Mr. T.W. Barkley

WATS ON

Ref: J5/464

C

SERVICE 3 MICROSCOPE

Many of you will know that we have received criticism of the fixing of the inclined monocular head on this microscope. It has been found that a wrong grub screw was being used to locate into the recess of the inclined head itself. This has now been corrected in production but of course it is possible that some of the earlier deliveries made to customers may be faulty.

When you are visiting customers who possess Service 3 microscopes delivered between October 1963 and February 1964 would you discreetly check, where possible, that the heads are being clamped properly by the securing screw. If you find or if a customer reports trouble with this locking arrangement, please return the instrument to Barnet for rectification as soon as possible.

There has been some criticism of the fine adjustment motion on the Service 3 microscope and this also has necessitated a change in production procedure. If you receive complaints from users, please return the instruments in question for modification. Perhaps you would at the same time check your own demonstration instruments to determine whether or not there is any loss in the fine adjustment, as it is extremely important to insure against any criticism being made during a demonstration.

A production Service 3 microscope has recently been finished in black and its general appearance is most pleasing. One or two customers have been advised that this finish is available but it is expected to cost £2 more than the hammer finish for quantities of less than 25. For larger quantities, we are considering undertaking this type of finish without extra charge. You will be notified as soon as a firm decision has been made on this point. In the meantime would you kindly comment on whether or not you feel the extra £2 is justifiable and acceptable.

WATS ON

Some news of a more optimistic nature is that we have successfully negotiated a substantial order for Service 3 microscopes at the University of Durham, Department of Zoology, together with a substantial order for Stereoscopic microscopes. This order was obtained in face of strong competition, particularly by Vickers who attempted price cutting methods. The information regarding the order is unclassified but the information regarding Vickers must be treated as confidential.

WATS ON

Ref: J6/464

C

FRICTION DRIVE STAGE FOR BACTIL MICROSCOPE

Production of this stage is expected to be ready by August of this year when it will at first be fitted to the Bactil-60 microscope, so that the run-down on the old stage will be with the standard Bactil. As and when the Friction Drive Stage is fitted to the Bactil, the following points of interest are worth noting :-

1) The substage focusing right hand milled head is replaced by an end cap, so that substage focusing will only be possible with the left hand.

2) When the microscope is used in the normal position, the iris unit has to be rotated through 180°. Again this would allow convenient operation by the left hand.

3) In the event of the microscope being supplied with a reversible binocular head and Friction Drive Stage, No. 2 above does not apply and in No. 1 above, the left hand milled head is replaced by an end cap.

4) An interesting feature of the Friction Drive Stage is that it incorporates a substage motion stop screw, thereby eliminating condenser flushing by Barnet by means of altering the length of the condenser mount sleeve which is current practice. Any difficulties arising as a result of changing condensers by the customer can be therefore easily overcome.

WATS ON

Ref: J7/464

U.C.

SLOW MOVING STOCKS

Our attention has been drawn to a number of items(of which there are large stocks) which do not sell very quickly. There is a good case for trying to push these as much as possible, particularly in connection with the sale of standard instruments. It is suggested that you make a list of the following items and offer them for sale where possible :-

1) Stage Micrometer divided in inches. There is no reason why this could not be sold in place of the millimetre stage micrometer as you will appreciate that all rulings are arbitrary until calibrated with the eyepiece scale.

2) Arm Rests for Box Foot and Research Stereos. It is probable that many of our customers with these microscopes do not possess arm rests and do not know of their existance. It is always worthwhile mentioning, during a demonstration, that arm rests are available and the price is a very small proportion of the total value of the outfit.

3) Substage Lamp outfit for Box Foot Stereo. The majority of Box Foot instruments are ordered with mirrors and it could be pointed out that the substage lamp is very much more convenient.

4) Projection and Drawing Prism. At any suggestion of projection work, please offer to send one of these prisms on approval. It may also help to further the sales of lamps such as the Universal model.

5) Wide Angle Diffusing Rod. Although this in many ways has been obsoleted by the new Fluorescent Illuminator, there are a considerable number of Streamlite and Spot lamps in every day use, and for the addition of a diffusing rod, the benefits obtained with the Fluorescent Illuminator are immediately apparent.

6) Foot Focusing Unit. This is restricted for use with the Research Stereo and where possible should be offered to existing users as well as new prospects.

7) x 8 Huymic and x 8 Pointer Eyepieces. Perhaps these can be offered instead of the standard x 10, to dispose of these would be particularly attractive as x 8 does not figure in the range of rationalised eyepieces.

8) Aplanatic Magnifiers x 5 and x 20 in pocket mounts. Many Botanists use these types of magnifiers and it could be something you produce from your own pocket to offer as and when the occasion arises.

9) Labgear-Harding Microdissector. When present stocks are exhausted, no further supplies will be available. Why not have one attached to your demonstration Research Stereo!

10) Vertical Binac Attachment. About one dozen of these are still available and you are reminded that they can be used with straight monocular microscopes of any manufacture.

11) Sodium Lamps. There are a number of laboratory applications for this type of illuminator apart from their use with interference objectives, and sales might be increased simply by mentioning them in conversation.

12) The Unisect. This is a workman-like little instrument and it is suggested that the leaflet on this is left wherever you go. Please let us know your leaflet requirements there are plenty available.

WATS ON

Ref: J8/464

U.C.

Several enquiries have been received requesting data regarding the tubes used in the Fluorescent Illuminator. For your information;

1) The average rated life is 5,000 hours.

2) There is no U.V. present.

3) There is a striking time of 1 to 5 seconds depending on ambient temperature.

4) Lumin output is 74.

5) Luminance approximately 5 cd/sq. in.

We are still receiving a considerable number of enquiries. Please order further depot stocks in good time.

WATS ON

Ref: J9/464

R.

