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An introduction to practical astronomy:
containing descriptions of the various instruments, that have been usefully employed in determining the places of the heavenly bodies, with an account of the methods of adjusting and using them

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§ LXXXVI. MICROMETER BY AMICI. [PLATE XXI.]

1. At the time when we printed our descriptions of the various micrometers, we had not seen the double-image micrometer of the ingenious Amici of Modena, which we have mentioned at page 194; but the distinguished inventor has since been in England, and has supplied us with the identical instrument, which he had used in his observations of double stars. We have therefore now an opportunity of introducing an account of this micrometer. Figures 4 and 5 of Plate XXI. represent this appendage to a telescope; the former gives a view of its external appearance, facing the eye when applied to a telescope, and the latter shows a section of its parts, as they would be seen edgewise. The same letters of reference apply to the corresponding parts of both. In the lower figure *a* is a short piece of tube, having a female screw which receives an adapter, for applying the micrometer to any particular telescope; its upper end carries a large flanch to which the graduated circle *c* is screwed fast; and round the centre of this circle the plate *b* revolves which bears the cranked vernier *d*, lying nearly in contact with the circle, on the upper side of which a dove-tail appears, into which a reading lens is occasionally fitted by sliding. Upon this plate, *b*, is fixed, by four small pillars, a brass frame having for its bottom a plate *e*, two inches and seven-eights long, and two inches and a quarter wide; the end *e* being the narrower: the covering plate, *f f*, of this frame is six inches and three-eights long, and two inches and six-tenths wide at both ends, but a little wider in the middle, to receive the four screws entering the upper ends of the pillars, as seen in both figures: the milled heads, *g* and *h*, have each an arbor, passing down through the long plate, and resting on small cocks, *i*, with each a pinion formed at their lower ends, of which one only is seen near *i*, in fig. 5. Immediately under the long plate, or cover *f*, lies another narrow bar, *k k'*, indented at the edge, with which the contiguous pinion acts; this narrow plate is 5 ·4 inches long, and 1 ·1 wide, and is indented through 4 ·2 inches, leaving 0 ·6 at each end without teeth. The divided scale *l l'*, which lies above the long covering plate, and parallel to the subjacent indented bar, is made fast to the latter by two strong steel screws, that pass through a long perforation running parallel to the side of the long plate, and as the pinion *g* is turned, and moves the indented bar, the scale, thus connected with it, moves also; the parallel direction being preserved by the stems of the said screws, sliding without shake along the opening with parallel sides, made in the covering plate *f f'*, under the scale. Below each end of the indented bar, at *k* and *k'*, are attached small cocks in which the ends of a long bar of glass *r r'* are fixed, with its sides cemented to the under face of the indented bar; so that when this bar and attached scale are moved by the pinion, the glass also moves with them. The scale is seven inches long, but is divided only about 6 ·55 of that length, into one hundred and sixty divisions and subdivisions, numbered 0, 10, 20, &c. at the longer strokes. Another plate *m m'*, cut away except at the two ends, contains a pair of verniers, one or the other of which always reads with the divisions on the graduated scale, whatever may be its position, as it regards right and left. This vernier plate, *m m'*, is fixed in the same manner as the scale *l l'*, by two screws, passing through a second long parallel opening in the covering plate, to a second indented bar, in every way like the former bar *k k'*, and also carrying a second bar of

glass cemented, and screwed to it underneath. A part of the second opening is seen at *n*, and at *o* a portion of the second indented bar, which is turned by a second pinion on the lower end of another arbor, carrying the milled head *h*: so that when the head *h* is turned, the verniers and attached subjacent bar of glass are moved by it, in a line parallel to the scale. The two bars of glass, which are each almost five inches long and 0 ·8 wide, are nicely ground to a straight edge, and placed with those edges in contact, as seen within the central circular hole *p*, made at the middle of the long cover. The extreme end of the second glass bar is visible at *q*, near the end of the second indented bar, holding one of its cocks visible in fig. 4, and also in fig. 5, where it appears as a continuation of the first glass bar *r r'*, though at the remote side of the centre. These glass bars are about two tenths of an inch thick at one end, and something more at the other, the faces deviating a very little from parallelism; and as the ends are reversed they refract in opposite directions, and consequently produce two images of an object in all relative positions, except when their ends coincide, which is their zero position, where they give but one image. The head *g* will carry the scale over fifty-one divisions, and the head *h* will move the vernier plate over forty-seven, so that the whole effective portion of the scale is measured by ninety-eight divisions: and as the pinions will carry the scale and verniers in either direction, to the right or left, a measure may be taken to the whole extent of ninety-eight divisions, on either side of zero, which mode of application makes the index error vanish.

