Chapter 3 Film Based Equipment:

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The first requirement is a movie camera that is capable of single shot control.
I have built time-lapse systems for both 16 mm and 35 mm formats, and I will write a bit about each of the cameras advantages and disadvantages.

Bolex 16 mm camera with a Tobin time-lapse motor
runs on 12 volts DC

BOLEX Cameras: 16 mm

You have to love these cameras, built to Swiss watch standards they are rugged, have the single shot ability, and the ability to mount an external motor.

The film transport through the Bolex cameras does not have a registration pin, only pull down claws. This means that the positioning of the film during the exposure is not as precise as a camera that has a registration pin. The Bolex does not seem to leak light when the shutter is closed. So, a separate shutter is not required in blocking light from getting into the film. It is always a good idea to shut the viewer off in a reflex camera so that light will not leak in through the eyepiece when the camera is running (or exposing).

There are four main ways to control a Bolex in my view. These techniques are standard to most cameras and are presented in the following sections of this FAQ. I will write about both the advantages and disadvantages of each technique.

16 mm Arriflex Time-Lapse Rig on the 35 hour shoot
For the independent movie Certain Death

ARRIFLEX: (model S) 16 mm

Cameras like the basic Arriflex model S (which is no longer in production) are better designed, have a better film path, can hold more film, but have the drawback of being expensive (around $2,000) and DOES NOT having a focal plain shutter. This means that a camera with the shutter closed will fog the film within a few seconds. To get around this problem, a capping shutter is used. The capping shutter goes in front of the lens and opens when an exposure is made. These professional level cameras also have many unique features that are not found on the Bolex cameras. Arriflex cameras can be modified for great time-lapse work, but be prepared for a lot of machining to fit a stepping motor in the motor cavity. Arriflex has been very helpful with questions and supplying manuals for their discontinued cameras.

I purchased an original time-lapse controller for the Arriflex-S. This was mainly to compare design features. Arriflex corp. made several of these units in the mid 1970's but will not admit to it! They officially have no record of ever making such a device. The controllers are power hogs and take 6 amps of power that is too much for remote use off an inverter. The Arriflex-S has several interesting problems. One is that the motor shaft has to rotate 3 times for each exposure. When driving an Arriflex-S in this mode the constant starting/stopping causes the slip fitting on the shaft to start to move around. If there is only a few degrees slippage, the motor will not stop the shutter in the correct location and the shot will be ruined. To increase the friction between the motor and the camera shaft I use double sided sticky tape - Still I get nervous if I ever have to use the Arriflex-S in the true time-lapse mode.

As nice as the Arriflex cameras are, they are not really designed for time-lapse work. The machining problems combined with the lack of a focal plane shutter make this camera (and Arriflex cameras in general) a poor choice for time-lapse work.

MITCHELL 35 mm

After months of researching 35-mm camera bodies, mechanisms and designs, I settled on the Mitchell camera bodies to be superior to many other designs. The design of these cameras is remarkable. By mounting A stepping motor to the drive shaft the camera became a serious time-lapse tool. This professional level camera has a variable shutter. Besides the larger film format the camera offers dual pin registration. The pin registration holds the film in position when the exposure takes place. These mechanisms are also known to be very stable and repeatable.

Commercial assignments prefer the 35-mm format above all else.

Solenoids to activate the camera (Bolex):

This technique is fairly simple to build. A 12 volt solenoid is activated by a TTL logic trigger, either from a computer, or a timing circuit to trip the single shot feature of the Bolex. The solenoid creates a lot of torque and has the ability to easily move or jerk the whole camera assembly if the camera is not well secured. I use a very heavy tripod, weighted down with a large mass (20 Kg) to increase the inertial mass of the tripod. This system works well and is fairly reliable if the duty cycle of the solenoid is observed. Since the solenoid needs to be turned on for about one second, the coils of the solenoid will heat up. If the solenoid is on for more than 25% of the time, say one second in four, the solenoid will start to misfire. That is, when triggered there will not be the required torque to trip the shutter of the camera. To increase the collapse of the magnetic fields in the solenoid, a diode can be mounted in reverse in parallel with the solenoid.

A solenoid attached to a Bolex-Rex

close up of solenoid rig.

