AMERICAN ENGINEERS & SURVEYORS INSTRUMENTS

TWENTY FIFTH EDITION

W & L. E. Gurley's Instrument Manufactory, Established 1845.

W. & L. E. GURLEY,

MANUFACTURERS OF

Civil Engineers' & Surveyors' Instruments,

TROY, N. Y.

A

MANUAL

OF THE PRINCIPAL

INSTRUMENTS

USED IN

AMERICAN ENGINEERING AND SURVEYING,

MANUFACTURED BY

W. & L. E. GURLEY,

TROY, N. Y.

TWENTY-FIFTH EDITION.

TROY, N. Y.
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1884.

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PRICE LIST.

TROY, JANUARY, 1884.

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.

TRANSITS.

No.		Price
1.—	Engineers', two verniers to limb, 4 inch needle, plain telescope,* leveling tripod	$145 00
2.—	do do do 4½ do do do	150 00
3.—	do do do 5 do do Fig. 1	150 00
4.—	do do do 5 do with theodolite axis	185 00
5.—	do do do 5 do with Solar Attachment vertical arc, level on telescope, clamp and tangent to axis of telescope and variation plate, leveling tripod, Fig. 8	250 00
6.—	Light Mountain do 4 do plain telescope, and patent extension tripod	150 00
7.—	do do do 4 do with level, vertical arc, clamp and tangent to axis of telescope, and Solar Attachment, and patent extension tripod, Fig. 9	245 00
12.—	Surveyors', two verniers to limb, 4 do plain telescope, leveling tripod	125 00
13.—	do do do 5 do do do	130 00
14.—	do do do 5½ do do do	130 00
15.—	do do do 5 or 5½ do 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, leveling tripod, Fig. 19	160 00
16.—	do do do 5 do with Solar Attachment, vertical arc, level on telescope, clamp and tangent to axis of telescope, leveling tripod, Fig. 22	226 00
20.—	Surveyors', one vernier to limb, 4 inch needle, plain telescope, leveling tripod	110 00
21.—	do do do 5 do do do	115 00
22.—	do do do 5½ do do do	115 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.

TRANSITS.—*Concluded.*

No.		Price
23.—	Surveyors', one vernier to limb, 5 or 5½-inch needle, but with level on telescope, and clamp and tangent movement to axis of telescope, leveling tripod, Fig. 21	$133 00
24.—	do do do 5 do with Solar Attachment, vertical arc, level on telescope, clamp and tangent to axis of telescope, leveling tripod, Fig. 22	211 00
28.—	Vernier Transit Compass, 4 inch needle, plain telescope, compass tripod	70 00
29.—	do do do 5 do do do	70 00
30.—	do do do 6 do do do	75 00
31.—	do do do 6 do but with vertical circle reading to 5 minutes, level on telescope, and clamp and tangent movement to axis of telescope, compass tripod, Fig. 23	101 00

EXTRAS TO TRANSITS

35.—	Patent Solar Attachment	$60 00
36.—	Variation Plate furnished with new Engineers' Transit when ordered	4 00
37.—	Variation Plate added to any Engineers' Transit sent for repairs	15 00
38.—	Plummet Lamp for Mining Engineering, hung in gimbals, Fig. 16	10 00
39.—	Diagonal Prism for Eye-piece, Fig. 13	8 00
40.—	Reflector for object-glass of Transit Telescope, Fig. 12	4 00
41.—	Vertical Circle, 3½ inches diameter, divided on silver, vernier reading to five minutes	8 00
42.—	Vertical Circle, 4½ inches diameter, divided on silver, reading to single minutes	12 00
43.—	Vertical Arc, 6 inches diameter, divided on silver, with vernier, movable by tangent screw, reading to 30 seconds	18 00
44.—	Clamp and tangent movement to axis of telescope	6 00
45.—	Gradienter, combined with clamp and tangent, Fig. 18	18 00
46.—	Level on telescope, with ground bubble and scale	12 00
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 Fig. 14 or 15	25 00
51.—	Graduations of limb on solid silver	10 00
52.—	do do to read to 20″ or 30″	10 00
53—	do do to read to 10″	30 00
54.—	do on 4½-inch vertical circle, to read to 20″ or 30″	5 00
55.—	Jones' Patent Latitude Arc, with reversible level bubble, Fig. 11	72 00
60.—	Leveling tripod head, with clamp and tangent movement, fitted to Vernier Transit Compasses, Nos. 28 to 31 ... extra	13 00
61.—	Patent extension tripod, furnished instead of regular tripod, with any new instrument ... extra	5 00

Y LEVELS.

70.—	Fifteen-inch telescope, with leveling tripod, Fig. 44	$90 00
72.—	Eighteen do do do	110 00

Y LEVELS.—*Concluded.*

No.		Price
73.—	Twenty-inch telescope, with leveling tripod, Fig. 42	$110 00
74.—	Twenty-two do do do	115 00
75.—	Architects' Level, eleven-inch telescope, with leveling tripod, Fig. 45	45 00
76.—	Farmers' or Drainage Level, with jacob-staff mountings	15 00
77.—	do with plain tripod	20 00
78.—	do with tripod and leveling screws, Fig. 47	25 00
85.—	Quick-leveling tripod head, Fig. 67	6 00
86.—	do do when ordered with new instrument, either Level or Transit, Figs. 65 and 66	5 00

PLANE TABLES.

90.—	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, with square base	15 00
	Alidade with compass sights, Fig. 56	15 00
	Total	$75 00
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. 132, with stadia, vertical circle to 5 minutes, level, and clamp and tangent, Fig. 57	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 5 minutes, level on telescope, and clamp and tangent, mounted on column as in Engraving, Fig. 54	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, $4\frac{1}{2}$-inch vertical circle on silver to 1 minute, level on telescope, and clamp and tangent, on column, power of telescope 24 diameters, Fig. 58	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

SOLAR COMPASS.

100.—	Burt's Solar Compass, with leveling adopter, compound tangent ball, and leveling tripod, Fig. 25	$210 00

NOTE.—For Pocket Solar Compass, see No. 140, and Fig. 33.

RAILROAD COMPASSES.

No.				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 Fig. 29	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 Fig. 30	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 Fig. 31	35 00

EXTRAS TO COMPASSES.

120.—Compass Tripod, cherry legs	$5 00
121.—Patent Extension Tripod, furnished with any compass	10 00
122.—Compass Tripod, with leveling screws, and clamp and tangeut movement	18 00
123.—Compass Tripod Mountings, without legs	4 00
124.—Compound Tangent Ball, Fig. 24	6 00
126.—Leveling adopter, large size, Fig. 27, a	7 00

TELESCOPIC SIGHT.

ATTACHABLE TO COMPASS SIGHT. (See Figs. 28, 32, 35.)

Patented July 9, 1878.

130.—Nine-inch Achromatic Telescope, power about 10 diameters	$12 00
131.—Nine-inch Achromatic Telescope, larger diameter of object glass and power about 20 diameters, Fig. 32	17 00
132.—Same Telescope as No. 131, but furnished with micrometer or stadia wires for measuring distances	20 00

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. (Fig. 33.)

No.	Price
140.—Pocket Solar Compass, with staff mountings and mahogany box......	$100 00
141.—Side Telescope and counterpoise fitted to Pocket Solar Compass.......	25 00
Note.—When desired, we add to the side telescope, extras Nos. 133, 134, and 135, at prices named.	
142.—Leather case with shoulder strap for Pocket Solar Compass............	5 00
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, Fig. 41	16 00

POCKET COMPASSES, AND EXTRAS.

150.—With folding sights, $2\frac{1}{2}$-inch needle, very serviceable for retracing lines once surveyed...	$8 00
151.—Same as above, with jacob-staff mountings, Fig. 38..................	10 00
152.—With $3\frac{1}{2}$-inch needle, and jacob-staff mountings, do..................	12 00
153.—Same as above, and two levels....	13 50
154.—Same as 152, but without jacob-staff mountings......................	10 00
155.—Vernier Pocket Compass, with folding sights, staff mountings, two levels, and $3\frac{1}{2}$-inch needle, Fig. 36	16 00
156.—Same as above, $4\frac{1}{2}$-inch needle, do	18 00
157.—Railroad Pocket Compass, with folding sights, staff mountings, two levels, $3\frac{1}{2}$-inch needle, with limb reading to five minutes..............	23 00
158.—Railroad Pocket Compass, $4\frac{1}{2}$-inch needle, clamp and tangent to limb, with limb reading to one minute..................................	28 00
159.—Railroad Pocket Compass, one vernier to limb, Fig. 34................	40 00
159A.—Railroad Pocket Compass, $4\frac{1}{2}$-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	65 00
159B.—Same as above, but with telescopic sight No. 131, Fig. 35	70 00
159C.— do do do No. 132........	73 00
160.—Vernier Pocket Compass, $4\frac{1}{2}$-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
161.—Same as above, but with telescopic sight No. 131, Fig. 37	60 00
162.— do do do No. 132	63 00
167.—Leather case with shoulder strap for pocket compasses	2 00 to 5 00
168.—Tripod for pocket compass	5 00
169.—Tripod for pocket compass, with leveling plates and clamp and tangent	15 00
170.—Patent extension tripod for pocket compass	10 00
171.—Tangent movement for ball spindle of pocket compasses Nos. 151 to 159	5 00
172.—Rack movement to vernier of Vernier Pocket Compass	4 00
173.—Leveling adopter, small size, Fig. 64..................................	5 00

MINER'S COMPASSES OR DIPPING NEEDLES.

FOR TRACING VEINS OF MAGNETIC IRON ORE.

No.		Price
178.—	3-inch needle, glass on both sides, wood box, stop to needle, Fig. 39...	$12 00
179.—	do do do brass covers, stop to needle........	12 00
180.—	do do one side, brass cover, stop to needle	12 00
181.—	"Norwegian Needle," glass on both sides, brass covers, 3-inch needle, superior article, Fig. 40	12 00
182.—	Same as above, 4-inch needle..	15 00
	The first three of the Miners' Compasses furnished without stop (each)	10 00

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

LOCKE'S HAND LEVEL.

185.—	Bronze, in box, Fig. 59..	$9 00
186.—	Nickel plated, in box, Fig. 59...	10 00

ABNEY LEVEL AND CLINOMETER.

187.—	This is an improved "Locke's Hand Level," giving angles of elevation, and is also divided for slopes, as 1 to 1, 2 to 1, etc., in case, Fig. 60...	$15 00
188.—	Clinometer, or Slope Level, to $\frac{1}{2}$ deg., 7 inches long, in walnut case	8 00
189.—	Ditto (Gunner's quadrant pattern), with vernier to 5 min., 18 inches long, in walnut case..	15 00

LEVELING RODS.

190.—	Architects' Rod, $5\frac{1}{2}$ ft. closed, sliding to 10 ft., Fig. 53	$6 00
191.—	Troy Rod, $6\frac{1}{2}$ ft. closed, sliding to 12 ft., Fig. 51	10 00
192.—	Boston Rod, 6 ft. closed, sliding to 11 ft., Fig. 49	16 00
193.—	Philadelphia Rod, $7\frac{3}{10}$ ft. closed, sliding to 13 ft., Fig. 48...............	16 00
194.—	Philadelphia Metric Rod, $2\frac{1}{10}$ metres closed, sliding to $3\frac{7}{10}$ metres......	16 00
195.—	New York Rod, $6\frac{8}{10}$ ft. closed, sliding to 12 ft., Fig. 50.................	16 00
196.—	do in 3 parts, either 5 ft. closed, sliding to 13 ft., or $5\frac{6}{10}$ ft. closed, sliding to $14\frac{1}{2}$ ft., Fig. 52	18 00
197.—	do in 4 parts, 5 ft. closed, sliding to 16 ft..................	20 00
198.—	New York Metric Rod, $2\frac{1}{10}$ metres closed, sliding to $3\frac{6}{10}$ metres........	16 00
199.—	Telemeter, or Stadia Rod, 6 ft. folded, unfolding to 12 ft..............	12 00
200.—	English Rod, telescope pattern, 5 ft. long, sliding to 14 ft., Fig. 53A....	24 00

FLAG STAFFS, ETC.

210.—	6 feet long, with steel-pointed shoe, and divided off in feet, which are painted red and white, alternately..	$2 50
211.—	8 feet long, do do do	2 75
212.—	10 feet long, do do do	3 00
215.—	Rod level for plumbing a rod or flag staff..................................	5 00

CHAINS.

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

STEEL BRAZED CHAINS.

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

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

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
241.—	20 do	20 do	100	do	10 do	....	3 50
242.—	10 do	10 do	50	do	8 do	... .	2 50
243.—	20 do	20 do	100	do	8 do	....	4 00
244.—	10 do	10 do	50	do	10 best steel wire	....	4 00
245.—	20 do	20 do	100	do	10 do	....	7 00
246.—	10 do	10 do	50	do	8 do	....	5 00
247.—	20 do	20 do	100	do	8 do	....	9 00
248.—	10 do	10 do	50 links,	brazed links and rings No. 12 steel wire, tempered.		....	5 50
249.—	20 do	20 do	100	do	do	12 do	10 00

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
260.—	66 feet,	No. 15 tempered steel wire,		100 links,	weight	$1\frac{1}{4}$ lbs. With 10 extra links.	$9 00
261.—	33	do	do	50	do	$\frac{3}{4}$ lb. With 5 extra links.	5 00
262.—	100	do	do	200	do	2 lbs. With 15 extra links.	11 50
263.—	50	do	do	100	do	1 lb. With 10 extra links.	6 00
264.—	33 feet,	No. 12 wire,	5 tallies, with	5 extra links,		$1\frac{10}{16}$ lbs.	5 50
265.—	66	do	10 do	10	do	3 lbs.	10 00
266.—	50	do	5 do	5	do	$2\frac{1}{8}$ lbs.	6 00
267.—	100	do	10 do	10	do	$4\frac{1}{8}$ lbs.	11 50

268.— 50 feet, No. 18 tempered steel wire, 100 links, with attachments of spring-balance, level, and thermometer, for very accurate measurements; weight $\frac{3}{4}$ lb. 15 00

270.—Brass Plummet, to use with light chain 2 00

271.—Spring-balance to use with chains Nos. 260 to 263 .... 2 00

MARKING PINS.

275.—	Set of 11 Pins,	iron wire, No. 4	$1 50
276.—	do	steel wire, No. 6	2 00
277.—	do	brass wire, No. 4	3 00
278.—	do	steel wire, loaded	3 00
279.—	do	steel wire, very light, with leather case	2 00

280.—Timber scribes or Marking irons, each 1 25

CHESTERMAN'S METALLIC TAPE MEASURES.

These tapes are made of linen thread, interwoven with fine brass wire, not so liable to stretch as the usual linen tape, and better calculated to withstand the effects of moisture. They are in substantial leather cases.

285.—	Metallic tape measures,	33 feet long,	in 10ths or 12ths,	each	$2 35
287.—	do	50	do	do	3 00
288.—	do	66	do	do	3 30
292.—	do	100	do	do	4 75

CHESTERMAN'S METALLIC TAPES WITHOUT BOXES.

295.—	Chesterman's metallic tapes,	without box,	50 feet,	10ths or 12ths.	$1 75
296.—	do	do	66	do	2 25
297.—	do	do	100	do	3 25

NOTE.—We can furnish Nos. 285 to 297 of any intermediate lengths required.

CHESTERMAN'S STANDARD STEEL TAPE MEASURES.

Steel tape measures; all steel, to wind up in a box, same as linen measures, the most accurate, durable and portable measures.

No.						Price
300.—Steel tape measure, 10 feet long, in 10ths or 12ths, in German silver case, each						$3 50
301.—Steel tape measure, 10 feet long, tape divided on one side to 12ths, and on the other to centimeters and millimeters						3 75
302.—Steel tape measure, 25 feet long, in 10ths or 12ths each						5 75
303.—	do	33	do	do		6 25
305.—	do	50	do	do		8 50
306.—	do	66	do	do		11 00
307.—	do	75	do	do		12 50
308.—	do	100	do	do		16 00
309.—	do	50	do	do	extra wide and heavy	13 00

POCKET STEEL TAPE MEASURES.

315.—Pocket Steel tapes, in German silver cases, with spring and stop, divided in 10ths or 12ths of feet, 3 feet long						$1 35
316.—	do	do	do	4	do	1 50
317.—	do	do	do	5	do	1 75
318.—	do	do	do	6	do	2 00
319.—	do	do	do	8	do	2 25
320.—	do	do	do	12	do	3 00

These pocket tapes, with divisions to centimetres and millimetres on the other side, 25 to 50 cents per tape higher, according to length.

PAINE'S PATENT STANDARD STEEL TAPES.

IN LEATHER CASES, FLUSH HANDLES.

325.—Steel tape measure, 33 feet long, 10ths or 12ths							$5 50
326.—	do		50	do	do		8 00
327.—	do		66	do	do		10 00
328.—	do		75	do	do		12 00
329.—	do		100	do	do		15 00
330.—	do	in japanned case, 25 feet long, 10ths or 12ths					3 50
331.—	do	do	33	do	do		4 50
332.—	do	do	50	do	do		6 00
333.—	do	do	66	do	do		8 00
334.—	do	do	75	do	do		10 00
335.—	do	do	100	do	do		12 00

Tapes Nos. 325 to 335, without cases, 10 cts. per foot.

Tapes Nos. 325 to 335, with metric measure on reverse side, at an extra cost of 5 cts. per foot.

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

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

STANDARD STEEL RIBBONS.

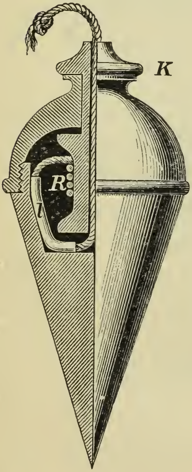
Our own manufacture, without joint, for testing chains or tapes, or for bridge work. Ribbon, $\frac{3}{8}$ to $\frac{1}{2}$ inch wide, graduated on soldered brass plates.

No.					Price
345.—Steel Ribbon,	33	feet long,	with handles and reel	....	$3 00
346.— do	50	do	do	....	4 00
347.— do	66	do	do	....	6 00
348.— do	100	do	do	....	7 00

Nos. 345 and 347 are graduated each foot up to ten feet, and also at each sixteen and one-half feet.

Nos. 346 and 348 are gratuated each foot up to ten feet, and at each ten feet thereafter.

Longer tapes to order.



NEW ADJUSTABLE PLUMB BOBS.

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

No.	Price
350.—10 oz	$2 50
354.—30 oz.	5 00

BRASS PLUMB BOBS.

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

ODOMETERS.

FOR MEASURING DISTANCES BY THE REVOLUTION OF A CARRIAGE WHEEL.

No.	Price
365.—Odometer, Fig. 63, outside dial, with bolts for attaching, complete	$10 00
366.—Odometer, Fig. 61, inside dial, with leather case and straps	15 00

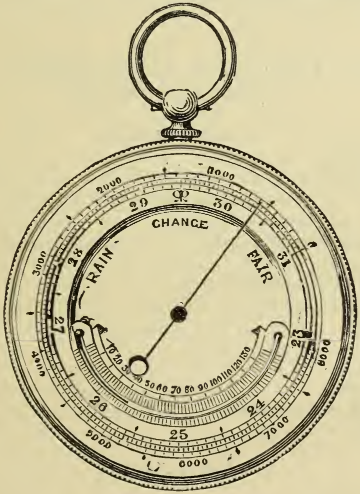
ANEROID BAROMETERS.

FOR ASCERTAINING HEIGHTS, DIFFERENCES OF LEVEL AND METEOROLOGICAL CHANGES, APPROACH OF STORMS, ETC.

370.—Mountain Aneroid Barometers, compensated for temperature, with silvered dials, in morocco cases, accompanied by a hand-book of instructions.

These instruments as now made are nearly as portable as an ordinary watch, and yet are fully as accurate as the larger sizes. They 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, $1\frac{3}{4}$-inch dial, altitude scale to				8000 feet	$18 00
B.—	do	do	do	10000 feet	20 00
C.—	do	do	do	15000 feet	25 00
D.—	do	do	do	20000 feet	27 00
E.—	do	do	do	15000 feet, and thermometer	27 00



H.—Pocket Aneroid, $1\frac{7}{8}$-inch dial, altitude scale to 10000 feet, and opposite side with pocket compass and thermometer $28 00

K.—Pocket Aneroid, $2\frac{5}{8}$-inch dial, altitude scale to				3000 feet	19 00
L.—	do	do	do	5000 feet	19 00
M.—	do	do	do	8000 feet	20 00
N.—	do	do	do	10000 feet	22 00
O. -	do	do	do	15000 feet	25 00
P.—	do	do	do	20000 feet	27 00

ANEROID BAROMETERS.—*Concluded.*

No.		Price
Q.—	Pocket Aneroid, $2\frac{5}{8}$-inch dial, altitude scale to 10000 ft., and thermometer	$24 00
R.—	do do do 15000 ft., do	27 00
S.—	Government Pattern Aneroid, $4\frac{1}{2}$-inch dial, altitude scale to 4000 feet, and thermometer, with leather case and strap	33 00
T.—	do do but with altitude scale to 8000 feet	35 00
U.—	do do do do 10000 feet	36 00
V.—	do do do do 15000 feet	38 00
W.—	do do do do 20000 feet	40 00
X.—	Plain Aneroid, no altitude scale, 5-inch dial, with thermometer and open face to show mechanism, for parlor use	20 00
Y.—	do but with $6\frac{1}{2}$-inch dial.	25 00

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 prices.

A Treatise on the Aneroid Barometer; its construction and use. Illustrated 50

PRICES FOR PARTS OF INSTRUMENTS LIABLE TO LOSS OR INJURY.

FOR TRANSITS.

Needle and centre pin	$2 50
Ground glass level vial for plate or standard, each	50
do do brass mounted complete, for plate or standard, each.	2 50
do do for telescope, each.	1 50
Cap for eye-piece or object-glass, each	75
Shade for object-glass	75
Clamp screws for horizontal limb, each	75
Tangent screw for leveling head	1 50
Clamp do do	75
Leveling do do each	1 50
Eye-piece complete	6 00
Object-glass complete	6 00
Platina cross-wires and diaphragm	3 00
do stadia do do	5 00

FOR Y LEVELS.

Ground glass level vial	$2 00
Cap for eye-piece or object-glass, each	75
Clamp screw for leveling head	75
Tangent do do	1 50
Leveling do do each	1 50
Eye-piece complete	6 00
Object-glass complete	7 00
Platina cross-wires and diaphragm	3 00
do stadia do do	5 00

FOR SURVEYORS' COMPASSES.

	Price
Needle and centre pin	$2 50
Plain glass level vials, each	25
do do brass mounted complete	2 00
Brass cover for compass of our make	1 00
Outkeeper	1 00
Staff mountings, brass head	2 50
do steel point	60
Ball-spindle	1 50
Compass sight vanes, each	2 50
Clamp screw for spindle or sight vane	75
Tangent screw for moving vernier	1 50
Staff mountings complete for pocket compass	2 50 to 3 50

MISCELLANEOUS.

Patent Extension Tripod, Fig. 17, for Transit or Level	$15 00
Extension legs only, with clamps, do do per set	10 00
Plain Mahogany Tripod, do do	10 00
Mahogany tripod legs only, do do per set	5 00
Wooden cap, with brass screw plate, for tripod head	1 00
Ring for tripod legs	25
Brass bolts do each	50
Metal points do do	50
Screw drivers, each	25
Steel adjusting pins, each	10
Brass wrench for centre pin	10
Glass circle for compass face	25
Mahogany case with lock and key and leather strap, fitted complete for Transit or Level	6 00
do do do for Compass	5 00
Regraduating compass circle	5 00
do horizontal limb and verniers of Transit	10 00
do vertical do do	5 00
Reading microscope	75
Plumb-bob for Transit or Level	1 50
Target for New York or Philadelphia Rod	5 50
Clamp for New York Rod	2 50
Rubber hood for Transit or Level	1 00
Chamois skin, best quality	65
Chain handles each	75
Chain tallies, per set of nine	50

SPECIAL NOTICE.

Many of our smaller instruments, such as pocket compasses, chains, tapes, small packages of paper and parts of large instruments, can be sent by mail securely packed, and at much lower rates than are charged by express companies.

In all cases where goods are to be sent by mail, the cash for postage as well as for the goods must accompany the order. All articles forwarded by mail are at purchaser's risk.

Price List of all our Drawing Instruments, Drawing Materials, and Books—a fully Illustrated Catalogue of one hundred pages—sent to any address postpaid, on application.

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

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 or optical instruments, at catalogue prices.

INFORMATION TO PURCHASERS.

Selection of Instruments.—Where only original surveys or the bearing of lines in the preparation of County Maps is 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 Compass 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 and Pocket Solar Compass, with or without Telescopic Attachments, 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, and the Dial 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.

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

Instances may sometimes occur, in a business as large and widely extended as ours, where, owing to careless transportation, or to defects escaping the closest scrutiny of the maker, instruments may reach our customers in bad condition. We consider the retention of such 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 with the quality of our work, and who therefore feel unwilling to make a final purchase of an article, of the excellence of which they are not perfectly assured.

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

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

EXTENT OF OUR BUSINESS.—The manufacture of surveying instruments has been conducted by us over thirty-nine years, and thousands of our instruments have been distributed to customers in all parts of the United States and Canadas; in 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 (1884) greatly increased by the introduction of new machinery and tools of the most improved construction. Our manufactory has been rebuilt of 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 strap for convenience in carrying. Each case is provided with screw-drivers, adjusting pin, and wrench for centre pin, and, if accompanied by a tripod, with a brass plumb-bob; with all instruments for taking angles, without the needle, a reading microscope is also furnished.

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

When sent to the purchaser, the mahogany cases are carefully enclosed in outside packing boxes, of pine, made a little larger on all sides to allow the introduction of elastic material, and so effectually are our instruments protected by these precautions, that of many thousand sent out by us during the last thirty-nine years, in all seasons, by every mode of transportation, and to all parts of the Union and the Canadas, and to 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 and Canadas, regular agents being located at all the more important points, by whom they are forwarded to smaller places by stage. The charges of transportation from Troy to the purchaser are in all cases to be borne by him, we guaranteeing the safe arrival of our instruments to the extent of express transportation, and holding the express companies responsible to us for all losses 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, as is most common, may pay the agent on receipt of the instrument in funds current in New York or Boston.

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 these 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 head in which they are inserted need never be sent, unless themselves in need of repairs.

COMPASSES.—These come to us with the plates sprung, the sights bent or broken, the glass or level vials fractured, and the pivot so dulled as to render the needle sluggish and unreliable. The cost of repairing the defects above named, ranges from $2 to $8 or $10. A new pair of sights fitted costs $5 ; a new needle, with jeweled centre and pivot complete, $2.50 ; a new jeweled centre, $1.50 ; regraduating compass circle, $5.00.

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

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

The injuries sustained by the falls of Engineers' and Surveyors' Transits are usually much more serious ; in these the plates, standards and cross-bar of telescope are often bent, and the sockets or centres 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 dollars, the new sockets alone costing from 15 to 20 dollars.

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

PLATINUM CROSS-WIRES.—None but a practised 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.

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 desired 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 (see Fig. 3)	$3 00
Stadia wires, with diaphragm, etc. (see Figs. 4 & 5)	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 dollars; a new level vial set in the tube costs two dollars.

Repolishing Instruments.—The cost of repolishing an instrument, involving also of course its complete renovation and adjustment, varies with the different kinds, but may be stated generally as follows:

Compasses, from	$5 to $10
Transits, do	15 to 20
Levels, do	12 to 15

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,

Fulton St., opposite North End of Union R. R. Depot, Troy, N. Y.

PREFACE

TO THE TWENTY-FIFTH EDITION.

SINCE the twenty-third edition of our MANUAL in 1878, the number and variety of the instruments manufactured by us have so rapidly increased as to require that the book should be largely re-written.

Our facilities for manufacturing have also greatly multiplied, and we now occupy over twenty 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 these are twelve graduating engines, of which six are automatic, three engraving and figuring machines, over one hundred lathes, and other tools too numerous to be further described.

The business which has been conducted by us for over thirty-nine years, has now become so widely known that our customers are found all over the civilized world.

To this 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.

W. & L. E. GURLEY.

TROY, N. Y., January, 1884.

SURVEYORS' INSTRUMENTS.

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

ENGINEERS' TRANSIT.

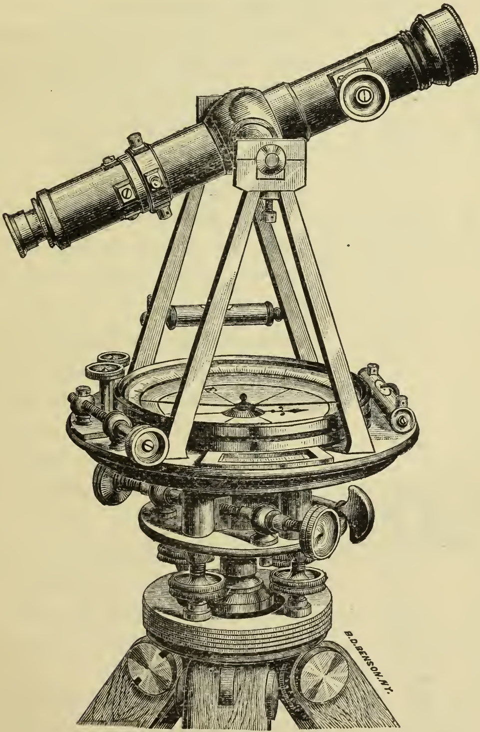


Fig. 1.

Price as shown above, with 5-inch needle and tripod, $150.00.

