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# REMARKS

ON

## ENGINEERS' SURVEYING INSTRUMENTS.

BY

HELLER & BRIGHTLY.

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## TO THE ENGINEERING PROFESSION.

When we some three years since first introduced our "Improved Transit" to the Engineering profession, we had no idea that it would meet with so immediate favor as it has, especially as we made no particular efforts to spread the knowledge of the improvement. The first public knowledge was conveyed through the paper read before the American Philosophical Society by J. PETER LESLEY, Esq., Dean of the Faculty of the new Department of Science of the University of Pennsylvania, as well as Professor of Mining and Geology in that institution; than whom no person is better qualified by extensive practice in the field to judge of the quality of Surveying instruments. On the publication of this paper, we resolved to submit our instruments to a committee of experts to be appointed by the Franklin Institute of Philadelphia. This committee was composed of the following gentlemen: JNO. C. TRAUTWINE, Civ. Eng., author of the "Engineers' Pocket-Book," works on "Excavations," "Curves," etc., and whose knowledge regarding all matters connected with Civil Engineering is too well known to need recapitulation, was Chairman; SAM'L L. SMEDLEY, Chief Engineer and Surveyor of the city of Philadelphia; CHAS. S. CLOSE, Esq., of the Philadelphia Survey Department; L. M. HAUPT, Civ. Eng., Prof. of Civil Engineering in the University of Pennsylvania; and ELLWOOD MORRIS, Civ. Eng., author of "Earthworks," formerly Chief Engineer of the Ohio and Chesapeake Canal, and of other works, being the remaining members. After a thorough examination in whole and in detail of the instruments and the principles of their construction, they unanimously made the report that will be found in the body of the pamphlet. In proof of the sincerity of the opinions of each individual member of the committee, we may state that since the report was submitted, the Survey Department of the city have procured from us *all* the new instruments required since that date, amounting to eight in all; also that the University of Pennsylvania have purchased from us all the Engineering instruments required by that institution; and, moreover, we have sold instruments either to every member of the committee directly, or to other Engineers at their recommendation.

As we have in the last three years made two improvements in Telescopes, a word of explanation may be necessary to distinguish them apart. In 1870 we improved the formula in general use for Telescopes in such a manner as to practically annihilate the chromatic and spherical aberration. This Telescope is the one referred to in the Philosophical Society paper, and in the report of the Franklin Institute Committee of Civil Engineers; and this Telescope is on all of our instruments from No. 4100 to No. 4592 inclusive. (All of our instruments are numbered on the face.)

Early in 1873 we commenced experimenting in order to increase the power of our Telescopes, and we only brought our experiments to a perfectly satisfactory conclusion in the latter part of December of the same year. We have made but comparatively few instruments with this new Telescope attached (from No. 4593 to 4645 inclusive). This latter Telescope is, however, the one which we are *now* placing on *all* of our new instruments; and it was with a Telescope of this kind on a Transit that we made for the City of Philadelphia Survey Department, that the comparisons as to power, range and definition, as compared with an ordinary Transit Telescope, were made by Mr. Stauffer.

The articles extracted from the editorial columns of the *United States Railroad and Mining Register* will give the full details concerning the "Improved Telescope;" and the "Franklin Institute Report" first sees the light in these pages. Having within a short time doubled our force of skilled workmen and tools, and having also called in the aid of steam, we hope in the future to supply any reasonable demand on us for instruments, and to avoid the vexatious delays that we heretofore frequently have had to subject our friends to. Our present price list, which supersedes all others, will be found at the end of the book.

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# REMARKS

ON

## ENGINEERS' SURVEYING INSTRUMENTS.

We are often applied to by Engineers respecting the methods to be employed in testing the accuracy of the various parts of **Engineers' Instruments**, the **errors** to which they are **liable**, and the means of **correction**. (These queries are, however, mostly from those just commencing practice, their elder brethren, as a general rule, knowing how to make an instrument "prove itself.")

In the following articles we have endeavored to comply with these requests. It would surprise those who think "one instrument as good as another" to be informed that in perhaps no other branch of mechanism are palpable "**errors of omission and commission**" more common than in ours—surveys extending over months of time have been rendered almost useless from "instrumental error," and a considerable portion of the business of our courts of law is caused directly and indirectly by imperfections of instruments.

The recent case of the **City of Burlington, N. J.**, is in point.\* Here the courts were so frequently annoyed by land suits from defective surveys that the Legislature of the State was compelled to pass a law that an entire re-survey, by a competent person and first-class instruments, should be made. A law requiring every instrument to be tested and proved by a competent person (not necessarily a manufacturer) would have a tendency to weed out instruments which, like "Peter Pindar's" razors, are made, "not to use, but to sell."

We will not stop to speak of the ordinary adjustments of instruments, as they are found in every elementary work pertaining to Civil Engineering—if a knowledge of these, however, be required, "Trautwine's Engineers' Pocket-book" will give them in detail. We will mention in their order, the Transit, Level, Telescope, Compass, Solar Compass and Plane Table.

### THE TRANSIT.

A first-class Transit Instrument should possess the following qualities: In the first place, *all its graduations* should be on **silver plate** (*instead of on the plain brass and silver washed, as is usual*)—all astronomical instruments are done in this way, as a smoother, truer graduation can be had. The *divisions* of the horizontal limb should be **truly graduated and centred** (*i. e.*, the graduations should be *precisely* the same distance from each other—the centre of the graduations and the centre of revolution should be *precisely* at the same point). The instrument should always have **two opposite verniers** to the **horizontal limb** (and these verniers should be **equally spaced**). In astronomical instruments more than two verniers are absolutely necessary, but we are now speaking of Engineering Instruments.

The interior of the glass level tubes should be **ground**, in order that their bubbles may act correctly. The **needle** should be sensitive enough to coincide with the verniers of the horizontal limb without disagreeing more than 3'. The **centre** upon which the **vernier plate** turns, and the common centre upon which the entire instrument revolves (we are now having one of the best class of Transits under consideration—*i. e.*, *one with long compound centres*), should be **concentric with each other**, and the levels, if adjusted to one centre, should reverse upon either one at will. *Both of the centres should be always covered, and not detachable from the main plates.*

The tripod and tripod head should be firm and steady, the **centre of gravity** of the instrument brought as near to the tripod head as possible, and the instrument **not top-heavy**. The tripod should be furnished with an **adjustable tripod head** for precise centring of the instrument (the adjustable tripod head

\* See H. S. Haines' letter, accompanying Franklin Institute Report of Civil Engineers.



is intended for precisely centring the instrument, after approximately setting by the legs in the following manner). First approximate by the legs to within an inch or less, loosen two of the levelling screws, then move the entire instrument until the plummet is precisely centred. While placing the instrument level by means of the levelling screws it is again clamped.

The levelling screws should have deep threads, good milled finger-heads, and be well fitted to their nuts.—The openings and windows in the upper plate for reading the verniers of the horizontal limb should be as wide as possible, to admit light freely upon the verniers and plate, thus facilitating an accurate reading (this single point as a general rule being overlooked). The vertical arc or circle (if one is used) should have a diameter of not less than  $4\frac{1}{2}$  inches, to allow single minutes (at least) to be read easily.

The plates and centres should move smoothly in all temperatures.

The spindle of a turning lathe can never be made precisely round, and of course any article turned in a lathe can only be as true as its spindle. Any work that is required to be precisely round and true, such as the journals of the axes of an Astronomical Transit or its centres, is turned on a lathe in which the spindle remains stationary, and the work revolves between centres.—In order to insure the actual truth of the centres of all of our instruments, they are made by this method (termed turning between “dead centres”), although it has heretofore only been used for astronomers’ instruments.

The mechanical construction should be so arranged that all the parts shall as far as possible brace each other. The tangent screws should move smoothly and have no “back lash.”

The Telescope should be balanced in its axis. Its length from 10 to 12 inches, to allow of its reversing in its standards, both at eye and object ends; it should have power enough to set an ordinary flagpole at 1000 feet; its object glass slide should move in and out in a perfectly straight line, in order that the line of collimation, when adjusted for a long distance, shall be correct for a short one. (This precaution does not always receive the attention it should, and young Engineers are frequently at a loss to account for discrepancies in their observations which are due to this cause.)

The slide of the object glass should be long enough to be able to focus an object five feet from the instrument. The adjustments of the telescope (and in fact of the whole instrument) should be as few as possible, every part admitting of it to be made as permanent as practicable. One end of the axis of the telescope should be adjustable, so as to make the “line of collimation” revolve truly in a vertical plane; and this adjustment should be provided with a jam nut, in order to fasten it securely after adjustment. The best method of testing this adjustment is by a star as near vertical as the telescope will allow of; if, after careful levelling of the instrument, the telescope cuts this star and its reflection in a basin of quicksilver, it is equivalent to cutting the two ends of a plumb line at least 50 million million miles long.

Having mentioned the traits a good transit should possess, we will pass in review some of the more common defects; and in this connection will take the opportunity of remarking that all the defects we will enumerate are matters of almost every-day observation in establishments that have a large amount of outside repairing to do.

As the Telescope has been termed “the brain; and the graduations the soul of a Transit,” we will first take imperfect graduation, as this is the most serious and damaging imperfection, and one of the most difficult to avoid in practice, as any of the following causes may defeat it during the process of construction. Namely—an imperfect graduating engine, defective centring, unstable cutting arrangement; and even if all these be correct, in the very act of graduating the plate may shift on the engine, from change of temperature; or the clamps, metal of the plate, or engine, may expand unequally from the same cause; in fact, the manufacturer, with all the care he may take, is not sure himself whether the process of graduating a plate has proceeded correctly until the graduations themselves are proved by means of its own opposite verniers, and until “testing reversions,” for the purpose of proving the centre and graduations, have been

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taken on all parts of the circle; the "*fertile principle of reversion*" and its peculiar merit of "doubling the real error, thus making it twice as easy to perceive" here, as in every other adjustment of the instrument, making each part prove itself.

It was mentioned among the points of a good transit that the horizontal limb should have two opposite verniers. Without these even the manufacturer himself cannot (as explained above) be sure of the accuracy of his graduations; however, by taking a mean of two opposite readings, reversing and repeating, an accurate angle can be taken even though there be an imperfect graduation.

One very rare cause of error of observation may be mentioned in speaking of the reading and testing of graduations. We refer to those persons who, probably from some defect of the humors of the eye (not from advancing age), are unable to read a vernier correctly. Extreme cases of this "*personal aberration*" are fortunately rarely met with; the writer in fifteen years' intercourse with hundreds of Engineers has only met with two; in both of these, if a reading was taken and noted by them, the vernier might be shifted two minutes to the right or left, and these parties could perceive no change in the reading,—and in their field operations close readings of graduations had to be taken by assistants. We do not here refer to the "difference of reading" of two persons, which under the term of "*personal equation*" is calculated and allowed for in refined astronomical observations.\*

If the Engineer is satisfied that his graduations are correct, he need read but one of his verniers, rendering the window of the opposite one opaque (to prevent mistake by reading the wrong vernier) by dulling it with oil, or pasting a wafer on it. It is a good method, where two verniers are used, to have some mode of designating them apart; our own mode is to engrave the letter A upon one, B upon the other. The numbering of the degrees may be done in several ways; our own method is to place on both the horizontal limb and needle ring two rows, one behind the other, and each row of a different sized figure, to prevent mistakes; one row in quadrants ( $0^{\circ}$  to  $90^{\circ}$  each way), and the other a continuous one or from  $0^{\circ}$  to  $360^{\circ}$ . What are known in the trade as Surveyors' Transits (a form which we never make), and sold cheaper than the regular Engineers' instruments, have but one vernier. The centres, etc., of this class of instrument are not of a construction to admit of, or made as a general rule accurate enough to allow of double verniers, and of course great accuracy cannot be attained with such instruments. Those who purchase an instrument will find it the best policy to procure one accurate enough for the best work they may ever be called upon to do, but only to work up to the full accuracy of their instrument when the character of the work may require it. As to the amount of error of graduation found in the ordinary run of instruments, it ranges from one to five minutes;† some exceptional cases going even beyond this; but these latter were evidently caused by some disarrangement of the graduating engine, and could not have been overlooked had the instruments had opposite verniers.

As a minute of arc causes an error of over 18 inches in a distance of a mile, in no case should the error of graduation be allowed to reach a minute. It is best in reading the graduations to hold the magnifier as near parallel over the graduations as possible, move the head slightly and notice whether the graduations seem to move; if they do, parallax is the cause; raise or lower the magnifier until no movement is seen. It is best not to use a magnifier with too high a power; one from two to three inches focal length is sufficiently powerful for general use. The spacing of the verniers should also be exact—that is, in a minute vernier (reading a half degree plate) they should be precisely  $29'$  apart,—

\* To show that this "*personal equation*" is inborn and not the result of inexperience, we may mention the cases of the two celebrated astronomical observers Bessel and Struve, between whom at one period of their lives it amounted to .8 of a second, and at a later period to a full second.

† Much dissatisfaction with these instruments (Engineers' Transits) was expressed by the assistants; their objections were these,—first, an eccentricity or imperfection of graduation of two minutes, more rarely three minutes, was frequently found in the reading of the verniers of the horizontal limbs, etc.—Extract from Report of Chief of Engineers, U. S. A., to the Sec. of War, House of Rep., pub. doc., 1873.

one common error in verniers is the not spacing all the lines equal (*i. e.*, some being 28' 30'', others 28' 45'' apart). One of the easiest methods to prove their freedom from this defect is by setting the halfway line (15') to cut a line on the horizontal limb, and the other three 15' must cut (presuming that the verniers are double, and opposite, properly adjusted, and a truly graduated horizontal limb). **Our own practice** in adjusting Transits is to test our horizontal limb with powerful microscopes, by opposite readings and "repeating reversions" on every part of the circle.

It also serves to keep the instrument in better order if the tripod head, with its levelling screws, can be detached and packed away with the instrument proper. **In travelling** the tripod should have a cap to its head, and a ring to confine the legs. The adjustments will keep better if four india-rubber washers are screwed at the corners of the bottom of the box, as these washers often absorb shocks and prevent their reaching the instrument with so much force. Remember also that the necessarily experienced frequent adjustment of an instrument, more especially of the cross wires, is due not so much to use as to the common error of supposing that the tighter screws are forced, the firmer and more lasting will be the adjustment. On the contrary, something must be strained, and every change of temperature is then more liable to alter the adjustment.

The adjusting levers should be rather short than otherwise (say about 1½ inches)—inasmuch as by using a long one too much force may be inadvertently applied, and thus either snap a screw or overstrain some more delicate part of the instrument; in fact, a brass wire would perhaps make the best adjusting pin, as it would bend if undue pressure were applied. Another common error is to place leather washers under the levelling-screws. This should never be done, especially on a Levelling instrument, the leather being affected both by the weather and by the pressure of the ends of the screws. It is almost impossible for an instrument with such leathers to retain *precisely* the same line of sight even for a few moments.

The brass of which the instrument is made should not be ordinary yellow brass, for several reasons—first, because the brass as it comes from the melting-pot is too soft for use, and requires to be condensed with a hammer; and this hammering can never be so equally done but that some parts will be more condensed than others, and unequal expansion and contraction, and hence derangements of adjustment at every change of temperature, are the results; second, the zinc which is a prominent part of the alloy of yellow brass will in time by mere atmospheric exposure change the texture of the metal, so as to make it lose a certain percentage of its cohesion. Lockmakers and those who use thin brass of this kind for springs well know that if it is exposed to the weather for some time it loses its cohesion, and breaks at the slightest pressure like pie-crust—in their phrase becomes "rotten." Of course this is almost an imperceptible change, but some unaccountable variations of the adjustments of instruments (the heavier, the more liable) can only be explained on this hypothesis. **The proper metal for instruments** is an alloy with little or no zinc, and in density at least as close as the best hammered brass; hard "bell-metal" being the best.

A variation plate is also sometimes added to the ordinary transit in the manner of the variation plate of the ordinary Surveyors' Compass, and for the same purpose. This adds however to the weight of the instrument. Any contrivance for taking sights at a right angle to the telescope will be found useful for offsetting. We always add one to our complete transits.

The ordinary Plummetts that are used with the transit to centre it over a stake or point will also require examination, inasmuch as some of these, from cavities in their interior (from defective casting), although apparently solid on the outside, will not hang plumb; and in nice operations may be an unsuspected cause of error. The best method of testing these is while holding the string of the plummet in the hand, to twist the string somewhat, and while the string is untwisting, to lower the point of the plummet into a basin of water; if the weight is not truly distributed, and consequently the plummet not true, the eccentric motion of the steel-point will scatter the water.

As the defects of the telescope will be treated under that head, and those of



the magnetic needle under "Surveyor's Compass," the reader is referred to those articles.

We here close the "errors of workmanship" of the transit instrument; as to the defects of the plan of their construction, and the methods devised for their remedy, the reader will find this subject treated in detail in the paper from the American Philosophical Journal, and in the exhaustive report of the Committee of Civil Engineers, a little further on.

### MINING TRANSIT.

A full description of our new Transit, intended for mining purposes, will be found in Prof. R. W. Raymond's paper further on. Since that paper has been written we have made several changes which render them more complete for the purposes intended. Instead of a prism to the eye-piece, an extra telescope is placed on the end of the axis of the regular telescope, on the side opposite to the vertical arc.—This side telescope swings clear of the plates, and allows a vertical sight to be taken directly up or down a shaft; or any angle of elevation or depression to be taken too steep for the central telescope to measure. This telescope makes the instrument similar to the "eccentric or German Mining Transit," with this advantage over that form—that when a steep slope is not required to be measured it can be removed in a moment and packed away in the box, and the central telescope used as usual.—This side telescope is adjusted so as to be parallel with the central one; and the horizontal wires of the two telescopes will cut the same level line. It is also so arranged that the long level and vertical circle of the centre telescope can be used by the side one.

As the proper reading of the graduations is one of the greatest troubles the Mining Engineer has to encounter, we have devised two articles to facilitate it. One is a small reflector that weighs  $1\frac{1}{2}$  ounces;\* the other is a small attachment to the transit tripod for placing a lamp on; this consists of a small table, on which by a "Cugnot's joint" and double centre arrangement a lamp can be placed in any position or angle that may be necessary.—This arrangement is strong, compact and effective, only weighing 24 ounces, and can be packed away in the transit box.

