The correction is made by filing. It is then screwed fast and permanently fixed in its place. Then the collimation is made level by sliding the prism tube back and forth until the line given by the hand level is the same as that given by a Y Level.

The prism tube can best be reached by removing the object end of the main tube, and it is clamped by a small screw on the lower side.

LOCKE'S HAND LEVEL



No. 185.

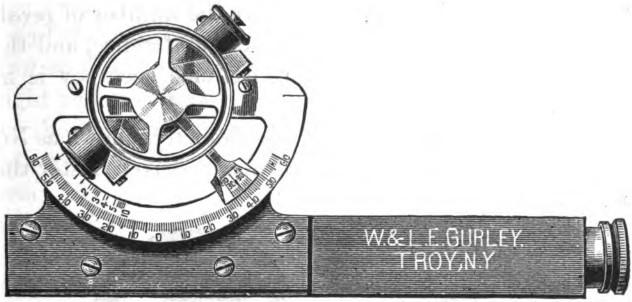
Consists of a brass tube about six inches long, having, as shown in the figure, a small level on top and near the object end, there being also an opening in the tube beneath, through which the bubble can be seen, as reflected by a glass prism, immediately under the level. Both ends of the tube are closed by plain glass settings to exclude the dust, and there is at the inner end of the sliding or eye tube a semicircular convex lens, which serves to magnify the level bubble, and cross-wire underneath, while it allows the object to be clearly seen through the open half of the tube.

The cross-wire is fastened to a little frame moving under the level tube and adjusted to its place by the small screw, shown on the end of the level case. The level of any object in line with the eye of the observer is determined by sighting upon it through the tube and bringing the air-bubble of the level into a position where it is bisected by the cross-wire.

PRICES.

No.			Post.
185.—	Locke's Hand Level, Bronze, in box	\$9 00	\$ 12
186.—	do do Nickel Plated, in box	10 00	12

THE ABNEY LEVEL AND CLINOMETER.



No. 187.

The Abney Level is an English modification of that shown on page 218, combining with it an excellent clinometer as represented in the cut. As now made the arc is divided to ninety degrees each side of zero.

Here, when the level is brought to the center by setting the vernier arm to zero, on the divided arc, the bubble is seen through the eye end and the level ascertained precisely as with the Locke's Level. And the main tube being square it can be applied to any surface, the inclination of which may be ascertained by bringing the level bubble into its center, and reading off the angle to five minutes, by the vernier and arc.

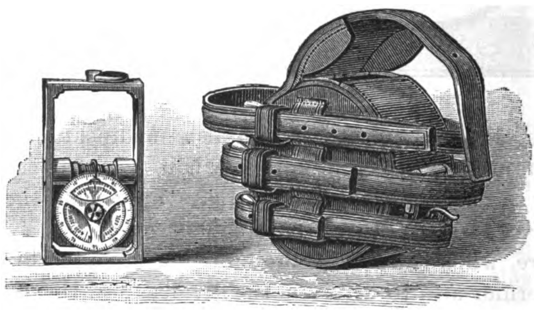
The inner and shorter arc indicates the lines of different degrees of slope, the left-hand end of the vernier being applied to the lines and the bubble brought into the center as usual. A small compass of about 1½ inch needle is sometimes applied to the upper surface of the Abney Level, and a jacob-staff socket below.

No.	PRICES.		Post.
187.	—Abney Level, 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	$ 15
187A.	—Ditto, and with compass and staff socket attached	18 00	20

THE ODOMETER

Is an instrument designed to register the number of revolutions of a wagon wheel of a given circumference, and thus indicate distances in cases where extreme accuracy is not required.

In measuring distances with the odometers shown as Nos. 366 and 365, the carriage should not be driven faster than about eight miles an hour.



No. 366. Price, $15.00.

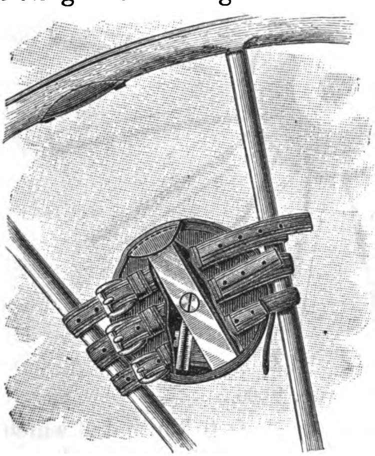
The odometer here shown on the left, consists essentially of a square brass weight or pendulum, hung within a rectangular frame which revolves with the wheel, while the pendulum remains vertical. Upon the front face of the pendulum are two brass wheels two inches in diameter, the inner surfaces of which are in contact, the edges of both uniting to make a groove corresponding to a worm cut in the middle of a shaft fastened to the sides of the frame.

The front wheel has one hundred teeth, the rear one ninety-nine, and both pitch into and are moved by the revolving worm of the frame.

There are also the same number of divisions as of teeth on each wheel, and they are figured, the front wheel from

0 to 100, the rear one from 0 to 9000. The front wheel has three spokes, an index being also cut down on its perimeter to read the divisions of the rear wheel, the front wheel itself being read by a slender steel wire fastened to the brass weight and curving over the worm, so as to be immediately over the divisions of the wheel. Now, when the frame is made to revolve by the revolution of the wagon wheel, the worm will turn both wheels, and each will be moved forward one tooth by every turn, and when one hundred turns are made, the front wheel will have moved completely around, and the index of its zero division will have been carried over one division of the inner wheel.

And thus by noting the positions of the indices of both wheels the number of revolutions of the wagon wheel can be easily obtained up to 9900, when both wheels will be at zero again. The wagon wheel being of a given size, the number of feet traveled can be at once ascertained by noting the readings of the wheels, at the beginning

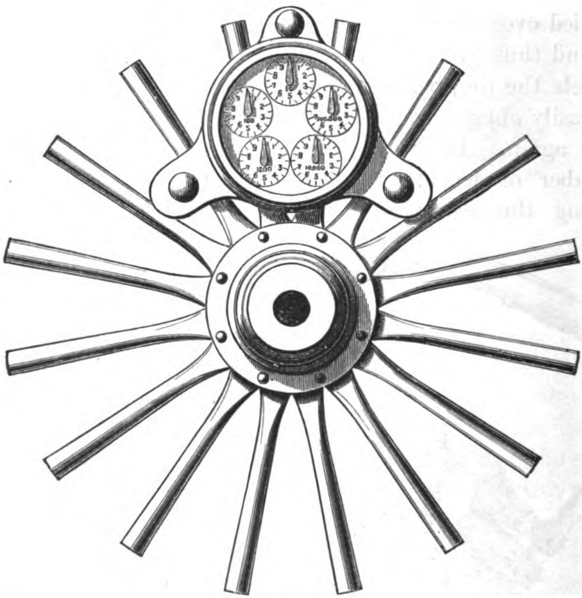


and end of the journey, subtracting one from the other and multiplying the perimeter of the wagon wheel by the number of turns made.

The metal case of this odometer is inclosed within a stout leather box as shown. The opening through which the rectangular frame is inserted or removed when the reading of the register is desired is covered with a leather flap secured by a strap and buckle, as shown in the cut. The manner in which the odometer case is attached to the wheel is shown on page 221.

The Odometer in use is set into a metal case, which is itself inclosed in a leather cover, to which are attached strong straps for fastening the instrument firmly to the spokes of the wagon wheel.

A form of the Odometer devised by us is represented as No. 365, the pendulum of which is fastened to a shaft turning in the center of a strong circular metal box. On this shaft and turning with it is a pinion giving motion to a train



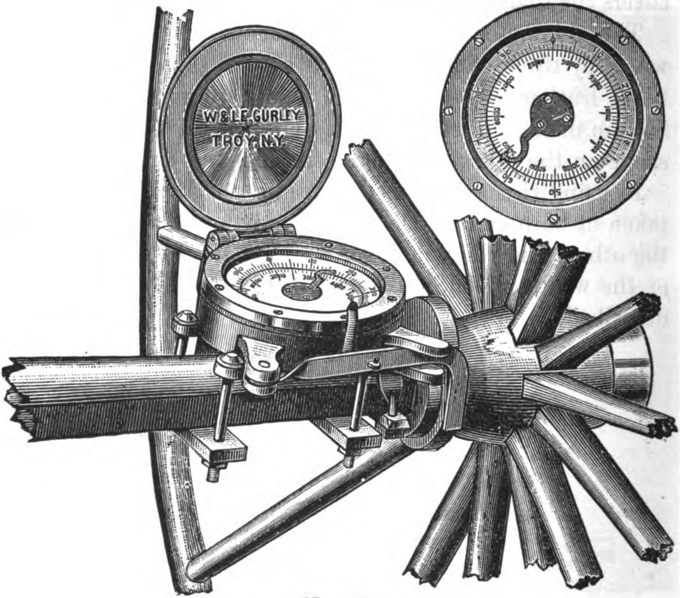
No. 365. Price, 10,00.

of wheels, each of which has also a shaft to the end of which an index is fastened. There are dials for each index as shown, and the number of turns of the wagon wheel can thus be counted up to 100,000. A strong bezel ring with thick glass covers the dials and allows them to be easily read.

The Odometer is securely fastened to the spokes of the wheel by three carriage-bolts as shown, there being also a thick leather washer on each side confined between the bottom of the projecting arms, and a metal washer of same shape on the other side of the spokes.

In using this Odometer the reading of the dials must be taken at both ends of the journey, the one subtracted from the other, and the remainder showing the number of turns of the wagon wheel, multiplied into its perimeter as before described.

POSITIVE MOTION ODOMETER.



No. 367.

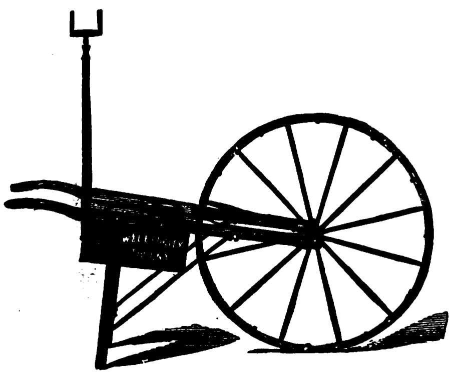
Price **$20.00**

The Positive Motion Odometer, represented above, for counting the revolutions of a carriage wheel, is of the most substantial construction. The wheel work is contained in a solid metal case, with glass covering the face of the dial. On the chamfered surface are 100 divisions, which are figured in tens and read by an index carried forward one space on the dial by every upward movement of a steel lever shown underneath. A wheel with 99 divisions upon it revolves under the index, immediately beneath the divided edge of the dial, and is carried forward a single division on the dial by every complete revolution of the index; the wheel is numbered from 0 to 9900.

This Odometer is intended to be fastened to the axle of a wagon by the bolts as shown, a cam on the hub of the wheel giving the upward motion to the steel lever above described. This form of the Odometer secures entire accuracy in recording the revolutions of the wheel either slow or fast, and has been adopted in the Topographical Surveys of the United States as superior to any other.

WHEELBARROW ODOMETER.

An apparatus often used in surveys for county maps, measuring roads, &c., is represented below. The wheel is carefully made with brass axle bearings and tire, the last having a perimeter of just half a rod. The braces, bolts, and all the other metal work are also made of brass to avoid any attraction of the magnetic needle. The upright staff carries a vernier pocket compass with 3½-inch needle, by which bearings may be taken at any point desired. The number of revolutions of the wheel are counted by the positive motion odometer, fixed to the top of the wooden box; motion being conveyed through a brass rod carried forward by a cam on the axle of the wheel.



No. 368.

PRICES.

No. 368A.—	Wheelbarrow	Odometer,	complete, as shown	$120 00
No. 368B.—	do	do	omitting Compass	104 00

GENERAL MATTERS.

TRIPODS.

In the tripods of all our instruments the upper part of the leg is flattened, and slotted to fit closely on each side of a strong tenon, projecting from the under side of the tripod-head, there being also a strong brass bolt with large head and nut on opposite sides of the leg, by which it is held firmly in place.

The tripod-head is made of the best bell-metal, the tenons and upper part being cast in one piece and firmly braced together.

The legs are round, and taper in each direction from a swell, turned about one-third the way down, from the head to the point.

The point, or shoe, is a tapering brass ferule, having an iron end; it is cemented, and riveted firmly to the wood.

The legs of all our tripods are about four feet eight inches long, from head to point. We make four sizes of tripods with solid legs, which we will now separately describe.

1. ***The Heavy Tripod,*** shown with the Engineers' Transit, having a brass plate of four and one-fourth inches diameter, with mahogany legs one and three-eighths of an inch at the top, one and three-fourths at the swell, and

one and an eighth at the point, is used with the Engineers' Transit, and larger leveling instruments.

2. ***The Medium Sized Tripod,*** shown with the Surveyors' Transit, has a plate of same diameter as the former, and mahogany legs which are one and one-eighth of an inch at the top, one and five-eighths at the swell, and one and one-sixteenth at the point, and is used with the Surveyors' Transit, the light Engineers' Transit, and the fifteen-inch Level.

3. ***The Compass Tripod,*** seen in part in the cut of the Vernier Transit Compass, has a brass head about three inches in diameter, and legs which are about one inch at the top, one and three-eighths at the swell, and seven-eighths at the bottom.

The legs are usually made of cherry, and the tripod is used with the various kinds of compasses, and with the Vernier Transit Compass.

4. ***The Pocket Compass Tripod*** shown with the various smaller instruments, has a strong bronze head and legs which are nearly three-fourths of an inch at top and bottom, and one and one-eighth of an inch in the swell.

EXTENSION TRIPODS.

We also make several sizes of extension tripods. The medium size is shown on page 228, and is used with the Mountain Transit, and the lighter instruments.

A larger size with bronze head and heavier legs is used with the larger transits and leveling instruments; and a smaller and lighter one with the various pocket compasses.

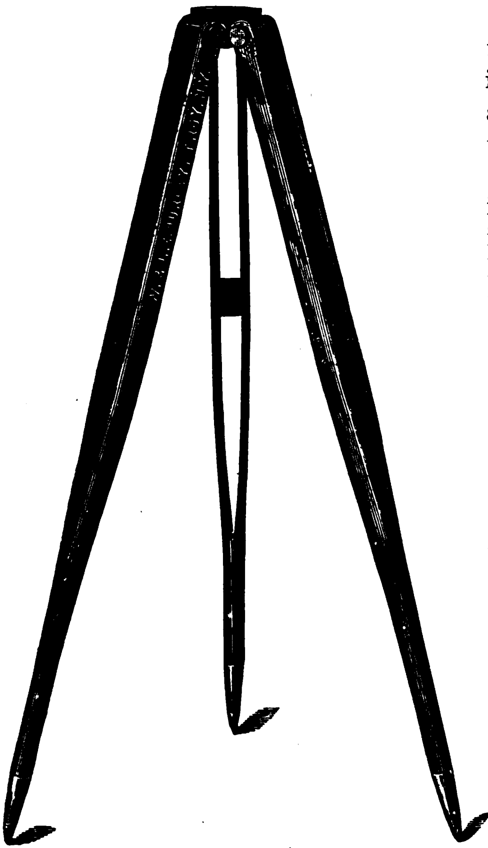
EXTENSION TRIPODS.

No. 63.

PRICES.

No.		
61.	—**Extension Tripod**, furnished instead of regular tripod, with any new Transit (Nos. 1 to 5, and 12 to 24), extra	**$5 00**
62.	—**Extension Tripod**, furnished instead of regular tripod, with any new Transit Compass (Nos. 25 to 31), extra	**7 00**
63.	—**Extension Tripod**, for Transits (Nos. 1 to 24)	**15 00**
63A.	—**Patent Extension Tripod for Transits** (Nos. 25 to 31)	**12 00**
80.	—**Extension Tripod for Y Levels** (Nos. 70 to 74), instead of regular tripod, ext.	**5 00**
81.	—**Extension Tripod** for Architects' Level, instead of regular tripod, extra.	**7 00**
82.	—**Extension Tripod** for 15, 18, 20, or 22 inch Y Level	**15 00**
121.	—**Extension Tripod** furnished with any compass (Nos. 105 to 117)	**12 00**
170.	—**Extension Tripod** for pocket compasses (Nos. 140 to 162)	**10 00**

SPLIT LEG TRIPODS.



No. 64.

These are made as shown in No. 64, with a brace between the two parts of the leg, and having a broad bearing on the brass head for the attachment of the leg above.

The arrangement supplies a very firm and light tripod, though more bulky and expensive than that with solid legs.

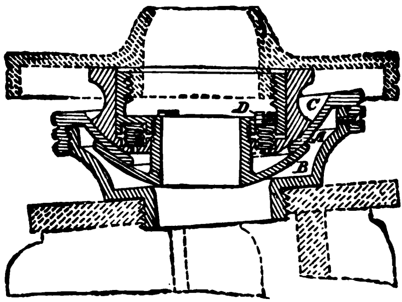
They are also made of several sizes like the tripods already described.

No.	PRICES.	
64.—	Split leg tripod, for Transits (Nos. 1 to 5, and 12 to 24).................	$15 00
65.—	Split leg tripod, for Transits, instead of regular tripod, extra...........	5 00
66.—	" " instead of extension tripod, at same price.	
83.—	" " for 15, 18, 20, or 22 inch Y Level,........................	15 00
84.—	" " for Levels (Nos. 70 to 74), instead of regular tripod, extra	5 00

QUICK LEVELING ATTACHMENT.

We have for several years past made a quick leveling arrangement, which was patented by us in November, 1878, and has given general satisfaction; it is specially adapted to tripod-heads of our own make, but can also be applied to those of other makers.

The arrangement of this attachment will be readily understood by inspection of the cut.



Nos. 58 and 85.
(Patented Nov. 5. 1878.)

To use the quick leveling attachment, 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 levels 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.

The cut shows the Quick Leveling Attachment as screwed fast to a tripod of any pattern now in use.

Prices.—When furnished with a new instrument, $5.00. For same, adapted to any instrument already in use, $6.00.

N. B.—When ordered for any instrument already in use, 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.

LACQUERING.

All instruments are covered with a thin varnish, made by dissolving gum shellac in alcohol, and applied when the work is heated.

As long as this varnish remains, the brass surface will be kept from tarnishing, and the engineer, by taking care not to rub his instrument with a dusty cloth, or to expose it to the friction of his clothes, can preserve its original freshness for a long time.

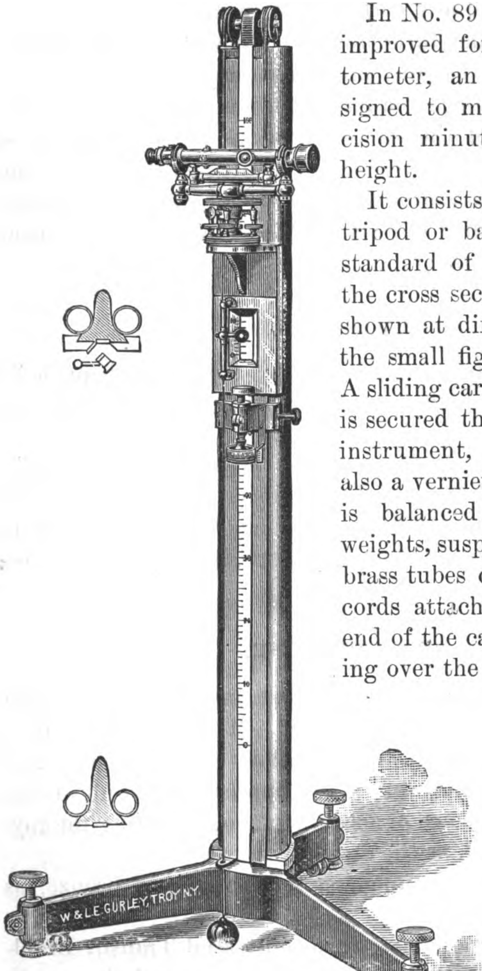
BRONZE FINISH.

Instead of the ordinary brass finish, most engineers prefer instruments blackened or bronzed. This is done with an acid preparation, after the work has been polished, and gives the instrument a very showy appearance, besides being thought advantageous on account of not reflecting the rays of the sun as much as the ordinary finish.

We finish our instruments either bright or bronze, as may be preferred.

If no direction is given, we usually send Transit, Leveling, and Solar instruments of bronze finish, and Compasses of bright finish.

CATHETOMETER.



No. 89.

Price, as shown........$250.00

In No. 89 is represented an improved form of the Cathetometer, an instrument designed to measure with precision minute differences in height.

It consists of a solid brass tripod or base supporting a standard of the same metal, the cross section of which is shown at different points by the small figures on the left. A sliding carriage upon which is secured the small leveling instrument, and which has also a vernier scale as shown, is balanced by heavy lead weights, suspended within the brass tubes on either side by cords attached to the upper end of the carriage, and passing over the pulleys shown at the top of the column.

The movable clamping piece below the carriage is fixed at any point required by the screw, shown at its side.

The screw

passing through its center is of steel, cut accurately to a given number of threads, the value of which is known.

The head of the screw is divided into one hundred equal parts, and having an index at its side affords a ready means of reading a very small movement of the carriage as it is carried up or down by the end of the screw.

The scale shown in front of the standard is divided as may be required, either into feet and hundredths, or in parts of a meter, and read by the vernier on its side; there being also a microscope, as represented, sliding on a rod to read any point of the vernier.

This column is made accurately plumb by noting the position of a line suspended from the top and attached to a brass ball below.

The operation of plumbing the line is effected by the three leveling screws in the arms of the tripod below.

The small leveling instrument has a fine telescope furnished with the usual cross-wires, determining a point or line on the object observed.

The level is carefully adjusted before it is screwed to its place; the telescope having a movement in azimuth of about 90°, can be turned to a number of objects if desired.

In the instrument represented, the scale is divided 8 millimeters, which, by the vernier, is read to 1-20ths, and by the divided head of the micrometer screw to 1-100ths of a millimeter, the smallest movement being easily detected by the cross-wires of the telescope.

Of course, any fractional part of a foot could be read with equal facility.

This Cathetometer weighs about 150 lbs., and is extremely solid, substantial and accurate in all its indications.

The Current Meter.

This instrument, now so generally used to ascertain with precision the velocities of currents in harbors, rivers, and smaller streams, is shown in what we consider its best and most substantial form on page 235, at A, invented by W. G. Price, and patented Aug. 25, 1885. The wheel of this meter carries five conical buckets, as shown, so arranged as to feel the force of the slightest current and cause the wheel to revolve.

The ends of the axis of the wheel revolve in bearings contained in air chambers of metal, which protect them from the water, and any gritty matter it may contain, and the friction is thus reduced to a minimum and made a constant quantity.

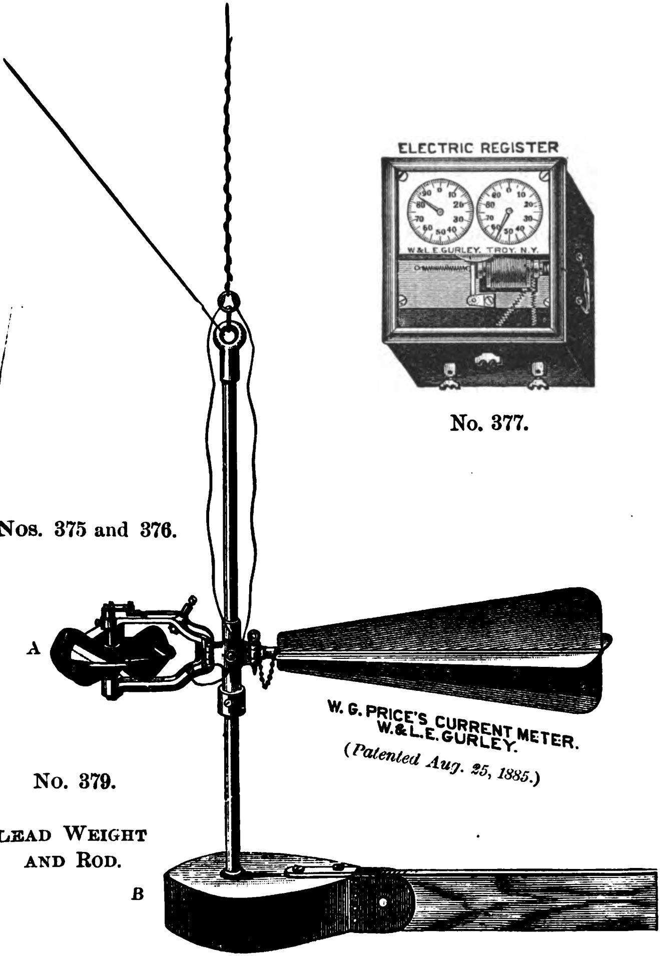
The form of the wheel and buckets is such as to insure great strength, and thus resist injury from driftwood, etc., while, at the same time, it is not liable to obstruction from floating leaves and grass.

The upper end of the axis of the wheel extends above its bearing, entering an air-tight metal box hereafter named, and is cut down for a small distance, through the diameter, one half of the end of the shaft being cut away, and this piece then replaced with a thin slip of ivory between the two parts, insulating them from each other.

Upon this divided part of the axis a light spring bears, and successively makes and breaks the electric circuit as the wheel revolves.

The spring and divided axis just described form the *contact-breaker*, and are both contained in the little metal air-tight box, as shown in the cut.

A hollow cylinder of bronze, termed the ***trunnion***, fitting easily upon the rod, supports the frame of the meter by a pivot on each side, and thus by the rod and pivots the



No. 377.

Nos. 375 and 376.

A

W. G. PRICE'S CURRENT METER.
W.&L.E. GURLEY.
(Patented Aug. 25, 1885.)

No. 379.

LEAD WEIGHT
AND ROD.

B

meter is free to move both horizontally and vertically, and so adjust itself to the direction of the current.

The frame of the meter is made of bronze, and is very solid and strong. The *rudder* has four light metal wings, or vanes, secured to a central rod, and is made to balance the weight of the wheel and give direction to it, and thus keep the wheel in both directions in line with and its buckets opposed to the current.

The meter frame has a hinged side secured by a spring key, allowing the meter and trunnion, which is itself in two parts, to be detached from the rod when desired; in the older form the trunnion was left on the rod.

The connecting wires are passed upward through the trunnion of the meter, and so have no tendency to pull the meter out of the line of the current.

The rod is of brass three-fourths of an inch in diameter, and two feet long, its upper end having an eye of brass screwed firmly on and pinned, and its lower end screwed into a brass socket in the lead weight *B*, and secured thereon by a jam-nut; a sliding ring of metal, with set screw, as shown, allows the meter to be raised to any point on the rod.

The weight *B* is of lead, and weighs about sixty pounds; it has a rudder of wood, as shown, secured to the weight by brass cheek pieces, which are also securely fastened to the weight by sockets cast into the lead. The rudder can be set at any angle with the weight, or turned up parallel with the rod, for convenience in transportation.

The weight *B* is only used where the meter is employed in deep water and harbor surveying, where the currents are very strong. In shallower waters the meter is suspended upon a rod of wood or metal, and this may be in one piece, or formed of several short rods screwed together.

Electric Register.

The number of revolutions of the meter-wheel is recorded by an electric register, shown on page 235, actuated by a battery of two or three cells.

The electric current proceeding from one pole of the battery, is carried by an insulated copper wire down through the trunnion of the meter, and thence up to the insulated binding post on the upper arm, as shown in the cut; thence through the contact-breaker, the axis of the wheel, and the lower arm to the binding screw, shown on that arm; thence by a second copper wire up through the trunnion to one binding post of the register; thence through the register to the other binding post; and thence finally by another wire to the other pole of the battery.

The electric register, No. 377, is inclosed in a mahogany case, showing two dials under a glass face, and has an electro-magnet which, when the circuit is made, moves a lever, at the end of which is a pawl carrying forward a ratchet-wheel one tooth at every break of the current.

The dials are each divided into one hundred spaces, and figured, both reading to the right—that on the right hand in the figure being counted to 100, and that on the left to 10,000; each space on the last-named dial denoting one hundred spaces on that at the right.

Sizes of the Meter.

We make two sizes of this meter, the larger having a wheel of seven and a half inches in diameter, and the other one of six inches. The larger meter, including the rudder vane, is about 35 inches long; the smaller, about 24½ inches long.

The larger size is intended for deep-water and harbor surveying, where great strength is required, and usually the weight is to be employed; the smaller size is designed for use in smaller rivers and streams, and is used either with or without the weight.

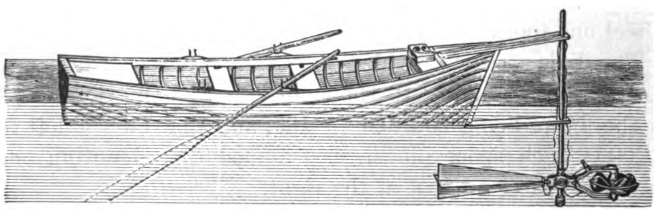
The Price Meter is the result of six years' experience in measuring the velocity of water in the Ohio and Mississippi Rivers by different methods, while the inventor was in the employ of the U. S. Engineer Corps.

It is used by the U. S. Engineer Corps, the U. S. Coast and Geodetic Survey, and by hydraulic engineers in different parts of the country.

Rating the Meter.

Before using the meter it is necessary to obtain its rate, which is the number of revolutions of the wheel made in passing over a measured distance, at different velocities.

The meter should be rated in still water, which is not less than five feet deep, and to secure a good rating there must be but little wind.



It should be attached to the bow of a skiff, as shown in the cut, and immersed not less than two feet. The boat should have no rudder. The observer should also stake out two parallel range lines on shore, about two hundred feet apart, and at right angles to the course the boat is to take.

Attach a quarter-inch cotton cord, about three hundred feet long, to the bow of the boat, and pass it around a pulley which is placed in line with the course; if there is a bend in the bank a pulley may not be necessary.

It will require three or four men to pull the boat fast enough for the high velocities, and there must be a boatman with oars in the boat with the observer, to prevent its running into the bank.

Haul the boat over the measured base at very slow, very fast, and medium velocities, which should be as nearly uniform as possible during each passage.

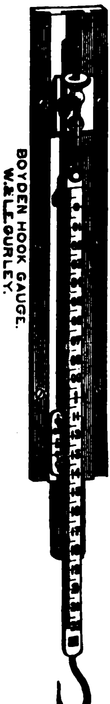
Note before each trial if the meter is free to point in the direction of the current, as the connecting wires are liable, in backing over the course, to get twisted, so as to pull the meter out of line.

Fasten a vertical rod on the boat by the seat of the observer, to enable him to sight at the range stakes as he passes them; start the stop-watch and register on the first range line, and stop them on the second; and note accurately the time as given by the stop-watch, and the number of revolutions of the wheel, as indicated by the register. For a further account of the calculations involved in the reduction of the observations made, and the determination of the rate of the meter, we refer to the printed circular which is prepared to accompany every instrument sold.

Engineers usually prefer to rate their own meters; but, if desired, we will carefully make the rating and computation, at a cost of $10 for each meter rated.

The rating of a meter will not change as long as the wheel turns freely, and has not been seriously injured.

Boyden's Hook Gauge,



No. 385.

Price, $25.00.

So called from the name of its inventor, is used in determining the depth of water flowing over weirs, etc.

As represented in the cut, it has a frame of wood, three feet long and four inches wide, in a rectangular groove of which another piece is made to slide, carrying a metallic scale divided to feet and hundredths, and figured from zero to two feet, and two-tenths, as shown.

Connected with the scale is a brass screw passing through a socket, fastened to another shorter sliding piece, shown above, which can be clamped at any point on the frame, and the scale with hook moved in either direction by the milled head nut.

There is also a vernier attached to the frame, and movable under the screw-heads which secure it, in order to adjust its zero to correspond with the point of the hook, as will be described hereafter. The vernier reads the scale to thousandths of a foot.

The hook is of brass, and has a sharp point which, when raised to the surface of the water at rest, indicates its precise level.

To use the Hook Gauge.

The hook gauge is used in a box attached to a flume at any convenient point near the weir, the water in the flume being conveyed to the box by rubber or lead pipes, and thus indicating the precise level of the water in the flume, the surface of the water in the box being also at rest.

When the depth of the water passing over a weir is required, the exact level of the crest of the weir should be taken by a leveling instrument and rod, and designated by a line drawn in the still-water box above the surface of the water.

The scale of the gauge being previously set at zero, with the vernier, the frame is fastened to the box above the water in such a position that the point of the hook is at the same level with that of the crest of the weir, the precise point being secured by the adjusting screw of the scale.

Now see that the zeros of the scale and vernier are in line, and if not, move the vernier under the screw-heads until the zeros correspond, and set the vernier fast.

The point of the hook will of course be under water, and at the same time level with that of the crest of the weir.

The depth of the water flowing over the weir is the distance between the point of the hook in the position named, and the exact surface of the water.

To find this the hook is raised by turning the milled head nut until the point of the hook, appearing a little above the surface, causes a distortion in the reflection of the light from the surface of the water; then a little movement of the hook in the opposite direction, so as just to cause the distortion to disappear, will indicate the surface, with precision.

The reading of the scale will then give the depth of water passing over the weir, in thousandths of a foot.

It will be understood from the cut that the longer movements of the scale are made by moving the clamping-piece over the frame, the smaller adjustments being effected by the milled nut.

CHAINS.

Surveyors' Chains.

Four Pole Chains.—The ordinary surveyors' chain is sixty-six feet, or four poles long, composed of one hundred links, each connected to the other by two rings, and furnished with tally marks at the end of every ten links.

In all the chains we manufacture, the rings are oval, are sawed, and well closed, the ends of the wire forming the hook being also filed and bent close to the link, so as to avoid the danger of "kinking."

A link in measurement includes a ring at each end.

The handles are of brass, and each forms part of the end links, to which it is connected by a nut, by which also the length of the chain is adjusted.

The tallies are also of brass, and have one, two, three, or four notches, as they are ten, twenty, thirty, or forty links, from either end; the fiftieth link is rounded, so as to distinguish it from the others.

Two Pole Chains.—In place of the four pole chain just described, many surveyors prefer one of two rods or thirty-three feet long, having but fifty links, and counted by its tallies from one end in a single direction.

Snap for Altering Chains.—We often make four pole chains so arranged, that by detaching a steel snap in the middle, the two parts can be separated, and then one of the handles being removed in the same manner, and transferred to the forty-ninth link, a two pole chain is readily obtained. This modification is only made without charge if ordered with the chain.

Sizes of Wire.—Our surveyors' chains are made of the best refined iron wire, of sizes No. 8 or 10, as may be preferred; the diameter of No. 10 wire being about one-eighth of an inch, and that of No. 8 wire nearly five thirty-seconds of an inch.

Engineers' Chains

Differ from the preceding, in that the links are each 12 inches long; the wire, also, is usually much stronger.

They are either fifty or one hundred feet long, and are furnished with swivel handles, tallies, &c.

In place of the round rings commonly made, we have substituted in these, and our other chains, rings of an oval form, and find them almost one-third stronger, though made of the same kind of wire.

The wire used for these chains is of sizes Nos. 8, 10, and 12, is of the first quality, and the whole chain is well and accurately made.

Steel Chains.

Chains made of steel wire, though more costly than those which we have just described, are yet often preferred on account of their greater strength.

They are made of any desired size or length, generally of No. 10, rarely of No. 8 wire, and are very stiff and strong.

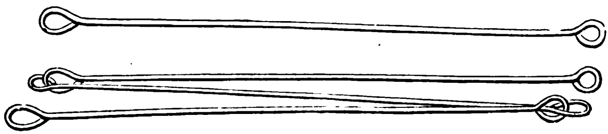
Brazed Steel Chains.—A very portable and excellent measure is made, by a light steel chain, each link and ring of which is securely *brazed*, after being united together and tested; the wire is also tempered.

The wire generally used by us is of size No. 12, or about seven sixty-fourths of an inch diameter; the rings are of oval form, the chain, though exceedingly light, is almost incapable of being either broken or stretched.

Our steel brazed chains have been found exceedingly desirable for all kinds of measurement, and for the use of engineers upon railroads and canals have almost entirely superseded the heavier chains.

Grumman's Patent Chains.

