Journal of the
Royal Microscopical Society

CONTAINING ITS TRANSACTIONS AND PROCEEDINGS

AND

A SUMMARY OF CURRENT RESEARCHES RELATING TO

ZOOLOGY AND BOTANY

(principally Invertebrata and Cryptogamia)

MICROSCOPY, &c.

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

FOR THE YEAR

1914

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FEBRUARY, 1914.

TRANSACTIONS OF THE SOCIETY.

I.— *The Binocular Microscope.*

By Felix Jentzsch, Ph.D.

(*Read December* 17, 1913.)

Figs. 1–3.

1. The Employment of Binocular Microscopes in the Past.

Ever since optical instruments were known, people have tried to make them suitable for use with both eyes. There was no special reason for this, nor had they any very clear idea of the requirements which such an instrument should fulfil, but one was quite contented with the somewhat obvious experience of daily life, that a man with both eyes intact is better than one who is blind on one side. Thus, for instance, in the beginning of the seventeenth century the Dutch spectacle-lens maker, Lippershey, was granted a patent for a double telescope. This instrument was provided with all sorts of improvements during the ensuing decades; as, for instance, an arrangement for placing the two objectives in a convergent position. In 1677 Cherubin d'Orleans hit on the idea of fitting up the Microscope as a binocular instrument. Whether his arrangement was ever carried out or not we do not know. At all events, and in spite of further experiments by Zahn in 1701, the whole question was lost sight of, and we have to place on record that for the next 150 years not the slightest interest was taken in binocular Microscopes.

It only came up again when C. H. Wheatstone developed his epoch-making ideas on stereoscopic vision. This gave the lead for an extended period in the development of binocular microscopy,

for now every maker aimed at the construction of a stereoscopic Microscope. In fact, at that period a plethora of new types appeared simultaneously, some of which produced pseudoscopic, while some attained orthoscopic effects. These effects were obtained in some cases by means of double Microscopes, in others by the use of a single objective, in which case a geometrical or physical division of the pencils of rays was produced. The history of these different types, numbering about twenty altogether, which appeared in the course of a very few decades, is admirably compiled by M. von Rohr * in his work of reference, "The Binocular Instruments."

While the Continental workers did not take very kindly to these types, the stands of English instruments were for a long time regularly provided with binocular fittings. The type most widely used was the one permitting the binocular arrangement to be thrown out of use in order to change to the ordinary monocular method of observation. This device could, however, be used only for quite low-power systems, otherwise two images were obtained differing widely in their coefficient of light intensity. With all forms of this construction the quality of the image suffered more or less deterioration, so that after the purely æsthetic pleasure of seeing stereoscopic views had passed by, it was realized even in England that for scientific investigations the monocular Microscope was always superior to these types. Later on, in Germany, E. Abbe † devised an arrangement with his stereoscopic eye-piece, which threw all previous types into the shade. Nevertheless, this eye-piece appears even to this day to enjoy a very restricted use. It is well known there has been in existence since 1897 a perfect type of instrument for low magnifications, namely, Greenough's Microscope.

As a matter of fact, in view of optical law, the importance of viewing stereoscopically diminishes in the same ratio as the magnifications and apertures in use are increased. Already, with medium magnifications and apertures, the penetrating power reaches values, so far as they can be calculated from purely dioptric data, which approach the limits of resolution of the Microscope, so that no further information of any importance bearing on the spatial structure of the specimen can be obtained. Taking physiological and psychological effects into consideration, the foregoing results will differ widely, which will be explained later. Many microscopists, especially in England, retained the binocular construction even with higher magnifications, in order to be able to use both eyes, as this was said to be less tiring. In spite of this,

* The Binocular Instruments. Berlin, 1907.

† Description of a New Stereoscopic Eye-piece, with general remarks on the conditions governing Micro-stereoscopic Observation. Kais. Zeit. f. Mikr., ii. (1880) pp. 207–34; see also Ges. Abhand., i. pp. 244–62.

during all this period, no one seems to have recognized clearly the great importance an instrument would have which, while being constructed for binocular use, should be definitely non-parallactic, but whose function should be to present to the eyes two identical or congruent images, and not two pictures which differ in their perspective. On the contrary, one reads frequent complaints * that a particular stereoscopic instrument is no good, or is even harmful, because it only produces simple binocular images. In recent years interest in this question, which had died out, seems to be reviving: thus, J. Amann† expressed quite definite requirements three years ago with regard to a purely binocular Microscope. The instrument which is to be described here was constructed, as far as the chief features are concerned, in the winter of 1909–10. In the year 1912 it was entirely reconstructed.

2. Geometrical and Physical Division of the Rays.

The designs hitherto adopted are unsuitable for meeting the conditions required. It may be noted that the chief advantage of observation by the binocular method only becomes specially apparent with very high magnifying powers and arduous examinations, such as are required for dark-ground illumination and ultra-microscopy. It is just in these cases that the earlier types fail. The Greenough Binocular is known to be suitable only for very low apertures, up to about 0·15. For higher magnifications larger apertures are necessary: these require, however, very short focal distances only obtainable by using one objective, therefore the division of the pencils of rays must be carried out above the objective. This can be done geometrically or physically, either by conducting certain groups of the rays, which leave the objective towards one eye and the remaining groups to the other eye; or by splitting each single ray into two parts, thus reproducing two images.

The geometrical division can be performed in very different ways. The most obvious method is to divide the circle of the objective into two semicircles by using reflecting prisms (45° prism, J. L. Riddell, 1852; 60° prism, Nachet, 1853) or by refraction (Wenham, 1860). Moreover, it has also been attempted (many years ago by the firm of Leitz) to divide the opening into one or more annular circles or into several rectilinear zones. With all these methods of construction, that is in every kind of geometrical division, a reduction of the aperture takes place, and consequently there must be a diminution in the resolving power of the instrument. Moreover, all the spherical and chromatic defects of the objective become much more marked with these diaphragms. (It

* Proc. R.M.S., No. 1 (1878) p. 149.

† Das Binokulare Mikroskop. Zeit. f. wiss. Mikr., xxvii. (1910) pp. 488–93.

may be noted here that this disability obtains with all ordinary opaque illuminators whenever prisms are employed.) Further, it may be pointed out that the division must take place in the upper focal plane of the objective, if a uniform illumination of the field of vision is desired. This, however, becomes an impossibility with dry lens systems of higher magnifying power, as in all systems known to me the upper focal plane is situated within the lens, where no mirrors or reflectors can be located, even if, as was done in several English types, the objective mounts were made very short.

All these objections disappear with the physical method of splitting up the pencils of rays, so that generally speaking this method is considered the more advantageous one. The aperture is not reduced, the field of vision is equally illuminated. There are several types which make use of this method of division, viz. (1) The binocular arrangement of Powell and Lealand,* where the partial reflection from a thick glass plate is employed; (2) The so-called Wenham †-Schröder objective-prism, made by Ross and Co., of London; and (3) the previously mentioned stereoscopic eye-piece of Abbe. The last two named types divide the rays at a thin film of air which transmits and reflects at the same time, and this arrangement, just as with Powell and Lealand's type, unavoidably causes a marked difference in the light intensity of the two fields of vision. This difference, which amounts to a ratio of about 1 : 2·5, with Abbe, and which is higher still with Powell and Lealand, is under some circumstances even a desirable factor for a stereoscopic effect such as is sought for in those types, while for purely binocular examinations it is undesirable. In addition to this it follows, at least with Abbe's arrangement, that two eye-pieces of different construction have to be used, one a Huyghenian and the other a Ramsden, and that only one degree of magnification in the eye-piece is available. A further disadvantage of Abbe's eye-piece is, that the two tubes are placed in a converging position (see pp. 6, 7).

3. The New Binocular Microscope.

The problem before us, therefore, was to construct a binocular Microscope which can be used with any desired pair of eye-pieces, in which the two fields of vision shall have equal intensity of

* Described by L. Dippel, Das Mikroskop und seine Anwendung. [2nd ed., 1882, p. 556.

† F. Wenham, On a Binocular Microscope for High Powers. Trans. London Micr. Soc., No. 14 (1866) pp. 103–6. Wenham himself does not appear to have carried out this type of construction. In mentioning the Wenham-prism, with English Microscopes, a different type, employing geometric division, is always alluded to.

light, and with which the employment of all objectives, including the most powerful oil-immersion lenses, shall be possible; so that

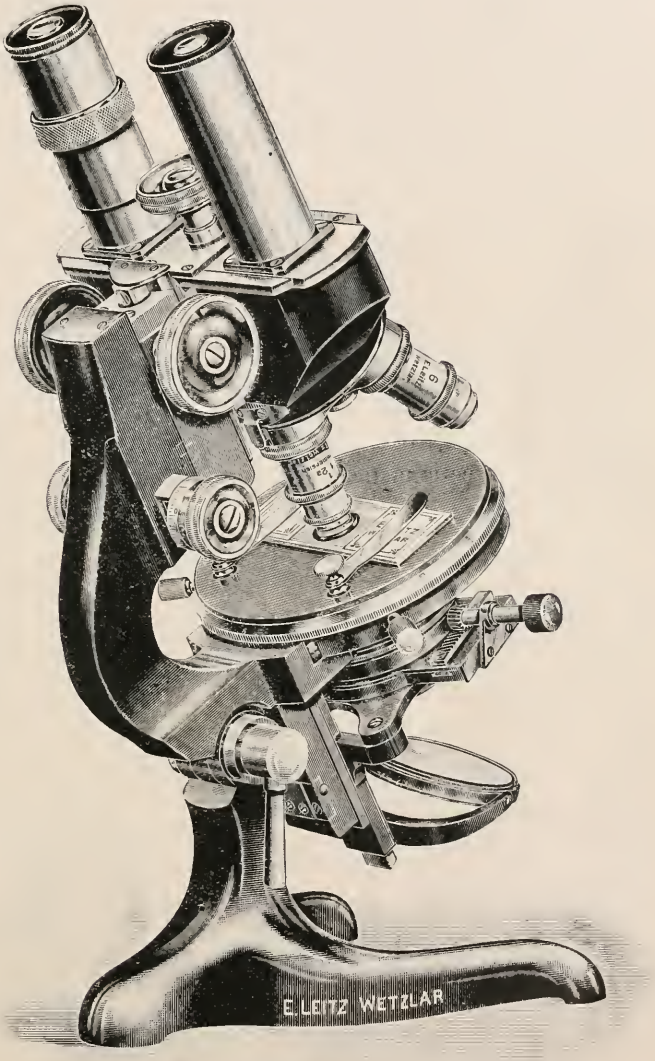


Fig. 1.

it would also include normal binocular ultra-microscopy. This problem has been solved, and it should be observed, that a noticeable deterioration of the image, which was to be feared owing to the large bodies of glass necessary, has not taken place.

Fig. 1 shows the external appearance of the instrument. The tube has become a flat box containing the system of prisms. At the upper end are situated the two eye-pieces, whose distance apart can be regulated to suit the eyes of the observer by means of a milled head which actuates two toggle levers inside the box. The distance apart can be varied between 54 and 74 mm. The eye-pieces slide in guides so constructed that no dust can enter the prism-box owing to this movement. On the left-hand side is a millimetre scale, permitting the correct setting to be made for observation.

As the two eyes are generally of unequal strength, it was found necessary to fit an independent adjustment on one of the eye-pieces. This can be placed in the right- or left-hand eye-piece. The usual way is to focus by coarse and slow adjustment, using the fixed eye-piece only, then the proper setting apart is given to the two eye-pieces, and finally, if necessary, a further adjustment by the movable eye-piece is made. All kinds of eye-pieces may be used. The eye-piece corresponding to the eye which is more shortsighted is of course set a little lower than the other.

The simple internal arrangement is shown in fig. 2. In the cemented prism nearest to the objective will be found a semi-transparent coating of silver, which effects the above-mentioned physical division of the pencils of rays. There is nothing novel about the arrangement of the prisms; on the contrary, it has been variously applied to optical apparatus in this and other modifications. It is derived from the so-called "Swan cube." The semi-transparent film of silver also finds application in physical instruments. It is technically possible to adjust the film of silver so exactly that the transmitted and reflected light are practically of equal intensity. The thickness of the glasses is chosen so that the length of the optical paths are equal both to the right and to the left, thus securing equal magnification.

The new Microscope has another peculiarity, namely, that the two eye-pieces are parallel. We know that in the human eye the actions of accommodation and adjustment for convergence are coupled so as to work together. A convergent action generally calls for an effort of accommodation corresponding to an approach of the object under observation nearer to the eyes, and vice versa. If, therefore, the eyes are forced to convergent action a certain accommodating effort is forced upon them, and this one would prefer to avoid because the eye-pieces of Microscopes are designed for the emergence of parallel rays, that is for an unstrained eye. Such observational work is very tiring when continued for any

length of time, principally owing to the fatigue of the muscles of the eye. Nevertheless, this method of construction for stereoscopic purposes is defensible at least in one respect, inasmuch as the purpose is to assist the purely optical effect by adding auxiliary psychological perceptions, in this case by convergence. For a purely binocular instrument, on the other hand, convergence of the optical axes of the eyes loses all its importance. We would rather require each eye to work as far as possible without effort of accommodation, that is without strain, and that the point of convergence

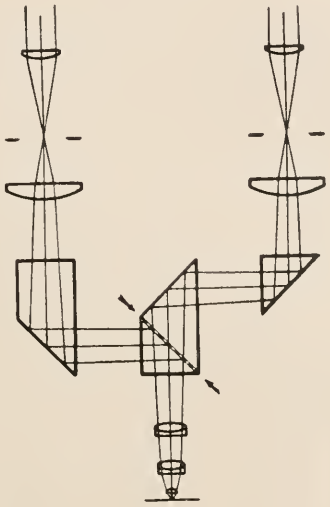


Fig 2.

of the axes of the two eyes should be as distant as possible: in other words we prefer to place the two eye-pieces parallel.

With this arrangement everyone * can succeed in making the two images coincide, and this is accomplished the sooner the more effectually one avoids any sort of strain in working. If the coincidence of the images takes place under conditions of complete relaxation, the tranquillity and steadiness of the image is surprising. The distance at which the image is located varies in individual cases as with the ordinary Microscope.

* It is a fact that anyone, who can see at all with both eyes, can use any properly designed and well-constructed binocular Microscope without previous practice.

4. The Hygienic Importance of Binocular Observation.

We know that in most "Introductions" on the use of the Microscope one is advised when working to change about from one eye to the other, and we likewise know that it is the custom not to follow this good advice! On the contrary, most microscopists have accustomed themselves to such an extent to the use of the one eye, that if they have to use the other eye for any length of time they experience acute discomfort. Very often they cannot use it at all. When stopping work after hours of tiring observation, everyone has probably noticed that it is not the eye which one has been using which is most tired, but the one which has been out of service and which was apparently idle. Some observers have even assured me that after working for a long period with the right eye they have noticed a disturbance in the sight of the left eye which has for some time hindered them when reading.

An explanation of this fatigue of the unused eye, which, by the way, is noticeable with any form of continuous observation with one eye, might be sought in the fact that the unemployed eye, in seeking a suitable point to focus on, causes the muscles or accommodation to be continually on the move, backwards and forwards so to speak, thus sustaining much more fatigue than the other eye, whose accommodation remains practically unchanged during the whole period of observation. It may, however, be just as likely that the seat of fatigue is more central, i.e. in the brain, for while we are working with the Microscope we have to ignore entirely the images received by one eye while concentrating our attention on the images received by the other. The idle eye has to be continually "called to order," i.e. it has to be forced into inactivity, a process which absorbs a good deal of "energy." However, this last-named discomfort only affects the beginner. With continued practice the impressions received by the one eye are suppressed unconsciously and without difficulty. It is no concern of the science of optics to decide which of these or perhaps other explanations is the correct one.

Owing to this fatigue not only is the period of observation reduced, but perhaps its value is diminished. At any rate Amann * considers that it is not improbable that, owing to the constant brain-effort which is required, the power and the discriminating efficiency of the working eye might be injuriously affected.

As a matter of fact I found it possible to carry on observations with the new binocular Microscope for a much longer period. It is astonishing how comfortable and how little fatiguing it is. Especially with dark-ground illumination the difference between monocular and binocular observation is remarkably great.

* Das Binokulare Mikroskop. Zeit. f. wiss. Mikr., xxvii. (1910) p. 492.

5. The Superiority of Binocular Observation.

The appearance of the microscopic image differs qualitatively from that with the monocular type of instrument. The first consideration is that in binocular observation one generally sees better than otherwise, and moreover one is able to detect more detail. It must, however, be admitted that there are marked differences in this respect in individual cases. The fact that more detailed examination is possible leads one to think that possibly an actual increase in visual power takes place in binocular work. Certain experiments tend to support this theory, but I have tried to explain the effect in the following manner.

According to the Duplex vision theory of von Kries, we possess two entirely different methods of vision, i.e. "daylight vision" and "twilight vision." Now the sensitive surface of the retina consists of two different sets of organs, the rods and cones, of which the former receive principally colour impressions while the latter are acted on by differences of light intensity. According to the above mentioned Duplex vision theory the cones are the organs for daylight vision and the rods for seeing in the semi-darkness.

Now it is often pointed out that the rods are missing from the *macula lutea*, therefore with direct vision only the colour-discriminating cones are employed and the rods only play a part in indirect vision or possibly only in the twilight. This is not stating the case quite correctly. The rods do not disappear entirely in the region of direct vision. They are not absent from the whole *area centralis*,* but only from the innermost spot, the *fovea centralis*, that is a region which externally only covers a field of vision of about 1° to 1·5°. Round about this region the rods make their appearance without any marked boundary line and varying greatly in individual cases. They increase in number farther away from the centre while the number of cones decreases. Besides these there are certain qualitative differences to be noted. At the points where the rods commence to diminish the cones gradually assume the shape of the former. This similarity is most marked in the *fovea centralis* itself.

During normal vision (excepting perhaps with very high light-intensities) the cones and rods act at the same time; only that the rods have a greater capacity for adapting themselves to darkness, so that a weak intensity of light suffices to excite the action of the rods but is insufficient to affect the cones. In the same way when one is using the Microscope both these organs are generally active.

In addition to the differences in intensity of light we have

* This expression is considered to be more suitable than the synonymous *macula lutea*, as according to Gullstrand the yellow colour of the so-called yellow region only refers to a post-mortem effect.

above all things to observe fine colour differences or shades. Now as both eyes are rarely equally efficient, it may happen that one eye is more fitted for the one, while the other eye is particularly well equipped to do the other kind of work. Thus if we are in a position to use both eyes we can also utilize their respective strongest points.

Everyone who makes much use of binocular instruments is aware that the two eyes assist each other to a much greater extent than would be expected from general consideration. With this method of observation there is not only a continual movement of accommodation, as is the case in monocular instrument working, in virtue of which as is known the penetrative efficiency of the instrument is increased, but the attention, the perceptive organs of the main cerebral centres, turn from one eye to the other as it were, thus combining the delicate shades of colour as seen by one eye with the fine contour lines of the image as seen by the other.

The process as described need not take place actually in such a simple manner. The capacity of our sense of sight is not exhausted by the mere perceptions of colour and light intensity. In analysing the sense of sight one would rather bracket the light- and colour-sense together as one factor and would then add the optical sense of space and position-perceptions, and finally the capacity for optical resolution and the sense of form. Although with the ordinary phenomena of sight all these senses come into action simultaneously, there will, nevertheless, generally speaking, always be differences between the two eyes of any individual with respect to these different phases. There may also be differences in the degree of sensitiveness of corresponding points on the retina. It may here be mentioned that the unpractised eye is generally less sharpsighted than the practised eye, while having greater sensitiveness to light.

All these differences are naturally less noticeable with the binocular method of observation than with the monocular, so that we can now more easily realize how it is that one can make better observations with a binocular than with the ordinary Microscope. Moreover, this conclusion holds not only for the Microscope but also for many measurements made by the aid of optical instruments, especially in photometric work. Observations in all these cases are directly comparable with normal binocular observations on far distances.

It is common experience that long distance observations made from an isolated mountain peak or from a balloon are rendered much more effective by using both eyes. It will also be necessary to take into consideration the binocular summation of stimuli and the so-called "vividity" of perception.

6. The Summation of Stimuli in Binocular Vision.

Although one generally has rather too much than too little light in the Microscope, it is necessary that we should be quite clear about the conditions of light intensity in the new instrument, as one might easily expect a certain amount of obscuration. First of all only about half the light transmitted by the objective reaches each eye-piece.* Further, a certain percentage is absorbed in its passage through the prisms and lost by reflection.

Experience teaches us that if there be any obscuration at all in the new binocular Microscope as compared with the ordinary Microscope, this does not appear to be as great as calculation would lead one to expect. This question of light intensity has to be handled with a certain amount of caution. For when we have arrived objectively at the determination of a certain degree of illumination, we have still to deal, in the case of an optical instrument, with its use considered subjectively, for here the sensibility to light impressions has to be taken into account.

It is known that in ordinary vision the same impression of light intensity is obtained with two eyes as with one. One can easily convince oneself of this by closing one eye when observing an illuminated surface. If the proper precautions are taken no obscuration will be observed. We know that in an experiment of this kind the pupil of the open eye becomes dilated. It is not possible, however, that this should simply make up for the loss of light. For, owing to the comparative slowness of this reflex action, a slight shadow should appear to cover the image during the first moment. This, however, is not the case. The experiment, moreover, only succeeds in a good light, and only then if the object is so far distant that it can be observed easily and well by both eyes, and provided that the person making the test is not accustomed to observe with one eye only, which happens rather often.

The opposite result, namely that the apparent illumination of a surface is greater when observed with two eyes than with one, is generally arrived at if a diaphragm be interposed in such a way that one eye sees only part of the test surface. On making the fields of vision coincide, the part seen by both eyes appears brighter than the other. According to this, therefore, binocular summation of light stimuli obtains in everyday life. I do not, however, consider this experiment to be decisive, for a fusion with the

* The light absorbed by the silver coating may be entirely neglected. No colouring of the images can be observed, although from theoretical considerations this might be expected owing to dispersion from the silver.

usually less bright image of the diaphragm itself takes place on the apparently darkened portion of the field of vision.

According to modern physiology, the binocular summation of stimuli only takes place with the eye adapted to obscurity, and in the case of vision in full light it is entirely absent. It appears to me, however, that there are certain transition stages, and that a very high degree of full light adaptation must indeed be necessary to entirely eliminate any summation of stimuli. It may even be discovered that the conditions of "twilight vision" are already entered upon at much higher intensities than has hitherto been supposed. I do not wish to go any further into this question in all its bearings, but only wish to emphasize that, according to my personal experience, this is actually the state of the case with the new binocular Microscope.

We know that a summation of stimuli takes place within one eye when the object is very small, and when the image approaches the size of an optical sensory element. In this case the intensity of light is proportional in the first instance to the number of sensory elements covered, but it will not increase as soon as the stimulated surface has reached a certain size. I suppose, therefore, that also in binocular vision an analogous summation of stimuli takes place (even with adaptation to bright light), as the objects to be examined are very small. This would explain the fact that on using both eyes in the new binocular Microscope a marked increase in the impression of light intensity is noticeable. However, it is also possible that this feature is greatly due to another phenomenon generally experienced, the so-called "vividity."

7. Vividity.

In using the new instrument, one has another observation to make which is not so easy to put into words. Perhaps the best way of giving expression to it is to say that everything appears more alive, more life-like than otherwise, so that the term "vividity" is perhaps the most suitable.

The expression "vividity" was introduced in psychological terminology by Richard Semon in order to characterize the vivacity of perception. Vividity is a quality of perception clearly different from "intensity" but not completely independent from it. For we are able to perceive an object of very small intensity, such as a distant light on a dark night, with great vividness (vividity), and on the other hand the effect which a brilliant arc lamp has may be one of very slight penetration. We hear, for instance, the steps of a person carefully coming nearer on tiptoes with great vivacity and distinctness though as something quite noiseless. On the other hand, the fortissimo of a noisy open-air

concert to which we listen only inattentively is the example of an intense but not vivid perception.

The difference seems to be related to the difference between attentive and inattentive observation, although it is not identical with it. For the greater impressiveness of a perception under equal objective intensity may, apart from the question of attentiveness, be conditioned by a multiplication of the areas susceptible to stimuli. The orchestra does not become less loud if we hear it through only one ear, nevertheless we feel the desire to increase its vividity by listening with both ears. Also, we do not always see more intently with two eyes than with one, but more vividly.

I am convinced that this holds good for all kinds of binocular instruments: thus the advantage of prismatic binocular field-glasses over the so-called "prismatic monoculars" lies not merely in their stereoscopic effect, which is in any case only apparent with comparatively near objects, but especially in the vividity, that is, the general increase in the "lifelikeness" of the impression, which is brought about by binocular as against monocular vision. In the new Microscope this advantage is similarly noticeable.

Now I will go a little further, and should like to make the suggestion that in the impression of vividity is included also a part of the sense of depth, that is, those psychological factors which occur only in binocular vision. For the sense of depth (spatial effect) is known to be not only a function of the impressions on the senses, but is composed of actual optical factors and of physiological and psychological effects. If you remove by any method the immediate perception of depth by submitting to the two eyes two identical images, the remaining physiological and psychological factors can still produce a conception of depth (spatial effect).

The estimation of the distance of a thing takes place according to the size of objects of a known extension: one judges from the appearance of the perspectives (covering, cast-shadows, intensity of colours, so called "air-perspectives") and many other incidental facts. Further physiological features may be mentioned, such as, the straining of accommodation and the convergence of the two visual axes.

In the new instrument not only are the purely optical conditions for depth-effect absent (the two images are identical) but the physiological factors are also eliminated (both eyes are parallel and are accommodated to infinity). The psychological effects which accompany an impression of depth may, however, be produced by some conditions and so give rise to a certain depth-effect. The majority of these accessory impulses in connexion with the sense of depth are also to be considered in connexion with monocular vision: some, however, only appear with binocular vision. Thus, for many observers, the stimulus for the conception

of depth lies in the fact that they are observing with both eyes. The certain expectation that "Now I shall see objects stereoscopically," suffices to induce the apparent effect. This suggestion, with the impression of greater vividity, produces, by the binocular Microscope, the impression of stereoscopic effect and life-like appearance.

8. Parallactic Effects.

Although parallactic perception of depth is out of the question with the new instrument, and the effect which sometimes astounds the observer is only psychological with higher magnifications, nevertheless conditions may be obtained with the binocular Microscope resulting in proper parallactic vision, and what is more both orthoscopic and pseudoscopic. This takes place when the eyes of the observer are not centred with the eye-pieces. One has only to take care that the half of the rays emanating from the object should reach each eye, and, moreover, on account of inversion in the Microscope, the rays from the left half of the object must be led to the right eye, and from the right half to the left eye if you desire an orthoscopic effect. In the reverse case we have pseudoscopic effect, i.e. parts which stand in relief appear to be depressed, and so on. These conditions were first made clear by Professor Abbe in 1882.*

As is shown in fig. 3,† this screening has to be done in the upper focal plane of the objective. It could, however, be moved to an image of this focal plane—the only one available in the ordinary Microscope being the Ramsden disk. There one would have to apply to the "exit pupil" as has been done by Abbe,

* On the Conditions of Orthoscopic and Pseudoscopic effects in the Binocular Microscope. Journ. R.M.S., 1881, pp. 203–11.

† Figure 3 shows the path of the rays in the Microscope from the image of an object P Q to an eye which looks into the Microscope from a position out of the direct line of the principal axis. The rays from P are indicated by dotted lines, those from Q by continuous lines. Both points are represented on the retina, hence the field of vision will not be limited. Of the eight rays proceeding from the object, pairs may be taken together which are parallel in front of the objective and therefore intersect in the upper focal plane of the objective. This focal plane is represented by means of the eye-piece in the Ramsden disk of the whole Microscope. If the eye of the observer is out of the line of the principal axis, some of the rays are prevented by the iris from reaching the inner eye. This is the case with all those rays in the figure which pass through one half of the focal plane of the objective, that is to say, only such rays contribute to form the image of the object P Q as run in a certain direction. In the example given in the figure only the shaded part of the path of the rays reaches the eye. If the other eye of the observer is so placed that it receives the other half of the path of the rays, then the two eyes receive two images of different perspective, and all the conditions of a stereoscopic perception of depth are fulfilled. If on this assumption the eye in the figure is a right eye, the observer will receive a pseudoscopic image; if, on the other hand, it is a left eye, the observer will receive an orthoscopic one. (We suppose ourselves to be opposite the observer.)

a semicircular diaphragm* in order to obtain all the desired effects. With normal microscopic observation, however, this is the spot where the "entrance-pupil" of the observer's eye should be placed so that inconvenience with the eye would be unavoidable; this would

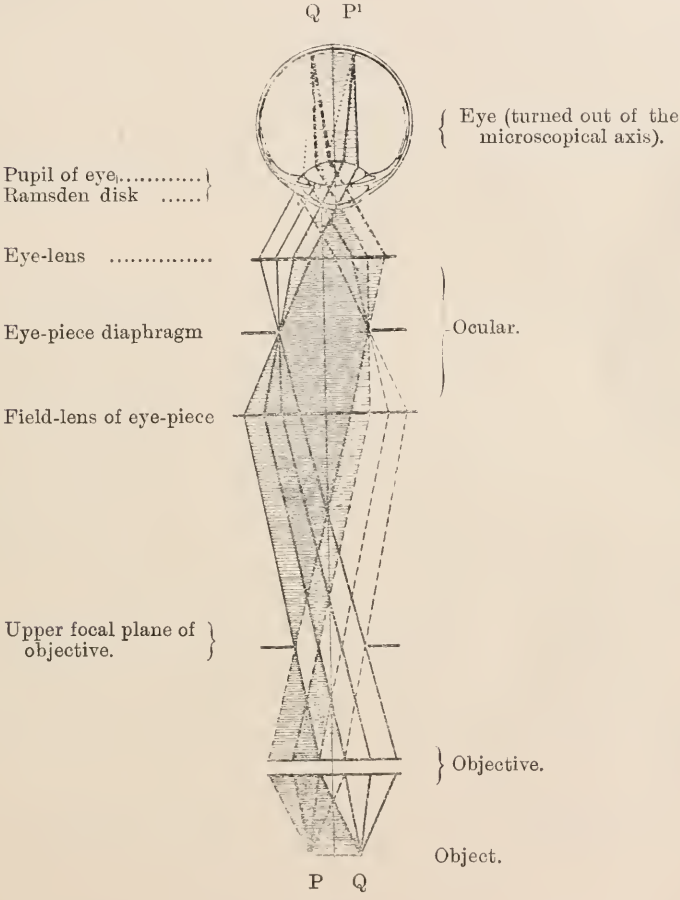


Fig. 3.

also be the case, for instance, with Abbe's stereoscopic eye-pieces. For a stereoscopic Microscope it would therefore be better to produce another image of the Ramsden disk between the objective and eye-lens of the ocular, and to do the screening there. This neces-

* It may be interesting to note that F. H. Wenham already in 1854 made a proposal of this kind. Quart. Journ. Micr. Sci., ii., pp. 132-4.

sary screening can, however, be done more conveniently in another way, by placing the pupil of the eye in a special way in the path of the rays. For example, if we make the space between the oculars somewhat less than the distance between the observer's eyes would be for parallel vision; but if, nevertheless, his eyes remain parallel and wholly without strain, then he must necessarily perceive an orthoscopic effect; on the other hand, pseudoscopic effects must be expected if the oculars are farther apart than the mean distance between the observer's eyes.

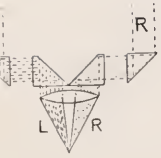
This consideration, which is a direct result of Abbe's theories, was proposed by A. C. Mercer.* Observation confirms its truth entirely for low power magnifications. With higher powers the Ramsden disk becomes so small that, probably owing to the movements of the eye, it cannot be observed in part but can only be taken in entirely or not at all.

This phenomenon can, however, best be observed with incident light, as the production of cast shadows is most conducive to an increase of stereoscopic effect. Besides all granular preparations, for instance, somewhat thicker test preparations of *Macroglossa stellatarum* are most suitable for observing this effect. The oblique illumination is best obtained in this case by fitting a concave Microscope mirror with spindle into one of the holes for the specimen clamps; the light may then be directed obliquely on to the preparation, the individual scales throwing shadows on each other and even at times on themselves. Coins are also very suitable with low-power magnifications. For this case with a suitable adjustment of the distance between the eye-pieces, one sees the lettering stand out with remarkable parallactic effect.

In conclusion, it may again be remarked that with medium and still more high power magnifications there can be no question of an actual parallactic effect. The advantage of the binocular Microscope lies in such cases in the qualitatively enhanced impression produced in different ways, and above all in its hygienic importance.

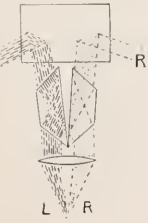
* Stereoscopic Vision with non-stereoscopic Binocular arrangements. Journ. R.M.S., 1882, p. 271.

TYPE 1



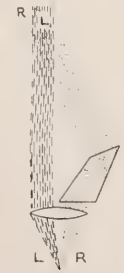
1 RIDDELL

2 WENHAM-RIDDELL



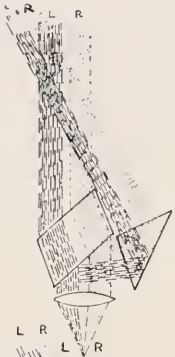
3 STEPHENSON

4 NACHET

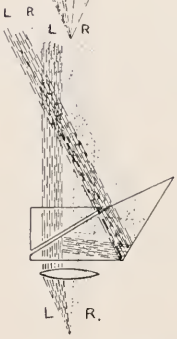


5 WENHAM

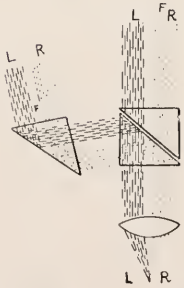
TYPE 2



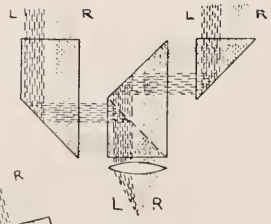
6 POWELL & LEALAND



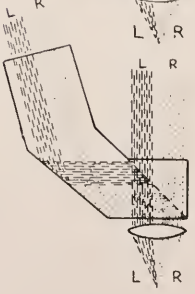
7 WENHAM-POWELL



8 ABBE



9 LEITZ



10 BECK

London Etching Co., Ltd., Eng.

II.—*The Binocular Microscope of the Past, and a New Form of Instrument.*

By Conrad Beck.

(*Read December* 17, 1913.)

Plates I, II.

The paper by Dr. Jentzsch has suggested that an exhibition of the chief types of binocular Microscopes of the past and present might be interesting. To illustrate the construction I show on Plate I diagrams of the optical arrangement of the various forms. Dr. Jentzsch has made a happy classification of binocular Microscopes into two kinds, and, adopting this classification, I would add a third.

I. The first type of binocular Microscope is that in which the light from a single object-glass is geometrically divided and half directed into each eye. The beam of light is bisected. This type includes in order of priority :

1. *The Riddell* (Plate I, fig. 1).—My example of this is a small dissecting compound Microscope, made by Smith and Beck.

2. *The Achromatic Prism of Wenham and Riddell* (Plate I, fig. 2).—I can only obtain one of the prisms of this type, but I have a simple achromatic Microscope on this principle made by Smith and Beck.

3. *The Stephenson Prism* (Plate I, fig. 3).—An example of this has kindly been lent by Mr. Rousselet, and another by Mr. Curties.

4. *The Nachet* (Plate I, fig. 4).—Sir Frank Crisp has kindly lent us a sample of this form.

5. *The Wenham Binocular* (Plate I, fig. 5).—I have two examples of this, one in use with a low power and the other in use with a high power mounted very close to the prism. I have also an old experimental one, in which the prism is actually mounted in the back cell of a $\frac{1}{6}$ object-glass so as to be practically in contact with the back lens, and another prism only mounted on an arm which projects down into the interior of a high-power object-glass. The Wenham form of binocular Microscope has been sold in thousands and is the only binocular Microscope that has had very great popularity.

II. The second type of binocular Microscope is that in which the light from a single object-glass is divided into two beams in a

manner described by Dr. Jentzsch as "physically." The beam of light is not bisected, but is as it were sifted into two so that some light from each portion of the beam goes to each eye.

6. *Powell and Lealand* (Plate I, fig. 6).—The earliest type will demonstrate this. The whole of the light impinges on the first surface of the thick plate No. 1, and while some enters the plate and passes through to form the direct image some is reflected at the first surface, and is caught by prism No. 2 and reflected at an angle up the second tube of the Microscope. I have one of these instruments, kindly lent by Mr. Muiron.

7. *The Wenham Modification of Powell and Lealand* (Plate I, fig. 7) cuts off the top of prism 1 and places it below between prisms 1 and 2, leaving an air space between prisms 1 and 2, and slightly alters the angle of these prisms to get a larger proportion of the light reflected. I have been unable to obtain a specimen of one of these, and it is doubtful if any but experimental instruments were made.

8. *The Abbe Binocular Eye-piece* (Plate I, fig. 8) is optically exactly the same as the Wenham-Powell, except that he divided prism 2 and altered its angle so as not to cross the right- and left-hand beams over. By his construction the length of path of the two beams of light had been much altered. He used a Huyghenian eye-piece on the left-hand body and a Ramsden eye-piece on the right-hand body to correct this, as a Ramsden eye-piece has its focus (F) at a much lower position than that of a Huyghenian. Abbe, instead of using this instrument nearly over the object-glass, placed it near the eye-piece.

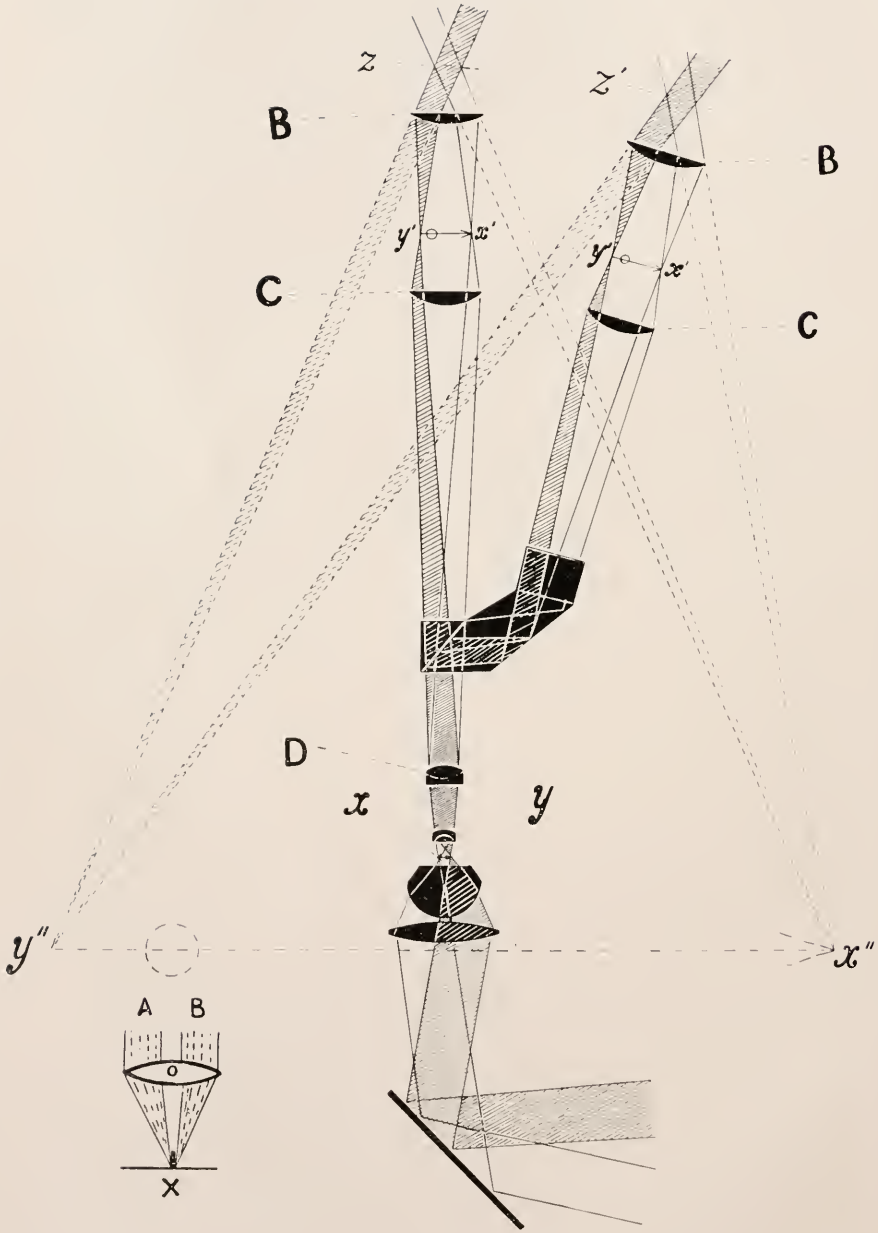
9. Dr. Jentzsch now describes the *New Leitz Binocular* (Plate I, fig. 9), which makes use of a half-silvered film cemented between two glass prisms to divide the beam.

10. I have devised a still further form (Plate I, fig. 10), which I am exhibiting here to-night, which is somewhat on the lines of the Wenham-Powell No. 6, but I am making use of the half-silvered film for dividing the light, and am not crossing over the beams for certain important mechanical reasons, and I also use a parallel block of glass on one of the prisms for equalizing the optical path of the two rays, so that both come to a focus at the same position in the eye-piece.

III. The third type of binocular Microscope consists of two complete Microscopes pointed obliquely at the same object, and is only useful for low powers.

The Greenough Microscope, as made by Mr. C. Baker, has kindly been lent me by Mr. Curties to illustrate this form.

The paper by Dr. Jentzsch is a most admirable and interesting comment on most of these instruments, and the qualities may thus be summarized.



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Properties of the First Type of Binocular Microscope, which has a geometrically bisected beam, one half going to each eye.

1. *Resolution.*—As compared to monocular vision this type is not equal to a monocular, because the diffraction image of a point is increased in consequence of the aperture of the light forming each individual image being half that of the object-glass, and each image has less detail in it on this account. The fact that the two images are combined in the brain does not fill in the detail when it has once been lost in the images in consequence of the half-size bundles of light.

2. The geometrical bisection of the beam must take place near the back nodal or equivalent plane. Dr. Jentzsch says it should take place at the back focal plane of the object-glass, but this is a mistake. It is even worse, as it should be at the back equivalent plane in order to ensure a proper sub-division of the rays, which come from the right-hand and left-hand sides of an object-point respectively, otherwise these rays have become mixed up and cannot be sub-divided except at the Ramsden disc outside the eye-pieces, which will be referred to later. For this reason this first type of instrument can only be used with low-power lenses, unless the high powers are specially mounted exceedingly close to the bisecting prism; even when this is done great care must be taken with the illumination to ensure equal lighting to both halves of the object-glass. I am exhibiting to-night a binocular form of the well-known Wenham make, with a $\frac{1}{12}$ oil-immersion mounted specially short showing tubercle bacilli, and you will notice that the performance is extremely satisfactory and the stereoscopic relief very marked, but the resolution is not equal to that of a monocular instrument. The change from binocular to monocular vision in this form by simply pushing the prism out of place is so quick and simple that I do not think the lack of resolution has been the only reason why this form has not more generally been used for high-power work.

3. *The illumination in each tube* in this type is similar in brilliance if the illumination is such that the two halves of the object glass receive equal amounts of light.

4. *Stereoscopic Relief.*—This type of instrument, excepting forms 1 and 2 which give pseudoscopic images, gives a stereoscopic relief of a very marked kind, indeed, of what is strictly a somewhat exaggerated character. This fact has at times been disputed, it has been stated that the stereoscopic effect is purely an illusion. The small diagram (Plate II) renders the reason for the stereoscopic relief clear. Suppose that O represents the objective, and that an object at X consists of a fine blade of material placed on end, all the light from the left hand of this blade which enters the object glass

at all reaches the left hand of the lens only and from the right hand side of X reaches the right hand side only. If the light from the lens O is geometrically divided and passed to one eye at A and the other at B, a perfect stereoscopic picture will result, as though the eyes were looking on both sides of a card held in front of them in the well known experiment on binocular vision. It must, however, be remembered that a Microscope inverts the image, and consequently to pass the correct image to the eyes to obtain the stereoscopic relief the two beams must be crossed over as in Form 4 the Nachet, and Form 5 the Wenham, or else the images must be re-erected as in Form 3.

5. The images are viewed in Form 1, Type I, with the two eyes parallel, in the other forms of this type with the eyes converging to a greater or less degree.

Properties of the Second Type of Binocular Microscope, which has a Physically Divided Beam.

1. *The resolution* of this type is in all cases equal to that of a monocular provided the surfaces of the prism are perfect, because each eye receives a full size beam of light.

2. The prisms may be placed in any position in the beam of light between the object glass and eye-piece, and need not be placed close to the back lens.

3. *The relative illumination* in the two eyes in No. 6 Powell and Lealand, No. 7 Wenham Powell, No. 8 Abbe, is very unequal. In the Leitz and my own form it is equal in the two eyes, and no special care is required as to the equal illumination of the two halves of the object glass. Even if a single beam of oblique light be used for resolving a diatom, which enters the object glass from only one side, the second type of binocular is as efficient as the monocular. In type 6, Powell and Lealand, the light when it reaches the first face of prism 1 is divided into a reflected beam and a transmitted beam, the latter being about five times as brilliant of that of the other. Wenham, in his modification of the above, by placing his reflecting surface at a greater angle to the incident light, increased the brilliance of the reflected light, but even then the relative intensity differed from about 1 to 3. Abbe adopted Wenham's modification in this respect; he claims that an unequal illumination is advantageous for those microscopists who, before taking to the use of a binocular Microscope, have already reduced the sensitiveness of one eye with a monocular instrument. This argument is one that is difficult to follow, for if the binocular Microscope should come into general use, which, now that the correct type of instrument is being designed is extremely probable, it is important that it should be constructed for the normal

observer whose eyes have not been previously damaged by the use of a monocular instrument. It is possible to suit special cases, in either the Leitz or my own new model, by constructing instruments in which the brilliance of the respective eyes is varied by varying the amount of the reflecting silver deposit, but it is probably not desirable.

4. *Stereoscopic Relief.*—Dr. Jentzsch says that the Abbe binocular eye-piece threw all previous models into the shade, though he states also that it had a very restricted use. Probably in Germany, where the Wenham Binocular was not popular, this is accurate, but in this country and also in America no instrument has yet thrown the Wenham binocular into the shade, and it may be said to be the only binocular instrument that has hitherto been made in large quantities. The Abbe eye-piece is a difficult instrument to keep in adjustment, and has various disadvantages, but it was of great interest from a scientific point of view on account of the controversy that it occasioned as to whether it gave a stereoscopic picture. To elucidate this problem, Abbe pointed out that the Ramsden circle of a Microscope is the conjugate image of the aperture of the object glass, and that if the beam of light entering the eye were divided at the Ramsden circle instead of at the aperture of the object glass, exactly the same rays would be excluded from each eye, and the optical effect would be the same. Suppose in Plate II *d* represents the object glass and *b c* the eye-piece of the Microscope, *z* the Ramsden disk, which is the conjugate image, i.e. a small picture of the lens *d*, a shutter cutting off half the lens D or a smaller shutter cutting half its image at *z* allows just the same rays to enter the eye. Thus Abbe proved that a stereoscopic effect can also be obtained with any of the second type instruments, provided a diaphragm be placed in the Ramsden circle of each eye-piece which cuts out half the rays. It could be turned into a pseudoscopic effect by cutting out the wrong half of the rays or no stereoscopic effect at all by making use of the whole aperture. If by means of a lens held above the eye-pieces the Ramsden disks of a Wenham binocular Microscope be examined, they will be found to be half discs in each eye, small pictures of the back of the bisected object glass, whereas in binocular Microscopes of the second and third type the Ramsden circle is a complete disk. Abbe pointed out that if in these Microscopes that give a complete disk, a D-shaped diaphragm be placed over the Ramsden circle, the same stereoscopic result would be obtained as in the so-called stereoscopic binoculars, except that half the light would be wasted. Theoretically this is quite correct, but there is a serious practical drawback. The proper use of the Microscope necessitates that the observer's eye should be placed so that the Ramsden disk is inside the eye very close to the pupil, and the diaphragm made by Abbe cannot therefore be placed in the right position. In consequence of the

observer's eyelashes it cannot be placed nearly at the correct position, and consequently many observers denied that any stereoscopic relief was obtained with his binocular eye-piece. The use of his eye-piece diaphragms with any but very low power eye-pieces is unsatisfactory, because the Ramsden disk is very close to the Microscope, except in the case of eye-pieces of either very low power or of special construction. But there is another way of stopping out the portions required to give a stereoscopic picture, and that is by placing the eye-pieces slightly too near or too far apart, so that the pupils of the observer's eyes form the necessary diaphragms to cut down the Ramsden disk; and as the stereoscopic effect with a high power object glass is generally exaggerated, a very slight movement of the eye-pieces is often sufficient to cause the necessary stereoscopic effect, and very little loss of light is occasioned.

5. In Types (5), (7), (8), and (10) the two eyes are converged to a point generally about 12 or 15 in. from the observer. Dr. Jentzsch states that to ensure comfort the eye should be looking out parallel. This is not borne out by experience, as the Wenham binocular of the ordinary form gives perfect rest to the eyes when used for hours at a time, and I am inclined to expect it will always be found more comfortable to use an instrument with the eyes converging at an angle of about 10° to 15°. One thing is certain, that the convergence must not be more than 18° and probably not so great, as this is an angle to which the observer is not accustomed. It will be noticed that with the Wenham binocular (Form 5), and the Powell and Lealand (Form 6), if the angle of convergence of the bodies is not to exceed the above convenient amount, the tubes must be long in order that the eye-pieces may be at the required distance apart. It is this fact, together with the trouble of illumination and loss of resolution, which has prevented the Wenham and Powell and Lealand (Forms Nos. 5 and 6) from being even more extensively used than has been the case. It is since the time of short tube-lengths that the popularity of binocular Microscopes has ceased to advance. Any binocular Microscope that is to be universal must have all the advantages of the monocular. In my design of binocular Microscope which I am showing for the first time to-night, I have been able to retain the small convergent angle of about 14° for the two tubes and yet use a tube-length so short that even with a triple nose-piece attached it does not exceed the 160 mm. standard short tube-length. You will notice that the apex of the triangle at which the optic axes of the tubes meet is 3½ in. below the prisms (see Plate II). This advantage is gained by altering the construction of the Wenham Powell model so that the rays do not cross over when deflected from the prisms into the tubes. It will also be noticed that if for certain purposes monocular vision is required, the prism may be pushed out of position with

a touch and either binocular vision with half light in each eye or monocular vision with full light in one can be employed as desired.

The question of slightly convergent versus parallel tubes for a binocular Microscope is one which depends on whether the observer who uses the Microscope uses his accommodation or not. It is, of course, well known to oculists that convergence and accommodation act together, not that they are actually interconnected, but that by long habit when the accommodation is used the eyes converge, and vice versa, and if when the accommodation is used the eyes are obliged to look out parallel, considerable eye-strain and fatigue are occasioned. For telescopes, which are used when the observer is viewing objects at a distance, the eyes are naturally looking out parallel, and parallel tubes should be used, but where the Microscope is employed, alternately with the examination of objects on the table along side it, at a distance of say 12 or 15 in. the observer's eyes are converged to this distance, and it would appear reasonable that such would be the angle at which the Microscope tubes should be set.

