CIRCULAR

OF

LYMAN'S TRIGONOMETER

AND

Universal Draughting Instrument.

CONTENTS.

PHILADELPHIA:

PUBLISHED BY HELLER & BRIGHTLY.

1878.

OFFICE OF HELLER & BRIGHTLY,
33 NORTH SEVENTH ST., PHILADA.

We herewith present to the notice of Civil Engineers, Surveyors, Architects, etc., a description of an instrument in which, we think, will be found remedied almost all the defects found to exist in the *table* instruments now in common use.

Our attention being called to the instrument by the article given below from the U. S. Railroad & Mining Register for December 13th, 1873, written by the editor, Prof. J. P. Lesley, we gave it a thorough investigation, and were so satisfied that it was an invention of merit that we have obtained from the patentee the exclusive right to its manufacture. The pamphlet that follows will give a detailed account of the various parts of the instrument and their uses, but the instrument may be briefly described as a draughting instrument combining in itself almost all the instruments ordinarily used, such as the protractor, T-square, straight edge, parallel rule, metal triangular scales, etc., each of which may be used by itself or in connection with the others, and this draughting instrument manufactured with all the care and exactness of a first-class engineer's field instrument, and with devices *for removing all the errors of manufacture*, and also with special arrangements for facilitating the accurate and easy manipulation of the various parts.

This instrument is protected by letters patent, issued May 25th, 1858, reissued May 15th, 1860, extended May 25th, 1872. Second patent issued April 14th, 1874.

TRIAL OF INSTRUMENTS BEFORE ACTUAL PURCHASE.

Judging from letters we have received, and the inability in some cases of properly explaining by letter some part of the instrument, or of its use, when if the instrument were to be seen it would explain itself, and in numerous cases a personal examination of the instrument and its various parts, before making a final purchase, would be more satisfactory to persons who are but slightly acquainted with us and our reputation,—to such we make the same proposition that we do with our regular Engineering Instruments. On making known to us the style of Trigonometer they wish ("Plain" or "Complete") we will forward it to their address by express; and we will direct the express agent on delivery of the instrument to collect the amount of our bill, but instead of forwarding to us immediately as is usual, he will hold the money on deposit for say four days, or until the purchaser shall have thoroughly tested the instrument in the office. The purchaser can take the instrument and give it an actual trial in the office (four days should be ample for this), and if not found as represented, strictly first-class in all parts, and perfectly satisfactory in every respect, he may return it to the express agent before the expiration of the four days, and receive the money paid in full and no sale. The express agent will then return the instrument to us at our expense. If, however, the instrument is not returned to the express agent within the four days, it will be presumed that it is perfectly satisfactory, and the agent will forward the money to us.

In sales of this sort, however, as in all our other sales, our original warranty holds good—*i. e.*, that at any time after purchase if any defect appears after reasonable use, we agree either to replace with a perfect instrument or to refund the purchase money.

The Engraving, Fig. 1, illustrates the **First Class** instrument, and Fig. 2 the **Plain**.

Letters of inquiry and orders may be directed to the Inventor, **Prof. Lyman**, whose residence is as above given, or to the **Manufacturers**,

HELLER & BRIGHTLY,

33 N. Seventh Street,

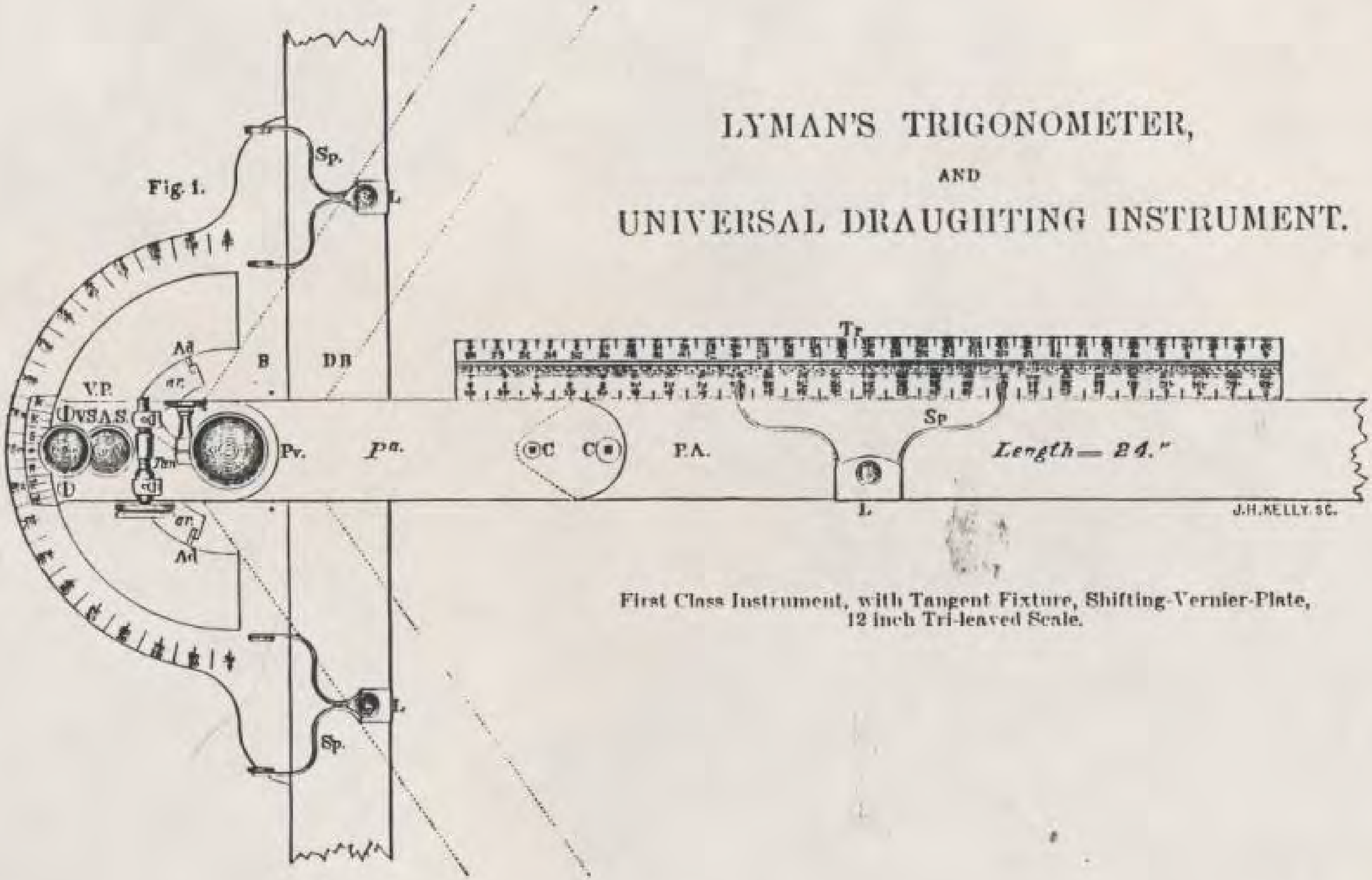
PHILADELPHIA, PA.

LYMAN'S TRIGONOMETER,

AND

UNIVERSAL DRAUGHTING INSTRUMENT.

Fig. 1.



First Class Instrument, with Tangent Fixture, Shifting-Vernier-Plate,
12 inch Tri-leaved Scale.

LYMAN'S TRIGONOMETER.

