JOURNAL OF THE ROYAL MICROSCOPICAL SOCIETY;

CONTAINING ITS TRANSACTIONS AND PROCEEDINGS,

AND A SUMMARY OF CURRENT RESEARCHES RELATING TO

ZOOLOGY AND BOTANY

(principally Invertebrata and Cryptogamia),

MICROSCOPY, &c.

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FELLOWS OF THE SOCIETY.

Minimis partibus, per totum Naturæ campum, certitudo omnis innititur quas qui fugit pariter Naturam fugit.—*Linnæus.*

FOR THE YEAR

1900.

LONDON:

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20 HANOVER SQUARE, W.;

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NOTES.

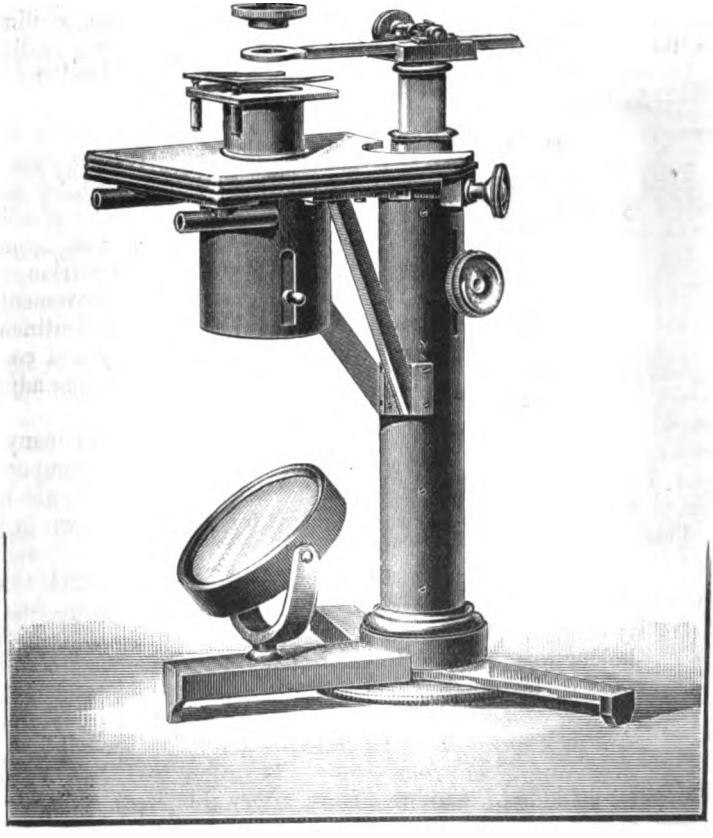
The Microscopes of Powell, Ross, and Smith.

By Edward M. Nelson.

II.—ANDREW ROSS'S MICROSCOPES.

The name of Andrew Ross first appears in the *Transactions* of the Society of Arts,* in connection with a Microscope he made in March 1831, for Mr. W. Valentine of Nottingham. At this time Mr. Ross's address was 5 Albemarle Street, St. John's Square, Clerkenwell; and it is probable that he was a philosophical instrument maker to the

Fig. 104.



* Vol. xlviii. p. 413 (1832).

trade, and that Mr. Valentine, in getting him to carry out his ideas, preferred to deal direct with the actual maker rather than through any of the retail opticians, who merely engraved their names on the instruments made by Messrs. Ross, Powell, and others.

Mr. Valentine's Microscope was a very good one in its day. It has been repeatedly figured, but important details in its construction, which have had much influence on the evolution of the Microscope, have been passed over without notice.

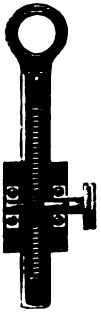
Description of this Microscope.—The foot was a flat folding tripod, fig. 104—a common form at that time; it was subsequently altered to a solid flat tripod. Stage—mechanical with slow rectangular movements, actuated by direct-acting screws.

This movement was a sort of fine adjustment stage movement, the coarse adjustment being the movement of the lens over the object; it should be remembered that for about three-quarters of a century it had been the custom to fix the object and move the lens over it.

