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CONTAINING ITS TRANSACTIONS AND PROCEEDINGS,

AND A RECORD OF CURRENT RESEARCHES RELATING TO

INVERTEBRATA, CRYPTOGAMIA, MICROSCOPY, &c.

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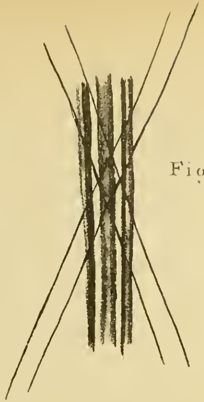

Fig. 1

Fig 5.

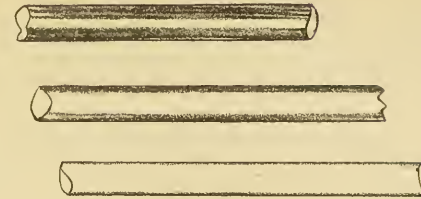

Fig. 2

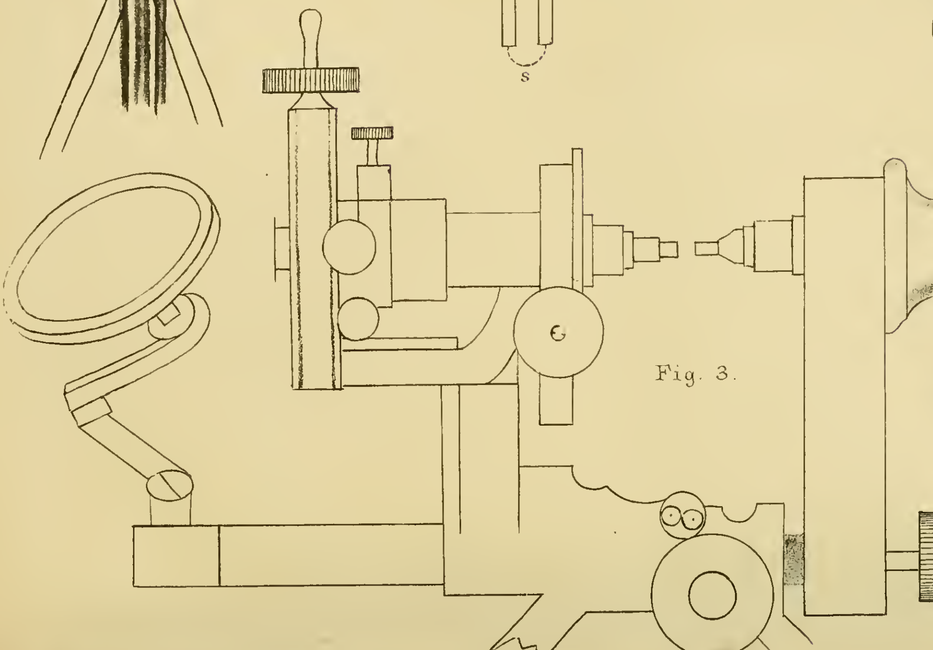

Fig. 3.

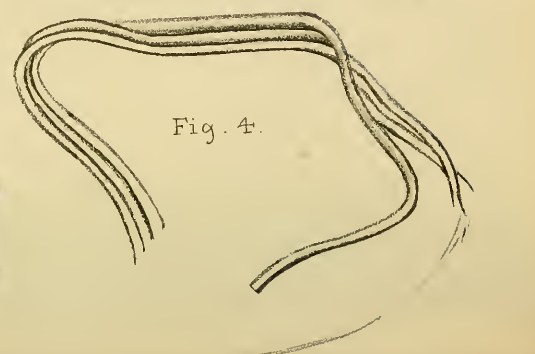

Fig. 4.

Royston-Pigott del.

Limits of Microscopic Vision

West Newman & Co. lith

II.—*A Further Inquiry into the Limits of Microscopic Vision and the delusive application of Fraunhöfer's Optical Law of Vision. No. II.*

By Dr. Royston-Pigott, M.A., F.R.S., &c.

(*Read 13th November*, 1878.)

Plate III.

The writer has been more particularly led into the present subject by the wide-spread belief that the limit of microscopic vision has been reached by the resolution of Nobert's lines drawn at the rate of 112,000 per inch, which probably gives the 1–200,000th for the diameter of the smallest line supposed to be visible. It will not be uninteresting to relate the history of this belief.

The celebrated Fraunhöfer (as stated in his Memoir to the Bavarian Academy of Sciences, June 14, 1823) succeeded in ruling lines as close as 30,000 to the Paris inch, which he found totally invisible with the Microscope. He also announced that if λ be the wave-length, and the light fell perpendicularly to the surface of the ruled glass, sine $\theta^{(n)}$ would become imaginary, and therefore the lines would produce no coloured spectra; and he concluded, says Sir John Herschel, "that an object of less linear magnitude than λ can in consequence never be discerned by Microscopes as consisting of parts." *

The skilful optician Nobert, believing in this result obtained by Fraunhöfer, utterly despaired that anyone would ever succeed in descrying his finest lines on glass.†

Now with regard to this very conclusion of Fraunhöfer, Sir John Herschel regards it as "one which would put a natural limit to the magnifying power of Microscopes, but "which," says he, "we cannot regard as following from the premises" (*sic*). ‡

Well, Dr. Woodward first achieved the honour of resolving these lines with a Powell and Lealand $\frac{1}{16}$ immersion in 1869; § and in consequence of the grave doubts expressed by their maker, he wrote to Dr. Barnard, a distinguished mathematician (Pres. Columbia College), who replied that "with an objective that takes

* Art. "Light," 'Encyc. Met.,' p. 490.

† Nobert thus wrote to Dr. Colonel Woodward, U.S., dated Barth, Feb. 26, 1869. He expressed his belief that the resolution of the higher bands is an impossibility when light is permitted to fall on closely ruled lines. "The formula," says he, "sin. $x = \frac{\lambda}{b}$ (Fraunhöfer's), if by λ we designate the length of the undulations, by b the distance between two lines of the grating, and by x the angle of the refracted rays, gives for sin. x an impossible value when b becomes less than λ;" that is to say, when the distance between two lines is less than a wave-length, the lines will become invisible.

‡ 'Encyc. Met.,' art. "Light," p. 490.

§ See 'Month. Mic. Jour.,' Dec. 1869, quoted by Dr. Woodward.

in a cone of an angle of from 140° to 175° it is nonsense to talk of this question as settled by theory. We shall continue to see closer lines just in proportion as Microscopes and modes of illumination are improved." *

That has long been the firm opinion of the writer. In the first paper on the subject of the limits of vision, he stated, "I believe this limit has not yet been reached;" † and farther on, p. 181, "With special adaptations to subdue or destroy the brilliant diffractions of too bright an illumination, many minute details before completely effaced may be brought into distinct revelation." When these remarks were made, the microscopical world had been recently favoured with the beautiful formula introduced independently, I believe, by Professors Helmholtz and Abbe, in which further elucidation of the principle was given by a new formula including the semi-angle of aperture of the objective used. Applying these similar results, I obtained, for mean rays of wave-length, $\frac{1}{46182}$ of an inch (46,000th nearly) the following results:—

A Table of Proportionate Resolving Powers ‡ (some of the details of which were as follows):—

Full Aperture of Object-glass.	Proportionate Resolving Power.	Semi-aperture.
179°	sin. α = 99996 per inch	$89\frac{1}{2}$°
175°	sin. α = 99905 ,,	$87\frac{1}{2}$°
150°	sin. α = 96590 ,,	..
120°	sin. α = 86600 ,,	60°
12° 38′	sin. α = 11000 ,,	6° 19′

I hope to show in the following paper that however truly this optical law may be deduced from the premisses, it utterly fails for minute dark lines.

An announcement that it is possible to descry with microscopic apparatus the millionth of an inch would be almost too startling to believe. The human eye can distinguish a hair under favourable conditions of light and background subtending an angle of even less than a second. The black line dividing close double stars, such as Xι Ursæ Majoris, which are both of the same (fourth) magnitude, does not subtend in the telescope with a power of 300 diameters many seconds of arc. Besides this, the Microscope differs only from the telescope in the length of its focus and smaller aperture, which, according to received dogma, gives great advantages of vision to the instrument with so great an angular aperture. We cannot doubt, either, from the tales of travellers, that birds of prey possess exceedingly acute vision, by which they can descry small objects at a

* See 'Month. Mic. Jour.,' Dec. 1869, quoted by Dr. Woodward.
† P. 175, 'M. M. Jour.,' Oct. 1876. ‡ P. 181, ibid.

great distance. I myself knew a friend who could see with the naked eye Jupiter's satellites, and dot down their position though ignorant of astronomy. If a simple organ of sight can distinguish such objects as subtend only a second or two, it would seem strange that modern glasses can only show objects presenting many seconds to the eye at the last visual image formed in the eye-piece.

In the following observations I shall endeavour to substantiate a fact apparently irreconcilable with the results of the now famous formula.*

In point of fact, the opinion has now become established both in Europe and America, that Nobert's lines 112,000 per inch (or lines of that size) are the closest that can be seen; and that the law enunciated in the footnote forbids the hope of farther advance in minute definition.

Now, considering the readiness with which a fine horsehair can be distinguished against a light cloudy sky, as also spider lines at several feet distance, I determined to mount upon glass several spider threads and measure their diameter by means of Browning's spider-line recording micrometer. After many trials, I found the smallest of these measured 1–35000th in diameter (Fig. 4).

I measured them by means of Powell and Lealand's magnificent $\frac{1}{8}$ dry lens. On this spider thread I could perceive irregularities, nodules, and marks; but the general thickness was remarkably true. Some others measured $\frac{1}{16000}$, $\frac{1}{18000}$, and coarse agglomerations, cord-like, were as thick as fine spun glass $\frac{1}{3000}$th.

It then occurred to me to make a novel use of the "Aerial Micrometer" formerly described by me, consisting of the "Browning" inverted beneath the sub-stage, as also placed in a reversed position (see Fig. 3).

The law established contains two remarkable elements: the kind of light, i. e. the length of the wave, and the aperture of the objective. For blue light (wave $\lambda = 53000$ per inch) intermediate between blue and indigo, this, with an aperture of 150°, would give

$$\left.\begin{array}{r}\text{Extreme limit of}\\ \text{visibility}\end{array}\right\} \epsilon = \frac{\frac{1}{53000}}{2 \sin. 75^\circ} = \frac{1}{53000 \times 2 \times \cdot 960}, \text{nearly} = \frac{1}{102000}.$$

* This is thus stated:—

If ϵ represent the smallest interspace recognizable between two bright lines or disks, on the condition that the diffraction fringe of one does not overlap that of its neighbour; and

If λ be the length of the wave of light under consideration, which for mean rays equals $\frac{1}{46182}$ of an inch; and

If α be the semi-aperture of the objective,

$$\epsilon = \frac{\lambda}{2 \sin. \alpha} = \frac{\lambda}{2} \text{ (when aperture } = 180^\circ\text{)},$$

and

$$= 1\text{–}96590\text{th (when aperture } = 150^\circ\text{)}.$$

So that with the more favourable blue ray the smallest interval visible among contiguous bright disks or lines is about one hundred thousandth of an inch, and that only with the largest aperture. Such is the belief disseminated.

About ten years ago I requested Messrs. Beck to make for me an "iris diaphragm" with "adapters" on each side. By this ingenious contrivance, screwed between an objective and the body, the angular aperture could be instantly reduced at will.

It seems, on the face of it, not a little surprising, considering this famous optical law, that the visibility of lines of great minuteness is very little affected by great reduction of objective aperture, by means of this instrument, or by using low-angled objectives of sufficient power and excellence of manufacture. Apparently this is another failure of the celebrated law, as roundly stated and generally received.

It will be convenient to explain here two practical points:—

A.—*The method used in finding the diameter of the spider lines enclosed within the micrometer.*

B.—*The method employed in measuring the absolute reduction of the object in miniature.*

A.—The Rev. Mr. Dallinger has given us his beautiful measurements of the flagella in monads, by drawing an equivalent line with a very hard fine pencil on white paper, by means of the *camera lucida.* By this process he, after a great many observations, determined its diameter to be less than the two hundred thousandth of an inch.

The plan I adopted was by finding divisions on glass placed in the focus of the eye-piece which appeared perfectly coincident in diameter with the observed spider line; and then substituting a scale of a hundred thousandth of a metre, a most careful measurement was made of the apparent size of the diamond cut. The process was much facilitated by altering the length of the draw tube, and changing the objective until the most acceptable result was arrived at. I am indebted to Mr. Beck for the use of an exquisite scale of this kind, as also for the loan of $\frac{1}{20}$th objectives, dry and immersion, which latter has reduced the miniature to the extraordinary minuteness and precision of definition, at seven inches, of one hundred and forty times less than the object.

On examining spider threads, gathered after recent spinning, with Powell and Lealand's best $\frac{1}{8}$ dry, and measuring them with the spider-line micrometer inserted in the body, I was charmed with perceiving the characteristic brilliant central band, due to a minute cylindrical lens of great beauty, and perfection of definition: and searching for threads lying flat and in close contact, I found some consisted of four cylinders in contact, showing four bright bands running longitudinally. Taking a pair of these, the cross wires of the micrometer were accurately adjusted in the centre of each bright space, the result for this order of spider was (making the power 1000) with the micrometer

$$\frac{6\cdot7}{10000} = \frac{1}{15000}\text{th very nearly (see Fig. 1).}$$

Different spiders spin much thinner webs, and seem to unite several according to the tension required. Another fibre measured $\frac{1}{17000}$, and some are discoverable $\frac{1}{35000}$th. See Plate III.

B.—The reduction by miniature will be readily understood from diagrams, shown Fig. 3. There are two ways of deciding the ratio of reduction: the one by examining the size of the miniature itself, the other by finding the magnifying power of the apparatus used as a Microscope.

For this purpose it was especially mounted on the arm of the Microscope used to carry the body (exhibited to the meeting).

In these ways it was found that:—

Immersion	$\frac{1}{8}$ Powell and Lealand,	miniatured	36·7	times at	$4\frac{1}{4}$ inches.
„	$\frac{1}{16}$ *b.* Gundlach	„	50·17	„	$4\frac{1}{2}$ „
„	$\frac{1}{20}$ R. and J. Beck	„	140	„	7 „

The distance between object and spider lines in the focus of the positive eye-pieces varied accidentally with the length of the objective mount itself. But the "Beck glass" required seven inches to do it justice, and also to get the miniature sufficiently reduced. It was easy to form the image at any desirable distance, but then the mirror could not be used very well beyond seven inches, nor the micrometer held sufficiently steady without complex arrangements. The one shown is simple and adequate.

The miniature can, it is evident, be carried to any extent; which, however, is limited to certain dimensions depending upon two important conditions—brilliance or darkness. A very brilliant line or disk is enlarged considerably, whilst a dark line is little changed.

If you miniature the sun's disk by viewing an aerial image of it formed by a 3-inch lens (100″ distant), employing a magnificent $\frac{1}{10}$ immersion, you will get a disk reduced 1000 times theoretically; and since $\frac{1}{38\cdot2}$ of an inch is the diameter of the image of the sun formed by the 3-inch lens, its diameter miniatured on the stage is 1000 times less, or

$$\frac{1}{382000} = \frac{4}{100000}\text{* nearly.}$$

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* See 'Proc. Roy. Soc.,' No. 146, p. 428.

But in the microscope it appears quite the ten thousandth of an inch, or nearly four times larger than it ought to be, if light had no undulatory waves. And this too, whilst using the most exquisite glasses obtainable. This tremendous fact shows how hopeless it is to expect brilliant disks to appear of the proper or natural size, if I may so speak, in the microscope.

In view of the extraordinary result of the measurement of solar spectra already alluded to, a very natural doubt will arise in the minds of those who have not had practice in this method of miniature, as to the correct effect of the glasses. Now the best process for solving the doubt is to watch the spider threads successively reduced from ten to fifty times. The operator will find it a slow process, as every possible adjustment of centricity and correction for aberration must be carefully attended to the whole time, as well as arranging the light. It cost me at first about six hours' work. But then the miniatures become so exquisitely smaller, the work in its very novelty becomes fascinating, and encourages one to persevere. The observer will have no chance of splendidly defining the millionth of an inch unless he is accustomed to high-power manipulation, and remembers that both upper and lower objectives must be both corrected by the screw collars for uncovered objects (dry or immersion), and change of distance of the focal images. Something too should be understood of the effect of change of "aperture" upon the appearance of a transparent cylinder of spider silk. It must be remembered that the aperture of the miniaturing objective, as this is used in an inverted position, is greatly reduced as regards the incident pencils emanating from the spider lines.

A pencil of rays proceeding from the cross or intersection of the spider lines about six inches from the back glass, enters it at an aperture of a few degrees only, perhaps ten. Now if a cylinder of glass or spider gum be viewed with a low-aperture objective (say $1\frac{1}{2}$), it will present two black borders, and the breadth of these borders narrows as the aperture is increased, and *vice versâ*. Also when the spider thread is diminished more and more, these black borders appear almost to coalesce until only a black line appears. The middle bright part vanishes with attenuation.

Then it may be further urged that a very fine glass forms miniatures of an object, theoretically, by merely optically reversing the rays as perfectly, indeed more so, than in the enlarged image of the same object. If therefore we can see the minute spider line very perfectly magnified one thousand times, we can, *a fortiori*, see the miniature, which is only fifty times smaller, with great precision. So much for the objection against the accuracy of miniatures formed by an excellently adjusted objective.

But *a crucial test is supplied by observing sets of cross wires separated a small space.* Fortunately I had requested Mr. Browning to put a double set of cross wires, and also a set of parallel wires, in the micrometer. The head of the instrument is divided into one hundred parts, and a half or quarter part is readily seen with the naked eye. I may here observe, when the wires are reduced thirty-eight times by the $\frac{1}{8}$ (as one division of the micrometer is the $\frac{1}{10000}$ of an inch of motion in the wires), a single division for the miniature then reckons $\frac{1}{380000}$th. But I found a quarter of a division made a perceptible difference in the apparent thickness of two coincident webs; *whilst three whole divisions separated the webs* so completely, that a narrow strip of light could be discerned between them (not much room here for swelling or enlargement of the lines!).

I then changed the glasses, putting the best glass in the body, and the older one (both newly formulated) in the micrometer: the definition was not so good. It required $3\frac{1}{2}$ divisions to separate the same lines.

This dividing of close lines by means of a very finely constructed micrometer is quite satisfactory to my mind, and I should hope conclusive as a *crucial* test to others who may witness it that the lines are very truly portrayed.

The following little circumstance has an interest of its own. Having conveyed my instruments home from the London Museum, S.K., I found the webs entirely covered with London dust. Upon getting them, however, into rapid vibration, I succeeded in shaking off nearly the whole before measuring them. A few minute particles adhere here and there; and though these webs are diminished fifty times—i. e. to the 300,000th of an inch—these particles of dust are visible on the web in this state of reduction. This result is the most surprising of all.

It was found that under this reduction (fifty times) it required five divisions to separate the spider lines, or a movement of $\frac{5}{10000}$ of the micrometer, i. e.

$$\frac{5}{50 \times 10000} = \frac{5}{500000} = \frac{1}{100000}.$$

Each division represented here on the micrometer head

$$\frac{1}{500000} \text{ of an inch}$$

in the field of view of the Microscope.

It is interesting to inquire what effect separating the spider lines has upon the discriminating power of vision. The optical conditions of seeing a black line upon a white ground, and separating or clearly dividing between two close minute black lines, are totally different. The researches of Dr. Jurin, 150 years ago, and of Dr. Robinson, F.R.S., the astronomer, on the subject, are very interesting; but no observations have yet been made of the minuteness about to be related. The question arose, Is it possible to estimate a bright space between two spider lines when *total* separation is only the eight millionths of an inch, the lines themselves being the 8000th and the 7000th of an inch respectively, and reduced in the miniature thirty-eight times? Reducing the numbers to decimals, if S be the space reckoned between the centres of the spider lines, it is evident if t and t' be the spider lines in diameters, and x be the required interval (see Fig. 5),

$$x + \tfrac{1}{2}t + \tfrac{1}{2}t' = \text{S};$$
$$\therefore \quad x = \text{S} - \tfrac{1}{2}t - \tfrac{1}{2}t' = \text{S} - (\tfrac{1}{2}t + \tfrac{1}{2}t').$$

The value of S was found by carefully measuring the movement of the micrometer $= \frac{3}{10000}$, which just brought the bright separating interval into view. Therefore we have the required size of interval (considering it diminished thirty-eight times),

$$\begin{aligned} x &= \frac{3}{38 \times 10000} - \frac{1}{2} \cdot \frac{1}{38.8000} - \frac{1}{2} \cdot \frac{1}{38.7000} \\ &= 0{\cdot}00000789 - 0{\cdot}00000164 - 0{\cdot}00000187 \\ &= 0{\cdot}00000789 \\ &\ -0{\cdot}00000351 \\ &= {\cdot}00000438 \\ &= \frac{1}{230000} \text{ nearly,} \end{aligned}$$

or about half the interval between the centres of the wires.*

The astounding sight of wires or webs separated by an interval of light less than the two hundred thousandth of an inch can only be explained by the light being subdued. Indifferent glasses cause diffraction images, besides clouding over the view with residuary spherical aberration much more difficult of cure than the colour. Without this interval—I may say, this extraordinary interval—one might conclude the webs are in some mysterious manner enlarged in the miniature beyond the calculated value. And so they are in poor glasses; for the image appears blurred—swelled, as it were—or adumbrated. But now the lovely precision of definition witnessed in high-class glasses, not only of the webs, but of dust on them and specks on the lamp-glass, precludes any suspicion, in face of this interval, of the enlargement of the lines encroaching much upon its dimensions. Besides all this, as the webs pass and repass

* Putting the decimals into fractions,

$$\text{S} = \frac{1}{127000}; \quad \tfrac{1}{2}t = \frac{1}{610000}; \quad \tfrac{1}{2}t' = \frac{1}{532000}.$$

The above calculation, it must be remembered, refers to the effect of the micrometer screw diminished thirty-eight times by the Powell and Lealand $\frac{1}{8}$ best immersion.

each other, the smallest movement of the screw changes their apparent thickness before division or separation is seen.

The miniatures were measured as follows:—

At Distance. Inches.		Miniature reduced. Times.
$6\frac{1}{4}$	Very old $\frac{1}{6}$ Powell and Lealand	49
$6\frac{1}{4}$	1862 $\frac{1}{8}$ Powell and Lealand (immersion)	58
$6\frac{1}{4}$	1875 $\frac{1}{8}$ " " "	55
7	1878 $\frac{1}{20}$ R. and J. Beck (immersion)	140
7	1878 $\frac{1}{20}$ Beck (dry)	118·6
$6\frac{1}{2}$	1873 $\frac{1}{15}$ Gundlach (immersion)	91·3
$5\frac{1}{2}$	1877 $\frac{1}{8}$ Zeiss (oil immersion)	49
$6\frac{1}{2}$	1863 1-inch Powell and Lealand	6·07
$6\frac{1}{4}$	1851 $\frac{1}{4}$ Andrew Ross	27·6
6	1870 $\frac{1}{2}$ Wray	13·4
6	1870 $\frac{1}{4}$ "	29·5

To accurately adjust the observing and miniaturing objectives in the same optical axis is easily done with low powers. If both are equal in power, the test of the quality is very severe, as I have shown elsewhere.* With a then excellent Powell and Lealand $\frac{1}{8}$ made for me in 1862, and improved by them after its return to the makers, a fog is still seen when observed by their brilliant newly-formulated $\frac{1}{8}$ immersion. But still the spider lines are visible. It is not till objectives of equal and I may say of surpassing beauty of definition are opposed to one another above and below, nose to nose, that their exquisite powers of displaying fine black details are exhibited.

The Gundlach immersion is of very fine quality. On reference to the table, it diminished the spider lines 91·3 times when the distance between them and the miniature was $6\frac{1}{2}$ inches. This gave for the first and second lines ($\frac{1}{8000}$ and $\frac{1}{7000}$th diameter respectively) miniature sizes of

1st web	$\frac{1}{730000}$ of an inch.
2nd web	$\frac{1}{640000}$ "

The sizes of the web No. 1 with the different objectives may thus be tabulated:—

Dist.	Inches focus.				
$6\frac{1}{2}$	1	$\frac{1}{4}$ Ross	$\frac{1}{6}$ Powell	$\frac{1}{8}$ Powell and Lealand	$\frac{1}{20}$ Beck
	$\frac{1}{48000}$	$\frac{1}{220000}$	$\frac{1}{300000}$	$\frac{1}{460000}$	$\frac{1}{1120000}$

These were mostly at $6\frac{1}{2}$ or $6\frac{1}{4}$ inches. At a greater distance —10 inches—the diameters of the spider line of $\frac{1}{8000}$ with the two latter glasses would be,

$\frac{1}{8}$ Powell and Lealand	$\frac{1}{20}$ Beck
$\frac{1}{640000}$	$\frac{1}{1600000}$

* 'Phil. Transact.,' vol. ii., 1871.

These astonishing results, so contrary to what had been generally supposed, demand thorough investigation. And with a view to elucidate this unusually important subject, it will be interesting to inquire what is the visual angle of fine-line objects just visible by different observers.

	Diameter of Hair.	Distance visible.	Angle.
		feet.	seconds.
Mr. Broun, F.R.S., 'Proc. Roy. Soc.' ..	·0026	36	$1\frac{1}{4}$
Mr. Slack, P.R.M.S.	·003	$45\frac{1}{2}$	1
With sun illumination and grey sky background	·003	76	6–10ths
Against white wall of house, sun still shining	·003	113	4–10ths
Lit up by sun glittering	·003	173*	..

It is now requisite to determine what would be the visual angle of the spider line $\frac{1}{8000}$ of an inch miniatured 140 times smaller with the Beck $\frac{1}{20}$, and then magnified up 1000 times by an eighth immersion with C eye-piece and about 10 inches of tube. Here

$$\text{Visual diameter of web } \delta = \frac{1}{8000} \div 140 \times 1000 \text{ at a distance of 10 inches.}$$

Hence

$$\sin.\ \theta = \frac{\text{Perp.}}{\text{Radius}} = \frac{\delta}{10} = \frac{1000}{140 \times 8000 \times 10} = \frac{1}{11200} = 18 \text{ seconds nearly.}$$

The most ready way of getting the value of the fraction in seconds is by recollecting that $60'' = \frac{1}{3438}$ nearly.

Referring now to the former table, it will be found by simple arithmetic that since the Beck $\frac{1}{20}$ immersion shows theoretically a visual angle of 18 seconds, miniaturing 140 times, a glass reducing only fifty-eight times ought to show at an angle of $7\frac{1}{2}$ seconds at a power of 1000, and at a power of 500 at about 4 seconds. I see the line plainly, most charmingly defined with 500, and can even see them when miniatured only thirty times. A good deal might be written on this extraordinary fact. As the aperture of the objectives is diminished the spider lines look blacker, and therefore *larger.* I reserve this question for future treatment.

In inferior glasses the spider lines are thickened, and, besides this, garnished with secondary lines, true diffraction lines, and this you may see. I first detailed the method of miniatures in the 'Philosophical Transactions' eight years ago; but I have had nearly twelve years' experience of this method, and I have several times recommended it to the microscopical world with great cor-

* The glittering line here would afford a broad spurious line greatly enlarged.

diality. It is superior to all others for detecting residuary errors, and when these are nearly compensated the miniatures of spider lines of any size are portrayed with enchanting precision.

To sum up:—The whole question of minute vision is the least visual angle first of naked vision, and secondly in instrumental vision.

It can hardly be expected that any Microscope, especially if connected with miniature apparatus, involving the total use of some twenty lenses arranged as nearly as possible with one continuous optical axis,—that any Microscope, I say, can ever equal the simplicity of human vision. But then, with the unassisted sight we can easily determine the limits of vision by receding from the object, and so making the visual angle smaller and smaller until the hair vanishes. This we may call the vanishing angle θ.

Now the art, if I may so speak, of making very minute objects visible, may be applied by my method to render them distinctly visible as they get smaller and smaller as miniatures, and at last reach the vanishing limit.

But to my eye, which is, I must confess, the worse for these experiments, lines can be formed under the Microscope which also by lowering the ocular power, or diminishing the miniature, resemble (I will not say absolutely identify themselves with) the vanishing phenomena of naked vision.

When I see spider lines sharply defined become beautifully less, and give one the same appearance as a hair upon a window-pane, vanishing as its visual angle reaches the limit, I am bound to believe, nay be assured, though against all modern belief and theory apparently, that I do see these exquisitely small lines just on the point of evanishment at a very small visual angle indeed. Anyone with ordinary sight can see a human hair on a window-pane against a moderately white sky at a distance of two feet and a quarter. This is an angle of 20 seconds.

At five feet it is	Nine seconds.
„ ten feet it is	Four and a half seconds.
„ twenty feet it is	Two and a quarter seconds.

Now, on comparison of the minute lines exhibited by me microscopically, the hair lines appear equally small in each mode, either by viewing them on a window-pane at a yard off, or in the microscope diminished fifty times, and then sufficiently enlarged. The irresistible conclusion from this comparison is that the eye can discover a minute hair line either on the window-pane or in the apparatus exhibited, at certainly a smaller angle than 20 seconds. In other words, the minute microscopic image appears as small as a hair several feet off, according to the acuteness of vision.

The highest experimental proof by comparison is thus strongly in favour of a line sharply and clearly defined, subtending an angle of 20 seconds, and probably a good deal less, as 2 seconds is the visual limit that can be seen in the apparatus or by the eye alone.

Another very curious point is worth mentioning. Dr. Jurin 150 years ago stuck two pins on a window-pane, and found that when placed near each other he could not divide them except when the interval between them reached the wide visual angle of 30″. But when only one pin was viewed, he could distinguish it at a visual angle of from 2 to 3 seconds!

This interesting fact explains what I have witnessed in separating the spider lines of the micrometer in these miniatures: the interval could only be seen when the lines were separated, centre to centre, three divisions (micrometer), each division representing $\frac{1}{400000}$ when a minuendo of *fifty times* was employed; yet one can see a most sensible thickening of the gossamers just beginning to separate by moving the micrometer half a division. From this, I presume, a similar phenomenon was produced, though very much less pronounced than Jurin's case. It is marvellous to me that a visible bright space between these lines can be seen at all when their centres are separated only three divisions, i. e. $\frac{3}{1000000}$ or $\frac{1}{300000}$ of an inch. Considering that there must be some residuary aberration, however small, and that the error of each set of glasses accumulates in the final image presented to the eye, it seems to me wonderful that, notwithstanding Jurin's fact, a division is visible between the gossamers at all with so light a movement as described.

In continuation of this subject, I propose to offer to the Society some researches on the effect of large and small apertures in object-glasses. I beg to commend this research to the earnest attention of the rising generation of microscopists. Unless I am very much mistaken, the idea propagated in reference to the limits of microscopic vision is totally erroneous; whilst for brilliant lines or minute disks of great brilliance, I have not the slightest hesitation in embracing the truths conveyed in the exquisite formula presented to the microscopical world by, I believe, independently, Professors Helmholtz and Abbe.

It is almost needless to remark that very firm supports and delicacy of the adjustments as regards spherical aberration and illumination are essential to the success of this refined kind of definition.

III.—*On some Recent Forms of Camera Lucida.*

By Frank Crisp, LL.B., B.A.. Sec. R.M.S., &c.