A further advantage of this method of constructing the tubes is that by a slight movement of the head backwards or forwards the observer can obtain stereoscopic, flat, or pseudoscopic vision. The distance apart of the eye-pieces of the Microscope is varied by rotating one tube with the finger and thumb. They should be set at such a distance apart that the complete Ramsden disk of each eye-piece is central with the pupil of each eye. Under these circumstances the full resolution and no stereoscopic relief is obtained. Now if the eyes be placed a little closer to the eye-piece the observer's pupils cut off the margins of the Ramsden disks and the stereoscopic effect is obtained ; on the other hand, if the eyes are drawn back a pseudoscopic image is seen. Under the Microscope which is on exhibition will be seen a number of *Coscinodiscus* showing the spines whose composition created discussion some time back in the Society. When the observer examines these, moving his eyes towards or from the Microscope, a pair of individual specimens, which are on different planes will completely change over their relative positions, at one time a specimen being behind, at another time in front of its neighbour. Thus an observer using this instrument for resolution under the most perfect conditions can instantly obtain the perception of the relative depth of the parts by a slight movement of the head.

In working with this Microscope so far I have found no disadvantage as compared with a monocular instrument, but even if such should sometimes exist, a touch slides the prism out of position and it is then exactly the same in every respect as the ordinary monocular Microscope.

MICROSCOPY.

A. Instruments, Accessories, etc.*

(1) Stands.

Watson's Vulcan Metallurgical Microscope.†—This Microscope (fig. 5) has been produced for the immediate examination of metals at the various stages of manufacture and machining. The manipulation

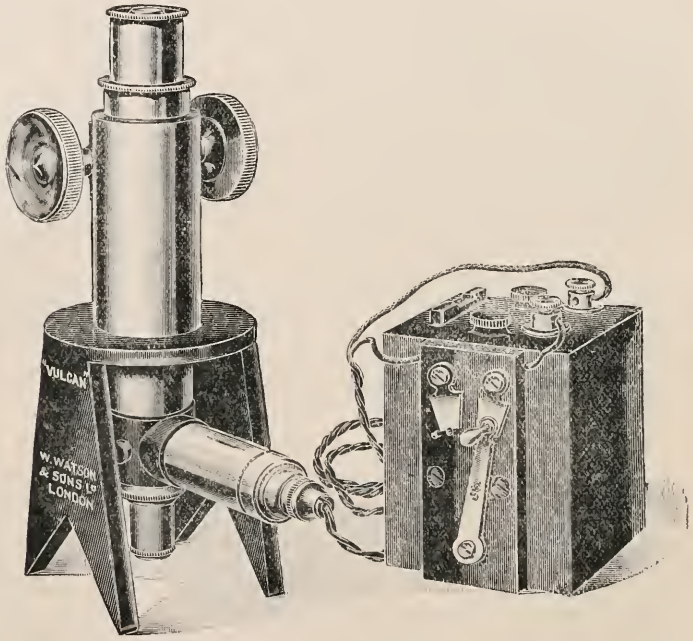

Fig. 5.

of the whole equipment is so simple that no adjustments are necessary other than the rackwork focusing. The instrument can, therefore, be used by those who are not microscopical experts. The stand is so arranged that it will find its own level on any cylinder of metal: for flat surfaces it stands on the four points. The focusing of the objective is by diagonal rackwork and pinion. At the lower end, immediately

* This subdivision contains (1) Stands; (2) Eye-pieces and Objectives; (3) Illuminating and other Apparatus; (4) Photomicrography; (5) Microscopical Optics and Manipulation; (6) Miscellaneous.

† W. Watson and Sons' Special Catalogue: Microscopes and Accessories for Metallurgy, p. 5.

above the objective, a modification of the Watson-Conrady new condenser vertical illuminator is fitted, the light from a 4-volt lamp and dry battery being directed to this reflector through a condensing lens. It is important to note that the relative positions of the light, the reflector, etc., are all fixed and cannot be disturbed, so that the whole instrument is in working order directly the light is switched on. Any objective, high or low, can be used, but the power usually recommended is $\frac{2}{3}$ inch.

Winder's Special Metallurgical Microscope for Observing Structure of Metals under Strain.*—This instrument has been designed by B. W. Winder, and is made by Messrs. Watson. It is intended to

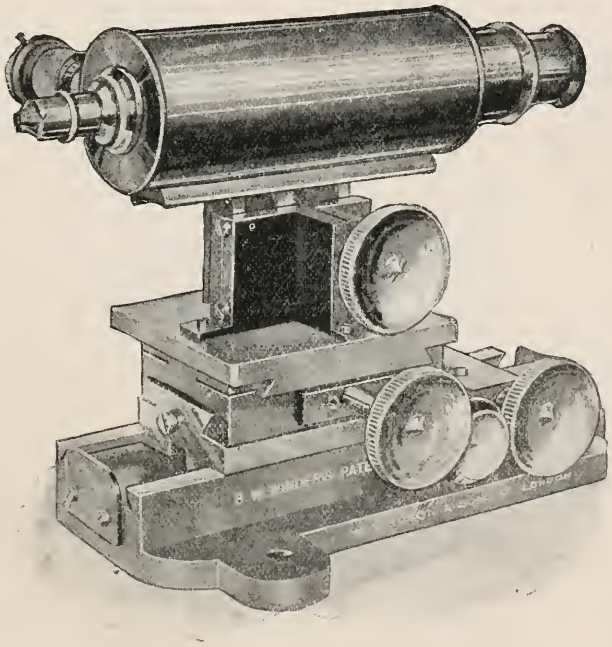

Fig. 6.

work in conjunction with a testing-machine during the time that metal is being tested for its breaking-strain. A testing piece, which has been duly shaped and etched, is placed in the jaws of the testing machine and the Microscope is focused upon it so as to observe and note, either visually, or by projection or photographically, the molecular changes which take place. To accomplish this the Microscope must be supported so as to be unaffected by the vibrations of the testing-machine, and by the shock when breakage takes place. During the process the test-piece of metal becomes gradually stretched, and, in order that observa-

* W. Watson and Sons' Special Catalogue: Microscopes and Accessories for Metallurgy, pp. 16, 17.

tions may be continuously maintained on one spot, the changing position requires readjustment of the instrument. The Microscope is, therefore, equipped so as to meet all these requirements. It will be noticed that all the milled heads are grouped on one side of the instrument so as to be readily accessible. The mechanical movements include :—coarse and fine adjustments to focus, rackwork adjustment to lower and raise the body, horizontal screw adjustment. In each case the mechanical movements are amply sufficient for the purpose in view. A Watson-Conrady condenser vertical illuminator is fitted at the side of the Microscope and built as a part of it. For ordinary visual work the 4-volt lamp is sufficient ; but for projection purposes it will be necessary to use an arc-lamp, and the makers have specially adapted the "Argus" arc-lamp for the purpose. It can be used in any supply circuit and requires only four amperes of current, suitable resistance being of course inserted. Fitted to the lamp is an aplanatic bullseye of such a diameter that, when it is in proper position, the parallel beam of light which issues from it will keep the vertical illuminator filled with light during all the vertical movement that would be necessary in observing the testing-piece. For projection purposes it will generally be found that a sheet of cardboard, or of linen, free from creases and about 24 × 18 in., set up at a distance of 6 or 7 feet from the Microscope eye-piece, will be the most suitable. It is found that the structural changes which take place in the test-piece are of great importance, the information thus conveyed being not only very interesting but very valuable.

Watson and Sons' Micrometer Microscope.*—The production of a Micrometer Microscope that will give readings of the accuracy that is invariably desired is fraught with complications and difficulty. Many instruments are made which are stated to give measurements to several thousandths of an inch, but they frequently fail to give even accurate readings in hundredths, not only on account of infinitesimal backlash and strain in the screw movements, but also because of the lack of exact co-ordination between the divided scales and the pitch of the screw, on the drum heads of which fractions of the scales have to be read. Messrs. W. Watson have produced an instrument (fig. 7) which they hope will satisfy the utmost demands in respect of accuracy. It will be noticed that the Microscope is made on the same principle as an ordinary instrument in the upper portion. It has coarse and fine adjustments to focus, the vital portion being the stage. The subject to be measured is placed between adjustable jaws A, and in order to save time, a quick-acting screw B is provided, by means of which a long subject can be moved rapidly across the field to the extreme point that is to be set. The horizontal movement is then effected by means of a standard micrometer screw C, which may have a thread in millimetres or inches, reading to $\frac{1}{1000}$ in. or $\frac{1}{100}$ mm. The scale D exactly corresponds with the screw. It is verified to be in correspondence with the screw thread, that is, if the screw thread is reputed to produce a movement of $\frac{1}{40}$ inch

* W. Watson and Sons' Special Catalogue : Microscopes and Accessories for Metallurgy, pp. 19–20.

or 0·5 mm. per turn, as the case may be, that amount will be recorded on the scale with unerring accuracy, and thereby enable fractions to be read on the drum of the micrometer. To obviate backlash, the screw works against a spring which is coiled in a box, thereby abolishing the inaccuracies that creep in on account of strain and backlash. The range of screw movement with the micrometer is one inch. If a greater length is required than this, the stage is moved by means of the quick-acting screw for a further inch, and a pivot bar F, exactly one inch in length is interposed between the end of the micrometer and the

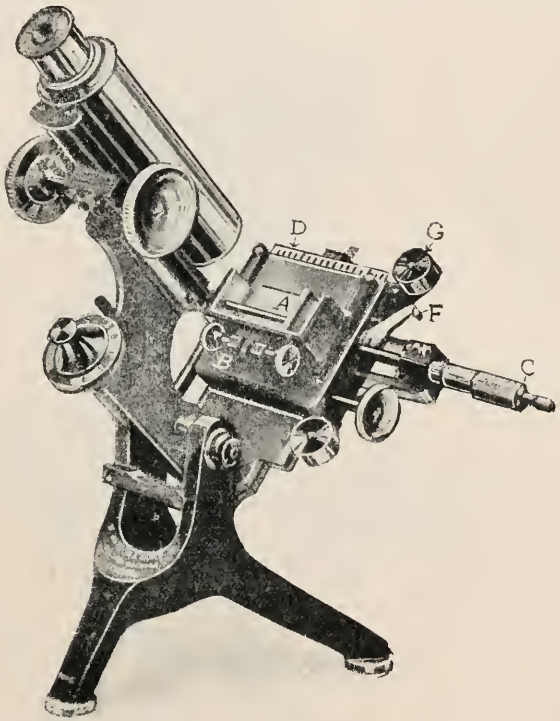

Fig. 7.

stage plate. This enables measurements up to 2 inches in length to be taken. The vertical movement is effected by means of a rack-and-pinion which again is maintained with a tension coiled spring shown at G. A divided scale of the same accuracy, reading by means of a vernier to $\frac{1}{10}$ mm. or $\frac{1}{250}$ in., whichever may be preferred, is fitted. The greater portion of the measurements are intended to be made in conjunction with the horizontal movement, hence the vertical movement is not provided with the same conveniences for fine measurement. These could, however, be provided, if required. The eyepiece is fitted with a single line for setting and reading, the two ends of the subject to be measured

being carried by means of the stage micrometer screw, so that the extreme edge is exactly on the eye-piece line. The eye-piece can be rotated for vertical measurements. For measuring screws a divided circle is fitted to the top of the body tube, so that by rotating the eyepiece, and reading on the divided circle in conjunction with the stage movements, the diameter, angle, and depth of cut can be exactly ascertained.

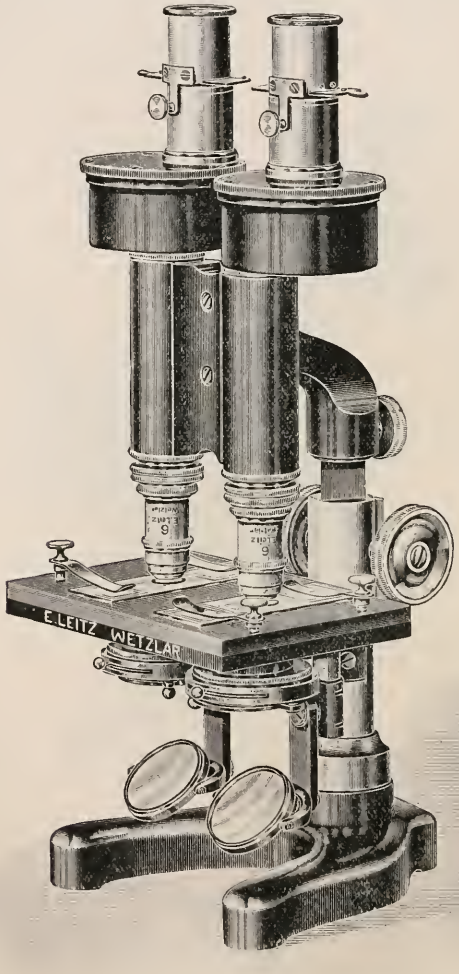

Fig. 8.

Leitz' Double Microscope.*—C. Metz describes this apparatus, which has an optical equipment essentially different from other forms of appar-

* Zeitschr. wiss. Mikrosk., xxx. (1913) pp. 188–91 (2 figs.).

atus intended for observation with both eyes. It consists of two Microscopes combined on a single stand. Each of these Microscopes possesses a complete optical equipment: mirror, illuminating apparatus, objective, and ocular. The stage is unusually large so as to receive two preparations. The coarse adjustment, which is by rack-and-pinion, acts simultaneously on the two combined tubes. Two fine screws between the tube and objectives serve as fine-adjustment. For regulation of the ocular width an arrangement is adopted similar to that used in the Greenough Microscope, and, as in the same instrument, the images are directed upwards by Porro prisms. The upper tube parts, containing the Porro prisms and the oculars, are both movable. The result is that the optical axes are moved parallel to one another and thus impinge on the observer's ocular width; both images therefore enter his eyes. The images overlap in accordance with that wonderful property of the eye, whereby an image received from the one eye is conveyed by means of a central nerve station to the other. But these images are usually not alike. If the objects can be so arranged that the resultant images group themselves separately in one field of view, both objects can be compared without any further precautions. If the objects do not lend themselves to this, as indeed is usually the case, the semicircular stops are applied to both oculars to stop out half of each field of view in such a manner that in the eye two semicircular fields form a complete circular field, in which both objects separated by a scarcely visible line of demarcation can be observed and compared. If it be desired to observe consecutively both complete images in quick succession, the stops can be opened and shut by a left and right movement. This property makes the double Microscope especially adapted for the comparison of healthy and unhealthy organs, or of adulterated and normal foodstuffs. It would be also possible to compare two objects under different conditions of magnification, of illumination, of bright and dark ground, of ordinary and polarized light. With the usual accessories the instrument could be used as a petrological Microscope for the examination of minerals. Its application to colorimetric and spectroscopic tests readily suggests itself. It is, moreover, pre-eminently suitable for stereoscopic observations.

Fig. 8 shows this instrument externally.

(3) Illuminating and other Apparatus.

Zeiss Pocket Refractometer for Mineralogists and Jewellers.* F. Löwe describes this instrument, which has been constructed at the suggestion of the gem expert W. Rau, and which involves an adaptation of the Bertrand-Leiss refractometer. The principle of this refractometer depends on observing the angle of total reflection of rays incident on a face of the crystal, the rays having previously passed through a flint-glass hemisphere horizontally placed and rotatory about its vertical axis. Fig. 9 shows a portable form of the instrument. The mirror *Sp* is adjustable and reversible, so that it can be used for downwards or

* Zeitschr. f. Instrumentenk., xxxiii. (1913) pp. 108–11 (2 figs.).

upwards light. The light can also reach the crystal K horizontally through a diaphragm : H is the hemisphere. After total reflection at the flint-glass-crystal surface the light rays pass into the reflection-prism P, and through the ocular-scale S*k*. in which lies the limit-line (Grenzlinie) and are observed through the ocular O. which can be tilted about the hinge A, and is independent of the ocular scale. The ocular tube can be inclined by means of the position-screw S*t*, and the hemisphere can be rotated by the screw-head G. It will be noted that the hemisphere partly functions as a telescope objective. The angle really measured is that between the normal to the crystal face and the limit-

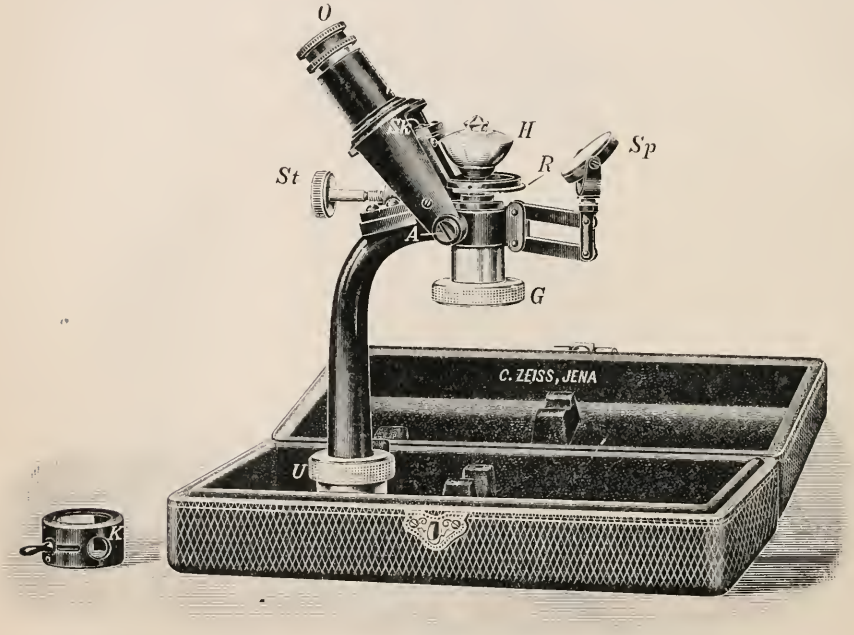

Fig. 9.

rays yielding the limit-line, i.e. the limit-angle of total reflection. The pillar of the instrument is provided with a bayonet-clutch by which it can be secured to a cast-iron base for laboratory use. In the portable form the same clutch is attached to an arrangement on the floor of the case. A diaphragm cap fits on to the ring R, so that extraneous light can be excluded and the incident beam admitted through a little window. Ordinary daylight suffices for the illumination, and the accuracy attainable is within one to two units of the third place of decimals. The readings are taken on the cylindrical-shaped ocular scale S*k* and range up to $n_D = 1{\cdot}85$. The axis of this cylinder is such that, on being tilted into the vertical position, it would, if the prism were removed,

pass through the centre of the hemisphere H. When the ocular is tilted about the hinge A, the limit-line can be brought into its axis, and therefore can be read off with all desirable sharpness.

Watson-Conrady Condenser Vertical Illuminator.*—This instrument is shown in fig. 10, and is intended to obviate the difficulties experienced in working with a vertical illuminator. The objects attained by this piece of apparatus are :—1. Bringing the illumination under a control as complete as that which is obtained with transparent objects and the best substage apparatus. 2. Obtaining the brightest possible illumination from small sources of light. 3. Simplifying and rendering certain the correct placing of the illuminant, whether it be supplied as a fixed portion of the apparatus or separately. 4. Rendering unnecessary the usual short mounting to objectives for metallurgy. Reference to the diagram will show that it is built on the plan of a condenser system in miniature complete with lenses and iris diaphragm. The reflector, which is mounted in a central box, is a large transparent plate. For general purposes a small 4-volt electric lamp may be fixed in a suitable position at the end of the condenser system, and, when work is to be

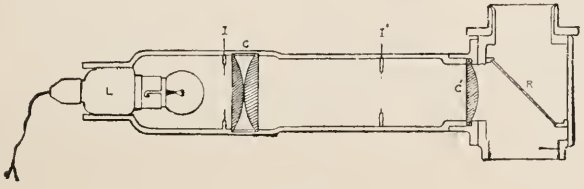

Fig. 10.

done, it is only necessary to switch on the current from the battery and everything will be found to be in good order. With this an illumination can be obtained sufficient for visual or photographic purposes. A specially constructed 25 candle-power lamp of small size is also supplied with fittings to attach to the illuminator, and this lamp can be connected to the ordinary current supply. If an independent illuminant is used, it should be set about $1\frac{1}{2}$ in. from the outer end of the tube. Any small source of light can be used, such as the edge of an oil lamp flame, or, if a very brilliant illumination is required for projection, a small arc-lamp should be used, such as the makers' "Argus."

The apparatus is used in the following manner :—The illuminator is attached to the nose-piece of the Microscope, the objective is screwed into it, and approximately focused on the polished metal objects. The light is turned on, and the illumination is then regulated by the inner iris diaphragm so as to cover the extent of the object actually under observation. This eliminates a large amount of stray light, and a consequent gain in contrast in the image is obtained. The iris diaphragm nearest the illuminant is then used in precisely the same manner as that of the ordinary substage condenser, and by its means the cone

* W. Watson and Sons' Special Catalogue : Microscopes and Accessories for Metallurgy, pp. 28–9.

of illumination is adjusted to give the best effect. The illuminator can be fitted with a permanently attached metallic filament lamp, which reduces to a minimum the trouble of setting-up and adjustment. Further, it enables metallurgical work to be done on an ordinary Microscope.

Wychgram's New Low-current Microscopical Lamp.*—E. Wychgram points out that a microscopist's lamp should satisfy the following requirements :—Stability and compactness, with light-control : applicability both to optical bench and to work-table : maximum light-production with minimum energy-consumption ; simplicity of construction and of eventual repairs ; absolute invariability of the position of the light-spot. The author points out that all these requirements are only satisfied by the use of right-angled carbons, the horizontal crater carbon lying in the optical axis. Even in such lamps of small dimensions the invariability of light-spot can be depended on. Automatic action combined with applicability either to optical bench or to work-table is not so easily attained, and, so far as the author knows, is only attained by a new form of Leitz lamp, which has, furthermore, the advantage of extreme compactness. This new Leitz lamp consists of a plane-sided rectangular box containing the rackwork for the carbon-holders. The positive carbon is moved forward parallel to the upper surface and lies horizontally in the optical axis ; the negative carbon is vertical and parallel to the front surface. Behind the box and secured to it is a clock-work, which, although of equal thickness, is half as large as the lamp-box : it is worked with a pendulum with a hair-spring and simple escapement, and can be delicately regulated. The clockwork is controlled externally so that the approximation of the carbons equals the velocity of carbon consumption. The gearing is large and strong, and the risk of magnetic attraction of the steel parts appears to be insignificant. A small hand-wheel regulates the coarse adjustment, the combustion of the lamp, and the length of the arc, exactly as in the Zeiss-Wenle lamp. Some of the lamp data are :—Current intensity, 4–5 amp. ; length of positive and negative carbons, 15 cm. ; thickness of positive carbon, 8 mm. ; ditto of negative, 6 mm. ; combustion duration, 2 hours ; periodicity of clockwork, 8–10 hours ; focal length of condenser lens, 75 mm. ; weight of lamp without foot, 1·36 kgm. ; thickness of pillar for rider, 10·8 mm. ; minimum distance at which the lens yields an image of crater, 80 cm.

The lamp is easily equipped with a U–V filter and can, therefore, be adapted to luminiscent investigations.

New Safety Device for High-power Lenses and Cover-glasses. This instrument (fig. 11) was exhibited and described by C. E. Heath at the November Meeting last year.† A gives the plan and elevation ; B shows it in use on an ordinary stage ; C is a modified form as adapted to an open mechanical stage. In use the apparatus is placed over the objective threads and the lens screwed home. The tube is then racked up till the chain can be slipped over the milled head so as to

* Zeitschr. wiss. Mikrosk., xxx. (1913) pp. 203–5.

† See this Journal, 1913, p. 644.

hang on its stem. When racked down and the focus found, the chain can be drawn taut by turning the adjusting screw at the bottom. The coarse adjustment is thus deprived of further extension downwards, while the fine adjustment is left quite uncontrolled. The protection given by the first form is the more reliable as the fine adjustment is limited also.

For a somewhat similar device see this Journal 1904, p. 114, where a "Focusing Safeguard" devised by S. E. Dowdy is described and illustrated.

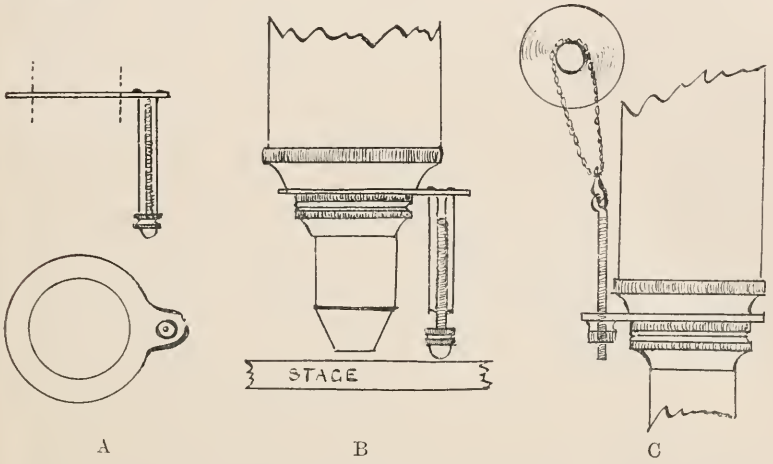

Fig. 11.

New Epidiascope.*—W. Freiherr of Wieser has designed some improvements in Zeiss' epidiascope for the purpose of producing episcopic projections of very large objects. His desire was to make the apparatus capable of showing the corpse of a fully grown person, and he has been quite successful in attaining his purpose.

Simple Method for Obtaining Photomicrographs.†—K. Huldschinsky describes a simple and inexpensive method of obtaining photomicrographs when a projection apparatus is not at hand. He uses for this purpose Leitz' drawing apparatus (fig. 12), which consists of a small mirror obliquely placed over the tube of the Microscope ; the most convenient light-source being Leitz' hand-regulated arc lamp, and the picture to be drawn being projected on to a sheet of paper near the Microscope. For the paper, however, the author substitutes a photographic plate. He screens off the whole light-field between mirror and plate with black paper, and, furthermore, confines the light within a piece of black cardboard inserted so as to enclose object, objective and Abbe condenser. The screen-paper might be replaced by a cardboard box.

* Anat. Anzeig., xlv. (1913) pp. 21–31 (4 figs.).
† Zeitschr. wiss. Mikrosk., xxx. (1913) pp. 206–7 (1 fig.).

with blackened inner surfaces, the mirror being set obliquely in one of its sides. The box has a lid for the insertion of the image, and laterally a catch for the insertion of the plate. The plate must be laid on a frame of corresponding size whose under surface can be raised or lowered to the height required for the image. In arranging the adjustment a piece of white paper the size of the plate is first laid in the frame. The insertion of the actual plate must naturally be performed in complete

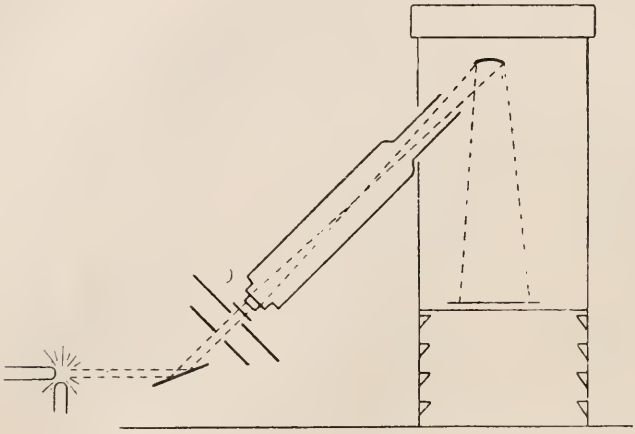

Fig. 12.

darkness. The light-exposure depends on the light-strength and magnification, and varies from fractions of a second up to two seconds. The author finds that with this apparatus very useful photomicrographs can be taken.

(5) Microscopical Optics and Manipulation.

Exercises in Scientific Microscopy.*—Part 2 of this series has now been published, and has been compiled by H. Ambronn and H. Siedentopf. It is exclusively devoted to Abbe's theory of the Microscopic image. All the usual grating experiments with their effects on pleurosigma angulation are collected and described in such a form that they may be easily followed by the student. The experiments are copiously and clearly illustrated.

Ainslie, M. A.—**Microscopical Measurement of Magnifying Power: Measurement of Numerical Aperture.**

[Two very practical and interesting letters on the above subjects.]

English Mechanic, xcviii. (1913) pp. 60 and 111.

Orueta, Domingo de—**La luz ultra-violeta y sus aplicaciones en microscopia con un resumen de los trabajos hechos en el laboratorio del autor durante el año 1911 y primer semestre de 1912.**

[The author gives a very complete account of ultra-microscopical methods and of the results obtained.]

Reprinted from the *Revista de la real Academia de ciencias exactas, fisicas y naturales de Madrid* (1913) 92 pp. (14 pls.).

* Ubung. zur Wiss. Mikrosk. Leipzig: S. Hirzel, Heft 2, 28 pp. (39 figs.)

(6) Miscellaneous.

Quekett Microscopical Club.*—The 493rd Ordinary Meeting of the Club was held on November 25, 1913, the President, Professor A. Dendy, F.R.S., in the chair. The President described a "Red Water Phenomenon due to *Euglena*." J. Burton (Hon. Sec.) read a note "On the Disk-like termination of the Flagellum of some *Euglenæ*." Earliest reference to this was *Science Gossip*, 1879. Saville Kent, "Mannal of Infusoria," p. 382, refers to the same phenomenon. After careful investigation the writer had to come to the conclusion that there is no disk, no bulb, or sucker, or anything of the sort or the end of the flagellum. The appearance is due to the "kinking" of the protoplasm of the flagellum, a quite common occurrence, and the "disk-like" appearance is observed when the distal end has happened, in coiling or kinking, to touch a part of the flagellum just behind the end, and has, in fact, overlapped and adhered to it. J. Burton also read a note on "A Method of Marking a given Object for Reference on a Mounted Slide." When the object is large enough to be recognized with a hand-lens, place a dot of water-colour over it large enough to be seen with the naked eye. When dry turn a small ring of dark cement round it on a turn-table. When the cement is hard, remove the water-colour with a damp brush. For objects too small to be recognized without a higher power—find and centre the object with a suitable power. For the objective first employed substitute a water-immersion say, a $\frac{1}{10}$; put on the front lens as small a drop of water as can be used, carefully focus, and centre. Then rather sharply raise the Microscope tube, and a tiny circular spot of water will be left on the cover-glass over the desired place. Colour this drop with water-colour, dry and ring as before. Any close-working objective may be used for this purpose if a water-immersion is not available. E. M. Nelson, F.R.M.S., "On the Measurement of the Initial Magnifying Powers of Objectives."

The 494th Ordinary Meeting was held on December 23, 1913. B. M. Draper exhibited and described "A Live Box for the Observation of Insects and similar Objects." He also recommended the use of the ordinary concave Microscope mirror, employed with lamp and bullseye, for the illumination of any large opaque object under the lowest powers. The mirror should be made removable, and can then be fixed, when required, to the upper side of the stage on the end of a jointed arm giving universal movement. B. M. Draper, "Dark-ground Illumination with the Greenough Binocular Microscope." The best form of patch-stop was found to be two small circular patches placed side by side and opposite the two front lenses of the twin objectives. E. M. Nelson, F.R.M.S., "A Peculiar Form of Diatom." E. M. Nelson, F.R.M.S., "On *Amphipleura lindheimeri*." A coarser form of this well-known test has been found having 67,000 striæ per inch instead of about 77,000 in the older form. The new *Lindheimeri* may be recognized by its very long terminal nodules, each nodule being one-third of the whole length of the valve.

In the old form the ratio was one-fifth. The length-breadth ratio in the new form is 7 : 5, in the old 8 : 5.

WRIGHT, F. E.—(1) **Graphical Methods in Microscopical Petrography.**
(2) **Graphical Plot for Use in the Microscopical Determination of the Plagioclad Feldspars.**
Amer. Journ. Sci., xxxvi. (1913) pp. 509–42 (10 pls.).

B. Technique.*

(1) Collecting Objects, including Culture Processes.

Cultivation of Cladothrix dichotoma.†—The material for cultivation was obtained from a ditch in the neighbourhood of a sewer. The water was turbid and contained organic impurities. In the month of July a strong growth of green plants was found at the edge of the ditch. Some leaves were taken, examined for the presence of cladothrix, and placed in a 0·5 per 1000 meat extract fluid in glass cylinders provided with close-fitting lids. These cylinders were kept, some in daylight, some in the dark. Vorticellæ and such types died out within twenty-four hours. After two or three days filaments of cladothrix were seen attached to the leaves. These were freed from the leaves and transferred to fresh fluid. After several such transferences to remove as far as possible extraneous organisms, the filaments were transferred to agar plates containing 0·05 p.c. meat extract. The cladothrix filaments on this medium soon outgrew the other organisms. A pure culture thus obtained was sealed up and kept under anaerobic conditions. It was found alive after two months.

P. Linde further describes the characters of the culture. It contained threads of varying dimensions, and it was thought possible that more than one species was present. Single-filament cultures were examined by means of the Indian ink method, and it was found that the same variations in size were to be observed.

Egg-broth.‡—A. Besrekda and F. Jupille have found that many organisms grow well on a medium containing four parts of white of egg (10 p.c. solution) in distilled water, one part of yolk (10 p.c. solution), and five parts of peptone broth. Such organisms as pneumococci, meningococci, gonococci, *B. melitensis*, and *B. pertussis* of Bordet and Gengou grew luxuriantly, and retained their vitality for several months. On a modified medium, containing 100 c.cm. of broth without peptone, 20 c.cm. of white (10 p.c.), and 5–20 c.cm. of yolk of egg (10 p.c.) tubercle grew with remarkable luxuriance and rapidity. A tuberculin

* This subdivision contains (1) Collecting Objects, including Culture Processes; (2) Preparing Objects; (3) Cutting, including Embedding and Microtomes; (4) Staining and Injecting; (5) Mounting, including slides, preservation fluids, etc.; (6) Miscellaneous.

† Centralbl. Bakt., 2te Abt., xxxix. (1913) pp. 372–5.

‡ Ann. Inst. Pasteur, xxvii. (1913) pp. 1009–17.

prepared from such a growth was found capable, when combined with serum from a tuberculous patient, of binding complement.

Cultivation of Spirochæta recurrens.*—S. Hata gives an account of his work undertaken in order to confirm that of Noguchi upon the cultivation of *S. recurrens*. Noguchi used fresh ascitic fluid in which a small piece of rabbit-kidney was immersed. This is inoculated with a small quantity of blood containing *S. recurrens*, and the organism multiplies when incubated at 37° C. for two to three days. The maximum growth is reached on the eighth day. Spirochætes thus cultivated show a tendency to rapid degeneration. Hata found it quite unnecessary to cover the ascitic fluid with paraffin oil as Noguchi had recommended. He found also that serum could be substituted for ascitic fluid. Blood was drawn from the veins of a horse into a tall cylinder, and set aside for the serum to separate. Serum is then put into tubes and mixed with normal saline : one part of serum to two of saline. The depth of fluid in each tube is about 7 cm. The tubes are placed in a water-bath at 58° C., heated slowly to 70° C., and kept at that temperature for thirty minutes. This semi-coagulated mass is a satisfactory substitute for Noguchi's ascitic fluid. Small pieces of rabbit's kidney are pushed into the mixture to rest at the bottom of the tubes. Hata found that the buffy clot from normal horse's blood may be used instead of kidney with equally good results. This part of the clot is cut into small pieces and pushed down to the bottom of the tube. This medium may be used in place of Noguchi's ; the materials are more readily obtained, and uniform results are obtained.

New Medium for Cultivating Gonococcus.†—Aug. Lumière and J. Chevrotier declare that the medium they have devised is eminently suitable for the cultivation of gonococcus. It is prepared as follows : A solution of 6 grm. of albumen in 1000 c.cm. of beer wort is autoclaved at 115° C. The medium is filtered while hot, and, after having been alkalinized, it is sterilized again at 110° C. for ten minutes.

It is advantageous to add 1·5 c.cm. horse or ass serum to 15 c.cm. of the wort medium, but this addition is in no wise indispensable. During sterilization it is important that the tubes should be kept sloped. This recommendation presumably refers to the second sterilization. Gonococcus, whether old or recent, flourishes in this medium, and its cultivation is as easy as that of the majority of micro-organisms. The authors mention that different races of gonococcus, recognizable by their size, retain their primitive characteristics even unto the tenth generation.

(3) Cutting, including Embedding and Microtomes.

Leitz' New Sledge Microtome.‡—This apparatus, which is described by S. Becher, resembles the Minot type of microtome to the extent that the knife is stationary and the object movable. As will be seen

* Centralbl. Bakt., 1te Abt. Orig., lxxii. (1913) pp. 107–12.
† Comptes Rendus, clvii. (1913) pp. 1097–9.
‡ Zeitschr. wiss. Mikrosk., xxx. (1913) pp. 192–202 (2 figs.).

from figs. 13 and 14, the object-portion consists essentially of a heavy metal block, of rectangular shape, which slides in a groove made in the upper surface of the heavy base-plate. The longer lower edges of this block are to a certain extent rounded off so as to minimize friction, and the movement is kept true by the presence of the vertical lateral faces of the block against the vertical faces of the groove. A slight allowance is made in dimensions, so that the block runs smoothly in its groove and jamming is impossible. As the block has been intentionally made very heavy, it cannot jump when the object meets the knife. Moreover, the object-holder is placed in the axial line of the block, and this arrangement secures that the resistances of object and knife are

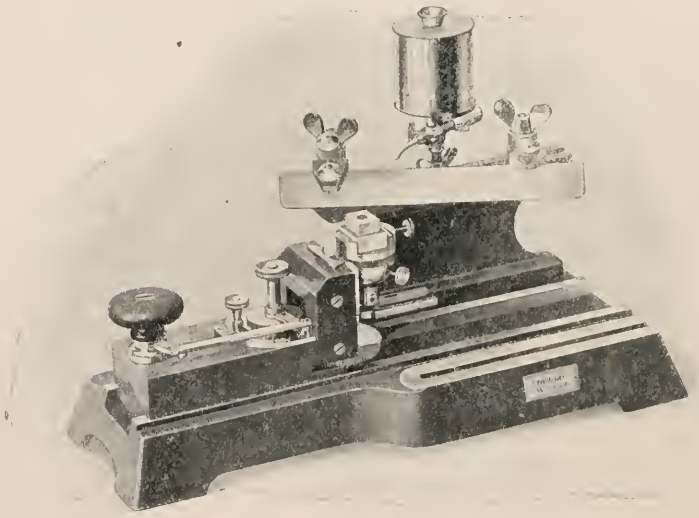

Fig. 13.

collinear with the axis of movement. The effect is, therefore, still further to reduce any risk of oblique disturbance of motion.

The object-block is operated by a knob rotatory on a vertical axis and geared to a disk, which again is geared to the object-holder. The disk is divided into 20 divisions, each of which corresponds to an elevation of 1 μ of the object-holder. The pointer of the disk is therefore set to correspond with the required thickness of section. A right turn of the operator's hand on the knob, puts the gearing into action, and therefore causes the elevation of the object ; a left turn then brings the knob back to zero. The order of operations would be : rotate knob to right, push forward, cut, draw back, rotate knob to left. Or the order might be : rotate knob to right, push forward, cut, rotate knob to left, draw back. It is found that after a little practice one hand can perform

these actions automatically, and therefore operate the whole machine. Thus the operator's other hand is free to look after the section-ribbon or for other purposes. The essential part of the object-holder is a micrometer spindle gripped by Leitz' well-known forceps-nut. The spindle itself glides without lateral disturbance in a swallow-tailed groove in the base-plate and is clamped from below. The knife may be fastened with one clamp or with two, and the knife below is provided with a scale for controlling the knife-inclination. The pillars for knife-attachment are connected with a broadened portion of the base-plate. The pillar used for single-clamping is permanent, but that used for the second clamp (fig. 14) works in a groove and is secured in its required position

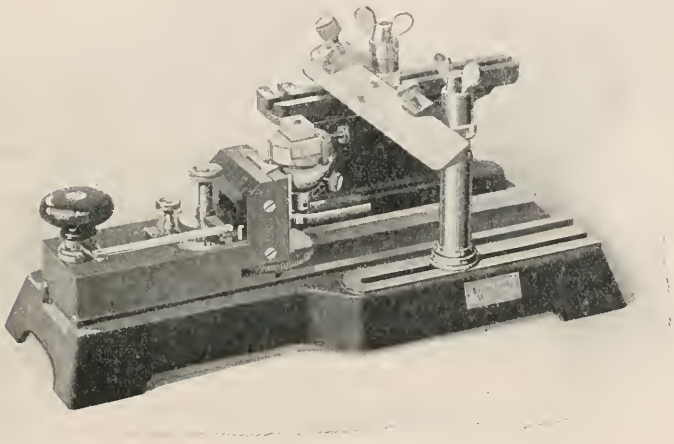

Fig. 14.

by a butterfly-nut attached to its base. The knife can be raised by the insertion of metal rings under the clamps. The author speaks highly of the accuracy and uniformity of the sections obtained by this machine.

Modification of Altmann's Method of Staining Chondriosomes.* H. Kull gives the following procedure:—Fixation in 3·5 p.c. bichromate of potassium, 80 c.cm. + 20 c.cm. 40 p.c. formalin for twenty-four hours, after which the pieces are transferred to the bichromate solution without formalin for three to four days. The pieces are then washed in running water and paraffin sections made. Celloidin sections may be prepared by Rubaschkin's method (see this Journal, 1907, p. 633).

Another method of fixation by means of osmic acid mixtures gives

* Anat. Anzeig., xlv. (1913) pp. 153–7.

good results. Small pieces are placed for twenty-four hours in a mixture of 7 parts of 1 p.c. chromic acid, 7 parts of 3 p.c. potassium bichromate, and 4 parts of 2 p.c. osmic acid. After removal they are washed in distilled water and then placed in a mixture of 1 part acid acet. pyrolignosum rect. and two parts of 1 p.c. chromic acid. After twenty-four hours they are washed for half an hour in distilled water, and then placed for three days in 3 p.c. bichromate of potassium. They are then washed in running water and afterwards embedded. The preparations are then treated in the following manner :—1. Stain, heating to vaporization, with Altmann's acid-fuchsin (20 grm. acid-fuchsin in 100 c.cm. anilin water). 2. Wash with distilled water. 3. Stain for 1 to 2 minutes in a saturated aqueous solution of thionin, or in a 0·5 p.c. aqueous solution of toluidin blue. 4. Wash in distilled water. 5. Differentiate with 0·5 p.c. solution of aurantia in 70 p.c. alcohol (20 to 40 seconds controlling under the Microscope). 6. Dehydrate in 96 p.c. alcohol, 7 absolute alcohol, 8 xylol of balsam.

The balsam used by the author is Merck's glass-hard balsam dissolved in pure benzol. Preparations mounted in this medium have kept unchanged, while controls mounted in other varieties of balsam have materially deteriorated.

Diagnosis of Rabies.*—Lena Negri Luzzani gives the technique by which the specific parasite of rabies may be demonstrated. She first describes the procedure for opening the skull and removing that portion of the brain known as the cornu ammonis. A minute portion of the nervous substance is placed on a slide and teased out with very dilute acetic acid. In this way a fair number of nerve cells may be isolated and the intracellular parasite detected. When it is not possible to carry out the foregoing technique at once, or if the examination has been negative, it is advisable to immerse small pieces of the cornu ammonis in Zenker's fluid : Bichromate of potassium, 2·5 ; corrosive sublimate, 5 ; water, 100 ; adding before use acetic acid 5. The small pieces are sufficiently fixed in from two to four hours, and then they are washed in water for a few minutes. Very little bits are then teased out on a slide and examined as before. It is easier to find the parasite after fixation by Zenker than in the fresh material. In certain cases it is necessary to investigate by means of sections. Paraffin sections are made in the usual way and then stained by Mann's method. The staining solution consists of aqueous solution of eosin, 1 p.c. 45 c.cm. ; aqueous solution of methylen-blue, 1 p.c. 35 c.cm. ; distilled water 100 c.cm. The eosin and methylen-blue solutions are to be mixed when required for use. The sections remain in the stain for about half an hour, and on removal are immersed in absolute alcohol for several minutes. When dehydrated they are differentiated in alkaline alcohol (absolute alcohol, 30 c.cm. ; caustic soda dissolved in absolute alcohol, 5 drops). Differentiation is continued until the sections lose the blue and become quite red. After a rapid wash in absolute alcohol the sections are plunged in tap-water, and then in distilled water acidulated with acetic acid. In the last bath

* Ann. Inst. Pasteur, xxvii. (1913) pp. 1039-62 (1 pl. and 3 figs.).

they turn blue again ; and then follow dehydration in absolute alcohol, xylol, balsam. Under the Microscope the parasites are stained red, and exhibit their characteristic appearance while the nucleus and cytoplasm are blue.

(5) Mounting, including Slides, Preservative Fluids, etc.

Use of Glycerin-jelly in Mounting Microscopical Objects.† L. W. Stansell, after remarking that mounting with this medium is quite simple, gives the following procedure :—The jelly in the stock-bottle is allowed to become liquefied by standing in the water-oven ; should it contain air-bubbles, time must be given for these to rise and escape. A few clean 3-in. by 1-in. glass slips are ready upon a flat bench ; then, with a glass rod, one drop of the limpid jelly is carefully placed on the centre of each slide, the drop not being allowed to fall from the glass rod, but almost *placed* in position. The drop of jelly soon sets to a clear, lens-like form, usually free from air-bubbles. Should one, however, be seen, it can be dispersed with a warm needle, or else by the same means drawn to one side and pushed out of the way before the jelly sets. These prepared slides are ready for immediate use, or if preferred they can be stored in a box out of the dust for some days until wanted. It is important to have objects for mounting in the moist condition ; particles of fibre from feeding-stuffs will already be in that state if the material has been prepared for the determination of cellulose ; they can be taken direct out of the final washing water. Portions of dry leaves, mosses, and similar structures are soaked for some days in a preservative fluid consisting of distilled water 2 parts, rectified spirit 1 part, and glycerol 1 part. Each specimen is kept in a small bottle or tube with a little of the fluid ; it gradually penetrates and will displace the air, more speedily if put in a warm place. Some tissues previous to this soaking may even be boiled in distilled water and allowed to remain there till cold. The air-free water helps to dissolve out residual air. A simple method of preparation to employ for leaves—tea, for instance—is to raise cautiously to boiling in a test-tube with dilute nitric acid, and then freely dilute with water. If the structures float owing to imprisoned air, further boiling in water is necessary before proceeding to wash. The cuticle separates and can easily be stripped off. The fragments of husk, cuticle, etc., are taken while wet and gently laid with forceps upon the flat bead of solid jelly, the excess of water or other fluid allowed to drain off for a moment, and then the slide slowly warmed over a very small flame. The jelly melts, and the object *in situ* will sink into the liquid jelly without as a rule the introduction of a single air-bubble. The cover-glass is applied and gradually lowered, placing a flattened bullet on it to keep it in position, then left for some minutes till the slide has set. Not much pressure should be exerted, or the cover-glass may have a tendency to spring up afterwards. At this stage the mount admits of microscopical examination. When this is completed, the processes of finishing the slide can be proceeded with, or, if desired, held over, and the slide reserved for treatment with others. Sediments and other finely divided

* Journ. Soc. Public Analysts, September 1913.

objects need different treatment. When mounting the deposit obtained from a water, or the washed residue from Demerara sugar, a conical settling-glass is provided, and when all suspended matters have settled, as much as possible of the supernatant fluid is decanted off until only a drop or two remains. The drop that is left, containing the residue of suspended matter, is poured over the bead of glycerin-jelly already solidified on a slide. By now placing this slide overnight in a level position in a desiccator, the water will be found next day to have become absorbed, leaving the sediment in position on the surface of the jelly. If now gently warmed and a cover-glass adjusted, any fine residue of suspended matter from water can be more successfully retained and fixed by such means than the usual methods of treatment allow.

(6) Miscellaneous.

Crystallization of Coumarin.*—At the November Meeting, 1913, G. H. Beaumont exhibited slides illustrating the crystallization of Coumarin (from Tonkin Bean). These slides were prepared by fusion. When cooled at the ordinary temperature, Coumarin crystallizes in a translucent grey-white mass, and shows little or no colour when viewed by polarized light. When allowed to cool more slowly it sometimes exhibits characteristic fan-like crystallization which is weakly doubly refracting. When crystallized under pressure it becomes highly doubly refracting, and exhibits the fine colour effects which were shown in the exhibits.

Metallography, etc.

Arsenic in Commercial Copper.*—P. Jolibois and P. Thomas have studied the microstructure of copper-oxygen, copper-arsenic, and copper-oxygen-arsenic alloys, to ascertain if copper can be deoxidized by additions of arsenic. It was found that arsenic additions did not affect the quantity of cuprous oxide present in oxygen-containing copper, but altered the appearance of the cuprous oxide globules, causing them to be larger and less numerous. Arsenic forms copper arsenide which enters into solid solution in copper, and accordingly does not deoxidize copper. Antimony has a similar effect. Tin, zinc, and magnesium remove oxygen from copper, and lead has some deoxidizing effect. Ammoniacal cupric chloride solution was used for etching.

Acicular Constituents of Alloys.†—F. Robin describes in detail constituents which appear in the form of needles in copper-aluminium and copper-tin alloys, and in special bronzes obtained by adding another element to one of these binary alloys. The mode of formation of martensite-like constituents, their true constitution, and the structural modifications which they undergo when heated, are discussed. Acicular constituents occur only in a few series of alloys, and appear to be dependent on the quenching of a solid solution which is unstable at ordinary temperatures. The reagent used for etching the aluminium bronzes was made up of ferric chloride 5 p.c., water 5 p.c., hydrochloric acid 30 p.c., isoamyl alcohol 30 p.c., ethyl alcohol 30 p.c., and was found to be suitable for all copper alloys, and for nickel.

Manganese-silver Alloys.‡—G. Arrivaut, in the course of an investigation of this binary system, has studied the microstructure of the alloys prepared. The manganese-silver system is peculiar in that the compound found, $MnAg_2$, forms a continuous series of solid solutions with silver, but is nearly insoluble in manganese.

Microscopical Examination of Standard Steels.§—H. S. Rawdon describes the microstructure of specimens which had been used for taking heating and cooling curves of a number of steels supplied by H. M. Howe, and containing 0·03 to 1·45 p.c. carbon. Though the thermal treatment had been carried out in a high vacuum, there was distinct evidence of slight decarburization of the surface.

So-called Fibrous Structure in Steel.‖—The arrangement of the constituents in a section taken from a steel casting which has been

* Rev. Métallurgie, x. (1913) pp. 1264–70 (14 figs.).
† Bull. Soc. d'Encouragement, cxix. (1913) pp. 12–41 (29 figs.).
‡ Rev. Métallurgie, x. (1913) pp. 1257–63 (8 figs.).
§ Bull. Amer. Inst. Min. Engineers, No. 78 (1913) pp. 1095–8 (6 figs.).
‖ Zeitschr. Anorg. Chem., lxxxi. (1913) pp. 156–69 (22 figs.).

suitably annealed is much the same whatever may be the direction of the polished face of the section. But in rolled or forged steel the constituents are commonly arranged in parallel bands or strings, and the appearance of a microsection accordingly depends upon the direction of the polished face with respect to the directions of flow of the steel during the mechanical working operations. P. Oberhoffer has studied this laminated structure in a large number of boiler plates, structural steels, and other hot-worked shapes. The laminated structure was found to persist after heating to temperatures not excessively high, followed by slow cooling. The origin of such banded structures probably lies in the action of slag-inclusions as nuclei upon which the ferrite crystallizes during cooling through the critical ranges.

