An Introduction to Video Recording at the Microscope

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Summary

Video recorders are a common household possession to record and replay broadcast programmes or pre-recorded video tapes. The acquisition of a simple video camera coupled to a microscope can enable the amateur to record, store, and replay microscopical images *via* a domestic video recorder and TV set or monitor. This paper recounts the basic information needed by those unfamiliar with video cameras and recorders, and has been compiled from the joint experience of the above members.

The Advantages of Video Recording

TO THE MICROSCOPIST whose main interest lies in observing living material, video recording has a great deal to offer over cine film:

Ease of operation.
Very much lower running costs.
Very much longer running times.
Instant playback of recordings.
A ready and convenient means of relaying microscopical images to small audiences.
Ease of exchange of recorded tapes between amateurs with like interests.

The Basic Equipment Requirements are:

A video recorder camera with its own built-in mains power supply, to convert the microscopes optical image into an electronic image.
A video recorder/player to receive the electronic image and record it on a video tape, and replay it as and when required.
A TV set or monitor to display the electronic signal as a visual picture.

Most domestic video recorders can accept the direct input from a camera via a 'video-in' connection which is preferred to using one of the R.F. (broadcast wavelength) channels of the TV set but where no 'video-in' connection is provided then the R.F. co-axial link from the recorder to the TV set must be employed. Best picture quality is preserved when tuning circuits are by-passed by the video-in connection.

The camera is linked to the recorder by co-axial video cable and the recorder to the TV set or Monitor likewise. Monitors do not have tuning circuits they are dual-purpose monitors cum TV sets, and not all TV sets have a video-in connection so an R.F. channel on the TV is then chosen and tuned to the recorder circuits in accordance with the makers instruction manual.

Portable TV sets with a monitor facility would have both R.F. (aerial) and 'video-in' connections.

Budgeting

The first step towards involvement in video microscopy is a budgeting exercise in parallel with gaining the knowledge of camera and recording equipment needed to make a sound assessment of what to purchase.

The budgeting exercise is individual, a new CCD colour camera with a colour monitor and a video recorder would need a budget of £1500/£2000, while an ex-security black and white camera and monitor can be bought within a budget of £150 and used with a domestic video recorder for observations to be recorded.

Guidance on what to purchase is not readily found in books or video magazines which seem mainly to extol the virtues of the latest form of 'compact' video camera/recorders that are expensive and not ideal for microscopy as they have fixed lenses, while the recording methods described are more aligned to those used in cine photography for the shooting of planned sequencies to a prepared script.

Choice of Camera

Non-portable mains powered cameras are preferred, as used in fixed positions for security and similar purposes. Compact style Camcorders (combined camera/recorders) with a non-detachable lens are not well suited to video microscopy. In budgeting the choice lies between black and white or colour cameras, new or second-hand. New black and white of suitable size and weight cost around £250£350, second-hand ex-security £60-£90. New colour CCD (charges coupled device as the latest and most suitable microchip sensors) around £800, secondhand rarely available.

Colour cameras with tubes cost around £250 secondhand in the simplest and more suitable forms but will be larger and heavier than black and white cameras because they have three tubes to individually sense the red, green and blue content of the image.

Black and white cameras have higher definition for the same target size than colour, and are quite adequate for most work where a colour image is not vital to the observation. Colour is always attractive but not necessary for most observations. To gain experience of video microscopy but with reduced risk of unwise expenditure, a black and white ex-security second-hand camera is very well suited to learn on. Most have a detachable lens with a 'C' mount thread (the standard for cine), but the lens is not needed unless captions or macro shots are to be videoed so the 'C' mount female thread on the cameras lens flange can accept a 'C' mount adaptor and be linked to a microscope adaptor. The most suitable microscope will have a focussing stage and a fixed limb to support the weight of the camera, but where the microscope chosen has a focussing limb and body and the weight of the camera is too much for the microscope's coarse adjustment to hold then the camera must be supported on its own stand over the microscope.