These chains, invented and patented by J. M. Grumman, of Brooklyn, N. Y., are made of very light steel wire, the links being finely tempered, and, as shown in the illustration,



so formed at the ends as to fold together readily, and thus dispense with the use of rings.

This construction gives only one-third as many wearing points as the ordinary chain, and affords the utmost facility for repairs, from five to ten extra links being furnished with each chain, which have only to be sprung into place to replace such as may have been broken ; it can also be taken apart at any link, and, by having a spring-catch on either handle, be made of any length desired. These chains are made of three different sizes of wire—the first two, termed drag-chains, being of size No. 12 and 15, and used for measuring on the surface, like the ordinary chain ; and the second, called the "suspended-chain," for very accurate measurements, made of No. 18 wire, and with spring-balance, thermometer and spirit-level attachments, to be held above the surface when in use, the extremities of the chain being marked upon the ground by the points of plummets let fall from the ends of the chain.

The drag-chains are all that are needed in common land surveys; for a mixed practice of village and country surveying, the spring-balance should be attached to the drag-

* No. 15 wire is about $\frac{1}{18}$ inch diameter.

chains, while for city surveying the suspended chain, with all its attachments, is the proper instrument.

We have purchased the patent for the Grumman chains, with the entire right to make and sell them, and shall be able to furnish them promptly.

Vara Chains.

The Spanish or Mexican Vara, which is in very general use in Texas, Mexico, and Cuba, is 33.372 inches long. The chains are made of ten or twenty varas, each vara being usually divided into five links; a link, including a ring at each end, is, therefore, 6.674 inches. A chain of ten varas has fifty links; of twenty varas one hundred links. Each vara is marked by a round brass tally, numbered from one to nine in the ten-vara chain, and from one to nineteen, in the twenty-vara chain. Sometimes, but rarely, the vara is divided into four links; a ten-vara chain then has forty links, and a twenty-vara, eighty links.

Meter Chains.

The French Meter is very generally used as a standard in South America, and chains of ten and twenty meters are often ordered; they are made either of iron or steel wire as desired, the number of links to a meter and the tallies being similar to those of the Vara.

Marking Pins.

In chaining, there are needed ten marking pins, or chain stakes, made either of iron, steel, or brass wire, as may be preferred, about fourteen inches long, pointed at one end to enter the ground, and formed into a ring at the other, for convenience in handling.

They are sometimes loaded with a little mass of lead around the lower end, so as to answer as a plumb when dropped to the ground, from the suspended end of the chain.

To Use the Chain.

In using the chain its length must be taken from its extreme ends, and the pins placed on the outside of the handles; it must be drawn straight and taut, and carefully examined to detect any kinks or other causes of inaccuracy.

Our chains are all carefully tested at every ten, sometimes at every link, and in their whole length by the U. S. standard, and when new may always be relied upon as correct.

But as all will alter, more or less, after long use in the field, it will be best for the surveyor to carefully lay down on a level surface the exact length of the chain when yet new, marking also its extreme ends by monuments which will not be liable to disturbance.

He will thus have a standard measure of his own to which the chain can be adjusted from time to time, and again be used with perfect confidence.

TAPE MEASURES.

The best are steel tapes, made of a thin ribbon of steel. Chesterman's English steel tapes are made in one piece, and wound up in a leathern case, having a folding handle.

Paine's American steel tapes are made of thin steel ribbon, straight spring temper, and in one piece. They are of narrower and heavier ribbon than the Chesterman, and can be detached from the case, and used with a pair of handles, with compensation scale for variations of temperature, for chain measurements. These tapes are wound up in a leather or japanned case as may be desired, having a folding handle. Paine's tapes are U. S. Standard measure at 62° temperature, and using about twelve pounds strain with a fifty-foot tape, and sixteen pounds strain with a hundred-foot tape.

These tapes are of all lengths, from twenty-five to one hundred feet, divided into feet and inches, and links, or, more usually, feet and tenths of a foot, and links, the figures and graduations being raised on the surface of the steel.

Note.—A 100 feet tape expands for each 10° rise in temperature, one inch in fourteen hundred feet.

CHESTERMAN'S METALLIC TAPES.

These are of linen, and have also fine brass wires interwoven through their whole length.

They are thus measurably correct, even when wet.

They are mounted like the steel tapes, of like lengths, and similarly graduated.

Note.—We can furnish most of our tape measures with metric or vara measure on the reverse side, instead of links, at an extra cost of one cent per foot for metallic tapes, and three cents per foot for steel tapes.

STANDARD STEEL RIBBON CHAIN-TAPES.

These are made of a thin ribbon of spring steel, $\frac{1}{4}$ inch wide, 33 feet to 500 feet in length. They are coming into general use for bridge and road work, also for testing chains and tapes.

The 33 and 66 feet lengths are graduated each link; the 50 and 100 feet lengths are graduated each foot. The reel is made to fold compactly when not in use, and can be carried in the pocket.

The longer tapes, from 200 to 500 feet, are usually graduated each five feet, and are mounted on a more substantial reel. (For prices see p. 21.)

TRAVERSE TABLES.

Course	Dist. 1.		Dist. 2.		Dist. 3.		Dist. 4.		Dist. 5.		
° ′	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	° ′
0 15	1.0000	0.0044	2.0000	0.0087	3 0000	0.0131	4.0000	0.0175	5.0000	0.0218	89 45
30	0000	0087	1.9999	0175	2.9999	0262	3.9998	0349	4.9998	0436	30
45	0.9999	0131	9998	0262	9997	0393	9997	0524	9996	0654	15
1 0	9998	0175	9997	0349	9995	0524	9994	0698	9992	0873	89 0
15	9998	0218	9995	0436	9993	0654	9990	0873	9988	1091	45
30	9997	0262	9993	0524	9990	0785	9986	1047	9983	1309	30
45	9995	0305	9991	0611	9986	0916	9981	1222	9977	1527	15
2 0	9994	0349	9988	0698	9982	1047	9976	1396	9970	1745	88 0
15	9992	0393	9985	0785	9977	1178	9969	1570	9961	1963	45
30	9990	0436	9981	0872	9971	1309	9962	1745	9952	2181	30
45	0 9988	0.0480	1 9977	0.0960	2.9965	0.1439	3 9954	0.1919	4.9942	0.2399	15
3 0	9986	0523	9973	1047	9959	1570	9945	2093	9931	2617	87 0
15	9984	0567	9968	1134	9952	1701	9936	2268	9920	2835	45
30	9981	0610	9963	1221	9944	1831	9925	2442	9907	3052	30
45	9979	0654	9957	1308	9936	1962	9914	2616	9893	3270	15
4 0	9976	0698	9951	1395	9927	2093	9903	2790	9878	3488	86 0
15	9973	0741	9945	1482	9918	2223	9890	2964	9863	3705	45
30	9969	0785	9938	1569	9908	2354	9877	3138	9846	3923	30
45	9966	0828	9931	1656	9897	2484	9863	3312	9828	4140	15
5 0	9962	0872	9924	1743	9886	2615	9848	3486	9810	4358	85 0
15	0.9958	0.0915	1.9916	0.1830	2.9874	0.2745	3.9832	0 3660	4.9790	0.4575	45
30	9954	0958	9908	1917	9862	2875	9816	3834	9770	4792	30
45	9950	1002	9899	2004	9849	3006	9799	4008	9748	5009	15
6 0	9945	1045	9890	2091	9836	3136	9781	4181	9726	5226	84 0
15	9941	1089	9881	2177	9822	3266	9762	4355	9703	5443	45
30	9936	1132	9871	2264	9807	3396	9743	4528	9679	5660	30
45	9931	1175	9861	2351	9792	3526	9723	4701	9653	5877	15
7 0	9925	1219	9851	2437	9776	3656	9702	4875	9627	6093	83 0
15	9920	1262	9840	2524	9760	3786	9680	5048	9600	6310	45
30	9914	1305	9829	2611	9743	3916	9658	5221	9572	6526	30
45	0.9909	0.1349	1.9817	0.2697	2.9726	0.4046	3 9635	0.5394	4.9543	0.6743	15
8 0	9903	1392	9805	2783	9708	4175	9611	5567	9513	6959	82 0
15	9897	1435	9793	2870	9690	4305	9586	5740	9483	7175	45
30	9890	1478	9780	2956	9670	4434	9561	5912	9451	7390	30
45	9884	1521	9767	3042	9651	4564	9534	6085	9418	7606	15
9 0	9877	1564	9754	3129	9631	4693	9508	6257	9384	7822	81 0
15	9870	1607	9740	3215	9610	4822	9480	6430	9350	8037	45
30	9863	1650	9726	3301	9589	4951	9451	6602	9314	8252	30
45	9856	1693	9711	3387	9567	5080	9422	6774	9278	8467	15
10 0	9848	1736	9696	3473	9544	5209	9392	6946	9240	8682	80 0
15	0.9840	0.1779	1.9681	0.3559	2.9521	0.5338	3.9362	0.7118	4.9202	0.8897	45
30	9833	1822	9665	3645	9498	5467	9330	7289	9163	9112	30
45	9825	1865	9649	3730	9474	5596	9298	7461	9123	9326	15
11 0	9816	1908	9633	3816	9449	5724	9265	7632	9081	9540	79 0
15	9808	1951	9616	3902	9424	5853	9231	7804	9039	9755	45
30	9799	1994	9598	3987	9398	5981	9197	7975	8996	9968	30
45	9790	2036	9581	4073	9371	6109	9162	8146	8952	1.0182	15
12 0	9781	2079	9563	4158	9344	6237	9126	8316	8907	0396	78 0
15	9772	2122	9545	4244	9317	6365	9089	8487	8862	0609	45
30	9763	2164	9526	4329	9289	6493	9052	8658	8815	0822	30
45	0.9753	0.2207	1.9507	0.4414	2.9260	0 6621	3.9014	0.8828	4.8767	1.1035	15
13 0	9744	2250	9487	4499	9231	6749	8975	8998	8719	1248	77 0
15	9734	2292	9468	4584	9201	6876	8935	9168	8669	1460	45
30	9724	2334	9447	4669	9171	7003	8895	9338	8618	1672	30
45	9713	2377	9427	4754	9140	7131	8854	9507	8567	1884	15
14 0	9703	2419	9406	4838	9109	7258	8812	9677	8515	2096	76 0
15	9692	2462	9385	4923	9077	7385	8769	9846	8462	2308	45
30	9681	2504	9363	5008	9044	7511	8726	1.0015	8407	2519	30
45	9670	2546	9341	5092	9011	7638	8682	0184	8352	2730	15
15 0	9659	2588	9319	5176	8978	7765	8637	0353	8296	2941	75 0
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Course
	Dist. 1.		Dist. 2.		Dist. 3.		Dist. 4.		Dist. 5.		

Course	Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		Dist. 10.		
° ′	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	° ′
0 15	5.9999	0.0262	6.9999	0.0305	7.9999	0.0349	8.9999	0.0393	9.9999	0.0436	89 45
30	9998	0524	9997	0611	9997	0698	9997	0785	9996	0873	30
45	9995	0785	9994	0916	9993	1047	9992	1178	9991	1309	15
1 0	9991	1047	9989	1222	9988	1396	9986	1571	9985	1745	89 0
15	9986	1309	9983	1527	9981	1745	9979	1963	9976	2181	45
30	9979	1571	9976	1832	9973	2094	9969	2356	9966	2618	30
45	9972	1832	9967	2138	9963	2443	9958	2748	9953	3054	15
2 0	9963	2094	9957	2443	9951	2792	9945	3141	9939	3490	88 0
15	9954	2356	9946	2748	9938	3141	9931	3533	9923	3926	45
30	9943	2617	9933	3053	9924	3490	9914	3926	9905	4362	30
45	5.9931	0.2879	6.9919	0.3358	7.9908	0.3838	8.9896	0.4318	9.9885	0.4798	15
3 0	9918	3140	9904	3664	9890	4187	9877	4710	9863	5234	87 0
15	9904	3402	9887	3968	9871	4535	9855	5102	9829	5669	45
30	9888	3663	9869	4273	9851	4884	9832	5494	9813	6105	30
45	9872	3924	9850	4578	9829	5232	9807	5886	9786	6540	15
4 0	9854	4185	9829	4883	9805	5581	9781	6278	9756	6976	86 0
15	9835	4447	9808	5188	9780	5929	9753	6670	9725	7411	45
30	9815	4708	9784	5492	9753	6277	9723	7061	9692	7846	30
45	9794	4968	9760	5797	9725	6625	9691	7453	9657	8281	15
5 0	9772	5229	9734	6101	9696	6972	9658	7844	9619	8716	85 0
15	5.9748	0.5490	6.9706	0.6405	7.9664	0.7320	8.9622	0.8235	9.9580	0.9150	45
30	9724	5751	9678	6709	963	7668	9586	8626	9540	9585	30
45	9698	6011	9618	7013	9597	8015	9547	9017	9497	1.0019	15
6 0	9671	6272	9617	7317	9562	8362	9507	9408	9452	0453	84 0
15	9643	6532	9584	7621	9525	8709	9465	9798	9406	0887	45
30	9614	6792	9550	7924	9486	9056	9421	1.0188	9357	1320	30
45	9584	7052	9515	8228	9445	9403	9376	0578	9307	1754	15
7 0	9553	7312	9478	8531	9404	9750	9329	0968	9255	2187	83 0
15	9520	7572	9440	8834	9360	1.0096	9280	1358	9200	2620	45
30	9487	7832	9401	9137	9316	0442	9230	1747	9144	3053	30
45	5.9452	0.8091	6.9361	0.9440	7.9269	1.0788	8.9178	1.2137	9.9087	1.3485	15
8 0	9416	8350	9319	9742	9221	1134	9124	2526	9027	3917	82 0
15	9379	8610	9276	1.0044	9172	1479	9069	2914	8965	4349	45
30	9341	8869	9231	0347	9121	1825	9011	3303	8902	4781	30
45	9302	9127	9185	0649	9069	2170	8953	3691	8836	5212	15
9 0	9261	9386	9138	0950	9015	2515	8892	4079	8769	5643	81 0
15	9220	9645	9090	1252	8960	2859	8830	4467	8700	6074	45
30	9177	9903	9040	1553	8903	3204	8766	4854	8629	6505	30
45	9133	1.0161	8989	1854	8844	3548	8700	5241	8556	6935	15
10 0	9088	0419	8937	2155	8785	3892	8633	5628	8481	7365	80 0
15	5.9042	1.0677	6.8883	1.2456	7.8723	1.4235	8.8564	1.6015	9.8404	1.7794	45
30	8995	0934	8828	2756	8660	4579	8493	6401	8325	8224	30
45	8947	1191	8772	3057	8596	4922	8421	6787	8245	8652	15
11 0	8898	1449	8714	3357	8530	5265	8346	7173	8163	9081	79 0
15	8847	1705	8655	3656	8463	5607	8271	7558	8079	9509	45
30	8795	1962	8595	3956	8394	5949	8193	7943	7992	9937	30
45	8743	2219	8533	4255	8324	6291	8114	8328	7905	2.0364	15
12 0	8689	2475	8470	4554	8252	6633	8033	8712	7815	0791	78 0
15	8634	2731	8406	4852	8178	6974	795	9096	7723	1218	45
30	8578	2986	8341	5151	8104	7315	7867	9480	7630	1644	30
45	5.8521	1.3242	6.8274	1.5449	7.8027	1.7656	8.7781	1.9863	9.7534	2.2070	15
13 0	8462	3497	8206	5747	7950	7996	7693	2.0246	7437	2495	77 0
15	8403	3752	8137	6044	7870	8336	7604	0628	7338	2920	45
30	8342	4007	8066	6341	7790	8676	7513	1010	7237	3345	30
45	8281	4261	7994	6638	7707	9015	7421	1392	7134	3769	15
14 0	8218	4515	7921	6935	7624	9354	7327	1773	7030	4192	76 0
15	8154	4769	7846	7231	7538	9692	7231	2154	6923	4615	45
30	8089	5023	7770	7527	7452	2.0030	7133	2534	6815	5038	30
45	8023	5276	7693	7822	7364	0368	7034	2914	6705	5460	15
15 0	7956	5529	7615	8117	7274	0706	6933	3294	6593	5882	75 0
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Course
	Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		Dist. 10.		

Course	Dist. 1. Lat.	Dist. 1. Dep.	Dist. 2. Lat.	Dist. 2. Dep.	Dist. 3. Lat.	Dist. 3. Dep.	Dist. 4. Lat.	Dist. 4. Dep.	Dist. 5. Lat.	Dist. 5. Dep.	
° ′											° ′
15 15	0.9648	0.2630	1.9296	0.5261	2.8944	0.7891	3.8591	1.0521	4.8239	1.3152	74 45
30	9636	2672	9273	5345	8909	8017	8545	0690	8182	3362	30
45	9625	2714	9249	5429	8874	8143	8498	0858	8123	3572	15
16 0	9613	2756	9225	5513	8838	8269	8450	1025	8063	3782	74 0
15	9600	2798	9201	5597	8801	8395	8402	1193	8002	3991	45
30	9588	2840	9176	5680	8765	8520	8353	1361	7941	4201	30
45	9576	2882	9151	5764	8727	8646	8303	1528	7879	4410	15
17 0	9563	2924	9126	5847	8689	8771	8252	1695	7815	4619	73 0
15	9550	2965	9100	5931	8651	8896	8201	1862	7751	4827	45
30	9537	3007	9074	6014	8612	9021	8149	2028	7686	5035	30
45	0.9524	0.3049	1.9048	0.6097	2.8572	0.9146	3.8096	1.2195	4.7620	1.5243	15
18 0	9511	3090	9021	6180	8532	9271	8042	2361	7553	5451	72 0
15	9497	3132	8994	6263	8491	9395	7988	2527	7485	5658	45
30	9483	3173	8966	6346	8450	9519	7933	2692	7416	5865	30
45	9469	3214	8939	6429	8408	9643	7877	2858	7347	6072	15
19 0	9455	3256	8910	6511	8366	9767	7821	3023	7276	6278	71 0
15	9441	3297	8882	6594	8323	9891	7764	3188	7204	6485	45
30	9426	3338	8853	6676	8279	1.0014	7706	3352	7132	6690	30
45	9412	3379	8824	6758	8235	0138	7647	3517	7059	6896	15
20 0	9397	3420	8794	6840	8191	0261	7588	3681	6985	7101	70 0
15	0.9382	0.3461	1.8764	0.6922	2.8146	1.0384	3.7528	1.3845	4.6910	1.7306	45
30	9367	3502	8733	7004	8100	0506	7467	4008	6834	7510	30
45	9351	3543	8703	7086	8054	0629	7405	4172	6757	7715	15
21 0	9336	3584	8672	7167	8007	0751	7343	4335	6679	7918	69 0
15	9320	3624	8640	7249	7960	0873	7280	4498	6600	8122	45
30	9304	3665	8608	7330	7913	0995	7217	4660	6521	8325	30
45	9288	3706	8576	7411	7864	1117	7152	4822	6440	8528	15
22 0	9272	3746	8544	7492	7816	1238	7087	4984	6359	8730	68 0
15	9255	3786	8511	7573	7766	1359	7022	5146	6277	8932	45
30	9239	3827	8478	7654	7716	1481	6955	5307	6194	9134	30
45	0.9222	0.3867	1.8444	0.7734	2.7666	1.1601	3.6888	1.5468	4.6110	1.9336	15
23 0	9205	3907	8410	7815	7615	1722	6820	5629	6025	9537	67 0
15	9188	3947	8376	7895	7564	1842	6752	5790	5940	9737	45
30	9171	3987	8341	7975	7512	1962	6682	5950	5853	9937	30
45	9153	4027	8306	8055	7459	2082	6612	6110	5766	2.0137	15
24 0	9135	4067	8271	8135	7406	2202	6542	6269	5677	0337	66 0
15	9118	4107	8235	8214	7353	2322	6470	6429	5588	0536	45
30	9100	4147	8199	8294	7299	2441	6398	6588	5498	0735	30
45	9081	4187	8163	8373	7244	2560	6326	6746	5407	0933	15
25 0	9063	4226	8126	8452	7189	2679	6252	6905	5315	1131	65 0
15	0.9045	0.4266	1.8089	0.8531	2.7134	1.2797	3.6178	1.7063	4.5223	2.1328	45
30	9026	4305	8052	8610	7078	2915	6103	7220	5129	1526	30
45	9007	4344	8014	8689	7021	3033	6028	7378	5035	1722	15
26 0	8988	4384	7976	8767	6964	3151	5952	7535	4940	1919	64 0
15	8969	4423	7937	8846	6906	3269	5875	7692	4844	2114	45
30	8949	4462	7899	8924	6848	3386	5797	7848	4747	2310	30
45	8930	4501	7860	9002	6789	3503	5719	8004	4649	2505	15
27 0	8910	4540	7820	9080	6730	3620	5640	8160	4550	2700	63 0
15	8890	4579	7780	9157	6671	3736	5561	8315	4451	2894	45
30	8870	4617	7740	9235	6610	3852	5480	8470	4351	3087	30
45	0.8850	0.4656	1.7700	0.9312	2.6550	1.3968	3.5400	1.8625	4.4249	2.3281	15
28 0	8829	4695	7659	9389	6488	4084	5318	8779	4147	3474	62 0
15	8809	4733	7618	9466	6427	4200	5236	8933	4045	3666	45
30	8788	4772	7576	9543	6365	4315	5153	9086	3941	3858	30
45	8767	4810	7535	9620	6302	4430	5069	9240	3836	4049	15
29 0	8746	4848	7492	9696	6239	4544	4985	9392	3731	4240	61 0
15	8725	4886	7450	9772	6175	4659	4900	9545	3625	4431	45
30	8704	4924	7407	9848	6111	4773	4814	9697	3518	4621	30
45	8682	4962	7364	9924	6046	4886	4728	9849	3410	4811	15
30 0	8660	5000	7321	1.0000	5981	5000	4641	2.0000	3301	5000	60 0
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Course
	Dist. 1.		Dist. 2.		Dist. 3.		Dist. 4.		Dist. 5.		

Course		Dist. 6. Lat.	Dist. 6. Dep.	Dist. 7. Lat.	Dist. 7. Dep.	Dist. 8. Lat.	Dist. 8. Dep.	Dist. 9. Lat.	Dist. 9. Dep.	Dist. 10. Lat.	Dist. 10. Dep.		
°	′											°	′
15	15	5.7887	1.5782	6.7535	1.8412	7.7183	2.1042	8.6831	2.3673	9.6479	2.6303	74	45
	30	7818	6034	7454	8707	7090	1379	6727	4051	6363	6724		30
	45	7747	6286	7372	9001	6996	1715	6621	4430	6246	7144		15
16	0	7676	6538	7288	9295	6901	2051	6514	4807	6126	7564	74	0
	15	7603	6790	7203	9588	6804	2386	6404	5185	6005	7983		45
	30	7529	7041	7117	9881	6706	2721	6294	5561	5882	8402		30
	45	7454	7292	7030	2.0174	6606	3056	6181	5938	5757	8820		15
17	0	7378	7542	6941	0466	6504	3390	6067	6313	5630	9237	73	0
	15	7301	7792	6851	0758	6402	3723	5952	6689	5502	9654		45
	30	7223	8042	6760	1049	6297	4056	5835	7064	5372	3.0071		30
	45	5.7144	1.8292	6.6668	2.1341	7.6192	2.4389	8.5716	2.7438	9.5240	3.0486		15
18	0	7063	8541	6574	1631	6085	4721	5595	7812	5106	0902	72	0
	15	6982	8790	6479	1921	5976	5053	5473	8185	4970	1316		45
	30	6899	9038	6383	2211	5866	5384	5349	8557	4832	1730		30
	45	6816	9286	6285	2501	5754	5715	5224	8930	4693	2144		15
19	0	6731	9534	6186	2790	5641	6045	5097	9301	4552	2557	71	0
	15	6645	9781	6086	3078	5527	6375	4968	9672	4409	2969		45
	30	6558	2.0028	5985	3366	5411	6705	4838	3.0043	4264	3381		30
	45	6471	0275	5882	3654	5294	7033	4706	0413	4118	3792		15
20	0	6382	0521	5778	3941	5175	7362	4572	0782	3969	4202	70	0
	15	5.6291	2.0767	6.5673	2.4228	7.5055	2.7689	8.4437	3.1151	9.3819	3.4612		45
	30	6200	1012	5567	4515	4934	8017	4300	1519	3667	5021		30
	45	6108	1257	5459	4800	4811	8343	4162	1886	3514	5429		15
21	0	6015	1502	5351	5086	4686	8669	4022	2253	3358	5837	69	0
	15	5920	1746	5241	5371	4561	8995	3881	2619	3201	6244		45
	30	5825	1990	5129	5655	4433	9320	3738	2985	3042	6650		30
	45	5729	2233	5017	5939	4305	9645	3593	3350	2881	7056		15
22	0	5631	2476	4903	6222	4175	9969	3447	3715	2718	7461	68	0
	15	5532	2719	4788	6505	4043	3.0292	3299	4078	2554	7865		45
	30	5433	2961	4672	6788	3910	0615	3149	4442	2388	8268		30
	45	5.5332	2.3203	6.4554	2.7070	7.3776	3.0937	8.2998	3.4804	9.2220	3.8671		15
23	0	5230	3444	4435	7351	3640	1258	2845	5166	2050	9073	67	0
	15	5127	3685	4315	7632	3503	1580	2691	5527	1879	9474		45
	30	5024	3925	4194	7912	3365	1900	2535	5887	1706	9875		30
	45	4919	4165	4072	8192	3225	2220	2378	6247	1531	4.0275		15
24	0	4813	4404	3948	8472	3084	2539	2219	6606	1355	0674	66	0
	15	4706	4643	3823	8750	2941	2858	2059	6965	1176	1072		45
	30	4598	4882	3697	9029	2797	3175	1857	7322	0996	1469		30
	45	4489	5120	3570	9306	2651	3493	1733	7679	0814	1866		15
25	0	4378	5357	3442	9583	2505	3809	1568	8036	0631	2262	65	0
	15	5.4267	2.5594	6.3312	2.9860	7.2356	3.4125	8.1401	3.8391	9.0446	4.2657		45
	30	4155	5831	3181	3.0136	2207	4441	1233	8746	0259	3051		30
	45	4042	6067	3049	0411	2056	4756	1063	9100	0070	3445		15
26	0	3928	6302	2916	0686	1904	5070	0891	9453	8.9879	3837	64	0
	15	3812	6537	2781	0960	1750	5383	0719	9806	9687	4229		45
	30	3696	6772	2645	1234	1595	5696	0544	4.0158	9493	4620		30
	45	3579	7006	2509	1507	1438	6008	0368	0509	9298	5010		15
27	0	3460	7239	2370	1779	1281	6319	0191	0859	9101	5399	63	0
	15	3341	7472	2231	2051	1121	6630	0012	1209	8902	5787		45
	30	3221	7705	2091	2322	0961	6940	7.9831	1557	8701	6175		30
	45	5.3099	2.7937	6.1949	3.2593	7.0799	3.7249	7.9649	4.1905	8.8499	4.6561		15
28	0	2977	8168	1806	2863	0636	7558	9465	2252	8295	6947	62	0
	15	2853	8399	1662	3132	0471	7866	9280	2599	8089	7332		45
	30	2729	8630	1517	3401	0305	8173	9094	2944	7882	7716		30
	45	2604	8859	1371	3669	0138	8479	8905	3289	7673	8099		15
29	0	2477	9089	1223	3937	6.9970	8785	8716	3633	7462	8481	61	0
	15	2350	9317	1075	4203	9800	9090	8525	3976	7250	8862		45
	30	2221	9545	0925	4470	9628	9394	8332	4318	7036	9242		30
	45	2092	9773	0774	4735	9456	9697	8138	4659	6820	9622		15
30	0	1962	3.0000	0622	5000	9282	4.0000	7942	5000	6603	5.0000	60	0
		Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Course	
		Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		Dist. 10.			

Course		Dist. 1.		Dist. 2.		Dist. 3.		Dist. 4.		Dist. 5.			
°		Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	°	'
30	15	0.8638	0.5038	1.7277	1.0075	2.5915	1.5113	3.4553	2.0151	4.3192	2.5189	59	45
	30	8616	5075	7233	0151	5849	5226	4465	0302	3081	5377		30
	45	8594	5113	7188	0226	5782	5339	4376	0452	2970	5565		15
31	0	8572	5150	7142	0301	5715	5451	4287	0602	2858	5752	59	0
	15	8549	5188	7098	0375	5647	5563	4196	0751	2746	5939		45
	30	8526	5225	7053	0450	5579	5675	4106	0900	2632	6125		30
	45	8504	5262	7007	0524	5511	5786	4014	1049	2518	6311		15
32	0	8480	5299	6961	0598	5441	5898	3922	1197	2402	6496	58	0
	15	8457	5336	6915	0672	5372	6008	3829	1345	2286	6681		45
	30	8434	5373	6868	0746	5302	6119	3736	1492	2170	6865		30
	45	0.8410	0.5410	1.6821	1.0819	2.5231	1.6229	3.3642	2.1639	4.2052	2.7049		15
33	0	8387	5446	6773	0893	5160	6339	3547	1786	1934	7232	57	0
	15	8363	5483	6726	0966	5089	6449	3451	1932	1814	7415		45
	30	8339	5519	6678	1039	5017	6558	3355	2077	1694	7597		30
	45	8315	5556	6629	1111	4944	6667	3259	2223	1573	7779		15
34	0	8290	5592	6581	1184	4871	6776	3162	2368	1452	7960	56	0
	15	8266	5628	6532	1256	4798	6884	3064	2512	1329	8140		45
	30	8241	5664	6483	1328	4724	6992	2965	2656	1206	8320		30
	45	8216	5700	6433	1400	4649	7100	2866	2800	1082	8500		15
35	0	8192	5736	6383	1472	4575	7207	2766	2943	0958	8679	55	0
	15	0.8166	0.5771	1.6333	1.1543	2.4499	1.7314	3.2666	2.3086	4.0832	2.8857		45
	30	8141	5807	6282	1614	4423	7421	2565	3228	0706	9035		30
	45	8116	5842	6231	1685	4347	7527	2463	3370	0579	9212		15
36	0	8090	5878	6180	1756	4271	7634	2361	3511	0451	9389	54	0
	15	8064	5913	6129	1826	4193	7739	2258	3652	0322	9565		45
	30	8039	5948	6077	1896	4116	7845	2154	3793	0193	9741		30
	45	8013	5983	6025	1966	4038	7950	2050	3933	0063	9916		15
37	0	7986	6018	5973	2036	3959	8054	1945	4073	3.9932	3.0091	53	0
	15	7960	6053	5920	2106	3880	8159	1840	4212	9800	0265		45
	30	7934	6088	5867	2175	3801	8263	1734	4350	9668	0438		30
	45	0.7907	0.6122	1.5814	1.2244	2.3721	1.8367	3.1628	2.4489	3.9534	3.0611		15
38	0	7880	6157	5760	2313	3640	8470	1520	4626	9400	0783	52	0
	15	7853	6191	5706	2382	3560	8573	1413	4764	9266	0955		45
	30	7826	6225	5652	2450	3478	8675	1304	4901	9130	1126		30
	45	7799	6259	5598	2518	3397	8778	1195	5037	8994	1296		15
39	0	7771	6293	5543	2586	3314	8880	1086	5173	8857	1466	51	0
	15	7744	6327	5488	2654	3232	8981	0976	5308	8720	1635		45
	30	7716	6361	5432	2722	3149	9082	0865	5443	8581	1804		30
	45	7688	6394	5377	2789	3065	9183	0754	5578	8442	1972		15
40	0	7660	6428	5321	2856	2981	9284	0642	5712	8302	2139	50	0
	15	0.7632	0.6461	1.5265	1.2922	2.2897	1.9384	3.0529	2.5845	3.8162	3.2306		45
	30	7604	6494	5208	2989	2812	9483	0416	5978	8020	2472		30
	45	7576	6528	5151	3055	2727	9583	0303	6110	7878	2638		15
41	0	7547	6561	5094	3121	2641	9682	0188	6242	7735	2803	49	0
	15	7518	6593	5037	3187	2555	9780	0074	6374	7592	2967		45
	30	7490	6626	4979	3252	2469	9879	2.9958	6505	7448	3131		30
	45	7461	6659	4921	3318	2382	9976	9842	6635	7303	3294		15
42	0	7431	6691	4863	3383	2294	2.0074	9726	6765	7157	3457	48	0
	15	7402	6724	4804	3447	2207	0171	9609	6895	7011	3618		45
	30	7373	6756	4746	3512	2118	0268	9491	7024	6864	3780		30
	45	0.7343	0.6788	1.4686	1.3576	2.2030	2.0364	2.9373	2.7152	3.6716	3.3940		15
43	0	7314	6820	4627	3640	1941	0460	9254	7280	6568	4100	47	0
	15	7284	6852	4567	3704	1851	055	9135	7407	6419	4259		45
	30	7254	6884	4507	3767	1761	0651	9015	7534	6269	4418		30
	45	7224	6915	4447	3830	1671	0745	8895	7661	6118	4576		15
44	0	7193	6947	4387	3893	1580	0840	8774	7786	5967	4733	46	0
	15	7163	6978	4326	3956	1489	0934	8652	7912	5815	4890		45
	30	7133	7009	4265	4018	1398	1027	8530	8036	5663	5045		30
	45	7102	7040	4204	4080	1306	1120	8407	8161	5509	5201		15
45	0	7071	7071	4142	4142	1213	1213	8284	8284	5355	5355	45	0
		Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Course	
		Dist. 1.		Dist. 2.		Dist. 3.		Dist. 4.		Dist. 5.			

