M. U. MITCELL

THE

SAEGMULLER SOLAR ATTACHMENT,

HOW TO ADJUST AND USE IT,

WITH

SOLAR EPHEMERIS AND REFRACTION TABLES.

FAUTH & CO.

MANUFACTURERS OF

Engineering and Astronomical Instruments,

WASHINGTON, D. C.

GIBSON BROS., PRINTERS AND BOOKBINDERS.
1888.

INTERNATIONAL EXHIBITION

AWARDED BY
UNITED STATES
CENTENNIAL
COMMISSION

PHILADELPHIA, MDCCCLXXVI

TESTIMONIALS.

The following letters testify to the merits of the Saegmuller Solar Attachment. Particular attention is called to the fact that since these letters were written essential improvements have been made in the construction of the "Solar" which warrant us in guaranteeing still better results.

CALUMET AND HECLA MINE, ENGINEER'S OFFICE,
CALUMET, L. S., MICH., *May* 2, 1884.

FAUTH & CO.:

The transit made by you for this mining company with the Saegmuller solar attachment and quick-levelling tripod head has been in use by me since its arrival, and, as yet, I have found no fault with it whatever; in all its parts it far exceeds my expectations, and bears every evidence of skilled and faithful work, and it is just what was wanted to meet the requirements at this mine.

The solar attachment is very simple, and, as I have a meridian line established by an elongation of polaris, I had an opportunity to test its accuracy, which I can vouch for. The quick-levelling tripod head answers admirably its purpose, and, from the nature of our work here, is frequently brought into play. The cross-hairs are satisfactory, and I like their arrangement. The graduations of the horizontal and vertical circles with their verniers are clear, precise, and distinct; the telescope, tangent, and clamp-screws, illuminated axis—in fact, the *whole outfit* is what it should be, and convinces me that I made no mistake in the selection of the makers.

I recognize the advance you, as mathematical instrument makers, have made over similar work done by others within a few years, and I congratulate you, as a result of this kind tends to promote a proper feeling and understanding between those who make and those who use instruments, which imperfections in their manufacture rather tended to destroy.

Very respectfully,

PRESTON C. F. WEST,
Engineer Calumet and Hecla Mine.

WASHINGTON UNIVERSITY, ST. LOUIS, MO.,
Oct. 20, '84.

Messrs. FAUTH & CO.,
Washington, D. C.:

DEAR SIRS: I am more than pleased with the Solar attachment you put on my transit last spring. I regard it as at once the cheapest and by far the best attachment in the market. It is readily adjusted and manipulated, is wholly out of the way in using the transit, and is accurate beyond any disc attachment. The latitude is readily obtained (by sun's meridian altitude) to the nearest minute, and in the most favorable portions of the day, say from 8 to 10 A. M. and from 2 to 4 P. M., I think the meridian may be determined to the nearest minute. I think you have solved the attachment problem.

Very truly yours,

J. B. JOHNSON,
Professor Civil Engineering.

HARPERSVILLE, N. Y., *Feb.* 5, 1885.

FAUTH & Co.,
Washington, D. C.:

DEAR SIRS: Yours of February 2d reached me to-day with inquiry as to how the transit suited. In reply, I would say I am pleased much better than I thought I could be. It arrived in good order and has done some of the finest work in Browne county. Have used the Solar attachment and am well pleased with its workings. I don't see how I got along with my old instrument.

This transit is a great arbiter of lines in this valley where it is known. They seem to lose sight of the surveyor in their admiration of the "beautiful instrument," as they call it. I have been out 30 or 40 days with it and it proves true every time. * * *

I have seen Mr. E. W. Lindsley, of Downsville, Del. Co., N. Y., who is using one of your transits, and he is well suited with it.

Wishing you success, yours, very truly,

H. S. WILLIAMS.

J. FRANCIS LEBARON, *Secretary.*
ROOMS OF THE SOUTHERN SOCIETY OF CIVIL ENGINEERS,
Rooms 4 and 5 Bostwick's Block, entrance foot of Pine St.,
JACKSONVILLE, FLA., *Nov.* 6, 1886.

Messrs. FAUTH & Co.,
Washington, D. C.

GENTLEMEN: I have now been using one of your transits for nearly four months constantly, and I desire to convey to you my appreciation of its merits, entirely unsolicited. I have used instruments constantly for 20 years, and have never seen one that excelled yours in accuracy of work and fineness of construction.

The only approach to your instrument, in my opinion, was made by J. H. Temple, of Boston, now deceased.

I have used instruments made by Temple, King, Poole, Gurley, Young, Gardam, Buff & Berger, Heller & Brightley, Wurdemann, Stackpole, Chapman (of London, Eng.), and other home and foreign makers, but never have found any excel, and few equal, your No. 1 transit, with Solar attachment. The quick levelling arrangement is a perfect success, combining ease and rapidity of manipulation with stability.

I found I could read the time on my watch at 850 feet without difficulty. This was the first and only trial I made. I turned off 90° and set a flag 3 times on top of a stake within a ring of 1 inch diameter at a distance of 1,600 feet.

The screws all work with a true and even motion, and the graduation is clear and distinct. In fact I do not think it possible to make a better instrument.

Truly yours,

J. FRAS. LeBARON, C. E.,
Secretary So. Soc. Civ. Engrs.

DEPARTMENT OF CIVIL ENGINEERING,
PENNSYLVANIA STATE COLLEGE,
STATE COLLEGE, CENTER CO., PA.,
June 15, 1887.

Messrs. FAUTH & Co.,

DEAR SIRS: I have used your Solar attachment for two years in the practical work of the Civil Engineers' Course, and have found it in all respects very satisfactory. It is readily attached, easily used, not liable to get out of adjustment, and moreover, since there is a telescopic line of sight, it is more accurate than previous forms of solars.

Very truly yours,

LOUIS H. BARNARD,
Prof. C. E.

CHATTANOOGA, TENN., *April* 16, 1888.

FAUTH & Co.,
Washington, D. C.

GENTLEMEN: You ask my opinion of the transit of your make, which I used in making Standard Parallel and Guides Meridian surveys in Dakota. I will candidly say that for steadiness in rough, windy weather, ability to endure hard usage, and accuracy of results obtained with it, I have never used a superior instrument. By the use of the Saegmuller Solar Attachment, very close approximations to a true meridian, sometimes an exact meridian, could be obtained not only when the weather was clear, but often when the sun could barely be discerned through the clouds. Judging from this instrument, another you made for me, and also others from your establishment which I have seen, I am sure any one wishing to buy a transit need not hesitate to order from you, for fear of getting a poor instrument.

Yours truly,

BENJ. THOMPSON,
U. S. Deputy Sureyor and C. E.

THE LEHIGH UNIVERSITY,
DEPARTMENT OF CIVIL ENGINEERING,
BETHLEHEM, PA., *April* 23, 1888.

Messrs. FAUTH & Co.

GENTLEMEN: Your favor asking regarding the Solar Attachment placed last year on our Wurdeman transit was duly received. We are highly pleased with it on account of the simplicity of its construction and use. A series of 21 observations of azimuth made with care by one observer gives 1′ 12″ as the probable error of a single observation, or 16″ as the probable error of the final result. The latitude was known very accurately; the circles of the transit read to 20″, but the circular bubble on the lower limb is not *sufficiently sensitive for solar work*, and there is no very precise way of adjusting the *horizontal axis of the telescope*. This latter point seems to *require particular attention* in work of this kind. This spring an accurate astronomical determination of the azimuth of the line will be made, and I can then inform you as to the actual error.

Yours truly,

MANSFIELD MERRIMAN.

ALBANY, LINN CO., OREGON,
June 1, 1888.

Messrs. FAUTH & Co.,
Washington, D. C.

GENTLEMEN: The Complete Engineer's Transit, with Solar Attachment, made by you for me came in good order, and after about one year's use I can fully recommend to those not acquainted with your instruments to be of excellent workmanship, with smooth, firm, and steady movement and fineness of graduation. And the various improvements have made the instrument light and quick in the manipulation of the various parts.

Yours respectfully,

J. A. WARNER.

BINGHAMTON, N. Y.,
July 13, 1888.

FAUTH & Co.

DEAR SIRS: The High Grade Transit, with Solar Attachment, which you made for me, is satisfactory in every respect, and after a careful examination of instruments of the principal manufacturers, I ordered of you, and am pleased that I did so. I have been unable to detect the slightest defect that would impair the efficiency and accuracy of the instrument.

Yours truly,

HENRY L. GRIFFIS,
Prof. of Physics, New Paltz Normal School,
New Paltz, N. Y.

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The Solar Ephemeris and Refraction Tables will be published every year. Those desirous of obtaining them will please forward their addresses.

THE SAEGMULLER SOLAR ATTACHMENT.

Patented May 3, 1881.

This attachment to the regular Engineer's Transit, by means of which the astronomical meridian may be obtained in a few minutes with an accuracy scarcely thought to be possible, has met with such success that it bids fair to supersede all other methods for the determination of the meridian by means of engineering instruments.

The transit has come to be the universal instrument for the engineer, and will be for the surveyor sooner or later, and the attachment of the solar apparatus to the transit has thus become a necessity.

Since its first introduction this attachment has been greatly improved, and, as now made, is well nigh perfect. Attached to any transit which possesses a telescope level and a vertical circle, it will give the meridian within the nearest minute. By using instruments which have a finer graduated vertical circle and better levels than are usually found on transits, the meridian can be determined with greater accuracy still.

Advantages of the "Saegmuller Solar Attachment" over the old form.

First. It is more accurate.

Second. It is simpler and easier of adjustment.

Third. It can be used when the sun is partly obscured by clouds, when the ordinary "solar" fails altogether.

Fourth. It can be used where the sun is quite close to the meridian.

Fifth. The time can be obtained with it reliable to within a few seconds with perfect ease.

It is as superior to all forms hitherto used as the transit is to the ordinary compass, or as a telescope is to common sights.

The sights of an ordinary solar compass consist merely of a small lens and a piece of silver with lines ruled on it placed in its focus. This is simply a *very primitive* telescope, since the exact coincidence of the sun's image with the lines has to be determined by the unaided eye, or at best with a simple magnifying glass.

That far greater precision can be attained by means of a suitable telescope is obvious; in fact, the *power* of the solar telescope is in keeping with the transit telescope, as it should be.

A glance at the cut will show that the "Saegmuller Solar Attachment" is far simpler than the ordinary form. By raising or depressing, it can be set to north or south declination. To effect this with the ordinary solar compass *two* sets of *primitive telescopes*—one answering for north, the other for south declination—are required, which are difficult to adjust.

The addition of the level on the solar telescope dispenses with the declination arc altogether, the arc or circle on the transit also serving for that purpose in conjunction with it.

The "Saegmuller Solar Attachment" is in fact the only one which should be used in connection with a transit instrument. *It solves the solar problem*, as has been attested seen by leading astronomers and engineers who have and used it.

Prof. J. B. Johnson, of Washington University, St.

Louis, Mo., has given it a thorough test, and writes as follows:

"In order to determine just what accuracy was possible with a Saegmuller Solar Attachment, I spent two days in making observations on a line whose azimuth had been determined by observations on two nights on Polaris at elongation, the instrument being reversed to eliminate errors of adjustment. Forty-five observations were made with the solar attachment on Oct. 24, 1885, from 9 to 10 A. M., and from 1.30 to 4 P. M., and on Nov. 7, forty-two observations between the same hours.

"On the first day's work the latitude used was that obtained by an observation on the sun at its meridian passage, being 38° 39′, and the mean azimuth was 20 seconds in error. On the second day, the instrument having been more carefully adjusted, the latitude used was 38° 37′, which was supposed to be about the true latitude of the point of observation, which was the corner of Park and Jefferson avenues in this city. It was afterwards found this latitude was 38° 37′ 15″, as referred to Washington University Observatory, so that when the mean azimuth of the line was corrected for this 15″ error in latitude it agreed exactly with the stellar azimuth of the line, which might have been 10″ or 15″ in error. On the first day all the readings were taken without a reading glass, there being four circle readings to each result. On the second day a glass was used.

"On the first day the maximum error was 4 minutes, the average error was 0.8 minute, and the 'probable error of a single observation' was also 0.8 minute. On the second day the maximum error was 2.7 minutes, the average error was 1 minute, and the 'probable error of a single observation' was 0.86 minute. The time required for a single observation is from three to five minutes.

"I believe this accuracy is attainable in actual practice, as no greater care was taken in the adjustment or handling of the instrument than should be exercised in the field.

"The transit has come to be the universal instrument for the engineer, and should be for the surveyor, so it is more desirable to have the solar apparatus attached to the transit than to have a separate instrument. The principal advantages of this attachment are:

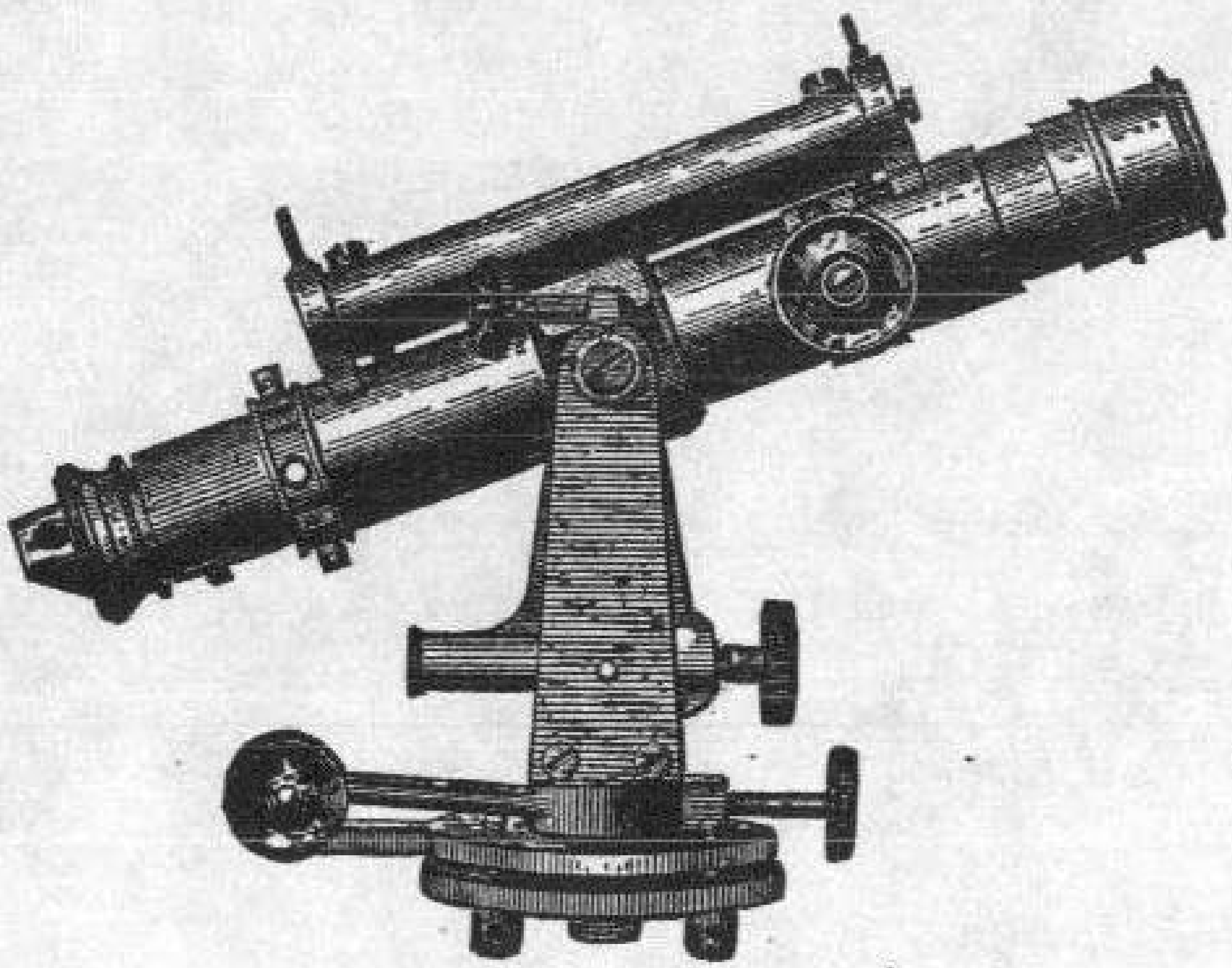
"1. Its simplicity.