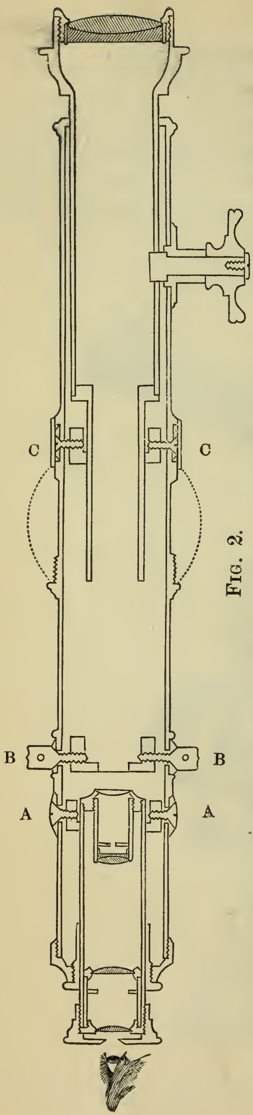


Fig. 2.

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 in Fig. 2.

The object-glass is composed of two lenses, so as to show objects without color or distortion, 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 plano convex 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.

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 (Fig. 13) 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.

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 in Fig. 2, 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 usually by twisting its milled end, the spiral movement within carrying the eye-tube out or in as desired; sometimes a pinion, like that which focuses the object-glass, is employed for the same purpose.

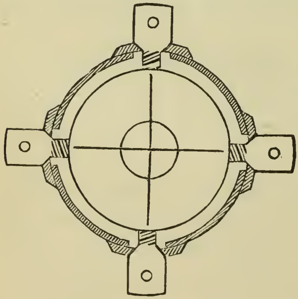


Fig. 3.

The Cross-Wires, Fig. 3, 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 centre 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, so that, when these 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 (Fig. 2) 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 centre of the field of view.

The adjustment of the object-slide, which will be hereafter described, secures the movement of the object-glass in a straight line, and thus 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.

FIG. 4.

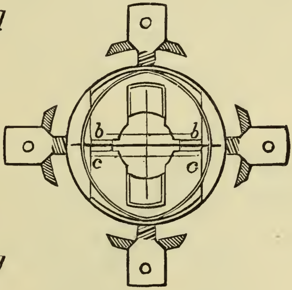


FIG. 5.

The Stadia, or ***Micrometer***, is a compound cross-wire ring or diaphragm, shown in Figures 4 and 5, 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.

Attachments to Telescope.—In Fig. 1, the telescope is represented as plain, or without any attachments such as vertical circle, level, etc., but many if not most engineers prefer to have two or more of these accessories. They are represented and described in the following articles, and can be attached to this or any other transit as desired.

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 in the cut, a little movable box, actuated by a screw underneath, by which the telescope axis is made truly horizontal, as will be hereafter described.

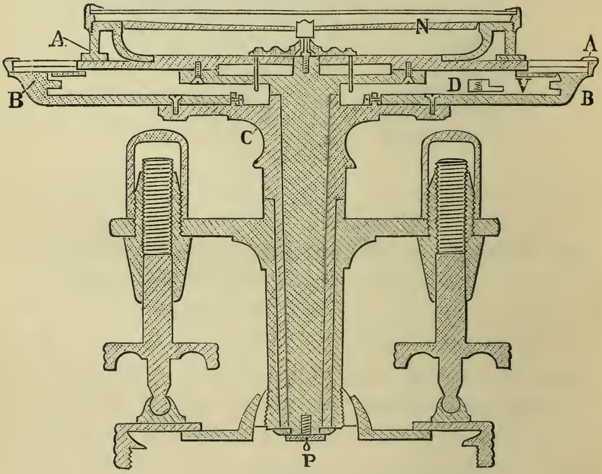


Fig. 6.

The circular plates, with their accompanying sockets, are shown in section in Fig. 6; 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 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, the degree marks being also cut down on its inner edge, and figured from 0 to 90 on each side of the centre or line of zero.

The Magnetic Needle is four to five inches long in the different sizes of transits, its brass cap having inserted in it a little socket or centre of hardened steel, perfectly polished, and this resting upon the hardened and polished point of the centre-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 centre of gravity of the needle, serves to show merely that the cap below is unobstructed.

The Clamp and Tangent Movement, shown in Fig. 1 on the upper plate, serves to fasten the two plates together, so that by the tangent screw they can be slowly moved around each other in either direction, or loosened at will and moved by the hand, thus enabling one to direct the telescope rapidly and accurately to the point of sight.

The opening for the clamp in the upper plate is covered by a plate or washer, as shown, to exclude the dust and moisture—the clamping piece into which the clamp-screw enters is shown at D, Fig. 6.

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 upper interior surface, so as to make the bubble move evenly and with great sensitiveness.

The Lower Plate or Limb B B, Fig. 6, 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 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. Many instruments, however, have a solid silver plate put over the brass, and the graduations made on the silver itself.

The last is more costly but ensures a finer graduation, with less liability to tarnish or change color.

The Sockets of the Transit, as shown in Fig. 6, 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 in Fig. 6, 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; and, as will be noticed, have threads only on the upper ends, the lower part of their stems turning closely in the lower unthreaded part of the nuts.

By this arrangement dust is excluded from the lower end of the screws, while the brass cover above equally protects the other end.

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 in Fig. 1, 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 screws, as will be seen, press on opposite sides of the clamp-piece, and thus ensure a very fine and solid movement of the instrument.

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 centre, in which the smaller lower one is shifted from side to side, or turned completely around.

By this simple arrangement, termed a "shifting centre," the instrument is easily moved over the upper plate, and the plummet which hangs from the centre P, Fig. 6, 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 in Fig. 1, 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.

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

The Extension Tripod described and figured 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.

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 centre of the opening. Without moving the instrument proceed in the same manner to bring the other bubble to its centre; 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 centre, 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 centre by the leveling screws, and repeat the operation until the bubbles will remain in the centre during a complete revolution of the instrument, and the adjustment will be complete. It should be remarked that in this, as in most of our Transits, the level on the standards has a movement only at one end, the adjustment being made by abutting screws, which are loosened and tightened in turn, in moving the level.

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 head 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 centre 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 centre 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.

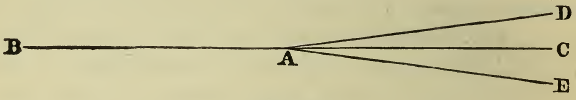


FIG. 7.

For, as in the diagram, let A represent the centre 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 centre 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 centre 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 centre 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 centre of the field of view by moving the screws A A, shown in the sectional view of the telescope, Fig 2, 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 shown in Fig. 2. 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-screws of 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 centre 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.

The Attachments of the Transit.—The engraving of the Surveyors' Transit hereafter described, represents the attachments often applied to the Engineers' Transit, viz: vertical circle, level on telescope, and clamp and tangent to telescope axis. They are of use where approximate leveling and vertical angles are to be taken in connection with the ordinary use of the Transit, and with their adjustments, &c., will be described in the account of the Surveyors' Transit.

ENGINEERS' TRANSIT.

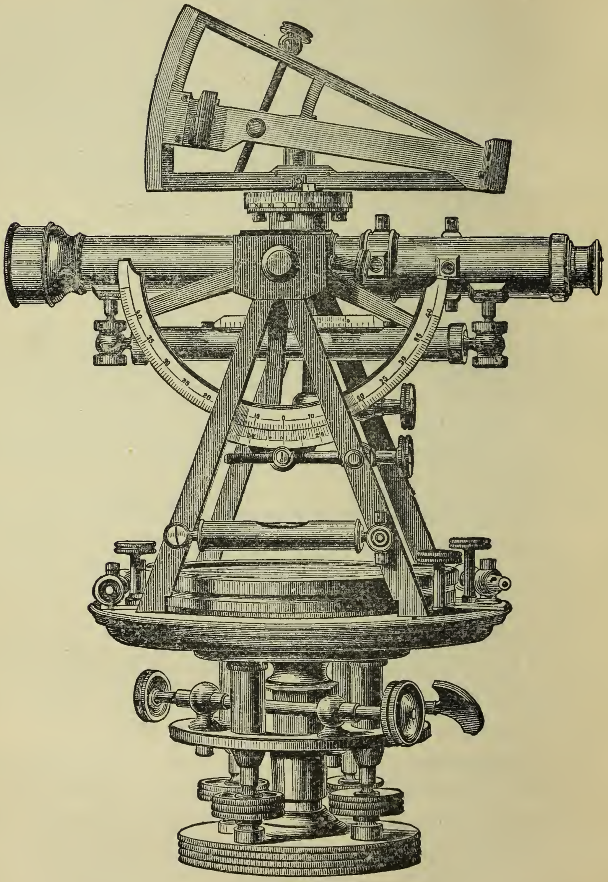


FIG. 8.

5-inch Engineers' Transit with Solar Attachment.
Price as shown, including tripod, $250.00.

ENGINEERS' TRANSIT WITH SOLAR ATTACHMENT.

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

For price of the instrument thus represented, refer to No. 5 in Price List.

The Theodolite Axis.

In place of the ordinary axis of the telescope represented in Fig. 1, we sometimes make one resembling the Y axis of the English Theodolite.

This modification is desirable, in cases where this instrument is intended to subserve the purposes of both level and transit.

In such an arangement, the telescope is confined in the axis with clips, by loosening which, it may be revolved in the wyes, or taken out and reversed end for end, precisely like that of the Y leveling instrument.

The standards also allow its transit, or complete revolution in a vertical direction.

In such an instrument, the adjustment of the wires, and level of the telescope, is effected in the same manner as those of the leveling instrument, the tangent movement of the axis serving, instead of the leveling screws, to bring the bubble and wires into position.

When desirable, a vertical wheel may be placed on the axis of the telescope of this instrument, and thus all the properties of the English Theodolite united with those of the American Transit.

PRICES.

Engineers' Transit, two verriers to limb, 5-inch needle, plain telescope, theodolite axis, leveling tripod.....	$185 00
Do do do. with vertical circle, level on telescope, clamp and tangent to axis.......	215 00

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,	13	pounds.
4½ "	"	14	"
5 "	"	16	"

LIGHT MOUNTAIN TRANSIT.

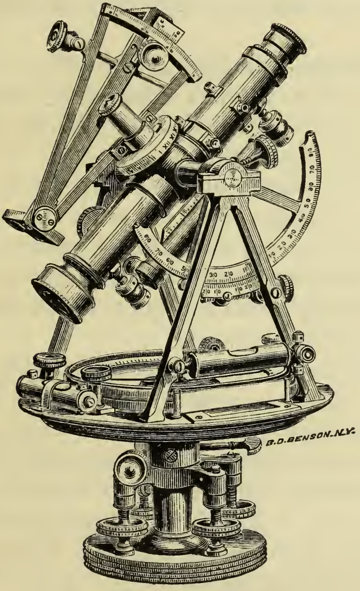


Fig. 9.

Price as shown, including extension tripod, $245.00.

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 in Fig. 6, and, with the leveling head, remain attached to the instrument; and its compass circle is movable about its centre, 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 one of 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.

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 centre, 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 centre, 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 Fig. 10, 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 illustrated 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

THE SOLAR ATTACHMENT

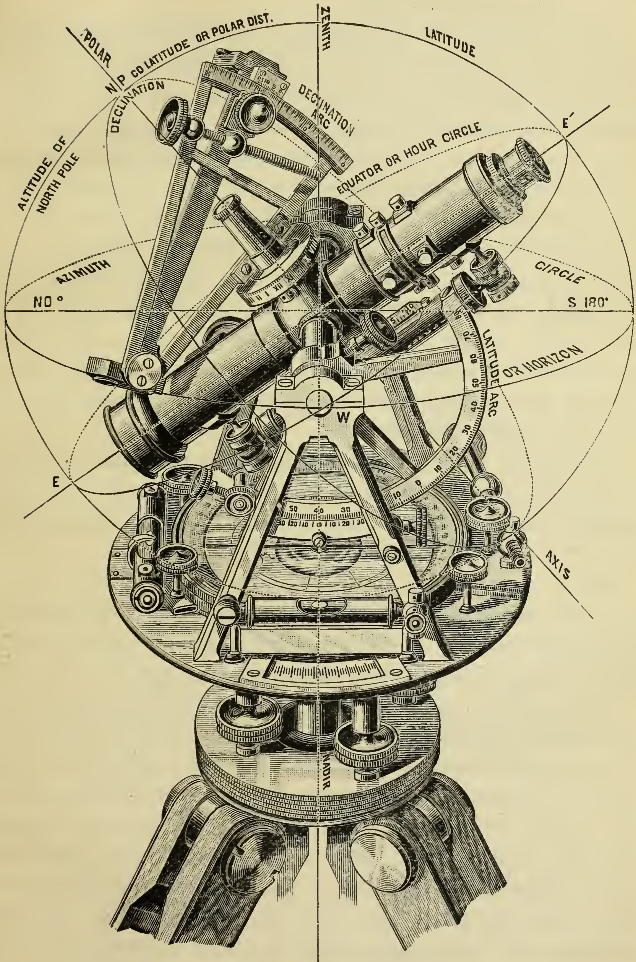


FIG. 10.

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 in Fig. 26, 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 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 centre 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 centre 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 centre 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 remain in the centre during a complete revolution of the instrument upon its axis.

Place the equatorial sights on the top of the blocks as closely as is practicable with the distinct view of a distant object; and having previously set the declination arm at zero, sight through the interval between the equatorial sights and the blocks at some definite point or object, the declination arm being placed over either pair of the capstan-head screws on the under side of the disc.

Keeping the declination arm upon the object with one hand, with the other turn the instrument half around on its axis, and sight upon the same object as before. If the sight strikes either above or below, move the two capstan-head screws immediately under the arm, loosening one and tightening the other as may be needed until half the error is removed.

Sight again and repeat the operation, if needed, until the sight will strike the same object in both positions of the instrument, when the adjustment of the axis in one direction will be complete.

Now turn the instrument at right angles, keeping the sight still upon the same object as before; if it strikes the same point when sighted through, the axis will be truly vertical in the second position of the instrument.

If not, bring the sight upon the same point by the other pair of capstan-head screws now under the declination arc, reverse as before and continue the operation until the same object will keep in the sight in all positions, when the polar axis will be made precisely at right angles to the level and to the line of collimation of the transit.

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 centre 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 centre 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 irs 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 centre, and running to 10 on either side.

R. M. Jones' Patent Latitude Arc.

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 in Fig. 11. The smaller arc having its centre directly under the cross-bar of the telescope, has an arm with vernier reading the arc to single minutes, and

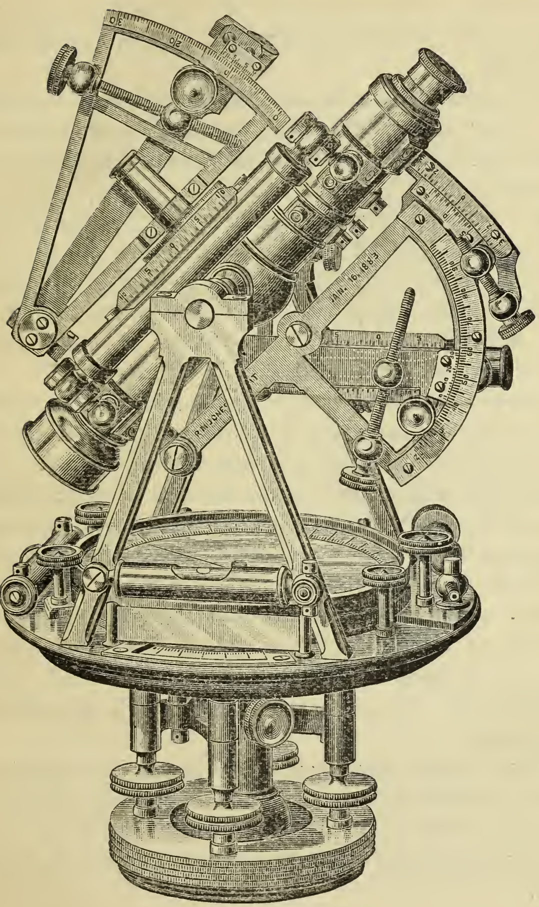


FIG. 11

Light Mountain Solar Transit, with Jones' Patent Latitude Arc, and reversible level bubble. Price as shown, including extension tripod, - $299.00.

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 centre 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 centre 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 centre of its scale.

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 centres in such condition that the level of the telescope will remain in the centre 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 tripod. 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.

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

As shown in the engraving, the cost of the combined light mountain transit and solar attachment is $245.

The cost of the solar attachment, combined with our double vernier surveyors' transit, and with the same extras, will be $226. (See Fig. 22.)

Combined with the engineers' transit, and having a variation plate, $250. (See Fig. 8.)

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.

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 leveled by leveling screws and parallel plates.

It can, however, be put on the telescope of our vernier transit compass, but in that case the angles taken from the meridian will be measured by the needle only.

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.

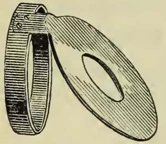


Fig. 12.

The reflector, Fig. 12, 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.

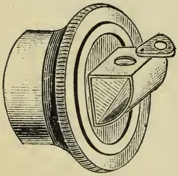


Fig. 13.

The diagonal prism, Fig. 13, 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.

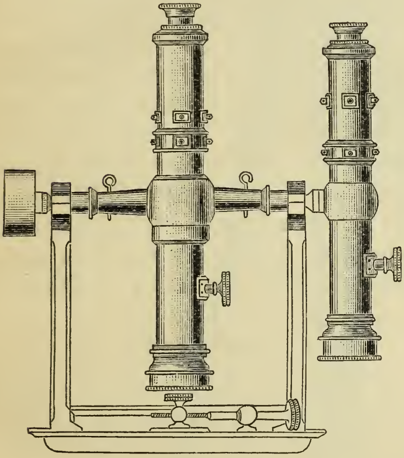


Fig. 14.

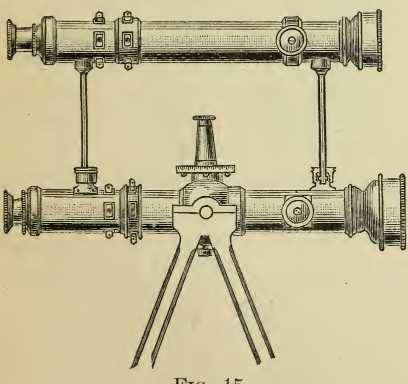


Fig. 15.

A common arrangement for sighting up or down a vertical shaft is shown in Fig. 14, 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 centre 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 Fig. 15, the extra telescope is connected with the main one by coupling nuts, which fasten it securely directly over the centre of the instrument, and allow its ready removal and replacement without disturbing its adjustments.

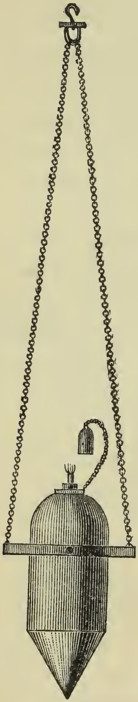


Fig. 16.

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 Fig. 14, and vertical in Fig. 15; 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 Fig. 14 or 15, $25.00.

PLUMMET LAMP.

As shown in Fig. 16, 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 centre, 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.

EXTENSION TRIPOD.

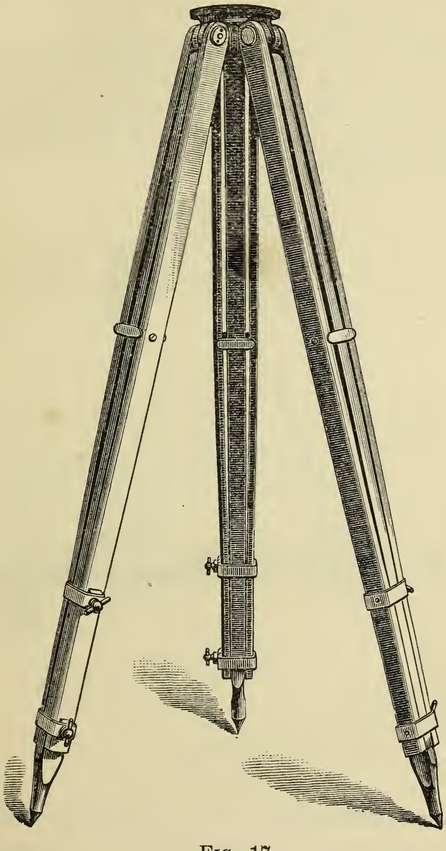


Fig. 17.

The Light Mountain Transit is almost always used upon our patent extension tripod, Fig. 17, 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. Price as shown $15.00.

GRADIENTER.

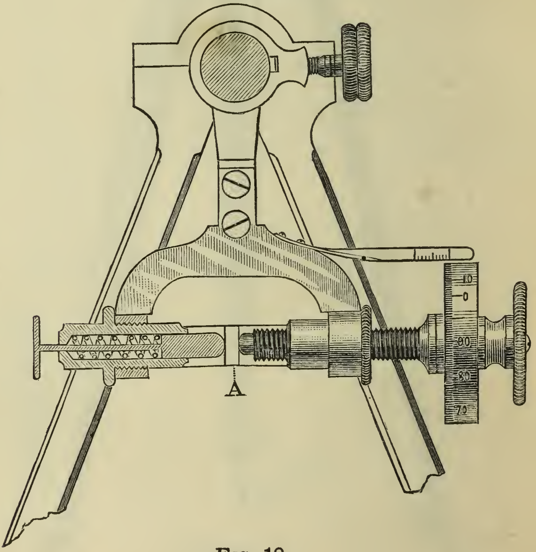


FIG. 18.

Price as shown $18.00. (See No. 45 in Price List.)

This attachment, as shown in Fig. 18, 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 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 a 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 centre 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 8½ pounds ; with solar attachment, arc, level, and clamp, as shown in figure, 9½ pounds. The extension tripod weighs about 8 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.

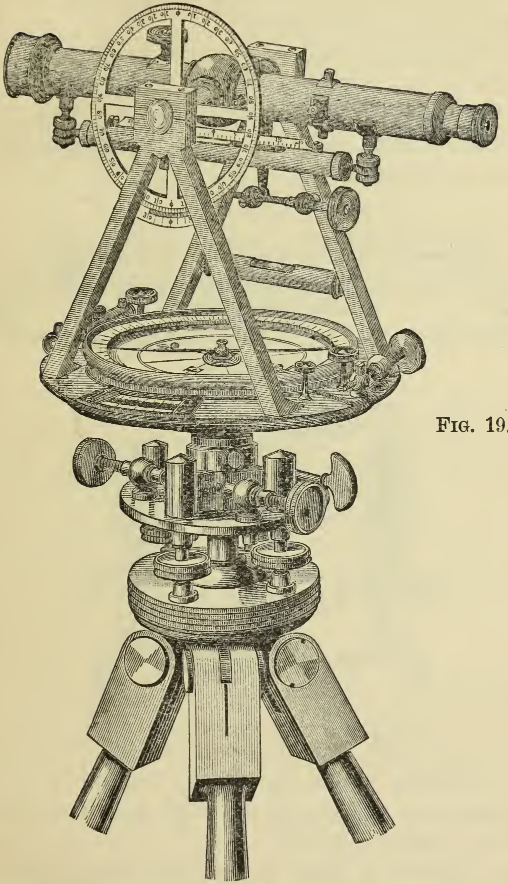


Fig. 19.

Price as shown, 5 or $5\frac{1}{2}$-in. needle, including tripod, $160.00.

The Surveyors' Transit has essentially the same construction as the instrument first described in the manual, but its compass-circle is movable about its centre, 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.

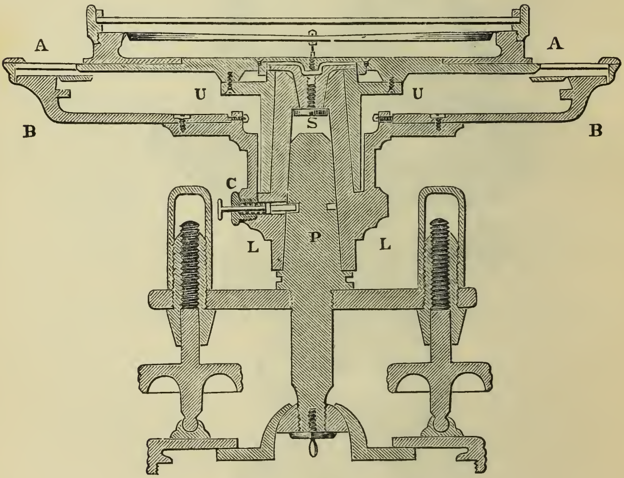


FIG. 20.

The sectional view, Fig. 20, 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 B is attached to the main socket of L L, which is itself carefully fitted to the conical spindle P, and held in place by the spring catch C.

The upper plate, A A, carrying the compass-circle, standards, &c., is fastened to the flanges of the socket, U U, which is fitted to the upper conical surface of the main socket L; 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 centre, in which from below is inserted the strong screw, S, is brought down firmly upon the upper end of the main socket L L, 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 centre contains the steel centre-pin upon which rests the needle, as shown; the disc is fastened to the upper plate by two small screws, as represented.

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 ensuring 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 C, 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 centre of the lower leveling plate, and the screw and loop for the attachment of the plummet.

To Take Apart the Surveyors' Transit.

When it is necessary to separate the plates of the transit proceed as follows:

(1) Remove the clamp-screw and take off the head of the pinion, both on the north end and 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 S from the underside of the conical centre, Fig. 16. (4) Drive out the centre from below by a round piece of wood, holding the instrument vertical so that the centre will not bruise the circle. (5) Set the instrument again upon its spindle, take out the clamp-screw to the tangent movement of the limb, and the work is complete. 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 under side 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 centre to 5, 10, 15, 20, on either side, and thus determines when the bubble is brought into the centre 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 as shown in Fig. 20, 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 centre 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.

The Surveyors' Transit with One Vernier to Limb

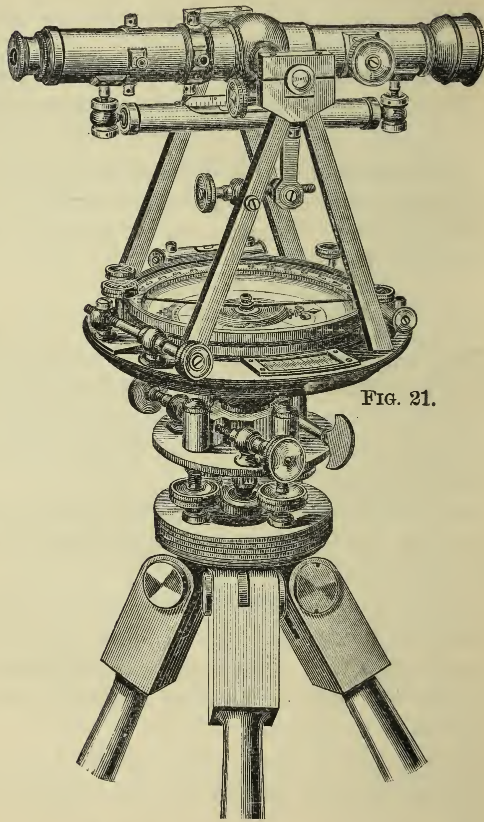


FIG. 21.

Price as shown, 5 or 5½-in. needle, including tripod, $133.00.

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 years the instrument has proved itself in every way efficient and satisfactory for all classes of work.

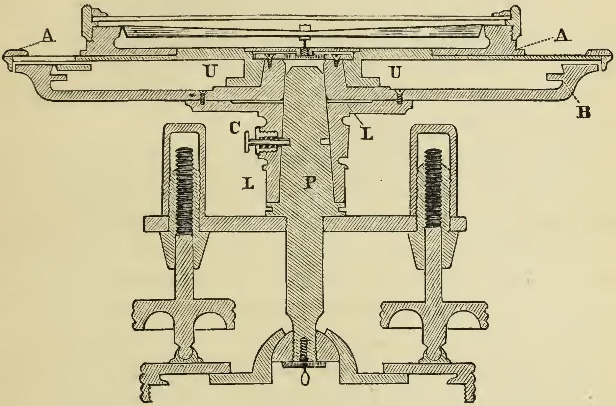


FIG. $21\frac{1}{2}$.

In Fig. $21\frac{1}{2}$ is shown the peculiar arrangement of the sockets of this instrument.

The main socket L L now, in a single piece, is fitted to the spindle P, and secured by a spring catch C. The socket, U U, is formed in the metal of the plates themselves, a strong washer as shown above keeping them securely together, but at the same time allowing them to turn freely around each other.

The vernier with the opening above is shown on the left at A. The arrangement of the centre-pin, needle, &c., is precisely like that of the transit with two verniers, and the instrument is detached from the leveling-head and replaced in the same manner.

This instrument may be taken apart by first removing the pinion-head and clamp-screw, near the north end of the compass circle, then unscrewing the bezel ring, taking out the needle and button underneath, and next removing the disc in which the centre-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, and when the clamp-screw is taken out 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.

