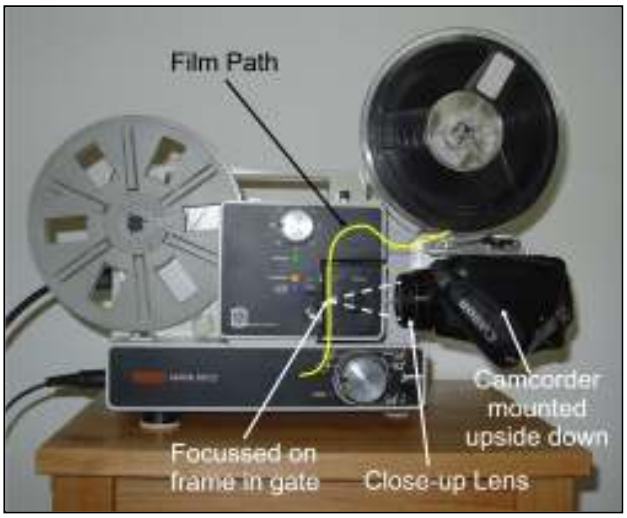
Construction of a Home Built Telecine Machine for Standard-8, Super-8 and Single-8 Cine Capture

Being dissatisfied with my earlier attempts to transfer old cine material to video, I looked into the possibility of constructing a system to capture the video directly from each film frame in the projector gate rather than by focussing on a screen image. This is not a novel technique having been described in magazine and web-based articles such as can be found at http://www.movie2video.com. However, other designs can seldom be copied directly and I wanted to use the equipment I already had to hand or could obtain easily and cheaply. Hopefully these notes will introduce one or two details to help others build a suitable machine.

The principle of the system adopted is to run the cine film through the projector at slow speed and when the frame has settled in the gate, to capture an image of that frame directly to a laptop computer. As each frame is captured, the resulting picture file is automatically placed in sequence in a selected folder for later transfer to the editing system.



When the sequence is on the timeline, the clean-up operations of removing bad frames, cropping, scaling, adding the sound captured separately and adjusting timing can all be carried out using normal editing techniques.

A modified projector is fundamental to this system and I had the choice of several old projectors that were available to me, and I chose the Eumig Mark 610D as being the most suitable for the following reasons:

- The 610D has multiple speeds of operation down to 3fps
- The projector can handle Standard-8 and Super-8/Single-8 cine film.
- The modifications render the projector useless for normal purposes and I could see no other future use for this machine as a projector
- The accurate speed control of a more sophisticated projector is not required.
- All mechanical and electrical parts including the gate are easily accessible and all metal construction simplifies any modifications/additions.
- Projector lens quality was unimportant as the fitted lens is not used.
- I was able to download a copy of the Service Manual which proved useful for re-assembly. (If anybody interested in a similar project would like a copy of this manual, I would be pleased to email it)

PROJECTOR ADDITIONS AND MODIFICATIONS

The projector modifications can be summarised as follows, and each item is then described in more detail. The additions are such that the unit will all be in one piece and once set up, can be placed anywhere to carry out its task, even in a well lit room.

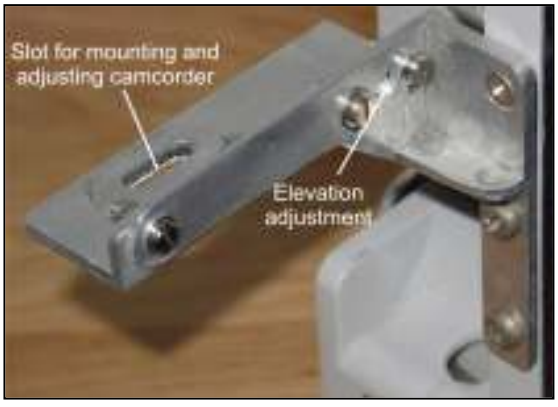
- Construct a camera mount so that the camcorder can be fitted to the projector when required and adjusted as necessary.
- Remove the shutter blades and heat filters
- Open out the gate apertures
- Fit a sensor switch and connector to operate once per pull down
- Construct a low powered lamp assembly to fit the space occupied by the normal projector lamp

The Camera Mount

The first item to construct was a platform to rigidly mount the camcorder on the projector frame. This did not entail any serious modifications to the Eumig so I was able to try out some techniques before taking a hacksaw to the projector working parts.

