Hints on photographing gems

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Cheap high-resolution digital cameras are often equipped with a built-in lens capable of focusing very close, so it is now easy to take photographs of gems. However, it is not at all easy to get perfect pictures.

There are several reasons for this:

One is that the focussed gem may have to be so close to the camera (Fig 1a) that it is difficult to illuminate properly. The centre of the gem tends to look dark. The reason for this is that cutting angles have been optimised, by trial and error over history, for a pattern of illumination where the only dark area in the environment of the gem is that due to a human head at a distance of about 300 mm (Harding).

As shown in Figure 1a, the body of a small digital camera may subtend a much larger solid angle at the gem than this (as shown by the dotted lines). The effect of this is that the centre of the gem is shaded by the camera body and cannot return light to the lens.

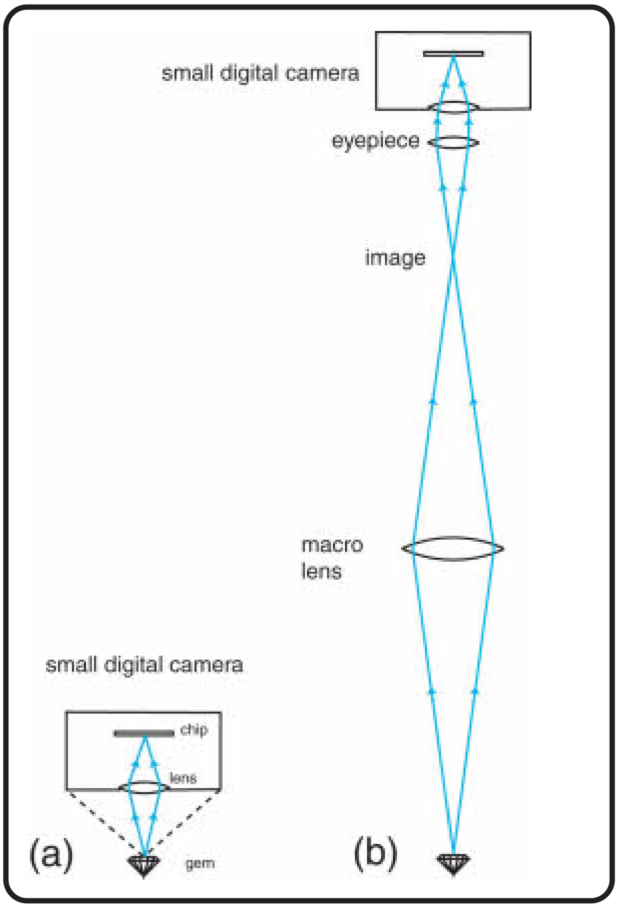

Figure 1.

Comparison of photography with a small digital consumer camera, which can focus as close as 20 mm or less and with a two-stage imaging system, using a macro lens and eyepiece in conjunction with the same camera set at infinity focus.

Another problem is that the viewfinder screen in such cameras have a lower resolution than the final image, making it difficult to judge focus.

Thirdly, a rigid stand is necessary to prevent the picture being ruined by vibration, particularly when tiny control buttons on the camera are being pressed. (With other macro subjects, such as insects or flowers, the depth of field can be increased, and the vibration problem eliminated, by using electronic flash. This works so well that the camera can be hand-held, but, unfortunately, direct flash does not work well with gems).

A big advantage of using a firm camera stand with a focus rack is that a series of photographs can be obtained at different positions of focus, and the sharply focused regions combined into a single digital projection, using the freeware CombineZM (see previous edition of Stonechat Issue 72).

In spite of these problems, a small consumer camera is extremely useful for photographing gems at shows or museums.

To go beyond this and achieve better illumination and control is surprisingly expensive. The purpose of this article is to describe some improved arrangements which the author has used, and others might like to read about, before choosing elaborate equipment.

The first improvement I tried was to add, to a consumer digital camera with a built-in lens, an eyepiece and a macro lens. In this setup, the imaging is done in two stages, as shown in 1(b). The consumer camera is left with its focus set at infinity at all times, and the eyepiece is used to enable the camera to focus on an intermediate image formed by the macro lens. If you are making your own setup, you need an eyepiece lens of the type found in a microscope and designed to be used with the eye quite distant from the top of the lens (called a 'high eyepoint eyepiece', such as is made for spectacle-wearers). The macrolens can be the kind used for 35 mm macrophotography.