We also make a lamp weighing about 5 ounces, which is more compact than the one ordinarily used; it is crescent shaped on the interior to fit to the curve of the observer's hat, and a simple arrangement secures it there.—It can be quickly detached and used either in the hand or on the table above mentioned.

Copper should always be the material of the Mining Engineer's lamp, and this copper should be tested as to its freedom from magnetic attraction. We now furnish with our Plummet Lamps cases large enough to enclose a pair; a strap on the outside of this case allows it to be carried over the shoulder.—The ordinary coal-oil such as is used for lamps is used; the wick to be adjusted for use so that the flame is about  $1\frac{1}{4}$  inches high. These last three (*i. e.*, the Reflector for the cross-wires, the Reflector for the graduations, and the Table) are also useful in taking astronomical observations with the ordinary Transit, such as, determining the magnetic variation, the true meridian, etc.

### TUNNEL TRANSITS.

The long Tunnels which have been built of late years, and the numerous others that are contemplated or in the course of construction, have created an

\* Another invention of this firm is a small reflector attachment to a mine transit, to facilitate the reading of the angles. It is metallic, in shape the quadrant of a cylinder, and it has a base or support which doubles up with the cylinder when not in use. It is placed just behind the vernier opening, and the light is reflected down upon the vernier, thus avoiding the soiling of the instrument with grease and smut, which occurs when holding the light over it, and the reflector can be removed when not in use.—Extract from the report of the committee of visitation of the Polytechnic College to the establishment of Messrs. Heller & Brightly, from the Polytechnic Bulletin, Nov., 18'3.

entirely new class of Transits, which to designate them are called **Tunnel Transits**.—These heretofore have been nothing more than the bar and centre of an ordinary Levelling Instrument, with standards high enough to allow of the reversing of the Telescope (which generally has been the ordinary 17-inch Level Telescope); but our attention having been called to the defects of this mode of construction, we have devised one that possesses all the accuracy of the Astronomical Transit.\*—In a **Tunnel Transit**, the principal adjustment being that of making the “line of collimation” revolve in a truly vertical plane, the same means employed in adjusting and testing the Astronomical Transit are also employed (*i. e.*, the ends of the axis of the Telescope are cylindrical and resting on small Y’s, to allow of its being taken out and reversed end for end. A sensitive striding level is attached to the axis at right angles to the line of sight).

The Telescope should be as powerful as possible, as very long sights are necessary in this class of work.

### LEVELLING INSTRUMENT.

A first class Levelling Instrument should possess the following qualities: The Telescope should be powerful enough to read the face of a levelling rod *direct* (*i. e.*, without the aid of a target) at at least 800 feet—the object slide of the Telescope (like that of the Transit) should slide in and out in a perfectly straight line, so that the “line of collimation,” when in adjustment for a long distance, shall be correct for a short one.—The tests for proving the optical performance of the Telescope will be treated under the head of Telescope.

The interior or the glass level tube should be ground to a regular curve, so as to secure both accuracy and sensitiveness in the bubble; if the bubble, instead of being cylindrical in bore, should be slightly funnel-shaped (which is very apt to be the case without great care), it will be quite impossible to either adjust or level with accuracy. This serious but common defect is no doubt the unsuspected cause of much inaccurate levelling.

The tripod and head should be very firm, and the centre of gravity of the level as near to the tripod head as possible. The centre of the instrument should be long, firm and well fitted to its socket, and not detachable from the instrument proper.

Inasmuch as it is difficult, on steep sideling ground, for either the rodman or leveller to know whether the rod is held vertical, we always place marks on the collar of the Telescope and inside of the Y’s; by observing if these are in contact, the leveller will be certain that when his instrument is levelled his vertical hair is truly vertical, and this enables him to keep the rod vertical, unless the rodman has a plummet or some contrivance similar to our “rod level.”

One form of Level (one which we never use) that is liable to constantly lose its adjustments unless great care is used is that in which the cone of the socket enclosing the centre fits into a recess in the tripod head. If any flying dust settles on this socket (which it is almost impossible to avoid), it will cause it to stick so fast that to take the instrument from off the tripod requires a sudden shock upward to release it from the recess; this shock of course cannot but be detrimental to the adjustments. The best plan, when this form of instrument is

\* On the eighth of December, Mr. Heller, of the firm of Heller & Brightly, by invitation, brought their “Improved Tunnel Transit” to the college and exhibited it before the several classes. He gave a short account of the construction of an ordinary Transit and of Tunnel Transits, and explained the adjustments requisite to prove their accuracy, after pointing out the distinguishing features of their Tunnel Transit as compared with the ordinary style, the principal of which Mr. Heller remarked having been suggested by J. Dutton Steele, Esq., and first applied in practice to the Tunnel Transit used by Mr. Steele in the alignment of Nesquehoning Tunnel (Carbon Co. Penna.), . . . and that another one of these Transits was now being used by Robert H. Sayres, Esq., of the Easton and Amboy R. R. in aligning a Tunnel on their road of over a mile in length, . . . At the close of Mr. Heller’s remarks, the Principal, after referring to the increase of Tunnelling operations at the present day, and the necessity of all the details connected therewith being closely studied by the scholars, a vote of thanks to Mr. Heller was moved and unanimously adopted.—From the Polytechnic Bulletin, January, 1874.

used, is to be careful before setting the instrument on the tripod to be sure that both the outside of the socket and its recess are scrupulously clean: all the above causes of instrumental error in levelling are well known to those who make levelling a specialty, especially to the "Canal Engineer." The sudden death of the late **Ellwood Morris, Esq.**, prevented the completion of a work for which he was peculiarly adapted, and for which he had been accumulating material for many years, on "**Levelling and Levelling Instruments.**" After serving as a member of the **Committee of Civil Engineers appointed by the Franklin Institute** to examine our "**Improved Transit,**" Mr. Morris entered into a long correspondence with us in reference to the defects of the ordinary Level, and the removal of them, in which he alluded to all the above defects. In referring to the above-mentioned defect of the **object slide not moving in a straight line**, he remarks: "One trouble I have frequently had—in the aberration caused by moving the tubes for short and long sights.—I once had a Level which I never could make agree with itself in a transfer across a river, though I knew it was in good adjustment at all points. . . . I have realized these defects from long experience and much anxiety, but am not enough of a mechanic to give the true remedies. . . . I have said that good work has been done with modern Levels, defective as they are, but it has been with a world of care and trouble on the part of Assistant Engineers, who are very far from being stupid men."

We were much struck, in our correspondence with Mr. Morris and others, to learn what a diversity of opinion existed even among experts as to what could be called "**close levelling**;"—Mr. Morris in one of his letters asserting, "I have long ago made up my mind that no man can be considered a 'proficient leveller' who cannot run a line of levels in a circuit of 100 miles without differing more than one-tenth of a foot upon his closing bench-mark." On mentioning this test of proficiency in levelling to another practical engineer, he retorts in this wise,—"**I have just, with my new level that you furnished me, run one line of levels about ten miles, and when I closed back on my bench to test my work found an error of 0.07 ft.,—this is close work, but it would not be close enough for your friend (Mr. Morris).—If any one should close on his bench with an error so small as he would expect ( $\frac{1}{10}$  in 100 miles), I would say it was simply an accident, and the several errors (rod errors and distant errors) had in the aggregate balanced each other, and led him to suppose himself an expert.**"

A third thinks that even Mr. Morris's error is too large, and that the levelling rods that read to  $\frac{1}{10000}$  of a foot do not read close enough, and that for his own use he has had a rod divided so as to read by vernier to  $\frac{1}{10000}$  of a foot,—but as the **Levelling Instrument** of this last expert, which he declared was in perfect order and adjustment, was found, on trial by us, to be out of adjustment  $\frac{3}{10}$  of a foot in 300 feet, perhaps his opinion may not carry much weight.

The result of four series of test levels in France, of from 45 to 140 miles, averaged a difference of  $\frac{1}{10}$  of a foot in 43 miles, and the greatest error was  $\frac{1}{2}$  of a foot in 56 miles; another series of test levels in Scotland of two sets of levels of 26 miles was 0.02 of a foot.

If the instrument is a good one, and in perfect adjustment, and used by a competent person, the only two causes of error in levelling that can occur (except by carelessness) are from what are called "**rod errors**" and "**distance errors**"—the "rod error" being caused by the assistant not holding the rod precisely vertical,—the "distance error" by the curvature of the earth affecting the result, when the "back" and "fore" sights are of very unequal length.

To counteract as much as possible these two causes of error, we have devised for the first a "**rod level**"\*—this "rod-level" is also intended for setting transit "**flag-poles**" vertical, as well as "**levelling rods.**"

\* "We were also shown a spirit level for the use of rodmen. It is an ordinary disk-level attached to an L-shaped piece of brass, a limb of the L extending downward, and at a right angle with the level. By placing this limb against the side of the rod or flag-staff, and clasp- ing it there, the rodman is enabled to know when his rod is vertical."—Extract from the report of the committee of visitation of the Polytechnic College to the establishment of Messrs. Heller & Brightly, from the Polytechnic Bulletin, Nov., 1873.

For the distance errors, we place on the "diaphragm," or ring carrying the ordinary cross-wires, two extra hairs,\*—these we adjust so as to *precisely* take in 1 foot of a rod placed at 100 feet distance from the instrument.—After taking the level reading, the space on the rod enclosed by these hairs is also noted, and the rod sent in the opposite direction until the hairs enclose the same space.—For example, if the hairs inclose  $3\frac{5}{10}$  feet on the rod, the rod is 350 feet away from the instrument.—To avoid taking the wrong hair in the "level sight" the "Stadia hairs" are placed **vertical**, and the telescope after taking the level sight must be turned quarter around in the Y's to read them.†

In a recess on the inner edge of the "clips" that confine the telescope in the Y's, there is generally placed a piece of cork, or a spring to bind the telescope.—When this cork, etc., fails to bind, either a new piece of cork must be substituted or paper placed between to clamp.—We have arranged our clips so that by slightly turning a milled head screw on their top the cork is forced out sufficiently to again bind the telescope.

In some level telescopes, it will be observed, while turning the telescope in the Y's, for the purpose of adjusting the cross-wires to the "line of collimation," that the object appears to move with the telescope.—The cause of this is that the object glass is not well centred (*i. e.*, the optical axis of the object glass does not lie in the same line as the axis of the telescope tube); this is a serious defect that can only be cured by substituting in whichever the defect happens to exist a new glass or tube.‡

## TELESCOPES.

A good Telescope should possess power, definition and light; and every part should be made with the greatest care, so as to have as few adjustments as possible.

As to the method by which we have doubled the power of our Telescopes without increasing their length, the reader is referred to the articles on pages 25 and 26.

If two Telescopes are to be compared, as to their power, definition and light, they should be placed side by side, and looked through at the same time,§ in order that any atmospheric or local influence should affect both equally. An optician's test, a watch dial, should be used; the difference of magnifying power between the two instruments can be seen by the apparent size of the dial; and if in one Telescope the dial appears twice as large as in the other, this Telescope has twice the magnifying power.—In the telescope through which the dial appears *brightest*, the light is most abundant; and the sharpness of outline of the figures and minute lines will give a good test of the definition.

If the face of the dial appears sharp black and white, with no tinge of color, and the image as sharp at the edge as at the centre of the field of view, the chromatic and spherical aberrations are well corrected.—Besides the above test (*i. e.*, the brightness of image) for the amount of light passing through the Telescope, let the two Telescopes stand side by side until twilight comes on; the one which will show objects latest has practically the most light.

Adequate magnifying power is the first requisite in a Telescope, not only for viewing objects at a distance, but for the purpose of doing more accurate

\* See article on Stadia measurements.

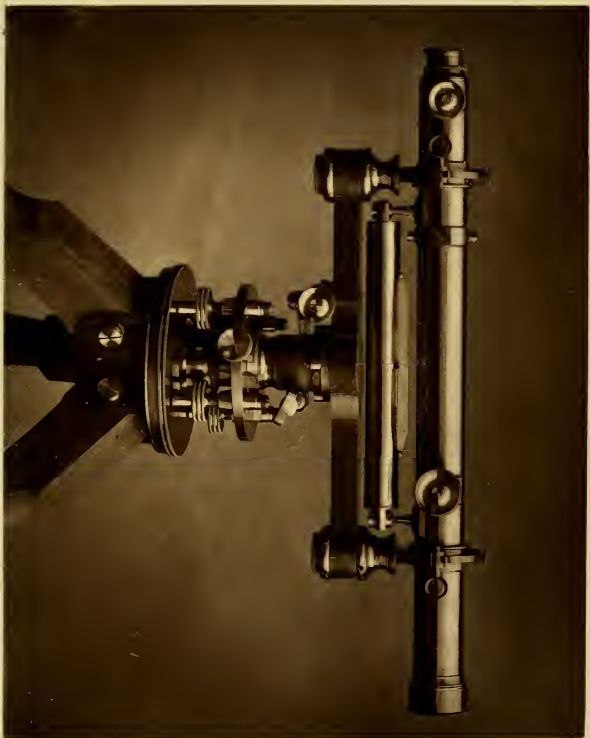
† These Stadia hairs will also be found useful as a means of measuring distances quickly when "flying levels" are taken.

‡ This "error of centring" must not be confounded with the error of the line of collimation not being the same "for long and short distances," the first being caused by a "defective object glass," the second by a defective "object slide or tube."

§ The best time for telescopic observations is not when the sun is shining, as is generally supposed; on the contrary, a clear cloudy day, or when the sun is slightly obscured. Recollect also that the best sight is always in a direction opposite to the sun (*i. e.*, sighting to the west in the morning, to the east in the afternoon). A good background to the object will facilitate the view (the sky is a very good one if it can be obtained); if none can be had naturally, improvise one of some neutral tint behind the object. This is specially needful in long ranges.



IMPROVED 17IN. Y LEVELLING INSTRUMENT,



Woodbury's process

MADE BY

HELLER & BRIGHTLY, PHILADELPHIA, PA.

A. F. R. P. Co., Phila.





work at comparatively short distances, as the ease with which sights can be taken and judged adds to the facility of the field work. Besides the above tests, after precise focussing of an object the slightest pushing in or drawing out of the object glass (by means of its milled head pinion) from the point of distinct vision should render the image confused and indistinct, "for a Telescope that will admit of much motion in the sliding tube without affecting sensibly the distinctness of vision will not define well at any point, for its object glass has spherical aberration."

The following test will show whether the glass is perfectly achromatic (or without color): "focus on a bright object, such as a star, etc.; alternately push in and draw out the eye piece from the point of distinct vision. If in the former case a ring of purple is formed around the edge, and in the latter a light green (which is the central color of the prismatic spectrum), the glass is achromatic, for these colors show that the extreme colors red and violet are corrected." The placing of diaphragms or stops within the object slide or body tube, so as practically to reduce the diameter of the object glass from  $\frac{1}{3}$  to  $\frac{1}{2}$ , is a common but reprehensible practice, inasmuch as such diaphragms exclude light, so that operations cannot be continued to as late an hour in the afternoon.

On examining the object glass head of our Telescopes, an index mark will be found across the cell of the glass and the head of the slide.—The object of this is, in case the object glass cell is ever taken out, that by seeing if these marks coincide when it is again screwed in, we may know that it is at the same place; or that the glass has not gotten loose by transportation.

Defective centring of the object glass, and of the lenses of the eye piece, and crooked tubes are by no means uncommon.—These last defects, however, may be concealed (except from experts) by screw adjustments (in the manner of the web diaphragm) of the eye piece and object glass.—These last, however, if the glasses and tubes are true, are unnecessary; for if the object glass and the lenses of the eye piece of a Telescope are properly made and mounted, the tubes perfectly straight, the sides properly fitted, the line of collimation (when adjusted) must come in the centre of the field of view, and if it does not, something must be wrong in some part of the Telescope, and any means of adjustment only conceals the evil.

One error of judgment is also sometimes made, and that is that the bore of the Telescope tube itself is so small as to cut off considerable of the light from the object glass.—Some Engineers prefer a small hole in the eye cap to sight through, others a large one,—but they must recollect that the size of this hole, as well as the size of the Telescope tube, is fixed by rule.

The eye-cap hole should always have a slide to cover it.—Both this and the cap on the object glass should always be kept on when not in use. This is a point that is almost universally neglected; the cap as a general rule being lost within a few weeks' time; but if it is recollected that the fine polish of the object glass gives in a great measure the sharpness and brilliancy to the object,—which if this polish is destroyed is also in a measure destroyed—more attention would be bestowed on it. Any one who has looked through an old ship's Telescope in which the polish has been destroyed by constant wiping of the glasses may have observed this.

If the object glass becomes dusty, brush it off with a fine camel's-hair brush, or a piece of soft, clean buckskin, linen or silk, taking care to use a fresh place on the buckskin at every rub. If the glasses become very dirty, wash them with alcohol.

## SURVEYOR'S COMPASS.

In a good surveyor's compass the slits of the sights should be precisely in a line with the two zero lines of the ring,—and these sights at right angles to the main plate.—It should be as light as is consistent with strength and steadiness. The magnetic needle is, however, the main point, and any one of the following defects will prevent its free working—bad steel,—too great heat in forging,—improper tempering or defective magnetism.

We sometimes receive communications from parties wishing to make magnetic needles,—the following will give them the information sought for.

The steel should be either of **shear** or the **best cast steel**, converted from Swedish Danemora iron (shear steel being the best, however).—If the needle is forged into shape, care should be taken not to overheat it during that process.—After filing and finishing into shape and length, it is to be **hardened and tempered**, and it is this operation that is most liable to be improperly performed,—the needle being so thin that it is apt to get too hot in places, and burnt steel never magnetizes properly.

Our own method is to heat a **crucible of lead** to a cherry red color, and to heat the needle therein, and when it is to the proper heat plunge it into water,—the beauty of this method being that, even though the needle be allowed to remain a considerable time therein, it can never attain a greater heat than the lead itself has.

After hardening, the needle should be tempered.—A good rule for the **degree of hardness** to which the steel is to be reduced is this: when the **length** exceeds **thirty** times the thickness, to temper to dark red, or **red blue**,—when the length is **under this**, to leave them **untempered**.