"2. Its accuracy of pointing, being furnished with a telescope which is accurately set on the sun's disk.

"3. In its providing that all angles be set off on the vertical and horizontal limbs of the transit, thus eliminating the eccentricity and other inaccuracies usually found in attachment circles or arcs.

"4. Its small cost.

"It is also readily removed and replaced without affecting its adjustments, and is out of the way in handling and reversing the telescope. It may be attached to any transit."



Saegmuller Solar Attachment.

The above cut represents the improved "Saegmuller Solar Attachment" as now made. It consists essentially of a small telescope and level, the telescope being mounted in standards, in which it can be elevated or depressed. The standard revolves around an axis, called the polar axis, which is fastened to the telescope axis of the transit instrument. The telescope, called the "Solar Telescope," can thus be moved in altitude and azimuth. Two pointers attached to the telescope to approximately set the instrument, are so adjusted that when the shadow of the one is thrown on the other the sun will appear in the field of view.

Adjustment of the Apparatus.

1. The Transit must be in perfect adjustment, especially the levels on the telescope and the plates; the cross axis of the telescope should be exactly horizontal, and the index error of the vertical circle carefully determined.

2. **The Polar axis must be at right angles to the line of collimation and horizontal axis of main telescope.**

To effect this, level the instrument carefully and bring the bubble of each telescope level to the middle of its scale. Revolve the Solar around its polar axis, and if the bubble remains central the adjustment is complete. If not, correct half the movement by the adjusting screws at the base of the polar axis, and the other half by moving the solar telescope on its horizontal axis.

3. **The line of collimation of the solar telescope and the axis of its level must be parallel.**

To effect this bring both telescopes in the same vertical plane and both bubbles to the middle of their scales. Observe a mark through the transit telescope, and note whether the solar telescope points to a mark above this, equal to the distance between the horizontal axes of the two telescopes. If it does not bisect this mark, move the crosswires by means of the screws until it does. Generally the small level has no adjustments and the parallelism is effected only by moving the crosshairs.

The adjustments of the Transit and the Solar should be *frequently* examined, and kept as nearly perfect as possible.

Directions for using the Attachment.

First. Take the declination of the sun as given in the Nautical Almanac for the given day, and correct it for refraction and hourly change. Incline the *transit telescope* until this amount is indicated by its vertical arc. If the declination of the sun is north, depress it; if south, elevate it. Without disturbing the position of the transit telescope, bring the solar telescope into the vertical plane of the large telescope and to a horizontal position by means of its level. The two telescopes will then form an angle which equals the amount of the declination, and the inclination of the solar telescope to its polar axis will be equal to the polar distance of the sun.

Second. Without disturbing the *relative* positions of the two telescopes, incline them and set the vernier to the co-latitude of the place.

By moving the transit and the "Solar Attachment" around their respective *vertical* axes, the image of the sun will be brought into the field of the solar telescope, and after accurately bisecting it the *transit telescope must be in the meridian, and the compass-needle indicates its deviation at that place.*

The vertical axis of the "Solar Attachment" will then point to the pole, the apparatus being in fact a small equatorial.

Time and azimuth are calculated from an observed altitude of the sun by solving the spherical triangle formed by the sun, the pole, and the zenith of the place. The three sides, S P, P Z, Z S, complements respectively of the declination, latitude, and altitude, are given, and we hence deduce S P Z, the hour angle, from apparent noon, and P Z S the azimuth of the sun.

The "Solar Attachment" solves the same spherical triangle by construction, for the second process brings the vertical axis of the solar telescope to the required distance, Z P, from the zenith, while the first brings it to the required distance S P from the sun.

Observation for Time.

If the two telescopes, both being in position—one in the meridian, and the other pointing to the sun—are now turned on their *horizontal* axes, the vertical remaining undisturbed, until each is level, the angle between their directions (found by sighting on a distant object) is S P Z, the time from apparent noon.

This gives an easy observation for correction of time-piece, reliable to within a few seconds.

To obtain the Latitude with the "Saegmuller Solar Attachment."

Level the Transit carefully and point the telescope toward the south. Turn the telescope an amount equal to the declination; if this is north, elevate it; if south, depress it.

Bring the solar telescope into the vertical plane of the main telescope, level it carefully and clamp it. With the solar telescope observe the sun a few minutes before its culmination; bring its image between the two horizontal wires by moving the transit telescope in altitude and azimuth, and keep it so by the slow motion screws until the sun ceases to rise. Then take the reading of the vertical arc, correct for refraction due to altitude by the table below. Subtract the result from 90°, and the remainder is the latitude sought.

Mean Refraction.

Barometer 30 inches, Fahrenheit thermometer 50°.

Altitude.	Refraction.	Altitude.	Refraction.
10°	5′ 19″	20°	2′ 39″
11	4 51	25	2 04
12	4 27	30	1 41
13	4 07	35	1 23
14	3 49	40	1 09
15	3 34	45	58
16	3 20	50	49
17	3 08	60	34
18	2 57	70	21
19	2 48	80	10

The following table, computed by Prof. Johnson, C. E., Washington University, St. Louis, will be found of considerable value in solar compass work:

"This table is valuable in indicating the errors to which the work is liable at different hours of the day and for different latitudes, as well as serving to correct the observed bearings of lines when it afterwards appears that a wrong latitude or declination has been used. Thus on the first day's observations I used a latitude in the forenoon of 38° 37′, but when I came to make the meridian observation for latitude I found the instrument gave 38° 39′. This was the latitude that should have been used, so I corrected the morning's observations for two minutes error in latitude by this table.

"It is evident that if the instrument is out of adjustment the latitude found by a meridian observation will be in error; but *if this observed latitude be used* in setting off the co-latitude the instrumental error is eliminated. Therefore always use for the co-latitude that given by the instrument itself in a meridian observation."

Errors in Azimuth (by Solar Compass) for 1 Min. Error in Declination or Latitude.

Hour.	For 1 Min. Error in Declination.			For 1 Min. Error in Latitude.		
	Lat. 30°.	Lat. 40°.	Lat. 50°.	Lat. 30°.	Lat. 40°.	Lat. 50°.
	Min.	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*
11.30 A. M. / 12.30 P. M.	8.85	10.00	12.90	8.77	9.92	11.80
11 A. M. / 1 P. M.	4.46	5.05	6.01	4.33	4.87	5.80
10 A. M. / 2 P. M.	2.31	2.61	3.11	2.00	2.26	2.70
9 A. M. / 3 P. M.	1.63	1.85	2.20	1.15	1.30	1.56
8 A. M. / 4 P. M.	1.34	1.51	1.80	0.67	0.75	0.90
7 A. M. / 5 P. M.	1.20	1.35	1.61	0.31	0.35	0.37
6 A. M. / 6 P. M.	1.15	1.30	1.56	0.00	0.00	0.00

Note.—Azimuths observed with erroneous declination or co-latitude may be corrected by means of this table by observing that for the line of collimation set *too high* the azimuth of any line *from the south point* in the direction S. W. N. E. is found *too small* in the *forenoon* and *too large* in the *afternoon* by the tabular amounts for each minute of error in the altitude of the line of sight. The reverse is true for the line set too low.

Correction for Refraction.

This correction is applied to the declination of the sun, and is equal to the refraction-correction of the sun's observed altitude multiplied by the cosine of the angle which the sun makes between the declination-circle and the vertical.

In order to reduce the refraction correction to the simplest possible form, we have added a separate column to the ephemeris containing them. They are thus brought in immediate juxtaposition with the declination angle, and we think the arrangement will be appreciated by those who use the Solar Attachment.

The Preparation of the Declination Settings for a Day's Work.

The Solar Ephemeris gives the declination of the sun for the given day, for Greenwich mean noon. Since all points in America are west of Greenwich, by 5, 6, 7, or 8 hours, the declination found in the ephemeris is the declination at the given place at 7, 6, 5, or 4 o'clock A. M., of the same date, according as the place lies in the "Eastern," "Central," "Mountain," or "Western Time" belts respectively.

The column headed "Refraction Correction" gives the correction to be made to the declination, for refraction, for any point whose latitude is 40°.* If the latitude is more or less than 40° these corrections are to be multiplied by the corresponding coefficients given in the table of "Latitude Coefficients," p. ——. Thus the refraction corrections in latitude 30° are 65 hundreths, and those of 50° 142 hundredths of the corresponding ones in latitude 40°. There is a slight error in the use of these latitude coefficients, but the maximum error will not amount to over 15″, except when the sun is very near the horizon, and then any refraction becomes very uncertain. All refraction tables are made out for the mean, or average, refraction, whereas the actual refraction at any particular time and place may be not more than one-half, or as much as twice, the mean refraction, with small altitudes. The errors made in the use of these latitude coefficients are, therefore,

* The corrections were computed by J. B. Johnson, Professor Civil Engineering, Washington University, St. Louis, Mo., whose name is a voucher for their accuracy.

very small as compared with the errors resulting from the use of the mean, rather than unknown actual refraction which affects any given observation.

Example I.

Let it be required to prepare a table of declinations for a point whose latitude is 38° 30′, and which lies in the "Central Time" belt, for April 5, 1890.

Since the time is 6 hours earlier than that at Greenwich, the declination given in the ephemeris is the declination here at 6 A. M. of same date. This is found to be + 6° 9′ 57″. To this must be added the hourly change, which is also plus, and equal to 56″.83. The latitude coefficient is 0.94. The following table may now be made out:

Declination Settings for Apr. 5, 1890, Lat. 38° 30′ Central Time.

Hour.	Declination.	Ref. Cor.	Setting.	Hour.	Declination.	Ref. Cor.	Setting.
7	+ 6° 10′ 54″	+ 2′ 00″	6° 12′ 54″	1	6° 16′ 35″	+ 37″	6° 17′ 12″
8	6 11 51	+ 1 10	6 13 01	2	6 17 31	+ 41	6 18 12
9	6 12 47	+ 51	6 13 38	3	6 18 28	+ 51	6 19 19
10	6 13 44	+ 41	6 14 25	4	6 19 25	+ 1 10	6 20 35
11	6 14 41	+ 37	6 15 18	5	6 20 22	+ 2 00	6 22 22

Example II.

Let it be required to prepare a declination table for a point in Lat. 45°, in the "Eastern Time" belt, for Oct. 10, 1890.

The time now is 5 hours earlier than that of Greenwich, hence the declination given in the ephemeris for Greenwich mean noon is the declination at our point at 7 A. M. The declination found is — 6° 43′ 56″, and the hourly change is — 56″.87. The latitude coefficient is 1.20.

The table then becomes:

Declination Settings for Oct. 10, 1890, *Lat.* 45° *Eastern Time.*

Hour.	Declination.	Ref. Cor.	Settings.	Hour.	Declination.	Ref. Cor.	Settings.
7	− 6° 43′ 56″	+ 5′ 35″	−6°38′21″	1	− 6° 49′ 37″	+ 1′ 16″	−6°48′21″
8	− 6 44 53	+ 2 31	−6 42 22	2	− 6 50 34	+ 1 24	−6 49 10
9	− 6 45 50	+ 1 44	−6 44 06	3	− 6 51 31	+ 1 44	−6 49 47
10	− 6 46 47	+ 1 24	−6 45 23	4	− 6 52 28	+ 2 31	−6 49 57
11	− 6 47 44	+ 1 16	−6 46 28	5	− 6 53 25	+ 5 35	−6 47 50

If the date be between June 20 and Sept. 20 the declination is positive, and the hourly change negative, while if it be between Dec. 20 and March 20 the declination is negative and the hourly change positive. The refraction correction is always positive; that is, it always increases numerically the north declinations, and diminishes numerically the south declinations. The hourly refraction corrections given in the ephemeris are exact for the middle day of the five-day period corresponding to that set of hourly corrections. For the extreme days of any such period an interpolation can be made between the adjacent hourly corrections if desired.

By using standard time instead of local time a slight error is made, but the maximum value of this error is found at those points where the standard time differs from the local time by one-half hour, and in the spring and fall when the declination is changing rapidly. The greatest error, then, is less than 30″, and this is smaller than can be set off on the vertical circle or declination arc. Even this error can be avoided by using the true difference of time from Greenwich in place of the standard meridian time.

Latitude Coefficients.