QUOTATIONS

From time to time Barnet receive orders from your customers accurately priced, stating a quoted delivery time and referring to an estimate of a particular date. Much time can be spent at Barnet tracing the estimate only to find that it was one made by a representative, sometimes verbally. It would be of considerable assistance if you could provide a copy of your quotation to the customer for our files. It is also felt important that verbal quotations given by you on the telephone, or during the course of a demonstration, should be confirmed in writing either by the representative concerned or by Barnet(request to be made on the standard report form). This does help to keep the matter warm and remind the customer that he has got to do something about that Watson microscope.

TELEPHONE CALLS

Many of you undertake the practice of reversing charges when telephoning Barnet and this is convenient when one has to keep finding small change in this day and age. Barnet are now on the Subscriber Trunk Dialling system and if your conversation is likely to be a lengthy one, reversing the charge can make the cost very considerable. It is not proposed that you try and restrict the length of your calls as this is not always possible, but it is suggested that you might be able to confine most of the calls to early in the morning when it is almost certain that the persons to whom you wish to speak are available at Barnet; such calls which might be between 9.00 and 9.30 in the morning, would then be from your own telephone number, the charge for which, is of course, an expense item. Alternatively, you are reminded that you can telephone Mr. Jackson during the evening at, Potters Bar 54637, which is at a time when rates are cheaper. This method is to be recommended if you wish to discuss anything of an urgent nature, or plan an early start the following day.

WATS ON

Ref: J10/464

U.C.

Mr. Terrell is publishing, as a Technical Sales Memorandum, the complete report made by the Mullard Radio Valve Company, Measurement Department, which deals with the Image-Shearing Eyepiece.

This Measurement Department is one of the leading Departments in the country and perhaps can be considered as much an authority in their particular sphere as can the National Physical Laboratory.

There are one or two points in the report to which I would like to draw your attention. Perhaps the most valuable comment is in the summary, where they have examined the sensitivity of the instrument and confirmed our catalogued figures. They also report, later on in the text, that the W.I.S.E. was found to be very easy to set and read and that repeatability of readings was found to be very good.

Under the section heading "Conclusion" it is interesting to note that their testers made favourable comment on the clarity of the images and that it was very easy to be certain when the images were touching each other.

It is felt certain that you will agree that this report is most encouraging and whilst we have not yet received permission to publish in full there is no objection to you using it in your discussions with prospective customers.

WATS ON

TO:- The Editor,
Wats On,
Barnet.

12.3.64.

Dear Sir,

I have received the first edition of this excellent production and I feel that I must compliment you on finding this way of filling a long-felt need in the Watson organisation.

Perhaps you will permit me to make a few comments and suggestions, as below:-

1. I wonder to what extent the technical representatives are handicapped when asked to give demonstration of equipment for fluorescence microscopy by the fact that so many objects which are used in this technique are impermanent and fade within days of their preparation.

I suggest that it might be profitable if anybody who has found a good demonstration specimen writes in to WATS ON giving details. My own contribution is this - In Liverpool Univ. Path. Dept., research on bone is being done and one of the approaches involves the use of the antibiotic tetracycline. This lodges in the lamellae of new growing bone, and, being fluorescent, shows up under U-V. Moreover, it is permanently fluorescent, and a ground section of a piece of bone with this fluorescent detail forms an excellent specimen to demonstrate fluorescence at the lower magnifications. Doubtless, an official approach to this Dept. would produce a number of specimens for use by reps. unless there is any restriction on the grounds of non-published work. I have not been able to find any permanent specimen for dem. under the highest powers.

2. Ref: T.S.M. No. T.2.

(a) I suggest that, to ensure that all your readers are equally conversant with terms used, a simple explanation of the term "transverse colour" be included in some future edition. There are some rather woolly ideas about concerning this.

(b) In the section on "To extend the exposure time", the use of the Neutral Filter is advocated. It might be of

/Contd...

interest to note that some workers in colour photomicrography have used such filters as ON10 to reduce intensity and have then been puzzled by the over-riding green tint which spoils the finished photograph. The cause of this is that both ON10 and ON11 are not straight-line filters for all wave-lengths but have a marked rise in transmission at about 0.4 micron. I suggest that this point be brought out in a later edition to avoid wrong information being given to customers who are not working in black-and-white.

(c) "Ultra Violet Stopping Filters". It is stated that a Tungsten light source emits little U.V. Readers might be surprised to know that this small emission is enough to be usable in one form of fluorescence microscopy. Using a clear 100 watt bulb, a copper sulphate solution and a Woods filter, Auramine stained T.B. in sputum shows up sufficiently well to make this a usable technique, far better than the standard Ziehl-Neelsen stain, but, of course, not of the quality obtainable by the U.V. lamp and interference filter as usually supplied. But, it works and is inexpensive. I have seen this in certain hospital labs. in Derby, Nottingham and Leicester.

3. Refs T.S.M. No. T.4.

There are two mentions of the laser, and it would seem that, in the future, there will be increasing references to it by customers in addition to the literature.

While the laser, as such, is of no immediate concern to the technical reps., they will come into contact with the name, and I would suggest that, if it were possible to give a very simplified explanation of what the laser is and does, this should be done, not to enable reps. to discourse on it, but to make them intelligent listners whenever it is discussed.

Yours faithfully,

(Signed)

Jos. D. Casartelli

Contd...

Ed. :- Thank you for your valuable comments;

1. We intend to publish a series of articles on Fluorescent Microscopy shortly and to encourage discussion of the subject. Perhaps we should start with an elementary account of the technique and its applications? A bone section with Tetracycline labelling is a good specimen for a 16mm objective - similar sections of teeth are also used.

2. (a) See T.S.M. No. T 8

2. (b) In cases where red or purple stains are used and a small amount of glare is present the residual green colour of a glass neutral filter can actually improve the background colour. Gelatine neutral filters have a flatter curve, Mr. G. Parkyn uses them routinely when making colour photomicrographs with a Bactil-60 without difficulty. Some workers use partly crossed polaroids as a neutral filter but these leave a purple or magenta residual colour.