Cold-rolling of Steel.*—H. Hanemann and C. Lind have studied the various properties of a steel strip containing 1·2 p.c. carbon at each stage of the manufacturing process, consisting of successive cold-rollings and annealings. Before the first cold-rolling the material consisted structurally of lamellar pearlite and a cementite network. At an early stage in the process the material had become wholly converted into granular pearlite, the excess cementite changing into small granules indistinguishable from the eutectoid cementite. Steel in which the carbide is contained in the form of granular pearlite is in the softest possible condition, capable of enduring without permanent injury severe change of form by cold-working, and is thus peculiarly adapted for cold-rolling. By a suitable final hardening or annealing, the granular pearlite may be replaced by a structure having greater strength.

Annealing of Steel Castings.†—P. Oberhoffer has studied the effect upon the properties of two steel castings, containing respectively 0·23 and 0·66 p.c. carbon, of annealing at different temperatures. The gradual replacement of the coarse casting structure by a fine-grained structure as the annealing temperature is raised, is illustrated by a series of photomicrographs. To remove completely the coarse ferrite network of the casting structure, the annealing temperature must not be lower than the temperature of first separation of ferrite.

Structure of a Broken Axle.‡ — M. Füchsel describes the microstructure of a railway-wagon axle, manufactured about twenty years ago, which broke in use. The ferrite and pearlite ran in parallel bands, forming a remarkably well-developed coarse, laminated, or banded structure. Numerous slag-inclusions were present in the ferrite. The individual ferrite grains of which the bands consisted were not elongated in the direction of the length of the bands. Such a structure indicates that the axle was rolled at a high temperature and slowly cooled. Annealing at 850° C., followed by cooling at a moderate speed, completely removed the banded structure, the ferrite and pearlite now being well mixed. A similar fine uniform structure was found in an

* Stahl und Eisen, xxxiii. (1913) pp. 551–5 (9 figs.).
† Stahl und Eisen, xxxiii. (1913) pp. 891–6 (22 figs.).
‡ Stahl und Eisen, xxxiii. (1913) pp. 1487–9 (5 figs.).

axle made according to present-day requirements, and forged after rolling. It is shown that poor mechanical properties accompanied the coarse, banded structure.

Microstructure of a Boiler Plate.* — Matweieff indicates some peculiarities in the structure of a boiler plate containing 0·06 p.c. carbon, after fifteen years' service. Neumann lines probably indicated that the material had been distorted when cold. The existence side by side of large and small ferrite grains might be the result of cold-work followed by annealing.

Fluidity of Rails.†—Babochine has found that steel rails which, in use, flow laterally to an undesirable extent, are commonly coarse in structure and contain well-formed lamellar pearlite. Better wearing qualities are accompanied by finer and more sorbitic structures.

Cracked Boiler Plates.‡—R. Baumann has examined thirty boiler plates from various sources which had developed cracks. Peculiarities of structure are described and illustrated with numerous photomicrographs.

Microstructure of Sintered Iron-bearing Materials.§—B. G. Klugh gives photomicrographs of sections of flue-dust and similar materials after they had been agglomerated by heating. In the description of the microstructure, the relative porosity of the products of different sintering processes is the chief point considered. When high temperatures are used the nodules become entirely coated with a clear violet-tinted glass of silicate of iron.

Metals, Crystalline and Amorphous.‖—W. Rosenhain defends the theory which explains certain properties of metals by the conception of an amorphous condition of the metal distinct from its normal crystalline condition. The theory consists of three propositions:—1. That mechanical disturbance of the surface of crystalline metal, as by polishing, produces a thin surface film of amorphous metal. 2. That a similar amorphous layer is formed within a metal crystal by the internal rubbing which occurs on surfaces of slip during plastic deformation. 3. That the crystals of which a piece of metal is composed are separated from each other by thin films of under-cooled liquid or amorphous metal acting as an intercrystalline cement. The whole question is reviewed on broad lines.

Micrometry as applied to Alloys.—C. H. Mathewson¶ discusses the application of the Microscope in the quantitative determination of the

* Rev. Métallurgie, x. (1913) pp. 1271–3 (3 figs.).

† Rev. Soc. Russ. Met., 1912, pp. 523–42, through Rev. Métallurgie, x. (1913) Extraits, pp. 613–17 (10 figs.).

‡ Stahl und Eisen, xxxiii. (1913) pp. 1554–61 (35 figs.).

§ Bull. Amer. Inst. Min. Engineers, No. 77 (1913) pp. 813–28 (13 figs.).

‖ Engineering, xevi. (1913) pp. 509–11, 537–9 (1 fig.). Paper read before British Association, 1913.

¶ Met. and Chem. Eng., xi. (1913) pp. 619–21.

composition of alloys, and describes the procedure he has adopted for the determination of aluminium in zinc-aluminium alloys, of oxygen in copper, and of iron in zinc, by measurements of areas occupied in photomicrographs, by eutectics, or by compounds. The outlines of constituents may be traced upon finely ruled squared paper, and the number of squares included in the area counted. In measuring areas occupied by eutectics, coalescence must be taken into consideration.

Z. Jeffries * has used for the same purpose a vertical photomicrographic apparatus having a glass plate, thinly coated on its upper surface with paraffin-wax, in the place of the camera screen. The areas are measured on the waxed surface with a planimeter. The addition of starch to the paraffin-wax increases its opacity and permits the use of a thinner coating.

Long-focus Microscope, and its Applications in Metallography.† F. Robin describes a Microscope designed for the examination of polished sections while they are being heated. By placing an achromatic biconcave lens in the Microscope tube, just behind the focus of the objective, the magnifying power is considerably increased, and moderately high magnification is obtained without reducing the distance between specimen and objective. Such an instrument, constructed by Nachet, gave a magnification of 200 diam., with a distance between specimen and objective of 5 cm. Oblique illumination is used. When used for the examination of specimens during heating the Microscope is horizontal. The specimen is held in a suitable clamp, heated by a Bunsen burner, and contains a small hole for the reception of a thermocouple.

The microscopic appearances during oxidation of various steels, and other metals and alloys, by heating in air are described, and the relative rates of oxidation of the different constituents are shown as curves, the relative thicknesses of the oxidation films being calculated from the wavelengths corresponding to the colours observed. An allotropic change occurring on heating may make itself evident by a sudden change in the progress of oxidation. The development of the crystal boundaries of metals and alloys during heating has also been studied in the same way. Antimony, bismuth, and zinc exhibited this phenomenon clearly. The visibility of the grain boundaries of a heated specimen appears to be due to an actual difference of level between adjoining crystals. An explanation of the development of this difference in level is suggested, depending on differences in the expansion of the crystals in different directions. The temperatures at which the grain boundaries first appeared were determined for a number of metals and alloys. Observations, by the same method, of appearances during heating connected with the sub-division of the large grains of metals, with the development of fissures, and with fusion are described.

Improved Vertical Illuminator.‡—F. E. Wright describes a device fitted to a vertical illuminator of the glass-plate type, which enables

* Met. and Chem. Eng., xi. (1913) p. 668.
† Bull. Soc. d'Encouragement, cxviii. (1912) pp. 204–31 (22 figs.).
‡ Journ. Washington Acad. Sci., iii. (1913) pp. 14–16 (1 fig.).

the observer to produce an aperture of any desired size in any part of the field. By its use the reflection of light from the objective-lens surfaces into the observer's eye can be largely prevented.

Microscopic Examination of Metals by means of Polarized Light.* H. Hanemann and K. Endell discuss the application of polarized light in metallography, describe J. Königsberger's apparatus for the observation of opaque bodies in reflected polarized light, and indicate by examples how isotropic and anisotropic constituents of metals and alloys may be distinguished.

* Stahl. und Eisen, xxxiii. (1913) pp. 1644–6 (1 fig.).

MICROSCOPY.

A. Instruments, Accessories, etc.*

(1) Stands.

Leitz' Stereoscopic Binocular Microscope for Metallurgical Purposes.†—A very complete and substantially built binocular Microscope, giving an erect and truly stereoscopic image and possessing many desirable features, has been constructed by the firm of E. Leitz to the specification

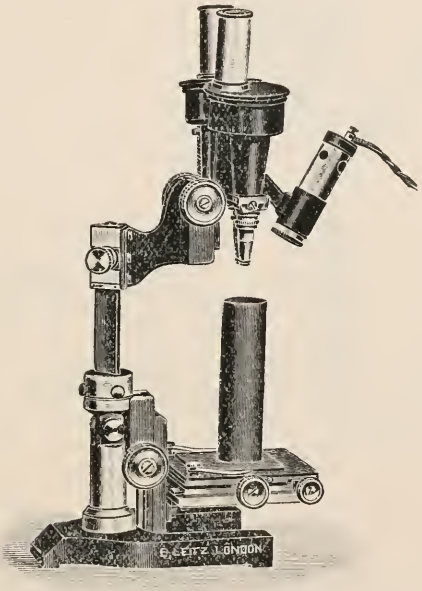

FIG. 20.

and design of Wesley Lambert, late Chief Metallurgist of the Royal Gun Factory at Woolwich. Figs. 20 and 21 serve to show the principal features of this model which is of the Greenough type. Two body-tubes are so arranged as to bring the same object into focus in the axis

* This subdivision contains (1) Stands; (2) Eye-pieces and Objectives; (3) Illuminating and other Apparatus; (4) Photomicrography; (5) Microscopical Optics and Manipulation; (6) Miscellaneous.

† Special Catalogue. E. Leitz, London.

of each tube, the tubes being set at an angle to each other for this purpose. Each tube carries both an objective and ocular. The two objectives are mounted on a single slide, the lenses being carefully paired, and provision is made by a suitable adjusting arrangement to enable one to focus the object for each eye separately. Correction is thus made for any slight difference that may exist in the eyes of the observer. Provision is also made for adjusting the oculars to the correct width between the pupils of the observer's eyes. The stand comprises a heavy horse-shoe base, of generous dimensions, carrying a substantial pillar, to which the stage and body are fitted. The latter is considerably over-

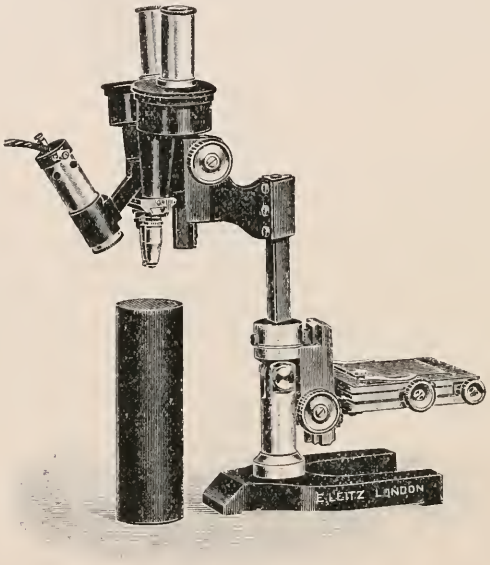

Fig. 21.

hung, and is secured by an approved hinged joint which permits the tilting of the instrument through an angle of 90°. By an extremely simple slide joint, locked by a single milled-head screw, the upper portion of the instrument may be detached and reversed (fig. 21). An examination is thereby possible of bulky specimens of too great a weight for the stage, or of such size that the Microscope must be mounted above or placed upon them. Independent rack-and-pinion movements are provided to the Microscope and the stage. These adjustments, together with the slide and clamp of the body of the Microscope, permit of the examination of specimens of considerable variation in length. The stage is modelled upon the English pattern, and is strongly constructed. It is provided with anterior, posterior, and lateral movements of considerable range. The surface-plate upon the stage is removable, and covers an opening. The instrument is thus available for such other purposes as

will readily suggest themselves to the laboratory worker. Further details include a small fixed illuminating lamp placed in such a position as will best illuminate the object. The 25, 40, and 48 mm. paired objectives with the 0 and III paired oculars are particularly suited for the examination of fractures, etc., at varying magnifications.

R. and J. Beck's New Binocular Microscope.*—The makers of this instrument (fig. 22) summarize its advantages thus: (1) resolution equal to that of monocular: (2) equal illumination, both eyes; (3) equal optical path and magnification, both eyes; (4) converted into a monocular by a touch; (5) prism removable for cleaning; (6) short tube length, compact microscope; (7) no special object-glass or oculars, no special requirements; (8) simple adjustment for interocular distance; (9) the standard angle for convergence, ensuring perfect comfort; (10) stereoscopic vision; (11) binocular vision, saving eye-strain and giving better results than monocular vision. The vital element in a binocular is, of course, the prism, and in this respect Messrs. R. and J. Beck have introduced a novelty which is responsible for most of the advantages claimed above. The prism is shown separately in fig. 24, and is placed above the object-glass. The whole of the light from the object-glass O passes through the surface of the glass B A to a surface E A, which is coated with a semi-transparent surface of silver. This allows part of the light to pass through and part to be reflected into the second tube of the Microscope as shown by the dotted lines; thus the full-size beam goes to form each image and no lack of resolution occurs. Two perfect pictures are produced, one in each eye. As the transparency and reflecting power of the surface E A can be regulated according to the amount of silver that is deposited, the relative intensity of each image can be made identical, and the right- and left-hand images are equal in brilliance. As to the intensity of the mental impression, it has been urged that when an initial body of light is divided into two parts, and one part is sent into each eye of the observer, the effect of brilliance is the same as if the whole light be directed into one eye only. Certainly there is some reason for this argument, though it may be an over-statement of the case. It is, however, no disadvantage if a slightly stronger light is required with a binocular than a monocular Microscope. The monocular observer, in order more readily to concentrate his attention on the employed eye, is apt to use an illumination that is far too brilliant, to the detriment of his eyesight. In the use of the binocular both eyes are equally stimulated, and there is no temptation to use excessive illumination, and theory goes to show that a low illumination is more efficient for displaying fine detail. The diagram of the binocular prism (fig. 24) shows that the distance from the surface E A, where the beam of light is divided into two portions to the two eye-pieces, is not of equal length; the light on the right-hand side has to travel a distance G H farther than the light that passes directly through. It would, therefore, not be possible to focus both beams of light to the same points in the two eye-pieces: if this were not compensated, one

* Special Catalogue: The Beck Binocular Microscope. Messrs. R. and J. Beck, London, 20 pp.

image would be out of focus when the other was sharp. The focus is corrected in the Beck Binocular by combining a parallel plate of glass of the required thickness with the right-hand prism: thus equality in the focus and in the magnifying power of the two images is ensured. The binocular prism is carried in a sliding box in the body of the Microscope (fig. 22). By sliding it out of the optic axis the Microscope is

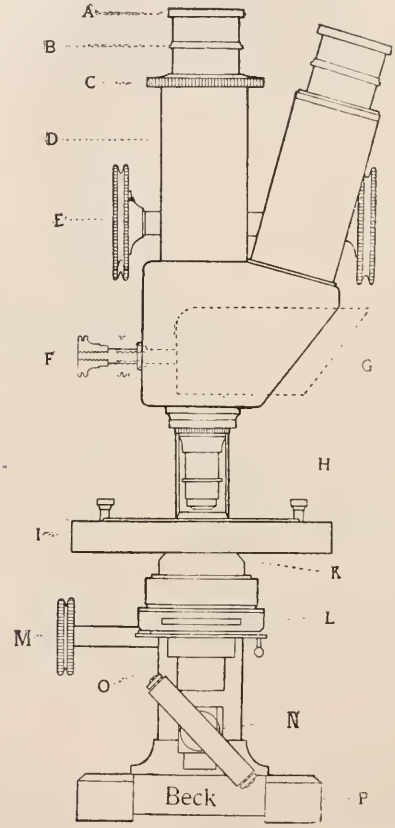

Fig. 22.

converted into a monocular instrument, or by unscrewing the knob (F, fig. 22) it can be slid completely out of the Microscope for cleaning or dusting. It is quite safe to remove the prism complete in its box, as it returns with accuracy to its exact position, and the adjustment will not be interfered with. The fact that when the prism moves to one side the instrument becomes absolutely the same as a monocular Microscope renders this Microscope equally useful for photography, drawing, micrometry, or any other purpose.

The construction of this binocular renders it possible to retain the short tube of the compact monocular Microscope. When the draw-tubes

are partially extended the tube is of the standard 160 mm. length ; the binocular Microscope is thus rendered as compact and serviceable as the monocular type. In the older types of binocular Microscopes a tube of about 9 in. to 10 in. in length was required in order to extend the eye-pieces to the necessary interocular distance ; but examination of the diagram fig. 23 shows that, owing to the peculiar construction of the prism, the tubes, instead of converging towards the prism, converge to an apex about $3\frac{1}{2}$ in. below it ; thus, although the standard angle of normal con-

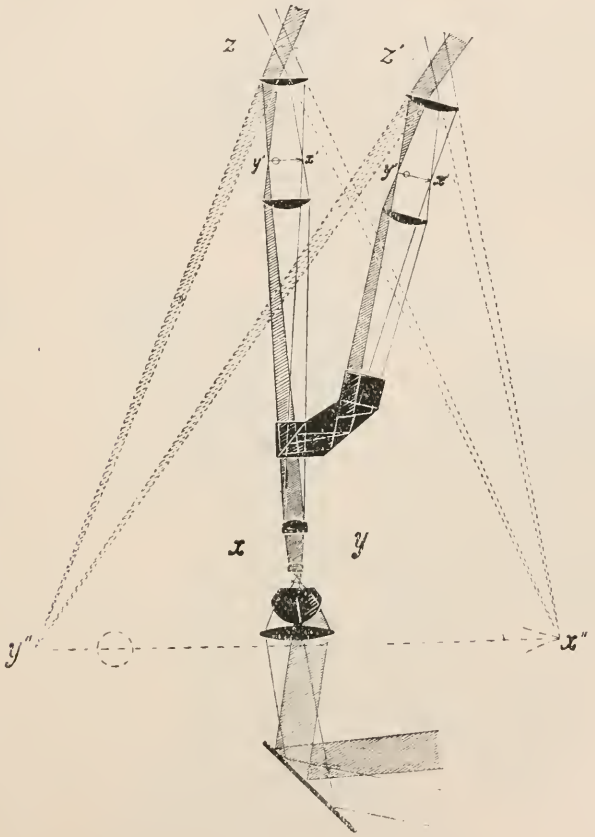

Fig. 23.

vergence is retained, the tubes need not be long to give the required separation for the eyes. The tubes converge at an angle of about 14°. This will be found in practice to give absolute comfort for either long or short periods of working. The eyes are in exactly the condition required for reading a book. Any make of object-glass or eye-piece of the standard size can be used. There are absolutely no special requirements—a revolving nose-piece, an objective changer, or any form of

apparatus can be employed. The interocular distance is varied by turning the milled ring (C, fig. 22) on the direct tube of the Microscope; this causes both draw-tubes to move in or out, and alters the distance between the oculars from 2 in. to $2\frac{1}{2}$ in., which, as the observer's eyes cannot be in contact with the eye-pieces, represents interocular distances of about $2\frac{1}{4}$ in. to $2\frac{3}{4}$ in. The tube-length is the standard 160 mm. at an intermediate position. For those whose eyes are farther apart than this, special tubes can be constructed to give the extra separation. If the two eyes of an observer are dissimilar, the necessary lens to render them equal is supplied in a cap to fit over the eye-piece.

Doubt has been at times expressed as to whether a Microscope looking at an object with a single object-glass can under any circumstances give a really stereoscopic relief. Those who have worked with a binocular Microscope do not retain such a doubt, and the explanation of the phenomenon is quite satisfactory. Suppose that O, fig. 25, represents the objective, and that an object at X consists of a fine blade

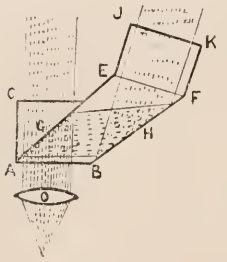

Fig. 24.

Fig. 25.

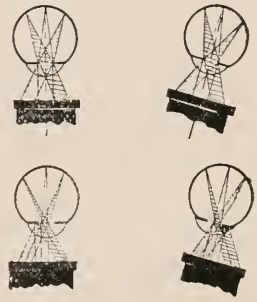

Fig. 26.

of material placed on end, all the light from the left hand of this blade which enters the object-glass at all reaches the left hand of the lens only, and from the right-hand side of X reaches the right-hand side only. If the light from the lens O is geometrically divided and passed to one eye at A, and the other at B, a perfect stereoscopic picture will result, as though the eyes were looking on both sides of a card held in front of them in the well-known experiment on binocular vision. A Microscope inverts the image, and consequently to pass the correct image to the eyes to obtain the stereoscopic relief, the light from the right-hand side of the object-glass must be passed to the left eye, and vice versa. By examining the diagram of the rays passing through a Microscope, as indicated in fig. 23, it will be seen that the rays of light intermingle after they leave the object-glass, and at no other place between the lenses could the right-hand half of the rays entering the object-glass be separated from the left half. It will, however, be noticed in fig. 23 that all the rays of light, after passing through the Microscope, pass through the Ramsden circle (ZZ^1) just above the eye-piece.

The observer naturally places his eyes so that the whole of the Ramsden disks (fig. 26) enter the pupils of the eyes, and he thus obtains all the advantages, as to aperture, resolution, and illumination, of a

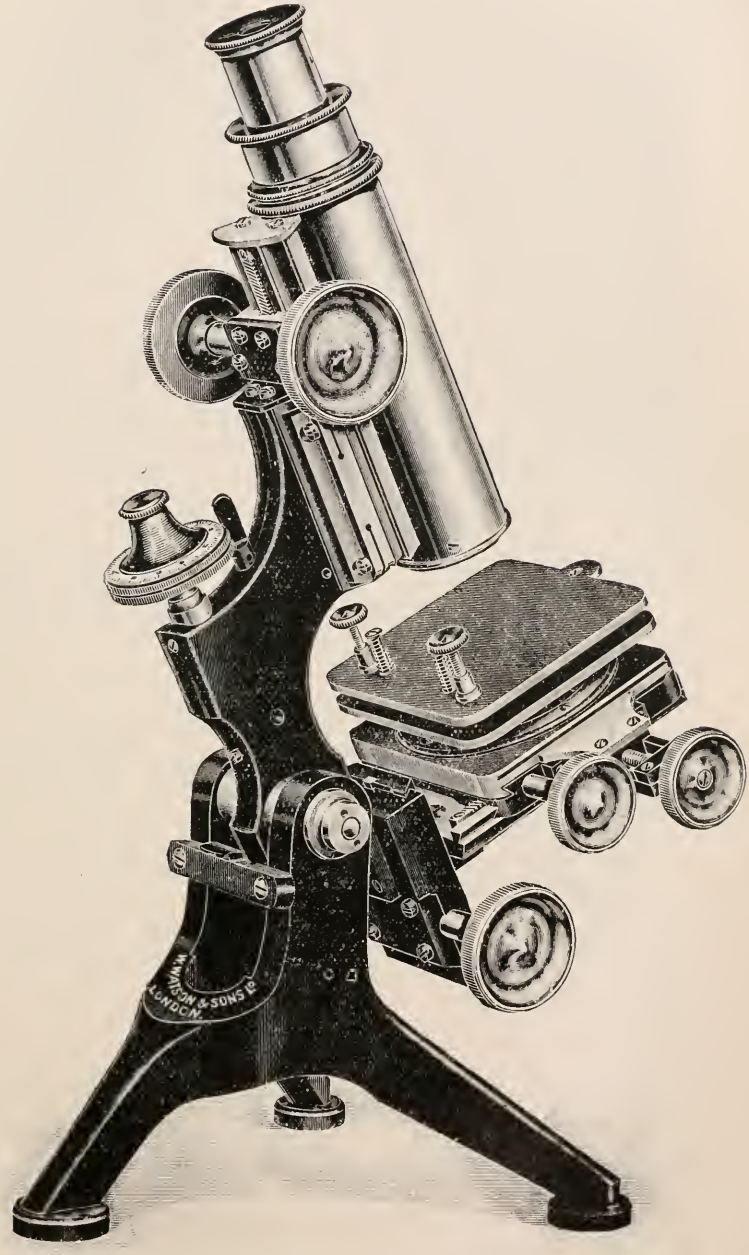

Fig. 27.

monocular Microscope. Then, by moving his head either forward or backward, he cuts off with his pupils the one or other side of the Ramsden disks, and obtains either stereoscopic or pseudoscopic relief instantly. The movement required is scarcely over one-eighth of an inch, and the result is that all the advantages of stereoscopic relief are obtained without sacrificing anything. The result of the movement of the head is very astonishing; if objects are being examined which lie on different levels, one point appears either in front of or behind another at will, and the position of the observer's head indicates which is the stereoscopic or pseudoscopic picture.

The makers adapt the binocular equipment to several of their well-known stands.

Watson and Sons' No. 2 Metallurgical Microscope.*—This instrument (fig. 27) is identical with the same firm's No. 1 model† except that it has a tripod instead of a horseshoe foot. This variation has been made to meet what is, apparently, a growing preference for the tripod on the part of microscopists.

(4) Photomicrography.

Handbook of Photomicrography.‡—This excellent text-book, the work of H. Lloyd Hind and W. Brough Randles, is, as the authors explain, the outcome of a series of articles originally published in the Photographic Monthly, and is intended as an introduction to photomicrography from a photographer's point of view. The first five chapters deal with the necessary apparatus; then follow experiments on illumination, including critical light. After this come chapters on low-power and critical photomicrography, colour screens and colour-sensitive plates, exposure, oblique and dark-ground illumination, metallography and colour photomicrography.

The last chapters are devoted to development, printing, enlarging, and lantern-slides, and to the use of photomicrography in pathology and medical practice.

The volume concludes with an appendix of formulæ and reagents.

The work is copiously and extremely well illustrated, and the publishers are to be congratulated on producing this handbook at a very moderate price.

(6) Miscellaneous.

Quekett Microscopical Club.—The 495th Ordinary Meeting was held on January 27, the President, Prof. A. Dendy, D.Sc., F.R.S., in the Chair. S. C. Akehurst on "Some Observations concerning Substage Condensers." The opinions of various authorities as regards the use of annular stops were reviewed. Only one phase of the subject was

* W. Watson and Sons' Special Catalogue: Microscopes and Accessories for Metallurgy, pp. 10, 11. † See this Journal, 1903, p. 87.

‡ London: George Routledge and Sons, Ltd., 1913, xii and 292 pp. (44 pls. and 71 text-figs.).

dealt with—annular light produced by a reflecting condenser used in conjunction with an oil-immersion objective for resolving fine structure on diatoms and displaying stained bacteria. The Leitz concentric reflecting condenser was the form used, and the results obtained when resolving fine structure in diatoms were very striking. T. A. O'Donohoe : "An Attempt to resolve *Pinnularia nobilis*." A series of lantern-slides were shown of photomicrographs of this diatom with varying illuminations, all of which failed to resolve it until the reflecting condenser above described was brought into use.

A very successful conversazione was held at King's College on February 10, about 500 members and visitors being present.

The 48th Annual General Meeting was held on February 24. The Presidential address was delivered by Prof. Dendy, who spoke on "Organisms and Origins." The extraordinary theories held even by leading men of science in the early part of the eighteenth century, relating to the nature and origin of fossils, were briefly dealt with. Spontaneous generation was considered, especially with reference to the recently published results of Dr. Charlton Bastian. The President said that these results to a certain extent are in accord with purely *à priori* expectations, but in other respects they appear improbable to the last degree, especially with regard to the claimed production of such comparatively highly organized forms as a *Penicillium* producing spores in the ordinary way.

B. Technique.*

(1) Collecting Objects, including Culture Processes.

Collection and Preservation of Hydroida.†—Generally speaking, says G. T. Harris, a shore strewn with large fucus-covered boulders, interspersed with rock-pools, indicates a good collecting ground, though even on such a shore the hydroid life may be curiously confined to a limited area. Clear limpid rock-pools are *not* necessarily indicative of hydroids, and they may often occur in abundance in muddy pools, where they are with great difficulty caught sight of. The easiest and best way of working a rock-pool is, as was pointed out by T. Hincks, to lie at full length on a mackintosh sheet with shoulders and arms projecting over the pool. Pools heavily draped with fucus afford the best chance of success, the sea-weed being turned back so as to expose the sides of the pool. The finer species of seaweed are very remunerative if taken home and looked over under a low-power of the Microscope. Small shells should be carefully examined if encrusted with marine growth, and also the carapaces of rock-pool dwelling crabs. Dredging is more especially the work of the professional naturalist : when undertaken by the amateur a small dredge and moderate depths will offer the best chance of success,

* This subdivision coutains (1) Collecting Objects, including Culture Processes; (2) Preparing Objects; (3) Cutting, including Embedding and Microtomes; (4) Staining and Injecting; (5) Mounting, including slides, preservative fluids, etc.; (6) Miscellaneous.

† Journ. Quekett Micr. Club, xii. (1913) pp. 143-54.

and it is wise to be guided by local boatmen, who will have a more intimate knowledge of the nature of the bottom than a chance visitor can hope to possess even with the aid of a chart. The sooner the hydroids are killed and fixed after collecting the better, as once the sea-water becomes stale the hydroids are with difficulty prepared in a sufficiently expanded condition. It answers best to divide the gathering by separating the Gymnoblastea from the Calyptoblastea, as the former can be best prepared by killing without the intervention of a narcotic. Before killing, the polyparies should be cleaned as much as possible from adherent matter, by gently brushing with a soft camel-hair pencil. Placed in clean fresh sea-water they quickly recover from the cleansing process, and are ready for narcotization and killing. With the Gymnoblastea it suffices to spray over the colony the killing and fixing agent when the tentacles are well extended. Lang's fluid is a good and quick acting solution, and so also is picric acid; Hermann's solution is excellent for small specimens, but with large colonies and robust forms killing is not sufficiently rapid to prevent considerable retraction of the tentacles. Cocaine hydrochlorate is probably the most generally useful narcotizer for the Calyptoblastic forms. A few drops of a 1 p.c. solution are added to a colony in a watch-glass and time allowed for it to become accustomed to the narcotizer before adding a further dose. When the tentacles fail to respond to the prick of a needle killing may take place. If it is necessary to store the material before staining and mounting, 70 p.c. alcohol seems the most satisfactory medium. Material stored in formalin does not always stain satisfactorily. Hydroids intended for mounting *au naturel* may, of course, be quite well stored in 5 p.c. formalin. It should be observed that specimens intended for mounting unstained require killing with an agent that leaves the cœnosarc in its natural condition—i.e. without rendering it opaque. If osmic acid is used, either alone or as in Hermann's solution, clearing afterwards with hydrogen peroxide, or potassium ferrocyanide, is certainly desirable. For permanently mounting small species, or representative portions of the trophosome, excavated glass slips are very convenient, more especially the oval excavations. A ring of old gold size is first run round the edge of the cell and allowed to become thoroughly tacky. The object is then placed in the cell with a suitable amount of 2½ p.c. formalin solution, the cover-glass placed on and thoroughly pressed into contact with the ring of gold size. Successive coats of gold size are then applied to finish.

Cultivations of Adult Animal Tissues in vitro.*—A. J. Walton describes his work upon the cultivation of tissues, such as spleen, thyroid, kidney, testicle, and liver from the adult rabbit. The article is illustrated with plates showing the nature of growth of these organs on artificial culture. The technique followed is that practised by Carrel, and is described in detail, particulars as to the preparation of the animal, the apparatus necessary, the method of removing tissues and plasma and of preparing the cultures being concisely stated. Throughout the whole experiment the utmost sterility is observed, every step being carried out

* Journ. Path. and Bact., xviii. (1914) pp. 319–24.

with the same precautions as in a surgical operation. Each step is important and therefore the description cannot be satisfactorily condensed.

Thermos Apparatus in Laboratory Work.*—J. L. Kritschewsky discusses the use of the "thermos" flask for scientific purposes, and points out that for cultural work, as well as for general pathological work in small laboratories, such apparatus may act as a fairly efficient substitute for a thermostat. Culture tubes inoculated and enclosed in a metal case are put into the flask and water at 38° C. is poured in. In this manner cultures of *Gonococcus*, *Staphylococcus aureus*, and other organisms may readily be obtained. The author describes a form of test-tube rack to fit the flask, with the help of which he has been able to carry out serological investigations, such as Wassermann and agglutination reactions. A larger type of flask than those at present available would be of use.

New Anaerobic Methods.†—M. Ogata and M. Takenouchi describe two simple methods of plate culture under anaerobic conditions. The apparatus required is as follows. Petri dishes, of two different sizes (10 cm. and 13 cm. diameter), a piece of glass rod bent into triangle form, a glass U-tube, potash, pyrogallic acid solution, and fluid paraffin. The necessary plate culture is made in the smaller-sized Petri dish on glucose-gelatin or agar. The large dish is half filled with 5 p.c. pyrogallic acid solution, the glass triangle is placed in position in this solution, a small piece of solid potash is put into the pyrogallic acid, and the inoculated culture plate inverted and set resting on the glass triangle. A piece of absorbent paper placed in the pyrogallic solution prevents frothing. The surface of the solution beyond the margins of the inverted culture-plate is covered with liquid paraffin. The cover of the large Petri dish is then placed over all.

In the second method, instead of a glass triangle, is used a circular glass trough of a sufficient diameter and size to permit of the margin of the inverted culture-plate resting within the trough. Three glass feet raise this trough from the bottom of the large Petri dish, which contains, as in the first method, pyrogallic acid and potash. The trough itself contains mercury, thus forming a perfectly air-tight joint all round the margin of the culture-plate. The free surfaces of pyrogallic are covered as before with liquid paraffin. In order to avoid splashing when removing the plate, air is introduced by means of a bent tube as shown in the diagram.

Diagnosis of Diphtheria.—E. Gildemeister and Günther‡ have investigated certain recent methods for the demonstration or isolation of diphtheria bacilli. They first discuss the staining method of Gins, which consists of the following steps: stain with Neisser I (acetic methylen-blue) for a few seconds; wash; treat with Lugol's iodin containing one p.c. lactic acid for five seconds; wash well and counter-

* Centralbl. Bakt., 1te Abt. Orig., lxxiii. (1914) pp. 77–80.
† Centralbl. Bakt., 1te Abt. Orig., lxxiii. (1914) pp. 75–7.
‡ Centralbl. Bakt., 1te Abt. Orig., lxxii. (1913) pp. 237–45.

stain with chrysoidin. The authors find that this method is very satisfactory for the examination of fresh films. The plating methods of Conradi and Troch, who recommend a tellurium medium, and of von Drigalski and Bierast, who use a bile-serum medium, do not give results any better than those obtained on Loeffler's medium. Heymann's enriching method has been found useless in the authors' hands.

A. Hanau * has carried out observations upon the relative values of Loeffler's serum, Rankin's potassium-sulphocyanide-neutral-red-glucose serum, and Conradi and Troch's tellurium medium. His results show that the newer media are in no way more reliable than Loeffler's serum.

E. Seligmann † has examined 86 cultures from 42 patients, including 11 cases of diphtheria, 3 cases of ozæna, 8 convalescents, and 20 healthy carriers, in the hope of finding certain criteria which would permit of a sharp line being drawn between diphtheria bacilli and certain allied forms. He finds that in the majority of cases the true diphtheria may be readily recognized, but there is no certain means of assigning some doubtful forms to their proper place.

(2) Preparing Objects.

Demonstrating Presence of Chondriosomes in Cartilage.‡—L. Torraca amputated the tails of a number of Tritons (*Triton cristatus*) and fixed the material at various periods of regeneration. The fixative used was Regaud's fluid (3 p.c. potassium bichromate 8 parts, formalin 2 parts). The decalcifiers were 3 p.c. nitric acid and 1 p.c. chromic acid or a mixture of equal parts of the two solutions. For staining, Heidenhain's iron-hæmatoxylin was exclusively employed. The technique was as follows :—1. Fixation in Regaud's fluid for 3 to 4 days ; the solution being renewed on the least evidence of turbidity. 2. Decalcification for 4 days in nitric acid or 5 to 6 days in chromic acid, or in the mixture for 4 to 5 days. 3. Prolonged washing in running water. 4. Mordanting in 3 p.c. bichromate of potassium for 10 days, the fluid being frequently renewed the while. 5. Washing in running water. 6. Dehydration in alcohol, and embedding in paraffin. Sections :— 7. Immersion for 24 hours in 2½ p.c. iron alum. 8. Staining in 1 p.c. hæmatoxylin for 24 hours. 9. Washing in running water. 10. Differentiation in the alum solution used for mordanting. 11. Washing in running water until the preparation has a distinct blue tint. 12. Dehydration ; balsam.

Fixation of Soil Protozoa.§—K. R. Lewin and C. H. Martin refer to a previous communication on this subject.‖ They have since found that the following mixture gives better results than picric acid. Saturated aqueous solution of mercuric chloride 1 part, methylated spirit 1 part. The soil should be crumbled into this fluid, and mixing is best accomplished by gently shaking the containing vessel, care being taken to avoid making the clay component of the soil pass into suspen-

* Centralbl. Bakt., 1te Abt. Orig., lxxii. (1913) pp. 245–9.
† Centralbl. Bakt., 1te Abt. Orig., lxxii. (1913) pp. 127–47.
‡ Anat. Anzeig., xlv. (1914) pp. 459–74 (5 figs.).
§ Nature, xcii. (1914) p. 632.
‖ See this Journal, 1913, p. 329.

sion. A delicate film containing Protozoa will appear on the surface of the liquid, and this can be removed by floating cover-slips over it and stained by the usual methods.

(4) Staining and Injecting.

McFadyean Staining Reaction for Anthrax Bacilli.*—J. D. E. Holmes reports that he has used the violet reaction in the diagnosis of anthrax for some years, and has never failed to obtain a positive result in anthrax blood. It is important that the original directions should be strictly followed. The film should not be too thin and should not be completely fixed : the temperature should not much exceed 100° C. if heat be used. Fixation may also be effected by immersing the dried films in absolute alcohol or methylated spirit for a few minutes. The preparation must not be washed in alcohol after staining. The staining solution should be freshly prepared from pure medicinal methylen-blue. Performed according to the original rite, the body of the bacillus is stained violet, and is surrounded by a well-marked pink capsule.

Staining Connective-tissues.†—P. Krüger recommends the following procedure. His method succeeds best after fixation in sublimate-acetic acid (5 p.c. solution and 5 p.c. acid). The sections (frozen, paraffin, or celloidin) are placed in iodopotassic-iodide solution until they are dark yellow. The preparation, having been rapidly washed, is placed in a solution of hæmatoxylin composed of : (1) a saturated solution of crystalline hæmatoxylin dissolved in absolute alcohol : (2) saturated solution of ammonia alum ; (3) pure glycerin ; and (4) methyl-alcohol. The constituents are mixed in the following proportions : (1) 100 c.cm. ; (2) 3750 c.cm. ; (3) 625 c.cm. ; and (4) 625 c.cm. This must be allowed to mature for at least three months. In this solution the sections are immersed for several hours to a day or more. When removed the preparations are washed in distilled water and then differentiated with hydrochloric acid-alcohol. Any excess of acid should be removed with ammonia-alcohol. Contrast-staining is best effected with eosin. The hæmatoxylin solution is approximately the same as Delafield's. The illustrations are very effective.

(5) Mounting, including Slides, Preservative Fluids, etc.

Mounting Preparations of Amyloid Material.‡—T. Mironisco gives the following method for mounting sections of material containing amyloid. The sections are made on a freezing microtome, and are then treated with a 1 p.c. solution of methyl-violet for 1 to 2 minutes. They are then washed for 2 or 3 minutes in a 2 p.c. solution of acetic acid, and afterwards with distilled water. After draining off the water one or two drops of a thick clear solution of gum-arabic are placed on this preparation. The slide is then placed in an incubator until the surface of the gum is dry. It is then mounted in balsam. In this way excellent permanent preparations can be obtained. The drying of the

* Agric. Research Inst. Pusa, Bull. No. 36 (1913) 3 pp. (1 pl.).
† Arch. Mikr. Anat., lxxxiv. (1914) pp. 75–90 (1 pl.).
‡ C.R. Soc. Biol. Paris, lxxvi. (1914) pp. 215–16.

gum requires attention, for if allowed to proceed too far the preparation loses its transparency; if not sufficient the thin pellicle may be torn by the balsam.

Circular Slide for Opaque Objects.*—At the December 1913, Meeting a circular revolving slide for opaque objects was exhibited by R. Finlayson. The illustration (fig. 28) shows this ingenious apparatus as fixed on the Microscope. A description of the apparatus was given by the inventor.

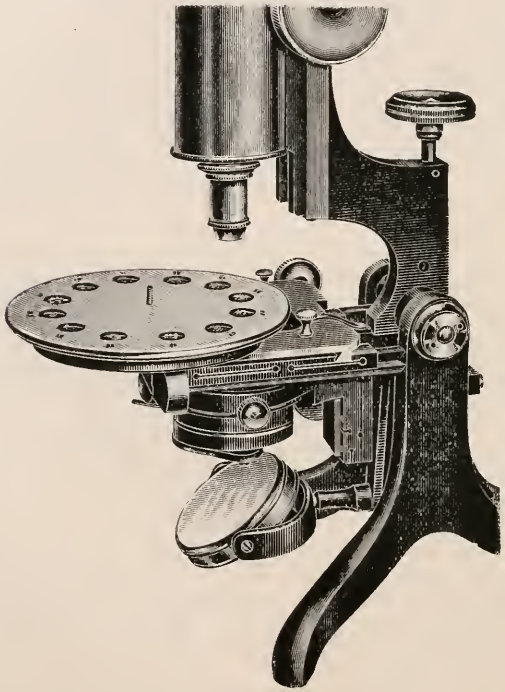

Fig. 28.

Simple Device for obtaining a Moist Chamber.†—R. Legendre describes this method of making a moist chamber for examining microscopical preparations which may be damaged or spoilt by the weight of the cover-glass. A clean rectangular cover-glass is picked up with forceps and the corners successively softened in the by-pass flame of a Bunsen burner. In this way little balls are formed which are of the same size when each of the corners are heated for the same time. A little practice will enable anyone to obtain balls of any desired thickness. Thus prepared, the cover-glass rests on its four corners and prevents the specimens from being unduly pressed on.

* See this Journal, 1913, pp. 94–5.
† C.R. Soc. Biol. Paris, lxxvi. (1914) pp. 265–6 (1 fig.).

(6) Miscellaneous.

Enumeration of Bacteria.*—E. Glynn, M. Powell, A. A. Rees, and G. L. Cox give the results of a large number of observations upon the counting of bacterial vaccines by the Wright, the hæmatocytometer, and the plate culture method. The cytometer method recommended by the writers is as follows: two stock solutions are prepared, one of saturated thionin blue (Grübler) in absolute alcohol, the other of 1 p.c. pure carbolic acid in tap-water. These are mixed in the proportion of 1 to 40 for most organisms, 1 to 20 for streptococci. The bacterial emulsion is suitably diluted and mixed with the stain. A drop is mounted in a Helber-Glynn counting-cell, that is to say, a cell 0·02 mm. deep and having an extra wide trough around the counting disk. A thin optically plane coverslip, strengthened by a glass collar, is pressed into position, and the drop examined with an immersion lens. The authors from their comparative observations find that the hæmatocytometer method is the best counting method available, and that the cell of 0·02 mm. depth is better than that of 0·1 mm. depth; in the former the optical definition of the bacteria is sharper and the free working distance greater; in the latter, settlement of bacteria upon the bottom of the cell is much delayed, and so counting is rendered more difficult. The Wright method, based on comparative enumeration of bacteria in an emulsion and cells in normal blood, usually greatly under-estimates the strength of the bacterial emulsion sometimes by 100 or even 200 p.c. This is largely due to defective distribution of the cells and bacteria in the film. The plate culture method is cumbersome and tedious. This also under-estimates the number of bacteria, first, on account of the impossibility of obtaining a homogeneous emulsion; second, because all cultures contain a large number of dead or moribund organisms incapable of forming colonies. Gravimetric methods of estimating bacterial vaccines will be considered in a further paper.

G. H. Macalister† recommends that organisms in a bacterial vaccine be counted directly in a Helber cell with dark-ground illumination. The suspension is diluted with decinormal hydrochloric acid, and a drop is mounted and examined. The Microscope is fitted with a Zeiss compensating ocular 18 and a dry 7 mm. objective Zeiss C. The eye-piece carries a grating micrometer, and the tube-length is so adjusted that four eye-piece squares fit one of those on the Thoma-Zeiss rulings. The condenser is Beck's old type of Abbe, carrying on the centre of the under surface of its lower lens a disk of black paper to cut off central rays of light. The acid diluent causes the bacteria to settle on the glass surfaces and become immobilised. They can then be counted in the two optical planes, and by focusing from one to the other, and observing the fine-adjustment graduations, the cell depth may be checked. Comparative observations show that this method gives more constant results, takes less time and causes much less eye-fatigue than any of the other methods in use. Further work is proceeding in order to find the effects

* Journ. Path. and Bact., xviii. (1914) pp. 379–400.
† Journ. Path. and Bact., xviii. (1914) pp. 441–2.

of different diluents, and to discover a means of ensuring evenness of distribution of the organisms over the surface of the cytometer field.

A. Cunningham* discusses the use of agar and gelatin plates for the enumeration of organisms in milk, soil, etc. He points out that on plates at 22° C. fresh colonies continue to appear on plates until the tenth day, so that counting of colonies at an earlier date gives wrong results. Liquefying organisms will, under ordinary circumstances, spoil a gelatin plate in four or five days, but if liquefying colonies, whilst still young, are touched with a fine silver nitrate point, as suggested by Hiltner and Störmer, further liquefying is prevented and the plate after ten or eleven days is still fit for counting. In platings from dung and soil, more organisms, as a rule, are found on gelatin plates than on agar at 22° C. In the case of milk more colonies appear on the agar than on the gelatin plates.

Metallography, etc.

Annealing of Gold.†—T. K. Rose shows that when hard-rolled plates of pure gold, consisting microscopically of thin parallel laminæ, are annealed, re-crystallization does not take place simultaneously throughout the mass, but occurs first in particular laminæ. Photomicrographs of partially annealed gold plates are given, showing some laminæ largely converted into minute crystals, while others remain unchanged.

Metallography of Commercial Zinc.‡—G. Rigg and G. M. Williams describe the microscopic appearance of the common impurities of zinc. Iron occurs as well-formed crystals, which are probably a solid solution of zinc and $FeZn_7$. Lead appears as small black globules, or as a black network if present in sufficient quantity. Cadmium is present in solid solution up to 1 p.c., and forms a eutectic at higher concentrations.

Copper-rich Kalchoids.§—S. L. Hoyt has investigated the equilibrium of the copper-tin-zinc system in the range 0–50 p.c. zinc 0–30 p.c. tin, and describes the microstructure of the alloys. The addition of tin to the brasses causes the visible breakdown of the β solid solution. The microstructure of the ternary alloys corresponds closely to that of the two binary systems. Two etching reagents were used, basic cuprous chloride, suitable for the zinc-rich alloys, and acid ferric chloride, preferable for the tin-rich alloys. Both reagents attack the copper-rich constituent first and leave the γ a bright grey.

Molybdenum-cobalt Alloys.‖—U. Raydt and G. Tammann describe the microstructure of the alloys used in their thermal study of this system. With 25 p.c. or less molybdenum, cored polyhedric structures

* Journ. of Hygiene, xiii. (1914) pp. 433–7.
† Journ. Inst. Metals, x. (1913, 2) pp. 150–74 (9 figs.).
‡ Proc. Amer. Soc. for Testing Materials, xiii. (1913) pp. 669–98 (25 figs.).
§ Journ. Inst. Metals, x. (1913, 2) pp. 235–74 (48 figs.).
‖ Zeitschr. Anorg. Chem, lxxxiii. (1913) pp. 246–52 (1 fig.).

were obtained; they were rendered homogeneous by annealing at 1250° C. At 30 p.c. molybdenum a eutectic appeared. In alloys containing 40 p.c. or more molybdenum a compound MoCo was observed as long needles. Primary molybdenum, or a solid solution, was found at concentrations exceeding 65 p.c. as small rounded masses enclosed in crystals of MoCo.

Silicon in Arsenical Copper.*—F. Johnson has studied the effect of silicon when used to deoxidize arsenical copper, and describes the micro-structures of specimens containing varying small amounts of arsenic, silicon, iron, and oxygen. The deoxidized specimens contained no cuprous-oxide globules, and the arsenic, silicon, and iron were present in solid solution in the copper. When specimens containing oxygen were annealed in hydrogen, the blue cuprous-oxide globules became black, the oxide being reduced to metallic copper.

Manganese-cobalt Alloys.†—K. Hiege finds that manganese and cobalt form a continuous series of solid solutions. Alloys containing more than 40 p.c. cobalt showed a cored structure, which was removed by annealing at 1000° C., except in the case of the alloy containing 90 p.c. cobalt; this still showed a want of homogeneity. Manganese-rich alloys were etched with 3 p.c. acetic acid, and cobalt-rich alloys with hydrochloric acid.

Lead-tin-antimony and Tin-antimony-copper Alloys.‡—W. Campbell discusses the constitution of the alloys of these two ternary systems, and describes their micro-structure in some detail. In the alloys are found crystals and dendrites of antimony, SbSn, Cu_3Sn, CuSn, lead, and α-tin set in a more or less plastic ground mass, which may be composed of Pb–SbSn, Pb–Snα or CuSn–Snα. The crystals and dendrites and the ground mass vary in hardness and plasticity: thus by varying the composition the physical properties may be controlled. Antimony and SbSn are lighter than the liquids out of which they freeze and tend to concentrate in the upper part of the ingot. 2 p.c. nitric acid in alcohol was found to be a good etching reagent for the lead-tin-antimony alloys.

Alloys of Zinc, Tin, and Cadmium.§—R. Lorenz and D. Plumbridge have studied the three binary systems and the ternary system formed by zinc, tin, and cadmium, and give a number of photomicrographs illustrating the structure of the alloys. The few solid solutions occurring are of very low concentration. Hydrochloric acid in alcohol was used for etching.

Thallium-bismuth Alloys.‖—N. Kurnakow, S. Zemczuzny, and V. Tararin give an account of their exhaustive revision of the equili-

* Journ Inst. Metals, x. (1913, 2) pp. 275–303 (11 figs.).
† Zeitschr. Anorg. Chem., lxxxiii. (1913) pp. 253–6 (8 figs.).
‡ Proc. Amer. Soc. for Testing Materials, xiii. (1913) pp. 630–68 (24 photomicrographs).
§ Zeitschr. Anorg. Chem., lxxxiii. (1913) pp. 228–42 (24 figs.).
‖ Zeitschr. Anorg. Chem., lxxxiii. (1913) pp. 200–27 (16 figs.).

brium of the thallium-bismuth system, and suggest that the γ-phase is a compound of variable composition. In spite of the softness of the alloys, fairly good sections were obtained by the usual cutting and polishing methods, but preparations for microscopic examination were also made by casting on a polished glass plate. With the thallium-rich alloys, however, the casting adhered so strongly to the glass that it could not be separated without spoiling the surface. The sections prepared in the ordinary way had been annealed, and sometimes differed markedly from the glass-cast preparations since the rapid cooling of the latter resulted in incomplete equilibrium. A dilute solution of bromine and hydrochloric acid in water, and a mixture of concentrated nitric and hydrochloric acids were used as etching reagents.