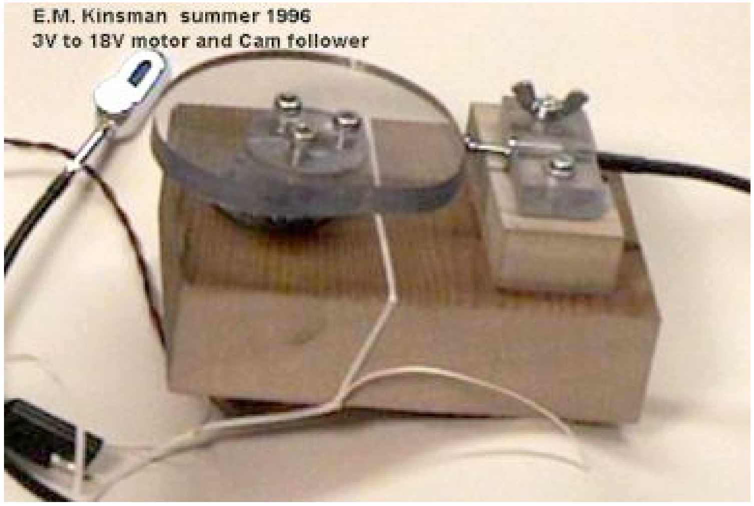
This duty cycle limitation of the solenoid effectively limits the time-lapse filming rate to times slower than 1 fame every 4 seconds. This limitation makes many subjects unsuitable of time-lapse work (fast clouds, sailboats). This limitation also makes it impossible for the shutter to be left open for long duration's, as would be desirable when filming lightning storms.

The solenoid is a power hog. This limits the portability to as far as your extension cords can take you, unless you have an inventor - which are heavy and a pain to carry.

I do have a nice solenoid rig, and it runs all day. It is the preferred technique for keeping a short shutter speed (1/30 sec for non-rex Bolex set at 24 fps) This is about as fast a shutter seed as you will get. I use this technique on a Bolex reflex camera that has an 8:1 drive on the motor. Since other options are not suitable, this is a nice match for the camera. With this technique the camera has to be kept wound about every 700 frames.

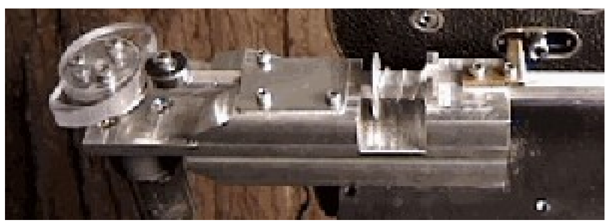
Cam system:

I use an electric motor that runs from 5 volts to 24 volts that is a high torque unit. By varying the voltage the revolutions of the motor change. Attached to the motor is a cam made out of 1/2 inch Plexiglas. The sides of the plastic are sanded smooth such that the end of a cable release can slide freely over its surface. The end of the cable release acts as a follower on the cam. When the cam pushes against the cable release once per revolution, the camera is tripped. This is a very portable system requiring only a small 12 volt supply and a variable resister to change the voltage. I built a connector to go into the cigarette lighter of my car to power this type of camera control.



Simple cam system

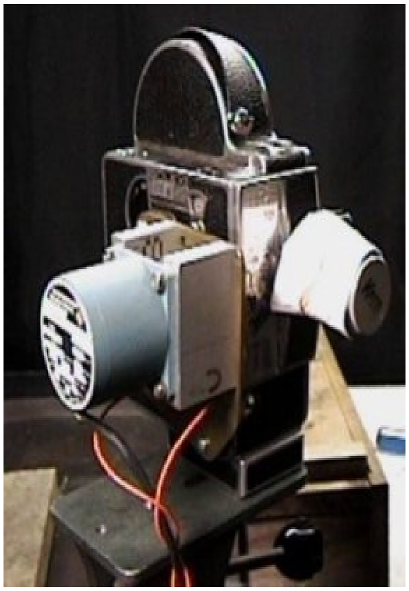
The cam system works from 1 frame every 6 sec to 1 frame every 18 sec. Different cams can be built to match your motor for faster of slower frame rates. This system is highly portable. The torque required to trip the shutter of the camera is quite high, causing alignment to be fairly critical.