(*Read* 11*th December*, 1878.)

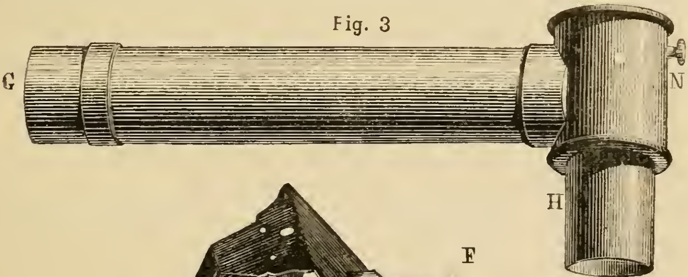
During the present year four or five forms of camera lucida have been brought forward, all claiming to be original, and to enable the observer to see more readily the image of the object and the point of the pencil at the same time, and I have thought it might be in some degree desirable to notice them—as a matter of history, at any rate.

(1) The first is that of Dr. Hofmann, the well-known optician, of Paris.

Fig. 1 shows the camera, properly so called, and Fig. 2 its transverse section.

The rays coming from the object, and passing through the lens C, meet the plate of silvered glass A, by which they are reflected to the transparent glass plate B, and thence to the eye through the

Fig. 3



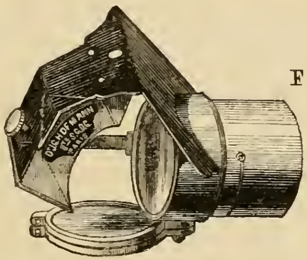


Fig. 1

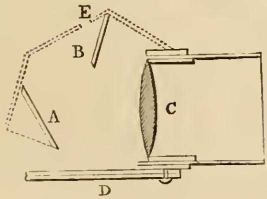


Fig. 2

Fig. 4.

aperture at E. At D are two lenses of different foci, which can be interposed between the eye and the paper, as with the ordinary Wollaston form.

With a vertical Microscope the additional piece of apparatus

(Fig. 3), containing a reflector at N, is employed, the camera fitting over it at G, and the whole being inserted into the tube of the Microscope by the part H.

The instrument is thus suitable for powers up to 500; beyond this limit, however, it is desirable to substitute for the colourless glass plate B a tinted one.

The camera, to use Dr. Hofmann's expression, "suppresses all existing eye-pieces," but with objects requiring only small magnification to be within the field of the camera the arrangement is employed which is shown in Fig. 4. It consists of two plano-convex lenses of different foci, and slides into H.

The part No. 2 may be used alone, No. 3 being taken away. If the image of the object is still beyond the field of the instrument, the lens in No. 2 is unscrewed, and No. 3 replaced, which gives a second amplification; and with both lenses in their place a third is obtained.

Dr. Hofmann writes that this apparatus is the result of an expenditure of no little time and thought on his part, and that it has been very highly commended by leading men on the Continent.

(2) A second form also originates in France, and is the invention of M. Pellerin, who describes its principle in the 'Comptes Rendus' * of the French Academy.

With the view, as he expresses it, of avoiding the weakening of one of the images through reflection by a transparent plate as in some forms, and the irksomeness of others which require that the object and the drawing should each be viewed with half the pupil, he suggests the following arrangement, which is an imitation of M. Cornu's polarizer, and gives two images of the same intensity and visible at the same time by the whole of the pupil.

A Wollaston camera lucida being made of glass having an index higher than the extraordinary index of spar, there are joined to the face which has an angle of 135° a plate of spar and a prism made of the same material as the camera, having its second face parallel to the face whence the rays emerge. Thus, at a suitable inclination, one-half the light coming from the object will be totally reflected as extraordinary rays, and a part of the light coming from the drawing will be transmitted as ordinary rays. The portions reflected and transmitted will be each one-half if there is no reflection of the ordinary rays, the condition for which is, that the glass of the two prisms and the cement which unites the pieces shall have the ordinary index, and in practice this can always be approximately attained.

For these assumed conditions, and the plate of spar being perpendicular to its axis, the following calculation is given of the field, which is then equal in all directions: in the interior of the glass

* Vol. lxxxvi. p. 764.

the extreme rays make an angle x the complement of the limiting angle,

$$\cos. x = \frac{n_e}{n_0}, \qquad x = 26°;$$

but that the faces of entrance and emergence may be cut perpendicularly to the mean direction of the rays, the angle of refraction of the extreme rays is $\frac{x}{2}$ and the angle of incidence y, so that

$$\sin. y = n_0 \sin. \frac{x}{2},$$

$$\sin. y = \sqrt{\frac{n_0 (n_0 - n_e)}{2}},$$

$$y = 22°.$$

The field (maximum in these conditions) is 44°; the instrument will take this in completely without rotation if the face attached to the spar is the third of the other, the aperture for the eye being near its edge. The angle adjacent to the spar is 90° − 13° = 77°.

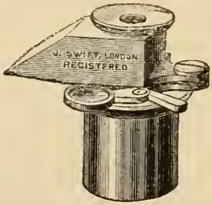
To regulate the intensity of the two images, a polarizer may be interposed in the path of the most luminous rays, such an apparatus, for example, as M. Cornu's made of the materials above mentioned.

No drawing accompanies M. Pellerin's paper. He adds that a camera lucida of the same description may be made for vertical Microscopes by replacing the quadrangular prism by a parallelopiped with an angle of 77°.

(3) The third arrangement is that of Mr. James Swift, shown in Fig. 5, and can be used at any inclination of the Microscope.

The principle of the instrument, as described by Mr. Swift, is that the image of the pencil and paper is received by a prism (enclosed in the box which projects on the left-hand side of the figure), by which it is reflected to a piece of neutral-tint glass placed at an angle of 45° over the centre of the upper lens of the eye-piece. The neutral-tint glass allows the image of the object in the Microscope to be distinctly seen, while that of the pencil and paper is at the same time visible on its first surface; no second image occurs by reflection from the back surface, owing to the tint of the glass.

Fig. 5.



A second disk of neutral-tint glass can be interposed when the light requires to be subdued to show the point of the pencil distinctly. It will be seen that in principle the instrument is an adaptation of Nachet's well-known form.

(4) The fourth form is that of Dr. Russell, which will be

exhibited by Dr. Millar this evening, and forms the subject of a separate paper.

(5) Although not a "form of camera lucida," yet it will not be out of place while dealing with this subject to call attention to a modification of a method of drawing objects under the Microscope originally described in 'Hardwicke's Science-Gossip' for 1867 (p. 236.) The method there suggested was to throw the image formed by the object-glass on to a sheet of paper fixed over a piece of common window-glass at one end of a "camera obscura," the Microscope being placed at the other end, and the eye-piece removed. Mr. H. E. Forrest, of Birmingham, now suggests that a rectangular prism should be placed over the eye-piece of a horizontal Microscope, thus throwing the image of the strongly illuminated object on to the paper on the table, the room being darkened. This method, while obviously requiring powerful illumination for high powers, is said to "enable even diatoms to be drawn with a $\frac{1}{6}$ objective."

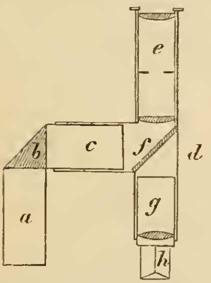
I have purposely abstained from any criticism on the various methods above described, preferring to confine myself to a simple record of the fact of their invention.

IV.—*Description of a New Form of Camera Lucida.* By J. Cunningham Russell, M.D., Lancaster.

(*Read 11th December*, 1878.)

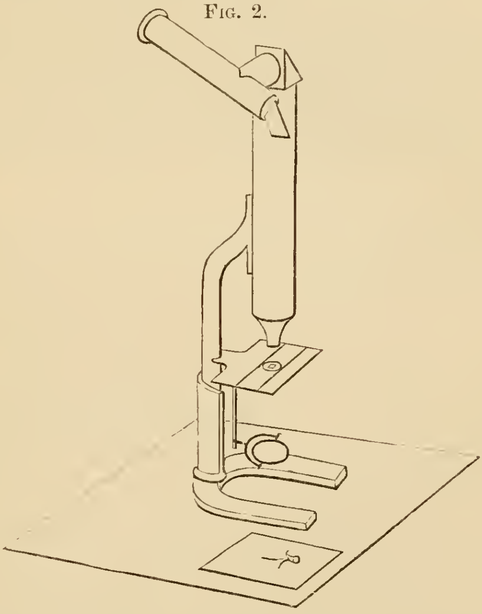
The principle of this instrument is that, in place of the paper or its reflection being viewed by the eye directly as in the cameras hitherto constructed, there is formed, by means of a lens acting as the object-glass of a telescope, a real image of the paper at the same point as the image of the object formed by the microscopic objective, and these two images forming one combined image are viewed through the eye-glass of the Microscope. The advantages of this construction are that the images being as one it is impossible that the image of the object should shift even in the least degree upon that of the paper, and that the images being at exactly the same distance from the eye, they are both in focus at once, and there is no straining of the eye to accommodate it to both object and paper, as is apt to occur with other instruments. It also avoids the necessity of looking through a small aperture, the ordinary eye-

Fig. 1.



a, Tube fitting into the Microscope.
b, Rectangular reflecting prism.
c, Horizontal tubes.
d, Vertical tube (inclined when in use), containing
e, Eye-piece.
f, Plane reflector of tinted glass, and
g, Telescopic object-glass.
h, Erecting prism attached to the last.

Fig. 2.



piece being used; and it admits of a convenient inclination being given to the eye-piece while the body of the Microscope is upright.

The construction of this instrument is shown in the accompanying figures and is as follows:—A tube fits into the tube of the Microscope: at the top of it there is a right-angled prism (in a box) which reflects the rays along a horizontal tube of convenient length; this is crossed at the end by a vertical tube, and at the intersection there is a piece of tinted glass which reflects the rays up the vertical tube. In the upper limb of the vertical tube is inserted the eye-piece, and in the lower limb the convex glass which acts as the telescopic object-glass, and the rays from which passing through the tinted glass form an image of the paper in the focus of the eye-piece. As this image is inverted, and it is necessary for easy drawing that it should be erect, an erecting prism is attached below the convex glass. In use the tube, which I have for simplicity called the vertical tube, is inclined, by a motion round the axis of the horizontal tube, to an angle of about 60° from the vertical, so that the lower face of the erecting prism becomes nearly horizontal, the paper is put on the table below it and focussed by sliding the object-glass in or out. The light on the object must of course be suitably modified so that the paper and pencil may be distinctly seen.

I do not put forward this model as the best possible form in which the principle may be applied; I have no doubt it is susceptible of many improvements, but the principle itself is, I believe, a sound one. It is equally applicable with the necessary modifications to drawing objects in the field of a telescope.

Lenses may be used to erect the image instead of a prism.

V.—*Immersion Illuminators.* By J. Mayall, jun., F.R.M.S.

(*Read 8th January*, 1879.)

The need of special apparatus for illuminating objects mounted in balsam, or other refractive medium, seems to have been clearly in Mr. Wenham's mind when he contributed his paper on "Illuminating Opaque Objects" to the 'Transactions' of the Society in 1856. The appliances then described were, a right-angled prism, a truncated hemispherical lens, used with his paraboloid, and the "paraboloid of solid glass with a flat top." These were, strictly speaking, *immersion illuminators:* the last is the original "immersion paraboloid." It was shown by diagrams that the illuminating rays were made to impinge on the upper internal surface of the cover-glass at an inclination beyond the "critical angle" (or flat-plate limit between glass and air), and reflected by *total reflexion* upon the object, which is then seen in a dark field.

The reflex illuminator designed by the same inventor, sixteen years later, was based on the same principle.

With these appliances, used according to the principle of construction, *dark-ground illumination* is produced with dry objectives, whether the illuminating rays are internally reflected from the cover-glass on to the balsamed object, or the object is capable of deflecting the *direct* rays from the illuminator so as to become self-luminous and visible by means of what may be termed *scattered* rays.

It has been generally held that, as stated by Mr. Charles Brooke, "the more minute structure of some objects is cognizable *only* by its influence on rays traversing the object at considerable obliquity." To this end many appliances have been designed to be used with dry objectives. In Amici's prism, Nachet's prism, the truncated paraboloids, right-angled prism, truncated hemispherical lens, Reade's dark-ground illumination, the "kettle-drum" diatom-prism, the reflex illuminator, and others too numerous to mention, we have either the use of an actual stop to block out portions of the rays, or the illuminator is placed in such a position as to provide light in particular directions. The main purpose in all is to utilize the more obliquely incident light to the exclusion of the central.

On the importance of regulating the obliquity of the illumination on the object in its relation to the apertures of dry objectives, I quote from Mr. Wenham's paper "On the Illumination of Objects . . ."*:—

"Practically it is found that there is a precise but different angle of illumination required for every aperture of the object-glass, in order to give the maximum of distinctness; or that will even at

* 'Quart. Journ.,' 1854, vol. ii. p. 152.

all develop the markings on difficult tests. For if we continue to increase the angle of the mirror [he refers to diagram] the object first acquires a pearly appearance, and is afterwards seen in a dark field known as 'Reade's back-ground [black-ground?] illumination' . . . . but the markings have again become indistinct or disappear altogether, showing that it is needful to allow a small portion of the light from the source of illumination to pass into the object-glass, and through the object, that the striæ may either be rendered more visible by the rays that they intercept, or that the field shall be partly luminous."

Within the last few years the apertures of objectives have been so considerably extended by means of the immersion system, that, in order to utilize their fullest power, it has been found necessary to use an immersion system of illumination. By these means we obtain *direct* rays (i. e. rays other than those merely deflected by the object) from the illuminator at greater inclination than the critical angle, which certain of these immersions will transmit, producing a luminous field.

When the object is in balsam, and the base of the slide plane and in air, no rays can reach it from beneath at an obliquity greater than the limiting angle for balsam. In order that *direct* rays may *enter* the balsam beyond the inclination of 41°, we must have recourse to an immersion condenser, or something equivalent.

But it must not be supposed that the limiting angle at which rays could be admitted into balsam from beneath, through a flat plate of glass, imposes the same limit to the angle up to which an immersion objective could collect image-forming rays, supposing them to have got into the balsam,—which assumes that the image-rays above the object are limited by the angle of the *direct* illuminating rays from beneath. This erroneous view has had some currency, and may be thus stated:—*Because* the object in balsam cannot receive light from beneath beyond the limiting angle for balsam, unless we have an immersion system of illumination (supposing the base of the slide plane and in air), *therefore* there are no rays from the object beyond that limit to be transmitted by the immersion objective, however great its aperture; the question arising—"Where can such rays come from?"

It is evident that, independently of the angular direction of the illuminating rays, if there be an object in the field capable of *scattering* (and not merely intercepting) light, it is seen luminous by *scattered* rays. Regarded then as a *self-luminous* object, rays are nascent therefrom and scattered equally in all directions, and therefore at greater inclination than 41°. There is no theoretical difficulty in their reaching the second surface of the front lens of an immersion of suitable form, and in their being transmitted. They cannot, however, take part in the formation of the image by a dry objective, because they are *internally* reflected by the cover-glass. These rays must be regarded as important for delicate markings, as evidenced by comparing the definition we obtain with the highest-angled immersions and dry objectives on a balsamed object with ordinary illumination,—that is to say, when the base of the slide is plane and in air.

The utilization of the whole of the very large cone of rays that might be condensed on the object by using an immersion illuminator having an aperture equal to that of the objective, in other words, the *direct* illumination of the whole aperture, is not the problem that has engaged the attention of those who have endeavoured to exhibit the fullest power of the apertures of immersions. It was long ago found that it is not so much mere *quantity* of light that is required on the object, as difference of illumination that can be rendered perceptible by the eye. The more difficult images are seen only as we utilize the extreme marginal aperture of the objective and the more oblique direction of the illuminating pencil. This can only be done practically by excluding all excess of central light. The objects on which the fullest power of the aperture is needed are generally so nearly of the same refractive index as the fluid in which they are immersed, that there is difficulty in making delicate differences of transparency perceptible. The immersion system of illumination becomes all-important to this end, as, by it, any required degree of intensity of light can be got upon the immersed object at the most favourable obliquity for the aperture of the objective.

It is found in practice that to obtain the fullest effect on the object, of the *extra*-oblique rays provided by immersion illumination, the objective must have an aperture capable of transmitting them, so that the field is luminous; they thus become a practical proof of the extent of the aperture. It follows also, as matter of observation, that up to the angle to which the objective refracts the *direct* rays from the illuminator to a luminous field, to that angle (or very nearly so) it refracts image-rays from the object; for we find that increasing the obliquity of the *direct* illuminating rays so as to approach to the dark-field produces, at the same time, distortion of the image,—showing that both systems of rays traverse the objective together.

The angle of the *direct* illuminating rays must not, however, be regarded as an essential condition of the *existence* of the aperture (as such). It proves the extent of the aperture of the objective by direct transmission; its effect in rendering visible minute structure is plainly matter of experience,—and experience shows that, so far as apertures have been carried, the gain has been in proportion to their capacity for *direct* transmission.

It will be understood that I refer only to objectives in which the corrections have been made to the fullest extent of the aperture; for it must be agreed that there is no such thing as *aperture*, properly speaking, unless the image of a point be rendered as, approximately at least, a point.

Now, although, as I have shown above, Mr. Wenham understood the need of special means for illuminating obliquely objects in balsam, and the importance of the angle of illumination in relation to the aperture of the dry objective, I do not think he can be credited with having understood (much less foreseen) the important part the immersion illumination of balsamed objects would take in the development of the fullest power of immersion apertures. Indeed, as he has contended that the 82° *limit* of dry objectives obtains equally in immersions, he must be held to deny the existence of any aperture beyond 82°: consequently, the application of the immersion illuminators above mentioned, for *directly* utilizing any such aperture, must be regarded as a discovery quite apart from his original application of them for dark-ground illumination.

It appears to me that to Mr. Tolles is due the merit of first applying immersion illuminators to balsamed objects in connection with immersion objectives for the distinct purpose of utilizing by *direct* transmission the excess of "interior angle" beyond 82°. He was the first to produce objectives having interior angle considerably beyond 82°, and to demonstrate their advantages. With these objectives a luminous field was obtained when the whole of the illuminating rays that can enter into a dry objective were blocked out, and none but rays beyond this limit admitted: thus exhibiting at once a luminous field and a definition of immersed objects by means of the *extra* aperture that had not been seen before. He appears to have experimented chiefly with the semi-cylinder, because of the facility it offered for immediately obtaining a reading of the precise degree of inclination the illuminating rays made with the axis, so as to determine the actual limit of the apertures of the objectives he had devised; the display of difficult test-objects being merely incidental to his efforts to improve the instrument.

Dr. Woodward has given special prominence to the principle of the immersion illumination, in its immediate connection with the development of the power of aperture, by his "simple device," in which he originally provided means to exclude all rays of less inclination in glass than 45° from the axis, so that no objective having "interior angle" less than 90° would give a luminous field with it: it thus affords a proof of his position in the aperture question. Viewing it as an illuminator only, Dr. Woodward has simplified the mode of mounting the prism, and slightly varied the angle in a second prism: his last paper referred to these changes. I was also led to design a modification of this device, which is, briefly, to utilize the four exposed surfaces of the prism by cutting them at different angles so as to approximate nearly to the semi-aperture of the objectives likely to be used. This purpose is attained with a success approaching perfection in Tolles's "traverse-lens," which I hope to place before you shortly with the inventor's notes.

Many experimental devices have been made for the same purpose. At the last meeting I exhibited another modification I had had made of Dr. Woodward's "simple device"; also a nearly hemispherical lens and a small semi-cylinder conveniently adapted for use on the sub-stage.

I mention Hyde's oblique illuminator for its novelty in combining a condenser with prism-illumination. It is a right-angled prism with a lens of short focus cemented on the long face, and will give a beam of condensed light up to a high degree of obliquity. Captain Tupman brought it from America four years ago. I am not aware whether the inventor designed this for the purpose of utilizing by *direct* transmission the *extra*-oblique rays that can be utilized only by immersions having "interior angle" beyond 82°, or he intended such rays to produce dark-ground illumination only. The plan is ingenious. I have, however, found by cementing a small lens on one of the exposed faces of Dr. Woodward's prism the same results are obtained more conveniently.

I refer also to a plan of illumination which Captain Tupman informs me is due to Mr. Tolles. It consists of placing a suitable prism in immersion-contact, on the surface of the balsamed slide, so that rays from a bull's-eye lens may pass directly to the internal surface of the base of the slide at an inclination beyond the critical angle, they are then *totally* reflected to the object. This requires some care in the manipulation.

Professor Abbe has adopted the use of a small lens * placed in immersion-contact with the base of the slide; which is a very simple and effective plan, and has been known for some years past. It is really so practical as almost to supersede the more elaborate contrivances for use beneath the stage.

Lastly, I refer to a reflecting immersion illuminator which I have suggested to Professor Abbe, and which he has undertaken to have made for me by Mr. Zeiss: this will be placed before you when completed.

Immersion illuminators are designed to secure a particular angular direction to the illuminating rays while actually in the body of the fluid in which the object is immersed, with a view to utilizing incident light of great obliquity; used in connection with the highest-angled immersion objectives, they have given fair grounds to expect that the future of the most difficult investigations in microscopy will be largely dependent on their successful application.

* At the Meeting in June I erroneously stated that Mr. Wenham had used a similar lens for the same purpose many years ago. He used the lens for reflex illumination from the cover-glass—*not* for *direct* illumination.

VI.—*Note on a Revolver Immersion Prism for Sub-stage Illumination.*

By James Edmunds, M.D., M.R.C.P. Lond., F.R.M.S., &c.

(*Read 8th January*, 1879.)

The value of a right-angled immersion prism as a sub-stage appliance for the illumination of objects under the Microscope was shown by Mr. Wenham in the year 1856, in a paper * published in the 'Transactions of the Royal Microscopical Society.' Mr. Wenham's paper is illustrated with a woodcut showing a right-angled prism attached to the under surface of a slide by means of oil of cloves, balsam, turpentine, or camphine; light concentrated by a bull's-eye being deflected upwards by means of an Amici prism. In the same paper Mr. Wenham also shows how, by means of a hemispherical lens, or "a small paraboloid of glass with a flat top" similarly attached to the under surface of the slide, other methods of immersion illumination may be made effective and, as he says, "show the Diatomaceæ with a degree of beauty and delicacy that he had never seen equalled."

The Tolles Microscopes have now for some years had fitted to their stages deep spherical and cylindrical lenses to be used for immersion illumination, and the splendid oil lenses now made by Zeiss are sent out accompanied by a small lens to be attached to the under surface of the slide with cedar oil, in order to supply light on the same principle. Colonel Woodward also has recently favoured this Society with two papers developing this most valuable method of illumination for high-angled lenses, and he has combined with the right-angled immersion prism two screens of thin metal perforated in line with the object, so that entering light may, when necessary, be demonstrably limited to parallel rays at a determinate angle.

The oil of cloves, used as an intermedium by Mr. Wenham, has been adopted by Colonel Woodward. Cedar oil, castor oil, or pure glycerine (Price's) also answer perfectly. As to the light, it will be found that a $1\frac{1}{2}$-inch achromatic objective serves much better as a condenser than a bull's-eye, and that an image of the edge of a paraffin-lamp flame should be accurately condensed upon the object.

I now have the honour to submit a new combination prism, con-

* "On a Method of Illuminating Objects under the Highest Powers of the Microscope." By F. H. Wenham, Esq. Read March 25, 1856. 'Transactions of the Royal Microscopical Society,' vol. iv. pp. 55–60.

structed for me by Messrs. Powell and Lealand,* which will, I think, be found to render immersion illumination more manageable and more generally useful. I have termed it the revolver prism, because, by its means, unrefracted light at four grades of obliquity may be successively thrown into the object simply by rotating the prism and altering the inclination of the Microscope. This prism is of hard white crown glass, and six or seven eighths of an inch in diameter. Above, it has a circular plane surface, with a border curving downwards so as to afford hold for a setting which does not rise high enough to touch the slide. Below, it has four facets produced by grinding down a spherical surface into two right-angled prisms, whose lower edges are located at right angles to each other, and whose faces respectively make with the top surface angles of 30° and 60°, 41° and 49°. These four facets, taken consecutively, are normal to light entering at 30°, 41°, 60° and 49° of obliquity to the optic axis. The prism is sprung into the top of a vertical tube deeply slotted for the passage of light to the various facets, each slot being cut down to a line at which the side of the tube would be intersected by the plane of the facet on the opposite side. Below, the tube screws or slides into an adapter, or expands into a ring for the sub-stage. The top surface of the prism connects to the slide by means of a minim of cedar oil or Price's glycerine, and glare is prevented by the fact that superfluous light is reflected out through the slot behind. Each slot is figured with the obliquity of the light for which it is cut, and by a simple addition the entering light may be demonstrably limited to a particular angle, as with Dr. Woodward's perforated screens.

By means of this immersion prism the obliquity of the illumination may be so graduated as to shut out the light field and the ordinary negative image in so far as is necessary to obtain the diffraction image at its best point. With light at 60° from the optic axis the diffraction image is so far isolated that *Amphipleura pellucida* in balsam may be seen upon a dark background with the new oil lens. With light at 49° or 41° the field becomes lighted in proportion to the angular aperture of the objective, and the diatom is finely displayed, but with light at 30° the lines disappear.

Amphipleura pellucida in air, whether upon cover or slide, may also be shown by this prism. If the diatom be upon the slide, an intense black-ground illumination may be produced through the higher-angled facets, and the lines are shown as green and black bands, as they are by means of the immersion paraboloid.† If the diatom be upon the cover, the two lower-angled facets will show it,

* I exhibited this prism on June 5, 1878, at the soirée of the Metropolitan Branch of the British Medical Association.

† "On the Paraboloid Illuminator.' Vide 'Monthly Microscopical Journal,' August, 1877, p. 81.

but for full illumination the facet at 30° is required. Light emerging from the slide at 30° is, of course, bent down so as to strike the under surface of the cover at about 49°, and in this light the dry diatom may be splendidly resolved. In balsam, light at about the same angle (49°) seems to resolve the diatom best. With *Amphipleura pellucida* the light should in all cases strike the diatom *end on*, or it will not be resolvable. The brilliancy of the field also must be kept in due subordination to the influence of the diffraction image, and as the following method of procedure makes this very difficult object quite easy, I may perhaps be permitted to describe it.

1. By means of a four-tenths objective, a diatom should be selected, centred, and turned so as to lie exactly north and south in the field.

2. If light at 49° is needed, the corresponding facet of the prism should be turned to the front. The Microscope tube should be inclined through the complementary angle (41°), so that the facet stands vertical.

3. The lamp flame—edge on—should be set on a level with the object, and at eight inches distance.

4. A $1\frac{1}{2}$-inch achromatic objective should be arranged in line, so as to condense upon the object a fine image of the lamp flame. In order to show that the image of the flame is accurately focussed upon the object, a piece of wet tissue-paper may be laid upon the top of the slide, or the image of the flame upon the face of the observing lens may be viewed through a side facet.

Under these circumstances the lines will be perfectly resolved if the lens have an adequate angular aperture and be properly adjusted. The method is very simple, but for want of it I have seen an experienced manipulator spend hours in "fiddling about for the lines," and utterly exhaust his eyes without determining whether or not the optical capacity of the lens on trial was at fault. By the method I have described, this difficult object may be resolved as easily as a Podura scale. If, when the lines are properly resolved, the eye-piece be taken out, there will be seen, on looking down the tube, at the southern edge of the field, a small clear image of the flame, and at the northern edge—diametrically opposite—a soft, greenish-blue diffraction image. Sometimes also an outline of the diatom crossing the field from one image to the other may be discerned.

The particular angles given to the prism now before the Society, were selected in order to enable a single prism to command the whole range of oblique illumination, and to enable so difficult an object as *Amphipleura pellucida* to be at once resolved whether in balsam or in air, and whether upon the slide or upon the cover. Through these facets, light at somewhat different angles may be passed without practical detriment, as only the edges of the beam would become chromatized, or other angles may be given to the revolver prism. If two such prisms were to accompany the Microscope, one might be cut at angles of 25°, 30°, 35°, and 40°, in order to light objects to be viewed under high-angled light in air on the cover, or under low-angled light if in balsam. The second prism might be cut at 40°, 45°, 50°, and 55°, in order to light objects to be viewed on the slide in air with black background, or under the highest working angular apertures if in balsam. Difficult objects, when set upon the slide in air for black-ground illumination, require the cover to be very close down upon them, or they will not be resolvable by high-angled lenses.

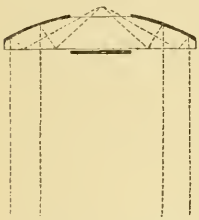
VII.—*A Catoptric Immersion Illuminator.*

By John Ware Stephenson, F.R.A.S., Treas. R.M.S.

(*Read 8th January*, 1879.)

As the subject of Immersion Illuminators is now before the Society (and I am very glad it is so, for without their help the full resolving powers of the recent large-angled objectives cannot be utilized), it may not be out of place to lay before the Fellows a brief account of an immersion condenser of very simple construction which I devised in 1877.

The diagram shows the form and size of the instrument which I now use, although it is sufficiently obvious that other sizes, in the same ratios, may easily be made—in fact, I have such.



The apparatus is simply a plano-convex lens, worked on a 1-inch tool, and having a diameter of 1·2 inches, which is then "edged" down to 1 inch, as being more convenient in size, and as giving an aperture sufficient for our purpose.

The upper, or convex side, of the lens is cut down or flattened, so as to give a surface $\frac{4}{10}$ of an inch in diameter, with which the slide is to be connected, when in use, by a drop of oil or water.

It matters not which fluid is used as long as the objective has a numerical aperture not exceeding 1·33 (the index of water), and it is very improbable that this will ever be exceeded to any *great* extent, as 1·50 is the *ideal* maximum of even an oil immersion.

The upper curved surface of the lens is silvered, and beneath the lens, a flat silvered plate $\frac{1}{60}$ of an inch thick, and corresponding in size and position with the upper flattened surface, is balsamed.

It will be seen that the incident ray is normal to the under surface, impinges on the curved silvered surface, and is thus thrown back on the plane, or under surface of the lens, whence the more oblique rays, falling beyond the critical angle, are totally reflected, and converge to a focus, giving a numerical angle of $1·30 = 120°$ in balsam.

The object of placing a silvered glass disk beneath the lens is twofold: in the first place, it reflects the less oblique rays which fall within the critical angle, and in the second it tends to diminish the spherical aberration which in this zone might otherwise be felt.

The stop is placed about $\frac{1}{8}$ of an inch, or less, below the condenser, and the opening used is of a lens-shaped form, as giving a broad beam without any appreciable spherical aberration in so narrow a zone of light.

It will be found that this instrument will work through any ordinary glass slip, gives a brilliant light, and, having no refracting surface, is necessarily achromatic, whilst the spherical aberration, as previously pointed out, is inconsiderable.

If used with a dry lens of the highest power on a balsam-mounted object, the light, unable to pass the upper surface of the covering glass, is thrown back on the object, giving opaque illumination; on the other hand, with dry objects adhering to the slide, the well-known dark-ground illumination can be obtained with any objective I have yet seen.

VIII.—*The Thallus of the Diatomaceæ.*

By F. Kitton, Hon. F.R.M.S.

(*Read 8th January*, 1879.)

