Centring Microscope

Adapting Equipment For Your Needs

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Usage and Making

As the name suggests, a centring microscope is used to find or ‘pick up’ the centre of some feature on a part such as a hole, centre punch mark or the intersection of scribed lines prior to machining. A centring ‘scope’ can be used in the tail stock of a lathe to aid setting-up on a faceplate or in the spindle of a milling machine. However, the spur for acquiring this piece of equipment was not for the usual pre-machining set-up, but to check escapement components already made that were not performing as expected.[1]

Having the ability to measure accurately the small parts that we deal with can help identify issues and enable replacements to be made. In many cases it is not possible to measure an unknown dimension directly by normal means (for example, the centre distance between two jewel holes).

Tool rooms and metrology labs often have a toolmaker’s microscope or a coordinate measuring machine to check the geometry of components accurately.

Such dedicated equipment is expensive and difficult to justify for most of us. But if you have a milling machine fitted with a good quality digital readout or digital dial gauges then, with the addition of a centring scope, you have the basis for your own coordinate measuring capability.

The next challenge is acquiring a scope that suits your particular machine. Online searches in the usual places were not particularly fruitful as items for sale were either too large, too expensive or both. The final solution was to make an instrument based on a Hemingway kit from www.hemingwaykits.com. I have since found out that J. Malcolm Wild FBHI can supply an item that might have been suitable and this could be a consideration for others.

This article covers the enhancements made to the Hemingway kit which comes with materials, drawings and instructions, hence the details here focus on the changes made. The finished scope is shown fitted to a BCA jig borer in **Figure 1**.

First some expectation setting. If you machine the kit to the drawings it will work as a centring microscope. However, given that the whole kit is only about £100, including optics, do not expect a high quality image out of the box. Also, I do not pretend to be an expert in optics; the various upgrades detailed here are the result of an empirical approach which will hopefully provide a useful starting point for others.

Lighting

The first addition, and probably the easiest, is a dedicated light source which is shown in **Figure 2**. As the magnification goes up, the influence of lighting increases and, as we are mainly dealing with reflective materials, this can make it difficult to discern edges and other key features such as the true centre of a pop mark or scribed lines. A toolmaker’s microscope often has built-in lighting below a glass stage for profile work as well

Figure 1.

as top or side lighting. Luckily for us, modern microscopes are built to take a standard lighting ring, **Figure 2**, that is held in place by three radial pinch screws and is easily adapted to fit the centring scope.

Various types are readily available and the one chosen for this application was a two row LED unit with control box. It is worth obtaining a unit which allows selection of the LED rows as well as a dimmer capability. The unit featured allows you to select the inner row, the outer row or both. Changing which row is on does change any shadow effect and has proven to be a useful feature.

The only departure from the standard design is to turn a 90 degree groove in the lower diameter of the main aluminium body, **Figure 3**. This makes the fitting secure without marking the body and, more importantly, ensures that the lighting ring is square as any appreciable misalignment will have an impact on the shadows cast.

Figure 2.

Figure 3.

Figure 4.

Note that the objective lens shown in **Figure 3** differs from the standard design. This is covered later in the article.

Eyepiece (x10)

If there is one thing that does let the kit down it is the eyepiece. The one supplied had a very narrow field of view and did not really provide as crisp an image as I would have liked. Some of this will be subjective but as a glasses wearer (like many of us), an eyepiece with some degree of eye relief would also be helpful.

A bit of digging around on the internet revealed that wide-field x10 magnification eyepieces are available for a reasonable price. One was bought and after reducing the overall length to focus on to the crosshairs graticule (see Figure 6 for overall layout), it was possible to see the full range of markings and not just the central 25%, as was the original case. The wider field of view makes it much easier to find and pick up on the required features of a part. Importantly, the image is a lot crisper.

Figure 5.

Eyepiece and Graticule

To extend the capabilities of the scope it was necessary to be able to change the crosshairs graticule for one with other markings such as angles and thread forms etc. However, this will destroy the carefully set alignment of the instrument and a reset for every changeover is not a viable option. Knowing that the eyepiece has to focus on the graticule to be able to see the markings provides a solution to the problem. A second eyepiece with a different focal point will not 'see' the main centred crosshairs. Instead it can be focused on to some other graticule with different markings. The eyepieces can then be changed as required to switch between centring and comparative work such as measuring angles.

Many microscope eyepieces include a facility to screw in a graticule which makes things even simpler and self-contained, **Figure 4**. Note that you do need to check the internal diameter first before ordering as they vary. A second x10 eyepiece was bought, a more expensive Olympus item with adjustable focusing, not because this type was essential (one similar to the initial replacement eyepiece would have done the job), but more to see what difference a higher quality lens would have. Not that much, as it happened.

The manufacturer of the graticule included with the kit offers a range of alternatives such as different crosshair designs, scales and a protractor.[2] The protractor variant was ordered in a size to suit the Olympus eyepiece and this proved invaluable for checking the relative angles of the locking and impulse pallets in the lever for the co-axial escapement.[3]

Prism

The prism deflects the light from the objective lens through 90 degrees and into a tube which holds the eyepiece. The supplied prism is actually a 45 degree mirror and it was felt that the quality of this item could be improved on.

There are a number of alternative approaches to a mirrored prism, the one chosen being a penta-prism which faithfully preserves the orientation of an image while still bending the light through 90 deg. Note that the overall image in the eyepiece will still be inverted.

Figure 5 shows the penta-prism and revised holder machined from aluminium. The prism is a 10mm x 10mm item which is the size of the viewing window and was purchased from www.thorlabs.com.