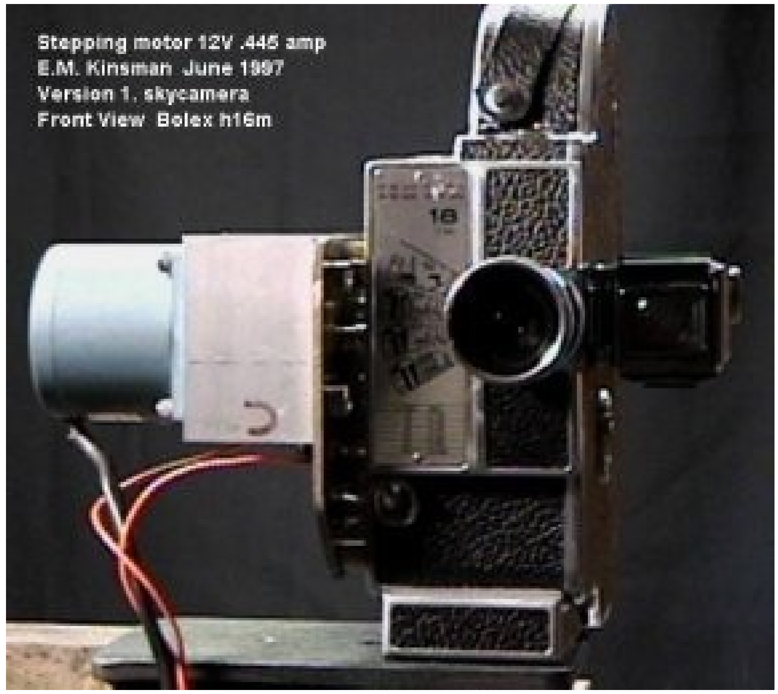


An advanced cam system - Bomb Proof!
The problem is you will still have to wind the camera

Stepping Motor Control:

This control is the most versatile, also the most difficult to build, but worth the effort. A stepping motor is a motor that is controlled by a sequence of current pulses. These pulses are given in a special sequence to make the motor turn. Most stepping motors are limited by speeds of 60 to 75 revolutions per minute. This limit is caused by the time it takes for the magnetic fields of the motor to collapse when the current is pulsed to the next coil in the stepping sequence. Still under computer control most motors take 200 steps to complete a revolution. This means that a computer can stop and start a camera shutter in any position for any length of time.





Stepping motor mounted to a bolex

Top view of rig

A stepping motor is mounted with a shaft that matches the motor shaft on the side of the Bolex camera. A process which can take some time. This pattern seems to be the same for many models. The securing bolts for the motor are metric 3.5 threads - often difficult item to find in the United States. To the motor drive shaft needs to be mounted a position sensing switch. This switch tells the computer that the shutter is home, or is closed.

Depending on the voltage of the motor, the stepping process can take varying amounts of current - this is very important for portable systems. My stepping motors take .44 amps at 12 volts. Since the motor is under computer control, the possibilities for photography are unlimited. The shutter can be run continuously for frame rates of about 1 fps, or at any rate slower. The shutter can be left open for any desired time before moving to the next exposure. This type of shutter control is desired for photographing lightning where the duty cycle of the shutter needs to be in the high 90%'s.

Bolex cameras have a 143 degree shutter, under this control the fastest exposure is .45 sec. This is relatively slow compared to the solenoid techniques, but can be effectively shortened by adding a number of neural density filters. The filters will decrease the amount of light that reach the film.

Stepping motor systems do not have to be wound and will shoot all the film in a magazine without stopping.

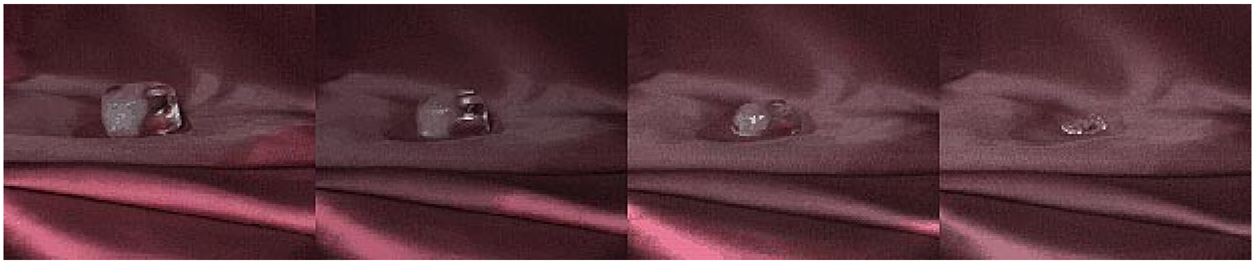
This system combined with an inexpensive laptop computer, and a portable 12-volt battery, make a good versatile photography unit.

Synchronous Motors:

Many animation photographers have built motors that are single shot for their cameras. These systems use a synchronous motor and a position switch to turn the motor off after a revolution. These can be nice systems. The power requirements are 120 volts for the synchronous motor. The motors are not particularly high acceleration, and although spin at 60 rpm they do not achieve this rate on the first revolution. These systems give affective fast exposures in the same area as the stepping motors at .33 sec. The synchronous motors do not have any control over the exposure rate as the stepping motor systems do. These systems are a lot easier to control than stepping motors if you are animating a cartoon or doing stop motion where all you want is to push a button and expose one frame.