Unfortunately, a setup like this cannot be purchased, you have to build it from parts obtained from a number of different suppliers . The setup in Figs 2 and 3 was made in this way on the basis of a Nikon Coolpix 995 camera, with a 'Navitar' eyepiece unit (see references).

As Figure 3 shows, the distance from gem to lens can thus be extended to many centimetres, so there is no problem with arranging lighting.

I found that the best form of illumination was obtained by placing over the gem a bell-shaped frosted glass lampshade, 150 mm high, with a hole at the upper end (where the handle of a handbell would be) about 30 mm in diameter (Figure 5).

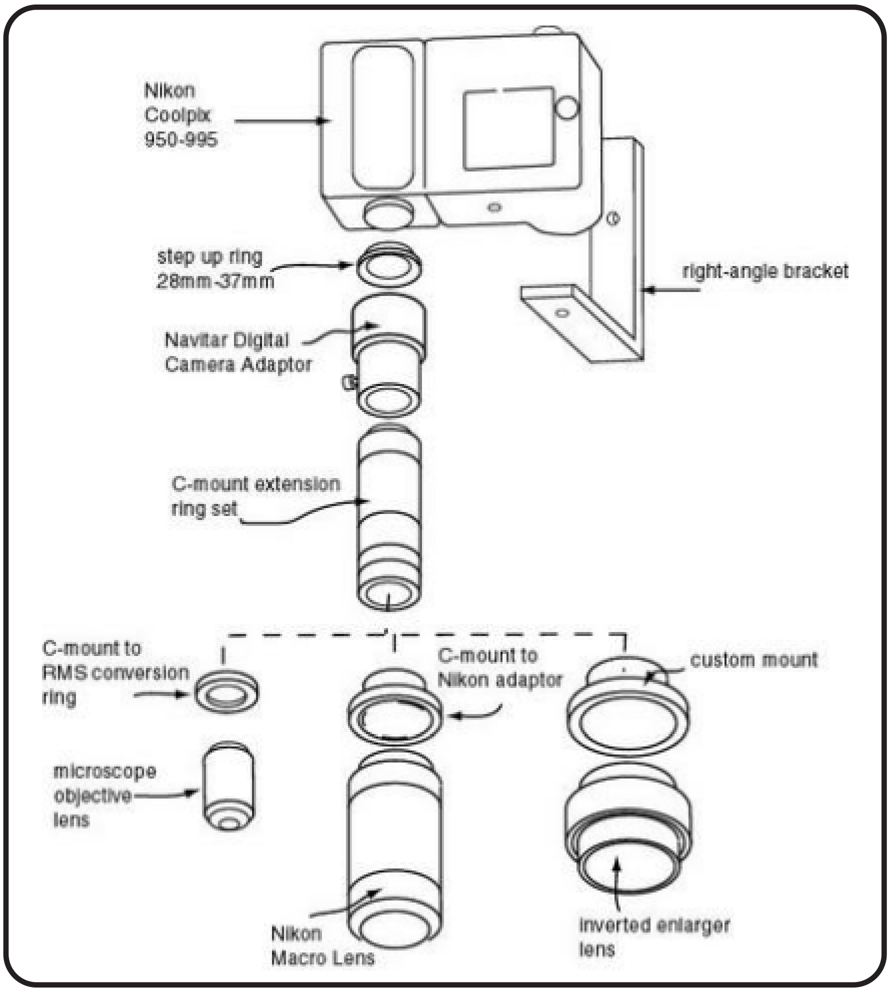

Figure 2.
The large number of parts needed to achieve the arrangement of diagram 1b.

Not all the alternatives are necessary:
a single macro lens (e.g. a Zeiss Luminar) with a focal length of 40 mm works well at a range of magnifications.

Setting up for photography involved messing about with tiny buttons, not ergonomically placed for macro work. It was necessary to be extremely careful about dust, which tended to appear on a glass surface within the eyepiece and invariably came to light only after the photo session was finished. This problem is a well-known consequence of using an eyepiece in this way, and arises from the fact that some of the glass surfaces in an eyepiece are very close to the intermediate image plane.
Although I can definitely recommend this camera- plus- eyepiece- plus- macrolens approach the setup is not easy for someone without access to a machine-shop to build and the final result is still not entirely easy to use.

While working with this Coolpix / eyepiece / macrolens arrangement I often wished that I had a simple camera back, containing a high-quality modern CCD chip with 5 million pixels or more, but without any buttons or indicators on the camera body. It would be ideal, I thought, to be able to operate the camera from a PC, see the image on a standard high-resolution screen, and use whatever macrolens I wanted without the need for an eyepiece.