Influence of Phosphorus on Copper-aluminium Alloys.*—A. A. Read has studied the properties of a number of alloys containing 0–11 p.c. aluminium, 0–1 p.c. phosphorus, and describes their microstructure. The phosphorus remained in solid solution up to about 0·2 p.c. Alloys containing more phosphorus showed envelopes of phosphide surrounding the crystals. On annealing, the phosphide was found to ball up.

Egyptian Metal Antiquities.†—H. Garland describes the microstructure of a number of copper and bronze Egyptian tools from 2000 to 7000 years old. Cored structures were prominent in some specimens, and the distorted crystalline structures also found were evidence of hammering or similar cold-working. Where re-crystallization had occurred the crystals were small. The author concludes that the structural changes taking place in such metals and alloys at atmospheric temperatures are trifling. 10 p.c. ammonium persulphate solution was found to be the best etching reagent for revealing cores, while chromic acid proved suitable for sharply defining the crystal boundaries.

Microchemistry of Corrosion.‡—C. H. Desch and S. Whyte have carried out corrosion experiments upon three copper-zinc alloys of β composition. One alloy contained 53 p.c. copper, 47 p.c. zinc; the other two were similar, but also contained respectively 1 p.c. tin and 1 p.c. iron. A surface finished on fine emery-paper was made the anode in a 5 p.c. solution of sodium chloride, the cathode being a platinum wire. An E.M.F. of 3 volts was applied. Corrosion was found to take place by removal of zinc from a surface layer, a skin of nearly pure copper remaining. This copper skin was not united to the alloy below by any zone of intermediate composition, the boundary between copper skin and unchanged alloy being quite sharp. The copper skin showed the outlines of the β crystals from which it was derived; it could be peeled off, leaving clearly visible the microstructure of the unchanged alloy beneath. Indications that corrosion began at the boundaries of the crystal grains were obtained.

* Journ. Inst. Metals, x. (1913, 2) pp. 344–70 (16 figs.).
† Journ. Inst. Metals, x. (1913, 2) pp. 329–43 (14 figs.).
‡ Journ. Inst. Metals, x. (1913, 2) pp. 304–28 (11 figs.).

Iron-cobalt System.*—R. Ruer and K. Kaneko find that the iron-cobalt alloys have a homogeneous polygonal microstructure. Alloys in the range 100–30 p.c. iron showed large polygons subdivided into smaller ones, while in the range 20–0 p.c. iron only large polygons, usually showing twinned lamellæ, were seen.

Structure of Zinc-iron Alloys.†—The zinc-iron system has hitherto been investigated only in the range 0–24 p.c. iron. U. Raydt and G. Tammann have now prepared a series of alloys containing 26–97 p.c. iron, by melting zinc and iron together, in an atmosphere of hydrogen, under pressures up to 130 atmospheres. The only phases found in the range of composition studied were the compound $FeZn_3$ and a solid solution of zinc in iron having a concentration of 20 p.c. zinc when saturated. Copper sulphate solution, nitric acid in amyl-alcohol, and iodine solution were the etching reagents used; some specimens were lightly re-polished after etching.

Iron-copper System.‡—R. Ruer and K. Fick, finding that iron and copper are incompletely miscible in the molten state, and yet do not separate into two layers, have made a microscopic examination of a number of melts. The presence of a little carbon causes separation of an alloy of equal weights of iron and copper into two layers, rich in iron and in copper respectively. It is suggested that in pure iron-copper alloys the copper may separate in "submicroscopic" form. The alloys 0–8 p.c. copper, and 0–2·5 p.c. iron, were microscopically homogeneous.

Heat-treatment of Steel.§—J. H. Nead has examined, microscopically and otherwise, specimens of steel which had been heat-treated in the form of round bars of sizes ranging from $\frac{1}{2}$ in. to $1\frac{3}{4}$ in. diameter. The bars of one series having the composition carbon 0·2, nickel 3·5 p.c., were quenched in oil from 1550° F., the bars of the other series, containing carbon 0·4, chromium 0·9, vanadium 0·2 p.c., were quenched in oil from 1650° F. and re-heated to 500° F. The bars $\frac{1}{2}$ in. in diameter in both series consisted solely of uniform martensite. The bars $1\frac{3}{4}$ in. in diameter contained some quantity of ferrite, with granular pearlite in the case of the nickel steel and granular troostite in the case of the chromium-vanadium steel. The effect of mass of quenched specimen upon the rate of cooling in oil, and thus upon the microstructure, was apparent in the gradual transition, with gradual increase in diameter of bar, from the martensitic to the pearlitic, or to the troostitic structure.

Heat-treatment of Hypo-eutectoid Steel Castings.‖—J. H. Hall describes the structure of specimens cut from steel castings containing less than 0·9 p.c. carbon, heat-treated in various ways. Ingotism is defined

* Ferrum, xi. (1913) pp. 33–9 (8 photomicrographs.).
† Zeitschr. Anorg. Chem., lxxxiii. (1913) pp. 257–66 (12 figs.).
‡ Ferrum, xi. (1913) pp. 39–51 (6 photomicrographs.)
§ Proc. Amer. Soc. for Testing Materials, xiii. (1913) pp. 489–509 (18 photomicrographs).
‖ Proc. Amer. Soc. for Testing Materials, xiii. (1913) pp. 514–24 (18 photomicrographs).

as the coarse crystalline structure of steel in the cast condition ; in hypo-eutectoid steels it is characterized by the presence of primary ferrite, which exists in one of two forms : (1) a network ; (2) as needles in a triangular or "delta" arrangement, constituting the Widmannstätten structure. If steel in the cast condition is heated above Ac_3 and cooled slowly, ferrite is re-precipitated more or less upon the lines originally occupied by it in the raw steel. The author's experiments now show that if the coarse casting structure is effaced by heating to 900° C. and cooling rapidly, it tends to re-appear if the steel be again heated above Ac_1 and cooled slowly.

New Etching Reagent for Steel.*—W. Rosenhain describes the action of a reagent composed of an acid solution of ferric chloride, such as is used for etching copper alloys, to which have been added about 0·1 p.c. cupric chloride and 0·05 p.c. stannic chloride. When this reagent is applied to a polished steel specimen, a thin deposit of copper is slowly formed on the ferrite, while pearlite and cementite are only very slightly affected. Under the Microscope the ferrite appears to be blackened, while the pearlite remains bright. In commercial steels the ferrite is not darkened uniformly, a strongly banded structure being developed. Apparently the rate of deposition of copper is greater as the freedom of the ferrite from impurities, especially phosphorus, is more complete. The patterns obtained by the use of the reagent indicate clearly the distribution of the phosphorus, and have been found to be identical with patterns obtained by Stead's "heat-tinting" process.

Optical Orientation of some Cast Metals.†—K. Endell and H. Hanemann give an account of their applications of Königsberger's methods by which opaque bodies are microscopically examined in polarized light. Sections are polished by the usual methods, but not etched ; they should show no "relief" effects. According to the character of the light which they reflect constituents, are distinguished as isotropic or anisotropic. The appearances observed in sections of quickly solidified ingots of the anisotropic metals, zinc, antimony, bismuth, and tin, are described. When allowed to solidify without disturbance, zinc and antimony form similarly oriented crystals, having their optical axes at right angles to the cooling surface. Primary crystals of the same metals occurring in a ground mass of eutectic were examined, as were also the various constituents and slag inclusions occurring in steel.

* Nature, xcii. (1914) p. 529.
† Zeitschr. Anorg. Chem., lxxxiii. (1913) pp. 267–74.

MICROSCOPY.

A. Instruments, Accessories, etc.*

(1) Stands.

Old French Microscope by Joblot.—This curious old Microscope (fig. 29) has been acquired by the Society for its collection, and was exhibited at the Meeting on March 18. It is one of three forms invented about 1716 by L. Joblot, "Professeur Royal en Mathématiques de l'Académie Royale de Peinture et Sculpture, demeurant sur le quay de l'Horloge du Palais, au gros Raisin," and is described by him in his work, Descriptions et usages de plusieurs nouveaux Microscopes, published in Paris 1718.

Joblot states in the text that the Microscopes designed by him were made for him by M. le Febvre, Ingénieur en Instruments de Mathématiques, but the present model bears the inscription : "J. Langlois, Elève du Sieur Butterfield, aux Armes d'Angleterre, à Paris," and, moreover, is richly engraved with ornate designs on the handle and principal surfaces, which are not shown in Joblot's plates. Langlois and his master, Butterfield, are both known as noted makers of astronomical quadrants, sundials, etc., in Paris, in the early part of the eighteenth century, and it is probable that this Microscope was made by the former some years after the publication of Joblot's description, say about 1720.

The design of this old Microscope is very peculiar ; it is used by holding against the sky or a candle. The handle consists of a somewhat flattened brass cylinder, octagonal in cross section, supporting a stage to which a brass-bound glass plate can be fixed. Below this is a tubular diaphragm, called "le canon" by Joblot, lined inside with black velvet, and with a stop at each end, an effective device for giving the best possible definition. (In 1831 Hugh Powell made, and probably re-invented, a similar cylinder diaphragm for the Microscope designed by Cornelius Varley.†) In front of the object-stage is the objective carrier, fixed to a movable arm actuated by a large focusing-screw ; the carrier receives the brass plates in which the objectives are mounted. The objectives consist of bi-convex lenses of various focus, about $\frac{1}{4}$ in. in diameter, held between two brass plates pierced with very small holes, so that only the centre of the lens is used, thus reducing the aberration and giving a fair definition, in the same manner and on the same plan as is found in Leeuwenhoek's Microscopes ; the two brass plates are not,

* This subdivision contains (1) Stands; (2) Eye-pieces and Objectives; (3) Illuminating and other Apparatus; (4) Photomicrography; (5) Microscopical Optics and Manipulation; (6) Miscellaneous.

† See this Journal, 1900, p. 232, fig. 74.

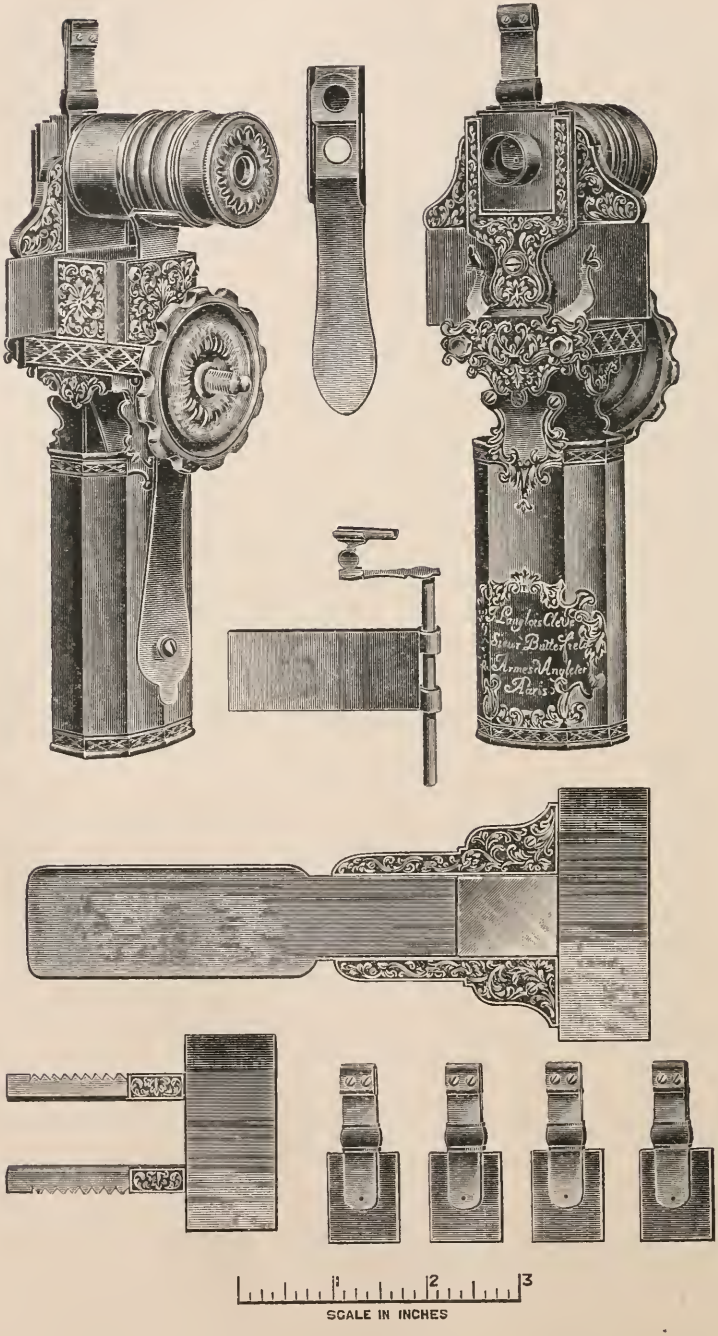

FIG. 29.

however, screwed together, but clamped and held together by a metal ring. There were six of these objectives, of various magnifying powers.

The object-stage carries, by sliding on, several devices for viewing drops of blood, of water from infusions, and also the circulation of the blood in small fishes' and tadpoles' tails. One of these devices is a brass-bound glass tube, fixed by means of a spring inside the handle of the Microscope ; the small fish being held in water in the tube with its tail spread out on the glass stage-plate.

Joblot calls this instrument in the text, "Troisième et dernier nouveau Microscope universelle," and used it principally for examination of the circulation of the blood in young fishes' tails, a subject which had been discovered some years previously by the famous English "Dr. Hervée" (as Joblot calls him), but not clearly demonstrated until the advent of a suitable Microscope. He also used it for the examination of drops of water from infusions of various substances, such as hay, leaves, wood, pepper, etc., as taught by Leeuwenhoek, and judging by the figures in his book, Joblot must have seen most wondrous and extraordinary creatures in these infusions : worms with snakes' heads, Crustaceans with a human face on their back, Rotifers and Infusoria of fantastic shape—the species of which can only be vaguely guessed at. In two places Joblot figures young dragons under his Microscope, or held in forceps, unless indeed the engraver of his plates took liberties with his drawings.

In spite of these defects, Joblot's Microscopes show clearly a considerable advance over those of his contemporaries, Leeuwenhoek, Hartsoeker, Musschenbroek, Bonani, Wilson, and even John Marshall. Most of Joblot's instruments are "simple Microscopes," and possess proper focusing arrangement, with steady motion for the objective by wheel and screw, and also efficient illumination with cylindrical diaphragms for excluding all extraneous light. One of them has a rotating stage. Joblot also invented some compound Microscopes, with three and four lenses, but he does not appear to have been very satisfied with these, because, though they gave him a larger field and greater magnification, the images were less clear than those obtained with his "simple" Microscopes, which is not to be wondered at. Several of the apparatus he devised, such as forceps for holding objects, apparatus for exhibiting the circulation of the blood, hollow-ground glass slides for viewing living objects in liquids and pond-water, were very neat, efficient, and well conceived.

The objectives used by Joblot in his Microscopes were small bits of glass, ground to a curved surface on both sides, thus making rough bi-convex lenses of various foci (only one of the lens-holders now contains the lens). In his text Joblot mentions object-glasses of $\frac{1}{4}$ to 12 lines focus ; the old Paris line was equal to 2·175 mm., therefore the range of his objectives appears to have been from about $\frac{1}{2}$ to 26 mm., or $\frac{1}{45}$ to $1\frac{1}{16}$ of an inch. He also describes a "Microscope à liqueurs" (that is, for the examination of liquids), by means of which "blown-glass lenses" ("lentilles soufflées et celles qui ne le sont point") can be employed, but he gives no description of these blown-glass lenses, or how they were made.

Greenough Binocular Microscope.*—F. Emich describes a method by which he has succeeded in increasing the magnifying power of binocular Microscopes of the Greenough type without diminishing their advantages. It is well known that without the use of very strong oculars it is difficult to get a magnification with this instrument higher than 50 to 60 diam. The author, however, has designed an objective in a special mount large enough to fit over the noses of the two tubes. Although there is a certain weakening of illumination, the efficiency of the instrument is practically unimpaired, and very satisfactory results have been secured. The firm of C. Reichert have constructed the special objectives for him with focal lengths of 12 and 8 mm.

With ocular ii the magnifications respectively attained are 90 and 150 diam., and with ocular iv, 125 and 210 diam. With ocular v magnifications of 190 and 320 diam. would be reached, but the author has not, so far, had occasion to use them. The special objectives are slid on in the usual way and can be conveniently exchanged. As an example of his results, the author mentions his observations of Brownian movement obtained in a damp chamber with a drop of hydrochloric acid and piperidin. Illuminated by an arc-lamp and viewed through a dark-ground condenser, the object forms a beautiful image.

Luminescence Microscope: its Construction and its Applications.†—In this monograph of upwards of fifty pages H. Lehmann deals very fully with the Luminescence Microscope. The author divides his article into six chapters, and we reproduce his table of contents.

I. *The Principle of the Luminescence Microscope.*—Luminescence. Luminescence analysis. The U-V filter. The U-V filter-lamp. The Luminescence Microscope. (Pages 418–22.)

II. *The Development of the Luminescence Microscope: Historical.*—A Köhler's U-V Microscope: fluorescence observations with bright- and dark-ground illumination. The author's experiments with U-V filter and dark-ground illumination. Reichert's fluorescence Microscope. Principle of the new Luminescence Microscope and its advantages. (Pages 422–27.)

III. *Theoretical.*—On the image theories of self-luminous objects and non-self-luminous objects. Lommel's law of emergent rays. Review of refraction-polarization of luminescent light. Test of the law of emergent rays by new modes of demonstration. New theory of marine light. Discussion of the appearances in the luminescence Microscope. (Pages 427–44.)

IV. *Experimental Arrangements for Visual Observation.*—The light-source. The illumination system. The U-V filter and the supplementary filter. The euphos cover-glass. The Microscope. Arrangement for illumination with visible light. Abbe's microspectral ocular. Engelmann's microspectral photometer. Observation through the analyser. The phosphoroscope. (Pages 444–55.)

V. *Experimental Arrangements for Photography.*—Photography on

* Zeitschr. wiss. Mikrosk., xxx. (1914) pp. 487–9 (1 fig.).
† Zeitschr. wiss. Mikrosk., xxx. (1914) pp. 418–70 (1 pl.).

ordinary plates. Colour-photography on Lumière autochrome plates. Spectographic photography. (Pages 455–58.)

VI. *Applications of the Luminescence Microscope.*—Physics and chemistry. Luminescence spectra of very small objects. Identification of traces of mixtures. Mineralogy; luminescence of thin slices. Botany; examination of thin sections, colour-stuffs, liquors. Biology; examination of living inferior creatures. (Pages 458–70.)

(2) Eye-pieces and Objectives.

Zeiss' New Homogeneous Immersion 1/7.*—The firm of Carl Zeiss has recently introduced a one-seventh oil-immersion objective. This objective has a working distance of 0·35 mm., its focal length is 3·5 mm. and the N.A. is 0·9. It may be used with either Huyghenian or with compensating eye-pieces, giving with the latter a more colourless image, more noticeable towards the margin of the field. Though this novelty is of quite recent production, the idea of making homogeneous immersions of small aperture was first entertained by Abbe many years ago. The advantages claimed by the makers are that there is less trouble than is the case when examining a specimen with a dry medium power and then changing to an oil-immersion; secondly, there is more perfect correction of spherical aberration; and thirdly, that the correction of the objective is far less sensitive to variations in the thickness of cover-glass and of the embedding material.

Healy's Comparison Ocular.†—D. J. Healy suggested to Mr. Bausch in January 1912, the convenience of equipping a Microscope with two objectives, so that on looking through the eye-piece one would see half of the field of each objective. The Bausch and Lomb Optical Co., however, ultimately developed the idea into the use of two identical Microscopes placed side by side. After removing the draw tubes the collars of the body tubes were replaced and a comparison ocular attached by fitting a short tube snugly into the body tube of the left-hand instrument, and another short tube loosely into the right-hand body tube. The comparison ocular itself consisted of a set of reflecting prisms within a horizontal box carrying a vertical eye-piece. The author claims that his instrument does not require a specially constructed Microscope, and that it is quite satisfactory in operation. He gives several microphotographs showing comparison fields.

(3) Illuminating and other Apparatus.

New Electrical Heating Apparatus applicable to any Microscope.‡—R. Brandt refers to the demand that the progress of microcrystallography and of microchemistry have raised for instruments with heating stages. As it is not easy to adapt such stages, as have hitherto been designed, to ordinary Microscopes, special instruments are usually

* Carl. Zeiss Special Catalogue, 1914.
† Journ. Amer. Med. Assoc., lxi. (1913) pp. 1958–9 (6 figs.).
‡ Zeitschr. wiss. Mikrosk., xxx. (1914) pp. 479–84 (1 fig.).

required for those who wish to pursue the above studies. Ordinary heating stages possess other inconveniences. They take too long in heating and cooling down, and the adjacent parts of the objective are sensibly heated, with consequent risk of damage to the optical parts. The author has endeavoured to meet all these difficulties, and has used his apparatus with satisfactory results for about two years. His stage is shown in fig. 30, which is about half size. He claims for his design the following advantages:—1. Applicability to every Microscope. 2. In spite of the insertion of an inevitably special heating stage, the preparation and condenser are a very small distance apart. 3. Analyzer, objective, object, spiral, condenser, and polarizer, fit together and are combined very compactly on the optic axis. 4. The effect is attained with small quantities of current. 5. The plane-spiral coiling of the incandescent wire guarantees a complete utilization of the heat and consequently produces its effect with high efficiency. 6. In spite of the

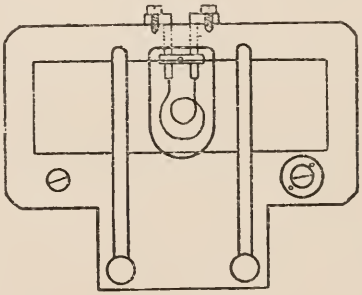

Fig. 30.

compactness (see 3) of the system, heating of the objective lenses scarcely occurs. 7. It accommodates itself instantaneously to changes of resistance, as only thin platinum wires are used. 8. Its cost is low.

The stage is made of vulcanite, 5 or 6 mm. thick, and forms the carrier for the heating wire, the electrical installation, the preparation clamp-springs, and the connecting plugs. The latter are inserted into the holes provided in every Microscope stage. The heating wire is arranged in a round-headed aperture and secured by copper plugs which are passed outwards through tubular apertures, and on their flanged or broadened extremities carry the cable connexions. The heating wire consists of thin platinum about 6 cm. long and 0·14 to 0·16 mm. thick. It takes the form of a flat spiral of about one and a half coils. Before use the spiral should be pressed downwards with thumb and forefinger until about 1 mm. distant from the object carrier, thereby securing that inner and outer winding do not short circuit. The temperature measurements were calibrated by observations on the melting of known substances previously embedded between cover-glass and object-glass. An amperemeter was introduced into the main current, and a voltmeter into the auxiliary current. About five to twenty seconds were required to raise the temperature to 200° C., at which point ordinary cover-glasses cracked.

From 200° to 450° C. quartz or thicker glass covers should be used. Above 450° the requirements of microchemistry and microcrystallography do not usually extend. But in the event of such higher temperatures being required, glass, unless made of a specially high melting-point, is useless, and recourse must be had to quartz slips and covers. A thicker platinum wire (0·2 to 0·25 mm.) is also desirable. A 6-volt accumulator-battery serves well as the source of energy. For the polarization arrangement, the author inserts an analysing Nicol in the connecting-piece between the objective and revolver. The polarizer is placed, as usual, in the diaphragm ring. The cooling of the object, in the case of overheating, is accomplished by directing an air-current on to the cover-glass. It is remarkable how small a heating effect is produced on the Microscope itself.

Berek and Jentzsch's Small Intense-light Monochromator.*—This auxiliary has been designed by M. Berek and F. Jentzsch

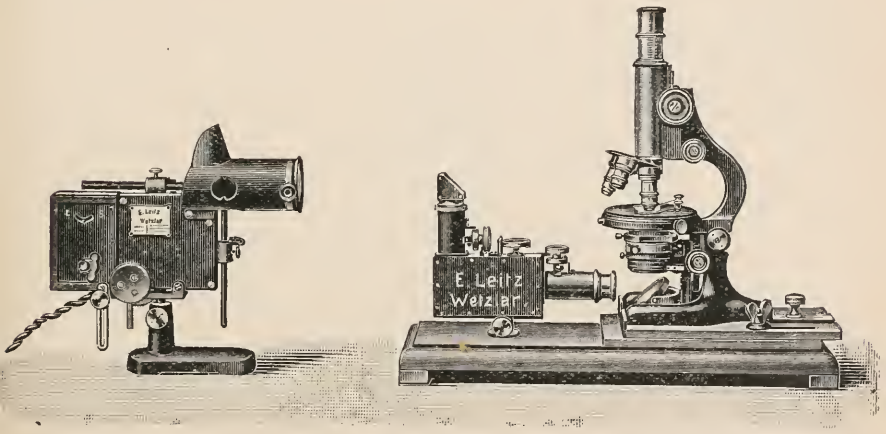

Fig. 31.

with especial reference to the needs of microscopists, although it will also be found useful in several branches of physical research. The external view is shown in fig. 31 and with the ray-path in fig. 32. It has been designed so that it may be used with any type of Microscope and with any type of lamp. The apparatus consists of a small box, adjustable in height, containing a Hilger prism, rotation arrangement and telescope objective. Two tubes mutually perpendicular contain each an illuminating lens, and a slit. The exit-slit must be directed accurately on the Microscope mirror so that the apparatus can be used as a lamp. Over the entrance-slit a small totally reflecting prism is so arranged that the rays of a light-source can be easily made parallel to the exit-tube. Both the entrance and the exit-slits are bilaterally adjustable, and can be regulated by a micrometer screw and

* Zeit. f. Instrumentenk., xxxiv. (1914) pp. 47–51 (2 figs.).

divided drum, each graduation on the drum signifying one-hundredth of a millimetre. The movement is limited by two hard stops. The beam of rays diverging from the entrance-slit is parallelized by the achromatic collimator objective inside the box and is then transmitted through the prism : these rays then pass through a telescope objective and throw a spectrum (visible length 12 mm.) in the plane of the exit-slit. By rotating the prism the whole spectrum can be made to traverse

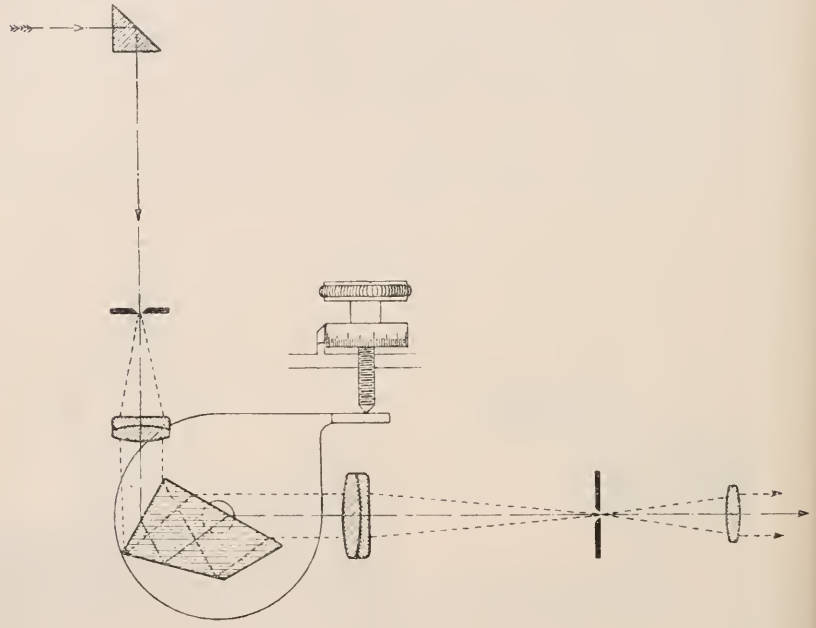

Fig. 32.

the slit so that any desired part can be brought into use. The actual position of the prism can be read off on a disk. It is possible to standardize the graduation according to the wave-length. The breadth of the exit-slit is usually twice as much as that of the entry-slit. It is very important to arrange the height of the apparatus so that the emergent rays exactly coincide with the axis of the Microscope mirror. The apparatus is mounted on a wooden base so that the Microscope can be moved in two mutually perpendicular directions.

(5) Microscopical Optics and Manipulation.

Demonstration Experiment on the Abbe Theory of Microscopical Perception.* — H. Ambronn describes a series of experiments he has undertaken for the purpose of illustrating Abbe's doctrine that

* Zeitschr. wiss. Mikrosk., xxx. (1914) pp. 289–99.

the perception of a colourless object is more distinct in proportion as the difference is greater between the refractive indices of object and embedding medium. His experiments were mainly with the cortical fibres of certain nettles (*Boehmeria tenacissima* Gaud.), and the media were a cinnamon oil of refractive index 1·597, and benzyl-alcohol sp.gr. 1·540. The following is a résumé of his conclusions.

1. An image of a colourless object can only be formed under the Microscope when there exists a difference of refractive index of object and surrounding medium. If object and medium are optically isotropic only a single value of this difference has to be considered. If the object is doubly refractive and if the actual section through the index ellipsoid in the object plane is an ellipse, then there must be two limiting values corresponding to the semi-axes of the ellipse. If these two different values vary from zero, diffraction spectra must exist which usually do not resemble each other. The interference efforts in the image plane must correspondingly vary and the microscopical image is due to their superposition.

2. If, however, one of these difference values is zero, no diffraction spectra can exist, and therefore no image of the object. If the refractive index of the isotropic embedding medium be expressed by n_0 and the two refractive of indices the object by n_1 and n_2, then either $n_1 - n_0$ or $n_2 - n_0$ can equal zero. In the first case the image depends on the difference $n_1 - n_0$ and in the second case on $n_2 - n_0$. The rays corresponding to the values n_1, n_2, as a result of the laws of double refraction, are polarized perpendicularly to one another.

3. If a bast-fibre of the nettle plant be chosen as object and n_3 corresponds to the semi-axis of the index ellipse lying parallel to the bundle-axis, and n_2 to the one perpendicular to it, then $n_1 \nearrow n_2$. If such a fibre be observed in benzyl-alcohol (ref. ind. = 1·540) over a polarizer, then usually no image is formed if bundle-axis and polarizing plane of the Nicol are parallel. If both directions are crossed, then a distinct image of the fibre is found by means of a ray which is polarized perpendicularly to the bundle-axis. If the observation be made in cinnamon oil (ref. ind. 1·597) the contours disappear if bundle-axis and polarizing-plane are crossed, and the image is formed, when both directions are parallel, by means of a ray polarized parallel to the bundle-axis.

4. From what has been said in (3) it follows that the fibre acts as an analyser in both cases. If between the fibre and the polarizer a selenite plate be diagonally inserted, the contours will appear in two positions, inclined at 90° to one another in the same colours.

5. Contours which in a bright field appear dark on a bright ground must in a dark field appear bright on a dark ground. The ray of the diffraction spectrum which through interference in the bright field produces a minimum of intensity must in the same position in the dark field attain a maximum of intensity. On the insertion of a selenite plate the colours in the two fields are complementary. Hence, by superposition of the images cast by the two fields combined with a little weakening of the central beam, the microscopical image can be usually made to disappear.

(6) Miscellaneous.

Output from Optical and Mechanical Workshops.*—Under the above title (Aus Optischen und Mechanischen Werkstätten) E. Wychgram contributes his sixth notice of the annual progress in optical work. In this case he deals with 1913, and the chief improvements in that year in German optical instruments will be found duly recorded.

Quekett Microscopical Club.—The 497th Ordinary Meeting was held on March 24, 1914, the President, Prof. A. Dendy, F.R.S., in the Chair. N. E. Brown, A.L.S. "Some notes on the Structure of Diatoms." This principally dealt with the observation of very minute pores having a diameter of the order of 0 1 μ, through which it was considered protoplasmic filaments were protruded to about 7 μ. The pores had been observed in *Nitzschia scalaris*, *Amphipleura lindheimeri*, *Stauroneis phœnicenteron*, and in a small unknown species of *Pinnularia*. The new $\frac{1}{7}$-inch oil-immersion objective, issued by Messrs. Zeiss, was described by E. M. Nelson, F.R.M.S.

The 498th Ordinary Meeting was held on April 28. E. M. Nelson, F.R.M.S., had calculated "a new low-power condenser." This, with the top on, has a focus of one inch, and with top off, two inches. A specimen was exhibited, arranged to give dark-ground illumination with a new device for centring the patch top, also designed by E. M. Nelson. N. E. Brown, A.L.S., described the structure of the flower of *Vinca minor*, with especial reference to the fertilizing devices, and metioned the extreme scarcity of the fruit of this plant both in this country and on the Continent. The Hon. Sec. (J. Burton) exhibited and described an abnormal form of *Arachnoidiscus ornatus*, from Mauritius, which had the appearance of a cylinder rather than the usual disk-like form of but slight depth. The depth of the abnormal form was from three to four times that of the normal, the diameter in both forms remaining constant.

B. Technique.†

(1) Collecting Objects, including Culture Processes.

Cultivation of Gonococcus.‡—A. Lumière and J. Chevrotier make a further communication about this method of cultivating gonococcus.§ They point out that the medium should consist of barley-malt, with or without hops, and should not contain a trace of any starchy or sugary substances. Beerwort should not contain more than from 22·5 to 55 grm. of reducing sugar per litre. The reaction of the medium should be distinctly alkaline. The addition of $\frac{1}{10}$ ass-serum is a distinct

* Zeitschr. wiss. Mikrosk., xxx. (1914) pp. 319-48 (30 figs.).

† This subdivision contains (1) Collecting Objects, including Culture Processes; (2) Preparing Objects; (3) Cutting, including Embedding and Microtomes; (4) Staining and Injecting; (5) Mounting, including slides, preservation fluids, etc.; (6) Miscellaneous.

‡ Comptes Rendus, clviii. (1914) pp. 1287-8.

§ See this Journal, *ante*, p. 83.

advantage. It is important to sow the medium with large drops of the suspected pus. Lastly they find that gonococcus is easily cultivable anaerobically on their medium. They do this either by covering the surface of the infected film with a layer of oil, or by cultivating in vacuo.

Collecting Eelworms.* — M. V. Lebour and T. H. Taylor, after alluding to the damage done to rhubarb by *Tylenchus devastatrix*, and to the ordinary methods of obtaining eelworms for examination, describe a procedure for cleansing the raw material. It is based on the habit that eelworms have of climbing up capillary films. For this purpose silk threads are employed, to each of which is suspended a blob of cotton wool. The cotton wool serves as a receptacle for holding the crude material obtained from the rhubarb. The upper ends of the threads are attached to a glass ring, which is supported upon the sloping sides of a funnel-shaped vessel containing water, this shape being chosen

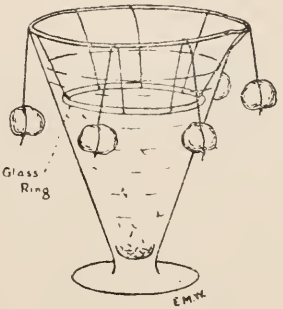

Fig. 33.

in order that the blobs may hang clear (fig. 33). As the threads become saturated the eelworms ascend along the silk strands and, passing over the brim into the water, congregate on the floor of the vessel.

Casein as a Cultivation Medium.† — G. Seliber has used for studying certain organisms a medium in which casein is the basis. The formula given is as follows:—K_2HPO_4, 1 grm.; $MgSO_4$, 0·3 grm.; NaCl, 0·1 grm.; $CaCl_3$, 0·1 grm.; distilled water, 1 litre. In certain cases it is useful to add to the foregoing a few drops of Fe_2Cl_6. The solution, to which 1 p.c. pepton may be added, is neutralized and then alkalinized with slight excess of NaHO. To the alkalinized medium is added 0·5 p.c. casein. The medium is heated over a water bath and shaken up in order that the ingredients may be disseminated throughout. When ready the solution is sterilized for fifteen minutes at 115° C., and then filtered. To the filtrate is added 1 p.c. sugar, and finally autoclaved previously to being distributed in test-tubes.

* Nature, May 7, 1914, p. 242.
† C.R. Soc. Biol. Paris, lxxvi. (1914) pp. 639–41.

Cultivation of Plasmodium vivax.* — P. I. Pitschugin, after a review of the work of Bass and Johns, Gurko and Hamburger, and others, upon the artificial culture of the malarial parasites, give an account of their own experiments with *Plasmodium vivax*. The technique followed was that of Bass. 10 c.cm. of blood withdrawn from the ulnar vein of a patient were put into a sterile cylinder containing 0·1 c.cm. of a 50 p.c. dextrose solution. The blood was defibrinated by stirring with a glass rod and put into an incubator at 40° C. Films were prepared and examined at intervals. These films were fixed with methyl-alcohol, and stained with Argutinski's methylen-blue eosin method. By means of these procedures the authors observed two complete, and a third incomplete, cycle of development of the parasites. In the third generation, only schizonts and merozoites were found. The addition of inactivated ascitic fluid or of dextrose solution in greater quantity than that stated above, does not have any influence on the growth of the organism. In the preparation of films for observation the authors recommend that some of the clear supernatant fluid be sucked up, so that thin films may be obtained.

Isolation of Single Trypanosomes.†—F. Henningfeld describes his method of separating individual trypanosomes for the purpose of microscopical observation and inoculation. First he used a modification of Lindner's method, which consists essentially in the mounting of a series of minute droplets of diluted suspension of organisms on a slide. He found, however, that the capillary pipette method was better. Measurement showed the pipettes used had a lumen of about 0·018 mm. in diameter. The glass wall was 0·006 mm. in thickness. Trypanosome-infected blood was diluted with broth, saline, or serum—the latter was the most satisfactory—and drawn into the pipette. A portion of the pipette about 7 cm. in length was placed on a slide and examined in detail with a compensating ocular Zeiss 12, and an objective of medium power. The ends of the pipette were sealed with wax. If a parasite was found lying in isolation the margins of the zone containing it were marked with a Leitz object marker. Then, while the portion containing the parasite was held in position with a superposed slide, the remainder of the capillary-tube was cut away with a knife. By this means individual parasites were obtained for observation and inoculation. Successful inoculations with mice of single specimens of *Trypanosoma brucei* and *T. equiperdum* were accomplished.

Single Cell Cultures.‡—M. A. Barber describes his method of making a series of cultures from single cells. A large cover-glass (38 × 65 mm.) is carefully cleaned, sterilized, and placed on an isolation chamber. Cross lines are ruled on its upper surface. By means of a bent pipette, droplets of sterile broth, 2 mm. in diameter, are placed in rows on the under surface. Two larger drops are put towards the ends of the cover. By means of a pipette a small portion of actively growing

* Centralbl. Bakt., 1te Abt. Orig., lxxiii. (1914) pp. 373–84.
† Centralbl. Bakt., 1te Abt. Orig., lxxiii. (1914) pp. 228–39.
‡ Philippine Journ. Sci., Sect. B, viii. (1913) pp. 539–57.

culture is transferred to one of the larger drops. This drop is now brought into observation under the Microscope, and a number of bacilli in medium dilution are drawn into a fine pointed pipette. The rows of hanging drops are then brought into view, and a minute droplet, containing a single bacillus, is ejected from the pipette in the immediate neighbourhood of each drop. If a proper dilution has been used, this is not difficult, but the droplet must be very small, so that the presence of a single cell may be readily determined. When a sufficient number of these minute single-cell droplets have been placed beside hanging drops, sterile broth is taken into a second fine pipette and is added to each hanging drop so as to make it over-run and absorb the adjacent inoculated droplet. The cover is then removed from the isolation chamber and sealed over a shallow moist chamber. On the following day, inoculations may be made from the hanging drops into test-tubes.

(2) Preparing Objects.

New Method of Examining the Cells in the Cerebrospinal Fluid.* B. Schlüchterer advocates the use of sublimate when examining cerebrospinal fluid. The solution is composed of sublimate, 3 grm. ; acetic acid, 1 c.cm. ; distilled water, 100 c.cm. To about 4 c.cm. of the fluid placed in a centrifuge tube, the solution is added drop by drop until the cerebrospinal fluid becomes milky. After shaking up, the fluid is centrifuged and then smears are made of the deposit. After the films are dried the slides are placed in iodine-alcohol for five minutes. The iodine is removed by a thorough washing with 70 p.c. alcohol. When dry the films are stained with methyl-green-pyronin solution for ten minutes ; after which they are dried and examined. The chief advantages claimed for this method are that probably all the cells are deposited, that the deposit makes good films, with no tendency to wash off, and that the pictures of the cells are excellent.

Washing Pieces of Tissue for Histological Purposes.†—E. Beatti describes a simple method of washing pieces of tissue to get rid of fixatives, decalcifying agents, etc., the presence of which might have a harmful effect on the after-treatment of the material. Many of the apparatus devised for washing tissues are complicated and sometimes costly. The author's method, which he has used for many years, is quite cheap and simple. It consists in fitting to the nose of an ordinary watertap an "antisplash" regulator and directing the stream near to the side of an ordinary tumbler. Owing to the direction of the currents set up there is no tendency for the pieces which are being washed to escape over the edge of the tumbler, most of which margin remains quite dry.

Demonstrating the Chromosomes of the Fowl.‡—Alice M. Boring and R. Pearl in their investigation on the spermatogenesis of the domestic fowl, used pure barred Plymouth rock and cross-bred males, varying in age from five months to two years. Three general methods

* Neurol. Centralbl, xxxii. (1914) pp. 420–2.
† Zeitschr. wiss. Mikrosk., xxx. (1914) pp. 485–7 (1 fig.).
‡ Journ. Exper. Zool., xxi. (1914) pp. 53–83 (91 figs.).

of technique were used in the preparations, stained sections, smears and aceto-carmine mounts. The last two gave the best results. Much difficulty was experienced owing to the stickiness of the chromosomes, and their separation was best found in smears and in aceto-carmine preparations, no matter in what they were fixed. Fixation for sections was mostly done in Gilson's, Flemmings or Hermann's solution : the first gave best results. Pieces left indefinitely in aceto-carmine gave very good results, and this led to experiments with other acids (butyric, formic), but neither was as good as acetic. Smears also were made after Guyer's method ; these were fixed in Bouin's solution and stained with iron-hæmatoxylin. These smear preparations were found to be favourable for drawing and photography and much better than sections stained in the same way. The chief object of the paper was to show that there is no valid evidence that any element which may be justly interpreted as an *x*-chromosome exists in the chicken.

Preparing Teleost Embryos for Class Use.*—Some of the most important features of development of the Teleost egg, such as discoidal cleavage and the part played by the germ ring in the formation of the embryo, require for their satisfactory demonstration that the entire egg shall be preserved and studied as nearly as possible in the natural form. For this purpose balsam mounts are of little value, for even with the vitelline membrane removed the egg usually collapses in the higher alcohols or in xylol.

For the convenient handling of cleavage stages to be studied as opaque objects, B. G. Smith has devised the following method. Pieces of $\frac{1}{8}$ in. glass tubing are sealed at one end by holding in a flame ; a few eggs fixed in corrosive-acetic and preserved in formalin are placed in each tube and the opening plugged with cotton. For these stages it is well to choose an egg with dark yellow yolk, this will aid in the differentiation of the snowy white blasto-disk. The eggs may be studied by dropping the tube into a watch-glass filled with water and examining them with a lens ; or the tube may be held in the hand and examined with the lens. The special advantage of the tube is that of ease of manipulation : any view desired can be secured and that without injury to the egg. An additional advantage is that the method allows little trouble from the inevitable mixing of stages that occurs when the material is handled in bulk by the student.

For stages with embryonic shield and germ-ring the preceding method should be used if the yolk is opaque ; but a better plan is to secure the small transparent eggs of the runner (*Ctenolabrus*) and mount them in formalin in a hollow ground slide, sealing the edges of the cover-slip with cement. Staining is not required. In this egg either the upper or under surface may be viewed simply by changing the focus.

Preservation of Bryozoa.†—Bessie R. Green gives the following method which was successfully used for preserving *Cristatella*, *Plumatella*,

* Trans. Amer. Micr. Soc., xxxiii. (1914) pp. 54-5.
† Trans. Amer. Micr. Soc., xxxiii. (1914) pp. 55-6.

and *Fredericella*. Chloretone was used for narcotization and 3 p.c. formalin for killing and subsequent preservation. The colony was placed in a tube or beaker of convenient size and covered completely with water. When the lophophores of the individual polypides were well extended the chloretone solutions were added in the following order :—(1) A few drops of sat. sol. chloretone in water ; (2) 1 part ditto to 4 parts water ; (3) 2 parts ditto to 3 parts water ; (4) 3 parts ditto to 2 parts water ; (5) 4 partsditto to 1 part water ; (6) saturated solution of chloretone.

The amount of each solution was equal to the amount of water containing the colony. Each solution was added drop by drop very slowly. Gradually some of the solution containing the colony was removed in order to keep the amount constant.

The time required for the application of each solution varied from 15 to 30 minutes. After the colony had been in the saturated chloretone solution for 15 minutes the killing agent was added. A 3 p.c. solution of formalin was diluted with a saturated solution of chloretone, and the following grades were used :—(1) 1 part 3 p.c. formalin to 2 parts sat. sol. chloretone ; (2) 1 part ditto to 1 part ditto ; (3) 2 parts ditto to 1 part ditto ; (4) 3 p.c. formalin.

These solutions were added drop by drop in the same manner as for narcotization, and 15 to 30 minutes were allowed for the application of each grade. Two and a half to five hours are necessary for the entire procedure. For *Cristatella* the minimum time is sufficient, but for *Plumatella* and especially for *Fredericella* the maximum time is necessary.

(4) Staining and Injecting.

Staining Methods for Microfilaria.*—F. Fülleborn discusses in considerable detail various methods of staining these parasites. For simple clinical diagnosis, he recommends the dry method ; two or three drops of blood are spread on a clean side, dried, dehæmoglobinized with distilled water, fixed with absolute alcohol, stained with Böhmer's hæmatoxylin, differentiated with weak acid, blued in tap-water, dried and mounted in cedar-wood oil. For diagnosis between *Microfilaria bancrofti* and *M. loa*, he recommends wet-fixation. In this case, the preparation is dehæmoglobinized with saline, fixed and passed through mounting alcohols to absolute alcohol and down again to distilled water, stained with hæmatoxylin and mounted. For anatomical study, fresh-stained (vital-stained) preparations treated with azur-eosin give good results. Finally, as a simple and satisfactory method, pyronin-methyl-green is recommended. A thick film is dried and dehæmoglobinized with saline. This is stained for half-an-hour or longer with Unna-Pappenheim's carbol methyl-green-pyronin, and differentiated and dehydrated simultaneously by rapid alcohol passage. It may then be mounted and examined For many important practical details and precautions to be observed in the following of any of these procedures, the original paper should be consulted.

* Centralbl. Bakt., 1te Abt. Orig., lxxiii. (1914) pp. 427–44.

Staining Pearls in Mussels.*—F. Alverdes used the pearls found in various kinds of mussels. The pearls with the surrounding tissue were cut out and then placed in the fixative, either Zenker or Flemming. Owing to the nature of these fluids the resulting decalcification was attended with rupture of the pearly layers and distortion of the tissue. In order to avoid this, acid-free fluids were used, Müller's fluid and sublimate-alcohol (equal parts of saturated aqueous sublimate solution and absolute alcohol) for fixation, the material being afterwards decalcified with 2 p.c. nitric acid, and later embedded in celloidin or in clove-oil-collodion. The sections were stained as a rule with anilin water-safranin-water-blue. This staining solution is composed of anilin water, 200 c.cm. ; absolute alcohol, 100 c.cm. ; safranin, 1 grm. The water-blue was made up with either an aqueous or alcoholic solution of picric acid. The staining is done by first thoroughly treating the sections with the safranin solution and then differentiating with 96 p.c. alcohol. The sections are then placed for a few minutes in the water-blue. In this way a multiple staining is obtained, and which is most effective if the fixation has been done with Flemming. Control stainings were made with hæmatoxylin and eosin, and with anilin-water safranin. In the last case the staining is differentiated with hydrochloric-acid-alcohol (1 : 1000).

Rapid Romanowsky Stain.†—G. Giemsa, for the rapid staining of films, recommends the use of a staining solution containing azur-II-eosin 3 grm., azur 0·3 grm., and glycerin 25 grm. in 475 grm. of methyl-alcohol. About 15 drops of this solution are applied to the unfixed film, and left in contact for about half a minute. Then diluted stain (10 drops of stain to 10 c.cm. of distilled water) is put on the slide for a period of ten minutes. The film is then washed in distilled water, dried, and mounted.

Studying the Musculature of Flies.‡—J. Thulin, in studying the musculature of flies, used chiefly *Hydrophilus piceus*. For fixation the strong Flemming solution was injected into the living animal, which was thereby almost instantly killed. The material was then treated with acetum pyrolignosum rectificatum and 1 p.c. chromic acid solution, and afterwards with bichromate of potassium. The paraffin sections were made in the usual way, the preparation of the section (1 to 3 μ) was aided by the use of an alcoholic mastic solution. The sections were stained with sodium alizarin sulphate and crystal-violet. Photographs were taken with the Vogel-Obernetter silver eosin plates, which are very valuable for their sensitiveness to colour.

Modification of Pal's Method of Staining Medullated Nerves.§ J. G. Schnitzler employs the following modification of Pal's method. The material is fixed with formalin or placed at once in 2·5 p.c.

* Zeitschr. wiss. Zool., cv. (1913) pp. 598–633 (2 pls.).
† Centralbl. Bakt., 1te Abt. Orig., lxxxiii. (1914) pp. 493–6.
‡ Anat. Hefte, xlvi. (1912) pp. 189–252 (12 pls.).
§ Neurol. Centralbl., xxxii. (1913) pp. 483–5.

bichromate of potash solution. When ready it is embedded and sections made. The sections are placed for three days in 2·5 p.c. potassium bichromate. After a wash in water they are stained for 12 to 24 hours in hæmatoxylin (10 parts of 10 p.c. alcoholic solution of hæmatoxylin to 90 parts water). After a wash in water they are treated with a freshly-made mixture of a 2 p.c. solution of red prussiate of potash, 10 parts; saturated aqueous solution of lithium carbonate, 30 parts. This preliminary differentiation is finished when the edge of the celloidin is decolorized (about 1 minute). After a thorough wash the sections are treated with 2·5 p.c. potassium bichromate for 30 seconds. After another wash the sections are further differentiated by Pal's method as follows: 30 to 60 seconds in 1 : 600 potassium permanganate, wash, and then bleach in a recently-made mixture composed of 1 p.c. oxalic acid, and 1 p.c. sulphate of soda, in equal parts. The differentiation is repeated until the tone is whitish throughout. The sections are darkened by immersion in ammonia or lithia-water.