Course	Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		Dist. 10.		
° ′	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	° ′
30 15	5.1830	3.0226	6.0468	3.5264	6.9107	4.0302	7.7745	4.5340	8.6384	5.0377	59 45
30	1698	0452	0314	5528	8930	0603	7547	5678	6163	0754	30
45	1564	0678	0158	5791	8753	0903	7347	6016	5941	1129	15
31 0	1430	0902	0002	6053	8573	1203	7145	6353	5717	1504	59 0
15	1295	1126	5.9844	6314	8393	1502	6942	6690	5491	1877	45
30	1158	1350	9685	6575	8211	1800	6738	7025	5264	2250	30
45	1021	1573	9525	6835	8028	2097	6532	7359	5035	2621	15
32 0	0883	1795	9363	7094	7844	2394	6324	7693	4805	2992	58 0
15	0744	2017	9201	7353	7658	2689	6116	8025	4573	3361	45
30	0603	2238	9037	7611	7471	2984	5905	8357	4339	3730	30
45	5.0462	3.2458	5.8873	3.7868	6.7283	4.3278	7.5694	4.8688	8.4104	5.4097	15
33 0	0320	2678	8707	8125	7094	3571	5480	9018	3867	4464	57 0
15	0177	2898	8540	8381	6903	3863	5266	9346	3629	4829	45
30	0033	3116	8372	8636	6711	4155	5050	9674	3389	5194	30
45	4.9888	3334	8203	8890	6518	4446	4832	5.0001	3147	5557	15
34 0	9742	3552	8033	9144	6323	4735	4613	0327	2904	5919	56 0
15	9595	3768	7861	9396	6127	5024	4393	0652	2659	6280	45
30	9448	3984	7689	9648	5930	5312	4171	0977	2413	6641	30
45	9299	4200	7515	9900	5732	5600	3948	1300	2165	7000	15
35 0	9149	4415	7341	4.0150	5532	5886	3724	1622	1915	7358	55 0
15	4.8998	3.4629	5.7165	4.0400	6.5331	4.6172	7.3498	5.1943	8.1664	5.7715	45
30	8847	4842	6988	0649	5129	6456	3270	2263	1412	8070	30
45	8694	5055	6810	0897	4926	6740	3042	2582	1157	8425	15
36 0	8541	5267	6631	1145	4721	7023	2812	2901	0902	8779	54 0
15	8387	5479	6451	1392	4516	7305	2580	3218	0644	9131	45
30	8231	5689	6270	1638	4309	7586	2347	3534	0386	9482	30
45	8075	5899	6088	1883	4100	7866	2113	3849	0125	9832	15
37 0	7918	6109	5904	2127	3891	8145	1877	4163	7.9864	6.0182	53 0
15	7760	6318	5720	2371	3680	8424	1640	4476	9600	0529	45
30	7601	6526	5535	2613	3468	8701	1402	4789	9335	0876	30
45	4.7441	3.6733	5.5348	4.2855	6.3255	4.8977	7.1162	5.5100	7.9069	6.1222	15
38 0	7281	6940	5161	3096	3041	9253	0921	5410	8801	1566	52 0
15	7119	7146	4972	3337	2825	9528	0679	5718	8532	1909	45
30	6956	7351	4783	3576	2609	9801	0435	6026	8261	2251	30
45	6793	7555	4592	3815	2391	5.0074	0190	6333	7988	2592	15
39 0	6629	7759	4400	4052	2172	0346	6.9943	6639	7715	2932	51 0
15	6464	7962	4207	4289	1951	0616	9695	6943	7439	3271	45
30	6297	8165	4014	4525	1730	0886	9446	7247	7162	3608	30
45	6131	8366	3819	4761	1507	1155	9196	7550	6884	3944	15
40 0	5963	8567	3623	4995	1284	1423	8944	7851	6604	4279	50 0
15	4.5794	3.8767	5.3426	4.5229	6.1059	5.1690	6.8691	5.8151	7.6323	6.4612	45
30	5624	8967	3228	5461	0832	1956	8437	8450	6041	4945	30
45	5454	9166	3030	5693	0605	2221	8181	8748	5756	5276	15
41 0	5283	9364	2830	5924	0377	2485	7924	9045	5471	5606	49 0
15	5110	9561	2629	6154	0147	2748	7666	9341	5184	5935	45
30	4937	9757	2427	6383	5.9916	3010	7406	9636	4896	6262	30
45	4763	9953	2224	6612	9685	3271	7145	9929	4606	6588	15
42 0	4589	4.0148	2020	6839	9452	3530	6883	6.0222	4314	6913	48 0
15	4413	0342	1815	7066	9217	3789	6620	0513	4022	7237	45
30	4237	0535	1609	7291	8982	4047	6355	0803	3728	7559	30
45	4.4059	4.0728	5.1403	4.7516	5.8746	5.4304	6.6089	6.1092	7.3432	6.7880	15
43 0	3881	0920	1195	7740	8508	4560	5822	1380	3135	8200	47 0
15	3702	1111	0986	7963	8270	4815	5553	1666	2837	8518	45
30	3522	1301	0776	8185	8030	5068	5284	1952	2537	8835	30
45	3342	1491	0565	8406	7789	5321	5013	2236	2236	9151	15
44 0	3160	1680	0354	8626	7547	5573	4741	2519	1934	9466	46 0
15	2978	1867	0141	8845	7304	5823	4467	2801	1630	9779	45
30	2795	2055	4.9928	9064	7060	6073	4193	3082	1825	7.0091	30
45	2611	2241	9713	9281	6815	6321	3917	3361	1019	0401	15
45 0	2426	2426	9497	9497	6569	6569	3640	3640	0711	0711	45 0
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Course
	Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		Dist. 10.		

SUPPLEMENT

TO

TWENTY-NINTH EDITION OF MANUAL.

JANUARY, 1891.

☞ When ordering goods always state what edition of Manual, and number in Catalogue.

*** The prices in this Catalogue may vary from time to time, on account of fluctuations in Market Rates.

This Price List supersedes all previous editions.

DRAWING INSTRUMENTS.

To guide the Surveyor and Engineer in the selection of Drawing Instruments, we here add a detailed description, with illustrations and prices of the separate pieces, and cases of the different kinds in general use.

Those we shall first mention are of Swiss manufacture, and are of the finest quality and finish.

The Brass Instruments are used in Schools and elementary practice.

The fine German Silver Instruments are of the best German make, intended for Engineers, Architects, and Machinists.

Parties wanting cases made up, can select the pieces, and we will make cases to suit, at an additional cost of from $2 to $10, according to the size and quality of the cases, which are made of morocco, rosewood, walnut, or mahogany.

For prices of regular size cases, see page 262.

For the convenience of our customers, we will furnish any articles not on our list, but described in the catalogue of any American manufacturer or dealer in mathematical instruments, at catalogue prices.

SPECIAL NOTICE.

Many of our smaller instruments, such as drawing instruments, 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. Packages not exceeding four pounds in weight can be sent in this way within the United States, Canada and Mexico at a cost of one cent per ounce.

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.

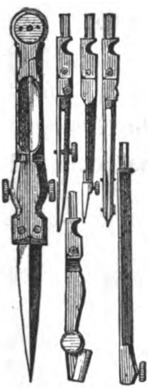
The postage required is mentioned in the second column of the Price List.

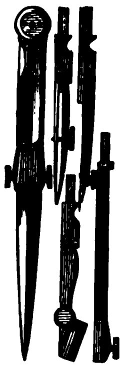
All articles can be registered at an extra cost of ten cents for each package besides regular postage.

We are not responsible for goods sent by mail.

SUPERIOR SWISS DRAWING INSTRUMENTS.

OF GERMAN SILVER, EXTRA FINE FINISH.


400.


401.


402.


403.


405.

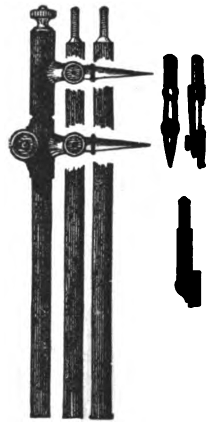
No.		Price	Post.
400.	—Drawing Compass, joints in legs, 6¼ inches long, with pen, pencil-holder, needle-point, lengthening bar and dot. pen....	$9 00	$. 10
401.	—Drawing Compass, 6½ inches long, with pen, pencil-holder, lengthening bar and needle-point...........................	6 50	.10
402.	—Drawing Compass, 6½ inches long, with fixed needle-point and loose pen and pencil-points and lengthening bar	6 00	.09
403.	—Hair-spring Dividers, 4½ inch................................	2 25	.03
404.	— " " 5½ inch.	2 50	.03
405.	—Plain Dividers, 4½ inch	1 50	.03
406.	— " 5 inch	1 75	.03
407.	— " 6 inch	2 35	.03
408.	—Drawing Compass, 4 inch, with pen, pencil-holder, and needle-point..	5 00	.04
409.	—Drawing Compass, 4 inch, with fixed needle-point, and pen and pencil-point, changeable............................	4 50	.04
410.	—Proportional Dividers, 6¼ inches long, finely graduated for lines.	8 00	.06
411.	—Proportional Dividers, 6½ inches long, finely graduated for lines and polygons...	9 00	.06
412.	—Proportional Dividers, 9 inches long, finely graduated for lines and polygons...	10 00	.10
413.	—Proportional Dividers, 9 inches long, with micrometer adjustment (413), finely graduated for lines and polygons	12 00	.10
414.	—Proportional Dividers, 8 inches long, with rack adjustment, graduated for lines	10 50	.08


408.

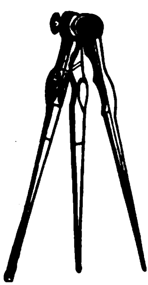

409.


412.


413.

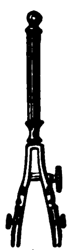

416.

No.		Price	Post.
415.—	Beam Compass, 19-20 inches long, in 2 German Silver bars....	$ 9 25	$ .15
416.—	" 21 " 3 "	10 50	.20
417.—	" 36 " 4 "	15 00	.35
418.—	" 54 " 4 "	21 00	.50


419.

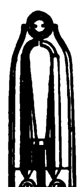

420.

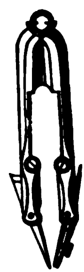

421.


423.


424.


425.

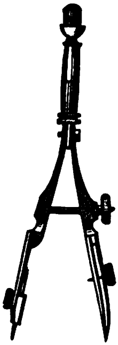

426.

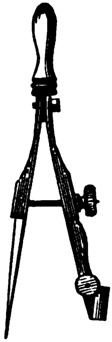

427.

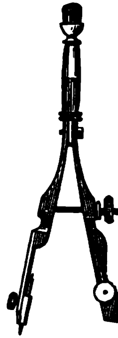
No.		Price	Post.
419.	—Triangular Compass	$4 25	$ .05
420.	—Dotting Pen, with one wheel	2 00	.03
421.	—Dotting Pen, in case, best article, with three wheels	3 75	.03
422.	—Road or Double Drawing Pen	3 75	.03
423.	—Road or Double Drawing Pen, Joint on each side	3 00	.03
424.	—Pocket Dividers, with sheath	2 40	.03
425.	—Bisecting Dividers	4 25	.04
426.	—Universal Compass, with points to shift	7 25	.04
427.	— " " " TURN	7 25	.04
428.	— " " " change, and handles to bow pen and pencil	8 00	.05

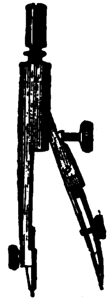
429. 430. 431. 433. 434. 435.

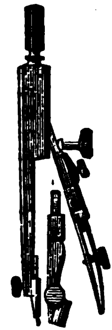
429.	—Dividers, 3½ inches long, with two fixed Needle Points	$3 00	$ .02
430.	—Dividers, 3½ inches long, with fixed Needle Point and Pen Point	3 00	.02
431.	—Dividers, 3½ inches long, with fixed Needle Point and Pencil Point	3 00	.02
432.	—Large Steel Spacing Dividers, 5 inches	2 50	.03
433.	—Small Steel Spacing Dividers, 3½ inches	1 50	.02
434.	—Small Steel Spacing Dividers, 3½ inches long, with Needle Points	2 50	.02
435.	—Small Steel Bow Pen, 3½ inches	2 00	.02
436.	—Small Steel Bow Pen, with Needle Point	2 50	.02
437.	—Small Steel Bow Pencil, 3½ inches	2 00	.02
438.	—Small Steel Bow Pencil, with Needle Point	2 50	.02
439.	—Bow Pen, German Silver, "	2 00	.02
440.	—Bow Pen, with pencil-holder, German Silver, with Needle Point	3 00	.02
441.	—Eccentric Rule	2 00	.04
442.	—Drawing Pen, with joint, 4½ inches long	1 25	.02
443.	— " " 5½ "	1 40	.02
444.	— " " 6 "	1 60	.02
445.	—Beam Compass furniture, for wood beams, $6.75; in Morocco box	7 50	.12
446.	—Horn Curves, A and C, each	75	.02
	Horn Curves, B, D, E, and F, each	65	.02
447.	—Drawing Compass, 4 inches, with long ivory handle, spring and micrometer, with two pens, pencil-holder and needle point	7 00	.04


436.


437.

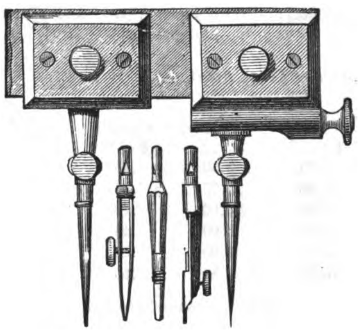

438.


439.


440.



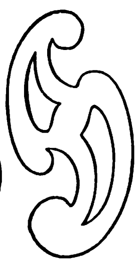

442. 443. 444.

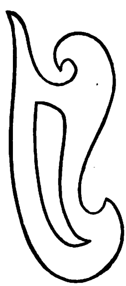

445.

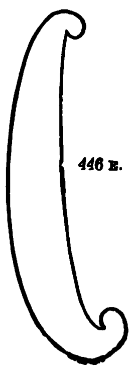

447.

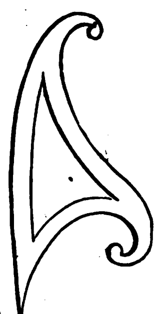

446 A.


446 B.


446 C.


446 D.


446 E.


446 F.

No.		Price	Post.
450.—Polar Planimeter, with printed instructions		$30 00	$ .15

By means of Amsler's Polar Planimeter a person entirely ignorant of Geometry may ascertain the area of any planimetrical figure, no matter how irregular its outlines may be, more correctly, and in much shorter time, than the most experienced Mathematician could calculate it.

The management of the instrument can be easily learned in half an hour, and in size it is no larger than a two-foot folding rule.

The Planimeter indicates square feet or square inches, and acres for surveying.

EMPTY CASES FOR DRAWING INSTRUMENTS,

With tray fitted complete, and with lock. Space under tray for colors, brushes, and pencils.

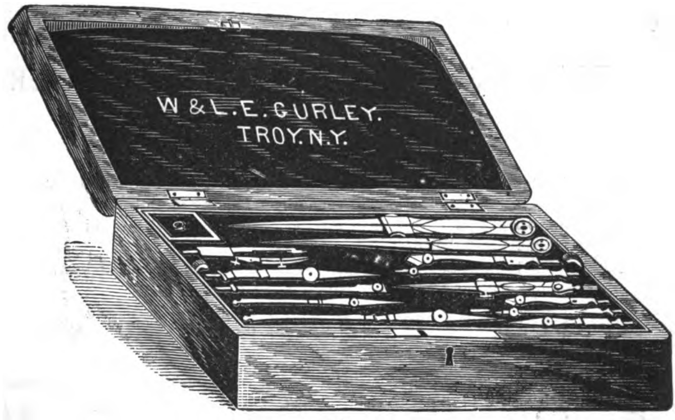
No. 455.—	Mahogany Cases fitted, with tray.				Morocco Cases fitted, without tray.	
	Size	Plain	Polished	Postage	Price	Postage
A.—	8×3½	$....	$....	$...	$2.50	$.08
B.—	8×4	2.75	3.50	.18	2.75	.09
C.—	8×5	3.00	3.75	.23	3.00	.12
D.—	9×5	3.25	4.00	.28	3.25	.15
E.—	10×6	4.00	5.00	.40	4.00	.20
F.—	11×7	4.75	6.00	.50	4.75	.25
G.—	13×7	5.75	7.50	.65	5.50	.40

Other sizes made to order.

SETS OF EXTRA FINE SWISS DRAWING INSTRUMENTS.

The following sets have beautifully finished Mahogany Boxes, with lock and key and tray.

No.	Price	Post.
461.—Contains plain Dividers, No. 406. Sets of Instruments, Nos. 401 and 408. Drawing Pens, Nos. 442 and 444. Triangular Scale, 6 inch	$23 00	$ .45
462.—Contains plain Dividers, No. 406. Sets of Instruments, Nos. 401 and 408. Drawing Pens, Nos. 442 and 444. Bow Pen, No. 439, Triangular Scale, 6 inch	24 00	.45



462.

No.		Price	Post.
464.—Contains plain Dividers, No. 406.			
	Hair Spring Dividers, No. 404.		
	Sets of Instruments, Nos. 401 and 408.		
	Drawing Pens, Nos. 442 and 444.		
	Bow Pen, No. 439, Triangular Scale, 6 inch..................	$27 00	$ .50
465.—Contains plain Dividers, No. 406.			
	Set of Instruments, No. 401.		
	Drawing Pens, Nos. 442 and 444.		
	Bow Pen, No. 435, Triangular Scale, 6 inch.....	19 00	.50
467.—Contains plain Dividers, No. 406.			
	Hair Spring Dividers, No. 404.		
	Sets of Instruments, Nos. 401 and 408.		
	One set Steel Bows, Nos. 433, 435, and 437.		
	Drawing Pens, Nos. 442, 443, and 444.		
	Triangular Scale, 12 inch.................	33 00	.60
468.—Contains plain Dividers, No. 406.			
	Hair Spring Dividers, No. 404.		
	Sets of Instruments, Nos. 401 and 408.		
	Proportional Dividers, No. 410.		
	One set Steel Bows, Nos. 433, 435, and 437.		
	Drawing Pens, Nos. 442, 443, and 444.		
	Triangular Scale, 12 inch................................	$40 00	$ .65

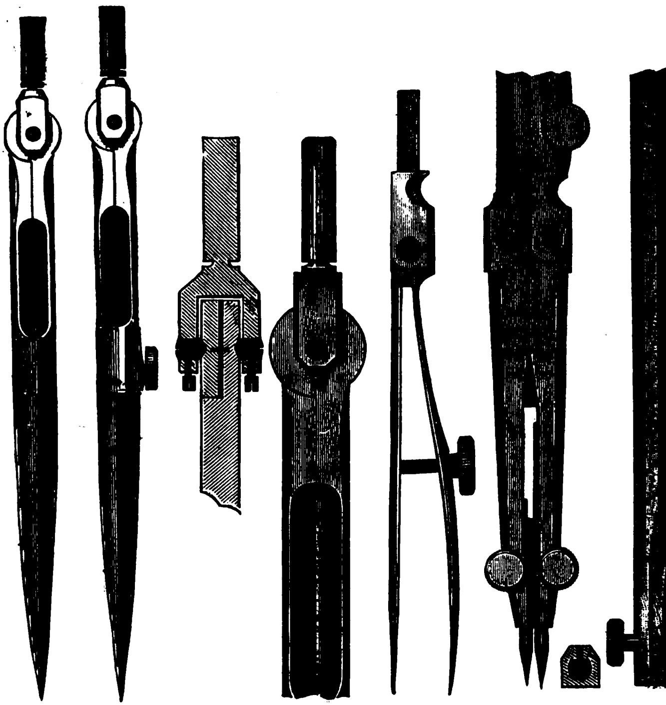
ALTENEDER'S PATENT JOINT GERMAN SILVER AND STEEL DRAWING INSTRUMENTS.

(*Warranted Genuine.*)

The excellency of these instruments consists in the joints of the dividers being so constructed as to prevent any irregular motion when the legs are opened or closed, also for the general care with which the instruments are finished.

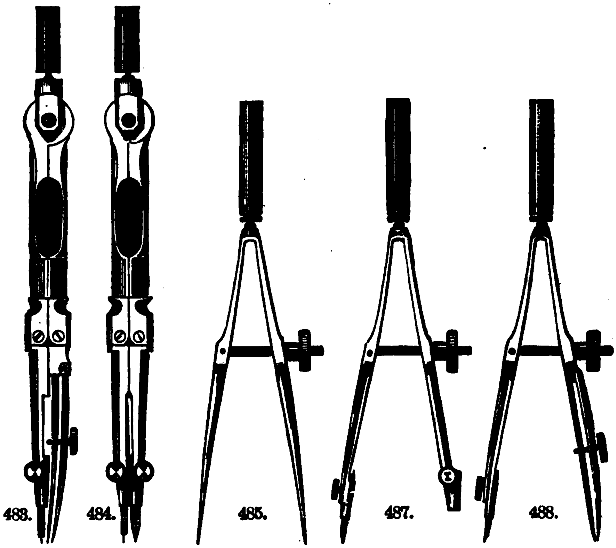
All the pens are thoroughly well made and pointed. In Fig. 480 is shown a sectional view of Alteneder's Patent Joint Divider head.

(For prices of empty cases for Drawing Instruments, see page 262.)



475. 477. 480.

No.	Price	Post.
475.—Plain Dividers, 3½ inches long	$2 25	$ .02
476.— " " 5 "	2 50	.03
477.—Hair Spring Dividers, 3½ inches long	3 50	.02
478.— " " 5 "	4 00	.03
479.—Dividers, 3½ inches long, with Pen, Pencil and Needle Point	6 00	.05
480A.—Dividers, 5½ inches long, with Pen, Pencil, Needle Point and Lengthening Bar	7 50	.08
480B.—Dividers, 5½ inches long, with Pen, Pencil, Needle Point with hair spring attachment, and lengthening bar	9 00	.08
481.—Dividers, 5½ inches long, fixed Needle Point and Pen	5 00	.05
482.— " 5½ " " and Pencil	5 00	.05



483. 484. 485. 487. 488.

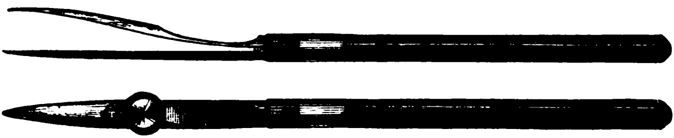
483.—Dividers, 3½ inches long, fixed Needle Point and Pen	4 00	.03
484.— " 3½ " " and Pencil	4 00	.03
485.—Steel Spacing Dividers, 3 inches long, Metal Handle	1 75	.02
486.— " 3 " " with Needle Points	2 50	.02
487.—Steel Bow Pencil, Needle Point, 3 inches long, Metal Handle	2 50	.02
488.— " Pen, " 3 " "	2 50	.02
489.—Steel Spacing Dividers, 5 inches long, Metal Handle	3 25	.04
490.— " 5 " " with Needle Points	4 00	.04
491.—Steel Bow Pencil, Needle Point, 5 inches long, Metal Handle	4 00	.04
492.— " Pen, " 5 " "	4 00	.04

493.

No.					Price	Post.
493.—Drawing Pen,	4½ inches long,	ebony handle		....	$1 25	$ .02
494.—	"	5 "	"	....	1 50	.02
495.—	"	5½ "	"	....	1 75	.02

IMPROVED DRAWING PENS.

(*Made with spring on upper blade to facilitate cleaning.*)

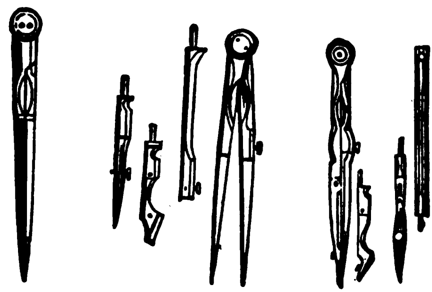


496.

496.—Drawing Pen,	ebony handle,	4½ inches long,	spring blade	....	1 40	.02
497.—	"	" 5 "	"	....	1 65	.02
498.—	"	" 5½ "	"	....	1 90	.02

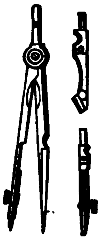
BRASS DRAWING INSTRUMENTS,

FOR SCHOOLS.



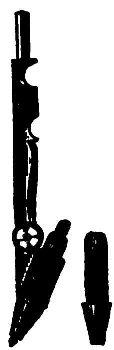
500. 507. 509.

No.		Price	Post.
500.—	Brass Dividers, 3½ inches long, screw joint	25	.02
501.—	" 4 " "	30	.02
502.—	" 5 " "	35	.03
503.—	" 6 " "	45	.03
504.—	" 4 " rivet joint	20	.02
505.—	" 5 " "	25	.03
506.—	" 6 " "	30	.03
507.—	Brass Dividers, 4½ inches long, with Pen and Pencil Points and Lengthening Bar	50	.04
508.—	Brass Dividers, 6 inches long, with Pen and Pencil Points and Lengthening Bar	75	.06
509.—	Brass Dividers, Needle Point, 4½ inches long, with Pen and Pencil Points and Lengthening Bar	75	.04
510.—	Brass Dividers, Needle Point, 6 inches long, with Pen and Pencil Points and Lengthening Bar	1 00	.06
511.—	Dividers, brass, medium quality, needle-point, with pen and pencil point, 3 inches	60	.02
512.—	Bow Pencil, brass	60	.02
513.—	Bow Pen, brass, needle-points, no spring	60	.02

511. 512. 513. 514.

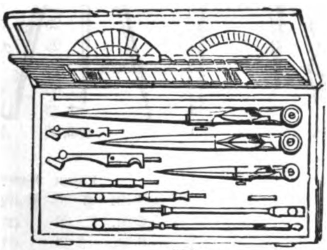
No.	Price	Post.
514.—Bow Pen, brass, needle-points, and adjusting spring	$ 70	$ .02
515.—Bisecting Dividers, brass	60	.02
516.—Proportional Dividers, brass, divided for lines	2 00	.05
517.—Drawing Pen, black handle	20	.02
518.—Drawing Pen, ivory handle	30	.02
519.—Roulette for dotting lines, with three wheels	85	.02
520.—Double Drawing or Road Pen, brass mounted	2 25	.02
521.—Patent Lead Holder, for pencil leg of Dividers	25	.02
522.—Wood Dividers, 12 in. long, with crayon holder, for black-board drawing	1 00	.10
523.— " 15 " " " "	1 25	.12
524.— " 18 " " " "	1 50	.15

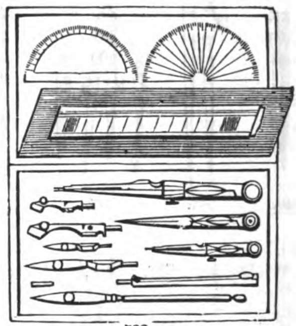
515. 516. 517. 519. 521.

CASES OF BRASS DRAWING INSTRUMENTS

No.		Price	Post
525.	—Wood Box; Pair 4½-inch Dividers, with pen and pencil points and Crayon Holder....................................	$ 50	$ .06
526.	—Wood Box; Pair 4½-inch Dividers, with pen and pencil points and lengthening bar; Ebony handle Drawing Pen; Wood Rule, Crayon Holder, and Protractor	60	.07
527.	—Wood Box; Pair of 4½-inch Dividers, with pen and pencil points and lengthening bar; Pair of 3½-inch plain Dividers, Drawing Pen, Protractor, Wood Rule, Crayon Holder.................	1 00	.0
528.	—Wood Box; Pair 5½-inch Dividers, with pen and pencil points and lengthening bar; Pair of 4½-inch plain Dividers, Drawing Pen, Protractor, Crayon Holder, and Wood Rule.............	1 30	.12
530.	—Rosewood Box; Pair of 6-inch Dividers, with pen and pencil points and lengthening bar; Pair of 4¼-inch plain Dividers, Drawing Pen; Pair of 3¼-inch Dividers, with pen and pencil points; Brass Protractor, Horn Protractor, Wood Rule.......	2 00	.15



530.



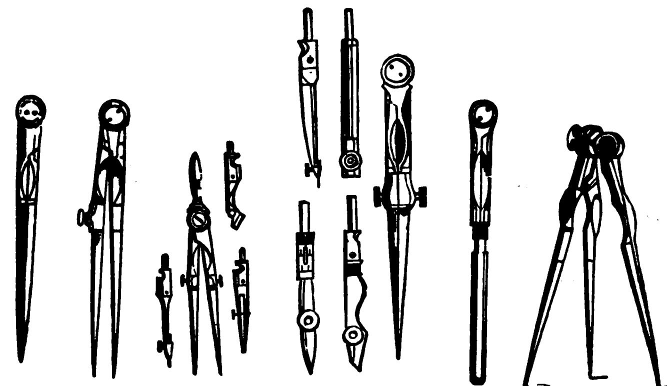
532.

No.		Price	Post
531.	—Same as No. 530, but with the instruments set in a tray, so that colors, etc., may be put below, per set........................	$2 25	$ .25
532.	—Rosewood Box; Pair of 6-in. needle-point Dividers, with pen and pencil points, and lengthening bar; Pair 4½-in. plain Dividers; Pair of 3½-in. needle-point Dividers, with pen and pencil points; Drawing Pen, Brass Protrac., Horn Pro., Wood Rule, per set.	2 75	.15
533.	—Same as No. 532, but with lock and key and the instruments set in a tray, so that the colors may be put below, per set........	3 00	.25
534.	—Rosewood Box, with lock and key, the instruments set in a tray, so that colors, etc., may be put below; Pair of 6-inch needle-point Dividers, with pen and pencil points, and lengthening bar; Drawing Pen, Pair 4½-inch plain Dividers, Brass Protractor, Horn Protractor, Pair of 3½-inch needle-point Dividers, with pen and pencil points; Spring Bow Pen, with needle-pt.; Wood Rule	4 00	.25
535.	—Same as No. 534, with addition of a pair Proportional Dividers, has no brass Protractor, but has wood Triangle and Irregular Curve	6 00	.30

BEST GERMAN DRAWING INSTRUMENTS.

OF FINE GERMAN SILVER AND STEEL.

(For prices of empty cases for Drawing Instruments, see page 262.)



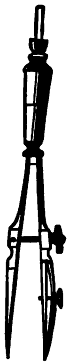
540. 544. 547. 548. 549. 550.

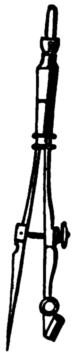
No.		Price	Post.
540.—	Dividers, Ger. Silver, steel joints, turned cheeks, fine finish, 4 in.	$ 70	$ .02
541.—	" " " " " 5 in.	80	.03
542.—	" " " " " 6 in.	1 00	.04
543.—	" " " " " 7 in.	1 25	.05
544.—	Hair Spring Dividers, German Silver; steel joints, turned cheeks, fine finish, 5 inch	1 75	.03
545.—	Hair Spring Dividers, German Silver; steel joints, turned cheeks, fine finish, 6 inch	2 00	.04
547.—	Dividers, German Silver; fine quality, needle-point, with pen and pencil point, 4 inches	2 50	.04
548.—	Dividers, German Silver; fine quality, with needle-point, pen, lengthening bar, and pencil-points, 6 inches	3 00	.06
549.—	Dividers, German Silver; 5 inch, fine finish, with sheath	1 50	.03
550.—	Dividers, German Silver; 5 inch, three-legged	3 50	.04
555.—	Proportional Dividers, Ger. Silver, 6¼ in. long, divided for lines.	2 50	.06
556.—	Bisecting Dividers, German Silver	1 12	.04
557.—	Spacing Dividers, all steel, with Spring and Adjusting Screw	1 25	.02
558.—	Bow Pen, all steel, ivory handle	1 50	.02
559.—	Bow Pencil, all steel, ivory handle	1 50	.02
560.—	Set of three Steel Bows, Pen, Pencil, and Dividers, in case, per set	4 75	.05

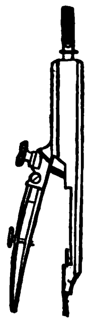

555.

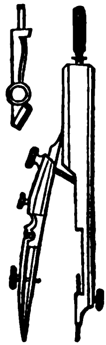

556.


557.

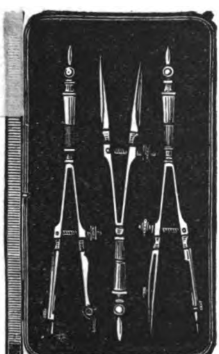

558.


559.

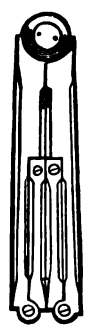

561.


562.

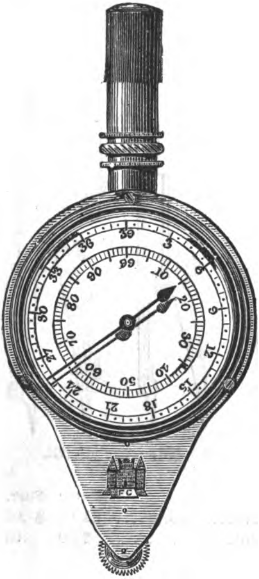
No.		Price	Post.
561.—	Spring Bow Pen, German Silver	$1 62	$ .02
562.—	" " with pencil-point	2 50	.03


560.

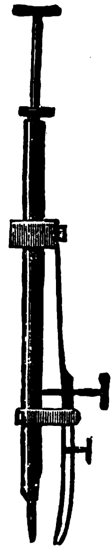
563.


564.

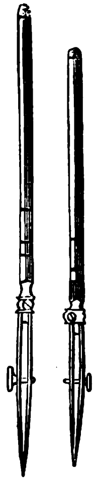
563.—Furniture for Beam Compasses, German Silver, with adjusting screw, in morocco case.................................... $5 00 $ .12



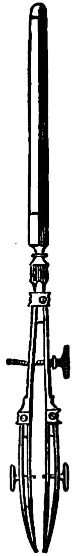
565.



566A.



567 to 570.

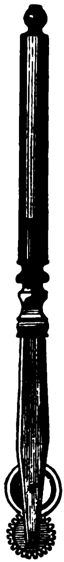
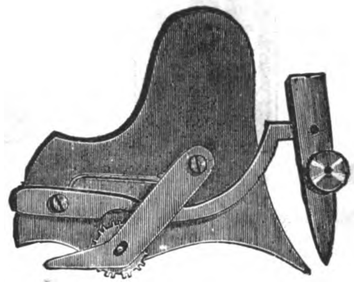


571.

572.

No.		Price	Post.
564.	Pocket Dividers. German Silver, folding pen and pencil points..	$5 00	$ .05
565.	Universal Map Measurer. The index-hand registers inches to miles, or centimeters to kilometers..............................	3 00	.05
566A.	Improved Bow Pen. The needle-point in this instrument being adjustable, it will draw extremely minute circles..............	3 00	.03
566B.	Improved Bow Pen, No. 566A, and with pencil point..........	4 00	.04
566C.	Spring Bow Pen, and with adjustable spring needle-point. New and superior...	3 00	.05
567.	Drawing Pen, medium finish, 4½ or 5½ inch......................	40	.02
568.	Drawing Pen, fine finish, hinge to pen, 4½ or 5½ inch............	50	.02
569.	Drawing Pen, fine finish, hinge to pen, and protracting pin, 4½, 5 or 5½ inch..	75	.02
570.	Drawing Pen, all German Silver, for red ink, 5 inch............	75	.02
571.	Double Drawing, or Road Pen, 5½ inch........................	2 25	.03
572.	Patent Double Drawing Pen. Will draw with one stroke one broad or two parallel lines of the same or different widths....	3 75	.03
573A.	Drawing Pen for curves..	1 25	.02
573B.	Do. do. with swivel handle....................	1 75	.02
574.	Do. for heavy border lines............................	2 50	.03
575.	Improved Drawing Pen, without set screw......................	1 50	.02



573A. 573B. 574. 576A. 576B.

No.	Price	Post.
576A.—Dotting Pen, one wheel, 5½ inch	$1 00	$ .02
576B.—Dotting Pen, with extra wheels (superior)	3 75	.05

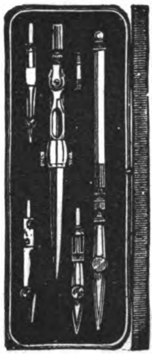
It consists of a small German silver plate, upon which is fastened a Pen, connected by a small bar, and a ratchet movement with a rolling wheel. The outer wheel is rolled on the edge of a T Square or Ruler and turns the ratchet wheel, which causes the pen to move up and down. The flat point close to the pen must slide on the paper.

CASES OF FINE GERMAN SILVER INSTRUMENTS.

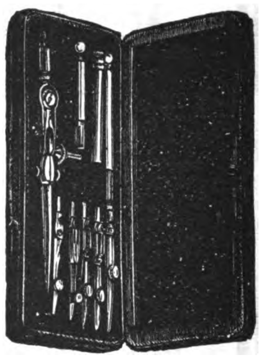
FOR ENGINEERS, ARCHITECTS, AND MACHINISTS.

580.—Morocco Box; pair of 4-inch dividers, with pen, pencil, and needle points, and drawing pen	$3 50	$ .05
581.—Morocco Box; pair of 4-inch dividers, with pen, pencil, needle point; pair of 4-inch plain dividers, and drawing pen	4 00	07
582.—Morocco Box; pair of 5½-inch dividers, with fixed needle point, pen and pencil Points, pair of 5-inch plain dividers, drawing pen	3 50	.10
583.—Morocco Box; pair of 5½-inch dividers, with pen, pencil, needle point, and lengthening-bar, pair of 5-inch plain dividers, drawing pen	5 00	.12

No.		Price	Post.
584.	—Morocco Box; 3½-inch spring-bow dividers, with long detachable handle, 2 pen points, pencil and needle points, 4-inch drawing pen	$6 00	$ .07

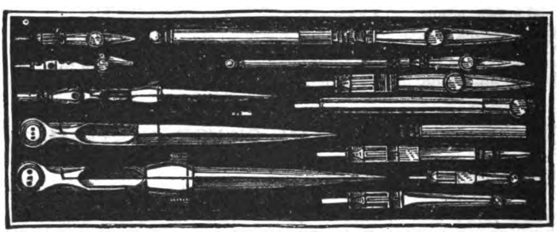


580.



584.

586.	—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..................	6 50	.12
587.	—Morocco Box; pair of 5½-inch dividers, with pen, pencil, and needle points, and lengthening-bar, pair of 5-inch plain dividers, pair of 4-inch dividers, with pen, pencil, and needle point, 2 drawing pens..................................	9 75	.15



587.