Note the heavy camera stand in Figure 3 (originally designed for supporting a Bolex 16 mm movie camera over a microscope). This particular type of stand has a fine rack-and-pinion vertical motion, but it was also convenient to have the specimen mounted on a LabJack for quick coarse focusing.

This setup has worked well. It has allowed photography under well-controlled illumination with excellent light-return from the gems, with no visible central dark spot. It is much better than using the digital camera on its own. However, the camera's screen has rather low resolution, and the video output (via a cable to a CCTV monitor) is also of low resolution.

In spite of selecting 'Manual Mode', I was unable, with this particular camera, to switch off maddening automatic features, which made the viewfinder image sharp and bright even when the recorded image subsequently proved to be out-of-focus and too dim. This made it necessary to bracket every exposure, just as one had to in the days of 35 mm film, and to take through-focus series as well.

Figure 3. *Camera with eyepiece and macro lens being used for transmitted light photography with polarizers.*

Note the very large object-to-lens distance.

My work with laboratory microscopes has revealed that such camera backs are in fact available. They are called 'microscope cameras' and are designed for mounting directly on microscopes, using a C-mount (a 1-inch diameter threaded hole, provided in the camera body, with no lens in it). All the major microscope manufacturers supply cameras of this type, but my tests have all been with a Nikon DS-L2 system with a non-cooled colour camera (DS-Fi1 as shown in **Figure 4**.

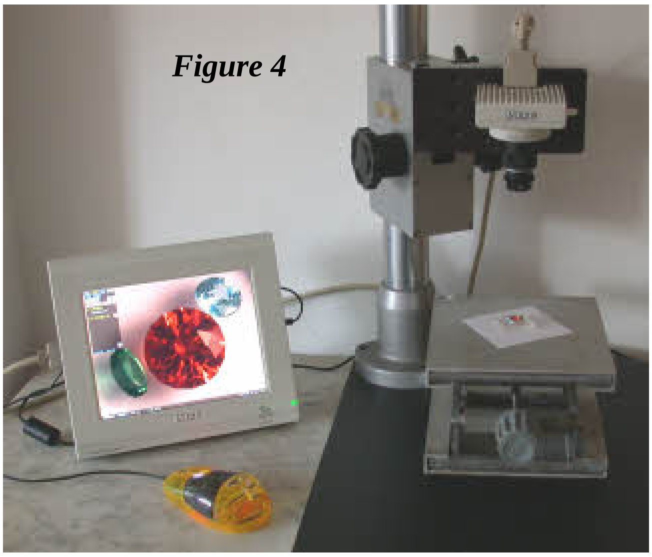

Figure 4

It's wonderful! This system is by far the easiest to use that I have found: it is never necessary to bracket images because you get everything right on the screen and the camera saves the image exactly as you have inspected it, at high resolution. The image can be viewed on the medium-sized 1024 x 768 monitor in the DS-L2 control box, or at even higher resolution on a standard LCD computer monitor, in which case the large detailed image is quite stunning (much better than the image from a video or webcam system). Even at full resolution, the refresh rate (chip readout rate) is 5.9 frames per second, and there is a 23 fps mode for rapid focusing.

The whole setup is quite small (see the mouse in figure 4 to get an idea of the scale) but comes with a mini-computer in the control box, allowing measurement, annotation, auto and (thank goodness!) truly manual exposure control and even some image processing facilities. You can also pop this type of camera directly on to a c-mount on a stereomicroscope. In **Figure 4** , I have removed the lamps and the diffuser. The macro lenses I use are of 40-60 mm focal length. The images can be removed by taking out the Compact Flash Card (which I do not like to do because of the danger of bending one of the tiny pins through repeated use), or, preferably, by means of a detachable USB memory stick.

The current list price for this system is approximately £6 K, so it is out of reach of me and most amateur faceters, but when such equipment begins to circulate in the used lab equipment market, it will be worth watching out for. I hope to convince the microscope manufacturers that a lower-cost version would be very popular as a studio macro camera for all sorts of photography, including gems.

There are many highly expensive digital cameras which are made to simulate the 35 mm single-lens-reflex design, and take macro lenses of long focal length, as advocated here. If you are thinking of purchasing such a camera, perhaps intending to use it for general photography as well as gem work, ask the following questions:

Can it be provided with total computer control, so there is no need to seek and press tiny buttons on the camera body?

Does it need special software for the computer interface?

Is there a full-resolution display that can be used for focusing?