Black and white cameras mostly use a Vidicon tube with a 'target' (image receiver and converter) sized from two-thirds to 1 inch, the larger tube having the greater resolution in proportion but also larger in bulk and weight.

If a second-hand black and white ex-security camera is chosen then it is important that it should have been set up by an experienced technician for video microscopy so that blacks are really black (known as 'setting the black

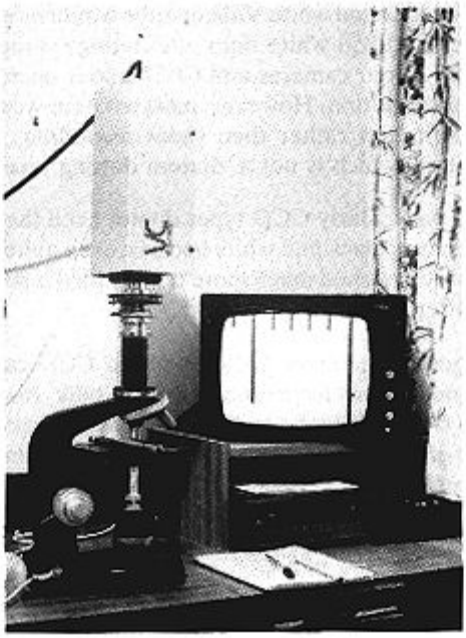

FIG. 1. Ex-security use Model V.C. 2502 camera with 1 inch Vidicon tube, attached to the rigid limb of a Nikon SKt microscope. The 12 inch black and white monitor screen shows a stage micrometer with 0.1 mm graduations under a × 10 objective and a × 12.5 ocular, covering 0.8 mm of half the 1.6 mm seen through the eyepiece.

level') and that a full range of grey tones can be rendered on the screen when viewing a Kodak Grey Scale Test Card. These adjustments require access to makers service handbooks and an oscilloscope.

It is important to link the video camera to the monitor or the video recorder by a co-axial cable designed for the purpose and identified as 75 ohm. A general purpose video cable of suitable specification is coded VRM 70.

Where a camera is purchased the matching cable and end-connectors should be purchased at the same time. End fittings vary between several standard types, from phono with a single centre pin and an outer push-on sleeve to a more complex form with a bayonetted fitting known as BNC, to a 21 pin SCART plug, all available from radio spares retailers who can also supply conversion kits to couple non-matching connectors together.

In the context of video, resolution is measured differently from methods used in microscopy. The number of 'lines' quoted refers to a count of each black and each adjacent white line, measured along a horizontal line mid-screen over a width equal to screen height. The vertical resolution or the spatial resolution depends partly on the number of lines in the TV raster (625 lines interlaced for the European PAL system) and upon whether the horizontal lines to be resolved lie parallel to the raster and fall on a sweep line or stretches across two adjacent sweeps when resolution would fall drastically.

A high resolution black and white Vidicon tube would be expected to resolve 700 lines (350 black and 350 white lines alternating) along a horizontal line while Vidicon tubed colour cameras and CCD colour microchips would have better than half that resolution. However, most amateur work would rely more on contrast and definition rather than sheer resolution, particularly when recording live material which is not a 'diatom dotting' exercise.

Colour cameras, particularly CCD types do not need the same attention to contrast enhancement as black and white because even quite subtle differences in colour hues are distinguished much more readily than is so when they have to be converted to differences in a grey scale.

Where the budget can be extended to a colour CCD camera then several advantages are gained as they have less weight and bulk, the target is much less subject to damage from accidental exposure to gross excess of light or to give 'comet tail' effects of streaking when a very bright object moves across a dark field or background.

Most cameras for use in fixed positions have their own built-in power supply, though for video microscopy that adds to weight and bulk. Where a camera without its own power supply is chosen be sure that any power pack purchased as an alternative to the original has adequate power and of the correct voltage(s). One of the authors uses a 12v 500 ma stabilised pack purchased for £12.