Design of a suitable bracket obviously depends on the devices in use. The camcorder that I intended to use was my Canon HV40 and I first tried handholding this in position to ensure that there was sufficient clearance between all parts when the camera image was properly focussed on the gate. (I describe the arrangement for close-up focussing and framing later). The only way that the physical position requirements could be met was by mounting the camera upside down, but as the picture in the gate is upside down anyway, this arrangement was quite acceptable. Horizontal flipping of the pictures in carried out later in the edit.

The bracket was constructed from scraps of aluminium angle that were to hand, riveted together and doubled up where necessary for additional strength. The only tools necessary were a hacksaw, files, drills and a hammer.



The camcorder is fixed to the bracket using the normal tripod mount and the bracket is held onto the projector front plate using two threaded holes that are provided to mount an optional Eumig Daylight Viewer accessory. A third screw fitting was added later to improve the strength.

With the HV40 jury rigged in the correct position, measurements were taken and a sketch made of the required bracket, ensuring that slots were provided to allow final adjustment in the three planes. Construction was then a matter of cutting, filing and

drilling with checks at each stage to ensure an adequate fit. The doubling of some parts was done later to stop a slight camera shake as the projector was slow speed running.

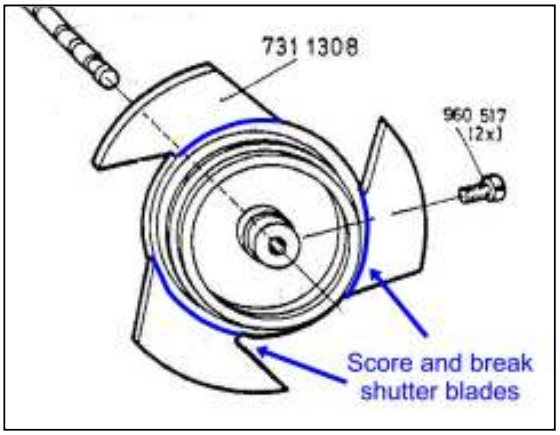
When complete, the camcorder/projector setup was tested before further modifications were made. For this test, the projector and camera were run in real time, recording to DV tape, and I was particularly interested how the 'rolling shutter' effect of the CMOS chip would cope with the projector blades. It didn't cope at all; there were many artefacts that do not occur with a CCD sensor.

This convinced me that I should carry on with the frame by frame method of capture and the modifications that this would entail.

Removal of the Projector Shutter Blades

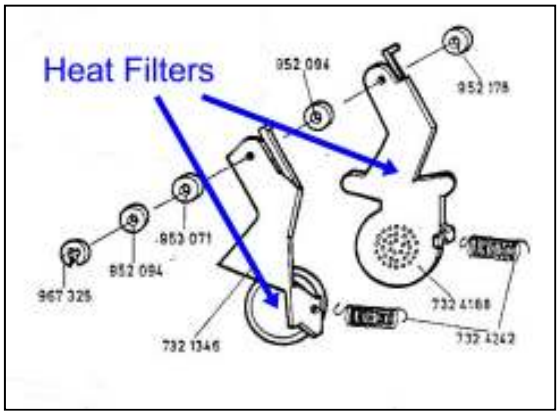
As is normal for a small gauge projector, the Eumig has a three bladed shutter and this is cast integrally with the pulley/cam arrangement needed to operate the various functions. The shutter itself cannot therefore be separately removed as an entity but the three blades must be cut off individually. This operation requires some stripping down, and if you are brave enough, the whole shutter assembly can be taken off the shaft for working on independently. However I decided on the removal of only the motor/fan assembly, transformer and other components that were in the way and then cut off the blades in situ.