The study of the living diatom has lately engaged the attention of many eminent foreign diatomists (M. P. Petit, Paris; M. J. Deby, Belgium; Count Castracane, M. Ardres, and others). The latest published observations are those of M. le Dr. Lanzi, of Rome, in his paper* on the "Thallus of the Diatomaceæ." By thallus is to be understood the stipes, cushion, tube, frond, or mucous pellicle. The latter is the material by which the film of diatoms is attached to wet walls, buttresses of bridges, &c. He communicates some interesting facts connected with the reproduction of these remarkable organisms. "In a gathering of *Epithemia ventricosa* made in the Villa Pamphilia, in Rome, I observed that some portions of the pellicle were composed of a great quantity of round granular corpuscles of a greenish-yellow colour. Most of these corpuscles were, to all appearance, the same as those contained in the interior of the frustules of the Epithemia, and imbedded in a hyaline plasma. Such was the resemblance, that no one could doubt that the granular bodies in the plasmatic thallus and those in the frustules were alike.

"At another time I made a gathering in a fountain in the interior of the Forum of Trajan, of a Cymbella in a state of reproduction, and I was again able to see the round corpuscles. They were very small, and of the same colour as the endochrome. They were contained in the thallus, and resembled those in the frustules. I followed these germs through their phases of development; and by repeated observations I ascertained that, whilst increasing in breadth, they preserved their circular form; that afterwards they commenced to elongate, in order to acquire the lunate and naviculoid outline of the mature frustule.

"Of these growing forms, some remained attached to the thallus, and some became free. The number of these corpuscles was considerable; and one was easily convinced that they were the result of a new kind of generation. The disparity in size was so considerable, that it would have been absurd to suppose that they had been produced by fissiparity.

"I am able to report other similar facts observed in *Navicula ambigua*, *Nitzschia minutissima*, *Amphora ovalis*; but of these I shall say nothing, in order to avoid useless repetitions, and shall confine myself to describing *Gomphonema olivaceum* only, in which I have followed the series of transformations from the time the frustule containing the germs had changed into a sporangial cell,

* See 'Annales de la Société Belge de Microscopie,' vol. iv.

until the thallus became charged with germs and frustules in various stages of development. In this same thallus was also seen the gradual transformation of the corpuscles into rudimentary frustules, their growth, and lastly the development of the dichotomous peduncle. When this cycle was completed, the thallus contained three different forms—the sessile sphenelloid form, the pedunculate (either simple or dichotomous), and the perfect or free form. From the preceding, it appears that there arrives a time when the plasma contained in the siliceous cells acquire a considerable volume, owing to the rapid development manifested at the time of reproduction, and which cannot be contained within the walls of the frustule by reason of the want of elasticity produced by the deposition of silex. The frustules being unable to follow the growth of the plasma, the valves separate from the pressure; but previous to arriving at this condition, the protoplasm had commenced to undergo the changes necessary to the formation of the new cellules, and we are able to see an aggregation of hyaline masses destitute of an external membrane. These are the Moneres of Haeckel. Amongst them are some that remain for a long time as plastid gymnocytodes—that is to say, without an external membrane, as named by Haeckel—and form in this manner the amorphous or indefinite thallus (*mucus matriculis* of authors); whilst those that take the form of stipes, peduncles, cushions, or some definite form, appear to belong to the plastid lepocytodes, that is to say, invested with an extremely thin external membrane. This membrane, although scarcely visible with the Microscope, nevertheless limits the outline of the thallus. . . . I have determined to place the above-mentioned facts before diatomists, in order to call their attention to the study of the thallus of diatoms. The study of the function of the thallus in this large family seems to me to be full of interest."

The presence of this "thallus" is by no means uncommon. I have detected it in many diatomaceous gatherings, particularly those from fresh water, but I never saw the corpuscles Dr. Lanzi mentions; they may not have been present, or, what is equally probable, I overlooked them. However, the discovery is of great interest; and I hope, with Dr. Lanzi, that other diatomists will turn their attention to the study of the living forms. The reproduction of the Diatomaceæ has not received that amount of attention the subject deserved. Their increase by self-division was the method first observed, more careful observations led to the detection of conjugation and production of sporangial frustules, or the formation of a sporangium by a single frustule; and we now find that another method has been observed, viz. that just described by Dr. Lanzi.

The author's figure (1) represents a number of circular bodies immersed in the thallus of *E. ventricosa*, and also in the frustule;

(2) thallus of *Cocconema cistula*, representing the corpuscles in various stages of development. Unfortunately the amplification is not stated, a matter of some importance. It is also to be hoped that Dr. Lanzi will make some experiments to test the power possessed by them to resist desiccation without losing their vitality. In Herr Grunow's "New Diatoms from Honduras," 'M. M. J.,' vol. xviii. p. 184, Pl. 196, Fig. 4 *b*, is described and figured a curious abnormity of *Cerataulus lævis.* Within the large frustule are two very small ones. Herr Grunow asks, "In what manner do these abnormal frustules multiply and reproduce a new series of normal forms? Certainly not by conjugation or self-division." Professor Cleve* figures a frustule of *Biddulphia aurita* with a small frustule within. In a note (p. 184), I suggested "that the endochrome, under certain conditions, might possess the power of producing (? by means of microspores) perfect frustules without conjugation." Dr. Lanzi's discovery confirms my supposition, and explains the formation of the small frustules within the large one.

* 'Bihang till Vet. Akad. Hand.,' band i. tab. iv. fig. 3 *a b*.

NOTES AND MEMORANDA.

Researches on the Proboscis of Butterflies.—W. Breitenbach has undertaken a series of observations * on the hairs with which the proboscis of butterflies is covered, and on the relation of these to the curious "Cylindergebilde" or sheathed hairs by means of which many *Lepidoptera* are enabled to pierce the tissues of plants for the purpose of getting at the contained juices.

The ordinary typical hairs consist of a basal portion or cylinder composed of a dark chitinous material, and either partly imbedded in the substance of the proboscis or projecting freely from its surface, and of the hair proper, the proximal portion of which is imbedded in the cylinder, while the distal, usually by far the larger part, is free. In *Zygæna filipendulæ* the hairs on the greater part of the proboscis have the ordinary characters, but, near the free end of the organ, the edge of the cylinder is produced into four elevations, placed at equal distances from one another; the cylinder itself, moreover, is proportionally longer and the hair proper proportionally smaller than in the typical hair. In *Pieris* a similar structure obtains, but the cylinder is strengthened by longitudinal bands, one for each of the five points into which its edge is produced, and of a darker colour and firmer consistency than the rest of the cylinder. In *Epinephele Janira*, the size of the whole apparatus is greatly increased, the processes on the edge of the cylinder have become actual teeth, and the hair proper is so much reduced as to form a mere papilla just overtopping the circlet of teeth. A structure is thus produced eminently fitted for piercing the tissues of plants. A further modification occurs in *Arge Galathea*, in which, besides the row of teeth round the edge of the cylinder, there are three other circlets, encompassing, at equal intervals, its lateral surface: each of the four circlets is six-toothed. In *Catocala hymenæa* the structure seems at first sight to be altogether different: the cylinder is provided with six vertical plates standing out from its lateral surface, and projecting over its edge in the form of sharp points: these plates may be considered as having been formed by the coalescence of superposed rows of teeth, such as exist in *Arge*.

From these observations it seems highly probable that the sheathed hairs have been developed from ordinary hairs by the gradual diminution of the hair proper, especially of its extra-cylindrical portion, and by the simultaneous increase in size and strength of the surrounding cylinder. The advantage accruing to the insect from the change is obvious; with a proboscis provided merely with ordinary hairs it would be able to take advantage only of free nectar, that is juice actually poured out by the secreting glands of the plant, whereas with the sheathed hairs it would be able to pierce the cell-walls and derive an additional quantity of nutriment by drawing upon the internal juices. This view is supported by the fact that *Lepidoptera* visit flowers which produce no free nectar.

* 'Archiv f. Mik. Anat.,' vol. xv. p. 8.

Contributions to our knowledge of the Protozoa.—Professor A. Schneider has a short but important paper (with a plate) on this subject, in the 'Zeitschrift f. wiss. Zool.,'* in which he describes his recent observations on *Actinosphærium*, *Miliola*, *Trichosphærium* (a new genus), and *Chlamydomonas*.

Actinosphærium Eichornii.—Schneider's comparison of his own researches with those of Brandt, Greeff, and F. E. Schulze, lead him to think that this species really includes four distinct species, agreeing with one another in the vegetative condition, and differing only in the reproductive stage. The observations on which this opinion is based are shown in the following table compiled from Schneider's paper.

I. In the process of division the nucleus divides repeatedly, and a number of the nuclei thus formed pass into each of the resulting spheroids.	1. After the completion of the process of division, each of the two spheroids comes to lie in a special cyst, or rather in a special compartment of the common cyst: the spheroids do not subsequently unite, and their siliceous case is single (Schneider).	Species A
	2. After division the two spheroids do not, or not always, lie in special cavities in the cyst: after the process of division the two spheroids unite again: their siliceous case is double (Greeff).	B
II. In the process of division the nucleus disappears, new nuclei afterwards appearing, one of which passes into each spheroid: the siliceous cases are thinner than in (I.).	3. After division the spheroids conjugate (Brandt).	C
	4. Conjugation of the spheroids does not take place (Schneider, F. E. Schulze).	D

A further evidence of the distinctness of this form is afforded by the difference in their habits: of the two observed by Schneider, the species A, from the canal in the Berlin Zoological Gardens, fed chiefly on *Cyclops*, to which it clung by its pseudopodia, allowing itself to be carried about by its prey until the latter was killed: the species D, from ditches at Giessen, never devoured Cyclopidæ, but fed chiefly on *Chlamydomonas*, and amongst higher animals confined itself to the smaller Rotatoria.

2. *Development of Miliola.*—In a species of this genus observed at Föhr, distinct nuclei were observed. Multiplication took place by the protoplasm being divided into nucleated masses, of which there were finally seen to be two kinds; small naked cells, probably representing spermatozoa, and large oval cells provided with a distinct membrane, and seeming to represent ova. No stage was found between these latter, and germ masses, consisting of a very distinct cell-wall enclosing contents half protoplasmic, half fat like. The fatty body disappeared, and the germ was converted into a young *Miliola*, with a single, globular, thin-walled chamber, provided with one large aperture and several small ones, through which pseudopodia were protruded: no nucleus was visible in this stage. The tubular portion of the shell was seen to begin as a hand-shaped process near the mouth. The young *Miliolæ* continued to grow through the winter, and then the

* 'Zeitsch. f. wiss. Zool.,' vol. xxx. (Suppl.), p. 446.

formation of germs began anew, but this time, apparently, asexually, as no sperm-cells were seen.

In a vessel of sea-water containing *Miliolæ* from Heligoland, were found small sandy accumulations, containing a transparent, hardish substance, devoid of silica, and enclosing about fifteen spaces containing capsules. The contents of these capsules were of four kinds, firstly, a great number of bright *Euglena*-like bodies, devoid of flagella, but exhibiting movements, probably spermatozoa; secondly, masses of protoplasm, probably ova; thirdly, undoubted young Miliolæ; and fourthly, some of the capsules were empty and probably represented empty sperm-capsules.

It will be seen at once that the evidence for the sexuality of *Miliola*, brought forward by Schneider, is by no means complete.

3. *Trichosphærium Sieboldii* (nov. gen. et sp.). — This species was discovered in water from Ostend, where it existed in such quantities as to form a white powder. Its shape is generally ovoidal, but undergoes considerable changes, so slowly, however, that the changes could not be followed by the eye. The surface is thickly covered with long bristle-like filaments (Borsten), which are unaffected by potash, but dissolve in dilute acetic or hydrochloric acid, without evolution of gas. When these bristles are dissolved, the animal is seen to be covered with a fine membrane produced into short cylindrical tubular processes, through each of which a delicate protoplasmic filament, slightly longer than the bristles, is protruded. *Trichosphærium* forms an intermediate genus between *Lieberkühnia* and the ordinary calcareous Foraminifera.

4. *Chlamydomonas*.—The author describes three species of this alga, *C. pulvisculus*, *C. tumida*, and *C. radiosa*, and also gives an account of the conjugation in the first-named species.

Cochineal for Staining.—Dr. Paul Mayer,* of the Zoological Station at Naples, when making experiments to find an alcoholic carmine solution with which to stain satisfactorily entire chitinous membrane, tried the tincture of cochineal, which not only answered the desired purpose, but showed itself suitable for general application wherever it is required to stain by an alcoholic method animal tissues preserved in alcohol, and to keep the preparations thus obtained in a resinous medium.

The pulverized cochineal is left for several days in contact with 70 per cent. alcohol, 8–10 c. cm. to a gramme, and the dark red liquid filtered. *The object to be stained must be free from acid*, and it is best to lay it for some time previously in fresh alcohol of 70 per cent. According to the intensity required and the nature of the object, the staining takes from a few minutes (infusoria, marine larvæ, &c.) to a few days (the higher crustacea, large annelida, young cephalopoda, organs of vertebrata, &c.).—The subsequent removal of the staining material which is not fixed in the tissue, is effected with 70 per cent. alcohol, and takes days in some cases; it can never, however. be continued too long, and should not be stopped until the alcohol takes no more up.

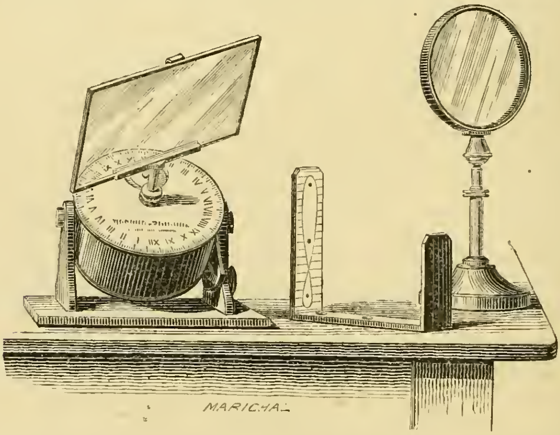
By this method, assuming that the object has been properly preserved, a very precise and nearly always intense nucleus stain is obtained,

* 'Zoologischer Anzeiger,' vol. i. p. 345.

and in by far the majority of cases this is not, as might be expected, coloured red, but hæmatoxylin. Dr. Mayer expects to be able to give the explanation hereafter of this strange phenomenon, which, however, is no detriment to the process. In consequence of the precision and tint of the stain, the preparations are for the most part not to be distinguished from those obtained with hæmatoxylin. The cochineal tincture also possesses, in common with the well-known alcoholic hæmatoxylin solution of Kleinenberg, the property of not altering the tissues; on the other hand, it compares favourably with it in the simplicity of its production and application, as also in the hold taken by the stain, which in this respect is equal to carmine. On the other hand, there is the defect that hitherto the attempt to stain large objects sufficiently deeply has not always succeeded; although the spinal marrow of the calf, in pieces one centimetre long and more, could be stained uniformly and deeply enough.

With a little care, permanent overstaining need not be feared, and can be removed by washing in acid alcohol (a drop of muriatic acid to about 10 c. cm. of 70 per cent. alcohol).

Prazmowski's Heliostat.—The woodcut represents this instrument, which, it is claimed, is much less complicated and cheaper than any existing form, and more easily regulated. The drum contains, as usual, the clock movement, and rotates a mirror upon its axis once in forty-eight hours. On the circumference of the drum is a dial with



the hours marked upon it, the spaces between each hour being divided into intervals of ten minutes. The drum rests upon supports, which allow it to be inclined in such a manner as to make the axis of the movement coincide with the direction of the earth's axis at the place where it is used.

This direction, which is given by the latitude of the place, need not necessarily be known to the operator, the adjustment of the instrument with respect to the latitude and the declination of the sun corresponding to the day of the year, being effected at once, and, so to speak, automatically. The apparatus is fixed after adjustment in were replaced by young plants, occupying the same position, springing, namely, from the fovea of the leaf. These were not the product of the germination of the macrospores within their sporangium, the macrosporangium being entirely suppressed. In their rudimentary stage these non-sexually produced plants are simply conical emergences, altogether resembling the rudiments of sporangia, but they gradually develop into plants with ordinary leaves. These shoots are not analogous to the bulbils which characterize many classes of vascular cryptogams, such as Lycopodiaceæ and Ferns, in which the Isoeteæ appear to be exceptionally entirely deficient, a phenomenon closely connected with the absence of branching. It is rather an instance of "apogamy" carried out to its most complete stage, namely, the complete suppression, not only of the sexual organs, but of the entire sexual generation.

MICROSCOPY, &c.

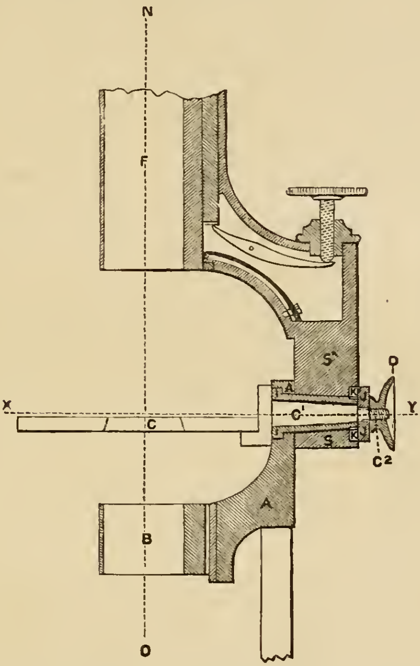
Microscopes with Swinging Tailpiece. — This addition to the Microscope has been revived within the last few years, and its novelty having been the subject of some discussion, we have referred to the provisional specification (not further proceeded with) of Mr. Thomas Grubb, at the office of the Commissioners of Patents, in July, 1854. The nature of the invention was thereby declared to "consist in the addition of a graduated sectoral arc to Microscopes concentric to the plane of the object 'in situ,' on which either a prism or other suitable illuminator is made to slide, thereby producing every kind of illumination required for microscopic examination, and also the means of registering or applying any definite angle of illumination at pleasure."

On 1st August, 1876, letters patent were granted to Mr. John Stuart (on behalf of Mr. Zentmayer, of Philadelphia) for improvements in Microscopes by means of which the sub-stage carrying the illuminating apparatus and accessories (together with the mirror if desired) and also the object stage may be placed at any required angle in relation to the optical axis of the Microscope and object-glass, and also at an angle in relation to each other for the purpose of more conveniently illuminating and viewing the object under examination, more particularly when oblique illumination is required.

The invention consists of a method by means of which the stem which carries the sub-stage and the mirror may be made to swing sideways to the right or left, either below or above the stage on a centre having for its axis of rotation a line in the plane of the object on the stage intersected by the optical axis, that is, a line passing through the centre of the body and the object-glass of the Microscope. The stage is also made to turn independently on a separate pivot, having for its axis of rotation the aforesaid line.

The figure represents in sectional elevation a portion of the Microscope.

S is the limb carrying the body with coarse and fine adjustments. A is the stem which carries the sub-stage B, and mirror if required. A is attached to S by the sleeve or socket I, clamped by the nut J, and on I, A may be swung sideways in either direction to the right or left either below or above the stage, the axis of revolution of which is the line X Y, that is, a line in the plane of the object to be viewed on the stage C, intersected by the optical axis of the instrument, that is, the line N O, passing through the centre of the body and the



object-glass of the microscope. The stage C is also attached to S by the pin C^1, terminated by the screen C^2, which pin passes through the centre of the socket I, and turns therein so that the stage C may be made to turn in either direction in conjunction with or independent of A, the axis of its revolution being also the line X Y.

By this arrangement the stage C and the stem A may be set at an angle to the axis of the microscope either below or above X Y, intersecting the plane of the object to be viewed and also relative to each other, and when so set the stage C may be clamped at the desired angle by the nut D on the screw C^2, acting on S and the collar K.

The specification then proceeds (in the language usual in such cases):—

"Having thus particularly described and ascertained the nature of the said invention and the manner in which the same may be performed or carried into effect, I would remark that I am aware that microscopes have been heretofore made in which a stem or tail-piece has been applied so as to swing from a centre situate below the plane of the object stage, and therefore no claim is herein made in general to a stem or tail-piece made so as to be swung in this position, but the invention which I consider to be novel and therefore desire to be secured to me by the herein in part recited letters patent, is—

"First. The making the stem A, which carries the sub-stage B, to swing to the right or to the left either below or above the stage of the microscope on a centre sleeve socket or joint I, the axis of revolution whereof is the line X Y, in the plane of the object to be viewed on the stage C, intersected by the optical axis, that is, the line N O, passing through the centre of the body F and the object-glass of the microscope, substantially as described and shown in the drawing.

"Secondly. The arrangement herein described and shown in the drawing for enabling the object-stage C to swivel or turn on a centre or pivot within the sleeve or socket I, so that the axis of rotation of the object-stage C shall be from the same centre as that on which the stem or part A turns to the right or left, and the method of clamping the object-stage C in the required angle, as herein described and shown in the drawings."

"Penetration" of Wide-angled Objectives.—It has been objected to wide-angled lenses that they possess less penetrating power, or, more properly, less depth of focus than narrow-angled lenses; that is to say, that the layer of an object, that can be seen without change of focus, is thinner with wide than with narrow-angled lenses.

Dr. Blackham, the President of the Dunkirk (U.S.) Microscopical Society, says that if this were true it would be an argument in favour of the wide-angled lenses, instead of against them; in reality, however, it does not depend upon the aperture, but is only residual spherical aberration, which can be left in and distributed in a wide-angled lens as well as in a narrow-angled one. This will be readily appreciated upon considering the action of an uncorrected plano-convex lens of crown glass. The rays from the nearer surface of the object which impinge upon the peripheral portions of the lens would, if the lens were free from spherical aberration, be brought to a focus further back than those from the further surface of the object which impinge upon the central portions of the lens. As it is, however, they are brought to the same focus, by reason of the spherical aberration. Such a lens has a good deal of *penetrating* power, or depth of focus, but its definition is not satisfactory. The same holds true of all objectives possessed of penetrating power, whatever their angular aperture. The only legitimate method of obtaining depth of focus or "penetration" is by increasing the anterior conjugate focus or frontal distance, so that the thickness of the layer that it is desired to see on each side of the true focal plane may be relatively small. Thus a 1-inch objective with an anterior focus of ·317 of an inch will bear amplification up to 400 diameters, and at that power might properly show, with reasonable clearness, a layer of the object on each side of the true focal plane much thicker than that which a one-fifth with only ·018 of an inch of anterior focus ought to show at the same amplification. It is perhaps true that, by skilful management, the residual spherical aberration can be so distributed, that several planes of an object can be in view at once; but this is always at the sacrifice of definition, and, as the better the image the more noticeable do errors resulting from this plan of overlapping several of them become, wide-angled glasses show the defects of this plan more markedly than narrow-angled lenses, whence has arisen the fallacy that narrow-angled lenses are possessed of an inherent property of "penetration" and a residual error has been lauded as a virtue.*

Process for Measuring the Solid Angles of Microscopic Crystals.—In the 'Bulletin de la Société Minéralogique de France' (1878, No. 4, p. 68) M. Thoulet gives the following method for measuring the solid angles of microscopic crystals:—

If, in a tetrahedron, we know the lengths of the six edges, we can ascertain the angles of the faces surrounding the same summit, and can consequently resolve the spherical triangle whose sides are respectively the angles of the faces of the tetrahedron, and whose angles are the dihedral angles of the edges of this same tetrahedron.

We place the crystal (which may be isolated or contained in a thin plate of rock) in any given position under the Microscope, and choose four special points, two on the edge, and the others respectively on one and the other of the two planes whose angle is to be measured. By means of the fine adjustment of the microscope, we successively bring into focus each of these summits, and note the vertical displacement in each case by the milled head.

Without moving the crystal, we replace the eye-piece by a camera lucida, and make a drawing of the crystal, marking very accurately by pricks the position of the four points; then the crystal is replaced by a stage micrometer, which will make a scale of the drawing to be made.

We now possess all the data necessary to calculate the solid angle. Each of the sides of the tetrahedron is determined: 1st, by its horizontal projection on the drawing; 2nd, by the difference in the vertical height of its two extremities, as indicated by the fine adjustment.

The rest of the work is only a trigonometrical calculation of three rectilinear triangles, whose three sides are known, and of which one of the angles has to be found, and, finally, the calculation of a spherical triangle whose three sides are known, and one of the angles of which is to be found.

Instead of drawing the whole crystal, it is evident that it would suffice to note the four essential points; the complete drawing, however, allows a subsequent verification, which is often necessary, and, besides, enables us to decide as to the crystallographic notations to be given to the crystalline face.

The solid angles of crystals having dimensions less than $\frac{1}{100}$ of a millimetre can be measured to less than a degree by this method.†

Method of Isolating the Connective-Tissue Bundles of the Skin.—Dr. George Thin, in a paper communicated to the Royal Society,‡ describes the method he has made use of for this object.

* From a paper read by Dr. Blackham before the Indianapolis Congress. Cf. a French translation in 'Journal de Micrographie,' iii. (1879).
† 'Bull. Soc. Belg. de Micr.,' v. (1878) 6.
‡ 'Proc R. Soc.,' xxviii. (1879) 251.

By the term *bundle*, or *secondary bundle*, Dr. Thin designates the ordinary bundle of authors, which is more or less conspicuous in all preparations of skin, and which is analogous in structure and size to the bundles as usually described and figured in tendon-tissue. The element described by Rollett as "connective-tissue fibre" he describes as *primary bundle*, to distinguish it more markedly from the fibrillæ which compose it. When groups of secondary bundles are isolated, each group being composed of several secondary bundles, he terms the group a *tertiary bundle.*

These elements can be isolated by first saturating the corium with chloride of gold solution, and then macerating the tissue in acids. Portions of skin, with a thick layer of the panniculus adiposus, were taken fresh from the mamma of a middle-aged woman, which had been removed for a tumour of the gland, the portions of skin chosen being well clear of diseased tissues. The stretched skin was pinned down to a cork board, the under surface uppermost, and then saturated with ½ per cent. chloride of gold solution. From time to time different thicknesses of the fatty layer were removed as the solution had had time to penetrate into the tissue, until, finally, the deeper layer of the cutis proper was laid bare. The tissue, still extended, was then placed in fresh gold solution for several hours. The object of the manœuvre was to secure the penetration of the fluid through the bundles, whilst these were still extended in their natural condition.

After a due action of the gold, the skin was cut into small pieces, which were then treated by acetic acid, and then the strength of the acetic acid raised to 20 per cent. of the ordinary concentrated acetic acid of commerce. Other portions were treated by formic acid. Some successful preparations were obtained from portions macerated first for a few days in a mixture of one part formic acid, of specific gravity 1·020, and one of water, and then in the undiluted acid for some days longer, but a strict adherence to these strengths was not found necessary.

Portions of the corium thus prepared were teased out in glycerine and examined directly or after staining by different dyes. Staining by picric acid was found very advantageous.

In this way he was able to isolate in a condition favourable for study the primary, secondary, and tertiary bundles. Generally speaking, although not invariably, the tertiary and secondary bundles were best seen in the tissues macerated in acetic acid, and the secondary and primary bundles in those treated by formic acid.

Numerous elastic fibres were isolated by both methods, the finest fibres more particularly in the formic acid preparation.

Various methods have been recommended by histologists for the demonstration of the ultimate fibrillæ of fibrous tissue, chiefly with reference to those of tendon bundles. Judging by the figures published in histological works, the fibrillæ of the cutis bundles are, Dr. Thin thinks, very seldom seen; the appearances usually observed in skin hardened by chromic acid and alcohol are unfitted for a study of the fibrillæ. In such specimens the bundles are more or less broken up, but the individual fibrillæ are not, as a rule, isolated. He found, however, that they were well shown by the following method:—A portion of fresh skin, with the panniculus adiposus attached, was pinned to a piece of cork in the manner already described, and treated in the same way, with the exception that this time glycerine, instead of chloride of gold solution, was used for saturation. When the saturated cutis tissue had been laid bare, the whole was placed in glycerine, and allowed to remain in it for several days. Small portions were then teased out in glycerine, stained by picro-carminate of ammonia, and examined in glycerine. In such preparations the secondary bundles were found isolated, the contours of the primary bundles not being preserved. In the secondary bundles the fibrillæ were seen more or less distinctly, in some of them with perfect distinctness.

Process for Preparing the Embryos of Fishes.—The ova of the Salmonidæ are generally employed by embryologists for the study of the development of osseous fishes. It is difficult to observe them in the fresh state, either whole, by transmitted light, on account of the thickness of their envelope, or after having opened them, in consequence of the small consistency of the germ, especially at the commencement of the segmentation. Chromic acid, the reagent most frequently employed to harden these ova, readily alters the young cells, and deforms the embryos by compressing them between the unextensible envelope of the ovum and the solidified vitelline mass. For the last two years M. F. Henneguy * has employed, in the laboratory of comparative embryogeny of the College of France, a process which allows the germs and embryos to be extracted from the ova of Trout and Salmon with the greatest facility, and without subjecting them to the least alteration.

He places the ovum for some minutes in a 1 per cent. solution of osmic acid until it has acquired a light brown colour; then in a small vessel containing Müller's liquid, and opens it in this liquid with a pair of fine scissors. The central vitelline mass, which is coagulated immediately on contact with water, dissolves, on the contrary, in the Müller's liquid, while the solidified germ and cutical layer may be extracted from the ovum, and examined upon a glass plate.

By treating the germ with a solution of methyl-green, and then with glycerine, Mr. Henneguy was able to observe in the cells of segmentation the very delicate phenomena lately pointed out by Auerbach, Bütschli, Strasburger, Hertwig, &c., and which accompany the division of the nucleus, namely, the radiated disposition of the protoplasm at the two poles of the cell, the nuclear plate, the bundles of filaments which start from it, and the other succeeding phases.

This fact proves that the treatment undergone by the ovum does not in any way alter the elements of the germ.

To make cross sections of the germs and embryos thus extracted from the ovum, they should be left for some days in Müller's liquid, and coloured with picro-carminate of ammonia. After having dehydrated them by treating them with alcohol of spec. grav. 0·828, and then with absolute alcohol, they are put for twenty-four hours into collodion. The embryo is then placed on a small plate of elder-pith

* 'Revue Internat. des Sci.,' iii. (1879) 150.

soaked with alcohol, and covered with a layer of collodion. When the collodion has acquired a sufficient consistency, very thin sections may be made, comprising both the embryo and the plate of pith; and these are to be preserved in glycerine. If the sections cannot be cut directly, the piece is placed in the 40 per cent. alcohol; the collodion then preserves its consistency, and allows the embryo to be cut at any time.

This process is applicable to every kind of embryo of little thickness, allowing it to be coloured *en masse.* It has the immense advantage of enabling one to see at what level of the embryo each section is made, to preserve it in the middle of a transparent mass, which maintains all the parts, and prevents their being damaged, as very often happens when an inclusory mass is employed, from which the section must be freed before mounting it.

In his 'Précis de Technique Microscopique' M. Mathias Duval has already recommended collodion for embryological researches, but without indicating his mode of employing it. We hope to render a service to embryologists by making known a process which may be of some utility.

Improvement in Aerating Apparatus of Sea-water Aquaria.—Dr. H. Lenz, of Lübeck, has employed with success the following method (suggested to him by Mr. A. Sasse, of Berlin) for producing very minute air-bubbles from the aerating apparatus. The aperture of the glass tube, instead of being drawn out into a fine point, is widened to 6–8 mm., or a glass tube 25 mm. long and 6–8 mm. wide is cemented with sealing-wax on to the short discharging arm. A piece of common sponge is then pressed pretty tightly into the wide opening. Instead of the somewhat large single air-bubbles, we then have hundreds of very small ones in clusters, and the tighter the sponge is pressed in, the smaller they become.