Attaching the Camera to the Microscope

Cameras can vary in weight from nearly 2 lbs to 6 lbs, so most would need either a focussing stage microscope or to be suspended independently of the microscope on a separate stand. Where the microscope can accept the weight of the camera, a 'C' mount adaptor on the camera can be married to a 42 mm threaded male flange of a microscope-to-film camera adaptor where the lower end of the adaptor clamps to the top of the microscopes body tube. Suppliers addresses are suggested at the end of this paper.

Where the camera is supported on its own stand then coupling to the microscope involves only some simple type of light trap in the form of bellows or similar style of flexible tube to allow for the rise and fall of the body tube during focussing adjustments.

When initially setting up the camera over the microscope the projection distance from the eyepiece to the camera 'target' (sensor) will depend on the size of the sensor as the larger it is the greater the distance will be, plus the power of the eyepiece and how much of the visual field is to be selected to view on the screen of the monitor. A CCD camera with a small sensor will work best without an eyepiece in the system, the image from the objective being projected directly on to the CCD disc to avoid the excess image enlargement otherwise given from the combined effect of the eyepiece plus the added

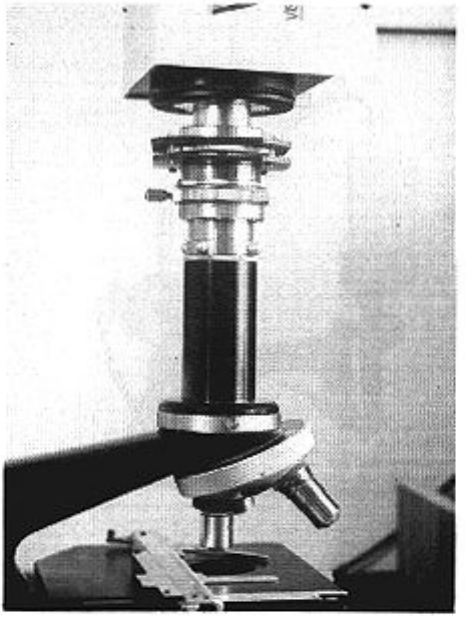

FIG. 2. The attachment of the camera to the microscope is by 'C' mount adaptor into the camera lens flange while the lower end of the 'C' mount adaptor is clamped to the top of an Exacta microscope adaptor clamped to the eyepiece tube. The Exacta microscope adaptor is constructed of a series of short threaded segments that allow the overall length to be varied to change the projection distance from the eyepiece to the camera to suit alternative eyepieces, a most useful feature.

projection distance from the eyelens to the CCD disc which can easily have the effect of doubling the magnification against the use of the larger sensors in videcon tubes.

Where eyepieces are used, as with Vidicon tubes, 'photo' (projection) eyepieces are preferred, several eyepieces should be tried to find the ones best suited to the objectives chosen and the area of field coverage selected. Stage micrometers are a very useful test for matching eyepieces to the camera, any thickening of the lines towards the edge of the field screened indicates field curvature or chromatic difference of magnification. Watch carefully also for central flare spots as eyepieces that are satisfactory for visual work or photography may not suit the video camera. If flare spots persist try changing the projection distance, shortening or lengthening on a trial and error basis.

The authors have access to a range of photo—eypieces from × 2, × 5, and × 10, and a × 12.5 Ziess compensating ocular.

Monitors

A purpose-made black and white security type monitor is preferred to the use of a TV set as a high definition monitor will be more compact and certainly more efficient in terms of picture quality as it takes the direct input from the