We have for years been familiar with the clumsy, inconvenient contrivances called "Draughting Instruments," with which the country has been flooded; and we have been aware especially, of the wide contrast in *accuracy* between these and field instruments. We have also observed the more recent attempts to supply the great want of a Draughting Instrument which should be at once convenient and reliable, by the introduction of instruments neatly made and accurately divided, but rendered *practically worthless* either by being inadjustable; or by lacking simple means for *connecting lines with angular points*; or, finally, by the invariable lack of any arrangement for *combining the laying off of angles and distances into a single operation.*

These defects and incongruities are aptly set forth in the number of Prof. Lesley's Mining Register published Dec. 13, 1873, in which he says: "When the field notes are brought to the office, the engineer's troubles begin. His drawing-boards warp; his rulers bend, or have not parallel edges; his rolling parallel-rulers wear their wheels unequally; his T squares are never square; his glass triangles will not prove four times round a circle; his paper protractor is badly divided, or shrinks in one direction and is awkward to use; his horn, brass or ivory semicircles are wretchedly manufactured; his Cleaver's protractor makes holes in his paper, and is always in the way, and, if taken up, cannot be put down again true to the meridian; his scales are difficult to read and subdivide by the eye, stick to the paper or slip too easily over it; and his prick-point makes oval holes instead of circular ones, and not exactly at the division line of his scale.

"Working under these disadvantages, it is no wonder that the engineer at his office-table loses the keen zest for accuracy which characterizes him in the field. His lines are all more or less forced to a conclusion, and he feels but little disposition to carry his topographical work a single rod beyond compulsion."

To remedy these defects, Prof. Josiah Lyman, of Lenox, Mass., many years since gave his study and experiment to protractors and scales. This resulted in the invention herein described, which is both an ingenious and strictly scientific combination; uniting in one machine the **Protractor, Base-Bar, Sliding Square or T, and Sliding Scale.**

The inventor has recently **improved** and **remodeled** the original instrument; first, by reversing the main clamp, elevating the main pivot and socket, and so **arranging the parts** that the under surface, including base and arm, is **brought into the same plane with the draughting-board or paper upon it;** thus enabling the operator to lay it flat upon any part thereof.

Secondly, by combining with the instrument a **Steel Bar**, arranged to be instantly clamped upon either the side or end borders of the board, or at *right angles* (at any point) across the board, or diagonally at *any required angle* across any one of its corners; upon which the trigonometer slides and to which it is held by spring force.

Thirdly, by substituting for the *Sliding Arm* lately employed a **vernier-plate capable of being shifted** to **right or left 45° or less, and there clamped** during any given operation. This arrangement, however, is applied only to that class of the instruments which is furnished with a *Tangent Fixture* for nice motion. But the same facility is practically secured to the other class by means of the *Steel Bar* just described.

Fourthly, by substituting for the *sliding* T a **Sliding Square**, either of whose arms (ordinarily of 15 and 6 inches length respectively,) may be held in contact with either edge of the Protractor arm, and *invertible.*

These changes greatly increase the convenience of the instrument, and add to the extent, reliability and accuracy of its operations, as well as diminish the expense of fixtures.

Its other peculiarities are first, so complete and perfect **adjustability** of all its parts as to enable the manufacturer to eliminate all the *imperfections* of *construction* before it leaves the shop.

Secondly, its combination with a **Sliding Scale**, so arranged that *angles* and *distances* are either laid down upon paper or measured, **at the same moment, without changing the instrument**; the divisions being graduated reliably to the thousandth of an inch, on edges beveled to such an angle (of 30° with the perpendicular,) that the needle-point in dotting distances is held **plumb** at the instant of dotting; the graduated marks being made of the requisite depth and width for guiding the needle entirely down to the paper, and thus **securing it against error.**

The scales are both **Tri-leaved.**

Figs. 1 and 2. Both are made of German silver about the fourteenth of an inch thick, and alike embrace the same principle of **beveled-edge graduation.** The ordinary lengths are 6½ and 12½ inches, with a fourth of an inch border at each end. The readings are both from right to left and left to right. These scales, when used with, and constituting a part of the Trigonometer, have attached to them a **sliding spring,** by which they are held in contact with either border of the Protractor arm, or either border of the short or long arm of the square, as occasion may require; giving to them a smooth, steady motion in sliding.

The **Flat** Scale, consisting of a single plate about an inch in width, has upon it two lines of graduation, viz.: one upon each edge.

The **Tri-Leaved** Scale consists of three plates of the metal, each about half an inch wide, attached to a central rod ¼ inch in diameter, and radiating therefrom at an angle of 120° with each other. It has a line of graduation upon each of its six faces, making six scales, viz.: one upon each side of the three leaves. The scales are divided *decimally* or *duodecimally*, according to their specific use, whether that of the civil, mining or mechanical engineer, the architect or the navigator. This Tri-leaved scale is considered by all competent engineers or other draughtsmen who see it the most convenient, accurate and expeditious scale they have known.

The **Protractor-plate** *B*, Fig. 1, of the Trigonometer, which constitutes its **Base,** is made of German silver or hard brass silver plated, about the twelfth of an inch thick, having a face usually 10 inches in length.

At an inch, or a little less, back from the face is inserted the *pivot Pr*, on which turns to right or left the **arm** of steel in two parts, viz.: the **attached** part *p a*, and the **arm proper** *PA*. To the former is clamped the **vernier-plate** *VP*. This terminates in an **arc** *a r* of German silver, embracing about 135°, on whose limb are graduated two **test-marks** *A d, A d*, and corresponding with these two similar ones on the base-plate underneath. By these the protractor-plate is adjusted for clamping. The two parts of the arm are fastened together by the **connecting-screws** *C, C*, Fig. 1; sufficient space between the arm proper and the protractor-face being given to allow the instrument to play freely along the **Draughting** or **Base-bar** *D B*, at an angle of 55° or less. The arm proper is therefore readily *detached* from the other part, thus allowing another of *different length* to be instantly attached in its stead.

On the limb of the protractor-plate (graduated to half-degrees, reading directly to minutes, or indirectly and reliably to half-minutes,) are **two readings,** the **inner,** giving the angle of the arm with reference to its **meridian** or **zero line**; and the **outer,** which gives the angle with reference to the protractor **face.** Hence every position of the arm indicates both the *direct angle* and the *complement* of the same. Therefore, in laying down the *direct* angle, the **Protractor arm only** is required for guiding and operating the **Sliding Scale,** but in laying down the *complementary* angle, the **Sliding Square,** *S. Sq.*, is necessary; and this answers all the purposes of *rectangular borders* to the board.

By means of its spring *Sp*, and *L i p L*, Fig. 2, the Square is held in contact with the *protractor arm*, and to it the scale is applied in the same manner as in the other case. It should, however, be observed that it is often convenient to **reverse this order.** Especially let it be remembered that if the **inner** reading in any case is used to denote the **complementary** angle, the **outer** reading must denote the **direct** angle **through the entire operation.**

Thus, if the *zero line* at the centre of the limb is taken as the *meridian*, then all readings on the *inner reading increasing from left to right* denote angles in the **north-west** or **south-east quadrants**; in which case the scales are applied to the *protractor arm only.* Also all readings on the *outer reading* increasing in the same direction, indicate angles in the **same two quadrants.**

On the other hand, all readings either on the *inner* reading increasing toward *the left*, or the *outer* reading increasing in the same direction, denote angles in the **north-east** or **south-west quadrants**; but in both cases the use of the *sliding square* has application only to the **outer reading.**

When, for convenience, the order of readings is **reversed**, as intimated above, then the *zero lines* **at the base** (supposed to be connected) **constitute the meridian.***

In using the Trigonometer for ordinary plotting, after the bar has been clamped to the board, the instrument is laid upon it and brought in contact with it by means of its springs Sp, Sp, as shown in Fig. 1, which in most cases need not be removed during the entire operation, nor the instrument taken from the paper. Next, in case the *direct* angle is to be used—*i. e.*, if in general the required angle be 45° or less—placing the scale by its spring in contact with the arm of the instrument, as shown in Fig. 1, the latter is carried to right or left till the vernier indicates the required angle, and clamped. The Base is then slid along the Bar till the outer edge of the scale nearly reaches the adjacent side of the dot, —*i. e.*, either the starting-point or last end of the previous line. The scale is then slid along the arm till the desired mark thereon (or such imaginary one as designates the required number of *tenths* of the subdivision) *coincides with the dot before-named*, and the required distance is dotted with the needle-point held plumb at the moment of dotting, **in the required unit mark**, along the scale, great care being taken to have the two dots *equidistant from the exact edge of the scale.*