The shutter is cast in an alloy material that is easily snapped, but first it is necessary to score a groove at the blade base where the break is to be made. I did this with a hand-held rotary tool fitted with a tiny saw blade, then snapped the blade off using pliers. However, before working inside the projector, it is wise to cover the working parts to prevent damage to the mechanism from any filings or other debris. The illustration shows an extract from the service manual indicating where the score line can be made.

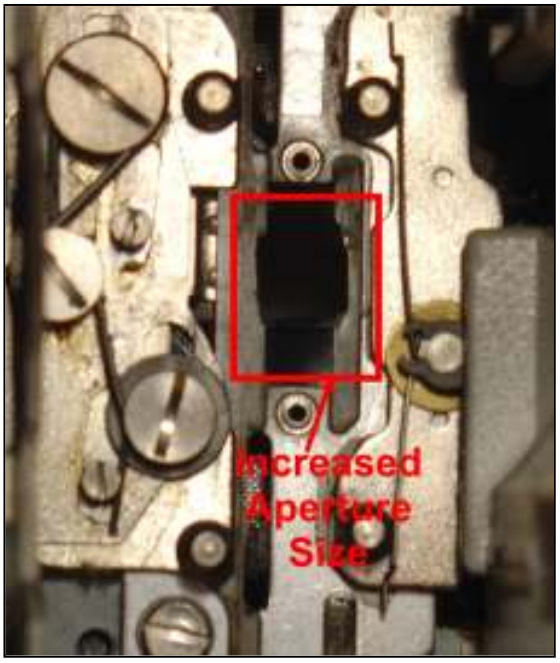


Removal of the Heat Filters

With the normal 100W lamp in place it is necessary for heat filters to automatically swing into position between the lamp source and film gate whenever the projector is showing stills. With the LED lamp replacing the tungsten lamp as described later, the power is less than 1W and the filters are not required. With the motor assembly out of the projector, the glass and perforated metal filters are easily removed.



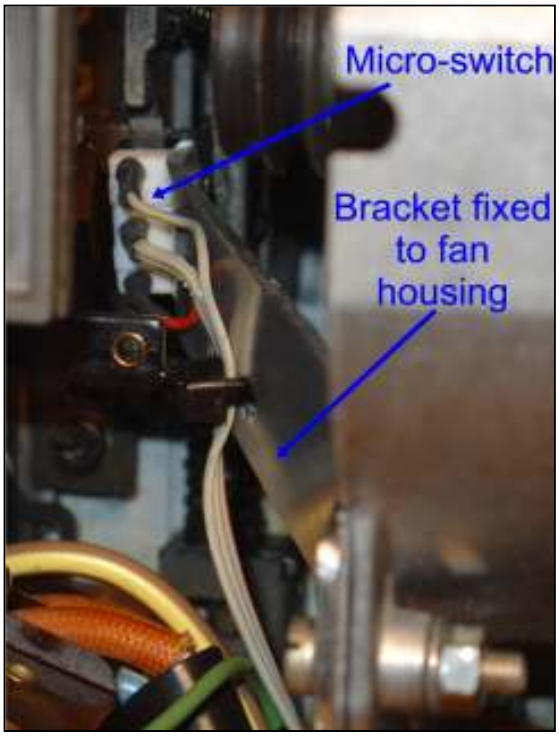
Increasing the Size of the Gate Aperture



An accurate gate aperture is no longer required to define the Standard-8 or Super-8 outline as this is done later by cropping and scaling at the editing stage. The sliding aperture plate has two masks, one for each gauge and the whole aperture assembly has been opened up as far as possible. The larger aperture allows more than the whole of the original cine frame to be captured and also minimises the normal accumulation of dust, hairs etc from intruding into the wanted area.

A fine, square edged Swiss file was used to carefully enlarge the aperture in situ, again ensuring that filings did not find their way into the mechanism.