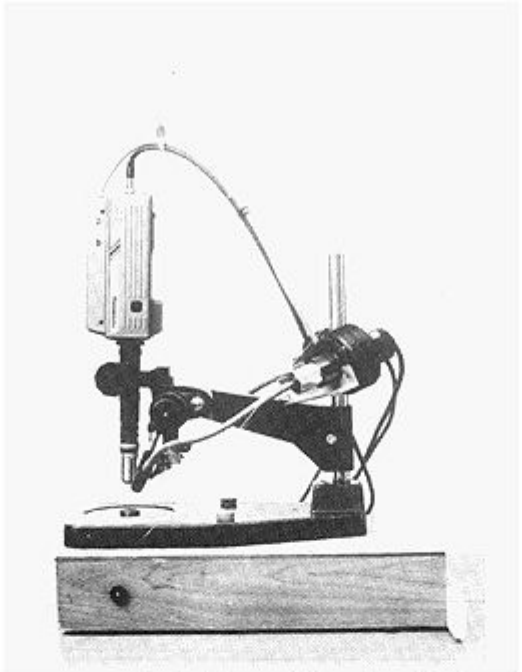

FIG. 3. An ingenious arrangement devised by one of the authors (Ken Jones) to adapt a 'macro' (close-up photography) stand with concentric coarse and fine focussing adjustment to a short rackwork carrying a Panasonic CCD colour camera fitted with a series of extension tubes to take a range of long working distance objectives with powers from × 2, × 5, × 10 and × 20, to project the image from the back lens direct on to the CCD sensor without using an eyepiece. A × 10 objective with a tube extension of 125 mm gives comparable magnification to the use of a compound microscope with a × 10 objective and a × 10 eyepiece. The length of the extension tubes can be varied to vary the magnification gained. In the wooden base illistrated, a lamp and a mirror to direct light through the base into the stage gives transmitted light, the whole arrangement giving 'top' light, transmitted light, or a mix as desired.

camera which TV sets do not as they have to be fed by a VHF modulated carrier (broadcast frequency). A TV set can be used *via* a video recorder through the VHF tuned circuits of the video recorder but better picture quality is gained if the tuning circuits can be by-passed and the signal from the camera fed direct to a monitor or the 'video-in' connection on the recorder to which the monitor is then linked via the video-out connection.

A TV set would mostly require the contrast control turned up to maximum and the brilliance at minimum, a monitor-camera combination adjusted to enhance microscopical images will give a wider range of contrast and brilliance control and better images overall. In fact video microscopy in that sense can be a form of contrast enhancement and is particularly useful in pond life observations.

The screen size chosen for the monitor should be related to the viewing distance, 8 inch, 9 inch and 12 inch monitors are very adequate for the shorter viewing distances normal to video microscopy rather than the 21 inch screens of a domestic TV set.

FIG. 4. The focussing rackwork has a ring clamp bored to fit the outside diameter of the extension tubes to which the camera is fitted at the top end via a 'C' mount adaptor. A Davis shutter (iris diaphram) is fitted above the objective to control aperture or glare.

The Recorder

Most domestic recorders are suitable but certain features are very desirable. Most up-to-date recorders have 'H.Q.' circuitry to enhance picture quality, look for H.Q specification if buying new.

Fast-forward or reverse 'search' modes are very helpful for quickly finding select sequences on any tapes which are to be kept or edited. The 'fast' speeds vary with different machines from 5 to 10 times normal running speed and this increased speed greatly assist searches. Tape travel counters that are closely related to time in seconds are useful too.

Putting the Equipment to Work

While video microscopy follows the pattern of setting up the microscope for visual work, several differences arise.

Firstly, having set up the microscope and object visually without the camera in operation, turn the lamp brilliance right down before attaching the microscope to the camera while ensuring the camera's power supply is switched off. This avoids the possibility of excessively strong light reaching the camera's sensor and overloading the circuits. While cameras have A.G.C., (automatic gain control) to give protection against such damage it should not be relied upon instead of care in handling.

Having switched on the camera and monitor and allowed full time for both to warm up, the lamp brilliance can be slowly and progressively turned up until an image is seen on the monitor screen. It is found that as lamp brilliance is further turned up, the screen brightness first dips and then levels off, at which point AGC ceases to boost the signal. Lamp brilliance can then be further increased but should not reach a level where bleaching of the highlights takes place.

Overall image quality will now be dependent on the optimum adjustment of lamp brilliance, substage condenser and iris setting, monitor contrast and brilliance, plus of course the level of ambient light under which the screen is to be viewed. Brighter than necessary room lighting will certainly degrade image contrast at the monitor screen.