2. (c) The other commonly used white source containing U.V. is daylight. The spectrum extends to shorter wavelengths than that of a Tungsten source and increased rapidly with altitude being quite troublesome in laboratories over 1,000 ft. above sea level.

3. We hope to publish something on lasers shortly.

WATS ON

APRIL 1964

U.C.

TECHNICAL SALES MEMORANDUM NO. T 5

Anti-reflection coatings

The performance of optical instruments with image forming lenses is usually regarded as a function of the aberrations of the lenses used but in practice it also depends on the amount of light lost in the instrument and the amount of glare or unwanted light present in the image. Light is lost both by absorption in the glass and by partial reflection from the air/glass surfaces, the former being serious only in instruments with a long optical path in glass and the latter in those with a large number of surfaces. Light reflected from the surfaces can also add to the glare usually by multiple reflections but an important case is when light is passing through a surface in both directions as glare can then be produced by a single reflection. This situation arises in objectives used for vertical bright field illumination and in the prism of the interference objectives.

The reflectivity of a typical uncoated air/glass surface is about 4% but this can sometimes be substantially reduced by a suitable coating. In principal a coating with optical thickness of $\frac{1}{4}$ wavelength and a suitable refractive index to give equal reflectivity from the front and back surface (= square root of the glass index) would ensure zero reflection. In practice single layer coatings have limitations because it is possible to have a quarter wave thickness only for one colour and also because the refractive index is dictated by the limited range of suitable materials which must be capable of controlled vacuum deposition and must be chemically and mechanically stable.

The notes following, indicating some of the problems and possibilities in this field, have been prepared by Mr. N. Smith of Watsons Technical Department.

Single layer coating

This is a single thin film of magnesium fluoride (MgF_2) deposited to an optical thickness (not geometrical thickness) of one quarter of a wavelength of light. It is designed to reduce reflection at the air/glass surface at the central yellow-green area of the visible spectrum. As the graph of reflection against wavelength is fairly symmetrical about the minimum this gives residual reflectances at each end of the spectrum which

/Contd...

combine to give the familiar purple tint, the correct reflectance colour for good blooming. Lines 'D' and 'E' in the graph show the performance of this type of coating on glasses of refractive index 1.52 and 1.626 respectively.

To deposit a film of this kind the lenses are cleaned and placed in a vacuum chamber. The chamber is evacuated to a pressure of 5×10^{-5} mm. of Hg. (the latest convention in the literature is to refer to mm. of Hg. as TORR, this is an abreviation of TORRICELLI the Italian physicist). Whilst under vacuum, the lenses are ionically cleaned by electron bombardment and heated to 250° C by radiant heat. The MgF_2 is then evaporated from a molybdenum boat. A monitor lens is observed during the evaporation and the process is stopped when the desired plum colour is obtained.

Two layer coating

The first layer is bismuth oxide (Bi_2O_3) deposited to a thickness of approximately .049 λ and the second layer MgF_2 deposited to a thickness approximately .33 λ. This coating is also designed to reduce reflection at the air/glass surface but the graph is not symmetrical about the minimum point, e.g. the curve rises steeply at the blue end of the spectrum and so if the minimum is moved too far over to the red end, the reflection of blue light would actually exceed that of an uncoated surface. Line 'C' on the graph shows the theoretical performance of two layer coating. The curves for crown and flint glasses are very similar, therefore only one is shown. The residual reflection colour depends upon the position of the minimum.

The depositing technique is very different from that for single layer MgF_2 coating. Special and expensive plant is required. Cleaning, chamber pressure, lens temperature and MgF_2 deposition are all similar to single layer coating but bismuth must be evaporated by cathodic sputtering not by heat. This means passing an electrical discharge between electrodes at a low gas pressure causing the cathode electrode to slowly disintegrate under the bombardment of the ionized gas molecules. In this way bismuth is caused to arrive at the surface of the lenses and during this process oxygen is leaked into the chamber and thus bismuth oxide is deposited. The other main difference is that the monitoring of the thickness of film deposited is a little more elegant than merely watching colour changes. Monochromatic light is used in conjunction with a modulated beam photometer to place the minimum at a specified wavelength in the spectrum and to stop depositing at the required thickness.

Other Multi-layers

These coatings are mainly theoretical at the present time although they have been produced and papers published on them. At least one American Company advertises an anti-reflection coating so efficient that it must be at least a triple layer (they will undertake to coat customers own lenses). The ultimate aim being of course to obtain a curve with very low reflectivity right across the visible spectrum. Multi-layers have curves similar to line 'F' on the graph with minima at three wavelengths for triple layers, four wavelengths for four layers and so on. The difficulty is in finding durable elements of the right refractive indices, and developing techniques to evaporate them as they are often rare earth elements. Also the computation work involved in arriving at the thickness required is tremendous.

Suitability to various types of glass

The efficiency of single layer coating depends on the refractive index of the glass, this can readily be seen in the graph. The reason is that for this coating to be efficient, the following formula should be satisfied:-

$$n_f = \sqrt{n_g}$$

Where n_f = refractive index of the film

and n_g = refractive index of the glass

Unfortunately other factors influence the choice of material for the film e.g. durability, ease of evaporation etc. therefore MgF_2 is a compromise of the various factors.

MgF_2 has a refractive index of 1.38 and $1.38^2 = 1.904$ and so it can be seen that on high index glasses where n = 1.6 or 1.7 conditions are approaching optimum but with low index glasses where n = 1.52 efficiency is lower.

These then are the limitations of single layer coating:

1) Its high minimum point (zero could be reached by using CaF_2 but this is mechanically weak as a thin film).

2) Its selectivity to refractive index of glass.

Two layer coating evens out the refractive index problem, the first

layer of Bi_2O_3 has a refractive index of 2.45 thus the MgF_2 is extremely efficient for both types of glass but has a disadvantage, if it can be called that, of being very selective to wavelength and not being a symmetrical curve.

A big advantage due to the depositing technique is that the minimum can be placed very accurately at almost any wavelength in the visible spectrum.