In magnetizing, two methods can be employed, first, by passing over each end the opposite poles of a fixed magnet; second, by a magnetic coil. If the first method be the one employed, a **thin film of oil** on the needle during magnetizing will greatly increase the power; but the method that is most certain of thoroughly magnetizing to "**saturation**," and with no possibility of "different polarities" being developed, is by passing the needle through a magnetic current.

To any one who wishes to make a coil for this purpose, the following hints may be useful. A cylindrical coil of copper wire as thick as it is long,—this cylinder to have a bore equal to its thickness, (the copper wire to be rather thick. Our own coil is of  $\frac{1}{4}$  inch thick wire).—The **exciting power** to be a voltaic apparatus on "Groves'" principle (platina and zinc);—and the needle to be magnetized passed up and down the interior of the copper cylinder.

After being magnetized it is necessary to know if this has been done properly (*i. e.*, if the latent magnetism of the needle has been fully developed, and if this magnetism is permanent); to prove the first the needle should lift a certain amount of soft iron; (our own needles will lift ten times their weight).—Second, after **noting the amount raised** on first magnetizing, it should be tried, after say a week's time, and it should then have lost but little of its power.—It must be recollected that a soft, untempered needle loses almost all its magnetism within a comparatively short time, though at first it will develop as much, if not more than a tempered one.\*

The **pin and the cap** on which the pin works, require a peculiar shape;—the centre of the cap to be at as obtuse an angle as possible, consistent with having a proper centre, and this centre perfectly smooth;—the **centre pin** to have a hard, round, smooth point; and this point with not too obtuse an angle. Defects of these two last, (cap and pin) are in eight cases out of ten the cause of the dull working of the needle.

To preserve the **fine point** of the centre pin from unnecessary wear or from being accidentally broken off, never jolt nor carry the compass without being sure that the needle is screwed off the pin.—In using the needle, lower it carefully, so that it gently rests, and does not fall upon the centre pin.

To prevent unnecessary wear of the centre pin, check the needle on first letting it down at the mean of its swing (*i. e.*, if the needle swings from say  $0^\circ$  to  $30^\circ$ , check it by raising it off the pin by means of its screw at  $15^\circ$ ; gently let it down again, and it will be within a few minutes of its proper settling place).

Never allow the needle to be played with by a knife or a piece of iron or steel, for two reasons;—first, the instrument should never be made a plaything; second, every near passing of a piece of iron or steel removes a portion of the

\* If the reader wishes to investigate thoroughly the subject of magnetism and magnetic needles, he will find ample material in the works of Scoresby, Sabine, Brewster, or the *Encyc. Britannica*, art. Magnetism.

magnetism of the needle (almost the entire magnetism can be removed by a series of such passings). A needle should never (excepting for special purposes) be more than six inches long, it being very difficult to magnetize properly beyond this length without developing different polarities on the same side of the needle. A five inch length is very good.

Be sure that **nothing to attract the needle** is carried on the person in the shape of **penknives**, watch-chains, buttons, or **iron rivets** in the **magnifier** used to read the graduations. Of late years **new causes of error** from this have arisen. The new **watches** in which the **movements are made of nickel** are almost as powerful in attracting the needle as if these **movements were made of iron**. The felt **hat-makers'** modern fashion of **stiffening the rims** of their hats by inserting around the edge a small **iron wire** (the extra broad brimmed, termed the military or Burnside hat, should especially be tabooed) should make the Surveyor examine both his hat and watch.

There is **one source of error** which even the manufacturer must have a special apparatus to detect; and this apparatus is as essential a part of his equipment as a lathe. This is a sensitive, mounted magnetic needle; and every piece of brass, even of the smallest size, is tested by being brought near to this needle, in order to see whether any magnetic attraction is concealed. The **brass-founder** is the one here **in fault**, as impure copper or the smallest piece of iron, such as a tack, core wire, or stirring his melted crucible with an iron rod will engender this cause. These impurities, melting and diffusing throughout the brass, although imperceptible to the eye, are brought to notice by the searching influence of the **test needle**. All the surveyors' **Compasses made before the last 80 years** are especially liable to error from this cause (those made by **Rittenhouse** are, however, notably free from it);—and those who own any such should have them tried by some maker's "test needle" to prove their freedom from it.

It would be a **matter of surprise** to some to know how many needle instruments are defective from this cause, and we will give one instance that occurred lately.

An **English Compass**, venerable with age and the associations connected with it, had been constantly used by a Surveyor for over 50 years, and by his father before him. This Compass was held in such repute that all the farm lines in a radius of 100 miles had been established by it. In fact, the Surveyor and his Compass were held in such veneration as to be called in to settle every land dispute in the neighborhood, and the judgment of the two was considered final. At last the old Surveyor died, and such was the desire of the surrounding land Surveyors to possess this Compass that at the auction sale of his effects it was sold for treble the price a new one could have been bought for.

The fortunate possessor brought it to us for cleaning and adjusting; and some vagaries that took place in the adjusting induced us to give the instrument a thorough examination; and we found that this defect of "**impure metal**" was present in such a marked degree that in turning the instrument on its centre it was sufficient to **draw the needle** from its proper position from 10 minutes to  $4^\circ$  (in some spots  $5^\circ$ ).<sup>\*</sup> We are not surprised to hear, since the old Surveyor's death, that several lawsuits are in progress in this locality from land disputes.

**One common error** of Surveyors is to **choose a heavy needle**; this is a mistake. A heavy needle soon wears out the fine point of the centre pin. The superficial surface, and **not the weight** of the needle, determines the **amount of magnetism** it is capable of receiving.

One simple effect has sometimes **bothered the young Surveyor**. His needle will sometimes not traverse, but will persistently stick to the under side of the glass; or one end at the lightest provocation would fly up to the glass and remain there. This is caused by the glass becoming charged with electricity (from rubbing against the clothing, or being rubbed by a silk handkerchief). Touching the

<sup>\*</sup>This unequal attraction is one of the worst features in this imperfection; if the iron were equally distributed throughout the metal, the attraction being equal, the needle would still point true.

upper part of the glass in several places with the moistened finger tip, or breathing on the glass, will remove the electricity.

### SOLAR TRANSIT AND COMPASS.

**The Solar Compass**, or Solar Transit, as ordinarily made, has the following defects:—first, it is very heavy and cumbersome; hard to get in adjustment, and very liable to lose its adjustment; and the Solar apparatus, by occupying the upper surface of the plates, prevents a Telescope being added in the manner of an ordinary Transit.

**The best method to prove** the Solar apparatus is the following:—Two hours before the sun culminates (10 A. M.) set up the instrument, level it carefully; with the latitude arc vernier set to the latitude of the place, and with the sun's declination for that hour laid off on the declination arc, move the whole instrument until it is in its meridian (*i. e.*, until the sun's image comes between its lines); let it stand until the sun is as much beyond its meridian as in the first observation it was before it (2 P. M.); the 4 hours' difference of declination arc to be added or subtracted (as the case may be) on the declination arc;—and if the sun's image still keeps between its silver lines, the polar axis of the instrument is parallel to the earth's polar axis; and the sun's image on the silver plate will follow the sun in its path during the day (allowance, however, being made for the refraction and hourly difference of declination).

It is, however, in very rare instances, that the instrument will stand the above test, its polar axis being generally out of adjustment so much that the afternoon's observation will require it to be moved east or west of its meridian from 5' to 45' (in some cases even more than this), to bring the sun's image again between the lines on the silver plate. If, however, the instrument stands this test, it only proves the truth of its Solar apparatus, and we must try whether the Telescope or sights are placed by the maker on the true meridian.

**The best method** of testing this is with an ordinary Transit, and an observation of the North Star, to first establish a true meridian line; and after setting up the Solar in the regular way, see whether the sights or cross hairs of Telescope cut the same line. By this observation it can also be seen whether the magnetic variation of the place agrees with the variation shown by the Solar Compass; and if not, the movable arc of the needle box vernier can be shifted until it does so.

**The successful addition of a Telescope** to the instrument has not heretofore been accomplished. The inventor, Burt, after numerous attempts, contented himself with placing a small inverting Telescope at the south end of the Compass plate; but the necessarily small size of the Telescope, and the one-sided weight that it added to the instrument, make this method an imperfect one.

**Another method** is to place a Telescope on the side, as in the "German Mining Transit;" but the side weight is also added to the instrument; the difficulty of adjusting the line of collimation of the Telescope, and the line of sight of the telescope, and the centre of the instrument not being in the same line, requiring a *constant* of this "difference of centre" to be applied to every sight, prevented it from becoming popular.

Another method is to place the Solar apparatus on the top of the axis of the Telescope of a regular Transit (the very worst place that could be thought of).

**The standards** of the Telescope of an ordinary Transit have also been bent outward, so as to allow the Telescope to reverse outside of the Solar apparatus—but as long as the Solar apparatus remains on top of the plates no Telescope can be successfully applied.

**The first idea of the inventor**, Burt, was to place the Solar apparatus below the main plates, which would have solved all the trouble as to the Telescope; but as on experiment it was found that the lens, to form the sun's image, must have a six inch focal length (and consequently a six inch bar), this was abandoned.

**We manufacture a Solar Transit** (patent of Benj. Smith Lyman, Esq.) which overcomes all these difficulties.—It is our regular Engineer's Transit, with the compound centres of the usual length, and a variation plate extra—with the Telescope in the centre as usual. **The Solar apparatus** is placed below



the plates, out of the way of harm. The lens-bar is only *two inches long*, the focal length of the lens is, however, the regular six inches' length; but before focussing on the silver plate the sun's rays are made to pass through **two opposite prisms**, making three passages across the bar (in contrary directions), of two inches each, or six inches in all. When it is called to mind that prisms do not alter the convergency of the rays, but only their *direction*, the beautiful simplicity of this arrangement will be seen. All the adjustments of the Transit, as to "line of collimation," etc., are the same as for the ordinary Transit. In fact, it can be used as an ordinary Transit without regard to the Solar apparatus if need be. The Solar apparatus is more compact than usual, and less liable to get out of order, and weighs about a pound, making the entire instrument weigh but little more than a regular Transit.

### ON THE DEFECTS OF THE ORDINARY CHAIN AND STEEL TAPE MEASURES, WITH AN ACCOUNT OF A NEW MEASURING APPARATUS FOR STRAIGHT LINES.

Before mentioning a new measuring apparatus, it might perhaps be best to allude to those in common use, and the objections found to them in actual practice.

The defects of the ordinary chain are too well known for us to enter much into detail—its weight, the unavoidable wearing of the points of contact of its numerous links and rings,\* the kinking and breaking of the links, etc.

The English steel ribbon tape is much more accurate, but it also has its defects; first, they are never precise United States standard length, it being our practice, whenever we furnish one of these steel tapes, to give its length as compared with the true United States standard, and the state of the thermometer at the time of trial. We have found that the 50 feet tape is generally from  $\frac{2}{100}$  to  $\frac{3}{100}$ , and the 100 feet from  $\frac{4}{100}$  to  $\frac{6}{100}$ , of a foot too short (the 50 feet over  $\frac{1}{4}$  of an inch, 100 feet  $\frac{1}{2}$  an inch, or in a mile more than 2 feet too short). The amount of error is small, and in a majority of cases would be of no consequence; but where accurate measurements are required would lead to error; second, the numerous joints in their length, (every joint in a tape being a source of weakness and inaccuracy);—their never being over 100 feet in length—(and in numerous cases, such as measuring across bridge piers, rivers or marshes, in shafts of mines or tunnels, etc., it is necessary to have a greater length than this)—their liability to breaking, and lastly their cost.

Having had occasion to make a measure 500 feet long that should be light, not easily broken, and very accurate, and not too expensive, we have devised a tape that fulfils these conditions. We are now prepared to furnish these tapes of any length, from 100 to 1000 feet, in one continuous ribbon—having no joint from end to end, and warranted **precise United States standard in length**. Large brass handles to unship at each end and a reel to wind the tape on are also furnished—as to their weight, a 400 feet tape (without handles) weighs  $2\frac{1}{4}$  pounds.

We are well aware that tapes of this material have been made before, but for the following reasons have never been popular. First, no reels were furnished with them; second, the steel ribbon, being of soft steel (not tempered), was liable to alterations in length. (Our own tape stretches taut with a strain of a few pounds, and after being taut allows of an extra strain even to breaking without perceptibly altering the measure); third, the graduations and numbering being scratched on the face of the tape itself, and the **tape always breaking at these marks** in cold weather, or when the tape was kinked in the slightest. To prevent this breaking, the graduations have been etched with acid on the face of the tape, or the marks were placed on a thin layer of tin soldered on the tape. But these marks were not legible enough, hard to find, and easy to efface.—The

\* If each of the 300 points of contact of a 100 foot chain (each link with its two rings having three points of contact) wears only the  $\frac{1}{150}$  of an inch, making 3 inches difference in the whole length.

marking of our tape is by a device entirely our own. It is not upon the face of the tape itself, is very legible, and the tape is stronger at the graduations than at any other portion.

For Mining and Bridge purposes these tapes are peculiarly adapted—the unshipping of the handles allowing the end handle to be taken off after a measurement, and the tape to be pulled forward with no handle to catch in any obstruction.

In City work tapes for close measurements are not used, but what are termed “Contact Rods” are adopted. These are rods of a certain length (10 feet being the most common), and are used in pairs; the two being joined together when in use by a “clamp socket” in their centre; or, after one is laid level, the second is brought in contact with it: the first one is then removed, and also then brought in contact with the second one, and so continued.

These rods are usually made from some well-seasoned, straight-grained wood, such as ash, cedar or pine, the wood protected from the weather by paint or varnish, the ends shod with brass, and the whole length made very exact in its measure.

In making these Rods, our own experience is that good, seasoned, straight-grained white pine, of what is termed “rafted lumber” (*i. e.*, wood that has been floated to its place of destination in rafts), is to be preferred. The immersion in the water for weeks washing all the sap from the timber, and thus too lessening its liability to change.

### STADIA OR MICROMETER MEASUREMENTS.

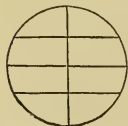
As considerable attention is now being bestowed on what are termed Stadia or Micrometer measurements, and this method being almost the only one that can be employed sometimes in such measurements as across rivers, inaccessible morasses, meandering along rivers and streams, etc., we will give a brief account of the means employed.

One method is this—first, carefully measure off say 100 feet on the ground, place a levelling rod at this point, and note on the vertical circle of a Transit the angle passed over by the horizontal cross wire of the Telescope, in moving over one foot of the Rod; and from this as a *constant*, a table is made. The second method is similar to the first, except that instead of reading on the vertical circle, the space passed over by the Telescope is noted by observing the number of revolutions and parts of revolutions of a tangent screw (by means of a micrometer head), and using this as a *constant*.

In this last method the instrument must be very carefully used; for if the tangent screw has the least “lost motion” or “back lash,” or if the screw threads wear unequally, the micrometer head will not measure correctly.

The first method is preferable to the screw; but the vertical circle should be larger than usual, so as to allow of a vernier reading to less than minutes of arc. Both of these methods require, however, constant care in the observations, and after calculations to get the precise distance. The United States Coast Survey, who have given the greatest attention to Stadia measurements, have adopted the two-hair method in their “Plane Tables.” This is the one we prefer, and is as follows:—beside the ordinary horizontal and vertical cross hairs, as seen in the field of view of the Telescope, two extra horizontal hairs are placed parallel with the central one, and equally distant on each side from it.

These two extra hairs are so placed that if a levelling rod is held 100 feet from the telescope, they will enclose one foot of its length. With this as a *constant* (1 foot in 100 feet), a table can be made, and any distance that the Rod may be from the instrument can be precisely measured by reading its face (*i. e.*, if the hairs take in  $2\frac{5}{10}$  feet of a rod, the rod is just 250 feet away,  $3\frac{1}{10}$ , 310 feet, etc.).



Stadia measurements have not heretofore given as good results in this country as in Europe, for the simple reason that (outside of the Coast Survey) the Telescopes have not had suffi-

cient power to read the rod, with the closeness consistent with the accuracy required for this operation. Our new Telescopes, however, remedy this.

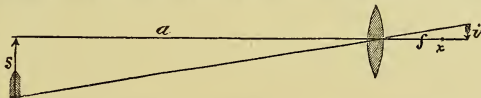
There is one fact in regard to Stadia measurements that is very little known, even by those who are constantly employed in using it on Plane Tables and other instruments; and which will account for many of the inaccuracies of Stadia measurements in close work.

The starting point for the Stadia measurements is generally supposed to be indiscriminately—either the centre of the instrument—the centre of the cross hairs—or from a plumb line dropped in front of the object glass; and all three places have their advocates. These are all wrong, however—the precise place being a point as far in front of the object glass as is its focal length;\* for example, if the focal length of the object glass is six inches,† the starting point is a point six inches forward of a plumb line dropped from the front of the object glass—and if a measurement be required from one fixed point to another, place the instrument back from the starting point this amount.

A still better mode, however (where a transit is used), is to also measure from the object glass to the centre of the axis of Telescope, and add this also to the focal length of the glass, and all the measures will then be from the centre of the instrument, bearing in mind, however, that this amount is a constant, and must be added to the recorded Stadia reading at every sight or change of the instrument. We will take, for example, one of the ordinary Transit Telescopes.—The object glass of six feet focal length, and the cross wires placed close up to the axis of Telescope, or about six inches from the object glass. In this case one foot must be added to every Stadia sight (not to every 100 feet), to bring it to the centre of instrument. In cases where the sights are long, this small amount is of no consequence; but where a series of short sights are taken—for instance, in a mine gangway—one so tortuous that seven sights of 100 feet each are necessary in that length, if the measurements are from the centre of the instrument, and a Transit of the above description employed, if this “constant of the focal length of objective” is not allowed, there would be an error of 7 feet.

The diaphragm to which the slides for carrying the Stadia wires are attached requires peculiar care in the workmanship, as the two slides to which the two extra hairs are attached (for the two hairs ought to be adjustable, independent of each other or of the ordinary cross hairs) must move firmly, truly and smoothly, so that at any time the hairs can be adjusted with the ordinary adjusting pin without disturbing the adjustments of the ordinary cross wires.