Is a studio camera stand available for macro work, and can the focus be shifted with a precision of ten microns or better, without lateral movement?

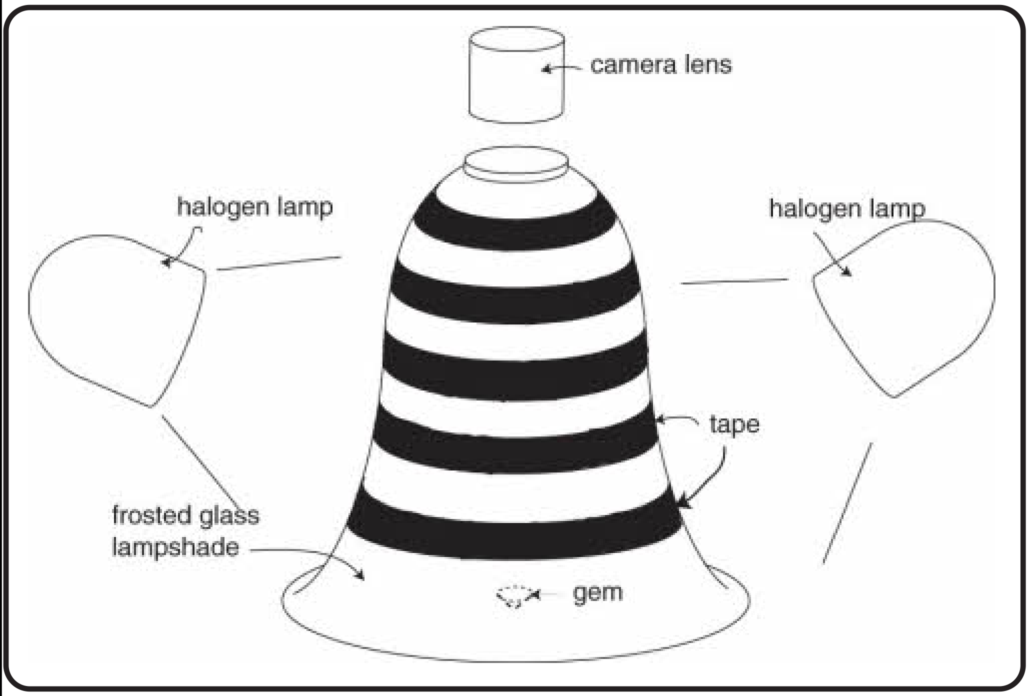

Figure 5

Bell-shaped frosted glass lampshade used as a diffuser, with opaque black insulating tape wound around to produce variegated lighting.

All these things are needed.

Finally, I wish to mention my current experiences in illuminating gems. I use a pair of cheap small halogen lamps on flexible stands, using the white-balance correction feature on the camera to correct for the low colour temperature of the light (i.e. its reddish colour relative to fluorescent light).

With reference to Figures 5 and 6, I use the bell-shaped diffuser **(Figure 5)** to eliminate the harsh contrast **(Figure 6a)** of the directly-illuminated gems. This often produces a bland result, lacking in contrast **(Figure 6b)**. However, if the light from the diffuser is broken up by winding strips of opaque insulating tape around the outside of the bell, the gem springs to life, with enough contrast to give an impression of sparkle even in the static image **(Figure 6c)**.

For this, the tape needs to be about 10 mm wide, with 10 mm gaps between successive turns. A good compromise between uniform and variegated illumination can be obtained by bringing one halogen lamp close to the taped diffuser so that one particular facet is highlighted (6d).

6(a) halogen lamps without a diffuser,

Figure 6

Photographs of a synthetic ruby round gem, using the apparatus of Figs. 4 and 5.

6(b) diffuser without tape,

6(c) diffuser with tape,

Above:
6(d) with tape, and with one of the two halogen lamps brought close to the diffuser

With colourless gems, the opaque tape trick is particularly effective, since it shows up dispersion colours well **(Figure 7)**. While you are changing the pattern of illumination in this way, the overall intensity varies enormously, so it is vital to have a manual exposure-time control that is easy to operate.

Left: Figure 7
A colourless gem (CZ) photographed with the taped diffuser, showing the dispersion colours, which are invisible unless the tape is added.

References (on the web)

Analysis of gem facet angles with regard to illumination:

Harding, Bruce L. Faceting Limits

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Navitar Digital Camera Adaptor:
http://machinevision.navitar.com/pages/product_information/accessories/digital_camera_adapter.cfm