Illumination.—Wollaston's illuminating apparatus, fig. 105, or a modification of it, as shown attached to the Microscope in fig. 104.

FIG. 105.

FIG. 106.



Focussing.—These movements were three in number:—1st, by drawing out the inner triangular bar; 2nd, by rack-and-pinion work, which moved the middle triangular bar; 3rd, by fine adjustment screw, which moved the outer triangular bar. So in principle the movement is not unlike that of the modern Continental Microscope, where the body and coarse adjustment are carried by the fine adjustment screw.

This Microscope was, like many of that date, both single and compound. The lens-holder, for either a single lens or a Wollaston doublet, is shown in fig. 106. These lenses, although non-achromatic, were excellent; their fields and apertures were small; nevertheless they gave very good images. I have in my cabinet a Wollaston doublet which shows tubercle bacilli. The lens-holder was attached to the top of the inner triangular bar by means of a conical pin; the lens was therefore capable of a motion in arc over the preparation as well as that given to it by means of the extension rackwork. This movement—a very convenient one for a simple dissecting Microscope—owes its origin to Ellis's Aquatic Microscope, made by J. Cuff in 1755; afterwards Benj. Martin was the first to add rack-and-pinion to the extension and a worm-wheel to the tangential movement.

The compound body was attached to the inner triangular bar by a conical pin, in the same manner as the lens-holder (fig. 107).* The important part of the Microscope lies in its fine adjustment; the screw with 50 threads to the inch had its head divided into 100 parts, and placed below the foot. This Microscope resembled, in three points, Adams's Universal Microscope of 1746, for both had upright pillars, both flat folding tripod feet, and both had the heads of their fine

FIG. 107.

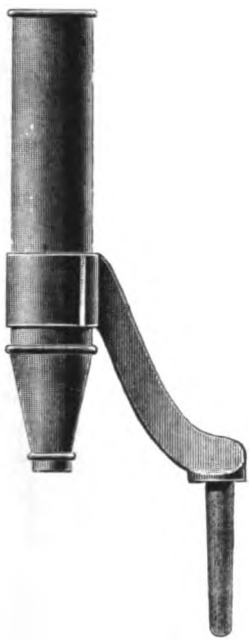
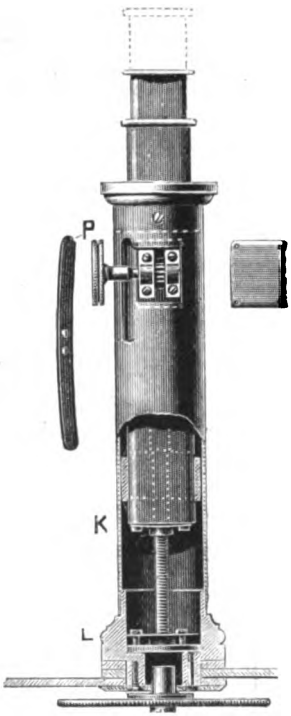


FIG. 108.



adjustment screws below the bases of their pillars; Adams's, however, was a stage focusser. This is the first instance we meet with of the head of a fine adjustment screw divided for micrometrical purposes; and it was the suggestion of Mr. R. H. Solly, whose liberality in defraying the cost of the plates illustrating these early Microscopes enables us to

* Mr. J. Mayall, junr., figures this Microscope, with the compound body and Wollaston condenser attached, in the Cantor Lectures of the Society of Arts for 1888, p. 14, fig. 20, but he has failed to note its identity with Valentine's Microscope. Had he known that an important feature in this Microscope was copied from a Microscope designed by C. Varley, he would probably have modified his adverse criticism on the latter's work.

ascertain many important facts with regard to their construction. But to return to the fine adjustment:—it had a sprung nut K, fig. 108, and also a sprung bearing for its lower portion at L, to prevent loss of time in its action. The spring in the rack-slide of the lens-holder, fig. 106, and also the spring P, fig. 108, which fits inside the round pillar, and presses the triangular bar into one of the angles of its slide, will be noticed. From the text we learn that this springing of the fine adjustment was copied from a Microscope designed by C. Varley,

FIG. 109.

which is figured and described in the same volume of the *Transactions* of the Society of Arts.* From the above account it will be seen that this first Microscope of Andrew Ross, or at least the first issued under his own name, was an excellent and thoroughly practical construction.