In Fig. 21½ 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 eye; 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 centre 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 centre 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 centre 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 centre, 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	$12\frac{1}{4}$	lbs.
5	"	"	"	$15\frac{3}{4}$	"
$5\frac{1}{2}$	"	"	"	$16\frac{3}{4}$	"

With one vernier to limb,

4-in. needle,	with leveling-head,	but no tripod,	about	$11\frac{3}{4}$	lbs.
5	"	"	"	15	"
$5\frac{1}{2}$	"	"	"	$16\frac{1}{4}$	"

Weight of the Attachments,

Vertical circle, $4\frac{1}{2}$-in., with vernier,	$5\frac{1}{2}$	oz.
Level on telescope, . . .	8	"
Clamp and tangent to axis, . .	4	"

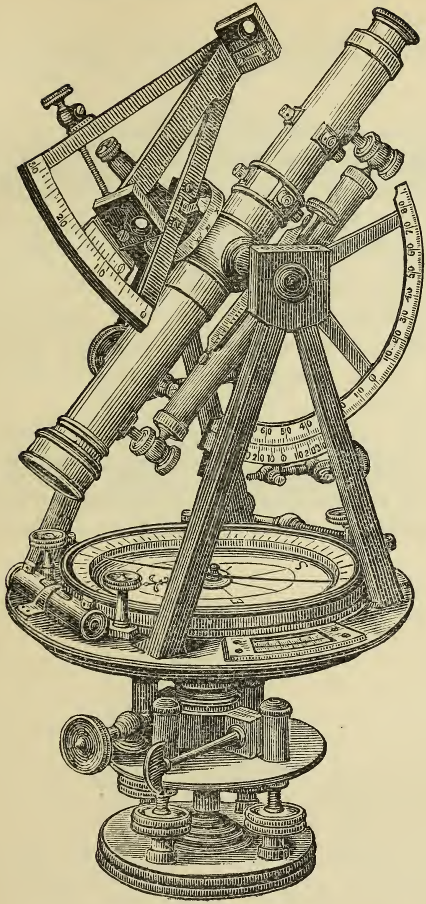


Fig. 22.

Surveyors' Transit with Solar Attachment.

Price as shown, with one vernier to limb, 5-inch needle, including tripod, $211.00.

If with two verniers to limb, $226.00.

SURVEYORS' TRANSIT WITH SOLAR ATTACHMENT.

The cut on preceding page represents our Surveyors' Transit with one vernier to limb and 5 inch needle, to which is adapted the Solar Attachment with vertical arc, level, etc.; both the vertical arc and that of the declination arm being divided on silver and reading to thirty seconds.

The Surveyors' Transit with two verniers to limb is also arranged in precisely the same manner, when desired; but the level, which is shown above on the plate, is then raised and fitted to the standards, so as to allow of the vernier opening beneath.

Both styles, represented and described herewith, have been for years in successful use in different parts of the country; the prices of each will be found respectively in Price List, Nos. 24 and 16; both have shifting centres to tripod.

VERNIER TRANSIT COMPASS.

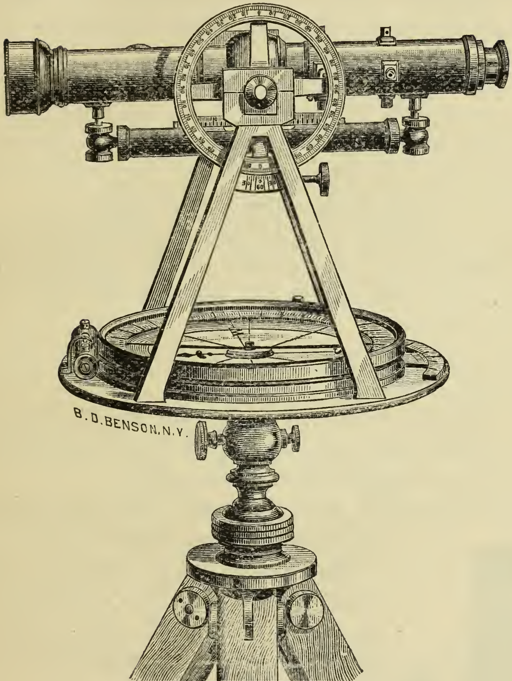


FIG. 23.

Price as shown, with 6-inch needle and tripod, $101.00.

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 inches; but all are of fine quality.

The compass-circle is moved about its centre 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.

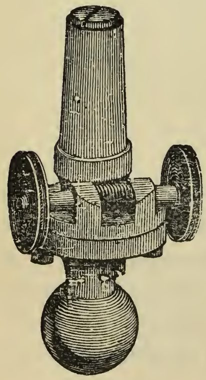


Fig. 24.

The instrument is commonly used on a ball spindle placed in a compass tripod as shown in Fig. 23, but is sometimes 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.)

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 shown in Fig. 23 is three and a half inches in diameter, plated with silver, divided 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 centre 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,	5	lbs.
5-inch	"	"	"	"	$8\frac{1}{2}$	"
6-inch	"	"	"	"	11	"

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 has since come 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 has long since become public property, and for over twenty 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 in Fig. 20, 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

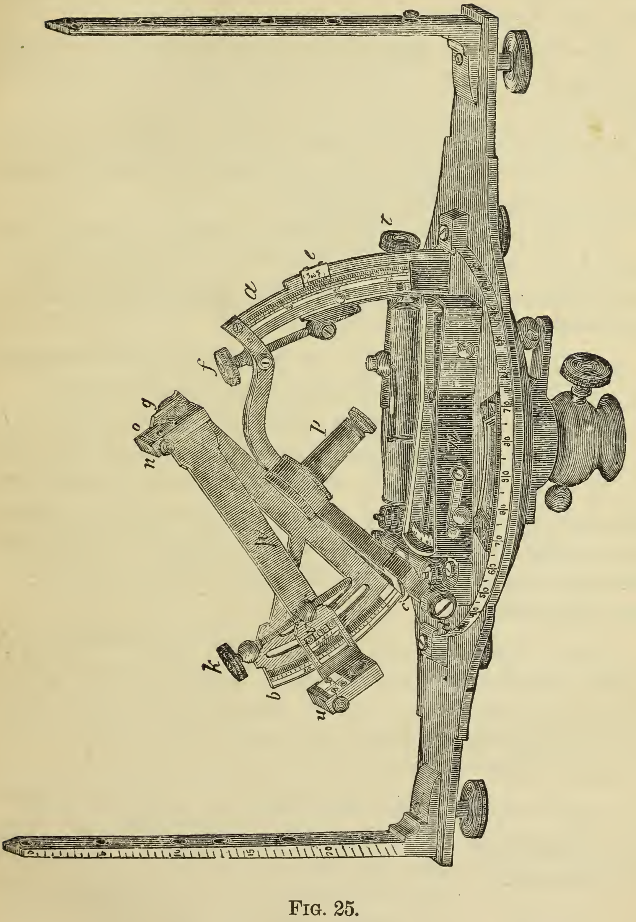


Fig. 25.

Price as shown, including leveling adopter, compound tangent ball, and leveling tripod, $210.00.

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

The Latitude Arc, *a*, has its centre 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 centre 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 of a little silver plate A, Fig. 26, fastened by screws to the inside of the opposite block.

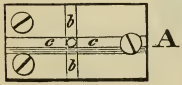


Fig. 26.

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.

In Fig. 25 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.

Equatorial Sights.—On the top of each of the rectangular blocks is seen a little sighting-piece, termed the equatorial sight, fastened to the block by a small milled head-screw, so as to be detached at pleasure.

They are used, as will be explained hereafter, in adjusting the different parts of the solar apparatus.

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 centre 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 centre 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 centre, 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 centre 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 centre 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 centre, 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*, in Fig. 26, 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*, Fig. 25.

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, *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 centre 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 centre 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*, Fig. 27, which is screwed into the top of the tripod like the ordinary leveling head.

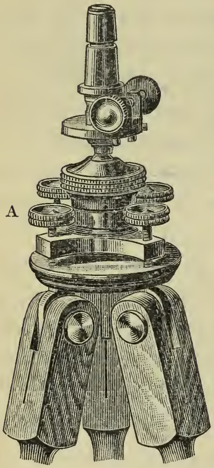


Fig. 27.

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.

A simple ball with extra cap is also supplied, which can be substituted for the compound ball, by unscrewing the cap which confines it, as shown in the figure.—The price of the leveling adopter, without tripod or ball spindle, is $7.00; with tripod and compound tangent ball, as shown in Fig. 27, $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.

Explanation of the Table of Refractions.

The table is calculated for latitudes between 30° and 50° at intervals of $2\frac{1}{2}$°, 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, 1883, 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, 1883,

N. 10° 6′ 2″ +

N. 10° 6′ 2″ +	Refr. 5 hrs.	1′ 58″	=10° 8′ 0″	=Dec. at	7 A.M. Troy
add hr. dif. 53″					
N. 10° 6′ 55″ +	" 4 "	1′ 11″	=10° 8′ 0″.6	= "	8 "
add hr. dif. 53″					
N. 10° 7′ 48″ +	" 3 "	0′ 52″	=10° 8′ 40″	= "	9 "
add hr. dif. 53″					
N. 10° 8′ 41″ +	" 2 "	0′ 39″	=10° 9′ 20″	= "	10 "
add hr. dif. 53″					
N. 10° 9′ 34″ +	" 1 "	0′ 36″	=10° 10′ 10″	= "	11 "
add hr. dif. 53″					
N. 10° 10′ 27″ +	" 0 "	0′ 36″	=10° 11′ 03″	= "	12 M.
add hr. dif. 53″					
N. 10° 11′ 20″ +	" 1 "	0′ 36″	=10° 11′ 56″	= "	1 P. M.
add hr. dif. 53″					
N. 10° 12′ 13″ +	" 2 "	0′ 39″	=10° 12′ 52″	= "	2 "
add hr. dif. 53″					
N. 10° 13′ 06″ +	" 3 "	0′ 52″	=10° 13′ 58″	= "	3 "
add hr. dif. 53″					
N. 10° 13′ 59″ +	" 4 "	1′ 11″	=10° 15′ 10″	= "	4 "
add hr. dif. 53″					
N. 10° 14′ 49″ +	" 5 "	1′ 58″	=10° 16′ 50″	= "	5 "

Again, suppose it was desired to obtain the corrected declination for the different hours of Oct. 16, 1883, at Troy, N. Y.

The difference in time being nearly 5 hours, and the declination at Greenwich, noon, S. 8° 51′ 47″.7, 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. 8° 51′ 47″.7	– Refr.	5 hrs.	9′ 24″ = 8° 42′ 23″ =	Dec. at	7	A.M.	at Troy
add hr. dif. 55″							
S. 8° 52′ 42″	– “	4 “	2′ 49″ = 8° 49′ 53″ =	“	8	“	
add hr. dif. 55″							
S. 8° 53′ 37″	– “	3 “	1′ 49″ = 8° 51′ 48″ =	“	9	“	
add hr. dif. 55″							
S. 8° 54′ 32″	– “	2 “	1′ 26″ = 8° 53′ 06″ =	“	10	“	
add hr. dif. 55″							
S. 8° 55′ 27″	– “	1 “	1′ 14″ = 8° 54′ 13″ =	“	11	“	
add hr. dif. 55″							
S. 8° 56′ 22″	– “	0 “	1′ 14″ = 8° 55′ 08″ =	“	12	M.	
add hr dif. 55″							
S. 8° 57′ 17″	– “	1 “	1′ 14″ = 8° 56′ 03″ =	“	1	P. M.	
add hr. dif. 55″							
S. 8° 58′ 12″	– “	2 “	1′ 26″ = 8° 56′ 46″ =	“	2	“	
add hr. dif. 55″							
S. 8° 59′ 07″	– “	3 “	1′ 49″ = 8° 57′ 18″ =	“	3	“	
add hr. dif. 55″							
S. 9° 00′ 02″	– “	4 “	2′ 49″ = 8° 57′ 13″ =	“	4	“	
add hr. dif. 55″							
S. 9° 00′ 57″	– “	5 “	9′ 24″ = 8° 51′ 33″ =	“	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 centre-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.

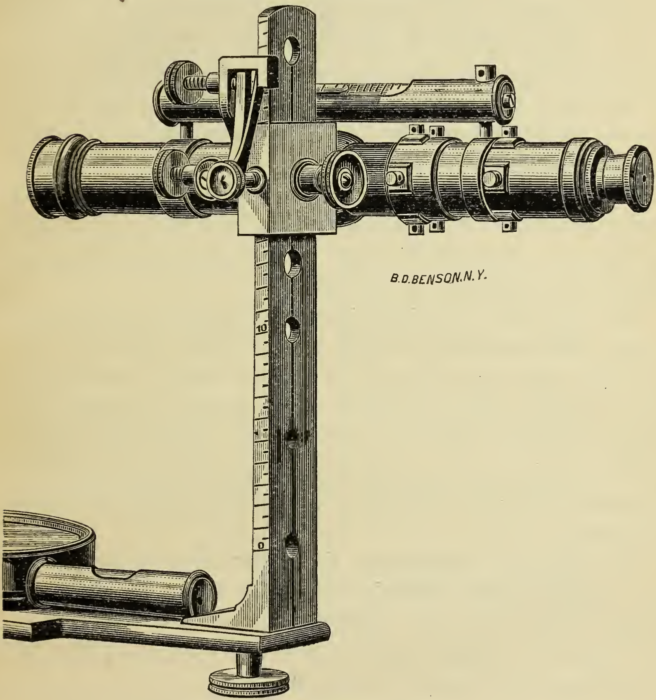


FIG. 28.

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 centre 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, believing that when its merits become better understood, it will come into more general use.

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, in Fig. 25.

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, as shown in Fig. 27.

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 14½ lbs.

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.								
	+20°	+15°	+10°	+5°	0°	−5°	−10°	−15°	−20°
	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 51	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′39″
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	

HOUR ANGLE.	DECLINATIONS.								
	For Latitude 42° 30′.								
	+20°	+15°	+10°	+5°	0°	−5°	−10°	−15°	−20°
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		
	For Latitude 45°.								
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 58	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			

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 centre-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.

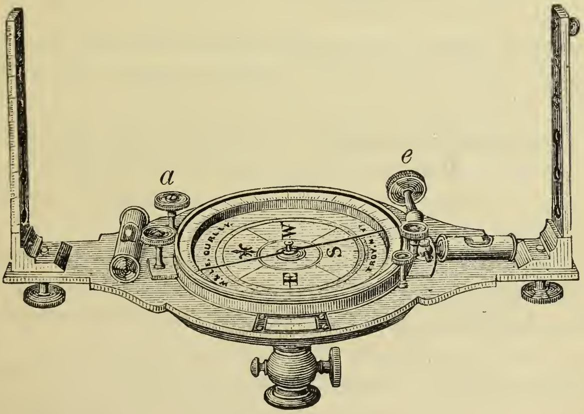


Fig. 29.

Price as shown above, with two verniers to limb, $5\frac{1}{2}$-inch needle and jacob-staff mountings, $75.00.

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.—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 in Fig. 29, 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, the openings through which they are seen being covered with slips of glass to protect the divisions from dust and moisture; only one of the verniers is shown in the cut.

The connection between the two plates is made by a clamp and tangent movement shown at *e*, 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 near the clamp-screw, on the same end of the plate.

On the opposite side of the compass-circle is seen the head, *a*, 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 centre 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 near the letter S in the cut.

Near the pinion-head is also 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 compass-ball, or still better, the tangent-ball already described, placed either in a jacob-staff socket, a compass tripod, or the leveling socket and tripod as shown with the solar compass.

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 centre 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 centre by the pinion *a*.

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 ten and a half 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 eleven pounds, and the five-inch, ten and a half 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 Fig. 30, has its compass-circle, to which is attached a "vernier," movable about a common centre 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 centre 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.

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

VERNIER COMPASS—6-INCH NEEDLE.

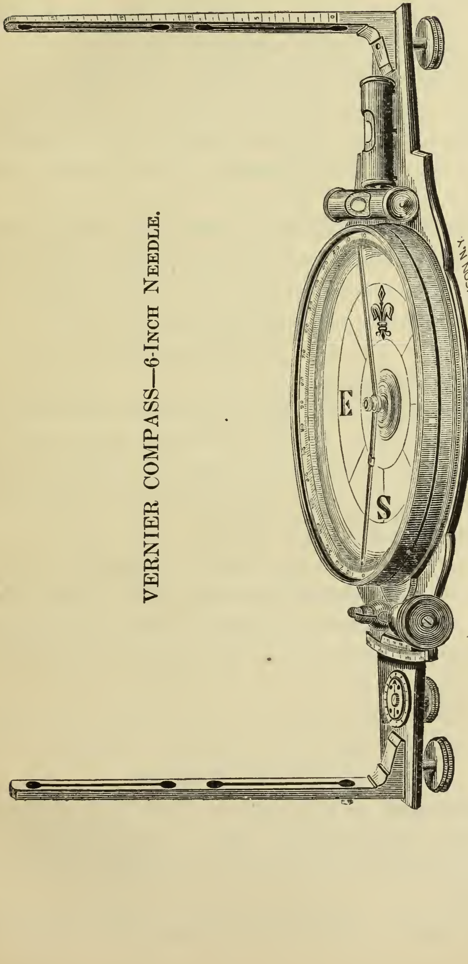


FIG. 30.

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 centres 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 centre-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 1865, N. 31° E., would in 1883, with the same needle, have a bearing of about N. 32° 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 centre 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 15° to 16° to the east, while in Maine it is from 17° to 18° to the west.

At Troy, in the present year, 1884, the variation is about 10° to the west, and is increasing in the same direction from two to three 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 centre, 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 centre, 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 centre-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 centre-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 centre-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 centre-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 retraced 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 centre 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 Centre-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 5½, 7½ and 9½ pounds.

THE PLAIN COMPASS.

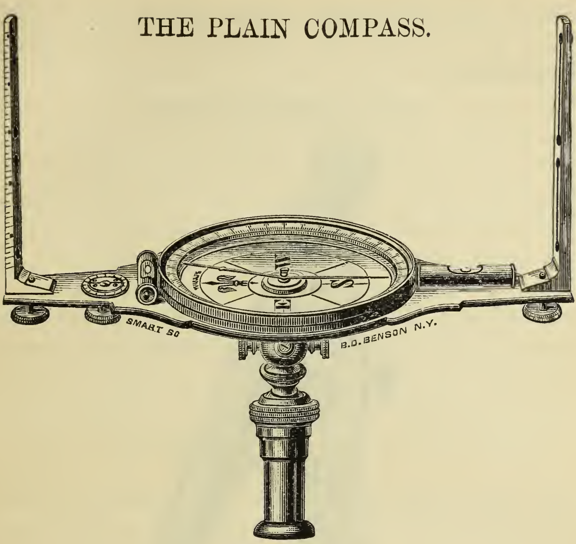


Fig. 31.

Price, with 6-inch needle and jacob-staff mountings, $35.00.

As represented in Fig. 31, the Plain Compass has a 6-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.

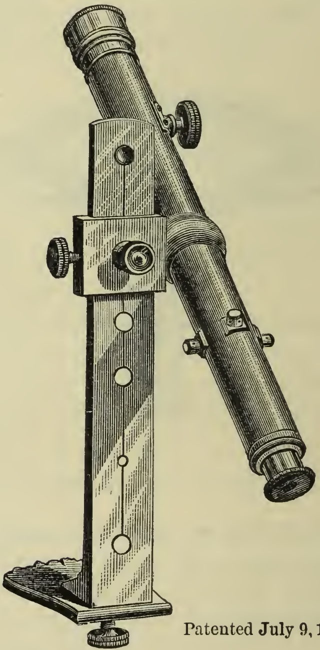


Fig. 32.

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, that the band may be set at the same point in subsequent use.

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

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

The Adjustments

Of the Telescopic Sight are as follows:

(1) To make the telescope axis horizontal.

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

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

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

To make the first adjustment :

(1) The compass being in good order, first bring the levels into the centre ; place the band in position upon the sight, as before described ; bring the telescope into focus and set the vertical cross-wire on the vertical edge of a building, distant from fifty to sixty feet, and at a point near the ground ; clamp the compass to the spindle, and 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 clamp-screw on the left, and with a small screw-driver turn in the little screw on the right side of the band and under the axis until the correction is made.

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

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

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

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

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

It should be here remarked that the adjustment just described, and which is usually termed the adjustment of the line of collimation, is fully described in 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 two screws in front of the band, as already described in the previous adjustment, until the correction is made ; and the telescope will then bisect the same object in either direction, as is indicated by the sight-vanes.

Of course, when the telescopic sight is fitted by us, either to a new or old compass, the adjustments above described are all completed before the instrument is sent out of our hands, but we have been thus minute in our description of them in order that surveyors sending for this 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 centre wire, and each fastened to a movable piece which is controlled by a screw on the outside of the telescope. The distance between the stadia wires can thus be adjusted so as to cover a certain vertical space on a divided rod, held at a given distance from the centre of the instrument, usually one foot or one link on the rod to one hundred feet or 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,	$5\frac{1}{2}$	lbs.
For the 5-inch	"	$6\frac{1}{2}$	"
For the 6-inch	"	8	"

POCKET INSTRUMENTS.

THE POCKET SOLAR COMPASS.

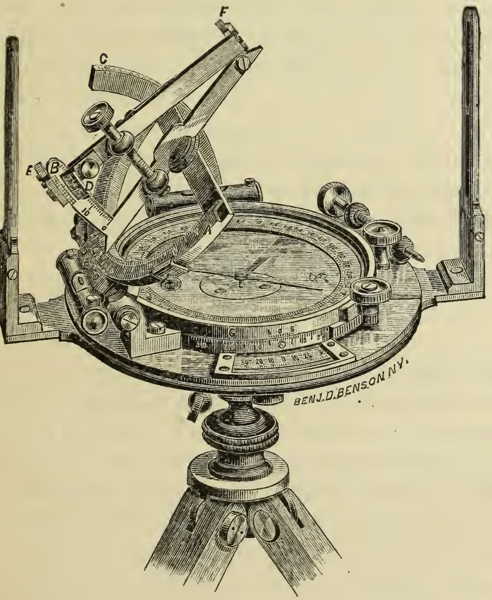


FIG. 33.

Price, with	Staff Mountings	$100 00
"	" Light Tripod, as in Fig. 33	105 00
"	" Light Extension Tripod	110 00
"	" " " and Leveling Plates	120 00
"	of Side Telescope and Counterpoise fitted to New Pocket Solar Compass	25 00
"	of Leather Case with Shoulder Strap for New Pocket Solar Compass	5 00

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, well shown in Fig. 33, 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 also a clamp with tangent-screw between the two plates, and another to the whole instrument about its spindle.

The distance between the sights is nearly 7 inches, the sights themselves are 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 flange of the upper plate, and consists of the usual *hour, latitude,* and *declination arcs,* marked respectively A C and B in the cut, with an arm, F F, to the last named, carrying the solar lenses and lines as in the larger instruments. The latitude and declination arcs are each divided to half degrees, and read by verniers, the latitude arc to five minutes, and the declination arc to single minutes of a degree; the hour arc is divided on its inner edge into hours and twelfths, or spaces of five minutes each, the index of the declination arc above easily enabling one to read the time to single minutes.

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

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

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

The Pocket Solar is set up for use either upon a ball spindle, with staff mountings, or as in Fig. 33, 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.

POCKET RAILROAD COMPASS.

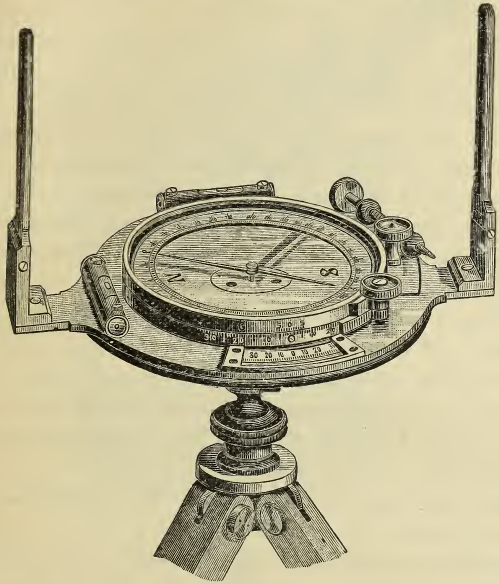


FIG. 34.

Price as shown, with tripod, $45.00.

This instrument is a single vernier Railroad Compass in miniature, the arrangement of the plates being in appearance very similar to those of the Pocket Solar just described, except that the compass-circle with levels, sights, &c., is now on the upper or main plate.

The limb is on the lower plate, is five inches in diameter, and reads to single minutes by the vernier. The needle is 3½ inches long, and its variation can be set off to single minutes as in the larger instruments.

The Pocket Railroad 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 which we have just now introduced with staff mountings only will be $40, with light tripod $45, and if with extension tripod $50.

Another and more common form of this instrument is shown in Fig. 35, with attachments of telescope, etc.

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

The limb is underneath the compass-face, but not shown in the cut, and read by one double vernier under the glass to five minutes of a degree in the $3\frac{1}{2}$-inch needle instrument, and to single minutes in the one with $4\frac{1}{2}$-inch needle; the last-named has also a clamp and tangent to the limb, the $3\frac{1}{2}$-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 $4\frac{1}{2}$-inch needles we have recently adapted a telescopic attachment as in Fig. 35. When the sights are raised upright, a cross-piece is fastened by milled-head screws to their tops, and thus a telescope placed in position, making the instrument in effect a very light Surveyors' Transit.

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

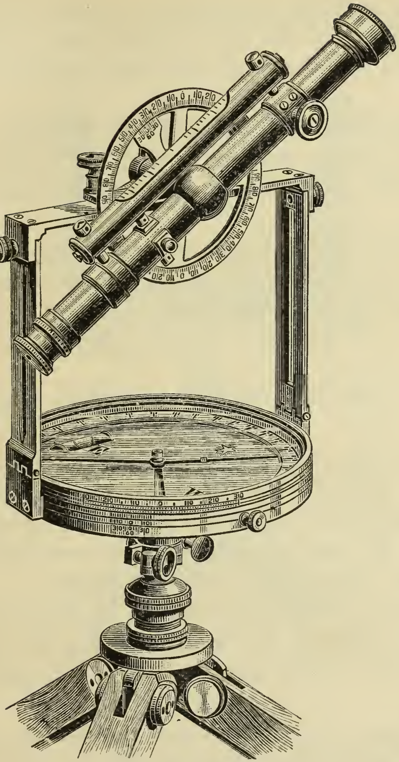


FIG. 35.

PRICES.

Railroad Pocket Compass, $4\frac{1}{2}$-inch needle, clamp and tangent to limb, with limb reading to one minute, with jacob-staff mountings................	$28 00
Tripod for Pocket Compass..	5 00
Clamp and Tangent Movement to ball spindle..............	5 00
Telescope No. 131, with vertical circle, level on telescope and clamp and tangent to telescope axis..	32 00
Or complete, as shown in Fig. 35...	70 00
" " " and with stadia wires.....................	73 00

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

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

The Pocket Railroad Compass can be used either on a jacob-staff, or with small tripod, as in Fig. 35, and if desired, with small leveling head.

THE VERNIER POCKET COMPASS. (Fig. 36.)

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 $3\frac{1}{2}$ and $4\frac{1}{2}$ inches respectively; the smaller size has the compass-circle divided to single degrees, and the variation vernier reads to five minutes; in the $4\frac{1}{2}$-inch size, the circle is divided to half-degrees, and the variation set off to single minutes. When desired, a rack-movement with pinion is supplied, in order to set off the variation more readily. (See "Pocket Compasses and Extras," in Price List.)

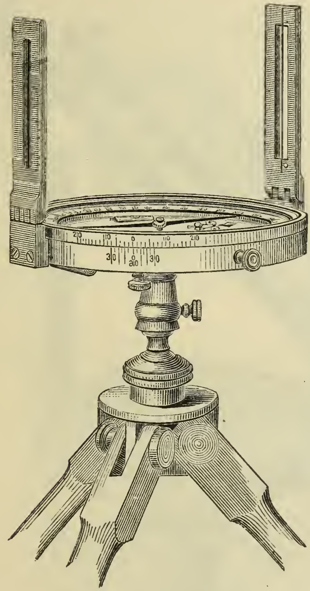


Fig. 36.

Price as shown, 3½-inch needle, with tripod, $21.00.
If 4½-inch needle, and tripod, 23.00.

TELESCOPIC ATTACHMENT, ETC.

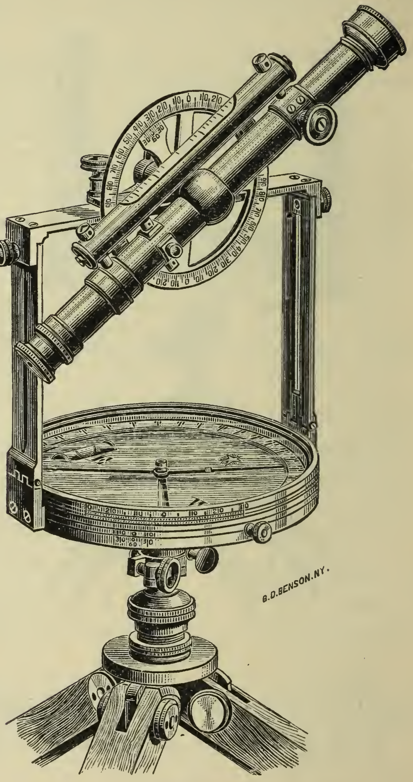


FIG. 37

Price, complete as shown, $60.00.

(See Price List No. 161.)

Fig. 37 shows the arrangement for attaching to the sights of the 4½-inch Vernier Pocket Compass a telescope and extras, 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 centre, 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 cross-piece 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 in Fig. 37, is very generally added.

THE PLAIN POCKET COMPASS.

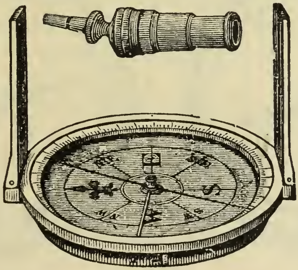


FIG. 38.

See Price List Nos. 150 to 154.

Besides the Vernier Pocket Compass we also furnish an instrument without a vernier, but often a very serviceable compass.

These are made of $2\frac{1}{2}$ or $3\frac{1}{2}$-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.

MINERS' OR DIP COMPASSES.

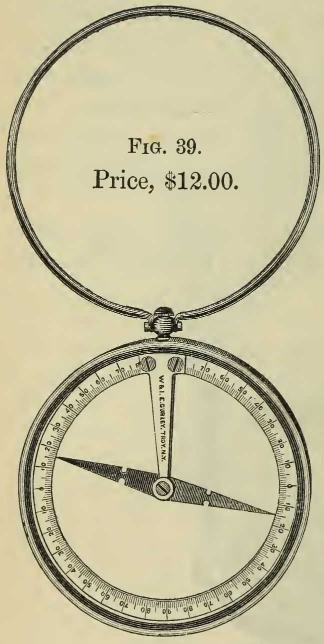


Fig. 39.
Price, $12.00.