By this means the air is as finely divided as by the syringe apparatus of the large aquaria. Very slight, if any, increase of pressure is found necessary; and should in time algæ, &c., become attached to the sponge, it can easily be taken out and cleansed. Dr. Lenz used his sponge for three months before it wanted cleaning.*

Further Improvements in studying the Optical Characters of Minerals.—Mr. H. C. Sorby has lately improved his method of studying the optical characters of minerals. He says: †—

"It is a curious example of how a method may be invented and then lost sight of, that the determination of the index of refraction in the way I have previously described, was proposed by a French savant upwards of a hundred years ago. I have not yet consulted the original publication, but I very strongly suspect that the proposal was more theoretical than practical, and that with the instruments then at disposal the results were found to be so inexact that the whole system became obsolete and practically forgotten. I may, however, claim to have so modified the method, and brought the instrumental means to

* 'Zool. Anzeiger,' ii. (1879) 20.
† 'Mineralogical Magazine,' ii. (1878) 103.

such perfection, as to make it fully equal to the requirements of practical mineralogy. Whilst speaking on this point, it may be well to give an illustration of the accuracy with which it is possible to measure the index with the apparatus which I have now at disposal. Thus, in the case of a specimen of quartz, about ·372 inch thick, five different determinations of the index of the ordinary ray for the light transmitted by red glass, which corresponds to the solar line c, were 1·5513, 1·5531, 1·5524, 1·5531 and 1·5513, so that no observation differed more than a unit in the third place of decimals from the mean value, which may therefore be looked upon as true to the third place of decimals, assuming that the equation $\mu = \frac{T}{T - d}$ needs no correction.

There was no difficulty in thus proving that there is a slight but well-marked difference in the index for different specimens. The mean for five was 1·5543, whereas, according to Rudberg, it is 1·5418. In a similar manner I found that my method invariably gave too high a result in the case of other minerals. After many careful measurements I came to the conclusion that this can be satisfactorily attributed to the spherical aberration due to the introduction of a transparent plate in front of the object-glass, as suggested by Professor Stokes. The amount of this error depends partly on the index of refraction, and partly on the special correction of each particular object-glass; and when great accuracy is desired, it is necessary to construct a small table showing the amount that must be deducted in each case. I thus find that, when using my $\frac{2}{3}$ object-glass, if the index is about 1·5 I must deduct ·0100, and when 2·0, must deduct ·0180.

Having thus shown how accurately the index may be measured, it may be well to briefly allude to some improvements in the apparatus. I find two cross lines in the focus of the eye lens very useful in keeping constant the focal adjustment of the eye itself. In adjusting the focus of any object it is always arranged so that the cross lines are also in sharp focus. Without this precaution there may be an important difference, according as the focus is adjusted by moving the object-glass up or down. I have also found it desirable to take the means of two or more sets of measurements made in slightly different parts of the scale, so as to eliminate any error due to imperfect graduation. This is easily managed by moving the fine adjustment. It is by adopting these precautions that I have been able to make such concordant and accurate measurements as those given above in the case of quartz, and to prove that the limit of error may be made very small.

When first I commenced to apply my method to the study of various minerals, with the view of comparing mathematical theory with observation, I soon found that there were a few discrepancies. For some time I thought it just possible that these might be due to errors in the measurements, but I found that these discrepancies became the more and more marked as by degrees I was able to remove every apparent source of error. The principal discrepancy is in the case of bi-axial crystals like aragonite, but some are also met with in the case of uniaxial crystals. I have not yet been able to thoroughly ascertain the laws which govern these special peculiarities, and no kind of explanation has yet suggested itself either to Professor Stokes or myself; and therefore it appears to me undesirable to enter more fully into the question, which relates more to the mathematical theory of light than to practical mineralogy. It may, however, be well to say that the discrepancy to which I refer is in the ratios of the values of the real and apparent indices."

Mr. Sorby gives an illustration of the application of the method to the identification of doubtful minerals, in the case of certain crystals, which he determined to be an unusual secondary form of calcite.

Improved Achromatic Condenser.—Messrs. R. and J. Beck have introduced a modification of the achromatic condenser, in which a series of combinations of lenses are made to revolve excentrically, so as to be brought consecutively into combination with a lower fixed series of lenses. The apertures vary from 40° to 170°, and two of the revolving combinations are truncated and blackened, so as to stop out the central rays to the limits of 60° and 120°.

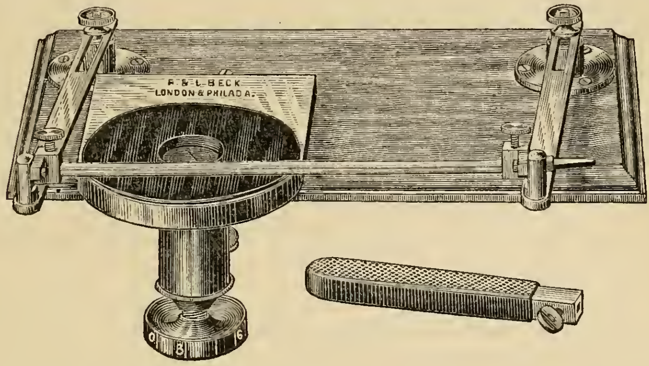
The latest addition to the instrument consists of the application of a revolving diaphragm, with various sized apertures beneath the entire combinations.

Seiler's Mechanical Microtome.—Dr. Carl Seiler, of Philadelphia, is the inventor of an apparatus for enabling the knife, in cutting sections, to be carried through the tissues with an even motion and at the same inclination—a necessary point to ensure success, but not so easy as might be imagined, because the hands usually are not sufficiently steady without a great deal of practice.

It occurred to Dr. Seiler, therefore, that if the knife could be rigidly fastened to some apparatus by means of which it could be moved over the well of the microtome in the same manner that the hands move it, sections of any size and thinness could easily be made, even by an unpractised hand; and after some experimenting he constructed, with the aid of Mr. Zentmayer, a mechanical microtome which proved to be all that could be desired.

It consists of two rigid, parallel arms of metal, which at one end revolve on pivots attached either to the microtome itself, or to the table to which the microtome is to be clamped. On the other end of these arms are fastened revolving clamps which hold the knife, the edge of which, when in position, rests upon the glass plate of the microtome. The handle of the knife is removed, so as to prevent a slipping and hindrance to the motion of the knife, but can be easily attached by means of a screw, for the purpose of stropping.

When in position and ready for cutting, the knife is pressed upon the glass plate, and a slight side-motion is given to it by the hands, which causes it to pass through the tissue, and cut a thin, even section without difficulty. With this apparatus he was able to cut a thin section of the leg of a five months' fœtus, from the knee downward, including the foot, the section measuring 2 inches in length by $\frac{3}{4}$ inch in width. Several mechanical microtomes have been constructed by various workers, but to his knowledge they are all deficient in one point, viz. the knife or cutting instrument in them is carried through the tissue like a chisel; or, in other words, the cutting edge is pressed through the tissue. But a knife, in order to cut well and evenly,



must be carried through the substance to be cut, especially if it is soft, in a slanting direction, so that each point of the edge describes a curve which is equal to a part of a circle. By referring to the figure it will be seen that in Dr. Seiler's apparatus this is exactly what takes place when the knife is moved, the radius of the curve being the length of the arms from the centre of the clamps to the centre of the pivots.*

Size of Histological Preparations.—Dr. Seiler, in the same article ("Practical Hints on Preparing and Mounting Animal Tissues"), considers that the advantage of having the sections of sufficient size to bring into view the different parts of which it is composed has not as yet received sufficient attention from microscopists, especially from those engaged in the study of pathological histology, and yet it is of the greatest importance, for very frequently a pathological new growth will present different appearances in different parts, and often an erroneous conclusion is arrived at in regard to the nature of the tissue from the fact that but a small section has been examined.

"Microscopy" and "Microscopical" Societies.—Under the title of "Is there a Science of Microscopy?" we gave at page 365 of vol. i. an extract from an article by the Editor of the 'American Quarterly Microscopical Journal,' and stated our intention of adding in a later number a translation of an article by Dr. Kaiser, the Editor of the Berlin 'Zeitschrift für Mikroskopie.' This intention we are obliged to abandon, as we find it impossible to do justice to the author's views within reasonable limits of space, the article occupying twenty-five pages of the German Journal. It must suffice here to say that Dr. Kaiser, after referring to Professor Harting's protest against the use of the word Microscopy, and his attempt to contrast it with Ophthalmoscopy ("the science of observation with

* 'Amer. Quart. Micr. Journ.,' i. (1879) 134.

the naked eye"), defines the former as "a free independent scientific discipline of the natural sciences," and "claims the elementary forms as the original and peculiar domain of special Microscopy."

It seems to us, with all deference to those who have from time to time laboured to define "Microscopy" as some special branch of Biology, that they have been led to a fallacious result, through a preconceived idea as to what it would be convenient for the definition to be.

There is, we think, no need to object to "Microscopy" being limited to the Microscope as an instrument (the methods of its application as well as its principles), and the hesitation to admit this has apparently arisen on account of objections that it was thought would then be urged against the existence of a "Microscopical" Society, to which objections, however, there are obvious answers.

The first is, that a "Microscopical" Society, if "Microscopy" refers only to the instrument, is equivalent to a "Lancet" or a "Theodolite" Society.

Even if a Society were established for the single purpose of dealing with the Microscope as an instrument, it would not by any means stand on the same footing as the Lancet or the Theodolite. The Microscope is an instrument *sui generis*, and is not comparable with any other. It is not only as regards its optical principles and mechanical form, but in the various methods of its application, that it might usefully furnish scope for a Society devoted only to those points without regard to any others.*

But further, it is an entire misapprehension if it is supposed that the objects of any known Microscopical Society of the present day are confined to the Microscope as an instrument. The objects of this Society in particular have always been twofold, and have included to an equal extent, to say the least, those branches of natural science conveniently summarized as "the subjects of Microscopical research."

The term "Microscopical," which, as applied to a Society, was no doubt originally used in a sense more nearly agreeing with its strict etymological meaning, has come to be no more than a sign and a symbol, as much as the title of 'Lancet' applied to a newspaper, or those of "Royal" or "Linnean" to a Society.

When this first objection is thus answered, it is then said that another Society for the investigation of subjects of natural history is not required.

It must, however, be obvious that if fifty or twenty-five years ago the Royal Society and the Linnean Society were sufficient to meet the requirements of the biology of that day, the great advance that has been made since that time, and the enormous extension in the ground to be travelled over, is sufficient to justify the existence not of one but of several additional Societies. Notwithstanding that there were

* The most recent instance of the practical benefit to be derived from abstract optical (Microscopical) principles is to be found in the oil-immersion objectives (the origination of which is due to the Treasurer of this Society, Mr. Stephenson), and which are the outcome of the highly technical, and to the biologist no doubt extremely uninteresting discussions on angular aperture, but which have put into his hands a tool which is admitted to mark a greater improvement in the means of investigation than any made since the perfecting of achromatic objectives.

older Societies which covered the same ground, there has been found to be room for another mainly devoting itself to the larger animals—the Vertebrata, and in the same way there was obviously room for one mainly devoting itself to the smaller animals—the Invertebrata, and to the development and minuter structure of the higher forms.

We therefore should define "Microscopy" as the science and art of the Microscope as an instrument both in regard to its theoretical principles and its practical working; but a "Microscopical" Society, as a Society established on the one hand for the improvement of the Microscope and the methods of its application ("Microscopy" proper), and also for the communication of observations and discoveries in the various branches of Biology (Invertebrata, Cryptogamia, Embryology, Histology, &c.), which more especially require the aid of the Microscope for their investigation.

Oil-Immersion Objectives.—We are glad to find that the English opticians are at length turning their attention to these objectives, which it has hitherto been impossible to procure of English manufacture, although we believe we are correct in saying that their construction was primarily urged upon opticians in this country when the idea first suggested itself of the desirability of oil objectives.

Messrs. Powell and Lealand exhibited at the meeting of the Society on the 9th April, an $\frac{1}{8}$ oil-immersion objective of their manufacture, and we believe that the construction of higher powers is being proceeded with.

Method of Preserving Infusoria, &c.—A note by M. A. Certes in 'Comptes Rendus'* describes a method of obtaining permanent preparations of the Infusoria, which he hopes may help to create collections of which all the Museums of Europe are at present deficient.

The method which he suggests is the employment of the vapour or a solution of osmic acid (2 per cent.), the former, although well known in histology, "never yet having been applied to the Infusoria,"† and he claims that the organisms are instantaneously fixed, so that the least details, cilia, cirrhi, flagella, and buccal armature may be observed with the highest powers, the Euglenæ and Paramecia preserving their characteristic colour. The nucleus and nucleolus stand out clearly, and show, when these occur, the curious phenomena described by Balbiani. The process may be applied successfully not only to the Infusoria, but also to the Rotatoria, Anguillulæ, Bacteria, and Vibrions.

The important point is to make the osmic acid act promptly and with a certain force. Two means are available for obtaining this result with some certainty. The first, which is suitable for most cases, consists in exposing the Infusoria to the vapours of the acid for a period of from ten to thirty minutes. For very contractile Infusoria the process is different, the immediate contact of the osmic acid being obtained by putting a drop of the solution on the cover-glass before placing the latter on the drop of water. The excess

* 'Comptes Rendus,' lxxxviii. (1879) 433.

† Compare, however, Dr. Pelletan's process—this Journal, i. (1878) 189. Also Huxley and Martin's 'Biology.'

of liquid is then removed by blotting-paper, and thereby a slight and advantageous pressure produced on the cover-glass.

After the cover-glass is in place, two of the opposite sides should be fastened either with paraffin or Canada balsam to prevent displacement in colouring.

To colour the organisms he uses eosin or Ranvier's picro-carminate. Infusoria previously treated with the osmic acid may be coloured direct with the picro-carminate, but when it is employed alone, it is not easy to control the colouring, so that the preparations often turn out opaque. After several attempts, he found that a mixture of glycerine and picro-carminate will enable any degree of colour to be obtained (glycerine 1 part, water 1 part, picro-carminate 1 part). Introduced suddenly, the glycerine even when diluted frequently produces an abnormal retraction of the tissues, which does not always disappear. Professor Ranvier gives in his 'Histology' a very simple means of avoiding this inconvenience, which M. Certes has employed with success for the most delicate organisms, such as *Oxytricha* and *Stentor;* it consists in placing the preparations, fastened as above described, in a moist-chamber, and putting a drop of carminated glycerine on the edge of the preparation. The water evaporates very slowly, and in twenty-four hours is replaced by the diluted glycerine. By the same process the latter may be replaced by concentrated glycerine, which assures the preservation of the preparations.

All methods of sealing down may be applied. It is, however, better to use dry Canada balsam dissolved in chloroform. The organism to be examined might be at the side of the glass, and this varnish, being thin and perfectly transparent, does not hinder observation even with the highest powers.

Mixture of Oils for Homogeneous-Immersion Objectives.—Professor Abbe points out that in regard to the performance of oil-immersion lenses with *central* light it is a matter of importance to regulate carefully the oil-mixture as regards refraction and dispersion. He noticed some time ago that some of the samples of fennel-oil and olive-oil were rather strong in both respects, so that it is possible that better performance will be got with central illumination when a small additional quantity of olive-oil is added for reducing the refraction to that of the oil of cedar-wood, and then further adding $\frac{1}{3}$ or $\frac{1}{2}$ of cedar-oil to the mixture to reduce the dispersion (the latter specially for thin covers).

New Fluids for Homogeneous Immersion. — The result of Professor Abbe's later experiments will be found at p. 346 of the 'Proceedings.'

Standard Micrometers.—A letter from Professor R. Hitchcock (the editor of the 'American Quarterly Microscopical Journal') on this subject is printed at p. 349 of the 'Proceedings.'

Unit of Micrometry.—The resolution come to by the meeting of the Society on the 9th April will be found at p. 349 of the 'Proceedings.'

OBITUARY.*

Seven Fellows have died during the past year, viz.:—Mr. R. J. Bagshaw (London), elected 1846, died 14th August, 1878; Mr. R. Branwell, M.R.C.S. (Brighton), elected 1873, died 23rd September, 1878; Dr. H. Owens, M.D., M.R.C.S. (London), elected 1867, died 9th September, 1878; Captain E. W. Roberts, F.R.G.S. (Boxmoor), elected 1866, died 12th June, 1878 (of whom we have not received any Obituary Notices); and the following:—

Mr. John Robert Burton (a successful merchant, and one of the founders of the "British Empire Life" and "Perpetual Building Society," on the management of which he continued to the last) died at his residence, Huskards, Ingatestone, on the 20th November, 1878. He was elected a Fellow of the Society in 1861, and though rarely seen at the meetings, was much attached to the use of the Microscope, and occupied himself in his leisure hours with mounting objects.

Mr. George Guyon was a descendant (the great-grandson) of the famous French Huguenot family of Guyon; the head of which, Guyon de Geis, Sieur de Pampelona, came over to England at the Revocation of the Edict of Nantes, and took service under William III. He was born at Richmond, in Surrey, on March 10th, 1824, after the younger of the senior members of his family had grown up. One of these, General Guyon, became famous subsequently for his defence of Kars (in conjunction with Sir Fenwick Williams) against the Russians.

From his birth Mr. Guyon was so delicate as to preclude the possibility of his being educated for any profession. He very early exhibited the strongest predilection for science, and especially for natural science, devoting himself at one period of his life largely to Entomology. He leaves an extensive and valuable collection of Coleoptera. He later took up the Microscope enthusiastically, and became an expert and dexterous manipulator. His neatness in mounting objects was remarkable, and he had accumulated a large number of specimens illustrative of various branches of natural history. By his physician's order, he was for some years compelled to pass the winter at Ventnor, which he ultimately made his permanent residence, and where he erected an astronomical observatory, furnished with a fine equatorial, &c.

There were few more delightful men in society than Mr. Guyon. His varied and extensive reading supplied an inexhaustible fund of conversation; while his numerous accomplishments, and unflagging readiness to enter into any scheme of amusement or instruction, rendered him a favourite both with old and young. Nor was his pen idle. He contributed, *proprio nomine*, and under his initials "G. G.," pretty frequently to 'Science-Gossip'; appearing at other times as "Vectensis" in the 'English Mechanic.' Lastly, he was a munificent anonymous donor to nearly all the leading charities in England.

* Pressure on our space made it necessary to omit this in the last number. It should have accompanied the Report of the Council.

He was elected a Fellow of this Society in 1858, and died 25th February, 1878, in his fifty-fourth year.

Dr. Edward James Shearman, M.D., F.R.S.E., F.L.S., &c., who died at Rotherham on the 2nd October, 1878, in his eighty-first year, was born at Wrington, in Somersetshire, next door to the celebrated Hannah Moore, and received his early education at Mr. Catlow's School, at Mansfield, where he was articled to a surgeon. He passed the Apothecaries' Company in 1820, having had the opportunity of studying under Brodie (afterwards Sir B. C. Brodie), at St. George's Hospital, and settled at Rotherham about 1823, where he very soon took a leading position as a general practitioner in the town and neighbourhood. He afterwards passed the College of Surgeons, and some ten years ago was made a Fellow. He took the degree of M.D. of Jena in 1841, and became a Member of the Royal College of Physicians, London, in 1869, having obtained the extra Licentiate in 1843.

His contributions to medical literature have been numerous and varied in almost all the journals of his time. In 1845 he published an "Essay on Properties of Animal and Vegetable Life." In 1846 he was elected one of the Council of the Provincial Medical Association, and in 1847 was appointed to write the "Retrospective Address on Diseases of the Chest," which was read by his son in 1848 at the annual meeting, and was afterwards published by the Council. He was elected a Fellow of the Royal Society of Edinburgh, of the Medico-Chirurgical Society, and of several other learned bodies. In 1856 he was elected a Fellow of this Society, having been early associated with the pioneers of the Microscope in medicine, and he continued to the last to manifest a most striking love for microscopical science, in diagnosis of disease, of which he had early become an adept. More than twelve months before Dr. Golding Bird published his first edition of 'Urinary Deposits,' he read before the Sheffield Medico-Chirurgical Society an "Essay on the Changes in the Urine affected by Disease," and the tests to distinguish them, which was published in the 'Lancet'; and the information which he gave to the town on sanitary matters was very interesting, exposing the evils which existed at the time, which attached more particularly to bad water and faulty drainage. His microscopical examinations of the water caused great alarm, and thoroughly opened the eyes of the people to the unsanitary condition of the town as regarded sewage and water, and paved the way for a new and better era.

He was married twice, first to the daughter of Mr. Brooks, of Old Moor, Wath, by whom he had three children; the death of his surviving son, Dr. Charles, who died about fourteen years ago, aged fifty, was a great blow to him, as he was a man of acumen and great promise in his profession. In 1872 he was married to Miss Turner, of South Grove, who survives him. Dr. Shearman was held in the highest esteem by large numbers, not only of friends, but of patients in various parts of the country, who had been in the habit of constantly consulting him.

JOURNAL

OF THE

ROYAL MICROSCOPICAL SOCIETY;

CONTAINING ITS TRANSACTIONS AND PROCEEDINGS,

AND A RECORD OF CURRENT RESEARCHES RELATING TO

INVERTEBRATA, CRYPTOGAMIA, MICROSCOPY, &c.

Edited, under the direction of the Publication Committee, by

FRANK CRISP, LL.B., B.A., F.L.S.,

ONE OF THE SECRETARIES OF THE SOCIETY.

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1879.

Searching for Trichinæ.—Mr. George W. Morehouse, of Wayland, N.Y., says * that it is undeniable that microscopists waste a good deal of valuable time by the use of higher powers than are necessary, and by imperfect preparation of objects for examination. In nothing is this more forcibly illustrated than in the examination of pork for trichinæ. For this purpose it is customary to use powers of 75 diameters and upwards (seldom as low as 50), and the meat is not always made sufficiently transparent for ready detection of the parasites. A power of 25 diameters, obtained with a good 2-inch objective, and 2-inch ocular, is amply sufficient. With the 2-inch we have greater depth of focus, the object is still shown with great clearness, and, most important of all, we are able to do as much searching in one hour as it would take about nine hours to accomplish with a $\frac{2}{3}$-inch objective.

As to preparing pork for present, rapid, and accurate observation, he has found the following method to work well:—Cut thin longitudinal sections from the extremities of muscles, and from other favourite localities where the worms, in migrating, stop in greatest abundance, and place the sections in a watch-glass, covering them with acetic acid. In a few minutes the tissues will be transparent enough to enable one to see the letters through the specimens when the watch-glass is placed on a printed page. Drain off the acid, add water and examine, or wash and transfer to a glass slip (large, with large cover, for a number of sections at once), either in water or glycerine, and cover. For permanent preservation, while the sections are still in glycerine, press them for several days between plates of glass, and mount at leisure in pure glycerine. When thus prepared, the parasites remain coloured more highly than the surrounding muscular fibres, and readily attract the eye. They are so plain, that none, when brought into the field of view, can escape instant detection. The process is simple, takes but little time, and is inexpensive.

Method of Studying the Structure of Vegetable Matter.—M. Merget, of Bordeaux, finding that mercurial vapour easily permeates disks of wood, recommends it as a means for studying the structure of vegetable matter. If wood, after exposure to the vapours of mercury, is brought in contact with a sensitive paper (obtained by saturating paper with an ammoniacal solution of nitrate of silver) a distinct design of the fibro-vascular bundles and of the medullary rays will be obtained. We may thus design the stomata of a leaf, and show that in the case of those possessing stomata on both surfaces the air circulates from one epidermis to the other.†

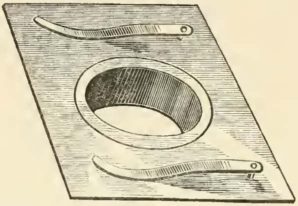
Thin Stages.—It is, we think, a matter for surprise that with all the attempts that have been made to produce stages of excessive thinness, to allow of the use of light of extreme obliquity, opticians have never provided their Microscopes with any contrivance for allowing the slide to be attached to the under side of the stage. Such a contrivance would cost a very trifling sum, and by its adoption the

* 'Am. Journ. Micr.,' iv. (1879) 36.

† 'M. Journ. Sci.,' i. (1879) 389.

utmost possible limits of obliquity would be attained. This is the more important at the present time, when the apertures of object-glasses are being so largely increased.

Contrivance for holding Objects beneath the Stage.—Since the preceding note was in type the 'Monthly Journal of Science' has published * a note on a simple contrivance for holding the object beneath the stage of the Microscope when extreme obliquity of illumination is required. It is the device of Mr. John Phin, of New York,



and has the advantage of being easily adapted to any Microscope. The little "sub-stage" (shown in the annexed woodcut) with clips attached slides into the aperture in the stage, and the mode of use is obvious. Mr. Phin states that the plan of holding the object beneath the stage is not new, having been invented by Mr. C. S. Spencer about twenty years ago.

New Microtome.—Several years ago, wishing to make some thin sections of animal tissue, and not having the educated hand, Dr. S. W. Fletcher, of Pepperell, Mass.,† set about devising an instrument for doing such work. The conditions to be fulfilled appeared to him to be: to attach the cutting blade to a carrier so arranged as to draw repeatedly the edge of the blade over the specimen with any desired inclination and in exactly the same course; to prevent every part of the blade, except the edge actually cutting, from touching the preparation; to immerse the object in alcohol or other preservative fluid whilst being cut; and to approach the specimen to the blade to any desired extent, the whole instrument being made heavy and firm enough to prevent any considerable trembling under ordinary use. These conditions he has endeavoured to fulfil in the following manner:—

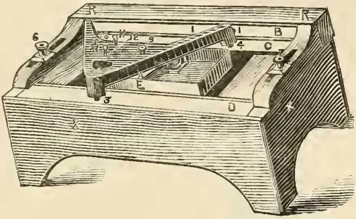
X X, Fig. 1, is a wooden frame 16 inches in length, 8 inches in width, and $5\frac{1}{2}$ in height; to the top of this is clamped the wooden bar R R by means of the bolts 6 and 7, which pass through the slots cut in the arms which project from each end of it. B is a piece of thick plate-glass cemented to the side of the bar R R, and C and D are similar pieces of glass cemented to the top of the frame X X. In the centre of

* 'M. Journ. Sci.,' i. (1879) 392.

† 'English Mechanic,' xxix. (1879) 108 (from 'Boston Medical and Surgical Journal').

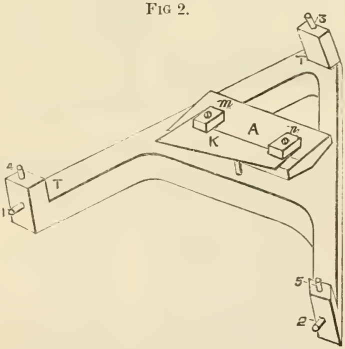
the frame is the brass pan E. Near the centre of this pan is a well, 1 inch in diameter and 2 inches deep. At one side of the well is a clamp, 4, which by the screw 1 is pressed tightly against the specimen to be cut. Over this pan is the iron tripod T T (see Fig. 2), beneath which is suspended a brass plate A by means of the bolts 8 and 9.

Fig. 1.



This plate is made to incline more or less towards the glass plate C, and is fastened firmly in position by the set screws 11 and 12. By these any desired inclination can be given to the cutting blade, which is clamped to the under surface of the plate A. He commonly used a wide Le Coulter razor blade for cutting. The legs of the tripod have ivory pins driven firmly into holes drilled deep in their ends; these

Fig 2.



pins project one-fourth of an inch, and their points, 3, 4, 5, rest on the glass plates C and D. From the sides of two of the legs ivory pins project in the same way, and their points, 1 and 2, rest against the glass B. The opposite sides of the well are grooved on their outer surfaces, and in these grooves rest brass guide-pieces, which are firmly bolted to the frame X X, and connected with these guide-pieces is a screw, the point of which presses against the lower part of the bottom of the well. The threads of this screw are forty-eight to the inch, and the circumference of its head is divided into fifty equal parts.

Fig. 2 represents the tripod seen from below, showing the ivory points 1, 2, 3, 4, 5, the brass plate A, and the blade K fastened by the clamps *m* and *n*.

Fig. 3 shows the shape of the heads of the bolts 8 and 9, Fig. 1, and the manner in which they are let into the plate A.

Fig. 4.

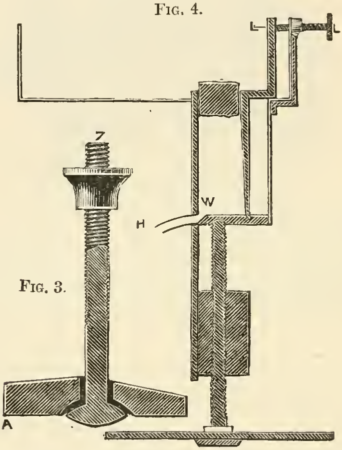


Fig. 3.

Fig. 4 represents a section through the pan, showing the arrangement of the well W, clamp L, and screw for raising the pan. H is a rubber tube, leading from the bottom of the well, for drawing off the alcohol in the pan after using the instrument.

Fig. 5.

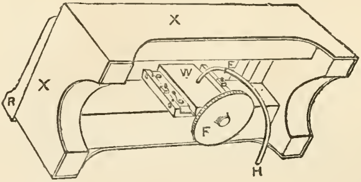


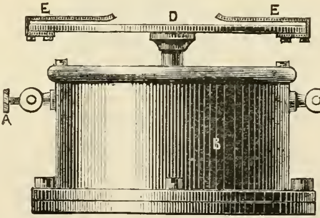
Fig. 5 represents the frame X X seen from below, showing the pan, well W, screw F, rubber tube H, and brass guide-pieces, and the manner in which they are attached to the frame.

The ivory points being well oiled, fill the pan with alcohol, so as to cover the top of the specimen O; place the tripod over the pan, and as far to the left as possible; turn up the screw F until the top of the object to be cut reaches the blade; push the tripod forward from left to right, and the blade will shave the top of the preparation; draw the tripod from the glass B for half an inch, or raise the leg of the tripod resting on D half an inch; it can then be pushed to the end of the glass plates from which it started without the knife touching at any point. Now let the tripod approach the glass B until the points 1 and 2 touch the glass; turn the screw F so as to elevate the pan more or less, according to the desired thickness of the section; again repeat the moving of the tripod as already described, and a section is obtained of uniform thickness and any desired thinness the blade is capable of cutting. With a well hardened specimen and a very thin, sharp blade, sections three-fourths of an inch wide, 1 inch long, and 1-2400th part of an inch thick can readily be made. Very delicate objects need to be imbedded in wax or paraffin; ordinary ones are held by the clamp L without any such preparation.

The whole instrument weighs about 16 lbs., and costs about twenty-five dollars, not including the blades. The cost of four or five blades is not far from five dollars, or one dollar each.

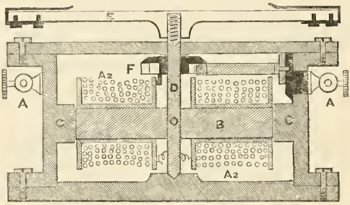
Electrical Mounting Table.—Mr. F. M. Rogers, of Moorgate Station Buildings, E.C., communicates the following:—Microscopists who mount their own objects must have felt the want of a mounting table that would automatically run at any desired rate of speed, while allowing the mounter free use of both his hands. The instrument represented in the woodcuts, which has been devised by him, supplies these requirements, the motive power being electricity, derived preferably from a small and very inexpensive bichromate battery.