Once per Frame Sensor Switch



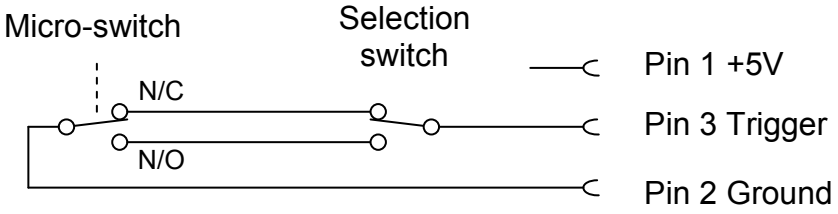
To take the digital image of the cine frame that is stationary in the gate, a signal must be sent to the computer to initiate a single capture process. 'Capturix' requires a contact closure to trigger this process and a micro-switch has been fitted to the projector to be actuated on pull down.

When the Eumig 610D is running at slow speed, in this case 3 fps, the actual shaft speed is not changed and the claw continues its up and down action at 18 fps. A gearbox is incorporated in the projector mechanism and with a play speed of 3fps selected, a gearing reduction of 6 to 1 activates a pawl every 6 rotations. This pawl pushes the claw forward into the film sprocket holes and pulls the film down one frame. This pawl is the only moving part of the mechanism operating at 3fps and a small end of it protrudes from the gear area. This is the moving part that must operate the micro-switch and so this switch needs careful positioning to ensure reliable operation of the switch.

A sub-miniature lever micro-switch was obtained from Maplins (Item GW67X) and an aluminium bracket cut and formed to shape for mounting on the fan housing. Slots to fit the micro-switch and a single bolt fixing to allow rotation of the bracket gave enough movement to accurately align the micro-switch lever against the actuating pawl.

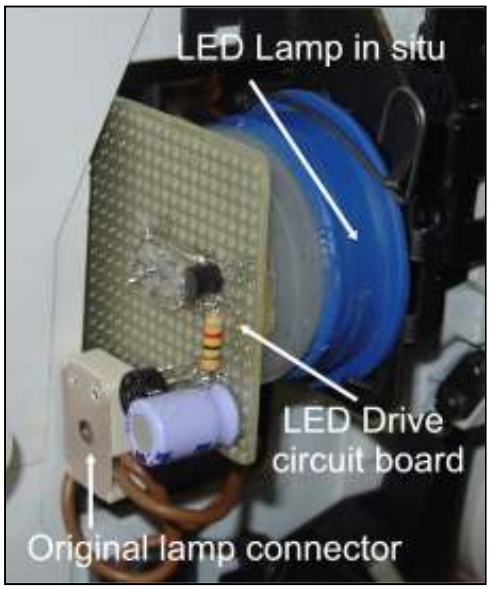
The micro-switch has change-over action so either normally-open or normally-closed contact closure can be chosen. So that I could later choose the best method for triggering capture, I fitted a slide switch to select either mode. In fact it didn't make any difference so it has been left on the normally closed position, i.e. trigger after pull down.

The contact connections were brought out to a DIN socket mounted at the rear of the projector (replacing sync connector) as shown in the picture and diagram below. +5V from the computer interface has also been made available at the projector in case I needed to add some circuitry in the future



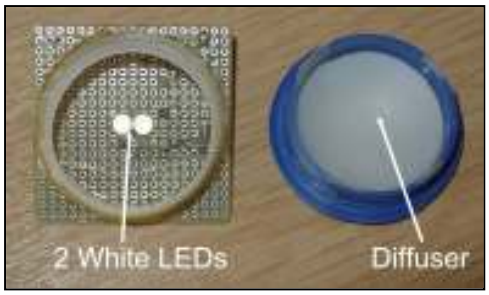
The above section refers to a speed of 3fps which is the setting on the projector but by moving the drive belt to the 60Hz pulley position, this was slowed to 2.5fps. This lower speed gives a bit more leeway for capture if necessary and by actually slowing the frame pull down, the claw is a little kinder to old splices. The speed can be further lowered if necessary by wiring a resistor in series with the motor. I found that about 10% reduction could be reliably achieved before the motor had difficulty in starting.

