



## XXVII. A new instrument for comparing linear measures

M. de Prony

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of a great number of solar observations only by  $\frac{1}{1000}$  of a second. In this calculation, I have supposed the mean parallax of the sun equal to  $8.59''$ , corresponding with that which I have deduced from my theory of the moon, compared with the inequality of the lunar motion, known by the name of *parallactic inequality*, and which M. Burckhardt has determined by means of a very great number of observations. M. Ferère, a learned Spanish astronomer, has lately confirmed this parallax by a new investigation of the transit of Venus in 1769; in which, by his own observations, he has corrected the latitude and longitude of places where this transit has been observed in America. The agreement between all these computations determined by phenomena so vague, is an additional confirmation of the principle of universal gravitation.

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XXVII. *A new Instrument for comparing Linear Measures.*  
By M. DE PRONY\*.

THE comparison of linear measures, when great accuracy is necessary, requires careful and delicate operations, as well as the use of machinery not generally employed in commercial concerns, and difficult to be procured. I have already published the description of an instrument of this kind, invented and made by M. Lenoir, member of the Board of Longitude, which is as perfect as can be wished; but its expense and size put it out of the power of common observers to procure, and render it useless to travellers, who wish to know the proportion between some given standard, and the linear measures of any country through which they may pass.

I have had made for my own use, a *comparer*, which joins the two advantages of œconomy and portability: all the pieces of which it is composed may be fitted into a box of the size of a quarto book. The dearest part is a microscope; but even this requires nothing different from those with which observers are commonly furnished. In general it is only necessary to be at the expense of making three additional pieces, which I shall describe presently.

The properties and use of my *comparer* are founded on the progress which the art of dividing a right line has made within the last half century. This instrument has therefore, independently of the above advantages, that of requiring no *vernier* nor *micrometer screw*, &c.

It is well known that M. Richer, one of the first artists of Paris for the construction of mathematical instruments, has

\* Communicated by Dr. Evans.

long been in the habit of making divisions on glass that are very clear and minute at the distances of 100ths of a millimeter, and even less\*. A glass having two or three millimeters with the division of one of them into 100 parts costs at his house, ten or twelve francs.

Some foreign artists have also succeeded in this kind of work. I procured in my travels in Italy, two small discs of glass on each of which are two millimeters, the one divided into ten and the other into a hundred equal parts. I had them of M. Capello of Turin, an artist who is equally celebrated for his inventive mind and his ability to execute what he has conceived.

I know also at Paris an amateur, M. Le Baillif, who applies all the leisure moments which his situation under government affords, to the cultivation of the sciences; and who among his other talents possesses that of dividing a right line on glass in a rare and remarkable manner. He has had the kindness to trace for me on a small disc of glass 21 tenths of a millimeter; ten of which are subdivided into 100dths and 200dths. These divisions of 200dths are very neat, and perfectly visible with a microscope magnifying 100 times.

Those persons who wish to possess a *comparer* like mine, ought first to procure one of these glasses on which a right line is divided into as many millimeters as they please, and one of these millimeters subdivided into 100dths. The first 10, 20, 30, &c. strokes of this subdivision into 100, are prolonged, and the 5, 15, 25th, &c. should be also prolonged, but less than the former, in order that the tenths and half-tenths of a millimeter may be distinguished at the first glance of the eye.

The piece of which I have just spoken must be fixed at one of the extremities of a brass rule, the lengths of the strokes of the divisions being perpendicular to the length of the rule which carries at its extremity a steel stud, intended to be put in contact with the ends of the linear measures which we may have to compare.

Another fixed stud must be screwed and held very solidly on a board or a table which holds the measures and all the apparatus.