NOTE.—**Needle-point.** By *needle-point* is intended literally an ordinary sewing-needle about the 40th of an inch in diameter, so much of the eye-end being broken off as to leave about ⅜ of an inch length of the point. This may be inserted into a cylindrical piece of hard wood ⅜ of an inch in diameter, and 2½ or 3 inches long; or, as is more common, it may be connected with the handle of one's draughting-pen. With this even microscopic dots may readily be made, and the largest should never exceed the *breadth of a hair.*

Fractional Parts of Units. Let it be further observed here, that if *the distance is short*, it is not essential that *either end* of the line should terminate in the *0 mark* of the scale; but it is essential that in *all cases* in which the distance includes **hundredths of the unit**—or, in other words, a **fractional part of the subdivision**—that fractional part shall be determined by the eye **at the dot before made**, and the next dot made **in some one of the unit-marks of the scale.** Lastly, these two dots (surrounded, if preferred, with little pencil circles, in order that they may be readily seen,) are connected by a **very fine hair-mark** made with a **very hard pencil sharpened to a knife-edge**, first on fine sand-paper, and finished on fine emery-paper. In the same manner the process continues until the entire outline is completed.

But in case the angle to be laid off is taken from the *outer* reading of the protractor-limb, or in general is *more than* 45°, the **Sliding Square**, as shown in Fig. 2, is to be applied by its spring to the **Protractor Arm**, and the **Scale to the Square**, the remaining part of the operation being the same as in the former case.

In a similar manner the outlines of any sketch may be **measured**, the angles being read off on the protractor-limb, and the distances on the scale.

Shifting the vernier-plate. The object of this movement is to enable the operator so to lay down his sketch that some convenient side shall be *parallel or at right angles with one of the borders of his board.* This necessitates *shifting the meridian of the instrument*, and it is accomplished by shifting the *vernier-plate* in the **opposite direction.** For instance, if he wishes to shift the meridian 10° **to the right**, he shifts the vernier-plate 10° **to the left.** To do this the arm of the instrument is set at the required degree and minute of change, and the vernier-screw VS clamped. The arc-screw AS is then sufficiently *un*-clamped to allow of smooth, easy motion of the arm, which is next carried back till the visible

* The ordinary length of the Base-Bar is 22 inches, width 1½ inch, and thickness $\frac{7}{16}$ inch. Extreme cases may require either greater length or two or more bars placed end to end.

test mark thereon coincides with the corresponding one on the base, and clamped, so to remain during the entire operation; after which it is restored to its former position by reversing the process.

It is immaterial in any of the foregoing or similar operations whether the data embrace the *bearings of lines with reference to any* **given meridian,** or the **angles included between the several lines,** since the latter may be *readily* reduced to the former, first, by assuming **any one of the lines to be the meridian,** and by drawing or supposing to be drawn *lines through all the other angular points* **parallel with this meridian.** Then, by subtracting the angles adjacent to this line from 180°, we have the courses of those lines which are connected with it: and these courses furnish data for proceeding in a similar manner with the remaining angles, till the courses of all the sides of the survey or plot are obtained.

The following example will illustrate the operation:

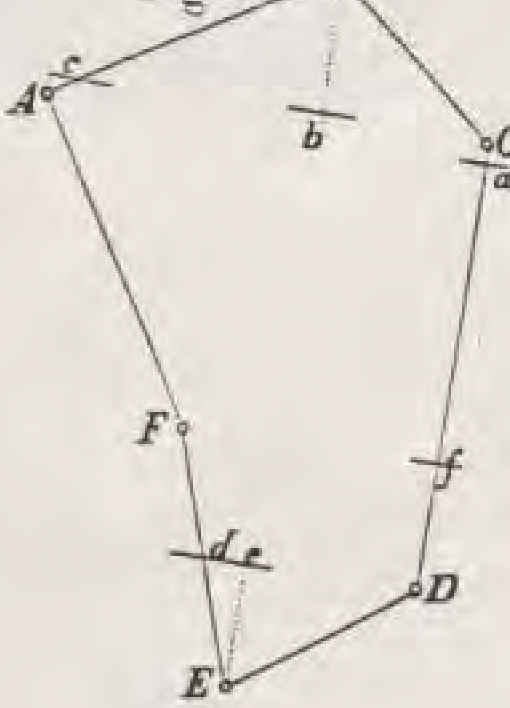
Given the angle at $A = 89° 7'$
" " " " $B = 109° 45'$
" " " " $C = 129° 30'$
" " " " $D = 125° 15'$
" " " " $E = 73° 25'$
" " " " $F = 167° 2'$

For convenience sake let the side CD, Fig. 3 (drawn about ¼ the linear size required for accurate plotting), be assumed as the meridian.

Through the points A, B, E, F, draw pencil lines (guided by the eye) parallel with CD, and produce CD both ways, as in the figure.

Fig. 3

Fig. 4.



Then the courses of the several sides may be obtained, as follows:

$BC = 180° - 129° 30' =$ S. 50° 30′ E.
$CD =$ South.
$DE = 180° - 125° 15' =$ S. 54° 45′ W.
$EF = 73° 25' - 54° 45' =$ N. 18° 40′ W.
$AB = 109° 45' - 50° 30' =$ N. 59° 15′ E.

As the angle at F is *re-entrant*, it is first subtracted from 180°, and the difference added to the course of EF. Thus,

$FA = 180° - 167° 2' + 18° 40' =$ N. 38′ W.

The ordinary method of **obtaining the area of a figure or survey, having an irregular outline,** is illustrated by Fig. 4, identical in courses and distances with Fig. 3.

Set the protractor-arm either parallel with or at right angles to the side CD, assumed to be the meridian, as before. Then from the angular points, C, A, F, D, draw with the knife-edge pencil, (and with the finest hair-lines,) such portions of the parallels of latitude Cc, Aa, Ff, Dd, as are necessary both to intersect the opposite lines of the figure, and any meridians *supposed* drawn for measuring accurately any of the latitudes, as in the figure. This divides the figure into two triangles and three trapezoids. Now measure with the scale slid along either the protractor-arm or square, the *parallels* Cc, Aa, Ff, Dd. Lastly, measure with the scale transferred to the *other* arm of the instrument the *latitude*, Bb, Ca, af, fD, eE, and record them for convenient addition and multiplication. Thus,

$$Cc \times Bb + (Cc + Aa) \times Ca + (Aa + Ff) \times af + (Ff + Dd) \times fD + Dd \times eE.$$

These, added, multiplied and collected, give *twice the area* of the plot or field surveyed.

Or, if the distances of the several sides be given, (which may be in feet, or yards, or rods, or chains,) *figures* may take the place of the letters. For the sake of simplicity of illustration let them be given in chains, as follows:

$AB = 12.50$ chains.
$BC = 8.75$ "
$CD = 17.85$ "
$DE = 8.30$ "
$EF = 10.35$ "
$FA = 14.11$ "

Then substituting the figures, we have—

For the longitudes: $Cc = 16.10$ ch., $Aa = 17.49$ ", $Ff = 10.10$ ", $Dd = 8.40$ "

For the latitudes: $Bb = 5.56$ ch., $Ca = .83$ ", $af = 12.01$ ", $fD = 5.00$ ", $eE = 4.31$ "

Multiplying and adding, we have,

$16.10 \times 5.56 =$	89.52	square chains.
$(16.10 - 17.49) \times .83 =$	27.88	" "
$(17.49 + 10.10) \times 12.01 =$	331.35	" "
$(10.10 + 8.40) \times 5.00 =$	92.50	" "
$8.40 \times 4.81 =$	40.40	" "
Twice the area,	581.65	" "

This divided by 20 gives 29,082 acres.