In 1832 we find Andrew Ross at 15 St. John's Square, Clerkenwell, and achromatic objectives bearing his name with this address upon them are still extant. In 1838 his address is 33 Regent Street.

* See figs. 72, 73, *ante*, p. 284.

Piccadilly, and in 1839 the article "Microscope" in the *Penny Cyclopædia*, written by him, was published. In this article is figured a simplified form of Valentine's Dissecting Microscope, fig. 109. It has no fine adjustment, but as there is a thoroughly well sprung rackwork coarse adjustment acting upon a triangular bar, its focussing

FIG. 110.

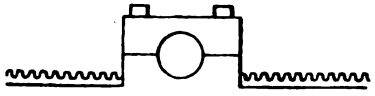
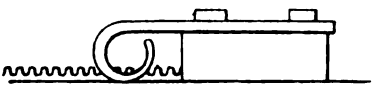
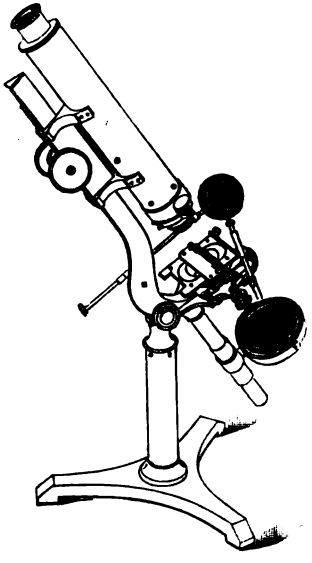


FIG. 111.



capabilities are quite equal to the work it is intended to perform. The springing of the coarse adjustment pinion of this Microscope was an advance upon that of Valentine; for while Valentine's was like fig. 110, this Microscope had one like fig. 111. This kind of sprung coarse adjustment was first used in C. Varley's Vial Microscope, made by Hugh Powell in 1833, and it is even now by far the best method of mounting the pinion; but it has been given up by all manufacturers except Powell. This instrument is very portable, for the pillar unscrews from the foot, the mirror unships, and the two screws seen at the back liberate the stage, which can be packed flat in the case. This Microscope is also figured in vol. iii. p. 220 of the *Quarterly Journal of Microscopical Science* (1855).

FIG. 112.



The next Microscope, a compound, fig. 112, is also figured in the *Penny Cyclopædia*. The foot and pillar are similar to those of the dissecting stand, but the feature that at once attracts attention is the Lister limb supporting a cradle which carries the body. It has been thought that this form of mount was suggested by Mr. G. Jackson; but we learn, from a note in the *Quarterly Journal of Microscopical Science*,* that the editors have Mr. Jackson's authority for saying that it was originally made by Mr. Ross. The fine adjustment is of the short lever nose-piece type. Although the name of the inventor of this kind of fine adjustment is not stated, it is pretty certain that it was Andrew Ross. James Smith fitted a somewhat similar arrangement to one of his early Microscopes in 1839. The stage is mecha-

* Vol. i. p. 219 (1853).

nical, with rectangular motions performed by two racks and two pinions, both pinions being at right angles to the stage, in which respect Smith's Microscope was also similar. An achromatic condenser could be fitted beneath the stage instead of the rotating diaphragm. The compass joint was supplied with a screw clamp to fix the instrument at any inclination.

FIG. 113.