Lat.	Coeff.	Lat.	Coeff.	Lat.	Coeff.
15°	.30	31°	.68	47°	1.29
16	.32	32	.71	48	1.33
17	.34	33	.75	49	1.38
18	.36	34	.78	50	1.42
19	.38	35	.82	51	1.47
20	.40	36	.85	52	1.53
21	.42	37	.89	53	1.58
22	.44	38	.92	54	1.64
23	.46	39	.96	55	1.70
24	.48	40	1.00	56	1.76
25	.50	41	1.04	57	1.82
26	.53	42	1.08	58	1.88
27	.56	43	1.12	59	1.94
28	.59	44	1.16	60	2.00
29	.62	45	1.20		
30	.65	46	1.24		

1888. At Greenwich. Apparent Noon.

JAN.	THE SUN'S *Apparent* Declination.	Dif. for one hour.	Equation of Time to be *added to Apparent Time.*
	° ′ ″	″	m. s.
1	S. 23 1 50.5	+12.14	3 39.55
2	22 56 45.5	13.28	4 7.77
3	22 51 13.0	14.42	4 35.66
4	22 45 13.2	15.56	5 3.18
5	22 38 46.4	16.69	5 30.32
6	22 31 52.7	17.80	5 57.04
7	22 24 32.2	18.91	6 23.32
8	22 16 45.2	20.00	6 49.13
9	22 8 31.9	21.09	7 14.44
10	21 59 52.6	22.17	7 39.23
11	21 50 47.5	23.24	8 3.46
12	21 41 16.9	24.29	8 27.10
13	21 31 21.1	25.34	8 50.15
14	21 21 0.3	26.37	9 12.56
15	21 10 14.8	27.40	9 34.30
16	20 59 5.0	28.41	9 55.36
17	20 47 31.1	29.39	10 15.72
18	20 35 33.6	30.36	10 35.37
19	20 23 12.7	31.33	10 54.27
20	20 10 28.9	32.28	11 12.41
21	19 57 22.3	33.22	11 29.78
22	19 43 53.4	34.14	11 46.36
23	19 30 2.7	35.05	12 2.15
24	19 15 50.4	35.94	12 17.13
25	19 1 16.9	36.82	12 31.30
26	18 46 22.5	37.68	12 44.66
27	18 31 7.7	38.53	12 57.22
28	18 15 32.8	39.36	13 8.96
29	17 59 38.3	40.17	13 19.88
30	17 43 24.4	40.97	13 29.98
31	S. 17 26 51.6	+41.75	13 39.27

JAN.	Refraction Correction Lat. 40°.	
		′ ″
1	1h.	1.58
2	2	2.16
	3	3.04
3	4	6.23
4	1	1.54
5	2	2.11
6, 7	3	2.59
8	4	6.01
9	1	1.51
10	2	2.07
11, 12	3	2.51
13	4	5.40
14	1	1.46
15	2	2.01
16, 17	3	2.40
18	4	5.00
19	1	1.42
20	2	1.56
21, 22	3	2.31
23	4	4.35
24	1	1.37
25	2	1.58
26, 27	3	2.22
28	4	4.07
29	1	1.32
30	2	1.44
	3	2.13
31	4h.	3.41

1888. At Greenwich. Apparent Noon.

FEB.	THE SUN'S *Apparent* Declination.	Dif. for one hour.	Equation of Time to be *added to Apparent Time.*
	° ′ ″	″	m. s.
1	S.17 10 0.3	+42.51	13 47.76
2	16 52 50.8	43.26	13 55.44
3	16 35 23.6	43.99	14 2.32
4	16 17 39.1	44.71	14 8.39
5	15 59 37.6	45.41	14 13.67
6	15 41 19.6	46.09	14 18.15
7	15 22 45.5	46.75	14 21.84
8	15 3 55.7	47.40	14 24.75
9	14 44 50.7	48.03	14 26.88
10	14 25 30.8	48.64	14 28.23
11	14 5 56.4	49.23	14 28.81
12	13 46 8.1	49.80	14 28.62
13	13 26 6.3	50.36	14 27.66
14	13 5 51.3	50.90	14 25.94
15	12 45 23.5	51.41	14 23.48
16	12 24 43.5	51.91	14 20.27
17	12 3 51.6	52.39	14 16.32
18	11 42 48.4	52.86	14 11.65
19	11 21 34.2	53.31	14 6.27
20	11 0 9.4	53.74	14 0.19
21	10 38 34.5	54.16	13 53.44
22	10 16 49.8	54 56	13 46.02
23	9 54 55.7	54.94	13 37.95
24	9 32 52.7	55.31	13 29.25
25	9 10 41.1	55.66	13 19.94
26	8 48 21.5	55.99	13 10.04
27	8 25 54.1	56.30	12 59.58
28	8 3 19.2	56.60	12 48.57
29	S. 7 40 37.3	+56.89	12 37.03

FEB.	Refraction Correction Lat. 40°.	
		′ ″
1		
2		
3	1h.	1.26
4	2	1.37
5		
6	3	2.04
7	4	3.21
8	1	1.21
9	2	1.31
10		
11	3	1.56
12	4	3.04
13	1	1.16
14	2	1.25
15	3	1.48
16	4	2.47
17	5	8.39
18	1	1.12
19	2	1.20
20	3	1.40
21	4	2.31
22	5	6.49
23	1	1.07
24	2	1.15
25	3	1.33
26	4	2.18
27	5h.	5.29
28		
29		

1888. At Greenwich. Apparent Noon.

MAR.	THE SUN'S Apparent Declination.				Dif. for one hour.	Equation of Time to be added to Apparent Time.	
		°	′	″	″	m.	s.
1	S.	7	17	48.8	+57.15	12	24.98
2		6	54	54.1	57.40	12	12.45
3		6	31	53.5	57.64	11	59.46
4		6	8	47.3	57.86	11	46.03
5		5	45	36.1	58.07	11	32.18
6		5	22	20.1	58.26	11	17.94
7		4	58	59.7	58.43	11	3.30
8		4	35	35.4	58.59	10	48.30
9		4	12	7.6	58.73	10	32.97
10		3	48	36.5	58.85	10	17.31
11		3	25	2.6	58.96	10	1.31
12		3	1	26.2	59.05	9	45.02
13		2	37	47.8	59.13	9	28.46
14		2	14	7.7	59.19	9	11.64
15		1	50	26.5	59.24	8	54.57
16		1	26	44.5	59.27	8	37.27
17		1	3	2.0	59.28	8	19.75
18		0	39	19.3	59.27	8	2.05
19	S.	0	15	36.9	59.25	7	44.17
20	N.	0	8	4.8	59.22	7	26.12
21		0	31	45.4	59.17	7	7.94
22		0	55	24.7	59.11	6	49.65
23		1	19	2.3	59.03	6	31.28
24		1	42	37.8	58.93	6	12.83
25		2	6	10.8	58.82	5	54.32
26		2	29	41.0	58.70	5	35.79
27		2	53	8.1	58.56	5	17.27
28		3	16	31.8	58.41	4	58.78
29		3	39	51.6	58.25	4	40.34
30		4	3	7.4	58.07	4	21.96
31	N.	4	26	18.8	+57.88	4	3.67

MAR.	Refraction Correction Lat. 40°.	
		′ ″
1	1h.	1.03
2	2	1.10
	3	1.27
3	4	2.06
4	5	4.39
5	1	0.59
6	2	1.06
7	3	1.21
8	4	1.56
9	5	4.04
10	1	0.55
11	2	1.02
12	3	1.15
13	4	1.47
14	5	3.34
15	1	0.52
16	2	0.58
17	3	1.10
18	4	1.39
19	5	3.08
20	1	0.48
21	2	0.54
22	3	1.05
23	4	1.32
24	5	2.51
25	1	0.45
26	2	0.50
27	3	1.01
28	4	1.25
29	5	2.34
30	1	0.42
31	2h.	0.47

1888. At Greenwich. Apparent Noon.

APR.	THE SUN'S *Apparent* Declination.	Dif. for one hour.	Equation of Time to be *added to* / *subtracted from Apparent Time.*
	° ′ ″	″	m. s.
1	N. 4 49 25.4	+57.67	3 45.50
2	5 12 27.0	57.45	3 27.48
3	5 35 23.1	57.22	3 9.61
4	5 58 13.4	56.97	2 51.91
5	6 20 57.6	56.71	2 34.41
6	6 43 35.5	56.44	2 17.13
7	7 6 6.7	56.15	2 0.08
8	7 28 30.6	55.84	1 43.26
9	7 50 47.0	55.52	1 26.71
10	8 12 55.6	55.19	1 10.44
11	8 34 56.1	54.84	0 54.46
12	8 56 48.1	54.47	0 38.77
13	9 18 31.0	54.09	0 23.38
14	9 40 4.7	53.70	0 8.32 [added to]
15	10 1 28.8	53.29	0 6.40 [subtracted from]
16	10 22 43.0	52.87	0 20.78
17	10 43 46.8	52.43	0 34.79
18	11 4 39.9	51.98	0 48.42
19	11 25 20.0	51,51	1 1.67
20	11 45 52.7	51.03	1 14.52
21	12 6 11.8	50.54	1 26.95
22	12 26 19.0	50.03	1 38.95
23	12 46 13.8	49.51	1 50.50
24	13 5 56.0	48.98	2 1.60
25	13 25 25.3	48.44	2 12.22
26	13 44 41.3	47.88	2 22.34
27	14 3 43.8	47.32	2 31.96
28	14 22 32.4	46.74	2 41.08
29	14 41 6.9	46.14	2 49.66
30	N.14 59 27.0	+45.53	2 57.70

APR.	Refraction Correction Lat. 40°.	
		′ ″
1	3h.	0.57
2	4	1.19
3	5	2.18
4	1	0.39
5	2	0.44
6	3	0.54
7	4	1.14
8	5	2.08
9	1	0.36
10	2	0.41
11	3	0.51
12	4	1.10
13	5	1.58
14	1	0.34
15	2	0.38
16	3	0.48
17	4	1.06
18	5	1.49
19	1	0.32
20	2	0.36
21	3	0.45
22	4	1.02
23	5	1.42
24	1	0.30
25	2	0.34
26	3	0.42
27	4	0.58
28	5	1.36
29	1	0.28
30	2h.	0.32

1888. At Greenwich. Apparent Noon.

MAY.	THE SUN'S *Apparent* Declination.	Dif. for one hour.	Equation of Time to be *subtracted from Apparent Time.*
	° ′ ″	″	m. s.
1	N.15 17 32.4	+44.91	3 5.19
2	15 35 22.7	44.28	3 12.11
3	15 52 57.6	43.63	3 18.47
4	16 10 16.8	42.97	3 24.26
5	16 27 20.1	42.30	3 29.48
6	16 44 7.0	41.61	3 34.12
7	17 0 37.4	40.91	3 38.17
8	17 16 50.9	40.20	3 41.63
9	17 32 47.2	39.48	3 44.51
10	17 48 25.9	38.74	3 46.81
11	18 3 46.8	37.99	3 48.54
12	18 18 49.6	37.23	3 49.70
13	18 33 34.0	36.46	3 50.29
14	18 47 59.6	35.67	3 50.32
15	19 2 6.1	34.87	3 49.79
16	19 15 53.3	34.06	3 48.72
17	19 29 20.8	33.23	3 47.10
18	19 42 28.5	32.40	3 44.93
19	19 55 16.1	31.56	3 42.23
20	20 7 43.2	30.70	3 39.01
21	20 19 49.7	29.83	3 35.26
22	20 31 35.3	28.85	3 31.00
23	20 42 59.7	28.06	3 26.23
24	20 54 2.8	27.17	3 20.95
25	21 4 44.2	26.27	3 15.17
26	21 15 3.9	25.36	3 8.91
27	21 25 1.7	24.44	3 2.17
28	21 34 37.2	23.51	2 54.95
29	21 43 50.4	22.57	2 47.27
30	21 52 41.1	21.63	2 39.14
31	N.22 1 9.0	+20.68	2 30.57

MAY.	Refraction Correction Lat. 40°.	
		′ ″
1	1h.	0.28
	2	0.32
2	3	0.39
	4	0.55
3	5	1.30
4	1	0.26
5	2	0.30
6	3	0.37
7	4	0.53
8	5	1.26
9	1	0.25
10	2	0.29
11	3	0.36
12	4	0.51
13	5	1.22
14	1	0.23
15	2	0.27
16	3	0.34
17	4	0.49
18	5	1.18
19	1	0.22
20	2	0.26
21	3	0.33
22	4	0.47
23	5	1.15
24	1	0.21
25	2	0.25
26	3	0.32
27	4	0.46
28	5	1.13
29	1	0.20
	2	0.24
30	3	0.31
	4	0.44
31	5h.	1.11

1888. At Greenwich. Apparent Noon.

JUNE.	THE SUN'S *Apparent* Declination.	Dif. for one hour.	Equation of Time to be *subtracted from* / *added to Apparent Time.*
	° ′ ″	″	m. s.
1	N.22 9 14.0	+19.72	2 21.58
2	22 16 55.9	18.75	2 12.18
3	22 24 14.5	17.78	2 2.38
4	22 31 9.7	16.80	1 52.20
5	22 37 41.3	15.82	1 41.67
6	22 43 49.2	14.83	1 30.80
7	22 49 33.2	13.83	1 19.63
8	22 54 53.2	12.83	1 8.18
9	22 59 49.1	11.82	0 56.46
10	23 4 20.8	10.81	0 44.51
11	23 8 28.1	9.79	0 32.35
12	23 12 10.9	8.77	0 19.99
13	23 15 29.2	7.75	0 7.47
14	23 18 22.8	6.72	0 5.17
15	23 20 51.8	5.69	0 17.91
16	23 22 56.1	4.66	0 30.75
17	23 24 35.5	3.63	0 43.65
18	23 25 50.2	2.60	0 56.58
19	23 26 40.1	1.56	1 9.52
20	23 27 5.2	+ 0.52	1 22.45
21	23 27 5.4	— 0.52	1 35.36
22	23 26 40.8	1.55	1 48.22
23	23 25 51.3	2.58	2 1.00
24	23 24 37.1	3.61	2 13.68
25	23 22 58.2	4.63	2 26.27
26	23 20 54.7	5.66	2 38.74
27	23 18 26.6	6.68	2 51.06
28	23 15 33.9	7.70	3 3.22
29	23 12 16.7	8.72	3 15.20
30	N.23 8 35.2	— 9.73	3 26.96

JUNE.	Refraction Correction Lat. 40°.	
		′ ″
1	5h.	1.11
2		
3	1	0.19
4	2	0.23
5	3	0.30
6	4	0.43
7	5	1.10
8	1	0.18
9	2	0.22
10	3	0.29
11	4	0.43
12	5	1.09
13	1	0.18
14	2	0.22
15	3	0.29
16	4	0.42
17	5	1.08
18	1	0.18
19	2	0.22
20	3	0.29
21	4	0.42
22	5	1.08
23	1	0.18
24	2	0.22
25	3	0.29
26	4	0.42
27	5	1.08
28	1	0.18
29	2	0.22
	3	0.29
30	4h.	0.43

1888. At Greenwich. Apparent Noon.

JULY.	THE SUN'S *Apparent* Declination.			Dif. for one hour.	Equation of Time to be *added to Apparent Time.*	
	°	′	″	″	m.	s.
1	N.23	4	29.4	—10.74	3	38.49
2	22	59	59.4	11.75	3	49.78
3	22	55	5.4	12.75	4	0.80
4	22	49	47.4	13.74	4	11.54
5	22	44	5.6	14.73	4	21.96
6	22	38	0.1	15.71	4	32.04
7	22	31	31.1	16.69	4	41.77
8	22	24	38.7	17.66	4	51.13
9	22	17	23.0	18.63	5	0.08
10	22	9	44.3	19.58	5	8.61
11	22	1	42.7	20.53	5	16.69
12	21	53	18.4	21.47	5	24.30
13	21	44	31.6	22.41	5	31.44
14	21	35	22.5	23.33	5	38.08
15	21	25	51.3	24.25	5	44.21
16	21	15	58.4	25.15	5	49.81
17	21	5	43.8	26.05	5	54.87
18	20	55	7.7	26.93	5	59.38
19	20	44	10.4	27.81	6	3.33
20	20	32	52.3	28.68	6	6.72
21	20	21	13.5	29.54	6	9.53
22	20	9	14.3	30.38	6	11.77
23	19	56	54.8	31.22	6	13.42
24	19	44	15.4	32.04	6	14.50
25	19	31	16.3	32.86	6	14.99
26	19	17	57.8	33.66	6	14.90
27	19	4	20.1	34.45	6	14.22
28	18	50	23.5	35.24	6	12.96
29	15	36	8.3	36.02	6	11.12
30	18	21	34.7	36.77	6	8.69
31	N.18	6	43.0	—37.52	6	5.67