588.	—Same instruments as in No. 587, with addition of spring-bow pen..	11 00	.18
588½.	—Morocco Box; 5½-inch dividers, with pen, pencil, needle points, and lengthening-bar, 5-inch dividers, spring-bow pen, spring-bow pencil, spring-bow dividers, 2 drawing pens.....	11 50	.15

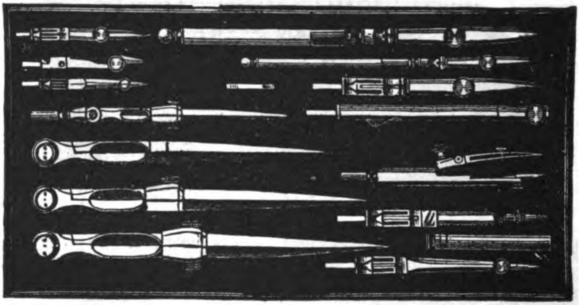
588½.

The following sets have beautifully finished Mahogany Boxes, with lock and key and tray.

No.		Price	Post.
589.	—Set containing pair 5½-inch dividers, pen, pencil, and needle-point, pair 5-inch hair-spring dividers, pair 4-inch dividers, pen, pencil, and needle-point, 2 drawing pens..................	$12 50	$ .40

589.

590.	—Containing 5½-inch dividers, with pen, pencil, and needle-point, and lengthening-bar, pair of 5-inch plain dividers, pair of 5-inch hair-spring dividers, pair of 4-inch dividers, with pen, pencil, and needle-points, Spring-bow pen, with needle-point, 2 drawing pens, German Silver or Rubber Square, German Silver Protractor..	16 00	.45



590.

No. Price Post.

591.—Containing pair of 6-inch needle-point Dividers, with pen and pencil points, and lengthening-bar,
Pair 5-inch hair-spring Dividers,
Pair of 4-inch Needle Point Dividers, with pen and pencil points,
Pair of Proportional Dividers, No. 555,
3 Drawing Pens, Bow Pen, No. 561,
Horn Protractor, Wood Curve and 2 Wood Squares,
Ivory Protractor Scale, No. 676.................................. $21 00 $ .50

592.—Containing pair of 6-inch needle-point dividers, with pen and pencil points and lengthening-bar,
Pair 5-inch hair-spring Dividers,
Pair of 4-inch Dividers, needle-point, with pen and pencil points,
Pair of Proportional Dividers, No. 555,
Bow Pen, No. 561, 3 Drawing Pens,
Beam Compass, No. 563,
8-inch Horn Protractor, Ivory Protractor Scale, No. 678,
1 Wood Curve and 2 Wood Triangles.......................... 29 00 .60

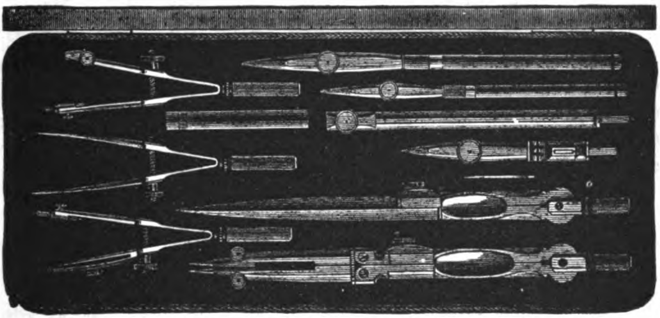
593.—Containing pair 6-inch dividers, with pen, pencil, and needle-point, and lengthening-bar,
Pair 5-inch plain Dividers,
Pair 5-inch Hair Spring Dividers
Pair 4-inch Dividers, with pen, pencil, and needle-point,
Bow Pen, German Silver, 2 Drawing Pens,
1 Red Ink Pen, 1 Road Pen, Protractor No. 644,
Pair Proportional Dividers, No. 555,
Triangle and Triangular Scale, 12-inch,
Beam Compass, No. 563.................................. $30 00 $ .50

PERFECT PIVOT JOINT INSTRUMENTS OF BEST GERMAN MAKE.

FINE GERMAN SILVER AND STEEL.

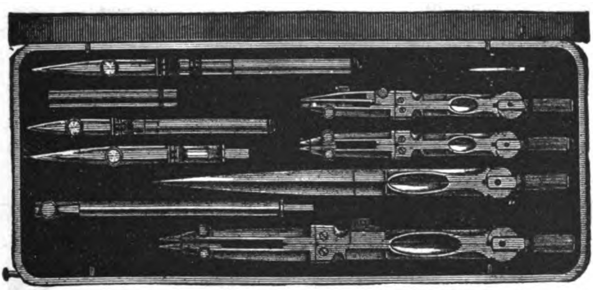
In Morocco Cases.

No.		Price	Post.
595.	—Morocco case, containing Dividers, 6 inches long, with Pen, Pencil, Needle Point, and Lengthening Bar, Plain Dividers, 5 inches long, 1 Drawing Pen	$ 9 50	$ .12
596.	—Morocco case, containing Needle Point Dividers, 3½ inches long, with Pencil Point, Needle Point Dividers, 3½ inches long, with Pen Point, Plain Dividers, 3½ inches, 1 Drawing Pen	10 50	.10



597.

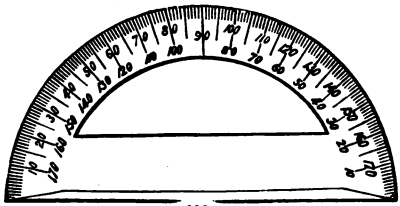
597.	—Morocco case, containing Dividers, 6 inches long, with Pen, Pencil, Needle Point, and Lengthening Bar, Hair Spring Dividers, 6 inches, Steel Spacing Dividers, Steel Bow Pen, Steel Bow Pencil, 2 Drawing Pens,	14 50	.15



598.

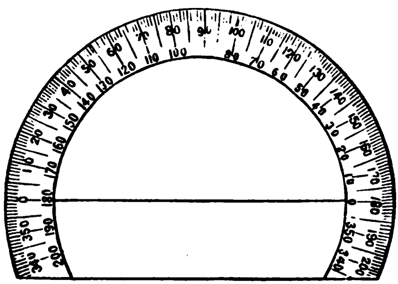
598.	—Morocco case, containing Needle Point Dividers, 3½ inches, with Pencil Point, Needle Point Dividers, 3½ inches, with Pen Point, Dividers 6 inches long, with Pen, Pencil, Needle Point, and Lengthening Bar, Plain Dividers, 5 inches, 2 Drawing Pens	18 00	.15

EXTRA FINE SWISS GERMAN SILVER PROTRACTORS.



600.

No.	Price	Post.
600.—4-inch diam., half circle, whole degrees, center on outer edge...	$1 50	$ .03
601.—5-inch " " half " " " ...	2 00	.04
602.—6-inch " " half " " " ...	3 00	.04
603.—6-inch " " quarter " " " ...	3 25	.04



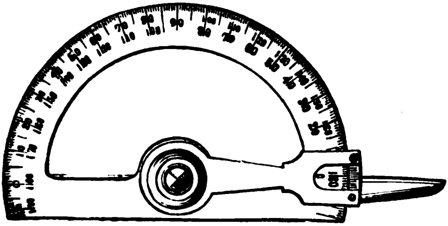
604.

604.—5-inch diam., half circle, half degrees, center on inner edge.....	$2 50	$ .04
605.—6-inch " " " " "	3 50	.05
606.—6-inch " " quarter degrees, center on inner edge..	4 00	.05

EXTRA FINE SWISS GERMAN SILVER PROTRACTORS, WITH ARMS, AND WITHOUT VERNIERS.

611.—6-inch diam., half circle, half degrees, with arm.........	$8 50	$ .10
613.—8-inch " " " "	9 50	.15
614.—5-inch " whole circle, half degrees, with arm..............	9 00	.15
615.—6-inch " " " "	10 00	.20

EXTRA FINE SWISS GERMAN SILVER PROTRACTORS WITH ARMS AND VERNIERS.



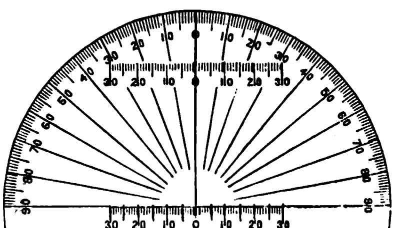
620.

No.		Price	Post.
620.—	Protractor, 5¼ inches diameter, half circle, half degrees, with vernier reading to three minutes	$11 00	$ .10
621.—	Protractor, 8 inches diameter, half circle, quarter degrees, with vernier reading to one minute	14 00	.15
622.—	Protractor, 10 inches diameter, half circle, quarter degrees, with vernier reading to one minute	18 00	.18
623.—	Protractor, 5¼ inches diameter, whole circle, half degrees, with vernier reading to three minutes	14 50	.20
624.—	Protractor, 8 inches diameter, whole circle, quarter degrees, with vernier reading to one minute	16 00	.25

☞ Mahogany Cases, lined with velvet, for Protractors Nos. 611 to 624, according to size; from $1.50 to $3.00.

DUFFIELD'S PATENT PROTRACTOR.

Made of transparent celluloid, and with two parallel scales of twenty parts to the inch, to enable the zero line to be set parallel to meridian lines drawn on the paper.



No. 626.

626.—	Protractor, 6 inches diameter, half circle, half degrees	$3 00	$ .04
627.—	“ 9 “ “ “	3 50	.08
628.—	“ 12 “ “ quarter “	4 00	.10

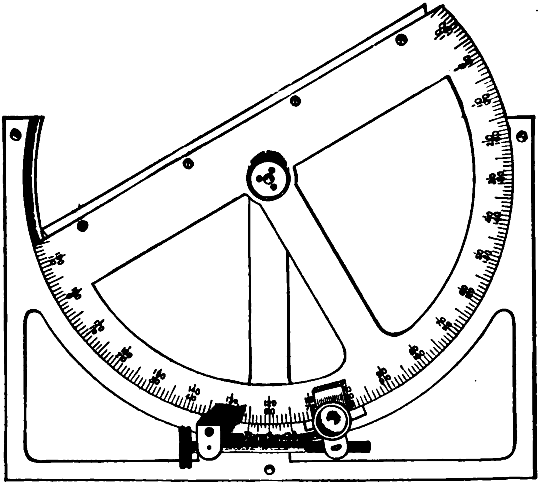
PROTRACTORS OF HORN, BRASS, GERMAN SILVER, RUBBER, AND PAPER.

No.		Price	Post.
630.	—Railroad Curve Protractor, of horn, 8 inches diameter, having laid off on it twenty-three curves from ½ degree to 8 degrees, with a scale of 400 feet to the inch	$1 50	.05
631.	—Horn Protractor, 5 inches diameter, whole circle, half degrees.	1 00	.05
632.	— " 6 " " "	1 25	.06
633.	— " 7 " " "	1 50	.08
634.	— " 4 " half circle, whole degrees	15	.02
635.	— " 5 " " half degrees	25	.02
636.	— " 6 " " "	30	.03
637.	— " 7 " " "	50	.05
638.	— " 8 " " "	75	.05
639.	—Brass Protractor, 4 " " whole degrees	10	.02
640.	— " 4 " " half degrees	35	.03
641.	— " 5 " " "	55	.05
642.	— " 6 " " "	65	.07
643.	—German Silver Protractor, 4 in. diameter, half circle, whole deg.	50	.03
644.	— " " 5 " " half degrees	85	.05
645.	— " " 6 " " "	1 00	.07
646.	— " " 7 " " "	1 15	.10
647.	— " " 5 " beveled edge, half deg.	1 25	.05
648.	— " " 6 " " "	2 00	.07
649.	— " " 7 " " "	2 65	.10
650.	—Hard Rubber Protractor, 6 " " "	3 00	.05
651.	— " " 8 " " "	3 75	.08
652.	— " " 6 " whole circle, "	3 75	.10
653.	— " " 8 " " "	5 00	.12

PAPER PROTRACTORS.

No.		Price	Post.
655.	—Whole Circle Protractors, 8 and 13 inches diameter, half degrees, on drawing paper, each	$ 30	$ .05
656.	—Whole Circle Protractors, 8 and 13 inches diameter, half degrees, on Bristol board, each	40	.08
657.	—Half Circle Protractor, 5 in. diameter, half degrees, card board	25	.02
658.	—Half Circle Protractor, 6 in. diameter, half degrees, card board	30	.02
659.	—Circular Protractor on tracing paper, 14 inches diameter, quarter degrees, (these are used by the U. S. Coast Survey, and U. S. Navy, and give entire satisfaction)	25	.05

CROZET'S PROTRACTOR.



660.

No.
660.—Eight inches diameter, vernier reading to one minute, German silver, in case, price .... $40.00 [Post. .60

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.

LIMB PROTRACTOR.

BRONZE HEAD, STEEL BLADE, VERNIER TO ONE MINUTE.

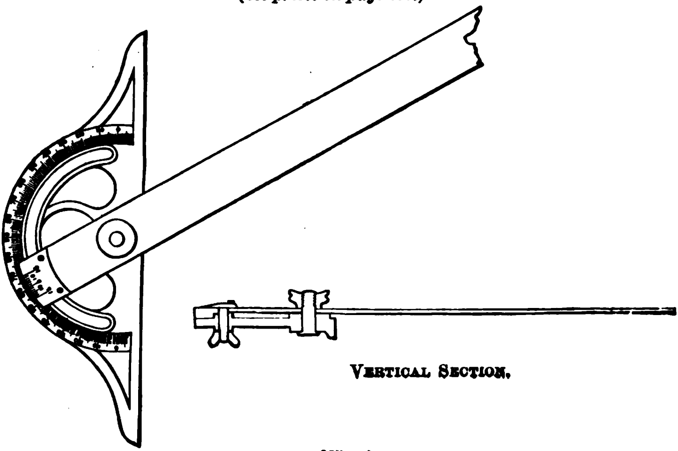
(See Fig. 665.)

No.						Price		Price	Post.
665.—	Protractor, blade	24	inches long,	Plain.		$ 8 00	Nickel-plated.	$8 75	$ .60
666.—	"	"	30	"	"	8 75	"	9 65	.70
667.—	"	"	36	"	"	9 50	"	10 50	.80
668.—	"	"	42	"	"	10 25	"	11 35	.90
669.—	"	"	48	"	"	11 50	"	12 75	1.00
670.—	"	"	60	"	"	13 50	"	15 00	

LIMB PROTRACTOR.

BRONZE HEAD, STEEL BLADE, VERNIER TO ONE MINUTE.

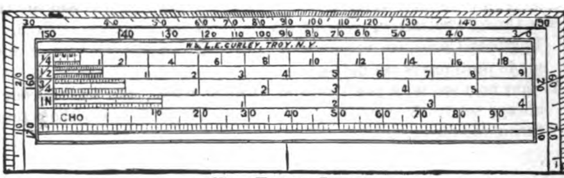
(See prices on page 281.)



VERTICAL SECTION.

665.

IVORY PROTRACTOR SCALES.



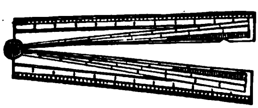
675.—FRONT SIDE.

No.		PRICE	POST.
675.	—Ivory Rectangular Protractor, 6 inches long, $1\frac{3}{4}$ inches wide, with scales as follows: front sides divided around edges from 0 to 180 degrees in single degrees, scales of $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 inch to the foot, and scale of chords. Reverse side scales of 30, 35, 40, 45, 50 and 60 parts to the inch, scale of chords and diagonal scale of inches and $\frac{1}{100}$ths........................	$1 25	$ .05
676.	—Ivory Rectangular Protractor, 6 inches long by $1\frac{3}{4}$ inches wide, with scales as follows: front side, the edge divided into single degrees from 0 to 180 degrees, scales of $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, and 1 inch to the foot, and scale of chords. On the reverse side, scales of 30, 35, 40, 45, 50 and 60 parts to the inch, scale of chords and diagonal scale of $\frac{1}{100}$ths..................	1 75	.05

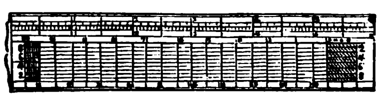
No.		Price	Post.
677.—Ivory Rectangular Protractor, 6 inches long by 2 inches wide, with scales as follows: front side, the edge divided in single degrees from 0 to 180 degrees, scales of ⅛, ¼, ⅜, ½, ⅝, ¾, ⅞, 1, 1⅛, 1¼ inches to the foot, scale of chords, and line of 40 parts on lower edge. On the reverse side, scales of 20, 25, 30, 35, 40, 45, 50, 60 parts to the inch, diagonal scale of $\frac{1}{100}$ths.		3 25	.06
678.—Ivory Rectangular Protractor, same as No. 677, but has the Protractor divided in ½ degrees........................		4 00	.06
679.—Ivory Rectangular Protractor, 6 inches long by 2¼ inches wide, with scales as follows: front side, the edge divided in ½ deg. from 0 to 180 deg., scales of ⅛, ¼, ⅜, ½, ⅝, ¾, ⅞, 1, 1⅛, 1¼, 1⅜, 1½ inch. to the foot, scale of chords, and scale of 40 parts on the lower edge. Reverse side, scales of 10, 15, 20, 25, 30, 35, 40, 45, 50, 60 parts to the inch, and diagonal scale of $\frac{1}{100}$ths...		4 50	.06
680.—Ivory Rectangular Protractor, 6 inches long by 2½ inches wide, with scales as follows: front side, the edge divided in ¼ degrees from 0 to 180 degrees, scales of ⅛, ¼, ⅜, ½, ⅝, ¾, ⅞, 1, 1⅛, 1¼, 1⅜, 1½ inches to the foot, scale of chords, and scale of 40 parts on lower edge. Reverse side, scales of 20, 25, 30, 35, 40, 45, 50 and 60 parts to the in., 2 scales of chords, scales of latitude, sines, tangents, hours, longitudes, secants, rhombs..		6 00	.08
681.—Ivory Rectangular Protractor, 8 inches long by 2 inches wide, with scales as follows: front side, the edge divided in ½ degrees from 0 to 180 degrees, scales of ⅛, ¼, ⅜, ½, ⅝, ¾, ⅞, 1 inch to the foot, scale of chords, and scale of 40 parts on lower edge. Reverse side, scales of 30, 35, 40, 45, 50, 60 parts to the inch, scale of chords and diagonal scale of $\frac{1}{100}$ths......		5 00	.08

682.—Ivory Rectangular Protractor, 12 inches long by 2½ inches wide, with scales as follows: the edge divided in ½ degrees from 0 to 180 degrees, scales of ⅛, ¼, ⅜, ½, ⅝, ¾, ⅞, 1, 1⅛, 1¼, 1⅜, 1½, scale of chords and scale of 40 on lower edge. Reverse side, scales of 10, 15, 20, 25, 30, 35, 40, 45, 50, 60 parts to the inch, scale of chords and diagonal scale of $\frac{1}{100}$ths ....$11 50 [Post. .15

IVORY SECTORS AND SCALES.



685.



686.

	Price	Post.
685.—Ivory Sector, 6 inches long, opens to 12 inches long.............	$2 25	$ .04
686.—Ivory Scale, 6 inches long, for school drawing....................	75	.03
687.—Flat Ivory Scale, 6 inch, divided ⅛, ¼, ⅜, 1 inch to the foot, each	2 50	.03
688.— Do. do. 12 do. ⅛, ¼, ⅜, 1 do. do.	3 75	.05
689.— Do. do. 12 do. ⅜, ¾, 1½, 3 do. do.	3 75	.05

IVORY CHAIN SCALES.

690.

No.		Price	Post.
690.—	Ivory Chain Scales, 12 inches long, graduated on two edges with either 10 and 50, or 20 and 40, or 30 and 60 parts to the inch, each..........	$3 75	$ .05
691.—	Do. with 80 and 100, each..........	5 50	.05
692.—	Ivory Off-set Scales, 2 inches long, 10 by 50, 20 by 40, 30 by 60..	75	.02

ARCHITECTS' IVORY SCALES.

693.

695.—	Ivory Scales, 12 inches long, with 12 scales, as follows: ⅛, 3/16, ¼, ⅜, ⅝, ⅞, 1, 1¼, 1½, 1¾, 2 and 3 inches to the foot, the first division of each scale subdivided into 12 parts, diagonal scale reading to 1/100 and 1/100 of an inch, each..........	3 00	.05
696.—	Same as No. 695, but has the first division of each scale subdivided into 10 parts, each..........	3 00	.05
697.—	Ivory Scale, 12 inches long, one side rounded, the other flat, with the following scales, the graduations of which are all brought to the edge: 3/32, ⅛, 3/16, ¼, ⅜, ½, ⅝, ¾, ⅞, 1, 1¼, 1½, 1¾, 2, 2½ and 3 inches to the foot, the first division of each scale is subdivided into twelve parts, each..........	3 00	.05
698.—	Same as No. 697, but the first division of each scale subdivided into ten parts, each..........	3 00	.05

BOXWOOD SCALES AND PROTRACTORS.

No.		PRICE	POST.
700.	—Boxwood Protractor, 6 inches long, 1¾ inches wide, whole degrees, with scales ¼, ½, ¾, 1 inch, scale of chords, diagonal scale	$0 50	$ .03
701A.	—Boxwood Scale, 6 inches long, for School use	15	.02
701B.	—Boxwood Sector, 6 inches, opens to 12 inches	1 00	.03
702.	—Flat Boxwood Scale, 6 inch, divided ⅛, ¼, ½, 1, or ⅜, ¾, 1½, 3 inch to the foot, as ordered, each	60	.03
703.	—Flat Boxwood Scale, 12 inch, divided ⅛, ¼, ½, 1, or ⅜, ¾, 1½, 3 inch to the foot, as ordered, each	1 00	.05
704.	—Flat Boxwood Scale, 24 inch, divided ⅛, ¼, ½, 1, or ⅜, ¾, 1½, 3 inch to the foot, as ordered, each	2 50	.12

BOXWOOD CHAIN SCALES.

706.	—Boxwood Chain Scales, 12 inches long, graduated on two edges with either 10 and 50, or 20 and 40, or 30 and 60 parts to the inch, each	$1 00	$ .05
707.	—Boxwood Off-set Scales, 2 inches long, graduated 10 by 50, 20 by 40, 30 by 60, each	35	.02

ARCHITECTS' BOXWOOD SCALES.

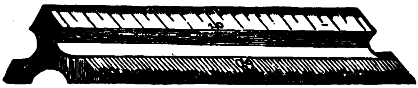
710.	—Boxwood Scale, 12 inches long, with 12 scales, as follows: ⅛, 3/16, ¼, ⅜, ⅝, ⅞, 1, 1¼, 1½, 1¾, 2, and 3 inches to the foot, the first division of each scale subdivided into 12 parts, and diagonal scale reading to 1/100 and 1/200 of an inch, each	1 25	.05
711.	—Same as No, 710, but has the first division of each scale subdivided into 10 parts, each	1 25	.05
712.	—Boxwood Scale, 12 inches long, one side rounded, the other flat, with the following scales, the graduations of which are all brought to the edge: 1/16, ⅛, 3/16, ¼, ⅜, ½, ⅝, ¾, ⅞, 1, 1¼, 1½, 1¾, 2, 2½, and 3 inches to the foot, the first division of each scale subdivided into 12 parts, each	1 25	.05
713.	—Same as No. 712, but has the first division of each scale subdivided into 10 parts, each	1 25	.05
715.	—Boxwood Gunter Scales, 12 inches long	75	.05
716.	— do do 24 do	1 25	.10
717.	—Boxwood School Rule, 12 inches, 3/16 inch, bevel edge	10	.03
718.	— do do 18 ⅛ do	35	.05

FLAT METALLIC CHAIN SCALES.

(A new and superior article, our own make, made of brass, and nickeled with a dull finish.)

No.		Price	Post.
719.—	Flat Metallic Chain Scale, 12 inches long, graduated on two beveled edges, 10 and 20, or 20 and 40 parts to the inch, each	$3 00	$ .10
719A.—	Do. with 30 and 50, or 40 and 60 parts, each	3 75	.10
719B.—	Do. with 50 and 60, or 40 and 80 parts, each	4 25	.10
719C.—	Do. with 50 and 100, or 80 and 100 parts, each	5 00	.10
719H.—	Do. 30 centimeters long, divided to millimeters	3 00	.10

TRIANGULAR SCALES OF BOXWOOD AND METAL.



720.

No.		Price	Post.
720.—	Triangular Scale of Boxwood, 24 inches long, graduated 10, 20, 30, 40, 50, and 60 to the inch	$4 50	$ .10
721.—	Do. 20, 30, 40, 50, 60, and 80 to the inch	5 00	.10
721A.—	Do. 18 inches long, graduated same as No. 720	3 00	.08
722.—	Triangular Scale of Boxwood, 12 inches long, graduated same as No. 720	1 50	.05
723.—	Do. graduated same as No. 721	1 75	.05
724.—	Do. 12 inches long, graduated 100, 200, 300, 400, 500, 600 to the foot, each	1 50	.05
725.—	Do. 6 inches, graduated same as Nos. 720 or 721	1 00	.03
726.—	Triangular Scale of Boxwood for Off-sets, 2 inches long, 10, 20, 30, 40, 50, and 60 parts	60	.02
727.—	Triangular Scale of Boxwood, 24 inches long, graduated 3/32, 3/16, 1/8, 1/4, 3/8, 1/2, 3/4, 1, 1 1/2, and 3 inches to the foot, and 16ths of inches	4 50	.10
727A.—	Do. 18 inches long, graduated same as No. 727	3 00	.08
728.—	Do. 12 inches long, do.	1 50	.05
729.—	Do. 6 inches long, do.	1 00	.03

The Metallic Triangular Scales are made from brass tubing with the ends closed, nickeled with a dull finish, and weigh less than three and one-half ounces.

The liability of the wood scales to crack, warp, or twist, the chipping of their edges, and their variation from standard measurement, are well known to all who have used them. These objections have been overcome in the metallic scale.

730.—	Metallic Triangular Scale, 12 inches, graduated same as No. 720	3 00	.08
731.—	Do. do. do. No. 721	3 00	.08
732.—	Do. do. do. No. 727	3 00	.08
733.—	Guard for Triangular Scale (preventing all errors)	25	.02

PAPER SCALES.

No.		Price	Post.
735.	—Paper Scale, printed on card-paper, 1¼ inch wide, 12 inches long, graduations on one edge inches and 10ths, and the other feet and 100ths........	$ 10	$ .02
736.	—Paper Scale, same as 735, edges 20 and 40 parts to the inch......	10	.02
737.	—Paper Scale, same as 735, edges 16 and 48 parts to the inch......	10	.02
	Paper Scales, printed on card-paper, 19 inches long, for architects and engineers, as follows:		
738.	—Series A contains 6 scales, one each divided to ¼, ½, ¾, 1, 1½, and 3 inches to the foot, each scale........	.20	.03
739.	—Series B contains 6 scales, one each divided to $\frac{3}{32}$, ⅛, $\frac{3}{16}$, $\frac{5}{16}$, ⅜, and ⅞ inches to the foot, each scale........	.20	.03
740.	—Series C contains 6 scales, one each divided to 10, 20, 30, 40, 50, and 60 parts to the inch, each scale........	.20	.03

The advantages of these scales are—they expand and contract nearly the same as drawing-paper, do not soil the work, and distances can be set off from them without the use of dividers.

METRIC SCALES AND RULES.

No.					Price	Post.
741.	—Flat Boxwood, fully divided,		10 centimeters long	....	$ 60	$ .02
742.	— Do.	do.	20	do.	90	.03
743.	— Do.	do.	30	do.	1 25	.05
744.	— Do.	do.	50	do.	1 75	.10
745.	—Flat Ivory,	do.	10	do.	2 50	.02
746.	— Do.	do.	20	do.	3 50	.03
747.	— Do.	do.	30	do.	4 25	.05
748.	—Triangular Boxwood,	do.	20	do.	1 50	.03
749.	— Do.	do.	30	do.	2 00	.05
750.	—Metric Rule, boxwood, 4 feet, 8 fold, divided $\frac{1}{16}$ inch and meters				.60	.04
751.	—Engineers' Metric Rule, 4 feet, 8 fold, with spring joints, divided to $\frac{1}{16}$ inch and meters........				.90	.05

We manufacture, to order, scales to any divisions, in Ivory, Boxwood, Rubber, or Metal.

STANDARD STEEL RULES.

No.	Price	Post.	No.	Price	Post.
755.—1 inch	$ 20	$ .01	761.—12 inch	$1 50	$ .08
756.—2 "	30	.01	762.—18 "	2 25	.14
757.—3 "	40	.02	763.—24 "	3 00	.18
758.—4 "	50	.02	764.—36 "	7 00	.30
759.—6 "	75	.04	765.—48 "	10 00	.50
760.—9 "	1 12	.06			

The rules in this list are divided in parts of inches as follows :

No. 1 Graduations.	*No. 2 Graduations.*	*No. 4 Graduations.*
1st cor. 10, 20, 50, 100	10, 20, 50, 100	1st cor. 64
2d cor. 12, 24, 48	12, 24, 48	2d cor. 32
3d cor. 16, 32, 64	16, 32, 64	3d cor. 16
4th cor. 14, 28	8	4th cor. 8

Always give the graduation desired when ordering these goods.

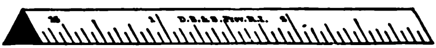
770.—36-inch Steel or Standard Yard, full divided.................... $3 00 $ .22

STANDARD STEEL RULES, FRENCH MEASURE.

No.	Price	Post.	No.	Price	Post.
773.—$\frac{1}{10}$ meter	$ 45	$ .01	776.—$\frac{3}{10}$ meter	$2 50	$ .08
774.—$\frac{1}{10}$ "	85	.02	777.—½ "	4 00	.15
775.—$\frac{1}{4}$ "	1 75	.05	778.—1 "	10 00	.32

They are divided on three edges to millimeters, and on one edge to fifths of millimeters.

TRIANGULAR STEEL RULES.



780.

No.	Price	Post.	No.	Price	Post.
780.—3 inch.	$ 50	$ .02	782.—6 inch.	$1 00	$ .04
781.—4 "	70	.02	783.—12 "	2 50	.07

Graduations.

16, 64, 100 to the inch whole length.
16, 32, 64 " "
20, 50, 100,—12, 24, 48,—16, 32, 64 to the inch.

The 12 in. are divided only as follows : 8, 10, 12, 14, 16, 20, 24, 28, 48, 50, 64, 100 to the inch

SQUARE STEEL RULES.

785.

No.	Price	Post.	No.	Price	Post.
785.—3 inch................	$ 45	$ .02	787.—6 inch.	$ 90	$ .04
786.—4 "	60	.02			

Graduations.

8, 16, 32, 64 to the inch whole length.
16, 32, 64, 100 " "
16, 64, 50, 100 " "

STANDARD STEEL STRAIGHT EDGES.

Of same width and thickness as Standard Rules.

No.	Plain	Nickel-Plated	Post.	No.	Plain	Nickel-Plated	Post.
790.—18 inch........	$1 80	$2 30	$ .14	792.—36 inch........	$6 00	$7 00	$ .30
791.—24 "	2 40	3 15	.18	793.—48 "	9 00	10 35	.50

STEEL STRAIGHT EDGES.

FOR DRAUGHTSMEN.

No.	Plain	Nickel-Plated	Post.	No.	Plain	Nickel-Plated	Post.
800.—15 inch........	$ 90	$1 30	$ .07	804.—36 inch........	$3 00	$4 00	$ .25
801.—18 "	1 00	1 45	.08	805.—42 "	3 75	4 85	.30
802.—24 "	1 50	2 20	.14	806.—48 "	5 00	6 25	.45
803.—30 "	2 25	3 15	.20	807.—60 "	7 00	8 35	

STEEL AND GERMAN SILVER TRIANGLES.

OPEN STEEL TRIANGLES.

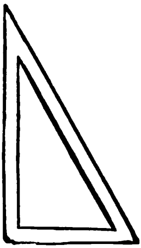
30° × 60° × 90°.

No.	Price	Post.	No.	Price	Post.
810.—6 inch................	$3 00	$ .06	811.—10 inch...............	$4 00	$ .08

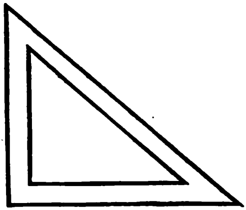
45° × 45° × 90°.

812.—5 inch................	$3 00	$ .06	813.—8 inch................	$4 00	$ .08

For Nos. 810 and 812, if Nickel-plated, add 40 cts. each.
do 811 and 813, do 50 do



810 and 815.



812 and 820.

824.

OPEN GERMAN SILVER TRIANGLES.

30° × 60° × 90°.

No.	Price	Post.	No.	Price	Post.
815.—6 inch..............	$2 50	$ .06	817.—10 inch............	$4 00	$ .08
816.—8 "	3 00	.07	818.—12 "	5 00	.12

45° × 45° × 90°.

820.—5 inch..............	$2 25	$ .06	822.—8 inch...............	$4 00	$ .08
821.—6 "	2 75	.07	823.—10 "	5 00	.12

STRAIGHT EDGES, OF RUBBER AND WOOD.

(*For steel straight edges, see Nos. 790 to 807.*)

Hard Rubber Straight Edges, one edge beveled.

825.—18 inch..............	$ 85	$ .06	828.—36 inch............	$1 75	$ .20
826.—24 "	1 25	.10	829.—42 "	2 00	.25
827.—30 "	1 50	.15	830.—60 "	3 50	.50

Hardwood Straight Edges, one edge beveled.

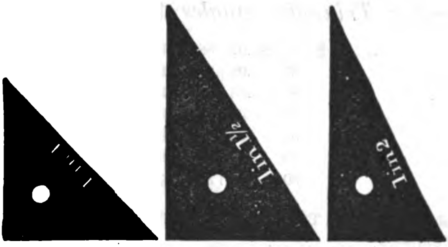
835.—18 inch..............	$ 25	$ .06	839.—42 inch............	$ 65	$ .25
836.—24 "	30	.10	840.—48 "	75	.30
837.—30 "	40	.15	841.—60 "	1 00	.50
838.—36 "	50	.20	842.—72 "	1 35	

Polished Rosewood, Satinwood, or Mahogany Straight Edges, one edge beveled.

No.	Price	Post.	No.	Price	Post.
846.—24 inch..............	$ 75	$ .10	849.—42 inch..............	$1 50	$ .25
847.—30 "	1 00	.15	850.—48 "	2 00	.30
848.—36 "	1 25	.20	851.—60 "	2 50	.50

Cross Section Triangles.

HARD RUBBER.



855.

855.—Cross Section Triangles, set of seven Cross Section Triangles made of hard rubber as follows: ¼ to 1, ½ to 1, ¾ to 1, 1 to 1, 1¼ to 1, 1½ to 1, 2 to 1, per set.............................. $3 00 $ .08

Single Triangles of set No. 855, each.............................. 50 .02

TRIANGLES.

RUBBER, ROSEWOOD, SATINWOOD, OR HARDWOOD.

(For prices, see pages 292 and 293.)

(*For Steel and German Silver Triangles, see Nos.* 810 *to* 823.)

860.

875.

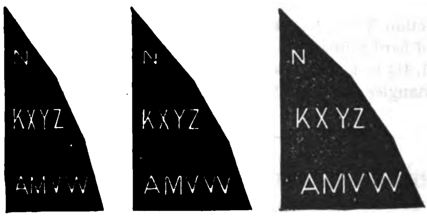
Hard Rubber Triangles, angles 30, 60, *and* 90 *degrees.*

No.	Price	Post.	No.	Price	Post.
860.—3 inch..............	$ 20	$ .02	867.—10 inch..............	$ 65	$ .06
861.—4 "	25	.02	868.—11 "	75	.07
862.—5 "	30	.03	869.—12 "	90	.08
863.—6 "	35	.03	870.—13 "	1 00	.08
864.—7 "	40	.04	871.—14 "	1 25	.10
865.—8 "	50	.04	872.—15 "	1 50	.12
866.—9 "	60	.05	873.—16 "	1 75	.16

Hard Rubber Triangles, angles 45, 45, *and* 90 *degrees.*

No.	Price	Post.	No.	Price	Post.
875.—3 inch..............	$ 30	$ .02	882.—10 inch..............	$1 00	$ .10
876.—4 "	35	.02	883.—11 "	1 25	.10
877.—5 "	40	.03	884.—12 "	1 35	.12
878.—6 "	45	.04	885.—13 "	1 50	.12
879.—7 "	55	.05	886.—14 "	1 65	.15
880.—8 "	65	.07	887.—15 "	2 00	.18
881.—9 "	80	.07	888.—16 "	2 40	.20

	Price	Post.
890.—Hard Rubber Lettering Triangles, 3 in set, 3½ inch, per set.....	1 25	.05
Single Templets..	50	.02



890.