With equal ease and accuracy of result may this instrument be applied to all problems for obtaining the varied lines and angles in **architecture**, or the **construction of bridges** or other similar works, with the sizes, forms and position of all timbers, blocks of wood, stone or iron connected therewith.

For the use of engineers in **cross-sectioning** excavations of earth or rock, for railroads or canals, or any *other* similar work, no instrument will compare with it for convenience or expedition. The same is true of its application to **military fortifications**, as well as in the construction of machinery in the navy yards or other public works.

When known by mariners, it will often supersede the use of the tables in their daily labors.

It has also beautiful application to the **mensuration of heights and distances**, and especially to the **projection of eclipses** and other calculations connected with astronomy.

With the greatest facility and accuracy, therefore, may *any desired* operation of **triangulation** be effected or **trigonometrical problems solved** by the use of this instrument. It hence renders *unnecessary in all cases traverse tables*, and for most purposes even *logarithms*, saving in all ordinary trigonometrical calculations half to three-fourths of the time and labor.

With *equal facility* may outlines of lots or tracts of land or other irregular figures be *plotted* **without either courses or angles**, viz., when the *data consist merely of rectangular distances* related to each other like the ordinates and abscissas of a curve; or, like portions of a meridian, and similar portions of several parallels of latitude; and after such figure is plotted, either the courses and distances of the angular points in its outline may with extreme ease and accuracy be determined, or the angles included between the several lines obtained.

Another very essential use of the Trigonometer is in the **division or laying out of lands.** Indeed, the inventor assures us that, after fifteen years of its constant use, not unfrequently does he discover some *new application* before unthought of by him; and the same will be true, no doubt, generally of others who use it.

The foregoing statements are but the embodiment of the testimony of all draughtsmen who have become familiar with using the instrument *without the improvements* herein described, but which are now introduced into its construction. It therefore needs only to be known to render its use a necessity to every surveyor, to every engineer, civil, mechanical or mining, to all draughtsmen of rectilinear sketches or designs, and especially to all map-makers, as well as to every teacher of these branches in the scientific schools or colleges, and in classes pursuing the same in these institutions. Besides, its cost is so reasonable as to place it within the reach of every practical man.

For the nicer operations of this instrument, a *microscope* arranged to be held upon the eye without the aid of the hand is essential. This will be furnished to purchasers on application.

PRICES OF THE TRIGONOMETER.

Plain instruments, including Base-bar and Springs, with Case	$20.00
Instruments with Tangent Fixture for nice motion, Shifting Vernier-plate, Base-bar, Springs and Case	30.00

EXTRA.

Scale with Spring, graduated 6 inches	4.00
" " " " 12 "	6.00

NOTE 1.—For Surveyors and Civil Engineers the Scales are divided *decimally*; the ordinary divisions being 10, 20, 30, 40, 50 and 60 to the inch. For Architects and Mechanical Engineers the divisions are 12, 24, 48, 64 to the inch, *duodecimally* divided, and 40 and 50 to the inch, *decimally* divided. Other series are furnished when preferred; but for every line of division exceeding 64 to the inch, one dollar extra is added.

NOTE 2.—The Base-bar, Sliding Square and one Scale being indispensable, are always sold with the instrument; and the set is *incomplete* without *one long* and *one short scale*.

For the accommodation of *classes in the scientific schools*, if three or more of the plain instruments are ordered *at once*, they are furnished with Base-bar, Sliding Square, one short Scale and Case for $25. This includes the privilege of subsequently adding by order any of the other scales afterward to the set, at the prices specified.

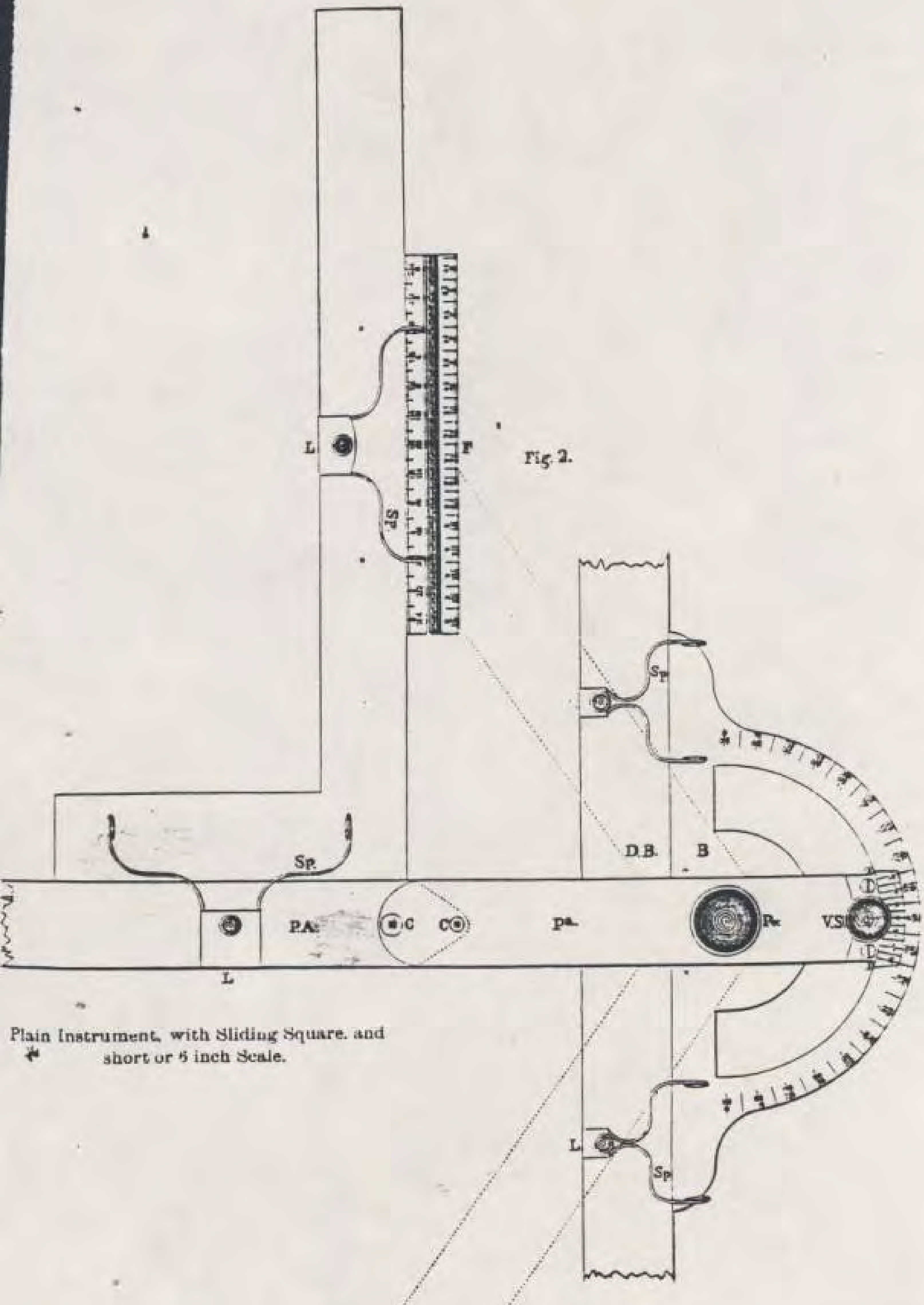


Fig. 2.

Plain Instrument, with Sliding Square, and short or 5 inch Scale.

RECOMMENDATIONS.

The following are a few among many testimonials as to the worth of the Trigonometer, which have been received from gentlemen of unquestioned scientific authority in this department, and of wide practical experience in actual office work:

FROM ALBERT HOPKINS,

Late Professor of Natural Philosophy and Astronomy in Williams College.