When we wish to compare any two linear measures, one of them must first be placed in such a way that one of its extremities

\* I have a micrometer screw made by this able artist, two decimeters in length. He engaged to cut these divisions at intervals of a half millimeter, and he succeeded so well that the most rigid proofs could not discover the least inequality that was sensible throughout the whole 200 divisions. This is one of the most difficult tasks that can be undertaken of this kind.

may rest against the fixed stud, and its other end in contact with the moveable one; the whole being so disposed, that the axes of the rules, the axis of the linear measures, and the middle points of the divisions on the glass are exactly in right lines. The microscope held by the same board, or the same table on which the other parts of the apparatus and the linear measures are laid, must be so pointed to one of the divisions on the glass, that after some preliminary trials, or first approximative data, on the ratios of the linear measures, we may be certain that the second measure to be compared, when we have made the same dispositions respecting it, will bring the 100dths or 200dths of a millimeter under a *stroke*, which is afterwards to be determined when placed in the focus of the microscope; which microscope, when the collimation has been established, with respect to the beginning of the divisions, must be kept immoveable during the comparison of the two linear measures.

The apparatus is to be disposed in such a way, that the glass carrying the divisions may be placed between the reflecting mirror of the microscope and the object lens; and if we wish to adjust the focus-line to the line at the beginning of the divisions, we make the supports of the microscope to abut against the point of a fixed horizontal screw and nut; this support being made to slide along a rule parallel to the linear measures. The parallelism between the focus-line and the strokes of the division is easily obtained by the hand, by causing the microscope to turn round in the circular horizontal ring in which it is inclosed.

The collimation of the focus-line with one of the strokes on the divisions on the glass being thus well established, we remove the first linear measure, and replace it with the second, by resting the moveable stud against one of its ends, and making its other end to abut against the fixed stud. The point of collimation will change, if the measures are not equal; and their difference of length will be given by the quantity that the second measure shall have removed the first stroke of the divisions from the division on which the collimation was established for the first; which quantity of removal is measured by the number of millimeters, and 100dths of a millimeter, contained between the two successive points of collimation.

I return to the line placed in the focus of the microscope. It is easy to conceive the extreme fineness that this line must have, since it ought to appear on the space contained between two consecutive divisions on the glass; which spaces are 100dths of millimeters, and so as to permit their evaluation by estimation to 1000dths of a millimeter. I believe it would be in vain to attempt to perform this by placing a wire in the focus; and that the finest of those that are commonly adapted to telescopes,  
either

either for the purposes of surveying, or for those of astronomy; cover spaces much too great to allow of a similar estimation, although they only undergo the magnifying power of the eye-glass. I received from M. Breguet, member of the Board of Longitude, a platina wire made in England by an ingenious process. This wire had been passed through a hole when enveloped in a covering of silver; and when the compound of the two metals had been reduced to its greatest fineness, the silver was dissolved, and the platina wire left uncovered. The maker had written on the piece which contained the wire of which I speak the number 6000, to indicate that its diameter is  $\frac{1}{6000}$ th of a fraction of an English foot, which M. Breguet thinks is a *line*. If he has been rightly informed in this respect, there is an enormous miscalculation in the evaluation of the maker; for his wire, when stretched and put in contact with the division of 100dths of a millimeter, covered the interval between two strokes, and the strokes themselves. Its magnitude is therefore more than 0.01 millimeter, whilst the English evaluation only makes it 0.00035 millimeter; and if, as I am inclined to believe, it is not 6000dths of a *line*, but only 6,000dths of an inch, that he intended to indicate by the number 6000 written on the side of the wire, there is still an error of 3-5ths; for the  $\frac{1}{6000}$ th part of an English inch = 0.0042 millimeter.

This wire, which has probably the greatest degree of fineness that can be attained in the present state of the arts, does not therefore give us the most delicate line that can be rendered perceptible to the eye; and my divisions of 100dths of millimeters on glass serve as a proof of this. The thickness of each line of this division is only about the third of the length of the interval contained between two immediately adjoining strokes; so that this thickness is, according to what I have said above, less than the third of the diameter of the English platina wire. For these reasons I have determined not to put the wire in the focus of the microscope, but to put a piece of plain glass there, on which M. Richer has traced for me two lines at right angles, of such a degree of fineness and neatness, that when one of these lines projects itself between two strokes of the divisions on glass, the proportion between its distances from each adjoining stroke may easily be estimated. This expedient affords also the advantage of great solidity, and that of rendering the application of a vernier to the apparatus quite easy by having on the glass in the focus ten parallel strokes, which should cover 9 or 11 of the divisions of 100dths of a millimeter.