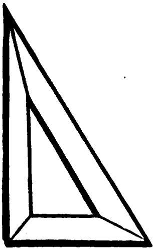
Rosewood or Satinwood Triangles, open centre, framed.

30° × 60° × 90°.

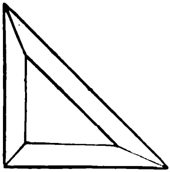
No.	Price	Post.	No.	Price	Post.
900.—10 inch, plain.......	$ 50	$ .06	902.—15 inch, plain.......	$1 00	$ .15
901.—10 " polished....	60	.06	903.—15 " polished ...	1 25	.15

45° × 45° × 90°.

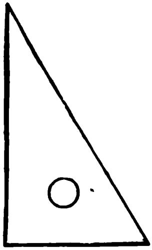
905.—7 inch, plain........	$ 50	$ .06	907.—12 inch, plain.......	$1 00	$ .15
906.—7 " polished.....	60	.06	908.—12 " polished ...	1 25	.15



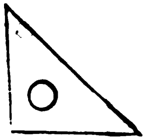
900 and 910.



905 and 919.



920.



925.

Hardwood Triangles, open center, framed.

30° × 60° × 90°.

No.	Price	Post.
910.—6 inch	$ 25	$ .03
911.—8 "	30	.04
912.—10 "	40	.06
913.—12 inch	$ 50	$ .08
914.—14 "	65	.12

45° × 45° × 90°.

915.—5 inch	$ 25	$ .03
916.—7 "	30	.06
917.—9 "	40	.08
918.—11 inch	$ 50	$ .13
919.—13 "	65	.15

Hardwood Triangles, plain.

30° × 60° × 90°.

920.—4 inch	$ 10	$ .02
921.—6 "	12	.03
922.— 8 inch	$ 15	$ .04
923.—10 "	25	.06

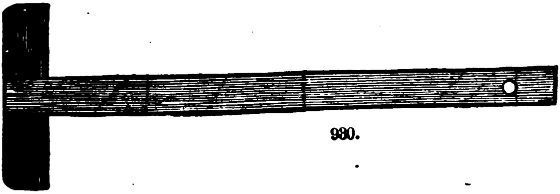
45° × 45° × 90°.

925.—4 inch	$ 12	$ .02
926.—5 "	15	.03
927.—6 inch	$ 20	$ .04
928.—8 "	25	.06

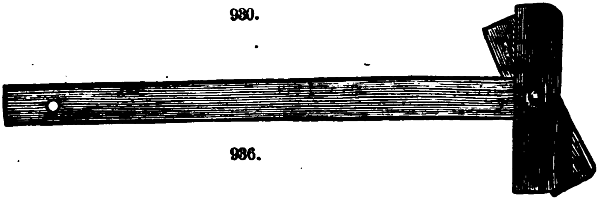
Batter Slopes.

929.—Set of three forms of hard rubber for Batters of walls and rock, giving the following slopes: 1 in 4, 1 in 5, 1 in 6, 1 in 8, 1 in 10, 1 in 12, per set	$2 00	$ .05
Single forms of set No. 929, containing two slopes, each	75	.02

T SQUARES.



930.



936.

Hardwood T Squares, fixed head.

No.	Price	Post.	No.	Price	Post.
930.—15 inch	$ 30	$ .15	933.—30 inch	$ 50	$ .40
931.—20 "	40	.20	934.—40 "	85	.50
932.—25 "	45	.30	935.—50 "	1 25	

Hardwood T Squares, shifting head.

No.	Price	Post.	No.	Price	Post.
936.—20 inch	$ 90	$ .25	939.—40 inch	$1 35	$ .55
937.—25 "	95	.35	940.—50 "	1 75	
938.—30 "	1 00	.45			

Rosewood T Squares, fixed head, polished.

No.	Price	Post.	No.	Price	Post.
941.—30 inch	$1 75	$ .45	942.—40 inch	$2 50	$ .55

Rosewood T Squares, shifting head, polished.

No.	Price	Post.	No.	Price	Post.
943.—30 inch	$2 75	$ .55	944.—40 inch	$3 50	$ .60

945.—"R. P. I." Hardwood T Square, fixed head, 30 inch blade, superior .... $1 25 $ .40

Rubber Blade T Squares, Hardwood head, fixed.

No.	Price	Post.	No.	Price	Post.
946.—21 inch	$1 25	$ .20	948.—30 inch	$2 00	$ .40
947.—24 "	1 50	.30	949.—36 "	2 50	.50

Rubber Blade T Squares, Hardwood head, shifting.

No.	Price	Post.	No.	Price	Post.
951.—21 inch	$1 75	$ .25	953.—30 inch	$2 50	$ .45
952.—24 "	2 00	.35	954.—36 "	3 00	.50

T Squares, Steel Blades, Nickel Plated, Bronze heads, fixed.

955.—18 inch	$3 25	$ .30	957.—30 inch	$5 50	$ .50
956.—24 "	4 50	.40	958.—36 "	6 50	.60

T Squares, Steel Blades, Nickel Plated, Bronze heads, shifting.

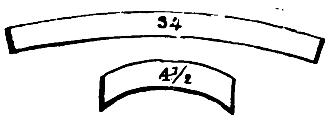
959.—18 inch	$4 75	$ .40	961.—30 inch	$7 00	$ .60
960.—24 "	6 00	.50	962.—36 "	8 00	.70

Any of our T Squares with longer blades made to order.

OVALS, HYPERBOLAS, AND PARABOLAS.

965.—Pearwood Ovals, 1¼ to 6 inches long, 10 in a set, per set	$2 00	$ .08
966.— Do. 1 to 6 do. 6 do. do.	1 25	.04
967.— Do. ¾ to 7 do. 43 do. do.	5 00	.25
968.—Pearwood Hyperbolas, 2 to 5 inches long, 8 in a set	1 50	.08
969.— Do. Parabolas, 12 do.	3 00	.15
970.— Do. do. 1½ to 6 do. 8 do.	1 50	.08
971.—Hard Rubber Ellipses, 6 in a set, 1½ to 6 in. long, per set	2 00	.06
972.— Do. 10 " 1½ to 6 in. "	2 75	.08

RAILROAD CURVES OF CARDBOARD, WOOD, AND RUBBER.



985.

The following curves are cut to a scale of inches, the outside of arcs only finished.

No.	Price	Post.
985.—Set of ten Curves, from 12 to 120 in. radius, varying every 12 in.:		
A.—Set, complete, of card-board, in box	$3 00	$ .15
B.— Do. wood, do.	3 50	.20
C.— Do. rubber, do.	6 00	.20
986.—Set of seventeen Curves, from 12 to 60 inches radius, varying every 3 inches:		
A.—Set, complete, of card-board, in box	5 00	.20
B.— Do. wood, "	6 00	.25
C.— Do. rubber, "	9 00	.25

RAILROAD CURVES.—*Concluded.*

No.		Price	Post.
987.—Set of twenty-four Curves, from 1½ to 24 inches radius, Varying ½ inch from 1½ inches to 10 inches, Do. 2 inches do. 10 inches to 24 inches:			
	A.—Set, complete, of card-board, in box	$ 7 50	$ .25
	B.— Do. wood, do.	8 00	30
	C.— Do. rubber, do.	14 00	.30

The following Curves are cut to a scale of 50 feet to the inch, and have both inside and outside of arcs finished:

No.		Price	Post.
990.—Set of fifteen Curves, rising every 30′ to 3°, then single deg. to 12°:			
	A.—Set, complete, of wood, in box	7 50	.25
	B.— Do. rubber, do.	11 00	.25
991.—Set of twenty Curves, rising every 30′ to 10°:			
	A.—Set, complete, of wood, in box	10 00	.30
	B.— Do. rubber, do.	15 00	.30

The following Curves are cut to a scale of 400 feet to the inch, and are finished only on outside of arc:

No.		Price	Post.
995.—Set of twenty Curves, from 30′ to 10° by every 30′:			
	A.—Set, complete, of wood, in case	8 00	.30
	B.— Do. rubber, do.	11 50	.30

IRREGULAR CURVES OF HARD RUBBER AND WOOD.

No.		Price	Post.
1000.—Hard Rubber, Irregular Curves, Nos. 1, 2, 14, 16, 17, 22, 25, and 26, each		$ 35	$ .03
	Hard Rubber, Irregular Curves, Nos. 5, 15, 18, 21, and 23, each	40	.03
	Do. do. Nos. 3, 4, 13, 19, 20, and 24, each	50	.04
	Hard Rubber, Irregular Curve, No. 27	75	.07
	Do. do. No. 28	2 25	.10
	Do. Logarithmic, Spiral Curve, No. 29	1 50	.05
1005.—Wood, Irregular Curves, Nos. 1, 5, 21, 25, and 26, each		20	.03
	Do. do. Nos. 3, 4, 13, 19, 20, and 24, each	25	.04
	Do. do. No. 27	35	.07

HARD RUBBER AND WOOD IRREGULAR CURVES.

1000 and 1005.

ADJUSTABLE CURVE RULER.

No.		Price	Post.
1010.—	Adjustable Curve Ruler, 14½ in. long	$1 87	$ .10
1011.—	Do. do. 30 do.	2 87	.30

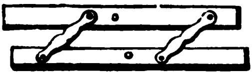
These rulers can be instantly adjusted and retained to any form of curve.

This tool is recommended by architects and draughtemen, and meets a want long felt. It is well made and neatly finished in nickel plate.

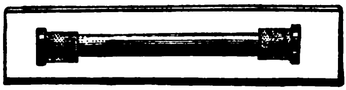
PANTOGRAPHS.

1015.—	Pantograph of hardwood arms	$3 00	$ .15
1016.—	Do. pearwood arms 22 inches long	5 00	.20

PARALLEL RULES.



1035.



1042.

Parallel Rulers, Ebony, Brass Mounted.

No.		Price	Post.	No.		Price	Post.
1035.—	6 inch	$ 25	$ .03	1038.—	15 inch	$1 00	$ .12
1036.—	9 "	50	.05	1039.—	18 "	1 25	.15
1037.—	12 "	75	.10	1040.—	24 "	2 00	.25

1041.—Parallel Ruler, Ebony, German-silver Mounted, 12 inch ... ... 1 25 .10

Parallel Rulers, Ebony, on Rollers.

1042.—	12 inch	$3 25	$ .15	1044.—	18 inch	$5 00	$ .25
1043.—	15 "	4 00	.20				

Parallel Rulers, Ebony, on Rollers, Ivory Graduated Edges.

1045.—	12 inch	$5 00	$ .15	1047.—	18 inch	$7 50	$ .25
1046.—	15 "	6 50	.20				

Parallel Rulers, all Brass, on Rollers.

No.	Price	Post.	No.	Price	Post.
1048.— 9 inch	$6 50	$ .25	1050.—15 inch	$10 00	$ .40
1049.—12 "	8 00	.33	1051.—18 "	12 00	.50

Nos. 1048 and 1049, if nickel-plated, extra 75
" 1050 and 1051 do do 1 00

Parallel Rulers, all German Silver, on Rollers.

1052.—12 inch	$10 00	$ .33	1054.—18 inch	$15 00	$ .50
1053.—15 "	12 00	.40			

SECTION LINERS.

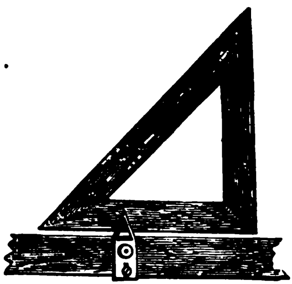
1059.—Positive T Square and Section-Liner.

This instrument combines a Section-Liner, Protractor, and T Square. Being positive in all its motions, measurements in fractional and decimal parts of an inch can be made with mathematical accuracy; lines can be drawn at any angle, in any direction, and on any part of the board. Directions for use furnished with each instrument.

	Price	Post.
A.—Size for Drawing Boards 10 × 14 or less, each	$10 00	
B.— do do 12 × 16 " " do	12 00	
C.— do do 20 × 31 " " do	17 00	

Each instrument packed in neat case.

D.—Notched wheels for producing decimal or fractional parts of an inch, each	1 50	
1060.—Bergner's Patent Section-Liner, in Morocco case	7 50	$ .10
1061.—Harden's Improved Section-Liner	3 75	.10
1062.—Marion's Section-Liner, German-silver slide and screws, with rubber triangle and ruler	2 00	.10



1062

1063.—"Universal" Ruler and Section Liner, for drawing parallel lines and circles, and for curved or irregular work.

A.—Six-inch Ruler, without Center Point	$4 50	$ .10
B.—Eight and one-half inch Ruler, with Center Point	5 00	.15
C.—Velvet-lined case for either size	1 00	.10

THUMB TACKS AND HORN CENTERS.


1065.


1066.


1068.


1069.


1075.


1076.

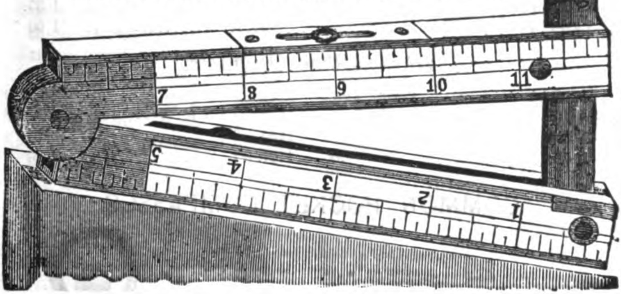
No.		Price	Post.
1065.—	Thumb Tacks, brass, round flat heads, 3/8 inch diam., per doz.	$ 20	$ .02
1066.—	Do. do. do. 1/2 do. do.	30	.02
1067.—	Do. German-silver, round flat heads, 3/8 in. diam., per doz.	35	.02
1068.—	Do. do. do. 1/2 do. do.	45	.02
1069.—	Do. do. do. 5/8 do. do.	55	.02
1070.—	Do. do. superior, 1/2 do. do.	75	.02
1071.—	Do. do. do. 5/8 do. do.	90	.02
1072.—	Do. steel, do. 5/16 do. do.	60	.02
1073.—	Do. do. common. 3/8 do. do.	20	.02
1074.—	Paper Fasteners, round heads, 1/4 inch diameter, prongs 3/8 inch long, per doz.	10	.01
1075.—	Horn Center	15	.01
1076.—	Do. with German-silver rim	35	.01
1078.—	Thumb Tack Extractor and Impressor, nickel-plated	25	.02

POCKET RULES.

No.		Price	Post.
1080.—	One Foot, four Fold, boxwood, each	$ 15	$ .02
1081.—	Do. do. do. edge plates	20	.02
1082.—	Do. do. do. brass edges, bound	40	.03
1085.—	Two feet, four Fold, boxwood	20	.03
1086.—	Do. do. do. edge plates	30	.03
1087.—	Do. do. do. brass bound, with drafting scales	60	.05
1088.—	Do. do. do. inside edges beveled, with drafting scales	65	.03
1089.—	Two Feet, six Fold, boxwood, brass bound, graduated 8ths, 10ths, 12ths, and 16ths of inches, and 100ths of a foot on edges.	1 25	.04
1090.—	One Foot, four Fold, ivory, German-silver mounted	1 25	.03
1091.—	One Foot, four Fold, ivory, German-silver mounted, graduated in 8ths, 10ths, 12ths, 16ths of inches, and 100ths of a foot on edges	1 50	.03
1092.—	One Foot, four Fold, ivory, graduated in 8ths, 10th, 12ths, 16ths of inches, and 100ths of a foot, German-silver bound...	1 75	.04
1093.—	One foot, four Fold, ivory, Caliper, graduated in 8ths, 10ths, 12ths, and 16ths of inches	2 00	.04
1093A.—	One Foot, four Fold, ivory, Caliper, graduated in 8ths, 10ths, 12ths, and 16ths of inches, German-silver bound	2 25	.05
1094.—	Two feet, four Fold, ivory, German-silver mounted, with 8ths, 10ths and 16ths of inches, and 1/4, 3/8, 1/2, and 1 inch drafting scales	3 25	.08
1095.—	Two feet, four Fold, ivory, same as No. 1094, German-silver bound	4 00	.10

BOXWOOD COMBINATION RULE.

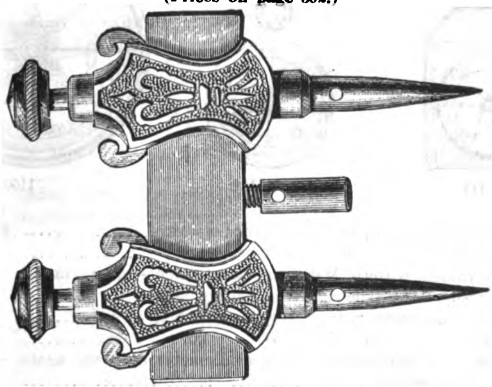
1096.—Combination Rule, One Foot, Two Fold, boxwood. This is the most convenient and useful pocket-rule ever made; it combines in itself a Carpenter's Rule, Spirit Level, Square, Plumb, Bevel, Indicator, Brace Scale, Draughting Scale of equal parts, T Square, Protractor, Right-angle Triangle, and with a straight edge can be used as a Parallel Ruler, all the parts of which, in their separate application, are perfectly reliable.................................$2 00 [Post. .10



1096.

IMPROVED TRAMMEL POINTS.

(Prices on page 302.)



1110.

No.		Price	Post.
1097.	Pattern Makers' Shrinkage Rule, 24¼ inches, two Fold, boxwood, 8ths and 16ths	$1 00	$ .10
1098.	Slide-Rule, two Feet, two Fold, with Gunter's Slide, Engineering and Octagonal Scales	1 00	.10
	Treatise on Slide Rule, 200 pages	1 00	—

Trammel Points (see page 301).

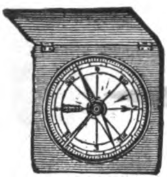
These tools are used by all who have occasion to strike arcs or circles larger than can be done by compass dividers.

No.		Price	Post.
1110.	Small, per pair	$1 10	$ .05
1111.	Medium, per pair	1 35	.10
1112.	Large, per pair	1 50	.15

Horse Shoe Magnets.

No.		Price	Post.
1115.	2 inch	$ 12	$ .03
1117.	3 "	25	.04
1118.	4 "	35	.06
1119.	5 inch	$ 50	$ .10
1120.	6 "	75	.13
1121.	7 "	1 10	.18

COMMON POCKET COMPASSES.



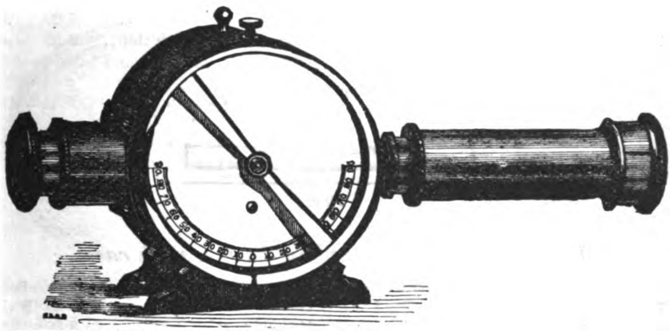
1141.

1144.

1150.

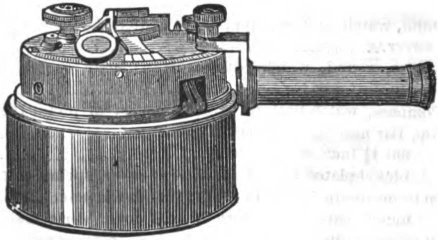
No.		Price	Post.
1141.	Mahogany Case, stop to needle, 2 inches square	$1 50	$ .03
1143.	Do. do. 3 do.	2 25	.05
1143A.	Government pattern, Mahogany Case, 3 inches square, raised ring, superior needle with stop, Gurley, maker	3 50	.05
1144.	Brass, round, watch pattern, stop, agate center, 1½ inch	1 00	.03
1145.	Do. do. do. do. 2 do.	1 25	.04
1146.	Do. with cover, 1½ inches diameter, stop and agate center to needle	1 25	.04
1147.	Do. 2 do. do.	1 50	.03

No.		Price	Post.
1148.	—Brass, round, watch pattern, stop, agate center, 1½ inch, with hinged cover	$1 50	$ .03
1149.	—German-silver, round, watch pattern, stop, agate center, 1½ inches, with hinged cover	2 00	.03
1150.	—Pocket Compass, watch pattern, gilt, enameled or metal face, stem stop, Bar needle, 1¼ inches in diameter	4 50	.04
1151.	— Do. but 1½ inches in diameter	5 00	.04
1152.	— Do. nickel-plated case, with hinged cover, spring catch and stop to needle in joint of cover, 1½ in. in diameter	3 50	.05
1153.	— Do. nickel-plated case, with hinged cover, spring catch and stop to needle in joint of cover, 2 inches in diameter	4 50	.05
1155.	—Pocket Compass, watch pattern, gilt, stem stop, in case, 1½ in. diameter, Singer's patent pearl dial	5 00	.04
1158.	—Pocket Compass, nickel-plated hunting case, raised ring, stop to needle, folding sights, 2¾ inches in diameter	7 00	.10
1159.	—Pocket Compass, nickel-plated hunting case, raised ring, stop to needle, folding sights, with level, 2¾ inches diameter	8 00	.10
1159A.	—Geological Compass, of Brass, with pendulum for ascertaining the angle of dip in rocks	4 00	.05
1160.	—Gilt Charm Compasses to hang to watch guard	25 cts. to 1 50	.01
1161.	—Prismatic Azimuth Compass, 2-inch brass case, with hinged cover, floating dial	15 00	.15
1162.	—Prismatic Azimuth Compass, 3-inch brass case and cover, floating dial, folding prism and sight, leather sling case	17 50	.25



1163.

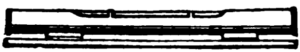
1163.—Pocket Alt-Azimuth, with Telescope, for travelers and military surveyors. Altitudes, azimuths, compass bearings, clinometer degrees and levels are all obtained by this instrument. Size 6⅛ × 2⅛ × 1⅛, in case.......... $50 00 [Post. .30



1164.

No.		Price	Post.
1164.—	Pocket Sextant, divided to ½ degrees, with vernier to 1 minute, telescope, sun glasses, reading glass, tangent screw, etc. In metal case, 3 in. diameter	$42 50	$ .40
1165.—	Surveyor's Cross—for right angles	3 00	.30
1166.—	" " and with magnetic compass, 1¾-in. needle	5 00	.35
1167.—	" " with vertical axis divided to 1 degree and vernier to 3 minutes—with magnetic compass, 2½-in. needle	12 00	.45
1168.—	Rectangular Prism, for right angles, in morocco case	5 00	.05
1169.—	Artificial Horizon, with black glass plane mounted in brass frame, with 3 leveling screws, and sensitive level vial	16 00	.25
1170.—	Pedometer, watch form, registers distance walked up to 12 miles by each ¼ mile	4 50	.05
1171.—	Pedometer, watch form, registers distance walked up to 50 miles by each 80 yards	5 00	.05
1172.—	Passometer, or Step Counter, watch form, registers each step	6 50	.05

POCKET SPIRIT LEVELS.



1180.

Pocket Levels, Mounted in Brass, with cases.

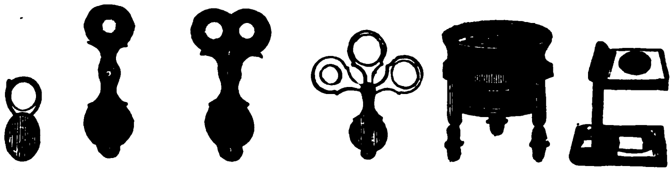
No.		Price	Post.	No.		Price	Post.
1180.—	3 inch	$ 75	$ .05	1182.—	9 inch	$2 25	$ .12
1181.—	6 "	1 50	.08	1183.—	12 "	3 00	.17

1185.—Plain Level Vials, unmounted, 1½ in., 10 cts.; 2 in., 12 cts.; 2½ in., 13 cts.; 3 in., 15 cts.; 3½ in., 18 cts.; 4 in., 20 cts.; 4½ in., 25 cts. Post, $ .02 to $ .06

1187.—Ground Level Vials, unmounted, 1½ in., 35 cts.; 2 in., 45 cts.; 2½ in., 50 cts.; 3 in., 60 cts.; 3½ in., 70 cts.; 4 in., 85 cts.; 4½ in., $1.00; 5 in., $1.25; 5½ in., $1.35; 6 in., $1.50; 6½ in., $1.65; 7 in., $1.75. Post, $ .02 to $ .15

MICROSCOPES, &c.

SIMPLE MICROSCOPES, TO FOLD IN CASES.



1200. 1220. 1225. 1230. 1235. 1238.

Hard Rubber Case and Frame, round form, 1 double convex lens.

No.	Price	Post.	No.	Price	Post.
1200.—¾ inch	$ 30	$ .01	1203.—1½ inch	$ 75	$ .02
1201.—1 "	40	.02	1205.—2 "	1 25	.04
1202.—1¼ "	60	.02			

Hard Rubber Case and Frame, round form, 2 double convex lenses.

1210.—⅝ and ¾ inch	$ 60	$ .02	1214.—1¼ and 1½ inch......	$1 35	$ .04
1211.—⅞ " 1 "	80	.03	1216.—1¾ " 2 "	2 15	.06
1213.—1⅛ " 1¼ "	1 15	.04			

Hard Rubber Case and Frame, bellows form, 1 double convex lens.

1220.—¾ inch.............	$ 40	$ .01	1222.—1 inch.............	$ 60	$ .02

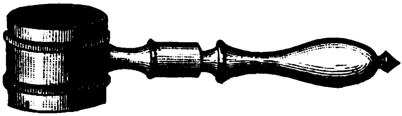
Hard Rubber Case and Frame, bellows form, 2 double convex lenses.

1225.—⅝ and ¾ inch........	$ 75	$ .02	1227.—⅞ and 1 inch........	$1 00	$ .03

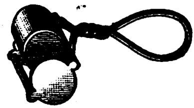
Hard Rubber Case and Frame, bellows form, 3 double convex lenses.

1230.—½, ⅝, and ¾ inch.....	$1 00	$ .03	1232.—¾, ⅞, and 1 inch.....	$1 35	$ .04

No.		Price	Post.
1235.—Microscope on three legs with screw adjustment for focus......		$ 75	$ .01
1236.—Linen provers or microscope for counting threads in linen or wool fabrics. Hard rubber 1 inch open space.......		1 75	.02
1237.— Do. Brass, $\frac{1}{4}$ and $\frac{1}{2}$ in. open space........................		50	.02
1238.— Do. do. $\frac{25}{100}$ in. square can be changed to $\frac{15}{100}$ in Diam.		60	.02



1240.



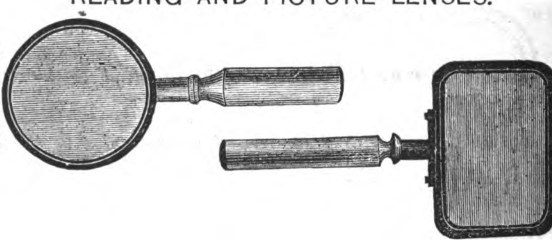
1244.

1240.—Coddington Lens, brass frame, three sizes ......$1 00, $1 50 and		$2 00	$ .04
1244.— Do. $\frac{1}{2}$ inch focus, nickeled frame and cover......		1 75	.03
1245.— Do. $\frac{3}{4}$ do. do.		2 00	.04
1246.— Do. 1 do. do.		2 50	.05
1247.—Achromatic Triplet, three sizes, $\frac{1}{2}$, $\frac{3}{4}$, and 1 inch focus, in nickeled mounting, each..................................		9 50	.08

These triplets are of superior quality, and give perfect definition and flat field.

READING AND PICTURE LENSES.

1250 and 1260.



1255.

Reading Glasses, hard rubber frame, double convex lens.

No.	Price	Post.	No.	Price	Post.
1250.—2 inch	$ 80	$ .04	1252.—3 inch..............	$1 50	$ .07
1251.—2½ "	1 00	.05	1254.—4 "	2 50	.10

Reading Glasses, hard rubber frame, double convex lens.

1255.—2 inch........	$ 90	$ .04	1257.—3 inch..............	$1 50	$ .07
1256.—2½ "	1 10	.05	1259.—4 "	2 50	.10

Reading Glass, oxidized metal frame, two plano-convex lenses.

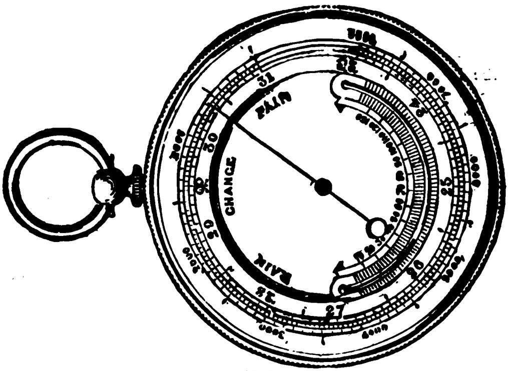
1260.—2½ inch.............	$1 50	$ .06	1262.—3½ inch	$3 25	$ .10
1261.—3 "	2 25	.08	1263.—4 "	4 00	.15

1265.—Picture Glass, metal frame, double convex lens, 5 inches diameter, superior...	4 50	.25
1266.— Do. 6 inches diameter do. do.	7 50	.35

ANEROID BAROMETERS.

FOR ASCERTAINING HEIGHTS, DIFFERENCES OF LEVEL AND METEOROLOGICAL CHANGES, APPROACH OF STORMS, ETC.

No.		Price	Post.
1270.—	**Mountain Aneroid Barometers, compensated for temperature, with brass cases and silvered dials, in morocco cases, accompanied by a hand-book of instructions.** These instruments are of very great service to the engineer and tourist, as well as to the scientific observer, and are rapidly coming into general use.		
A.—	Pocket Aneroid, $1\frac{7}{8}$-inch diameter, altitude scale to 8000 feet....	$18 00	$ .10
B.—	Do do do 10000 feet....	19 00	.10
C.—	Do do do 16000 feet....	21 00	.10
D.—	Do do do 20000 feet....	23 00	.10
E.—	Do do do 16000 feet, and thermometer....	23 00	.10



1270.

No.		Price	Post.
H.—	Pocket Aneroid, $2\frac{1}{8}$-inch diameter, altitude scale to 10000 feet, with thermometer, and opposite side with pocket compass,	28 00	.20
J.—	Do do do 16000 feet.....	30 00	.20
K.—	Pocket Aneroid, $2\frac{3}{8}$-inch diameter, altitude scale to 3000 feet.....	19 00	.18
L.—	Do do do 5000 feet.....	19 00	.18
N.—	Do do do 10000 feet.....	20 00	.18
O.—	Do do do 16000 feet.....	22 00	.18
P.—	Do do do 20000 feet.....	24 00	.18
Q.—	Do do do 10000 feet, and thermometer..........	23 00	.18
R.—	Do do do 16000 feet, and thermometer..........	25 00	.18
1278.—	Plain Aneroid, no altitude scale, 5-inch diameter, with thermometer and open face to show mechanism, for parlor use,	15 00	.65
1279.—	Do but $6\frac{1}{2}$-inch diameter..........	19 00	

SURVEYING AND MINING ANEROIDS.

No.		Price	Post.
1280.	Surveying Aneroid, 3-inch diameter, compensated for temperature, silvered metal dial, with vernier and magnifier, in leather sling case, with altitude scale to - - - 6000 feet..	$40 00	$ .30
1281.	Do do do 10000 feet..	43 00	.30
1282.	Mining Aneroid, 3-inch diameter, but arranged to register 2000 feet below sea-level to 4000 feet above	40 00	.30
1285.	Surveying Aneroid, 5-inch diameter, do 5000 feet..	45 00	.70
1286.	Do do do 10000 feet..	48 00	.70
1287.	Do do do 15000 feet..	50 00	.70
1288.	Do do do 20000 feet..	58 00	.70

The Surveying and Mining Aneroid has been constructed especially for the use of Surveyors and Engineers, for ascertaining slight variations in gradients, levels, etc., and from its extreme sensitiveness will be found of considerable utility in Mining and Surveying work generally.

The Vernier Scale is moved by a rack-work adjustment, and a magnifying lens which rotates on the outer circumference of the Instrument facilitates the reading of minute quantities.

NOTE.—The barometers described above are the most desirable styles. We can, however, furnish any of the styles mentioned in the catalogues of other dealers, at their list price.

A Treatise on the Aneroid Barometer; its construction and use. Illustrated.. .... .50

TO MEASURE ALTITUDES WITH ANEROID BAROMETERS.

WITHOUT ALTITUDE SCALE.

Roughly speaking, the barometer falls one inch for every 900 feet of ascent; or at mean atmospheric pressure in this latitude

Above sea-level	917 feet,	the barometer falls	....	1 inch
Do	1860	do	do	2 inches.
Do	2830	do	do	3 do
Do	3830	do	do	4 do
Do	4861	do	do	5 do

TO FIND THE RELATIVE HEIGHT OF TWO GIVEN PLACES.

Take a reading of the Aneroid at first station; subtract from this the reading at the second station. The product multiplied by 9 will give the difference of altitude in feet, thus:

First Station	30 20
Second Station	29 99
	21
	9
Difference of altitude	189 feet.

This under ordinary pressures and with a temperature about 50° F. will give good results. If the temperature is over 70° F., multiply by 10.

The table prepared by Mr. Symons is more strictly accurate:

MEAN TEMPERATURE.	30°	40°	50°	60°	70°	80°
Mean pressures, 27 inches	9.7	9.9	10.1	10.3	10.5	10.8
do 28 do	9.3	9.5	9.8	10.0	10.2	10.4
do 29 do	9.0	9.2	9.4	9.6	9.8	10.0
do 30 do	8.7	8.9	9.1	9.3	9.5	9.7

TO USE THE ANEROID, WITH ALTITUDE SCALE.

Find the height in feet at first station and subtract this from the height in feet at second station. If the mean temperature is greater or less than 50° F., apply correction for temperature as before given.

Example:

Aneroid at Station A, 1800 feet. Thermometer, 50°.
do do B, 800 do do 70°.

The approximate height is 1000 feet. The sum of the temperature is 120. A correction of +20 is therefore applied. This is 20 feet.
The difference of elevation is therefore 1000 + 20 = 1020 feet.

ANEMOMETERS.

FOR MEASURING THE PRESSURE AND VELOCITY OF CURRENTS OF AIR IN COAL MINES, AND VENTILATORS, FLUES, ETC., OF PUBLIC BUILDINGS.

"Robinson's" improved and simplified. The improvement consists—1st.—In a re-arrangement of the works, which admits of the column carrying the arms and cups rising from the *center* instead of from one *corner*, as in the models now in use; and, 2ndly, in an arrangement by which the enumeration is effected by two hands which can be moved to "zero" on the commencement of an observation, thus obviating the necessity of taking a reading of the present condition of the Index before proceeding to make a fresh observation.

(See pages 310, 311, 312.)

No.		Price
1290.	—Robinson's Improved Anemometer, central column, adjustable index.	$32 00
1291.	—Robinson's Anemometer, original pattern, 4 Dials, reading to 1,000 miles	35 00

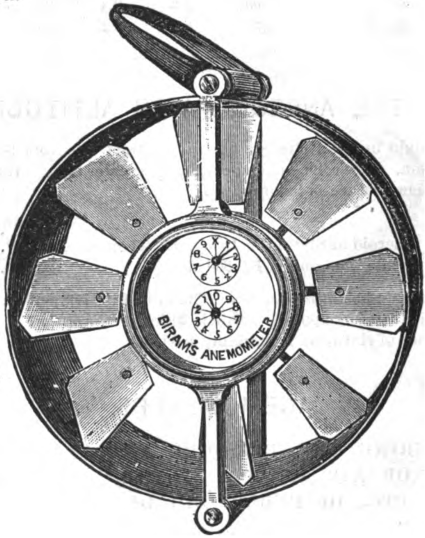
To ascertain the velocity of the wind for a short period: Take two readings of all the dials with an interval of twelve minutes. The difference of these readings, divided by ten, is the velocity of the wind in miles per hour.