Fig. 6.



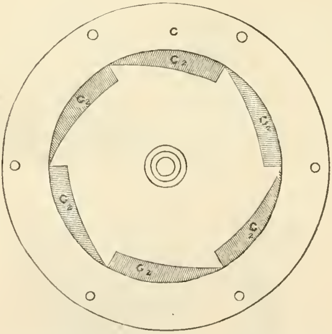
Upon joining up the two connecting wires from the battery to the terminals marked A, Figs. 6 and 7, a current flows through the insulated wire A^2 surrounding the bar of soft iron B, which is pivoted to the spindle D, and carries the table E. The bar is thus rendered powerfully magnetic, and instantly turns towards the top of the nearest inclined armature, of which there are six, C^2 (Fig. 8), cast in the case C. By means of a circular contact-breaker F, Fig. 7, fixed to the spindle D, but insulated from it, the current is only allowed to excite the magnet when its poles are at the foot of any of

Fig. 7.



the inclined armatures; as it turns towards the top, or point nearest its poles, the current ceases, and with it any retarding action upon the magnet. Acquired momentum carries it to the foot of the next

Fig. 8.



incline, and the process is repeated, a steady rotary motion resulting, which can be regulated by exposing more or less of the zinc in the battery to chemical action.

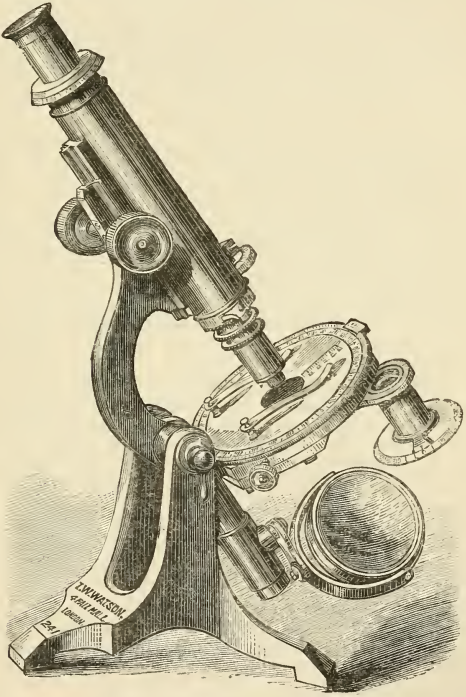
English Microscope for Students of Mineralogy and Petrology.—Mr. Frank Rutley describes * a new Microscope, specially suited for mineralogical and petrological research, constructed for him by Mr. T. W. Watson, of Pall Mall.

An examination of one of the Microscopes devised by Professor Rosenbusch and manufactured by Fuess, of Berlin, showed that, although that instrument possessed many features of great merit, it

* 'Nature,' xx. (1879) 13.

also had certain defects which could be best overcome by adopting and modifying a good English model.

The great defects in most of the Microscopes built on the continental patterns consist in their fixed vertical position, the smallness of their stages, and, very commonly, in the absence of any means of coarse adjustment, except by a sliding movement of the body or tube, which, if working stiffly, is very inconvenient, while, if sliding easily, it is apt to be shifted by a very slight touch.



The instrument now manufactured by Mr. Watson is in most respects quite equal in performance to Rosenbusch's, so far as the mechanical appliances and adjustments are concerned, and is, in point of convenience, decidedly superior to the latter instrument.

The general form of the instrument is sufficiently shown in the accompanying woodcut. In the stand first made the milled head of the fine adjustment was divided for the measurement of the thickness of sections, but in future it is proposed to effect this object in a different manner by divisions engraved upon the limb and the sliding portion of the coarse adjustment (a vernier). The right trunnion carries a clamp to fix the instrument at any angle. The head of the tube or body carries a bevelled disk which is divided to 10° spaces. A corresponding disk with an index is attached to the bottom of the analyzer-fitting, and rests directly upon the fixed divided disk; so that the analyzer can be set in any required position, and any amount of revolution imparted to it can also be registered. The eye-piece, when inserted, is kept in a fixed position by a stud, which falls into a small slot. Crossed cobwebs are fixed within the eye-piece for the purpose of centering the instrument. A small plate of calc-spar, cut at right angles to the optical axis, is mounted in a little metal ring, which can be placed between the eye-glass and the analyzer for stauroscopic examinations.

At the lower end of the Microscope-tube a slot is cut to receive a Klein's quartz plate or a quarter-undulation plate, both of which are set in small brass mounts. When these are not in use the aperture can be closed by means of a revolving collar.

The stage is circular, and capable of concentric rotation, and it is divided on the margin to 360°. A vernier is attached to the front of the stage, giving readings to one minute. The edge of the stage is milled, and rotation is imparted by hand.

The polarizer slides into a fitting which is fixed to an arm pivoted on the lower, movable surface of the stage, so that it can readily be displaced when ordinary transmitted illumination is required, and replaced with equal facility.

Two little lenses, affording a strongly-convergent pencil of light, are set in metal rings which drop into the top of the fitting which surrounds the polarizing prism. When these are employed and the analyzer is used, without lenses in the eye-piece (a separate fitting is supplied for this purpose), examinations of the rings and brushes presented by sections of certain crystals, can be advantageously carried on, and a quarter-undulation plate can also be employed when needful. The lower end of the fitting which carries the polarizer is surrounded by a divided disk, turning beneath a fixed index, so that any position of the prism can be recorded, and the rotation imparted to it can be measured.

From the foregoing description it will be seen that this instrument is capable of performing the functions of an ordinary Microscope, a polariscope, a stauroscope, and, to some extent, a goniometer. A spectroscope could be fitted to it if needful, as well as an apparatus for heating sections of crystals.

Female Microscopical Society.—We gather from a report of a "regular meeting" of the Microscopical Society of Wellesley College, U.S., on March 15, reported in the 'American Journal of Microscopy,'* that it consists exclusively of lady members. The

* 'Am. Journ. Micr.,' iv. (1879) 71.

President, Miss Cook, was in the chair. Miss Dickinson read a paper upon animal and vegetable hairs, which was illustrated by slides of horizontal sections of the scalp prepared by Miss Nunn, Professor of Biology; Miss Beattie presented a paper on Bacteria; Miss Whipple gave a demonstration of the method of cutting and double staining vegetable sections, beginning by describing the proper method of honing a razor; slides mounted by Misses Cummings and Whipple were exhibited; Miss Whiting called attention to the receipt of fifty of Smith's slides of Diatomaceæ; and, finally, the report is attested by "Marion Metcalf, Corresponding Secretary."

Oblique Illumination.—Mr. C. Hue says that he has obtained highly successful results where extreme obliquity of illumination is required, by the use of the parabolic illuminator, in conjunction with a small super-stage, similar to that of Dr. Matthews.

Limits of Accuracy in Measurements with the Microscope.—Professor Rogers calls attention to the note on p. 345 of vol. i., and says that the error referred to consists in the report from which we quoted having given 32 millionths instead of 32 ten-millionths.

Royal Society Conversazione.—On April 30th, at the above Conversazione, the following were the exhibits relating to microscopy:—

Messrs. Powell and Lealand:—Their new $\frac{1}{8}$ oil-immersion lens, with *P. angulatum*.

Mr. F. Ward:—New micro-spectroscope, in which a rectangular quartz prism is substituted for the usual metallic slit. (This Journal, vol. i. p. 326.)

Mr. J. Mayall, jun.:—Zeiss's new $\frac{1}{18}$ oil-immersion lens, with *Amphipleura pellucida* (in balsam); and the improved immersion illuminator designed by the exhibitor with special reference to the Ross-Zentmayer stand.

Mr. Crisp:—Powell and Lealand's new $\frac{1}{8}$ oil-immersion lens, with *Frustulia Saxonica* (dry), and a similar illuminator.

four hours in equal parts of methylated alcohol and water, had been kept sixteen months in glycerine.*

Preparation of Diatoms in situ: means of avoiding Air-bubbles.†—M. Petit, referring to the process of Brebisson of preparing *Odontidium Tabellaria*, viz. by placing the filaments on thin glass or mica, and heating on a plate of platinum, says that this presents serious difficulties to amateurs who regard the beauty and cleanness of their preparations. In the first place, it is rare that we are able to carry the calcining sufficiently far to completely destroy the cellulose, which reduced simply to charcoal blackens the frustules; secondly, preparations thus calcined are with difficulty penetrated by Canada balsam, even although care may have been taken to make it sufficiently fluid by the addition of an essential oil, &c.; thirdly, in calcining on the cover-glass only one of the faces of the diatom is ordinarily seen, whilst it is often essential in determining the species to see the two aspects.

He therefore proposes the following method to get rid of these inconveniences. He places the diatoms (previously washed in fresh water if they are marine) in concentrated cold nitric acid for twelve hours; this time is sufficient to "nitrify" the cellulose, without destroying it or dislocating the filaments After sufficient washing, they are placed on the cover-glass, and calcined to a red heat on a plate of platinum until the deposit has become white; it is then easy to make dry preparations in which there is no deposit of charcoal; for in this case the cellulose, owing to the action of the nitric acid, is destroyed without appreciable residue.

To avoid bubbles of air with Canada balsam, he makes use of oil of lavender, placing a small drop, after the calcination and when the preparations have got cold, on the cover-glass; this infiltrates into all the cavities, and facilitates the penetration of the balsam. The cover-glass should then be placed on a drop of balsam deposited on the slide, and heat applied with a spirit lamp, so as to drive away the oil of lavender and to evaporate a part of the balsam.

In order to prepare diatoms *in situ* in their various aspects on one slide, he boils about the third part of the collection, and mixes this, after washing, with the two other parts, treated with cold nitric acid as above mentioned, and thus obtains excellent preparations containing both diatoms *in situ* and those separated, which is of great advantage for study.

Mechanical Turntables.‡—Mr. Spencer Rolfe, referring to Mr. Rogers' electrical mounting table,§ says that some time since he

* The method is one that might be used for the examination of the retina of rare animals when the eyes have to be procured from a distance. After the remarkable observation of the anastomosis of the ganglion cells of the elephant's retina by Corti, to which there has been as yet no parallel, a further examination of the retina of that animal is very desirable. The eyes of elephants in a condition suitable for such an examination are not easily procurable, but by the use of the above method available specimens might be had from India.

† 'Brebissonia,' i. (1879) p. 121. ‡ 'English Mechanic,' xxix. (1879) p. 139.

§ This Journal, ii. (1879) p. 469.

thought he would apply clockwork to a table, but on considering the matter, it seemed unnecessary to give it a continuous motion, as a slide can be ringed in a very short time, and the table must then be stopped to remove it. He therefore adopted a method which he considers simpler, more convenient, and less costly.

The milled portion which is used to spin an ordinary turntable is replaced by a small cog-wheel, and in a horizontal slot in the mahogany support, in a line with this wheel and gearing into it, is a segment of about one-sixth of a cog-wheel, say $4\frac{1}{2}$ inches diameter; this segment is continually pressed by a strong spring to the left-hand side, against a small indiarubber stop, and has then moved so far as to be out of gear with the small wheel, and plenty of clearance. A trigger in the form of a hook, working vertically in the mahogany—the hook catching the lower side of the segment when pushed over—completes the arrangement. The action is as follows:—The segment is pushed over and is held by the catch, the slide being in position. On placing the hand holding the brush on the support, the catch is released, the segment flies round, carrying the table round in the opposite direction; and clearing it, the table continues to revolve. If we could only manage to remove and replace the slides, a moderately well-balanced and weighty table would turn a sufficient time to ring, perhaps, five or six slides.

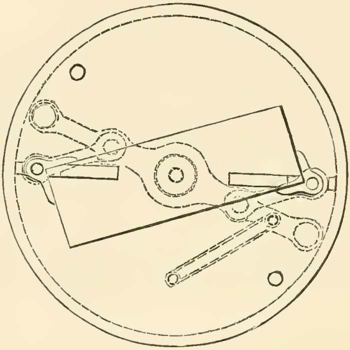
Improved Turntables.*—Mr. Rolfe also communicates the following (the apparatus having been exhibited at a recent meeting of the Quekett Microscopical Club):—My object has been to remove the following objections which I have experienced whilst using the ordinary turntable. A slide having been partly finished and allowed to dry, it is very difficult to replace it with the cell or ring of varnish perfectly centered, and indeed with great practice such can only be done by a considerable expenditure of time and patience. Again, should a very delicate object be mounted, it is very often driven with the rush of fluid near the outside of the cell, and unless the finishing ring of varnish can be put on correctly it stands great chance of being covered by it. With only the springs to hold the slide it is constantly shifting about, and I have found it most annoying when, as has frequently happened, I have spoilt a carefully mounted object from this cause.

My first endeavour to avoid these disadvantages is shown in Fig. 1. It consists of a parallel system of levers, actuating two clips, working in slots in the table, each clip embracing one corner of the slide. The clips are constantly drawn together by an elastic spring. I found this work admirably for a time, but by wear the slides were not correctly centered, and I found moreover that nearly every slide I used was a trifle out of square, and it was therefore necessary to take care that the same corners were always engaged by the same clips. This fact gave me the idea of a far simpler and equally efficient turntable, shown in Fig. 2. The top A has two small pins B B projecting about the thickness of a glass slide, and diagonally opposite

* 'English Mechanic,' xxix. (1879) p. 365.

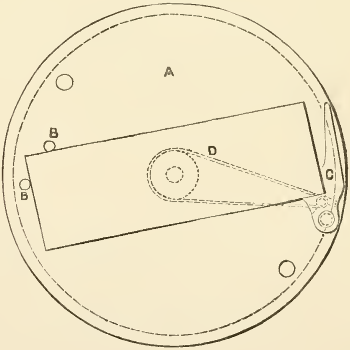
these is a catch C, a pin from which projects through a slot in the table, and is drawn towards the centre by a spring, shown dotted. This I find acts admirably in every way, and provided the slide to be

FIG. 1.



re-ringed has been previously ringed in it, it will always go back truly centered. The stops B B are placed in such a position that the centre of the slide is a little out of truth with the centre of the table, and it

FIG. 2.



is then seen in a moment, when a slide is placed in the clip, if the right corners are engaged, and if not correct it only requires reversing end for end. Glass cannot be held in a rigid grip, and I find the pressure given by common elastic bands admirable, and they can be renewed at a nominal cost.

The two holes shown in both the tables are to take springs in order to be able to use it in the usual way for old slides. I have found it of great advantage to make the support for the hand (not shown in the figures) slide back so as to be able to take in exceptionally large or deep cells.

Large Micro-photographs.*—Dr. S. Th. Stern says that to obtain a micro-photograph on a large scale the screen of the camera has to be placed at too great a distance from the objective for the operator to be able to adjust the focus without complicated machinery for connecting the fine adjustment with the camera which is uncertain in action, troublesome to work, and of considerable cost. He dispenses with the machinery by simply placing a mirror behind the ground-glass screen. The image thrown upon the screen is reflected in this mirror, and may be viewed through an opera-glass by the operator as he stands by the objective and adjusts it. The adjustment is effected by this means with the greatest ease.

Dr. Sorby at Cambridge.—The following neat reference to Dr. Sorby's labours made by the Public Orator at Cambridge on the occasion of conferring the LL.D. degree, may appropriately find a place in this Journal which numbers so many readers "*qui minuta curiositate arcana illa quæ oculorum aciem fugiunt instrumentorum novorum auxilio perscrutantur*":—

"Quam magna est rerum natura, in magnis quam immensa, in minimis quam magna! Quam multa miracula, antiquis ignota, illis nuper ostendit qui minuta curiositate arcana illa quæ oculorum aciem fugiunt, instrumentorum novorum auxilio perscrutantur! Hic autem ille est qui, et terrestrium et de cælo delapsorum lapidum investigandis elementis primis, primus inter Britannos talium instrumentorum usum accommodavit. Nuper Societatis Geologicæ præses electus, annorum triginta labores oratione cumulavit in qua vere marmoreum sibi monumentum exegit.† Illud vero acutissimum quod crystallis etiam minutissimis exploratis in quibus (ut fit) pars altera est aquæ plena, altera aëris quoque vacua, olim indicavit qua potissimum caloris temperie inclusa illa aqua totum illud vacuum implere, quo potissimum rerum statu saxum illud, quondam ignibus prorsus liquidum, primum durescere potuisset. Scilicet crystallum illud (ut Claudianus ait)

'Non potuit toto mentiri corpore gemmam,
Sed medio mansit proditor orbe latex
Auctus honos; liquidi crescunt miracula saxi
Et conservatæ plus meruistis aquæ.'

Suo phaselo vectus quot maria mox lustrabit, in terra iam pridem unum saltem Argonautarum, qui terram oculis penetrabat, eatenus æmulatis, quod in intima saxorum materia perspicienda, ipse oculo

* 'Zeitsch. Mikr.,' i. (1879) p. 321.

† In allusion to Dr. Sorby's Presidential Address "On the Structure and Origin of Limestones."

potuit 'quantum contendere Lynceus.' Duco ad vos Henricum Clifton Sorby."

Unit of Micrometry.*—Referring further to this subject, Professor Romyn Hitchcock points out that the resolution of the Indianapolis Congress did not deal as is sometimes supposed with a unit for micrometer-makers to subdivide, for which the $\frac{1}{100}$ of a millimetre would probably be the most appropriate subdivision, but with a *unit* in the sense of the smallest whole number used in giving dimensions.

The $\frac{1}{1000}$ mm., the so-called micromillimetre, or *micra* of the French (designated μ), appears to him more suitable for the *unit.* A few examples of its application may serve to support this view.

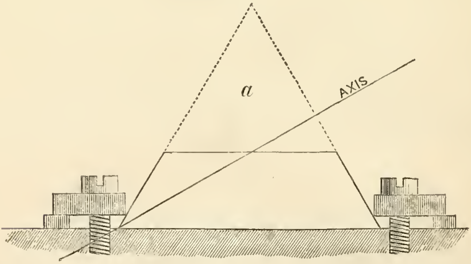
The diameter of a human blood-corpuscle is about $7 \cdot 7\ \mu$ ($\cdot 0077$ mm.). In birds, the corpuscles measure from 12 to 14 μ in one direction and from 6 to 8 μ in the other ($\cdot 012$ to $\cdot 014$ mm. $\times$ $\cdot 006$ to $\cdot 008$ mm.). The corpuscles of *Proteus anguinus* measure $58\ \mu$, and still larger are those of *Amphiuma tridactylum*, $175\ \mu$ ($\cdot 058$ and $\cdot 175$ mm.).

If the reader will assume some other unit, as the cm., or mm., or even the $\frac{1}{100}$ mm., and endeavour to express the same dimensions in these terms, the advantage of the micra will, he thinks, be obvious. With it a single decimal is sufficient for ordinary purposes.

Formation of the Paraboloid as an Illuminator for the Microscope.†—In an article in the 'American Quarterly Microscopical Journal' Mr. Wenham gives some useful information relating to practical methods of obtaining parabolic forms.

The glass parabolic illuminators are ground up to form by means of templates. These may be accurately formed by a purely mechanical method, based on the principle that every section of a cone taken in a plane parallel to the opposite side, is a parabola. Proceed as follows :—

FIG. 1.



Turn a cone either of metal or hard wood, between the lathe centres, then on the face plate (which of course should run quite true) chuck the cone on one side, either by cement or clamps as shown in Fig. 1.

* 'Am. Quart. Micr. Journ.,' i. (1879) p. 235. † Ibid., p. 186.

With the slide rest take off the section *a*, remove the cone, and on the parabolic face screw a well-flattened piece of sheet brass slightly exceeding it in size; back this up by a block of the same wood as the cone; fix both thereto by two countersunk screws passing through holes drilled in the brass plate. The cone is now returned to the lathe centres and the surplus piece of wood turned down, together with the edge of the brass plate, by means of the slide rest till the cone is again complete. A dead smooth file may then be held against the

FIG. 2.

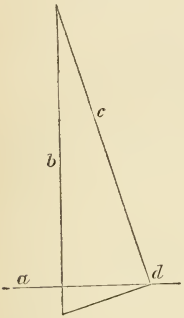
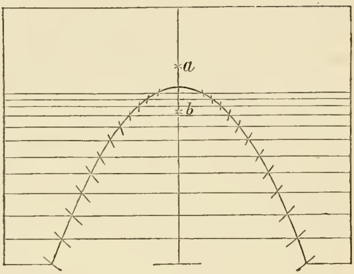


FIG. 3.



revolving cone; this trims the edge of the contained template which comes out as a true parabola. Unless this is made to match a parabolic figure of known focus, it may be necessary to ascertain the focal point of the blank parabola. This can be easily found as follows (Fig. 2):—Draw a line *a* equal to the diameter of the base of the parabola; take a perpendicular to this *b*, equal to the height from the base to the

EXPLANATION OF FIGURES.

FIG. 1.—A wooden cone clamped down by screws on to the face plate of a lathe. The axis from which the cone was turned inclined in the direction shown. The dotted section *a* is turned off parallel with the opposite side; on the parabolic face the template is formed.

FIG. 2.—Method of finding the focal distance of a blank parabolic figure.

a. Diameter of base.
b. Distance from base to vertex.
d Half the semidiameter.

Connect *d* with end of *b* by line *c*; a perpendicular from this, taken from *d* at the point where it intersects the axis below the base, will be equal to the focal distance below the vertex.

FIG. 3.—Outline of rectangular brass plate to form a template for paraboloid.

b. Focal distance.
a. Equal to focal distance above vertex of parabola.

Cross lines drawn at irregular but increasing distances, as shown, measurements on the axis, by compasses, from *a* to each of these lines; each line bisected by the same measurements from the focus or point *b* describes the outline of a parabola.

The dotted segment of a circle is struck from the focus *b* representing a non-immersion paraboloid.

vertex; from the termination of the perpendicular take a line c intersecting the half-diameter of the base line at d; another line is set off from this point at right angles to c; the distance at the intersection of the axis beyond the base line will be the required focal distance of the parabola.

To those not possessing the requisite tools, this method of cutting out a template, of course, cannot be available. The plan of drawing with a square and piece of string, described in all elementary works on geometry, is so irregular in its action, as to be useless for small parabolas; bisection must therefore be resorted to, which by careful manipulation gives a very true figure. This operation depends upon the following property of a parabola: that any point taken on the axis at a distance beyond the vertex equal to the distance of the focus within it, to any transverse line on the axis, will be equidistant from the same line to the focus. Proceed as follows:—

Provide a thin brass plate (Fig. 3) perfectly square and flat, of sufficient size to enclose the required parabola for which it is to serve as a template. In a centre line quite parallel with the sides, prick off two equidistances, the directrix a without, and the focus b within the vertex of the parabola. Draw a number of parallel lines at right angles across the centre line; these lines need not be set at any particular distance, but may be ruled at sight, taking the precaution of setting them close together towards the vertex, and progressively increasing the distance between them towards the base. With fine-pointed dividers, take the distances of these lines on the axis from the directrix or outside mark a in succession. For each measurement, shift the point to the focus b within the vertex, and bisect the line from which the distance was taken on both sides; the intersection of all the lines by the arcs from the focus will give the outline of a true parabola. The crossing points are now to be dotted in with a thin, sharp-pointed centre punch applied at the right spot under a hand magnifier. The surplus brass is cut out with a fine saw, and the template carefully filed up till the punch marks appear as sunk in the metal.

The block of glass if intended for a flat-topped or immersion paraboloid, should have both its base and apex polished off to the right thickness before it is cemented to the lathe-chuck with black sealing-wax. By means of the rough edges of an old saw-file, ground on one side and used with plenty of turpentine, the glass is turned away at a very slow speed till it is seen approximately to fit the template. The edges of this are then slightly smeared with reddle and oil, and the paraboloid fine turned with a keen edge, until the template marks it evenly all over. In order to take out the rings left from the turning, a block of brass, not larger than half an inch square, is traversed over the revolving glass with coarse and then smoothing emery, till all scratches disappear. The glass is then polished with a buff-stick, and crocus and water, and finally a piece of hard beeswax is held against it with finer crocus, in order to obtain the last degree of polish.

If the paraboloid is to be a non-immersion one with a cupped top, it may be turned flat on the end till the required thickness is arrived at and the hemispherical cavity roughly turned out to a half-circle template till the centre is brought to the focus; the cavity is then finished in the same way as a concave lens. Finally, while rotating in the lathe the paraboloid is perforated through the axis with a steel drill and turpentine.

Paraboloids can be made true enough for most purposes if finished as above described; but if great accuracy is a desideratum, the figure may be corrected after the rough turning by means of the following appliance.

It is a property of the paraboloid that the face of every section taken parallel to the axis, is an exact counterpart, and, in form, is the same parabola. This enables us to verify and correct the figure. From the further end of a base board, clamped to the bed of the lathe, hinge a piece of board about two inches wide. Let this be so adjusted that when the front edge is raised, the upper plane of the board falls exactly parallel with the lathe centres. Rough file out a piece of sheet brass, something like the template, to serve as a grinder. Lay this on the face of the hinged piece of wood, and press it up on the revolving glass, smeared with fine emery and water. After a few turns, lower the board and shift the brass grinder endways to another position, either in or out. Repeat this continually, occasionally turning the brass over to equalize the sides. By this operation the parabolic figures, of both the grinder and the glass, will soon correct each other. Of course a piece of the swing board must be scooped out sufficiently to admit nearly half the paraboloid.

In accordance with the above mode of procedure, the parabola is originated and its size predetermined by the given focal distance. The ordinary dry parabolic illuminator is usually made about $\frac{1}{8}$ inch focus; for an immersion $\frac{1}{10}$ will do better; but if this is to be used as an animalcule-holder, $\frac{1}{15}$ will be found sufficient.

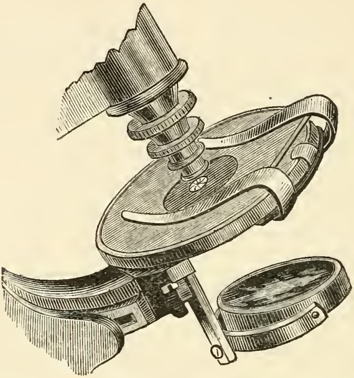
Black-Ground Illumination.—Mr. Wenham in the same article says, that he has never seen minute organisms or animalcula so beautifully displayed as by the truncated paraboloid described in a paper published in the 'Transactions of the Microscopical Society of London' in 1856. The paraboloid is mounted so as to be used also as an animalculæ cage or live box, the object to be placed in water on the flat top, and confined by a thin glass cover; rays from a lamp made parallel to be sent in beneath, using a dry object-glass. The minutest details are visible in their true colours on a black field. He is not aware that anyone has provided himself with this piece of apparatus, and the knowledge of its effects probably does not extend beyond the half-dozen friends who have seen his demonstration.

Rotating Clips for Cheap Microscopes.*—The rotating stage, when well made, is acknowledged to be a most important and useful addition to any Microscope. It has this objection, however, that when well made it is expensive, and when badly made it is worthless. Moreover, it adds considerably to the thickness of the stage, thus interfering with the use of very oblique light.

* 'Am. Journ. Micr.,' iv. (1879) p. 93.

In the new Microscope of Mr. George Wale these difficulties are obviated by means of a rotating clip, shown in the annexed woodcut.

In this form the stage is circular, but immovable; near the outer edge of the stage, both on the upper and the under sides, are two narrow circular grooves, in which slide two pins attached to a bar, which lies beneath the stage (as shown in the figure) and which carries the clips. To the middle of the bar is attached a spring, which keeps the frame of the clips in place on the stage.



This arrangement not only allows the clips to rotate round the stage, and thus permit the object to be placed in any direction as regards the light, but it enables the microscopist to remove the clips instantly from the stage, and thus leave a clear space for work when the Microscope is used in a vertical position. The clips may also be placed on the under side of the stage, so as to hold the slide from beneath. In this way light of the utmost degree of obliquity may be used, as the stage then virtually has no thickness whatever.

Contrivance for holding Objects beneath the Stage.*—Dr. Phin himself describes in his Journal the contrivance which we quoted and figured under this heading (at p. 466) from an English contemporary. In addition to what is there said, Dr. Phin remarks that another important feature of the sub-stage is that if the spring clips be made very light the arrangement serves as a safety stage, and the most delicate slides may be used even by bunglers without danger of having the slide or cover fractured.

* 'Am. Journ. Micr.,' iv. (1879) p. 92.

in the atmospheric dust without being found in a living state in adjoining water; and thus Ehrenberg's question is answered.

It is very possible that these diatoms belong to those in which the phenomena of deduplication, conjugation, and formation of spores are the most active, rapid, and easy to follow, and it is on this account that the study of *terrestrial* diatoms deserves attention.

The Rev. George Davidson, of Scotland, told M. Deby that for several years he has searched mosses for diatoms, and has found that the mosses growing at the foot of elms on the side exposed to the north furnish the greatest number.

MICROSCOPY, &c.

Method of preserving Infusoria, &c.*—M. Certes repeats in the 'Journal de Micrographie' the account of his observations, which have already appeared in the 'Comptes Rendus,' † to which he adds the following remarks:—

To obtain good preparations the following conditions must be fulfilled.

1. The absence of any movement of the cover-glass which could crush the Infusoria.
2. *Rapid* action of the osmic acid and *complete elimination* of the reagent as soon as the desired action is obtained.
3. *Slow and progressive* action of the colouring reagent, whatever it is, and elimination of it by glycerine.
4. *Very slow* substitution of the pure glycerine for the diluted and coloured glycerine.
5. *Hermetical* sealing, which cannot be obtained either with paraffin or with sealing wax dissolved in alcohol, or with Canada balsam if the margins of the preparation are not perfectly dry.

Hæmatoxylic Eosin and its employment in Histology.‡—It is known that eosin, soluble in water, colours the protoplasm of the cell elements, without having any selective action for the nuclei, so that when we wish to bring out these latter in a preparation coloured with eosin, recourse must be had to the method of double colouring proposed in 1876 by Wissotsky, a method which is long and requires several successive washings, which easily leads to the deterioration of the sections. Moreover, alcoholic or aqueous solutions of eosin precipitate that of hæmatoxylin prepared after Boehmer's classic formula.

M. J. Renaut, having remarked that eosin in an aqueous or alcoholic solution does not precipitate the hæmatoxylin of Boehmer's liquid, when the mixing is effected in the presence of neutral glycerine, conceived the idea of employing a liquid prepared in this manner. He mixes one part, by volume, of neutral glycerine and one part of a saturated solution of eosin in alcohol or water (according as pure eosin or eosin à la potasse is used). There is then added drop by drop hæmatoxylin prepared according to Boehmer's formula until the

* 'Journ. de Micr.,' iii. (1879) p. 242.
† See this Journal, ii. (1879) p. 331.
‡ 'Comptes Rendus,' lxxxviii. (1879) p. 1039.

green fluorescence of the mixture is scarcely visible. The filtered liquid gives a violet solution, which he calls *hœmatoxylic eosin*, and is employed in the same way as picro-carminate of ammonia in mounting preparations in glycerine or in Canada balsam. In the latter case the dehydrating is effected with alcohol charged with eosin and clarified with oil of cloves similarly charged.

Preparations made after the action of osmic acid or chromic solutions colour very well with this reagent, showing very regular differentiations. The nuclei are tinted violet, the connective tissue pearl-grey, the elastic fibres and the blood-corpuscles dark red, the protoplasm of the cells and the axis cylinders of the nerve-tubes a very intense light rose, &c.