"I was glad of the opportunity, furnished by your call, to examine your new instrument, the *Trigonometer*, of which I had before heard. It strikes me as a decided advance upon anything I have seen intended to answer the same purpose. You are able by its aid to lay down angles and lines with an exactness limited only by the nicety of the graduation, and of the adjustments, which latter seem to be quite under your control. The former, of course, must depend upon the artist, whom I should judge to be extremely competent, from the specimen I saw of his work.

"Your instrument, in fact, enables the operator to introduce into the business of plotting, an accuracy like that which the astronomer attains in determining his data; certainly if you apply the microscope, which you might easily do.

"In addition to the uses for which you primarily intended it, I think your instrument will be found of essential service in the projection of eclipses, and other delicate operations of a like kind."

FROM H. L. EUSTIS,

Professor of Civil Engineering in the Lawrence Scientific School, Harvard University.

"I have examined an instrument patented by MR. LYMAN, of Lenox, Mass., and called by him the *Trigonometer*. As an instrument for plotting surveys and calculating areas it possesses great accuracy, and in the hands of a careful draughtsman would save a great deal of time and labor. It should be in the office of every surveyor."

FROM ALEX. C. TWINING,

Practical Engineer and Professor of Mathematics and Civil Engineering, New Haven, Conn.

"The demand for accuracy in graphical processes and delineations is constantly increasing, so that instruments, which ten years ago would have been considered mere beautiful exhibitions of skill and nicety, will now be esteemed of great practical value. On the other hand, a *universal protractor*, as I may term it, such as you have invented and patented, which is far more nice and accurate than any hitherto employed, will both satisfy the demand and augment it. Every man who has constant occasion for plotting and calculating areas or distances for ordinary purposes will, I think, find it an object to possess your *Protractor*."

"ENGINEERING DEPARTMENT, NORTHERN CENTRAL R. R. Co.,
Sudbury, Pa.

DEAR SIR: I have had your improved Trigonometer, with its T Square and Sliding Scale attachments, in my office and elsewhere during the last year, and have no hesitation in recommending them as *the most complete drawing apparatus in existence.* It enables the draughtsman to place upon paper the results of Railroad, Trigonometrical or Land Surveys with the greatest rapidity and *most perfect accuracy.* With its ingenious combination of several instruments hitherto in use, viz., the Protractor, Right-Angled Triangle, Parallel Rule, T Square, and Sliding Scale, no draughtsman can *afford to be without it*, and no Architect, Mechanic, Master Builder, or Machinist should be without, at least, the Scale, which, with its improved beveled edge graduation, ensures the greatest accuracy in the measurement of distance.

F. C. ALMS, *Engineer, N. C. R. R.*

"The undersigned have examined Lyman's Patent Trigonometer, and T Square and Sliding Scale attachments, and fully concur in the above recommendation of its undoubted merits:

ALLEN CAMPBELL, *President N. Y. & Harlem R. R.*
L. TILTON, *President Great U. R. R., Illinois.*
T. L. CARTER, *Civ. Eng. and Gov. Director Union Pacific R. R.*

"I concur in the above.

EDMUND BLUNT, *1st Assistant U. S. Coast Survey.*

"*Brooklyn, N. Y., Apr. 18th, 1865.*"

JOSIAH LYMAN'S PROTRACTING TRIGONOMETER

Peggy A. Kidwell

Josiah Lyman (1811-1889) came to study technical problems in a roundabout way. Son of Daniel and Sally Lyman, he was born in Easthampton, and spent most of his life in western Massachusetts. Like several of his brothers, he attended Williams College. After graduating in 1836 Lyman taught in various academies in New York and New England, and took an AM at the theological seminary in Auburn, New York in 1843. He eventually went to teach at the academy in Lenox, Massachusetts. There he was remembered as "an able scholar an teacher and especially brilliant mathematician and mechanic" whose scientific experiments and lectures were up to the standard of contemporary colleges. Poor health forced Lyman to resign his teaching post in 1849, but he remained in Lenox the rest of his life, marrying and raising two children.[1]

Lyman, who called himself a civil engineer, was clearly more interested in technical matters than in teaching or preaching. Soon after he left the Lenox Academy he built a 9-inch aperture reflecting telescope said to be the largest available in the United States. In 1863 Lyman obtained a patent (#38,904) for a drafting scale. The patent model for this is in the collections of NMAH. In 1871 he patented a beam compass (#111,954). As far as I know, neither of these instruments was ever produced.

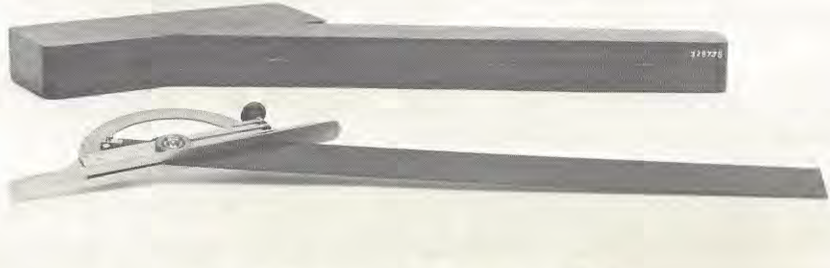
Lyman's first and most important patent (#20,356), issued May 25, 1858, was for an instrument which combined a protractor, a straight edge, and a scale. Lyman thought this device, which was especially suited to the cartographic task of drawing meridians and parallels of latitude, would be useful to surveyors. It might also be used in architectural drawings. According to Lyman, in addition to its use in drawing, the protractor might be used to solve trigonometry problems and measure surface areas. In fact, Gunter's scale, printed tables, and the newly popular slide rule proved of more general use in trigonometric calculations. To find the area of plotted surfaces, surveyors used the planimeter, invented at midcentury and increasingly affordable.[2]

To judge from objects in the NMAH collections, Lyman was not the only American who made complex drawing instruments by combining traditional ones. Lebbeus Dod built an instrument in which the base of a protractor served as one edge of a parallel rule. J. & H. M. Pool combined a protractor with a set of scales. M. Jeff Thompson combined a protractor with a table engraved on a straight edge in his rule for describing polygonal forms.

Lyman's instrument had three main parts. The first was a long flat rule, shaped at one end into a 140° circular wedge. This rule was divided into inches and tenths of inches, with a vernier that allowed readings to hundredths of an inch. The rim of the wedge, which was divided from 70° to 0° to 70°, served as the protractor. It had a vernier that allowed readings to $\frac{1}{2}$°. The second part was a frame for the protractor rule, attached to it by a pivot. The third part was a clamp to set the first two parts at the desired angle. When the protractor made an angle of 0° with its frame, the instrument resembled a T-square.

Two years later, in May, 1860, the Patent Office granted Lyman rights to an improvement on his original invention, now termed a protracting trigonometer.[3] In this version the protractor was no longer on the same piece of metal as the rule. Instead, Lyman used a conventional semi-circular protractor that fit into a crossbar along its diameter. The rule was pivoted so that its length extended from the center of the crossbar. This separation of the rule and protractor undoubtedly made the instrument easier to make. Another element of the improvement concerned the rule, which now might carry as many as 9 scales. Some would be in inches, but others could be metric. Use of metric units would be increasingly common as the century passed, but is still noteworthy in 1860.

With about $4272 (of which $1500 was borrowed), not to mention what he estimated as $1000 of his own time, Lyman proceeded to sell the trigonometer.[4] He wrote *A Manual of the Protracting Trigonometer with Its Application to Rectilinear Draughting and Plotting, Trigonometry, and Surveying* (New York, 1862), and he arranged with a firm of mechanics in Brattleboro, Vermont to make 100 of the devices. Brass instruments with a 20 inch rule sold for $22, while German silver instruments with a 30 inch rule sold for $37. The case was extra. Trigonometers were available from the manufacturers, from Lyman himself, and from his agents, the well-known mathematical instrument makers, W. & L. E. Gurley in Troy, New York.