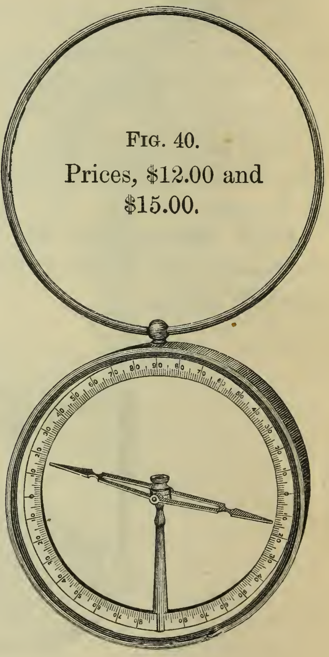


Fig. 40.
Prices, $12.00 and $15.00.

The Dip Compasses, two forms of which are shown in figures 39 and 40, 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; that shown in Fig. 39, with a 3-inch needle, has the two sides of glass, and is provided when desired with a stop for the needle, worked by the little brass knob between the ends of the ring.

Another form has a brass back with cover of the same material and a needle of $2\frac{1}{2}$ inches.

The Norwegian Compass, Fig. 40, 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.

The Norwegian Compass is usually provided with brass covers on both sides; Fig. 39 is packed in a light mahogany box.

THE DIAL COMPASS.

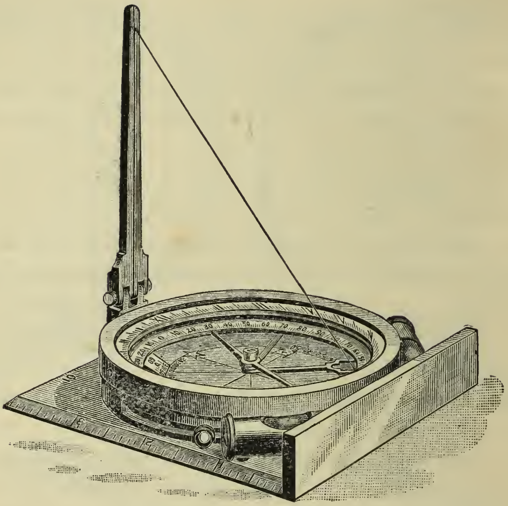


FIG. 41. Price, $16.00.

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 centre 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.

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. Its use as a clinometer has been already described.

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, Fig. 42, 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 (Fig. 43), 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.

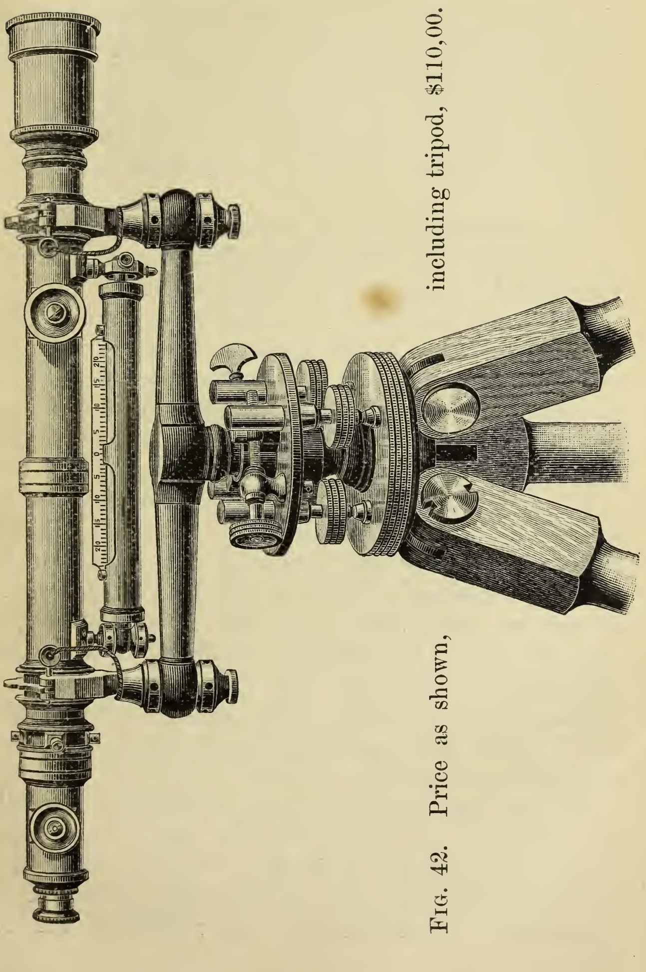


Fig. 42. Price as shown, including tripod, $110,00.

The interior construction of the telescope will be readily understood from Fig. 43, 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 in Fig. 43.

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

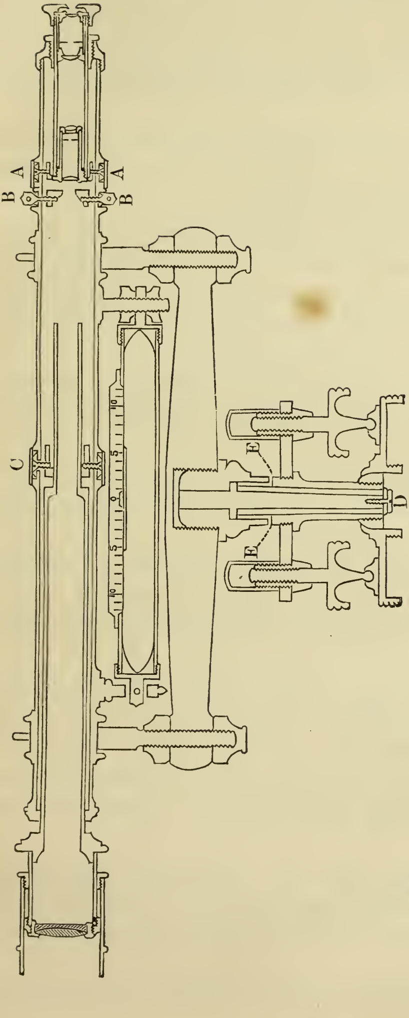


FIG. 43.

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 centre 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 centre 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 centre 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 vertical position of the level and 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 Tripod-Socket is compound ; the interior spindle D, Fig. 43, 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 tripod-head.

The bronze cylinder is held upon the spindle by a washer and screw, the head of the last having a hole in its centre, 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 tripod-head ; and this also, as in the case of all our instruments, can be unscrewed from the legs, so that both may be conveniently packed in the box.

A little under the upper parallel plate of the tripod-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 in the tripod 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, however, is commonly single.

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 centre 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 (Fig 43), 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 centre of the field of view, by moving the little screws A A (Fig. 43), 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 own 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 tripod-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 (Fig. 43) at A A, and move each pair in succession with a small screw-driver, nntil the wires are brought into the centre 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 centre of the tube.

Now turn the telescope in the wyes, so as to bring the level-tube on either side of the centre of the bar. Should the bubble run to the end, it would show that the vertical plane, passing through the centre of the bubble, was not parallel to that drawn through the axis of the telescope rings.

To correct the error, bring the bubble entirely 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 centre of the bar, and the bubble to the centre, 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 centre 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 centre 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 centre 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 centre during an entire revolution of the instrument.

To do this, bring the level-tube directly over the centre 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 centre, 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 centre, 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 vertical-wire may be applied to the edge of a building, 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 vertical ; 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 centre 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 tripod-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 shock to the bar, taking care also to hold his hands so as to grasp it the moment it is free.

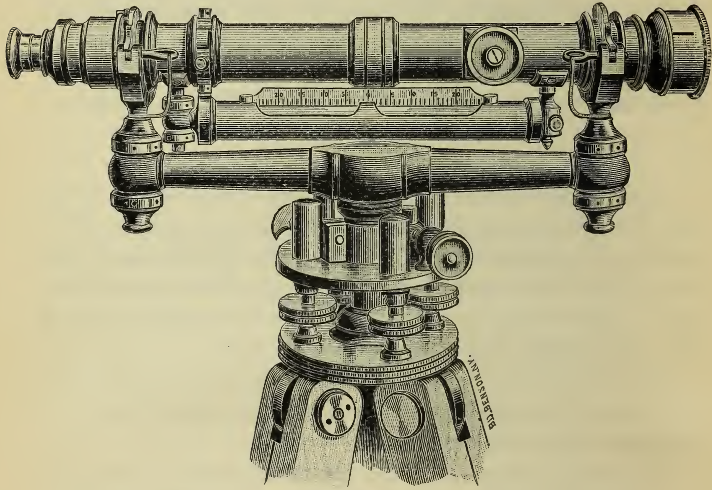


FIG. 44.

Price as shown, with tripod, $90.00.

Our fifteen-inch Level is shown in Fig. 44; it 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 is also somewhat smaller and lighter than those of the other sizes.

Weight of Leveling Instruments.

The average weights of the different sizes of this instrument, exclusive of the tripod-legs, are as follows:

15-inch telescope, with leveling head	11 lbs.
18-inch " "	12½ "
20-inch " "	13½ "
22-inch " "	14 "

THE ARCHITECTS' LEVEL.

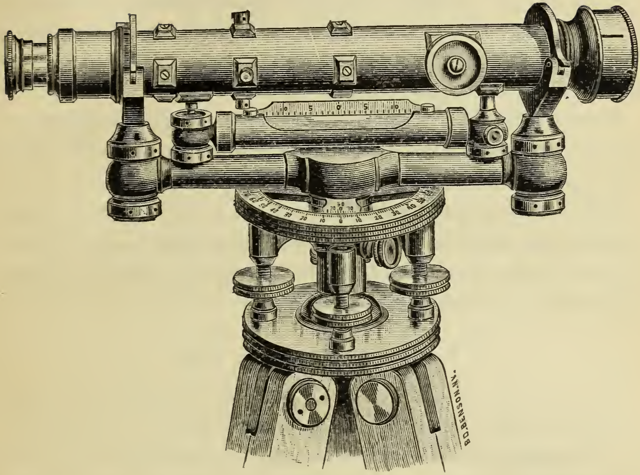


FIG. 45.

Price as shown, with tripod, $45.00.

The figure represents the level introduced by us nine years ago, and which has since been very largely used by architects, builders, and millwrights in all sections of the country.

It has a telescope of 11 inches, mounted in wyes as usual; furnished with the accessories of the larger instruments, 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 when the telescope is directed towards it.

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 centre 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 centre 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 screws at the ends, and go over the adjustment until the bubble will stand in the centre 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 centre 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 centre-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 centre-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, Fig. 46, 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 centre the bubble, the point of the plummet below indicating the required distance of the side of the new building from the front A B.

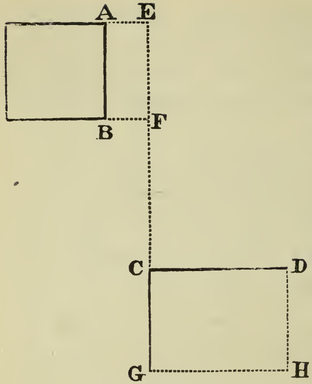


Fig. 46.

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 centre 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.

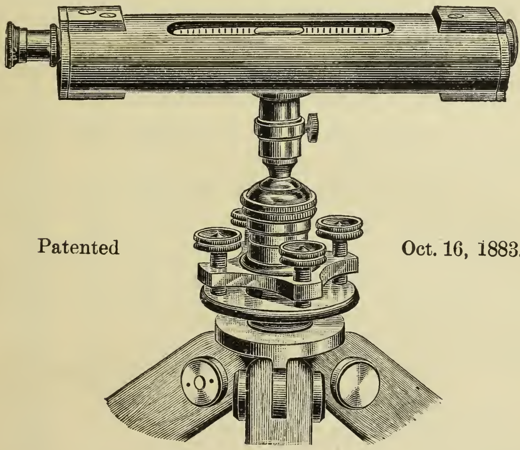
Other applications of the Level—as the setting of floor timbers, of window and door sills, the leveling of floors, etc., will readily occur to one who has been engaged in building, where it can be made of very great and increasing advantage, as he becomes familiar with its use.

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 millpond, 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.

FIG. 47.

PRICES.

Farmers' or Drainage Level,		with jacob-staff mountings	$15 00
do	do	with plain tripod....	20 00
do	do	with tripod and leveling screws	25 00

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

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 two screws 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.

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

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

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

The simple sliding leveling rod (Fig. 53) 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.

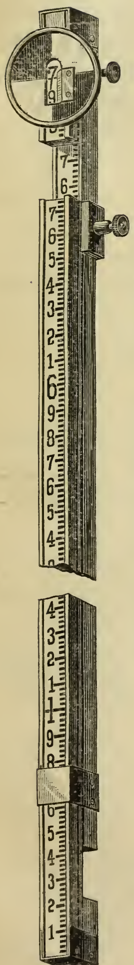


FIG. 48.—*Philadelphia Rod.* Price, $16.00.

THE PHILADELPHIA ROD.

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 an inch long, the tenth figures black and eight-tenths of an inch long. 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.

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 two 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 two hundredths of a foot.

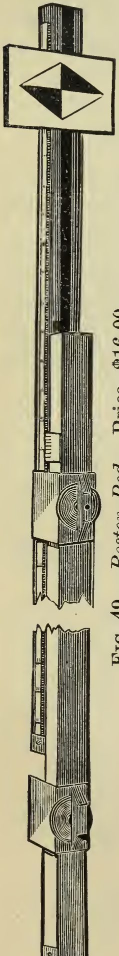


FIG. 49.—*Boston Rod.* Price, $16.00.

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 slid out, the scale on the back giving the readings like those of the target to two hundredths of a foot.

THE BOSTON ROD

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

FIG. 50.—*New York Rod.* Price, $16.00.

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 NEW YORK ROD.

This rod, which is shown in the engraving as cut in two, so that the ends may be exhibited, is made of maple, in two pieces like the former, but 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; 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.

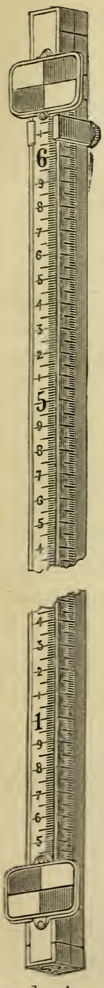


FIG. 51.—*The Troy Rod.* Price, $10.00.

Fig. 51 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 centre 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 from the top downwards, beginning with three-tenths, that being the height of the centre 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.

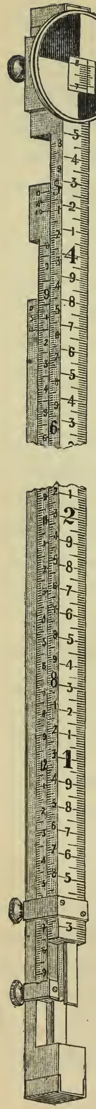


FIG. 52.—*New York Rod, in 3 parts.* Price, $18.00.

THE NEW YORK ROD.

(*Patented Oct. 23, 1883.*)

In 3 or 4 Parts.

We have just introduced a modification of this favorite rod, which we believe will be generally approved.

In the new rod as shown in Fig. 52, 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 thirteen 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.

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.

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 in Fig. 53 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

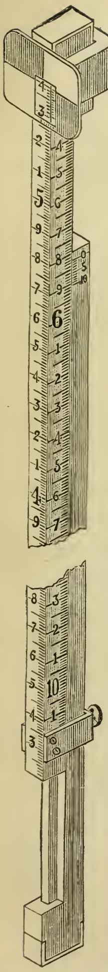


FIG. 53.—*Architects' Rod.* Price, $6.00.

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.

METRIC RODS.

Besides the usual divisions of the leveling rods into parts of a foot, we also divide both the Philadelphia and New York Rods into meters, decimeters, and centimeters, the scales on the target and sides of the rods reading the centimeters to millimeters.

TELEMETER RODS.

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 a simple observation in the same manner as the Philadelphia Rod already described. Price, $12.00.

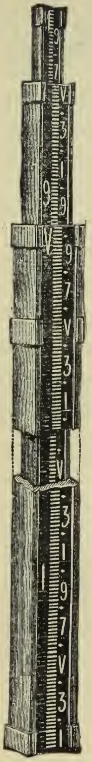


FIG. 53A.—*English Rod.* Price, $24.00.

ENGLISH OR TELESCOPIC ROD.

A rod of English make 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.

We also furnish this rod with divisions in meters, decimeters, and centimeters; length when closed one and a half meters, and sliding out to four meters.

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.

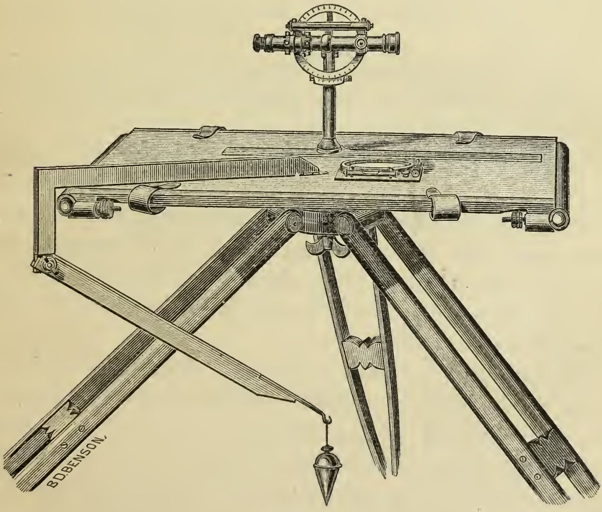


FIG. 54.

Price as shown, $130.00. (See No. 92 in Price List.)

As shown in Fig 54, the Plain 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 in Fig. 55, 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-ring 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.

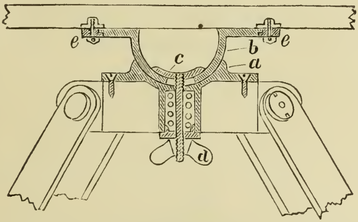


FIG. 55.

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.

THE ALIDADES.

The different styles of our Plane Tables vary only in their Alidades, of which we make four kinds.

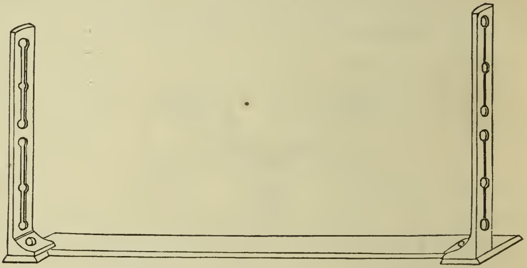


Fig. 56.

Price $15.00. (See No. 90 in Price List.)

(1.) The first or most simple Alidade is shown in Fig. 56, 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.

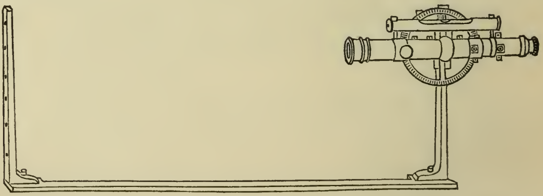


Fig. 57.

Price, $50.00. (See No. 91 in Price List.)

(2.) Fig. 57 shows the simple Alidade (Fig. 56), 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.

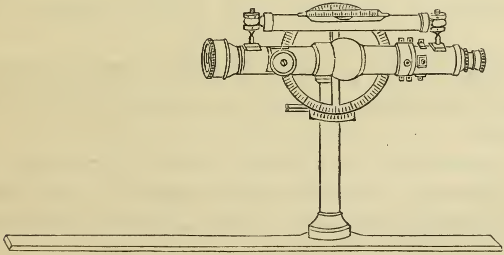


FIG. 58.

Price, $90.00. (See No. 93 in Price List.)

(4.) In the Alidade shown in Fig. 58, the telescope is precisely the same as that used on 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.

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*, Fig. 55; 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 centre 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.

SMALLER INSTRUMENTS AND APPLIANCES.

LOCKE'S HAND LEVEL

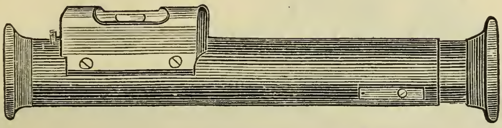


FIG. 59. Prices, $9.00 and $10.00.

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.

A short telescope is sometimes applied in place of the plain glass ends and enabling levels to be taken at greater distances and with increased accuracy.

THE ABNEY LEVEL AND CLINOMETER.

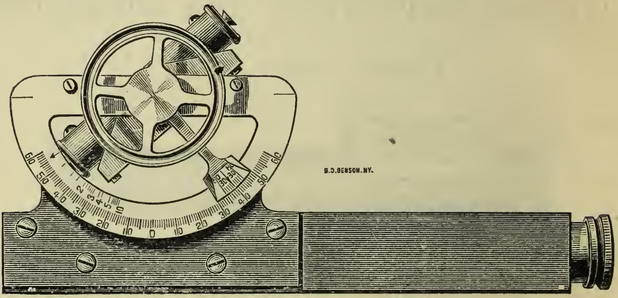


FIG. 60. Price, $15.00.

The Abney Level, Fig. 60, is an English modification of that shown in Fig. 59, combining with it an excellent clinometer as represented in the cut.

Here, when the level is brought to the centre 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 centre, 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 edge of the vernier being applied to the lines and the bubble brought into the centre as usual.

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.

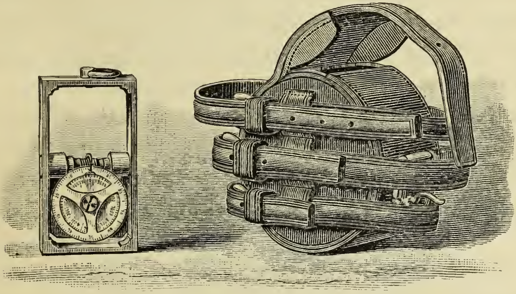


FIG. 61. Price, $15.00.

The odometer shown in Fig. 61, 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 at the right of Fig. 61. 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 in Fig. 62.

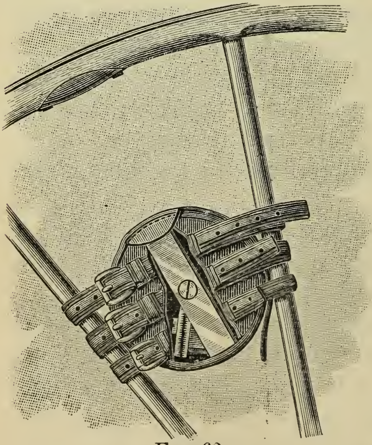


FIG. 62.

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 in Fig. 63, the pendulum of which is fastened to a shaft turning in the centre of a strong circular metal box. On this shaft and turning with it is a pinion giving motion to a train 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.

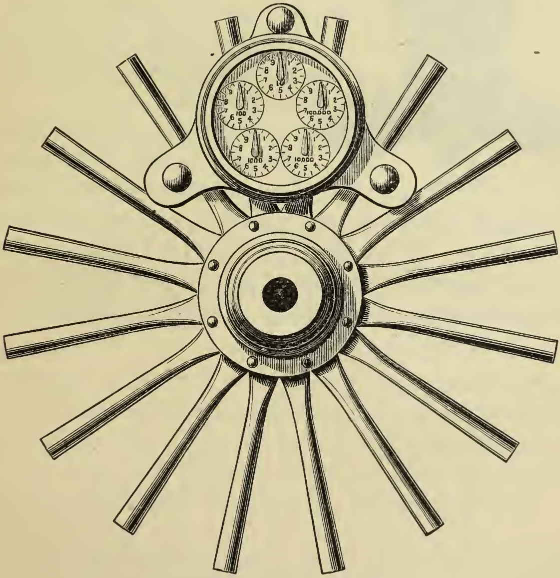


Fig. 63. Price, $10.00.

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.

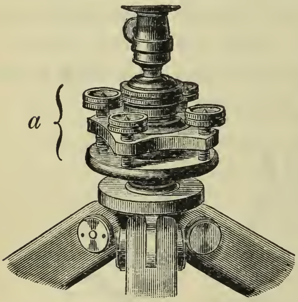


FIG. 64.

Leveling Adopter.—We have just introduced the appliance shown in Fig.64, at *a*, for use with the Pocket Compasses, &c., giving in connection with the ball, a rapid and accurate means of leveling any of the smaller instruments.

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. (See Price List No. 173.)

We also make a larger size of the adopter for use with our larger compasses. Price, $7.00. (See Price List No. 126.)

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 above, 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, sometimes of mahogany, 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 three sizes of extension tripods of which the medium size is shown in Fig. 17, in our account of the Mountain Transit, and is used with 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.

QUICK LEVELING TRIPOD.

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, as shown hereafter.

The arrangement of this attachment will be readily understood by inspection of the following cuts:

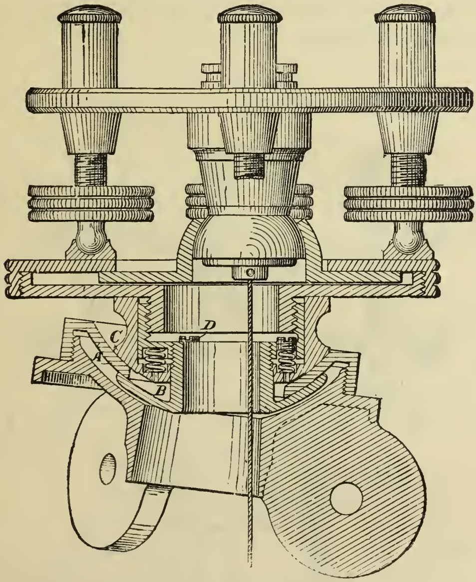


FIG. 65.

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.

Fig. 65 shows the Quick Leveling Tripod with shifting plate for use with transit.

QUICK LEVELING ATTACHMENT.

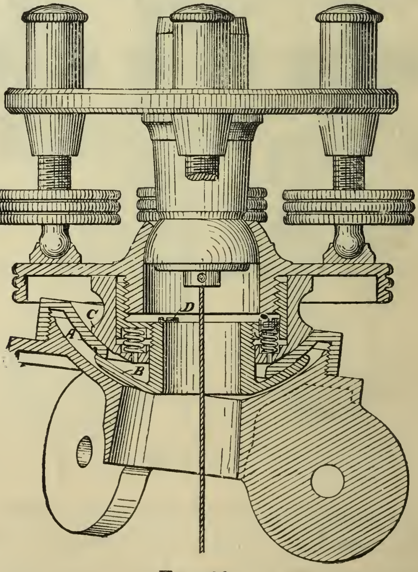


FIG. 66.

Fig. 66 shows the Quick Leveling Tripod-head designed for level or transit, and without shifting plate.

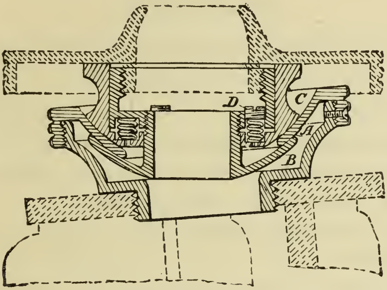


FIG. 67.

Fig. 67 shows the Quick Leveling Attachment as screwed fast to a tripod of any pattern now in use.

Prices.—As shown in Figs. 65 and 66, when furnished with a new instrument, $5.00. For same, adapted to any instrument already in use, as in Fig. 67, $6.00.

N. B.—When Fig. 67 is ordered for any instrument, the lower plate of the leveling-head, as shown in outline of same figure, or the brass head of the tripod, the legs being removed, may be sent to us by mail or express, prepaid, with the remittance of—say $7.00—to pay for attachment and return charges.

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 and Leveling instruments of bronze finish, and Compasses of bright finish.

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 made whenever desired, and without any additional charge.

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 a sixteenth larger.

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 handles, tallies, &c., and sometimes with a swivel in the middle to avoid being twisted in use.

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.

Sizes of Wire, &c.—The wires used for these chains is of sizes Nos. 8 and 10, is of the first quality and the whole chain 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 lightness and 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, 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,

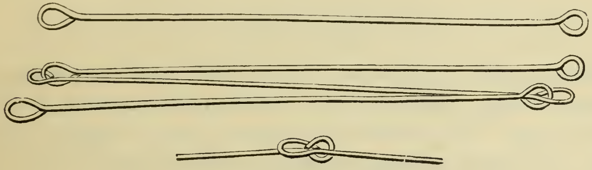


Fig. 68.

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-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 hereafter be able to furnish them promptly.

Vara Chains.

The Spanish or Mexican Vara, which is in very general use in Texas, Mexico, Cuba and South America, is $33\frac{1}{3}$ 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, $6\frac{2}{3}$ 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 ten, each way, 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.

Metre Chains.

The French Metre is very generally used as a standard in South America, the West Indies, &c., and chains of ten and twenty metres are often ordered; they are made either of iron or steel wire as desired, the number of links to a metre 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 jointed at intervals, 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 three 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.

STANDARD STEEL RIBBONS.

These are made of a thin ribbon of steel, $\frac{3}{8}$ to $\frac{1}{2}$ inch wide, 33 feet to 500 feet in length, and in one piece. They are coming into general use for bridge work, also for testing chains and tapes. They are graduated and mounted as described in the Price List, Nos. 345 to 348.

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. 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.	
° ′											° ′
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	9839	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	98 5	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	7951	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.		Dist. 7.		Dist. 8.		Dist. 9.		Dist. 10.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	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	1897	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.	
	Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		Dist. 10.		Course

Course	Dist. 1.		Dist. 2.		Dist. 3.		Dist. 4.		Dist. 5.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
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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	0555	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. 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.	
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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	1325	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-FIFTH EDITION OF MANUAL.

JANUARY, 1884.

☞ 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 $15, according to the size of the cases, which are made of morocco, rosewood, walnut, or mahogany.