Formula for velocity and pressure of the wind:

The pressure varies as the square of the velocity, or $P : V^2$. The square of the velocity in miles per hour multiplied by .005 gives the pressure in pounds per square foot, or $V^2 \times .005 = P$. The square root of 200 times the pressure equals the velocity, or $\sqrt{200 \times P} = V$.

"Biram's"—For registering the velocity of currents of air in mines, tunnels, etc., by means of a light fan, the revolutions of which are recorded on a dial in the center of the instrument.

This instrument placed in the passage of a mine registers automatically the rate at which the air is traveling through it, and a simple observation will detect any slackening of the current arising from obstruction of the ways, or want of attention at the ventilating furnace, or fan wheel.



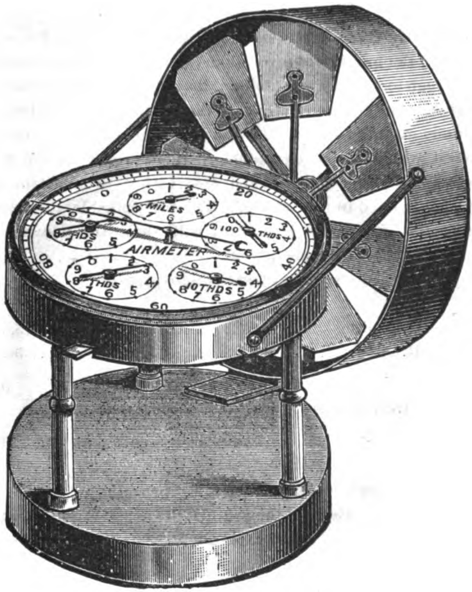
1292.

No.		Price	Post.
1292.	—Biram's Anemometer, 3 in. diam., reading to 1,000 feet, without disconnector	$20 00	$.30
1293.	— Do do 4 do do 1,000 do do disconnector	22 00	.40
1294.	— Do do 6 do do 1,000 do with disconnector	24 00	.50
1295.	— Do do 6 do do 100,000 do with disconnector	26 00	.50
1296.	— Do do 6 do do 10,000,000 do with disconnector	36 00	.50

Pocket Size (2 *inches diameter*)—Is made in the form of a watch —the top and bottom of the case, when opened, form a base for the instrument, a check-spring passing through the pendant acts as a stop to the movement, on being pressed by the finger at the expiration of the time necessary to make the observation. The movement is jeweled at four points. The outer circle of divisions on the dial records by single feet up to one hundred; the smaller dial continues the enumeration up to one thousand feet.

No.		Price	Post.
1297.	—Watch Anemometer, very small and sensitive, in white metal hunting case, reading to 1,000 feet..........................	$34 00	$.15

AIR METERS.



1298.

1298.	—The Portable Air Meter, 6 dials, diameter of fan wheel 2¾ inches, with disconnector, which is extensively used for testing the ventilation of Hospitals, Schools, and Public Buildings, forms also an admirable Pocket Anemometer for tourists....	$25 00	$.30
1299.	—Air Meter, same as preceding, with 2 dials, and reading only to 1,000 feet	20 00	.30

The portable "*Air Meter*" is for the measurement of currents of air through Mines, Tunnels, Sewers and the Ventilators of Hospitals, Public Buildings, etc. The indications are obtained by means of a delicately poised fan-wheel, the recordings being commenced by the long hand, which traverses the extreme outer circumference of the main dial for the passage of one hundred feet of air. The enumeration is continued up to ten millions of feet (say 1,894 miles), by a series of smaller dials as shown in the illustration. A "Disconnector" projecting from the band of the instrument, opposite the fan-wheel, serves to throw the mechanism out of gear, and arrest its action, when required. The instrument is packed, with the usual Universal jointed socket holder, in a box about four inches square.

HOW TO USE THE ANEMOMETER.

The Anemometer consists of a series of vanes, which revolve with the action of the air-current, the number of revolutions, or numbers proportioned to the revolutions, being registered by a pointer on the face of a dial, forming part of the instrument itself. An observer has only to record the position of the several indices at the first observation (by writing the lower of the two figures on the respective circles, between which the index points, in their proper order), and deduct the amount from their position at the second observation, to ascertain the velocity of the air which has passed in the interval. This multiplied by the area in feet of the passage, where the instrument is placed, will show the number of cubic feet which has passed during the same period.

Thus, suppose the observation of one minute gives:

Second Reading	5,525
First Reading	5,225
	300
Add correction, say	30
	330

Size of passage in feet, 10x5x330=16,500 feet per minute.

The correction added above is the value of the constant of friction, which must be found for each machine by actual experiment.

TO FIND THE VELOCITY OF THE AIR IN THE PASSAGE,

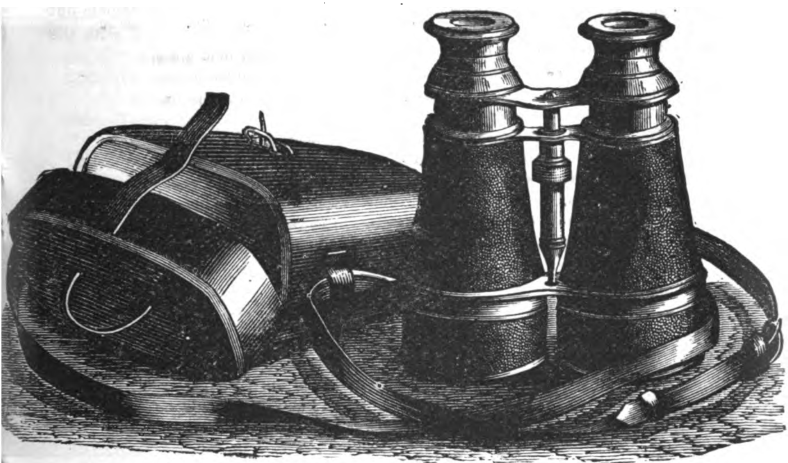
Proceed thus:—Suppose the Anenometer indicates 330 feet per minute. 330÷88 =3.75 or 3¾ miles per hour, 88 being 1-60th of a mile.

To ascertain the force of the air current, multiply the square of the velocity of the air in feet per second by .0023.

MARINE AND FIELD GLASSES.

The power and sharpness of definition of a Field Glass depends upon the diameter of the object-glass; the greater the diameter the higher the power, and more clearly distant objects are seen.

These Glasses are designated and priced according to the diameter of the object-glasses in French lines, eleven lines being equal to one inch.



1300.

No.		Price	Post.
1300.	—Six Lens Achromatic Field Glass, metal body, covered with morocco, sun-shades to extend over the object-glasses, and leather case, with strap.		
	A.—Body 4¾ inches long; object-glasses 21 lines in diameter...	$7 00	$ .30
	B.— Do 5¾ do do 24 do ...	8 00	.35
	C.— Do 6¼ do do 26 do ...	9 00	.40
1301.	—U. S. Army Signal Service Six Lens Achromatic Marine or Field Glass, metal body, covered with Turkey morocco, sun-shade to extend over object-glass, and heavy leather case, with strap.		
	A.—Body 5⅜ inches long; object-glasses 21 lines in diameter..	$13 00	$ .35
	B.— Do 5⅞ do do 24 do ...	14 00	.40
	C.— Do 6¼ do do 26 do ...	15 00	.50
1302.	—Bardou's U. S. Army Signal Service Marine or Field Glass, six lenses, achromatic object-glasses, metal body, covered with Turkey morocco, sun-shade to extend over the object-glasses, and heavy leather case, with strap; very superior.		
	A.—Body 6 in. long when adjusted, object-glasses 21 lines in diam.	$16 00	$ .40
	B.— Do 6¾ do do do 24 do	18 00	.55
	C.— Do 7½ do do do 26 do	20 00	.60

No.		Price	Post
1303.—Bardou's U. S. Army Signal Service Marine or Field Glass, six lenses, achromatic object-glasses, body covered with Turkey morocco, with hinge adjustment for different widths of eyes, sun-shades to extend over the object-glasses, in fine leather case, with strap.			
	A.—Body 6 in. long when adjusted, object-glasses 21 l. in diam.	$18 00	$ .40
	B.— Do. 6¾ do. do. do. 24 do.	20 00	.55
	C.— Do. 7½ do. do. do. 26 do.	22 00	.60

1304.—**Binocular Telescope.** This form of marine and field glass has great power and wonderful optical qualities, and has a centering screw, by which the two tubes can be adjusted to the distance between the eyes.

The Binocular Telescope is one of the best instruments for yachting, deer-stalking, military service, and general field use. It is furnished with screw shades, a strong sole-leather case, and a strap.

	Length.	Diam. of Object Glasses.	Power.	Price	Post
A.—	9 inches....	10 lines, or 1 inch....	12 diameters..........	$35 00	$ .50
B.—	9½ "	16 " or 1¼ inch..	16 "	45 00	.65
C.—	11 "	19 " or 1½ inch..	20 "	52 00	.75
D.—	5¼ "	8 " or ¾ inch...	10 "	30 00	.85

1305.—**Rancheman's Glass.** Six Lens Achromatic Field Glass, metal body covered with morocco, sun-shades to extend over the object-glasses, in fine leather case, with strap. A superior glass.

	Price	Post
A.—Body 6¾ inches long, object-glasses 26 lines in diameter...	$18 00	$ .50

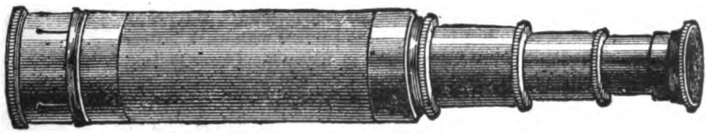
IMPROVED OPERA AND FIELD GLASS.

This glass has a double draw to the eye end, like a telescope; is very portable, with good power.

		Price	Post
1307.—	A.—Body 3½ inches long, object-glasses, 17 lines diameter.....	$16 00	$ .25
	B.— Do. 4 do. do. 19 do.	17 00	.30
1308.—	Bardou's Pocket Army Field Glass, conical body, 5 inches long, object-glasses 19 lines diameter; very portable, with good power and definition....................................	16 00	.25

Note.—We also have constantly on hand a full and choice assortment of plain and fancy Opera Glasses, of best make. Sizes from 11 to 19 lines diameter. Prices from $3,00 to $25,00 each.

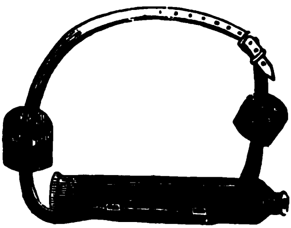
ACHROMATIC TELESCOPES.



1325.

No.		Price	Post
1325.	—Telescope, wood body, 3 draws, 15 inches drawn out, 6 inches shut, object-glass 1 inch in diameter, power 13 times..........	$2 50	$ .12
1326.	—Telescope, wood body, 3 draws, 16 inches drawn out, 6 inches shut, object-glass 1⅛ inches in diameter, power 16 times.....	3 50	.15
1327.	—Telescope, wood body, 3 draws, 23 inches drawn out, 8 inches shut, object-glass 1⅜ inches in diameter, power 20 times......	4 75	.20
1328.	—Telescope, wood body, 3 draws, 30 inches drawn out, 10 inches shut, object-glass 1⅝ inches in diameter, power 25 times.....	7 00	.30
1329.	—Telescope, wood body, 4 draws, 37 in. drawn out, 11 in. shut, object-glass 1⅞ in. in diam.; superior glass; power 35 times.	12 00	.60
1330.	—Telescope, wood body, 4 draws, 42 inches drawn out, 11½ inches shut, object-glass 2⅛ inches in diameter, power 40 times.....	20 00	.64
1331.	—Telescope, wood body, 4 draws, 48 inches drawn out, 13½ inches shut, object-glass 2⅜ inches in diameter, power 50 times.....	30 00	.75

TOURISTS' GLASSES.



1341.

No.		Price	Post
1341.	—Tourist's Achromatic Spy-glass, with brass body, covered with black Turkey morocco; three draws, 17 in. long when drawn out, 6 in. long when shut up; object-glass 1¼ in. diameter; sun-shade to slip beyond the object-glass; heavy leather caps to cover both the eye-glass and object-glass; strong leather strap to sling over the shoulder. Power 20 times............	$8 00	$ .15
1342.	—Same as No. 1341, but is 21 in. long when drawn out, 7 in. long when shut up; object-glass 1⅝ in. diam. Power 25 times....	11 00	.20
1343.	—Same as No. 1341, but is 24 in. long when drawn out, 9 in. long when shut up; object-glass 1¾ in. diam. Power 30 times....	14 00	.25

No.		Price	Post.
1344.	—Signal Service Spy-glass, same as No. 1341, but has four draws, and is 36 inches long when drawn out, 10 inches long when shut up; object-glass 2 inches diameter. Power 35 times....	$20 00	$ .35
1345.	—Rifle Spy-glass, 10¾ in. long, body covered with black leather; achromatic object-glass ⅞ inch in diameter. Power 10 times.	2 50	.10
1350.	—Wooden Tripod Stand, with vertical and horizontal motion, upon which to place a spy-glass; an exceedingly useful article, as a glass of much power cannot be held in the hand with sufficient steadiness to produce the best effect....................	5 00	.35
1351.	—Brass Clamp with Gimlet Screw, to fasten a spy-glass to a post or tree, three sizes to fit any of the foregoing spy-glasses.	$1 50 to 3 50	.05

ASTRONOMICAL TELESCOPES.

1355.—Astronomical Telescope, Polished brass body, 35 inches long, mounted on firm tripod stand, achromatic object-glass 2¾ inches in diameter, one terrestrial eye-piece, rack and pinion for adjusting the focus. Power 50 times $65 00

1356.—Astronomical Telescope. Same as No. 1355, with one terrestrial eye-piece giving power of 50 times, and one celestial eye-piece giving power of 100 times.. .... 70 00

1357.—Astronomical Telescope. Body of Brass, 35 inches long, has rack and pinion for focusing, achromatic object-glass 2½ inches in diameter, terrestrial eye-piece, power 40 times; celestial eye-piece, with black sun-glass, power 80 times; firm tripod stand of walnut, having horizontal and vertical movements, walnut case, with lock and key, for receiving the body and eye-pieces................................ 70 00

1358.—Astronomical Telescope. Same as No. 1357, but with body 40 inches long, achromatic object-glass 3 inches in diameter, terrestrial eye-piece, power 55 times; celestial eye-piece, with black sun-glass, power 110 times, with walnut case........ ....100 00

DRAWING PAPER.*

ARCHITECTS' PAPER FOR PLANS.

FINE QUALITY, WHITE AND VERY STRONG. SMOOTH SURFACE.

No.					Price	Post.
1395.—Medium,	23 × 18	per sheet,	$ .06;	per quire,	$ 1 25	$ .35
1396.—Super Royal,	28 × 20	do	.08;	do	1 75	.45

WHATMAN'S DRAWING PAPERS.

SELECTED, BEST QUALITY, GRAINED SURFACE.

1400.—Demy,	20 × 15	per sheet,	$ .05;	per quire,	$ 1 00	$ .20
1401.—Medium,	22 × 17	do	.07;	do	1 40	.28
1402.—Royal,	24 × 19	do	.09;	do	1 75	.35
1403.—Super Royal,	27 × 19	do	.10;	do	2 20	.45
1405.—Imperial,	30 × 21	do	.17;	do	3 00	.58
1407.—Atlas,	33 × 26	do	.22;	do	4 75	.84
1408.—Double Elephant,	40 × 26	do	.25;	do	5 50	1.12
1409.—Antiquarian,	52 × 31	do	1.25;	do	28 50	1.75

PATENT OFFICE DRAWING PAPER.

1410.—Patent Office Bristol Board,	15 × 10,	per sheet,	$ .06;	per quire,	$ 1 20	$ .15
1411.— do do	20 × 15	do	.12;	do	2 40	.30
1412.— do do	printed with border, etc., 15 × 10,	per sheet,	$ .10;	per quire,	1 70	.15

These Bristol Boards are especially made for Patent Office Drawings. They are of the thickness, quality and size required by the U. S. Patent Office and can be rolled up, without injury to the drawing.

DETAIL DRAWING PAPER, CREAM BUFF TINT.

SUPERIOR QUALITY, IN ROLLS OF 30 TO 40 LBS.

1413.—36 inches wide, thick, per pound, 25 cts.;	per yard	$ 15	$ .12
1414.—42 do do do 25 cts.;	do	20	.20

NOTE.—Small quantities of paper, and paper of great width, must be put on a wooden roller when sent by mail. Several yards can be put on a single roller, with but little extra cost for postage. The pound price for papers Nos. 1413 to 1432 applies only to full rolls.

* NOTE.—For writing paper, envelopes, etc., see page 337.

BLEACHED MANILLA, BUFF TINT PAPER.

FOR WORKING DRAWINGS, BEST AMERICAN MAKE, IN ROLLS OF ABOUT 50 POUNDS.

No.						Price	Post.
1415.—36 inches wide, thick, per pound, 15 cts.; per yard					....	$ 10	$ .12
1416.—40	do	do	do	do	....	12	.14
1418.—48	do	do	do	do	....	15	.18
1419.—54	do	do	do	do	....	18	.20

AMERICAN WHITE ROLL DRAWING PAPER.

VERY STRONG AND OF EXCELLENT QUALITY, IN ROLLS OF ABOUT 40 POUNDS.

1420.—36 inches wide, smooth, per pound, 50 cts.; per yard					....	$ 25	$ .12
1421.—42	do	do	do	do	do	30	.14

EXCELSIOR WHITE ROLL DRAWING PAPER.

IN ROLLS OF ABOUT 40 POUNDS.

1425.—36 inches wide, grained, per pound, 40 cts.; per yard					....	$ 25	$ .14
1426.—42	do	do	do	do	do	30	.15

LEONINE ROLL DRAWING PAPER.

1428.—62 inches wide, smooth, per pound, 45 cts.; per yard..........	$ 50	$ .20

BEST EGGSHELL DRAWING PAPER.

IN ROLLS OF ABOUT 40 POUNDS.

1429.—36 in. wide, pebbled surface, per pound, 45 cts.; per yard						.....	$ 30	$ .13
1430.—42	do		do	do	do	do	35	.15
1431.—58	do		do	do	do	do	45	.18
1432.—58	do	heavy	do	do	do	do	50	.20

DRAWING PARCHMENT.

1435.—40 in. wide, medium, per roll of 20 yards, $8.50; per yard							......	$ 25	$ .07
1436.—40	do	thick,	do	10	do	4.00;	do	50	.12

MOUNTED DRAWING PAPER.

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

1438.—American, 36 in. wide, smooth surface, per roll, $8.00; per yd..								$ 90	$ .18
1439.— do	42	do		do	do	9.00;	do ..	1 00	.20
1441.—Excelsior,	42	do	grained	do	do	9.00;	do ..	1 00	.21
1443.—Leonine,	62	do	smooth	do	do	13.50;	do ..	1 60	.30

MOUNTED DRAWING PAPER.—*Continued.*

No.		Price	Post.
1444.—Eggshell, 36 in. wide, pebbled surface, per roll, $8.00; per yd..		$ 90	$ .18
1445.— do 42 do do do 9.00; do ..		1 00	.21
1446.— do 54 do do do 12.00; do ..		1 35	.26
1447.— do 58 do do do 13.50; do ..		1 50	.28

Large pieces for City, County, or State Maps, mounted to order.

TRACING PAPER.

1450.—Domestic, common, in rolls of 25 yards, 27 in. wide, per roll ...	$1 25	$ .35
1451.—French, common, in rolls of 11 yards, 48 in. wide, per roll	1 50	.20
1452.—Manilla, common, in rolls of 20 yards, 48 in. wide, per roll	1 00	.85
1453.—Thin Parchment, in rolls of 20 yards, 39 in. wide, per roll	2 50	.50
1454.—Thick Parchment, in rolls of 20 yards, 40 in. wide, per roll	4 00	.56
1456.—Vegetable Royal, 24 × 18 in., per sheet, 10c.; per quire	2 00	.13
1457.— do Super Royal, 27 × 19 in., per sheet, 12c.; per quire ...	2 25	.15
1459.—"Flaxine," American tracing paper, white, very strong.		
A.—31 × 21 inches, per sheet, 12c.; per quire	2 50	.17
1460.—Bond paper, for tracings, very tough.		
A.—21 × 16 inches, per sheet, 6c.; per quire	1 00	.12
B.—24 × 19 do do 7c.; do	1 20	.16
C.—30 × 19 do do 8c.; do	1 40	.20

TRACING OR VELLUM CLOTH.

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

1465.—Imperial, 18 inches wide, per yard, 22 cts.; per roll	$ 4 00	$ .40
1466.— do 30 do do 35 cts.; do	6 90	.62
1467.— do 36 do do 40 cts.; do	7 50	.80
1468.— do 42 do do 50 cts.; do	10 50	.95

THE BLUE PROCESS OF COPYING TRACINGS.

Special attention has recently been directed to this easy process of copying tracings, and its great value to all Engineers, Architects, and Mechanical Draughtsmen fully recognized.

The instructions in using are—

1. Provide a flat board as large as the tracing which is to be copied.

2. Lay on this board two or three thicknesses of common blanket or its equivalent, to give a slightly yielding backing for the paper.

3. Lay on the blanket the prepared paper with the sensitive side uppermost.

4. Lay on this paper the tracing, smoothing it out as perfectly as possible, so as to insure a perfect contact with the paper.

5. Lay on the tracing a plate of clear glass, which should be heavy enough to press the tracing close down upon the paper. Ordinary plate-glass of three-eighths thickness is quite sufficient.

6. Expose the whole to a clear sunlight by pushing it out on a shelf from a window, or in any other convenient way, from four to six minutes [in winter, six to ten minutes]. If a clear sky only can be had, the exposure must be continued from twenty to thirty minutes; and under a cloudy sky from sixty to ninety minutes may be needed, the shade depending on the time.

7. Remove the prepared paper and wash it freely for one or two minutes in clear water, and hang it by one corner to dry.

NOTE.—Too light a blue means under-exposure, and too dark a blue is over-exposure.

PREPARED SENSITIVE OR BLUE PROCESS PAPERS.

ALWAYS READY FOR IMMEDIATE USE.

No.			Price	Post.
1470.—Demy,	21 × 16, per dozen sheets		$ 75	$ .15
1471.—Super Royal,	28 × 20,	do	1 65	.25
1472.—Double Medium,	36 × 23,	do	2 10	.40
1474.—Sensitized Paper,	30 inches wide, per roll of 10 yards		2 25	.40
1475.— do	36	do do do	3 00	.50
1476.— do	42	do do do	4 00	.60
1477.—White Ink, for making alterations and additions on Blue Process copies, per bottle			25	.06

BLUE PRINT FRAMES AND BATH TRAYS.

						Price
1478A.—Print Frame,	complete with	Plate Glass and Cushion,		24 × 20 in.,	each	$10 00
1478B.—	do	do	do	30 × 24	do	13 50
1478C.—	do	do	do	42 × 30	do	24 00
1479A.—Zinc Bath	Tray, for	Washing Copies,		24 × 20	do	3 75
1479B.—	do	do	do	30 × 24	do	4 50
1479C.—	do	do	do	42 × 30	do	6 00

BLUE PRINT PAPER, NOT PREPARED.

				Price	Post.
1481.—30 inches wide, thick, per roll of 10 yards				$1 50	$ .35
1482.—36	do	do	do	1 75	.45
1483.—42	do	do	do	2 00	.55

SOLID SKETCHING BLOCKS.

Each Block consists of 32 leaves of best quality Whatman's Drawing Paper.

1486.—4to Royal,	12 × 9,	unbound,	$1.00;	bound *	$2 00	$ .16
1488.—8vo Imperial,	10 × 7,	do	.75;	do	1 40	.10
1489.—4to do	14 × 10,	do	1.50;	do	2 25	.20
1490.—Half do	20 × 14,	do	3.00;	do	4 00	.40

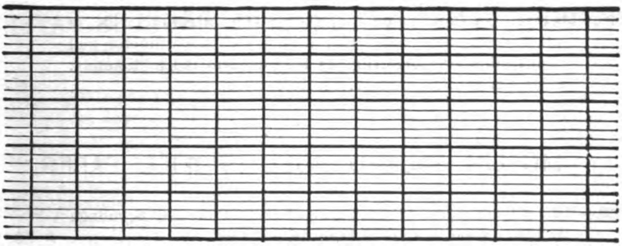
* The binding has Cloth Sides and Leather Back, with a Portfolio and Loop for Pencil inside. The Portfolio will last for a number of blocks.

TOWNSHIP PLOTTING PAPER.

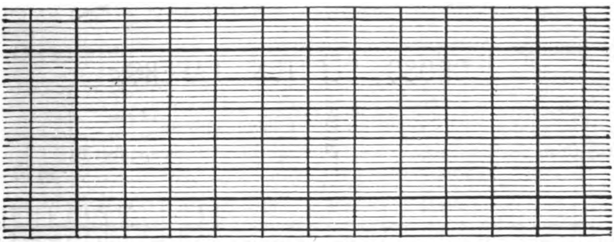
No.		Price	Post.
1495.	Township Plotting Paper, Rulings 6 × 6 blocks, blocks 1 inch square, per quire	$ 60	$ .06
1496.	Township Plotting Paper, Rulings 12 × 12 blocks, blocks 2 inches square, per quire	75	.16

PROFILE PAPERS.

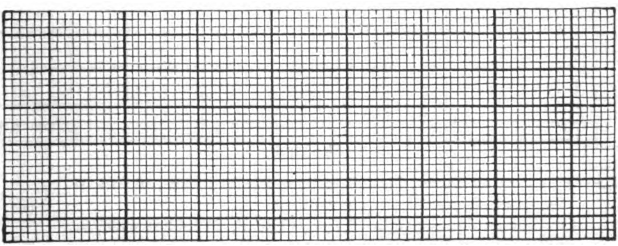
(Prices on page 322.)



PROFILE PAPER, PLATE A.



PROFILE PAPER, PLATE B.



PROFILE PAPER, METRIC.

PROFILE PAPER.

Sheets: lines printed in green.
Continuous: lines printed in green or red.

No.		Price	Post.
1500.	—Plate A, 42 × 15 in., horizon. ruling 4, vertical 20 to in., per sh.	$ 40	$ .05
1501.	—Plate B, 42 × 13¼ do. 4, do. 30 do. do.	40	.05
1502.	—Plate C, 42 × 15 do. 5, do. 25 do. do.	40	.05
	Nos. 1500, 1501, and 1502, per quire	8 50	.60
1503.	—Continuous Profile Paper, Plates A or B, rulings 20 inches wide, per yard	30	.04
1505.	—METRIC.—In Continuous Roll, rulings 50 centimeters wide, in millimeters, with each fifth millimeter, each centimeter, and each decimeter, proportionally heavier than the millimeters. Price, per yard	30	.04

MUSLIN BACKED ROLL PROFILE PAPER.

No.		Price	Post.
1510.	—Muslin Backed Roll Profile Paper, of either Plate A or B, rulings 20 inches wide, in rolls of 20 yards, per yard	$ 75	$ .07
1515.	—METRIC.—Muslin Backed, Rulings 20 inches wide, in rolls of 20 yards, per yard	75	.07

CROSS SECTION PAPERS.

Sheets: lines printed in red or green.
Continuous: lines printed in green.

No.		Price	Post.
1522.	—Cross Section Paper, Plate C, rulings 20 × 16 inches, 8 feet to inch, per sheet, 25 cents; per quire	$5 00	$ .32

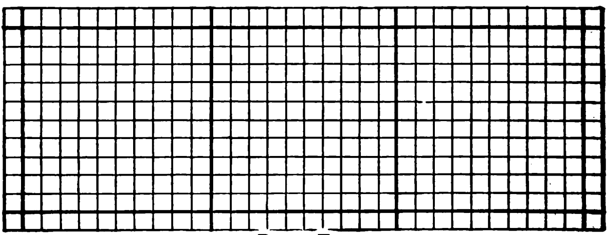


PLATE F.

No.		Price	Post.
1523.	—Cross Section Paper, Plate F, rulings 20 × 16 inches, 10 feet to inch, per sheet, 25 cents; per quire	5 00	.32
1523½.	—Continuous Cross Section Paper, Plate F, 20 inches wide, in rolls of 50 yards, per yard	30	.05

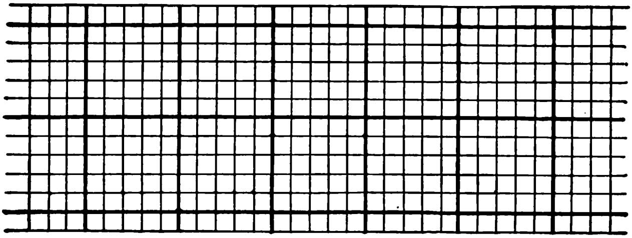
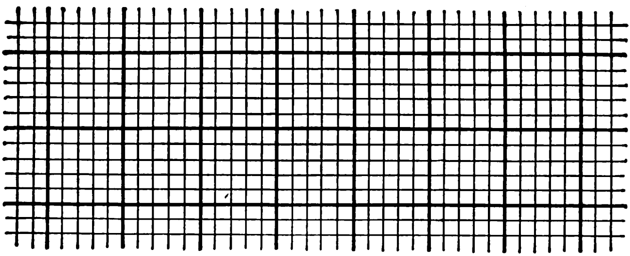


PLATE G.

No.		PRICE	POST-
1524.	–Cross Section Paper, Plate G, rulings 22 × 16 inches, 10 feet to inch, every fifth line heavy, per sheet, 25 cents; per quire...	$5 00	$ .32
1524½.	—Cross Section, Plate G, printed on Parchment Tracing Paper, in sheets, 20 × 18 inches, per sheet, 25 cents; per quire......	5 00	.15
1525.	—Cross Section Paper, Plate H, rulings 21 × 16 inches, 16 feet to inch, per sheet, 25 cents; per quire..........................	5 00	.32
1525½.	—Continuous Cross Section Paper, Plate H, 20 inches wide, in rolls of 50 yards, per yard......................	30	.05



METRIC.

1526.	—Cross Section Paper, Metric, rulings every two millimeters, size of sheet, 50 × 40 centimeters, per sheet, 25 cts.: per quire	5 00	.32
1526½.	—Continuous Cross Section Paper, Metric, 50 centimeters wide, in rolls of 50 yards, per yard.....................	30	.05

The following list of Cross Section Papers, being ruled, are much cheaper than those printed from copper plates:

1528.	—Ruled Cross Section Paper,	4	spaces to in.,	21 × 16	in., per quire		1 00	.16
1529.—	Do	do	8	do	21 × 16	do	1 00	.16
1530.—	Do	do	10	do	21 × 16	do	1 00	.16
1532.—	Do	do	12	do	21 × 16	do	1 00	.16

1533.	—Topographical Paper, 17 × 14 in., ruled 400 feet to the inch, per quire..	80	.10

BOUND PROFILE BOOKS.

These books are for field or office purposes, being printed on a tough thick paper, and bound in flexible covers, convenient for the pocket. Each page will contain a profile of three thousand feet in length, so that each folio will contain an average section of a road as usually laid out for construction. Railroad and other engineers will find them very useful. The rulings correspond to our large profile plates A and B.

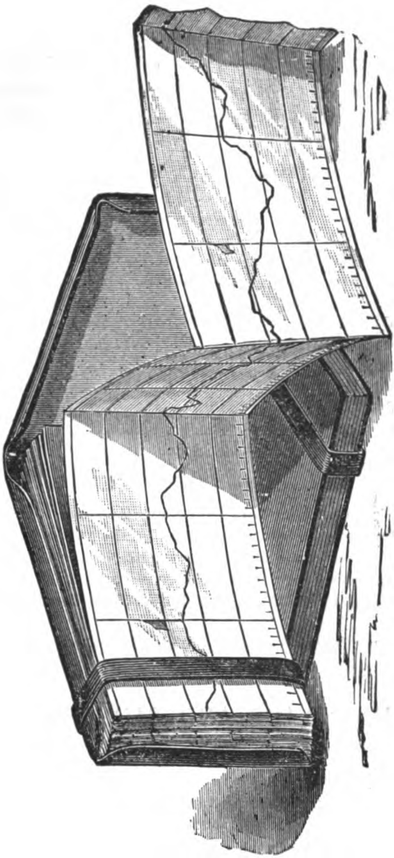
No.		Price	Post.
1540.—	Plate A, 25 leaves, Dark Roan Leather	$2 50	$ .08
1541.—	Do 50 do do do	3 50	.10
1542.—	Do 100 do do do	5 00	.18
1545.—	Plate B, 25 do do do	2 50	.08
1546.—	Do 50 do do do	3 50	.10
1547.—	Do 100 do do do	5 00	.18

CONTINUOUS PROFILE BOOKS.

These are an improvement over the books described above, as they admit of the use of a continuous sheet for profile use. They are printed upon fine sheets of paper, and mounted upon a continuous piece of muslin and bound in book form.

1550.—	Plate A, 8 × 5½ inches, profile 15 miles, Russia binding	$2 50	$ .06
1551.—	Do do do 25 do do	3 00	.08
1552.—	Do do do 50 do do	5 00	.12
1553.—	Do do do 100 do do	8 00	.20
1554.—	Plate B, 8 × 4¾ inches, do 15 do do	2 50	.06
1555.—	Do do do 25 do do	3 00	.08
1556.—	Do do do 50 do do	5 00	.12
1557.—	Do do do 100 do do	8 00	.20

KETCHAM'S CONTINUOUS PROFILE BOOK.



1550.
(Patent applied for.)

ENGINEERS' BLANK FIELD BOOKS.

No.		Price	Post.
1560.	—Level Books, 7 × 4 inches, per dozen, $5.00; each..............	$ 50	$ .05
1561.	—Transit Books, 7 × 4 inches, per dozen, $5.00; each...........	50	.05
1562.	—Record Books, 7 × 4 inches, per dozen, $5.00; each.....	50	.05
1563A.	—Cross Section Books, 8 × 7 inches, for Topography, per dozen, $10.00; each.....	1 00	.08
1563B.	—Cross Section Books, 7 × 4 inches, ruled both sides, 5 spaces to one inch, per dozen, $5.00; each...........	50	.05
1564.	—Profile Level Books, 7 × 4 inches, per dozen, $7.50; each,......	75	.05

LYONS' TABLES.

No.

1570.—Lyons' Tables. A set of Tables for finding at a glance the true cubical contents of Excavation and Embankments for all Bases, and for every variety of Ground and Side Slopes. By E. M. Lyons, C. E.

Sheet No.	5.	Base	15	feet, Slopes	....	¼ to 1
do	6.	do	15	do	....	1 to 1
do	7.	do	15	do	....	1½ to 1
do	8.	do	16	do	....	¼ to 1
do	15.	do	24	do	....	¼ to 1
do	16.	do	24	do	....	1½ to 1
do	17.	do	25	do	....	1½ to 1
do	18.	do	26	do	....	1½ to 1
do	19.	do	28	do	....	¼ to 1
do	20.	do	30	do	....	1 to 1
do	21.	do	30	do	....	1¼ to 1
do	22.	do	30	do	....	1½ to 1
do	23.	do	32	do	....	1 to 1
do	24.	do	32	do	....	1½ to 1

Per sheet .... 15 cts.; post., 5 cts.

The Tables are printed in clear, bold type, on tinted paper, sheets 25 × 16 inches. They may be used by candle-light without injuring the eye-sight. Each sheet is complete in itself, and embraces all that is wanted in connection with Base or Slope designated, whether on level or side-hill cross section.

Tables Nos. 1, 2, 3, 4, 9, 10, 11, 12, 13, and 14, quoted in our previous catalogues, are now out of print.