\* If the size of the object seen through the telescope be called  $s$ ; the distance from the object to the centre of the objective  $a$ ; the size of the conjugate image of the object, equal to the distance apart of the two horizontal cross hairs,  $i$ ; the distance of this image from the



centre of the objective  $x$ ; and the focal length of the objective  $f$ ; then,  $\frac{a}{x} = \frac{s}{i}$ ; But the general formula of foci of lenses gives  $\frac{a}{x} = 1 - \frac{a}{f}$ . Therefore,  $a - f = \frac{f}{i} s$ ; or  $a = \frac{f}{i} s + f$ . Practically, the distance  $a$  has commonly been reckoned so large that the small distance  $f$  was neglected, and the formula became  $a = \frac{f}{i} s$ ; in which  $\frac{f}{i}$  is a numerical coefficient peculiar to the instrument, and determined by observation once for all. The distances, in that case, are reckoned proportional to the space cut off on the rod, counting from the centre of the instrument, whereas they ought strictly to be counted from a point as far in front of the objective glass as the focal length of that lens.—Extract from paper on Telescopic Measurements in Surveying, by Benjamin Smith Lyman, Esq., in the Journal of the Franklin Institute, April, 1868.

† The focal length of any glass can be found close enough for this purpose by focussing the Telescope for an ordinary sight, and then with a foot rule measuring from the outside of the object glass to the capstan head adjusting screws of the cross hairs.

In closing these remarks, it may be advisable to call attention to one cause of instrumental error which sometimes comes under our notice. We refer to cases where instruments injured by accident or worn by use are placed for repair in the hands of incompetent persons, or those who have not the facilities for properly repairing first-class work. This is not so uncommon as may be supposed. One extreme case of it was recently brought to our own notice, where a very costly and accurate instrument (made in Germany) was for ten years classed as having an inaccurate graduation and an inferior Telescope; when in fact both faults were the result of ignorance in repairing the instrument.

The centre upon which the instrument turned had originally been made in a "dead centre lathe" (see page 4), but the repairer had replaced this centre (for which change there was no occasion) with one turned on an inferior ordinary lathe; and in attaching the new centre, it had drawn the horizontal limb to one side in such a manner that the graduations were over seven minutes (7') from their true place; and moreover, in "improving" (?) the telescope, the diaphragms in the eye piece had been altered from their true places, so as to cut off over half of the light that should have passed through the Telescope.

It is the best policy, where repairs may be needed, to put the instrument into competent hands; and if none such can be found in the immediate neighborhood, the railroad Express system of the present day allows such to be readily reached.\*

\* In conclusion, we would state that if any gentleman who owns an instrument, and wishes to compare its power, etc., with ours, will bring it to our office, we shall be happy to assist him in doing so. We have a watch-dial placed at a sufficient distance from our room to afford a satisfactory test.



PAPER READ BEFORE THE AMERICAN PHILOSOPHICAL SOCIETY, MAY 5, 1871, BY PROF. J. PETER LESLEY.

(From Journal Proceedings American Phil. Soc., Jan. to July, 1871.)

Heller and Brightly's New Transit.

The Engineers' and Surveyors' Transit, as at first constructed, commonly termed a "flat centre," or "Railroad Transit," although superior to the English Theodolite, which it superseded, yet in practice has been found defective in the following mechanical details:

1st. The upper or vernier plate, resting, and turning upon the under or graduated limb, was accompanied by so much friction, caused by the large extent of the rubbing surfaces, that, in turning the vernier plate around the limb, the whole instrument would sometimes be moved upon the lower spindle. 2d. The oil that was necessarily used to lubricate the plates, would become so congealed in cold weather that the plates would not move at all, and old Railroad Engineers will readily recall the thawing out of their instruments over large fires, at every fall of the thermometer, before they could be used. 3d. The spindle upon which the entire instrument turns, being detached from the instrument, thus violating one of the standard rules, that, by long experience in this country and Europe, has been found necessary in the construction of any instrument with any pretensions to accuracy, viz.: "*any instrument having a graduated plate and levels, should be so constructed that both of the centres upon which the instrument turns, should be always covered and not detachable from the main plates.*" To prove the utility of this rule, it is only necessary, after adjusting the levels of one of this class of Transits, so that they will reverse on the top centre, to clamp the two plates together, and turn the instrument on the lower spindle, and the levels will invariably be found out of adjustment, showing conclusively, that through some cause, most frequently the settling of flying dust, etc., upon the surface and shoulder of the spindle, the spindle is not at right angles to the surfaces of the plates. 4th. The centre around which the graduated limb revolves, can only be the thickness of the graduated limb; this centre, by reason of its small surface, wears after comparatively short use, and does not exactly fit the conical hole in the graduated limb; and two readings of the same object taken without any change in the position of the instrument, have been found to differ by 5', and from no other cause than this.

These various defects have caused this style of instrument to be entirely discarded in city work, and for this another construction is used, in which the two main plates do not touch each other, thus obviating the two first evils, viz.: the friction of the two plates rubbing one over the other, and the stiffness of motion of the plates in cold weather. The sockets and spindles upon which the main plates revolve, being long and fitting one inside of the other, and neither of them being exposed or detached from the instrument, thus remedying the two last causes of error. These two are the only styles of Transit made, and are respectively termed the "short centre Transit" and the "long centre Transit." The "long centre," although the most perfect in its construction, has never been a favorite among Railroad Engineers for the following reasons:

1st. The increased size of the centres making it heavier, and this being a very serious objection where an instrument must be carried several miles every day, as is frequent in Railroad surveys. 2d. The instrument not being detached from the tripod, except at the base, compelled the Engineer in moving the instrument from one station to another, to either carry the entire instrument himself, or trust it to his assistant; while in the short centre, the instrument lifting off the spindle, the Engineer could take the comparatively light instrument, with all the important parts, and leave his assistant to carry the heavier portion of the tripod, with its leveling screws, legs, etc. 3d. The removing and replacing of the instrument on the tripod, being accomplished by means of a large screw thread, is a very tedious and unsafe method, and if not very carefully performed, is liable to injure the instrument. 4th. The extra skill, time and care required in making the long centre, was so much greater than the flat centre, that the price of the instrument was materially increased.

Ever since the introduction of the Transit, numerous endeavors have been made to reduce the weight of the instrument, but as they have all been conducted on the same



principle—i. e., reducing the thickness of the various plates, etc.—their only effect was to make the instrument so slight as to be unsteady, their bearing surfaces so short as to soon wear loose, and the instrument always losing its adjustment. The manufacturers of this instrument have had their attention drawn to the increased strength and steadiness that the employment of the “transverse section,” “ribbing or bracing,” imparted to metals; and the amount of metal that could be removed from a solid plate of metal, and its strength and steadiness not impaired, but even added to, if only judicious ribbing was resorted to. In this improved Transit, which is a long centre, the weight as compared with an ordinary Transit of the same size, is reduced one-half, and the instrument is not contracted in any part, but in some parts, where increased size would be an advantage, such as the graduated plate, centre, etc., it has been done, but all the plates, etc., are ribbed in such a way, as to be stronger than a solid plate, and all metal that did not impart either strength or steadiness has been removed.

The Railroad Engineer has in this instrument, a long centre Transit that can be taken from off the tripod and replaced in a quicker and surer way than the short centre Transit, but, unlike the short centre, keeps all the centres covered and not removable from the instrument, and leaves the tripod head and legs with the four levelling screws, etc., to be carried by his assistant. The difference in weight will be appreciated by the Railroad Engineer, when we inform him that a plain Transit, with all its centres, etc., only weighs about as much as a Surveyor’s Sight Compass; and is more steady and keeps in adjustment better than the ordinary long centre Transit, weighing from twenty-five to thirty pounds.

The City Engineer has in this instrument all the advantages of the ordinary “long centre Transit” with only half the weight, and an increase of steadiness.

There are several defects that are common to all Transits, among which are—

1st. The “tangent or slow motion screw” that moves the upper or vernier plate, by use becomes worn, and does not fit precisely the thread in the interior of the nut through which it passes. When this occurs, the tangent screw can be turned sometimes a complete revolution without moving the vernier plate. This “lost motion” or “back lash” of the tangent, is one of the worst annoyances of Engineers, and has been the source of serious errors in the field. Several methods have been devised to overcome this, which we will here describe. The nut through which the screw works has been made in two sections, to allow of being drawn together when the screw wears. This plan would answer if the screw always wore equally in every portion of its length—in other words, was a cylinder—but this it never does; and if the nut is tightened so that the lost motion is removed from the thinner portion of the screw, it will move so tightly as to be useless when it comes to the portions that are not worn so thin. There are several methods of drawing the nut together, but they have all the same objections as the above—that is, they are not effective in the entire length, and the nut must be pressed so very hard on the screw as to make the working of the tangent very tense, especially in cold weather. Another and the last method has been to apply a long spiral spring between the nut and the head of the screw that acts as the finger-piece, thus pressing the nut and the screw from each other, and consequently removing all “lost motion” from the screw. This plan, though in theory very good, in practice has been found inoperative, for the following reason: the spiral spring had of necessity to be made long enough, and stiff enough, to act in every portion of the screw’s length, the alternate opening and closing of the spring by use weakened it, and in a short time it failed to remove the “back play.” To get rid of this defect of “lost motion” in the tangent screw, opposing or butting screws have been sometimes substituted, but in use they do not give satisfaction, as two hands must be employed in using them, and standing from the edge of the plate, they are liable to be injured by blows, and they are apt, unless very carefully used, to throw the instrument out of level.

In this instrument we have an improved tangent screw, that, no matter how much the screw may wear by use or time, will never get “lost motion,” but will instantly obey the slightest touch of the hand: this is effected by means of a long cylinder nut, from the interior of which two-thirds of the screw have been removed; into half the recess thus left in the nut, is nicely fitted a cylindrical “follower,” with the same length of screw thread as the nut; this follower is fitted with a “key,” that prevents it turning in the recess, but allows motion in the direction of its length. A strong spiral spring is placed in the remaining half of the recess, between the fixed nut and the movable follower, and the spring has always tension enough to force the follower and fixed thread in contrary directions, and thus to remove any “lost motion” that may occur in the screw. It will be observed that in this method, the spring always remains in a state of rest, instead of closing and opening, as has been the case in all other applica-

tions of springs, and which have been the cause of their failure. Tangent screws that have had as much as 10' play have been made to work entirely taut by this method.

The mode of attaching the tangent screw to the plates in this instrument is entirely new; it is a miniature modification of the "Gimbelling" of a ship's compass, and allows the tangent screw, by its free swivelling, to be tangent to the plates in every part of its length, and thus never to bind. This tangent screw is also of value for sextants, astronomical instruments, etc., where "lost motion" is detrimental, and a smooth, easy motion is required. In all instruments the brass cheeks in which the three legs of the tripod play are fastened to the lower parallel plate by a number of small screws, commonly twelve. When the legs wear in the cheeks and become unsteady, the only method the Engineer has of tightening the legs is by drawing the cheeks in which the leg moves by means of the bolt that passes through the leg; this of necessity draws the cheeks out of perpendicularity, and strains the small screws that bind the cheeks to the parallel plate so much as frequently to loosen them. This source of instrumental error hardly, if ever, occurs to the Engineer, but very good instruments have been condemned as unsteady, when an examination has shown the fault to be the above. This source of error can never occur in this instrument, as the cheeks and the parallel plate are made in one solid piece. But to come to the last and most serious evil. The effective power of the Telescope is impaired by spherical aberration; that is, the field of view, as seen in the Telescope, is not a perfect plane or flat, but is spherical. To prove this, take an ordinary telescope and focus it so that an object will be clearly defined at the intersection of the cross hairs or the centre of the field of view; then, by means of the tangent screw, bring the same object to the edge of the field of view, and it will be found in every case to be indistinct and not in focus; on the contrary, focus it so as to be distinct at the edge, and it will be indistinct when brought to the centre. In some telescopes, however, it is impossible to focus at the outer edge of the field, and objects will be tinged with prismatic colors, showing that these glasses are affected by chromatic aberration also; sometimes the cause of this defect lies in the object glass, but in the majority of cases the lenses composing the eye-piece are in fault.

These aberrations affect the working of the telescope in several ways. First, it practically diminishes the size of the object glass, and the view is never so clear and distinct as it ought to be. Second, it is very difficult, and in some cases almost impossible, to adjust the eye-piece to prevent parallax, or "travelling" of the cross wires, when the eye is shifted from side to side; and practical Engineers know what a sharper power of defining and how much less trying to the eyes a "soft glass" has—that is, one that has a "flat field." This defect has prevented the general use of the Stadia, or Micrometer wires, as a method of measuring distances without a chain, as the two horizontal hairs that are used, being in different parts of the field of view, cannot, in a majority of cases, be focussed so as to be devoid of parallax, and the slightest travelling of the wires in this operation will give an erroneous result. The evils of this defect were most forcibly brought to Mr. Heller and the late Wm. J. Young's notice when one of their best Transits failed to define in tunnel work, from loss of light, from this cause; and they both endeavored, to within a short time of Mr. Young's death, to remedy it, trying all the known formulæ of almost all the opticians in the country, but without any good results. In the Telescope of this instrument these evils are entirely removed by the employment of a new eye-piece, and advantage has been taken of the improvements that Optics have made in the last few years in the curvatures and arrangements of the lenses that compose it; and the test referred to above, of focussing an object in the centre of the field of view and then bringing the same object to the edge, and it still remaining in sharp focus, can be done with this telescope, and the object shows no tinge of prismatic color, showing that both chromatic and spherical aberration have been removed.

The advantages of this improved Telescope are: a clear and sharply defined field of view; a field of view so flat that the cross hairs are without parallax in every part of it, and micrometer hairs or Stadia can be used with favorable results. The whole effective power of the object glass being used and none of the light lost, work can be commenced earlier in the morning and continued later in the afternoon than is usual. This, in the winter season, is no slight matter to the engineer; and lastly, there is no straining of the eyes in sighting. The spider's web, by reason of its fineness, is the only article hitherto used for cross hairs, yet in use these have been attended with some difficulties: first, the spider's web is hygrometric, or is affected by the humidity of the atmosphere—when exposed to dampness lengthening, and of course throwing the line of collimation from its true place. This defect is more serious in the Engineer's Levelling Instrument than in the Transit, instances being known where the line of

collimation has altered two or three times in the course of ten hours by reason of atmospheric changes, and of course any observation taken at those times would be defective; lastly, the spider's web being a transparent and not an opaque substance, in some positions it is impossible to see the hairs at all: this is more especially the case when sighting in the direction of the sun—that is, an easterly course in the forenoon, or westerly in the afternoon. To remedy this defect, platina cross hairs  $\frac{1}{1000}$  of an inch in thickness, or as fine as spiders' web, are substituted; these being opaque, and not transparent, in sighting in the direction of the sun are still visible, and any atmospheric changes, dampness, etc., do not affect them. They believe that they are the first ones in this country who have drawn wire so thin, and the only ones who have made any practical use of Dr. Wollaston's experiment. The platina hairs are invaluable in Mining and Tunnelling Instruments, that are so constantly exposed to dampness, and being opaque, no reflector to illuminate the cross wires is required.

To prevent the stiffness of working of the levelling, tangent and other screws in cold weather, which arises from the congealing of the grease that is used in lubricating them, no oil is used upon the screws of this instrument, but they are lubricated with pure plumbago.

By a simple arrangement of the clamps on the axle of their complete Transits, they make them also answer the purpose of a pair of Compass sights, for taking offsets at right angles to the telescope.

From the above, it will be seen that this instrument has the following improvements over the ordinary Transit: 1. A simple, secure and steady method of attaching and detaching from the tripod, being the only long centre transit made that detaches as easily as a short centre. 2. An important decrease of weight, without decrease of size, and an increase of steadiness. 3. All the working parts of the tangent screw, etc., brought within the plates, making the instrument more compact. 4. An improved tangent screw, telescope, cross hairs and tripod head. 5. A pair of sights for taking offsets; and 6. A new method of lubricating the screws.

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## REPORT OF COMMITTEE OF CIVIL ENGINEERS APPOINTED BY THE FRANKLIN INSTITUTE TO EXAMINE A NEW TRANSIT INSTRUMENT.

No. 863.

HALL OF THE FRANKLIN INSTITUTE,  
Philadelphia, December 18, 1871.

The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania for the promotion of the Mechanic Arts, to whom was referred for examination the Transit instrument made by Messrs. Heller & Brightly, of No. 33 N. Seventh Street, Philadelphia,

### R E P O R T

That the instrument exhibits the best of workmanship, and combines several novelties of construction which, in the opinion of the Committee, render it superior to those now in common use. Among these novelties are, 1st. A great reduction of weight, without any loss of strength or steadiness. 2d. An improved method of attaching and detaching the instrument to and from the tripod head. 3d. All the working parts of the tangent-screw, etc., are brought within the circumference of the plates, thus diminishing liability to injury, and at the same time making the instrument more compact. 4th. An improved tangent-screw. 5th. Cross-wires of platina instead of spiders' web. 6th. A pair of sights placed in the standards, by means of which a right angle can at all times be laid off from the line of the telescope; this is very useful for taking offsets from the line of survey. 7th. An improved telescope. 8th. A shifting or extension tripod leg, for use in mining or other contracted workings. 9th. The brass cheeks for the legs and the tripod head are cast in one piece. 10th. An improved lubricator for the screws.

The following is a detailed description of the above-enumerated improvements:

First. The weight is reduced to about one-half that of an instrument of the same size, made in the usual way, by rubbing and bracing the plates, etc.; and all metal that does not impart either strength or steadiness is removed, the size of the instrument not being reduced thereby in any part.

Second. The method of attaching the instrument to and detaching it from the tripod head is as follows: The upper parallel plate of the tripod head has two (2) fixed and one (1) movable lug on its upper surface. These three (3) lugs are placed equidistant from each other. There is also a flange on the exterior of the socket which encloses the centres. Three (3) recesses on the edge of this flange allow the flange itself to lie on the parallel plate and to enclose the lugs. The whole instrument is now turned until the lugs are outside of the recesses, and the whole is then clamped by the milled head-screw of the movable lug. By this process a three- (3) pointed clamp is obtained. A forked guide-piece fitting into a groove in the clamp-screw and traveling with it prevents its being screwed out and lost.