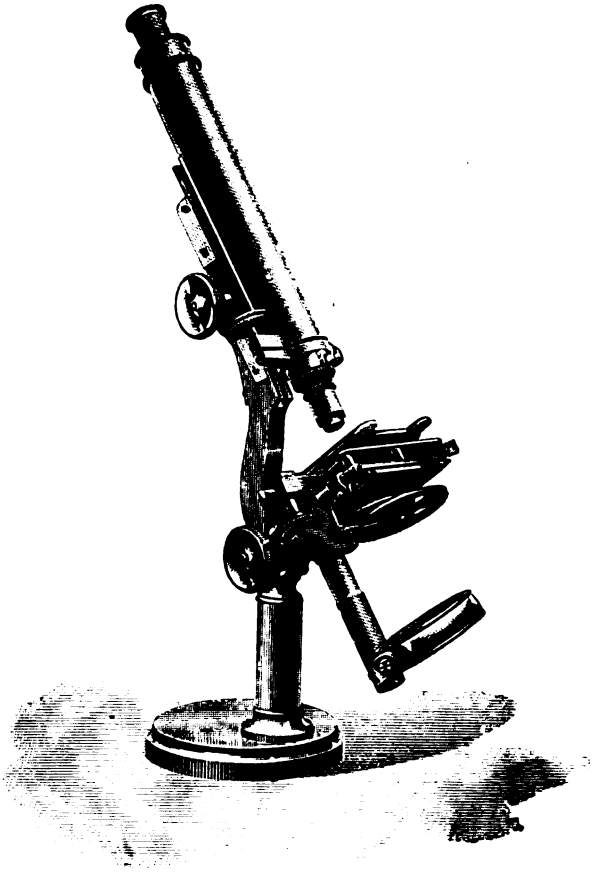
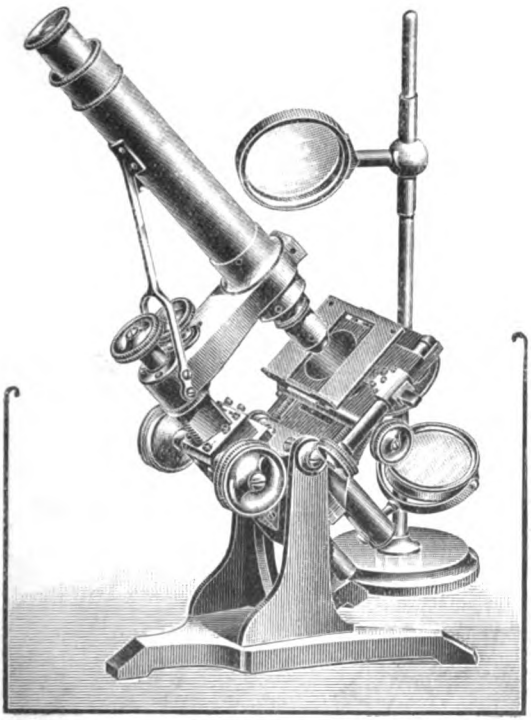


Fig. 113 shows the next stage in the evolution of Ross's Microscopes. Here the Lister limb is retained, but the cradle is dispensed with, the limb itself being grooved and the rack attached to the body. This capital form of mount was designed by Mr. Jackson, but it is impossible to say who was the first manufacturer to carry it out practically. We know that both Powell and Smith adopted this plan in 1841, and probably Ross made this Microscope in that year. The

fine adjustment and the stage remain as before; the lower part of the stage is better seen in this figure; the rotating diaphragm is attached to a plate, which slides in grooves below the stage; it is removable, and an achromatic condenser can be inserted in its place. The large lower milled head is the clamp of the compass joint. The foot is circular and capable of rotation, so that the greatest amount of stability can be secured when the instrument is used in either an inclined or a vertical position. This excellent idea, which was first introduced by Cuff in 1765, is still carried out.

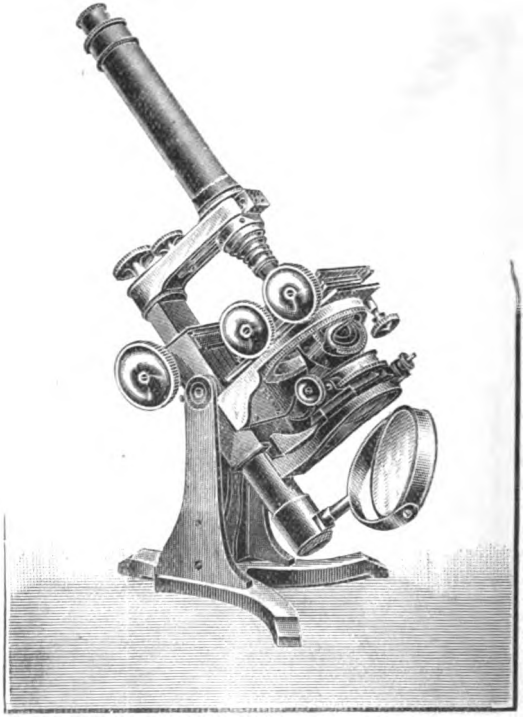
Fig. 114.