As many optical instruments are illuminated by tungsten light sources which are deficient in blue wavelengths and as glass absorbs more light from the blue end of the spectrum, then any gain of transmitted blue light (by decreasing the reflection losses at this end of the spectrum) is obviously a help to the colour rendering of the object being observed.

Durability and Mechanical Strength

MgF_2 films are very resistant to corrosion from humid atmosphere, alkaline and acid fumes and also impart a degree of corrosion resistance to the glass base.

Watson's single and two layer films will take 100 rubs with an emery impregnated ink eraser loaded with a 7-lb. weight, before a change in colour is noticed, the change in colour denoting, of course, that the film is decreasing in thickness. This shows in fact that the coating will stand up to all normal, and even some abnormal, cleaning.

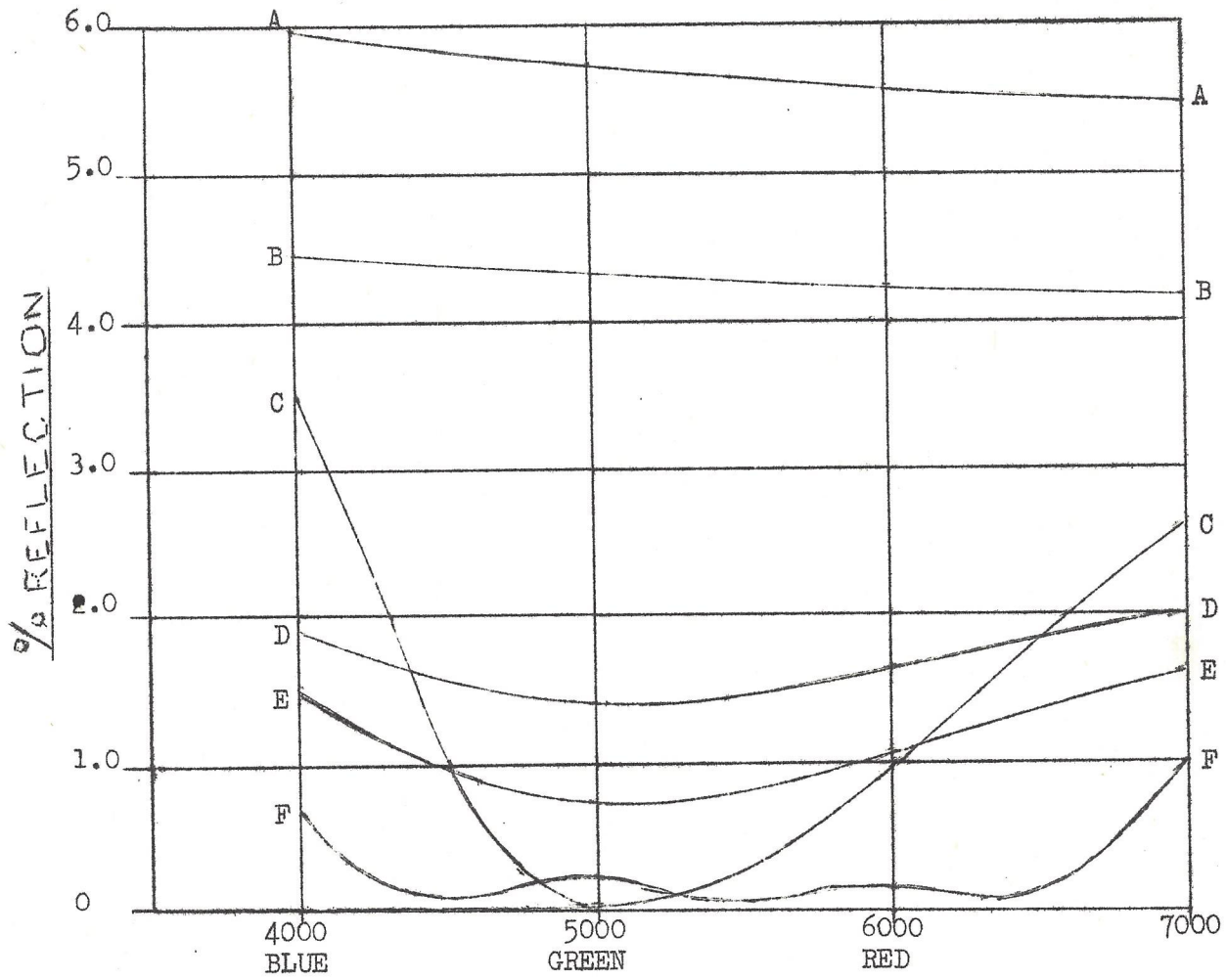
Current Watson Practice

Current Watson Practice is to two layer coat the optics of any instruments which contain large numbers of low index lenses or where the very low zero at a specified wavelength is an advantage, e.g. Cystoscopes, W.I.S.E., x 20 Compensating eyepiece, Trinocular head and also the second surface of beam splitters in the Standard Met. microscope.

Future Trends

These will almost certainly be towards more complicated multi-layers to achieve Achromatic coatings. As stated earlier the difficulty is in evaporating the elements which would give the desired results but as techniques improve and computors are used more and more to tackle

the complex mathematics involved, the remaining problem will probably be one of cost of plant and development versus the improvements in light transmission, glare and definition. A great deal of interest is also shown towards coatings working in the ultra-violet and infra-red for special applications, e.g. guided weapons, Lasers. Improvements in the efficiency of beam splitters are also envisaged but that is outside the scope of these notes.



A	UNCOATED D.F. GLASS n = 1.626
B	UNCOATED H.C. GLASS n = 1.519
C	2 LAYER ON H.C. & D.F. GLASSES
D	SINGLE LAYER ON H.C. n = 1.519
E	SINGLE LAYER ON D.F. n = 1.626
F	TRIPLE LAYER

WATS ON

APRIL 1964

R.