Third. An examination of the instrument renders this third point so obvious as to require no explanation.

Fourth. The tangent-screw is constructed so as to overcome all lost motion in the following manner: A long cylindrical nut has two-thirds of its screw-thread removed. In one-half of the recess thus formed is fitted a cylindrical follower, with a key which prevents its rotation, but permits it to move forward or back. A spiral spring is placed in the other half of the recess, the tension of which forces the fixed thread and follower in contrary directions.

Fifth. The platina cross-wires ( $\frac{1}{1000}$  of an inch in thickness, or as thin as ordinary spiders' web) prevent the sagging which the spiders' web undergoes from dampness. Not being transparent, they can be easily seen when sighting toward a light. This is an advantage when looking toward the sun, or when locating a meridian line by means of the North star.

Sixth. A pair of right-angle sights is obtained in the following way: The slits in the clamps on the axis of the telescope are extended downward so as to reach almost to the bottom of the clamps, and in these slits the sighting-holes are made. The slits are then adjusted by the maker to cut a right angle, and index marks are then made on the clamps and standards. By bringing the index marks to coincide, an accurate sight at right angles to the telescope is had.

Seventh. The curvatures and distances of the lenses composing the eye-piece are so arranged as to overcome all spherical and chromatic aberration in the telescope. The spherical aberration of the ordinary telescope has prevented satisfactory results from Stadia measurements.

Eighth. The shifting tripod leg has a play of from three (3) to five (5) feet. It is composed of two (2) semi-circular cylinders, sliding one on the other on their plane surfaces, as in a levelling-rod, and clamping in any position. This leg dispenses with eccentrics, and will slide easily and clamp well, even if the wood of the halves be swollen or warped.

Ninth. Having the tripod head and the cheeks for the legs in one piece prevents the possibility of any unsteadiness from the loosening of the cheeks from tightening the legs.

Tenth. Pure plumbago is used as a lubricator for all the screws, preventing hard working in cold weather.

The side adjustment on the standard, by which one end of the axis of the telescope may be raised or lowered in order to make the vertical hair lie in a vertical plane through the axis, and the nice balancing of the telescope upon its centre of gravity, are also noticed as very important features in engineers' transits. There is, however, no claim to novelty in the application of these principles.

The ribbing of the instrument is judiciously placed, and the metal of which all castings are made is *bell*, instead of the ordinary brass. The Committee see no reason why it should not keep its adjustments and maintain its steadiness at least as well as any other. To solve all doubts, however, on this subject, letters were addressed to two engineers who had been using the transits of Messrs. Heller & Brightly almost daily for six (6) months. Both were engaged in operations requiring the best instruments—viz., one in city street locations, and one in a tunnel nearly four thousand feet in length. The answers of both were satisfactory in the highest degree, pronouncing said instruments superior to any they had ever used.

The substitution of platina wire for spiders' web was found to be especially advantageous in tunnel work, by contributing in an appreciable degree to the accuracy so necessary in that kind of work or in mining.

In conclusion, the Committee express themselves highly pleased with the instruments of Messrs. Heller & Brightly, and consider it but a simple act of justice to these gentlemen to say that, in its opinion, the deviations which they have made from the



common styles of transit are decided improvements. It may not be amiss to add that their instruments cost no more than those of the ordinary style of our best makers.

JOHN C. TRAUTWINE, *Chairman*.  
CHARLES S. CLOSE,  
LEWIS M. HOUPY,  
SAMUEL L. SMEDLEY,  
ELLWOOD MORRIS.

By order of the Committee.

D. S. HOLMAN, *Actuary*.

The following are the two letters of inquiry referred to by the Franklin Institute Committee in their report. The letters to which these are the answers had, among other inquiries, the following:—Is the instrument steady? Does it keep its adjustment? if not, how frequently has it been adjusted since you first received it?

BURLINGTON, N. J., October 23, 1871.

MESSRS. HELLER & BRIGHTLY, PHILADELPHIA:

GENTLEMEN:—Your inquiries regarding the Transit purchased of you last spring is at hand.

I am happy to say that when put to test of unremitting use for several months with constant and critical examination during the entire period for the discovery of faults that are ordinarily supposed to exist, I have not been able to detect anything amiss.

Besides using the Transit for the customary purposes of a general practice, I have employed it in the careful reorganization and rectification of the Surveys of our city, and the preparation of a *strictly accurate* Atlas, similar to that which is in use in the Survey Department of Philadelphia; and in two very essential respects I have found it superior to any other that I have ever known; I refer to stability and permanence of adjustment.

I have frequently left it standing in one position for hours, and on my return found the telescope maintaining the same line with entire exactness; and in point of adjustment, it is as correct and reliable to-day as it was after the searching examination you gave it in my presence on the day of its delivery to me.

The graduation of the plates is exceedingly accurate, and in that respect my Transit is superior to the majority of those in common use; in fact, the results obtained from its use have been such that, had they not been frequently repeated with equal success, should have been attributed to chance.

The needle, too, is excellent in all the essential particulars of straightness, correct centring and magnetic power. In perhaps a hundred readings of angles by the needle as compared with the readings of the vernier, in no one has the difference amounted to more than three minutes.

I am yours, etc.,

H. S. HAINES.

OFFICE OF THE LEHIGH COAL AND NAVIGATION COMPANY,

NESQUEHONING TUNNEL, PA., November 1, 1871.

MESSRS. HELLER & BRIGHTLY, PHILA.:

DEAR SIR:—Your favor of 28th ult., inquiring about the instrument made for use on this work, is received.

The instrument has proven entirely satisfactory in every respect;—it is perfectly steady—it keeps its adjustment admirably, it not having been touched in this respect since it came from your shop, and is now perfectly correct.

The platina hairs have never shown the least indication of sagging from the moisture of inside work; and they are the only hairs that we have not had trouble with in this respect;—the instrument has frequently been in the dampness of a Tunnel for hours at a time. . . .

We were enabled to bring our lines together with your instrument with a lateral variation of  $1\frac{1}{8}$  inches in a Tunnel 3800 feet long.

We have found another great advantage in the use of the platina: namely, that when the light is reflected on them by a lamp, instead of the indistinct line which the spider web gives, we have a clearly defined black mark.

Yours, etc.,

THOS. C. STEELE, Engineer.



## HELLER & BRIGHTLY'S IMPROVED TELESCOPE.

(From the editorial columns of the U. S. Railroad and Mining Register, Jan. 10, 1874.)

### Improved Transit Telescope.

Every improvement in engineering instruments is of consequence; and the very great increase of power gained by Messrs. Heller & Brightly in their new telescope, as described in their letter and accompanying circulars given below, is of sufficient importance to attract the immediate attention of every engineer:

*Editor U. S. R. R. and Mining Register:*

PHILADELPHIA, January 7, 1874.

DEAR SIR:—Having just brought to a successful conclusion a series of optical experiments, having for their object the increasing the power and range of the ordinary telescope, and knowing the interest you take in any improvement of field instruments, we enclose you the results we have arrived at. An ordinary Transit Telescope, 10 inches long, magnifies 12 diameters; an ordinary Level Telescope, 17 inches long, magnifies 25 diameters. Without any increase of length, our new Transit Telescope magnifies 28, and the new Level 48 diameters—in other words, without any increase of length, we give the Transit Telescope more power than a regular Level Telescope has. We have lately furnished the Survey Department of Philadelphia with a Transit for use at the “new South Street Bridge,” and the engineer in charge there has been making some tests of the power and range of the new telescope as compared with another very good telescope made in the ordinary way. A copy of his letter we enclose. While making the tests the instruments were placed side by side and seen through at the same time, in order that any atmospheric unfavorableness should affect both equally. We think, however, that the first test should read, “set a  $\frac{1}{4}$  inch flag” (instead of  $\frac{3}{4}$ ), as the  $\frac{1}{4}$  inch white space was the object sighted at, and the black only marking the boundaries of the white. As to the extreme range of the telescope, the enclosed extract from the Fairmount Park Engineers, may give some idea. Yours, &c.,

HELLER & BRIGHTLY, 33 North Seventh Street.

[COPY.]

ENGINEERS' OFFICE, SOUTH STREET BRIDGE,  
PHILADELPHIA, December 22, 1873.

DEAR MR. HELLER:—I have just finished some very satisfactory tests of the new Transit you lately sent me—and knowing that a statement of the results would be as gratifying to you as it was to me, I send it to you in detail. The Transit with which I compared the power of yours, was made by the late Wm. J. Young, for Strickland Kneass, Esq., when the latter was Chief Engineer and Surveyor of the city, the instrument is considered a very good one of its kind:

	W. J. Young.	Heller & Brightly.
Set a flag, $\frac{3}{4}$ inch wide, accurately.....	450 feet.	1,535 feet.
Could just see hands on a watch—very dimly.....	212 feet.	1,231 feet.
Read time within one minute.....	180 feet.	983 feet.

The “flag” test was on a target made of paper, with three  $\frac{1}{4}$  inch stripes, two black and a centre one of white. This target was sent off until the white stripe was just barely discernible. The watch used was a “Tobias” make,  $1\frac{3}{4}$  inch diameter of dial, face white, and hands 1-50th of an inch wide at ends. On the first “watch” test, it was sent off until I could merely tell that there were hands on the dial. At the second test I read the time within about one minute. The length of telescope in the Young Transit is 10.8 inches, and in yours 10.7 inches when both are focussed on the same object.

Yours, &c.,

D. M. STAUFFER.

[EXTRACT.]

FAIRMOUNT PARK, December 6, 1873.

MESSRS. HELLER & BRIGHTLY:—At your request I tested the power and range of your new telescope. On account of the haziness of the atmosphere the day was unfavorable. As to range, from sights taken at Falls of Schuylkill in direction of Conshohocken, I could see and locate a flag staff at about seven miles.

THOMAS G. JANVIER,  
Assistant Engineer, Fairmount Park.

As the following letter from the editorial columns of the Railroad and Mining Register gives the manner by which we have increased the power of our Telescopes, we give it in full. It is in answer to a correspondent who, seeing the above article giving the comparative tests of our new Telescope as compared with an ordinary one, asks for information on some points mentioned in it that were not perfectly clear to him.

First, not knowing the means by which we increased our power, he of course imagined that we used the old "regular formula," such as had been used and abandoned for high powers years ago; inquiry is also made, whether the "Kneass Transit" was a fair sample of the ordinary Telescope; and if the powers of the regular Telescope, as made at present, might not be sufficient for ordinary purposes. The correspondent was also under the impression that the magnifying power of an ordinary Telescope was somewhat higher than we had stated. The correspondent not taking into consideration that the day of trial was one of the shortest and darkest of the whole year (December 22), thought very naturally that the flag might have been seen at a greater distance than it was (1535 feet); seeing that time was read on a watch-dial at 983 feet. Mr. Stauffer's letter explains this.

(From the editorial columns of the "United States Railroad and Mining Register" for January 31, 1874.)

*To the Editor of the U. S. R. R. & Mining Register:*

DEAR SIR:—The correspondence in your issue of the 17th inst., criticising the tests and results of the trial of our "new Transit Telescope," calls for some notice from us. The complaint of want of power in the glasses of field instruments is no new thing; when Richard B. Osborne, Esq., some years since endeavored to introduce the American form of Transit into England, the want of power in the telescope was the principal objection urged against it (the European telescopes of the same length being much more powerful than those used in this country, from the fact that the "inverting" telescope is almost exclusively used there). Our Mr. Heller, who for fifteen years continuously was connected with the late Wm. J. Young in business (for a greater portion of it as a partner, under the firm name of Wm. J. Young & Co.), and Wm. J. Young, were well aware of this want of power, and labored together for several years previous to Mr. Young's death to correct it, but without success, and up to the date of his decease (July, 1870), the formula for their telescopes was practically the same as had been used for at least fifteen years before. The "City Transit," with which our "improved Transit Telescope" was compared by Mr. Stauffer, was known in their manufactory as "Kneass Transit," and was used by the city during his entire term; and although the other parts of the instrument were somewhat worn, the telescope was considered good. To prove, however, if the telescope of the "Kneass" instrument was a fair sample of its class, we having in our establishment at the present time two Transits for repairs, that are of the make mentioned by your correspondent, but made within the last few years—the telescopes of these are respectively 11 and 12 inches long, and time was read on a watch similar to the one used in the last test at 195 and 210 feet, showing that (taking the lengths of telescopes into consideration) they are not superior in power to the one with which Mr. Stauffer experimented. As regards the statement of your correspondent in reference to the powers of Transit Telescopes of various modern makers, we would remark that one fact respecting telescopes must be taken into consideration (*i. e.*, that the calculated magnifying power and their actual performance in the field are sometimes sadly at variance); we now have in our possession for repairs a Transit made in New York City, the nominal magnifying power of which is 18 diameters, yet it is impossible (in consequence of its poor defining power) with it to set an ordinary flag-pole (accurately) at the distance of 300 feet. Although the "achromatic, compound lens," eye-piece of Kellner (or a similar combination), has been of late years adopted in Europe for fine telescopes, still from its great expense, and the objection of American engineers to an "inverting" telescope, it has been comparatively unknown here; the United States Coast Survey Department use it almost exclusively on all their new instruments.

Your correspondent states that the same combination of lenses that is in the "improved telescope" was known "years and years ago;" we think he must be mistaken. Mr. Young and Mr. Heller, during their exhaustive experiments and researches referred to above, knew nothing of it, and so lately did we bring our own experiments

to a successful conclusion that, although we have lately (1872 and 1873) furnished the Survey Department of this city with Transits for the new bridges now in the course of erection over the Schuylkill at Girard Avenue, Fairmount and South Street, none except the last has the new telescope—in fact, so very recently have we ourselves adopted it that, although we receive orders from the University of Pennsylvania to spare no expense or pains to make the equipment of field instruments for the new Department of Science as perfect as possible, we did not insert it in their field instruments. In referring to Transit Telescopes, we of course mean such as are in common use by engineers, from 10 to 12 inches long, capable of reversing their standards both at eye and object ends, and showing objects erect, instead of inverted—those for special purposes of extra power and length (we have made them 20 inches long) and with “inverting” telescopes, we do not class as ordinary ones. We have never made any secret of the mode by which we increase the power of our telescopes. The improvement consists in our availing ourselves of the formula of Kellner, with the addition in our telescopes of the two extra lenses necessary for producing an erect image. If your correspondent will do us the pleasure to call on us, we shall be happy to show him the numerous experiments we have made, and the results; he can also examine the two instruments mentioned above at any time. If we have caused any engineer to think seriously on a subject which he has heretofore taken mainly on trust (*i. e.*, the power of his telescope), he will find the subject repay investigation. If engineers will call on us, we will with pleasure show them the new telescope and let them judge for themselves; or if a committee of the American Society of Civil Engineers (or any kindred body) would like to make a thorough trial, we will furnish them with the means. As to the remarks of your correspondent denying the desirability of an increase of power, we think that the majority of engineers differ from him in opinion, and any one who has stood with watering eyes endeavoring to accurately set a flag at a moderate distance, will agree with us that a Transit Telescope with the power of a Level Telescope is a gain, and that the opinion of such men as John C. Trautwine, Eckley B. Coxe, Richard B. Osborne and R. P. Rothwell, that the new telescope is “a most important and useful improvement,” is entitled to some weight. If it were not against our rule to publish correspondence, we could give letters from parties of weight in the engineering profession which would, more strongly than anything we could say, corroborate what we have written—in fact, we have obeyed our repugnance so far that we have for two years refrained from publishing an exhaustive report of a committee of civil engineers appointed to examine the new Transit which we introduced at that time, although the favorable opinion of such men as John C. Trautwine, Elwood Morris, L. M. Haupt, Samuel L. Smedley and Charles S. Close might be thought of some value. In conclusion, we are sorry that a friendly private letter, giving you information that might interest you, and not intended for publication, but which you thought contained matter of interest sufficient to warrant publishing, should have caused your correspondent's letter. In the hands of the engineers we now leave the matter; if we have made an improvement, it will speak for itself. We merely repeat our invitation to engineers, instrument makers, etc., who feel desirous to test this matter for themselves to call upon us; we will freely communicate to such any information in our possession. Yours, etc.,

HELLER & BRIGHTLY, 33 North Seventh Street.

January 22, 1874.

ENGINEERS' OFFICE, SOUTH STREET BRIDGE,  
PHILADELPHIA, January 22, 1874.

*To the Editor of the U. S. R. R. & Mining Register:*

DEAR SIR:—A word of explanation may be necessary to explain away a seeming discrepancy pointed out by your correspondent of January 17th, in his criticism on the performance of Mr. Heller's New Telescope, lately tested by me. The test results were communicated to Mr. Heller in a friendly letter, not intended for publication, or I should have been more explicit in my explanation. The Transits were tested side by side, and at the same time, so that any local influence would have been felt by both. But the *first* test was made on the flag about 9 A. M., with the sun obscured by clouds, and in an atmosphere decidedly hazy, with the flag located in a depression of South Street, the worst point for an observation. The watch test was made more than three hours after, when the sun was shining brightly and all haziness removed; had I then again tried the flag, I have no doubt the results would have been more favorable than stated. Yours, etc.,

D. M. STAUFFER.

## STROLL THROUGH AN ENGINEERS' INSTRUMENT MANUFACTORY.

Having recently visited some of the establishments of our "Engineering and Surveying Instrument Makers," we became possessed of some facts which may be of interest to general readers, and also showing the immense development of this branch of industry since the early days when the Drapers, Rittenhouses and Stancliffes gave to Philadelphia mechanics their pre-eminence in the manufacture of these "instruments of precision."

But the staid plodding artisans of those days would be amazed if they could see the revolution that time has made in the details of their whilom business—the intricate machinery (one of the old establishments, with all its tools, not costing as much as one first class modern lathe with all its appurtenances), the appliance of steam, graduating engines, and the vast range it has taken in its various details.

On our list we will first take the well-known establishment of the Messrs. Heller & Brightly, and from them and their books have gleaned the facts for the following article.

The first thing to forcibly strike the stranger's attention is the widespread ramification of an establishment of reputation—in looking over their "order book," we found every State from Maine to Florida represented, and the Survey Department of almost every important city and town (the Middle and Western States predominating, however).