Replacement Projector Lamp



The 100W tungsten projector lamp normally fitted is far too powerful for capturing directly from the film in the gate and would certainly burn the film if run at the slow speed with no shutter or filters. Use of a LED light source has previously been successfully used by others and I have taken this idea to create a lamp that physically and electrically replaces the 100W halogen lamp but draws less than 1 Watt.

The first requirement was that the new lamp assembly would fit into the existing space using the same wire clamp to hold it in position. Scrounging in the junk box and kitchen found an old connector housing and a plastic bottle that were about the right diameter to slot in position. These were cut and shaped so that they would push together with a rim trimmed to the right size to fit the projector lamp mount.

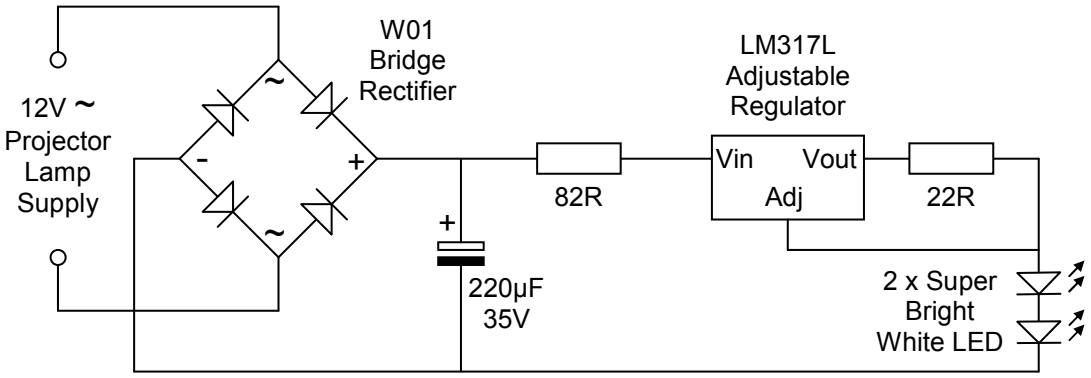


To evenly illuminate the film gate it was considered necessary to fit a diffuser as bare LEDs with their integral lenses would probably create hot spots. A white opal spherical plastic disco ball was found in the decorations box and a circular piece cut from this sphere was trimmed to fit. The efficacy of this diffuser in producing even illumination is shown later.

To mount the LEDs and associated circuits, a square of perforated printed circuit board was cut to fit and the whole assembly temporarily glued together to ensure that it would mount in its intended position and to see what space and locations were available to fit the necessary electronic components.

I decided to use two LEDs with the idea that these would better illuminate the rectangular frame. These two LEDs were mounted through the board in a central position slightly angled for best coverage of the desired area. The chosen LED was a 5mm Super Bright White Maplins code N28FN with clear lens.

This LED is rated at a maximum forward current of 100mA, but to keep them running well within the rating, I constructed the circuit shown below to supply a constant 55mA to the two LEDs in series.



The new lamp circuit is driven from the 12 VAC supply and so is switched on with the projector control in the normal way. This lamp supply is AC whereas the LEDs need to be fed DC and for stability under conditions of mains voltage variations etc the circuit was designed to provide a constant current. The AC rectified by the W01 bridge produces about +16 VDC smoothed by the 220µF capacitor. The LM317 is actually a voltage regulator but in the configuration shown, it provides a regulated current to the two LEDs in series defined by the 1.2 v reference of the chip and the 22R resistor, LED current is 1.2/22 A ≈ 55mA. The 220µF capacitor and regulator assure that the current source is absolutely ripple free.

With the LEDs already mounted on the board, two pins were then soldered in a suitable position to allow the 12V supply connector to be plugged in without fouling. All other components were then put in available places and wired up. The circuit placements are not critical.