TECHNICAL SALES MEMORANDUM NO. T 6

Notice of Product Changes :-

R.J. Beck incident dark field illuminator

The objectives for use with this illuminator have been re-designed. The new range has refracting illuminating optics instead of the reflectors in the original design. The range of magnifications is now :-

x 7, x 12.5, x 25, x 50

The numerical apertures are similar to the originals.

The illuminator itself is unchanged and the new and old objectives are interchangeable.

It is intended to publish comments on the performance of the new lenses when they are available for inspection.

(The new Beck price lists are still not available but prices can be quoted on all products within a short time).

WATS ON

APRIL 1964

R.

TECHNICAL SALES MEMORANDUM NO. T 7

Report on W.I.S.E. from the Measurement Department of the Mullard Radio Valve Company.

The Mullard Radio Valve Company have a Measurements Laboratory at Mitcham which is a Service Laboratory for the Philips Group in the United Kingdom. They possess a Timbrell Image-Shearing microscope and have examined in detail the Cooke instrument. We have recently loaned them a W.I.S.E. and they produced the following report on its performance which we consider most encouraging.

COMMENTS UPON THE WATSON IMAGE-SHEARING EYEPIECE DEMONSTRATED BY MESSRS. W. WATSON AND SONS LIMITED

1. SUMMARY

At the request of Mr. Gardner, Thin Film Department, Mitcham, and Mr. Mould, Quality Engineering Department, Blackburn, a Watson Image-Shearing Eyepiece fitted to a microscope was secured on loan for a period of two days. The sensitivity of the instrument was examined and the manufacturers figures confirmed. The magnitude of the random variation in repeated measurements was assessed and given in the form of a $\pm$ figure representing the accuracy of determination. The results are extremely promising and we would recommend that this instrument should be considered seriously by anyone wishing to carry out work of very high precision.

2. GENERAL DESCRIPTION OF THE EQUIPMENT TESTED

The equipment tested comprised a Watson Image-Shearing Eyepiece (W.I.S.E.) fitted to a basic Watson microscope stand. The eyepiece

can, however, be used with most microscopes having a Royal Microscopical Society (RMS) standard tube diameter.

Technical details and principles were as specified in the manufacturer's literature.

In the course of the examination various objective lenses were used, together with x 10, x 10 compensating and x 20 orthochromatic eyepieces.

By the use of a dichroic beam splitter the two images, when in shear, appear red and green respectively and make the setting positions extremely easy to achieve.

Readings are made in the form, for example, 1728 units where the first two figures, 17, represent the number of revolutions of a drum and the remaining figures 28 represent tenths and hundredths of a revolution respectively.

The method of reading is by :

(a) a digital counting device geared to the drum which records the number of revolutions and tenths of a revolution. In our example, this will read 172.

(b) the drum itself is marked by 10 equally spaced lines dividing its circumference into 10 equal parts. As the drum rotates each line in turn passes a fixed index scale of 10 equal divisions (reading 0 to 10) each division having a length equivalent to one hundredth of a complete rotation. This enables the final figure in the reading to be made, in our example it is 8.

The makers give the following figures:

Objective Magnification and focal length.	Largest Measurable dimension approx. Microns	Approx.value of one unit. Microns
x 4 (40mm)	560	1.10
x 10 (16mm)	225	0.45
x 20 (8mm)	110	0.22
x 40 (4mm)	56	0.11
x 100 (2mm)	25	0.05

3. SOME DETAILS OF THE EXAMINATION

The examination was carried out in the Measurement Department of the Mullard Radio Valve Company, Mitcham on the 20th and 21st February 1964 by Messrs. Barsellotti, Killick and Rawson. Approximately 500 readings were made.

All three men are very experienced in the field of mechanical engineering and fine measurements. Messrs. Barsellotti and Rawson work in our Metrological Standards Room and are therefore familiar with instruments of the highest precision.

The items measured were :

A "line on a glass plate" - Heidenhain plate No. 13 with a series of lines of various widths from one micron to 16 microns in one micron stages. The 10 micron line, which has a verified size of 10.4 microns, was used in this examination.

A piece of gold plated tungsten wire of nominal diameter 10 microns was also used.

Mr. Barsellotti was in the throes of an attack of influenza: at the end of the experiment he went to the Medical Department where his temperature was found to be 101 and he was sent home.

4. RESULTS OBTAINED

Before turning our attention to the results there are two matters of importance which must be explained.

4.1. As we have said in section 2, the readings are made on a digital counting device andindex scale in the form, for example, 1728 units. When the W.I.S.E. is properly fitted into a microscope the value of one unit in terms of the size of the work-piece under examination will be constant. It can be changed by changing the magnification of the objective lens, but is not affected by the magnification of the eyepiece lens.

The ratio $\frac{\text{True size of work-piece in microns}}{\text{Difference in readings in units}}$

will be spoken of as the conversion factor.

4.2. There are basically two setting positions in which a reading can be obtained; with the two images sheared or coincident. Starting

from the position of coincidence we can, by rotating the drum so that the reading increases or decreases, obtain two positions of shear which we will for convenience call positive and negative shear respectively.

It follows then that the instrument might be used in three ways.

4.2.1. Make a reading at the position of positive shear then at negative shear and take the difference. In the table we have appreviated this method to S-S.

4.2.2. Read at coincidence, then at either positive or negative shear. This we have called the C-S method but we have not tabled it in our results.

For any particular size of work-piece, it will be seen that the difference in the readings in units will be half that obtained by the S-S method. It follows that the conversion factor is double compared with that of the S-S method (assuming the instrument to be linear in operation over the range of movement being considered).

4.2.3. Obtain a reading at coincidence at the start and assume that it remains fixed. Thereafter make one reading only at either positive or negative shear and take the difference from this constant reading. In the table this is called to F/S method. The conversion factor is as in paragraph 4.2.2.

4.3. In our tests all readings were made at coincidence and both positions of shear, thus we could estimate accuracies of determination for all three methods. We have confined ourselves to calculating the accuracy of determination for the S-S and F/S methods only.