Orders from Japan, China, Chili, Peru, Brazil and Canada jostle each other; the order of Arinori Mori, the Japanese ambassador, for a complete set of field instruments for the "Kaitakuski of Hokaido" (whatever that may mean) stands side by side with those of the "Survey Department of Philadelphia"—Meigs, the railroad king of South America—the University of Pennsylvania—and the Centennial Building Commission—and we were shown with commendable pride a "cable telegram" order for a Transit from Hong-Kong, China, which ran thus: "One Heller, Philadelphia, send Transit Instrument like General Capron's."

The greater part of their business, like that of the majority of those in the same line, is however with the railroads; and this need not be a surprise to any one, the Pennsylvania Railroad and its numerous branches alone using up enough instruments, to keep a respectable sized manufactory constantly employed.

The Survey Departments of cities must also be constant consumers, judging from the fact that that of Philadelphia alone ordered 8 instruments within the last two years.

We were curious to learn if, in sending their wares to every point of the compass in this manner, whether they ever had trouble in receiving the money for the same; and for the character of the Civil Engineers as a class, we were proud to hear that they have yet to make the first bad debt.

Great confidence must exist between the producer and consumer, for assuredly in no other business would valuable goods be sent to a perfect stranger thousands of miles away on the faith of a telegram (as happened on the day of one of our visits) worded thus—"Send Transit to lay out town site to ———, Arizona."

An instance of the credulity of human nature, and the tenacity with which a popular belief will descend from generation to generation, we learned here that somewhat surprised us.

A letter from Massachusetts received a few days before was shown us—the writer wished to be informed whether a "divining rod" "needle" or "treasure sand"—that would be attracted by hidden gold, silver or gems in the earth, in the same manner as the magnetic needle is attracted by iron—could not be purchased by him.

On our expressing surprise that in the present age of enlightenment a belief in such an article should exist, we were informed that this letter was one of a



class. That from 12 to 40 letters or calls were received yearly—the majority of them however were received from parties on the Atlantic coast, from Maine to New York north, and from Maryland to Florida south, and the treasures to be found were those said to have been buried by the piratical Captain Kyd (he who “sailed, sailed”).

Besides these “treasure seekers,” calls are received in more or less numbers every year for the “witch hazel divining rod” (for discovering hidden springs by divination).

The “perpetual motion” inventors have also not “perished from off the face of the earth,” judging from the number of models that are sent to Messrs. Heller & Brightly for their opinion, each of which (according to the inventor) solves the long mooted problem.

Solomon's axiom of there being “nothing new under the sun,” and the persistence with which an idea will crop out in one generation, die away and seemingly be rediscovered in another, only to meet the same fate, was shown to us in the model of a “distance measurer” that had shortly before been received—and which the inventor thought was entirely original, and his fortune of course secured. Those who have delved in the old volumes of the various mechanics' magazines—the proceedings of the various scientific societies—or the back numbers of the patent office reports, may recollect the “Monsieur Tonson” that was ever turning up, in the shape of a “distance measurer” (an instrument by means of which the distance of any far object could be ascertained without the tedious process of chaining), in which, though the details might have been varied, the principle underlying them all was the same (*i. e.*, a fixed Telescope or vane sights placed at right angles to, and at one end of a base more or less long, generally from 2 to 3 feet, a second Telescope movable along this base, and this Telescope slightly inclined toward the first one—the movable Telescope being slid along the base until the line of sight of both it and the fixed one cut the same object. The distance of the object from the instrument being then read off from a scale on the base). This same instrument in various forms is as old as Archimedes at least. The fatal defect of the instrument is that the base necessarily being short, and the angle formed by the two Telescopes consequently being too acute for accuracy. During the late war we were informed that at least thirty applications for patents had been made for an instrument of this class, all having the above idea, and each patentee imagining himself the original discoverer.

Knowing from experience how very poorly, some twenty years ago, the institutions that made a specialty of teaching Civil Engineering were supplied with field instruments, and the inferior character of those they did have, we were curious to know whether this state of affairs continued, and were most agreeably surprised at the change we found.

The “order book” was again brought in requisition to answer our queries. First, our attention was directed to the list of instruments and their character furnished the new “Department of Science” of the venerable University of Pennsylvania.

Besides the usual Transits, Levels, Compasses, Sextants—we found such comparatively modern costly “instruments of precision” as the Solar Transit, Plane Table, etc.,—in fact, the sum total of their outlay for instruments alone would have appalled some of the other institutions; and the orders for field instruments from colleges situated where twenty years back naught but forests flourished—was a striking proof of the tremendous strides the country has made since then.

*En passant*, we were somewhat amused during one of our visits. A graduate of a so-called “college,” having received a situation on a railroad, came to purchase a Transit Instrument.—One was shown him such as is used for city work. The vernier reading of the horizontal limb, however, was not close enough for him—half minutes being entirely too inexact, and nothing but a ten second (10'') subdivision answering.—His dogmatical assertions that a half minute (30'') reading might answer for common work, such as running a straight line or turning a right angle, but not for deflecting for railroad surveys, was amusing; as was also his blank look of astonishment and doubt when informed that two of the most



difficult of his field operations, would be those very two that he treated so cavalierly, (namely, turning, a precise right angle and establishing a straight line).

We were informed, in answer to queries, that the most elaborate and accurate instruments, without regard to cost, were demanded, as a general rule, by the Mining Engineers of Lake Superior.—These were followed by the Survey Departments of the various cities—the Mining Engineers of Colorado, California and this State came next.

Judging, however, from the minuteness of detail and seeming disregard as to cost of some orders on their books from Engineers who have made Bridge Building and Tunnelling a specialty, the precision requisite for such work must require the best instruments.

To the curious spectator the several details of the manufacture—the graduating engines—the patient exactness required of the workmen (one of their proverbs being that Job would most assuredly have lost his patience, had he belonged to their craft)—are matters of surprise, and where in the finished instrument all the parts he had seen in detail could be placed would perplex him (a complete Engineer's Transit with all its belongings numbering 362 separate parts).

To an engineer, who, knowing the longevity of a Transit, and the comparatively small class by whom they are used, and seeing the number of instruments turned out of an establishment of this class—they just finishing at the time of our visit 50 Transits, and commencing 100 more—knowing that this process was continued through the entire year, and that this was only one of numerous similar establishments—the one absorbing question to him would be (as it was to us), What becomes of all the Transits?—and the answer to which would be as hard to give as to the other equally celebrated one, "What becomes of all the pins?"—(*Engineer*, March, 1874.)

## MODERN PRACTICE OF FIELD-WORK IN RAILROAD SURVEYS, BY RICHARD B. OSBORNE, CIVIL ENGINEER.

GIRARD HOUSE, October 5, 1873.

MR. CHARLES S. HELLER, PHILADELPHIA :

DEAR SIR:—You have asked me to state in what I consider your improved Transit with its vertical arc superior as a field instrument to the ordinary plain field Transit.

When an Engineer is entrusted with the location of a railroad, his first inquiry should be,—what is it intended to transport? and having learned the quantity and quality of traffic *each way*, and made a reconnoissance of the general route, and ascertained the impediments to be overcome in the location of the line, he can at once determine on the *ruling gradient* and a maximum load for a given weight of Engine.

He will find, perhaps, that a part of the line will be over gently undulating ground, while other parts will be through a mountainous country.

According to the length of time through these different kinds of land, the number of Transits of each description required can be obtained.

For the first, or easy country, the plain Transit is the best, as a little more portable and less costly.

For the mountains, none but the Transit with its fine improved telescope and *vertical arc* should be chosen.

Experience has taught me that the most economic, accurate, expeditious and successful work is done when well-tryed principles and systematic plans control the operations. "Rule-of-thumb" work seldom succeeds; the good results even in close Engineering work have been attained by a bold dash based only on clear judgment—clear, I mean, to the mind using it.

The old system of "trial and error" lines is unfit for our profession now; we

have taught the whole world all they know about location of railroads, and *we* should advance.

When the Engineer, either by the barometer or by "flying levels," approximately ascertains the elevations of the highest summits he has to overcome, as well as the *distances* (the other elements for making out his grades), he can determine on the **ruling gradient**, which will then determine his *maximum* load.

Experience should teach us that it is inexpedient, if not wrong, as a general rule, to *spend large sums* of money to reduce gradients at *other points* of the line *below* the **ruling gradient**, because it will not financially benefit the working capabilities of the Engines, whose maximum load is already controlled.

With such fixed data in his mind, the Engineer can view in a ride the easy country, where a line generally can be at once *located*, without any experimental survey, by the eye and judgment, because the grades, being all less than the **ruling grade** over the mountains, can have the grades fitted to the country over which the maximum loads can be taken.

For such work the *plain Transit is best adapted*.

But in a country which presents mountain ranges that must be crossed, the case is *wholly different*.

Each ridge should be explored, and the elevation of its lowest available summit obtained, also the distances by time, or the pedometer, and thus the required gradient be worked out.

Then the Transit with its **vertical arc is indispensable**.

Its utility consists in perfecting with *one* experimental line, which it **vividly points out by its valuable adjunct, the vertical arc**, the exact position of the *best location* that can be made on the ground of **uniform grade**, with the **least work**. By it the exact profile of a located line can be had, on which I have even let work to contractors *before* the *field* location was made.

Hundreds of thousands of dollars would have been saved, if this had been in use in the last twenty years, the work too would have been better done, and trains would be able to mount to many summits with more ease than they now do.

**Here is the modus operandi** in explanation, and Engineers who keep the old method will see that mountain surveys, which are tedious and laborious, are thus made easy and agreeable.

**The Engineer, knowing then the average grade that will carry the line to the summit with a given cutting at that point, sets, before starting, his vertical arc to the angle corresponding to said grade.**

A flag on a pole the height of the Transit Telescope from the ground is taken ahead by the Engineer in charge, as far as *he can be seen by the Transit*, and with his judgment aided by the pocket level he gets approximately in position, so that all clearing can be done while the Transit is moving up and getting set on last transfer-point.

The Transit then sets the grade flag accurately, and the chaining is done to the grade flag, when the exact transfer point is set, **which is grade**.

On this the Transit moves, and thus continues till the summit is reached by a **true grade line**.

Cross sections with the clinometer are taken at every 100 feet station, well to right and left, where the angles are great, when that portion of the line is ready for plotting, on which the located line can be planned, the centres being all at grade.

The line can be straightened, curves introduced—profile made out, and in the office a tale will be fully told of all the characteristics of the future location.

Thus two quickly run lines will fit the contour of the mountain, with work just as light or heavy as the Engineer may select to give him the **best** line that can be put on the ground.

But in other ways the Transit arc is of great use.

Here is one example:

To test a line advancing toward a high summit when 8 miles from it, I once had a flying level run from the summit to a point at *the foot of a tall pine* 5 miles from the summit.

I converted this tall pine, by the *vertical arc*, into a levelling staff, and using it

as a **back rod**, transferred the level to the mountain side, high over the valley, where I fixed a point which the advancing line should pass through, so as to reach the summit with a fixed cutting thereat and on the ruling grade.

It worked *to a charm*, and my *grade came out to a nicety*.

I would as soon send a party into the field without a **chain** under such circumstances as I would without a **Transit** with your vertical arc.

These are its uses in survey work.

**In construction** it is a most desirable instrument, as the assistant needs but one instrument, which is both **Transit** and **Level**, which is a great desideratum.

I am, yours truly,

RICHARD B. OSBORNE.

## ON A NEW MINING TRANSIT AND PLUMMET LAMP.

(From Van Nostrand's Engineering Magazine for June, 1873.)

A communication to the American Institute of Mining Engineers, at the Boston meeting, February 19, 1873, by Prof. R. W. Raymond, President of the Institute:

Having had recently the opportunity of examining a Transit and a Plummet Lamp, manufactured by Messrs. Heller & Brightly, of Philadelphia, and intended for the use of mining engineers in underground surveying, I thought a description of them would be interesting to such of our members as have work of that kind to do, and accordingly I requested the makers to prepare and send to me a detailed account. There is nothing specially novel, I may remark, in the construction of the Transit; its claims to favor most rest upon its compactness and lightness, together with the general excellence of its workmanship. The principal peculiarity is the ribbing and flanging of the parts requiring strength, so as to dispose the minimum amount of material where it will secure the greatest rigidity. This Transit is said to be the lightest of American make. I believe Caselli has sent some from London which are still lighter; but they are perhaps not so completely furnished for field-work. I confess I do not see how the weight can well be reduced any further, unless an instrument can be made of aluminium—a plan which Mr. Rothwell once suggested; but which may not, perhaps, be entirely practicable, and, at any rate, has not been tried.

The following is the manufacturers' description of this Transit, which they have designed and introduced within the last year:

It is a small portable angle instrument, similar in principle to the ordinary "Engineer's Transit," and a *fac simile* in every respect (excepting size and weight) of their "complete Engineer's Transit." It has long compound centres; the horizontal limb is read by two double opposite verniers, placed outside the compass box; the vernier openings in the plate being made very wide, so as to allow the easy reading of the graduations. There is a three inch magnetic needle, and its ring is divided to half degrees. The telescope is  $7\frac{1}{4}$  inches long, with object glass fifteen-sixteenths inch in aperture, and shows objects erect and not inverted. A sensitive level,  $4\frac{1}{2}$  inches long, is attached to the telescope, for reading angles of elevation and depression, levelling, etc. The tripod is furnished with an adjustable head for precise plumbing of the instrument over a centre; and the wooden legs of the tripod are made in such a manner as to form one leg when folded together. The plates, vertical circle, etc., are provided with clamps and tangent-screw movements; and the clamps on the axis of the telescope are arranged with sighting slits and indexes, so as to answer also for right angle sights. The numbering of the compass ring and horizontal limb, instead of being in quadrants from  $0^{\circ}$  to  $90^{\circ}$  each way as usual, is a continuous one, or from  $0^{\circ}$  to  $360^{\circ}$ ; but every quadrant of the horizontal limb is also marked with its magnetic bearing, *i. e.* from  $0^{\circ}$  N. to  $90^{\circ}$  E., every ten degrees is marked N. E.—from  $90^{\circ}$  E. to  $180^{\circ}$  S., every ten degrees is marked S. E., etc. The advantage of this arrangement is, that, if at starting, the vernier of the horizontal limb be set to read the same bearing as the needle, the needle can be screwed up, and both the angles and magnetic bearings read from the horizontal limb, without using the needle for the remainder of the survey, thus precluding any error from local attraction, reading from the wrong end of the needle, or loss of time in waiting for the needle to settle. The telescope, though short, is a very powerful one, magnifying and having the clearness of an ordinary 17-inch level telescope.

A reflector for illuminating the cross wires in dark places is used, as is also an extension tripod leg for lowering or raising the instrument. All the working parts of the needle-lifter, clamp and tangent screw movement are concealed between the plates, making the instrument more compact. A prism and tube for attaching to the eye-piece of the telescope, for sighting vertically in shafts, is also furnished. The weight of the instrument, exclusive of the tripod, is about  $5\frac{1}{2}$  pounds; the weight of the tripod is  $3\frac{1}{2}$  pounds; the height of the instrument from the tripod legs is 7 inches; the extreme diameter of plates, 5 inches; the diameter of the horizontal plate at the point where verniers and graduations meet,  $4\frac{1}{2}$  inches. The instrument and tripod head are packed in a box  $7\frac{1}{2}$  inches square, arranged with straps to allow its being carried over the shoulder in the same manner as an army officer's field glass, while the folded tripod legs answer as a cane. Though these instruments have been specially designed for mining use, yet from their lightness and compactness they are also meeting with favor for geological surveys, and for preliminary railroad reconnaissances; when used for these purposes, an extra pair of hairs for stadia purposes (*i. e.* measuring distances without chaining), besides the ordinary cross-hairs, is added.

The same manufacturers make a very convenient Plummet Lamp, for underground work. It consists of a brass lamp, suspended by two chains, and terminated below in a conical plummet. The so-called compensating ring is an equatorial ring, surrounding and supporting the lamp, which swings freely within it, upon an axis. The two chains are attached to this ring at the extremities of a diameter perpendicular to the axis. By means of this arrangement, the point of suspension, centre of lamp flame, and steel point of plummet always lie in a true vertical line, no matter how much the brass supporting chains may alter in length from the heating of the Lamp, kinking or wearing of the links. A shield at the top prevents the flame from burning the string. These Lamps are generally used in pairs for back and forward sights.

I understand that Mr. McNair of Hazleton and Mr. Coxe of Drifton, both members of this Institute, have used this instrument with satisfactory results.

## USE OF THE PLUMMET LAMP IN UNDERGROUND SURVEYING.

(From Van Nostrand's Engineering Magazine for July, 1873.)

A paper, read at the Boston meeting of the American Institute of the Mining Engineers, February 19, 1873, by Eckley B. Coxe:

In the anthracite coal regions of Pennsylvania the custom has been to sight either at an open light (generally a mine lamp), or at the string of a plumb-bob. If the station was intended to be a permanent one, a spud, as it is called, that is, a nail resembling a horse shoe nail, with a hole in the head, is driven into the timbers over the station, or, if there be no timber, a hole is drilled in the coal or rock roof into which a wooden plug is driven, which serves to hold the spud.