Andrew Ross's next model was constructed upon a totally different plan, as we can see from fig. 114, which is copied from a very rare book, the *London Physiological Journal* for Dec. 1813. This figure is so clear, and the model so well known, that a description is superfluous; the following improvements may however be pointed out. The hanging of the instrument between two supports is far preferable to the former method of fixing it upon the top of a compass joint; this, as we have seen, was the invention of George Jackson; its centre of gravity is lowered, and its poise is in every way better.

The pinions of the rectangular movements of the stage, though placed at right angles to one another, are both in the same plane as the stage. By placing the fine adjustment lever inside the transverse arm, a far steadier movement is secured. The coarse adjustment, obtained by racking a well sprung and stout triangular bar out of the limb, is a very sound construction, which yields a smooth and steady movement, and which also possesses the advantage that the milled heads of the pinion are brought down closer to the table. Compare this with figs. 112, 113. The substage arrangements are

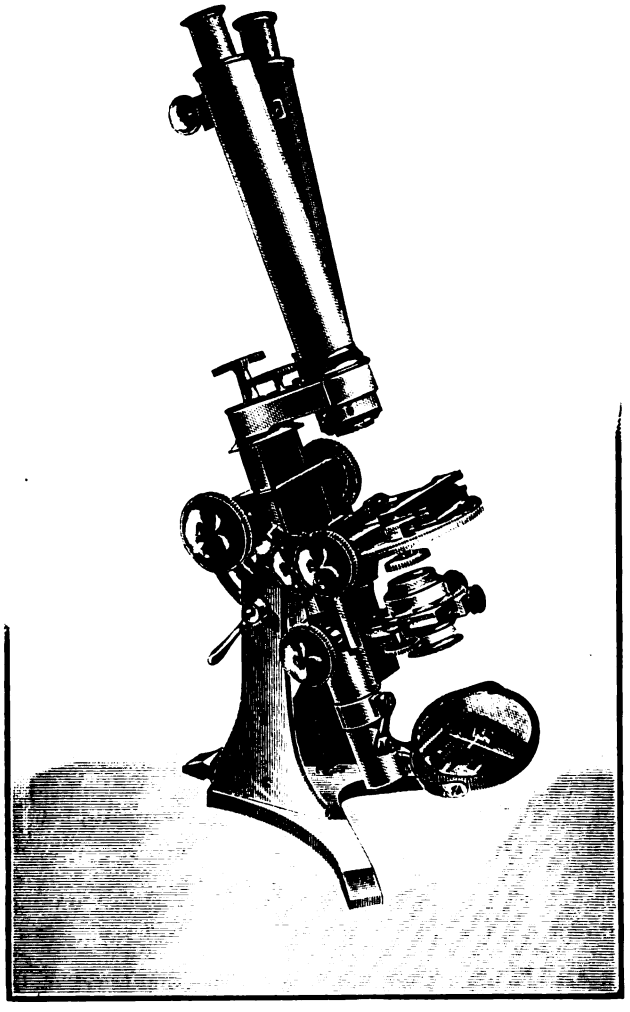
FIG. 115.



the same as in the previous model. There is one feature this Microscope possesses which has been generally overlooked, viz. that the body, together with its transverse arm, can be removed, a plain arm can be substituted for the purpose of carrying a single lens or a Wollaston doublet, so this instrument can be used either as a simple or compound Microscope. About 1847 Andrew Ross moved to 2 Featherstone Buildings, Holborn, and about 1850 a new model was brought out; but fig. 115, taken from the 2nd edition of Quekett (1852), plate 11, dated 1851, shows that the general form of the instrument

remained much the same as it was before. The following alterations may be enumerated :—1st, a rectangular bar was substituted for the triangular bar in fig. 114, and the back-stay to the body was omitted ; 2nd, the pinions controlling the rectangular stage movements were

FIG. 116.



placed parallel instead of at right angles to one another ; 3rd, concentric rotation was added to the stage ; 4th, a complete substage with rectangular and rotary movements was supplied.