Demonstrating the Structure and Innervation of Dentine.*—The material used by C. Fritsch consisted chiefly of normal human teeth and also some from the calf, dog, and hedgehog. The teeth were preserved in formalin for at least 4 weeks, and were then decalcified by Schaffer's method.† Sections were prepared by the freezing method. For staining the nerves a modification of the Bielschowsky procedure was adopted.‡ The sections were taken from distilled water and placed in pyridin for 24 hours. They were then transferred to distilled water, frequently changed, for 24 hours. After this the sections were placed for 5 to 8 days in 3 to 5 p.c. silver nitrate, and then after a short wash were immersed in the following ammonia-silver oxide solution. To 5 c.cm. of 20 p.c. silver nitrate, 5 drops of 40 p.c. caustic soda were added. The resulting precipitate is then cleared up by adding, drop by drop, pure ammonia. This ammoniacal silver solution was then made up to four times its volume with distilled water, and into this solution the sections were placed for 4 to 5 minutes. After reduction with 20 p.c. formalin they were treated with distilled water acidified with 1 drop of acetic acid. After washing with distilled water the process was repeated, the best results being obtained after a repetition of ten to twelve times. After being gilded the sections are placed in a solution of gelatin, transferred to a slide, and then covered with gelatin. The slides dry in about 24 hours, and can then be examined with an oil-immersion. The gelatin solution is prepared by dissolving 10 grm. of pure gelatin in 100 distilled water, then liquefying in a water-bath at 50° and filtering in an incubator.

Demonstrating Elastic Fibres.§ — L. Liperovsky demonstrated the presence of elastic fibres in the human mammary gland at ages of 15, 18, 20, 39, 42, 68, and 70 years, by the following procedure. The

* Arch. Mikr. Anat., lxxxiv. (1915) pp. 307–20 (2 pls.).
† See this Journal, 1903, p. 558.
‡ See this Journal, 1906, p. 735; 1907, p. 498; 1910, p. 670.
§ Anat. Anzeig., xlv. (1914) pp. 504–11 (7 figs.).

fixative chiefly used was Flemming's fluid. Small pieces of tissue were immersed for one to two days, and after a careful washing in water were dehydrated in alcohols of increasing strength. They were then embedded in celloidin. The sections were stained in an acid solution of orcein. After a stay in the staining solution for twenty-four hours, the sections were decolorized for five minutes in 96 p.c. acid-alcohol. Novikoff's method was also used. This stain consists of 0·01 p.c. solution of triphenylrosanilnitrisulphate of sodium in saturated aqueous solution of picric acid. In this fluid the preparations remain for twenty-four hours, and then are differentiated in 45 to 50 p.c. alcohol. In these preparations the elastic fibres are yellow, connective-tissue blue, and muscle green. Another method tried was staining the celloidin sections with safranin or twenty-four hours, and then washing in water followed by weak alcohol, afterwards transferring to orcein solution for 6 hours, and finally differentiating in acid-alcohol or in picric acid.

Fixation was done with Müller's fluid, with or without addition of formalin, but the resulting pictures were not so clear or distinct.

Staining Spirochæta pallida.*—According to C. Birt, the most effective way of staining *Spirochæta pallida* is as follows :—The films are first air-dried and then fixed in a fluid composed of acetic acid, 1 c.cm. ; formalin, 20 c.cm. ; distilled water, 100 c.cm. This must be renewed several times in the course of a minute. After washing in water the films are mordanted with 5 p.c. tannic acid in 1 p.c. carbolic acid. The slide covered with mordant is heated to vaporization, and after half a minute is washed with water. While still moist the film is stained with 0·25 p.c. silver nitrate in distilled water, to which a minute trace of ammonia is added until slight turbidity occurs. The film covered with stain is heated to vaporization and left for half a minute. It is then washed, dried, and mounted in xylol-balsam. The spirochætes are jet black, and appear to be much thicker than when stained with anilin dyes.

Morphology of the Eye-muscle Nerves.†—In the course of the present study H. V. Neal used different methods. Among those which have given the best results are Cajal's nitrate of silver, Paton's modification of Bielschowsky's method, Held's molybdic acid-hematoxlin stain and vom Rath's picro-acetic-osmic-platinic chloride-pyrogallic acid treatment. The Vom Rath ('95) method is as follows :—

1. Fix in the dark for one to three days in the following mixture (use plenty and change each day) : Saturated and filtered solution picric acid, 200 c.cm. ; glacial acetic acid, 2 c.cm. ; Platinic chloride (dissolve in 10 c.cm. water), 1 grm. ; osmic acid 2 p.c., 25 c.cm. Owing to the great brittleness of embryos fixed in this fluid all changes of liquid should be made with pipette in the same dish, avoiding as far as possible any movement of the embryos. 2. Stain in 0·5 p.c. pyrogallic acid in the dark for twenty-four to forty-eight hours with several changes.

* Journ. R.A.M.C., March 1914.
† Journ. Morphol., xxv. (1914) pp. 1–87 (9 pls.).

3. Grades of alcohol from 35 p.c. slowly by the siphon capillary drop method to avoid shinkage. Xylol, to which paraffin is added as it dissolves. 4. Embed in rather hard paraffin of best quality. 5. Thin sections, not over 8 μ, preferably 4 to 6 μ.

Vom Rath's method is not specific for the neurofibrils, which are nevertheless deeply stained. Cell boundaries are shown with special distinctness and shrinkage is slight. The process is advantageous in demonstrating cell relations in the stages when nervous connexions of tube and somite are effected.

Flemming's stronger formula gives excellent fixation of Selachian embryos, but does not allow the use of pyrogallic acid for subsequent staining. Fixation seems quite as faithful as in Vom Rath preparations, but cell boundaries are not so distinct as in the latter. Iron-hematoxylin gives the best stain, subsequent to the use of Flemming's fluid, but it is necessary to paint the sections with 0·5 p.c. celloidin in order to prevent their loss in staining on the slide.

For the specific purpose of demonstrating the neurofibrils Cajal's method has given uniformly satisfactory results, which appear somewhat less refined than those obtained by the Bielschowsky-Paton process. The Cajal method is as follows :—

1. Fix in absolute alcohol and 1 p.c. ammonia for forty-eight hours. 2. Wash for one-half to three minutes in distilled water. 3. Pyridin for twenty-four hours. 4. Distilled water—many changes—for twenty-four hours. 5. A 2 p.c. aqueous solution of silver nitrate for three days at 35° C. in the dark. 6. Rinse in distilled water. 7. Four p.c. pyrogallic acid in 5 p.c. formalin for one to two days. 8. Paraffin sections.

The Simarro-Cajal silver reduction method, following fixation in 70 p.c. pyridin, which has given such splendid results when applied to Mammal and other Amniote embryos, has proved a complete failure in the case of *Squalus* embryos.

Excellent results in the differentiation of the neurofibrils have followed the use of the molybdic-acid hematoxylin process as developed by Held (1909). Tissues may be fixed by various methods, including Zenker's fluid and Rabl's picro-sublimate. The stain is effected by a solution of molybdic acid in a 1 p.c. solution of hematoxylin in 70 p.c. alcohol. The stain is better after months or years. Immediately before use, several drops of this tincture—depending on the strength wanted—are dissolved in distilled water, and the sections are stained warm on the slide at 50° C., or for a longer time cold. The sections may be stained directly, or they may be mordanted in iron-alum.

The neurofibrils are differentiated by the Bielschowsky-Paton process, but, like the Cajal method, this does not demonstrate the fibrils within the neuroblast cell in the earliest stages of histogenesis. By this method the neurofibrils are stained a dark brown or black, while other tissues are light brown or yellowish brown. In the process only tested distilled water, and absolutely clean glass-ware and glass or bone spatulas—no metal—should be used.

1. Fix and keep embryos in 10 p.c. formalin, neutralized or made slightly alkaline with magnesium carbonate. 2. Wash in running tap-

water for twelve hours. 3. Wash in three or four changes of distilled water for a half-hour. 4. Place in pure 1 p.c. nitrate of silver for six days in the dark, at a temperature of about 70° C. Tissues must become reddish brown in colour. If they become yellowish-brown, throw away. 5. Place in a solution of silver nitrate freshly prepared as follows: 20 c.cm. of 1 p.c. silver nitrate. Add two drops of 40 p.c. caustic soda to form a grey precipitate. Then add twenty to thirty drops of strong ammonia, enough to dissolve the precipitate while stirring. Allow to remain at least forty-five minutes. 6. Wash quickly in two baths of distilled water and quickly place in distilled water to every 20 c.cm. of which five drops of glacial acetic acid have been added. Leave in this five to fifteen minutes or until the reddish-brown becomes yellowish-brown. 7. Wash quickly and place over-night in 1 p.c. hydroquinone containing 5 p.c. neutral formol. 8. Wash quickly in distilled water, run up through alcohols rapidly and embed in paraffin through benzole or chloroform. 9. Cut sections and fix on slide. Dry well, then paint slides with 0·5 p.c. celloidin. This is followed by absolute alcohol-xylol, and absolute alcohol-xylol again. Then absolute alcohol to 95 p.c. alcohol down to water (distilled). 10. Then one to two hours in 0·1 p.c. solution of gold chloride neutralized with lithium carbonate. Grubler and Hollborn's gold chloride should be used (flavum, not fuscum). 11. Rinse in distilled water and fix in 5 p.c. hyposulphite of soda for fifteen minutes. Wash in running tap-water for two hours. Then alcohols up to absolute. Then absolute and eosin for a minute. Absolute alcohol, xylol, and mount in neutral balsam.

(5) Mounting, including Slides, Preservative Fluids, etc.

Celluloid Covers for Large Microscopical Slides.*—C. Brookover recommends tissue-celluloid sheets for covering large slides such as are necessary for serial sections of large objects, e.g. advanced embryos. These slides may be quite large, 7 × 3, and the advantage of tissue-celluloid is that high powers and oil immersion may be used. Tissue-celluloid is obtainable from dealers in photographic supplies. The writer mentions one disadvantage, which is that the celluloid cover has a tendency to squeeze the balsam out at the edges where it curls up.

Venetian Turpentine as a Cover-glass Cement.†—M. Plant advocates the use of Venetian turpentine for sealing off botanical preparations and for other purposes. The resin (Venezian. terpent. rect.) obtained from Grübler, is placed in a porcelain pan and heated in a sand-bath to remove the terpene. In from 4 to 6 hours the desired consistence is attained. The mass is then dissolved in ether and placed in a metal can devised and described by the author. When required for use heat is applied to the can and the contents poured out through the spout. Turpentine prepared as above stated is of a gold yellow hue, strongly refracting, and when cold and solid is not sticky.

* Trans. Amer. Micr. Soc., xxxiii. (1914) pp. 56–7.
† Zeitschr. wiss. Mikrosk., xxx. (1914) pp. 476–8 (3 figs.).

(6) Miscellaneous.

Electro-chemical Disinfection.*—F. C. Lewis recommends for use in bacteriological laboratories, in place of the familiar jar of lysol for the disinfection of slides and cultures, a jar containing sodium chloride, in which, by means of an electrical current, sodium hypochlorite, a powerful disinfecting agent, is produced. He uses a glass museum jar three-quarters full of a 10–20 p.c. solution of common salt. The current is obtained from the ordinary lighting circuit, a bench-lamp providing the necessary resistance. One of the cords of the lamp is cut, the severed copper wires are bared and fixed to carbon plates. The exposed wire is thickly coated with paraffin or sealing-wax. The carbon electrodes are placed in the salt bath. The bath soon acquires high bactericidal powers : tests with anthrax spores and other organisms prove this. These powers are retained for several days after the passage of the current is discontinued. As the bactericidal power is readily regenerated, the method is economical.

Bacteriological Examination of Food and Water.†—The Syndics of the Cambridge University Press are publishing a series of volumes dealing with subjects connected with Public Health, and one of these, "The Bacteriological Examination of Food and Water," is written by W. G. Savage, who has had great experience in the subjects dealt with in the present volume. The work fills up a considerable gap, for most text-books which deal with the bacteriology of food and water do so in a somewhat perfunctory manner. After chapters on general considerations and methods for the isolation and identification of indicator organisms such as *B. coli*, *B. enteritidis*, sporogenes, streptococci, etc., the special subjects of water, soil and sewage, shellfish, milk and its products, meat and air, are dealt with in a luminous and practical manner. There is also a useful chapter on the determination of antiseptic and germicidal power, the volume concluding with an appendix in which are described the different media and their composition required for the examinations mentioned in the work. The methods given are those which the author has found from experience to be of practical value, and the utility of which he has personally proved.

* Journ. of Hygiene, xiv. (1914) pp. 48-51.
† Cambridge University Press, 1914, 173 pp. (16 figs.).

Metallography, etc.

Silver and Cuprous Oxide.*—C. H. Mathewson and C. H. Stokesbury find that cuprous oxide dissolves freely in molten silver, but is practically insoluble in the solidified metal. Thus silver and copper are alike in their behaviour towards cuprous oxide, silver and cuprous oxide forming alloys containing a eutectic. The eutectic contains 1·3 p.c. Cu_2O. As in the copper-cuprous oxide alloys, the cuprous oxide coalesces readily. The primary crystals of silver tend to encroach on the eutectic areas. The structure is apparent in polished sections, but a mixture of concentrated ammonia and hydrogen peroxide has been found suitable for etching.

Alloys of Cerium with Silicon and Bismuth.†—R. Vogel has made extensive use of microscopic examination in the determination of the equilibrium diagrams of the cerium-silicon and cerium-bismuth systems. The compound CeSi, melting above 1500° C., was observed in unetched sections as yellow rounded crystallites. The eutectic of CeSi and silicon had a well-formed lamellar structure. Free silicon was found as hard needle-shaped crystals. The cerium-bismuth alloys were polished with alumina on wet cloth, but oxidized very rapidly. The structural characteristics of the four compounds and the eutectics occurring in the cerium-bismuth system are described.

Metallography of Electrolytically-deposited Alloys.‡—R. Kremann, C. T. Suchy, and R. Maas find that iron-nickel alloys deposited electrolytically from a solution of ferrous and nickel-sulphates are analogous in structure to alloys prepared by fusion. A structure characteristic of the electrolytic alloys consisted of concentric layerings. Cross-sections of the deposits had a lamellar appearance.

Protective Oxidized Coating on Sheet-iron.§—Matweeff has examined microscopically transverse sections of thin Russian sheet-iron used for roofing; this material is remarkably resistant to corrosion. The specimens were embedded in gum-lac for polishing. The layer of oxide was not homogeneous, and consisted of compact ferrous oxide which could be polished, intermixed with friable and porous magnetic oxide. Protection against corrosion appears to be conferred by the magnetic oxide, which is retained in position by a kind of skeleton of the mechanically stronger ferrous oxide.

Crystallizing Properties of Electro-deposited Iron.‖—J. E. Stead and H. C. H. Carpenter have studied the structure of pure electro-deposited iron strip containing 99·967 p.c. iron, subjected to various

* Int. Zeitschr. Metallographie, v. (1914) pp. 193–212 (12 figs.).
† Zeitschr. Anorg. Chem., lxxxiv. (1913) pp. 323–39 (10 figs.)
‡ Monatsh. Chem., xxxiv. (1913) pp. 1757–1809, through Journ.Chem. Soc., cvi. (1914) pp. 96–7.
§ Rev. Métallurgie, xi. (1914) pp. 480–2 (5 figs.).
‖ Journ. Iron and Steel Inst., lxxxviii. (1913, 2) pp. 119–70 (41 figs.).

forms of heat-treatment. No marked change in crystallization occurred at temperatures below 900° C. Re-crystallization occurred at 910° to 915° C., and was complete after two or three seconds in that temperature zone. Specimens heated above 910° C. had a fine structure if quenched in water, but when any slower rate of cooling was adopted the crystals formed were relatively enormous, the resulting structure being very much coarser than that of the original strip. The first new crystals were equiaxed, but specimens which had been heated to 930° C. contained radial crystals, which increased at the expense of the equiaxed crystals with higher temperatures of treatment.

By quenching at different temperatures on cooling from above Ac_3, the temperature of recrystallization, it was shown that the large crystals were formed during the passage through Ar_3. Coarse crystals did not develop with any rate of cooling after a very prolonged heating above Ac_3. The large crystals, once formed, could only be destroyed by mechanical work, or by quenching from above Ac_3, or by prolonged heating above Ac_3. The formation of the excessively large crystals described did not occur in electro-deposited iron if the thickness of the strip exceeded a critical value lying between 0·011 and 0·012 inch, and did not occur at all in wrought-iron or mild steel. It is suggested that the formation of the coarse crystals may be promoted by the persistence of nuclei of crystallization when heating above Ac_3 is not prolonged, but that long-continued heating above Ac_3 destroys these crystal nuclei.

Belaiew's Researches on the Structure of Steel.*—N. T. Belaiew's account of his studies upon the structure of steel was published in book form in the Russian language. W. Guertler now gives a summary, illustrated with 22 photomicrographs, and points out the general significance of the observations recorded and their parallels in other series of alloys. The structures described are chiefly those of specimens heated for long periods at high temperatures and very slowly cooled.

Structural Changes of Iron during Annealing.†—D. Ewen has studied the heat-reliefs formed on polished specimens of pure Swedish iron on heating to temperatures of 400° to 1000° C. in a high vacuum. Three distinct types of heat-relief, corresponding to (1) initial α- and β-iron structure, (2) γ-iron structure, and (3) final β- and α-iron structure, are described. The development of the α-iron heat-relief on heating is ascribed to selective volatilization from the crystal boundaries, while the γ-iron and final β- and α-iron heat-reliefs obtained on cooling are attributed to differences in dilatation of the allotropic modifications involved. An etching effect, frequently giving rise to definitely oriented pits, was obtained above A_3, more especially when the metal was heated by passing a heavy current through it, and is ascribed to a species of electrical disintegration.

Damascene Steel.‡—W. Guertler criticizes the various methods that have been proposed for preparing damascene steel. True damascene

* Int. Zeitschr. Metallographie, vi. (1914) pp. 72–89 (23 figs.).
† Int. Zeitschr. Metallographie, vi. (1914) pp. 1–17 (10 figs.).
‡ Int. Zeitschr. Metallographie, v. (1914) pp. 129–41 (9 figs.).

steel contains 1·0 to 1·6 p.c. carbon, and consists structurally of small grains of cementite embedded in ferrite. Lamellar pearlite is wholly absent. Zones rich in cementite alternate with zones containing much less cementite. It is shown that the damascene structure cannot be obtained by prolonged heating at temperatures above the critical range. Long heating below 700° C. is necessary to convert the cementite into the desired form, while some previous treatment, such as mechanical working within a particular temperature range, appears to be required to secure the remaining characteristics of damascene steel.

Iron-carbon System.*—W. Guertler gives a critical account of the researches of Wittorf and of Hanemann on the iron-carbon system, and discusses the probability of the existence of the carbides FeC_2 and Fe_4C.

Hyper-eutectic Iron-carbon Alloys.† — H. Hanemann has heated pure iron-carbon melts with excess of carbon (sugar-charcoal) to temperatures ranging from 1200° to 2500° C. Most of the twenty-two melts were cooled rapidly, others slowly. The structures are described in tabular form. The maximum carbon-content, 18·5 p.c., was found in an alloy heated to 2500° C. In specimens quenched from temperatures above 1400° C., graphite was found as a primary product, and not as a decomposition-product of cementite. The so-called primary cementite could only be obtained by extremely rapid cooling. In quenched specimens the cementite crystallized radially from the centre. Wittorf's dendritic carbide, Fe_4C, was shown to be austenite, as it was converted into martensite by cooling in liquid air, and into pearlite by annealing.

Ternary Alloys of Iron, Carbon, and Phosphorus.‡—J. E. Stead gives the results of a detailed microscopic study of a number of iron-carbon-phosphorus alloys. An alloy containing 2 p.c. phosphorus and 0·12 p.c. carbon, was submitted to cementation, yielding a mass in which the central portion remained unchanged, while the carbon in the outer layer was raised to 1·3 p.c. Alloys containing 1·2 p.c. phosphorus and varying amounts of carbon were prepared by fusion. Phosphorus-rich pig irons, and an alloy containing 0·3 p.c. carbon and 0·5 p.c. phosphorus were also studied. The ternary eutectic in grey cast iron decomposes on cooling into the binary eutectic and pearlite or iron. In the solidification of a low-carbon alloy containing 2 p.c. phosphorus, crystallites free from carbon first form, and the ternary eutectic solidifies last. On slow cooling, the carbide diffuses out of the eutectic, forms a pearlite fringe round the eutectic, and throws some of the phosphide out of solid solution. This phosphide appears as fine lamellæ in juxtaposition to the pearlite carbide. A fringe having a characteristic structure and consisting of ferrite, carbide, and phosphide is thus formed. The effect of carbon in diminishing the solid solubility of iron-phosphide in iron, and the tendency of phosphorus to concentrate in segregated areas free from carbon, are discussed and copiously illustrated.

* Int. Zeitschr. Metallographie, v. (1914) pp. 239–77 (30 figs.).
† Zeitschr. Anorg. Chem., lxxxiv. (1913) pp. 1–23 (31 figs.).
‡ Journ. Soc. Chem. Ind., xxxiii. (1914) pp. 173–84 (44 figs.).

So-called "Crystallization through Fatigue."*—F. Rogers has failed to find any experimental evidence in support of the prevalent idea that fatigue may cause a development of crystallization in iron or steel. It is probable that the only alterations in structure which repeated stress is capable of causing are destructive. Strain effects may be classified as (1) slip-bands; (2) intergranular weakness; (3) twinning, and the formation of Neumann lamellæ; (4) change of structure. Of these the first is the commonest and is almost universal. The examination of numerous samples has led to the conclusion that if a piece breaks in service with a crystalline-looking fracture, it would also have done so when new. Pieces which had broken in use, giving fractures partly crystalline and partly fibrous, were found to be heterogeneous in structure, the different types of fracture corresponding to different structures.

Preparing Sections of Fractures of Steel for Microscopic Examination.†—For the examination of a section through a fracture, A. Campion and J. M. Ferguson recommend the embedding of the fracture in a fusible alloy, in cases where time is not available for the lengthy process of electro-deposition of copper or iron. Suitable alloys are :—

	A	B
Bismuth	50 parts	50 parts
Lead	30 ,,	30 ,,
Tin	25 ,,	10 ,,
Zinc	3 ,,	..
Cadmium	..	10 ,,

Both alloys melt below 100° C. A is the better alloy, but has a melting-point 25° C. above that of B. If a section through a fractured test-piece is required, the fracture is momentarily dipped in hydrochloric acid of 1·1 sp. gr., then in zinc-chloride solution, and is then plunged into a quantity of the molten alloy in a suitable mould. The alloy is re-warmed to ensure fluidity and to allow trapped air to escape. The embedded specimen, when cold, may be sawn in any required direction and polished by the usual methods.

Transparence or Translucence of the Surface Film Produced in Polishing Metals.‡—If a specimen of copper containing blow-holes is polished, the smaller pits in the surface become covered over by the surface skin formed by polishing. G. T. Beilby shows that the film which covers the pits is transparent, or at any rate highly translucent, and that the mobile film has been carried across the empty pit without any support from below, such as might have been given by particles filling up the pit. By carefully regulated etching of the surface with a reagent which dissolves copper, the film can be reduced to extreme thinness and finally dissolved completely, exposing the open pit. In the polished surface, under high magnification, the pits appear as blue spots on a rose-coloured ground. Some of the blue spots showed patches of red. By dissolving away the film the patches of red were shown to be due to

* Journ. Iron and Steel Inst., lxxxviii. (1913, 2) pp. 392–8 (2 figs.).
† Journ. Iron and Steel Inst., lxxxviii. (1913, 2) pp. 385–91 (5 figs.).
‡ Proc. Roy. Soc., Series A, lxxxix. (1914) pp. 593–5 (4 figs.).

red light reflected upwards from the inner concave surface of the pit, thus demonstrating the transparence of the film and the emptiness of the pit when covered by the film. The thickness of the films covering the pits is probably of the order of 10 to 20 micro-millimetres. Reproductions by the three-colour process of autochrome photomicrographs at magnifications of 800 and 1800 diameters illustrate the paper.

Microscopic Metallography in Three Dimensions.*—A. Portevin describes the apparatus he has devised for studying the solid structure of metal specimens by the histological method of serial sections. The piece to be examined is permanently fixed, by means of gum-lac or other cement, in a specimen-holder, which is an accurately turned hollow steel cylinder. The holder fits into a recess in a bronze base-plate, which fits in turn into the stage opening of the Le Chatelier Microscope. The stage, base-plate, and specimen holder bear register marks, which are made to coincide when the specimen is re-examined after each successive polishing. The accurate replacement of the specimen in the same position in space with respect to the Microscope stage, thus rendered possible, permits the re-examination of any field, after removal of a layer of known thickness, by means of recorded readings of the micrometer heads of the mechanical stage. The thickness of the layers successively removed by re-polishing is determined by measuring the length of the specimen-holder, after each polishing, by means of a micrometer calliper with anvil of large diameter. In polishing, care must be taken to maintain the face accurately at right angles to the axis of the specimen-holder. A number of serial photomicrographs are given, of an antimony-tin-copper-lead bearing metal, and a copper-tin alloy, the distance between the successive parallel faces varying from 0·05 to 0·12 mm.

Cohesion of Metal Masses.†—W. Guertler agrees with Rosenhain's amorphous cement theory, provided that the thickness of the amorphous layers is not assumed to exceed molecular dimensions. The existence of independently stable amorphous masses is disputed, chiefly on the ground of the higher stability of the crystalline state.

Colour-photomicrographs of Ores.‡—G. Rigg has found Lumière autochrome photomicrographs useful for recording the microstructure of thin slices of ores illuminated by transmitted light. The fineness of the constituents, the shape of the different minerals, and the mode of association of the valuable minerals with the gangue, are revealed by microscopic examination.

* Int. Zeitschr. Metallographie, vi. (1914) pp. 58–71 (35 figs.).
† Int. Zeitschr. Metallographie, v. (1914) pp. 213–27 (2 figs.).
‡ Met. and Chem. Eng., xii. (1914) p. 30.

MICROSCOPY.

A. Instruments, Accessories, etc.*

(2) Eye-pieces and Objectives.

Measurement of the Initial Magnifying Powers of Objectives.* E. M. Nelson points out that the problem involved is merely that of solving the equation $m = \frac{10}{f}$, but that the focal length (f) of an objective is a very difficult thing to measure directly. Indeed, it is usually found by an indirect method of measuring the magnifying power, for, as above, $f = \frac{10}{m}$. Probably the best way of measuring the focal length by the indirect method is to project the image of a measured object placed 100 in. from the stage, and to measure the diminished image at the focal point of the objective by means of a Microscope fitted with a screw micrometer; the magnification (m) thus obtained will give the focal length with great accuracy, for $f = 100 \div (m + 2)$. As the numerator is 100, the result can be found in a reciprocal table without the necessity of doing a division sum. Simple as this seems, it is, however, a troublesome thing to do; but the author describes a method by which the initial power and consequently the equivalent focus of a Microscope objective can be quickly and easily measured.

The apparatus required is a stage micrometer and a screw micrometer with a positive eye-piece. With a tube of a length as described below, the interval of two divisions of the micrometer scale on the stage is read on the drum of the eye-piece, and this reading will be the initial magnifying power of the objective. The only difficulty here is the determination of the proper tube-length. The tube-length is to be measured from the web in the eye-piece to the end of the nose-piece of the Microscope.

The formula for the determination of the tube-length is

$$15\sqrt{\frac{1}{p} + 0{\cdot}335}$$

where p is the nominal initial power. Example: The initial power of

* This subdivision contains (1) Stands; (2) Eye-pieces and Objectives; (3) Illuminating and other Apparatus; (4) Photomicrography; (5) Microscopical Optics and Manipulation; (6) Miscellaneous.

† Journ. Quekett Micr. Club, xii. (1914) pp. 295–300 (1 fig.).

a half-inch is required. The nominal power of a half-inch is 20, which is p, then

$$15\sqrt{\frac{1}{20}+0\cdot335} = 15\sqrt{0\cdot385} = 15\times0\cdot62 = 9\cdot3 \text{ in. tube-length.}$$

The tube must be drawn out until the web is 9·3 in. from the nose-piece, and with the half-inch on the nose-piece, two $\frac{1}{100}$ in. divisions on the stage micrometer are spanned by the webs. The drum then is read, say, 22·4, and this is the initial power of that half-inch, without any further calculation ; its focal length is $\frac{10}{22\cdot4}$ or 0·446 in. In case the nominal initial power is unknown, it is first determined with, say, a 9½-in. tube ; the value thus found is inserted in the equation and the measurement made again with the correct tube-length. All powers of ¼-in. and less focus, all Zeiss's apochromats of whatever focus, and other makers' apochromats, require a 9-in. tube.

For lower powers the accompanying table, computed by the above formula, gives the necessary tube-length.

TABLE.

O, objective ; N, nominal power ; T, tube-length in inches.

O	N	T	O	N	T
	3	12·3	1	10	9·9
3	3·5	11·8	¾	12	9·7
	4	11·5	⅔	15	9·5
	4·5	11·2	½	20	9·3
2	5	11·0	$\frac{4}{10}$	25	9·2
	5·5	10·8	⅓	30	9·1
	6	10·6		35	9·05
1½	7	10·4	¼	40	9·0
	8	10·2			
	9	10·0			

J. Grundy gives some experimental details of Nelson's method. The Microscope is placed horizontally ; a low-power objective, 3, 2, or 1½ in., according to circumstances, is placed in position ; screw-micrometer eye-piece ; the objective to be measured is placed in substage, with its front lens facing the stage. A card cut to the pattern as shown in figure (fig. 34) is fixed by means of a clip in front of the window ; the card should be placed at the exact measured distance of 100 in. from the stage of the Microscope. The stage micrometer is placed on the stage, and the constant of the screw-micrometer determined. The focus of the Microscope is not to be disturbed, but, by

means of substage focusing, the lens to be measured is racked up until the image of the card is sharply focused. Then one of the sides of the card is spanned by the webs of the eye-piece micrometer, and its

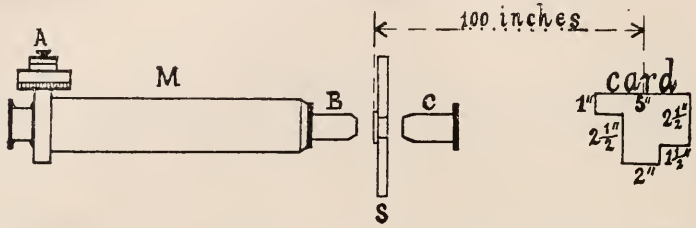

Fig. 34.—Diagram to show Relative Positions of the Apparatus.

M.—Microscope tube. B.—Objective.
A.—Screw micrometer. C.—Objective to be measured, in substage.
S.—Microscope stage and micrometer.

size measured and the magnifying (or, rather, diminishing) power found ; then

$$f = \frac{100}{m + 2}$$

Of course, the idea of the 5 in. is that the reading is doubled, and then $10 \div x$ (say) gives the magnification, m, which can be found from reciprocal tables, as well as the value of

$$\frac{100}{m + 2}$$

It is not difficult, but a little more trouble, to make the calculations without tables.

This method will also measure the foci of large photographic lenses. In that case

$$f = \frac{100}{m + 2} - \frac{100}{(m + 1)^3}$$

This second term is only necessary when f is large compared with 100 in. ; for microscopic lenses it is not wanted.

The screw-micrometer eye-piece is perhaps a drawback, as an ordinary screw-micrometer with a negative eye-piece is no good for lens measurements. The eye-piece must be of the Ramsden type, and it is very doubtful if any ordinary ruled glass micrometer eye-piece would be sufficiently accurate. A screw-micrometer is necessary for both the methods described.

(3) Illuminating and other Apparatus.

Improved Form of Cheshire's Apertometer.*—J. Grundy describes E. M. Nelson's improved form of Cheshire's valuable instrument, the

* Journ. Quekett Micr. Club, xii. (1914) pp. 281–2 (1 fig.).

aim of the improvement being to read off the N.A. with greater ease and accuracy. Distinctness and clearness of reading have been effected by increasing the number of marked values of N.A. from 9 to 22, without the confusion that overcrowding of the lines would entail. To accomplish this, short arcs of circles are used instead of whole circles. A valuable property of these is the clear visibility of the ends or edges of the arcs ; they are seen more distinctly than complete circles would be. The contrast between the white ground and the short black lines favours this. The exterior edges of the arcs denote the N.A., and thus give most convenient, accurate, and definite positions for reading. The first or lowest marked value is 0·05 N.A., and the values increase by increments of 0·05 up to 0·5 N.A. From 0·5 the values increase by 0·033 up to 0·9 N.A.

The apparatus consists of an apertometer diagram (fig. 35), printed

Fig. 35.

on a small card about the same size as Cheshire's form, another card of explanations and instructions, a cubic inch of wood, and a metal diaphragm with a hole not more than 1·25 mm. in diam. Nelson lays some stress on the hole in the diaphragm being not more than 1·25 mm. in diam. He says : "If the hole is larger than that, some objectives, especially low powers, will read a great deal too high. And accuracy is, relatively, more important with the small apertures, because, for example, an error of 0·01 or 0·02 will make a far greater percentage of difference than it would with, say, the N.A. of an oil-immersion objective. If 1·25 and 1·27 be compared with the N.A. 0·11 and 0·13 of a 3-in. objective, the actual difference between the two pairs of values is 0·02 in each case, but the percentage difference with the higher N.A. is only 1·6 as compared with 18 in the case of the low values." Nelson also makes another important remark, namely, "The working aperture is larger than the correctly measured true aperture, so that low powers resolve more than they are entitled to theoretically. This is

probably due to the practically enlarged aperture caused by the rolling motion of the eye from side to side."

It will also be noticed that the diaphragm to be used with the apertometer is made convex on one side, and if the convex side is put into the larger aperture of an eye-piece—or other—diaphragm, it rests steadily in position.

Two Simple Apertometers for Dry Lenses.*—These are due to F. J. Cheshire, who begins his description by quoting Abbe's authority † that it is useless to attempt an accuracy greater than 1 p.c. in an apertometer. Fig. 36 shows a plan of the author's form of an apertometer for dry lenses, which for simplicity in use and for the accuracy of its results probably leaves nothing to be desired. A strip of vulcanite A (the right-hand end is shown broken off) is so divided that the distance D of any line from the zero of the scale is given by the equation ‡

$$D = 2\,\Delta \tan (\sin^{-1} \text{N.A.})$$

The graduations are marked with the corresponding N.A. values for a value of Δ equal to 25 mm. In use the apertometer is placed upon the stage, and the object-plane of the lens to be tested adjusted at a height of 25 mm. above the plane of the scale. The upper focal plane of the objective is then observed in any known way, and the apertometer adjusted on the stage until the inner edge of the fixed white block B is seen on one edge of the objective opening. This adjustment effected, the sliding white block C is slid along the strip A until its inner edge is seen on the opposite edge of the objective-opening to that on which the block B is just seen. The N.A. value found opposite to the inner edge of the block C on the scale is that of the lens tested. The graduations from 0 to 0·9 N.A. proceed by steps of 0·02 and from 0·9 to 0·96 N.A. by steps of 0·01.

Fig. 37 shows a modification of the form of apertometer described in the author's original paper in 1904. He has substituted for the concentric circles there shown curved lines which project optically into the upper focal plane of the lens being tested as a number of equi-distant straight lines of equal thickness. The projected image of the apertometer scale is thus a simple linear scale upon which N.A. values can be read directly. The scale runs from 0·0 to 0·9 N.A. by steps of 0·05, i.e. the divisions starting from the centre have the values 0, 0·05, 0·10, 0·15, 0·20, etc., of N.A. The short curved lines of the scale should strictly be hyperbolas, but such curves are very difficult to draw accurately, and it was not until the author's son, R. W. Cheshire, suggested to him that they might be replaced by arcs of circles with curvatures equal to those of the corresponding hyperbolas at their vertices, that the apertometer described became a practical construction.

The author is of opinion that there are several objections to Nelson's form § of his apertometer which was introduced by him in 1904. These

* Journ. Quekett Micr. Club, xii. (1914) pp. 283–6 (2 figs.).
† See this Journal, 1880, p. 20.
‡ Journ. Quekett Micr. Club, ix. (1904) p. 1. § Vide supra.

may be briefly indicated. In the first place, no advantage can result from the use of the outer edges of the lines, instead of the middles, as

Fig. 36.

Fig. 37.

is usually done, as the part of the lines from which distances, and therefore N.A.'s, must be estimated by eye. Further, in Nelson's form the thickness of the lines varies in different parts of the diagram, and

has no assigned or stated thickness in terms of N.A. This is a fatal defect, because when the thickness of a line has a N.A. value of, say, 0·02, such thickness, especially when dealing with low-power lenses, provides an invaluable standard of reference when estimating by eye N.A. values intermediate to those represented on the scale. In apertometers of the kind in question the further the subdivision of the scale is carried the greater must be the complexity of the image presented to the eye—the advantage of one is balanced by the disadvantage of the other. Possibly, however, most people would prefer the simplicity of a diagram with the larger divisions to the optical Hampton-Court-maze necessitated by the smaller ones.

Variation of Cheshire's Apertometer.*—M. A. Ainslie states that experience in the use of both the original forms of Cheshire's Apertometer, and the modification thereof recently introduced by E. M. Nelson,

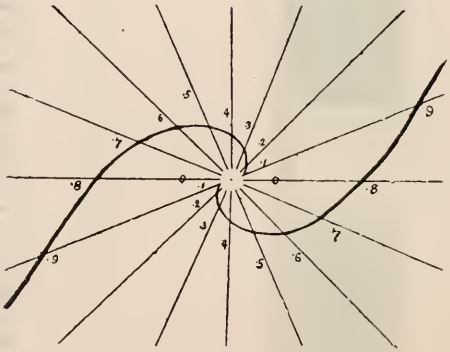

Fig. 38.

have revealed one or two difficulties in connexion with the reading of the instrument—that is, if any accuracy in the second place of decimals is required—and the present instrument is an attempt at removing these. The first difficulty is due to the fact that in Cheshire's instrument we have to interpolate or estimate between two divisions on a scale, one of which is not visible, being outside (apparently) the margin of the back lens of the objective. This renders the estimation of the second place of decimals in the N.A. uncertain, and although Nelson's modification of the original instrument is somewhat better in this respect, yet the very means adopted to improve the reading, namely, the introduction of a large number of additional circles, is likely to confuse the diagram and bewilder the observer.

The author's instrument, which consists, in the form for dry lenses, of a card diagram placed on the stage, is constructed as follows: A series

* Journ. Quekett Micr. Club, xii. (1914) pp. 287–9 (2 figs.).

of radial lines are drawn from a common centre, making equal angles with one another; the precise number is immaterial, but it has been found convenient to divide the circle into sixteen equal parts. One of these (preferably that lying horizontally) is selected as a zero, and points are marked off along the others at distances equal to a constant length (usually 25 mm. or 1 in.) multiplied by the tangent of the semi-angle of aperture, i.e. the tangent of the angle whose sine is the numerical aperture. This is done for every 0·1 of N.A., and a spiral curve drawn through the points thus obtained; this curve being repeated turned through 180°. The curves are shown with fair accuracy in fig. 38.

The diagram is used precisely as the Cheshire Apertometer: either the objective is focused on the upper surface of a cube of wood, as in the Cheshire instrument, or else a pinhole in the centre of the diagram is focused, and the body racked back 25 mm. or 1 in., this being measured easily enough with a scale. This latter method is preferable

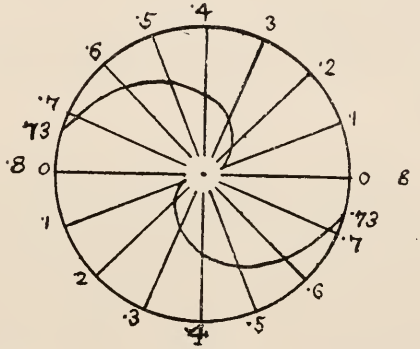
 ·5 ·4 3 ·2 1 0 ·6 ·7 ·73 ·8 0 ·1 2 ·3 ·4 ·5 ·6 ·7 ·73 0 ·8

Fig. 39.

for objectives of high aperture. A low-power eye-piece is employed. On examining the Ramsden disk with a hand-lens (a watch-maker's eye-glass does well) the appearance in fig. 39 is seen, and the method of estimating the value of the N.A. is fairly obvious. We have only to start from the zero and count in the direction of the spiral 0·1 for each radial line passed over. The second figure is found by estimating the position between two adjacent radial lines of the point where the spiral cuts the margin of the back lens. In fig. 39, for example, the N.A. is about 0·73.

The procedure is the same with the form suited to immersion lenses; the upper surface of a plate of glass is focused, and the diagram is balsamed to the lower surface. It might be preferable to have twelve radial lines instead of sixteen, and read like a clock; this is a matter for experiment.

Of course the value of the radius vector of the curve for a diagram in optical contact with glass will not be quite the same as before. Instead of $r = \mathrm{C} \tan \phi$, where $\sin \phi = \mathrm{N}$, we shall have $r = \mathrm{C} \tan \phi'$

where $\mu \sin \phi' = N$; but the principle is the same. The equation to the curve presents some interesting features; it is

$$r = C \frac{a\theta}{\sqrt{1 - a^2\theta^2}}$$

where C is the distance of the diagram from the lower focal plane of the objective and a is a constant depending on μ and on the number of radial lines in the circle; for sixteen radial lines, and $\mu = 1$ (dry form), $a = \frac{4}{5\pi}$. The radius representing N.A. = 1·0 is obviously an asymptote to the curve; in the case of the glass form, N.A. = μ will be the asymptote.

It is of interest to note that the same curve will serve for any refractive index of the medium beneath which it is mounted. If we change the refractive index from 1 to μ, we merely have to close up the radial lines in that ratio, leaving the curve unaltered. For instance, if we had 16 radii for the dry form we could use the same curve, but with 24 radii for a plate of glass of $\mu = 1 \cdot 5$.

In practice the instrument proves of great utility, and very reliable and easily used. All that is necessary is to be accurate in centring; this is easily seen to be correct when the reading of each end of the spiral is the same.

Dark-ground Illumination with the Greenough Binocular.* — The Greenough pattern of binocular consists, says B. M. Draper, of two separate Microscopes, one for each eye, with paired objectives of very low power. Like other binoculars, it is particularly well-suited for use with dark-ground illumination, and a good way of getting the dark-ground with its higher powers is to put a stop behind the condenser. As, however, the front lenses of the twin objectives stand out some distance on either side of what would be the optic axis of an ordinary Microscope, the stop has to be correspondingly broad from side to side; otherwise direct rays would enter the objectives and would spoil the dark-ground at the sides of the field. But it is not necessary that the rectangular diameters of the stop should be equally great; on the contrary, if an ordinary circular stop be used, some rays are needlessly obstructed. On trial, a double or twin stop, corresponding with the twin objectives, gave much better results. This stop consists of two small circular patches placed side by side in the same plane, and touching each other, so as to form a figure of eight. It is used behind the condenser in the same way as an ordinary circular stop, and with almost equal ease. It is only necessary to be careful that the two circular patches shall be placed horizontally, i.e. so as to be opposite the two front lenses of the twin objectives. This position can easily be secured by arranging the stop in the carrier approximately, and then, whilst watching the object, shifting the whole condenser round in its sleeve until the best effect is obtained. A standard low-power condenser such as Swift's Paragon, with its top lens off, gives very satisfactory results. The twin and the ordinary

* Journ. Quekett Micr. Club, xii. (1914) pp. 313–14.

circular patterns of stop were compared experimentally by using a condenser fitted with two stop carriers, one behind the other, so that either stop could be used separately, or both together. The twin stop used by itself gave a good dark ground. The circular stop was purposely chosen too small to give a good dark ground; there was light at the sides of the field. Nevertheless when the circular stop was turned in above the twin stop whilst the object was under observation, there was a marked drop in the brightness of the image. This loss of light was due almost entirely to the circular stop, not to the clear white glass on which it was mounted, since it was found that the interposition of such a piece of glass, even when rather dirty, made very little difference to the light. Evidently, therefore, the circular stop, though too small in one direction, was too large in the other, and kept out some rays which might safely have been admitted. Of course, if the circular stop had been large enough to darken the background when used by itself, the loss of light would have been still more noticeable.

Changer for Use with Substage Condensers.*—S. C. Akehurst has frequently felt the need of a method for quick change of substage con-

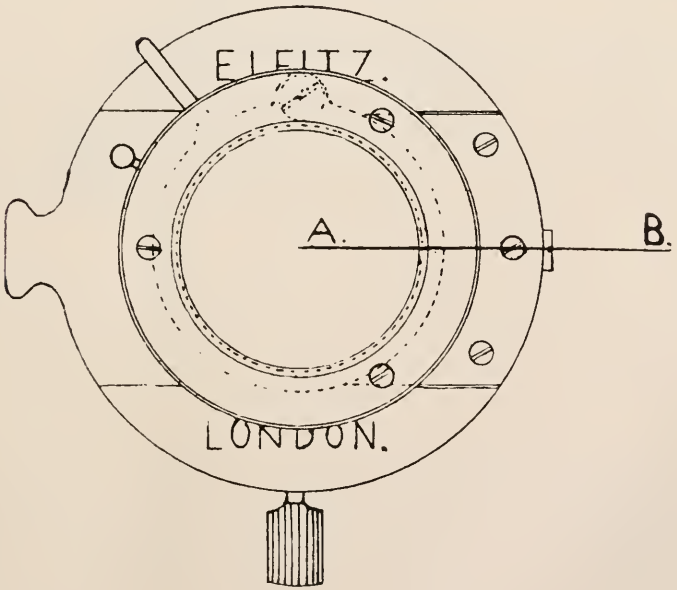

Fig. 40.

densers. He found the revolving nose-piece to carry three condensers did not work satisfactorily, and therefore adapted the principle employed

* Journ. Quekett Micr. Club, xii. (1914) pp. 277–8 (2 figs.).

in the sliding objective changer to the substage fitting, and found this enabled him to get an easy and rapid change of condensers. The scheme consists of a metal slide, $2\frac{1}{2} \times 1\frac{1}{2}$ in., with bevelled edges, on which the condenser is mounted, and, when necessary, a throw-out arm for stops, and an iris-diaphragm. Two D-shaped metal plates, the flat sides of which are set $1\frac{1}{2}$ in. apart, form a groove for the slide to work in. These plates are screwed to a metal collar, the diameter of which is such as to allow the slide-condenser changer to be fitted to any Microscope that has a substage made to the R.M.S. gauge.

Fig. 40 shows a plan of the slide-changer in position, while fig. 41

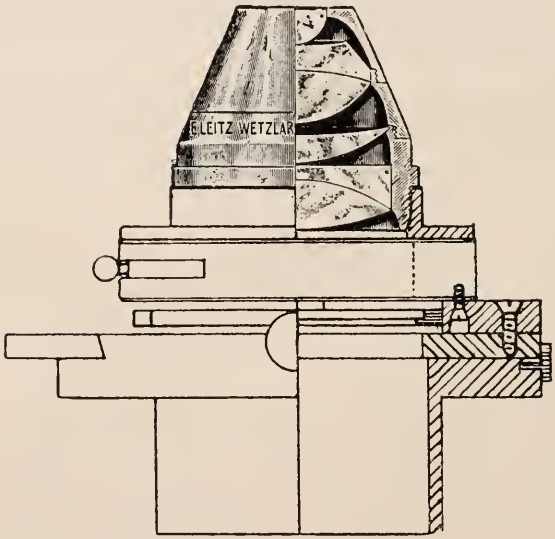

Fig. 41.

gives a sectional elevation along the line A B (fig. 40). When three or more condensers are used it is desirable to have each mounted on a separate slide ; but when only two condensers are used, one slide may be sufficient, as the optical parts can be made interchangeable. When the slide with condenser has been pushed home, a screw, working through one of the plates, holds this firmly in position. This changer does away with the necessity of a throw-out substage, and any variation of centrality in the condenser can be adjusted by the centring screws in the regular way. To rack down the substage fitting, withdraw, and insert a new slide, are all the movements that are required to obtain a change of condenser, and this can be effected as readily as a change of objective on a revolving nose-piece.

Substage Illumination.*—S. C. Akehurst urges the convenience of employing annular light with objectives of high aperature, the annular light being obtained by the use of a concentric reflecting condenser. By this means there is no chromatic dispersion, and the spherical aberration is reduced to a minimum. Moreover, with the reflecting condenser there is no loss of high-angle rays, because the excess of light is modified by stopping out a portion of the central or dioptric beam ; hence the fullest possible advantage can be taken of the N.A. aperture of the whole optical system. The absence of chromatic dispersion results in a pure image and in the possible application of photomicrography to critical work. The author gives photographs of *Pleurosigma angulatum* and other well known diatoms, taken with annular illumination under magnifications, in some cases, as high as 3000 diam.

New Microscope Illuminators.†—F. Levy describes two forms of illuminators which he has found satisfactory. The first is adapted for illuminating a Microscope hall, and consists of a centrally placed 2000-candle Osram half-watt lamp in a hemispherical milk-glass globe. The glass should have a slightly bluish tinge. Such a lamp should be placed about 2 m. above the work-tables, and would suffice for one hundred Microscopes.

His second lamp is for individual use with high-powers in a laboratory, and consists of a special Osram lamp with wavy metal filaments of 100 candle-power. The front side of the globe is matted ; the rear side mirrored. The lamp is enclosed in a frame in such a manner that the greater part of the light falls on the Microscope mirror. The frame is provided with grooves for the insertion of filter or matt disks. Near the grooves openings are left so that the working space may be illuminated without blinding the worker.

Application of Direct Coolers to Projection.‡—O. Zoth points out the inconveniences of those forms of coolers which are operated by water straight from the water-main. In such cases the water is under pressure, and there is considerable risk of cracking, bursting, or loosening the cover-glass. The author finds it better to use water at a pressure less than the atmospheric. He accomplishes this by means of a siphon arrangement, at the highest point of which is the cooling chamber. By means of a tube the chamber is connected with a large trough of water, iced if necessary, under the projection stage. Another tube leads from the cooling chamber to a vessel on the floor at a lower level than the trough. A gentle sucking at this second tube will start the siphon, and the flow of the liquid can be controlled by a pinchcock. A difference of level equal to 50 or 60 cm. is found to be sufficient. It is easy to see that there is now no risk of damage to the cover-glass. By exchanging the levels of trough and vessel and adjusting tube-lengths the flow can be reversed and the same liquid used again.

* Journ. Quekett Micr. Club, xii. (1914) pp. 301–8 (3 pls.).
† Zeitschr. wiss. Mikrosk., xxxi. (1914) pp. 99–100 (2 figs.).
‡ Zeitschr. wiss. Mikrosk., xxxi. (1914) pp. 97–8.

(4) Photomicrography.

Photographic Dark-box for Field Work.*—The difficulties encountered in doing photographic work in the field where dark-room conveniences are lacking led to the making of a dark-box which is an adaptation of the inoculating chamber in common use in plant pathology. Elda R. Walker has found it so satisfactory that he uses it entirely for plate work even in the laboratory where a dark-room is available. The dark-box (fig. 42) is a plain light-tight box 24 in. long, 18 in. wide, and 20 in. high. It is made of light-weight lumber $\frac{3}{4}$ in. thick. To avoid all chances of light entering, it is made of well-seasoned lumber; all corners are joined, as shown in the accompanying diagram, at *k*, and all seams in the sides are made by inserting a strip-"tongue," $\frac{1}{4} \times \frac{3}{4}$ in.