4.4. Results.

As stated in section 2 the manufacturers give conversion factors of 1.10, 0.45, 0.22, 0.11 and 0.05 microns per unit for objectives of magnification x 4, x 10, x 20, x 40 and x 100 respectively. Figures obtained for objectives of magnification x 10, x 40, x 50 and x 90 are in agreement with the suppliers figures.

In order to assess the accuracy of determination of the size of a work-piece measured by means of the eyepiece, the testers repeated their readings until they had four readings for each observation made. In the ideal state the four readings would always be identical but, as with all fine measurements, we expected to see some variation and

this proved to be so. The readings obtained are assumed to be from a distribution having a single peak. From the ranges of the sets of four readings obtained we estimated the standard deviation of the distribution and from this in turn we estimated the accuracy of determination of a single reading (see section 5.4). For the latter we multiplied the standard deviation by ± 2.58: a single reading will deviate by more than this amount on the average only once in a hundred times.

In work of this nature, the instrument must only be used as a comparator and it must be set with a master, the size of which should be very close to that of the work-piece to be measured hence - apart from the limitation set by the accuracy of determination of the size of the master - the random error is the only source of error.

The various values obtained are set out in the table which follows, in which the entry, for example, 50/10 against the accuracy of determination ± 0.14 microns indicates that Mr. Killick obtained this accuracy with a combination of x 50 objective and x 10 eyepiece.

TALLY OF ACCURACIES OF DETERMINATION

Kk = Mr. Killick. Ba = Mr. Barsellotti. Rn = Mr. Rawson.

Accuracy of Determination in microns	S-S Method Measured by:			F/S Method Measured by:		
	Kk	Ba	Rn	Kk	Ba	Rn
± 0.23					50/20	
0.17					50/10	
0.16					40/20	
- 0.15 -		50/10		50/10	90/10	
0.14	50/10	50/20,90/20				
0.13				40/20,50/20		40/10
0.12						50/10
0.11	40/20	40/20				
- 0.10 -	50/20	90/10		50/10		
0.09	50/10		40/10,50/10	40/10		
0.08						
0.07				90/20		
0.06	40/10,90/20			90/10		
- 0.05 -	90/10					

The accuracy of determination is seen to range from ± 0.05 to ± 0.23 microns.

The figures obtained by Mr. Barsellotti are somewhat higher than those of the other two men; it will be remembered that he was unwell at the time.

The three people testing the instrument were impressed with the clarity of the images. It was easy to be certain when the images were touching each other - and also when they were coincident.

For the 10 micron wire viewed with the x 90 objective, the image is improved by employing oil immersion.

5. COMMENTS ON THE RESULTS

5.1. Our figures for the conversion factor are in agreement with those given by the manufacturer as stated in section 4.4.

5.2. Putting aside Mr. Barsellotti's results which may have been influenced by his being unwell, it appears that the S--S method is perhaps slightly more accurate. However, the F/S method is considerably quicker and would no doubt be used where the accuracy it gives is sufficient.

5.3. The readings were made by people who have experience of fine measurement and Messrs. Barsellotti and Rawson have had recently some experience of double image measurement. It is probable that with further experience on this particular instrument we would have an accuracy of determination in the order of ± 0.1 microns for a x 40 objective and ± 0.05 microns for a x 90 objective. This might conceivably be further decreased by estimating tenths of a unit.

The accuracy of determination for objective lenses of lower magnification was not tested during this experiment. From our experience of other instruments we would estimate that it would be in the order of ± 0.15 microns with a x 20 objective and ± 0.2 microns with an objective of magnification x 10.

5.4. It is emphasised that the figures relate to the accuracy of determination of a single reading. If the reading is repeated a number of times and the average of the readings obtained, then the accuracy of determination of this average is better than that of a single reading. It will equal the figure for the single reading divided by the square root of the number of readings which have gone into the average. Thus the accuracy of determination of the average of four readings is numerically half that of a single reading.

6. COMMENTS AND SUGGESTIONS ABOUT THE INSTRUMENT

6.1. With the instrument in its present form, making a measurement by the S-S method involves two settings and two readings, obtaining the figure and converting this figure to the true size.

The instrument was found to be very easy to set and read in any of the positions referred to in the text of this report.

Repeatability from either direction of rotation of the drum was found to be very good and obviously due to the movement being spring loaded thereby eliminating any possible backlash.

It was found that with the microscope stand used on this occasion, operators tended to get a stiff neck due to the upright position of the eyepiece, however this can quite easily be avoided by either tilting the complete stand unit or lowering the instrument with respect to the operators head height; we would suggest the former method.

6.2. Linearity tests were not made, we therefore cannot either confirm or dispute the manufacturers claims for a linearity value of 0.1%.

6.3. It might be possible to arrange for an additional adjustment whereby the reading magnification could be set to the nearest convenient multiple of 2, 5 or 10 for any of the usual lens combinations. This has been mentioned to Messrs. Watson on the telephone. One method would be to provide adjustment in the distance between the eyepiece and the objective lens. Further discussion on this point might be advisable.

6.4. No attempt was made to estimate by eye tenths of readings on the index scale, but as we have seen, the results achieved are most encouraging, and we feel that any estimations made might not be of any significant benefit to the precision of the results.

7. CONCLUSION

The conversion factor

$$\frac{\text{True size of work-piece in microns}}{\text{Difference in readings in units}}$$

is inversely proportional to the magnification of the objective lens.

The results we have obtained at the higher magnifications are in agreement with the figures in the manufacturer's leaflet.

By use of the shear to shear method of reading at x 90 or x 100 magnification we can achieve 0.023 microns per unit or approximately 1 micro-inch per unit.

The figures obtained for the apparent accuracy of determination are extremely encouraging and support the favourable comments made by our testers on the clarity of the images.

The sensitivity of the instrument for sizes up to 25 microns and its accuracy of determination render the instrument suitable for most measurements: with practice it would be suitable for the measurement of the diameter of fine wires. It must be remembered that in attempting measurements in this order of precision we are approaching the limits of what is possible by rapid means using visible light.