Lyman's Protracting Trigonometer, NMAH

The National Museum of American History has a 22-inch trigonometer, formerly owned by Amherst College. Made primarily of German silver, it is marked "PATENTED BY J. LYMAN / MAY 25. 1858" and "CRANE & VINTON / MAKERS BRATTLEBORO. VT." Unfortunately, the set of scales is missing from the rule, as is the vernier for the semi-circular scale. The unusually shaped case is of butternut.

Scientific American commended the protracting trigonometer as a "scientific combination of drawing instruments" and a skillfully constructed mechanism that was "a triumph of the art." Similar praise was offered by professors at Williams, Amherst, Harvard and Yale, and by Edmund Blunt, assistant in the U. S. Coast Survey.[5] Nevertheless, trigonometers did not sell well. What Lyman would call "the great war of Rebellion" swept the country, "utterly prostrating all business." In May 1863 Lyman was forced to assign the rights to his patent to an associate, George I. Tucker.[6]

Despite these reversals, Lyman remained confident that the trigonometer offered great promise. In 1872--with the help of letters from three civil engineers stating that the protracting trigonometer was a time-saving improvement of traditional drawing instruments, and that it had not yet been adopted as widely as it deserved, as well as a letter from John D. Philbrick, superintendent of the Boston schools, who also examined the device and "cheerfully" gave his testimony in its favor--Lyman applied for and received a seven year extension on his original patent. He then proceeded once again to publicize the trigonometer,[7] but the financial upheavals of 1873 were probably no better for his business than the Civil War had been.

I have not found any mention of trigonometers in contemporary Gurley catalogs. Gurley did, however, introduce a new limb protractor in 1890, the year after Lyman died.[8] In this, as well as in other guises, combination protractors lived on into the 20th century.

Acknowledgments

I thank Ruth T. Degenhardt of the Berkshire Athenaeum, Tab Lewis of the National Archives and Records Administration, and George Norton of NMAH for their assistance with the preparation of this paper.

1. Payson W. Lyman, *History of Easthampton...* (Northampton, 1866), p. 167. Calvin Durfee, *Williams Biographical Annals* (Boston, 1891), pp. 497-8. The quotation is from [na], *One Hundredth Anniversary of Lenox Academy...* (Pittsfield, Ma., 1905), p. 26.

2. "Gunter's Scale" in Rees (ed.), *The Cyclopaedia; or Universal Dictionary of Arts, Sciences, and Literature* (London, 1819), vol. 17 (not paginated). Florian Cajori, "A History of the Logarithmic Slide Rule and Allied Instruments" in *String Figures and Other Monographs* (New York, 1960). On planimeters and other integrating devices see Henry S. H. Shaw, *Mechanical Integrators* (New York, 1886).

3. Additional Improvement #280, dated May 15, 1860, in "Additional Improvements," vol. 2, pp. 90-4. Records of the Patent Office, Record Group 241, National Archives and Records Administration.

4. Josiah Lyman to Commissioner of Patents, April 6, 1862. This letter is part of the Examiner's Report, dated May 3, 1872, on an extension allowed on patent #20,356. It is in the Records of the Patent Office, *op. cit.*

5. "Lyman's Improved Protracting Trigonometer," *Scientific American* 5 (1860): 341.

6. "Digest of Assignments, January 23, 1837 to June 30, 1864," L, No. 1, p. 229. Patent Office Records, *op. cit.*

7. "A Valuable Drafting Instrument," *Scientific American* 29 (1873): 264.

8. W. & L. E. Gurley, *Civil Engineers' and Surveyors' Instruments* (Troy, 1890), p. 59.

A LYMAN PROTRACTING TRIGONOMETER

MADE BY HELLER & BRIGHTLY

Robert C. Miller

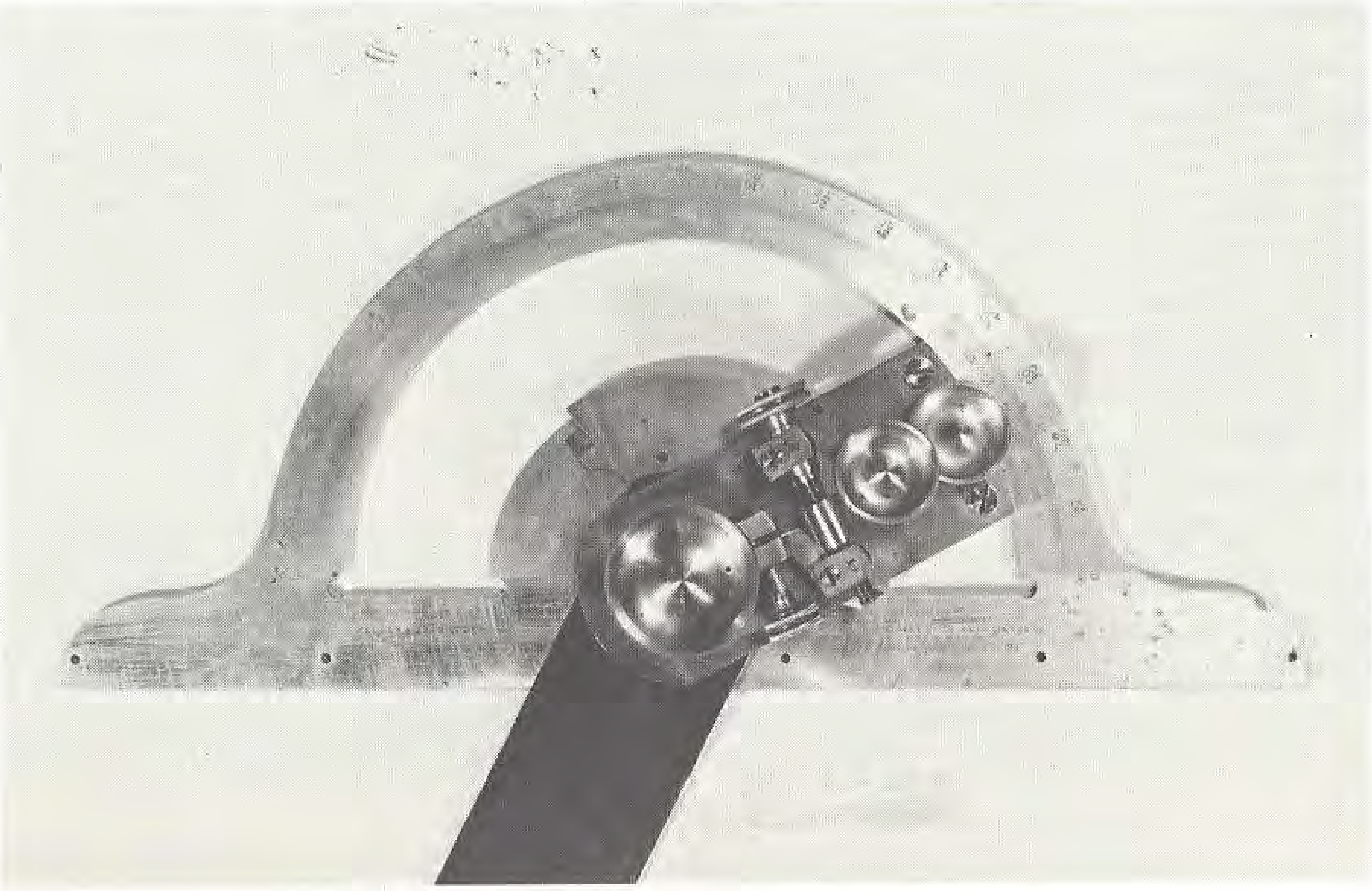
Peggy Kidwell's article in *Rittenhouse* (vol. 3, #1, pp. 11-14) discusses Josiah Lyman's protracting trigonometer as made in Brattleboro, Vt. It appears that there is a second chapter to this story. I purchased in 1984, in southeastern Pennsylvania, a similar instrument marked on the protractor:

HELLER & BRIGHTLY
MAKERS PHILA

and

PAT'D MAY 25,58-REIS. MAY 15, 60
EXT'D MAY 25, 72
2^D PAT. ISS'D APR 11 74

Heller & Brightly was founded in Philadelphia in 1870 by Charles S. Heller and Charles H. Brightly. The firm, which manufactured mathematical instruments, continued through a number of reorganizations and changes in management until 1946 when all operations were suspended and the tools, parts, and unfinished instruments were placed in storage.