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 intruments, 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 at a cost of one cent per ounce.

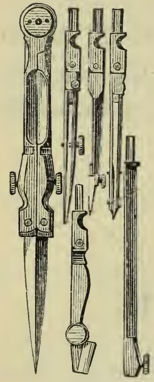
In all cases where goods are to be sent by mail, the cash for postage as well as for the goods must accompany the order.

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,

SWISS DRAWING INSTRUMENTS.

OF GERMAN SILVER, EXTRA FINE FINISH.



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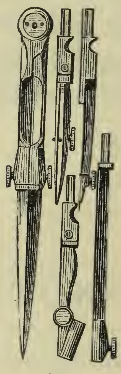

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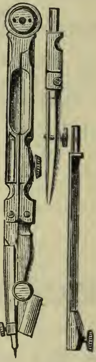

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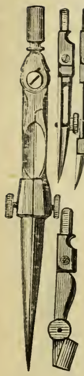
No.		PRICE
400.	Drawing Compass, joints in legs, $6\frac{1}{2}$ inches long, with pen, pencil-holder, needle point, lengthening bar and dot. pen	$9 00
401.	Drawing Compass, 6 inches long, with pen, pencil-holder, lengthening bar and needle-point	6 50
402.	Drawing Compass, $6\frac{1}{2}$ inches long, with fixed Needle Point and Loose Pen and Pencil Points and Lengthening Bar	6 00
403.	Hair Spring Dividers, $4\frac{1}{2}$ inch	2 25
404.	" " $5\frac{1}{2}$ inch	2 50
405.	Plain Dividers, $4\frac{1}{2}$ inch	1 50
406.	" 5 inch	1 75
407.	" 6 inch	2 35
408.	Drawing Compass, 4 inch, with pen, pencil-holder, and needle-point	5 00
409.	Drawing Compass, 4 inch, with fixed needle-point, and pen and pencil-point, changeable	4 50
410.	Proportional Dividers, $6\frac{1}{2}$ inches long, finely graduated for lines	8 00
411.	Proportional Dividers, $6\frac{1}{2}$ inches long, finely graduated for lines and polygons	8 75
412.	Proportional Dividers, 9 inches long, finely graduated for lines and polygons	10 00
413.	Proportional Dividers, 9 inches long, with micrometer adjustment (413), finely graduated for lines and polygons	12 00
414.	Proportional Dividers, 8 inches long, with rack adjustment, graduated for lines	10 50



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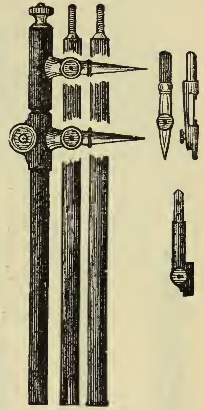

416.

No.					Price
415.—	Beam Compass,	19-20 inches long,	in 2	German Silver bars............	9 25
416.—	"	21	" 3	"	10 50
417.—	"	36	" 4	"	15 00
418.—	"	54	" 4	"	21 00

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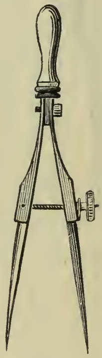
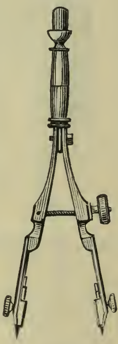
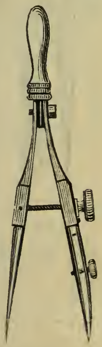
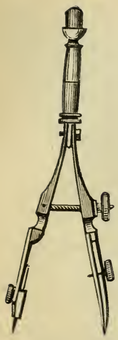
No.		Price
419.—	Triangular Compass	$4 25
420.—	Dotting Pen, with one wheel	2 00
421.—	Dotting Pen, in case, best article, with three wheels	3 75
422.—	Road or Double Drawing Pen	3 75
423.—	Road or Double Drawing Pen, Joint on each side	3 00
424.—	Pocket Dividers, with sheath	2 40
425.—	Bisecting Dividers	4 25
426.—	Universal Compass, with points to shift	7 25
427.—	" " " TURN	7 25
428.—	" " " change, and handles to bow pen and pencil	8 00



429. 430. 431. 433. 434. 435.

No.		Price
429.—	Dividers, 3½ inches long, with two fixed Needle Points	$3 00
430.—	Dividers, 3½ inches long, with fixed Needle Point and Pen Point	3 00
431.—	Dividers, 3½ inches long, with fixed Needle Point and Pencil Point	3 00
432.—	Large Steel Spacing Dividers, 5 inches	2 50
433.—	Small Steel Spacing Dividers, 3½ inches	1 50
434.—	Small Steel Spacing Dividers, 3½ inches long. with Needle Points	2 40
435.—	Small Steel Bow Pen, 3½ inches	1 90
436.—	Small Steel Bow Pen, with Needle Point	2 40
437.—	Small Steel Bow Pencil, 3½ inches	1 90
438.—	Small Steel Bow Pencil, with Needle Point	2 40
439.—	Bow Pen, German Silver "	2 00
440.—	Bow Pen, with pencil-holder, German Silver, with Needle Point	3 00
441.—	Eccentric Rule	2 00
442.—	Drawing Pen, with joint, 4½ inches long	1 25
443.—	" " 5¼ "	1 40
444.—	" " 6 "	1 60
445.—	Beam Compass furniture, for wood beams, $6 75 ; in Morocco box	7 00
446.—	Horn Curves, A, B, C, D, E, F, each	65
447.—	Drawing Compass, 4 inches, with long ivory handle, spring and micrometer, with two pens, pencil-holder and needle point	7 00



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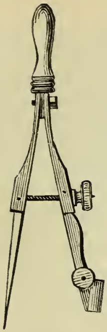

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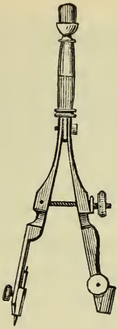

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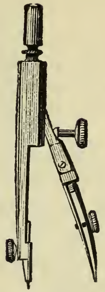

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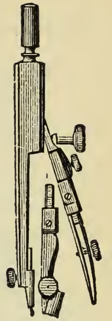

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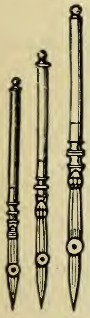
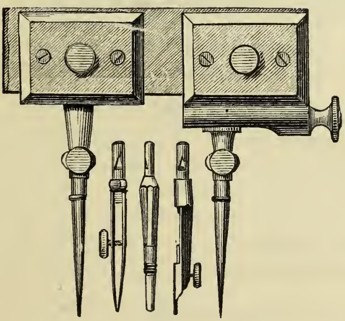


442. 443. 444.



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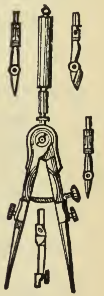


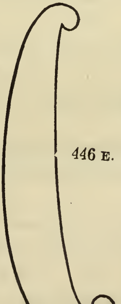
447.

446 A.

446 B.

446 C.

446 D.



446 E.

446 F.

No. PRICE

450.—Polar Planimeter, with printed instructions........................... $30 00

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.

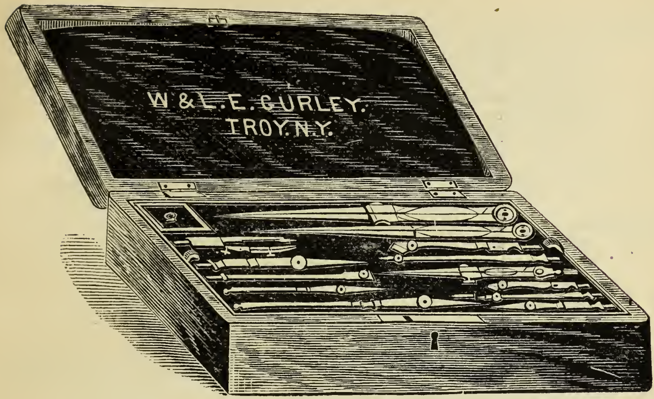
SETS OF EXTRA FINE SWISS DRAWING INSTRUMENTS.

The following sets have beautifully finished Mahogany or Walnut Boxes, 9½ inches long by 6 inches wide, with lock and key and tray.

460.—Contains pair plain Dividers, No. 406.
Set of Instruments, No. 401.
Steel Spacing Dividers, No. 433.
Steel Bow Pen, 3½ inches, No. 435.
Steel Bow Pencil, 3½ inches, No. 437.
Drawing Pen, No. 443.
Triangular Scale, 6 inch... $21 00

461.—Contains pair plain Dividers, No. 406.
Set of Instruments, No. 401.
Do. No. 408.
Drawing Pen, No. 442.
Do. No. 444.
Triangular Scale, 6 inch... 22 00

462.—Contains pair plain Dividers, No. 406.
Set of Instruments, No. 401.
Do. No. 408.
Bow Pen, German Silver, No. 439.
Drawing Pen, No. 442.
Do. No. 444.
Triangular Scale, 6 inch... 24 00



462.

No.		Price
463.—Contains pair plain Dividers, No. 406.		
	Pair Hair Spring Dividers, No. 404.	
	Set of Instruments, No. 401.	
	Steel Spacing Dividers, No. 433.	
	Steel Bow Pen, No. 435.	
	Steel Bow Pencil, No. 437.	
	Drawing Pen, No. 442.	
	Do. No. 444.	
	Triangular Scale, 6 inch	$25 00
464.—Contains pair plain Dividers, No. 406.		
	Pair Hair Spring Dividers, No. 404.	
	Set of Instruments, No. 401.	
	Do. No. 408.	
	Bow Pen, German Silver, No. 439.	
	Drawing Pen, No. 442.	
	Do. No. 444.	
	Triangular Scale, 6 inch	28 00

The following sets have beautifully finished Mahogany or Walnut Boxes, 13 inches long by 6 inches wide, with lock and key and tray.

465.—Contains pair plain Dividers, No. 406.		
	Set of Instruments, No. 401.	
	Steel Bow Pen, No. 435.	
	Drawing Pen, No. 442.	
	Do. No. 444.	
	Triangular Scale, 12 inch	20 00

No. PRICE

466.—Contains pair plain Dividers, No. 406.
Sets of Instruments, Nos. 401 and 408.
Steel Bow Pen, No. 435.
Steel Bow Pencil, No. 437.
Drawing Pens, Nos. 442 and 443.
Triangular Scale, 12 inch.......................... ....$26 50

The following sets have beautifully finished Rosewood Boxes, 13 inches long by 7½ inches wide, with lock and key and tray.

467.—Contains pair plain Dividers, No. 406.
Pair Hair Spring Dividers, No. 404.
Sets of Instruments, Nos. 401 and 408.
Pair Steel Spacing Dividers, No. 433.
Steel Bow Pen, No. 435.
Steel Bow Pencil, No. 437.
Drawing Pens, Nos. 442, 443, and 444.
Triangular Scale, 12 inch.......................... .... 33 00

468.—Contains pair plain Dividers, No. 406.
Pair Hair Spring Dividers, No. 404.
Sets of Instruments, Nos. 401 and 408.
Proportional Dividers, No. 410.
Steel Spacing Dividers, No. 433.
Steel Bow Pen, No. 435.
Steel Bow Pencil, No. 437.
Drawing Pens, Nos. 442, 443, and 444.
Triangular Scale, 12 inch.................................. . ... 40 00

469.—Contains pair plain Dividers, No. 406.
Pair Hair Spring Dividers, No. 404.
Sets of Instruments, Nos. 401 and 408.
Proportional Dividers, No. 411.
Steel Spacing Dividers, No. 433.
Steel Bow Pen, No. 435.
Steel Bow Pencil, No. 437.
Beam Compass, No. 416.
Drawing Pens, Nos. 442, 443, and 444.
Road Pen, No. 423.
Dotting Pen, one wheel, No. 420.
Triangular Scale, 12 inch 57 00

The following set has beautifully finished Rosewood Box, 15½ inches long by 10 inches wide, with lock and key and tray, and lined with finest silk velvet.

470.—Contains pair plain Dividers, No. 406.
Pair Hair Spring Dividers, No. 404.
Set of Instruments, No. 400.
Proportional Dividers, No. 413.
Steel Spacing Dividers, Nos. 432 and 433.

No. PRICE

Beam Compass, No. 417.
Steel Bow Pen, No. 435.
Set of Instruments, No. 447.
Steel Bow Pencil, No. 437.
Drawing Pens, Nos. 442, 443, 444.
Road Pen, No. 422.
Dotting Pen with 3 wheels, No. 421.
Protractor, No. 623.
Triangular Scale, 12 inch.
Set of Color Cups, No. 1587.......... .... $95 00

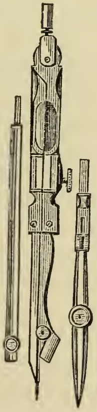
ALTENEDER'S PATENT JOINT DRAWING INSTRUMENTS.

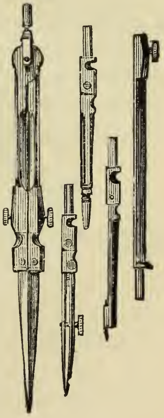
The excellency of these instruments consists in the joints of the dividers being so constructed as to prevent any irregular motion when the legs are opened or closed, also for the general care with which the instruments are finished.

All the pens are thoroughly well made and pointed. No. 474 represents a sectional view of Alteneder's Patent Joint Divider head.


474.


481.


483.


486.

475.—Plain Dividers of German Silver, $3\frac{1}{2}$ inches long, with Alteneder's patent joint, each.. $2 00

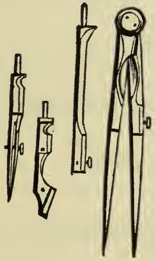
476.—Plain Dividers of German Silver, 5 inches long, with Alteneder's patent joint, each.. 2 75

No.	Price
477.—Plain Dividers of German Silver, 6 inches long, with Alteneder's patent joint, each	$3 25
478.—Hair Spring Dividers of German Silver, 3½ inches long, with Alteneder's patent joint, each	3 00
479.—Hair Spring Dividers of German Silver, 5 inches long, with Alteneder's patent joint, each	3 50
480.—Hair Spring Dividers of German Silver, 6 inches long, with Alteneder's patent joint, each	4 00
481.—Needle Point Dividers, 3½ inches long, of German Silver, with Pencil Point and Alteneder's patent joint, each	4 25
482.—Needle Point Dividers, 3½ inches long, of German Silver, with Pen Point and Alteneder's patent joint, each	4 75
483.—Needle Point Dividers, 6 inches long, of German Silver, with Pen and Pencil Point and Lengthening Bar, and Alteneder's patent joint	7 50
484.—Needle Point Dividers, 3½ inches long, of German Silver, with Pen and Pencil Point, and Alteneder's patent joint	6 00
485.—Steel Point Dividers, 6½ inches long, with Pen, Pencil, Needle Point and Lengthening Bar	8 50
486.—Steel Point Dividers, 6½ inches long, with Pen, Pencil, Needle Point, Lengthening Bar and joint in each leg	11 00
487.—Steel Point Dlviders, 3½ inches long, with Pen, Pencil, and Needle Point.	7 00
488.—Steel Spacing Dividers, 3 inches long	1 75
489.—Steel Bow Pen, 3 inches long, round points	2 25
490.— " " " with Needle Point	2 75
491.— " Pencil " with round point	2 25
492.— " " " with Needle Point	2 75
493.—Drawing Pen, 4½ inches long	1 50
494.— " 5½ "	1 70
495.— " 6½ "	1 90

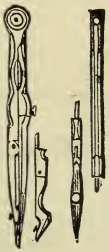
BRASS DRAWING INSTRUMENTS,

FOR SCHOOLS.

500.

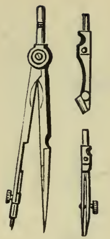


507.



509.

No.		PRICE
497.—	Wood Dividers, 13 in. long, with crayon holder, for black-board drawing.	$1 00
498.—	" 16 " " " "	1 25
499.—	" 20 " " " "	1 50
500.—	Brass Dividers, 3½ inches long, screw joint	25
501.—	" 4½ " "	30
502.—	" 5½ " "	85
503.—	" 6½ " "	45
504.—	" 4½ " rivet joint	20
505.—	" 5½ " "	25
506.—	" 6½ " "	30
507.—	Brass Dividers, 4½ inches long, with Pen, and Pencil Points and Lengthening Bar	50
508.—	Brass Dividers, 6 inches long, with Pen and Pencil Points and Lengthening Bar	75
509.—	Brass Dividers, Needle Point, 4½ inches long, with Pen and Pencil Points and Lengthening Bar	$ 75
510.—	Brass Dividers, Needle Point, 6 inches long, with Pen and Pencil Points and Lengthening Bar	1 00



511.

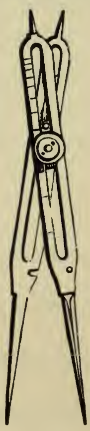
512.

513.

514.

No.	Price
511.—Dividers, brass, medium quality, needle point, with pen and pencil point, 3 inches	$ 60
512.—Bow Pencil, brass	60
513.—Bow Pen, brass, needle points, no spring	60
514.—Bow Pen, brass, needle points, and adjusting spring	70
515.—Bisecting Dividers, brass	60
516.—Proportional Dividers, brass, divided for lines	2 00
517.—Drawing Pen, black handle	20
518.—Drawing Pen, ivory handle	30
519.—Roulette for dotting lines, with three wheels	85
520.—Double Drawing or Road Pen, brass mounted	2 25
521.—Patent Lead Holder, for pencil leg of Dividers	25

515.



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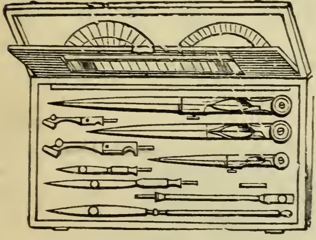
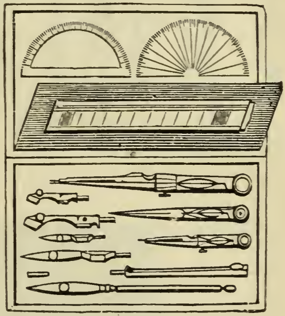
521.

CASES OF BRASS DRAWING INSTRUMENTS.

No.		Price
525.	—Wood Box; pair 4½-inch Dividers, with pen and pencil points, and Crayon Holder	$ 50
526.	—Wood Box; pair 4½-inch Dividers, with pen and pencil points and lengthening bar; Ebony handle Drawing Pen; Wood Rule, Crayon Holder, and Horn Protractor	80
527.	—Wood Box; Pair of 4½-inch Dividers, with pen and pencil points and lengthening bar; pair of 3½-inch plain Dividers, Drawing Pen, Horn Protractor, Wood Rule, Crayon Holder	1 00
528.	—Wood Box; Pair 5½-inch Dividers, with pen and pencil points and lengthening bar; Pair of 4½-inch Plain Dividers, Drawing Pen, Horn Protractor, Crayon Holder, and Wood Rule	1 30
530.	—Rosewood Box; Pair of 6-inch Dividers, with pen and pencil points and lengthening bar; Pair of 4½-inch plain Dividers, Drawing Pen; Pair of 3½-inch Dividers, with pen and pencil points; Brass Protractor, Horn Protractor, Wood Rule	2 00



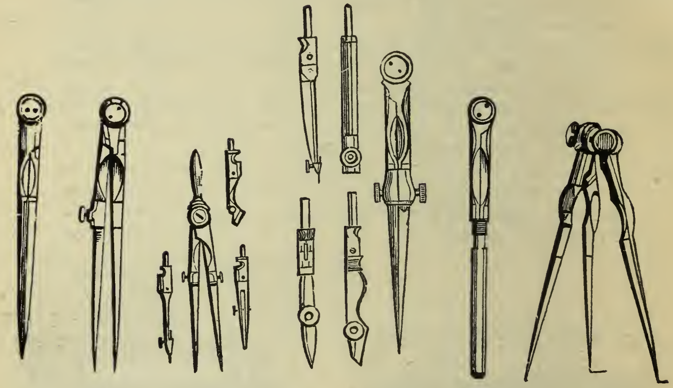
530.



532.

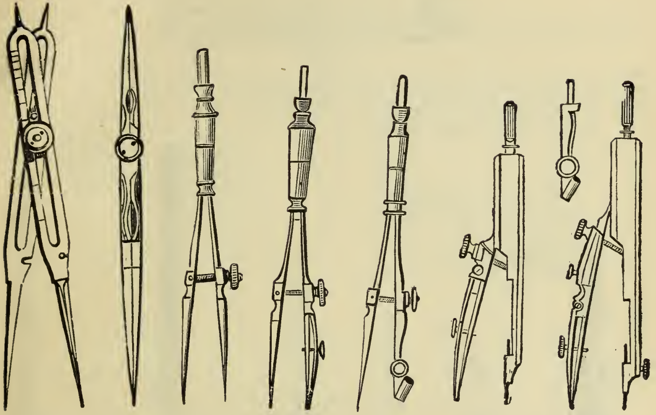
531.	—Same as No. 530, but with the instruments set in a tray, so that colors, etc., may be put below, per set	$2 25
532.	—Rosewood Box; Pair of 6-inch needle-point Dividers, with pen and pencil points, and lengthening-bar; Pair 4½ inch plain Dividers; Pair of 3½-inch needle-point Dividers, with pen and pencil points; Drawing Pen, Brass Protractor, Horn Protractor, Wood Rule, per set	2 75
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
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-point; Wood Rule	4 00
535.	—Same as No. 534, with addition of a pair Proportional Dividers, has no brass Protractor, but has wood Triangle and Irregular Curves	6 00

FINE GERMAN SILVER INSTRUMENTS.



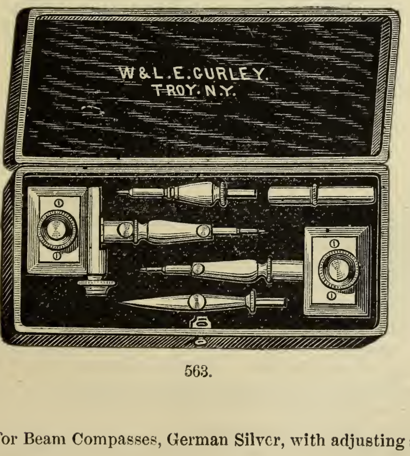
540. 544. 547. 548. 549. 550.

No.		Price
540.	—Dividers, German Silver, steel joints, turned cheeks, fine finish, 4 inch.	$ 70
541.	— " " " " " 5 " .	80
542.	— " " " " " 6 " .	1 00
543.	— " " " " " 7 " .	1 25
544.	—Hair Spring Dividers, German Silver; steel joints, turned cheeks, fine finish, 5 inch	1 80
545.	—Hair Spring Dividers, German Silver; steel joints, turned cheeks, fine finish, 6 inch	2 10
547.	—Dividers, German Silver; fine quality, needle-point, with pen and pencil point, 4 inches	2 50
548.	—Dividers, German Silver; fine quality, with needle-point, pen, lengthening-bar, and pencil-points, 6 inches	3 00
549.	—Dividers, German Silver; 5 inch, fine finish, with sheath	1 50
550.	—Dividers, German Silver; 5 inch, three-legged	3 50
554.	—Proportional Dividers, German Silver; 7 inch, with points bent rectangular, for Lines and Circles	7 00
555.	—Proportional Dividers, German Silver, $6\frac{1}{2}$ inches long, divided for lines.	2 50
556.	—Bisecting Dividers, German Silver	1 12
557.	—Spacing Dividers, all steel, with Spring and Adjusting Screw	1 25
558.	—Bow Pen, all steel, ivory handle	1 50
559.	—Bow Pencil, all steel, ivory handle	1 50
560.	—Set of three Steel Bows, Pen, Pencil, and Dividers, in case, per set	4 75



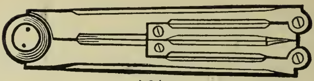
555. 556. 557. 558. 559. 561. 562.

No.		Price
561.—Spring Bow Pen, German Silver		$1 62
562.— " "	with pencil-point	2 50



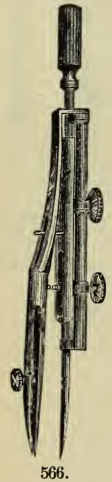
563.

No.	Price
563.—Furniture for Beam Compasses, German Silver, with adjusting screw, in morocco case	$5 00



564.

No.		Price
564.	—Pocket Dividers, German Silver, folding pen and pencil points..........	$5 50
565.	—Map Perambulator for measuring the length of curved lines, rivers, railroads, etc., on maps, each....................................	1 50



566.

567.

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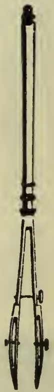

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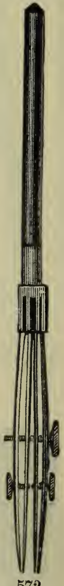


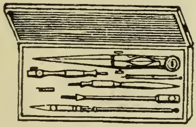
572.

574.

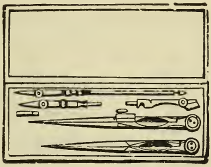
566.	—Improved Bow Pen. The needle-point in this instrument being adjustable, it will draw extremely minute circles............................	$3 00
567.	—Drawing Pen, German Silver, medium finish...........................	40
568.	—Drawing Pen, German Silver, fine finish, hinge to pen..................	50
569.	—Drawing Pen, German Silver, fine finish, hinge to pen, and protracting pin..	75
570.	—Drawing Pen, all German Silver, for red ink............................	75
571.	—Double Drawing, or Road Pen.	2 25
572.	—Patent Double Drawing Pen. Will draw with one stroke one broad or two parallel lines of the same or different widths..........................	3 75
573.	—Drawing Pen for curves...	1 50
574.	— Do. for heavy border lines	2 50
575.	—Patent Lead-holder, for pencil-leg of Dividers (Fig. 521)................	25

CASES OF FINE GERMAN SILVER INSTRUMENTS.

FOR ENGINEERS, ARCHITECTS, AND MACHINISTS.

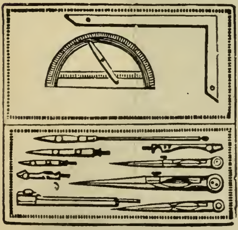


581.



582.

No.	Price
580.—Morocco Box; pair of 5½-inch dividers, with pen and pencil points, drawing pen..	$3 00
581.—Morocco Box; pair of 4 inch dividers, with pen, pencil, and needle points, and lengthening-bar, drawing pen..............................	4 00
582.—Morocco Box; pair of 5½-inch dividers, with pen and pencil points, pair of 5-inch plain dividers, drawing pen..................................	3 50
583.—Same as No. 582, with addition of needle-points and lengthening-bar, to 5½-inch dividers, per set..	5 00
584.—Morocco Box, round corners, for carrying in the pocket; pair of 4¾-inch dividers, with hinge in one leg, needle-points, with pen and pencil points, and lengthening-bar, spring-bow pen, needle-point, pair of 4-inch plain dividers, rounded point, drawing pen, ivory handle, 5-inch ivory rule, divided into eighths, per set................................	7 50



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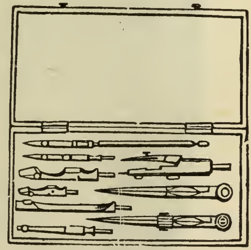
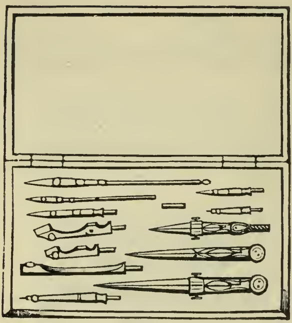
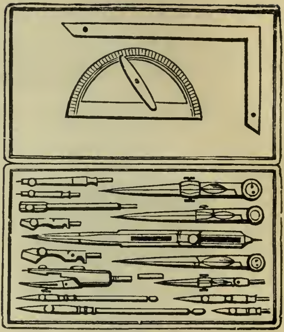


586.

585.—Morocco Box; pair of 5½-inch dividers, with pen and pencil points, and lengthening-bar, pair of 5-inch plain Dividers, pair of 4-inch dividers, with pen and pencil points, drawing pen, German silver protractor, German silver square.. $8 50



587.



594.

No.		Price
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
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, per set	9 75
588.—	Same instruments as in No. 587, with addition of spring bow-pen, per set	11 00

589.

No. PRICE

589.—"R. P. I." Polished Mahogany or Walnut Box, with lock and key and tray, containing pair $5\frac{1}{2}$-inch dividers, pen, pencil, and needle point, pair 5-inch hair-spring dividers, pair 4-inch dividers, pen, pencil, and needle point, 2 Swiss pens, Nos. 442 and 444. .... $14 00

590.—Polished Mahogany or Walnut Box; containing pair $5\frac{1}{2}$-inch dividers, with pen, pencil and needle points, and lengthening-bar,
Pair 5-inch plain 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.................................... 12 50

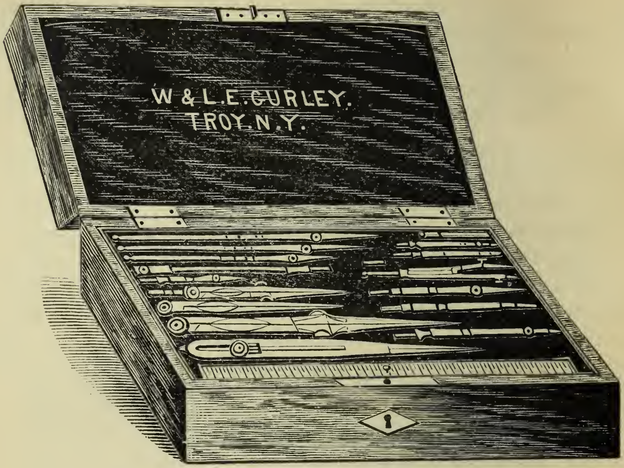
591.—Same as No. 590, with lock and key and tray........................ 13 50

592.—Polished Mahogany or Walnut Box; containing $5\frac{1}{2}$-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.................................... 15 00

593.—Same as No. 592, and the box much larger, with lock and key and tray thus affording space for extra instruments or colors, etc.............. 15 50

594.—Polished Mahogany or Walnut Box, with lock and key and tray; 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,
Pair Proportional Dividers, No. 555,
Protractor, 4-inch, half circle, whole degrees,
Triangle and Triangular Scale, 12-inch.............................. 26 00

595.—Same as No. 594, with addition of Beam Compass....................... 31 00



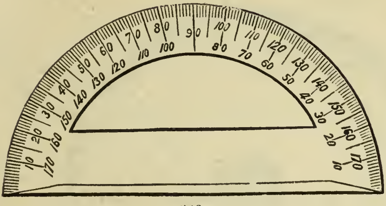
596.