It is unnecessary to trouble ourselves about the loss of light occasioned by this glass in the focus; for notwithstanding its interposition between the eye and the object, an intensity of light  
that

that the eye still supports very well, causes the strokes marked on the glass, bearing the divisions into 100dths of a millimeter, to disappear. It has sometimes happened, that I have intercepted a part of this light by placing my hand before the reflecting mirror: and I have remarked, that in seeking by the vertical motion of this hand the proper position for the degree of light that I wanted, I made the point of collimation to vary within the limits of about  $\frac{1}{1000}$ th of a millimeter. According to this observation it is necessary, whilst we are comparing the linear measures, to keep the quantity of light thrown on the divided glass in the interior of the microscope always in the same state.

The accuracy and convenience of my new *comparer* has already been submitted to frequent trials. The ratios of some of the linear measures on which it has been tried had been determined with the great *comparer* of M. Lenoir, and the agreement between the results furnished by both instruments has been very satisfactory. Among the operations from which these results are derived there is one that I made with my colleagues Messrs. Bouvard and Arrago. One of the objects of comparison was the standard platina *metre* of the observatory.

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*To Mr. Tilloch.*

DEAR SIR,—IN consequence of the observations made in the preceding paper, on the size of the very fine platina wire so ingeniously contrived and made by Dr. Wollaston, I deemed it proper to inform him that I intended to present you with a translation of M. de Prony's Memoir for publication in your valuable Magazine. I have accordingly been favoured by that gentleman with the subjoined information on the subject, which not only explains the difficulty, but informs us of the manner in which the wire is produced, and the mode adopted for estimating its size. The portions of an inch called *lines*, which the French scientific gentlemen use very commonly, are rarely employed in this country: it was therefore very natural to conclude, that M. Breguet must have made some mistake, in the statement of its dimensions which he carried back with him to France, and communicated to M. de Prony.

I remain, dear sir,

Yours, &c. &c.

Christ's Hospital, Feb. 20, 1816.

T. S. EVANS.

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“When Mr. Breguet was in London, he received from Dr. Wollaston a specimen of platina wire  $\frac{1}{8000}$ th of an *inch* in diameter.

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"The data from which Dr. W. infers the dimensions of so small a wire may serve as a means of estimating the accuracy of M. Prony's method when applied to the measure of such objects.

"A wire of pure platina is drawn till ten grains of it measure 24 inches, so that its diameter is thus known to be  $\frac{1}{100}$  dth of an inch.

"A portion of this wire is then coated with silver cast round it in a cylindrical mould, (about  $\frac{3}{8}$ ths of an inch in diameter).

"The cylinder is then drawn till each inch is elongated to 400 inches, in which state the diameter of the platina is known to be reduced in the proportion of the square root of 400 or twenty-fold: so that its diameter is then  $\frac{1}{2000}$  dth of an inch.

"If any portion of the silver wire be then further drawn till one inch measures nine inches, the platina wire within it is then reduced to  $\frac{1}{9}$  d part of its last diameter, and is consequently  $\frac{1}{18000}$  dth of an inch in thickness.

"If the silver wire be then dissolved by nitric acid, the diameter of the platina which remains undissolved (although kept perfectly clean) could not with confidence be pronounced inaccurate by a mensuration in which its dimensions were at first presumed to be  $\frac{1}{18000}$  dths of an inch.

Feb. 20, 1816.

"W. H. WOLLASTON."

XXVIII. *Remarks on the Geological Sketch of a Part of Cumberland and Westmoreland.*

To Mr. Tilloch.

SIR, — IN your Magazine for last month, (p. 41,) in an article entitled "A Geological Sketch of a Part of Cumberland and Westmoreland," your correspondent notices as a fact, that carbonate of strontites has been found in the basalt of the Giant's Causeway. This is a circumstance that has frequently been noticed to me, and specimens have been shown me, as carbonate of strontites, which I have uniformly found to be carbonate of lime. It is nothing uncommon to mistake the one substance for the other, the carbonate of strontites from Braunsdorf in Saxony having long been considered as the hard carbonate of lime among the German mineralogists.—I should therefore be glad to know from your correspondent, through the medium of your Magazine, whether the specimen he refers to has been submitted to analysis.

Your correspondent likewise notices that the clay-slate and hornblend slate of Skiddaw rest immediately on granite; which would