My Heller & Brightly instrument is basically an improved T-square. It has no graduations on the base bar or the protractor bar, or anything else to suggest that it was to be used as a trigonometer. Its markings refer to Lyman's original patent, discussed by Kidwell, as well as to Lyman's second patent (#149,590) on this device, issued in 1874. The 1874 patent described an instrument with two notable features. The first is a vernier which can be adjusted to read zero when the blade is placed parallel to the edge of the drawing. This arrangement was probably well known by 1874, and thus not patentable. The second, the only feature claimed in the patent, was a sliding arm which allows a line to be drawn in a direction normal to the blade of the square. The combination of a protractor and a T square had been covered by Lyman's 1858 patent.

The functioning of the Heller & Brightly protractor is the same as that described in Lyman's 1874 patent, but the construction is very different. Lyman's sliding arm was replaced with a simple brass square, and the arrangement for the adjustment of the zero of the vernier was redesigned to make it easier to use and more reliable.

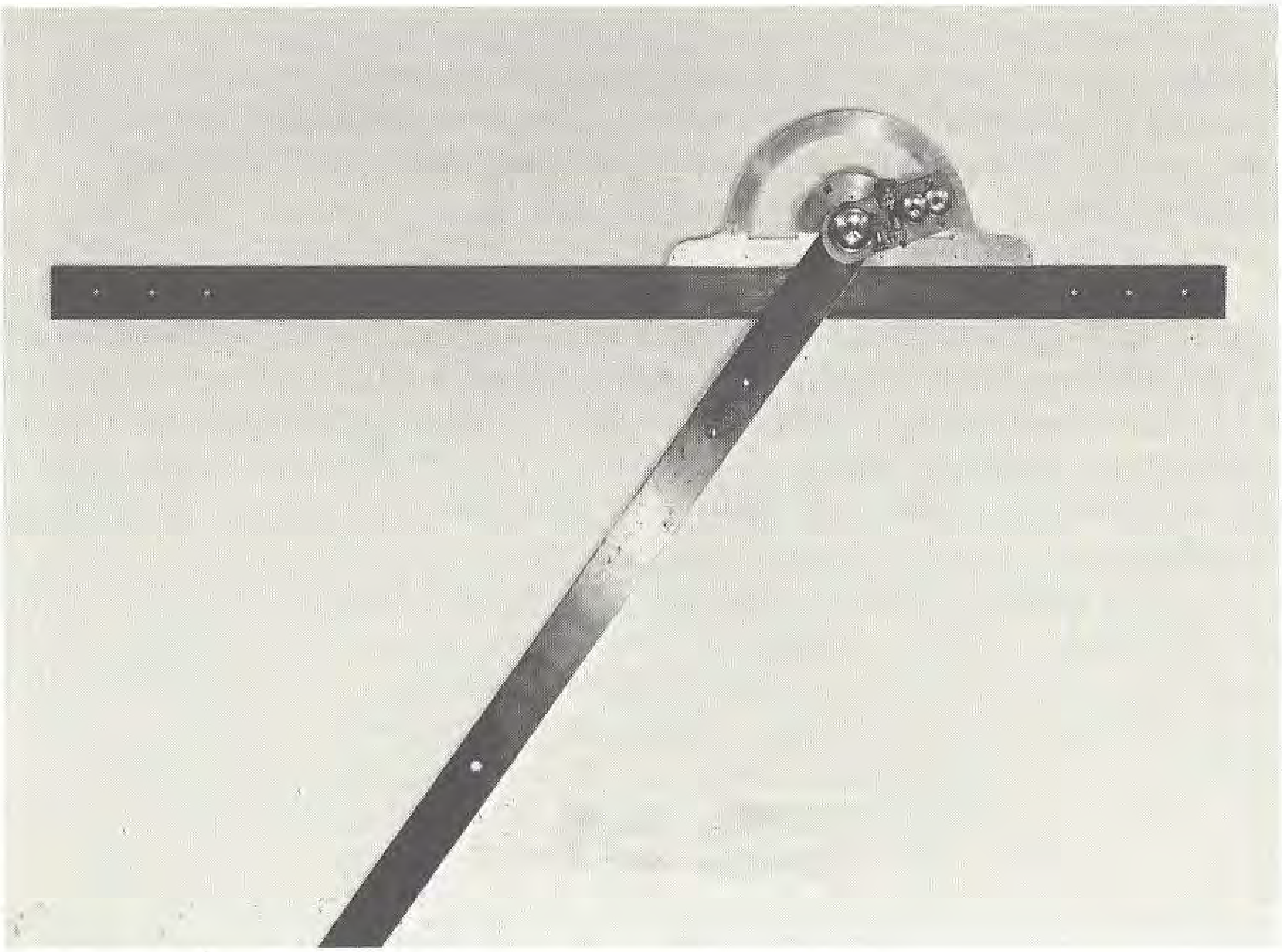
In addition to the protractor T square and the brass square, the Heller & Brightly instrument consists of a steel base bar and clamps, and several unidentified objects (pen holders?) neatly fitted into a poplar box. The base bar could be attached to the side of a drawing board, with the clamps providing a smooth, accurate surface on which the protractor could slide. The hardware and style of construction suggest that the box itself was made by Heller & Brightly. Glued to the inside of its lid is a set of instructions describing the proper method of attaching the bar to the drawing board. The fact that these instructions are printed suggests that production of a sizeable number of instruments was planned.

The numbers 51 and 52 stamped on a number of parts of the Heller & Brightly protractor, and the 64 on the brass square, may be assembly numbers. If so, one might guess that at least one lot of approximately 75 to 100 instruments were made. There is no mention of this instrument in any of the Heller & Brightly *Catalogues* or *Price-Lists* which I have checked, and thus it is not possible to determine if Heller & Brightly retailed this instrument, or if they made them for Josiah Lyman to sell.

The numbers 1, 2 and 3 stamped on the three clamp screws probably refer to the numbers used to identify these knobs in an instruction book which was supplied with the instrument. Deborah Warner reports having seen a reference to a *Circular of Lyman's Trigonometer and Universal Draughting Instrument* issued by Heller & Brightly in 1875. If anyone knows of the whereabouts of this *Circular*, I would certainly like to obtain a copy.

It is interesting to note that an incomplete protractor head marked with the number 100, made in Brattleboro, Vt., and nearly identical to that pictured in Kidwell's article, was found among the Heller & Brightly material which had been placed in storage in 1946. It is probable that Lyman provided this head to Heller & Brightly, to assist them in the design of their instrument. It is also interesting to speculate that Benjamin Smith Lyman, a prominent Philadelphia engineer who was related to Josiah Lyman and who was an admirer of Heller & Brightly, was involved in arranging to have these instruments made in Philadelphia. Finally, it should be noted that neither this instrument, nor that at the NMAH, have any graduations on the bar or anything else to suggest that they could have been used as trigonometers. The question remains: did Josiah Lyman ever produce a trigonometer, or was it all a dream?

An instrument functionally similar to the Heller & Brightly protractor T square was offered by Keuffel & Esser. This was listed as a "Double Protractor" in their *Catalogue* (1887 and later), and described at length in *The Compass* 3 (Oct. 1893): 36-38. This "Monthly Journal for Engineers, Surveyors, Architects, Draughtsmen, and Students" was published by Keuffel & Esser, and edited by William Cox, inventor of the Duplex slide rule.