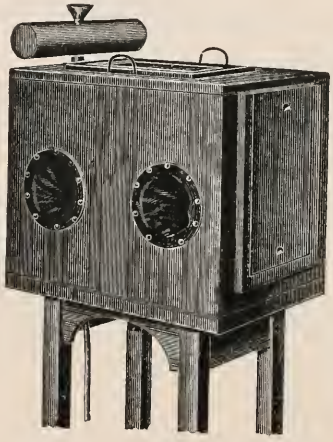

Fig. 42.

in cross-section, as is shown at *m* in the diagram. Besides these precautions, all joints are glued as well as nailed. In the right-hand end is a door, 14 × 11 in., for admitting to the box plates, plate-tank, and such things as are to be used in the work. In the top and back are red-glass windows, 10 × $8\frac{1}{2}$ in., set firmly with putty. The back one serves to admit light, and the top one permits the operator to see what he is doing in cases where light is needed. (When using the windows it is well to cut out side lights by throwing a focusing cloth over the head. For most work, however, the windows are covered by wooden doors, and the work is done without sight.) All doors are of the sliding kind and work in a groove, as is shown in the diagram at *a*. This shuts out all light. In front of the box (fig. 42) are two round holes for the operator's arms; these are 6 in. diam. They are 7 in. apart, and 6 in. from the bottom of the box (outside measurement). These are convenient dimen-

* Trans. Amer. Micr. Soc., xxxiii. (1914) pp. 51–4 (5 figs.).

sions for an average-sized person. These holes are closed each by two sleeves, with rubber tape at the wrist to draw them tightly about the arms. The sleeves are 12 in. long, and are tapered slightly to eliminate surplus fullness at the wrist. The inner sleeves, which are tacked on the inner side of the box about the openings, are of black oilcloth, for protection from chemicals as well as to cut out any possible light that might have come through the outer sleeves. These are of fine black sateen, and are tacked to the outer side of the opening (fig. 42). Each sleeve is finished separately with a rubber draw-string, so that should any light pass the closing of the outer sleeve it would be cut out by the

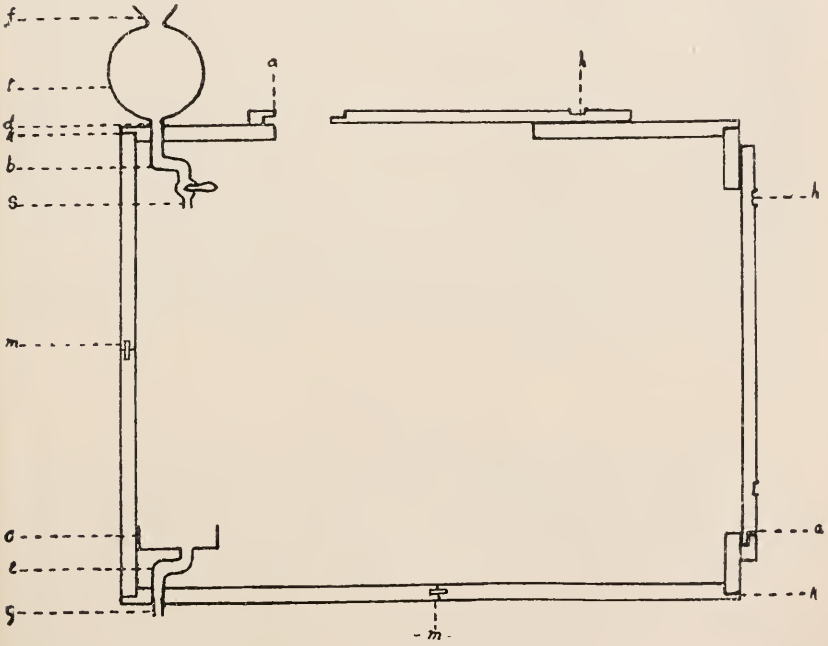

Fig. 43.

inner one. On the top, at the left-hand end of the box, is a cylindrical copper tank for holding water (fig. 43, *t*, and fig. 42). This is $3\frac{1}{2}$ in. diam. and 18 in. long, and is provided with a funnel (fig. 43, *f*, and fig. 42) above for convenience in filling. From the tank a short section of $\frac{1}{2}$-in. water-pipe passes into the box, where it is bent to form two elbows (fig. 43, *b*) to prevent the entrance of light. To this pipe is attached a small faucet (fig. 43, *s*) through which water can be drawn as needed. The tank screws on to the pipe (fig. 43, *d*) so that it can be removed for convenience in transportation. Directly below the faucet is a copper pan (fig. 43, *c*), 5 × 6 in. diam. and $1\frac{1}{2}$ in. deep, for receiving waste liquids. The drain from this has two elbows (fig. 43, *e*),

as in the tube above. At the bottom of the drain-pipe is a short removable section (fig. 43, *g*) to which a piece of rubber tubing can be attached to carry the waste to a convenient receptacle. The doors are fitted with metal finger-pulls (fig. 43, *h*) for convenience in sliding, and two metal handles are attached at the top for lifting the box. The whole is painted inside and out with a dull black shellac. It stands on a small table, in which there is a hole to permit the passage of the drain-tube. I have found the most convenient height of the table for use with an ordinary chair to be 2 ft. In the field a box or two chairs serves very well for a support in place of the table.

When filling plate-holders, the box of plates and the holders are placed in the dark-box and all openings closed. The workman sits with his arms in the sleeves, which are pulled well on at the wrists, and fills the holders in perfect comfort.

In developing the plates, the plate-tank containing the developer, the plate-cage and the plate-holders are placed in the box as before. When the cage, containing the plates, is safely in the closed tank, the box can be opened until the developing is done, when the tank is returned to the box, where the developer is poured off through the drain (fig. 43, *c*). The plates are then washed in several changes of water, which is drawn from the faucet (fig. 43, *s*); then they can be taken to the light of the room and placed in the fixing-bath.

The box as described is a convenient size for use with 4 × 5 and 5 × 7 plates. With a 5 × 7 plate-tank it would be well to make the water-tank slightly larger.

(6) Miscellaneous.

Manual of Petrographic Methods.*—This book removes a long-standing reproach to English Petrography. It is, as is stated in the preface, "the first attempt to give in English a comprehensive review of petrographic methods." The author has abundantly realized his aim, and produced a book which, in our opinion, must long remain the standard book of reference on petrographic methods in the English language. It represents a colossal amount of literary research, which will be appreciated when it is stated that more than 130 periodical publications, in some half a dozen languages—mainly, however, in English, French, and German—are referred to. In addition, eight bibliographies are given at the ends of as many chapters, together with copious references in the form of foot-notes on nearly every page.

The first twelve chapters of the book are of a more or less introductory nature, dealing as they do with general and crystallographic optics; the action of the various optical elements used in petrographic research—more especially polarizing prisms—being very fully dealt with. The various forms of petrological Microscopes, too, come in for a good share of attention. Chapters XIII to XX deal principally with observations in

* By Albert Johannsen, Ph.D., Assistant Professor of Petrology, University of Chicago. New York and London: McGraw-Hill Book Co., Inc., 1914, xxviii. and 649 pp. (765 figs. in text).

ordinary as opposed to polarized light. The various methods that have been proposed from time to time for the determination of refractive indices, commencing with that of the Duc de Chaulnes (1767), and ending with the more modern methods of Schroeder van der Kolk, Pauly, De Souza-Brandão, Clerici, and Becke, are given in brief, as are also the various modifications of the method of Delesse for the determination of the volume percentage of the constituents of rocks by the measurements of areas and lines. No less than eight chapters, of more than one hundred pages—illustrated by remarkably good reproductions of plates from Dr. Hauswaldt's magnificent atlas entitled "Interferenzerscheinungen im polarisirten Lichte"—are devoted to the consideration of the examination of sections in plane, polarized, and convergent light. The work of Becke in determining the positions of the isogres in random sections, by making use of the curves of equal velocities (isotaques) and their orthographic projections (skiodromes), is dealt with. The measurement of the optic axial angle by the most approved modern methods receives satisfactory treatment in two well-illustrated chapters, as does also the determination of specific gravity in succeeding chapters. The final chapters deal with the mechanical separation of rock constituents; micro-chemical reactions; the cutting and preparation of thin rock sections, and petrographic collections.

Enough has been said, we doubt not, to convince English petrographers that Dr. Johannsen's book is one that cannot be dispensed with for their future work.

B. Technique.*

(1) Collecting Objects, including Culture Processes.

Trap for Free-swimming Organisms.†—Simply stated, this is an arrangement which cuts off the retreat of the creatures after they have been attracted into a small receptacle by light. The first trap used by the writer, S. C. Akehurst, was made of glass, in two pieces. The top is funnel-shaped, and holds about 5 oz. of water. This is attached to a horizontally-placed cylinder, 1 in. diam. and $1\frac{3}{4}$ in. long, the whole being mounted on a stem and foot. Into the cylinder is fitted a glass spigot, which has been ground in to avoid water passing. There is a hole at the bottom of the funnel flask which allows free access of the water to a small well in the glass spigot. When the trap is working, this well opens immediately under the hole at the bottom of the flask, and into this the organisms can enter freely. When desiring to fix the catch, give the spigot a slight turn—the mouth of the well then presses against the side of the cylinder and the contents become locked in.

To set the trap, fill the flask with pond-water, cover the entire

* This subdivision contains (1) Collecting Objects, including Culture Processes; (2) Preparing Objects; (3) Cutting, including Embedding and Microtomes; (4) Staining and Injecting; (5) Mounting, including slides, preservative fluids, etc.; (6) Miscellaneous.

† Journ. Quekett Micr. Club, xii. (1914) pp. 279–80 (1 fig.).

funnel-shaped flask with some light-proof material, and direct all the light that can be gathered by a bullseye on to the cylinder which contains the glass spigot. Any swimming phototactic organism in the water will at once react and pass into the well, which is brightly illuminated—usually 10 to 15 minutes is sufficient to allow for this, but longer time can be given if necessary. Give the spigot half a turn and, as already explained, this locks the creatures in the well. The water can then be poured off from the flask, the spigot withdrawn, and the rotifers, or whatever may have been trapped in the well, can be taken up with a pipette and transferred to the slide for examinatiom. After the

Fig. 44.

first catch has been taken the trap can be set again and a second lot secured. Work can therefore be carried on without interruption or loss of time until all the water has been dealt with. Should there be any sediment, this can be allowed to settle and then trapped off before any attempt is made to catch the organisms.

There is difficulty in obtaining this trap made in glass, so another has been worked out in metal (fig. 44). This consists of a round box, 1 in. deep, $3\frac{1}{4}$ in. diam., the top and bottom slightly convex, mounted on a tripod. A hole in the bottom allows the water to pass through a short tube, which is in three sections, the first part metal, the second rubber, and the third glass. A pinch-cock can be applied to the rubber connexion, which will prevent water passing when the glass tube has

been removed for examination of contents. The metal box to hold the water is now made almost flat, which will allow any sediment to settle at the bottom. If the water is very muddy, a cork can be fitted into the outlet hole and left until the debris has settled, first filling the tube with clean pond-water. If the cork is carefully removed, very little, if any dirt will pass down the tube. Should some slip by, this can be trapped off, and the tube refilled with water, when a perfectly clear gathering can be secured. A strainer is provided, to be used, when necessary, for removing larvæ or any of the entomostraca.

It is important that as much light as possible should be concentrated on the glass tube. To arrange for this a bi-convex lens, $1\frac{1}{2}$ in. diam., silvered on one side and mounted in a metal holder with a movable support allowing it to be tilted at an angle, is placed under the tube, light from a bullseye condenser is received by the lens, and a bright beam passed up the tube. This method of transmitting the light is very effective, and the trap in consequence acts more rapidly and effectively than when the bullseye condenser only is employed. The lens, placed in position, is shown in the illustration.

New Hæmoglobin-agar Medium for the Cultivation of Bacillus influenzæ.*—W. Thalhimer, having failed to obtain satisfactory growth of *Bacillus influenzæ* on crystalline hæmoglobin-agar, has devised a culture medium prepared with amorphous hæmoglobin, which has given encouraging results in his hands. The new medium is prepared as follows: Dissolve about 10 c.cm. of amorphous powdered hæmoglobin in 100 c.cm. distilled water and filter through a Reichel porcelain filter. Add a sufficiency of the filtrate to fluid agar to give it the colour intensity of ordinary blood-agar. The mixture is then poured into tubes and slanted. With regard to the failure of crystalline hæmoglobin, it is suggested that in the process of crystallization the hæmoglobin becomes so changed that it is no longer available for the growth of *B. influenzæ*.

New Method of Investigating Anaerobic Stab Cultures.†—Konrich recommends the following method of obviating the difficulties that usually attend the abstraction of culture material from "stab cultures," which not infrequently involve the breaking of the test-tube and the contamination of its contents. Seize the culture tube with a Cornet's forceps near the middle; remove the plug and flame the edge and upper part of the tube, which is then introduced between the two halves of a sterile Petri dish. Now hold the lower part of the test-tube for a moment in the Bunsen flame till some of the agar becomes liquid. The small portion of liquid agar becoming vaporized expels the agar column (just as the expansion of steam drives forward the piston of a steam-engine), which glides uninjured into the Petri dish, where it can be cut longitudinally or in cross-section and the culture material conveniently abstracted. During the expulsion of the agar hold the test-tube slightly

* Centralbl. Bakt., 1te Abt. Orig., lxxiv. (1914) pp. 189–90.
† Centralbl. Bakt., 1te Abt. Orig., lxxiv. (1914) pp. 191–2.

downwards. In old cultures, where the upper portion of the agar has adhered to the tube, the medium can be loosened with a suitable spatula.

The above method applies to agar and serum agar cultures (which do not stick to the tube). With gelatin cultures the test-tube should be held in warm water until the layer next the glass becomes melted. If the tube is then held steeply the culture column will often glide out into the Petri dish without further manipulation.

Demonstration of Streptococci in the Flowing Blood.*—S. Reichstein draws attention to the fact that bacteriological investigation in cases of septicæmia is often unsatisfactory, and suggests modifications in technique in order to bring about better results. His investigations were carried out on rabbits infected with *Streptococcus pyogenes*. The bleedings were made by means of aspiration of the jugular vein, which vein presents advantages over (1) the marginal vein of the ear, as the blood can be procured sterile and without producing thrombosis; and (2) the carotid artery, as repeated samples can be taken for purposes of continued research. The use of a medium-sized syringe is insisted on, as in the filling of a large syringe coagulation of the blood may take place. Samples of blood taken at varying periods were defibrinated or treated with oxalate solution or leech extract to prevent coagulation. The first method gave poor results on account of the organisms becoming entangled in the fibrin clot; the other methods, however, gave satisfactory counts on plating out. The blood samples were inoculated on to the surface of glycerin-agar, glucose-agar, and ascitic-fluid agar respectively, but no significant variation in the number of the resulting colonies was observed. Blood samples should be placed for twenty-four hours in the incubator previous to plating; if left at room-temperature the contained organisms may decrease in numbers or perhaps die out completely.

(3) Cutting, including Embedding and Microtomes.

Paraffin Ribbon-carrier.†—The carrier described by Robert T. Hance was designed to handle the paraffin ribbon as it comes from the microtome in such a way as to preserve a perfect series and to eliminate some of the difficulties encountered with the usual method. Not only is the old method of cutting long serial sections into short pieces and laying them upon a sheet of paper tedious, but the danger of losing a part of the sections in a sudden draught or having them hopelessly mixed is great. Without careful shielding, ribbons placed upon paper may not be allowed to lie for any length of time before mounting. With the use of the carrier long unbroken series may be wound on the drum and allowed to remain until used. The writer has allowed a ribbon to remain on the carrier for three days, exposed to all the draughts common in the average room, and at the end of the time was able to mount a perfect series with no difficulty. The inclined plane shown in the photograph

* Centralbl. Bakt., 1te Abt. Orig., lxxiii. (1914) pp. 209–23.
† Trans. Amer. Micr. Soc., xxxii. (1913) pp. 297–9 (2 pls.).

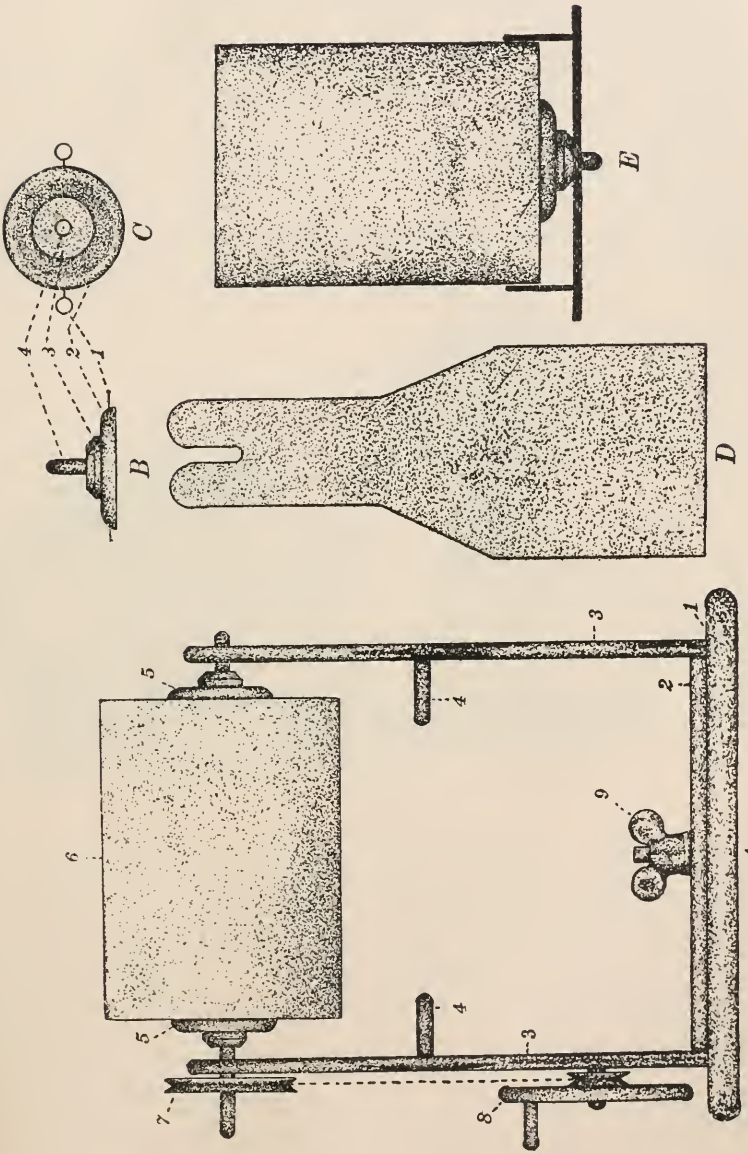

FIG. 46.

greatly facilitates mounting. The ribbon is unwound from the drum on to the plane, where it is cut to the desired lengths. The continuous ribbon does away with the bother of piecing bits together, as is frequently necessary when mounting from short strips laid on paper.

Directions for making. Material :—All the materials necessary for making the machine are easily obtained, and at slight expense. The wood used was poplar and yellow pine, taken from an old packing-box. A 1-lb. coffee-tin was made to serve as the cylinder or drum. *Dimensions* :—*1.* The base, $9 \times 6 \times \frac{1}{2}$ in. (fig. 46, A). A slot, $2\frac{1}{2} \times \frac{1}{4}$ in. (fig. 47, *10*), is cut in the centre to accommodate the winged nut (*9*), which fastens the uprights (*3*) to the base. *2.* The base to which the uprights are fastened, $7 \times 3 \times \frac{1}{4}$ in. A $\frac{1}{4}$-in. hole is bored in the centre of this base to pass the screw of the winged nut through. *3.* The uprights, $2 \times 3 \times \frac{1}{4}$ in. The width narrows 4 in. from the bottom to

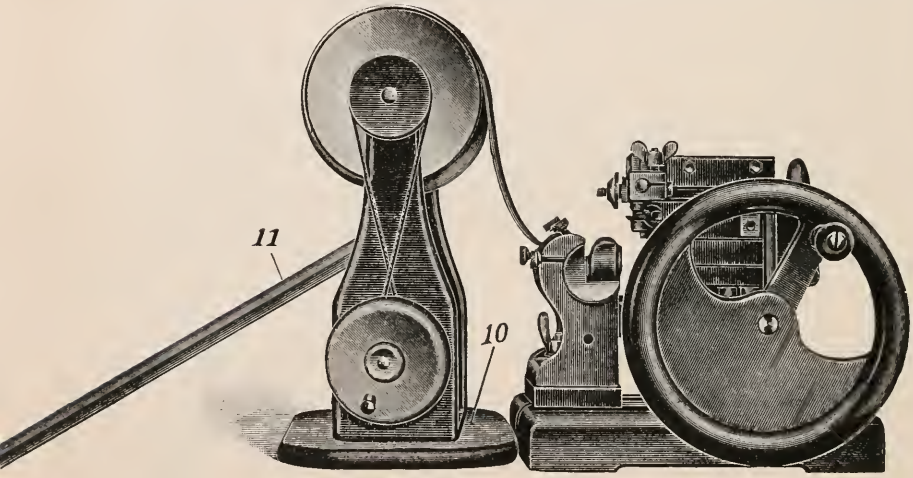

Fig. 47.

$1\frac{1}{2}$ in. Slots, $1 \times \frac{1}{4}$ in. are cut in the tops of the uprights (fig. 46, D) to accommodate the axles of the drum. The uprights were made for the Leitz Base Sledge Microtome, and though the height to which they raise the drum works very well with the rotaries, 2 in. might be cut from their length with advantage. *4.* These are pegs that are inserted $4\frac{3}{4}$ in. from the base to carry the inclined plane, shown in fig. 47, *11*. *5.* The axle support. This is a disk of wood $2 \times \frac{1}{4}$ in., through the centre of which a $\frac{1}{4}$-in. walnut axle is thrust. The end of a maple-spool is glued to the top of the disk to serve as a bearing (fig. 46, B *3*). *6.* The drum. The lid is soldered on to a 1-lb. coffee-tin, the measurements of which are 6×4 in. The can is covered with blotting-paper. This drum will carry about 14 ft. of $\frac{1}{2}$-in. ribbon. *7.* The drum pulley, $2 \times \frac{1}{4}$ in., and grooved as shown in the diagram. The belt runs from this pulley to one made by fastening the ends of a small spool together, and which is secured to the inner surface of the driving wheel. *8.* The driving

wheel, 3 × ¼ in. A handle is inserted in one side, as shown in the diagram, though very little use is found for it. *9.* Winged nut, ¼ in. in diameter. *10.* Slot, 2½ × ¼ in. (fig. 47), in which the bolt of the winged nut slides. This allows the adjustment of the drum to meet requirements. *11.* Inclined plane, 12 × 6¾ × ¼ in. At one end two pegs are placed to engage those shown in fig. 46, A *4*.

General Directions :—The only difficulty that will be encountered in the making of the carrier will be to fasten the axle supports squarely in the centre of the drum. Centring the axles may be easily accomplished by drawing a circle the exact size of the drum on a board, and then, after determining the centre, drill a hole the size of the axle (¼ in.) through it. Insert the axle into this hole (fig. 46, E). Drive long brads or nails at the periphery of the circle as shown in this fig. so as to hold the drum firmly in place when it is lowered. Coat the axle support with glue and press the drum tightly against it. The nails will hold the drum in place, and the axle will be in the exact centre of the cylinder. Glue may serve to fasten the axle permanently to the drum, but the author finds that it does not take a very firm hold of the tin and soon breaks away. This may be overcome by first placing small brads or screw-eyes (fig. 46, B *1*) in the sides of the axle supports and then gluing the disks on as directed above. After the glue has set firmly enough to hold the disks in place solder is run in under the screw-eyes and they are thus firmly fastened to the tin.

Directions for using :—Cut a ribbon from 8 to 10 in. in length and press one end lightly against the blotting-paper covering the drum. After this the ribbon is wound on the cylinder as it comes from the microtome (shown in fig. 47) by thumbing the edge of the driving wheel, which revolves the drum very slowly (the drum revolves once to every two and a half revolutions of the driving wheel). The winged nut allows the cylinder to be adjusted to the demands of the particular microtome in use. The ribbon is wound spirally upon the drum by sliding the carrier parallel to the knife. When ready to mount, the ribbon is unwound on to the inclined plane which is covered with blotting-paper and cut to the desired lengths.

(4) Staining and Injecting.

Viability of Dried Bacterial Preparations (Stained and Unstained).*—O. Thurn has investigated the effects of drying, and staining with different reagents, on slide preparations of various kinds of bacteria. The organisms principally used were micrococci, coli, typhoid, cholera, diphtheria, and yeast. Ordinary methods of drying film-preparations (including the usual rapid drawing three times through the Bunsen flame) had no effect on the viability of the bacteria. With regard to stained preparations, he found the Ziehl carbol-fuchsin stain killed most vegetative forms of bacteria, but spore-staining by Möller's method had no effect (*B. mesentericus* and *B. anthracis*). Acetic acid methylen-blue (Neisser's stain) prevented the growth of *B. diphtheriæ*,

* Centralbl. Bakt., 1te Abt. Orig., lxxiv. (1914) pp. 81–90.

and Gram's stain destroyed all vegetative forms of bacteria by virtue of the independent bactericidal action of anilin and iodin respectively.

Demonstrating the Structure of Mixed Nerves.*—S. W. Ranson used the human vagus nerve, and made sections some distance below the nodose ganglion. The steps of the technique were as follows :— The animal is exsanguinated and the desired tissue promptly removed and placed in absolute alcohol containing 1 p.c. strong ammonia for forty-eight hours, rinsed in distilled water, put in pyridin for thirty-four hours, washed thoroughly in distilled water for twenty-four hours, placed in 2 p.c. silver nitrate at 35° C. in the dark for three days, rinsed in water and placed for one day in a 4 p.c. solution of pyrogallic acid in 5 p.c. formalin. Paraffin sections are made. Medullated axons are stained yellow and are surrounded by a colourless ring of myelin. Non-medullated fibres are stained black, and are sharply differentiated from the light yellow endoneurium.

(5) Mounting, including Slides, Preservative Fluids, etc.

Method of Marking a given Object for Future Reference on a Mounted Slide.†—First find the object, says J. Burton, then with a fine camel-hair or sable brush carefully place a dot of water-colour over it large enough to be seen with the naked eye, set it on one side to dry. When dry put the slide on the turntable with the dot accurately in the centre and turn a ring round it with any dark cement you may have in use ; when this is hard the water-colour can be removed with a damp brush and the cover can be carefully cleaned with a piece of soft rag.

When the object is very small a more complicated variety of the foregoing plan is adopted. Again, first find the object with a suitable power such as $\frac{1}{4}$ in. or $\frac{1}{6}$ in., and let the specimen be as accurately placed in the centre of the field as possible ; then substitute for this power, preferably a water-immersion objective, say $\frac{1}{10}$, put on the front lens a small drop of water, and carefully focus. It is necessary that the slide should not be moved after contact is made, as it is desirable to keep the drop of water as small as possible. When the object is recognized as in the centre of the field, raise the Microscope tube rather sharply and a small circular spot of water will be left on the cover-glass right over the desired place. Now stain this spot with water-colour as in the other case—I always use the carmine kept for feeding infusoria, etc., but any colour will do. When this is dry the slide may be roughly examined and the object will be seen through the coat of colour, which for this purpose should not be too thick. If it be rightly placed, proceed as before, puting a fine ring of suitable size round the spot with some dark cement, and when this is dry carefully clean off the colour, and the arrangement is complete. Water-immersion lenses are not very commonly used now, and if the microscopist does not happen to possess one

* Anat. Anzeig., xlvi. (1914) pp. 522-5 (1 fig.).
† Journ. Quekett. Micr. Club, xii. (1914) pp. 311-12.

an oil-immersion may be used instead, but obviously it must be used with water, not oil ; but this will give a sufficiently good image for our purpose, which is merely to recognize the specimen for marking, not to examine it. If an oil-immersion be not available, any close-working objective, say $\frac{1}{8}$ in. or even $\frac{1}{6}$ in. may be used, but it is necessary that the front lens be a small one, so that the spot of water placed by it should be as local as possible.

There are, of course, some difficulties ; the chief is, that objects mounted in glycerin are somewhat liable to move if at all roughly handled, and may work out of the circle ; but with balsam or glycerin-jelly mounts, or even a shallow glycerin one, there is little danger of this. If a turn-table is not in the outfit of the experimenter, a sufficiently good circle may be drawn by hand, or a line drawn to indicate the position, or, as has been suggested, the barrel of a mapping pen or similar object may be used. But the first great difficulty is always to indicate the exact spot it is desired to mark, particularly if the object is a very minute one, and that is got over with facility by the method indicated.

Picking Out and Mounting Diatoms.—The art of selecting and picking out any considerable number of diatoms from a spread which contains a variety of species, and of arranging the selected diatoms successfully for mounting, appears to be attained by comparatively few persons. The methods by which successful results are secured are not generally known. Many workers are able to select a limited number of forms by the hand method of picking, but this method requires great concentration and nerve control. Among the difficulties to be surmounted, or at least allowed for, are the pulse beats that affect the hand, the high magnification making the pulsations quite apparent.

In 1895, J. M. Blake* devised an apparatus which overcomes many of the difficulties. This apparatus is a small pantograph made of light wire. It reduces the motion of the hand twenty-six times. It consists of a jointed parallelogram P made of No. 20 iron wire. This wire is flattened at the points where the rivets are placed. This parallelogram measures 5 in. on each side. Within this area, in one of its angles, is built a minute parallelogram twenty-six times smaller than *s*. This tiny parallelogram measures $\frac{3}{16}$ in. on each side. The apex of the larger outer form P is coincident with that of the small inner member *s*, and rotates on the same rivet. This rivet also passes through a short bit of wire, and on this wire P can be rotated in its own plane. This rotation gives P a horizontal motion, while the short bit of wire itself rotates in bearings which give an up-and-down motion at right angles to the plane of P ; P itself slips over and around the body of the Microscope. The short bit of wire referred to has its bearings held about $\frac{1}{4}$ in. above the stage of the Microscope. This leaves room for a glass slip $1\frac{1}{2}$ in. wide and 6 in. long to move underneath. A piece of sheet-tin is bent so as to form a clip to spring over the farther edge of the Microscope stage, and to this piece of tin the bearings of the short piece of wire are attached by supporting strips. In use the diagonally opposite apex

* Amer. Journ. Sci., xxxvii. (1914) pp. 535–8.

of P is to be held in the hand, and a short and finely pointed hair is attached by wax to the corresponding apex of *s*. This hair is the implement for picking up the diatoms, and points in a downward direction. The diatom spread is made on a cover-glass, and from this spread the selections are to be made. This cover-glass is attached by moisture to the first-mentioned slip of glass. The cover-glass to which the diatoms are to be transferred is also attached to this slip by wetting. The Microscope is inclined, and the slip of glass rests on the stage and slides on the top edge of a thin strip of wood, which also rests on the stage. This strip may be ½ in. wide and 1 ft. long. Attached to this strip of wood from below are two broader strips, which come level with the top of the stage and form a shelf or a rabbet along which the slip of glass can slide. This narrow shelf forms a lateral extension to the stage of the Microscope. Strips of wood attached by screws to the shelf from below bind it to the stage. These clamping pieces allow the shelf to be pushed up and down. The cover-glasses mentioned can also be pushed up or down on the glass slip, provided we preserve the moisture under them. The pantograph can be adjusted in position by slipping the tin clip on the Microscope stage. P is so arranged and adjusted that the point of the hair comes into the field of the Microscope. When it is desired to leave P for a time out of hand, a temporary support is provided so that the point of the hair is held just at the top of the field of view, but raised a little so as to be partly out of focus. When all the adjustments are completed, the working of the apparatus is as follows : The glass slip is moved along on its shelf to bring the spread into view, and the hair point is employed to loosen any desired diatom. This selected diatom is then picked up by the hair. In very dry weather electrical action often causes a good deal of trouble. Diatoms will sometimes suddenly jump out of the field. If we are successful in holding the diatom, it is then raised and the glass slip is moved to the position which brings the desired part of the reception cover into view, and the diatom is deposited at or near the desired place and worked about with the point until it is satisfactorily located. We now breathe upon the located diatoms through a flexible tube, which tube is attached in proper position for this purpose to the Microscope objective. Gentle breathing causes adhesion to the prepared cover-glass.

The preparation of the cover-glasses is as follows : The covers are cleaned so that liquid will flow freely over them without creeping. They are then dipped, while held singly in clean forceps, in filtered gelatin solution containing 10 gr. of gelatin and 5 gr. of sugar to the ounce. This is sometimes diluted to two volumes. The sugar may at times be omitted. We endeavour to adapt the gelatin solution to the atmospheric conditions at the time of coating. The gelatin itself may vary in quality. The aim is to make this coating sufficiently adhesive to hold the diatoms, and at the same time not to have it run in and obscure them. Contact with the fingers must be avoided. The covers are now stood on edge to drain and dry. Then a small central ring may be spun on them, and also a marginal ring to be mentioned later.

In this way any desired number of diatoms can be collected and

located. It is well to have an intermediate stamping ground for temporarily depositing the selected diatoms where they can be cleared from adhering fragments before finally locating them. It is important to have all these cover-glasses of the same thickness, so that no time will be lost in focusing as we pass from one to the other.

One difficulty in picking up from a diatom spread will be found due to adhesion to the glass surface. This adhesion is caused by dissolved silica, or by some other soluble substance which may come from the glass surfaces, or from the water in which the diatoms are suspended. This adhesion may be prevented in part, by repeated settlings from freshly distilled water ; but at the best, some of the more delicate shells will often break before they can be detached.

The author has recently tried a plan which promises to be a help in such cases. This plan is to grind down thin slips of baked pipeclay or similar material. This material is then finely surfaced and ignited to drive off moisture. These slips may be blackened by charring sugar solution, which can be soaked into them. They are then scrubbed in order to remove adhering particles, and again heated to drive off moisture. The diatom-spreading pipette is then drawn across the surface, and the liquid is at once absorbed before it has time to dry on the surface and cause adhesion of the diatoms. Porous arc-light carbon may be ground down thin and used for this purpose. Reflected light must be used over these opaque surfaces. A two-thirds objective will give sufficient working space, and the eye-piece should be an erecting one.

Monobromide of naphthalin has usually been regarded as a difficult mountant to make secure. Several of the monobromide mounts made by the author, however, in 1895 have kept in good order up to this date. For this reason it may be of interest to give some account of the method used in preparing them. They were sealed with gelatin. The refractive power of the unmixed monobromide used appears not to have suffered by lapse of time. Loss of refractive power has been reported to have occurred when a wax seal was employed. The glass covers that have been coated with thin gelatin in the way that has been described are next given a marginal ring, and the reception slide itself is also given a preparatory ring. This treatment secures reliable contact of gelatin and glass, as both gelatin rings are dried before the monobromide is applied. A binding ring of warm gelatin completes the adhesion of the two gelatin rings after the monobromide has been included. After this sealing ring has dried and has proved to be secure, and not till then, a final ring of shellac is applied. Any other cement that will resist the action of immersion fluids can be used in place of shellac. A recent sample of bleached lac has developed fine cracks on drying. The older slides did not show these cracks in the rings. The use of shellac is to protect the gelatin from damp.

The gelatin preparatory rings were composed of gelatin 20 gr., sugar 10 gr., and water 2½ drams. These preliminary rings need not be thicker than the height the diatoms make necessary. Experience has shown that these rings should be broad, and that the surfaces of contact

should be perfectly even. The final sealing gelatin ring may be made of more concentrated gelatin, rendered as thick by evaporation of a portion of the original preparation as will flow easily from the brush. The flow will depend to a great extent upon the temperature of the room. This gelatin seal can also be used for holding the solution of phosphorus in carbon disulphide when this solution is employed as a mounting medium.

(6) Miscellaneous.

Blocks.—For the loan of the blocks to figs. 34, 35, 36, 37, 38, 39, 40, 41 and 44, we are indebted to the Quekett Microscopical Club.

Metallography, etc.

Microchemistry of Corrosion.*—S. Whyte and C. H. Desch have made corrosion experiments upon four copper-zinc alloys of α composition, by a method substantially the same as that applied previously to β alloys.† All the alloys contained about 70 p.c. copper, the remainder being all zinc in one alloy, while the three others contained respectively 1 p.c. tin, 1 p.c. lead, and 2 p.c. lead. Corrosion appeared to proceed by dezincification in all cases; the loss of copper by corrosion, however, was greater than in the β alloys. The film of copper left was intimately mixed with basic salts, which adhered very firmly. Momentary immersion in very dilute hydrochloric acid removed the oxychloride, exposing the coppery layer, which was invariably made up of small crystals, mainly exhibiting octahedral angles. In the long-period tests etch-figures were conspicuously developed, cubic forms being frequently observed. The boundary between the brass and the dezincified (copper) layer was always perfectly sharp. In the brass surface, after the copper skin had been detached, the crystal boundaries were visible. The cored structure of an unannealed specimen was strongly developed during corrosion, finally leaving ridges in high relief, whilst the annealed alloys corroded very uniformly. When the adherent layer was detached from the alloys containing lead, each isolated mass of lead was seen surrounded by a ring of copper. The micro-structure of some corroded condenser tubes, which also showed pronounced dezincification, is described.

Vanadium in Brass.‡—R. J. Dunn and O. F. Hudson have made a thermal and microscopic examination of copper-zinc alloys containing 50 to 60 p.c. copper and 0 to 1·5 p.c. vanadium. No tendency towards the structural resolution of β into α and γ was observed even after prolonged annealing. The authors conclude that the usual structure of brasses, containing between 50 and 60 p.c. copper, is not greatly modified by the presence of small quantities of vanadium, and that vanadium to the extent of at least 1 p.c. appears to have no influence on the structural stability of the β constituent of the copper-zinc alloys.

Muntz Metal.§—In the course of a study of the properties of 60/40 brass after various heat-treatments, J. E. Stead and H. G. A. Stedman have examined numerous specimens microscopically. Long continued annealing at temperatures below 470° C. had the apparent effect of increasing considerably the volume of the α phase at the expense of the β.

* Journ. Inst. Metals, xi. (1914, 1) pp. 235–51 (6 figs.).
† See this Journal, 1914, pp. 220.
‡ Journ. Inst. Metals, xi. (1914, 1) pp. 151–68 (22 figs.).
§ Journ. Inst. Metals, xi. (1914, 1) pp. 119–50 (38 figs.).

It is suggested that the α constituent thus produced contained less than 62 p.c. copper. J. E. Stead describes a method for distinguishing the α, β, and γ phases in brass. Polishing is finished on a very wet block. The surface of the specimen is dried with a clean linen rag before the water has evaporated at all. The specimen is heated to 80–100° C., rubbed with chamois leather and floated on molten tin or lead. A gaseous mixture made by blowing air through dilute ammonium sulphide solution is directed on the polished surface until the desired tints appear. The α constituent passes through the range of colour, dark yellow, brown, carmine, blue, to slate-grey. The γ constituent when associated with α remains unaltered, and appears white on the coloured ground. The method may be used for detecting variations in distribution of copper in the α phase, since it is capable of developing the primary dendritic structure. For distinguishing β and γ when they occur together, air containing traces of bromine instead of ammonium sulphide may be used.

Structure of Electro-deposited Copper-tin Alloys.*—In the course of an investigation upon the electro-deposition of copper-tin bronzes, R. Kremann, C. T. Suchy, J. Lorber, and R. Maas have studied the micro-structure of the deposits. Alloys deposited from cyanide electrolytes were more uniform than those from a tartrate electrolyte.

Annealing after Quenching of Copper-tin and Copper-zinc Alloys.† A. Portevin has quenched and annealed a copper-tin alloy containing 80 p.c. copper and a copper-zinc alloy containing 58 p.c. copper. The bronze was quenched at 700° C., the brass at 825° C.; in each case some of the α constituent was dissolved in the apparent β upon heating, and retained structurally in the β by quenching. On reheating to temperatures which were raised in successive experiments, the α separated from the β in the form of needles, or at the grain boundaries. The needles produced the appearance of the Widmannstätten structure. The first effect of reheating the quenched alloys was to increase the hardness somewhat; the hardness then fell off again as the annealing temperature was raised. The copper-aluminium alloys have been shown to behave in a similar manner.

System Silver-silver-sulphide.‡—C. C. Bissett has made a thermal investigation of the equilibrium of this system, and has examined twenty alloys microscopically. Between 17 and 94 p.c. silver sulphide the molten alloys separate into two liquids. Silver sulphide appears to be slightly soluble in silver in the solid state. The eutectic contains 99 p.c. silver sulphide. No compounds in addition to the Ag_2S were found. Two etching reagents were used; hot potassium cyanide solution etched the sulphide without attacking the silver, while freshly prepared hot ferric sulphate solution etched the silver without attacking the sulphide.

* Monatsh. Chem., xxxv. (1914) pp. 219–88.
† Comptes Rendus, clviii. (1914) pp. 1174–7 (4 figs.).
‡ Journ. Chem. Soc., cv. (1914) pp. 1223–8 (7 figs.).

Alloys of Aluminium and Silicon.*—C. E. Roberts has found by thermal methods that the aluminium-silicon system is a simple eutectiferous one ; this was confirmed microscopically. The silicon crystallized in plates arranged in five- or six-rayed stars.

Tungsten and Carbon.†—O. Ruff and R. Wunsch have studied the equilibrium of the tungsten-carbon system, and describe the microstructure of a number of alloys prepared by melting in the electric furnace. When more than 2 p.c. carbon was present, final polishing with any of the usual polishing powders was ineffective owing to the great hardness of the alloys ; these were polished on emery-paper only. The specimens were etched with a mixture of nitric acid, hydrofluoric acid, and water, and washed with water and sodium-hydrate solution to remove the tungstic acid formed. Pure tungsten showed sharply-defined polyhedra. With 0·12 p.c. carbon a eutectic was observed at the crystal boundaries. As the carbon-content increased more eutectic appeared, and at 1·43 p.c. carbon the specimen consisted wholly of a eutectic of typical structure. With more carbon massive carbide appeared, and at about 2·1 p.c. the alloy appeared to be wholly the carbide W_3C. A second eutectic appeared in alloys containing more carbon. The carbides found were W_3C (melting point over 2700° C.), WC, and probably W_2C. In all, three eutectics were observed, one of which appeared to be a metastable ternary eutectic.

Copper-aluminium-nickel Alloys.‡—A. A. Read and R. H. Greaves have determined numerous properties of two series of alloys containing 5 and 10 p.c. of aluminium respectively. The nickel in each series ranged from 0 to 15 p.c. ; the remainder was copper. The authors find that of the typical α and β constituents of the copper-aluminium alloys the α certainly, and possibly the β, will dissolve nickel without change in appearance. In addition to these, two other constituents were met with : A, in the 10 p.c. aluminium series, a greyish-blue constituent which appears in the slowly-cooled metal at 5 p.c. nickel, but is suppressed by quenching up to 7·5 p.c. nickel ; with 10 p.c. and more it forms primary crystals which are not removed by quenching. B, in the 5 p.c. aluminium series : a constituent which in the slowly-cooled metal first appears at 5 p.c. nickel, but which is suppressed by quenching from 900° C. until the nickel exceeds 10 p.c. As a secondary constituent this etches brown or bluish, but with 15 p.c. nickel what is probably the same constituent forms primary dendritic crystals of a clear blue colour, persisting after quenching. The authors incline to the opinion that A is a nickel-aluminium compound, and B a copper-nickel solid solution (probably containing aluminium). The etching reagent generally used consisted of four parts of a solution of ferric chloride in water (1 : 12), and one part of concentrated hydrochloric acid.

Neumann Lines.§ — In examining specimens of steel containing 0·05 to 0·10 p.c. carbon, broken from a partially-rolled ingot, Matweieff

* Journ. Chem. Soc., cv. (1914) pp. 1383–6 (5 figs.).
† Zeitschr. Anorg. Chem., lxxxv. (1914) pp. 292–328 (19 figs.).
‡ Journ Inst. Metals, xi. (1914, 1) pp. 169–213 (28 figs.).
§ Rev. Métallurgie, xi. (1914) pp. 766–70 (7 figs.).

has observed straight lines, oriented in several directions, in the polished surface, after etching with 2 p.c. nitric acid in alcohol. The lines were considered to be Neumann lines. H. le Chatelier suggested that they originated during polishing. When a grain of emery scratched the surface in a direction identical with one of the cleavage planes of a particular crystal, twinning occurred in that crystal along the track of the scratch. Such lines would be interrupted where the scratch crossed a crystal of different orientation. A twinned layer formed in this fashion would be a Neumann lamella. The author has examined the specimens after deep etching and considers that the results confirm the truth of Le Chatelier's suggestion. It was found that the lamellæ were in relief and were cubical in transverse section.

A. Portevin and J. Durand * have found some exceptionally large crystals in the outer layers of a decarburized rail. A polished and etched section showed bundles of Neumann lines in the coarsely crystalline region. A very large crystal seen in the fracture, with one perfectly plane face (a cleavage face) was cut out for examination. The cleavage face was polished and deeply etched, and then showed very numerous Neumann lines. Out of the six possible different planes in which Neumann lamellæ can occur in one crystal, according to Osmond and Cartaud, five could be detected in the crystal examined. The authors point out that the so-called Neumann lines described by Matweieff (see above) appeared to be oriented in at least eight planes in one crystal. It is suggested that some of those lines were merely lines of cold-work caused by scratching during polishing. By re-polishing after deep etching it can be shown that Neumann lines are hollow grooves and are not in relief. The authors doubt whether Neumann lamellæ can be produced by the action of emery in polishing, and point out that the mode of preparation of Matweieff's specimens—by breaking under the hammer—is capable of developing a network of Neumann lamellæ, which are readily produced by mechanical shock.

Volume Changes of Steel in Quenching.† — M. Oknof has determined the specific gravity of seventeen steels, containing 0·08 to 1·67 p.c. carbon, after various heat-treatments, such as quenching from different temperatures. A number of the specimens were examined microscopically. Repeated quenchings of the hypereutectoid steels brought about decomposition of the cementite and a consequent progressive increase in volume, which masked the increase in volume due to hardening by quenching. The temper carbon formed was visible in polished sections, but not readily seen in the quenched specimens after etching, owing to the dark colour of the martensite and troostite. In the same specimens, after annealing, the temper carbon was readily visible within the pearlite ; in some cases each mass of temper carbon was surrounded by a ferrite envelope.

Structure of Hardened Steel.‡—H. Hanemann and E. H. Schulz discuss the changes in volume and form which occur in the hardening of

* Rev. Métallurgie, xi. (1914) pp. 771–9 (15 figs.).
† Ferrum, xi. (1913–14) pp. 1–12 (13 figs.).
‡ Stahl und Eisen, xxxiv. (1914) pp. 399–405, 450–7 (24 figs.).

steel, and the effect upon structure of the stresses set up by the volume changes. The results of quenching and annealing experiments upon seventeen steels, containing 0·09 to 1·2 p.c. carbon, are given. To avoid the laborious sectioning by grinding of quenched pieces, some of the specimens were cut in two before hardening, the cut faces were polished and placed in contact, the pieces were fastened together with wire, and the joint luted with sodium silicate. The compound piece was readily divided after heating and quenching. The formation of an outer ring of martensite, surrounding osmondite in which martensite particles are embedded in the form of an inner ring, is explained.

Iron-titanium Alloys.*—J. Lamort has studied the iron-titanium system in the range 0 to 24 p.c. titanium. Up to about 6 p.c. titanium the alloys consisted of crystals of a solid solution ; beyond this concentration a eutectic, increasing in amount with increasing titanium content, was observed. At about 13·2 p.c. titanium the alloy consisted wholly of eutectic. A phase K, which is possibly the compound Fe_3Ti, then appeared, and increased, at the expense of the eutectic, with increasing titanium content. The alloy, containing 21·5 p.c. titanium, consisted chiefly of K, and contained very little eutectic. The etching reagents used were hydrochloric acid, concentrated and also in dilute alcoholic solution, and hydrofluoric acid. The duplex character of the eutectic, which consisted of the saturated solid solution and the phase K, is clearly shown by the photomicrographs. Inclusions of rod or cube form, yellow or reddish-yellow in colour, were numerous, and were evident in polished unetched sections owing to their comparative hardness. They were shown to be nitride or nitro-cyanide of titanium. The structure of some samples of commercial ferro-titanium is described.

The 4·3 p.c. Carbon Eutectic.†—J. E. Fletcher discusses the manufacture, properties, and structure of cast-iron. Commercial cast-irons are regarded as modifications of the 4·3 p.c. carbon eutectic (white iron), which may be considered as the natural form of pure cast-iron. The modifications occur through the addition of silicon, manganese, or other elements, or because of peculiarities in the processes of manufacture.

Influence of Carbon and Silicon in Cast-iron.‡—F. Wüst and K. Kettenbach have determined the mechanical properties and studied the microstructure of a large number of pure cast-irons containing varying amounts of carbon and silicon. Grey cast-iron may be regarded as a carbon steel, the structure of which is mechanically interrupted by graphite crystals. The mechanical properties of grey cast-iron are essentially dependent upon the amount and form of the graphite. Changes in carbon and silicon content influence the mechanical properties chiefly through their effect on the amount and form of the graphite. Increase in carbon and silicon causes an increase in the size of the graphite flakes. The best mechanical properties are obtained when the graphite exists largely in the form of temper-carbon.

* Ferrum, xi. (1914) pp. 225–34 (37 figs.).
† Foundry Trade Journal, xvi. (1914) pp. 278–84 (15 figs.).
‡ Ferrum, xi. (1913–14) pp. 51–4, 65–80 (20 figs.).

Influence of Manganese in Cast-iron.*—F. Wüst and H. Meissner have investigated the mechanical properties and the microstructure of forty samples of grey cast-iron, falling into four series containing respectively 2·8, 3·1, 3·3, and 3·9 p.c. carbon, the manganese in each series ranging from about 0·2 to 1·5–2·5 p.c. The silicon content was about 1·6 p.c. Examination of large unetched sections at low magnifications indicated that the proportion of primarily-separated mixed crystals increased with increase of manganese. Thus the solid solubility of carbon in iron containing silicon at the temperature of solidification is raised by manganese, and the amount of the ledeburite eutectic is diminished; the size of the graphite flakes is also reduced. Graphite was found in two forms, lamellæ and small rounded inclusions which had apparently been formed in the temperature interval between final solidification and Ar_1. The pearlite was finer in structure as the manganese increased. The amount of graphite formed increased with increase of manganese up to 0·3 p.c., but further increase of manganese up to 2·5 p.c. had no further influence on the graphite content. The amount of ferrite diminished with increase of manganese.

Meteoric Iron.†—An account of the examination of a meteorite which fell at Winburg in 1881, by W. A. D. Rudge, includes a description of the microstructure. The specimen consisted essentially of iron containing about 7 p.c. nickel. It was formed of a mass of large ferrite crystals with veins of nickel-iron alloy running through, and with flakes and crystals of nickel-iron alloy disseminated throughout the mass. The details of the microstructure were most clearly developed by heat-tinting. The structure was considerably altered by annealing at 800° C.