It will take a little practice and experience to adjust each of the above-mentioned controls to produce the best possible images from the particular equipment operated. Substage iris settings will have a greater effect on contrast ratio than on resolution, closing the iris down increases contrast, opening it up will lessen contrast. Such adjustments will be carried out with parallel increase or reduction of the monitor brilliance control to maintain even screen brightness.

Editing Video Tapes

Having recorded a number of tapes it is inevitable when live material is involved that only some sections of each tape are worth keeping and it becomes desirable to transfer those to one edited tape in the sequence required.

The tape counter should be reset to zero on the insertion of any tape and the 'in' and 'out' point readings noted of any extract to be edited. The sequence of the extracts are then listed and the tapes gathered in that order for them to be replayed, preferably on the recorder that made the tape, into a second recorder to produce the final edited tape.

This method of editing is known as 'assemble editing', where one video machine is used to play the extracts and is linked to the second machine which does the recording. This second machine is linked to the monitor which thereby shows what is being recorded or what is being selected on the replay machine as the next sequence to be edited into the 'assemble'.

The replay machine is put into the play pause mode at the start point of the first sequence chosen, while a new tape is put into the record machine and held in record/pause until both machines can be taken off pause at the exact same time. The reason why both machines are held in pause at the start of each recording is because it takes time for machines to run up to full speed from start and that would cause a mis-match in synchronisation and picture break-up. At the end of the first recording of a chosen sequence start point and then held in pause ready to take both machines off pause together to start the second recording. This procedure is continued for as many sequences as there are to be edited.

Note that during any such editing programme the record machine is never put into the stop mode as this can break synchronisation with the prior recording and cause picture roll or break-up.

'Assemble' editing in the above manner is a quite straight forward and rewarding task, and where a lens is available for the video camera then captions can be added as a part of the finished edited tape.

Inserting a new sequence in substitiution for part of an existing recording requires special facilities is the video recorder not found in domestic machines. The recorder needs an 'Insert Edit' facility, where the erase head does not precede the record head, otherwise picture break-up will result at the end of the insert because the erase head will erase several seconds of play of the beginning of the sequence that follows the insert. Semi-professional recorders have an insert edit facility but cost from two to four or more times as much as a domestic video recorder.

Note that all references to video in this paper relate to standard ½ inch video tapes and not 'C' (compact), or the wider ¾ inch or 1 inch U-Matic professional tapes and associated machines which cost thousands of pounds rather than hundreds.

General Comments

It should not be assumed that the authors of this paper are expert, individually or collectively. The advice offered is a discourse on some of the more essential information to be absorbed to make a start at video microscopy on a restricted budget. To those who observe live material and discuss their findings with others, video is a substantial advantage over a written description even when that is supported by still photographs. It is extremely exciting and worthwhile for an original observation to be video recorded and later re-run for other interested persons to comment on.

This is the great advantage of this medium, to which can be added recording for instructional purposes or for general entertainment to small audiences or where large monitors are installed in a lecture theatre as at our Conference in Birmingham this year, a very basic low-cost ex-security camera relayed to a large audience each step of the manipulation of selected diatoms from their collection by a diatom finger to placing each one in a chosen position on a mount in preparation, all as if each member of the audience were looking down the eyepiece!

Buying Equipment

When buying new one turns to appointed retailers or agents to discuss budgets and specifications. Buying second-hand cameras and monitors is not so simple unless one has access to an unusually reliable source of advice that is informed on the use of video with a microscope or similar optical device.

In that context the authors are fortunate to have been introduced to a Service organisation who specialise in that field and who can offer ex-security cameras and monitors checked and adjusted for video microscopy, and whose name and address is:

Visual Electronic Services Ltd., 35 Hazelmere Road, Penn, High Wycombe, Bucks. HP10 8AD. Telephone (049481) 6111, contact Mr C. Jackson, and mention your Q.M.C. membership.

Buy the better quality camera the budget allows as camera quality and resolution are very important to the resolution of the 'system', that is the linked camera-recorder-monitor all in sequence.

A high-definition monitor is preferred to the use of a colour TV set, giving not only higher definition but also a greater range of grey tones, and will be more convenient to use.