No. PRICE

596.—Polished Mahogany or Walnut Box, lock and key, with tray, leaving space below for paints, rules, etc., containing pair of 6-inch needle-point dividers, with pen and pencil points, and lengthening-bar,
Pair 4½-inch plain Dividers,
Pair of 4-inch Needle Point Dividers, with pen and pencil points,
Pair of Proportional Dividers,
3 Drawing Pens,
Horn Protractor,
1 Wood Curve and 2 Wood Squares,
Bow Pen, German Silver,
Ivory Protractor Scale. $27 00

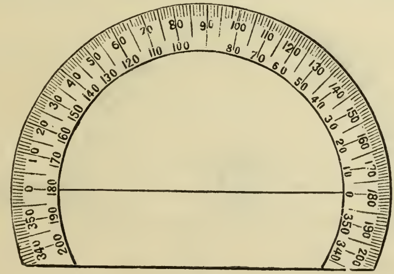
597.—Polished Mahogany or Walnut Box, lock and key, with tray, leaving space below for paints, rules, etc.; containing pair of 6-inch needle-point dividers, with pen and pencil points and lengthening-bar,
Pair 4½-inch plain Dividers,
Pair of 4-inch Dividers, needle-point, with pen and pencil points,
Pair of Proportional Dividers,
Bow Pen, needle-point,
3 Drawing Pens,
Furniture for Beam Compass, with Micrometer Screw,
8-inch Horn Protractor,
Ivory Protractor Scale.. 34 00

EXTRA FINE GERMAN SILVER SWISS PROTRACTORS.



600.

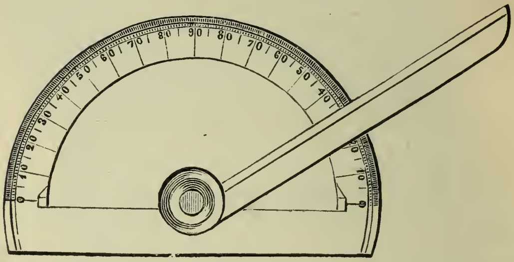
No.		Price
600.	—Protractor, 4-inch diameter, half circle, whole degrees, centre on outer edge	$1 50
601.	—Protractor, 5-inch diameter, half circle, half degrees, centre on outer edge	2 00
602.	—Protractor, 6-inch diameter, half circle, half degrees, centre on outer edge	3 00
603.	—Protractor, 6-inch diameter, half circle, quarter degrees, centre on outer edge	3 25



604.

604.	—Protractor, 5-inch diameter, half circle, half degrees, centre on inner edge	$2 50
605.	—Protractor, 6-inch diameter, half circle, half degrees, centre on inner edge	3 50
606.	—Protractor, 6-inch diameter, half circle, quarter degrees, centre on inner edge	4 00

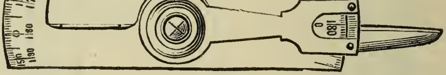
EXTRA FINE SWISS PROTRACTORS, OF GERMAN SILVER, WITH ARMS.



611.

No.		PRICE
611.	German Silver Protractor, 6 inches diameter, half circle, with arm, and divided in half degrees	$8 50
613.	German Silver Protractor, 8 inches diameter, half circle, with arm, and divided in half degrees	9 50
614.	German Silver Protractor, 5 inches diameter, whole circle, with arm, and divided in half degrees	9 00
615.	German Silver Protractor, 6 inches diameter, whole circle, with arm, and divided in half degrees	$10 00

EXTRA FINE SWISS PROTRACTORS, OF GERMAN SILVER, WITH ARMS AND VERNIERS.



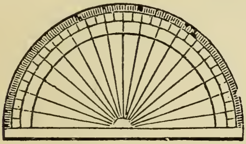
620.

620.	Protractor, 5½ inches diameter, half circle, half degrees, with vernier reading to three minutes	$11 00
621.	Protractor, 8 inches diameter, half circle, quarter degrees, with vernier reading to one minute	14 00
622.	Protractor, 10 inches diameter, half circle, quarter degrees, with vernier reading to one minute	18 00
623.	Protractor, 5½ inches diameter, whole circle, half degrees, with vernier reading to three minutes	14 50
624.	Protractor, 8 inches diameter, whole circle, quarter degrees, with vernier reading to one minute	16 00

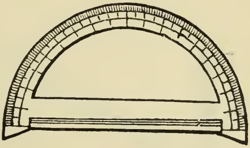
☞ Cases for Protractors, of wood, lined with velvet, according to size: from $1 00 to $3 00.

PROTRACTORS OE HORN, BRASS, GERMAN SILVER, RUBBER, IVORY AND PAPER.

No.					Price
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 radius of 400 feet to the inch				$1 60
631.—	Horn Protractor,	5	inches diameter,	whole circle, half degrees	1 00
632.—	"	6	"	" "	1 25
633.—	"	7	"	" "	1 50
634.—	"	4	"	half circle, whole degrees	15



635.



640.

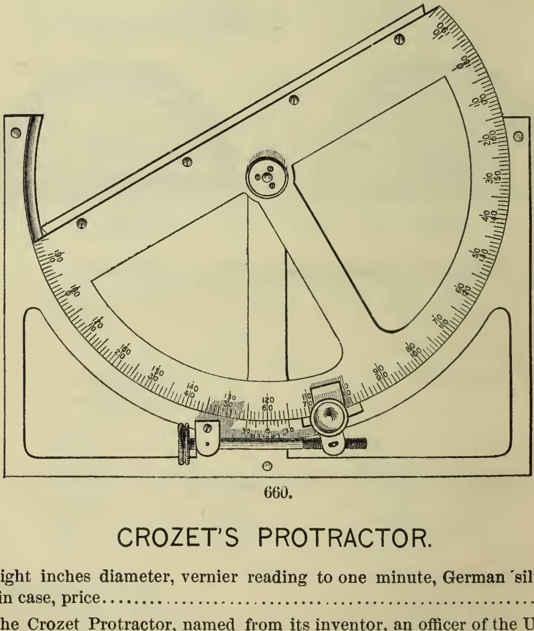
No.						Price
635.—	Horn Protractor,	5	inches diameter,	half circle,	half degrees	$ 25
636.—	"	6	"	"	"	30
637.—	"	7	"	"	"	50
638.—	"	8	"	"	"	80
639.—	Brass Protractor,	4	"	"	whole degrees	10
640.—	"	4	"	"	half degrees	35
641.—	"	5	"	"	"	55
642.—	"	6	"	"	"	65

No.								Price
643.—	German Silver	Protractor,	4	inches diameter,	half circle,		whole degrees..	50
644.—	"	"	5	"	"		half degrees	85
645.—	"	"	6	"	"		"	1 00
646.—	"	"	7	"	"		"	1 15
647.—	"	"	5	"	"	beveled edge,	half deg.	1 25
648.—	"	"	6	"	"	"	"	2 00
649.—	"	"	7	"	"	"	"	2 65
650.—	Hard Rubber	Protractor,	6	"	"	"	"	3 00
651.—	"	"	8	"	"	"	"	3 75
652.—	"	"	6	"	whole circle,	"	"	3 75
653.—	"	"	8	"	"	"	"	5 00

Other sizes and graduations to order.

PAPER PROTRACTORS.

No.	Price
655.—Whole Circle Protractors, 8 and 13 inches diameter, half degrees, on drawing paper, each	$ 30
656.—Whole Circle Protractors, 8 and 13 inches diameter, half degrees, on Bristol board, each	40
657.—Half Circle Protractor, 5 inches diameter, half degrees, card board	25
658.—Half Circle Protractor, 6 inches diameter, half degrees, card board	30
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



660.

CROZET'S PROTRACTOR.

660.—Eight inches diameter, vernier reading to one minute, German silver, in case, price $40 00

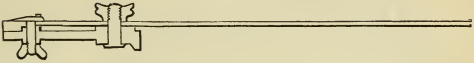
The Crozet Protractor, named from its inventor, an officer of the U. S. Engineer Corps, we recommend as the best among the various high grade protractors yet devised.

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

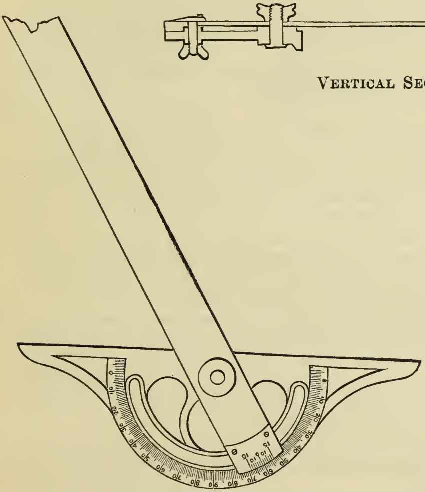
The feather edge is the only metallic bearing upon the paper, small ivory projections on the under side of the frame keep the metal from contact with the paper and prevent soiling it.

NEW LIMB PROTRACTOR.

BRONZE HEAD, STEEL BLADE, VERNIER TO ONE MINUTE.



VERTICAL SECTION.

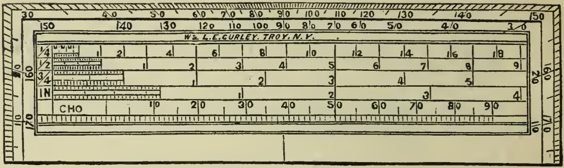


665.

No.		Price
665.—	Limb Protractor, blade 24 inches long	$8 00
666.—	" " 30 "	8 75
667.—	" " 36 "	9 50
668.—	" " 42 "	10 25
669.—	" " 48 "	11 00

If with nickel-plated blades, 50 cts. to 75 cts. extra. Longer blades made to order.

IVORY PROTRACTORS.



675.—Front Side.

No. Price

675.—Ivory Rectangular Protractor, 6 inches long, 1¾ inches wide, with scales as follows: front sides divided around edges from 0 to 180 degrees in single degrees, scales of ¼, ½, ¾ 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 50

676.—Ivory Rectangular Protractor, 6 inches long by 1¾ 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, 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... 2 25

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

678.—Ivory Rectangular Protractor, same as No. 677, but has the Protractor divided in ½ degrees....... .... 4 00

679.—Ivory Rectangular Protractor, 6 inches long by 2¼ 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, 1⅛, 1¼, 1⅜, 1½ inches 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

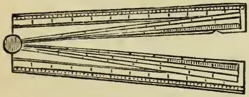
680.—Ivory Rectangular Protractor, 6 inches long by 2½ inches wide, with scales as follows, front side, the edge divided in ½ degrees from 0 to 180 degrees, scales of ⅛, ¼, ⅜, ½, ⅝, ¾, ⅞, 1, 1⅛, 1¼, 1⅜, 1½ inches to the foot, scale of chords, and scale of 40 parts on lower edge. Reverse side, scales of 20, 25, 30, 35, 40, 45, 50 and 60 parts to the inch, 2 scales of chords, scales of latitude, sines, tangents, hours, longitudes, secants, rhombs.. 6 00

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

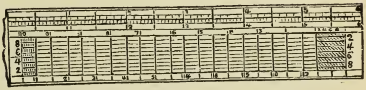
No. PRICE

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 1/100ths $11 50

IVORY SECTORS AND SCALES.



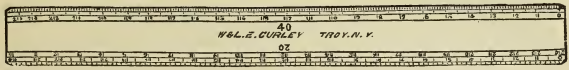
685.



686.

685.—Ivory Sector, 6 inches long, opens to 12 inches long.................... $2 25
686.—Ivory Scale, 6 inches long, for school drawing.............................. 75
687.—Flat Ivory Scale, 6 inch, divided ⅛, ¼, ½, 1 inch to the foot, each...... 2 00
688.— Do. do. 12 do. ⅛, ¼, ½, 1 do. do. 3 25
689.— Do. do. 12 do. ⅜, ¾, 1½, 3 do. do. 3 25

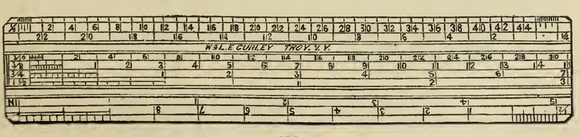
IVORY CHAIN SCALES.



690.

690.—Ivory Chain Scales, 12 inches long, graduated on two edges with either 10 and 10 parts, or 10 and 20, or 20 and 40, or 30 and 50, or 40 and 60, or 50 and 60, each $3 00
691.— Do. with 40 and 80, or 50 and 100, each.............................. 5 25
692.— Do. with 80 and 100, each.. 5 75
692A.—Ivory Off-set Scales, 2 inches long, 10 by 10, 10 by 20, 20 by 40, 30 by 50, 40 by 60, each 65

ARCHITECTS' IVORY SCALES.

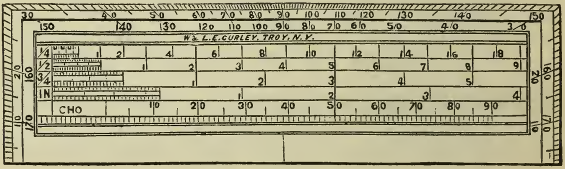


693.

693.—Ivory Scale, 12 inches long, with 16 scales, as follows: ⅛, 3/16, ¼, ⅜, ½, ⅝, ¾, ⅞, 1, 1¼, 1½, 1¾, 2, 2¼, 2½ and 3 inches to the foot, the first division of each scale subdivided in 12 parts, each.......................... $3 00

No.		PRICE
694.	Same as No. 693, but with the first division of each scale subdivided into 10 parts, each	3 00
695.	Ivory Scale, 12 inches long, with 12 scales, as follows: ⅛, $\frac{3}{16}$, 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 $\frac{1}{100}$ and $\frac{1}{200}$ of an inch, each	3 00
696.	Same as No. 695, but has the first division of each scale subdivided into 10 parts, each	3 00
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: $\frac{1}{16}$, ⅛, $\frac{3}{16}$, 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
698.	Same as No. 697, but the first division of each scale subdivided into ten parts, each	3 00

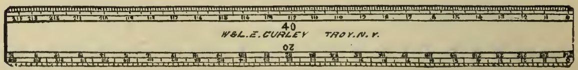
BOXWOOD SCALES AND PROTRACTORS.



700.—FRONT SIDE.

700.	Boxwood Protractor, 6 inches long, 1¾ inches wide, whole degrees. with 6 scales of equal parts, 4 scales of feet and inches, 2 scales of chords, and diagonal scale	$0 50
701.	Boxwood Scale, 6 inches long, same as in School Cases of Instruments	20
702.	Flat Boxwood Scale, 6 inch, divided ⅛, ¼, ½, 1 or ⅜, ¾, 1½, 3 inch to the foot, each	75
703.	Flat Boxwood Scale, 12 inch, divided ⅛, ¼, ½, 1 or ⅜, ¾, 1½, 3 inch to the foot, each	1 25
704.	Flat Boxwood Scale, 24 inch, divided ⅛, ¼, ½, 1 or ⅜, ¾, 1½, 3 inch to the foot, each	2 50
705.	Flat Boxwood Scale, 12 inch, beveled on both sides, graduated ⅛, ¼, ½, 1 and ⅜, ¾, 1½, 3 inch to the foot, each	1 50

BOXWOOD CHAIN SCALES.



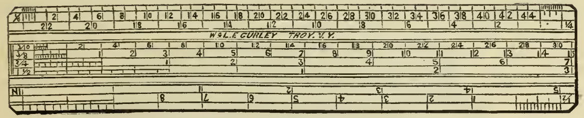
706

No. PRICE

706.—Boxwood Chain Scales, 12 inches long, graduated on two edges with either 10 and 10 parts, or 10 and 20, or 20 and 40, or 30 and 50, or 40 and 60, or 50 and 60.......... $1 25

707.—Boxwood Off-set Scales, 2 inches long, graduated 10 by 10, 10 by 20, 20 by 40, 30 by 50, 40 by 60, each.......... 25

ARCHITECTS' BOXWOOD SCALES.



708.

708.—Boxwood Scale, 12 inches long, with 16 scales, as follows : ⅛, $\frac{3}{16}$, ¼, ⅜, ½, ⅝, ¾, ⅞, 1, 1¼, 1½, 1¾, 2, 2¼, 2½ and 3 inches to the foot, the first division of each scale subdivided into 12 parts, each.......... $1 25

709.—Same as No. 708, but with the first division of each scale subdivided into ten parts, each 1 25

710.—Boxwood Scale, 12 inches long, with 12 scales, as follows : ⅛, $\frac{3}{16}$, 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 $\frac{1}{100}$ and $\frac{1}{200}$ of an inch, each.......... 1 25

711.—Same as No. 710, but has the first division of each scale subdivided into 10 parts, each.......... 1 25

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 : $\frac{1}{16}$, ⅛, $\frac{3}{16}$, 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

713.—Same as No. 712, but has the first division of each scale subdivided into 10 parts, each 1 25

715.—Boxwood Gunter Scales, 12 inches long.......... 75

716.— do do 24 do 1 25

717.—Boxwood School Rule, 12 inches, ⅛ and $\frac{1}{16}$ inch.......... 15

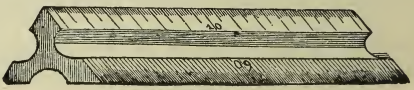
718.— do do 18 do do 50

FLAT METALLIC CHAIN SCALES.

(A new and superior article, our own make, made of brass and silver-plated.)

No.		Price
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
719A.	Do. with 30 and 50, or 40 and 60 parts, each	3 75
719B.	Do. with 50 and 60, or 40 and 80 parts, each	4 25
719C.	Do. with 50 and 100, or 80 and 100 parts, each	5 00
719H.	Do. 30 centimetres long, divided to millimetres	3 00

TRIANGULAR SCALES OF BOXWOOD AND METAL.



720.

No.		Price
720.	Triangular Scale of Boxwood, 24 inches long, graduated 10, 20, 30, 40, 50, and 60 to the inch	$5 00
721.	Do. 20, 30, 40, 50, 60, and 80 to the inch	5 00
722.	Triangular Scale of Boxwood, 12 inches long, graduated same as No. 720.	2 00
723.	Do. graduated same as No. 721	2 00
724.	Do. 12 inches long, graduated 100, 200, 300, 400, 500, 600 to the foot each	2 00
725.	Do. 6 inches, graduated same as Nos. 720 or 721	1 50
726.	Triangular Scale of Boxwood for Off-sets, 2 inches long, 10, 20, 30, 40, 50 and 60 parts	75
727.	Triangular Scale of Boxwood, 24 inches long, graduated $\frac{3}{32}$, $\frac{3}{16}$, $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{2}$, and 3 inches to the foot, and 16ths of inches	5 00
728.	Do. 12 inches long	2 00
729.	Do. 6 inches long	1 50

We desire to call the attention of Draughtsmen to the new Patent Metallic Triangular Scales, which are of the exact size and shape of the common 12-inch Triangular Boxwood Scales. They 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 new scale.

No.		Price
730.	Metallic Triangular Scale, 12 inches, graduated same as No. 720	3 00
731.	Do. do. do. No. 721	3 00
732.	Do. do. do. No. 727	3 00
733.	Guard for Triangular Scale, white metal. The use of this Guard, prevents all errors	25

PAPER SCALES.

No.		Price
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
736.	—Paper Scale, same as 735, edges 20 and 40 parts to the inch.............	10
737.	—Paper Scale, same as 735, edges 16 and 48 parts to the inch.............	10

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, per set.......................................	$1 00
739.	—Series B contains 6 scales, one each divided to 3/32, ⅛, 3/16, 5/16, ⅜, and ⅞ inches to the foot, per set....	1 00
740.	—Series C contains 6 scales, one each divided to 10, 20, 30, 40, 50, and 60 parts to the inch, per set.......................................	1 00
	Single Scale of any of the above series, A, B, C—each scale............	20

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.

We manufacture, to order, scales to any divisions, in Ivory, Boxwood, Rubber, or Metal.

METRIC SCALES AND RULES.

741.	—Flat Boxwood, fully divided, 10 centimetres long........................					$ 60
742.	— Do.	do.	20	do.	....	90
743.	— Do.	do.	30	do.	....	1 25
744.	— Do.	do.	50	do.	....	1 75
745.	—Flat Ivory,	do.	10	do.	....	2 25
746.	— Do.	do.	20	do.	....	4 00
747.	— Do.	do.	30	do.	....	5 00
748.	—Triangular Boxwood,	do.	20	do.	....	1 50
749.	— Do.	do.	30	do.	....	2 00
750.	—Metric Rule, boxwood, 1 metre, 6 fold, with springs at each joint.......					75
751.	— Do.	do.		4 fold, divided inches and metre........		60
752.	—Same as above, but in ivory					1 75
753.	— Do.	do.		and only ½ m. in length.......		1 00
754.	—Engineers' Metric Rule, 4 foot, 8 fold, divided to inches and meters......					75

STANDARD STEEL RULES.

No.		Price	No.		Price
755.—1 inch		$ 25	761.—12 inch		$2 00
756.—2	"	40	762.—18	"	3 00
757.—3	"	50	763.—24	"	4 00
758.—4	"	75	764.—36	"	8 00
759.—6	"	1 00	765.—48	"	12 00
760.—9	"	1 50			

The rules in this list are divided five ways in parts of inches as follows:

	No. 1 *Graduations.*	*No.* 2 *Graduations.*	*No.* 3 *Graduations.*
1st cor.	10, 20, 50, 100	10, 20, 50, 100	16, 32, 64
2d cor.	12, 24, 48	12, 24, 48	16
3d cor.	16, 32, 64	16, 32, 64	16
4th cor.	14, 28	8	8

No. 4 *Graduations.*

1st cor. 64
2d cor. 32
3d cor. 16
4th cor. 8

No. 6 *Graduations.*

1st cor. 32 whole length.
2d cor. 48 "
3d cor. 50 "
4th cor. 64 "

766.—12 in. Steel Rule of No. 5 graduation.................................. $3 00
767.—24 in. " " 6 00

No. 5 *Graduations.*

1st cor. 16, 32, 64
2d cor. 11, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25
3d cor. 26, 27, 28, 29, 30, 31, 33, 34, 35, 36, 37, 38
4th cor. 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 100

Always give graduation when ordering these goods.

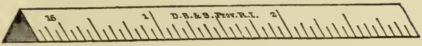
770.—36-inch Steel or Standard Yard, full divided.......................... $3 00

STANDARD STEEL RULES, FRENCH MEASURE.

773.—$\frac{1}{20}$ metre		$ 45	776.—$\frac{3}{10}$ metre		$2 50
774.—$\frac{1}{10}$	"	85	777.—½	"	4 00
775.—$\frac{1}{5}$	"	1 75	778.—	"	10 00

They are divided on three edges to millimetres, and on one edge to fifths of millimetres.

TRIANGULAR STEEL RULES.



780.

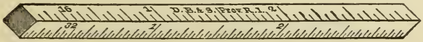
No.			Price
780.—3 inch	$ 60	782.—6 inch	$1 20
781.—4 "	80	783.—12 "	3 00

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.

785.—3 iuch	$ 50	787.—6 inch	$1 00
786.—4 "	75		

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.

790.—18 inch	$2 25	792.—36 inch	$6 00
791.—24 "	3 00	793.—48 "	9 00

STEEL STRAIGHT EDGES.

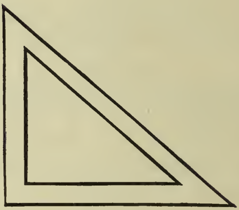
FOR DRAUGHTSMEN.

800.—15 inch	$ 90	804.—36 inch	$3 00
801.—18 "	1 00	805.—42 "	3 75
802.—24 "	1 50	806.—48 "	5 00
803.—30 "	2 25	807.—60 "	7 00

We also furnish Nos. 790 to 807, Nickel Plated, at an extra cost of 25 cts. to $1 50, according to length.

STEEL AND GERMAN SILVER TRIANGLES AND SQUARES.

810 and 815.



812 and 820.

824.

OPEN STEEL TRIANGLES.

30° × 60° × 90°.

No.			Price
810.—6 inch	$3 25	811.—10 inch	$4 25

45° × 45° × 90°.

812.—5 inch	$3 25	813.—8 inch	$4 25

For Nos. 810 to 813, if Nickel Plated, add 50 cts. each.

OPEN GERMAN SILVER TRIANGLES.

30° × 60° × 90°.

815.—6 inch	$2 50	817.—10 inch	$4 00
816.—8 "	3 00	818.—12 "	5 50

45° × 45° × 90°.

820.—5 inch	$2 25	822.—8 inch	$4 00
821.—6 "	2 75	823.—10 "	5 00

Other sizes of Steel and German Silver Triangles made to order.

824.—German Silver Squares, perpendicular 5 to 6 inches........................ $ 75

STRAIGHT EDGES, OF RUBBER AND WOOD.

(*For steel straight edges, see Nos.* 790 *to* 807.

Hard Rubber Straight Edges, one edge beveled.

No.	Price	No.	Price
825.—18 inch	$ 70	828.—36 inch	$2 00
826 —24 "	1 00	829.—42 "	2 50
827.—30 "	1 50	830.—60 "	3 50

Hardwood Straight Edges, one edge beveled.

835.—18 inch	$ 25	839.—42 inch	$ 65
836.—24 "	30	840.—48 "	75
837.—30 "	40	841.—60 "	1 00
838.—36 "	50	842.—72 "	1 35

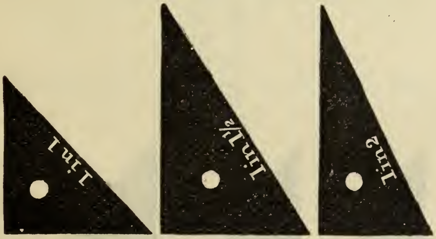
Polished Rosewood, Satinwood, or Mahogany Straight Edges, one edge beveled.

846.—24 inch	$ 75	849.—42 inch	$1 50
847.—30 "	1 00	850.—48 "	2 00
848.—36 "	1 25	851.—60 "	2 50

Other lengths made to order.

Cross Section Triangles.

HARD RUBBER.



855.

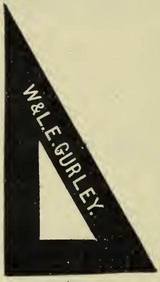
855.—Cross Section Triangles, set of seven Cross Section Triangles made of hard rubber as follows: ¼ to 1, ½ to 1, ¾ to 1, 1 to 1, 1¼ to 1, 1½ to 1, 2 to 1, per set $3 00

Single Triangles of set No. 855, each 50

TRIANGLES.

RUBBER, ROSEWOOD, SATINWOOD, OR HARDWOOD.

(*For Steel and German Silver Triangles, see Nos.* 810 *to* 823.)



860.

875.

Hard Rubber Triangles, angles 30, 60, *and* 90 *degrees.*

No.	Price	No.	Price
860.—3 inch	$ 25	867.—10 inch	$ 65
861.—4 "	25	868.—11 "	75
862.—5 "	30	869.—12 "	95
863.—6 "	35	870.—13 "	1 10
864.—7 "	40	871.—14 "	1 25
865.—8 "	55	872.—15 "	1 50
866.—9 "	60	873.—16 "	1 75

Hard Rubber Triangles, angles 45, 45, *and* 90 *degrees.*

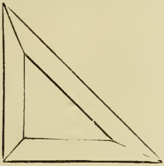
No.	Price	No.	Price
875.—3 inch	$ 30	882.—10 inch	$1 10
876.—4 "	35	883.—11 "	1 25
877.—5 "	40	884.—12 "	1 35
878.—6 "	50	885.—13 "	1 50
879.—7 "	60	886.—14 "	1 65
880.—8 "	70	887.—15 "	1 80
881.—9 "	85	888.—16 "	2 00

890.

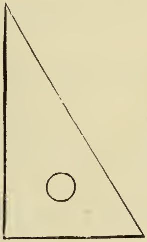
No.		Price
890.	—Hard Rubber Lettering Triangles, 3 in set, 3½ inch, per set	$1 25
	Single Templets	50

Rosewood, Satinwood, and Hardwood Triangles.

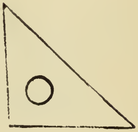
900 and 910.



905 and 919.



920.



925.

Rosewood or Satinwood, open centre, Framed.

30° × 60° × 90°.

900.—10 inch, plain finish	$ 50	902.—15 inch, plain finish	$1 00
901.—10 " polished	60	903.—15 " polished	1 25

45° × 45° × 90°.

905.—7 inch, plain finish	$ 50	907.—12 inch, plain finish	$1 00
906.—7 " polished	60	908.—12 " polished	1 25

Hardwood Triangles, framed with open centre.

30° × 60° × 90°.

910.—6 inch	$ 25	913.—12 inch	$ 40
911.—8 "	30	914.—14 "	50
912.—10 "	35		

45° × 45° × 90°.

915.—5 inch	$ 25	918.—11 inch	$ 50
916.—7 "	30	919.—13 "	65
917.—9 "	40		

Hardwood Triangles, plain.

30° × 60° × 90°.