JULY.	Refraction Correction Lat. 40°.	
		′ ″
1	5h.	1.09
2		
3	1	0.19
4	2	0.23
5	3	0.30
6	4	0.43
7	5	1.10
8	1	0.20
9	2	0.24
10	3	0.31
11	4	0.44
12	5	1.11
13	1	0.21
14	2	0.25
15	3	0.32
16	4	0.46
17	5	1.13
18	1	0.22
19	2	0.26
20	3	0.33
21	4	0.47
22	5	1.15
23	1	0.23
24	2	0.27
25	3	0.34
26	4	0.49
27	5	1.18
28	1	0.25
29	2	0.29
	3	0.36
30	4	0.51
31	5h.	1.22

1888. At Greenwich. Apparent Noon.

AUG.	THE SUN'S Apparent Declination.	Dif. for one hour.	Equation of Time to be added to / subtracted from Apparent Time.	AUG.	Refraction Correction Lat. 40°.
	° ′ ″	″	m. s.		′ ″
1	N.17 51 33.5	—38.26	6 2.06	1	
2	17 36 6.5	38.98	5 57.87	2	1h. 0.26
3	17 20 22.3	39.69	5 53.10	3	2 0.30
4	17 4 21.1	40.39	5 47.74	4	3 0.37
5	16 48 3.3	41.08	5 41.79	5	4 0.53
6	16 31 29.2	41.75	5 35.25	6	5 1.26
7	16 14 39.0	42.42	5 28.12	7	1 0.28
8	15 57 33.1	43.07	5 20.41	8	2 0.32
9	15 40 11.9	43.71	5 12.12	9	3 0.39
10	15 22 35.6	44.33	5 3.25	10	4 0.55
11	15 4 44.5	44.94	4 53.80	11	5 1.30
12	14 46 38.9	45.53	4 43.78	12	1 0.30
13	14 28 19.3	46.11	4 33.19	13	2 0.34
14	14 9 45.9	46.68	4 22.04	14	3 0.42
15	13 50 59.0	47.23	4 10.33	15	4 0.58
16	13 31 59.0	47.77	3 58.08	16	5 1.36
17	13 12 46.2	48.29	3 45.30	17	1 0.32
18	12 53 20.9	48.80	3 32.01	18	2 0.36
19	12 33 43.3	49.31	3 18.22	19	3 0.45
20	12 13 53.9	49.80	3 3.94	20	4 1.02
21	11 53 52.9	50.28	2 49.19	21	5 1.42
22	11 33 40.6	50.74	2 33.97	22	1 0.34
23	11 13 17.3	51.19	2 18.32	23	2 0.38
24	10 52 43.4	51.63	2 2.26	24	3 0.48
25	10 31 59.1	52.06	1 45.79	25	4 1.06
26	10 11 4.7	52.47	1 28.93	26	5 1.49
27	9 50 0.6	52.87	1 11.71	27	1 0.36
28	9 28 47.0	53.26	0 54.15	28	2 0.41
29	9 7 24.2	53.63	0 36.26	29	3 0.51
30	8 45 52.7	53.99	0 18.04	30	4 1.10
31	N. 9 24 12.7	—54.34	0 0.48	31	5h. 1.58

1888. At Greenwich. Apparent Noon.

SEP.	THE SUN'S Apparent Declination.	Dif. for one hour.	Equation of Time to be subtracted from Appparent Time.	SEP.	Refraction Correction Lat. 40°.
	° ′ ″	″	m. s.		′ ″
1	N. 8 2 24.4	—54.68	0 19.28	1	1h. 0.39
2	7 40 28.2	55.00	0 38.35	2	2 0.44
3	7 18 24.5	55.31	0 57.68	3	3 0.54
4	6 56 13.6	55.60	1 17.25	4	4 1.14
5	6 33 55.8	55.88	1 37.05	5	5 2.08
6	6 11 31.5	56.14	1 57.06	6	1 0.42
7	5 49 1.1	56.39	2 17.27	7	2 0.47
8	5 26 24.8	56.63	2 37.66	8	3 0.57
9	5 3 43.1	56.85	2 58.22	9	4 1.19
10	4 40 56.2	57.06	3 18.93	10	5 2.18
11	4 18 4.5	57.24	3 39.77	11	1 0.45
12	3 55 8.3	57.42	4 0.73	12	2 0.50
13	3 32 8.1	57.58	4 21.79	13	3 1.01
14	3 9 4 1	57.73	4 42.94	14	4 1.25
15	2 45 56.6	57.87	5 4.15	15	5 2.34
16	2 22 46.0	57.99	5 25.40	16	1 0.48
17	1 59 32.8	58.10	5 46.65	17	2 0.54
18	1 36 17.0	58.20	6 7.90	18	3 1.05
19	1 12 59.1	58.28	6 29.12	19	4 1.32
20	0 49 39.4	58.35	6 50.29	20	5 2.51
21	0 26 18.3	58.40	7 11.37	21	1 0.52
22	N. 0 2 56.0	58.44	7 32.36	22	2 0.58
23	S. 0 20 27.2	58.47	7 53.22	23	3 1.10
24	0 43 51.0	58.49	8 13.93	24	4 1.39
25	1 7 14.8	58.49	8 34.47	25	5 3.08
26	1 30 38.6	58.48	8 54.81	26	1 0.55
27	1 54 1.9	58.45	9 14.93	27	2 1.02
28	2 17 24.5	58.41	9 34.81	28	3 1.15
29	2 40 45.9	58.36	9 54.42	29	4 1.47
30	S. 3 4 5.9	—58.29	10 13.76	30	5h. 3.34

1888. At Greenwich. Apparent Noon.

OCT.	THE SUN'S *Apparent* Declination.				Dif. for one hour.	Equation of Time to be *subtracted from Apparent Time.*	
		°	′	″	″	m.	s.
1	S.	3	27	24.0	—58.21	10	32.80
2		3	50	39.9	58.11	10	51.52
3		4	13	53.3	58.00	11	9.91
4		4	37	3.8	57.87	11	27.95
5		5	0	10.9	57.72	11	45.62
6		5	23	14.2	57.56	12	2.91
7		5	46	13.6	57.38	12	19.80
8		6	9	8.4	57.18	12	36.28
9		6	31	58.2	56.97	12	52.33
10		6	54	42.8	56.74	13	7.92
11		7	17	21.8	56.50	13	23.04
12		7	39	54.8	56.24	13	37.68
13		8	2	21.4	55.96	13	51.83
14		8	24	41.1	55.67	14	5.46
15		8	46	53.5	55.36	14	18.56
16		9	8	58.4	55.03	14	31.09
17		9	30	55.4	54.69	14	43.05
18		9	52	44.0	54.34	14	54.41
19		10	14	23.9	53.98	15	5.15
20		10	35	54.7	53.59	15	15.25
21		10	57	16.1	53.19	15	24.70
22		11	18	27.7	52.77	15	33.47
23		11	39	29.1	52.34	15	41.55
24		12	0	19.9	51.89	15	48.91
25		12	20	59.9	51.43	15	55.55
26		12	41	28.5	50.95	16	1.44
27		13	1	45.4	50.45	16	6.57
28		13	21	50.2	49.93	16	10.93
29		13	41	42.4	49.40	16	14.50
30		14	1	21.7	48.85	16	17.28
31	S.	14	20	47.7	—48.29	16	19.26

OCT.	Refraction Correction Lat. 40°.	
	′	″
1	1h.	0.59
2	2	1.06
3	3	1.21
4	4	1.56
5	5	4.04
6	1	1.03
7	2	1.10
8	3	1.27
9	4	2.06
10	5	4.39
11	1	1.07
12	2	1.15
13	3	1.33
14	4	2.18
15	5	5.39
16	1	1.12
17	2	1.20
18	3	1.40
19	4	2.31
20	5	6.29
21	1	1.16
22	2	1.25
23	3	1.48
24	4	2.47
25	5	8.39
26	1	1.21
27	2	1.31
28	3	1.56
29	4	3.04
30	5	11.01
	1h.	1.26
31		1.37
		2.04

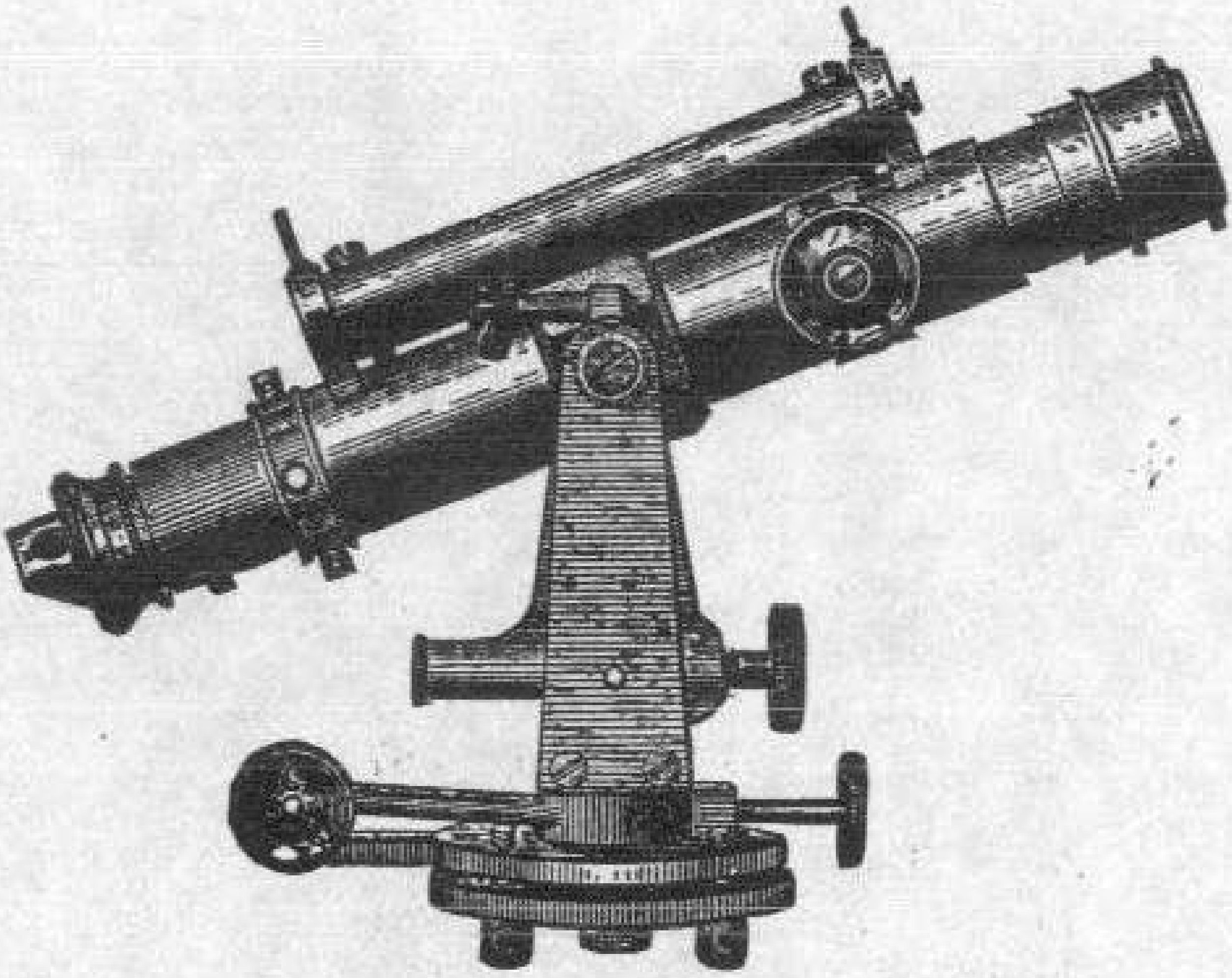
1888. At Greenwich. Apparent Noon.

NOV.	THE SUN'S *Apparent* Declination.			Dif. for one hour.	Equation of Time to be *subtracted from Apparent Time.*		NOV.	Refraction Correction Lat. 40°.	
	°	′	″	″	m.	s.			′ ″
1	S.14	39	59.9	—47.71	16	20.43	1	2h.	3.21
2	14	58	58.0	47.12	16	20.78	2	3	13.57
3	15	17	41.4	46.50	16	20.31	3	4	
4	15	36	9.8	45.86	16	19.02	4	5	
5	15	54	22.7	45.21	16	16.91	5	1	1.32
6	16	12	19.7	44.54	16	13.97	6	2	1.44
7	16	30	0 4	43.84	16	10.20	7	3	2.13
8	16	47	24.4	43.14	16	5.59	8	4	3.41
9	17	4	31.2	42.42	16	0.15	9	5	
10	17	21	20.5	41.68	15	53.89	10	1	1.37
11	17	37	51.8	40.92	15	46.79	11	2	1.50
12	17	54	4.6	40.14	15	38.86	12	3	2.22
13	18	9	58.6	39.35	15	30.10	13	4	4.07
14	18	25	33.5	38.54	15	20.51	14	5	
15	18	40	48.9	37.72	15	10.10	15	1	1.42
16	18	55	44.3	36.88	14	58.86	16	2	1.56
17	19	10	19.3	36.03	14	46.79	17	3	2.31
18	19	24	33.6	35.16	14	33.89	18	4	4.35
19	19	38	27.0	34.28	14	20.17	19	5	
20	19	24	33.6	33.38	14	5.64	20	1	1.46
21	20	5	9.4	32.46	13	50.29	21	2	2.01
22	20	17	57.5	31.53	13	34.14	22	3	2.40
23	20	30	23.2	30.59	13	17.18	23	4	4.59
24	20	42	26.2	29.64	12	59.43	24	5	
25	20	54	6.2	28.67	12	40.91	25	1	1.50
26	21	5	22.8	27.69	12	21.63	26	2	2.06
27	21	16	15.6	26.70	12	1.60	27	3	2.49
28	21	26	44.3	25.69	11	40.85	28	4	5.33
29	21	36	48.6	24.67	11	19.39	29	5h.	
30	S.21	46	28.3	—23.63	10	57.25	30		