It is highly probable that this model was prepared for the Exhi-

bition of 1851; but we are unable to obtain any information on the subject from the Report of the Jurors of the Microscopical section. This was the last Microscope Andrew Ross designed. He died in 1859, and was succeeded by his son, Thomas Ross.

Thomas Ross prepared for the Exhibition of 1862 a new model very similar to the previous one, the chief difference being the addition of a binocular body, fig. 116. This form of binocular, which was invented by Wenham in Dec. 1860, is by far the best of all the contrivances that have as yet been introduced. The stage was made a little thinner, and the diameter of the substage tube was altered from 2 in. to 1·527 in.

On March 15th, 1843, Ross delivered the Microscope which had been ordered by the Microscopical Society of London on May 26th, 1841; but unfortunately we are now unable to determine what that Microscope was like, because it was exchanged in 1863 for the binocular Microscope in our cabinet, which was made by Thomas Ross, fig. 116. The original Andrew Ross model must have been like either fig. 113 or fig. 114. If we assume that it was like the latter figure, which was then an entirely new pattern, some time must have been taken with alterations and adjustments, and so the delay in its delivery would be accounted for.

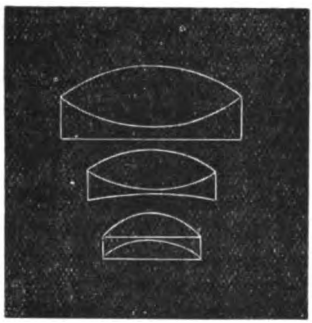
THE OBJECT-GLASSES OF ANDREW ROSS.

The first achromatic Microscope object-glass constructed in this country was made to the order of Dr. Goring by W. Tulley, the telescope maker, of Islington, in 1824; it was an uncemented triplet, and cost 90*l*. Mr. J. J. Lister, in 1824, began experimenting with achromatic object-glasses; on seeing a 4/10 and a 2/10 which Tulley had made for Dr. Goring, he suggested some improvements, the result of which was the production of the celebrated 9/10 by that firm. Subsequently Mr. Lister ground and polished lenses himself. On January 21st, 1830, he read his paper on the two aplanatic foci before the Royal Society. In 1837 he designed an 1/8 object-glass for Andrew Ross. This had a triple front (Mr. Lister's invention) and two doublets (fig. 117); for the lower powers he suggested a double combination, which was formed by combining a front (one of Andrew Ross's failures) with one of Lister's backs (this is Lister's own account; but, according to Ross, it was a Lister front that was combined with a Ross back). I am rather inclined to think that there is a clerical error in Lister's account, and that Ross is correct. If this is so, then the lens will have a back similar to the middle combination of the lens in fig. 117 and a front of the form shown in fig. 121. In 1840 Lister obtained Ross's consent to instruct James Smith in the construction of object-glasses; he says, "even in 1843 it was with the understanding that he should not go to deeper powers than 1/4 in.,

and 'Smith's quarters' were long in repute. Some variations too have been since made in the construction in which I have had no part; but for all, the principle of the two aplanatic foci has furnished the clue."

Andrew Ross began making Microscope object-glasses in 1832; the following list gives a tabulated history of his work. One of his

Fig. 117.



most important discoveries was that of the aberration caused by the cover-glass (1837), and its method of correction by lens distancing was suggested to him by Mr. Lister's paper on the two aplanatic foci. In 1849 Ross added a correctional collar to the Gillett's condenser; he was also the inventor of the silver side reflector in 1836.

In 1855 Mr. Wenham made the correcting collar of objectives in such a manner that it moved the back lenses of the combination

Fig. 118.