Wheelwright of the Heavens: The Life & Work of James Ferguson, FRS by John R. Millburn, in collaboration with Henry C. King. Vade-Mecum Press Ltd, London, 1988, 328 pp., illustrated, £30.

In this day of mass education, computer literacy gained by those barely out of kindergarten, and advanced university degrees a requisite for all but the most rudimentary of careers, the accomplishments of James Ferguson hold a unique fascination. Ferguson was a lecturer and a writer whose pragmatic and easily-understood approach to scientific subjects made him much sought-after. His fame spread from the old world to the new, with numerous American editions of his books, the last one more than forty years after his death. The continued popularity of his writings in America indicates the strong influence he had on the study of science and the use of demonstration instruments here.

Born in 1710 in a remote village of Scotland, Ferguson had no more than six months in total of formal schooling. He taught himself to read, and later learned some of the rudiments of astronomy from observing the night sky whilst employed as a shepherd boy in his native Banffshire. Ferguson made careful drawings of the constellations, and devised little models to help himself understand how the heavenly bodies related to each other. As his mechanical skills expanded into artistic ones, Ferguson began making sketches of his neighbors and developed a facility for painting miniature portraits. He utilized this ability as a major source of income well into his mature life.

Although hard-pressed to earn a living, Ferguson nonetheless spent a significant amount of time teaching himself astronomy and mechanics, designing and building models, and writing papers about them. Before long, he found he could readily explain to others what he had discovered for himself. Capitalizing on that, he began to give lectures on a modest scale. Encouraged by the increased audiences at his lectures, in 1743 Ferguson took the dramatic step of moving to London.

It was in London that James Ferguson found his *métier*. He expanded his lectures to encompass what was, in effect, the entire "popular science" of the mid-Georgian period. He designed and constructed orreries, globes, clocks, and all manner of demonstration apparatus to enhance his lectures, and published tracts and books illustrative of what he taught. Indeed, so lucid were his books that they remained useful texts in successive editions well into the Victorian era. His lectures appealed to such a broad clientele, that he traveled widely to deliver them. As an itinerant lecturer over a quarter-century period (and burdened down with crates of demonstration models as well as the normal accoutrements of travel), Ferguson was estimated to have covered at least 7,000 miles of bad 18th century roads in ill-sprung stage coaches of the day.

A greater legacy to science than his ability to endure the discomforts of continual travel was Ferguson's publications--an impressive list by any standard, and much more so when his humble self-taught background is considered. His *Astronomy explained upon Sir Isaac Newton's Principles....* went through at least 15 editions including American versions, the last one being in 1841, 65 years after Ferguson's death. There were six other major books, each in multiple editions, 14 lesser works, and more than a dozen articles.

Of direct benefit to Ferguson as a result of these accomplishments was an annual pension from King George III of £50, a steadily increasing cache of capital, and election in 1764 to the Royal Society. To this last honor was added the unusual privilege of exemption from the admission fee of five guineas and the annual subscription of £2 12s 6d.

John R. Millburn, collaborating with Dr. Henry C. King, has written a comprehensive biography of Ferguson, rendering obsolete the 1867 biography by Ebenezer Henderson. This new work has resulted from a massive research effort by Mr. Millburn into dusty and far-flung archives in England and Scotland.

Although the source material may have been dry and obscure, the book Mr. Millburn has produced is lively and pertinent. Constructed on a roughly chronological armature, the story nonetheless becomes topic-oriented whenever that format is more suitable, smoothly returning to the time-line when appropriate. Interweaving historical and biographical material, Mr. Millburn relates James Ferguson to the people and events of his day. The relationship between Ferguson and Benjamin Martin is investigated, with evidence pointing to both a friendship and a rivalry. Mr. Millburn is on especially solid ground when speaking of Benjamin Martin, as he has written a major biography of Martin (1976), a Supplement to that volume (1986), and an important analysis of Martin's scientific instrument catalogues (1986). Besides the Martin connection, Ferguson was friends with the instrument makers Edward Nairne and John Troughton, to whom Ferguson's son James junior was successively apprenticed. Nairne later served as one of Ferguson's six pall bearers, and yet another instrument maker, George Adams the younger, swore an affidavit attesting to Ferguson's signature on his Last Will and Testament. Readers may be intrigued by one more Ferguson friendship--with the statesman Benjamin Franklin.

After a full and financially rewarding life of popularized lectures on most of the then-known aspects of science, Ferguson died in 1776 at the age of 66. An article in an 1883 issue of *Blackwood's Edinburgh Magazine* denigrated Ferguson's activities, complaining that he devised his orreries and mechanical devices "not for correct motions, but merely to *show* them." The anonymous writer continued, "He could not account for them, or attain even that perfect accuracy which mathematics can accomplish; but by all manner of cunning little wheels and elaborate contrivances, he could make it apparent how the Sun and Moon moved in their courses, how the tides rose, and how the night and day succeeded each other. It is too much to call him an astronomer. He was sort of star-mechanic--the carpenter, the wheelwright of the heavens."

The best response to this, and an appropriate summary of James Ferguson's place in the world of science, is the final paragraph of John Millburn's biography:

> "Although this may seem a rather cruel assessment of the work of a distinguished Fellow of the Royal Society, it contains an element of truth. Looking back today, over two hundred years after his death, Ferguson's outstanding achievement is seen to have been not the advancement of knowledge, but the (no less valuable) ability to make the principles of astronomy and mechanics both understandable and interesting to the layman: as he put it, 'to those who have no knowledge of mathematics'. In this he was greatly helped by his ability to design and make demonstration models, and by his lucid style of writing which was the product of his self-education. He was fortunate not only in having these talents, but also in living at a time when the state of scientific development, and of adult education, enabled them to be put to good use. Half a century earlier, the demand for his services amongst the gentry of the late Stuart period would have been minimal; half a century later, the physical sciences had become more theoretical, more specialized, and better taught, leaving little scope for itinerant lecturers on 'experimental philosophy'. Though a few of the latter could still be found in early Victorian times, by then their primary function had degenerated into theatre-style entertainment rather than instruction. James Ferguson, FRS, may well have been a 'wheelwright of the heavens', but in no sense was he a mere travelling showman."

Andrew Alpern

TO PREVENT INJURY to the TRIGONOMETER, READ the following RULES Carefully BEFORE USING.

All the screws are numbered as follows:

No. 1—Screw to clamp Vernier plate.
" 2 " " " Arc.
" 3 " " " Centre.
" 4 " " move Tangent screw.
" 5 " for friction of Centre.

3 & 5 **Being merely to take up wear** are never to be touched by the Surveyor.

To bring all the Zeros to coincide and to bring Steel Blade at right angles.

Clamp 2 and unclamp 1, shift protractor plate until its zero 0° coincides with the 0 of the vernier, using tangent screw 4 to effect this—Now Clamp 1, unclamp 2 and turn steel blade until the two test marks on its small arc coincides with the two lines on the Base Plate below them—on again clamping 2 all the parts are in adjustment with each other and clamped—**To turn off an angle,** unclamp 1 and turn steel blade by hand, bringing the reading precise **by using tangent 4.**

(Never use tangent 4, until 1 is unclamped, as this tangent is dissimilar to those on field instruments in the following points:—A field instrument is brought almost to the point by hand, then clamped and the tangent used to bring to a precise point.—The protractor is also brought to the point by hand, the tangent used without clamping, and only clamped fast after using the tangent.)

No. 5 is never to be touched, excepting when the Tangent is found not to carry the Vernier Arm around—then the friction of the arm on the centre is increased by slightly turning No. 5—**No. 3 is never to be touched.**—

To shift the meridian, or to shift the vernier plate.

The object of this movement is to enable the operator so [illegible] down his sketch that some convenient side shall be [illegible] *angles with one of the borders of his* [illegible] *the meridian of the instru-* [illegible] *vernier-plate*