In treating sections of the salivary glands of *Helix Pomatia*, the author discovered two kinds of cells—the one secreting mucus and colouring an intense blue, the other secreting a special matter distinct from mucus and colouring rose; this distinction is not observable when other colouring matters are used.

In sections of the salivary glands of mammals, and particularly of the Solipedes, the same fact is, remarkable to say, presented. In each acinus (from an ass) *the clear cells which secrete the mucus were coloured pale blue;* the nucleus buried at the base was coloured violet. The *crescent* cells of Gianuzzi, that is, *the cells which secrete the salivary ferment, were coloured a deep rose* and showed a violet nucleus contained in the centre of the protoplasmic mass.

Brösicke's Staining Method.*—Dr. G. Brösicke, of Berlin, recommends a combination of osmic acid and oxalic acid for staining the tissues, instead of osmic acid alone.

Small pieces of the tissue, or prepared sections, are placed for an hour in one per cent. osmic acid solution, and then carefully washed to remove all superfluous acid. They are then immersed for twenty-four hours or longer in a cold saturated aqueous solution of oxalic acid (one to fifteen), and are ready for examination in water or glycerine.

The result is that while certain substances, such as mucin, cellulose, starch, bacteria, the outer coat of certain fungi, &c., are scarcely at all coloured, other tissues, such as the vitreous humour, the substratum of the cornea, the walls of the capillaries, and various intercellular connective tissues, appear of a bright carmine; and muscular fibres, tendon, hyaline cartilage, the outer fibrillary substance of decalcified bone, and most of the tissues rich in albumen are stained a darker carmine. The grey substance of the central nervous system, most nuclei, and many cells, assume a dark Burgundy red tint. In all these cases, however, each particular tissue is stained a slightly different shade, so that it can be readily distinguished from its neighbours.

None of the objects treated by this method swell up or exhibit signs of internal coagulation. The oxalic acid produces darker or lighter shades in proportion to the length of time the specimen had

* 'Sci.-Gossip,' No. 175 (1879) p. 160.

previously been immersed in osmic acid, and if the latter has once completely blackened the tissue, the oxalic acid is powerless afterwards to redden it. Mixed solutions of osmic acid and oxalic acid stain proportionally to the relative strength of each. The chief drawback to this method is the small penetrating power of osmic acid, which prevents the whole thickness of a specimen from being equally stained.

Method of examining Living Cells of Larva of Newt, see p. 692.

Undescribed Microscopes.—We believe that the following Microscopes have never yet been described in any English treatise or journal. We propose to add from time to time the descriptions of any other extant forms which present any specialty, and have not hitherto been described in this country.

Fig. 1 represents the "*Microscope nouveau grand modèle renversé avec miroir argenté*" of Messrs. Nachet.

If the eye-piece of a Microscope is removed considerably from the objective, the image is of course largely increased, but to obtain the full advantage, it is necessary that the eye-piece should be of increased diameter. The weight of this and the long tube presents, however, a practical difficulty in addition to the fact that the observer is so far from the stage that it is impossible for him to manipulate properly.

To avoid these difficulties, M. Nachet conceived the idea of the Microscope represented in Fig. 1.

A strong tripod base supports a hollow brass column, the upper end of which is closed by a plate with a central hole, and to which is fixed a socket in which the tube carrying the objective A is moved by the milled head B forming the coarse adjustment. A fine adjustment is obtained by means of a second tube moved by the milled head V.

To the side of the column is soldered another tube (placed obliquely as shown in the figure), the interior of which is in communication with that of the column by an elliptic opening and having the eye-piece at the upper end. At the bottom of the column is placed a plane mirror silvered on its upper surface, and inclined at such an angle as to be perpendicular to the line bisecting the angle formed by the two tubes, so that all the rays from the objective pass to the eye-piece. The mirror does not appreciably deteriorate the image, the loss of light being insignificant. The distance of the eye-piece from the objective is 90 cm., and very large amplification can be obtained.

The stage is supported above the objective on three supports, and is supplied with movements by G and D. Above the stage is a "super-stage" C (which can be turned aside from the Microscope) for illuminating apparatus, and over that the mirror with universal movements, supported on an upright rod, which can be moved round the summit of the column.*

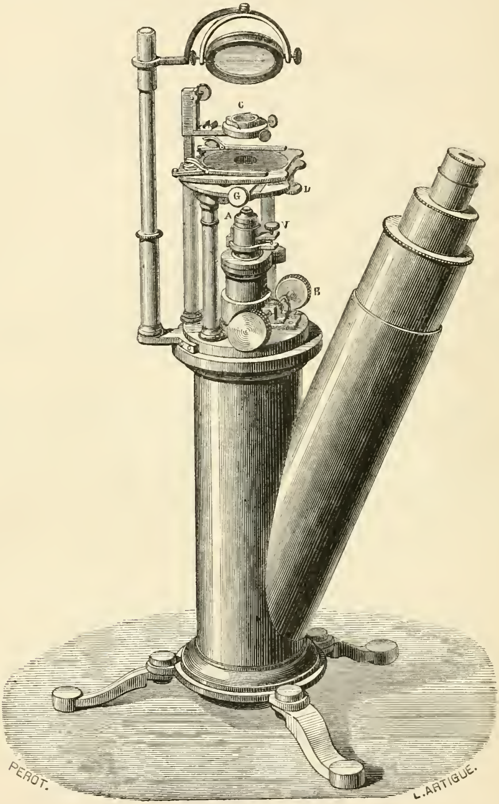
One of these instruments (from Mr. Crisp's collection) was exhibited at a recent soirée of the Quekett Microscopical Club. It was first exhibited at the Vienna Exhibition.

* Cf. Robin's 'Traité du Microscope,' 2nd ed. (1877) p. 62.

Fig. 2 represents the *Portable Demonstration Microscope* of Messrs. Nachet, which is very handy and convenient for class demonstration.*

It consists of a tube carrying the objective and eye-piece, which

Fig. 1.



slides within another attached to a handle by means of which the Microscope is held by the observer and directed to the light. To the handle is fixed a rod which carries the stage and illuminating apparatus.

* Cf. loc. cit., p. 81.

A speciality of the stage is that the object is fixed to its *under* side, so that no change of focussing is required with preparations mounted on slides of varying thickness. The coarse adjustment is made by sliding the tube carrying the objective through the outer one, and there is in addition a special fine adjustment moved by a screw close to the objective.

By means of the handle and the fork at the end of the rod which carries the stage, the instrument can be rested on the table without any danger of injuring the slide.

Fig. 2.

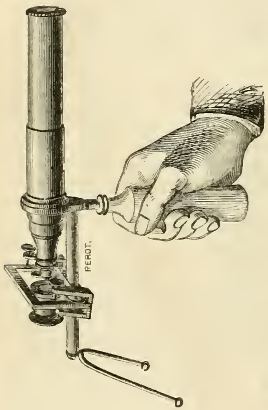
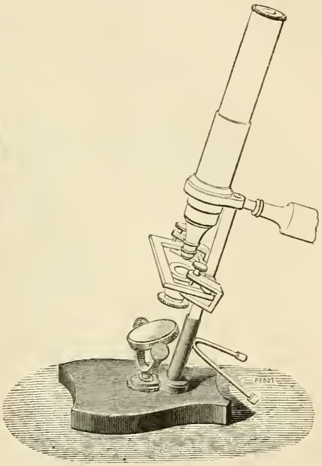


Fig. 3.



If in a preparation any point difficult to find is required to be shown, the Microscope can be fixed in the base which carries a mirror (shown in Fig. 3), and the preparation examined in the ordinary way.

This instrument will be shown at the next meeting of the Society.

Novel Method for Focussing.*—The Société de Biologie of Paris devote a page of their 'Comptes Rendus,' just issued, to a description by M. d'Arsonval of an arrangement which he has devised for focussing, "without touching either the object or the Microscope." The inventor states that he discovered the method several years ago, but neglected to communicate it, though at the same time he wishes it to be understood that he makes no claim for priority.

The idea was suggested to him by the observation that if an object is viewed through a parallel plate of glass, it will appear the nearer

* 'CR. Soc. Biol.,' xxix. (1877, pub. 1879) pp. 124–5.

as the plate is thicker. He accordingly arranges a layer of liquid between the objective and the eye-piece, the tube which carries the eye-piece being closed by a piece of glass, above which is a small tube communicating with a syringe full of water. On pushing the piston, water is injected between the objective and the eye-piece, and it is thus possible to vary the thickness of the layer of water to the extent of the whole distance which separates the two.

The method enables thicker cover-glasses to be used, and is available with the most powerful immersion objective, in which it differs from the arrangement of M. Govi (who placed a horizontal glass vessel of water between the object and the objective, and varied the thickness of the layer of water), that being only applicable to Microscopes which have a focal distance of at least 1·01.

The method may also be very conveniently used, according to the inventor, for photography, as coloured solutions may be employed to give monochromatic light.

Roy Microtome.*—The woodcut (Fig. 4) represents this instrument in natural size, the design of Dr. C. S. Roy. The object aimed at is simply to combine the accuracy gained by the use of a good microtome with the simplicity and convenience with which sections can be cut with the unsupported razor, not a few of the best histologists having abandoned microtomes on account of the trouble and waste of time occasioned, more especially in pathological work when a few sections are required from each of several different specimens, or from different parts of the same specimen.

The horse-shoe shaped piece of glass rod *a* is intended to support and guide the knife or razor which is used for cutting, and which glides on the surface turned in the figure towards the observer. This glass rod is firmly fixed by its two extremities in the brass plate *b*. The smaller brass plate *c*, on the upper surface of which a thin layer of cork is cemented, can be moved forward or backward by the fine-threaded screw *d*, movement in any direction being prevented by the form of the bed which has been cut in the larger plate for its reception. The small thumb-screw *e* serves to connect the movable plate with the end of the larger screw *d*, and admits of the plate being removed when desired.

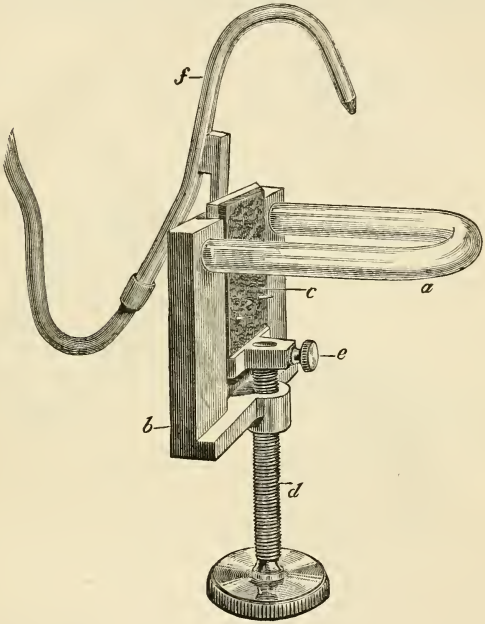
Fastened underneath the larger plate in such a way that it can be readily removed and replaced is the bent brass tube *f*, which is intended to admit of a few drops or of a constant flow of spirit being projected on the knife and specimen while sections are being cut. This tube is connected with a test-tube arranged after the principle of a Wolff's bottle, and which can conveniently be suspended by a thread from the button-hole. A caoutchouc tube, with a mouthpiece of glass attached to it, permits of air being blown into the test-tube, forcing out a part of the contained spirit or water by the tube *f*.

The method of using the instrument is exceedingly simple. The portion of tissue to be cut is imbedded in an appropriate imbedding mass, and is then placed upon the movable plate *c*. Upon this it is held fixed by the thumb of the left hand, the index and middle fingers

* 'Journ. Physiol.' (Foster), ii. (1879) p. 19.

of which pass under the plate *b*, and exert a counter pressure. Both the specimen and the microtome are thus held in the same manner as one holds the specimen when no section-cutter is employed. The plate and imbedded specimen are pushed gradually forward by turning the milled head of the screw *d*.

FIG. 4.



The imbedding mass employed by Dr. Roy is the well-known mixture of white wax and olive oil (equal parts by weight for warm, with a larger proportion of oil for cold weather) used with small oblong moulds of zinc without bottoms (instead of the usual paper boxes). They have the convenience of giving a cast suited to the size of the plate on which it is to rest. If the specimen is not imbedded, a pallet of wax or of wax and oil is placed between the tissue and the cork plate so that the edge of the razor may not come in contact with the latter.

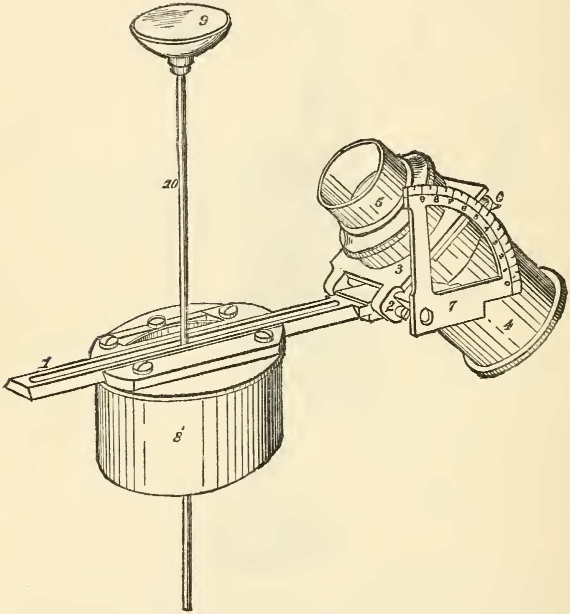
Woodward's Oblique Illuminator.*—Colonel Woodward has devised an apparatus, to which he gives the above name, intended to

* 'Am. Quart. Micr. Journ.,' i. (1879) p. 268.

obtain with certainty illumination at definite angles with Microscope stands which are not fitted with a swinging substage. The inventor describes it as follows:—

"A perspective view of the apparatus (slightly reduced in size) is shown in Fig. 5. It consists of a transverse bar of brass (1), at one end of which, attached by a hinge (2), is a square brass plate (3), which can be inclined at any desired angle. This plate is transfixed

Fig. 5.



centrally by a brass tube half an inch long, in which a second tube (4) an inch and a half long slips easily. The slip-tube (4) is provided at one end with the Society's screw, by which a 3-inch objective (5) or any other preferred for the purpose, can be attached. The movable square plate is provided with a spring catch (6) which fits into any one of a series of notches in the edge of a brass quadrant (7), and thus serves both to hold the plate in position and to register the angle of obliquity. The transverse bar (1) slips in a groove on the upper surface of a strong brass tube (8), fitted to the substage of the Microscope. The bar itself has a longitudinal slot running nearly its whole length, so that it can be pushed to any desired position without disturbing the position of the central steel rod (10), at the upper end of which a lens (9) is fastened. The lens (9) is such a segment of a hemisphere of crown glass, that when brought into optical contact (by oil of cloves) with the under surface of an ordinary glass object-slip, the object to be studied will be as nearly as possible at its centre of curvature, and the rod (10) slips freely in the top of the substage tube (8), so that the lens may be pushed into position or withdrawn at pleasure.

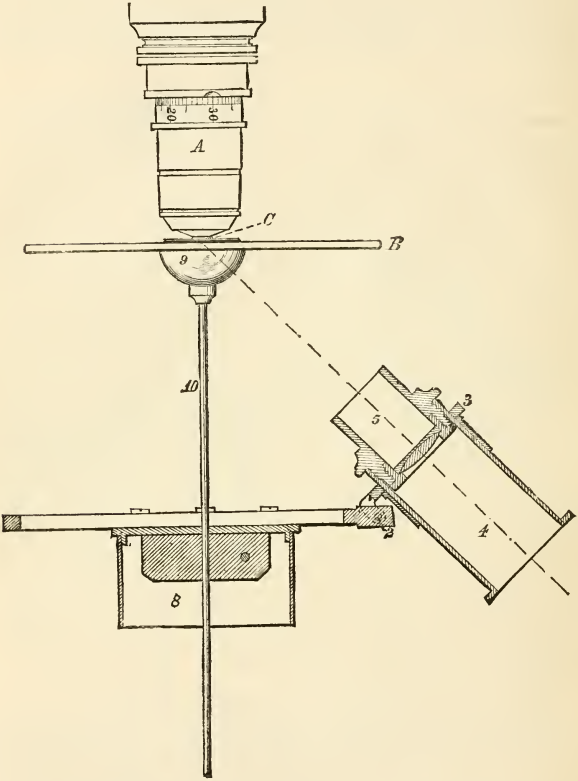
In using this apparatus with monochromatic sunlight, I first set the square brass plate)3) at the desired angle as read on the quadrant, and then slip the transverse bar (1) backwards or forwards as may be necessary, until the pencil of monochromatic sunlight (to which the desired degree of obliquity has been previously given by means of a prism) falls centrally through the slip-tube (4) and illuminating objective (5) upon the face of the lens with which the object is viewed. By means of the slip-tube, the illuminating objective (5) is then brought to the proper focal position. Ordinary illumination is thus obtained of any desired obliquity, from about 30° to the limit of the thickness of the stage. When I desire still greater obliquity I use Powell and Lealand's extra stage, and slip the transverse bar into the groove at the upper end of the holder which those makers provide with it to carry the small bull's-eyes they furnish for the examination of *Amphipleura pellucida*. In this manner I can get more oblique illumination up to 80° or even 85°, but of course the oblique pencils thus obtained are refracted at the under surface of the glass slip that carries the object, and cannot possibly reach the object itself at an obliquity greater than 41°. To obtain greater obliquity than this, I make use of the hemispherical lens (9). The illuminating objective is set at the desired angle, say 45°, and the object illuminated as described above. When this is satisfactorily done a drop of oil of cloves is placed on the flat surface of the hemispherical lens, which is then pushed up into contact with the under surface of the slide on which the object is mounted. The light now enters in the line of a radius of the hemisphere, at the angle registered on the quadrant (7). Fig. 6 represents a section of the apparatus when thus in use (also slightly reduced in size). The numbers in the two figures correspond. In addition, on Fig. 6, A is the objective, B the slide carrying the object, and C the immersion fluid.

I have found this apparatus exceedingly convenient for the purposes of photo-micrography and sunlight work generally; for when I have once obtained any particular result by means of a certain obliquity, I am able to reproduce the effect at pleasure without any loss of time. It has also proved useful, for the same reason, by ordinary lamplight. When, however, the object of the microscopist is merely to resolve *Amphipleura pellucida* or similar tests mounted in balsam, by lamplight, with suitable objectives, I still give preference to the simple substage prism I described last year,* through which I can throw the light at once at an angle of 45° by means of the concave

* See this Journal (1878), p. 246.

mirror or a small bull's-eye, and thus obtain for this particular purpose equally good effects, with less expenditure of time in making the adjustments."

Fig. 6.



Improvements in Microphotography.*—Dr. E. Cutler describes the apparatus he adopted for photographing with Tolles' $\frac{1}{75}$ objective, the special features in which the apparatus differs from Colonel Woodward's plan (besides portability) being (1) in the size of the

* 'Am. Journ. Sci. and Arts,' xviii. (1879) p. 93.

condenser, and (2) the absence of the ammonio-sulphate of copper or alum cells, which are troublesome.

The condenser consists of an 18-inch Voigtlander photographic objective, about 3 inches in diameter, and is probably the largest ever employed in microphotography. The reason of its selection was simply to avoid heat. It is easy to see that if a 2-inch condenser is regarded as sufficient, the same amount of light could be obtained with a 3-inch, away from the heat focus and thus avoid the effect of focussing the sun's rays on the object and the objective. This practical point has been of great value, and explains the absence of contrivances to prevent the passage of destructive heat.

Modern Applications of the Microscope to Geology.*—An interesting article on this subject is contributed by M. L. Fouqué to the 'Revue des Deux Mondes.' The progress of human knowledge, he says, is not accomplished in a regular and continuous manner, but by starts. Sometimes a man of genius gives a new impulse to science by the power of the divine reflex which animates him, but more often, particularly in experimental researches, each clearly marked impulse of the scientific movement is signalized by the employment of a new method of investigation. Thus the invention of the Microscope was the point of departure of brilliant discoveries in natural history, and each of its improvements corresponded to a period of progress in the development of the science to which it was applied. To-day the manufacture of the instrument has arrived at a remarkable degree of perfection, its magnifying power is enormous, its images are of an extreme clearness, and ingenious arrangements have rendered the instrument more manageable without having lessened precision, and its constructors have known how to adapt it to the special requirements of each class of research.

The consequences of these innovations were soon manifest. The study of organized beings took an unexpected turn, anatomy and vegetable physiology were entirely transformed, the domain of the zoological sciences was enlarged beyond conception, and the secrets of life have been explored in their most mysterious functions.

The application of the Microscope to the examination of the inorganic world took place more tardily in consequence of special obstacles. These difficulties are now happily surmounted. A harvest of new results is being reaped, so rich that it dazzles the imagination of those who gather it.

In the first part of the article is traced the historical development of modern "Microscopical Petrology," commencing with 1858, when Dr. Sorby's memorable researches first appeared, and on whom is passed a warm eulogium as "the real initiator and propagator of the new method," and after dealing with the labours of Zirkel, Vogelsang, and Rosenbusch the author regrets as a "curious matter and one difficult to explain that though in Germany microscopical petrography is now studied with unequalled ardour, in England, the country of its origin, it seems to make but slow progress."

* 'Revue des Deux Mondes,' xxxiv. (1879) pp. 406–31.

The second part explains the results obtained by the application of the Microscope to the study of minerals and rocks, and particularly the light thereby thrown on the actual constitution of the latter, and on the complex structure of a great number of crystals supposed to be simple, their mode of formation and the changes in the temperature, chemical composition, and stability of the media during the process. The Microscope is thus able to give an account of the conditions which prevailed when the minerals were being formed, as well as doubling the field to which geology can extend its conquests.

The third part gives a summary account of the methods of examination by polarized light, and the modern improvements which have been made in the examination of minerals by its means.

Adams' Measuring Polariscope.—This consists of three principal parts. The lower section consists of a mirror, a lens, a Nicol's prism, and two other lenses. The upper section consists of lenses and Nicol's prism arranged in the reverse order. Each lens and Nicol's prism is supported separately by screws, and its position can be altered independently of the others. These two parts form a complete polariscope.

Besides these there is a middle piece, consisting of two lenses (nearly hemispheres) forming a box to enclose the crystal immersed in oil, their curved surfaces being concentric. The whole middle piece is supported on the tubes of the upper and lower portions, and may be turned about the optical axis of the instrument. The vertical graduated circle carrying the central lens and crystal may be turned through an angle about its horizontal axis. By means of an arc fastened perpendicularly on the graduated circle, with its centre at the centre of curvature of the central lenses, the crystal may be turned about another horizontal axis at right angles to the former, so that the crystals and the central lenses can be turned about each by three axes which are mutually at right angles. By means of a system of toothed wheels in gear with the rims of the central lenses, the central and crystal lenses may be turned separately about the optical axis of the instrument, so as to bring the planes of the optic axes of a biaxial crystal parallel to the plane of the vertical graduated circle.

Homogeneous Immersion.—From conversations which we had with microscopists at the time of Professor Abbe's recent visit, it appears that the difference between the modern "Homogeneous Immersion" and the "Oil-Immersion" of Amici and Hartnack has not been appreciated.

One of the leading points of Professor Abbe's theory of 1874 was his explanation of the important bearing which the *diffraction pencils* have on the formation of the microscopic image so that the resolving power of an object-glass is dependent upon the diffraction pencils that are taken up by it.

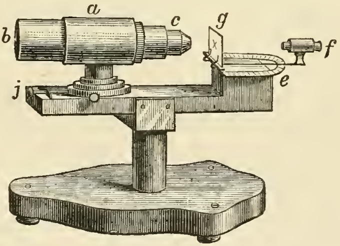
This fact was not previously known, and in the absence of that knowledge it is not surprising that those who suggested the use of oil instead of water abandoned it in practice, not thinking it worth while to follow it up. The use of oil as an immersion fluid would obviously have seemed at that time to be a *disadvantage* so far as aperture was concerned, in consequence of the diminution of *angle* which was necessarily caused.

When, however, the bearing of Professor Abbe's theory was appreciated, it was seen that an object-glass acting in oil might take up diffraction pencils which one of larger angle acting in air could not reach, and hence, although the *angle* was reduced by the use of oil, yet the diffraction pencils belonging to an *aperture* of more than 180° in air would be compressed (so to say) within the lesser angle, and greatly increased *apertures* could be utilized.

"Homogeneous immersion" is thus seen to be essentially dependent upon the principles enunciated by Professor Abbe in 1874, and the reason why it was not previously discovered, even by those whose minds were directed to the subject, is explained.*

Hamilton Smith's "Universal Apertometer."†—Prof. Hamilton L. Smith describes this apparatus devised by him (Fig. 7), which he uses for measuring the true angle in all cases, the old system being, he considers, all wrong, telling a false story in either case, dry or immersion. For angles in glass, or for immersions, the new apparatus may be used precisely like Dr. Abbe's apertometer, and indeed, as it seems to him, has some advantages over that instrument, which will not give the direct air angle, but deduces it from the angle

Fig. 7.



in glass; a separate graduation being required when it is to be read off directly. The 180° are compressed into an arc of 82°, and the whole space on that arc between 60° and 80° is not more than that between 0° and 10°, i. e. the graduations are necessarily unequal, and the instrument is only graduated to every fifth degree. The cylindrical surface, though it may show a sliding edge with sufficient clearness, is not so good as the more easily made spherical surface

* Mr. Stephenson draws our attention to an error in his note on p. 490, in which he says that the present homogeneous system "gives an *angle* greatly in excess of even the ideal maximum of a dry lens (180°)"—for "*angle*" should be read "*aperture*."

† 'Am. Quart. Micr. Journ.,' i. (1879) p. 194.

which forms a part of the new instrument, and by means of which one may bisect a minute white circle with the greatest accuracy. Moreover, few would be able to graduate the "apertometer" correctly, and the process of computation, though easy enough, is not necessary.

A brass tube *a* (Fig. 7), say 2 inches long, is supported on a pillar, into which another tube *b* slides easily, carrying at one end the objective *c*; the other end *b* is open except when a cap with a small hole is put on for purposes of centring, and when it is used after the manner of Abbe's apertometer; *e* is an arc (a good protractor answers very well) graduated to degrees (any higher refinement is quite useless, as in the larger angles there will always be an uncertainty of at least a quarter of a degree, a space readily estimated). An arm moving freely on a pin at the centre of the arc, carries at its end an eye-lens in a small sliding tube, and having a small eye-hole *f*, the lens having its focus over the central pin; *g* is an ordinary glass slide (3 by 1), which can be slipped in or out of place at will, and is held at right angles to the plane of the graduated arc by two springs, which press it against two uprights, so that the front surface of the glass is exactly over the centre of the arc, and therefore of the pin on which the movable arm turns. The glass slide is held by a separate brass holder, which can be pushed forward when the focal point of the objective is just over the pin until the slide touches the front lens, and a black bar with a straight edge painted on the glass can be made to cut off just half of the surface of the front lens, by putting in the perforated cap at *b*, and looking through *f*, which is supposed to be standing over the middle of the arc. This is for using Mr. Wenham's method, and it gives very nearly the same results as his (Prof. Smith's) own. The apparent aperture of the uncovered half is measured (twice this will give an extravagant angle), the whole aperture is then measured, but in the usual way, i. e. until the light disappears; the angle of the half is now subtracted from that of the whole, and twice the remainder is the true angle; this method is only available when the front lens is flush with the surface.

The mode in which he prefers to use the instrument, however, and which gives the true air angle, is as follows:—The front surface of the slide *g* is brought accurately over the centre of the arc by slipping the brass holder quite home; two fine cross lines ruled with a diamond on the glass, are, by sliding the glass laterally, brought directly over the centre of the arc or pin on which the arm carrying *f* moves; their intersection is thus placed directly over the centre of motion; the objective is focussed on these lines: it is not necessary to use an eye-piece unless the focal length be very long. Yet for true angle, independent of definite length of tube, it would be sufficient simply to focus upon the lines without an eye-piece; the screw *j* may be used for this purpose, or it may be effected by simply sliding the tube *b* in *a*. Suppose now the eye-lens *f* to be over the middle of the arc; on looking through towards the objective one will see something like Fig. 8, where the outer circle is the periphery of the front lens, the middle one is the image of the diaphragm at the back of the objective; or, if this diaphragm is sufficiently large, the margin of the posterior system; the inner circle is the image of the end of the tube *b*, and within the area of this will be an inverted picture of external objects crossed at the centre by the lines on the glass; the objective *c* and the eye-lens *f* forming a sort of miniature telescope, and having the lines as a common focal point: the smaller circle would disappear if the end of the tube *b* was large enough, and there would be but these two—the periphery of the front lens, and the image of the diaphragm or posterior system—and it is with this last we are to deal. A piece of tissue paper, or cap with

FIG. 8.

FIG. 9.

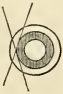


FIG. 10.

FIG. 11.

ground glass, is now put on at *b*, and immediately a soft light fills the field, and the lines appear like cobwebs stretching across it. The sector arm carrying the lens *f* is now swung round until the intersection of the lines is tangent to the image of the margin of the posterior system or diaphragm, as in Figs. 9 and 10, which represent the circles as they would appear with very small angles; with wide angles they are foreshortened as in Fig. 11, where the larger circle is,

FIG. 12.

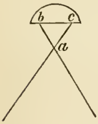
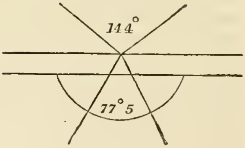


FIG. 13.

FIG. 14.



as before, the margin of the front lens; the next inner one is the image of the diaphragm, and the smaller (partly obscure) is the bright field still visible, and which gives the exaggerated angle to measurements made in the old way. The sector arm may be swung many degrees farther on each side before this will disappear. When the fine lines are thus projected on the face of the front lens, they will, as in Fig. 12, mark the extremities of a diameter of the circle which, if stopped out, would exclude all light from passing through the objective when used to form an image in the field of the eye-piece of the Microscope.

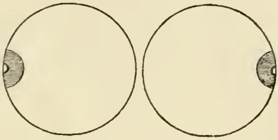
So much for the air angle; for balsam, or what we will here consider as the same thing, angle in glass, the slide *g* is replaced by another (Fig. 13) of the same thickness, but with a small bull's-eye—say 0·25 inch radius—cemented to it, and of such thickness that its centre of curvature is in the front surface of the slide; fine lines are also ruled on this slide passing through the centre of curvature of the lens. When the bull's-eye is properly adjusted, it will make no difference in the distinctness with which the images of external objects are exhibited when using the objective and eye-lens *f* as a little telescope, whether the glass slide and bull's-eye are in position, or whether they are removed, the rays pass through the slide and bull's-eye, emerging without refraction at the convex surface; they will emerge indeed at a much smaller angle, as shown in Fig. 14, from the refraction at the front surface; and in this refraction nearly all the rays which give the exaggerated angle disappear, and the angle of the emergent rays is the true angle in glass, from which the true air angle may be computed. To avoid this computation, Zeiss constructs the apertometer with another scale, upon which an arc of 82° corresponds to 180°, and one of 77·5° to 144°, &c.

A Spencer $\frac{1}{8}$ inch, when the systems were closed, and it was adjusted on the cross lines in the centre of curvature of the hemispherical lens, transmitted rays making an angle of 77·5°. The natural sine of half this angle is ·6259, and this, multiplied by 1·52, assumed as the index of refraction of glass, gives ·9513, the natural sine of 72·05°, twice which, or 144·1°, is the air angle. Measured directly, using the glass slide *g*, and the lines as before described, 144° was obtained. Measured on the sector in the old way, there was no difficulty in getting 179° before the light disappeared.