1888. At Greenwich. Apparent Noon.

DEC.	THE SUN'S Apparent Declination.	Dif. for one hour.	Equation of Time to be *subtracted from* / *added to Apparent Time.*
	° ′ ″	″	m. s.
1	S.21 55 43.0	—22.58	10 34.44
2	22 4 32.4	21.52	10 10.99
3	22 12 56.3	20.45	9 46.93
4	22 20 54.3	19.37	9 22.28
5	22 28 26.2	18.29	8 57.07
6	22 35 31.8	17.19	8 31.35
7	22 42 10.8	16.08	8 5.15
8	22 48 22.9	14.96	7 38.48
9	22 54 8.1	13.83	7 11.37
10	22 59 26.0	12.68	6 43.87
11	23 4 16.5	11.53	6 16.01
12	23 8 39.5	10.38	5 47.81
13	23 12 34 8	9.23	5 19.29
14	23 16 2.3	8.07	4 50.49
15	23 19 1.8	6.91	4 21.45
16	23 21 33.4	5.74	3 52.20
17	23 23 36.9	4.57	3 22.76
18	23 25 12.2	3.38	2 53.16
19	23 26 19.3	2.21	2 23.43
20	23 26 58.1	—1.03	1 53.61
21	23 27 8.7	+0.15	1 23.72
22	23 26 51.1	1.33	0 53.78
23	23 26 5.1	2.50	0 23.82
24	23 24 50.8	3.68	0 6.10
25	23 23 8.3	4.85	0 35.96
26	23 20 57.6	6.03	1 5.73
27	23 18 18.7	7.20	1 35.38
28	23 15 11.8	8.37	2 4.87
29	23 11 36.9	9.53	2 34.16
3	23 7 34.1	10.69	3 3.22
31	S.23 3 3.5	+11.85	3 32.02

DEC.	Refraction Correction Lat. 40°.	
		′ ″
1	1h.	1.54
2	2	2.11
	3	2.59
3	4	6.01
4	5	
5	1	1.58
6	2	2.16
7	3	3.04
8	4	6.23
9	5	
10	1	2.00
11	2	2.19
12	3	3.09
13	4	6.38
14	5	
15	1	2.01
16	2	2.20
17	3	3.11
18	4	6.47
19	5	
20	1	2.01
21	2	2.20
22	3	3.11
23	4	6.49
24	5	
25	1	2.00
26	2	2.19
27	3	3.09
28	4	6.43
29	5h.	
30		
31		



Saegmuller Solar Attachment.

AS MADE BY FAUTH & CO., WASHINGTON, D. C.

Price of attachment	$50 00
Revolving prism and sun-shade for same......	10 00

We make no charge to attach it to instruments of other make.

DESCRIPTION AND PRICES

OF

Improved Engineering Instruments,

AS MADE BY

FAUTH & CO.

WASHINGTON, D. C.

THIS PRICE LIST SUPERSEDES ALL FORMER EDITIONS.

Plain Transit, No. 1.

Cut No. 1 represents one of our improved Plain Transits. The circle is $6\frac{3}{4}$ inches diameter, reading by opposite verniers to 30 seconds; long centres of hard metal; telescope is balanced in axis; has an objective of $1\frac{1}{4}$ in. diameter, well corrected for spherical and chromatic aberration, magnifying about 24 diameters, and showing objects erect; dust-guard over object slide; compass-needle $4\frac{1}{2}$ inches long, swinging on jewelled centre; levels ground and graduated; action of the clamp entirely on the centre; tangent-screws work smoothly, and are entirely free of play; compass-ring reaches over and forms a cover for the graduation; verniers covered with ground glass; four levelling-screws with shifting tripod. By the use of hard metal and judicious ribbing and bracing great lightness and strength is obtained.

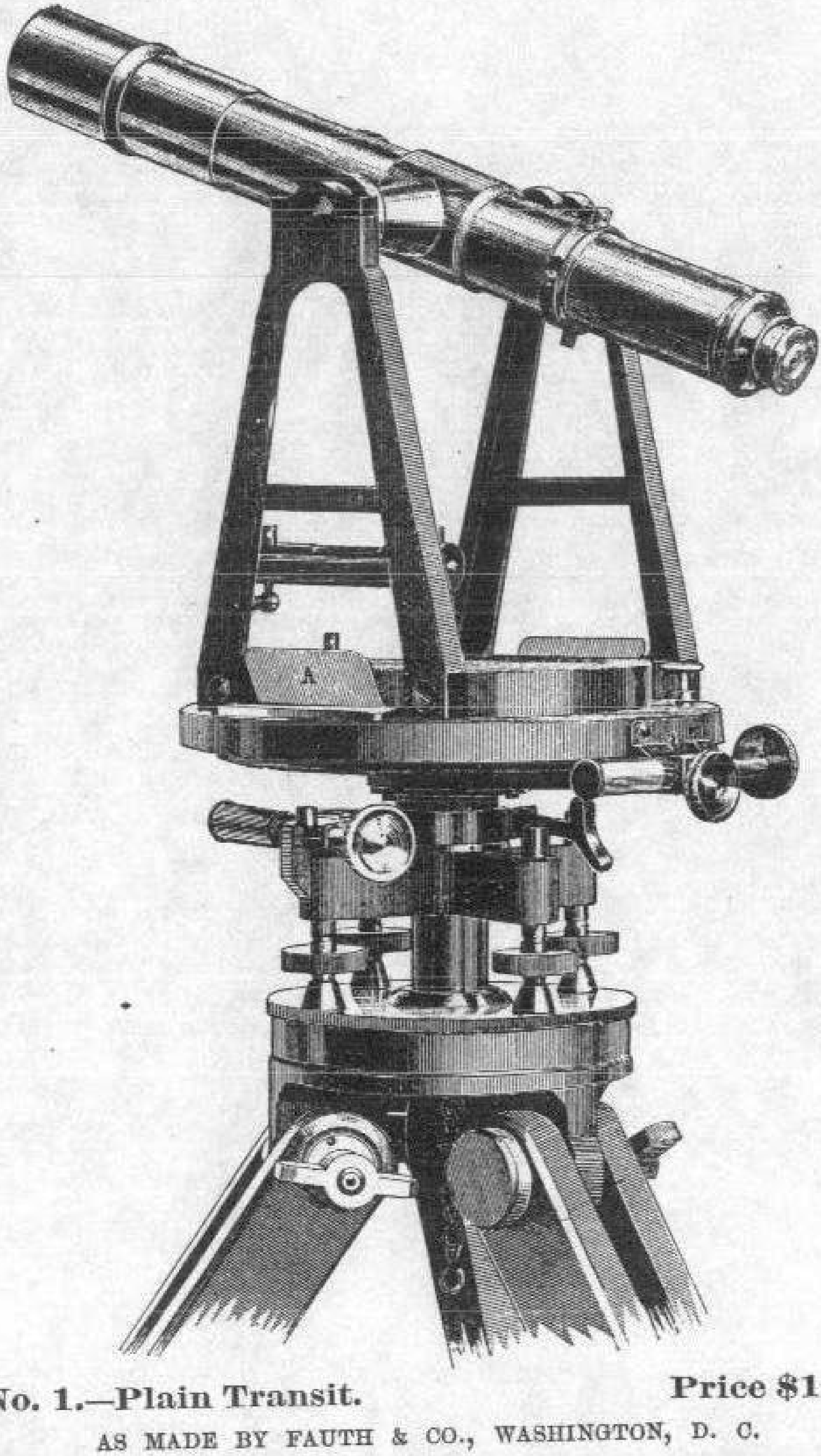
Weight of instrument about 13 pounds.

Weight of tripod about 7 pounds.

The instrument is securely packed in a neat case, provided with leather strap, and contains, also, a sun-shade, screwdriver, plumb-bob, magnifier, and a couple of adjusting pins.

Extras to No. 1.

Graduations on solid silver....................	$10 00
Focusing rack for eye-piece (in place of screw arrangement)..................................	5 00
Vernier shades...........................	3 00
Fixed stadia wires........................	3 00
Right angle off-setting arrangement............	5 00
Variation plate.........................	20 00
Quick-leveling tripod.....................	10 00
Gossamer cover.........................	1 00



No. 1.—Plain Transit. **Price $185**

AS MADE BY FAUTH & CO., WASHINGTON, D. C.

Engineer's Transit, No. 2,

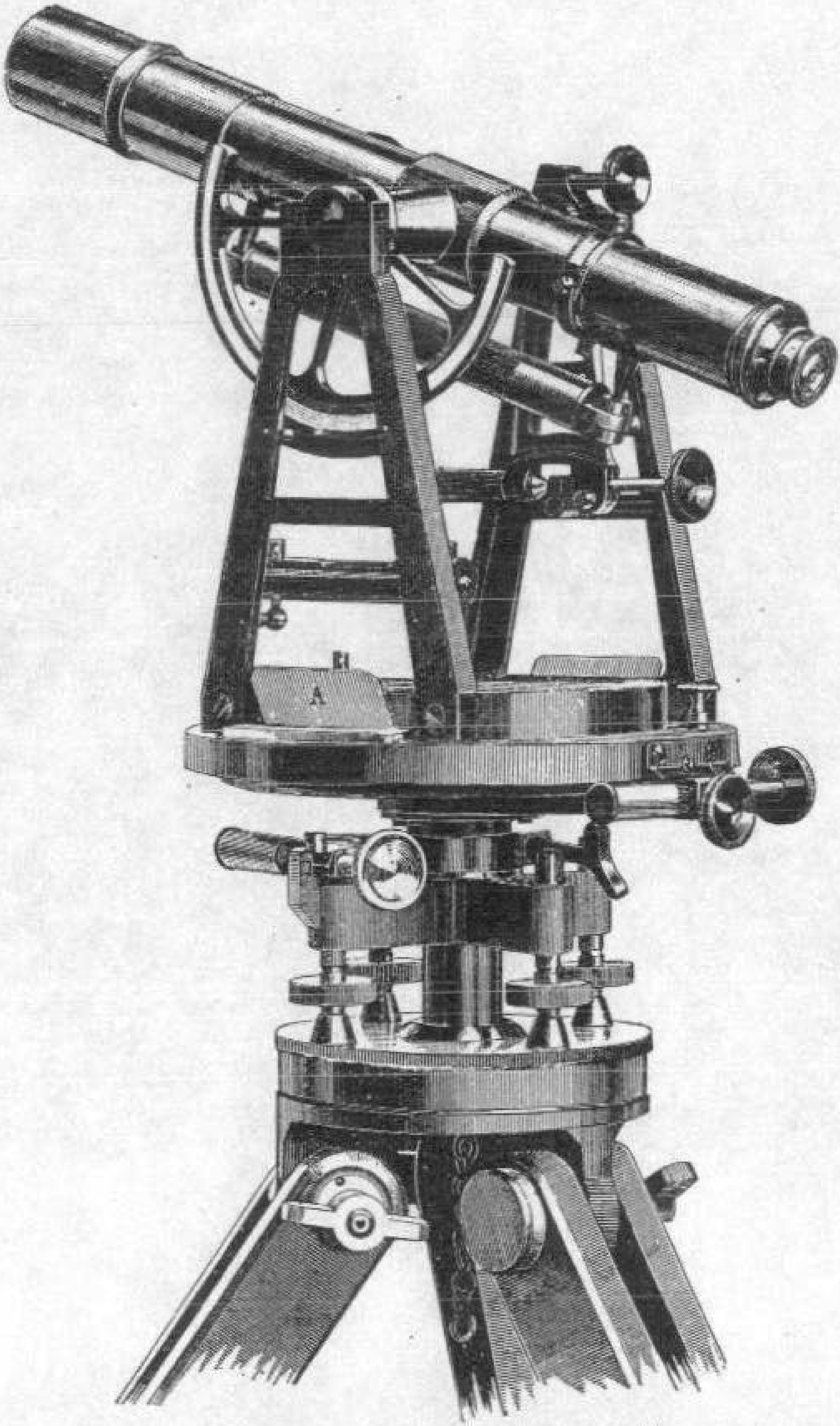
Is exactly like No. 1, with the addition of a vertical arc, level, clamp, and tangent to telescope.

Weight of instrument about 13½ pounds.

Weight of tripod about 7 pounds.

Extras to No. 2.

Graduation of horizontal circle on solid silver....	$10 00
" " vertical arc " "	5 00
Gradientor attachment..........................	5 00
Vernier shades..................................	3 00
Fixed stadia wires............................	3 00
Right angle off-setting arrangement............	5 00
Variation plate.................................	20 00
Quick-leveling tripod..........................	10 00
Gossamer cover................................	1 00
"Saegmuller's" patent solar attachment.........	50 00
Eye-piece prism and extra sun-shade for same...	10 00



No. 2.—Engineer's Transit.
With vertical arc, level, clamp, and tangent to telescope
Price of Instrument, $230.
AS MADE BY FAUTH & CO., WASHINGTON, D. C.

Complete Engineer's Transit, No. 3,

Is exactly like No. 1, with the addition of **Saegmuller's Patent Solar Attachment, Vertical Circle, Level, Clamp, Tangent** to telescope, **Quick-leveling Tripod,** and **Solar Attachment.**

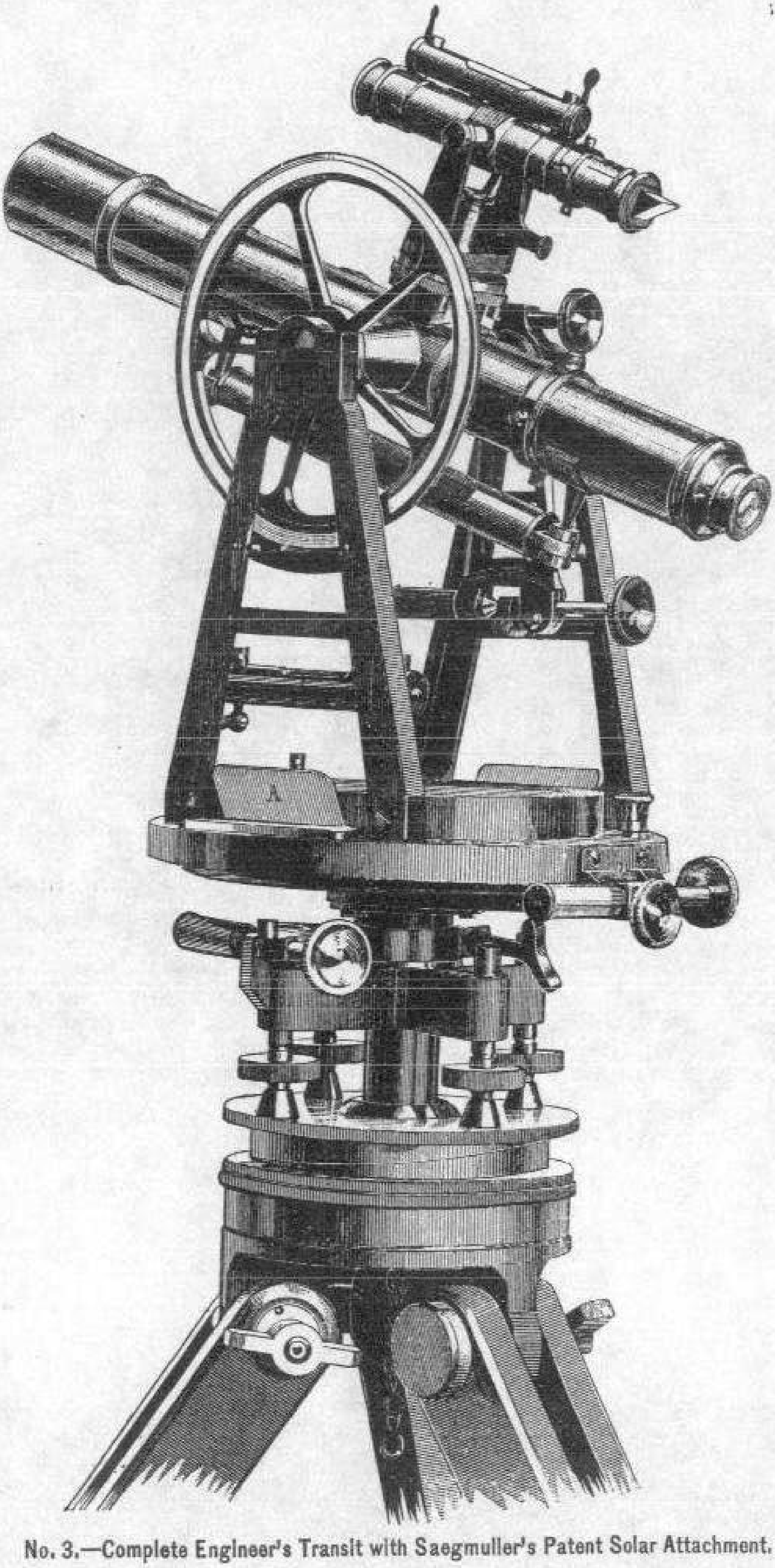
Weight of instrument about 14 pounds.