The first operation in making a survey, is to lay out the stations, that is, to mark the place where the holes are to be drilled for the points on the timbers where the spuds are to be driven in. This should be done before any instrumental work is begun, as much labor can generally be spared and the use of very short sights can often be avoided, by carefully laying out the stations beforehand. When the stations were laid out, a plumb-bob was hung from the innermost spud, which I will call No. 1, the instrument was put in position at No. 2, by plumbing down and putting a centre pin under the spud, and then setting up over the centre pin, and another plumb-bob was suspended from No. 3. If great accuracy was not required, a mine lamp was set up under the plumb-bobs at No. 1 and No. 3, and the engineer sighted at them. If great accuracy was required, a lamp or some white surface was held by an assistant behind the strings of the plumb-bobs. To work with any speed by the latter method (*i. e.*, the accurate one), it was necessary for the engineer to have three assistants on whom he could rely, even when the chaining was done afterwards, *viz.*: one to hold the light behind the string at No. 1, one at No. 3, and an assistant at the instrument to hold the light while levelling, reading the instrument, etc. When using lamps on the ground, it is necessary to examine them from time to time to see that they have not sunk in the mud or turned on one side, etc.; besides, the flame of a mine lamp is a



very large object to sight at, and sometimes it is impossible to see it on the ground (when it can be well seen two or three feet above it), in consequence of some intervening obstacles. Being so situated that it was necessary for me to do a certain amount of accurate work, where I could not rely upon having more than one competent assistant, I had the plumb-bob lamps constructed, and I work with them with a single assistant in the following manner:

When the stations have been laid out, I go to station No. 2 with the Transit, and by means of the plumb-bob belonging to the instrument, I place the centre pin, (a small block of lead with a steel pin in it,) precisely under the spud No. 2; I then remove the plumb-bob and set up my instrument. While I am doing this, my assistant takes the two lamps, suspends one from spud No. 1, and the other from spud No. 3, and then comes back to hold the light for me while I make the final adjustments and take the readings. My instrument is graduated to  $360^\circ$ , and has two verniers  $180^\circ$  apart. I set the vernier at zero, and sight backwards to lamp No. 1. The flame is very small and has a blue central cone which I bisect. I then read the compass needle, invert the telescope, deflect and sight at No. 3, and read both verniers and the needle. I then turn the telescope back, sight upon No. 1, and turn the vernier plate round nearly  $180^\circ$  until I sight No. 3, and again read both verniers. I obtain thus four readings of the deflection from the vernier, and a compass reading as a check, and, as the lights are steady and small, the readings can be made very accurately and quickly. If the four readings agree (with their difference of  $180^\circ$ ), I am sure there is no mistake and go on. I then take up my Transit, go to No. 3, run down the lamp to near the ground, put my centre pin under it, remove the lamp and begin to set up.

In the meantime, the assistant brings the lamp from No. 1 to No. 2, and then takes the lamp from No. 3 to No. 4, and comes back to No. 3 to assist me at the reading of the instrument. The work goes on in this way until all the angles are measured. I then go back and chain the distance from one station to another, and take notes of the workings, etc. In this way, two persons can make a very accurate survey as quickly as three can by the old method. Of course if one has assistants enough the chaining can go on with the instrumental work.\*

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\* This paper of Mr. Coxe's and the preceding paper of Prof. Raymond's were also republished in the Engineering and Mining Journal, U. S. Railroad and Mining Register, Western Mining Review, and in the Transactions of the American Institute of Mining Engineers.

Work has been commenced on the Centennial Building, in Philadelphia. Within two days after his appointment, the engineer in charge had already broken ground. The engineers' instruments used in the surveys are of the most approved make, and are furnished by Messrs. Heller & Brightly, Philadelphia. The Telescopes on the transits and levels, made by this firm, are much superior to the old-style instruments we have been accustomed to.—*From the Engineering and Mining Journal, New York, February 14, 1874.*



(From the United States Railroad and Mining Register, June 28, 1873.)

### LESLEY'S MICROMETER FOR FIELD-NOTE PLOTTING.

Read before the American Philosophical Society, April 18, 1873.

I desire to place on record in the proceedings of the Society a description of my Micrometer for plotting field-notes, which appears to be coming into favor with Civil and Mining Engineers.

It was many years ago that the need of such a little instrument forced itself on my attention, as a substitute for a vernier attachment to a scale for use on the office-table. The strain upon the eyes in constant plotting on small scales, say on the common scale of 1000 feet to the inch, or the not uncommon one of 2000, is greater than the best human organs of vision can endure without permanent injury, to say nothing of the loss of time involved in adjusting the dividers, or applying the paper edge, if a paper scale be used directly. Every field worker who has constructed elaborate contour line maps covering an extensive region of country will bear me out in this assertion.

Considering also the liability to error in counting the decimals and hundredths or thousandths of the scale-unit of *distances*, after hours of application to work has lowered the tone of the nervous system, I sought some mechanical substitute analogous to Mr. Cleaver's Protractor, now in almost universal use for plotting *courses* with ease and precision.

Many forms of such an instrument passed through my mind, but over-occupation, or perhaps laziness, prevented me from taking the necessary steps to realize the idea in even tentative forms, although I spoke of it several times to Mr. Young, the accomplished and experienced instrument maker of Philadelphia, now dead.

During my wanderings in Europe in search of health in 1866, 1867, and 1868, I was several times the guest of my old friend and fellow-laborer in the Anthracite coal fields (1853), Prof. Edouard Desor, at his charming residences on the Combe Varin and in Neufchatel, Switzerland. One day we strolled into the well-known philosophical instrument manufactory of Mr. Hipp, to whom, among other things, I mentioned the need of a Micrometer Divider for plotting, and drew at his request three of its possible forms, such as seemed to me the most feasible, giving him an order for one, and leaving him to select the form he preferred.

On my return to Philadelphia in the spring of 1868 I received it in a broken condition. The chain had been snapped by some custom house official, too curious to learn its nature to treat it with much delicacy of handling. It was, however, easily repaired, and I found it all I could desire: handy, accurate in its action, and perfectly relieving the eyes from the strain of measuring. \* \* \* The original was in constant use by one of my assistants in my office throughout the spring and summer of 1872. When the course of instruction in the Department of Science of the University of Pennsylvania commenced last fall, I accustomed my special geological students to use this instrument among others, and ordered of Heller & Brightly, instrument makers, a duplicate of it, set, however, not to centimeters and millimeters, but to inches and hundredths of an inch. While making it, Mr. Eckley Coxe and other civil and mining engineers saw it, and ordered others like it for their own use, and these orders have become so numerous that it has evidently taken its place among the accepted apparatus of the engineer's office-table. I hope many will in future enjoy the relief and comfort from it which I have enjoyed since 1868.

I was urged to patent it, as Mr. Cleaver patented his Protractor. But I feel a natural prejudice against patenting a little thing which may become to some extent a public benefit, at all events within the not altogether narrow limits of one of the scientific professions. I desire, however, to prevent any one else from hampering its progress by a patent, and to that end beg leave to place this record of its invention among the proceedings of this Society. Any one can obtain the instrument free of patent royalty, from the makers above named, or may order it made for themselves anywhere else.

This Micrometer consists of an arc set with three, four or more needle-points fixed at intervals of one centimeter, one-half inch, or any other unit adopted for the survey, equivalent say to 100 feet (yards, links, rods, etc.).

A handle projects upward from the inside of the arc by which to hold it, and by which it may be applied to the line of course and be gently rotated, so that each needle-point in its turn pricks its (100 feet) unit distance along the line.

Between the last two needle-points fix a supernumerary needle-point or compass-

leg, jointed high up on the handle, and swung or floated to and fro by a simple ratchet and watch chain, turned at will by means of a button, projecting from the centre of a circular disc on the handle; the disc circle being divided into hundredths (thousandths, etc.), and traversed by an index which starts from and comes round to a stop at zero.

While the index travels over the disc from 0 to 100 the supernumerary needle-point travels from needle-point to needle-point, one unit.

Example of use: Suppose a distance 327 feet to be laid off on a course; the fifth needle is applied to the station (point of tangent, or point of curve) and the arc rotated, so that the fourth needle pricks 100, the third 200, the second 300 feet. Then, the index being brought to 27, the floating needle pricks 327.

Mr. Eckley Coxe has had a useful addition made to his instruments in the shape of a set of removable rings, divided for 100ths, 1000ths, 66ths, 33ds, etc., etc. Two little screws hold the ring in place, whichever one may be in request for any particular plotting. When plotting on the scale of some other unit of distance is required, another ring is substituted.

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[COPY.]

PHILADELPHIA, OCT. 24, 1873.  
530 NORTH SIXTH ST.

WALTER SHANLY, ESQ., *Hoosac Tunnel*.

DEAR SIR:—At Mr. Heller's request I drop you this note, to say that I have examined his improved Telescope, and that it is really a *most important and useful affair*. I could scarcely believe my eyes when I first saw for myself the extraordinary power of his instruments. I add on my own responsibility that I consider the engineering instruments of Messrs. Heller & Brightly superior, by far, to any others that are made.

They need, however, to be seen and used before such a sweeping remark can be fully realized.

In haste,

Yours, very truly,

JOHN C. TRAUTWINE.

## INFORMATION TO PURCHASERS.

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As we have only **one grade of goods**, and **one price**, and never deviate from either, it is **not absolutely necessary** for parties to apply to us in person, for the purpose of purchasing or selecting any of our instruments.

The modern system of **Express Agencies** is now so complete as to have their agents at every important point in the United States and British America, and these agents in their turn forwarding by stage, etc., to places where there is no Express agency. This Express system renders it safer and more expeditious at the present day to send goods one thousand miles than to have sent them thirty miles away twenty years since.

As to the **good condition and safety** of the instruments that may be transported by express;—We **pack** in such a **manner**, and make such provision for their safe transportation, that we guarantee the good condition of the instruments on their arrival at their place of destination, after being forwarded by express; and hold the express company liable to us for all loss or damage that may be incurred on the way.

It is perhaps unnecessary to say that we **warrant** the instruments, in all their parts, to be made of good material and of good workmanship, and with no original defects.

**In ordering instruments**, all that is necessary, is to write or telegraph to us the kind of instrument desired, and we will forward by Express, (unless a different method be desired). In giving the address to where the articles are to be forwarded, be careful to **give the County as well as the State**, thus: Send "Combined Transit and Levelling Instrument," price —, and the following extras, —, —, by express, to **Wm. Andrews, Civil Engineer,**

**Linden,  
Cass County,  
Texas,**

as in some States there are several Express stations of the same name.

As there are three Chicagos, three Cincinnati's, six Philadelphia's, etc., in the United States, and each of them in a different State, it is best to **always do this**, even if the articles are to be sent to a **large city**.

Terms of payment are uniformly cash, and any of the following methods can be adopted: remitting to us a draft on any banker or broker, in this or any eastern city; or a "post-office money-order." **The best method** is however by the **Express C. O. D.** system (collect on delivery). That is, the party ordering, paying the amount of our bill to the Express Agent on receipt of the goods.

Although we have our own standard and approved patterns, **if any change** in the style of the instrument, graduations, or numbering of the degrees be desired, we can do it.

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## HOW TO SEND INSTRUMENTS FOR REPAIRS.

**In sending instruments** of our own, or any other makes, to us for repairs, it is only necessary to place them in their own boxes, fill the box with some elastic material, such as paper, rags, etc. Place this in a packing-box at least an inch larger in its dimensions than the instrument box, and fill the space between the two with shavings, straw, hay, etc. Mark on the box simply **Heller & Brightly, Mathematical Instrument Makers, Philadelphia, Penna.** Send it to us by express, and get at the same time from the agent two receipts; keep one, and **forward the duplicate** to us. Send by mail at the same time, a letter to us giving the items as to what repairs are needed and the time when the instrument is again required; and place a duplicate of this letter in the box with the instru-

ment. If the Express charges to Philadelphia are prepaid by the sender (which is optional), it will be so stated in the receipt before mentioned.

Our charge for repairs can be paid by the Express Agent (C. O. D.), on our returning the articles. Remember, however, **always to send the spindle** (or ball and socket, if it be a Surveyor's Compass) on which the instrument turns, as it cannot be adjusted without; and a socket must be improvised at additional cost to the owner, if it be not sent. If, when the instrument is not of our make, it is required to be **tested for magnetic attraction, or defective graduation**, the fact must be mentioned in the letter of advice to us.

If the distance be not too great, it would also be **best to send us the tripod legs and head**, as the legs are frequently loose in their cheeks, and the iron shoes at their ends shaky and points worn off.

When instruments are sent to us to be repaired, we will, if **requested, test** any steel **tape or chain** that may be forwarded with them without extra charge, and give their difference in length as compared with the true United States standard (see "straight line measurements"), and the state of the thermometer at the time of trial. If, however, any repairing or adjusting of the chains, etc., be required, there will be an extra charge.

We have been frequently asked, since we have increased the power of our Telescopes, whether we could not **place our new Telescope on instruments made by other firms**. We have heretofore uniformly refused, as our new Telescope is a distinguishing feature of our instruments as compared with others. We have however reconsidered our determination, and will alter any Telescope to our new one; **but in cases of this sort** we will engrave on the Telescope tube the name of our firm. In altering the Telescope, all that will be necessary in a majority of the cases, will be to **remove the old object glass and eye piece**, insert new ones, and to **change the place of the cross wires**.

OFFICE OF HELLER & BRIGHTLY, }  
33 NORTH SEVENTH ST., PHILADELPHIA. }

## TRIAL OF INSTRUMENTS BEFORE ACTUAL PURCHASE.

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We judge from numerous letters received by us since the knowledge that we have increased the power of the ordinary Telescope, has been made public, that a personal examination of the Telescope (and instrument) before making a final purchase, would be more satisfactory to parties who are but slightly acquainted with us and our reputation. We make to such the following proposition: On making known to us the kind of instrument they desire, 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 field. The purchaser can take the instrument and give it an actual trial in the field (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 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.

MARCH 25, 1874.





**HELLER & BRIGHTLY,**  
 MATHEMATICAL, OPTICAL, ENGINEERING, AND SURVEYING INSTRUMENT MAKERS,  
 33 North Seventh Street, Philadelphia.

**PRICE LIST.**

PHILADELPHIA, March, 1874.

**TRANSIT.**

Complete "combined Transit and Levelling Instrument," for Civil Engineers and Surveyors (similar to illustration)—5 inch magnetic needle. "Long compound centres" to plates—all graduations on silver plate. The degrees of the ring and horizontal plate numbered in two rows, one row in quadrants ( $0^{\circ}$  to  $90^{\circ}$  each way), and the other row a continuous one (for repeating an angle) from  $0^{\circ}$  to  $360^{\circ}$ .—Double opposite verniers to horizontal limb.—All the level bubbles ground.—Long sensitive level bubble, vertical arc, clamps and tangent screw movement to axis of Telescope.—Tangent screw motions, both to the horizontal limb and vernier plate. Clamps on Telescope axis, arranged with sighting slits and index marks, for right angle sighting (for offsets). Telescope achromatic and erecting, of extra high power and range, (magnifies 23 diameters; and will read time on an ordinary watch dial at 983 feet distance). Telescope balanced in its axis, reversing both at eye and object ends, and with one end of its axis adjustable.—Slide for closing aperture in cap, when not in use. Shifting tripod head to tripod, for precisely centring the instrument over a point, after approximately setting by the tripod legs. Extra wide openings in vernier plate for reading the horizontal limb.—Tripod head, with the levelling screws, etc., detachable both from the instrument proper, and from the tripod legs, for packing away in the box.—Length of Telescope  $10\frac{1}{2}$  inches; Diameter of object glass  $1\frac{1}{2}$  inches..... \$220.00

The instrument is securely packed in mahogany box, with leather strap, hooks, lock and key.—India-rubber washers to the bottom of the box to prevent disarrangement of the adjustments by transportation.—Packed in each box, and included in the price, are a magnifier for the easy reading of the graduations, plummet, sun-shade for Telescope, adjusting-levers, and two screw-drivers.

Plain Transit—similar to the above in every respect, excepting that it has no level, vertical arc, clamps nor tangent screw motion to the axis of Telescope..... \$175.00

**EXTRAS TO PLAIN TRANSIT.**

By attaching the first three following extras (weight about 16 ounces) to a plain Transit, it is changed into a "complete, combined Transit and Levelling Instrument.

- Vertical circle  $4\frac{1}{2}$  inches diameter (reading to minutes of arc)..... \$20.00
- Or vertical arc, 7 inches radius, and vernier clamp..... 15.00
- Clamp and tangent movement to axis of Telescope..... 15.00
- Long level on Telescope, ground bubble and scale ..... 15.00
- "Slit sights" on Telescope, to fold down on the Telescope when not in use. 12.00

**EXTRAS TO EITHER PLAIN OR COMPLETE TRANSIT.**

(Any or all of which may be added at will.)

- Rack and pinion movement to eye piece (for focussing cross-wires)..... 5.00
- Adjustable Stadia hairs (with accurate and firm adjustment to the slides, and so arranged that the Micrometer or Stadia hairs can be adjusted without disturbing in the least the adjustments of the ordinary horizontal and vertical hair). Unless otherwise ordered, we adjust them so as to

precisely take in 1 foot of a rod, placed at 100 feet distance from the instrument.....	\$10.00
<b>Extra detachable side Telescope</b> , for vertical sighting in shafts. For description of this Telescope, and manner of its use, see page 7.....	12.00
(This Telescope is only furnished at this price when ordered with the instrument.)	
<b>Plated reflector for graduations</b> (see page 7).....	4.00
“ “ “ cross wires (see Professor Raymond's paper).....	4.00
<b>Extension leg</b> for lowering or raising the Transit (see report of Committee of Civil Engineers of Franklin Institute).....	5.00
<b>Small adjustable Table</b> to attach to tripod for holding lamp, weighing 24oz., and packing away in box (for description and use see page 7).....	15.00
Extra magnetic needles, centre pins, levels, compass dial glasses, magnifiers, adjusting levers, plummets, plummet cord, camel's hair brush and buckskin for glasses of Telescope, small waterproof bag to place over the Transit in case of rain—furnished whenever so desired.	

### SMALL MINING AND RECONNOISSANCE TRANSIT.

A full detailed description of this new instrument, which we have lately designed and introduced, will be found in the paper of Professor R. W. Raymond read before the Association of Mining Engineers (which see).

**Small Mining and Reconnaissance Transit**, with level, vertical arc, etc. (similar in every respect excepting size and weight to our complete combined Transit and Level—which see)..... \$195.00

Our attention has been called to imitations of our Mining Transits that have been placed on the market since we first introduced our style; and as from the tenor of the communications and inquiries we have received persons may be deceived by the close imitation, we give some of the leading points in which they differ. As far as the size is concerned, they are close copies, Professor Raymond's paper giving all the various dimensions, and rendering imitation in this direction easy. They can, however, be detected in the following points.—The metal of which they are made is the ordinary hammered yellow brass;—the windows for reading the verniers of the horizontal limb are only half the length; (our window openings being full two inches long). Our verniers are opposite, have double readings, and read to single minutes of arc; the imitation has single readings, and in some cases only read to three minutes (3'). Our graduations are upon silver plate; the imitation on the brass and silver washed. Our centres are the “long compound;” the imitation has the “flat Surveyor's style.” Our plates, etc., are “ribbed” and “braced;” the imitation ones are solid, and of course the instrument heavier. The Telescope is, however, the part where the greatest difference exists, ours being erecting, 7½ inches long, and of a high magnifying power (over 17 diameters), the imitation having the ordinary inverting eye piece (Ramsden's), and being longer.