The critical dimensions of the revised holder are the O/D to suit the internal bore of the body of the scope and the width

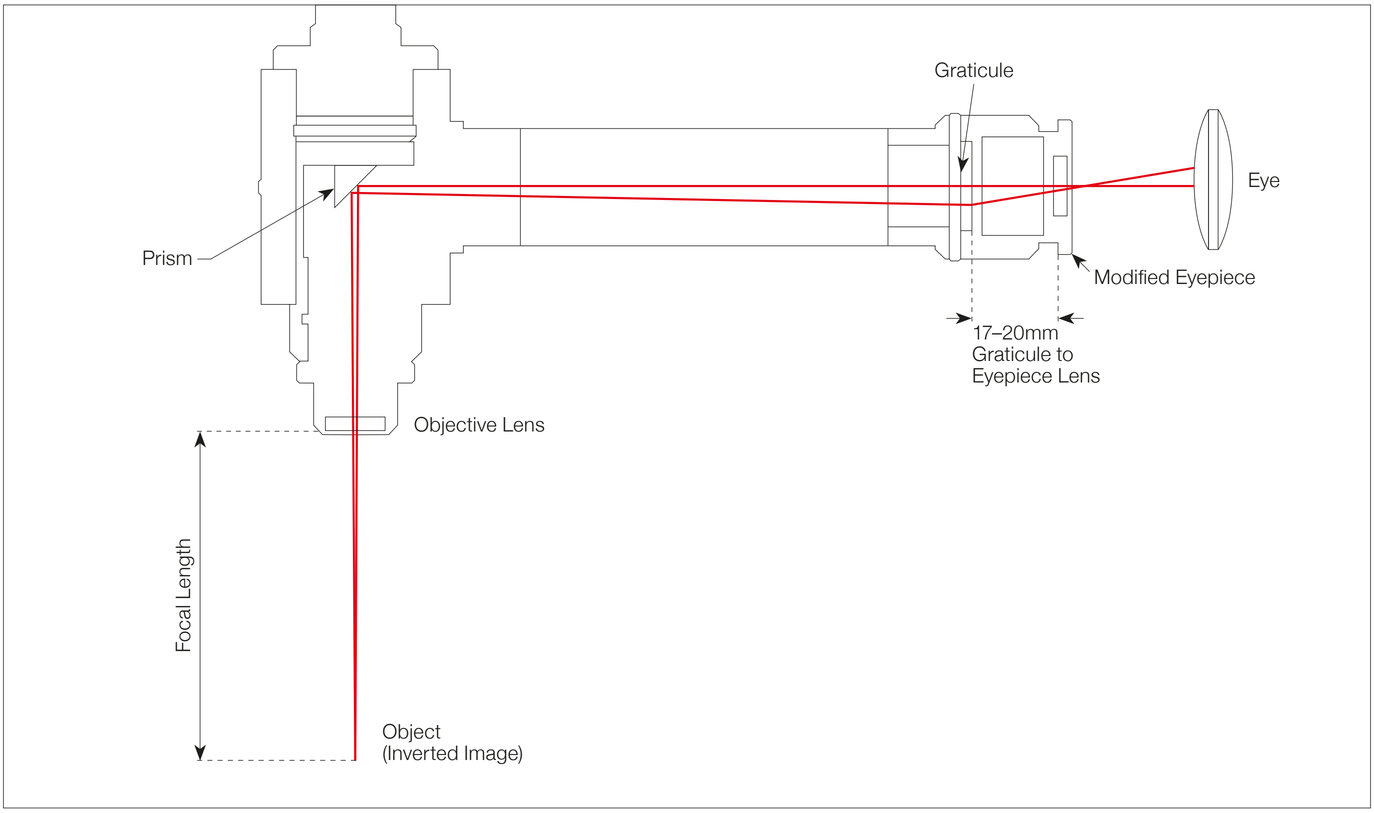

Figure 6.

and depth of the slot to ensure that the centre of the square face of the penta-prism is central to the body. Unlike the standard prism, this alternative approach allows for vertical movement in the slot to obtain the correct position with respect to the viewing tube and so provides a bit more wriggle room. Note there is also a small slug of plastic between the prism and the M3 grub screw.

Objective (x4)

The drawings state that the thread for the objective lens is a standard and so generally available microscope items should fit. Having changed all the optics other than the objective it seemed a logical progression to purchase a commercial item and compare any differences.

This is the one change that probably had the least impact on the image quality, but did have a useful outcome in that the focal length is about half that of the supplied lens. Given the limited height above the table on the BCA (a combination of the length of the scope body and a loss of some head height due to the revised spindle bearing arrangement) this has proven very useful.

Magnification

The magnification of the microscope is calculated as the product of the objective and the eyepiece. Therefore, the magnification of the revised optics is 4 x 10 giving a total of x40, while the magnification for the original kit is stated as x20. I suspect that this is incorrect as using the commercial 4x objective resulted in a similar magnification to that with the supplied lens.

Conclusion

While making tooling and equipment is time consuming, it does mean that you end up with something that suits your particular requirements and methods of working. Like anything else, the more you do, the more you learn and so the easier it becomes.

In this case, the resulting piece of equipment was key to tracking down errors in the escapement components, enabling replacements to be made to the correct dimensions. The instrument will also improve the quality of future work such as accurately picking up on the intersection of scribed lines for screws and pivot holes.

ENDNOTES

1. D. Cottrell, 'Making a Tourbillon Pocket Watch', *The Horological Journal*, 159 (November 2017) pp490–493.
2. NE25 Half Protractor, 20.4mm diameter, from www.pyseroptics.com.
3. D. Cottrell, 'Making a Tourbillon Pocket Watch', *The Horological Journal*, 159 (November 2017) pp490–493.