When fitted in position, the LED light was tested for adequate and even illumination of the gate. The camcorder was set up as described later and a shot of the bare light was captured with the projector operating but no film threaded. When adjusted to cover the Super-8 frame size, the illumination looked perfectly even and the RGB Parade of this frame shows the evenly balanced light produced by this LED lamp, rather better than could be expected from the original projector lamp

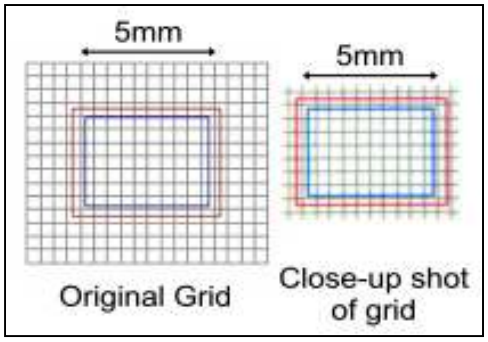
CAMCORDER SET-UP

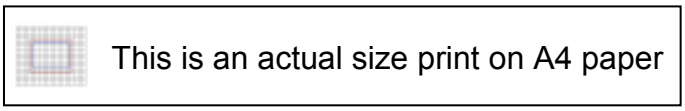
No modifications are necessary to use the camcorder as the capture device, just the addition of a close up lens and making the appropriate settings.

Close-up Lens

To fill the video view with a single frame of 8mm cine film, the camcorder lens must be set to near full telephoto and focus much closer than the normal focussing range. The HV40 sensor size and zoom range is in the specification, and from these figures calculations show that the close-up lens must be about 70 to 80mm focal length, or about 12 to 14 dioptres. The longitudinal positioning of the camcorder mount together with the zoom and focus ranges, allow sufficient latitude to frame and focus with a close-up lens anywhere in the required range.

Close-up lenses of this power are not normally available although they could be stacked up; say a 10 + 4 dioptre. However I did have a cheap (£13 Ebay) Wide Angle Adaptor Lens with a 43mm thread mount to fit my HV40. This lens unscrews and the back part can be used separately as a close-up lens. Not knowing its characteristics, I first measured the focal length and found this to be about 75mm (13.3 dioptres), ideal for the purpose. Secondly, to estimate any geometric distortion or other aberrations that this accessory lens may introduce, I drew a grid with a pitch of 0.5mm (using the draw mode of Word) and superimposed the outline of Standard-8 and Super-8 frames. This drawing was then printed onto plain paper in actual size.





The paper print of the grid was then filmed using the HV40 with close-up lens and a single frame extracted using Premiere. The original drawn grid and a print from the video is reproduced here and this shows the negligible distortions introduced by the accessory lens, The results were pleasing and I decided to use this configuration for the project.

Camcorder Settings

The HV40 is not loaded with tape and only needs to be switched to 'Camera' mode during capture and the 'Start/Stop' button does not need to be pressed, For monitoring and capture using 'Capturix' the DV output must be connected to the computer using a normal firewire cable. Power for the camcorder is preferably from the mains, but if battery powered then 'Power Save' must be turned off so that the camcorder does not shut down.

The following HV40 settings are suitable for this application:

- Standard definition DV
- 4:3 Aspect ratio
- Manual exposure
- Manual Focus
- Manual white balance
- Image stabiliser off

With these settings made, the camcorder can be mounted on the projector using the bracket previously described and a standard tripod screw. With the projector turned on and a stationary film in the gate, the camcorder can be set up while monitoring on the LCD screen and the computer. Hopefully a picture of the gate area will be seen and zooming in should nearly fill the screen. It is then a matter of setting the exposure and using the elevation and azimuth axis adjustments to centre the image and the zoom, focus and longitudinal settings to frame and focus the image. Framing should include the whole image, including ragged edges, as it will be tidied up in final production. Repeat as necessary until this process produces a satisfactory result. White balance is then best completed with no film in the gate.