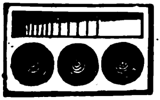
For Excavation and Embankment and other Earthwork Tables in book form, see pages 349 and 350.

INK SLABS AND SAUCERS.

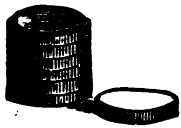
Ink Slabs.

For India Ink and Colors; containing 3 holes or cups and 1 slanting division.

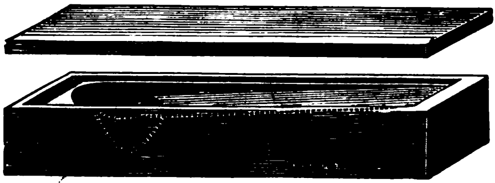
No.		Price	Post.
1575.	—Measuring 2¾ × 1½ inches, each	$ 15	$ .03
1576.	— do 3¾ × 2⅜ do	25	.06
1577.	— do 4⅜ × 2¾ do	35	.12
1578.	— do 4¾ × 3 do	40	.15
1579.	— do 5 × 3½ do	45	.20
1580.	—Patent Ink Slab, 4½ × 1¾ inches, with cover, each	50	.12
1581.	— do 5¼ × 2½ do do	60	.18
1582.	—Slate Ink Slab, 4 × 4 inches, with ground glass cover, each	75	.23
1583.	—Opal Glass Ink Saucer, 3¼ inches diameter, with cover	50	.15



1575.



1585.



1580.

Cabinet Nests.

Porcelain Saucers in nests; fitted on each other.

No.							Price	Post.
1585.—	Containing 5	saucers and a cover,	2½	inches in diam'r,	per nest		$ 60	$ .10
1586.—	Do 5	do	2¾	do	do		70	.13
1587.—	Do 5	do	3¼	do	do		80	.16
1588.—	Do 5	do	3¾	do	do		1 00	.25

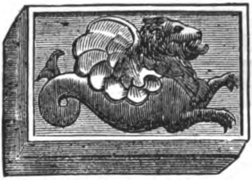
WINSOR & NEWTON'S WATER COLORS.

HARD COLORS IN CAKES, OR MOIST IN CHINA PANS.

(The moist colors are usually preferred, as they do not waste by crumbling.)

No.		Price
1600.—	Whole 25 cents; Half	$ 15

1 Antwerp Blue.
2 Bistre.
3 Blue Black.
4 British Ink.*
5 Bronze.*
6 Brown Ochre.
7 Brown Pink.
8 Burnt Sienna.
9 Burnt Umber
10 Chinese White.
11 Chrome Yellow
12 Cologne Earth.
13 Deep Chrome.
14 Dragon's Blood.*
15 Emerald Green.
16 Flake White.*
17 Gamboge.
18 Hooker's Green No. 1.
19 Hooker's Green No. 2.
20 Indian Red.
21 Indigo.
22 Italian Pink.
23 Ivory Black.
24 King's Yellow.*
25 Lamp Black.
26 Light Red.
27 Naples Yellow.
28 Neutral Tint.
29 New Blue.
30 Olive Green.
31 Orange Chrome.
32 Payne's Grey.
33 Prussian Blue.
34 Prussian Green.
35 Raw Sienna.
36 Raw Umber.
37 Roman Ochre.
38 Sap Green.
39 Terre Verte.
40 Vandyke Brown.
41 Venetian Red.
42 Vermillion.
43 Yellow Lake.
44 Yellow Ochre.



WHOLE CAKE.

HALF CAKE.

WHOLE PAN.

HALF PAN.

No. **PRICE**

1601.—Whole 45 cents each; Half... $ 25

45 Black Lead.*
46 Brown Madder.
47 Cerulean Blue.
48 Constant White.*
49 Crimson Lake.
50 Indian Yellow.
51 Mars Yellow.
52 Neutral Orange.
53 Purple Lake.
54 Roman Sepia.
55 Rubens' Madder.
56 Scarlet Lake.
57 Scarlet Vermilion.
58 Sepia.
59 Warm Sepia.

1602.—Whole, 65 cents each; Half... .... $ 35

60 Cobalt Blue.
61 Orange Vermillion.
62 Violet Carmine.

1603.—Whole, 90 cents each; Half............. .... $ 45

63 Aureolin.
64 Burnt Carmine.
65 Cadmium Yellow, Pale.
66 Cadmium Yellow.
67 Cadmium Orange.
68 Carmine.
69 French Blue (or French Ultramarine).
70 Gallstone.
71 Green Oxide Chromium.
72 Indian Purple.
73 Intense Blue.
74 Lemon Yellow.
75 Pink Madder.
76 Pure Scarlet.
77 Rose Madder (or Madder Lake).
78 Viridian.

1604.—Whole, $1.40 each; Half... $ 70

79 Field's Orange Ver.*
80 Madder Carmine.*
81 Mars Orange.
82 Purple Madder.
83 Smalt.
84 Utramarine Ash.

1605.—Quarter Cake, each.... .... $2 25

85 Genuine Ultramarine.

Colors not made in pans are marked *.—Postage, per cake or pan, $ .01.

The following colors are generally used by Architects and Civil and Mechanical Engineers:

Burnt Umber	to represent	Earth.
Do. Sienna	do.	Wood.
Light Red	do.	Brick.
Sepia and Yellow Ochre	do.	Stone.
Prussian Blue	do.	Wrought Iron.
Payne's Grey	do.	Cast do.
Gamboge	do.	Brass.
Do. and Carmine	do.	Copper.
Prussian Blue and Carmine	do.	Steel.

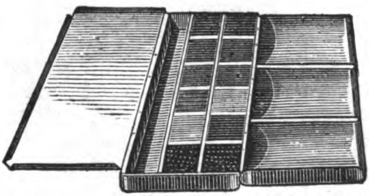
In Topography the following colors are generally used.

Hooker's Green No. 2	to represent	Grass.
Burnt Sienna	do.	Cultivated ground.
do. and Hooker's Green	do.	Uncultivated do.
Indigo do. do.	do.	Swamp.
Gamboge do. do.	do.	Trees.
Yellow Ochre	do.	Roads and Streets.
Indigo	do.	Water.
Carmine	do.	Buildings, Bridges, and Masonry
Sepia	do.	Hills.
do.	do.	Shade lines and shadows.

WATER COLOR SLIDE-LID BOXES.

No.		Price	Post.
1610.—	Color Boxes to hold 6 whole or half cakes	$ 40	$ .04
1611.—	Do. 12 do.	50	.05
1612.—	Do. 18 do.	60	.07
1613.—	Do. 24 do.	75	.08

EMPTY JAPANNED TIN BOX, FOR MOIST COLORS.



1615.

1615.—	For 6 full or 12 half-pans, each	$1 00	$ .07
1616.—	For 12 do. 24 do.	1 45	.13
1617.—	For 16 do. 32 do.	1 60	.17
1618.—	For 24 do. 48 do.	2 00	.25

WINSOR & NEWTON'S WATER COLOR LIQUIDS.

IN GLASS BOTTLES.

No.	Price	No.	Price
1620.—Carmine	$ 35	1625.—Indian Ink	$ 35
1621.—Indelible Brown Ink	35	1626.—Chinese White	35
1622.—Prout's Brown	35	1627.—Sepia	35
1623.—Gold Ink	35	1628.—Silver Ink	35
1624.—Extract of Ox Gall	35	1629.—Prussian Blue	35

Postage on Nos. 1620 to 1629, each................ $ .05.

No.	Price	Post.
1630.—Pure Gold, in shells, 20 cents; in cups, 25 cents; in cakes	$2 00	$ .01
1631.—Silver Cakes, in shells, 15 cents; in cups	35	.01

WINSOR & NEWTON'S WATER COLOR BOXES.

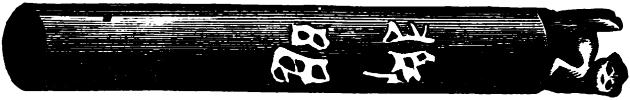
Polished Mahogany Box, with lock and key, and drawer, paint-stone, water-glass India ink, brushes, and colors.

1635.—12 colors, whole cakes		$ 9 00	$ 85
1636.—18 do	do	13 50	95
1637.—24 do	do	18 00	1 00
1638.—12 do	half cakes	6 00	45
1639.—18 do	do	7 75	55

"COMPLETE."

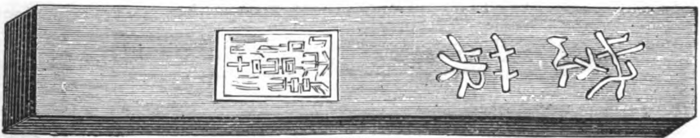
1635.—"Complete" Box.

INDIA INK.

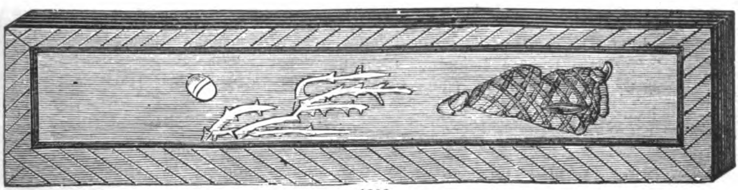


1650.

1652.



1654.



1660.

The Chinese Inks are most suitable for general draughting. The Japanese, only for those drawings in which the ink-lines are frequently washed in applying water colors.

CHINESE INDIA INK.

No.				Price	Post.
1650.—Oval, black, Lion head, per cake				$ 40	$ .02
1651.—Round,	do	do		25	.02
1652.—Round,	do	do		75	.04
1653.—Hexagon, per cake				50	.03
1654.—Square, black, Super Super (choice), per cake				1 50	.05
1655.—	Do	do	do half cake	75	.04
1656.—Blue, Red, and Yellow India Ink, each, per cake				75	.04

(*For Japanese Ink see next page.*)

JAPANESE INDIA INK.

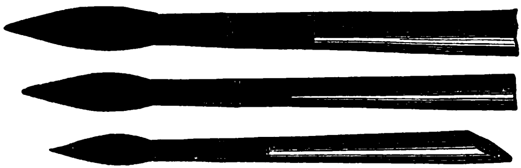
No.						Price	Post.
1660.—Oblong, black, with Figures, best small cake, per cake.........						$1 00	$ .04
1661.—	do	do	do	medium	do	2 00	.05
1662.—	do	do	do	large	do	3 00	.06

These Inks are imported for us from China and Japan.

AMERICAN DRAWING INKS.

			Price	Post.
1664.—	Higgins'	General Black Ink, per bottle..........................	$ 25	$ .08
1665.—	do	Waterproof Black Ink, per bottle......................	25	.08
1666.—	do	Carmine Ink, per bottle.....	35	.08
1667.—	do	Blue Ink, per bottle..................................	25	.08
1668.—	do	Green Ink, per bottle..................................	25	.08

WATER COLOR BRUSHES.



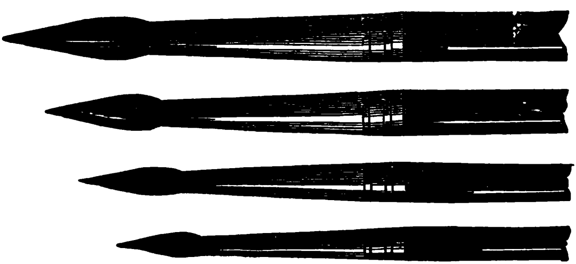
6. 5. 3. 1670 and 1675.

1670.—Camel Hair in Quills,

	No. 1.	2.	3.	4.	5.	6.	7.	8.	
each,	$ 05	05	06	06	08	08	10	10	[Post., $ .01

1675.—Red Sable in Quills,

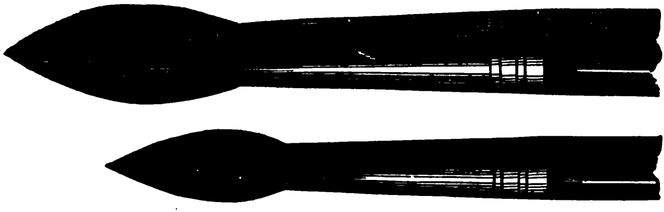
	No. 1.	2.	3.	4.	5.	6.	7.	8.	
each,	$ 10	12	15	20	25	30	35	40	[Post., .01



6. 5. 3. 2. 1680.

1680.—Camel hair in Tin, with handle,

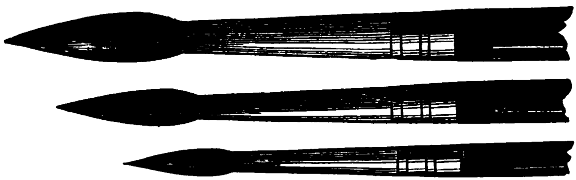
	No. 1.	2.	3.	4.	5.	6.	
each,	$ 10	10	12	12	15	15	[Post., .02



6. 3. 1685.

No.
1685.—Camel Hair Sky or Wash Brush,

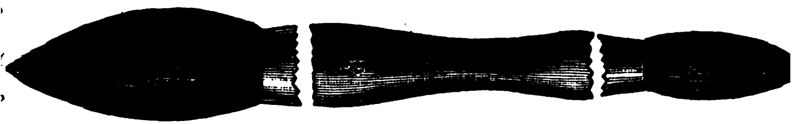
	No. 1.	2.	3.	4.	5.	6.	Post.
each,	$ 18	20	25	30	35	40	$ .02



6. 4. 2. 1690.

1690.—Red Sable in Albata, with handle,

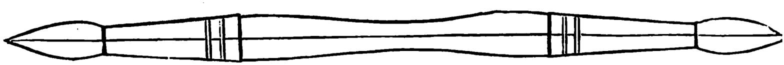
	No. 1.	2.	3.	4.	5.	6.	7.	13.	14.	Post
each,	$ 25	30	40	50	60	70	95	1 25	1 65	$ .02



1695.

1695.—Camel Hair Wash Brushes in Tin, with 2 points,

	No. 0.	1.	2.	3.	
each,	$ 40	50	60	75	[Post., $ .02



1698.

1698.—Red Sable in Albata, with 2 points,

	No. 00.	0.	1.	2.	
Sizes,	3×5	4×6	5×13	7×15	
each,	$1 00	1 25	1 75	3 00	[Post., $ .02

GILLOTT'S STEEL PENS.

No.	Price	Post.
1700.—Mapping, on cards, per dozen	$ 75	$ .02
1701.—Lithograph, on cards, per dozen	75	.02
1702.—Lithograph Crow Quill, on cards, per dozen	75	.02
1703.—Extra Fine, No. 303, per dozen, $ .20 ; per gross	1 50	.04
1704.— Do. 170, do. .15 ; do.	1 25	.03
1705.—Falcon Pens, 048, do. .12 ; do.	1 00	.05
1706.—Commercial Pens, do. .10 ; do.	75	.05
1707.—Business Pens, do. .10 ; do.	75	.05

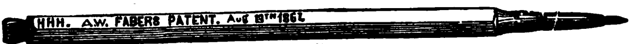
SOENNECKEN'S ROUND WRITING PEN.

1709A.—Single-pointed Pens, Nos. 1 to 6, assorted, per dozen	$ 18	$ .02
B.—Double-pointed Pens, Nos. 10, 20, 30, assorted, per dozen	50	.02
C.—Text Book for Round Writing, giving full instructions..	65	.05
D.—Sample assortment of Pens, 25 in a box	35	.05

FABER'S LEAD PENCILS.

No.	Price	Post.
1710.—Hexagon, very best Siberian, Nos. 4 B to 6 H, per dozen	$1 25	$ .04
1711.— Do. do. Drawing, Nos. 1 to 5, do.	75	.04
1712.—Black round, best, Nos. 1 to 4 do.	60	.04
1714.—Round, for Divider Points, No. 4, do.	75	.02

Artist Pencil with Siberian Lead.



1715.

1715.—Artist Pencil with Siberian lead, each	$ 30	$ .02
1716.—Leads for Artist Pencils, Siberian, 6 in box, per box	65	.04

These leads fit the new pencil-holders in Alteneder and Swiss sets.

1717.—Round red, blue, green, and yellow, per dozen	1 25	.03
1718.—One box, containing 5 pencils, BB to H	50	.04
1719.— Do. do. 7 do. BBB to HH	65	.05
1720.— Do. do. 10 do. BBBB to HHHH	90	.07
1725.—Red Chalk Pencils for marking stakes, per dozen	50	.05
1726.— Do. in lump, per pound	15	.17
1727.—French Venetian Crayons, for marking stakes (superior quality), per dozen	60	.12

SPONGE RUBBER.

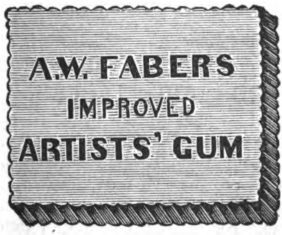
FOR CLEANING DRAWINGS.

No.		Price	Post.
1730.—	Sponge Rubber, 2 × 2 × 1 inch	$ 40	$ .03
1731.—	Do 4 × 2 × 1 inch	75	.05

INDIA RUBBER.

1734.

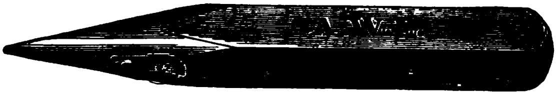
1734A.—	W. & L. E. Gurley, Satin Finish, oblong, 1¾ × ⅜ inches, each	$ 04	$ .01
1734B.—	Do. do. do. 2¾ × ⅜ do.	06	.01
1734C.—	Do. do. do. 3 × ½ do.	10	.02
1734D.—	Do. do. do. 3¼ × ⅝ do.	16	.02
1734E.—	Do. do. do. 3¾ × ¾ do.	25	.02



1735.

1742.

1735.—	A. W. Faber's First Quality, white, 1⅜ × 1 inch, each	$ 05	$ .01
1736.—	Do. do. do. 1¾ × 1¼ do.	10	.02
1737.—	Do. do. do. 2 × 1⅜ do.	15	.02
1738.—	Do. do. do. 2¼ × 1½ do.	25	.03
1739.—	Do. do. do. 3 × 2½ do.	50	.05
1740.—	Do. do. Black pure Gum, 2 × 1⅜ inch, each	20	.02
1741.—	Do. Improved Ink Eraser, 1½ × 1 inch, each	05	.01
1742.—	Do. Combined Ink and Pencil Eraser, each	15	.01
1743.—	Do. do. do. do. Mammoth, each	25	.02



1744.

No.		Price	Post
1744.—	A. W. Faber's Pointed Rubber, $2\frac{1}{8} \times \frac{5}{16}$ inches, each...........	$ 09	$ .01
1745.—	Do. do. $3 \times \frac{3}{8}$ do.	12	.01

1746.

1746.—	Davidson's Velvet Rubber, oblong, $1\frac{5}{8} \times \frac{3}{8}$ inch, each..........	$ 06	$ .01
1747.—	Do. do. do. $2\frac{1}{4} \times \frac{9}{16}$ do.	12	.02
1748.—	Do. do. do. $3\frac{1}{4} \times \frac{5}{8}$ do.	20	.02
1749.—	Do. do. do. $3 \times 2\frac{1}{4} \times \frac{9}{16}$ do.	50	.05

STEEL ERASERS.

1750.—	Steel Blade, Cocoa Handle, each..............................	$ 50	$ .02
1751.—	Do Ivory do. do.	75	.02
1752.—	Knife-blade Eraser, Ebony Handle, each......................	75	.02

DRAWING BOARDS AND TABLES.

No.		Price
1754.—	Pinewood Drawing Board, 14 × 10 inches............................	$ 35
1755.—	Do. do. 20 × 15 do. tongue and groove ends......	75
1756.—	Do. do. 28 × 20 do. do.	1 50
1757.—	Do. do. 40 × 28 do. do.	2 50
1759.—	Drawing Board, Mahogany frame, centre, 17 × 12 inches, of Pine and removable	2 50
1760.—	Do. do. do. 25 × 17 do.	4 00
1761.—	Drawing Table, black walnut top, 22 by 26 inches, instrument shelf 7 by 26 inches, two instrument drawers, ornamented iron stand, mounted on castors..	12 50
1762.—	Similar to No. 1761, top of selected, polished walnut, iron stand, bronzed and tastefully ornamented................................	15 50

These tables, suitable for architects' offices, counting-rooms, &c., or for home use, can be readily fixed at any height from 30 to 44 inches, with the top horizontal, vertical, or inclined at any angle, while the instrument shelf and drawers always remain level. In any of these positions the top can be allowed to rotate, or the whole firmly clamped. Total weight, 55 pounds.

MISCELLANEOUS.

No.		Price	Post.
1775.	—Best Foolscap Paper, 12¼ × 8 inches, per ream, $4 50; per quire	$ 30	$ .15
1776.	—Best Letter Paper, 10 × 8 do. do. 3 50; do.	20	.10
1777.	—Best Commercial Note, 8 × 5 do. do. 2 00; do.	15	.06
1778.	—Superior Post Office Paper, buff tint, 24 × 19, per ream, $6 00; per quire	35	.30
1780.	—Specification Paper, extra fine, 12¼ × 8, per ream, $5 00; per quire	30	.15
1783.	—Superior White Envelopes, 5⅞ × 3⅝, per hundred	35	.14
1784.	— Do. Buff do. do.	30	.14
1785.	— Do. do. do. 8⅞ × 3⅞, "legal," per hundred	75	.18
1786.	—Arnold's Writing Fluid, per quart	75	.60
1789.	—David's Carmine, 2 ounce bottles, per bottle	50	.10
1790.	—Rubber Bands, ¼ in. wide, 2 in. long, per gross, $1 00; per dozen,	10	.02
1791.	— Do ¼ do 2½ do do 1 25; do	12	.02
1792.	— Do ¼ do 3 do do 1 50; do	15	.02
1795.	— Do ½ do 2½ do do 2 25; do	25	.02
1796.	— Do ½ do 3 do do 2 50; do	28	.02
1797.	— Do 11 sizes assorted, 1¼ to 3 in. long, per box	1 00	.10
1798.	— Do 1/16 in. by ⅞ in., for tickets, per gross,	15	.02
1799.	— Do 1/16 do 1¼ do do	20	.02

All other sizes Rubber Bands furnished at proportional rates.

1800.	—Mucilage, per cone (3 oz.)	25	.15
1801.	— Do. quart	1 25	.60
1802.	—Handy Paper-Cutter, Brass, each	50	.02

This little instrument is of important service to Draughtsmen, for cutting drawings from the board. It is slid along the ruler or T Square without injuring the edge. The cutter is adjusted by the side screw to cut only the thickness of the paper, without striking the Drawing-board.

Copying Books, Copying Ink and Presses, Blotting Paper, and all articles of Stationery needed in Engineers' offices furnished at reasonable rates.

Envelopes, Letter and Note Heads, Cards, &c., printed and lithographed at usual prices.

1805.	—A.—Arkansas Oil Stones, fine quality, 4 to 6 inches long, $1 00 to $2 50		.08-30
	B.— Do. do. do. for Drawing Pens, Needles, &c	25	.02
	C.—Arkansas Oil Stones, fine quality, in case with cover, 3½ in.	75	.15
	D.— Do. do. do. do. do. 5 in.	1 50	.35
1806.	—A.—Washita Oil Stones, fair quality, 4 to 6 inches long	50 to 1 25	.08-30
	B.— Do. do. do for Drawing Pens, &c.	15	.02
1807.	—A.—Brass Blow Pipes, plain, 7 to 13 inches	15 to 45	.03
	B.— Do. do. with bulb, do	30 to 60	.05
1808.	—Carpenters' and Masons' Spirit Levels, plain and adjustable, wood body, brass mounted, 18 to 30 inches long	75 to 5 00	

No.		Price	Post
1809.	—Machinists' Tools, Lathe and Drill Chucks and Drills, Steel Squares and Gauges, Brass Tubing and Wire, Sheet Brass and German Silver, Stubs' Steel Wire, &c.. &c., at Manufacturers' prices.		
1810.	—A.—Thermometers, Japanned cases	.25 to 1 50	.10
	B.— Do. Fancy Wood backs	1 00 to 3 00	.10
	C.— Do. self-registering, maximum or minimum, each	3 00 to 5 00	.20
1815.	—Hydrometers, for testing Spirits, Ammonia, Ether, Alkalies, Vinegar, Molasses, Salt Water, Urine, Milk, Oils, Beer, Bark, &c.	.75 to 2 00	.10
	Twaddel's Hydrometers, Nos. 1 to 5, each	1 00	.10
1820.	—Smithsonian Rain Gauge, made entirely of brass. This gauge has been adopted by the Smithsonian Institute and U. S. Patent Office, and is the most simple in its construction of any now in use. It is furnished with a graduated scale which reads to 10ths and 100ths of inches; also a wooden cylinder to insert in the ground for the protection and ready adjustment of the instrument	5 00	.25

STENCIL PLATES, ALPHABETS, AND FIGURES.

HEIGHT OF LETTERS.	¼ in.	⅜ in.	½ in.	⅝ in.	¾ in.	1 in.
1900.—Alphabet	1.25	1.35	1.50	1 65	1.80	2.00
1901.—Alphabet	1.75	1.85	2.00	2.25	2.50	2.75
1902.—Alphabet	....	4.00	4.25	4.50	4.75	5.00
1903.—Alphabet	1.75	1.85	2.00	2.25	2.50	2.75

Set of figures to match any of above styles of letters, at one-half the price of the alphabet.

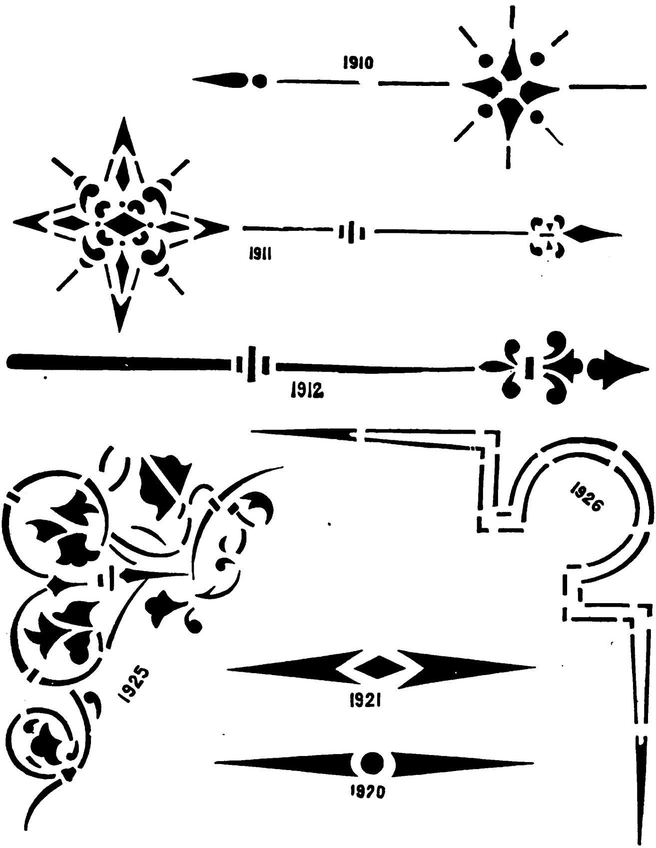
Postage on each alphabet, ¼, ⅜, or ½ in	$ .05
" set of figures, " "	.03
" each alphabet, ⅝, ¾, or 1 in	.08
" set of figures, " "	.05

No.		Price	Post.
1910.	—North point, full size	$0 65	$ .02
1911.	— " "	1 00	.02
1912.	— " "	75	.02
1920.	—Dasher, 1¾ inches long	25	.01
1921.	— " 1½ "	25	.01
1925.	—Ornamental Corner	1 25	.02
1926.	— " "	1 00	.02
	Stencil Brushes, two sizes 5 cts. and	10	.02

A Stencil brush is furnished with each alphabet or set of figures, without extra charge. Use thick India ink for marking.

STENCIL PLATES.

1900. 1901. 1902. 1903. 1904. 1905



W. & L. E. GURLEY'S

BOOK CIRCULAR,

JANUARY, 1891.

ARCHITECTURE, BRIDGES, CIVIL ENGINEERING, SURVEYING, CONSTRUCTION, STRENGTH OF MATERIALS, GEOLOGY, MINING, POCKET BOOKS, TABLES, INSTRUMENTS, ETC.

NOTE.—Parties ordering should either send drafts on New York, or postal orders on Troy, N. Y.; or if money is enclosed in letters, such letters should be registered at the post-office where mailed.

We prepay postage on nearly all American and English Books when the price is sent to us in advance.

Books can be registered at an extra cost of ten cents for each package.

Orders for over $10 will be sent by express "C. O. D." if desired; but for smaller sums, parties will please remit the necessary amount with their order.

Write all letters legibly, give your Post-office, County, and State, and be sure to sign your letter before mailing.

We are not responsible for loss of goods sent by mail.

Should any other works on kindred topics be desired, we will furnish them at publishers' prices.

PUBLISHED BY W. & L. E. GURLEY,

TROY, N. Y.

ARCHITECTURE, CARPENTRY, AND BUILDING.

	PRICE
BALDWIN, W. J. Steam Heating for Private Houses and large Buildings. 11th edition. 1888. 12mo	$2 50
BROOKS, S. H. Erection of Dwelling Houses, with Specifications, Quantities of Materials, etc. 27 plates. (Weale's series)	1 00
BULLOCK, J. Rudiments of Architecture and Building. 1888. Illus	3 50
DOBSON, E. Masonry and Stone Cutting. (Weale's series)	1 20
DOWNING, A. J. Cottage Residences. New edition. 1887. 8vo	2 50
GOULD, L. D. American Stair Builders' Guide. 3d edition. 8vo. Illus	3 00
" Carpenters' and Builders' Assistant, and Wood Workers' Guide. 4th edition. 8vo. Illustrated	2 50
HATFIELD, R. G. The American House-Carpenter. 10th edition. 8vo	5 00
HURST, J. T. Hand Book for Architectural Surveyors and Builders. 13th edition	2 00
KEMP, EDWARD. Landscape Gardening. 3d edition. 1889. Illustrated. 12mo	2 50
LEEDS, L. W. Lectures on Ventilation. New York. 8vo	1 50
LEUCHARS, R. B. How to Build and Ventilate Hot-Houses. Illustrated. 12mo	1 50
PALLISER'S Model Homes, showing a Variety of Designs for Model Dwellings. 8vo. Cloth. 15th thousand	1 00
REID, D. B. Ventilation of American Dwellings. 12mo	1 50
WOODWARD, G. E. Cottage and Farm Houses. With 178 Designs	1 00
" Rural Church Architecture; containing 18 Designs	4 00
" Suburban and Country Houses. With 70 Designs	1 00

ASTRONOMY.

BOWDITCH, N. American Practical Navigator. An Epitome of Navigation and Nautical Astronomy. New edition. Washington, 1887. 8vo	$2 50
CHAUVENET, WM. A Manual of Spherical and Practical Astronomy; its Special Application to Nautical Astronomy, and the Theory and Use of Fixed Astronomical Instruments. 2 vols. royal 8vo. Philadelphia	7 00
LOOMIS, E. Practical Astronomy, with a collection of Astronomical Tables. This work furnishes a description of the instruments required in the outfit of an observatory, as also the methods of employing them, and the computations growing out of their use. Of the method of determining time, latitude, and longitude, with the computation of eclipses and occultations. The work is designed for the use of amateur observers, practical surveyors, and engineers. 7th edition. 1888. 8vo	2 00
NAUTICAL Almanac. Published by authority of the Secretary of the Navy, Washington. Each year	75
" and Ephemeris. Large 8vo. Each year	1 50
NEWCOMB, S. Popular Astronomy, with 112 engravings and 5 maps of the stars. 5th edition. 8vo	2 50

	Price
NORTON, W. A. Treatise on Astronomy—Spherical and Physical, with Astronomical tables and numerous plates. 5th edition. 8vo	$2 50
PROCTOR, R. A. Half-Hours with the Telescope. 1889. 12mo. Illus.	1 25
" Half-Hours with the Stars. A plain and easy guide to the knowledge of the constellations, with explanation of each map. 1888. True for every year. Demy 4to.	2 00

BRIDGES, ROOFS, ETC.

BENDER, C. B. Principles of Economy in the Design of Metallic Bridges, including Cantilever Bridges. 1887. 8vo	$2 50
BOLLER, A. P. Practical Treatise on the Construction of Iron Highway Bridges; with a short essay upon the Application of the Principles of the Lever to a ready Analysis of the Strains upon the more customary form of Beams and Trusses. 3d edition. Illustrated. 8vo	2 00
BUCK, G. W. A Practical and Theoretical Essay on Oblique Bridges. 3d edition. Corrected by W. H. Barlow. 8vo	4 50
BURR, WM. H. Stresses in Bridges and Roof Trusses, Arched Ribs, and Suspension Bridges, complete, concise, and practical. 4th edition. 1888. Illustrated with plates. 8vo	3 50
DOWLING, C. H. Iron Work. Practical Formulæ and Rules for finding the Strain and Breaking Weight of Wrought Iron Bridges. 16mo	40
GREENE, C. E. Roof Trusses. Diagrams for Steady Load, Snow and Wind. 8vo. 2d edition. 1888	1 25
" Bridge Trusses. Single, Continuous, and Draw Spans; Single and Multiple Systems; Straight and Inclined Chords. 8vo. 3d edition	2 50
" Arches in Wood, Iron, and Stone. For Roofs, Bridges, and Wall openings; Arched Ribs and Braced Arches; Stresses from Wind and change of Temperature. 8vo. 2d edition	2 50
HAUPT, H. Bridge Construction. With practical illustrations. 8vo	3 50
" Military Bridges; Designs for Trestle and Truss Bridges. 8vo.	6 50
MERRILL, W. E. Iron Truss Bridges for Railways. With a comparison of the most prominent Truss Bridges. Illustrated. 4to. 4th edition	5 00
MERRIMAN, PROF. M. Text Book on Roofs and Bridges. 8vo. 1888	2 50
SHREVE, S. H. Strength of Bridges and Roofs. With practical applications and examples for the use of Engineers. 89 cuts. 8vo. 3d edition	3 50
WADDELL, J. A. L. Practical Work on Iron Bridges for Highways. 8vo. Illustrated. 2d edition. 1886	4 00
WHIPPLE, S. Bridge Building. Practical Treatise on Iron and Wooden Bridges. 4th edition. 8vo	4 00
WOOD, DE VOLSON. Treatise on the theory of the Construction of Bridges and Roofs. 8vo. 5th edition. 1888	2 00

CHEMISTRY, PHYSICS, &c.

	Price
ATTFIELD, J. Chemistry, General, Medical, and Pharmaceutical. 12mo..	$2 75
BAYLEY, THOS. A Pocket-book for Chemists, Chemical Manufacturers, Metallurgists, Dyers, Distillers, Brewers, &c. 32mo, oblong............	2 00
CHURCH, A. H. The Laboratory Guide; Practical Chemistry for Colleges and Schools, especially arranged for Agricultural Students. 12mo......	2 50
EISSLER, M. Modern High Explosives. 3d edition. 1890. Illustrated. 8vo.	4 00
GANOT-ATKINSON. Elementary Treatise on Physics, experimental and applied. 8vo. 12th edition. 1886.....	5 00
MOTT, H. A., Jr. Chemists' Manual. A Practical Treatise on Chemistry, Assaying, Blowpipe Analysis, Mineralogy, Specific Gravities, &c. New edition......	4 00
PEPPER, J. H. The Boys' Play-Book of Science, including the various Manipulations of Chemical and Philosophical Apparatus required for Scientific Experiments. New edition, illustrated. 12mo...............	2 00
PLATTNER, T. H. Blowpipe Analysis. 4th edition, illus. 500 pp. 8vo..	5 00
PLYMPTON, G. W. The Practical Use of the Blowpipe. 12mo. Illus....	1 50
PRESCOTT, A. B. First Book in Qualitative Chemistry. 12mo. 2d ed...	1 50
REGNAULT, M. V. Elements of Chemistry. Translated from the French by T. Forrest Betton, M.D., and edited, with Notes, by James C. Booth, Melter and Refiner U. S. Mint, and Wm. L. Faber, Metallurgist and Mining Engineer. Illustrated by nearly 700 wood engravings. Two volumes, 8vo......	7 50

CONSTRUCTIONS, STRENGTH OF MATERIALS, &c.