(signed)
W. M. ANDERSON

20.3.64.

WATS ON

APRIL 1964

R.

TECHNICAL SALES MEMORANDUM NO. T 8

Notes on Transverse Colour

by A.C. Terrell

There are a few more generally misunderstood phenomena in microscopy. I have tried to explain below what it is and how various attempts have been made to reduce its effects. The opinions expressed in these notes are my own and not necessarily those of the Company.

A single glass lens has a focal length which varies with colour but it is possible to make the focal length the same for two colours in the visible part of the spectrum by constructing the lens of two components cemented together using two glass types with different refractive index and different dispersion. A lens of this kind is called an achromatic doublet and the mathematics of this, for thin (low power) lenses, is explained in most elementary books on optics. Low power microscope objectives are often made this way and 25mm. and 16mm. objectives are usually constructed of two achromatic doublets. The largest practical aperture with this kind of construction is about 0.3 N.A. For larger apertures a different form of construction is used - a steep curved, powerful, front lens is achromatised by an over corrected cemented back lens. An objective of this kind is achromatic - meaning that the images, of the two chosen colours, focus together - but shows a small change of magnification with colour. This change is called a transverse colour effect and can be about 1% for a 4mm. objective and as much as 2% for a 2mm. objective.

The appearance of an image with this aberration is easily recognisable but is far more obvious with some kinds of specimen than with others. It is most noticeable with a high contrast specimen having fine detail. A film of small opaque particles in a clear suspension shows the effect prominently. If one focuses on such a specimen with say a 4mm. Para objective and a Huygenian eyepiece, the particles in the centre of the field should appear well defined but those away from the centre show bright colour fringing - blue towards the centre of the field and orange towards the edge.

The standard answer is to use an eyepiece with "compensation" having a magnification varying with colour in the opposite sense to cancel the transverse colour of the objective. Unfortunately objectives require

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different amounts of compensation. The following solutions to this dilemma have been tried at various times:-

a) The most satisfactory solution from the optical point of view is too inconvenient to be generally used. It is to use a different eyepiece for each objective. One might use a low power Huygenian eyepiece without compensation for objectives up to x 10, a medium power Compensating eyepiece for x 20 to x 50 objectives and a high power eyepiece with double the usual amount of compensation for the x 100 objectives. An advantage of this solution is that the magnification range of the given set of objectives is extended. High power eyepieces with double compensation were designed and made in experimental quantities at Barnet but proved expensive to manufacture and have never been listed.

b) The Holos eyepieces were designed to have a variable amount of compensation. They represent a successful solution to this problem in the way that amputation of the arm cures a sore thumb. The eyelens drawtube which adjusts the amount of compensation also has the following effects:-

1. It varies the field curvature from bad to very bad.

2. It defocuses the field stop leaving a worrying coloured ring round the field.

3. It alters the magnification by up to 40%.

4. It alters the optical tube length of the microscope enough to cause spherical aberration.

c) One solution (see forthcoming T.S.M. "The Zeiss range of objectives") is to design a 2mm. objective with the minimum possible transverse colour and then to build in to all other objectives this same amount of the aberration so that the same range of Compensating eyepieces can be used for all objectives. This sounds highly satisfactory but has one major disadvantage for a manufacturer depending on inexpensive student microscopes for part of his turnover as it becomes impossible to offer cheap low power achromatic objectives for use with cheap uncompensated eyepieces.

The WATSON thinking on transverse colour has, over the years, dabbled with all these solutions. At present the 16mm. Fluorite,

8mm. and 4mm. Paras and the 3.6mm. Fluorite are all well corrected by the ordinary Compensating eyepieces (as are the 16, 8 and 4mm. Apos). It is proposed to develop a x 5 objective with built-in transverse colour which would bring us near to the Zeiss solution.

Transverse Colour often spoils photomicrographs. The following rather obvious rules may help you to avoid it:-

a) Use only Huygenian eyepieces for Para objectives up to and including 16mm.

b) Use only Compensating eyepieces for all other current Watson objectives.

c) Use green filters for black and white photography with all 2mm. objectives.

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TECHNICAL SALES MEMORANDUM NO. T 9

Abstracts from recent publications

'Internation Science & Technology', March 1964.

Sizing Solid Particles,
by Dr. B. Kaye of I.I.T. Research Institute, Chicago.
(formerly of Nottingham & District Technical College)

Dr. Kaye reviews the major methods of analysis and their size ranges. A lucid introduction to the subject by a leading authority.

'Discovery' April, 1964.

Lasers - Fact and Fiction,
by Dr. Deryck Goodwin of R.R.E. Malvern.

A review of Laser developments - gas, semiconductor and solid state (ruby) Lasers are discussed with speculations on future applications.

'New Scientist' 9th April, 1964.

Measuring "Hardness",
by B.W. Mott, of A.E.R.E., Harwell.

A comparative review of the various methods of measuring hardness. The optical problems are not seriously discussed.

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TECHNICAL SALES MEMORANDUM NO. T 10.

The V.A.M.M.I.S.E. is coming

We have been looking into the problem of measuring vibration amplitudes optically at Barnet as it seems probable that the W.I.S.E. can be used for this work. We have had help and advice from Messrs. Pye Ling of Royston who demonstrated a prototype at their open day attracting much attention.

Vibration engineering is a growing art and is used for testing structures for resonances and also for fatigue testing in many industries, notably in aircraft and automobile engineering. It is usually necessary to measure the amplitude of vibration, often at many points on the structure under test. This is done by attaching small accelerometers and measuring their electrical output. The accelerometer consists of a small capsule containing a piezzo electric crystal with a small mass attached to it. It works in much the same way as a gramophone pick-up. At present these accelerometers are usually calibrated by Standards Laboratories but there is a demand for optical measuring equipment to enable users to calibrate their own.