Weight of tripod about 7 pounds.

Price **$300**

Extras to No. 3.

Graduation of horizontal circle on solid silver....	$10 00
" " vertical " " "	5 00
Gradientor..................................	5 00
Vernier shades..............................	3 00
Fixed stadias...............................	3 00
Right angle off-setting arrangement............	5 00
Variation plate..............................	20 00
Latitude level...............................	15 00



No. 3.—Complete Engineer's Transit with Saegmuller's Patent Solar Attachment.

High-Grade Engineering Transit, No. 4, or Transit-Theodolite.

This instrument has been designed for the highest class of engineering work, and is used extensively in city surveying and for secondary triangulation. It has no compass permanently attached, but is usually supplied with a box-compass having a 5-inch needle which can be fastened to the top of the telescope and parallel to it. The magnetic bearing of any line can thus be as accurately established as by instruments having a fixed compass.

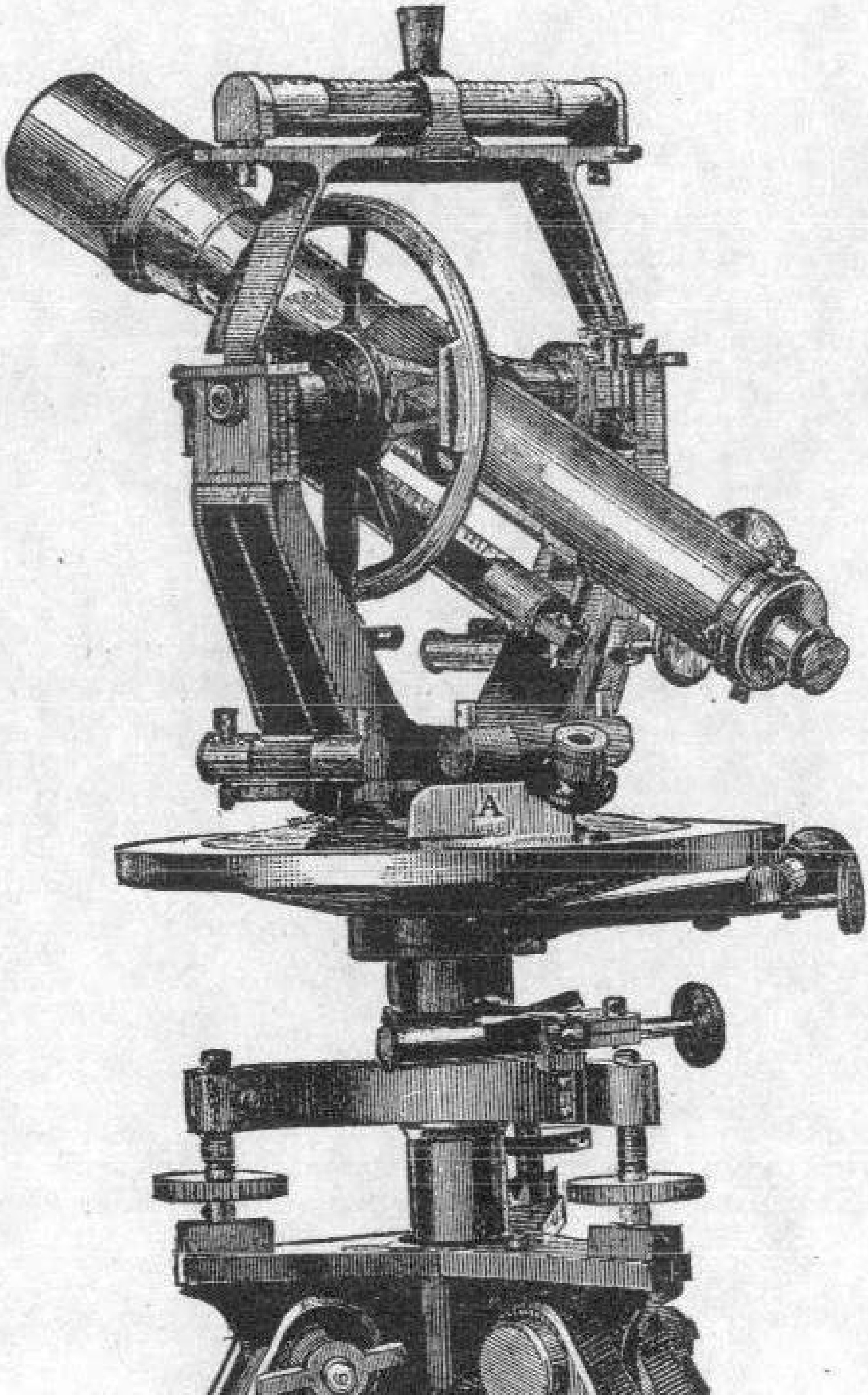
The great advantage which this instrument possesses over the previously described forms consists in the great strength of the telescope standard, which is cast in one piece, which, on account of its peculiar shape, is very light and strong. The telescope axis terminates in cylinders, and is held in the standards by caps. This arrangement assures the most accurate movement of the telescope in the vertical plane.

Horizontal circle 7 inches diameter, graduated on *solid silver*, and reading by opposite verniers to 30 minutes; powerful telescope of 1⅜ inches aperture and magnifying about 25 diameters; dust-guard over object-slide; extra sensitive levels, improved clamps and tangents; graduation covered; three leveling screws, &c.

Price of Plain Transit, - - - - - $240

Extras.

5-in. vert. circle, double opposite verniers, div. on silver	$25 00
Graduated level and reversible clamp and tangent movement to telescope	35 00
Gradientor	5 00
Stadia	3 00
Sensitive striding level, to rest on the cylindrical ends of telescope axis	20 00
Box compass, with variation plate to attach to telescope. Needle 4 inches long, with 12-degree arc	25 00
Field illumination through axis of telescope	8 00
Diagonal eye-piece (4-lens system, and 1 prism)	16 00
Eye-piece prism	7 50
Shifting head to tripod	6 00
Attached reading-glasses	15 00



No. 4.—Transit-Theodolite.

Engineer's Y Level.

The telescope has an aperture of $1\frac{3}{8}$ inches and magnifies 35 diameters. Erecting eye-piece with perfectly flat field. Improved arrangement to bring the cross-wire into exact focus. Protection to the object-slide. Hard bell-metal rings and centres. Long sensitive level, graduated on the glass. Clamp and tangent attached to the leveling-bar under the eye-piece. The telescope is balanced when focused for mean distance. Abutting stops to set the wires horizontal and perpendicular.

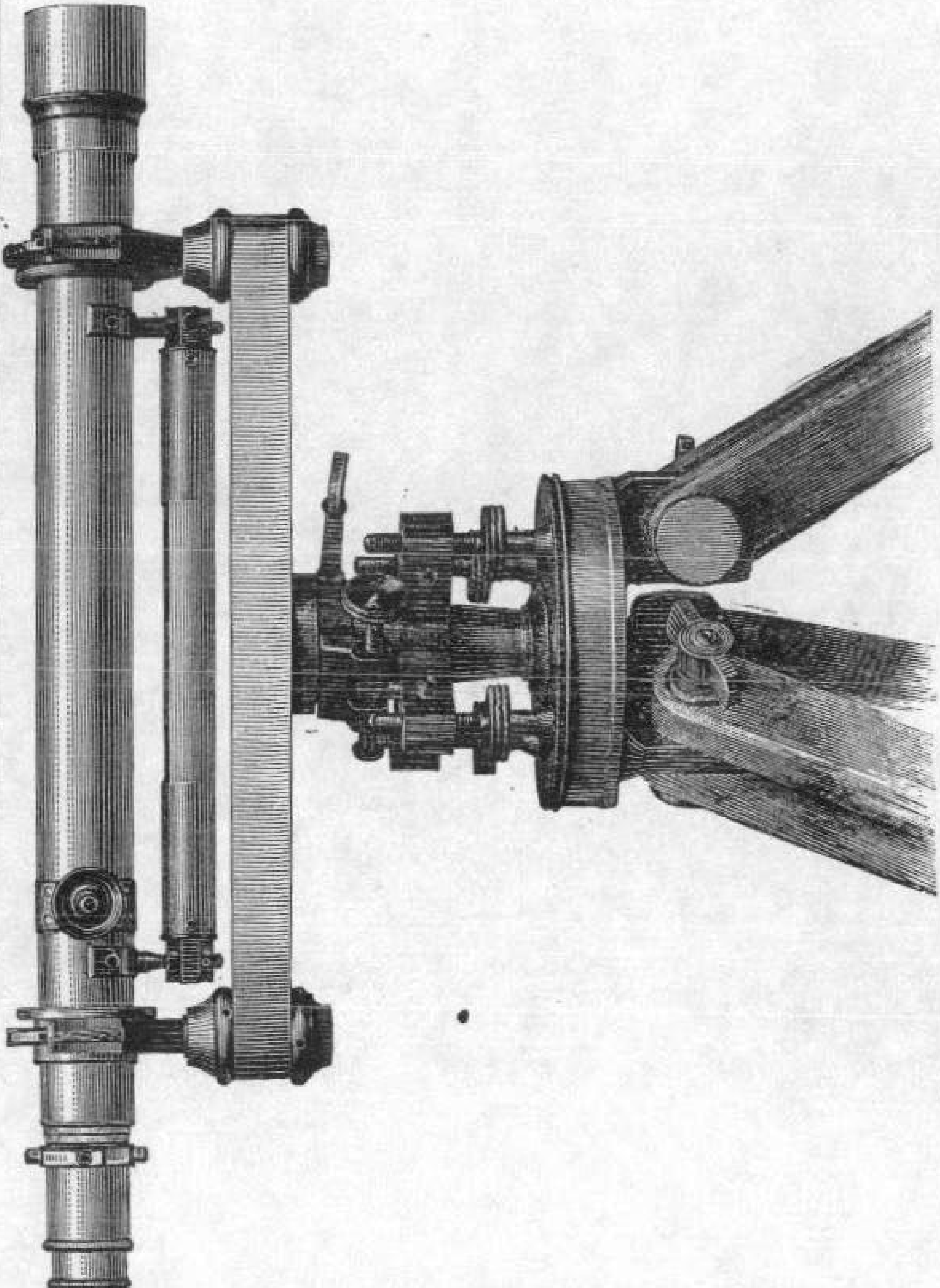
The instrument does not detach from the leveling-head; it packs into the case erect. The case contains sun-shade, screwdriver, and adjusting pins.

Weight of instrument about 11 pounds.

Weight of tripod about 7 pounds.

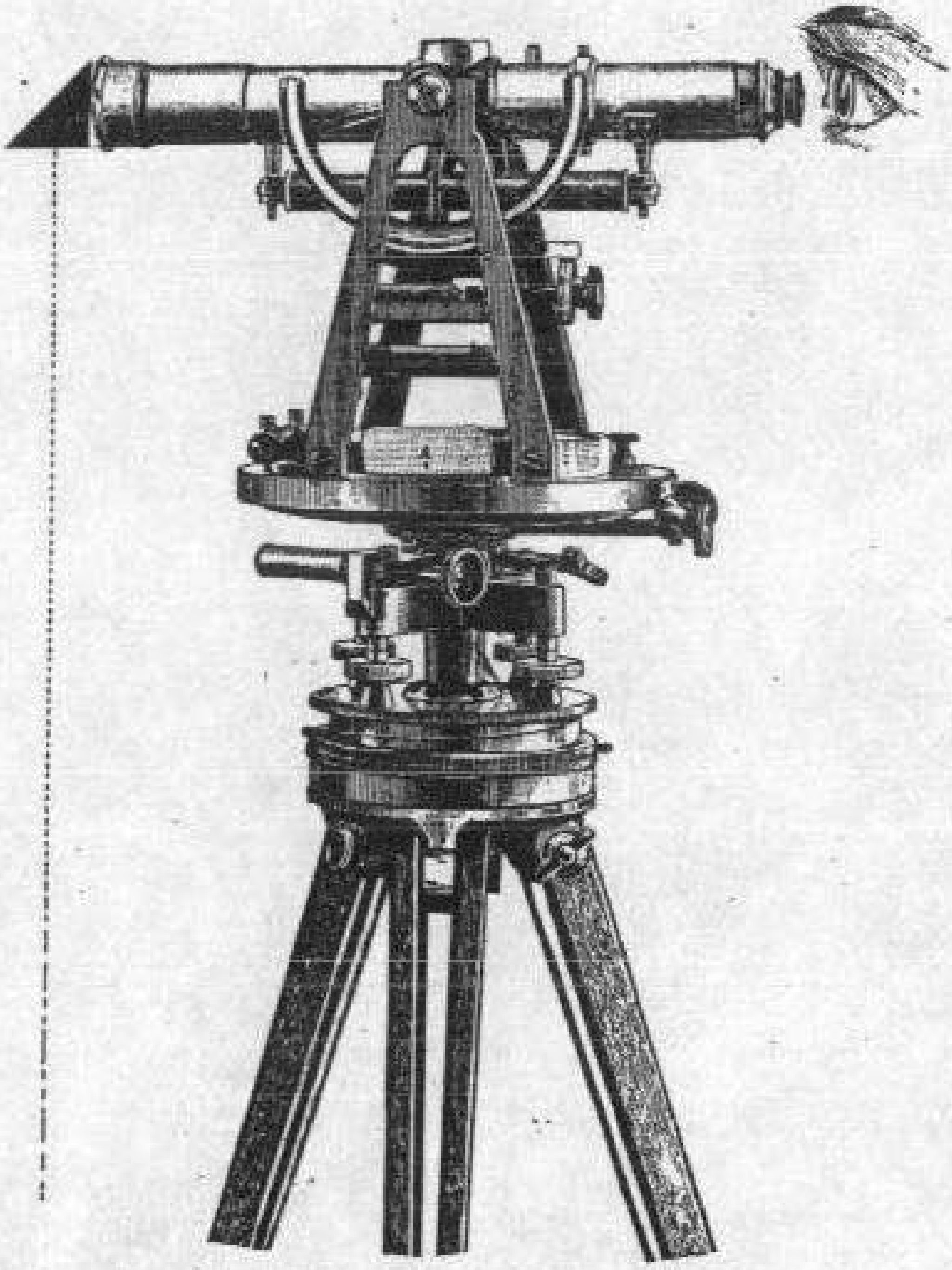
Extras to Y Level.