Suppliers

'C' Mount Adaptors

An adaptor with a 'C' mount male thread to fit the cameras lens flange at its upper end and a 42 mm female thread at the other end is available from: SRB Film Service, 286 Leagrave Road, Luton, Beds. LU3 1RB. S.A.E. for list.

This adaptor can be connected to a 42 mm thread microscope-to-35 mm camera adaptor of the type that clamps to the body tube of the microscope. Camera retailers can supply such adaptors, most of the well known makes of camera using 42 mm (Pentax) thread mounts would have had a microscope adaptor in their accessory range.

The combined use of those two adaptors is the easiest ready-made form of adaptor to adopt. However, they are not cheap and the two in combination may total a longer extension than is desirable, giving increased magnification to the screened image. There are clear advantages in cost and flexibility of use to fix the camera to its own stand where its height above the microscope can be adjusted at will to give the projection distance desired.

Cameras

Typical examples available to order from Messrs. Visual Electronic Services Ltd are:

Used V.C. 2502 Vidicon camers, 1 inch high-definition tube, with self-contained mains power supply, 75 ohm connecting video cable, 'C' mount lens flange, less lens. Refurbished at £75 + VAT. Weight approximately 6 lbs. Dimensions 11 inch × 4.75 inch × 4.25 inch . . . or . . . used RCA camera, model TC2500 vidicon camera with ⅔ inch tube, built-in mains power supply, 75 ohm connecting video cable, 'C' mount lens flange, less lens. Refurbished at £65 + VAT. Weight 2 lbs. Dimensions 9.25 inch × 4.5 inch × 3 inch.

Average Securicor delivery charge around £5 plus VAT.

New Colour Camera

Typical example available from specialist dealers:

Panasonic Model WD 130 Series, with CCD 6.6 mm × 8.8 mm pick-up (equal size to a ⅔ inch tube), horizontal resolution 380 lines at the centre of the screen (190 pairs of black and white lines). Budget price £900.00. Weight 2:4 lbs. Dimensions 7.5 inch × 2.75 inch × 2.75 inch.

Monitors
A typical monitor available from Messrs Visual Electronic Services, subject to remaining stock, is Ex-Security used black and white monitor, serviced, at £55 plus VAT and carriage.

A general-purpose colour TV-cum-monitor would cost between £200-£250, while a special purpose high-quality colour monitor would cost in the region of £500-£600.

Lenses
Try photographic dealers or magazine adverts, useful focal lengths are from 8 mm (wide-angle) to 25 mm (standard).

Books
Most booksellers offer a selection of books on the use of a video camera but the content is aimed at the use of video as a substitute for a cine camera with its associated techniques of film making and give little information or assistance to the application of video recording at the microscope. There is usually some useful advice on 'assemble' and 'insert' editing but not much if anything on sensitivity, resolution and how it is measured, contrast enhancement, etc. The authors suggest the use of Public Library facilities as the first source of some information. There is only one book known to the authors as comprehensive and detailed for reference by the amateur (or professional) microscopist and that is:

Video Microscopy, by Shinwa Inoue, published by Plenum Press, second printing March 1987, ISBN 0-306-42120-B. Price, depending on the $ rate approx £45.

Video Tape
The complexity of the record and replay machinery and the tape path coupled with the minuteness of the magnetic fields to be recorded and preserved all place severe demands on tape quality and subsequent handling and storeage.

Standard VHS tapes vary in specification and for monochrome video microscopy TDK Pro-120 and TDK Hi-Fi 120 are recommended. Extended play tapes will be thin based and likely to stretch.

To maintain recorded tapes to optimum standards they should always be fully rewound before removal fron the recorder and then stored on edge, not laid flat. This preserves the edge of the tape upon which accurate registration of the recorded tracks depend for replay.

Future Developments
The authors hope that members who take up video microscopy will communicate their advice and experiences through the *Bulletin* or *Microscopy*, as appropriate, while also communicating direct, member to member, in perhaps the form of a Video Circle. It is suggested that such interested members could ask for their names to be listed as video microscopists in future issues of the *Bulletin*.