2. On applying this micrometer to an achromatic telescope of 67 ·5 inches focal length, (our No. 3.) we found that it affected the place of distinct vision only about the tenth of an inch, and as it elongated the focal distance, the curve of the glass bars must be concave. When this telescope was directed to a distant object, and a spider's-line micrometer applied, as its eye-piece, to a piece of tube that screws into the central hole of the covering plate, the greatest angle, that the double image micrometer, at its position ninety-eight on the scale, would measure, was found equal to 7 ·17 revolutions of the other micrometer's screw, the value of which angle with this telescope is 3' 31" ·37 (pages 103 and 104), which, being divided by ninety-eight, gives 2" ·157 for the value of a single division, or 0" ·2157 for the value of unity on the vernier. The length of this eye-tube is about four inches and a half, but it contains an inner tube holding the eye-piece in its cell, which draws out upwards of three inches, to increase the distance of the focal point from the pair of glass bars of the micrometer; and when this inner tube is drawn out just two inches, so as to make the whole distance, from the focus of the positive eye-piece to the nearest face of the glass bars, = 7 ·85 inches, the greatest measure is increased to 4' 43" ·31, or 9 ·61 revolutions of the spider's-line micrometer, in which position the value of one division becomes $\frac{283".31}{98}$ = 2" ·891, showing that the value of the scale is different at each position of the inner sliding tube. To ascertain practically the nature of this change in the values of the scale, the tube was put back one inch, just half the distance it was before drawn out to, and the greatest measure was then found 8 ·39 revolutions only, or 4' 7" ·34, giving the value of one division now only = 2" ·524, which is just a mean between the other two determinations; this proves that the difference are constant, and that therefore the graduations on the inner tube, if formed into a scale of positions, would be equal divisions. This elongation of the eye-tube gives a property to the micrometer that we have called polymetric, and which the inventor in conversation had not mentioned.

3. At first sight there appeared to be a great resemblance between this micrometer and Ramsden's dioptric micrometer, as made by Mr. G. Dollond (§ XXXI); but on closer inspection this resemblance disappeared. In the instrument before us the cone of rays is divided at the distance of nearly six inches before the focal image is formed, and the eye-piece is of the celestial kind; whereas in the older construction the separation takes place close to the third lens of a terrestrial eye-piece. This micrometer has a circle for measuring angles of position, which the other has not; and will measure angular distances equally well at both sides of zero, which the other has not the means of doing. In this the scale and vernier are moved separately by their own pinions, from the position in which the instrument is packed; in the other one pinion turns both racked bars in contrary directions, by giving motion to the second pinion through the intervention of a wheel, acting with both; and its vernier is fixed so as to have zero of the scale at the index, when the two slips of glass, forming a portion of a concave lens, are drawn out to their full extent, the measure being taken in their return to the situation for packing: which is just the reverse of Amici's glass bars. In the Italian instrument a little more than one-half the

length of the scale is available at one measure, the verniers being at opposite ends; but in the English instrument the whole scale passes before the vernier, which has its station at the middle. In one the value of the scale is fixed, in the other it is variable. Hence, though there is a strong resemblance in principle, the constructions are dissimilar in various respects. They are, however, both liable to three inconveniences in use; first, their weight is too great for a telescope of ordinary dimensions, when mounted on the centre of gravity; secondly, they require the object to be seen near the centre of the field of view, to exhibit both images of the object, and with equal distinctness; and thirdly, the central portion of the large lens from which the bars are cut, are partially taken away in grinding them straight, thereby preventing exact superposition of the two images, which disjunction, in taking the distance of close stars, is objectionable; as something is left to estimation. But this indeed is the case, more or less, with all double-image micrometers depending on divided lenses, except perhaps the object-glass micrometer, in which sometimes an interposed slip of brass separates the semi-lenses, and supplies the place of the vitreous matter removed from the centre of the curve, by grinding the edges into a true shape. But the inconvenience peculiar to the micrometer we have here described is, that it cannot be applied to a common telescope till the total length of its tube has been shortened by five or six inches; yet when it has been so shortened, the spider's line micrometer may be substituted for an eye-piece, and then the measure of angular distance may be taken by either of the two micrometers, or indeed by both at the same time; and the parallactic line of the second micrometer will serve admirably to refer the angle of position to, when it is illuminated; for the two micrometers may be turned round together, from the equatorial position, till the spider's line, commonly called the horizontal wire, just covers all the four images, which is easily effected, when the telescope has a parallactic motion; and the position in which they form a straight line is that in which the angle of position is obtained, on the limb of the divided circle, as heretofore explained (§ XLIV).