Solidification of Metals.‡—C. H. Desch summarizes present knowledge on the subject of the earlier steps in the crystallization of metals from the liquid state. The summary is divided into the following sections; (1) the cellular structure of metals; (2) crystallization from centres and the formation of crystallites or crystal skeletons; (3) foam structures, and Quincke's hypothesis; (4) cellular structures in cooling liquids; (5) liquid crystals; (6) the influence of surface tension; (7) undercooling and the existence of a metastable limit; (8) changes of volume on solidification; (9) the thrust exerted by growing crystals. According to Quincke's hypothesis the first step in the process of crystallization is the separation of the liquid into two immiscible liquid phases. One of these, present in relatively very small quantity, forms the walls of "foam-cells" filled with the liquid present in greater quantity. Crystallization then proceeds within the foam-cells and is largely influenced by them. The crystal grain boundaries are the foam-cell walls. The author points out serious objections to Quincke's foam-cell hypothesis. Attempts have been made to connect the cellular structure of metals with a remarkable partitioning sometimes observed in cooling liquids. This effect, visible as geometrical patterns on the liquid surface, appears to be due to con-

* Ferrum, xi. (1914) pp. 97–112 (24 figs.).
† Proc. Roy. Soc., Series A, xc. (1914) pp. 19–25 (7 figs.).
‡ Journ. Inst. Metals., xi. (1914, 1) pp. 57–118 (9 figs.).

vection currents. It is probable that surface tension plays a part in determining the external form of metallic crystallites. The programme of experimental work proposed includes the microscopic examination during crystallization, of small masses of metals of low melting point, melted on an electrically heated Microscope stage, and covered by a thin cover-glass of transparent silica. The numerous references given form a useful bibliography.

Processes of Solidification and Grain Growth in Metals.*—F. Robin discusses the crystallization of metals from the liquid state and the phenomena observed during solidification and during the growth of metal crystals in the solid state. The results of a considerable volume of experimental work are reported. The observations of hot metals were made through the long-focus binocular stereoscopic Microscope previously described by the author. In a pure metal the solid surface, immediately after solidification, is smooth like the liquid surface, while crystallites may form in less pure metals. Then two systems of lines forming networks appear: (1) the crystal boundaries; (2) Cartaud's cellular network. All these lines are below the general level of the surface. On remelting, the network of crystal boundaries is the first to melt, and the level of the lines rises to that of the surrounding surface. The possibility of amorphous solidification followed by crystallization is suggested. Experiments on tin and lead have indicated that when a metal solidifies undisturbed by external mechanical influences the resulting structure is very stable and persists unchanged during reheating until the metal melts. Cartaud's cellular network is regarded as a contraction effect caused by a general shrinkage of the metal at the instant at which solidification is complete. Surface tension is an important factor in the growth of crystals on annealing.

Metallographic Laboratory.†— H. Hanemann states briefly the necessary requirements in the outfit of a metallographic laboratory.

* Rev. Métallurgie, xi. (1914) pp. 489–512 (21 figs.).
† Stahl und Eisen, xxxiv. (1914) p. 153.

MICROSCOPY.

A. Instruments, Accessories, etc.*

(1) Stands.

Binocular Microscopes.—F. E. Ives, F.R.M.S., of New York, has drawn our attention to a form of binocular Microscope which he invented in 1902, which would appear to foreshadow the new types of binoculars now being placed upon the market. Ives' design was described in our Journal, 1903, p. 85, but it does not appear that it has been placed in the hands of the public. Conrad Beck informs us that he had not seen or heard of this instrument, or he would have included a description of it in his paper on Binocular Microscopes, although his paper was only intended to describe the better known types. The optical design of Ives' binocular consists of a cube of glass composed of two right-angle prisms cemented together with a partially silvered surface at their cemented junction, and a right angle reflecting prism on one side to receive the beam of light which is reflected from the partially silvered surface. This right-angle prism is made very thick in order to equalize the optical length of the parts of the two beams in a similar manner to that of the Leitz left-hand prism.† The chief difference between the design of the Ives' binocular and that of the Leitz or Beck lies in the fact that this side prism is provided with an adjustment to vary the angle of the two beams of light which enter the two eyes in order to vary the interocular distance, whereas the angle of the other instruments is fixed and the interocular distance is varied by mechanical means, the prisms being rigidly set so that they are permanently in adjustment. The draw-tubes of the two eyes in the Ives' instrument are not connected, and to adjust the tube-length each tube is pulled out separately, presumably to some fixed scale on each tube.

(4) Photomicrography.

Scheffer's Mirror-reflex Camera for Photomicrography; Scheffer's Microscope-table for Subjective Observation and Photography.‡—In 1909 E. W. Scheffer described § the original form of his mirror-reflex camera. His experiences with the apparatus have suggested certain

* This subdivision contains (1) Stands; (2) Eye-pieces and Objectives; (3) Illuminating and other Apparatus; (4) Photomicrography; (5) Microscopical Optics and Manipulation; (6) Miscellaneous.

† See this Journal, 1914, p. 7, pl. 1.

‡ Zeitschr. wiss. Mikrosk., xxxi. (1914) pp. 84–96 (6 figs.).

§ See this Journal, 1909, p. 648.

improvements, and the new form of the instrument has certain advantages which he considers adapt it for undertaking the most difficult tasks in the best way.

His Microscope-table is intended to give facilities for the ready photomicrography of any important detail when found, and for the immediate resumption of subjective observations. He gives full details of both pieces of apparatus.

Obtaining Density in Photo-micrography.*—One of the chief difficulties, says C. F. Emeny, met with in photomicrography is—judging from the number of weak examples one sees, the product evidently of thin negatives—the securing of sufficient density in the negative so as to yield a print showing enough of contrasts to produce a pleasing effect; and in this article it is proposed to attempt to show how improvement may be secured. Let it be understood, however, that mechanical and microscopical conditions are assumed to be correct, and that only the photographic aspect is being considered.

Lack of density may be due to several causes, such as under-exposure, unsuitable developing agent, or unsuitable brand of plate—especially the use of a non-orthochromatic plate on an object more or less yellow in colour or put up in a more or less yellow medium. By the use of an orthochromatized plate of medium speed such as the "Imperial Non-filter," density is easily obtainable, always provided that sufficient exposure is given to allow the developer to give a good deposit of reduced silver in the film.

The choice of a suitable developer is a very important factor, and to the use of an unsuitable one may be ascribed much of the "lack of density" trouble. Amateur photographers are, from text-books and other sources, led to believe that the process of development is more or less automatic; but, while this may be to some extent true, it yet remains a fact that negatives of the requisite contrast and density are much more likely to be secured if thought is expended and care employed in the selection and use of a developer that will give the result sought for.

Two plates of the same subject and with identical exposures can yet be made to produce widely differing results—one a flat, dead picture, and the other a print full of brilliance and life, and this simply by the use of different developers. Metol-Hydroquinone developers (M.Q.) should never be employed where negatives giving brilliant results are desired; but the pyro-soda developer will be found much more satisfactory for the purpose, and if it is compounded according to the appended formula will be found to be practically non-staining.

Pyro-soda gives a negative having a deposit of far greater light-stopping properties than does the M.Q., and if two plates are developed to the same degree of *visual* intensity—one with each developer—the pyro-developed negative will be found to give a much more brilliant print than the other owing to the yellower and less actinic *colour* of the deposit in the film (quite apart from any question of *stain*); the M.Q.

* Journ. of Micrology, 1914, pp. 57–8.

developer gives a deposit of a bluer colour which allows the light to pass much more readily.

Then arises the important question of exposure. The action of the developer reduces to a metallic state the sensitive salts of silver present in the film which have been rendered reducible by the action of light: hence, in order that the developer may do its work efficiently, and reduce the requisite amount of silver, the exposure must be generous enough to allow full scope to the developer. If too little is given, no amount of prolonged development can make up the shortage, for, in other words, density and detail are settled by the exposure, and development simply makes visible the action of light.

With regard to any difficulty in securing density with high magnifications, it must be remembered that the plate used is not concerned with size of image, but with light-action only, so that if owing to high magnification, the light reaching the plate is dim, *sufficient exposure* must be given to compensate for the slow action of what light is passing. Even if exposed to so poor and slow a light as the red lamp of the dark-room *for a sufficient length of time*, full density (light-fog) will be obtained on any plate by development.

PYRO-SODA DEVELOPER.

(A)	Pyrogallic acid—crystals	1 oz.
	Potass. Metabisulphite	1 dram
	Potass. bromide	1 „
	Water to	80 oz.
(B)	Sodium carbonate—crystals	8 oz.
	Sodium sulphite	8 „
	Water to	80 „

To develop: take equal parts of each. Used at a temperature of 70° F. full density will be obtained in five minutes if the exposure has been correct.

Strong prints may sometimes be secured from thin negatives by making them on "gaslight" paper, though at the expense of "blocked shadows"; but it is far preferable to aim at the perfect negative, for then all is plain sailing. For photomicrographic prints "Enammo" paper is all that can be desired.

(6) Miscellaneous.

Possible Methods of Ruling used by Nobert.*—Nobert's ruled test-lines at one time, says John M. Blake, were the subject of much interest and discussion. They were regarded as marvels of mechanical skill. The rulings designed and used as a test of the performance of microscopic objectives were looked upon as the most wonderful of his productions.

It has been stated that, after his death, an investigation of his apparatus did not reveal his method of work. Possibly the apparatus

* Amer. Journ. Sci., xxxviii. (1914) pp. 147–8.

which he actually used appeared to the investigator so crude, and so far from what preconceived notions of what such an apparatus should be, that it was passed by as unworthy of notice.

The late William A. Rogers of Cambridge (Mass.) devoted much time and thought to the shaping of diamond points and edges for ruling purposes, and had much success in ruling fine and close lines. He took a great interest in what had been done by Nobert, and made measurements of the latter's bands of lines. Rogers' observations were published in the Proceedings of the American Academy of Arts and Sciences.

At that time the writer was interested in Roger's work, and it struck him forcibly that Nobert's bands could not have been ruled on a machine like that used by Rogers. Quite a different principle must have been employed. The writer went so far as to plan out an apparatus involving the supposed principle. This apparatus he hoped some time to make and put to the test. Its main features will be described, for we will assume that some interest in these rulings still remains, and that no better explanation of a method of ruling such bands of lines has yet been published.

The proposed method dispenses with all sliding ways, joints, and screws. The ruling point is to be held by a light spring bar, its motions controlled by electro-magnets ; and the spacing of the lines accomplished by change of temperature of bars of dissimilar metals at measured time intervals.

In carrying out these conditions, a chronograph cylinder would be used with contact points suitably disposed on its surface. Provision would be made for heat storage in a medium surrounding the machine. This apparatus would be placed in a room that could be kept at a constant temperature.

With this much provided, a preliminary trial of the ruling apparatus would be made, and a line ruled at each revolution of the chronograph cylinder during the fall in temperature. These preliminary lines would be expected to diminish in distance apart from the beginning to the end of the selected time interval, and they would afford the data for calculation and measurement by which the final working electric contact-points could be located. Success would depend upon the possibility of repeating the temperature conditions, provided the chronograph worked with precision.

The ruling point is a vital part of the apparatus. Rogers' experience tended strongly to the use of ground and shaped points and edges. It is expected, however, that, with the light pressure needed in ruling these short bands covering a very small area, and with the pressure controlled by a very light spring, a suitable working point might be selected from minute chance-broken fragments of diamond. A very delicate point might remain intact for a long time, since no heavy moving parts would be involved as in a ruling machine.

The errors in spacing and the curvature of the lines on a Nobert diffraction grating were revealed by placing two photo copies so that the film surfaces were in contact, and the lines on the two made nearly parallel. Shaded irregular bands were thus produced indicating the

errors in spacing. The writer has described this method in this Journal, July 1874.

These errors had apparently no periodicity such as would be expected to result from the screw motion on a ruling machine of the ordinary type. It also became apparent that the lines were curved, and it was estimated that the radius bar or spring-pole holding the ruling point was approximately eight feet in length.

We can see that this gives an insight into Nobert's methods; and the inference is that his most delicate ruled bands did not require the use of a screw or a sliding mechanism. The curvature of lines shown in his rulings would result from the ruling point being carried by a spring. The diminishing depth of ruling as the closest lines are approached may have been accomplished by placing the ruled surface in an oblique position rather than by a diminished magnetic pull on the spring carrying the diamond.

The indications are that in ruling his finest bands of lines, Nobert depended entirely upon changes of temperature through measured time intervals to give the required spacing.

B. Technique.*

(1) Collecting Objects, including Culture Processes.

Simple Method of Preparing Tissue-cultures.†—E. C. Rosenow recommends the following procedure for the bacteriological examination of pathological tissues. While in most infections, the investigation of normal body fluids and pathological exudates by the familiar laboratory methods give satisfactory results, in the case of extirpated lymphatic glands in Hodgkin's disease, the tissues in rheumatoid arthritis or arthritis deformans, gastric ulcers, and so forth, the ordinary methods of technique are not reliable, and the emulsification of the tissues under absolutely sterile conditions becomes necessary.

The apparatus consists of a metal drum, 23 by 19 cm., with a circular opening at one end, through which a long-sleeved thick-woven glove, lined with cotton-wool, is introduced and attached to the margin of the opening. On the upper surface of the drum a mica window is let in, for observation purposes, and at one side a round opening 2·5 cm., corked with cotton wool, is made. This opening is used for the purpose of introducing and abstracting material. The drum also contains a fixed shallow bowl, pestle, forceps, scissors, and test-tube. The whole apparatus is sterilized for an hour at 160° C. before use.

The aseptically removed pieces of tissue for examination are superficially sterilized by passing through the Bunsen flame, or by plunging into boiling water, and are then placed in sterile salt solution. The

* This subdivision contains (1) Collecting Objects, including Culture Processes; (2) Preparing Objects; (3) Cutting, including Embedding and Microtomes; (4) Staining and Injecting; (5) Mounting, including slides, preservative fluids, etc.: (6) Miscellaneous.

† Centralbl. Bakt. 1te Abt., lxxiv. (1914) pp. 366–8.

right hand is now slipped into the glove, the tissue introduced and cut in pieces with the scissors, the fragments dropping into the shallow bowl. These small pieces are then ground up, salt solution or bouillon added, and the material again macerated. The resulting emulsion is then drawn up by a sterile pipette through the lateral opening, and inoculated into various media, as required. For the crushing of larger tissue masses a special apparatus can be adapted, and various modifications of technique can be made to suit individual circumstances.

Egg Agar.*—A. Besredka and F. Jupille recommend the employment of "egg agar" as a culture medium for the rapid development of refractory organisms, such as the gonococcus, the bacillus of whooping cough, the pneumococcus, the meningococcus, etc.

The technique employed consists in adding 4 c.cm. of egg-broth to ordinary agar, contained in roux bottles. Before use the medium should be placed over night in the incubator, in order to complete the impregnation of the agar by the broth.

All the organisms mentioned exhibit luxuriant growth at the end of twenty-four hours, on this medium (with the exception of the bacillus of whooping cough, which requires forty-eight hours for satisfactory development). Tubercle bacilli (human and bovine) commence to grow after two days, and by the eighth day the surface of the medium is covered with innumerable granulations.

Cultivation of Human Tumour Tissue in vitro.†—D. and J. G. Thomson have succeeded in cultivating human tumour tissues in media composed chiefly of fowl-blood plasma. This is contrary to previous conceptions, as it was considered that the tissue of a certain animal could only grow in a medium composed of the blood-plasma of the same species of animal. The authors succeeded in cultivating papillomatous ovarian tissue in a medium composed of fowl-plasma 1 part, Ringer's solution (containing 0·5 p.c. of glucose) 1 part, and an extract of the tumour in Ringer's solution 1 part. On the third day of incubation at 37·5° C. definite growth appeared, which had increased considerably by the eighth day. The proliferation, like the original growth, consisted entirely of epithelial cells. Similarly, portions of carcinomatous gland grew most successfully in a medium composed of fowl-plasma 1 part, extract of embryonic chick 1 part. In this case the proliferation also resembled the original tissue, i.e. epithelial and connective tissue.

Estimation of Gas produced by Gas-forming Bacteria.‡—J. Cunningham suggests a method of estimating gas production by bacteria on a quantitative basis, with the employment of only very small quantities of sugar media. This is a matter of some importance when dealing with the higher priced sugars, such as dulcite and sorbite. The apparatus consists of a U-shaped pipette with limbs of unequal length, the long

* Ann. Inst. Pasteur, xxviii. (1914) pp. 576–8.
† Proc. Roy. Soc., Series B, lxxxviii. (1914) pp. 90–1 (1 pl.).
‡ Ind. Journ. Med. Research, i. (1914) pp. 735–40 (3 figs.).

limb being a capillary tube, with a small bulb (0·25 c.cm. capacity) in its upper part about 3 in. from the top of the tube. The short portion of the long limb above the bulb may be calibrated, and the long portion below the bulb should have an external diameter of about $\frac{1}{8}$ in. 0·25 c.cm. of the sugar medium is drawn up by teat-suction, followed by 10 c.mm. of a 24-hour culture of the gas-producing organism. The mixed fluid is so arranged that it occupies the glass bulb, its proximal end coming to lie at the commencement of the long portion of the capillary tube. The end of the pipette is then sealed, and the apparatus is placed in the incubator in the vertical position. As gas is formed during incubation, so the column of fluid is displaced downwards, and by careful marking of the level of the fluid at different times, the volume of gas evolved can be calculated.

Inset Absorption Appliance for the Test-tube Culture of Anaerobes.*—R. M. Buchanan has devised an inset absorption appliance for the test-tube culture of anaerobes which obviates many of the disadvantages incidental to the ordinary use of pyrogallic acid and potassium hydroxide for this purpose. The device consists of a short inset tube (30 by 13 mm.), with the lower end sealed round a shorter and narrower tubule (20 by 3 mm.), which extends upwards in the centre as a vent. The upper end is fitted with a rubber stopper, which also suspends the inset tube in the tube containing the nutrient medium, and hermetically closes the latter tube. The approximate quantities of pyrogallic acid and potassium hydroxide to be used with this apparatus have been worked out as 0·25 c.cm. of a 40 p.c. solution of each reagent for every 10 c.cm. air space. The pyrogallic acid may also be used in tabloid form, which allows more time for manipulation. The method is equally effective for liquid or solid media.

Disinfectant Action of certain Bacterial Stains.†—A. M. Jansen has conducted an investigation into the question of the viability of bacteria under the action of some of the commoner laboratory stains. Aqueous solutions of methylen-blue or fuchsin have little or no bactericidal action, even in dilutions as low as 1 : 200. Aqueous solutions of gentian or crystal-violet (1 : 10,000 for 30 min.), on the other hand, show a marked disinfectant action on staphylococci but not on *Bacillus coli*. With regard to the action of staining reagents made up for laboratory use, it is concluded that organisms in slide preparations which have escaped destruction by drying and fixing, are not safe to handle when stained with methylen-blue, but are innocuous when stained with anilin-gentian-violet, Gram's stain, or strong carbol-fuchsin.

Use of Glucose-Nasgar for Restoring lost Pigment-producing Properties.‡—E. Emrys-Roberts has demonstrated the fact that stock cultures of *Bacillus prodigiosus* and *B pyocyaneus* which have lost their

* Centralbl. Bakt., 1te Abt., lxxiv. (1914) pp. 526-7 (1 fig.).
† Journ. Infect. Diseases, xiv. (1914) pp. 255-60.
‡ Journ. Path. and Bact., xix. (1914) p. 127.

capacity to form pigments, can have this function rapidly restored by growing for twenty-four hours on nasgar containing 1 p.c. glucose, and subsequently for twenty-four hours at room temperature. The pigment-producing property thus restored is, however, not transmissible to agar from the cultures on glucose-nasgar.

Isolation of Bacillus Diphtheriæ by means of a Simple Medium containing Potassium Tellurate.*—J. F. Smith has found the following medium to give better results in the isolation of *Bacillus diphtheriæ* than the original medium of Conradi and Troch:—sheep serum, sterilized by intermittent heating for one hour at 57° C. 5 c.cm.; 1 p.c. potassium tellurate solution in distilled water 1·5 c.cm.; pepton-water agar (neutral to litmus) to 100 c.cm. On this medium *B. diphtheriæ* forms opaque white colonies after twenty hours growth at 37° C. Diphtheroids (Hoffman bacillus, Ozæna diphtheroids, etc.) also grow well. Such other organisms as grow, generally show colonies darkened by reduced tellurium. Streptococci form minute discrete colonies and are easily recognized as such.

Modified Fermentation Tube and a New Medium for Gas-forming Organisms.†—J. W. Hall and F. Nicholls describe a modified fermentation tube for collecting the gas produced by bacteria. It merely consists in a funnel-shaped expansion of the lower or open end. They also recommend as a good medium for *Bacillus coli* neutral veal broth with 2 p.c. silk pepton and 5 p.c. lactose. They note that silk pepton facilitates the growth of colon bacilli in solid media, e.g. agar

Change of Form of the Tubercle Bacillus when grown on Sperm-oil and Glycerin-egg Medium.‡—A. H. Miller has found that the tubercle bacillus when cultivated on Dorset's medium (glycerin-egg) to which has been added a little sperm oil (a liquid wax) undergoes certain changes. It becomes plumper, longer, and its ends are pointed. It is beset with large acid-fast granules, the intervening portions being decolorized by the acid. To make the medium the sperm-oil is poured on to the beaten up and filtered egg, and glycerin in normal saline is added to the amount required. The mixture is then well shaken in a flask, poured into sterile test tubes, and set. Coagulation takes place in about three minutes, care being taken not to let the media rupture. It is then sterilized by steaming for about an hour on three successive days.

(2) Preparing Objects.

New Self-regulating Paraffin Bath.§—A very simple form of paraffin bath for embedding tissue for the microtome has been used by C. W. Woodworth in his laboratory for several months, and has proved

* Journ Path. and Bact., xix. (1914) pp. 122–4.
† Lancet, 1914, ii. pp. 741–3 (1 fig.).
‡ Lancet, 1914, ii. pp. 739–40 (3 figs.).
§ Univ. California Pub. (Zool.) xiii. (1914) pp. 39–42 (2 figs.).

exceedingly satisfactory, being very convenient and maintaining a uniform temperature (figs. 48, 49).

The apparatus is simply a glass flask about one decimetre in diameter heated by vaporized chloroform. The neck of the flask is a slender

FIG. 48.—The new paraffin bath in operation.

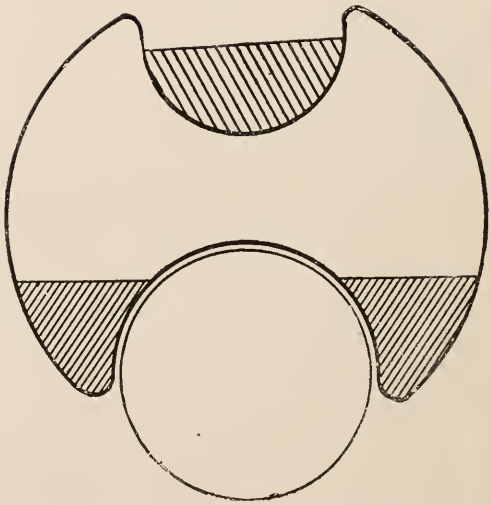

FIG. 49.—Cross section of paraffin bath shown in fig. 48. The shaded portion below near the electric lamp shows the chloroform; that in the cup above indicates the paraffin.

tube nearly a metre long, which ends above in a thistle tube-funnel for convenience in introducing the regulating fluid. A small quantity of chloroform is poured into the flask through the long neck. The heat from a sixteen candle-power electric bulb fills the flask with the vapour

of chloroform at its boiling temperature about 58° C., which is exactly right for the melting of the paraffin. Since the tube of the flask is open to the air, the temperature within cannot rise above that of the boiling point of the chloroform in air, which rises only slightly with the barometer. Practically all the chloroform is condensed and flows back into the flask.

A piece of cardboard may be placed over the flask to keep the dust out of the paraffin, and a towel is usually thrown over it to conserve the heat when warming up the bath. It takes about half an hour in a room at 16° C. to melt the paraffin. After it is once warmed up it maintains an invariable temperature, except on very cold days (5° C.)

The advantages of this new form of bath are :—1. Simplicity : the bath requiring no adjustment, and having no mechanical apparatus to get out of order. 2. Precision of regulation, since no variation of temperature in the heating medium occurs such as is necessary in an apparatus with a mechanical thermostat. 3. Illumination of cup : a convenience in handling the object in filtrating and an aid in keeping the cup clean. 4. Inexpensiveness, the cost of the whole equipment being not over 10*s*. 5. Safety, the heat being by electric lamp and the regulating fluid being non-inflammable.

Improved Method of Cleaning Diatoms.*—Diatoms, says John M. Blake, are microscopic organisms near the dividing line between animals and plants. It is important for our purpose that they have siliceous skeletons which take on very many symmetrical and beautiful shapes. The chlorophyll and organic matter with which they are associated can be destroyed by strong acids, but they still retain the clay and sand which were deposited with them. The process of cleaning consists in removing this foreign material. Unless this be done the forms will be obscured and difficult to detect.

Many observers have studied and classified the numerous species, and have spent much labour in preparing and mounting them for observation, for there is a fascination in these forms that appeals to all, and any plan for facilitating and lessening the labour of preparation would be likely to induce many more to take up the study.

An ordinary well-known method of separation is to digest the material with an acid, and then to dilute with water, and allow the heavier portions to deposit. After an interval, the lighter portions are poured away, and the process repeated until the clay, very fine sand, and broken diatoms have been removed, while those diatoms which have not been floated away during the process, remain with the coarse sand. This process takes up considerable time, and requires careful attention and timing to decant successfully, and, in spite of this care, some of the smallest and lightest forms can hardly fail to be lost.

The method now to be described was originated by the writer some twenty years ago, and recently, in recurring to the subject, it seemed that even at this date the method might appear novel, since it has not been exhibited during the interval, and no mention of a similar plan

* Amer. Journ. Sci., xxxv. (1913) pp. 19-22.

has been noticed in any published directions for treating diatoms. Therefore, the way seems open for a revival of interest in the subject, and this method by which, for instance, a small test sample of diatoms can be cleaned in five minutes' time from the acid-prepared material, should appeal to novices as well as experts, by reason of its saving of both time and effort.

The first attempt to supplant the ordinary method of separation and cleaning was made by using a cloth sieve made of partly worn cotton cloth stretched on a frame. The diatom material was treated in the usual way, in a separate vessel with acid. Then, when it had been largely diluted with water, the mass was placed in this cloth-bottomed tray, and agitated and jarred to carry off the clay through the cloth. More water was then added, and the process repeated until only sand and diatoms remained. This plan was not wholly satisfactory, since a large proportion of the diatoms passed through the cloth; yet a considerable bulk of partly cleaned diatoms was obtained, and by careful straining through a sieve the largest diatoms were separated from the smaller and the broken forms, and in this way were secured entirely free from debris. There was an abundance of this material for distribution.

Very soon after this first experiment, the writer originated an improved and more practical method which depended for its success upon the use of cross-sections of wood. Coniferous wood is the most suitable, since it has pores of nearly uniform size, whereas other kinds of wood nearly always have large and small pores commingled, which make them entirely unsuited for the purpose. These wood cross-sections bear dilute acid without injury, which would not be the case with a metal strainer of equally fine mesh, even supposing such a strainer could be made. Furthermore, such a strainer would be too frail to stand the required pressure.

A sharp, thin-edged chisel is used for making the sections, and the wood is kept in boiling water, and removed instantly before each cutting. It requires some care to secure an even thickness, which should be from one-quarter to one millimetre, as needed. The cut section is now to be wetted and surface-dried, and then cemented to a vial, the bottom of which has been cut off for the purpose. A very convenient size can be made from a two-dram vial, making the working aperture of the strainer about one-half inch The cement may be composed of rosin toughened by wax. Larger strainers may be made, but this size will answer for the first trials.

The digested diatom material, moderately diluted, is to be worked through the wood, a small portion at a time. The acid and the salts will pass with some freedom through this wooden grating, and the clay and fine sand are to be gradually worked out by the alternate pressure and release of a rubber compression bulb. The size used on camera shutters answers very well. This bulb is placed on the end of a glass tube 6 or 7 in. long. It is desirable, but not essential, to have a bulb blown in the middle of this tube. A short bit of rubber tubing of proper diameter is slipped over the free end of the glass tube, and this is to be inserted in the mouth of the vial so as to make a tight joint.

but this joint should be easily separable. In operation we take up a small portion of the material in a dropper, and squeezing it into the vial, we insert the rubber tip of the glass tube, and holding the strainer under water, press on the bulb, which will cause the air, acid, and salts to flow out together with a cloud of fine waste material. The pressure is now to be alternately applied and released, and the waste material is thus gradually removed. The discharge of clay and fine sand at last ceases, and the diatoms are left with the coarse sand and mica which can be removed by other means.

By thus eliminating the clay we will have disposed of one of the most serious obstacles to the cleaning of diatoms. One very important advantage of this method of working is the small quantity of material required, because there is very little waste. Successive portions as they are cleared can be united to make up the needed amount.

It is important that the strainer should not be overloaded, for that would cause it to pack and choke. This pack has to be broken up by shaking after each compression, more particularly in cleaning filamentous forms, in order to allow the imprisoned debris to escape at the next compression. As a general rule, and with the more granular forms, this packing requires only a little attention to avoid trouble. Violent compression will fracture many of the larger and more fragile forms of diatoms. The strainer vial should be kept in water when not in use, to avoid injury to the wood-section from contraction.

After the section has been in use for a considerable time the pores gradually become stopped with fine sand. Clay alone does not cause this condition. The only remedy is to cement on a new section.

An interesting point in this connexion is that when we burn an old strainer-section for the purpose of studying this clogged condition, we find that the ash will crumble if dampened, and will fall into numerous "sticks," each the length and diameter of a pore of the wood, and each of these "sticks" will be found to be packed with the small sand grains.

It may be said in regard to the selection of wood, that white pine—*Pinus strobus*—is excellent for ordinary use, since the strainers cut therefrom work freely. Certain light diatoms that would as a rule have been floated away in the usual settling and pouring-off process, are here retained by the pine section, because their length enables them to bridge across the pores. Some very short forms, however, will pass through to a considerable extent.

By saving the tailings from the pine and passing them through a spruce strainer, the majority of these short forms were retained. The spruce here referred to was a piece of flooring, and of a very white species of spruce. It was not identified. There are several other species that would probably answer equally well. In using spruce, the sections should be thin. The clay will be found to pass through the pores of spruce with some freedom, but not so rapidly as through pine.

There are some gatherings that will require a strainer of still finer grain. This may be said of the very smallest diatoms that grow on water plants. The majority of these may be retained by a quite thin section cut from the white outer wood of the red cedar *Juniperus Virginiana*. In one experiment some of these very minute forms

which had passed through the spruce were almost wholly retained by the red cedar.

It follows that from these three species of wood we can obtain a graded series of strainers, each capable of separating the clay from the diatoms, and at the same time furnishing a ready means of grading as regards size.

The pine strainer works the most rapidly and makes a very good separation, and will meet ordinary requirements. The spruce strainer can follow if we want a more thorough gleaning of the smaller forms; and then we have the red cedar section as a final resort to aid in securing the very smallest diatoms.

Method for Cleaning Diatomaceæ.*—There are a number of methods to be found in various books on microscopy for cleaning Diatomaceæ, none of which, says E. R. Darling, proves to be perfect in all details. The method generally resorted to is to boil with nitric acid. This does not, however, remove all of the organic matter, and leaves a mounted specimen contaminated with black specks. Another method is to boil the specimen with sulphuric acid and potassium chlorate. This, too, has its disadvantage, as in boiling neutral potassium sulphate is formed, this salt being sparingly soluble in water. The following method, which is a modification of that of Edwards,† will be found to work with great success.

The sample is first dried, and then about 5 grm. taken and well washed with distilled water. The washing is best done by placing the sample in a filtering paper fitted to a glass funnel, and replacing the water as it runs out. The washing is complete when about 250 c.cm. has run through. A hole is then punched in the apex of the filter paper and the sample washed into a 250 c.cm. beaker with concentrated hydrochloric acid, about 50 c.cm. being required. This is allowed to boil gently for 30 minutes, 100 c.cm. of hot water is then added, and the whole filtered. The sample is washed with hot water until it gives no white coloration when a drop is added to a weak solution of silver nitrate. The sample left on the filter-paper is then washed into the beaker with 50 c.cm. of concentrated nitric acid and gently boiled until red fumes cease to be given off. This is then diluted with hot water, filtered, and washed until free from acid.

The above method removes all the mineral matter except silica, Diatomaceæ, and a large part of the organic matter. The product from the last operation is removed to a beaker by means of a small spatula. To this is added a mixture of concentrated sulphuric acid and water, 8 parts of acid and 2 parts of water. In mixing care should be taken to add the acid to the water. This is boiled for about 30 minutes, or until the organic matter is charred. As soon as the acid starts to boil weigh out about 2 grm. of potassium chlorate and add to the acid in small quantities until the solution becomes colourless. The acid solution is then poured into 250 c.cm. of distilled water, filtered, and washed free from acid. The product is then washed into a beaker with about 20 c.cm.

* Amer. Journ. Sci., xxxviii. (1914) p. 282.

† See this Journ., 1859, p. 167.

of concentrated hydrochloric acid, and gently boiled for about 15 minutes. It is then diluted with hot water, filtered, washed first with distilled water acidified with hydrochloric acid, and then with hot water until free from acid, which is determined by adding a drop of a weak solution of silver nitrate.

By the addition of the potassium chlorate to the sulphuric acid solution the organic matter is destroyed. The neutral potassium sulphate which is formed is changed into the chloride by the addition of the hydrochloric acid. The chloride is soluble in hot water and is removed in this way. When thus purified the Diatomaceæ should be kept in a mixture of 6 parts of alcohol and 4 parts of water, to prevent them from matting together.

New Water-jet Air-pump, and the Fixing and Embedding of Microscopical Objects in vacuo.*—M. Wolff describes a new water-jet air-pump recently placed on the market by the firm of Erich Koeller, of Jena. The working principle consists in the fact that the entering jet of water passes with a whirlpool action round a glass funnel, into which the tube connected with the evacuation vessel fits. This tube is fitted with a reaction valve to prevent the overflowing of water into the vacuum. The apparatus is very powerful. A 2-litre vessel with 720 mm. air-pressure and 2·5 to 3 atmospheres water-pressure (and a water temperature of +13° C.) is evacuated up to 711 mm. mercury in seventy seconds. This apparatus is especially useful for fixing and embedding tissues in vacuo. Delicate structures (larvæ of arthropods and the like) are particularly suitable for vacuum embedding, as the processes are very much shortened and a minimum amount of injury is sustained by the tissues.

(3) Cutting, including Embedding and Microtomes

Leitz's New Rotary Microtome.†—S. Becher describes this apparatus in the course of an article on New Microtome Constructions. In this instrument (Figs. 50, 51), the delivery of the object part is combined with a circular cutting motion together with a push and drop movement of the knife. This combination gives to the instrument its individual character and distinguishes it from older types, and not only guarantees extraordinary facility but also astonishing uniformity of action. The object part consists essentially of a metal disk about 8 mm. thick and of 14 cm. diameter, whose perpendicular axis is secured above and below by a tapering steel bolt, thus securing easy rotation without the least vibration. The under bolt is attached to the base-plate, but the upper is inserted into a strong cast-iron arm whose other end is likewise attached to the base-plate. This arm is bent in such a way that the object clamped to the disk can easily pass under during the rotations. The object-clamp is rotatory about its axis and is universally inclinable; it is attached to a brass block, shaped like a segment of a sphere, which itself has a universal movement in a corresponding saddle

* Zeitschr. wiss. Mikrosk., xxxi. (1914) pp. 19–22.
† Zeitschr. wiss. Mikr., xxxi. (1914) pp. 103–13 (2 figs.).

of the disk and can be firmly clamped from below. The mean rotation-point of this spherical clamp arrangement lies only very little under the clamp, so that in changing the inclination of the object the height of

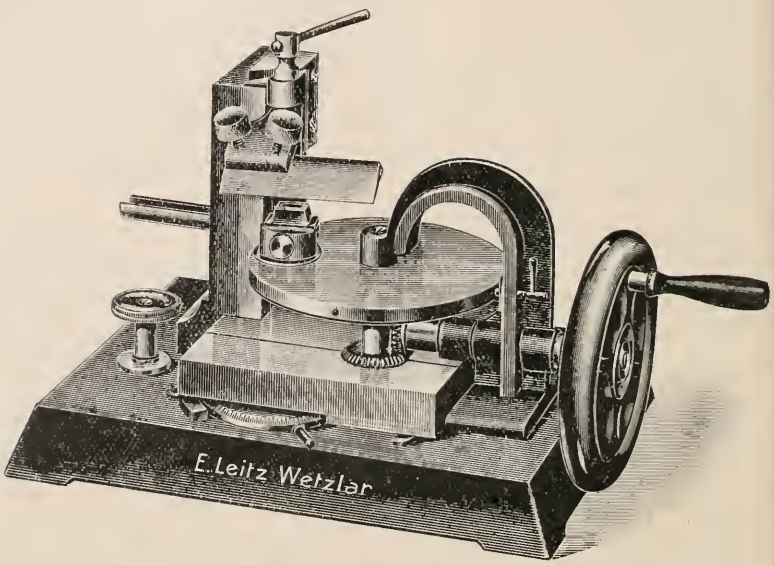

Fig. 50.

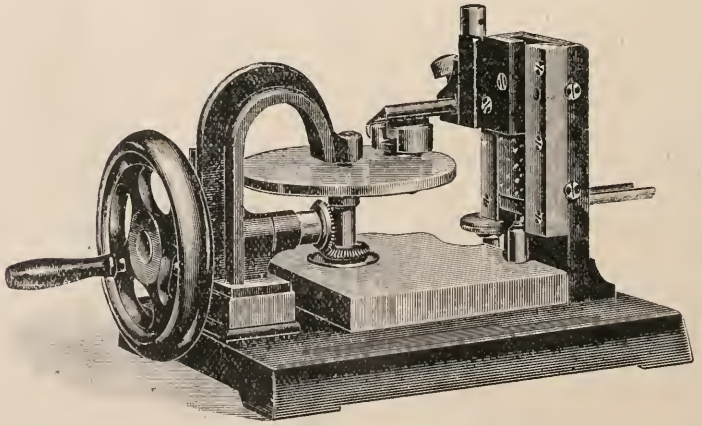

Fig. 51.

the object is only slightly altered. Blocks of wood or grooved metal disks with their paraffin or celloidin beds can be secured to the clamps, and by the addition of a little more molten matter the object and mean-

rotation point are brought still closer. The rotary gear consists of a winch-wheel whose axle passes through the base of the bent arm, and by means of two obliquely toothed wheels imparts its motion to the disk. As the winch is turned disk and object rotate with uniform velocity and always in the same direction. The mutual adjustment of knife and object depends upon the drop-movement of the knife, but it is automatic, being an effect of the gear motion transmitted by a micrometer spindle. This spindle is coupled with another axle, which carries at its upper end a saw-toothed wheel, rotatory by means of a connector. This connector is drawn forward at each rotation of the main disk by means of an eccentric disk fastened near the lower end of the connector in order to slide back afterwards. The number of teeth set in action in the wheel, the consequent drop of the knife and the resulting section-thickness are governed by a scale, every division of which corresponds to a thickness of $\frac{1}{1000}$ mm. It is possible to cut sections whose thickness may be any integral number of mikrons between 1 μ and 20 μ.

(4) Staining and Injecting.

Differential Staining of Fats.*—E. T. Bell employs a modification of Dietrich's and Ciaccio's stains for demonstration of fat in tissue sections. The technique enables him to distinguish fat droplets consisting mainly of triolein from those droplets that principally contain lipoids. The former appear in annular shape, the latter are quite solid. In the former case the central portion of the droplet is not chromated, and therefore dissolves out in the xylol used in embedding. The technique employed is as follows:—Fix tissue in 10 p.c. aqueous potassium bichromate 100 c.cm., glacial acetic acid 5 c.cm.; wash, dehydrate and embed in paraffin, cut in sections and fasten to the slide with albumin. Remove paraffin with xylol and xylol with absolute alcohol and transfer to freshly prepared saturated solution of Sudan III in 80 p.c. alcohol for 10 minutes. Rinse off excess of stain with 50 p.c. alcohol and transfer immediately to water to stop action of the alcohol. Counterstain with Delafield's hæmatoxylin and wash in water, differentiate with acid alcohol, wash and mount in glycerin-gum arabic.

New Hæmatoxylin Solution.†—A. von Szüts recommends the following modification of Mallory's phosphomolybdate or phosphoarsenate stain, which latter, although giving very beautiful results, especially in the investigations of nervous tissues, has the disadvantage of being somewhat expensive. The composition of the new solution is as follows:—1 p.c. watery hæmatoxylin solution 100 c.cm., 10 p.c. ammonium molybdate solution 25 c.cm. For fixation of sections of the central nervous system of Vertebrates formol-alcohol or formalin is suggested. After staining for one or two minutes, wash with distilled water and blue in strongly alkaline tap water for about five minutes. A metachromatic effect is produced by variation in the time of blueing of

* Journ. Path. and Bact., xix. (1914) pp. 105–13 (1 pl.).
† Zeitschr. wiss. Mikrosk., xxxi. (1914) pp. 17–18.

the various structures. Delicate tissues such as muscle, nerve, connective tissue, etc. quickly become blue, while the ground substance of cartilage, bones, etc. retain the red and violet for a longer period. An advantage of this stain is that it does not colour the celloidin of celloidin sections.

Employment of Fat Stains for Differentiation in Preparing Museum Specimens.*—R. H. Malone has employed fat stains in the preparation of museum specimens with good results, especially in the case of breast tumours, pancreas, and degenerated heart-muscle. The tissues are hardened in 10 p.c. formalin for one or two days, the excess of formalin washed off and the tissues transferred to a saturated solution of Scharlach R in 70 p.c. alcohol for two hours. Large quantities of staining fluid should be used, as the penetrative powers of the stain are very weak. The specimen is then washed and differentiated in a saturated solution of bichloride of mercury. The organ is then mounted in 5 p.c. formalin. This method is particularly good for showing up the "tabby-cat" striation of fatty degeneration of heart-muscle. Counterstaining with alum-hæmatoxylin will be found helpful in differentiating normal breast tissue from tumour growth :—stain with Scharlach R as above, counterstain with hæmatoxylin for one minute, wash and transfer to lithium carbonate (saturated solution) until the tumour is pale blue.

(5) Mounting, including Slides, Preservative Fluids, etc.

Mounting of Diatoms in Realgar.†—Chapman Jones says, "My attention was first directed a few years ago to the particular subject indicated by the title above‡ when I wanted a slide or two of the smaller diatoms mounted in realgar. Slides of this kind were included in the lists of all firms that deal in microscopical slides, but no one could supply me, and I was told that the individual who prepared them, after poisoning himself by the process, had made up his mind to have nothing more to do with it. It seemed to me that this was a highly unsatisfactory position for so valuable a means of investigation, and I began to look about . . . hoping to find some medium, or more than one, of high refractive power that should be workable without risk of poisoning by the microscopist who is not a chemist.

"Some objects need to be rendered more transparent for microscopical examination that their dark details may be made visible . . while others that are thin and transparent . . . are advantageously arranged so as to render the detail as conspicuous as possible. Thus in photomicrography we need media of various refractive powers.

"It will simplify matters if we limit our consideration to diatoms prepared in the usual way so that only the siliceous skeletons of them remain . . . stated to have a refraction index of 1·43. Diatoms are, therefore, fairly visible in air ("dry"), with its refraction index of 1·0. In water, refraction index 1 33, they are less visible, and some of the

* Journ. Path. and Bact., xix. (1914) pp. 102–4 (1 pl.).
† Journ. Roy. Photo. Soc., Jan. 1914.
‡ "On Media of High Refractive Power for Photomicrography."

more delicate kinds are invisible unless sought for by special means of illumination. In Canada balsam, refraction index 1·52, we have a medium of refractive power about as much above that of diatoms as water is below it, and which therefore gives much the same difficulty. Styrax, refraction index 1·58, is markedly superior to Canada balsam . . . Monobromnaphthaline, a liquid with a refraction index of 1·66, is very convenient for temporary use . . . and it is stated that in a few months mounts made with it lose the advantage of its high refractive power. . . . Piperine, with a refraction index of 1·68 , . . serves excellently for temporary purposes, as when the preparation is not wanted for more than a few months. . . .

"Canada balsam, styrax, and piperine allow of full advantage being taken of homogeneous immersion systems, and hence secure the maximum resolving power, while with air (a "dry" mount) the angle of illumination is limited to something under N.A. 1·0. But neither of these three media differs so much from the refractive power of diatom silica as air does, and therefore none of them equals air as a medium for the visibility (or photographability) of the object. When we approach a refraction index of 2·0 we surpass air in this matter. Sulphur alone has approximately this index, and realgar (pure As_2S_2) is stated to have an index of refraction of 2·45, so that such media give us advantages that we can never approach by media of refractive powers lower than that of diatom silica. . . .

"Realgar is a substance of definite composition (As_2S_2) which occurs as a mineral and can be prepared artificially, but when the word "realgar" is used to describe a medium for mounting it appears to mean no more than that arsenic and sulphur enter into its composition. . . . We may, for example, prepare a substance that contains arsenic and sulphur in definite proportions (1) by direct combination of the two elements; (2) by heating together arsenious oxide and sulphur; (3) by heating together realgar (As_2S_2) and sulphur; (4) by heating together the precipitated yellow sulphide of arsenic, or the mineral orpiment (As_2S_3) and sulphur; and the only matters for consideration are convenience and the purity of the materials. Purity is the most important matter, and it may be taken for granted that any tinge of brownness is due to dirt. Attempts at purification make matters worse rather than better . . . We see when the sun shines how full of motes the air is, and . . . none of these preparations nor the sulphur used in making them should be ground up or subjected to any avoidable friction . . . and any preparation made with sulphur that has been ground is obnoxiously dirty, though the sulphur may originally have been pure.

"In working with preparations such as we are speaking of, one always gets some small fragments, and if the preparation has proved good and clean, there is a temptation to melt up these small fragments so as to get a piece of useful size. But it is useless, for the mere manipulation of them seems to gather these aerial motes, and the stuff is brown after refusion.

"*Purification of Materials.*—I obtain the sulphur in a commercially pure condition and distil it twice. I have distilled the same portion seven or eight times successively, but there always remain in the retort

some black specks of foreign matter . . . and I now believe that they are nothing else than aerial motes attracted to the sulphur . . . I distil the sulphur in a small retort at such a rate that it condenses in the beak and flows down into a porcelain basin put to receive it. After a few hours, or next day, the cake in the basin is detached by gently warming the basin until the sulphur in immediate contact with it melts, and displacing the cake or turning it over. When cool again the cake is broken up with as little friction as possible and put into a bottle. Dust and even small fragments should be rejected. The distillation is repeated in exactly the same way for the sake of being as sure as possible of purity, though I have no direct evidence that the second distillation is necessary if the sulphur started with is fairly pure. If "pure" sulphur cannot be obtained, roll sulphur is preferable to flowers.

"The arsenic is also distilled twice, starting with the commercial substance. The second distillation should leave no residue whatever. A hard glass tube is appropriate for this distillation, as it requires a red heat. The tube is broken to get the arsenic out, and only the clear shining black crystalline parts are preserved.

"We must first make a definite preparation, and then use it so that it remains of the same composition throughout. The sulphur and the arsenic, purified as already described, are weighed out in proper proportions with as little manipulation as possible, and the quanity taken may be such as will extend about two-thirds up a test tube 3 in. long and $\frac{3}{8}$ in. in diameter, when the materials are in as large lumps as possible for the weighing and putting into such a tube. (The total weight of materials taken may conveniently be from 30 to 40 grains, or 2 to $2\frac{1}{2}$ grm.) The tube is then gently heated in the flame of a Bunsen burner till the sulphur melts and runs down to the bottom, carrying the arsenic with it. The lower part of the tube is then heated rather more strongly until an internal glow and commotion indicate that combination is taking place. Just at this time it is well to withdraw the tube from the flame to moderate the action. In a few seconds heat is again applied and continued until the material, which is now throughly fused, boils. It may be boiled up two or three times to ensure uniformity, and then put away to cool. After some time, preferably an hour or two or more, the tube is broken away from the little lump of material, the bits of glass are carefully removed from it, and the brittle preparation may be cut up by the large blade of an ordinary pocket knife into suitably sized pieces for preservation or for use. For the reason already given it should be handled and rubbed as little as possible. It should be very bright and of a rich amber colour. Any suggestion of brownness indicates impurity.

"*Mounting the Diatoms.*—The covers and the slips must be thoroughly clean. The best method that I know of is to put a drop of glacial acid in the middle of a slip, and to put another slip upon it so that the drop spreads over the central portion of both. As many as will be required are so treated, and then each pair is separated, well rinsed under the tap, and wiped and polished with an old soft linen pocket handkerchief, and the specially cleaned sides of the pair may be put together again to keep

them until wanted. The covers are put into a small vessel, such as a porcelain crucible, that contains two or three drops of glacial acetic acid, dropping in each cover separately to see that the acid wets it all over. Water is added and poured off two or three times, and then the covers are removed one at a time and dried and polished likethe slips.

"The covers that are to be used are placed on a suitable level surface, such as a piece of plate glass; if the prepared diatoms are in alcohol this is poured off and replaced by distilled water and a drop of the liquid is put upon each cover, seeing that it spreads suitably over the cover. A bell-glass is put over them, and they are left to dry spontaneously. Each cover is then examined all over its surface under a suitable low power, such as an inch, and hairs and other obnoxious things are removed, using either a bristle or a needle.

"They are now ready for the actual mounting. For this purpose I prefer a tray made of thin sheet copper with two sides and one end turned up about $\frac{1}{4}$ in., and of a size to just take a 3 × 1 slip easily. This is supported across one corner of the triangular top of the usual iron tripod as used in chemical laboratories, and by its side is placed a sheet of thick sheet copper about 4 in. × 3 in. A stout glass slip is put in the tray, and a Bunsen burner arranged so that a flame about $\frac{3}{4}$ in. high may be brought under the tray, the top of the burner being about $1\frac{1}{2}$ in. below the tray. The flame must be small so that the heating may be very gradual.

"One of the covers with the diatom on it is now finally examined under the Microscope, and any hairs, etc., that may have settled on it are removed; it is put on a flat piece of platinum foil that has two edges turned up and heated over a very small flame to just below redness. This gets rid of volatile matter, and any minute threads of organic matter are carbonized. The cover is placed, diatoms uppermost, on the slip in the tray, a piece of the medium of suitable size is put on the cover, the cleaned slip that is to be used is put on the plate by the tray, and the small flame as already described is brought under the centre of the tray. I place a rather large funnel over the tray and resting on the plate to prevent dust falling on the cover. In from 20 to 30 minutes the little lump of medium will have assumed a cushion shape, or it might be called spherical, except for the flat side upon which it rests on the cover. The heating must not be hurried or the medium will get too hot, and a good crop of small bubbles is likely to result. The assumption of this shape indicates that it is thoroughly softened. The cleaned slip is now removed from the plate, where it has got hot, dusted lightly with a soft brush in case anything may have fallen upon it, and gradually brought with its clean side downwards upon the softened drop of medium, and by means of the forceps it is pressed, at first gently and afterwards more strongly, down upon the medium, which is thus gradually flattened out. As it becomes thinner the process becomes slower, so that it is likely to be ten minutes or even more before it is thin enough. During the operation the reflections of the window frame or of the lamp, or some other convenient object, are watched from time to time to see that the slip that is being pressed down is parallel to the slip beneath that supports the cover glass, and finally the reflection from the cover-glass

(through the medium) is examined to see that there is no preceptible amount of distortion. It is well to allow the heating to continue for at least a minute or two after any pressing with the forceps, that the glass may resume an unstrained condition. This completes the mounting proper, though I prefer to use so small a quantity of the medium that when flattened out the disk does not quite reach the ridge of the cover glass, and to run in a little melted paraffin wax round the remaining space. The slide can be rung as usual when thoroughly cold."