No.	Price	No.	Price
920.—5 to 6½ inch	$ 10	922.—11 to 12 inch	$ 20
921.—8 to 9½ "	15		

45° × 45° × 90°.

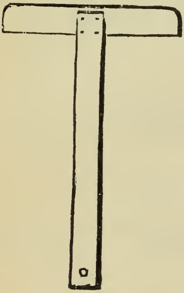
925.—4 to 6 inch	$ 15	926.—7 to 8 inch	$ 20

Batter Slopes.

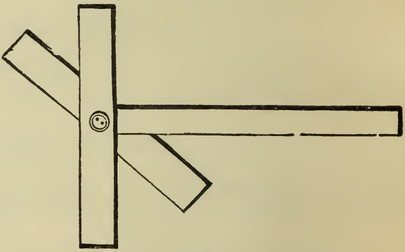
928.—Set of three forms of hard rubber for Batters of walls and rock, giving the following slopes: 1 in 4, 1 in 5, 1 in 6, 1 in 8, 1 in 10, 1 in 12, per set $2 00

Single forms of set No. 928, containing two slopes, each 75

T SQUARES.



930.



936.

Hardwood T Squares, fixed head.

930.—15 inch	$ 30	933.—30 inch	$ 50
931.—20 "	40	934.—40 "	85
932.—25 "	45	935.—50 "	1 25

Hardwood T Squares, shifting head.

936.—20 inch	$1 00	939.—40 inch	$1 50
937.—25 "	1 05	940.—50 "	1 75
938.—30 "	1 10		

Rosewood T Squares. fixed head, polished.

No.		No.	Price
941.—30 inch	$1 75	942.—40 inch	$2 50

Rosewood T Squares, shifting head, polished.

943.—30 inch	$2 75	944.—40 inch	$3 50

Rubber Blade T Squares, Hardwood head, fixed.

946.—20 inch	$ 80	948.—30 inch	$1 25
947.—25 "	1 00	949. 35 "	1 75

Rubber Blade T Squares, Hardwood head, shifting.

951.—20 inch	$1 75	953.—30 inch	$2 50
952.—25 "	2 00	954.—35 "	2 75

T Squares, Steel Blades Nickel Plated, Japanned Iron heads, fixed.

955.—18 inch	$3 25	957.—30 inch	$5 50
956.—24 "	4 50	958.—36 "	6 50

T Squares, Steel Blades Nickel Plated, Japanned Iron heads, shifting.

959.—18 inch	$4 75	961.—30 inch	$7 00
960.—24 "	6 00	962.—36 "	8 00

Any of our T Squares with longer blades made to order.

OVALS, HYPERBOLAS, AND PARABOLAS.

965.—	Pearwood Ovals, 2 to 6 inches long, 10 in a set, per set	$2 00
966.—	Do. 1½ to 4½ do. 6 do. do.	1 50
967.—	Do. ¾ to 7 do. 43 do. do.	5 00
968.—	Pearwood Hyperbolas, 2 to 5 inches long, 8 in a set	1 40
969.—	Do. Parabolas, 12 do.	3 00
970.—	Do. do. 1½ to 6 inches long, 8 do.	1 40

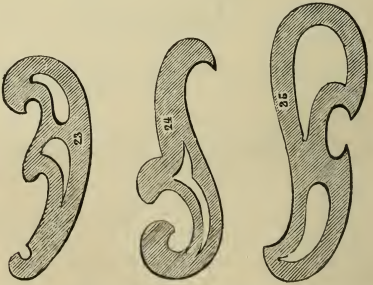
IRREGULAR CURVES.

WOOD.

No. PRICE

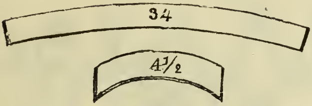
980.—Whitewood Irregular Curves, 5 to 15 inches long, various patterns, each.......... $ 20

982.—Whitewood Irregular Curves, of superior quality, 8 to 12 inches long, various patterns, each.......... $ 25



983.—Whitewood Irregular Curves, of superior quality, Nos. 23 to 25.......... $ 50

RAILROAD CURVES OF CARDBOARD, WOOD, AND RUBBER.



985.

The following curves are cut to a scale of inches, the outside of arcs only finished.

985.—Set of ten Curves, from 12 to 120 inches radius, varying every 12 inches:

A.—Set, complete, of card-board, in box				$3 00
B.—	Do.	wood,	do.	4 50
C.—	Do.	rubber,	do.	8 00

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
B.—	Do.	wood,	do.	7 50
C.—	Do.	rubber,	do.	14 00

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
B.—	Do.	wood,	do.	10 00
C.—	Do.	rubber,	do.	17 00

The following Curves are cut to a scale of 50 feet to the inch, and have both inside and outside of arcs finished:

990.—Set of fifteen Curves, rising every 30″ to 3°, then single degrees to 12°:

A.—Set, complete, of wood, in box			$7 50
B.—	Do.	rubber, do.	12 00

991.—Set of twenty Curves, rising every 30″ to 10°:

A.—Set, complete, of wood, in box			$12 00
B.—	Do.	rubber, do.	16 00

The following Curves are cut to a scale of 400 feet to the inch, and are finished only on outside of arc:

995.—Set of twenty Curves, from 30″ to 10° by every 30″:

A.—Set, complete, of wood, in case			$9 00
B.—	Do.	rubber, do.	13 00

HARD RUBBER IRREGULAR CURVES.

1000.

No. PRICE

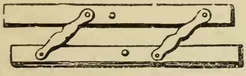
1000.—Hard Rubber Irregular Curves:

1.—5½ inches long, each....	$ 35	19.— 8 inches long, each.	$ 50
2.—5½ do.	35	20.—10½ do.	50
3.—9 do.	50	21.— 7½ do.	45
4.—9 do. ...	50	22.— 5 do.	35
5.—6 do.	40	23.— 6 do.	40
13.—9 do. ...	50	24.— 9 do.	60
14.—7½ do.	35	25.— 7 do.	40
15.—8½ do.	45	26.— 5½ do.	35
16.—4¾ do.	35	27.—12 do.	75
17.—9 do.	35	28.—12 do.	2 25
18.—8 do.	40		

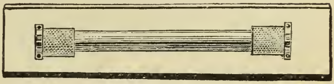
1030.—Hard Rubber Ellipses, 6 in a set, 1¼ to 4½ in. long, per set............ $1 50

1031.— Do. 10 do. 2 to 6 in. do. 2 00

PARALLEL RULES.



1035.



1042.

Parallel Rulers, Ebony, Brass Mounted.

1035.— 6 inch....................	$ 25	1038.—15 inch.	$1 00
1036.— 9 "	50	1039.—18 "	1 25
1037.—12 "	75	1040.—24 "	2 00

1041.—Parallel Ruler, Ebony, German-silver Mounted, 12 inch............ ... $1 25

Parallel Rulers, Ebony, on Rollers.

1042.—12 inch....................	$3 25	1044.—18 inch.....................	$5 00
1043.—15 "	4 00		

Parallel Rulers, Ebony, on Rollers, Ivory Graduated Edges.

1045.—12 inch....................	$5 00	1047.—18 inch.....................	$7 50
1046.—15 "	6 50		

Parallel Rulers, all Brass, on Rollers.

No.	Price	No.	Price
1048.— 9 inch	$6 50	1050.—15 inch	$10 00
1049.—12 "	8 00	1051.—18 "	12 00

Numbers 1048 to 1051 furnished Nickel-plated at an extra cost of 50c. to $1.00.

Parallel Rulers, all German Silver, on Rollers.

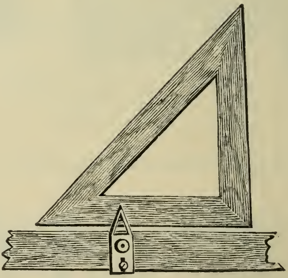
1052.—12 inch	$10 00	1054.—18 inch	$15 00
1053.—15 "	12 00		

SECTION LINERS.

1060.—Bergner's Patent Section Liner, in Morocco case.... $7 50

1061.—Harden's Improved Section Liner.... 3 75

1062.—Marion's Section Liner, German-silver slide and screws, with either polished satinwood, or rubber triangle, and ruler.... 2 00



1062.

PANTOGRAPHS.

1063.— Pantograph of hardwood arms.... $3 00

1064.— Do. pearwood, arms 22 inches long.... 5 50

THUMB TACKS AND HORN CENTRES.


1065.


1068.


1071.


1075.


1076.

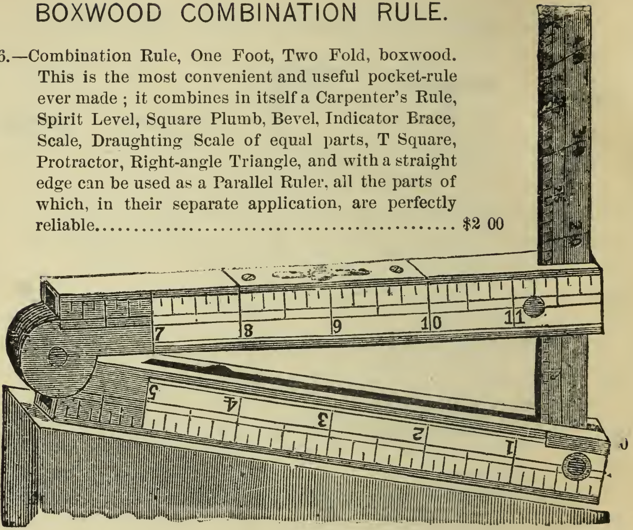
No.		PRICE
1065.—	Thumb Tacks, brass, round flat heads, ⅜ inch diameter, per doz.......	$ 25
1066.—	Do. do. do. ½ do. do.	35
1067.—	Do. German-silver do. ⅜ do. do.	60
1068.—	Do. do. do. ½ do. do.	75
1069.—	Do. do. do. ⅝ do. do.	1 00
1071.—	Do. brass, right-angled, per doz	75
1075.—	Horn Centre..........................	15
1076.—	Do. with German-silver rim.......	35
1078.—	Thumb-tack Extractor and Impressor, nickel plated	25

POCKET RULES.

1080.—	One Foot, four Fold, boxwood, each.....	$ 25
1081.—	Do. do. do. edge plates...........................	50
1082.—	Do. do. do. brass edges, bound....................	75
1085.—	Two Feet, four Fold, boxwood	30
1086.—	Do. do. do. edge plates...........................	60
1087.—	Do. do. do. brass bound, with drafting scales......	1 00
1089.—	Two Feet, six Fold, boxwood, graduated 8ths, 10ths, 100ths, and 16ths.	1 25
1090.—	One Foot, four Fold, ivory, German-silver mounted...	1 25
1091.—	One Foot, four Fold, ivory, German-silver mounted, graduated in 8ths, 10ths, 12ths, 16ths, and 100ths of a foot on edges...................	1 50
1092.—	One Foot, four Fold, ivory, graduated in 8ths, 10ths, 12ths, 16ths, and 100ths, with German-silver edges, bound...	1 75
1093.—	One Foot, four Fold, ivory, Caliper, graduated in 8ths, 10ths 12ths, and 16ths..	2 50
1093A.—	One Foot, four Fold, ivory, Caliper, graduated in 8ths, 10ths, 12ths, and 16ths, with German-silver edges, bound..	3 00
1094.—	Two Foot, four Fold, ivory, German-silver mounted, with 8ths, 10ths, and 16ths inches, and ¼, ⅛, ¾, and 1 inch drafting scales............	4 50
1095.—	Two Feet, four Fold, ivory, same as No. 1094, German-silver bound...	5 50

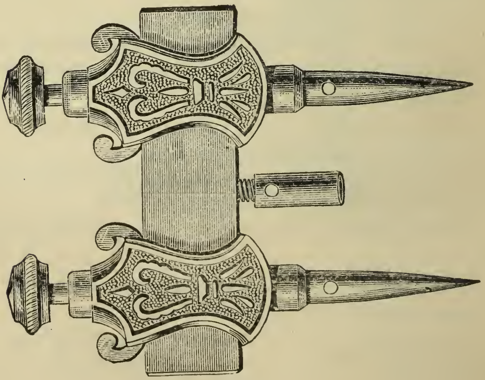
BOXWOOD COMBINATION RULE.

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



1096.

IMPROVED TRAMMEL POINTS.



1110.

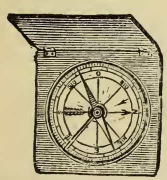
These tools are used by all who have occasion to strike arcs or circles larger than can be done by compass dividers. They may be used on a straight wooden bar of any length, and when secured in position by the thumb screws, all circular work can be readily laid out. They are made of bronze, and have steel points, either of which can be removed and replaced by pencil socket, which accompanies each pair.

No.	Price
1110.—Small, per pair	$1 25
1111.—Medium, per pair	1 50
1112.—Large, per pair	1 75

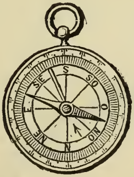
Horse Shoe Magnets.

1115.—2 inch	$ 15	1119.—5 inch	$ 70
1117.—3 "	25	1120.—6 "	1 00
1118.—4 "	45	1121.—7 "	1 25

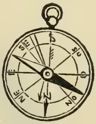
POCKET COMPASSES.



1140.



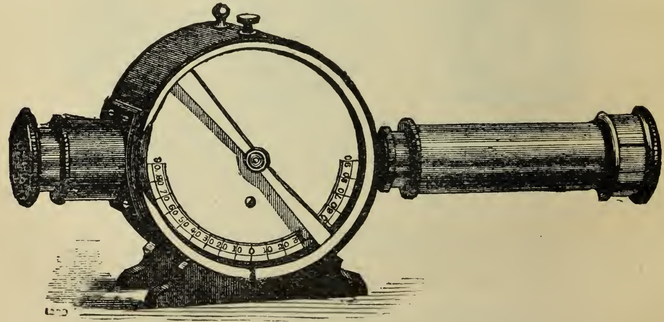
1144.



1160.

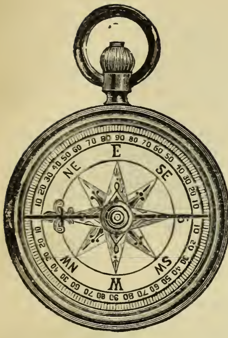
1140.—Mahogany Case, stop to needle, 1¼ inches square	$1 50
1141.— Do. do. 2 do.	2 00
1142.— Do. do. 2½ do.	2 25
1143.— Do. do. 3 do.	2 75
1144.—Brass, round, watch pattern, stop, agate centre, 1½ inch	1 25
1145.— Do. do. do. do. 2 do.	1 50
1146.—Brass, round, with cover, 1½ inches diameter, stop to needle	1 25
1147.— Do. do. do. and agate centre to needle	1 75
1148.—Brass, round, watch pattern, stop, agate centre, 1½ inch, with hinged cover	1 75

No.		PRICE
1149.	—German-silver, round, watch pattern, stop, agate centre, 1½ inch, with hinged cover	$2 50
1150.	—Pocket Compass, watch pattern, gilt, enamelled or metal face, stem stop, Bar needle, 1¼ inches in diameter	5 00
1151.	— Do. but 1½ inches in diameter	6 00
1152.	— Do. nickel-plated or gilt case, with hinged cover, spring catch and stop to needle in joint of cover	3 75
1153.	—Bar needle, nickel-plated or gilt case, with hinged cover, spring catch and stop to needle in joint of cover, 2 inches in diameter	5 00
1154.	—Pocket Compass, watch pattern, gilt, stem stop, in case, 1¼ inches diameter, Singer's patent pearl dial	5 50
1155.	—Pocket Compass, watch pattern, gilt, stem stop, in case, 1½ inches diameter, Singer's patent pearl dial	6 00
1156.	—Pocket Compass, watch pattern, nickel-plated hunting case, bar needle, 1½ inches in diameter, raised ring, metal face	4 00
1157.	—Pocket Compass, watch pattern, nickel-plated, but 1¾ inches in diameter	4 50
1158.	—Pocket Compass, nickel-plated hunting case, raised ring, stop to needle, folding sights, 2¾ inches in diameter	7 00
1159.	—Pocket Compass, nickel-plated hunting case, raised ring, stop to needle, folding sights, with levels	8 00
1159A.	—Geological Compass, of Brass, with pendulum for ascertaining the angle of dip in rocks	4 50
1160.	—Gilt Charm Compasses to hang to watch guard	25 cts. to 1 50
1161.	—Prismatic Azimuth Compass, brass, 2¾ in. diam	18 00
1162.	— Do. do. do. do. 4 do.	22 00

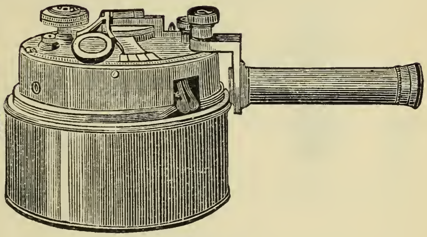


1163.

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 6½ × 2½ × 1⅛, in case .$50 00



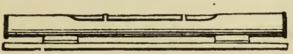
1150.



1164.

No.	Price
1164.—Pocket Sextant, with Telescope, very accurate	42 50
1165.—Surveyor's Cross—for right angles	3 00
1166.—Pedometer, for measuring distances walked, watch form and size, nickel-plated case	5 00

POCKET SPIRIT LEVELS.



1180.

Pocket Levels, Mounted in Brass.

1180.—3 inch	$ 75	1182.— 9 inch	$2 25
1181.—6 "	1 50	1183.—12 "	3 00

1185.—Level Vials, unmounted, 2 to 4 inches	25
1186.— " " 4 to 6 "	35
1187.— " " ground vials, 2 to 6 inches	50c. to 2 50

MICROSCOPES, &c.

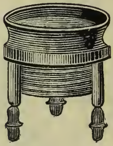
SIMPLE MICROSCOPES, TO FOLD IN CASES.

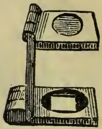

1200.


1220.


1225.


1230.


1235.


1238.

Hard Rubber Case and Frame, round form, 1 double convex lens.

No.	Price
1200.—¾ inch	$ 40
1201.—1 "	50
1202.—1¼ "	75
1203.—1½ inch	$1 00
1205.—2 "	1 50

Hard Rubber Case and Frame, round form, 2 double convex lenses.

No.	Price
1210.—⅝ and ¾ inch	$ 75
1211.—⅞ " 1 "	1 00
1213.—1⅛ " 1¼ "	1 25
1214.—1¼ and 1½ inch	$1 50
1216.—1¾ " 2 "	2 50

Hard Rubber Case and Frame, bellows form, 1 double convex lens.

No.	Price
1220.—¾ inch	$ 50
1222.—1 inch	$ 75

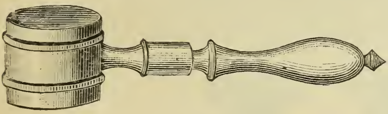
Hard Rubber Case and Frame, bellows form, 2 double convex lenses.

No.	Price
1225.—⅝ and ¾ inch	$ 90
1227.—⅞ and 1 inch	$1 25

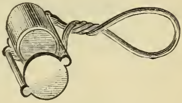
Hard Rubber Case and Frame, bellows form, 3 double convex lenses.

No.	Price
1230.—½, ⅝ and ¾ inch	$1 25
1232.—¾, ⅞ and 1 inch	$1 65

No.		PRICE
1235.—Microscope on three legs with screw adjustment for focus.............		$ 75
1236.—Linen provers or microscope for counting threads in linen or wool fabrics. Hard rubber 1 inch open space..............................		1 75
1237.— Do. Brass, ¼ and ½ in. open space.................		50
1238.— Do. do. $\frac{25}{100}$ in. square can be changed to $\frac{18}{100}$ in Diameter....		60



1240.

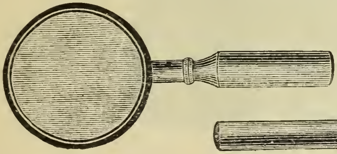


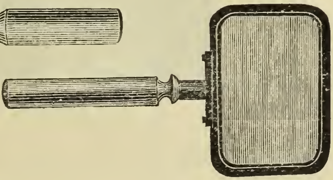
1245.

1240.—Coddington Lens, brass frame, three sizes... ....$1 00, $1 50 and	$2 00
1244.— Do. silver frame...........................	2 25
1245.— Do. do. with cover..............................	2 50
1246.— Do. do. do. large size...	4 00

READING AND PICTURE LENSES.

1250 and 1260.





1255.

Reading Glasses, hard rubber frame, double convex lens.

1250,—2 inch.......................	$1 00	1252.—3 inch.......................	$1 75
1251.—2½ "	1 25	1254.—4 "	3 00

Reading Glasses, hard rubber frame, double convex lens.

1255.—2 inch......	$1 25	1257.—3 inch........................	$2 00
1256.—2½ "	1 50	1259.—4 "	3 00

Reading Glass, oxidized metal frame, two plano-convex lenses.

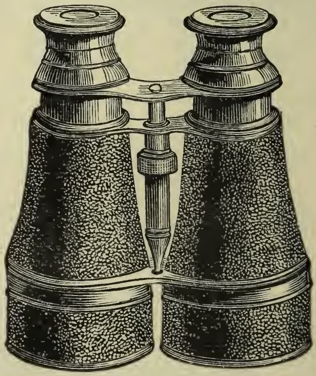
1260.—2½ inch....	$1 50	1262.—3½ inch....................	$3 25
1261.—3 "	2 25	1263.—4 "	4 00

1265.—Picture Glass, metal frame and handle, double convex lens, 5 inches diameter..............	5 00
1266.— Do. 5½ inches diameter....	6 00

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
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 50
B.— Do. 5¾	do.	do.	24	do.	....	8 50
C.— Do. 6¼	do.	do.	26	do.	....	9 50
1301.—U. S. Army Signal Service Six Lens Achromatic Marine or Field Glass, metal body, covered with Turkey morocco, sun shade to extend over the object-glass, and heavy leather case, with strap.						
A.—Body 5⅜ inches long; object-glasses 21 lines in diameter.........						$13 00
B.— Do. 5⅞	do.	do.	24	do.	....	14 50
C.— Do. 6¼	do.	do.	26	do.	....	15 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 inches long when adjusted, object-glasses 21 lines in diam.						16 50
B.— Do. 6¾	do.	do.	do.	24	do.	18 50
C.— Do. 7½	do.	do.	do.	26	do.	20 50

No. PRICE

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 inches long when adjusted,	object-glasses		21 lines	in diam.		$18 50
B.— Do. 6¾	do.	do.	do.	24	do.	20 50
C.— Do. 7½	do.	do.	do.	26	do.	22 50

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.

A.—Body 6¾ inches long, object-glasses 26 lines in diameter.......... 18 00

1306.—**The Gem.** A compact Field Glass, which is equally well adapted to the theatre or field ; and for the latter purpose, as well as for the use of the race-course, is a powerful, compact, and perfect instrument, being small enough to be carried in the pocket, with good power, large field of view, and sharp definition.

A.—Body 3½ inches long, object-glasses, 19 lines diameter. 20 00
B.— Do. 4 do. do. 21 do. 21 00

IMPROVED OPERA AND FIELD GLASS.

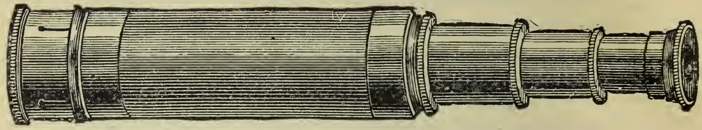
This glass is similar to "The Gem," but has a double draw to the eye-end, like a telescope ; is very portable, with good power.

1307.—A.—Body 3½ inches long, object-glasses, 17 lines diameter.............$16 00
B.— Do. 4 do. do. 19 do. 17 00

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

NOTE.—We also have constantly on hand a full and choice assortment of plain and fancy Opera Glasses, of best make. Sizes from 10 to 19 lines diameter. Prices from $3,50 to $25.00 each.

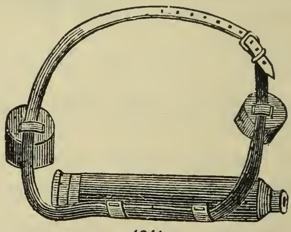
ACHROMATIC TELESCOPES.



1325.

No.		Price
1325.	—Telescope, wood body, 3 draws, 15 inches drawn out, 6 inches shut, object-glass 1 inch in diameter, power 13 times	$2 50
1326.	—Telescope, wood body, 3 draws, 16 inches drawn out, 6 inches shut, object-glass 1⅛ inches in diameter, power 16 times	3 50
1327.	—Telescope, wood body, 3 draws, 23 inches drawn out, 8 inches shut, object-glass 1⅜ inches in diameter, power 20 times	4 75
1328.	—Telescope, wood body, 3 draws, 30 inches drawn out, 10 inches shut, object-glass 1⅝ inches in diameter, power 25 times	7 00
1329.	—Telescope, wood body, 4 draws, 37 inches drawn out, 11 inches shut, object-glass 1⅞ inches in diameter; superior glass; power 35 times	12 00
1330.	—Telescope, wood body, 4 draws, 42 inches drawn out, 11½ inches shut, object-glass 2⅛ inches in diameter, power 40 times	20 00
1331.	—Telescope, wood body, 4 draws, 48 inches drawn out, 13½ inches shut, object-glass 2⅜ inches in diameter, power 50 times	30 00

TOURISTS' GLASSES.



1341.

1341.—Tourist's Achromatic Spy-glass, with brass body, covered with black Turkey morocco; three draws, 17 inches long when drawn out, 6 inches long when shut up; object-glass 1¼ inches 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

1342.—Same as No. 1341, but is 21 inches long when drawn out, 7 inches long when shut up; object-glass 1⅝ inches diameter. Power 25 times ... 11 00

1343.—Same as No. 1341, but is 24 inches long when drawn out, 9 inches long when shut up; object-glass 1¾ inches diameter. Power 30 times.... 14 00

No. PRICE

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

1345.—Rifle Spy-glass, 10¾ inches long, body covered with black leather; achromatic object-glass ⅝ inch in diameter. Power 10 times......... 2 50

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 bast effect......... .... 5 00

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 00

ASTRONOMICAL TELESCOPES.

1355.—Astronomical Telescope. Polished wood body, 47 inches long, mounted on firm tripod stand, achromatic object-glass 3 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 50 times; celestial eye-piece, with black sun-glass, power 100 times, with walnut case......... ....100 00

DRAWING PAPER.

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

WHATMAN'S HOT AND COLD PRESSED DRAWING PAPERS.

SELECTED, BEST QUALITY.

No.					Price
1400.—Demy,	20 × 15,	per quire,	$1 00;	per sheet	$ 06
1401.—Medium,	22 × 17,	do.	1 40;	do.	08
1402.—Royal,	24 × 19,	do.	1 75;	do.	10
1403.—Super Royal,	27 × 19,	do.	2 20;	do.	12
1405.—Imperial,	30 × 21,	do.	3 00;	do.	20
1407.—Atlas,	33 × 26,	do.	4 75;	do.	25
1408.—Double Elephant,	40 × 26,	do.	5 50;	do.	30
1409.—Antiquarian,	52 × 31,	do.	27 50;	do.	1 50

BLEACHED MANILLA, BUFF TINT.

FOR WORKING DRAWINGS, BEST AMERICAN MAKE, IN ROLLS OF ABOUT 50 POUNDS.

1415.—36 inches wide,	thick,	per pound,	15 cts.;	per yard	$ 10
1416.—40	do.	do.	do.	do.	12
1418.—48	do.	do.	do.	do.	15
1419.—54	do.	do.	do.	do.	18

AMERICAN WHITE ROLL DRAWING PAPER.

VERY STRONG AND OF EXCELLENT QUALITY, IN ROLLS OF 40 TO 50 POUNDS.

1420.—36 inches wide,	per pound,	60 cts.;	per yard	$ 25
1421.—42	do.	do.	do.	30
1422.—46	do.	do.	do.	35

EXCELSIOR WHITE ROLL DRAWING PAPER.

IN ROLLS OF 30 TO 50 POUNDS.

1425.—36 inches wide,	medium,	per pound,	45 cts.;	per yard	$ 25
1426.—42	do.	do.	do.	do.	30
1427.—56	do.	do.	do.	do.	50

BEST EGGSHELL DRAWING PAPER.

IN ROLLS OF 30 TO 40 POUNDS.

No.		Price
1430.	—42 in. wide, medium, rough surface, per pound, 45 cts.; per yard.......	$ 35
1431.	—58 in. wide, medium, rough surface, per pound. 45 cts.; per yard.......	45
1432.	—58 in. wide, heavy, rough surface, per pound, 45 cts.; per yard.........	50

The pound price applies only to full, unbroken rolls.

MOUNTED DRAWING PAPER.

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

1438.—American,	36	inches wide,	smooth surface,	per roll,	$8.00;	per yard	....	$ 90
1439.— Do.	42	do.	do.	do.	9.00;	do.	....	1 00
1441.—Excelsior,	42	do.	do.	do.	9.00;	do.	....	1 10
1442.— Do.	56	do.	do.	do.	13.00;	do.	....	1 51
1445.—Eggshell,	42	do.	rough surface,	do.	9.00;	do.	....	1 10
1446.— Do.	54	do.	do.	do.	12.00:	do.	....	1 25
1447.— Do.	58	do.	do.	do.	13.50;	do.	....	1 50

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

TRACING PAPER.