Attachable mirror, to read the level from the eye-end	$10 00
Hardened steel centre	10 00
Fixed stadias (1 in 100)	3 00
Gossamer cover	1 00



Engineer's 18-inch Y Level. **Price, $145**

AS MADE BY FAUTH & CO., WASHINGTON, D. C.



No. 5.—Light Mountain Transit.

Cut No. 5 represents a complete little Transit, which is especially designed for use in a mountainous country. It is a complete instrument in every respect, and differs from the regular Transit merely on account of its small size. Circles 4 in. diameter, with solid silver graduation, reading by opposite verniers to minutes; powerful telescope of $1\frac{1}{8}$ in. aperture; 5-in. vertical arc reading to minutes; sensitive level attached to telescope; clamp and gradientor screw; dust-guard over objective slide.

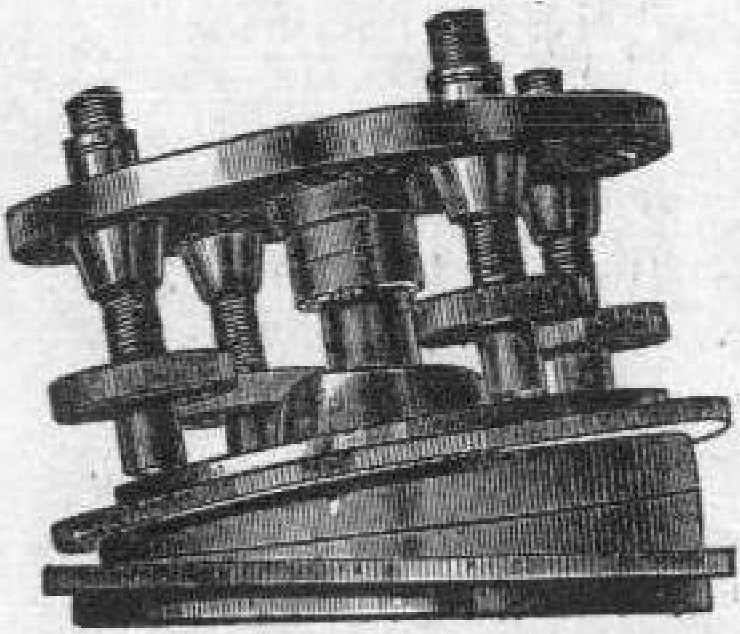
Packed in box, complete, with usual accessories.

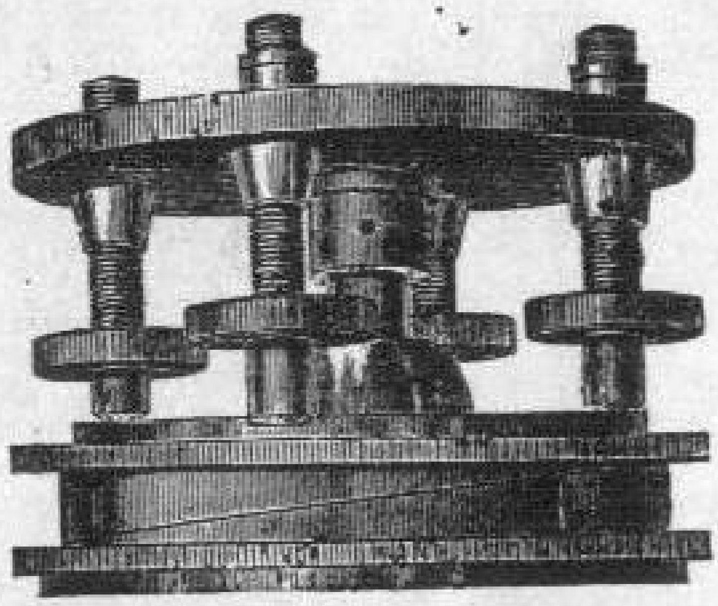
Weight of instrument 5 pounds; tripod, 4 pounds.

Price $225

New Quick-Levelling Tripod Head with Shifting-Plate.

PATENTED BY G. N. SAEGMULLER, WASHINGTON, D. C.

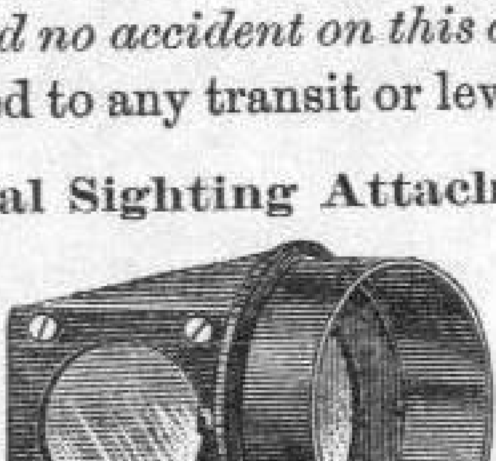




These engravings represent a new form of Quick-Levelling Tripod, which is the simplest and most convenient yet devised. It consists of two circular discs, which are wedge-shaped; that is, thicker on one side than the other. They are interposed between the levelling-screws and tripod-head proper. By turning one or the other of them around their common centre the instrument can gradually be brought to a vertical position. The final levelling touches are given by means of the usual levelling-screws, which at the same time clamp the instrument firmly. *The great advantage of this Quick-Levelling Tripod over other forms is that the instrument will not fall over even if it is not clamped, and no accident on this account can occur.*

It can be attached to any transit or levelling instrument.

Vertical Sighting Attachment.



Above cut represents a simple Attachment to engineer's transits, invented and patented by G. N. Saegmuller, for sighting vertically, upwards or downwards. It consists of a right angle prism placed in front of the objective, and has the effect of reflecting the rays at an angle of 90°. Thus, if the telescope be pointed horizontally, by putting the prism in front of it, so that the upper cathete surface is in a horizontal plane, the line of sight will be directed upwards; by changing the position of this prism 180° the line of sight will be vertically downwards. Turning the transit 180°, and taking the *mean* of the two sightings, the point vertically above or below the centre of the instrument is obtained.

This is the simplest and most exact method of getting a vertical sight. The use of a prism is far more convenient than the clumsy plan of attaching an extra telescope to the axis, which tilts the instrument, and is also very expensive.

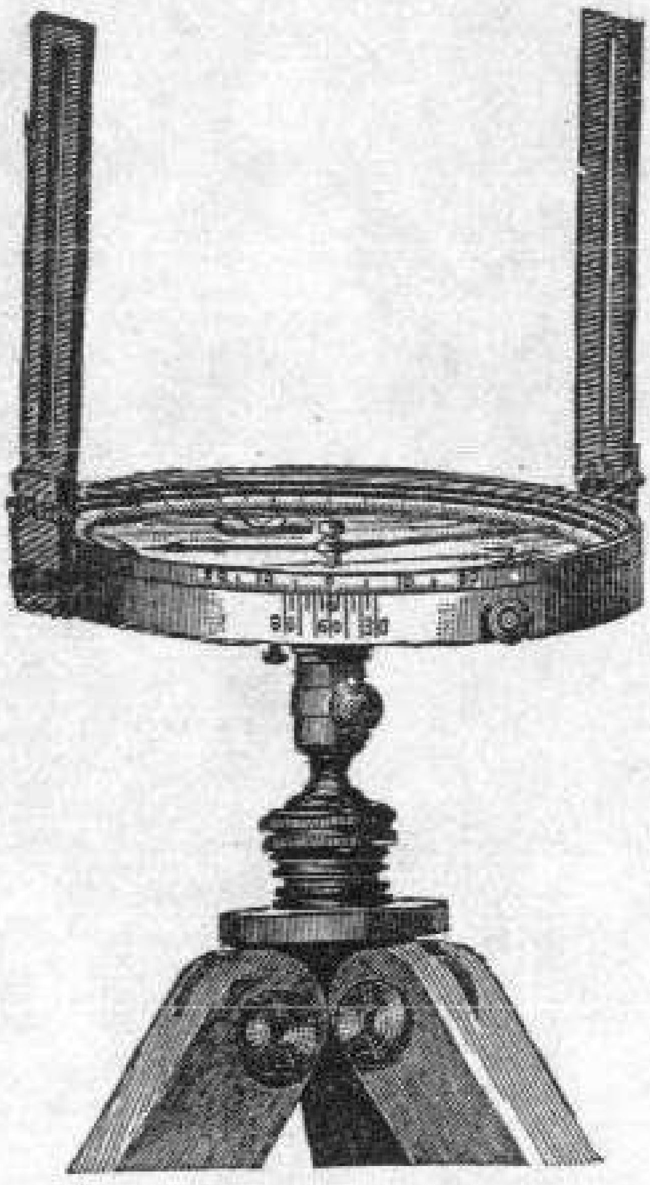
Although a plain mirror can be used for this purpose, it is objectionable on account of the double images caused by the front and back surface, and a prism is therefore preferable. By making the mirror slightly wedge-shaped, so as to throw the faint image out of the field, the annoyance of double images can be overcome. This style of mirror costs nearly as much as a prism, and altogether we find that prisms are the most satisfactory, as there is no silvering, which is liable to deteriorate. The prisms, however, have to be perfectly homogeneous, and must be ground to exact surfaces, as a bad prism would undo the work of a good objective.

It is readily seen that by turning the prism 90° it can also be used to offset at right angles. It can also be used for vertical sighting by attaching it to a level. This Attachment can be fitted to any instrument.

MISCELLANEOUS INSTRUMENTS

Made for and imported by us. Superior to those usually found in the market.

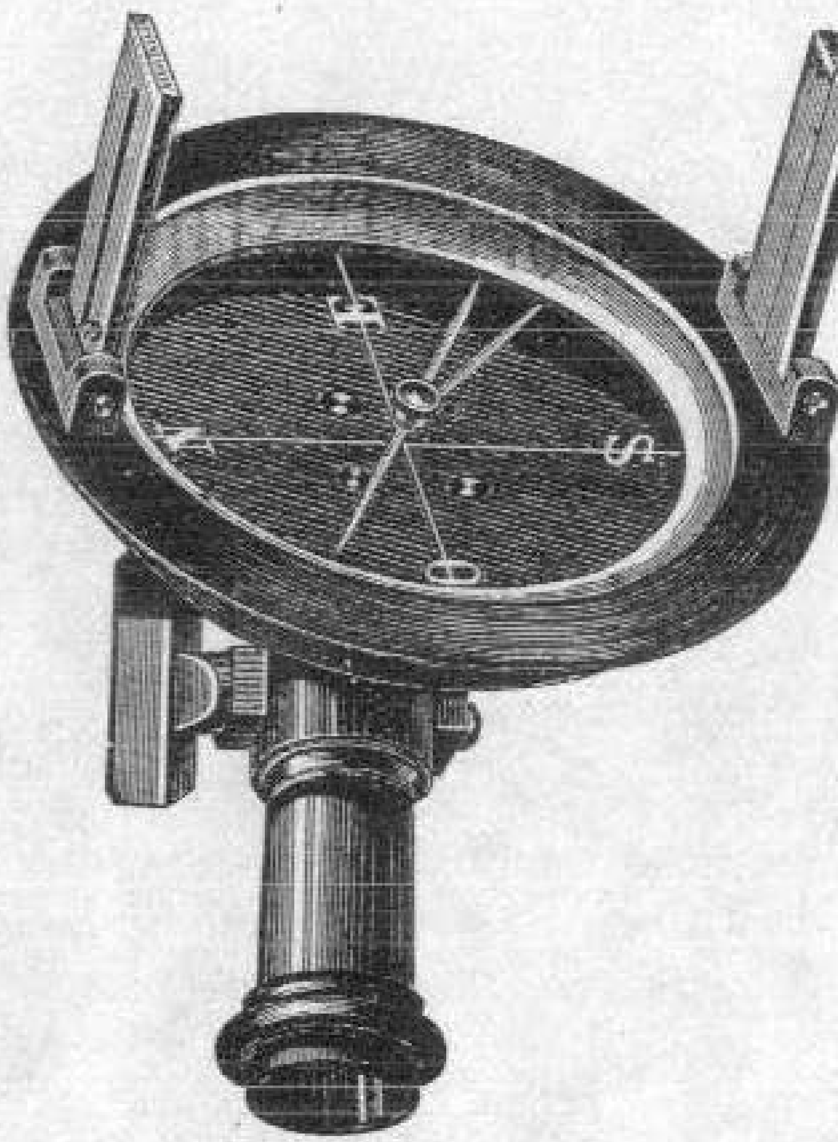
SURVEYING COMPASSES.



Surveying Compass,

With Two Bubbles, Folding Sights, Ball-and-Socket Joint for Jacob Staff Mountings and with Vernier, including Tripod,

		3½-inch Needle,	in case,	each,			**$24 00**
do.	do.	4	"	"	"	"	**25 00**
do.	do.	4	"	"	"	"	**27 00**



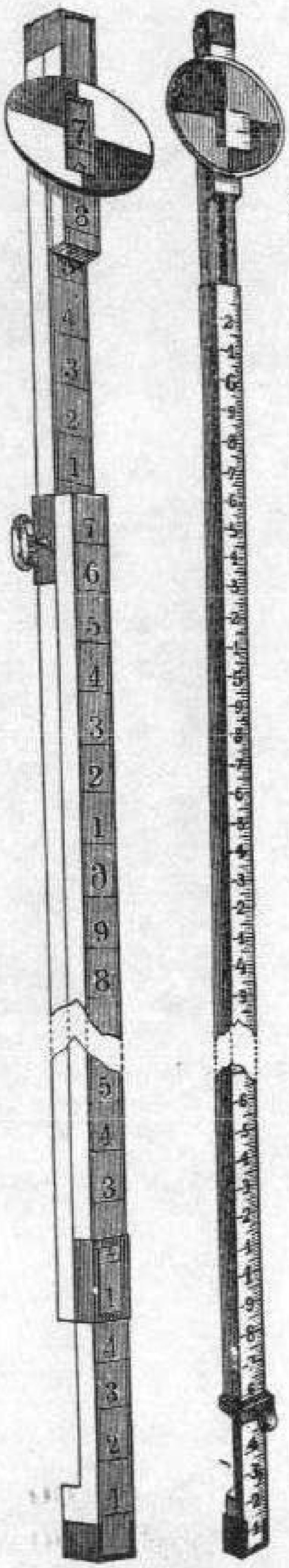
Pocket Compass,

With Level, Folding Sights, 4-inch Needle, with Ball-and-Socket Joint.