It will be understood that for immersion angle, or, as it is generally called, "balsam angle," all that is necessary is to introduce a drop of fluid (theoretically, this should have the same refractive index as the glass) between the objective front and the glass slide, and to re-focus on the lines. The $\frac{1}{8}$ inch, at the same closed point which gave only 77·5° from air into glass, will give 87° with glycerine interposed. There is very little difficulty in observing the true angle here; the proper point is when the circle of light, which is beautifully shown when the tissue paper covers the open end of the tube *b*, is dichotomized, and the slightest movement will cause it to disappear. This action is even more prompt with the fluid interposed than when air intervenes.

To convert the instrument substantially into Abbe's apertometer, it is only necessary to keep the slide and the bull's eye in place, focus on the lines, and then, putting on the cap with the small eye-hole at *b*, look in there instead of at *f*. Placing a sheet of paper in front of the graduated sector, and allowing the light to shine through it, we shall get a distinct picture of the end of the tube *f*, and see a little spot of light (the eye-hole) in the centre. The lines ruled on the glass may interfere with perfect definition in the middle of the field, but when the sector arm is swung round, the little circle of light can be neatly bisected on each side of the field, as shown in Figs. 15 and 16. A long focus lens may be applied at the eye-hole if necessary, or the supplemental tube recommended for Abbe's apertometer, but the Professor finds all that is required is his ordinary reading-glasses, and he can make the bisection of the little bright circle as accurately as when using a compound Microscope to view it even with a $\frac{1}{12}$ objective.

Fig. 15. Fig. 16.



If we remove the bull's-eye slide, and focus on the lines on the plain slide, we may obtain the air angle with great accuracy by simply looking through the eye-hole in the cap applied at the end of the tube *b* (Fig. 7), and observing, by aid of a long focus lens, when the image of the hole in *f* is neatly bisected on either side, as shown in Figs. 15 and 16. If, instead of a single lens, a short compound Microscope with an objective of 4 inches focus is used, the eye-hole will not be necessary. Except for higher amplification, this supplemental part is not needed. The highest air angle objective measured by Professor Smith is an old $\frac{1}{16}$ by Spencer, 163°. He has no doubt that some of the first-class modern dry objectives of recent date may reach 170° or more; but even with an angle of 163° the extreme rays strike with such obliquity, that more than half the light is reflected from the front surface, without entering the lens at all, and yet more at higher obliquities. Professor Smith does not mean to say that there is not a gain worth striving for in passing from, say, 160° to 170°, but an objective whose real air angle is more than that last named will have an inconveniently short working distance.

To compute rigidly the balsam or glass angle from the observed air angle, or *vice versâ*, the objective must not only be accurately focussed, but the intersecting lines *must* be used; otherwise an exaggerated angle (varying very much in different objectives, to the extent of 2° to 12°) may be obtained as the glass angle; and if from this we should compute the air angle, it might be 10° or 20° too much.

Carefully used, the instrument will give entirely concordant results. Moving to the right, the point of intersection will travel in the same direction as from Fig. 8 to Fig. 10, and to the left the change will be from Fig. 8 to Fig. 9. This is contrary to what one might at first suppose; a little reflection will show the reason for this.

As it seems to have been supposed that Professor Smith intended in his paper to cast doubts on the accuracy of Professor Abbe's instrument, we may point that the Professor himself says in his original article that "with high powers and wide angles, *the agreement between his own instrument and that of Professor Abbe is as close as could be desired*," while Colonel Woodward shows * the source of the erroneous readings which Professor Smith obtained when he attempted to use his apparatus after the Abbe method with low-power objectives.

Mr. Wenham, writing on this paper,† calls attention to the following experiments, not as indicating any defect in Professor Smith's principle, but in the mode of use which he considers may be the cause of error in the measurement:—

In order to well define the transmitting diameter or boundary of the light spot on the front of the glass, Professor Smith applies a piece of tissue paper or ground glass to the open end of the object-glass tube. This gives results in excess of truth, which may be attributed to the diameter of the screen. Instead of following this course, set a lamp a few feet away exactly in the axis of the object-glass, and focus the Microscope on the index line; the flame of the lamp will be beautifully in focus at the same time, showing that the examining Microscope does not in the least alter the focal distance of the object-glass under test. On traversing the lower Microscope sideways, the flame appears curiously projected, as if it were actually strung on to the lines ruled on the glass. At an obliquity greater or less according to the aperture of the objective, the flame shows a tendency to leave the line before it vanishes. Now, with the flame, this limit gives a result less than when the ground glass is used. The former is, therefore, the limit of aperture. The ground glass does not increase the transmitting diameter of the front, which remains the same under all circumstances; but it allows oblique rays from a screen or field of view to pass through. The lamp flame is distant, and in one fixed, axial, focal point. As the image of the flame and the ruled line are kept in the direction of the axis of the examining Microscope, the angular traverse of the line of this axis must indicate the true aperture.

Mr. Wenham also thus summarizes the facts upon which Professor Smith's conclusions are based:—

"1. That the front lenses of Microscope object-glasses only admit incident rays through a central area, far within their actual diameter.

"2. That angle of aperture strictly means the angle measured by a triangle taken from the extremities of the diameter of this light spot as a base line up to the focal distance in the axis, whether that distance is in air, water, or glass, with the difference of angle due to the refraction of each.

"3. That rays extending laterally from places without the central focal point do not constitute a proper angle of aperture, but cover an area known as field of view.

"4. That rays from every part of the field of view pass through every portion of the transmitting diameter of the front lens, and, together, enter the pupil of the eye from the eye-piece.

"5. That in the optical methods of measuring angles of aperture

* 'Am. Quart. Micr. Journ.,' i. (1879) p. 278. See infra, p. 784.

† Ibid., p. 280.

heretofore in use, rays from the light or index points have traversed and intersected all these exterior rays or oblique angles in succession to the limit of the field of view, which has been erroneously assigned as angle of aperture."

Measuring Aperture.—Professor Hamilton Smith in his paper above referred to describes an experiment with a Spencer $\frac{1}{8}$, made when the systems were closed and a small dot of ink put on the flat surface of the front lens, just large enough to cut off the little circle of light that appears when one looks into the objective with the front system toward the eye. Under these circumstances when the objective was attached to the Microscope, not a ray of light could be obtained except what came through the instrument, yet on the sector he was still able to see light when the arm was swung up to 179°. He further says, "The true air angle at the same closed point . . . . is only 141°."

Mr. J. Mayall, jun., properly points out * that this experiment is fallacious. "It being admitted that no aperture, properly speaking, can be measured unless the image of a point be rendered, approximately at least, as a point; does Professor Smith mean to say that when the system of lenses is closed he can measure the true air angle? My experience with immersion lenses of high angle is that when the system is closed, so as to get definition through the thickest cover-glass and the immersion medium, at that adjustment no true air angle can be obtained. The true air angle can only be actually measured when the objective is adjusted so as to give true focus in air, a focus sensibly free from aberration."

So far as Professor Smith's apertometer is applicable to immersion lenses, Mr. Mayall considers it is practically the same as Mr. Tolles's traverse lens which yields results equivalent to those obtained with Abbe's apertometer.

Woodward's Apertometer.†—Colonel Woodward describes an apertometer which he has been using for some time, which is a combination of the Abbe apertometer with the well-known sector, and which he thinks has advantages over both that and the Universal apertometer of Professor Smith.

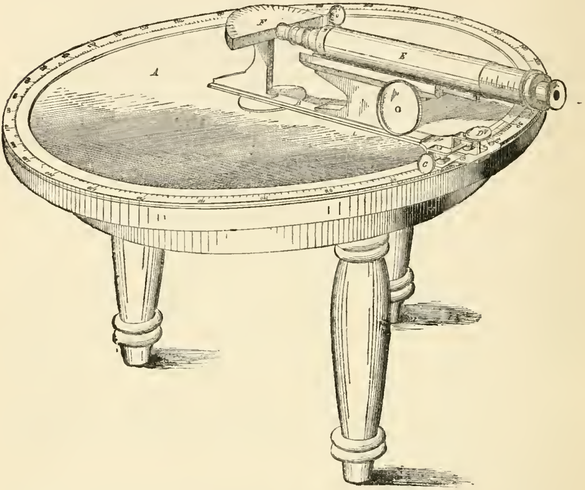
Colonel Woodward objects to the Abbe apertometer (1) in regard to the cutting away of the surface that corresponds to the diameter of the semicylinder at an angle of 45°, rendering necessary the silvered cover-glass with circular central spot, which should correspond to a path of the rays to the oblique surface, and thence by reflection upwards, just equal to the radius of curvature, an error in selecting this point rendering the reading inaccurate; and (2) in regard to the graduation into divisions corresponding to an arbitrary scale. The modified instrument is shown in Fig. 17.

A is a circular disk of brass of about 10 inches radius, inlaid near its circumference with a silver circle divided to sixths of a degree. It is mounted for convenience on a heavy three-legged stool of wood.

* 'Am. Quart. Micr. Journ.,' i. (1879) p. 284.
† Ibid., p. 272.

It was made a full circle, in order to use it for another purpose also; but a semicircle of the same size would answer equally well. Into a hole in the centre a pin is fitted, on which swings the radial arm B, which carries on one side of the centre of rotation the body of a Microscope E, while its extremity is provided with a vernier clamp D and

FIG. 17.



tangent screw C. On the other side of the central pin the radial arm carries a table, on which is mounted a semicircle of crown glass F of about two inches radius and half an inch thick. This is so mounted that the edge, which corresponds to the diameter of the semicircle, is directly over the centre of rotation, and the Microscope objective can be focussed exactly upon the centre of the semicircle. At this spot a thin glass cover, silvered except at a central circular hole (or vertical slit) about $\frac{1}{20}$ of an inch in diameter, is cemented with Canada balsam, the central hole (or slit) being fitted precisely over the centre of the semicircle. A suitable achromatic convex lens (a 4-inch objective answers very well) is screwed at the end of the draw-tube of the Microscope body, and serves to convert it into a telescope, precisely as in the apparatus of Abbe.*

The particular method for which the apparatus was constructed and by which exact measurements can be made, is as follows. Using

* This apparatus can be used precisely like his, if the semicircle is engraved to degrees, and two shutters or indices provided.

the Microscope as a telescope, some distant object is viewed so small that it only occupies an extremely minute portion of the field, and so bright that it can easily be discerned as the slit of a spectroscope placed at about 10 feet and illuminated by monochromatic (blue) sunlight. This appears when the adjustments are rightly made as an extremely minute blue star in the centre of the field. The radial arm is then swung until the star comes to the extreme margin of the field, the adjustment is made as exact as possible with the tangent screw, and the vernier read. The radial arm is then swung till the star comes to the opposite margin of the field where the same process is repeated. The difference between the two readings is the aperture of the objective for any medium of the same index of refraction as the crown glass semicircle. The apparatus reads to half minutes, which is closer than the observations can be accurately made. In fact, after the star comes to the edge of the field, it usually begins to fade just before it entirely disappears, and a motion of several minutes is necessary to effect the change. The best plan is to adjust the instrument as exactly as possible at the point at which the star begins to fade and then read to the next lowest sixth of a degree, neglecting the small fractional remainder. The same instrument answers very well to measure the glass angle corresponding to the actual air angle of dry objectives of any power, or the semicircle of glass being removed and the Microscope still used as a telescope to view the blue illuminated slit as before, air angles may be directly read with a degree of precision not attainable when the sector is used in the ordinary way.

From the angles of aperture measured in the semicircle of crown glass, it is quite as easy to compute air angles, water angles, glycerine angles, balsam angles, &c., as from the numerical scale of Abbe. It is only necessary to subtract the logarithm of the index of refraction of the rarer medium in which the aperture is to be expressed from that of the index of the glass semicircle, and to preserve the difference as a constant for use whenever the aperture in the selected medium is to be computed from the angle observed with the semicircle. Then to perform the computation, it will only be necessary to add this constant to the logarithmic sine of half the observed angle, and take from the table of logarithmic sines the angle corresponding to the sum, which will be half the angle required.

It will readily be understood that if the crown glass semicircle of the apparatus is of precisely the same index of refraction as the crown glass front of the objective, the rays of light passing into the objective from the semicircle will, after more or less refraction as they enter and leave the immersion fluid, resume in the crown glass front, precisely the same course they had in the semicircle. In this case the angle measured in the semicircle would be precisely equal to the aperture of the pencil passing through the crown glass front, and might be called the *first interior angle of aperture*, or briefly, the *interior aperture* of the objective. As this is the angle which after all determines the resolving power of the objective (provided its aberrations are properly corrected), Colonel Woodward thinks it would be better hereafter to express the angle of objectives in degrees of interior aperture instead of speaking of air, water, or balsam angles, or using the numerical scale of Abbe. This end will be obtained with sufficient exactness if the crown glass semicircle has an index of refraction of 1·525. In this case the angles read by the apparatus with each objective will be its interior aperture, and no computation will be necessary. But equally exact results can be obtained from a glass semicircle of higher or lower index, provided only its index of refraction is known. In this case it is simply necessary to compute the corresponding angle in a medium of 1·525 from the observed angle by the method already explained.

The index of refraction of the glass semicircle may be exactly determined in the ordinary way by measuring the angular deviation produced by a prism cut from the same piece of glass. But in the absence of conveniences for this determination it is one of the advantages of this apertometer that it affords the means of measuring the index of the glass semicircle with sufficient accuracy, for if the angle of any immersion objective that exceeds 90° of interior aperture be measured by it, and then the immersion fluid wiped away, and the angle measured with a very thin film of air between the front of the objective and the semicircle, the observed angle will be reduced to a figure which is constant for all objectives of the same or greater aperture, and which is independent of variations in the angles of such objectives, representing in fact double the angle of total reflection from the glass of the semicircle to air. If the sine of half this constant angle be divided into unity the quotient will be of course the index of refraction of the glass semicircle.

Provided the glass semicircle is nicely centred, the silvering of the glass cover which prevents vision from taking place except through the small hole or slit directly over the centre of the semicircle, would be unnecessary with the highest powers; for the diameter of the circular spot through which rays can pass into the objective is so small, as compared with the diameter of the semicircle, that the greatest possible chance of error from this source will be very small indeed. But with dry lenses of low power this is not the case; the greater the transverse diameter of the objective, the more readily would those rays enter it, which having passed through the semicircle but not through its centre, would indicate a greater aperture than the objective actually possessed. This is, Colonel Woodward supposes, the source of the erroneous readings which Professor Smith obtained* when he attempted to use his apparatus after the method of Abbe with low-power objectives. He did not use the opaque cover with a small central hole which is indispensable in this case.

Microscopical Researches in High-power Definition.†—Dr. G. W. Royston-Pigott presented a paper on this subject to the Royal Society in their last session (not yet printed *in extenso*), but of which the following is an abstract by the author.

* 'Am. Quart. Micr. Journ.,' i. (1879) p. 203.
† 'Proc. Roy. Soc.,' xxix. (1879) p. 164.

In its general scope the paper is intended to deal with difficulties in microscopic research, usually found insuperable, such, for instance, as the invisibility of minute *closely packed* refracting spherules, existing in double rouleaux, or promiscuously aggregated; when their individual diameter varies between the $\frac{1}{80000}$ to the $\frac{1}{200000}$ of an inch.

These difficulties are principally created by overlapping images, due partly to residuary aberration both spherical and chromatic, partly to the effects of diffraction, caused by brilliant illuminations of spurious disks of light, partly to the constant development of Eidola or false images, which vary the loci of their development according to the nature of underlying structures, and according to the object-glasses being over- or under-corrected, and partly, and indeed very considerably, created by the use of excessively large angular apertures.

The paper discusses also the relative effects on visibility, of large and small angular apertures in objectives.

It shows that the black margins or black marginal annuli of refracting spherules, constantly displayed by low aperture glasses, are attenuated gradually to invisibility, as the glasses employed are endowed with the largest apertures; that the black margins also of cylinders, tubules, or semi-tubules suffer similar obliterations; and that, in consequence, innumerable minute details are concealed or destroyed till the aperture is sufficiently reduced; that minute refracting bodies obey the laws of their refrangibilities, and display beautiful phenomena, discoverable by transcendent powers of definition, but totally unseen by inferior compensations; and that, in consequence, the so-called achromatism of modern glasses is an illusory approximation to correct vision.

Examples are given of molecular structures, varying in form, translucency, and refrangibility, in which natural pencils are caught and displayed in the order in which, as in a rain-drop, iridescent rays are emitted by the decomposed light. Several examples are also introduced, in which a high order of lenticular correction beautifully discovers structure, hidden, according to Dr. Carpenter, from the great bulk of observers.

As the paper deals so often with magnitudes very much less than the $\frac{1}{100000}$ of an inch, a method is introduced of readily estimating roughly such magnitudes between the $\frac{1}{80000}$ and the $\frac{1}{500000}$ of an inch, by means of a micrometer gauge. The writer has been emboldened to grapple with these difficult minutiæ, in consequence of the sharp and clear definition he has attained of spider lines miniatured down to the fourteenth part of $\frac{1}{100000}$ of an inch. The eye, accustomed to contemplate this subtlety of form, readily appreciates the one-fourth or one-sixth of this size, i. e. $\frac{1}{400000}$ or $\frac{1}{600000}$.

A new test for the Microscope is also described displaying bright lines of uniform thickness less than $\frac{1}{1000000}$, and sharp black lines of much less tenuity than those given by Nobert's celebrated lines ruled on glass, and incomparably more easy of illustration.

The employment of various fluids for immersion lenses is carefully considered; and the singular property of castor oil, discovered by the writer, is referred to.

As the author's paper on "A Searcher for Aplanatic Images," was inserted in the 'Transactions,' he now introduces a new form which offers some advantages, by its extended traverse, by its simplicity and economy of light with increase of magnifying power.

Finally, some examples are given of producing transcendent definition in cases found hopeless by a numerous body of observers. The means also of its attainment are minutely described.

XL.—*Immersion Stage Illuminator.*

By John Mayall, jun., F.R.M.S.

(*Read 12th November*, 1879.)

The illuminating device here described was obviously suggested by Professor Abbe's Apertometer-disk.

It is evident that every apparatus fit for observing the aperture of a high-angled object-glass must likewise be capable of being used for illuminating the marginal zone of such an objective.

The apertometer-disk itself was found to require modifications as to size, shape, &c., to render it more practical as an illuminator, especially for lamp-light. The modifications here detailed have been designed specially with a view to using the illuminator on the Continental stands provided with concentric rotating stage, many of which do not conveniently admit the use of very obliquely incident light from beneath.

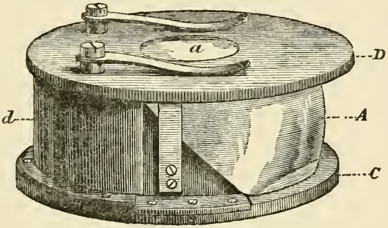


Diagram $\frac{2}{3}$ scale.

The plate of glass A is held on to the foot-plate C by means of vertical spring clips from which it can be removed for cleaning; the back edge is cut to an angle of 45° as in the apertometer-disk, for total reflection of illuminating rays; the peripheral margin, admitting the rays, is ground spherically instead of cylindrically, which adds to the illumination; it is supported by a brass semi-cylinder *d* which forms part of the foot-plate C. A brass object-plate D, carrying clips for the object-slide, is made to rotate on the upper surface of A round the circular glass plate *a* which is slightly below the surface of D and ground conical and cemented on to A and acts as a pivot to D, smooth rotation being obtained by means of a film of glycerine interposed.

The illuminator is to be secured firmly on the rotating stage by clamps on the projecting edges of the foot-plate after the centre of *a* has been centred with the optical system. The lamp and condensing lens to be suitably adjusted so that the reflected image of the flame is seen nearly in the plane of the object. The object-slide is placed in immersion contact with the plate *a* under the clips; the brass plate D will now rotate the object-slide to the required position with reference to the incident light, while the rotation of the Microscope stage (carrying the illuminator) will give every range of obliquity from central light to dark-field with any objective, the lamp and condenser remaining stationary.

It would doubtless be possible to dispense with a rotatory stage by inserting the glass plate A into a rotating plate in the foot-plate C, but there would be difficulty in making the rotation exactly concentrical to the rotation of the brass object-plate D.

My acknowledgments are due to Professor Abbe for the interest he has shown in the practical development of the plan: without his assistance even this experimental device would probably not have been made.

supplying it with rain, pond, and spring water, in turn, but always with the result that after a short time it disappeared. In October, 1878, however, he put a small quantity, probably not more than one hundred individuals, in a four-ounce bottle, having a mouth three-quarters of an inch in diameter, and set this on a shelf at the side of an outhouse, which had no gutter, so that the rain in running off the roof would drip into the bottle; here it has remained until November 1879, and instead of the few original specimens, they are now abundant. The water has never been changed or replenished, only that which dripped naturally from the roof into the bottle having been added to the original stock, and during the abundant rains of this year the bottle often overflowed. Several times a portion of the water containing the *Volvox* has been placed in the jars and dishes standing in various parts of the garden, but these always died in a short time, whilst those left in the small bottle, treated as above, remained in perfect health and multiplied. The position in which the bottle was placed faced the north, so that it only got the sun in the early morning of the summer months. During the severe weather of last winter, the water was several times frozen into a solid mass of ice, but apparently without injuring the *Volvox*.

MICROSCOPY, &c.

Soap as an Embedding Substance.*—Some of the chief objections to the methods of embedding in oleaginous or waxy mixtures seem to be successfully met by the use of the preparation recommended by Dr. Kadyi, and its capability of modification according to the different substances to be embedded is strongly in its favour.

The best materials and proportions are as follows:—28 grammes of shavings of stearate of soda soap (that sold as "weisse Wachskernseife" abroad is best), 100*g*cub. cent. of 96 per cent. alcohol, and, generally, 5 to 10 cub. cent. distilled water. The two first ingredients are warmed together on the water bath and to the liquid mass the water is added gradually, until it coagulates quickly into a transparent mass when dropped into a watch-glass. The mixture should be kept in a stoppered bottle.

For use, it is melted or boiled and the object at once plunged in. When cool, sections of it are taken with a razor wetted with strong alcohol, this liquid being also used, warm or cold, to dissolve out the soap from the sections.

Thus used, the material is adapted best to delicate objects; it possesses transparency and elasticity, and penetrates pores and cavities effectually.

A tougher preparation, suited to harder, such as chitinous, tissues, is obtained by increasing the proportion of soap to an almost equal amount by weight with that of the alcohol.

Logwood Staining Solution.†—Dr. E. A. Cook points out that in most text-books this is stated to be good in results but uncertain in action; and from the numbers of formulæ given for its preparation,

* 'Zool. Anzeiger,' ii. (1879) p. 476.
† 'Journ. Anat. and Phys.' (Humphry), xiv. (1879) p. 140.

it is evident that many experimenters have failed to hit upon a combination satisfactory in all points. The chemical nature of the colouring material of logwood is fairly stable, and affords no reason for any uncertainty, and it appeared desirable therefore to determine under what conditions the solution would yield the best results.

The colouring material consists of two substances—hæmatoxylin and hæmatein, differing by two equivalents of hydrogen. Hæmatoxylin (containing the larger amount of hydrogen) is soluble in alum solution, while hæmatein is slightly, if at all so. The latter is of no use for colouring animal tissues. Hæmatoxylin forms compounds with various metallic oxides which are soluble in alum solution also; and if a tissue be stained with hæmatoxylin, or with hæmatoxylin and a metallic oxide, and immersed in an aqueous solution of alum, the colour will be all discharged from the tissue and taken up by the solution; and the solution will thus take up fresh quantities of hæmatoxylin compound until it reaches a point of saturation beyond which it will take no more from tissues, but will, if over-saturated with it, give up the colouring matter freely to immersed animal material. Such a solution of hæmatoxylin, alum, and metallic oxide has a clear purple colour, becoming red on addition of acids. If alkaline earths, alumina, or hydrated earthy phosphates be suspended in it, they will absorb the colour, and the solution becomes purple. If the solution be treated with a very small percentage of a chromate, the purple will gradually be replaced by a yellowish-brown colour; or if a tissue which has been stained with alum-logwood solution be immersed in an exceedingly dilute bichromate solution, the purple will sooner or later be replaced by the yellow tint. If a section of any abnormal caseous concretion or abnormal growth be immersed in a neutral solution of alum-logwood, it will become of a more bluish purple than ordinary tissue, evidently from the presence in it of more than an ordinary amount of alkaline earthy matter or phosphate.

When the above facts are taken into consideration, it will appear unreasonable to expect tissues hardened in chromic solutions of any kind to colour as readily with an ordinary logwood solution as they would do if immersed in the fresh state. Sections of chromic-hardened tissues are exceptionally difficult to free from chromic compounds most probably because part of the chromic acid is in chemical combination and insoluble, and when freed from the hardening material the tissues will not be left in the natural neutral state, and thus less readily will the nuclei take up the colour. But it has been found that hardened tissues if cut into sections and well washed, may be as readily stained with logwood as fresh tissues if the solution be slightly modified.

It has been found that the cheapest and most practical logwood solution may be made as follows:—Take logwood extract, 6 parts; alum, 6 parts; sulphate of copper, 1 part; water, 40 parts. All ingredients must be free from iron. Grind the alum, logwood extract, and sulphate of copper in a mortar, and when powdered add sufficient water to form a thin paste; leave for one or two days with occasional stirring and then filter. The hæmatein contained in the logwood extract will be retained by the filter with the dirt, and the solution consists of hæmatoxylin, alum, and sulphate of copper, to which a crystal of thymol may be added to preserve it from mould. Fresh or alcohol-hardened tissues may be stained with this after sufficient dilution; but for chromic-hardened tissues, dilute 8 drops with 120 drops of water, and add one drop of $\frac{1}{10}$ per cent. solution of bichromate of potash just prior to use. Wash the stained solutions in water as usual. A larger proportion of bichromate solution will produce an ugly yellow; and if the mixed solution be kept many hours, some decomposition will go on.

Tissues stained in logwood may be mounted in glycerine or Farrant's solution or in dammar. In the two former they keep unchanged for any length of time; in the latter they are apt to fade unless care be taken, in preparing them for dammar, that the sections be thoroughly freed from water by absolute alcohol before being brought into contact with oil of cloves. If any moisture be left, fading will soon commence, and the preparation be spoiled.

Modification of Farrant's Medium.*—Professor P. Langerhans finds the following a very satisfactory modification of Farrant's medium for microscopical preparations of small animals:—Gummi arab., 5; aquæ, 5—to which after twelve hours add, glycerini, 5; sol. aquosa acid. carbol. (5 p. c.), 10.

With living marine animals it is only necessary to use enough to go under the cover-glass, and to add a little on the following day to make up for evaporation, and the preparation is then ready. The shrinking is very slight, and even many colours are preserved.

Staining Fluids for Vegetable Tissues.†—Mr. A. H. Barrett recommends the following as a simple and successful method of staining one section with two fluids.

The section is first immersed in an aqueous (1 per cent.) solution of Crawshaw's aniline blue dye. It is then removed into strong acetic acid, which seems to fix the colour in certain tissues, remove it from others, and prepare that not stained for the reception of another colouring fluid. It is then again removed into a weak solution of magenta (Judson's dye), also made strong with acetic acid; then mounted in glycerine jelly. The process effectually shows the "differentiation" of parts, both by the different colours and the varying intensity of colour.

The following are the colours with which the tissues of a section of Burdock are stained:—

Pith	Very pale magenta.
Cellular tissue	Deep magenta.
Spiral vessels of medullary sheath ..	Deep blue.
Pitted vessels	Blue.
Cambium	Deep blue.
Liber cells	Dark magenta.
Laticiferous vessels	Deep blue.
Cuticle parenchyma	Pale blue.
Epidermis	Deep blue.
Hairs	Pale magenta.

* 'Zool. Anzeig.,' ii. (1879) p. 575.
† 'Science-Gossip,' 1879, p. 255.

Chloride of Cadmium as a Fluid for Homogeneous Immersion.* —Colonel Woodward expresses his approval of one of the new immersion fluids proposed this year by Professor Abbe,† viz. the chloride of cadmium dissolved in glycerine, and sends photographs of *Amphipleura pellucida* taken with the Zeiss $\frac{1}{12}$ and Tolles' amplifier, both with cedar oil and with the cadmium solution. The last picture, as he points out, resembles that taken on the same day with the cedar oil almost as closely as if the two were prints from the same negative. The cadmium solution is not only convenient for use with objectives of considerable focal length (as the $\frac{1}{8}$ of Zeiss, for example), but is especially desirable for photography, as it cannot attack the balsam cement of the front lens of the objective. This he finds the oil of cedar may do. Slowly as it attacks solid balsam when cold, it appears to act more energetically when the temperature is somewhat raised, as happens during micro-photography. In the case of the Zeiss $\frac{1}{8}$ belonging to the Army Medical Museum, the oil of cedar has already in this way penetrated to the space behind the front lens of the objective, which he has in consequence been obliged to return to the maker for repairs. The substitution of the new fluid appears therefore to have advantages for photographic purposes which are well worthy of consideration.

Scientific Value of Microscopic Preparations.‡—Dr. Pelletan, of Paris, complains of the small scientific value of the majority of microscopic objects prepared for sale, though they are often very beautiful in appearance; the preparations of diatoms being alone, for the most part, satisfactory, often excellent, and sometimes marvellous. Certain preparations of cryptogamic botany are also, he considers, of value, and dissections, &c., of vegetable anatomy, thin cuttings of dense substances, animal, vegetable, and mineral, and particularly sections of wood, but of all other classes it is only by chance one meets with an interesting slide.

Many of the ordinary preparations, however, if not satisfactory to *savants*, interest *amateurs*, and they teach many things that otherwise would not have been known. "They are also useful in England, where they are sold in large numbers, because in that country the Microscope is more used for amusement and as an object of luxury than for working purposes. These slides, that for us have little interest, are therefore in this point of view of real utility. They give to ordinary people the taste for natural objects, and they furnish a thousand little instructions acquired without labour, and are also amusing. We must not, therefore, too much despise them.

"Histological preparations, whether normal or pathological, are those of least value. Preparers, with very few exceptions, have not sufficient knowledge of histology or of the necessary technical methods, or even the will to adopt them, because they are tedious and delicate, and, moreover, it is feared that the increased cost of the preparations would frighten those who might wish to acquire them. There is no foundation for this last reason, judging from the daily demands for

* See *post*, p. 988. † See *ante*, p. 346.

‡ 'Journ. de Micr.,' iii. (1879) p. 139. Translated in full in 'Science-Gossip,' 1879, No. 179, p. 250.

preparations made on these principles, even at an increased cost, when they are really instructive, and it cannot be doubted when we see the most common specimens of *Pediculus pubis* sold in America for 5 fr. 75 c., in which country it is not rarer than it is in France."

Counting of Blood-corpuscles.* — Professor Abbe has recently published a paper on this subject, in which he refers in the first place to an apparatus, the plan of which was suggested by Mr. R. Thoma, of Heidelberg. It presents no special novelty in design, its value consisting rather in the appropriate adaptation of the best means known, and the careful technical construction by which the faults of the measuring apparatus are kept within narrow limits, so that they may be neglected in practice.