THE COMPUTER

For this process I use a Dell laptop computer loaded with Capturix and Adobe Premiere Pro 2. Two connections need to be made between the machine and the computer and these are the standard firewire port for video transfer and a 'once per frame' trigger signal which can be either via RS232 or the game port. Unfortunately the laptop doesn't have either of these two trigger ports available and it was necessary to use an adaptor, luckily readily available, to connect through the USB port, I have used both types of port satisfactorily but prefer the game port as it has +5VDC available in case I want to build some additional circuits into the projector.

CAPTURIX Software

Video Capturix 2011 is a fully featured video capture tool with many more features than I need for this application. The software is fully described on their website www.capturix.com and a demo version is available for download. It is not expensive but I started with the free version then upgraded to the full version.

The Capturix settings and procedure that I use are:

- Choose capture device. Canon camera

- Set compressor - DV Video Encoder Settings DVSD PAL
- Set filename for capture
- Multiple JPEG File
- Click joystick or RS232

The output files appearing in the folder as named above comprises a sequenced set of jpg files corresponding to the sequence of frames captured as illustrated. The size of each file is about 230 kilobytes, or nearly one gigabyte to accommodate a 50ft film reel and the time taken to capture this size reel is about 25 minutes.

SOUND CAPTURE

Sound is captured quite separately from the movie and synchronised later in the process. Unfortunately I lost my box of striped films during a house move, but if they ever turn up I will have to borrow a stripe projector to take the sound off each film as well as capturing the cine. However I still have old Standard-8, Super-8 and Single-8 cine films, some silent and some with synchronised audio tape, and I am still the process of capturing these.

Capture of the audio from tapes is straightforward using the sound facilities and line input of the laptop. Complete tapes are captured as .wav files for later transfer to Premiere and tying up with the matching video.

POST PRODUCTION

I use Adobe Premiere Pro 2 for general video editing and it provides all the facilities needed to complete the cine capture and produce a DVD.

Open a new project for DV - PAL - 4:3 and when open, and before importing any files, go to Edit > Preferences > General and set the 'Still Image Default Duration' to 1 to ensure that each frame of the cine corresponds to one frame of the video.

The whole folder containing the sequence of jpeg files can be imported using 'Import Folder' and this folder can then be dragged to the timeline to produce a 'filmstrip' of jpeg images. At this stage it is worth scrubbing the timeline to locate any bad frames such as splices. Each bad frame can then be deleted and the adjacent frame lengthened to maintain the overall time. From now on it is best to work on an avi file so select the work area and export movie to render the sequence and generate the avi. The jpeg sequence can now be deleted from the timeline and replaced by the avi movie.

When played, it can be seen that this movie is laterally reversed, has untidy edges, runs too fast and at this stage has no sound. To properly finish the project, do the following:

Select the clip on the timeline and using the Effects Controls > Motion increase the 'Scale' and 'Position' as necessary until the wanted picture fills the 4:3 frame.

Drag the 'Horizontal Flip' effect (Video Effects > Transform) onto the clip to correct the lateral reversal.

The timeline plays at 25 frames per second, whereas the original cine was shot at 16, 18 or 24 fps so a speed correction is necessary. Right click on the clip, go to 'Speed/Duration' and set the Speed as necessary to suit the original film:

- For Standard-8 the speed was probably 16fps so set 'Speed' to 16/25 = 64%

- For Super/Single-8 the speed was probably 18fps so set 'Speed' to 18/25 = 72%

- Either could have been shot at 24fps, in which case set 'Speed' to 24/25 = 96%

Premiere will put in extra frames to stretch the total time to that of the original. Each extra frame comprises one field of the previous frame and a second field of the next frame so retaining smooth motion.

Any sound that has been separately captured can now be imported to the Premiere project as a wav file and dragged to the timeline. If the audio has to be tightly synchronised, it may be necessary to finely adjust the 'Speed' of the video or audio tracks to match. For this it is best to find two sync points on the video and audio tracks, read off the durations of the two sections and calculate any correction to be made. Finally line up the video and audio and make the movie.

I normally back this up on DV tape at this stage ready to make the DVD(s) when I have sufficient material,