1450.—English, in rolls of 20 yards, 40 inches wide, per roll..................	$4 00
1451.—French, common, in rolls of 11 yards, 43 inches wide, per roll..........	1 50
1452.— Do. do. do. 22 do. 43 do. do.	2 25
1453.— Do. vegetable, do. 22 do. 54 do. do.	4 50
1454.—Parchment, very tough and transparent, and does not discolor from age, in rolls of 33 yards, 38 inches wide, per roll......................	8 00
1455.—German, tough and transparent, in rolls, 43 inches wide, 22 yards long, per roll..	5 00
1456.—Vegetable Royal, 25 × 19 inches, per quire $2 20; per sheet............	12
1457.— Do. Super Royal, 26 × 21 inches, per quire, $3 00; per sheet.....	20
1458.— Do. Double Elephant, 40 × 28 inches, per quire, $8 00; per sheet.	50
1459.—"Flaxine," American tracing paper, white, very strong.	
A.—31 × 21 inches, per quire, $2 50; per sheet............................	12
B.—40 × 30 do. 3 50; do.	17
1460.—Bond paper, for tracings, very tough.	
A.—21 × 16 inches, per quire, $1 00; per sheet...........................	05
B.—24 × 19 do. 1 20; do.	06
C.—30 × 19 do. 1 40; do.	07

TRACING OR VELLUM CLOTH.

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

No.						Price
1465.—Imperial,	18 inches wide,	per roll,	$4 00 ;	per yard		$ 25
1466.— Do.	30	do.	do.	6 90 ;	do.	40
1467.— Do.	36	do.	do.	7 50 ;	do.	45
1468.— Do.	42	do.	do.	10 50 ;	do.	60

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.

PREPARED SENSITIVE PAPERS.

Packed in tubes to keep from light, one dozen sheets in each tube, and are always ready for immediate use.

1470.—Demy,	21 × 16,	per dozen	$ 85
1473.—Super Royal,	28 × 20,	do.	1 65
1474.—Double Medium,	36 × 23,	do.	2 25
1476.—Double Elephant,	40 × 27,	do.	3 50
1478.—Sensitized Solar Printing Paper, 42 inches wide, in continuous rolls of 10, 20, or 50 yards, per yard			40
1479.—Photo-Solution, per bottle			4 40

ROLL DRAWING PAPER FOR SENSITIZING.

No.		Price
1480.	42 inches wide, per roll of 10 yards, $2 50; 55 yards	$8 50
1481.	60 do. do. do. 3 50; do.	12 00
1482.	Steinbach's, 53 inches wide, very superior, light, per yard	35
1483.	Do. do. do. heavy, do.	50
1484.	Do. 26½ do. do. do. do.	30

SOLID SKETCHING BLOCKS.

Each Block consists of 32 leaves of best quality Whatman's Drawing Paper.

1486.—4to Royal,	12 × 9,	unbound,	$1 50;	bound*	$2 75
1488.—8vo Imperial,	10 × 7,	do.	1 25;	do.	2 25
1489.—4to do.	14 × 10,	do.	2 25;	do.	3 50
1490.—Half do.	20 × 14,	do.	4 00;	do.	5 75

* 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.

SKETCHING OR DESIGNING PADS.

1492.—Sketching Pads, plain block, 7 × 5 inches, 25 leaves, rulings either 4, 8, 10, or 12 spaces to inch, each $1 25

1493.—Sketching Pads, plain block, 14 × 10 inches, 25 leaves, rulings either 4, 8, 10, or 12 spaces to inch, each 2 50

TOWNSHIP PLOTTING PAPER.

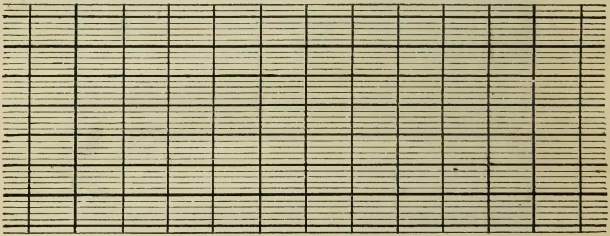
1495.—Township Plotting Paper, Rulings 6 × 6 blocks, blocks 1 inch square, per 100 sheets $2 00

1496.—Township Plotting Paper, Rulings 12 × 12 blocks, blocks 2 inches square, per 100 sheets 2 50

PROFILE PAPERS.

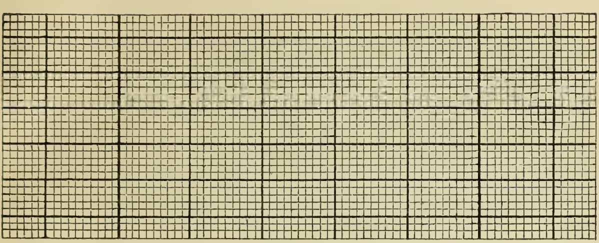
Printed in red or green.

PROFILE PAPER, PLATE A.



PROFILE PAPER, PLATE B.

PROFILE PAPER, PLATE C.



PROFILE PAPER, METRIC.

PROFILE PAPER.

No.		Price
1500.	—Plate A, 42 × 15 in., horizontal ruling, 4, vertical, 20 to in., per sheet...	$ 40
1501.	—Plate B, 42 × 13¼ do. 4, do. 30 do. do. ...	40
1502.	—Plate C, 42 × 15 do. 5, do. 25 do. do. ...	40
	Nos. 1500, 1501, and 1502, per quire....................................	8 50
1503.	—Continuous Profile Paper Plates, A or B, rulings 20 inches wide, per yard..	30
1505.	—METRIC.—In Continuous Roll, rulings 50 centimetres wide, in millimetres, with each fifth millimetre, each centimetre, and each decimetre, proportionally heavier than the millimetres. Price, per yard..	30

MUSLIN BACKED ROLL PROFILE PAPER,

1510.	—Muslin Backed Roll Profile Paper, of either Plate A or B, rulings 20 inches wide, in rolls of 20 yards, per yard..............................	$ 75
1515.	—METRIC.—Muslin Backed, Rulings 20 inches wide, in rolls of 20 yards, per yard..	75

CROSS SECTION PAPERS.

Printed in red or green.

1520.	—Topographical Paper, 17 × 14 inches, ruled 400 feet to the inch, per quire, $1.75, per sheet	$ 10
1521.	—Trautwine's Cross Section and Diagram, 10 feet to inch, for embankments of 14 and 24 feet, roadway, and for excavations of 18 and 28 feet, rulings 19¾ × 12 inches, per quire, $5.00, per sheet............ ...	25

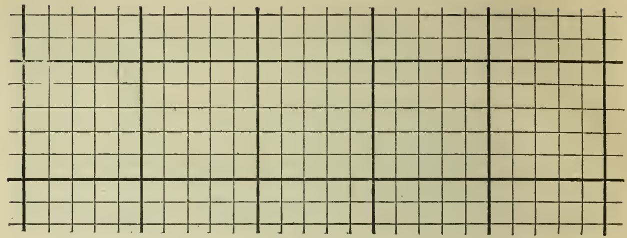


PLATE C.

No. PRICE

1522.—Cross Section Paper, Plate C, rulings 20 × 16 inches, 8 feet to inch, per quire, $5.00, per sheet.. $ 25

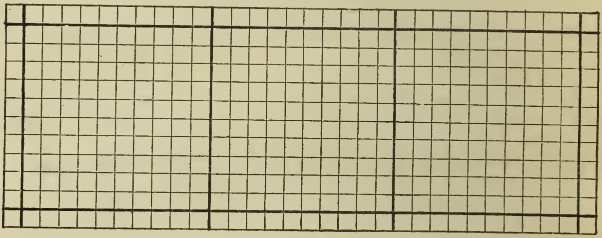


PLATE F.

1523.—Cross Section Paper, Plate F, rulings 20 × 16 inches, 10 feet to inch, per quire, $5.00, per sheet. .... $ 25

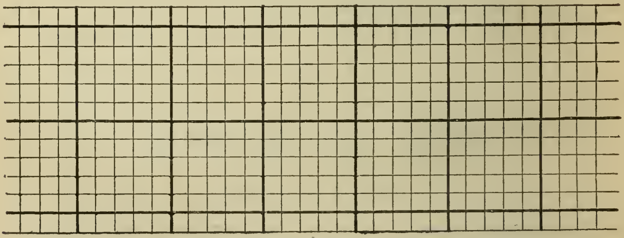


PLATE G.

1524.—Cross Section Paper, Plate G, rulings 22 × 16 inches, 10 feet to inch, every fifth line heavy, per quire, $5.00, per sheet.................... $ 25

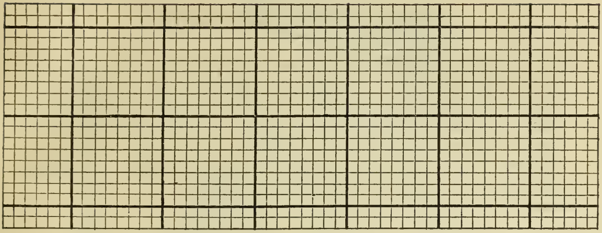
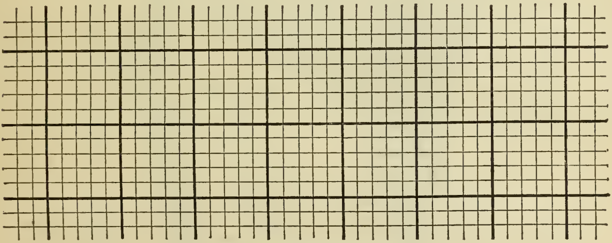


PLATE H.

No. PRICE

1525.—Cross Section Paper, Plate H, rulings 21 × 16 inches, 16 feet to inch, per quire, $5.00, per sheet . . . . $ 25



METRIC.

1526.—Cross Section Paper, Metric, rulings every two millimeters, size of sheet, 50 × 40 centimeters, per quire, $5.00, per sheet. . . . . $ 25

1527.—Cross Section, Plate G, printed on Parchment Tracing Paper, in sheets, 20 × 18 inches, per quire, $5.00, per sheet. 25

The following list of Cross Section Papers, being ruled, are much cheaper than those printed from copper plates, and are sufficiently accurate for sketching or designing purposes.

1528.—	Ruled Cross Section Paper,	4 spaces to inch,		28 × 20 inches,	per quire ..			2 50
1529.—	Do.	do.	8	do.	28 × 20	do.	do. ..	2 50
1530.—	Do.	do.	10	do.	28 × 20	do.	do. ..	2 50
1531.—	Do.	do.	10	do.	28 × 20	do.	5 to block, per quire	2 50
1532.—	Ruled Cross Section Paper,	12 spaces to inch,		28 × 20 inches,	per quire..			2 50

BOUND PROFILE BOOKS.

These books are for field or office purposes, being printed on both sides of 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. Size of book 9½ by 5¾ inches. The rulings correspond to our large profile plates A and B.

No.							Price
1540.—	Plate A,	25 leaves,	imitation Turkey morocco,		with elastic band	....	$3 50
1541.—	Do.	50	do.	do.	do.	do.	5 00
1542.—	Do.	100	do.	do.	do.	do.	8 00
1543.—	Do.	50	do. Turkey morocco, turned edges,			do.	6 00
1544.—	Do.	100	do.	do.	do.	do.	9 00
1545.—	Plate B,	25	do. imitation Turkey morocco,			do.	3 50
1546.—	Do.	50	do.	do.	do.	do.	5 00
1547.—	Do.	100	do.	do.	do.	do.	8 00
1548.—	Do.	50	do. Turkey morocco, turned edges,			do.	6 00
1549.—	Do.	100	do.	do.	do.	do.	9 00

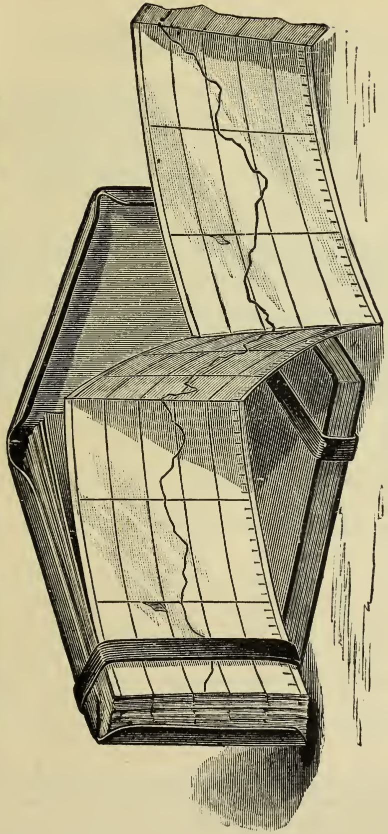
CONTINUOUS PROFILE BOOKS.

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	12 miles,	bound in	morocco,	with band	..	$3 00
1551.—	Do.	do.	25	do.	do.	do.	..	5 00
1552.—	Do.	do.	50	do.	do.	do.	..	8 50
1553.—	Do.	do.	100	do.	do.	do.	..	14 00
1554.—	Plate B, 8×4¾ inches,	do.	12	do.	do.	do.	..	3 00
1555.—	Do.	do.	25	do.	do.	do.	..	5 00
1556.—	Do.	do.	50	do.	do.	do.	..	8 50
1557.—	Do.	do.	100	do.	do.	do.	..	14 00

Profile Books, either plate, bound in seal skin, with turned edges, $1.50 additional to the above prices. Special lengths made to order and bound as may be desired.

KETCHAM'S CONTINUOUS PROFILE BOOK.



(Patent applied for.)
1550.

ENGINEERS' FIELD BOOKS.

No.		Price
1560.	—Level Books, 7 × 4 inches, per dozen, $5 00; each	$ 50
1561.	—Transit Books, 7 × 4 inches, per dozen, $5 00; each	50
1562.	—Record Books, 7 × 4 inches, per dozen, $5 00; each	50
1563.	—Cross Section Books, 8 × 7 inches, for Topography, per dozen, $10 00; each	1 00
1564.	—Profile Level Books, 7 × 4 inches, per dozen, $7.50; each	75

LYONS' TABLES.

No. **Price**

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 M. E. Lyons, C. E.

Sheet No.	1.	General Table for all Bases and all Slopes.			
Do.	2.	For Side Hill Cuts and Fills.			
Do.	3.	Base	12 feet	Slopes	1½ to 1
Do.	4.	do.	14	do.	1½ to 1
Do.	5.	do.	15	do.	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.	9.	do.	16	do.	1 to 1
*Do.	10.	do.	18	do.	¼ to 1
*Do.	11.	do.	18	do.	¾ to 1
*Do.	12.	do.	18	do.	1 to 1
*Do.	13.	do.	18	do.	1½ to 1
Do.	14.	do.	20	do.	1½ 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

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 eyesight. 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.

Per sheet, 25 cents; bound in one volume........................... $8 50

1571.—Zimmerman's Universal Table, for Excavations and Embankments, adapted to any base and slope whatever, and the calculations of all solids to which the Prismoidal Formula is applicable. By Wm. Zimmerman, C. E. Price.. 1 00

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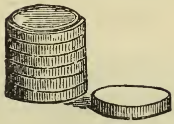
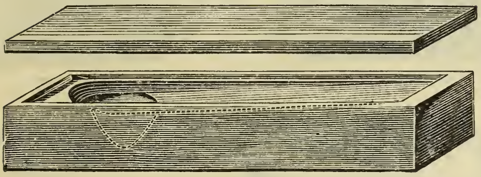
* Out of print.

INK SLABS, AND SAUCERS.


1575.


1585.


1580.

Ink Slabs.

For India Ink and Colors; containing 3 holes or cups and 1 slanting division.

No.		Price
1575.	—Measuring 2¾ × 1½ inches, each	$ 15
1576.	— Do. 3¾ × 2⅜ do.	25
1577.	— Do. 4⅜ × 2¾ do.	35
1578.	— Do. 4¾ × 3 do.	40
1579.	— Do. 5 × 3½ do.	45
1580.	—Patent Ink Slab, 4½ × 1¾ inches, with cover, each	50
1581.	— Do. 5¼ × 2⅛ do. do,	60
1582.	—Slate Ink Slab, 4 × 4 inches, with ground glass cover, each	75

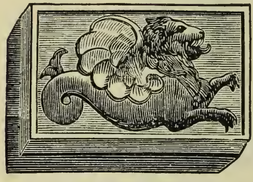
Cabinet Nests.

Porcelain Saucers in nests; fitted on each other.

1585.	—Containing 5 saucers and a cover, 2½ inches in diameter, per nest	$ 60
1586.	— Do. 5 do. 2¾ do. do.	70
1587.	— Do. 5 do. 3¼ do. do.	80
1588.	— Do. 5 do. 3¾ do. do.	1 00
1589.	—Architect's Basin, with 8 divisions and cup.	1 35
1590.	—Sloping Tile, 3 divisions 4 × 2½ inches, each	20
1591.	— Do. 4 do. 7¾ × 3⅛ do.	35
1592.	— Do. 5 do. 7¾ × 3⅛ do.	45
1593.	— Do. 6 do. 7¾ × 3⅛ do.	55

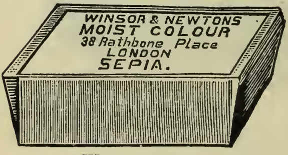
WINSOR & NEWTON'S WATER COLORS.

HARD COLORS IN CAKES, OR MOIST IN CHINA PANS.



WHOLE CAKE.

HALF CAKE.



WHOLE PAN.

HALF PAN.

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.

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 Vermillion.
58 Sepia.
59 Warm Sepia,

No.			PRICE
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 *.

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.

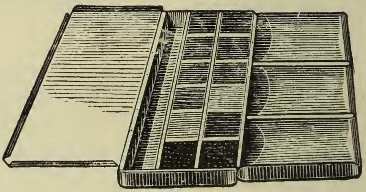
Hooker's Green No. 2	to represent	Grass.
Burnt Sienna	do.	Cultivated ground.
do. and Hooker's Green	do.	Uncultivated do.
Indigo do. do.	do.	Swamp.
Gamboge do. do.	do.	Trees.
Yellow Ochre	do.	Roads and Streets.
Indigo	do.	Water.
Carmine	do.	Buildings, Bridges, and Masonry.
Sepia	do.	Hills.
do.	do.	Shade lines and shadows.

WATER COLOR SLIDE-LID BOXES.

No.				Price
1610.—Color Boxes to hold		6 whole or half cakes		$ 40
1611.—	Do.	12	do.	50
1612.—	Do.	18	do.	60
1613.—	Do.	24	do.	75

EMPTY JAPANNED TIN BOX.

FOR MOIST COLORS.



1615.

1615.—For	6 full or 12	half-pans, each		$1 00
1616.—For 12	do.	24	do.	1 45
1617.—For 16	do.	32	do.	1 65
1618.—For 24	do.	48	do.	2 00

WINSOR & NEWTON'S WATER COLOR LIQUIDS.

IN GLASS BOTTLES.

1620.—Carmine	$ 45	1625.—Indian Ink	$ 35
1621.—Indelible Brown Ink	45	1626.—Chinese White	35
1622.—Prout's Brown	45	1627.—Sepia	45
1623.—Gold Ink	65	1628.—Silver Ink	40
1624.—Extract of Ox Gall	35	1629.—Prussian Blue	35

1630.—Pure Gold in shells, 20 cents ; in cups, 25 cents ; in cakes 2 00

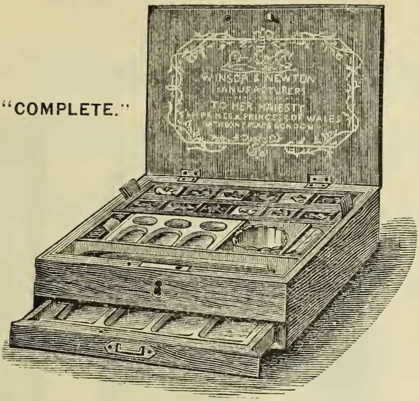
1631.—Silver Cakes in shells, 15 cents ; in cups 35

WINSOR & NEWTON'S WATER COLOR BOXES.

1635.—Polished Mahogany Box, wlth lock and key, and drawer, paint-stone, water-glass, India ink, brushes, and 12 colors, whole cakes $9 00, half $6 00

1636.—	Do.	do.	do.	18	do.	do.	14 00	do.	8 00
1637.—	Do.	do.	do.	24	do.	do.	18 00		

"COMPLETE."



1635.—"Complete" Box.

INDIA INK.

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.

No.		Price
1650.—	Oval, black, Lion head, per cake	$ 40
1651.—	Round, gilt, do. do.	25
1652.—	Round, gilt, Lion head, per cake	75
1653.—	Hexagon, gilt, per cake	50
1654.—	Square, black, Super Super (choice), per cake	2 00
1655.—	Do. do. do. half cake	1 00
1656.—	Blue, Red, and Yellow India Ink, each, per cake	75

JAPANESE INK.

1660.—	Oblong, black, with Figures, best small cake, per cake	$1 00
1661.—	Do. do. do. large do	3 00

These Inks are imported for us from China and Japan.

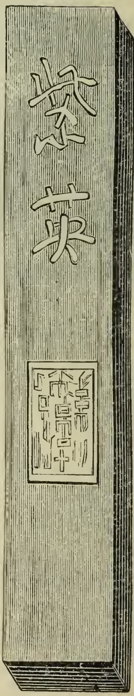
1665.—	Higgins' Waterproof Drawing Ink, per bottle	25

INDIA INK.

(For Prices, see pp. 293.)

1650.

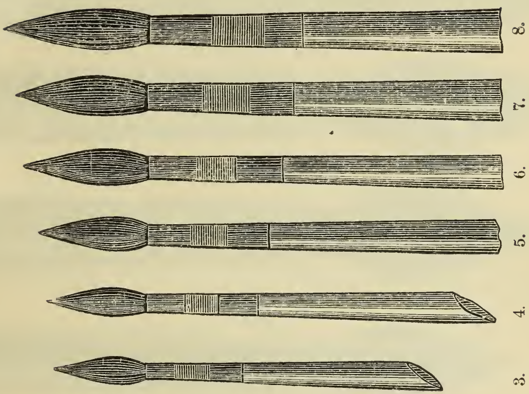
1652.



1654.

1660.

WATER COLOR BRUSHES.



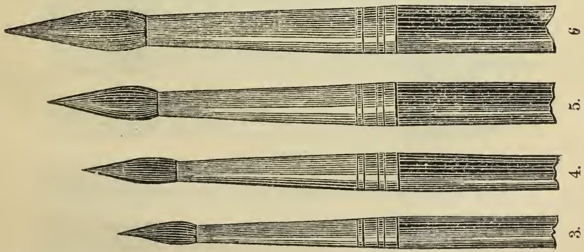
1670 and 1675.

1670.—Camel Hair in Quills,

	No. 1.	2.	3.	4.	5.	6.	7.	8.
each, $	05	05	06	06	08	08	10	10

1675.—Red Sable in Quills,

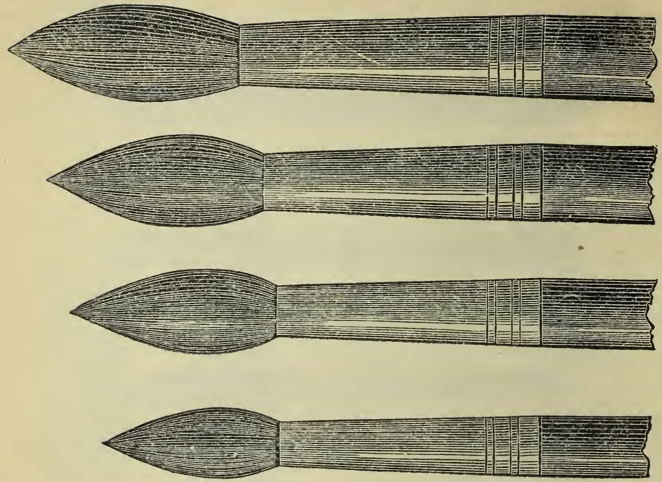
	No. 1.	2.	3.	4.	5.	6.	7.	8.
each, $	10	12	15	20	25	30	35	40



1680.

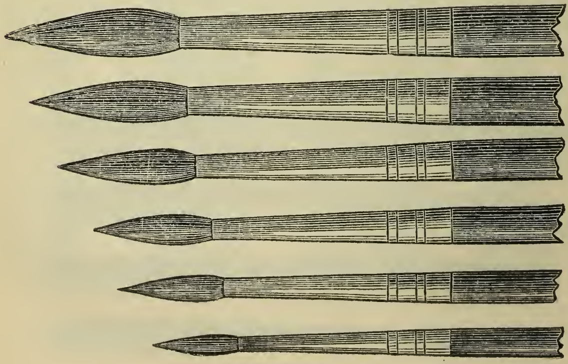
1680.—Camel Hair in Tin, with handle,

	No. 1.	2.	3.	4.	5.	6.
each, $	10	10	12	12	15	15



1685.—Camel Hair Sky or Wash Brush,

	No. 1.	2.	3.	4.	5.	6.
each,	$ 18	20	25	30	35	40



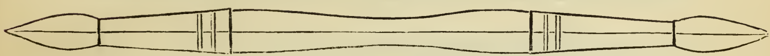
1690.—Red Sable in Albata, with handle,

	No. 1.	2.	3.	4.	5.	6.	7.	13.	14.
each,	$ 25	30	40	50	60	70	95	1 25	1 65

1695.

1695.—Camel Hair Wash Brushes in Tin, with 2 points,

	No. 0.	1.	2.	3.
each,	$ 40	50	60	75



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

GILLOTT'S STEEL PENS.

No.		Price
1700.	Mapping, on cards, per dozen	$ 75
1701.	Lithograph. on cards, per dozen	75
1702.	Lithograph Crow Quill, on cards, per dozen	75
1703.	Extra Fine, No. 303, per dozen, $.20; per gross	1 50
1704.	Do. 170, do. .15: do.	1 25
1705.	Falcon Pens, do. .12: do.	1 00
1706.	Commercial Pens, do. .10: do.	75
1707.	Business Pens, do. .10; do.	75

SOENNECKEN'S ROUND WRITING PEN.

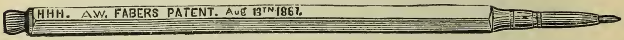
1709.	Single-pointed Pens, per gross, $1.10; per dozen	$ 20
	A.—Double-pointed Pens, assorted, per dozen	50
	B.—Copy Book, without instructions	60
	C.—Text Book for Round Writing, giving full instructions	1 10
	D.—Sample assortment of Pens, 25 in a box	35

LEAD PENCILS.

A. W. FABER'S.

No.		Price
1710.	—Hexagon, very best Siberian, Nos. 4 B to 6 H, per dozen	$1 25
1711.	— Do. do. Drawing, Nos. 1 to 5, do.	75
1712.	—Black round, best, Nos. 1 to 4, do.	60
1713.	—Hexagon, for Divider Points, No. 4, do.	1 00
1714.	—Round, do. do. do.	75

Artist Pencil with Siberian Lead.



1715.

1715.	—Artist Pencil with Siberian lead, each	$ 35
1716.	— Leads for Artist Pencils, Siberian, 6 in box, per box	65

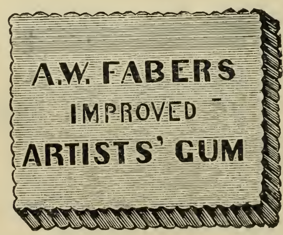
These leads fit the new pencil-holders in Alteneder and Swiss sets.

1717.	—Round red, blue, green, and yellow, per dozen	1 25
1718.	—One box, containing 5 pencils, BB to H	50
1719.	— Do. do. 7 do. BBB to HH	65
1720.	— Do. do. 10 do. BBBB to HHHH	90
1725.	—Red Chalk Pencils for marking stakes, per dozen	50
1726.	— Do. in lump, per pound	15
1727.	—French Venetian Crayons, for marking stakes (superior quality) per dozen	60

SPONGE RUBBER.

FOR CLEANING DRAWINGS.

1730.	—Sponge Rubber, medium cakes, each	$ 40
1731.	— Do. large do.	75

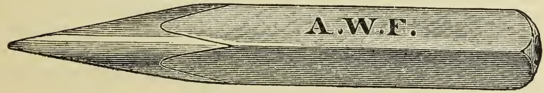


1735.

1742.

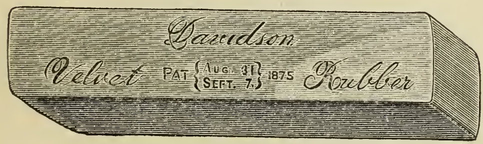
INDIA RUBBER.

No.		Price
1735.—	A. W. Faber's First Quality, white, 1½ × 1 inch, each	$ 06
1736.—	Do. do. do. 1¾ × 1¼ do.	12
1737.—	Do. do. do. 2 × 1⅜ do.	20
1738.—	Do. do. do. 3 × 2⅛ do.	50
1740.—	Do. do. Black pure Gum, 2 × 1⅜ inch, each	20
1741.—	Do. Improved Ink Eraser, 1½ × 1 inch, each	05
1742.—	Do. Combined Ink and Pencil Eraser, each	20
1743.—	Do. do. do. do. Mammoth, each	30



1744.

1744.—	A W. Faber's Pointed Rubber, 2½ × $\frac{5}{16}$ inches, each	$ 10
1745.—	Do da. 3 × ⅜ do.	15



1746.

1746.—	Davidson's Velvet Rubber, oblong, 1⅝ × ½ inch, each	$ 06
1747.—	Do. do. do. 2¼ × $\frac{9}{16}$ do.	12
1748.—	Do. do. do. 3¼ × ⅝ do.	20
1749.—	Do. do. do. 3 × 2¼ × $\frac{9}{16}$ do.	50

STEEL ERASERS.

1750.—	Roger & Son's Steel Blade, Cocoa Handle, each	$ 50
1751.—	Do. do. Ivory do. do.	75
1752.—	Do. Knife Eraser, Ebony do. do.	75

DRAWING BOARDS.

No.		Price
1755.	—14 × 10 inches, 35 cts.; 20 × 15 inches	$ 75
1756.	—Super Royal size, tongue and groove ends	1 25
1757.	—Double Elephant size, do.	2 50
1759.	—Framed Drawing Board, Mahogany, centre soft Pine and removable, 17 × 12 inches	3 00
1760.	— Do. do. do. 27 × 19 inches	5 00
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