I had pretty much dismissed synchronous motors for serious time-lapse work until a British Cinematographer started corresponding with me about his system. Julian Brooks who used to work for the famous Oxford Films designed a controller for his 16 mm camera around a very high speed synchronous motor. the motor turns at 20,000 rpm, but is geared down using a 50 to 1 ratio. The motor is stopped and started very quickly using an H-bridge circuit that applies reverse current to the motors coils to quickly stop the motor. Using this system and an array of digital timing circuits, Mr. Brooks is able to stop and start the camera 24 fps and get normal running speeds of of his time-lapse system. He has also built a series of timing circuits that ramp from 24 fps into time-lapse mode to effectively speed up a scene. This whole idea of using reverse current breaking to control a high speed synchronous motor leads to many interesting avenues of research. Mr. Brooks has also implemented many novel features into his time-lapse systems including a photo-flash trigger that is activated when the shutter is open.

Video Frame Grabbers



The above shot of an ice cube melting was taken with a video frame grabber.

There are a few problems with such a system. First, are you able to have that system dedicated to photograph you subject for the duration? Do you or the computer package have the ability to frame grab an image from the camera every time period? How good a video camera do you have and what do you know about tube burn in ? (if you have a tube cameras). These are just some of the problems that are involved with using a frame grabbing setup on a computer. The final clincher is hard disk space. If you have 1200 tiff files and are going to compress them into a movie then you will need a large hard drive.

I use a small CCD camera with a C mount lens on the front. I set up a time-lapse program using a Snappy Frame Grabber. This combination allows me to see how much the object has changed, or if there are problems that require the termination of a sequence. The added benefit of this process is an animated time-lapse sequence that is suitable for giving photo editors an idea of what your finished film will look like. These digital animation's can be as big or small as you want. They can be easily dumped to video for a quick demo tape to an advertisement firm, or can be used on a web site. I have found a growing interest in using computer frame grabbing to check timing before I load film into a camera. I have used a frame grabber to collect data on melting ice cubes for a project. The computer frame grabs were combined into an AVI format file and the timing, lighting, and background were verified before I started filming.

Many clients decide that when the finished product will be on video and the camera needs to run for several months unattended - video is the way to go. In the past year I have had to consult on several such projects - one was a dam being built that was to take several years, the video camera would get the correct exposure where a film camera would need expensive auto exposure controls. Several architects have contacted me about filming a housing development time-lapse, once again the only cost affective solution is a video frame grab.

The use of a video frame grabber system has become a basic tool in my lab. Editors can get an idea of what the finished product will look like, even before the film is processed. It is great to be able to do these motion tests before filming starts.

The procedure would look something like this:

1. Video camera focused on subject
2. Computer programmed to grab a frame every time cycle
3. Grabbed frames collected on computer hard drive

4. At end of collection, images are compressed into a movie

Cicada from video frame capture with about a 10 min wait time between the above images

Time-lapse with a Video Editor System:

The procedure would look something like this:

1. Video camera focused on subject (or video tape collected of the subject)
2. Editor is set up to record a few frames of video every time cycle
3. Final video is played at end of collection

Even with all the technical problems solved, you are still tying up a lot of money in equipment to obtain a digital time-lapse movie that is of poor quality when compared to a 16 mm movie. Single frame video recorders are also very costly. A very good 16 mm set-up can be built for $500. - that is including everything.

Now days (2006) it is fairly common to use a digital HDTV such as a Panasonic vari-cam to record several hours of a scene then to use a digital editing system to speed up the footage by many times. This works and gets the job done, but the Avid system will run several hounded dollars per hour, and rental of the camera will also be costly. Still this is often a cost effective way to get the desired image. I have worked on several projects using this technique.

If you are planing on marketing your time-lapse work, 16 mm film is the minimum format that is considered acceptable. Many image stock houses would prefer work to be on 35 mm film.

Now in 2006 digital still cameras are surpassing the quality of 35 mm film at a fraction of the cost. This fact is still not widely accepted by many cinematographers. As of this writing I have now sold all of my film cameras and concentrate solely in digital cinematography. If a client requests a film camera, I will rent it.

Many research labs do use video and or computers to create scientific time-lapse work exactly the way mentioned above. The benefits are a quick turn around and no film expenses.

My very first time-lapse was done on a video editing system with a video camera pointed out the window recording the clouds moving by. It was not great, but it got me thinking and researching how the technique could be done better.

Keeping equipment dry for the shoot.
Solenoid control rig. (1997)

The computer is a 8086 – it does not take much to run a stepping motor!