(6) Miscellaneous.

Simple Method of Collecting Centrifugates.*—G. C. Van Walsen has devised a simple method of collecting centrifugates for examination, the peculiarity of the method consisting in the fact that the centrifuge tube and the transport pipette are one and the same instrument. The following particulars refer to urine examination, but various modifications may be made to suit other purposes. The "centrifuge pipette" consists of a glass tube some 9 cm. long, which, at its lower end, tapers to a circular opening of 1 mm. diameter. The upper end of the tube is closed with a small cork stopper. The pipette is filled by closing the lower opening with the finger and introducing the fluid through the upper opening with a suitable pipette. The cork is then put back, the tube rotated and the cork gently screwed in until all air bubbles have been driven out. The centrifuge pipette is then placed in the centrifuge cup (11 cm. depth), which is filled with water just to cover the cork stopper. After centrifugalization, the pipette is removed, the outside cleansed as much as necessary, and a drop of the sediment allowed to fall on to a glass slide, for subsequent examination.

* Zeitschr. wiss. Mikrosk., xxxi. (1914) pp. 40–2 (1 fig.).

Metallography, etc.

Oxidation of Type-metal.*—R. Meyer and S. Schuster have examined, microscopically and otherwise, specimens of type of various ages up to seventy-five years, to ascertain the cause of the oxidation which occasionally results in the comparatively rapid destruction of the type. Oxidation was found to be due not to unsuitability of chemical composition, but in part to porosity, indicated by the presence of numerous microscopic holes, facilitating the absorption of moisture. A 10 p.c. solution of nitric acid in alcohol was used for etching.

S. Zinberg† gives some results showing the influence of moisture in promoting oxidation.

Electrolytically-produced Alloys.‡—R. Kremann, J. Lorber, and R. Maas have made metallographic studies upon various binary alloys electrolytically deposited from solutions containing salts of the two metals. Copper-antimony alloys differed from copper-tin alloys in that they showed a lesser tendency to form solid solutions. Iron-nickel alloys deposited at high temperatures contained solid solutions, and showed a concentric structure. Iron-magnesium alloys contained a solid solution or compound.

Antimony-lead-tin Alloys.§—In the course of an exhaustive study of the antimony-lead-tin bearing alloys, E. Heyn and O. Bauer describe the microstructure of numerous alloys prepared under different conditions of casting and cooling. Segregation was observed in slowly cooled but not in rapidly cooled alloys. The rapidly cooled alloys were finer in structure. Crystals of tin oxide were observed in certain alloys which had been heated to a high temperature. The effect of variations in rate of cooling upon the structure of antimony-lead-tin alloys to which 6 p.c. copper had been added is described.

Sulphide Inclusions in Steel.‖—S. Steinberg has sought to determine whether sulphide inclusions are present as such in liquid steel (either as liquid globules or as solid particles), or are in solution in the liquid steel and separate during solidification or subsequent cooling. Small melts of steel containing known percentages of manganese and sulphur were heated to high temperatures, were maintained for given lengths of time at temperatures above the melting point, and were cooled quickly or slowly, through given ranges of temperature. Sections of the ingots obtained were examined microscopically. Neither the

* Zeitschr. Angew. Chem., xxvii. (1914) pp. 121–7 (11 figs.).

† Zeitschr. Angew. Chem., xxvii. (1914) pp. 436–7.

‡ Monatsh. Chem., xxxv. (1914) pp. 581–601, 603–34, and 731–53, through Journ. Soc. Chem. Ind., xxxiii. (1914) pp. 752, 791–2.

§ Verh. Ver. Beförd. Gewerbfl., 1914, Suppl., 235 pp. (234 figs.).

‖ Rev. Soc. Russ. Met., i. (1913) pp. 514–21, through Rev. Métallurgie, xi. (1914) Extraits, pp. 313–16 (10 figs.).

treatment of the liquid steel, nor the mode of cooling from below the temperature at which the steel became completely solid, had any influence upon the quantity, form, and distribution of the sulphide inclusions. The rate of cooling during solidification, however, had a considerable effect upon the size and distribution of the inclusions. These observations indicated that the sulphides were present in solution in the liquid steel and separated from it completely during solidification. The inclusions in forged or rolled steel were not affected by heating, unless the temperature approached the melting point. Long heating of one specimen at 1200° C. caused each elongated sulphide inclusion to break up into a string of rounded inclusions. When the heating was sufficient to cause incipient fusion of the steel, the form and distribution of the inclusions were completely changed, and network formations resembling those found in steel castings resulted. Sulphide inclusions thus appear to be wholly soluble in liquid steel and wholly insoluble in solid steel.

Changes in Mild Steel caused by Annealing.*—A. Stadeler has studied the influence of length of time of annealing on the growth of grain in mild steel. Specimens cut from rolled plate, 15·5 mm. thick, of steel containing 0·1 p.c. carbon, were annealed for periods of $1\frac{1}{2}$ hours to 25 days, at a mean temperature of 860° C. A plate annealing furnace in which the atmosphere contained a slight excess of carbon monoxide, was used. Decarburization of the outside had begun after 3 hours, and was complete after 15 days annealing. Grain growth was observed after 3 hours annealing. In the outer layers, which had undergone some cold-work, the maximum grain diameter increased from 0·04 mm. to 2·5 mm. in 72 hours, while in the interior of the plate there was a regular but much less rapid grain growth, a maximum diameter of 1 mm. being reached in 25 days. The normal laminated microstructure of the plate became more distinct on annealing, and was evident until the pearlite disappeared.

Tungsten Steels and Nickel Steels.†—In the course of a paper dealing with the chemical and mechanical relations of iron, tungsten, and carbon, and of iron, nickel and carbon, J. O. Arnold and A. A. Read describe the structure of the alloys prepared. In the tungsten steels the pearlite was sorbitic. Tungsten does not form a double carbide with iron, but when sufficient tungsten is present iron carbide is replaced by tungsten carbide (tungsten cementite). The presence in steel of nickel in large proportion favours the separation of graphite, which appears to be a product of the decomposition of the unstable carbide Ni_3C.

Hardness of Iron-carbon Alloys.‡ — R. Vondráček criticizes Andrew's suggestion that the hardness of quenched steels is due to the presence of finely-divided cementite embedded in a ground-mass of austenite and α-iron. The total carbon in quenched steels is practically all in solution. It is probable that the ferrite in hypoeutectoid steels

* Ferrum, xi. (1914) pp. 271–6 (27 figs.).
† Proc. Inst. Mech. Eng., 1914, pp. 223–79 (17 figs.).
‡ Int. Zeitschr. Metallographie, vi. (1914) pp. 172–82 (3 figs.).

has an appreciable carbon content, which increases as the total carbon increases, and that eutectoid ferrite contains in solution 0·06 to 0·14 p.c. carbon according to the temperature.

Malleable Cast-iron.*—O. W. Storey has made a microscopical study of the changes which occur in the annealing process in the manufacture of malleable castings. Specimens of white iron containing 2·6 p.c. carbon, all combined, were heated under different conditions, the factors that were varied in different series of experiments being: (1) maximum temperature; (2) length of time for which the maximum temperature was maintained; (3) rate of cooling; and (4) packing material. The nature of the packing material did not affect the structure of the interior of the annealed casting, but had some influence on the structure of the skin. In general, the outside layer consisted of ferrite when the conditions of annealing were distinctly oxidizing, while under less oxidizing conditions a steely outside layer containing pearlite resulted. The interior of a well annealed "black-heart" casting consists of ferrite and temper-carbon. Slow rates of cooling are necessary to produce this, and pearlite is formed if the cooling is too rapid. Annealing temperatures exceeding 800° C. are necessary to cause the cementite to decompose within a reasonable time. The higher the annealing temperature the shorter is the time required. The author suggests that the cementite decomposes while it is in solution in the iron, that free cementite does not decompose, and that consequently no decomposition of cementite occurs below Ar_1.

Diffusion in Solids.†—L. Guillet and V. Bernard describe their experiments on "reserves" in cementation, which have led to the study of the more general question of diffusion in solid metals. In the operation of case-hardening it is frequently necessary to prevent the cementation of portions of the surface of the article undergoing treatment, since the hardened skin is desired only on the remainder of the surface. Protection of the surfaces which are to remain soft is secured by covering them with substances calculated to prevent the access of the solid or gaseous cementation medium. Clay and similar materials are only partially effective, since they are porous at case-hardening temperatures and permit the access of carbon monoxide to the coated surface. The effectiveness of any coating is most readily determined by microscopic examination of a section through the coated surface after the case-hardening operation. Copper deposited electrolytically or by the Schoop spraying process, was found to be effective if the layer was sufficiently thick. Nickel did not prevent cementation, unless used in very thick layers, apparently because nickel is permeable to carbon monoxide. In the experimental study of diffusion in solids, specimens in which two metals were in perfect contact were prepared by mechanical means or by electrolytic deposition, and were heated as shown in the table below. In each case the temperature of heating was below the melting point of either metal, and was in a range in which a solid solu-

* Met. and Chem. Eng., xii. (1914) pp. 383–9 (12 figs.).
† Rev. Métallurgie, xi. (1914) pp. 752–65 (32 figs.).

tion of the two metals was stable. Microscopic examination of cross sections of the specimens after heating indicated that diffusion had taken place in every case, frequently to a marked degree.

Pair of Metals.	Time of Heating, and Temperature.
Iron-aluminium	50 hours at 635° C.
Iron-copper	5 ,, 1000°
Copper-nickel	10 ,, 1000°
Copper-bronze (20 p.c. tin)	50 ,, 750°
Copper-zinc	50 ,, 400°
Copper-tin	50 ,, 218°
Copper-brass (42 p.c. zinc)	50 ,, 800°

Micro-actions of Acids and Metals.*—J. Scott describes the microscopic appearance of the salts obtained when small fragments of metals were dissolved in a few drops of nitric acid on glass slips and the solutions allowed to evaporate. The preparations were photographed with oblique illumination.

Structure of Fire-brick.†—G. Rigg describes the microstructure of a number of specimens of fire-brick, examined in the form of thin slices. The more compact and close-textured bricks possess good resisting power against the penetrating action of corrosive slags and gases.

National Physical Laboratory.‡—Among the subjects of metallurgical investigation to which microscopic methods have been applied were the aluminium-zinc and aluminium-zinc-copper alloys, the effects of strain in metals at high temperatures, brittleness in steel, structure of steel at high temperatures, and intercrystalline cohesion in metals. In the study of cases of failure of rails, tyres and similar articles, the microscopic examination of complete cross sections proved useful, since local defects do not readily escape detection when this method is used.

* Foundry Trade Journ., xvi. (1914) pp. 523–5 (6 figs.).
† Journ. Ind. and Eng. Chem., v. (1913) pp. 549–54 (7 figs.).
‡ Nat. Phys. Lab. Ann. Report, 1912.

MICROSCOPY.

A. Instruments, Accessories, etc.*

(1) Stands.

Watson-Conrady "Bicor" Binocular Attachment.†—W. Watson and Sons intend this auxiliary to afford the student the advantage of

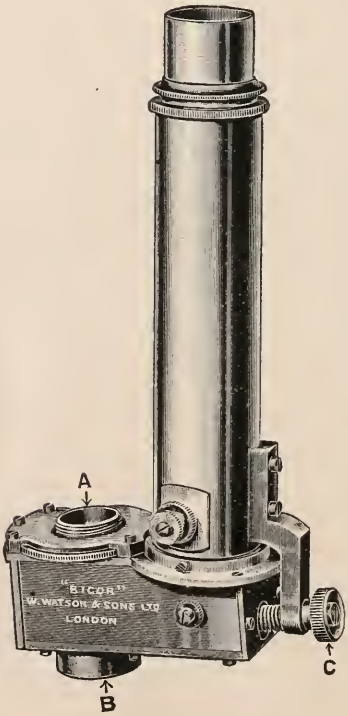

Fig. 56.

using two eyes instead of one in his observations. It also affords the means of readily converting a monocular into a binocular Microscope,

* This subdivision contains (1) Stands; (2) Eye-pieces and Objectives; (3) Illuminating and other Apparatus; (4) Photomicrography; (5) Microscopical Optics and Manipulation; (6) Miscellaneous.

† Catalogue, "Microscopes and their Accessories," W. Watson & Sons, London (1914–15).

or vice-versa. It is supplied in two forms : (1) attachable ; (2) built-in. The attachable form is shown separately in fig. 56, and in position in fig. 57, and is screwed to the objective-glass end of a monocular body in precisely the same way as an ordinary revolving nose-piece is fitted. It can, therefore, be placed on the instrument required, and thus convert a monocular into a binocular. The built-in form is a complete binocular body, and is provided with a sliding carrier for the prism, whereby the prism can be withdrawn from the field and the light, therefore, enabled

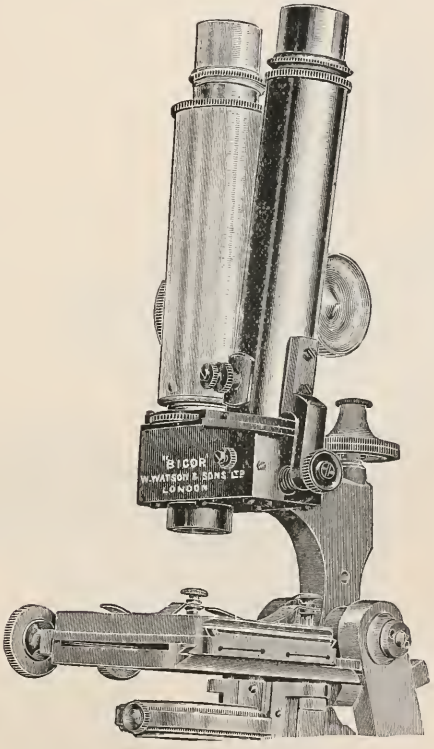

Fig. 57.

to pass directly up the monocular body only, without obstruction, when so desired. The binocular thus becomes a monocular. Both forms depend upon an optical system, first employed by Abbe, for dividing the light coming from the objective, the dividing prism being placed close to the objective, and the lateral prism being provided with a glass extension of such length as to cause the two separated beams to focus at the same distance from the objective. The instrument also includes an ingenious arrangement for adjustment of width of eyes without alteration of tube length. The lateral prism and the tube carrying

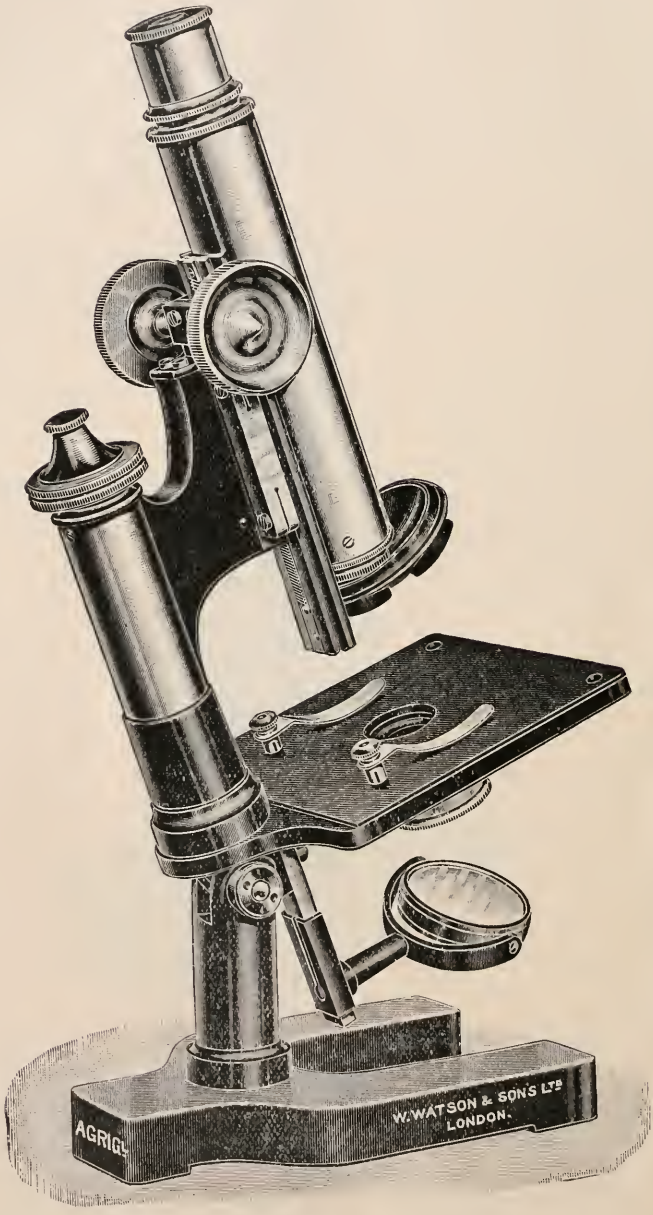

Fig. 58.

the lateral eye-piece are mounted together on hinged bearings set in such a position that the beam of doubly reflected light always occupies the same position with reference to the axis of the lateral tube. By turning the screw C (fig. 56) the binocular tube is gently altered in its angular position until the user's width of eyes is suited. If, then, it is necessary to change the tube length, the inter-ocular distance can be at once reset. In addition to the advantages already referred to, the makers state the following :—1. Suitability for all objectives from 1 in. to $\frac{1}{12}$ in. oil immersion, the full resolving power of every objective being retained. 2. Equal brilliance of image in both tubes. 3. Maintenance of definition so perfect that the interposition of the prism is unobservable. 4. Good range of tube length. 5. Production of stereoscopic or pseudoscopic effect at will by setting the interocular distance slightly narrower or wider than the interpupillary distance of the observer.

W. Watson and Sons' Agricultural Microscope.*—This Microscope (fig. 58), has been designed specially for use in botanical and agricultural work in which very low magnifications are frequently necessary for the general examination of large specimens without loss of the usual precision for medium and high-power observations. The coarse adjustment, is W. Watson and Sons' regular spiral rack-and-pinion pattern ; the fine adjustment being their standard lever form. The important feature of the instrument is its very long range of coarse adjustment which enables the highest and lowest power objectives to be used with ample margin. This will be understood from the fact that with an object $1\frac{1}{2}$ in. thick laid on the stage, with a triple nose-piece in position, a 3-in. objective of the parachromatic or Argus series will focus with rackwork to spare. The stage is of extra large size, $4\frac{5}{8}$ in. square. When the tube is racked down high powers such as $\frac{1}{6}$ in. or $\frac{1}{12}$ in. can be employed.

W. Watson and Sons' Grand Model Van Heurck Microscope (1914 Model).†—The new model of this well-known instrument is shown in fig. 59. It has been revised in several respects in order to meet the demand for a long range of mechanical stage movement with complete rotation at any position. The stage now has 2 in. of horizontal traverse, and is fitted with movable object clips and removable spring bar clips. The range in the vertical direction is about $1\frac{1}{4}$ in. The milled heads work on one centre, and, if desired, can both be rotated simultaneously, thereby affording a diagonal movement. The stage now has a diameter of 5 in., and has complete concentric rotation. The object is gripped by double sliding bars. It will be readily seen that the altered shape of the limb gives great freedom to the surface and, incidentally, acts as a convenient handle.

* Catalogue, " Microscopes and their Accessories," W. Watson & Sons, London (1914–15) pp. 34–5.

† Catalogue, " Microscopes and their Accessories," W. Watson & Sons, London (1914–15) pp. 74–5.

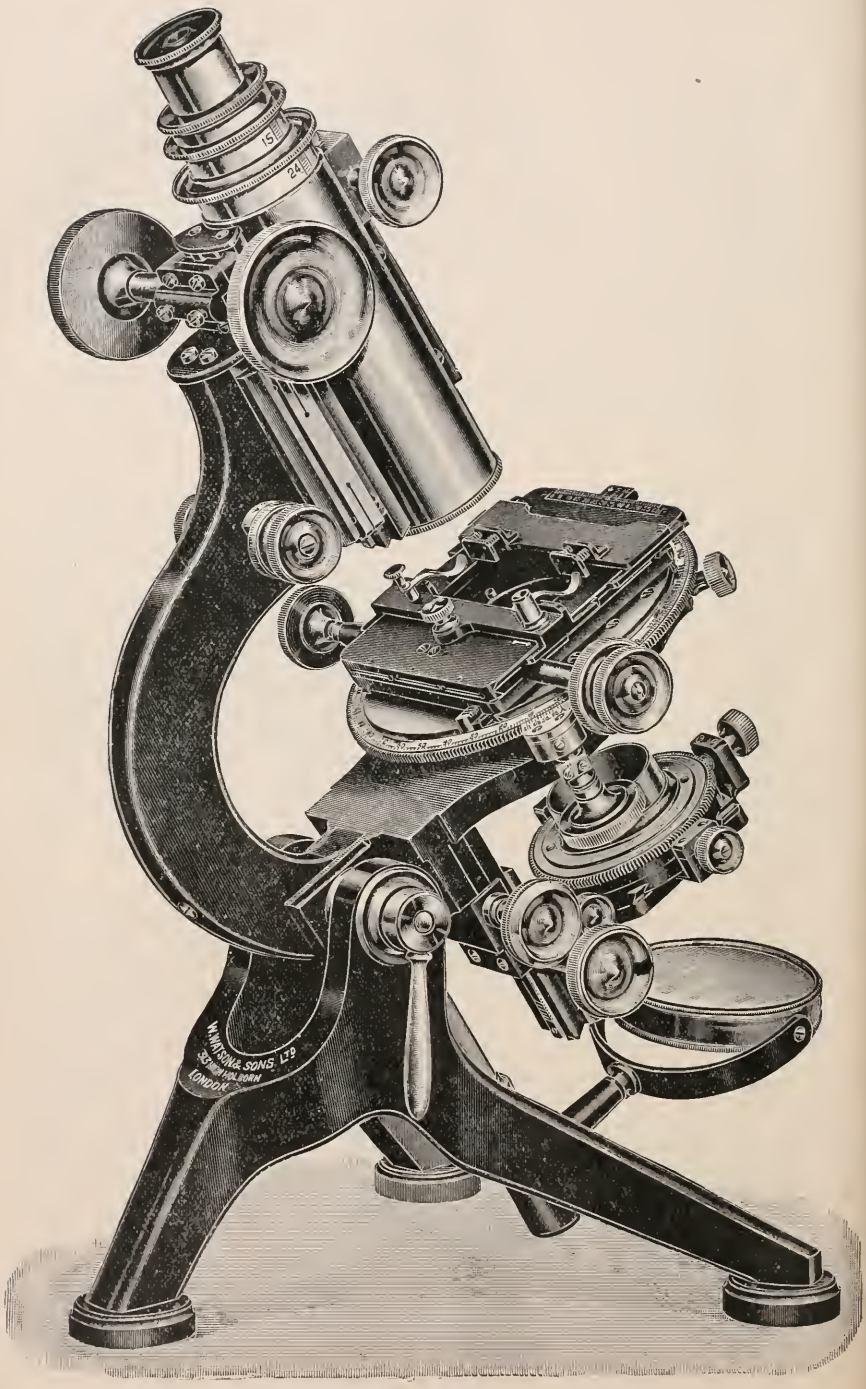

Fig. 59.

(6) Miscellaneous.

Glass for Optical Purposes.*—S. D. Chalmers calls attention to this important subject, and incorporates in his paper a series of historical notes likely to act as useful hints to any manufacturers contemplating improvements in British methods. In view of the importance to our industries and to the army and navy of an adequate supply of optical glass of various types, it is most desirable that our optical glass should be made in this country, and the author thinks that the manufacturers should be encouraged to meet this demand. Success in this direction is, however, most likely to be achieved by scientific experimental work carried out in conjunction with those manufacturers who have already acquired valuable and essential experience in the manufacture of optical glass. The manufacture of the optical glass is not, indeed, to be lightly undertaken. Great difficulties are associated with the purity of the materials and their proper mixing ; the pots must be of clay, free from impurities which might colour the glass. The preparation of these pots requires skilled workmen of long experience, and the same may be said of the melting temperatures, the proper period of stirring, the rate of cooling, and the whole annealing process. At the same time small variations of composition or treatment will affect the optical properties quite considerably. The experimental work associated with the production of special types of glass is expensive and troublesome, since the principal difficulties arise when we endeavour to change from the laboratory to the works scale.

The history of optical glass-making is to a large extent the history of optical progress. Dollond's discovery of the achromatic combination (1757) created a demand for flint glass suitable for optical purposes. The demand for large disks of flint glass led Guinand (1748–1824) to work out new methods of melting flint glass. Guinand in conjunction first with Utschneider and later with Fraunhofer improved his process so as to make good flint disks up to 10 in. in diameter. He afterwards made them up to 14 in., and on his death in 1824 the secret passed to his sons and through them to Bontemps in France. Bontemps' work was carried on by the French house of Feil, now Paira-Mantois, while Bontemps himself brought the secret process, in 1848, to the glass-works of Messrs. Chance. The calculation of the Petzval portrait lens and its successors led to a large demand for a glass intermediate in type between the ordinary flint and the crown, and by 1880 it was possible to make a complete series of glasses with their refractive indices ranging from 1·515 to 1·72. But these glasses had two special characteristics : as the refractive index increased the dispersion increased more rapidly ; also the dispersions of two glasses of different refractive index were not proportional throughout the spectrum. The consequence was that all images appeared coloured. The experiments of the Rev. W. V. Harcourt (1789–1871) which extended from 1834–1871 showed that this problem could be solved ; he proved that the effect of substituting boric acid for

* Nature, 2344, Oct. 1, 1914, pp. 171–2.

part of the silica in the glass was to reduce the dispersion of the blue end of the spectrum and so to make a flint glass which more nearly matched the ordinary crown glass. He was also able to modify the crown glass by using phosphoric acid, but wrongly attributed the result to the presence of titanic acid. Unfortunately these experiments did not lead to practical results, probably because of the expense attaching to experimental meltings on a practical scale. Schott and Abbe (1881–1886) confirmed Harcourt's results as to the action of boric acid, and correctly attributed the effects observed by him to phosphoric acid. In addition they were able to determine the effects of barium both with and without boric acid. Now the use of boric acid in the ordinary lead glasses always leads to a glass which is more or less liable to spot, but by the use of barium instead of some of the lead this effect is reduced. The boric acid barium glass is, however, of special value, because in this case a high refractive index is associated with a low dispersion. It behaves as a crown glass as regards its dispersion, but as a flint glass in respect of its refractive index. This property is of special value in the construction of modern anastigmat photographic lenses. These researches of Schott and Abbe were followed by the establishment of the Jena glass-works. The immediate results were :—

1. The manufacture of flint glasses containing boric acid ; by the aid of these glasses it was possible to make three lens objectives free from secondary spectrum, but these glasses are not so permanent as the older types. 2. The series of phosphate glasses which proved chemically unstable and deteriorated in use. 3. The boro-silicate crown glasses, which are of somewhat lower refractive index and dispersion than the ordinary crown glass. These are good glasses, and are now extensively used for small objectives and for prisms in prism-binoculars. 4. The dense barium crown glasses containing barium and boric acid. These glasses are used in nearly all anastigmat photographic lenses, but they are difficult to make because such abnormal optical qualities are closely associated with chemical instability. 5. The most important result was, however, the possibility of obtaining a large range of refractive index and dispersion, so that the designer was able to regard the dispersion and refractive index as more or less independent of each other.

These great successes led at first to a concentration of the optical glass industry in Jena, but the success of Chance in improving the quality of the older types of glass, and of Mantois in making the newer types, have somewhat modified this situation, though we are still dependent on Jena for some of the special glasses.

B. Technique.*

(1) Collecting Objects, including Culture Processes.

Purification of Crude Silk Peptones.†—I. Walker Hall has devised a method for the removal of the pigment of crude silk peptone (a mixture of the hydrolytic products of the original silk fibre) by filtration through argilla-alba. After three filtrations the residue is washed with distilled water, and the total filtrates are evaporated almost to dryness. The viscid mass is extracted several times with hot methyl-alcohol, the residue powdered, dissolved in water, and the process repeated. The extracts are poured into ethyl-alcohol, filtered off and placed in a vacuum. The filtrates are allowed to stand for 24 hours, and the flocculent precipitate removed as a second peptone. The products are tested for their peptone contents. Purified silk peptone provides a valuable medium for bacteriological purposes.

Cultivation of Pathogenic Spirochætes.‡—J. W. McLeod and A. R. B. Soga have devised a simple method for the obtaining of anaerobic conditions with the valuable though complex fluid media introduced by Noguchi. A test-tube is fitted with a perforated rubber bung, and a bent glass tubule with a capillary end is introduced to within a short distance of the lower end of the bung. The test-tube is now half filled with pepton bouillon, which is then boiled. On cooling, a portion of sterile rabbit's kidney is introduced, and a piece of cotton-wool, which has been threaded through a glass bead, is soaked in the inoculating material and dropped into the test-tube. Ascitic fluid is then run in to near the mouth of the test-tube, and the bung introduced. As the bung is pushed downwards, so the fluid rises in the narrow tube until it reaches the bent portion. The capillary end is then sealed off. Fluid can be easily drawn off at any stage of culture and subculture prepared. This method is capable of general application to the cultivation of anaerobic bacteria, with the exception of such as cause active gas formation.

Culture of the Plankton Diatom Thalassiosira gravida.§—E. J. Allen gives the following summary of his investigations as to the artificial cultivation of diatoms. Attempts to obtain good cultures of *Thalassiosira gravida* in a purely artificial medium, made by dissolving in doubly distilled water Kahlbaum's pure chemicals in the proportions in which the salts occur in sea-water, adding nitrates, phosphates, and iron according to Miquel's method and sterilizing the medium, have not succeeded. If, however, a small percentage of natural sea-water (less than 1 p.c.

* This subdivision contains (1) Collecting Objects, including Culture Processes; (2) Preparing Objects; (3) Cutting, including Embedding and Microtomes; (4) Staining and Injecting; (5) Mounting, including slides, preservative fluids, etc.; (6) Miscellaneous.

† Journ. Path. and Bact. (1914) xix. pp. 286–304.

‡ Journ. Path. and Bact. (1914) xix. pp. 210–13 (1 fig.).

§ Journ. Marine Biol. Assoc., x. (1914) pp. 417–39.

will produce a result) be added to the artificial medium and the whole sterilized, excellent cultures are obtained which are often better than any which have been got when natural sea-water forms the foundation of the culture medium.

The result appears to be due to some specific substance present in minute quantity in the natural sea-water, which is essential to the vigorous growth of the diatoms. The nature of this substance it has not been possible to determine, but some evidence seems to suggest that it is a somewhat stable organic compound. Provided that 1 p.c. of natural sea-water is added, the various constituents of the artificial sea-water forming the basis of the culture medium can be varied in amount within wide limits. The salinity of the medium can also be considerably altered without serious detriment to the cultures.

The experiments recorded are of interest as furnishing another instance of the importance in food substances of minute traces of particular chemical compounds. They may also eventually throw light upon the nature of the conditions in the sea, which are specially favourable to the production of plant life, and therefore also of the animal life which that plant life sustains. In connexion with the foregoing, allusion is made to W. B. Bottomley's paper on Accessory Factors in Plant Growth and Nutrition.* The experiments of Gowland Hopkins on the feeding of rats also bear on the same point.

Growth of certain Fresh-water and Soil Protista.†—H. G. Thornton and G. Smith record most interesting experiments with the object of indicating certain lines upon which it may be possible to attack the problem of cyclical development in ponds and lakes. The general results they arrive at are that, as compared with *Euglena*, soil flagellates are able to live in cultures to which organic compounds of very varying nature have been added. This comparative impartiality is the result of the holozoic mode of nutrition, the development of the flagellates being absolutely dependent on the bacterial growth. The presence of the Miquel salts in the solution is necessary for the growth of the soil flagellates and for the proper development of the bacteria upon which they feed. The flagellates can feed upon a variety of different types of bacteria.

Method of Making Cultivation Media without Prepared Peptones.‡—S. R. Douglas describes a method of media making which gives constantly an efficient medium, and has proved more simple and easier than Haffkine's method. Fresh bullocks' hearts having been obtained, the fat and large vessels are removed. The meat is then finely minced, and to the mince thus obtained from an average-size heart four litres of water are added. This mixture, after being thoroughly stirred and rendered faintly alkaline to litmus, is heated to between 70° and 80° C. After cooling to 45° C. 1 p.c. of trypsin solution (40 c.cm. to the 4 litres) is added, the preparation of trypsin used being Allen and Hanbury's liquor trypsin co. This, in view of the fact that

* Proc. Roy. Soc., lxxxviii. (1914) p. 237.
† Proc. Roy. Soc., lxxxviii. Ser. B (1914) pp. 151–65 (1 pl.)
‡ Lancet, 1914, ii. pp. 891–2.

the preliminary heating has destroyed the anti-tryptic power of the meat juices, rapidly breaks down some of the albumins present. The trypsin is allowed to act for from two to three hours, the temperature being kept raised by placing the vessel containing the mixture in an incubator at 37° C. The next process is to precipitate the unaltered albumins and to render the broth easily filtrable, and with this in view the mixture is rendered slightly acid with acetic acid and brought to the boil. The coagulated proteids and other solid matters can now be almost entirely separated by straining through a bag of close-meshed muslin.

After rendering the fluid thus obtained alkaline to litmus, a small quantity of calcium chloride (about 0·5 grm. to the 4 litres) and 0·25 p.c. of sodium chloride are added, and the resulting broth is then autoclaved for an hour at 115 C.° so as to precipitate thoroughly any phosphates that may be in solution, filtered through filter paper, and then tubed and sterilized as in the case of ordinary peptone broth. In making agar the agar powder is best added before the phosphates are precipitated, as the prolonged heating brings the agar thoroughly into solution.

This medium has the following advantages over that made from beef extracts and prepared peptones:—1. The cost is very much less. 2. The growth of the bacteria both on the solid and liquid forms has proved to be very much more abundant than that obtained on the media usually employed; for instance, it has been found that four times more typhoid bacilli were obtained from agar bottles in a given time containing medium thus made than in the case of medium made from beef extract and Witte's peptone.

Peptone-free Medium for the Cultivation of the Tubercle Bacillus.*—The medium, the preparation of which is described by S. R. Douglas, was the outcome of the following observations. In the first place, it was noticed in cultivating tubercle bacilli on glycerin potato, that frequently an abundant growth of the tubercle bacillus occurred on the surface of the glycerinated salt solution which was contained in the lower part of the tube. Attempts were therefore made to make a broth from potatoes which would give a good growth of such bacilli. On such a broth good growths were frequently obtained, but from time to time an individual brew gave but unsatisfactory results. These unsatisfactory results seemed to rest with some quality of the potatoes rather than with any variation of alkalinity, etc. Noting, however, that the tubercle bacillus seemed readily to assimilate even coagulated albumin, it was determined to try the effect of adding some form of soluble albumin, unaffected by the temperature necessary for the sterilization of the broth, and with this in view various casein preparations on the market, sold under patent names, were tried in order to ascertain if these, when added to the extract of potatoes, would ensure a medium giving constant and abundant growth of the tubercle bacilli. The preparation giving the most satisfactory results was that sold under the name of "Plasmon."

The medium is made in the following manner. Potatoes are skinned, then passed through a mincing machine, and the resulting pulp

* Lancet, 1914, ii. p. 892.

is weighed. To each pound one litre of water is added and allowed to extract over night at room temperature. The solid matter is now removed by straining through muslin, and the resulting fluid is heated in the autoclave to 115° C. A sufficient quantity of acetic acid to render the hot fluid faintly acid is next added, which causes the suspended matter, starches, albumins, etc., to agglutinate into large masses, rendering the passage of the fluid through filter paper rapid and easy. The fluid thus obtained is rendered faintly alkaline to litmus, and 0·25 p.c. of glucose, 5 p.c. of glycerin, and 200 c.cm. per litre of a 2 p.c. slightly alkaline solution of plasmon are added. On the addition of a white of an egg to each litre a further heating to 100° C. clears the fluid, and on filtration gives a clear brown-coloured broth, which is then distributed in flasks and sterilized by steaming for 30 minutes on three successive days. Agar medium can also be made from this broth, which gives an abundant growth of human tubercle bacilli having but very slight adherence to the agar surface, and in consequence easily lifted off with a coiled platinum wire, and floated on to the surface of broth when it is desirable to grow the organism on fluid media.

(2) Preparing Objects.

Gametogenesis of Grantia compressa.*—A. Dendy obtained this sponge from near the Plymouth Laboratory, from Drake's Island and Rum Bay. A large number were microscopically examined in the living condition, either by teasing, or by hand sections, or by pipetting out the contents of the central gastral cavity, but search for living spermatozoa was fruitless. The material that turned out satisfactory was fixed either in strong Flemming's solution, or in a mixture of Flemming, formol, and sea-water. In the former case, it was graded up after washing to 70 p.c. alcohol, in the latter it was preserved in formol sea-water.

The sections were for the most part cut of a thickness of 5μ, and stained on the slide. Iron-brazilin gave excellent results, but iron-hæmatoxylin was also used. For staining in bulk boraxcarmin or paracarmin was employed, the latter being sometimes followed by picro-indigo-carmin, but without much effect.

(4) Staining and Injecting.

Chromosome Complex of Culex pipiens.†—Monica Taylor fixed the material in Benda's fluid, acetic bichromate, Gilson's mercuro-nitric, Flemming, and Gilson-Petrunkewitsch, the two latter being the most successful for the cytology proper; the two former were useful for interpreting cytoplasmic details. Thionin, iron-hæmatoxylin, Mayer's cochineal, Ehrlich hæmatoxylin, and safranin, were the stains employed. Many slides were first studied in thionin, and then the coverslip removed, the thionin washed out, the sections restained in iron-hæmatoxylin, and comparisons made between the results of the two stains. Although

* Quart. Journ. Micr. Sci., lxxxviii. Ser. B (1914) p. 319.
† Quart. Journ. Micr. Sci., lxxxviii. (1914) p. 379.

the aceto-carmin preparations of the whole gonad are very useful for mapping out quickly the main facts of spermatogenesis, they are not permanent, not so good for finer details, and not useful for somatic mitosis.

New Reaction of Fats.*—L. Martinotti states that a group of dyes belonging to the class of amino-azo compounds has the property of fixing fats, and in the presence of an oxidizing agent of making them insoluble. In staining by this method, in which chrysoidin and chromium are the essentials, the material is fixed in 10 p.c. formalin, and the sections, cut on a freezing microtome, are immersed for five to ten minutes or so in a 1 p.c. aqueous solution of chrysoidin. After a wash, the sections are immersed in 10 p.c. chromic acid or potassium bichromate for one minute, then washed and mounted.

(5) Mounting, including Slides, Preservative Fluids, etc.

Mounting Microfungi.†—J. Burton recommends the use of the following medium as an excellent staining-mounting fluid: Pure glycerin 3 parts, distilled water 1 part, Hoffman's blue solution q.s. The exact quantity of the blue solution cannot be stated, but sufficient should be added to tint the fluid a rather dark blue when in bulk.

(6) Miscellaneous.

Diascopy of Traces of Blood.‡—Angelo de Dominicis finds that the following procedure serves to detect traces of blood in cases where all other methods fail, and is especially valuable where a very small quantity of blood is present on heavily rusted iron. With dried blood adhering to a substrate, a scarcely visible particle is introduced into a trace of origanum oil on a Microscope slide placed on a white background, and is thoroughly disintegrated by means of the rounded end of a glass rod. After the addition of a drop of a saturated or more dilute solution of eosin in paracetaldehyde, the preparation is examined in artificial light passing through a suitable diaphragm. A drop of euparal may be employed subsequently to render the preparation permanent. Where the blood has penetrated the subtrate, the latter and the blood are scraped off by means of a sharp knife in the form of a fine powder, which is treated as above. Particles of blood appear wholly or partly coloured, and the red corpuscles, in groups or isolated, may be distinguished; the diameter of the corpuscles can be measured.

Study of Restitution Masses.§—W. De Morgan and G. H. Drew in their study of the restitution masses formed by the dissociated cells of the Hydroids, *Anteunularia ramosa* and *A. anteunina*, followed the

* Zeitschr. Phys. Chem., xci. (1914) pp. 425-39.

† Journ. Micrology (1914) p. 71.

‡ Boll. Chim. Farm., liii. (1914) pp. 162-3. See also Journ. Chem. Soc., cv. and cvi. (1914) ii. p. 759.

§ Journ. Marine Biol. Assoc. x. (1914) pp. 440-63 (9 figs.)

technique initiated by H. V. Wilson. The Hydroids were cut in pieces, and pressed through bolting silk, 50 meshes to the inch, with the result that isolated cells and small cell aggregates were obtained: these soon aggregated together to form compact masses, and in from 12 to 18 hours a perisarc was secreted by a definite layer of ectoderm cells. The endoderm cells form definite tubules similar in structure to the cœnosarcal tubules continuous with the enteric cavities of the normal hydranths. The masses were kept alive for at least 60 days. No sign of cell division was ever noticed, and hydranths never regenerated.

Microchemical Detection of Aluminium.*—According to E. Kratzmann, characteristic crystals of cæsium alum are obtained when a drop of a solution containing an aluminium salt is mixed on a Microscope slide with a drop of a reagent consisting of equal volumes of a 2 mol. cæsium chloride solution and an 8 mol. sulphuric acid solution. As little as 0·001 mg. of aluminium nitrate may be detected by the test. Plant ashes may be tested directly, but the addition of sulphuric acid is recommended when much calcium carbonate is present. The crystals are also obtained when sections of plants are treated with the reagent. Aluminium is of very frequent occurrence in plants, but the "alumina grains" mentioned by Radlkofer and Wehnert as being present in the leaves of *Symploceæ* could be identified as aluminium compounds only in the case of *S. lanceolata* and *S. polystachya*.

Metallography, etc.

Growth of Metallic Eutectics.†—F. E. E. Lamplough and J. T. Scott have sought to determine the effect of under-cooling at the beginning of solidification of the eutectic on the structure of lead-tin, cadmium-tin, and many other binary alloys. No relation could be discovered between under-cooling and the formation, around the primary crystals, of a halo or envelope of the second constituent, separating the primary crystals from the banded eutectic. Under-cooling almost always occurred when care was taken to prevent surface oxidation. Whilst in some cases considerable superfusion existed without the formation of such structures, in others marked halos were accompanied by slight superfusion only. When superfusion at the moment of eutectic formation was prevented, either by inoculation, or by shaking, the formation of the envelope was in no way affected. By quenching at various stages in the formation of the eutectic, it was ascertained that in some cases the growth of the eutectic originated at the primary crystals, while in other cases the growth of the eutectic was independent of the primary crystals. The halo appeared to be formed around a primary crystal when the eutectic, originating independently, had reached the primary crystal in its growth. The solidification of the eutectic at this point consisted in the deposition

* Journ. Chem. Soc., cv. and cvi. ii. (1914) p. 678.
† Proc. Roy. Soc., Series A. xc. (1914) pp. 600–4 (4 figs.).

of a layer upon the surface of the primary crystal of that constituent present as primary, the other constituent solidifying as an envelope surrounding the primary.

Hardening of Metals.*—C. A. Edwards and H. C. H. Carpenter develop a theory of the cause of the hardening of steel and other alloys upon quenching. In the operation of quenching such alloys, severe stresses are set up which cause pronounced crystal twinning. This twinning appears to be directly connected with the intensity of the thermal changes, such as the Ar_1 inversion, which occur when the mass is slowly cooled, but are suppressed by quenching. At all the surfaces of slip upon which twinning occurs, amorphous layers are formed, similar to those developed when a metal is hardened by cold-working. The hardening resulting from quenching is due to the presence of the amorphous layers. The authors regard martensite as austenite in which twinning has occurred.

Theory of Hardening.†—A. M'Cance gives the results of experimental work on which he bases a theory of the hardening of steel by quenching. β-iron is not a separate allotropic condition, but is α-iron which has lost its ferromagnetism through purely thermal causes. On cooling, the change from γ to α-iron takes place with very high velocity, and cannot be appreciably retarded by quenching. A quenched steel contains carbon in the state of solution, which retains a portion of the iron in the γ condition. Most of the iron is in the α condition, but is hard owing to its state of interstrain, resembling the state of a metal hardened by cold-working. The author describes a peculiar structure developed in a disk of steel, containing 0·86 p.c. carbon, clamped between two larger masses, heated, and quenched, so that the disk was cooled only from its edge. A number of concentric zones, alternately hard and soft, and appearing alternately light and dark in the polished and etched surface, were found surrounding the dark-etching centre of the disk.

Cast-iron of Unusual Structure.‡—K. W. Zimmerschied describes the structure of a cast-iron consisting wholly of pearlite and graphite, and compares it with cast-irons having more usual structures.

Titanium nitride in Steel.§—G. F. Comstock has investigated the constitution of certain hard non-metallic inclusions found in rails made from steel, to which ferrotitanium had been added. They were never found in rail steel which had not been treated with titanium. The inclusions were minute, were not segregated in groups but always uniformly distributed through the section of the rail, and were not elongated in the direction of rolling. They were usually rounded in shape, and sometimes

* Journ. Iron and Steel Inst., lxxxix. (1914, 1) pp. 138–91 (28 figs.).
† Journ. Iron and Steel Inst., lxxxix. (1914, 1) pp. 192–265 (24 figs.).
‡ Foundry, xliii. (1914) pp. 404–8 (11 figs.).
§ Met. and Chem. Eng., xii. (1914) pp. 577–80 (16 figs.).

had angular outlines. In the light from a carbon arc they appeared bright pink in colour. As it was not possible to isolate sufficient of the substance for analysis, various compounds of titanium were incorporated with untreated rail steel, melted in a vacuum, until a substance was found which gave inclusions having the same microscopic characteristics as the pink spots. Titanium sulphide and carbide did not give pink inclusions. Titanium nitride gave inclusions precisely similar to those found in the rail steel, and the same result was obtained when the experiment was repeated with special precautions to exclude alumina, thus indicating that the pink inclusions were not alumina coloured with titanium. The author concludes that the pink inclusions are titanium nitride, possibly containing small amounts of iron or carbon, but no alumina.

Structure of Manganese Steel.*—In the course of an investigation upon the magnetic and mechanical properties of steel containing 12 p.c. manganese and 1·25 p.c. carbon, R. A. Hadfield and B. Hopkinson have examined specimens microscopically. Quenched from 1000° C. the alloy had a fine-grained polygonal structure, and was non-magnetic and tough. On heating for some hours at 500° to 600° C., the material became magnetic and brittle, and developed an acicular, martensite-like structure. The changes occurring were more evident in specimens which were polished and not etched. The alloy quenched from 1000° C. showed no structure. After heating at 400° C. for six hours, and polishing, the surface became covered with interlacing lines, apparently the edges of plates of hard material. Further heating at about 400° C. caused a growth in the amount of the hard constituent, which appeared to form a stiff unyielding network enclosing grains of a more ductile material. A steel containing 2 p.c. carbon, 0·14 p.c. manganese, quenched from 1200° C., consisted largely of austenite, which was changed to martensite by heating for 75 hours to 200° C.

Failures of Heavy Boiler Shell Plates.†—S. A. Houghton discusses the causes of a number of failures of mild-steel boiler plates. Among the defects described and illustrated by photomicrographs are carbonless bands, some of which were high in phosphorus content, local deformation caused by hammering, blowholes, coarse crystallization, and sulphide and silicate inclusions.

Sulphides in Steel Ingots.‡—J. O. Arnold and G. R. Bolsover describe the microscopic forms of the sulphide inclusions found in a number of experimental steel ingots containing different amounts of sulphur and manganese, with about 0·25 p.c. carbon. In ingots containing less than 0·1 p.c. manganese and about 0·6 p.c. sulphur, pale brown meshes of iron sulphide only were seen. With 0·4 to 1·1 p.c. manganese, and 0·4 to 0·6 p.c. sulphur, the specimens contained both the pale brown iron sulphide and dove-grey manganese sulphide. An

* Journ. Iron and Steel Inst., lxxxix. (1914, 1) pp. 106–37 (14 figs.).
† Journ. Iron and Steel Inst., lxxxix. (1914, 1) pp. 266–316 (31 figs.).
‡ Journ. Iron and Steel Inst., lxxxix. (1914, 1) pp. 396–406 (7 figs.).

ingot with 1·01 p.c. manganese, 0·28 p.c. sulphur, contained only the dove-grey manganese sulphide. The existence, at some stage in the solidification of the steel, of a eutectic of iron and sulphide of manganese, is inferred from the appearances observed.

Recrystallization of Deformed Iron.*—C. Chappell describes and discusses the changes of structure, in relation to temperature, which occur when cold-worked iron and steel are heated. In uniformly deformed specimens no change takes place in the external boundaries of deformed ferrite crystals up to about 500° C. At about 350° C., however, changes begin to occur within the crystals. Rough granular markings in the etched crystals, frequently in the form of parallel bands, appear to be regions in which disintegration and incipient recrystallization of the deformed ferrite crystals have taken place. These markings indicate the recrystallization of the very severely deformed ferrite existing on and about the planes along which deformation of the crystal had taken place during cold-working. The disintegration of the crystals develops with rise of temperature until at about 500° C. many of the crystals present a completely granular appearance. With further rise of temperature, minute independent crystals appear in the disintegrated regions : these crystals grow with great rapidity. At about 570° C. the crystal debris is wholly replaced by the new crystals. From 570° to 700° C. these crystals steadily increase in size ; above 700° C. further growth is very slow, until complete recrystallization occurs at Ac_3. Numerous experiments were made on the recrystallization on heating of locally deformed specimens, in which the degree of deformation varied from point to point. The gross crystallization occurring under certain conditions, in such specimens, is described and explained. It is suggested that the growth of crystals on annealing takes place by the sudden combination into one crystal of two or more contiguous crystals, and not by the gradual absorption by a large crystal of the smaller crystals surrounding it. The process of recrystallization of deformed ferrite crystals is one of refinement followed by growth. The extent to which refinement takes place increases proportionately with the degree of plastic deformation. The ultimate crystal size after annealing deformed iron may be regarded as the resultant of these two opposing tendencies, and increases regularly with decrease in the degree of deformation. The temperature of crystallization becomes lower with increase in the degree of deformation.

National Physical Laboratory.—A Leitz† Metallograph has been installed, and has proved useful for rapid work. Two metallurgical Microscopes have been mounted on hinged supports, over openings in the table. By a single movement of the hand, the Microscope can be pushed into a receptacle, formed by a large bellows, beneath the table ; the opening being then covered, the table is clear, and the Microscope completely protected. The progress made in various researches is indicated in the report.

* Journ. Iron and Steel Inst., lxxxix. (1914, 1) pp. 460–502 (25 figs.).
† Nat. Phys. Lab. Annual Report, 1913–14.

New Reagent for Etching Mild Steel.*—W. Rosenhain and J. L. Haughton, give an amplified account of this reagent.† The formula recommended is :—

Ferric chloride (Fe_2Cl_6)	30 grm.
Hydrochloric acid (conc.)	100 c.cm.
Cupric chloride ($CuCl_2$)	1·0 grm.
Stannous chloride ($SnCl_2$)	0·5 ,,
Water	1 litre.

The steel surface must be perfectly clean before etching ; this is best secured by finishing the polishing on a very wet block, washing the specimen immediately in a jet of alcohol, and immersing it completely in the reagent. The structure of martensite is developed very clearly. The principal value of the reagent, however, lies in its capacity for indicating phosphorus segregation, as described previously.

* Journ. Iron and Steel Inst., lxxxix. (1914, 1) pp. 515–27 (17 figs.).
† See this Journ., 1914, p. 222.