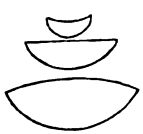
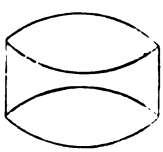


Fig. 119.



instead of the front; this constituted a real advance, and this plan has now become general; it is mentioned here because Ross made lenses from formulæ supplied by Mr. Wenham. In 1850 Ross made a chromatic condenser consisting of three lenses; the front was a hemispherical meniscus, the middle a plano, and the back a crossed lens; this lens was designed by the Rev. W. Kingsley, professor of mathematics at Cambridge (fig. 118). It was a very good condenser for a non-achromatic one, and its performance was not unlike Abbe's three-lens

condenser; it however did not become popular here, as the achromatised condenser was preferred.

Date.	Focus.	Angular Aperture.	N.A.	Character.	Remarks.
1832	1	14°	·12	Two achromatic doublets	Made for Mr. R. H. Solly.
1833	1	18°	·16	Uncemented triple	Tulley's form.
1834	1/4	55°	·46	.. ..	Belonged to Prof. Quekett.
1836	1	15°	·13	Cemented triple	Fig. 119.
1837	1	22°	·19	Designed by Mr. J. J. Lister	Fig. 117.
„	1/8	64°	·53		
1842	1/2	44°	·37		
„	1/4	63°	·52		
„	1/8	74°	·60		
1843	2	10°	·09		*London Physiological Journal.*
„	1/6	66°	·55		
„	1/12	90°	·71		
1844	1/8	85°	·68	Copied from objectives constructed by Prof. Amici	
„	1/12	135°	·92		
1848	2	12½°	·11		From 1st edition of Quekett.
„	1/12	120°	·87		
1851	1	27°	·23		Report of Jurors, Exhibition 1851.
„	1/2	60°	·50		
„	1/5	113°	·83		
„	1/8	107°	·80		
„	1/12	135°	·92		
1852	1/4	75°	·61		2nd edition of Quekett.
„	1/4	105°	·79		
„	1/12	150°	·97		
1855	1/2	65°	·54		3rd edition of Quekett.
„	1/4	120°	·87		
„	1/6	135°	·92		
„	1/8	150°	·97		
„	1/12	170°	·99		

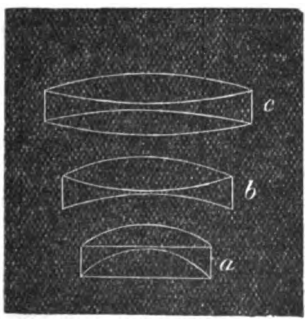
The following (see next page) are in the possession of the author. The numerical apertures and the optical indices are from actual measurement.

It is very difficult at this date to ascertain who was the inventor of the various improvements in objectives; nothing was published about any improvement at the time of its introduction, and much secrecy was observed. I should be disposed to regard Ross's 1832

Date.	Focus.	N.A.	O.I.	Character.	Remarks.
1836	1	·14	12·7	Cemented triple, fig. 119	Address, 15 St. John's Sq., Clerkenwell.
„	1/2	·19	7·9	„ „	
Post 1837	1	·21	16·7	Two doublets and triple fronts, fig. 117	A fine lens.
Ante 1837	1/2	·28	12·7	Three doublets	Well corrected. Address, 33 Regent St., Piccadilly.
„	1/4	·40	9·5	Ditto, ditto. No correction collar	Well corrected.
Ante 1847	1/4	·54	9·8	Correction marked, covered and uncovered. Two doublets and triple front, fig. 117	Well corrected.
1854	1/6	·93	12·9	Three doublets and single front. An early example of single front lens. The mount, which is dated, is very massive, and weighs 4 oz. A fair lens. Correction collar graduated	
Circa 1840	1/12	·81	6·2	Correction marked covered. Triple front, triple back, double middle, fig. 120	Well corrected.
1856	1	·21	19·1	Two doublets, front fig. 121, back same as middle, fig. 117	Not so good as 1-in. above; lens is dated.

objective as a copy of a Continental one, and his 1833 objective as a copy of Tulley's. The triple front, fig. 117, was undoubtedly due to Mr. J. J. Lister.

FIG. 120.



Mr. Wenham, writing * in 1869, claims to have been the inventor, about the year 1850, of the single front; but in an article written by him for the third edition of Quekett in 1855, he does not even mention

* Mon. Micr. Journ., i. (1869) pp. 111, 170.