A wide range of frequencies are used, from 5 c.p.s. to many k.c/s and the useful range of amplitudes varies from several cms at the lower frequencies to a few microns at the highest. The large amplitudes, above 5mm., can be measured easily by attaching a graticule with a focal triangle type of pattern on it to the vibrating accelerometer and viewing with a very low power microscope. The accuracy can be increased by using stroboscopic illumination. At amplitudes less than about 10 microns no satisfactory method is known but work is being done by some users with modifications of the Ferranti Moire fringe measuring system.

In the middle range - 5mm. to 10 microns - measuring microscopes are normally used. The standard method is to use a target with bright spots on a dark background (a 'star test' type of specimen). The 'stars' extend to lines when vibrated and the length of the line can be measured against an eyepiece graticule. The accuracy of the method is only about 5%, one difficulty being the low frequency drift often encountered especially with vibrators having electro-magnetic field coils.

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We considered the possibility of making much smaller focal triangle graticules, possibly by ruling on glass, but such a graticule would need to be fixed very rigidly to the accelerometer and would be very difficult to make to the required accuracy. The second and more promising approach has been to use the W.I.S.E. This has the advantage of being unaffected by the low frequency drifts and also seems to give remarkable repeatability. An instrument is being prepared on a special long arm stand with a range of low power objectives and a stage micrometer for calibration. This will be fully tested by Messrs. Pye Ling before being offered on the market. The diagram shows the stages in taking a measurement with this outfit.

The instrument has come to be called the Vibration Amplitude Measuring Microscope with Image-Shearing Eyepiece but V.A.M.M.I.S.E. is less of a mouthful.

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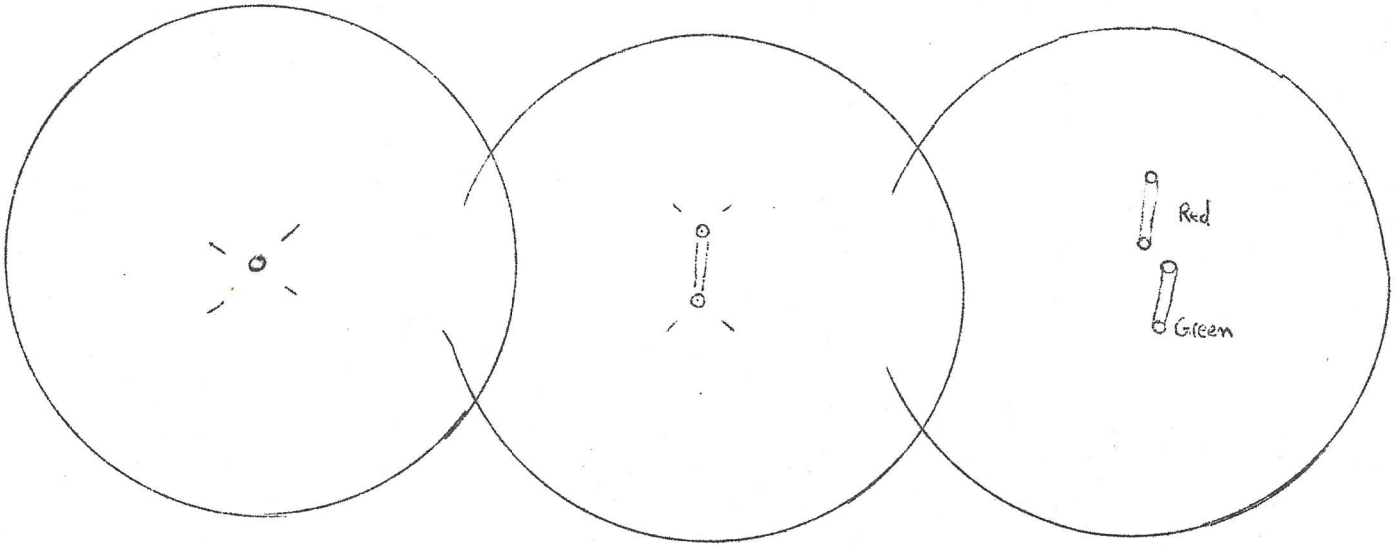
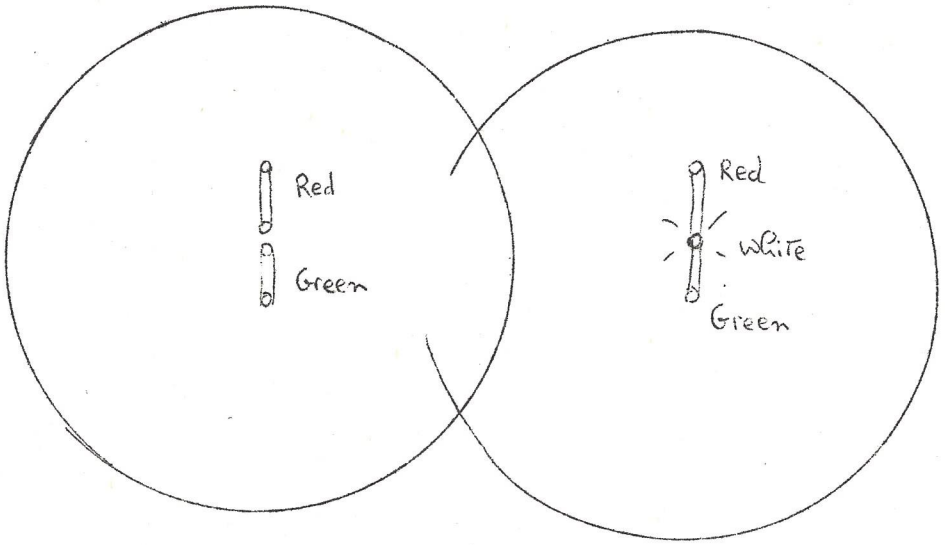
Stages In Setting VAMMISE



1. Set WISE To zero, Focus 'Star'.
2. Start Vibrator.
3. Shear WISE more than amplitude



4. Align WISE by rotating in E/P Tube.
5. Reduce shear To regenerate original 'STAR'
6. Read WISE Scale