The leading features are—(1) the method of mixing the blood so as to dilute it in a simple known proportion, and (2) the special apparatus for counting which enables the microscopist to take a determinate volume of the diluted blood fluid. For the first Malassez's mixer is used, modified so as to facilitate the purifying and to keep the consistency constant. The capillary tube holds about 6 mgr. of blood; its volume, which is taken as unity, is made the one-hundredth part of the volume of the mixing bulb (exact to about 0·5 per cent.). The correct length of the capillary is determined from data as to the capacity of the tube and mixing bulb, obtained by weighing, water being used for the latter instead of quicksilver, as on account of the glass ball used for mixing, a non-adhering fluid would not properly fill out the space.

For counting, an adaptation is made of Hayem's chamber, which consists of a slide to which a thin glass plate with a circular hole is firmly cemented and ground down parallel to the surface of the slide, so that a superposed flat plate would enclose a stratum exactly 0·1 mm. deep. For cutting off a definite volume of this stratum, instead of a micrometer in the eye-piece of the Microscope, Gower's method is adopted, and divisions are cut on the bottom of the chamber, so that a square millimetre is divided into small squares, the sides of which are 0·05 mm., and the area $\frac{1}{400}$ square mm. As the blood-corpuscles in the artificial serum of Malassez sink to the bottom in a few moments, the contents of a thousandth of a cubic millimetre in the field of the Microscope may be readily counted, being the contents of any four of the divisions. When normal blood is diluted in the proportion of 1 : 100, about fifty blood-corpuscles are found in this space, and the number being multiplied by 100, gives the contents of the thinned blood per thousandth cubic millimetre, which furnishes figures convenient for comparison.

The divisions on the bottom of the counting apparatus are a great advantage over the eye-piece micrometer, as they avoid the necessity of ascertaining the value of the divisions of the latter, which of course varies with the objective and length of the tube; a fruitful source of errors is avoided, and complete freedom is obtained in the choice of objectives and magnifying power.

* 'SB. Jen. Gesell. Med. und Nat.' (1878).

The apparatus is so delicately constructed that, if carefully manipulated, the errors in measuring will never exceed about 1 per cent.

The mathematical theory by which the probable extent of the error of counting is determined may be briefly summarized as follows. If n denote the average number of blood-corpuscles to a given space, the relative frequency of other numbers is expressed by the respective terms of the expansion of e^n (where e denotes the base of natural logarithms) divided by the complete value of e^n. Thus, the probability that k corpuscles will appear instead of n is,

$$W_k = e^{-n} \frac{n^k}{1 \cdot 2 \cdot 3 \ldots k}.$$

Making $k = n + \Delta$, where Δ expresses the deviation, positive or negative, from the average number, the above expression becomes approximately

$$W_\Delta = \frac{1}{\sqrt{\pi}} \frac{1}{\sqrt{2n}} e^{-\frac{\Delta^2}{2n}}.$$

Consequently, the "probable error," that is, the error which in repeated observations would be as often exceeded as not reached, may be expressed as a function of n, or, calling this error w,

$$w = 0 \cdot 4769 \sqrt{2n}.$$

If the ratio of this probable deviation to the average number be denoted by ω we get

$$\omega = \frac{0 \cdot 674}{\sqrt{n}}.$$

In a large number of observations, if ω denote the probable error, then, according to the laws of probability,

An error less than	$\frac{1}{4}$ ω	occurs once in every	7	cases.
" "	$\frac{1}{2}$ "	" "	4	"
" "	1 "	" "	2	"
" greater than	1 "	" "	2	"
" "	2 "	" "	5–6	"
" "	3 "	" "	23	"
" "	4 "	" "	160	"
" "	5 "	" "	1,385	"
" "	6 "	" "	20,000	"

and hence may be directly deduced what reliance is to be placed on the result of a single observation, that is, what approximation to the correct average value may be safely expected when the value of ω has been computed from the above formula, suited to the conditions of the particular observation.

The above formula for ω shows that the probable error expressed as a percentage of the average number decreases in the same proportion as the square root of the average number increases. Thus, the value of ω is reduced to about 5 per cent. if n is made to equal 200, that is, when the counting extends over a volume of four thousandths of a cubic mm. or to sixteen fields of the micrometer, and the result of this would be that an error of 10 per cent. would have the probability of one-fifth. ω would fall to 2 per cent. if the counting were extended to 1250 or 100 squares, and the probability of an error of 4 per cent. would be one-fifth. An error of 6 per cent. would have the small probability of only one-twenty-third, and an error of 10 per cent. might be expected to occur once in 1400 cases, which is as good as being excluded altogether.

Moreover, the limitation of the probable error to 1 per cent. would be ensured by extending the number counted to a total of about 5000, which, under the conditions here assumed, would correspond to the contents of the whole square millimetre. In this case, therefore, the mean value may safely be assumed as true to within 2 to 3 per cent., because an error of 4 per cent. would occur once only in 160 cases.

This method of judging of the exactness of the results is capable of being applied to various other scientific investigations of the same kind.

Cheilo-angioscopy.*—This name is applied by Dr. C. Hueter to his new process for the direct observation of the circulation in the human subject.

The apparatus consists of a frame, something like that used by photographers, for supporting the head of the person under observation, and having attached to it a stand on which a microscope and lamp are supported. The patient's lower lip is drawn out, and fixed with clips on the stage of the microscope: a strong light is then concentrated on its inner surface by means of a condenser, and it is examined by an objective of low power, the superficial vessels which can be seen even with the naked eye being brought into focus.

The vessels look, at first, as if filled with an opaque red injection; but with a little practice and careful focussing, the observer is soon able to make out the movement of the blood stream, and even to distinguish the red and the colourless corpuscles. The epithelial cells of the mucous membrane, and the apertures of the mucous glands, may also be seen.

By the application of slight pressure to the lip, the phenomena of venous stasis may be studied: it is also easy to observe the effect of cold, by touching the lip with ice, or that of innocuous reagents, such as glycerine or ammonia. The various pathological conditions of the circulation, characteristic of certain diseases, are also easily studied with complete accuracy.

Hueter remarks that the pathological observations he has already made by means of cheilo-angioscopy, prove conclusively the importance of the new process: a good deal of practice is, however, necessary, before it can become clinically useful.

Value of the Microscope in Law and Medicine.—Dr. R. H. Ward, of Troy, N.Y., in his able presidential address † at the opening meeting of the American Society of Microscopists, held at Buffalo in August last, deals at some length with the legal uses of the Micro-

* 'Cblt. med. Wiss.,' Nos. 13 and 14 (1879).
† 'Buffalo Daily Courier,' Aug. 20, 1879.

scope, "a department so large that it might almost be regarded as a new science, under the title of 'Microscopical Jurisprudence.'" The determination of hand-writing is more particularly referred to.

The 'Bulletin Scientifique du Département du Nord' also contains an article on the use of the Microscope in medicine, especially pathological histology.*

It is not possible usefully to give an abstract of either paper.

Unit of Micrometry.—In his address mentioned above, Dr. Ward says with regard to the resolutions of the Indianapolis Congress of 1878, that "as too often happens, their incidental faults attracted more attention than their really scientific object. The unit proposed ($\frac{1}{100}$ mm.) was evidently too large for integers, and too short for fractions, and unlikely to receive a single approval either at home or abroad; and the proposal of international action, though its object was universally approved, was in a form not likely to accomplish that object."

The new committee appointed by the various Societies (see p. 154) has not yet made its report

Comparators for Measures of Length.†—Professor W. A. Rogers has devised a comparator of the design shown in Fig. 1 to remedy the defects found to exist in the eye-piece and filar micrometer as well as in the Merz stage micrometer (A *a*).

The comparator proper consists of a bed-plate, within which is fitted a slide carried by the precision screw *b*. The object to be measured is held in position upon the moving plate by the clips shown in the figure. Instead of two parallel springs there is a single cord attached to the centre of the moving slide which runs on the guide pulley *d*, and is attached to a spring which is fastened to a pin on the back side of the bed a little to the right of and below *b*. The action of the spring, therefore, is wholly in the line of the screw, and as the direction of the cord falls a little below the motion of the slide, it has a slight tendency to keep the slide in contact with its seat without introducing friction. The screw *e* moves the whole bed-plate, including the precision screw *b*. The whole comparator has a circular movement in the socket *f* attached to the original substage *e* of the Microscope. The filar micrometer is shown at *h*, and an eye-piece with a micrometer, having some advantages over the usual form, is shown at *i*. Slow motion to the tube is given through the lever *g*.

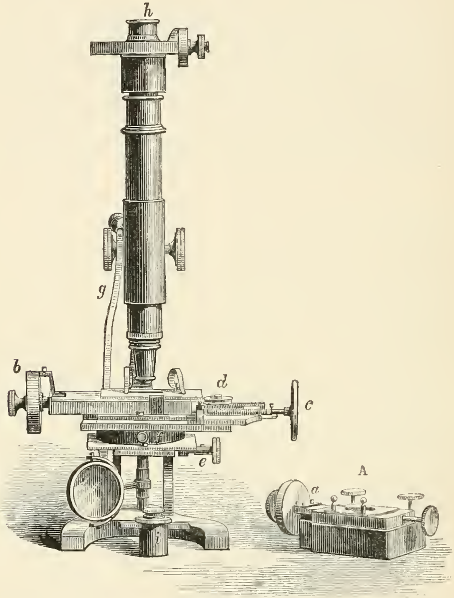
The operation of using the comparator is as follows:—

After the slide containing the graduations to be compared has been placed in proper position under the objective, with the right hand, the screw-head *b* is set at the zero of position; with the left hand, line 1 is brought in contact with a single line of the eye-piece micrometer; with screw-head *b*, line 2 is brought in contact with the fixed line of the eye-piece micrometer, and the number of revolutions and parts of a revolution are read off. Screw *b* is then brought back

* Cf. 'Bull. Soc. Belg. Micr.,' v. p. 243.
† 'Am. Quart. Micr. Journ.,' i. (1879) p. 208.

to zero, and the setting is made on line 2 by means of the screw *c*. In moving over the space from line 2 to line 3 with the screw *b*, it will be seen that *the same part of the screw is used as in going from line* 1 *to line* 2. Hence the comparison of these two spaces is *independent of the errors of the comparing screw.*

Fig. 1.



The number of spaces which can be compared in this way is only limited by the length of the screw *c*, and the length of the opening through the bed-plate.

Again, suppose we measure the spaces 1, 2, 3, 4, . . . 100 by a continuous forward motion of the screw. Such measures will involve all the errors of the screw itself. But if after the measures are made we set the screw *b* back at zero, turn the ruled plate around 180°, and set on line 100 with screw *c*, the continuous forward motion of the screw *b* from line 100 to line 1 will be over the same part of the screw as from line 1 to line 100. In the first case the screw measures the accumulated errors of the ruled plate from line 1 to any point up to line 100, but such measures involve the errors of the comparing screw. In the second case the accumulated errors are measured in the same way from line 100 to line 1. But if we subtract the measures from line 1 to line 100 from the corresponding measures from line 100 to line 1, *the difference will give twice the accumulated errors at any point for strictly periodic errors independent of the comparing screw.* The only exception to this rule is found when the curve of errors takes a wave form. In a general way this will be the case when the maximum error falls near line 25, and the minimum near line 75.

As an an illustration of the character of the work which may be done with a comparator of this form, Professor Rogers gives a Table of the measures of five standard micrometers ruled at different times. As these micrometers are somewhat different in form from any with which he is acquainted he gives a brief description of them.

1. A half-inch is divided into 50 equal parts, the 1st, 25th, and 50th spaces being again subdivided into 10 equal parts. The length of the lines is about $\frac{1}{8}$ inch, the 5th and 10th lines being a little longer.

2. After arranging the position of the ruling carriage, so that the lines of the second series of graduations should begin near the point where those of the first end, coincidence is made mechanically with the first line of the series already ruled. For a short distance the ruling point goes over the same ground twice. A centimetre is then subdivided into 10 equal parts. The 1st, 5th, and 10th spaces are again subdivided into 10 equal parts, and one of the middle subdivisions is still further subdivided, giving ·01 mm. Near by is a band of 21 lines, each space being equal to ·001 mm.

The table shows that the individual errors of graduation are practically insensible.

The errors obtained are, it is to be noted, entirely relative errors. They give no indication whatever of the absolute value of any of the spaces measured. If the entire length of the half-inch is e. g. ·001 inch too long, to each of the corrections given in the table must be applied still further the correction ·00002 inch.

It is therefore necessary to make a careful investigation of the entire length of the half-inch and of the centimetre.

This is done with a comparator adapted to the comparison of spaces, ranging from coincidence to an entire yard or an entire metre. Comparators of this class are usually constructed with two sliding plates, each carrying its own Microscope. A fundamental objection to this form is found in the fact that the Microscopes cannot be brought much nearer together than 3 inches by any direct means. For want of space and of illustrations, Professor Rogers is able to give only a general description of the form which he has had constructed.

It consists of an iron bed 60 inches long and 14 inches wide. V-shaped grooves 6 inches apart run the entire length. In the centre of the bed a fine-toothed rack reaches from end to end. Two sliding plates are carried along the ways by means of a pinion set in the centre of the plates and working so loosely in the rack that the slides are free to follow the law of gravity. A Microscope is attached to each plate, giving the form usually adopted. Instead of two Microscopes, however, it is found better to use but one. The Microscope plate is followed on the other side by plates terminating in tempered steel tops which are at will either made free or clamped firmly to the bed of the comparator. If one wishes to compare two metres the method of proceeding is as follows:—

(*a*) One stop is set at or near one end of the bed.

(*b*) The metre with which comparison is to be made is placed in position under the Microscope so that contact is made between the end line and the zero line of the eye-piece micrometer.

(*c*) The microscopic plate is then moved by means of the rack and pinion till the other end line forms contact with the zero line of the micrometer

(*d*) The second stop is then brought up against the other end of the plate and adjusted so that when contact takes place between the stops, contact also takes place between the end line and the zero line of the micrometer.

(*e*) Having made the adjustment of the stops perfect, the metre to be compared is then placed in position. When contact is made with the first stop by mechanical adjustment the end line is brought in contact with the zero line of the micrometer. The Microscope plate is then brought into contact with the second stop. If the other end line is now in coincidence with the zero line of the micrometer the two metres have the same length. By noting the number of divisions which the end line falls short of or passes beyond the zero line of the micrometer, the difference in the entire length can be found, the only element yet unknown being the value of one division of the micrometer.

After the comparison has been made it is better, as a matter of precaution, to again compare the standard with the distance between the stops. Since the stops can be set in actual contact with the Microscope plate at either end it is obvious that this method admits of a comparison of short spaces as well as of long ones. The only criticism which it is imagined will be urged against this form of construction is that founded on a doubt whether the contact between the stops always indicates the same measured space. The arm of the pinion has a head of about 2½ inches in diameter. In his own case the sense of touch has been so far cultivated that he is able to make 100 successive contacts without a single deviation exceeding ·000035 inch, and very few deviations reach ·00001 inch. A comparator of this form possesses one decided advantage over all others, viz. that after the stops are once set *any adjustment of the Microscope may be made without interfering with the comparison.* The only condition required is that the relation between the stops and the bed shall remain unchanged during the short time required for the comparison. This does not usually take over ten minutes.

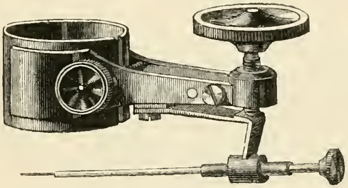
In order to compare separate subdivisions of the same standard we proceed as follows:—

The stops are set e. g. equal to 1 decimetre. After the reading of the first decimetre has been taken as indicated above, the bar is then moved along till the first line of the second decimetre forms a contact with the zero of the eye-piece micrometer, when at the same time contact is formed with the first stop. Moving the plate to the second stop the reading for the second decimetre is taken. A comparison of the several values obtained with the mean value will show how much each is in error, provided the entire length is correct.

Tolles' $\frac{1}{75}$ Objective.—Dr. Cutter gives some further particulars respecting this objective (made in 1873), in the 'Journal de Micrographie.'* It works both dry and immersion, is composed of three systems, and has 170° aperture. Its frontal distance is $\frac{1}{250}$ inch. The correction collar moves only $\frac{1}{8}$ of a circle. The aperture of the front lens is $\frac{1}{64}$ inch, and the "diameter of the objective at the other extremity" $\frac{1}{4}$ inch, its length being about $2\frac{1}{2}$ inch. The field is remarkably clear and very flat, the resolution good, and the definition, having regard to the enormous amplification, excellent.

Rezner's Mechanical Finger.†—This form was designed by Dr. W. B. Rezner, of Cleveland, Ohio, and is adapted to any Microscope, whereas the forms heretofore made were only designed for Microscopes having substages.

FIG. 2.



In use, the sleeve, seen in Fig. 2, is passed up over the objective far enough to have firm bearing, and so that the bristle point will be in focus when depressed nearly to its limit; it is clamped in place by the small thumb-screw. The wire in which the bristle is carried is drilled at the point to receive it, and slides easily, but not loosely, through a small sleeve, so that the end of the bristle can be brought into the centre of the field when in focus, and the wire can be revolved so as to view every side of the object picked up by the bristle. The wire stands at a greater angle than is shown in the cut, and the vertical part of the spring is not so long as figured.

When using the finger, the bristle is first raised by means of the micrometer screw till so far within focus as to be nearly or quite invisible, then the objective is focussed on the slide and the desired object sought for and brought to the centre of the field; the bristle point is then lowered by the screw till it touches the object, which

* 'Journ. de Micr.,' iii. p. 297.
† 'Am. Journ. Micr.,' iv. (1879) p. 65.

usually will adhere to it at once, and may be examined by rotating the bristle wire by means of its milled head.

Professor H. L. Smith, in a subsequent paper,* gives some hints which he thinks will greatly facilitate the use of the "finger," and which, though simple, are the fruit of long experience, will save much valuable time, and "conduce to general morality."

The "bristle" or "hair" is to be held in the spring forceps, and, after adjustment, a drop of sealing wax put on the forceps to bind all tight. To make the "hair," cut a slip of glass, and by a spirit lamp draw it out into a slender thread; snip off the thread by a knife, so as to present a bevelled edge (Fig. 3, magnified). This thread is so fine as to be quite flexible, and if dirtied can easily be cleaned. It is not affected

Fig. 3.

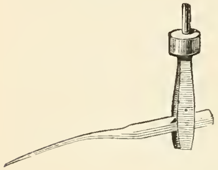
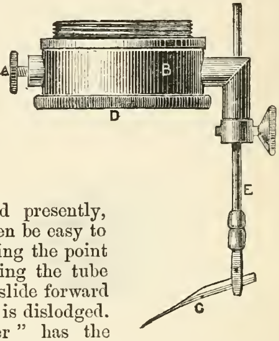


Fig. 4.



by moisture, applied as described presently, *a very important point.* It will often be easy to pick up a diatom by simply touching the point to the slide, and then by depressing the tube of the instrument, causing it to slide forward on the glass plate till the object is dislodged. His modification of the "finger" has the Society screw, and will receive any objective, though he prefers a $\frac{2}{3}$ inch. (Fig. 4.) When the screw A is loosened, the ring B and the hair C can be revolved, and made to point towards the centre of the field in any required direction, which will be found convenient for pushing a diatom into place in arranging. The objective screws in at D, and by raising or depressing the rod E, the point of the hair can be brought into focus. It should point downwards at a slight angle. If when it has been brought into focus, we unscrew the front lens of the objective slightly, this will throw the point out of focus, and now the objective may, by the rack, be brought down to give a distinct view of the material from which the object is to be picked, *without any danger of the hair point touching it.* When the object is found, then by turning home the unscrewed front lens, the point will come into focus, and by slightly racking down the tube, the point can be made to touch the object, and by racking back to lift it. If dirt is raised a light tap on the tube will instantly set it free, and leave the hair clean, or it may be cautiously wiped off with tissue paper. One of the greatest objec-

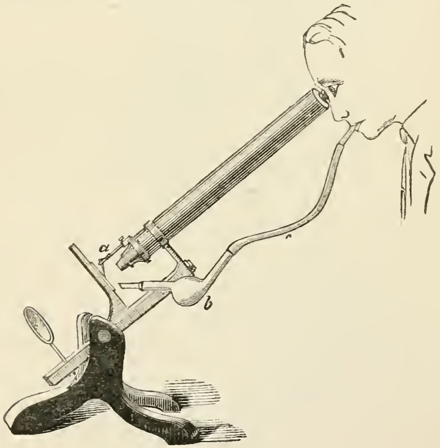
* 'Am. Journ. Micr.,' iv. (1879) p. 102.

tions to ordinary bristles, &c., is that after lifting a diatom, it is often impossible to make it let go, on touching the place where one wishes to deposit it, a difficulty rarely experienced with the glass hair. Although somewhat brittle, yet with care it may be used a long while, and can be easily replaced.

The material from which the selection is to be made is spread on a piece of thin glass, and heated red hot, if it contains diatoms, to burn out the organic matter; this piece of glass is attached to an ordinary glass slide, a little to the left of the centre; and to the right is put on the same slide the clean glass cover to receive the picked out specimens, and directly under the centre of this cover, on the under surface of the slide, a small ink dot, which can be easily recognized though out of focus, when, having secured the object on the end of the hair, the slide is pushed along to bring the cover into view. In this way one can readily pass from the crude material to the cover, without danger of detaching the specimen picked up. If the specimens are to be mounted in balsam, it is necessary to put a little thin solution of gelatine on the cover, and dry it.

With regard to the principal part of the manipulation, the method of taking off the object, just where and when we wish, and of arranging into lines, circles, &c.; this process is not his own as to idea; he has

Fig. 5.



reason to believe it is, substantially, that used by the professional preparers of these objects, though it has never before been made known. Fig. 5 shows the Microscope with the finger attached at *a*, and the hair just above the slide; *b* is a glass tube having a bulb, and attached to the stand; a short bit of tube slides into the end nearest the stage, and may be drawn out till it nearly touches the slide; to the other end is attached a rubber tube *c* with a mouthpiece. When the object on the end of the hair is brought directly over where it is desired to be placed on the cover, the tube is carefully racked down till the object nearly touches the cover; now, by gently breathing through the tube, a film of moisture will form on the cover in the most beautiful manner if the tube be pointed right at its lower end, and will, if we stop breathing, again quickly disappear. Suppose now, we flood the cover with moisture, and depress the tube, the hair touching it, the object will be at once taken off, and by a little manipulation not easily described, but easily performed, and mainly consisting in so placing the hair by revolving the ring that its point, slipping forward on the glass, as the tube is depressed, will push the object here or there, into lines or circles, without danger of its flying off, or being again picked up, if we keep the cover moistened by gently breathing. It is astonishing how gentle a breath will flood the cover with moisture, and one must be very careful not to blow through the tube before the object is dislodged, or it will inevitably be blown away. When the moisture evaporates, as it will at once, the gelatine will hold all fast, and then there is no need of any heating of the cover, which might do harm by possibly charring the gelatine, only one must be sure it is really dry before placing it on the little drop of balsam on the slide. The bulb *b* catches the condensed moisture, and must be emptied occasionally.

Apparatus for Focussing Dissecting Microscopes.*—Herr Hilgendorf, of Berlin, suggests an arrangement to be worked by the *leg* for focussing dissecting Microscopes. These, as is known, strain the eyes, owing mainly to the necessity of using both hands in the dissecting process, which makes the constant adjustment of the focus irksome.

The inventor's apparatus (which can be at once applied to any instrument without the help of a mechanic) consists of a rather strong brass wire, $1\frac{1}{2}$ mm. diameter, which at one end is hooked to the knee, and at the other is twisted round a cork, the latter being hollowed out in the middle, so that it can be pressed firmly over the adjusting screw of the Microscope. The wire should be bent at right angles 5 cm. from the screw; and then, by the raising or lowering of the leg, or side motion of the knee, it can be moved in the desired direction, and the focus varied. The flexibility and elasticity of the wire offer peculiar advantages, and do away with any complicated mechanism of levers and screws.

Improved Mounting for Cameræ Lucidæ.† — Professor L. Malassez suggests an improvement to the mounting of the cameræ lucidæ of Milne-Edwards, Nachet, and others.

These are fixed to the Microscope by means of a ring which encircles the tube, and on which they are jointed. The opticians

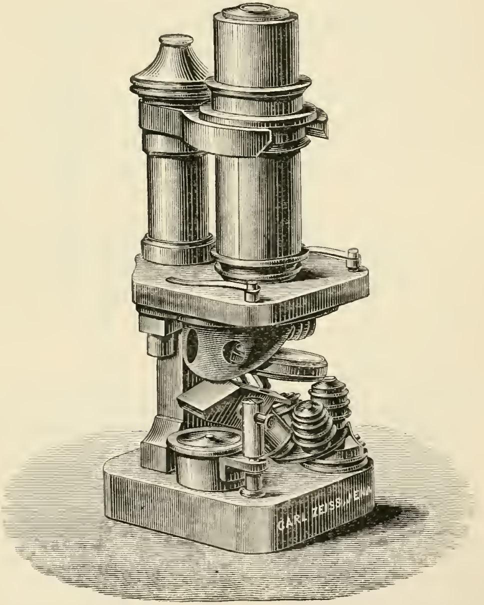
* 'SB. Gesell. Naturf. Freunde, Berlin,' 1878, p. 187.
† 'Travaux Laborat. Histol. Coll. France,' 1877–8 (1879) p. 117.

always place this joint at the *side*, so that the draughtsman cannot avoid knocking (his nose) against it, or else is obliged to give a very fatiguing inclination to the head. This inconvenience may be avoided by placing the joint not at the side, but at the *anterior part* of the camera.

In addition to this, the axis of movement is *vertical*, and when the camera is removed from the eye-piece, it is difficult to put it exactly back in the place it occupied, which is, however, very desirable. An axis with *horizontal* movement would be much better, and by such an arrangement the camera would be raised and lowered on the eye-piece like the cover of a box.

Zeiss' Travelling Microscope.—Fig. 6 represents the "Travelling Microscope" of Herr Zeiss, of Jena, which was exhibited at the November meeting of the Society.

Fig. 6.

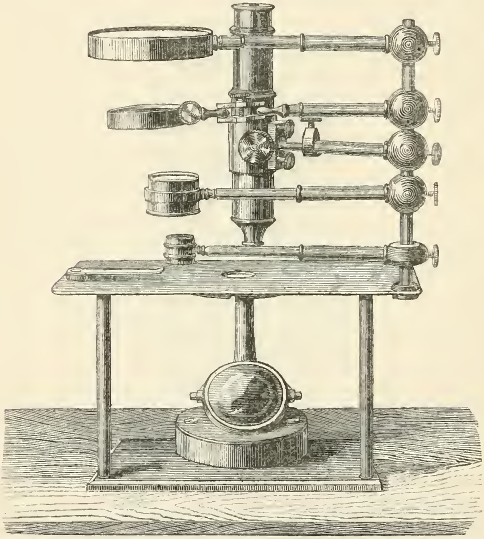


It consists of the Zeiss stand No. VI., the general construction of which is sufficiently shown by the woodcut; and it packs into a case $8\frac{1}{4}$ inches high by 4 inches square.

The tube can be readily replaced by a Brücke lens; the stage is hollowed out beneath, and has a concave diaphragm, shown in the foregeing figure, specially adapted to it. The four object-glasses are attached to a revolving "nose-piece," of exceptionally small size, which in packing can be screwed to the foot of the stand. The space beneath the stage is also utilized, in packing, for the Camera Lucida as well as the mirror. The latter is provided with universal movement by an extremely simple and ingenious arrangement. The upper part of the instrument with the stage can be turned round the optic axis.

Schöbl's Dissecting Microscope.*—This instrument, which is shown in Fig. 7, consists of a heavy brass base-plate (17 cm. by 12 cm.), on which is supported the stage (22 cm. by 12 cm.) by three uprights, the mirror being attached to one of them.

Fig. 7.



At one of the corners of the stage furthest from the observer is an upright rod 16 cm. high, to which five movable arms of $2\frac{1}{2}$ cm. diameter are attached, each arm being capable of being fixed by a screw, as shown in the figure. The lowest carries an aplanatic lens magnifying 30 times; the next, a similar lens, magnifying 15 times, the third, an ordinary dissecting Microscope, magnifying up to 150

* 'Arch. Mikr. Anat.,' xvii. (1879) p. 165.

times; and the fourth and fifth carry two other lenses of low magnifying power (7 and 3 times), the former having a jointed attachment to allow of the lens being placed in any position.

The arm carrying the Microscope is ordinarily turned away from the stage to the left of the observer, while the other arms which are not in actual use are placed forwards so as to be out of the way, but are at once available when required.

The inventor claims the following as the special advantages of the instrument:—

(1) The stage is entirely free for work, nothing being in the way of the observer's hands or head on the side at which he stands.

(2) It allows of a particularly rapid and convenient change of powers; and

(3) The preparation need never be moved from its place during work, and thus a great saving of time is effected.

Ward's Improved Microtome.—At the November meeting of the Society, an improved form of microtome was exhibited and described by Mr. F. H. Ward. It is a modification of the one introduced by Stirling, from which, however, it differs in the indicator. The thickness of the section is indicated by means of a screw having thirty-six threads to the inch, to which is attached a wheel containing thirty-five notches upon its circumference; into these notches a spring catch falls in rotation as the screw is turned. This spring is attached to a metal plate through which the screw works, but which is prevented from turning round with the screw by a brass rod fixed into the base of the microtome.

The bottom of the well is removable, and is retained in place by two bayonet catches. When removed from its fitting, the bottom is separable into two halves so as to release the screw. The continuity of the thread in the internal screw is maintained in the two halves when in position by means of two metal pegs on the face of one half accurately fitting into holes on the face of the other. The object of this contrivance is, that when the screw has been turned round to its extreme limit, by a slight backward turn the bottom of the well is removed, the two halves separated and the screw is set at liberty, thus avoiding the wear to the thread and the spring catch, which must inevitably result from rapidly turning the screw in the reverse direction through about two inches of its length.

A thick plate of glass, with an aperture the size of the well, covers the upper brass plate, and slides into position by means of a dovetail on each side.

Matthews' Section-cutting Machine.*—Dr. John Matthews has contrived a machine for making sections of such substances as bone, hard wood, ivory, nut, and other materials which are too hard to be cut with the section knife, and not of a nature to require the lapidary's wheel.

The carriage holding the saw runs smoothly yet firmly between friction rollers, and derives its reciprocating motion from a crank,

* 'M. Journ. Sci.,' i. (1879) p. 823.

which can be turned either by hand, or, when a higher speed is required, driven by a treadle and pulley. The saw is provided with adjustments to secure its parallelism and proper tension; the section is regulated by a screw of fifty threads to the inch, reading to thousandths by means of a micrometer head; the feed is either automatic by means of a cup, in which a suitable quantity of shot can be placed, acting by gravitation on a lever; or, as Dr. Matthews prefers, is capable of being regulated by hand. Owing to the steady motion of the saw when in proper adjustment, sections of suitable tissues can be cut as thin as the thousandth of an inch; the surfaces show no trace of the saw-cut, and are almost polished; very little after-treatment is needed to remove the few scratches left by the saw, and if required for mounting in balsam it can be done at once, taking the usual precautions to prevent penetration, and the consequent obliteration of structure.

Zeiss' $\frac{1}{18}$ Objective.—Colonel Woodward's views on this will be found at p. 988 of the 'Proceedings.'

Micrometry.—A reference to this subject will be found at p. 988 of the 'Proceedings.'