### EXTRAS TO SMALL MINING TRANSIT.

(Any or all of which may be dispensed with at will.)

<b>Extra side Telescope</b> , detachable at will, for vertical sighting (see page 7 for description of this Telescope and manner of its use).....	\$10.00
(This Telescope is only furnished at this price when ordered with the instrument.)	
<b>Adjustable Stadia</b> or “Micrometer” hairs (see regular, complete, etc., Transit).....	7.00
<b>Extra tripod head</b> with three extension legs (see “Franklin Institute Report”), to lower or raise the instrument in contracted workings.....	15.00
Or one extension leg, to suit regular Tripod.....	5.00
<b>Plated reflector for graduations</b> (see page 7).....	3.00
“ “ “ cross hairs “ “ “.....	3.00
<b>Small adjustable Table for lamp</b> “ “ “.....	15.00
<b>Lamp</b> for Mining Engineer of new design, can be used either attached to the hat, in the hand, or on table, made of heavy sheet copper; seams lapped, and the copper tested as to its freedom from magnetic attraction; weight about 5 ounces (for full description see page 7).....	3.00

## TUNNEL TRANSIT.

**Tunnel Transit**, with Telescope 17 inches in length—long compound centres, 5 inch magnetic needle, double opposite verniers to horizontal limb. (See page 8, Franklin Institute Report, and letter of Mr. Steele for further details).....\$260.00

## SOLAR TRANSIT.

**Solar Transit** (Benj. Smith Lyman's patent); this is our regular—"Complete combined Transit and Level Instrument," with the addition of a variation plate, Stadia hairs, and the solar apparatus *underneath* the main plates, all the graduations on silver plate (see Solar Transit, page 14)..... 300.00

## PLANE TABLE.

**Plane Table** of the most approved modern construction, with **Alidade**—detached **Compass box**, level, scale, etc.—**Table** 24 inches square—alidade with *movable edge* (this is a most important and time-saving improvement, as double the amount of field work can be done in the same time as with the ordinary style of instruments, and with greater accuracy). Telescope extra powerful with vertical arc, and with adjustable Stadia hairs—Tripod very firm and with shifting head.—The whole instrument braced in a manner to best resist side torsion ..... 290.00  
**Telemeter Rod** (hinged and graduated) to use with Plane Table..... 25.00

All the above instruments (as well as those that follow) are reduced to about half the weight of instruments made in the ordinary way.—This being effected by "ribbing" and "bracing," all the parts.

The mode is fully explained in "the Report of the Committee of Civil Engineers appointed by the Franklin Institute of Philadelphia to examine Heller & Brightly's improved Transit," and in the paper read before the "American Philosophical Society."

## LEVELLING INSTRUMENT.

**Engineer's Levelling Instrument**, with "long centre" (instrument similar to illustration), Telescope, bar and centres arranged in such a manner as to detach above the levelling screws, without the possibility of jarring the instrument or its adjustments.—Tripod head and levelling screws detachable from the tripod legs, for packing away in box.—Telescope 17 inches long, erecting, achromatic and extra powerful.—**Index lines** on Telescope and Y's for setting vertical hair truly vertical, packed in mahogany box with sunshade, adjusting pins, etc.,.....\$140.00

## SMALL MINING AND RECONNOISSANCE LEVEL.

This **Mining and Reconnoissance Level** is a companion instrument to the Mining and Reconnoissance Transit, and is a fac-simile of our regular Engineer's Levelling Instrument (which see) in every respect excepting size and weight—length of Telescope 10 $\frac{3}{4}$  inches—aperture of object glass 1 inch—magnifying power 28 diameters, shows objects erect, and will read face of a levelling rod *direct* (*i. e.*, without the aid of a target) at 700 feet. This Levelling Instrument fits the tripod head of the **Mining Transit**, and one tripod, if need be, will answer for both.—The whole instrument weighs without tripod 2 $\frac{1}{2}$  pounds, and is packed in a mahogany box, 12 inches long, 4 in. wide, and 6 inches deep; a strap is furnished to carry box over the shoulder in the manner of army officer's field-glass.

Price without tripod (where Transit tripod interchanges with Level)..... \$95.00  
 Tripod head and legs..... 10.00  
**Plummet lamps** with "compensating ring" (for description and manner of use see Prof. Raymond & Eckley B. Coxe's papers before the American Association of Mining Engineers), singly. .... 13.00  
 Per pair ..... 25.00

Neat light box, with lid and shoulder strap, to carry a pair of these lamps, is also furnished if desired.





**SURVEYOR'S AND ENGINEER'S CHAINS.**

Surveyor's Chain, 2 poles, 50 links, No. 9, wire oval rings.....	\$2.00
“ 2 “ 40 “ 8, “ .....	2.75
“ 2 “ 50 “ 8, “ .....	2.75
“ 2 “ 50 “ 7, “ .....	3.75
“ 4 “ 100 “ 9, wire round rings.....	3.50
“ 4 “ 100 “ 8, wire oval rings.....	4.50
“ 4 “ 100 “ 7, “ .....	5.50
“ 4 “ 100 “ 12, best steel wire, brazed links and rings.....	14.00
“ 2 “ 50 “ 12, best steel wire, brazed links and rings.....	7.00
Engineer's Chain, 50 feet, 50 “ 7, wire.....	4.00
“ 100 “ 100 “ 7, “ .....	6.00
“ 50 “ 50 “ 12, best steel wire, brazed links and rings.....	8.00
“ 100 “ 100 “ 12, best steel wire, brazed links and rings.....	15.00

**CHESTERMAN'S STEEL TAPE MEASURES.**

These steel Tapes we always test with the true United States standard, and give the purchaser a note of the comparison and the state of the thermometer at the time of testing. (See straight line measurements.)

Steel Tape Measures; all steel, to wind up in a box, same as linen measures.	
Steel Tape Measure, 10 feet long, in 10ths or 12ths, in German Silver case, each. ....	\$4.00
Steel Tape Measure, 10 feet long, tape divided on one side to 12ths, and on the other to centimeters and millimeters.....	4.25
Steel Tape Measure, 25 feet long, in 10ths or 12ths, each.....	6.00
“ “ 33 “ “ “ .....	7.50
“ “ 40 “ “ “ .....	8.50
“ “ 50 “ “ “ .....	10.00
“ “ 66 “ “ “ .....	13.00
“ “ 75 “ “ “ .....	15.00
“ “ 100 “ “ “ .....	19.00
Steel Tape Measure, 3 feet long, in German Silver case, with spring and stop, tape divided into 10ths or 12ths of a foot.....	2.00
Steel Tape Measure, 4 feet long, in German Silver case, with spring and stop, tape divided into 10ths or 12ths of a foot, .....	2.25
Steel Tape Measure, 5 feet long, in German Silver case, with spring and stop, tape divided into 10ths or 12ths of a foot .....	2.50
Steel Tape Measure, 6 feet long, in German Silver case, with spring and stop, tape divided into 10ths or 12ths of a foot.....	2.75
Steel Tape Measure, 3 feet long, tape divided on one side to 12ths of a foot, and the other side to centimeters and millimeters. ....	2.25
Steel Tape Measure, 4 feet long, tape divided on one side to 12ths of a foot, and the other side to centimeters and millimeters.....	2.50
Steel Tape Measure, 5 feet long, tape divided on one side to 12ths of a foot, and the other side to centimeter and millimeters.....	2.75
Steel Tape Measure, 6 feet long, tape divided on one side to 12ths of a foot, and the other side to centimeters and millimeters.....	3.00

**CHESTERMAN'S METALLIC TAPE MEASURE.**

Metallic Tape Measure, 24 feet long, in 10ths or 12ths, each.....	\$2.40
“ “ 33 “ “ “ .....	2.75
“ “ 40 “ “ “ .....	3.00
“ “ 50 “ “ “ .....	3.50
“ “ 66 “ “ “ .....	4.00
“ “ 70 “ “ “ .....	4.25

Metallic Tape Measure, 75 feet long, in 10ths or 12ths, each.....	\$4.50
“ “ “ 80 “ “ “ “ .....	4.75
“ “ “ 100 “ “ “ “ .....	5.50

SWISS DRAWING INSTRUMENTS.

Being frequently called upon to furnish the entire field and office outfit for Railroads and Civil Engineers, we here insert the prices of some strictly first-class German Silver instruments, and of office stationery. The drawing instruments are somewhat higher in price than the common sort, but are such as we furnish when the quality is left to our judgment. They are examined by us before forwarding, to see that the steel points are properly hardened and tempered, that the joints work equally, the drawing pens properly rounded and sharpened. We can, however, furnish, at catalogue prices, those of any firm that may be desired.

Plain Dividers, 4½ inches long, each.....	\$1.90
Plain Dividers, 5 inches long, each.....	2.25
Plain Dividers, 6 inches long, each.....	2.70
Hair Spring Dividers, 4½ inches long, each.....	2.65
Hair Spring Dividers, 5 to 6 inches long, each.....	3.00
Dividers, 6½ inches long, with Pen, Pencil, Needle Points and Lengthening Bar.....	8.50
Dividers, 6½ inches long, with fixed Needle Point and Loose Pen, and Pen Points and Lengthening Bar.....	6.75
Dividers, 6½ inches long, joints in each leg, with Pen, Pencil, Needle Points, Dotted Pen and Lengthening Bar.....	11.00
Dividers, 4 inches long, with Pen, Pencil and Needle Points.....	6.00
Dividers, 4 inches long, with fixed Needle Point, and Pen and Pencil Points, changeable.....	5.25
Dividers, 4 inches long, with two fixed Needle Points.....	3.25
Dividers, 4 inches long, with fixed Needle Point and Pen Point.....	3.60
Dividers, 4 inches long, with fixed Needle Point and Pencil Point.....	3.60
Dividers, 4 inches long, with Spring and Set Screw, Needle Point, Pencil Point and two Pen Points.....	8.50
Proportional Dividers, 6½ inches long, finely graduated for lines.....	8.75
Proportional Dividers, 6½ inches long, finely graduated for lines and polygons.....	10.00
Proportional Dividers, 9 inches long, finely graduated for lines and polygons.....	12.25
Proportional Dividers, 9 inches long, with micrometer adjustment, finely graduated for lines and polygons.....	14.75
Proportional Dividers, 8 inches long, with rack adjustment, graduated for lines.....	12.75
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“ “ 3½ “ with Ivory or Metal Handle.....	1.70
“ “ 3½ “ with Ivory Handle and Needle Points..	3.00
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Beam Compass, 21 inches long, in 3 bars.....	13.00
“ 36 “ 4 “ .....	19.00
“ 54 “ 4 “ .....	22.50
Furniture for Wood Bar Beam Compasses, in morocco box.....	8.75
Furniture for Wood Bar Beam Compasses, not in morocco box.....	8.30
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Pillar Compasses, or Pocket Set of Instruments, with Points to change.....	8.50
Pillar Compasses, or Pocket Set of Instruments, with Points to change, and Handles to Bow Pen and Pencil.....	10.00
Pillar Compasses, or Pocket Set of Instruments, with Points to turn.....	9.00
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“ “ with Needle Point, all steel, Ivory Handle.....	3.00
“ “ German Silver.....	2.65
“ “ “ with Pencil Point.....	3.60
All Steel Spring, Bow Pencil, Ivory Handle.....	2.25
“ “ “ “ Needle Point.....	3.00

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“ 5½ “ “ .....	1.70
“ 6½ “ “ .....	1.95
Road, or Double Drawing Pen.....	4.15
“ “ “ with joint in each side.....	3.80
Dotting Pen, with one wheel.....	2.65
“ with six wheels.....	4.00
Horn Centre, with German Silver edges.....	50
German Silver Centre, with handle.....	30
“ Fastening Tacks, per dozen.....	80
Steel Fastening Tacks, per dozen.....	80
Irregular Curves of Horn, each.....	75
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Eccentric Rule, 11 inches long.....	2.65

Parties wanting cases made up of these Instruments can select the pieces, by the above list, that are best adapted to their purpose, and we will have boxes made to suit, at an additional cost of from \$7 to \$15, according to the size of the boxes, which are made of rosewood, mahogany or walnut, highly finished.

PAPER PROTRACTORS.

Whole Circle Protractor, 13 inches diameter, half degrees, on drawing paper, each.....	30
Whole Circle Protractor, 13 inches diameter, half degrees, on Bristol boards, each.....	40
Half Circle Protractor, 5 inches diameter, half degrees, on Bristol boards, each.....	25

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Plate B.—Rulings 9 inches wide, Horizontal Divisions, four to the inch ; Vertical Divisions, thirty to the inch, and having every fourth horizontal division line and every twenty-fifth vertical division line heavier than the others. Price, per yard.....	20

## MUSLIN BACKED ROLL PROFILE PAPER.

Muslin Backed Roll Profile Paper, of either Plate A or B, 22 inches wide, in rolls of 20 yards, per yard.....	75
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*Plate B corresponds to that in sheets known as Brown's Profile Paper.*

## CROSS SECTION PAPERS.

Topographical Paper, 14x17 inches, ruled 400 feet to the inch, per sheet 12 cents.....	per quire	\$1.75
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Cross Section Papers, rulings 22x16 inches, 8 feet to inch, per sheet 25c.,	"	5.00
" " " " 10 " " 25c.,	"	5.00
" " " " 10 " every fifth line		
heavy, per sheet 25c., per quire.....		5.00
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*All the Profile and Cross Section Papers can be furnished, printed with red or green lines.*

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" 100 " " " " .....	8.00
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" 50 " " " " .....	5.00
" 100 " " " " .....	8.00
" 50 " Turkey morocco, turned edges, with elastic band.....	6.00
" 100 " " " " .....	9.00

## PAPER PROTRACTORS.

Whole Circle Protractor, 13 inches diameter, half degrees, on drawing paper, each.....	30
Whole Circle Protractor, 13 inches diameter, half degrees, on Bristol boards, each.....	40
Half Circle Protractor, 5 inches diameter, half degrees, on Bristol boards, each.....	25

DRAWING STATIONERY.

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

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"	42 " thin,	" 40, " .....	25
"	54 " thick,	" 55, " .....	50
"	54 " thin,	" 55, " .....	35
Best egg shell,	59 " thick,	" 55, " .....	75
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" " "	59 " thin,	" 55, " .....	45

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" 36 " " 11.00, " .....	60
" 42 " " 15.00, " .....	75
Sagar's Patent, 18 " " " 7.00, " .....	35
" 30 " " 9.50, " .....	50
" 36 " " 11.00, " .....	60
" 42 " " 15.00, " .....	75





# REMARKS

ON

## ENGINEERS' SURVEYING INSTRUMENTS.

BY

HELLER & BRIGHTLY.

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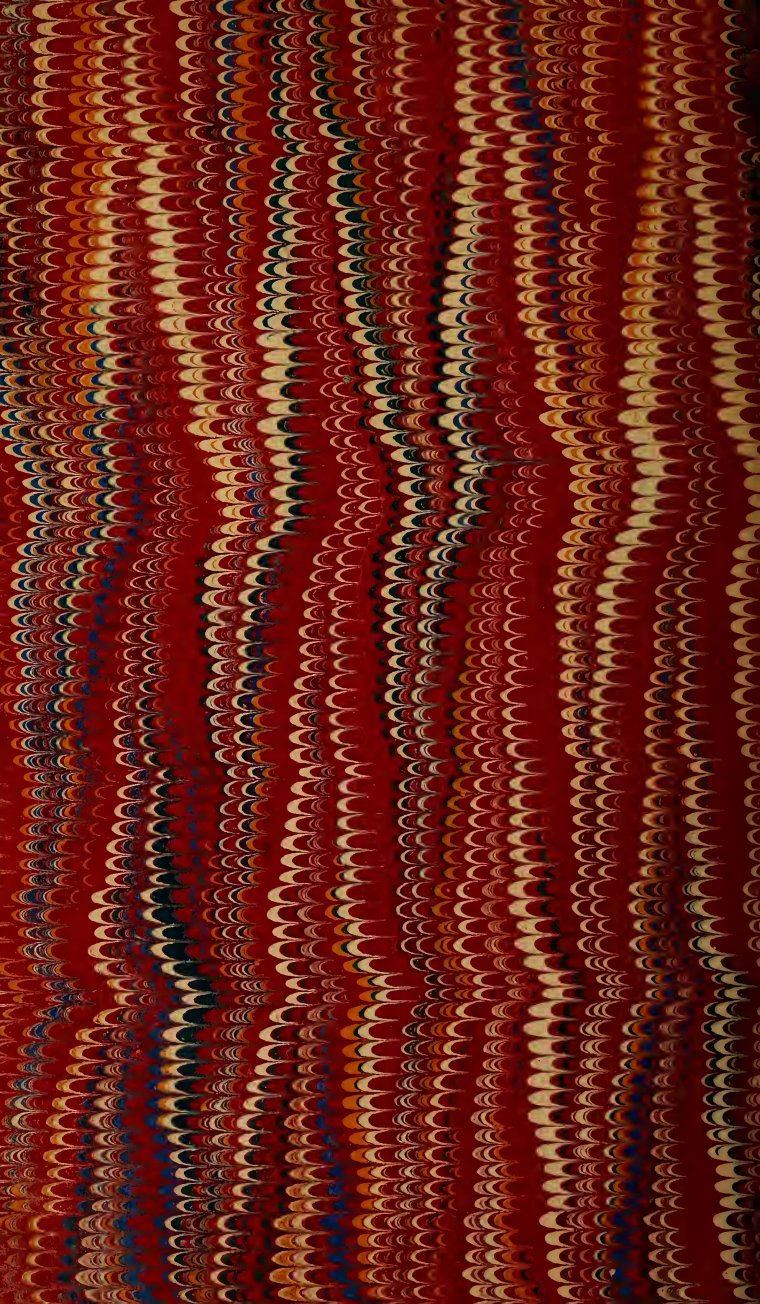
















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