Price, $20 00

POCKET COMPASS.

No. 28.—**Prismatic Compass,** 3 inches diameter, with divided ring on needle and folding sights; packed in neat case..**$30 00**



LEVELLING RODS AND POLES.

New York Rod, Hardwood, of light color, with **improved Clamp** and **Target,** machine divided to 10ths and 100ths of a foot, 6½ feet long, sliding out to 12 feet.. .... **$16 00**

Philadelphia Rod, Mahogany, with **Vernier, Clamp,** and **Target,** 7 feet long, sliding out to 12 feet............................... **18 00**

Boston Rod, Mahogany, machine divided on Satinwood, with **Vernier** at each end, 6 feet 6 inches long, sliding out to 11 feet 4 inches....... .... **16 00**

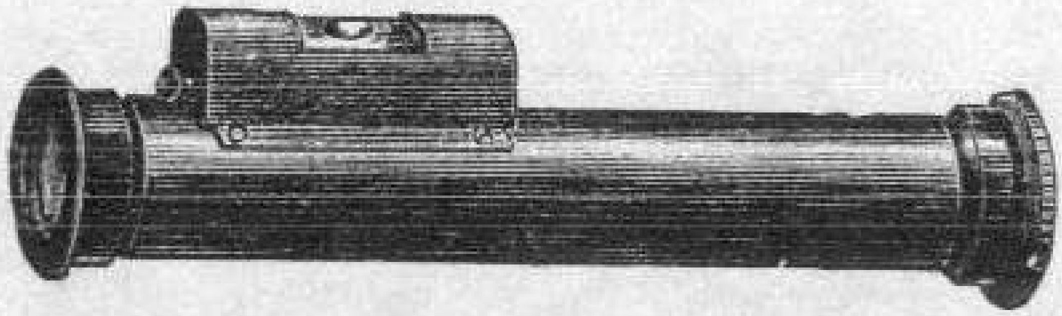
RANGING POLES.

¾-inch iron tube, poles 6 feet long, with steel shoe............................**$3 50**

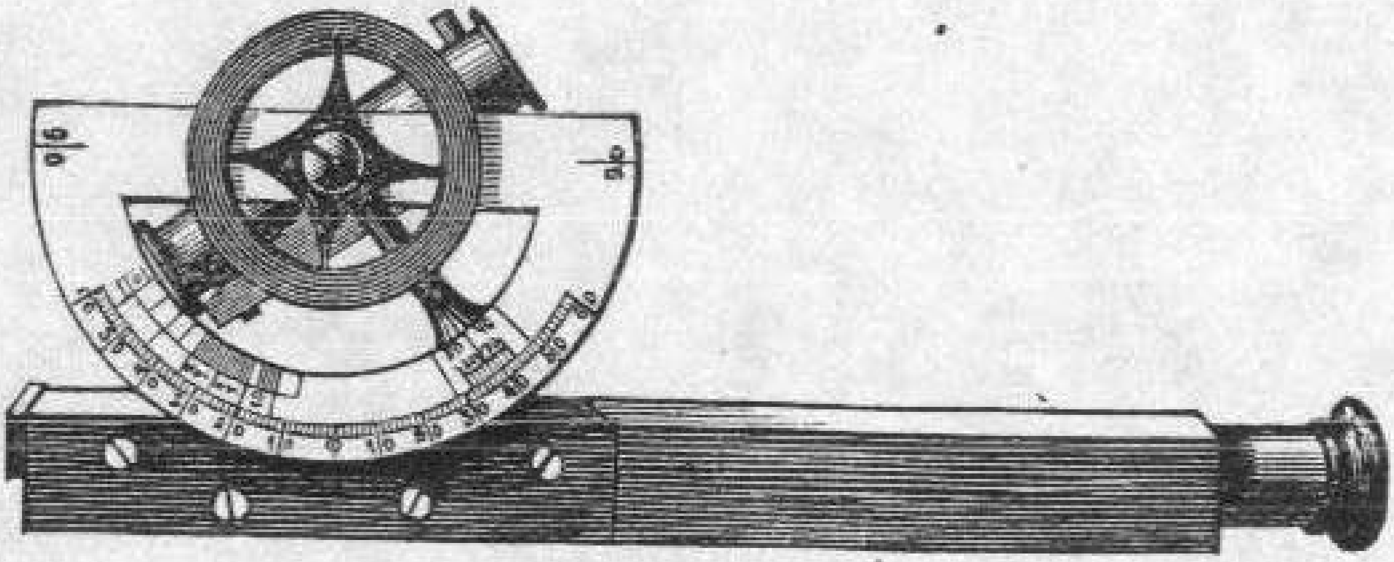
Wooden pole, 8 feet long, with steel shoe.................................... ..... **3 50**

These poles are divided in feet, alternately painted white and red.

HAND LEVELS.

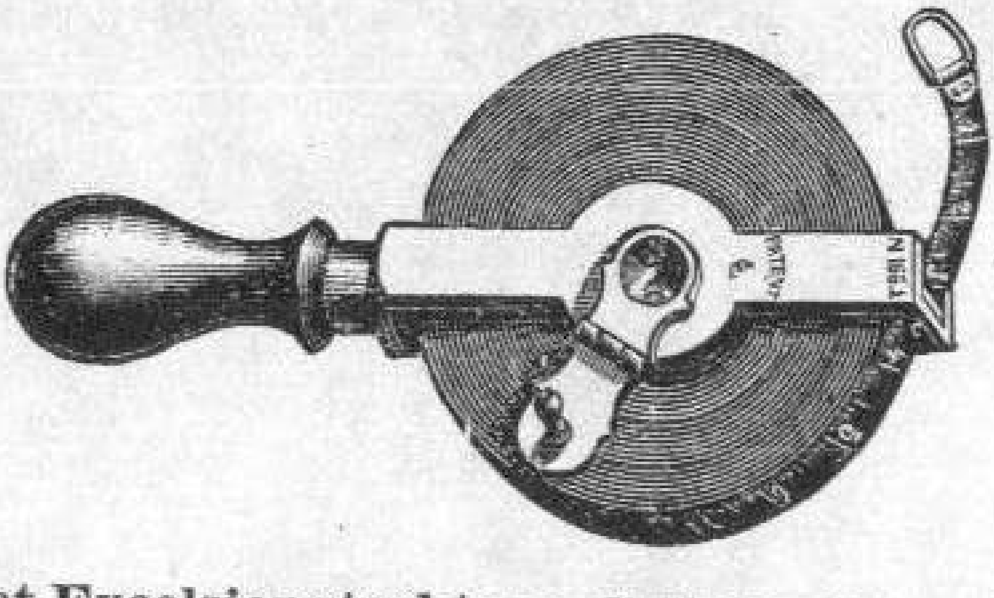


Locke's Hand Level, Brass, in case..............each **$9 00**
do. do. German silver, in case...........each **10 00**

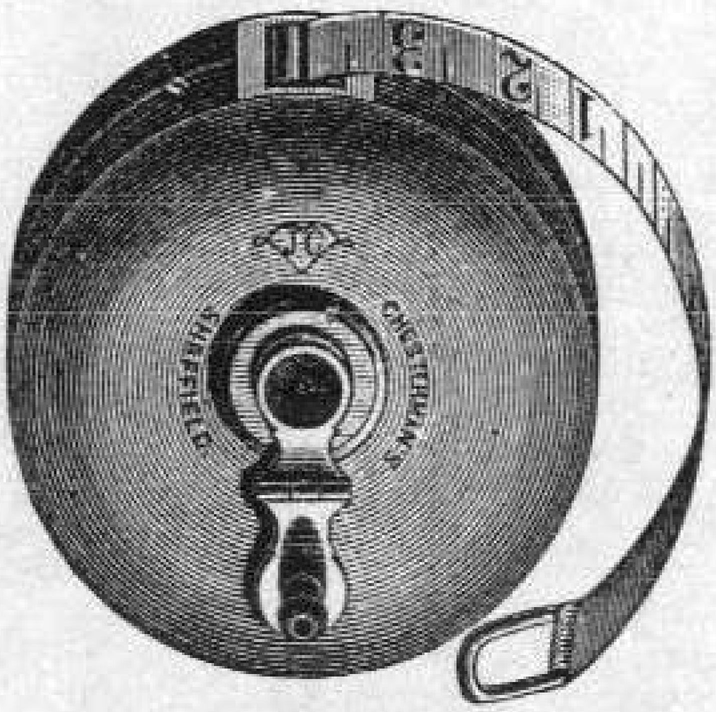


Abney Level and Clinometer...... ....**$15 00**

STEEL TAPES.



50 feet Excelsior steel tape, divided in 10ths... **$9 00**
100 feet do. do. **16 00**



Same, in leather boxes.

50 feet	**$8 00**
100 feet	**15 00**

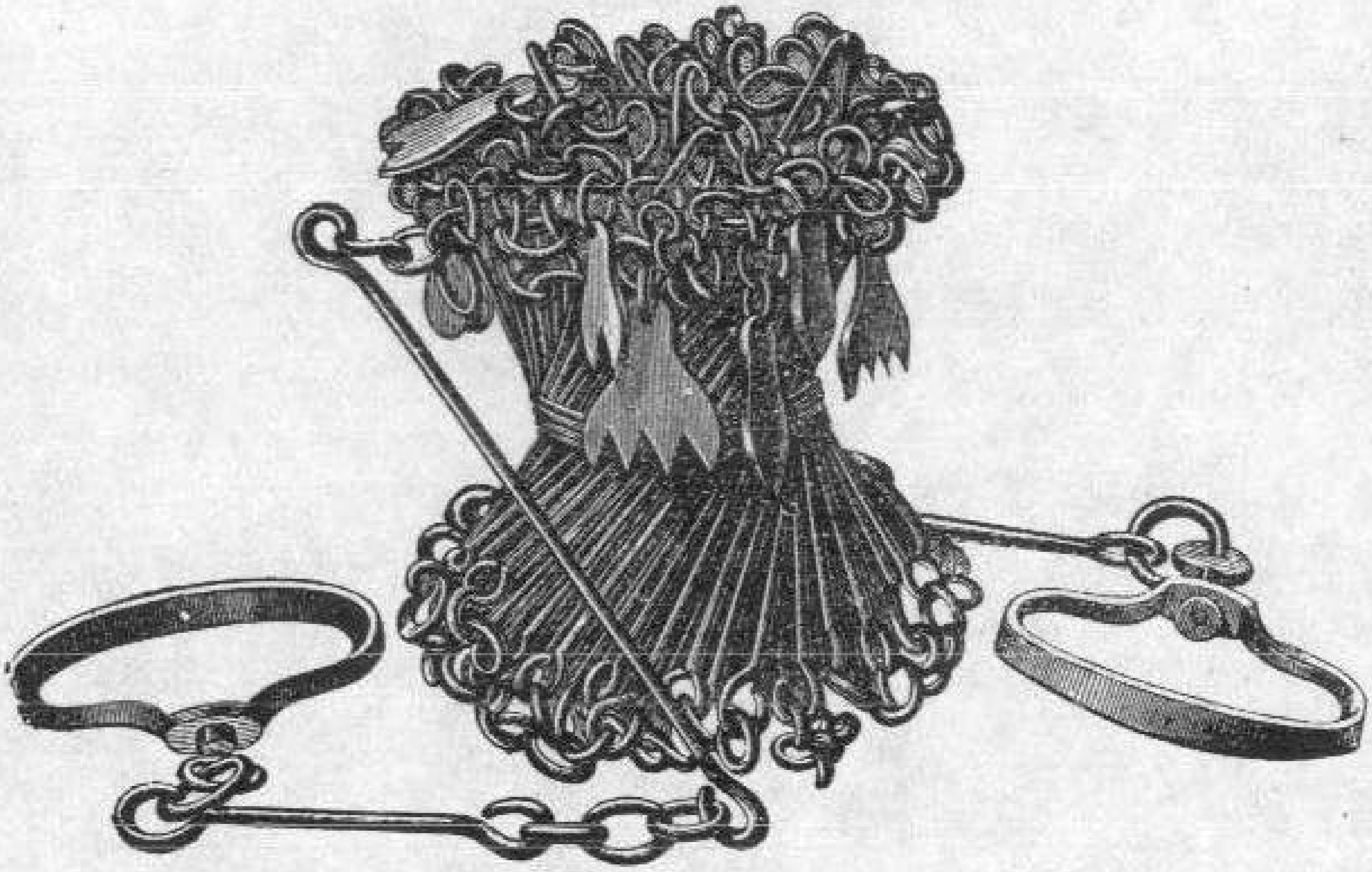
STANDARD STEEL TAPES

In any length from 100 to 1,000 feet. Made out of narrow steel band $\frac{3}{32}$ in. wide. Generally graduated at every 10 feet, the last 10 into single feet, and the last foot into 10ths.

Price of 100 feet Tape, graduated as above, on solid reel with double handles	**$16 00**
Every additional 50 feet	**3 00**

Note.—All tapes sold by us are compared with our standard; if desired we can have them compared at the U. S. Bureau of Weights and Measures, who undertake these comparisons at a very moderate charge, the price ranging from $2.00 to $6.00, according to length of tape. They furnish a tabular statement showing the errors of graduation. In order to obtain the coefficient of expansion it is necessary to make the comparisons at a high and low temperature.

SURVEYOR'S CHAINS.



Surveyor's Chains of No. 12 steel wire, brazed links and rings.

2-Pole Chain, 50 links	**$5 50**
4-Pole Chain, 100 links	**10 00**
50-Feet Chain	**6 00**
100-Feet Chain	**11 50**

MARKING PINS.

Set of 11, No. 6 steel wire **$2 00**

READING-GLASSES.

Pocket Reading-Glasses, oval pattern, mounted in rubber:

1 lens, 1½ inch diameter	$0 60
2 lenses, " "	1 50
Coddington lenses, brass frame and handle, nickel-plated, ¾ inch	1 50
Coddington lenses, brass frame and handle, nickel-plated, 1⅛ inch	2 00

For other Instruments,

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