BAKER, I. O. Treatise on Masonry Construction. With 160 engravings, 87 tables. 4th edition. 8vo. 1890......	5 00
BARBA, J. The Use of Steel in Construction. Methods of Working, Applying, and Testing Plates and Bars. 12mo. Illustrated................	1 50
BURR, WM. H. Elasticity and Resistance of the Materials of Engineering. 8vo. 2d edition. 1888. Illustrated......	5 00
CLARK, D. K. Tramways; their Construction and Working. 200 illustrations and 13 plates. 2 vols. 8vo......	12 50
DUBOIS, PROF. A. J. Strains in Framed Structures. With numerous practical Applications to Cranes, Bridge, Roof and Suspension Trusses, Braced Arches, Pivot and Draw Spans, Continuous Girders, &c. Fully illustrated. 4to. 5th edition. 1890......	10 00
GILLMORE, GEN. Q. A. Notes on the Compressive Resistance of Freestone, Brick Piers, Hydraulic Cements, Mortars and Concretes. 1889. 8vo......	3 50
" Treatise on Limes, Hydraulic Cements and Mortars. Papers on Practical Engineering, U. S Engineer Department. 8vo. 9th edition. 1888	4 00
HATFIELD, R. G. Theory of Transverse Strains, and its application to the Construction of Buildings, Iron Girders, Roofed Trusses, &c. 8vo	5 00
HUNTINGTON, W. S. Roadmaster's Assistant and Sectionmaster's Guide	1 50

	Price
JERVIS, J. B. Railway Construction and Management. 12mo............	$2 00
MAHAN, PROF. D. H. Mechanical Principles of Engineering and Architecture. By H. Mosely. Edited, with additions, by Prof. L. H. Mahan. 8vo........	5 00
PARSONS, W. B. Track; a complete Manual of maintenance of way, according to the best American Railroad practice. Illustrated. 8vo.....	2 00
SHIELDS, J. E. Notes on Engineering Construction, and description of the materials employed in Tunneling, Bridging, Canal and Road Building, &c. Illustrated. 12mo........	1 50
SMITH, J. B. Cable Tramways, as applied to the working of Street and other Railways. Illustrated. 8vo. 1887	2 50
STONEY, B. B. The Theory of Strains in Girders and similar structures. With observations on the application of theory to practice, tables of strength of materials, &c. New edition, complete, 1 vol. 8vo..........	12 50
WEYRAUCH, J. J. Strength and Calculations of Dimensions of Iron and Steel Construction, with reference to the Latest Experiments. 8vo. plates........	1 50
WOOD, DE VOLSON. Resistance of Materials, and an appendix on the Preservation of Timber. This book contains the theory of the strength of materials, theories of flexure and rupture from transverse stress, and the limits of safe loading for mechanical structures, &c. 8vo. 6th ed..	2 00
WRIGHT, A. M. American Street Railways; their Construction, Equipment and Maintenance. 300 pp. 12mo. 1888........	5 00

DRAWING.

ANDRE, G. G. Draughtsman's Hand-book of Plan and Map Drawing. With instructions for Engineering, Architectural and Mechanical Drawing. Illustrated. 8vo........	$3 75
APPLETON'S Cyclopedia of Drawing. New edition, enlarged. 1886. 8vo.	10 00
CHURCH, A. E. Elements of Descriptive Geometry, with its Applications to Spherical Projections, Shades and Shadows, Perspective and Isometric Projections. 8vo, and atlas of Plates, 4to. Text-Book at West Point Military Academy, and Rensselaer Polytechnic Institute........	3 50
COPLEY, F. S. A Set of Alphabets of all the Various Hands of Modern Use, with Examples in each style; also, the Mechanical and Analytical Construction of Letters, Figures and Titles........	2 00
CROMWELL, J. H. System of Easy Lettering........	50
DAVIES, C. Treatise on Shades and Shadows, and Linear Perspective. 8vo.	3 25
ESSER. Draughtsman's Alphabets. 3d edition........	1 50
KEAM, P. A Hand-Book of Map Drawing. Small 4to........	75
LIETZE, ERNST. Modern Heliographic Processes. Royal 8vo. Illustrated. 1889........	3 00
MAHAN, D. H. Industrial Drawing; comprising the Description and Uses of Drawing Instruments, the Construction of Plane Figures, the Projections and Sections of Geometrical Solids, Architectural Elements, Mechanism, and Topographical Drawing. Revised by Prof. D. F. Thompson. 1 vol. and atlas. 8vo. New edition. 1888........	3 50

	Price
MAXTON, J. Workman's Manual of Engineering Drawing. 6th ed. 12mo	$1 80
MINIFIE, WM. Mechanical Drawing, including an Introduction to Isometrical Drawing, and an Essay on Linear Perspective and Shadows. Finely illustrated. 8vo..................	4 00
" Geometrical Drawing—an abridgment of the above. 8th edition. 12mo..	2 00
ROSE, JOSHUA. Mechanical Drawing Self-Taught, Elementary Instruction in Practical Mechanical Drawing. 8vo....... ...	4 00
SMITH, R. S. Manual of Topographical Drawing, by Lt. R. S. Smith. U. S. A. Revised and enlarged by Chas. McMillan, C. E. Illustrated. 8vo. New edition..	2 50
STANLEY, W. F. Mathematical Drawing Instruments; with hints upon Drawing and Coloring. 12mo. 5th edition	2 00
TUTHILL, W. B. Practical Lessons in Architectural Drawing. 5th edition. 1889. 8vo. Illustrated..	2 50
WARREN, S. E. Free-hand Drawing (with plates). 12mo..................	1 00
" Manual of Projection Drawing. 12mo....................	1 50
" Manual of Linear Perspective. 12mo....................	1 00
" Plane Problems in Elementary Geometry. 12mo........	1 25
" New Descriptive Geometry. 8vo.........................	3 50
" General Problems of Shades and Shadows. 8vo..........	3 00

ELECTRICITY, TELEGRAPHY, &c.

CLARK (Latimer) and Sabine (Robert). Electric Tables and Formulæ for the Use of Telegraph Inspectors and Operators. Illustrated. 12mo....	$5 00
CULLEY, R. S. Hand-book of Practical Telegraphy. 8th edition. 8vo...	6 00
DOLBEAR, A. E. The Telephone. An Account of the Phenomena of Electricity, Magnetism and Sound, as involved in its Action, with Directions for Making a Speaking Telephone. Illustrated.........................	50
FISKE, Lt. B. A. Electricity in Theory and Practice; elements of electrical engineering. 5th edition. 1888. 180 illustrations. 8vo................	2 50
KEMPE, H. R. Hand-book of Electrical Testing. New edition, revised...	5 00
LOCKWOOD, T. D. Electricity, Magnetism and Electric Telegraphy. A Practical Guide and Hand-book of General Information for Electrical Students, Operators and Inspectors. 8vo. 378 pp., 152 illustrations....	2 50
POPE, F. L. The Modern Practice of the Electric Telegraph. 11th edition. 8vo. New York..	1 50
PRESCOTT, G. B. The Speaking Telephone, Electric Light, and other recent Electrical Inventions. 8vo. Illustrated....	4 00
" Electricity and the Electric Telegraph. 8vo. Illustrated. 6th edition..................................	5 00
SAWYER, W. E. Electric Lighting by Incandescence, and its application to interior illuminations. 8vo. 3d edition. Illustrated.	2 50
SPRAGUE, J. T. Electricity; its Theory, Sources and Applications. New edition, with numerous illustrations......	6 00

GEOLOGY, MINING, AND METALLURGY.

	PRICE
BAUERMAN, H. Metallurgy of Iron. Outlines of the History of Iron Manufacture, Analysis of Iron Ores, &c. 5th edition. 12mo	$2 00
BODEMANN, T. Treatise on the Assaying of Lead, Silver, Copper, Gold and Mercury. 12mo 1889	1 50
BOWIE, A. J., JR. Practical Treatise on Hydraulic Mining in California, with Description of the Use and Construction of Ditches, Flumes, Wrought-iron Pipes and Dams; Flow of Water on Heavy Grades, and its Applicability, under High Pressure, to Mining. 1885. 313 pp. 72 illustrations. 8vo. 2d edition	5 00
BYRNE, O. The Practical Metal-worker's Assistant. 600 engravings. 8vo.	7 00
DANA, J. D. Manual of Geology, treating especially of American Geological History. 3d edition. 1884. 8vo	5 00
" Manual of Mineralogy, including Observations on Mines, the Reduction of Ores, &c. 8th edition. 1890. 12mo	2 00
" Text-Book of Geology. 4th edition. 1881. 12mo	2 50
" A System of Mineralogy. Descriptive Mineralogy, comprising the most recent Discoveries. 9th edition. 1890. 8vo. 600 illustrations	10 00
GUETTIER, A. Metallic Alloys; a Practical Guide to their Chemical and Physical Properties, their Preparation, Composition and Uses. 12mo	3 00
LARKIN, JAMES. The Practical Brass and Iron Founders' Guide. 12mo.	2 25
OVERMANN, F. Practical Mineralogy, Assaying, Mining. 12mo. 11th ed.	1 00
" A Treatise on Metallurgy; Comprising Mining and Metallurgical Operations. 372 engravings. 8vo. 6th edition. 1887	5 00
PEPPER, J. H. Play Book of Metals, including Narratives of Visits to Coal, Lead, Copper and Tin Mines. 8th edition. 8vo	2 00
PHILLIPS, J. S. Explorers' and Assayers' Companion. Vol. 1, Rocks, Veins, Testing and Assaying. 8vo. San Francisco	6 00
SMYTH, W. W. Treatise on Coal and Coal Mining. 5th edition, revised. 12mo.	1 75
VAN WAGENEN, T. F. Manual of Hydraulic Mining, for the Use of the Practical Miner. 18mo	1 00
WILSON, E. B. Practical Mine Ventilation, for Use of Mining Engineers. 16mo. 1888	1 25

HYDRAULIC AND SANITARY ENGINEERING.

	PRICE
ADAMS, J. W. Sewers and Drains for Populous Districts. Embracing Rules and Formulas for the dimensions and construction of works of Sanitary Engineers. Second edition. 8vo. 1889	$2 50
BAYLES, J. C. House Drainage and Water Service in Cities and Towns. 8vo. 5th edition	3 00
BILLINGS, W. R. Details of Water-works Construction. 2d edition. 1889. 8vo. Illustrated	2 00
BOX, THOS. Practical Hydraulics; a Series of Rules and Tables for the Use of Engineers, &c. 12mo. 9th edition. 1889	2 00
DEMPSEY, G. D Draining Districts and Lands, and Drainage and Sewerage of Towns and Buildings. New edition, 1887. 12mo	3 00
DYE, F. Hot Water Supply; a Practical Treatise on Hot Water Apparatus for Domestic and General Purposes. Illustrated. 12mo	1 00
ELLIS, G. A. Work done by, and Power required for, Fire Streams. With 26 tables. 16mo	1 50
FANNING, J. T. A Practical Treatise on Water Supply Engineering; relating to the Hydrology, Hydrodynamics, and Practical Construction of Water-works, in North America. 8vo. 180 illus. 7th edition. 1889	5 00
FRANCIS, JAS. B. Lowell Hydraulic Experiments on Hydraulic Motors, on the Flow of Water over Weirs, in Open Canals of Uniform Rectangular Section, and through Submerged Orifices and diverging Tubes. Made at Lowell, Mass. 4th edition, revised. 4to. Illustrated	15 00
FRENCH'S Principles, Process, and Effects of Draining Lands. New edition. Over 100 illustrations 12mo	1 50
HEWSON, WM. Embanking, Rivers, Levees, &c. 8vo. 3d edition	2 00
LEFFEL, JAS. Race and Reservoir Embankments and Head Gates, Gauging Water Supply. Construction of Mill Dams, &c. 8vo.	2 50
" The Construction of Mill Dams. 16mo	50
MERRIMAN, M. Treatise on Hydraulics, Hydrostatics, Hydraulic Motors, &c. Numerous Tables and Diagrams. 1889. 8vo	3 50
STALEY-PIERSON. The Separate System of Sewerage. Theory and Construction. Illustrated. New edition, 1891. 8vo.	2 50
STEVENSON, D. Canal and River Engineering. 3d edition revised. Illustrated. 8vo	10 00
" THOS. The Design and Construction of Harbors. 3d edition revised. Illustrated. 8vo	10 00
STEWART, H. Irrigation for the Farm, Garden, and Orchard. Illustrated. 1889. 2d edition	1 50
WARING, G. E. Sanitary Drainage of Houses and Towns. 12 mo. 9th edition. 1887	2 00
" Draining for Profit and Health. How to lay out and construct a system of drains. Illus. 12mo. 1887. 3d edition	1 50
" Sewerage and Land Drainage. 250 pp., and full page plates. Quarto. 1889	6 00

PRICE

WEISBACH, J. Hydraulics and Hydraulic Motors, with numerous practical examples for the calculation and construction of Water Wheels, as well as a special discussion of the various forms of Turbines, translated from the fourth edition of Weisbach's Mechanics, by A. J. Du Bois. 380 engravings. 8vo. 1889.. $5 00

MACHINERY AND MECHANICS.

APPLETON'S Dictionary of Mechanics. 5,000 engravings. Large 8vo. 2 vols., sheep binding.. $15 00

BOURNE, JOHN. A Catechism of the Steam Engine. New edition. 12mo. 1 75

" Hand-book of the Steam Engine. Constituting a key to the "Catechism of the Steam Engine." Illustrated with 67 woodcuts. 12mo........................ 1 75

BROWN & SHARPE Mfg. Co. Gear Wheels and Gearing. Practical Treatise, with Tables. Illustrated. 1886. 8vo........................ 2 00

CLARK, D. K. A Manual of Rules, Tables, and Data for Mechanical Engineers, based on the most recent investigations. Illustrated with numerous Diagrams. Large 8vo. 3d edition........................ 5 00

COOPER, J. H. Use of Belting for Transmission of Power. 8vo. Illus... 3 50

FORNEY, M. N. Catechism of the Locomotive. New edition. 1890. 709 pages. 487 illustrations. 8vo........................ 3 50

GOODEVE, T. M. Text-book on the Steam Engine. 12mo. Illus. 9th ed. 2 00

HEMENWAY, F. F. Indicator Practice and Steam Engine Economy. 12mo 2 00

HUGHES, WM. C. American Miller and Millwrights' Assistant. 12mo.... 1 50

ISHERWOOD, B. F. Engineering Precedents for Steam Machinery. Arranged in the most practical and useful manner for Engineers. With illustrations. 8vo........................ 2 50

ROPER, S. Hand-book of Land and Marine Engines, including their Modeling, Construction and Management. 8th edition, revised and enlarged. 1888. 12mo........................ 3 50

" Hand-book of the Locomotive, including Construction and Management of Locomotive Engines and Boilers. 14th edition. 1889. 18mo........................ 2 50

SCHUMANN, F. A Manual of Heating and Ventilation. Embracing a series of Tables and Formulæ for dimensions of heating, flow and return pipes for steam and hot-water boilers, flues, &c. 12mo. Illustrated.... 1 50

WARREN, S. E. Elements of Machine Construction and Drawing. 2 vols. Illustrated. 8vo........................ 7 50

WEISBACH, J. Mechanics of Engineering and Machinery of Transmission. New edition. 1890. 8vo. 800 illustrations........................ 5 00

WOOD, DE VOLSON. Elements of Analytical Mechanics. 6th edn. 8vo.... 3 00

POCKET-BOOKS, TABLES, &c.

	PRICE
BELLOWS-HODGMAN. Surveyors' Tables; being the 21 tables as printed in Bellows' Manual of Surveying. 16mo. 103 pages	$1 00
BOILLEAU, J. T. Traverse Tables; showing the difference of latitudes and the departures to every minute of the quadrant. 8vo. 4th edition.	5 00
BRUHNS, DR. Manual of Logarithms to seven places of Decimals. 8vo..	2 50
BURT, W. A. Key to the Solar Compass, and Surveyors' Companion. All the rules necessary for use in the field; Linear Surveys and Public Land System of the United States, Notes on the Barometer, suggestions for an outfit for a survey of four months, &c. 5th edition	2 50
BUTTS, EDWARD. Civil Engineers' Field-Book; designed for the Locating Engineer. With numerous tables. 2d edition. 1890	2 50
CLEVENGER, S. V. A treatise on the method of Government Surveying. With complete Mathematical, Astronomical, and Practical Instructions, for the use of United States Surveyors. 3d edition	2 50
CRANDALL, C. L. Railway and other Earthwork tables. 1887. 8vo	1 00
HAMILTON, W. G. Useful Information for Railway Men. 8th edition	2 00
HARDAWAY, B. H. Tables and Formulæ for Railroad Engineers. 1886	2 00
HASWELL, C. H. Engineers' and Mechanics' Pocket-Book. Tables, Rules and Formulas Pertaining to Mechanics, Mathematics and Physics, &c. 52d edition (936 pp). 12mo. 1888	4 00
HENCK, J. B. Engineers' Field-Book. Containing formulæ for laying out Curves, determining Frog Angles, leveling, calculating Earthworks, &c.; also numerous tables. 10th edition	2 50
KIDDER, F. E. Architects' and Builders' Hand-book. 7th edition. 1890	3 50
LAW, H. Tables of Logarithms; with Tables of Natural Sines, &c	1 40
LEE, COL. T. J. Tables and Formulæ useful in Surveying, Geodesy and Practical Astronomy, being No. 12 Professional Papers of the corps of Engineers of the U. S. Army. 3d edition	5 00
MOLESWORTH, G. L. Pocket-Book of Formulæ for Engineers. Revised.	2 00
MORRIS, E. Easy Rules for Measurement of Earthworks. 8vo	1 50
NYSTROM, J. W. Pocket-book of Mechanics and Engineering. 19th edition. 1887, Revised	3 50
SCHUMANN, F. Formulas and Tables for Architects and Engineers in calculating the strains and capacity of structures in Iron and Wood	2 50
SCRIBNER, J. M. Engineers' and Mechanics' Companion. 19th edition.	1 50
SEARLES, WM. H. Field Engineering. Theory and Practice of Railway Surveying, Location, and Construction, and containing a large number of Useful Tables. 13th edition. 1890	3 00

PRICE

SEARLES, WM. H. The Railroad Spiral. Theory of the Compound Transition Curve reduced to Practical Formulæ and Rules for Application in Field Work. 5th edition. 1890........ $1 50

SHUNK, W. F. The Field Engineer. A handy book of practice in the Survey, Location, and Track-work of Railroads, containing a large collection of Rules and Tables applicable to both the standard and Narrow Gauge. 7th edition. 1888.... 2 50

" Treatise on Railway Curves........ 2 00

STILES, A. Tables for Field Engineers. Designed for use in the field. Tables containing all the functions of a one degree curve, from which a corresponding one can be found for any required degree, also tables of natural sines and tangents. 156 pp. 8vo........ 2 00

TRAUTWINE, J. C. Excavations and Embankments, 9th edition. 1887. 2 00

" Railroad Curves. 13th edition. 1889........ 2 50

" Civil Engineer's Pocket-Book of Mensuration, Trigonometry, Surveying, Hydraulics, Hydrostatics, Strength of Materials, Masonry, Principles of Wooden and Iron Roof and Bridge Trusses, Stone Bridges and Culverts, Trestles, Pillars, Suspension Bridges, Dams, Railroads, Turnouts, Turning Platforms, Water Stations, Cost of Earthwork, Foundations, Retaining Walls, &c. 14th edition. 1890.... 5 00

VEGA, BARON VON. Logarithmic Tables. 8vo. 1887........ 2 50

SURVEYING AND ENGINEERING.

See also Pocket-Books, Tables, &c.

BELLOWS-HODGMAN. Manual of Land Surveying, giving the law and the practice. The Law is from the Statute Books of the United States and about 160 decisions from the highest courts in the land; the Practice is from the best authorities. 5th edition. 1891........ $2 50

BROUGH, B. H. Treatise on Mine Surveying. For Managers of Mines and Collieries. 8vo. Illustrated. 1888........ 2 50

CARHART, DANIEL. Plane Surveying. Plane Table, Government, City and Mine Surveying. Leveling, Topography, &c. And Tables. 8vo. 1888........ 2 00

CLARK, J. M. New System of laying out Railway Turnouts. 1884. 12mo. 1 00

CLEEMANN, T. M. The Railroad Engineers' Practice. 12mo........ 1 50

DAVIES, CHAS. Elements of Surveying and Leveling; Topography, Railway Curves, and Mining Surveying. Revised. 12mo........ 2 50

DORR, B. F. The Surveyors' Guide and Pocket Table Book. The Rules cover every case likely to occur in a surveyor's practice, and are based on United States laws, and have the written approval of the Commissioner of the General Land Office. 2d edition. 1888........ 2 00

FAUL, A. Leveling by Vertical Angles; and Measuring Distances by Telescope and Rod. 8vo........ 1 00

		PRICE
GILLESPIE, W. M.	Practical Treatise on Surveying. The two volumes, "Land Surveying" and "Leveling and Higher Surveying," are now revised and united in one volume. 8vo. 677 pp. 1888...	$3 50
"	Principles and Practice of Road-Making. 12mo. 10th edition...	2 50
GILLMORE, GEN. Q. A.	Practical Treatise on the Construction of Roads, Streets and Pavements. Illustrated. 12mo. 6th edition. 1888...	2 00
HAUPT, L. M.	A Manual of Engineering Specifications and Contracts, designed as a Text-book and Work of Reference for all who may be engaged in the Theory or Practice of Engineering. 8vo. Illustrated. 5th edition. 1888...	3 00
"	The Topographer; his Instruments and Methods. Fully illustrated. 8vo. 1884...	4 00
HAWES, J. H.	System of Rectangular Surveying; being a Manual of U. S. Government Surveying. 8vo...	3 00
JEFFERS, W. N.	Treatise on Nautical Surveying. 8vo. Illustrated...	5 00
JOHNSON, J. B.	Text-Book of Surveying. Land and Railroad Surveying, Hydrography, Geodetic and Mining Surveying. 7th edition. 1891. 8vo.	4 00
MAHAN, D. H.	A Treatise on Civil Engineering. 8vo. Revised by De Volson Wood. 1890...	5 00
MURRAY, D.	Manual of Land Surveying; with Tables of Logarithms, Sines and Tangents, Natural Tangents and Cotangents, and Traverse Table. 12mo...	2 00
PHELPS, H.	Practical Marine Surveying. 8vo. 1890...	2 50
PLANE TABLE,	and its use in Topographical Surveying. From the papers of U. S. Coast Survey. Illustrated. 8vo...	2 00
RANKINE, W. J. M.	Civil Engineering, comprising Engineering Surveys, Earthwork, Foundations, Masonry, Carpentry, Metal-works, Roads, Railways, Canals, Rivers, Water-works, Harbors, &c., with numerous tables and illustrations. 16th edition. 8vo. London...	6 50
ROBINSON'S	Surveying and Navigation. With use of instruments, essential Elements of Trigonometry, Mensuration, and the necessary Tables. Edited by Oren Root, A.M., of Hamilton College. 8vo...	2 25
SIMMS, F. W.	A Treatise on the Principles and Practice of Leveling. 5th edition, revised. With Law's method of laying out Curves. 8vo...	2 50
"	Practical Tunneling. 3d edition, revised. 8vo...	7 50
VOSE, GEO. L.	Hand-book of Railroad Construction, with plans, maps, &c. The most complete hand-book of railway construction yet published...	12 50
WELLINGTON, A. M.	The Economic Theory of the Location of Railways. 1,000 pp., 313 engravings, 204 tables. 8vo. 4th edition. 1890...	5 00
"	Railway Earthworks, with Diagrams. 2 vols. Illustrated...	4 00

TREATISES ON INSTRUMENTS, &c.

	PRICE
BREWSTER, SIR DAVID. Treatise on Optics. 12mo	$1 40
GURLEY, W. & L. E. Manual of the Principal Instruments used in American Engineering and Surveying. 29th edition, revised. 1891	50
HOARE, C. The Slide Rule, and How to Use It; containing full, easy, and simple instructions to perform all business calculations with unexampled rapidity and accuracy. With a slide rule in tuck of cover	1 00
HULME, F. E. Mathematical Drawing Instruments, and how to use them. Illustrated. 12mo	1 50
LANKESTER, EDWIN. Half Hours with the Microscope. 16mo	2 00
NUGENT, E. Treatise on Optics. 12mo. 103 illustrations	1 50
STANLEY, W. F. Surveying and Leveling Instruments. Theoretically and practically described. 12mo. 552 pages. 345 illustrations	3 00
WARREN, S. E. Drafting Instruments and Operations. 12mo	1 25

MISCELLANEOUS.

ALEXANDER, J. H. Weights and Measures, Ancient and Modern, reduced to Standard of the United States of America. 8vo	$3 50
BENJAMIN, PARK. Engineers' and Mechanics' Recipes. 14th edition. 12mo. 300 pp	2 00
CHAUVENET, W. Treatise on Elementary Geometry. 8vo	1 75
" Plane and Spherical Trigonometry. 8vo	1 60
CLARKE, D. K. Fuel; its Combustion and Economy. 12mo	1 50
CRAIG, B. F. The Decimal System of Weights and Measures	50
DAVIES, C. Analytical Geometry. 8vo	2 00
" Elements of Calculus. 8vo	2 00
" Metric System	1 00
GREGORY, O. Mathematics for Practical Men. For Engineers, Surveyors and Architects. 8vo. New edition. 1889	3 00
KNIGHT, E. H. American Mechanical Dictionary; a Description of Tools, Instruments, Machines and Engineering, &c. 4 vols. 8vo. Illustrated.	27 50
LIPPINCOTT'S Pronouncing Gazetteer of the World. 4to, sheep	12 00
MERRIMAN, M. Text Book on the Method of Least Squares. 8vo	2 00
ROBINSON'S Geometry and Trigonometry. 8vo	2 25
SPON, E. Workshop Receipts. 8vo	2 00
URE'S Dictionary of Arts, Manufactures and Mines. Revised. 4 vols	24 00
WEBSTER'S Unabridged Dictionary. 4to, sheep	12 00

No.
32.—Cable Making of Suspension Bridges, as Exemplified in the East River Bridge, By Wilhelm Hildenbrand, C. E. With illustration.
33.—Mechanics of Ventilations. By Geo. W. Rafter, C. E.
34.—Foundations. By Prof. Jules Gaudard, C. E. Translated from the French, by L. F. Vernon Harcourt, M. I. C. E.
35.—The Aneroid Barometer: Its Construction and Use. Compiled by Geo. W. Plympton.
36.—Matter and Motion. By J. Clerk Maxwell, M. A.
37.—Geographical Surveying. Its Uses, Methods, and Results. By Frank De Yeaux Carpenter, C. E.
38.—Maximum Stresses in Framed Bridges. By Prof. Wm. Cain, A. M., C. E. Illust.
39.—A Hand-Book of the Electro-Magnetic Telegraph. By A. E. Loring. Illust.
40.—Transmission of Power by Compressed Air. By Robert Zahner, M. E. Illust.
41.—Strength of Materials. By Wm. Kent, C. E. Illustrated.
42.—Voussoir Arches Applied to Stone Bridges, Tunnels, Culverts, Groined Arches and Domes. By Prof. Wm. Cain, C. E.
43.—Wave and Vortex Motion. By Dr. Thomas Craig, of Johns Hopkins University.
44.—Turbine Wheels. By Prof. W. P. Trowbridge, Columbia College. Illustrated.
45.—Thermodynamics. By Prof. H. T. Eddy, University of Cincinnati.
46.—Ice-making Machines. From the French of M. Le Doux. Illustrated.
47.—Linkages: the Different Forms and Uses of Articulated Links. By J. D. C. De Roos.
48.—Theory of Solid and Braced Arches. By Wm. Cain, C. E.
49.—On the Motion of a Solid in a Fluid. By Thomas Craig, Ph.D.
50.—Dwelling Houses: their Sanitary Construction and Arrangements. By Prof. W. H. Corfield.
51.—The Telescope: its Construction, &c. By Thomas Nolan.
52.—Imaginary Quantities: Translated from the French of M. Argand. By Prof. Hardy.
53.—Induction Coils: How Made and How Used.
54.—Kinematics of Machinery. By Prof. Kennedy. With an Introduction by Prof. R. H. Thurston.
55.—Sewer Gases: their Nature and Origin. By A. De Varona.
56.—The Actual Lateral Pressure of Earthwork. By Benj. Baker, M. Inst. C. E.
57.—Incandescent Electric Lights, with Particular Reference to the Edison Lamps at the Paris Exhibition. By Compte Th. Du Moncel and Wm. Henry Preece. Second edition revised.
58.—The Ventilation of Coal Mines. By W. Fairley, M. E.
59.—Railroad Economics. By S. W. Robinson, C. E.
60.—Strength of Wrought Iron Bridge Members. By S. W. Robinson, C. E.
61.—Potable Water: and Methods of Detecting Impurities. By Chas. W. Folkard.
62.—The Theory of the Gas Engine. By Dugald Clerk.
63.—House Drainage and Sanitary Plumbing. By W. P. Gerhard.
64.—Electro-Magnets. By Th. Dumoncel.
65.—Pocket Logarithms to Four Places of Decimals.
66.—Dynamo-Electric Machinery. By S. P. Thompson.
67.—Hydraulic Tables. By P. J. Flynn.
68.—Steam Heating. By R. Briggs.
69.—Chemical Problems. By J. C. Foye.
70.—Explosives. By M. Bertholet.
71.—Dynamic Electricity. By John Hopkinson, J. A. Schoolbred, and R. E. Day.
72.—Topographical Surveying. By Geo. J. Specht, Prof. A. S. Hardy, John B. McMaster and H. F. Walling.
73.—Symbolic Algebra; or, The Algebra of Algebraic Numbers. By Prof. W. Cain.
74.—Testing Machines, their History, Construction and Use. By Arthur V. Abbott.
75.—Recent Progress in Dynamo-Electric Machines. Being a Supplement to Dynamo-Electric Machinery. By Prof. Sylvanus P. Thompson.
76.—Modern Reproductive Graphic Processes. By Lt. Jas. S. Pettit, U. S. A.
77.—Stadia Surveying. The Theory of Stadia Measurements. By Arthur Winslow.
78.—The Steam Engine Indicator, and its Use. By W. B. Le Van.

THE RENSSELAER POLYTECHNIC INSTITUTE,

TROY, N. Y.

FOUNDED IN 1824.

FACULTY AND INSTRUCTORS.

JOHN HUDSON PECK, A.M., PRESIDENT.

DAVID MAXSON GREENE, C. E., DIRECTOR,
Professor of Geodesy, Road Engineering, and Topographical Drawing.

JAMES HALL, A.M., LL.D., N. Y. STATE GEOLOGIST,
Emeritus Professor of Theoretical, Practical, and Mining Geology.

DASCOM GREENE, C. E.
Professor of Mathematics and Astronomy.

HENRY B. NASON, PH.D., M.D., LL.D.
Professor of Chemistry and Natural Science.

DWINEL FRENCH THOMPSON, B. S.
Professor of Descriptive Geometry, Stereotomy, and Drawing.

PALMER CHAMBERLAINE RICKETTS, C. E.
William Howard Hart Professor of Rational and Technical Mechanics.

WILLIAM PITT MASON, C. E., M.D.
Professor of Analytical Chemistry.

RICHARD HALSTED WARD, A.M., M.D.
Professor of Botany.

CHARLES WELLMAN PARKS, C. E.
Acting Professor of Physics.

JULES GODEBY, A.B.
Instructor in the French Language and Literature.

CHARLES WINTHROP CROCKETT, C. E., A.M.
Assistant Professor of Mathematics and Astronomy.

HUGH ANDERSON, C. E.
Assistant in Rational and Technical Mechanics.

EDWARD R. CARY, C. E.
Assistant in Geodesy.

JOHN H. EMIGH, C. E.
Assistant in Mathematics and Geodesy.

JOHN G. MURDOCK, A.M.
Instructor in the English Language, and Assistant in Mathematics.

EDWARD FENEMORE CHILLMAN,
Assistant in Descriptive Geometry and Drawing.

GUY BENNETT WAITE, C. E.
Assistant in Mathematics and Geodesy.

COURSE OF STUDY.

The course of study in Civil Engineering is now the only course of the Institute.* All the regular members of the Institute pursue this course, and the degree conferred is that of Civil Engineer.

The Institute is now able to offer students of Civil Engineering very superior facilities for the study of that subject, much greater even than those it ever before possessed.

It should be stated, perhaps, that Civil Engineering is understood to include Mechanical or Dynamical Engineering, Road Engineering, Bridge Engineering, Hydraulic Engineering, Steam Engineering, Electrical Engineering, Mining Engineering, and Sanitary Engineering.

The studies of the course are designed to secure to all the graduates a professional preparation, at once thorough and practical, for the following specialties of engineering practice:

The location, construction, and superintendence of public works, as railways, canals, water works, etc.; the design, construction, and management of mills, iron works, steel works, chemical works, and pneumatic works; the design and construction of roofs, arch bridges, girder bridges, and suspension bridges; the survey and superintendence of mines; the design, construction, and use of wind motors, hydraulic motors, air engines, and the various kinds of steam engines; the design, construction, and use of machines in general, and the determination of their efficiency; the survey of rivers, lakes and harbors, and the direction of their improvements; the determination of latitude, longitude, time, and the meridian in geographical explorations, or for other purposes, together with the projection of maps; the selection and test of materials used in construction; the construction of the various kinds of geometrical and topographical drawings.

---

* At the beginning of the Scholastic Year, 1885-6, it was decided to give a modified course, leading to the degree of Bachelor of Science. This course covers a period of four years, and during the first two years is identical with the course in Civil Engineering. During the last two years, however, the course in Natural Science embraces less of higher Mathematical subjects and more of Natural History, Chemistry, and Geology.

(See next page for Terms of Admission, Expenses, etc.)

TERMS OF ADMISSION.

CANDIDATES FOR ADMISSION to Division D are thoroughly examined in the following subjects:

Geography.
English Grammar, including Spelling.
Arithmetic, as treated in the higher text-books.
Algebra, through Equations of the second Degree.
Plane Geometry, first five books of Wentworth's Geometry.

These examinations are partly oral and partly written, including both the demonstration of principles and the working of examples.

ADVANCED STANDING.—Candidates for advanced standing are examined in the preparatory studies, and also in the previous studies of the Division which they propose to enter.

AGE.—No one can be admitted to Division D, till he has completed his sixteenth year, nor to an advanced standing without a corresponding increase of age.

TESTIMONIALS.—Satisfactory testimonials of good moral character are in all cases required; and those who are admitted from Colleges or other Scientific Schools, must present certificates of dismission in good standing.

Young gentlemen desiring to attend the exercises in particular departments, without becoming candidates for Degrees, are allowed to do so, provided they have the requisite preparation for the study of the subject selected.

EXPENSES.

INSTITUTE FEES.—In the general course, the fees for instruction, use of astronomical and field instruments, use of consumable materials, chemicals, etc., are $100 for each semi-annual session; and in the partial course, they are in the same proportion for the time of study. These Fees must be paid to the Treasurer in advance for each session. The Graduation Fee, including the Diploma, is $18, and must be paid to the Treasurer at least two weeks before the time of graduation.

LIVING EXPENSES.—Members of the Institute find board and lodgings with respectable private families in the city. The prices asked for suitable board and furnished lodgings vary, at the present time, from $6.00 to $10.00 per week. The total expense of board, furnished lodgings, laundry, fires, lights, etc., varies from about $300 to $500 for the scholastic year.

Young gentlemen who contemplate taking a thorough course in the NATURAL SCIENCES, and in the Higher Mathematics, with a view to fitting themselves for the professions of CIVIL, MECHANICAL, or MINING ENGINEERING, should apply for the new Register for 1890.

Applications may be made to DAVID M. GREENE, C. E., *Director*, or WILLIAM H. YOUNG, *Treasurer*.

Troy, N. Y., June, 1890.

TABLE OF CONTENTS.

Smith