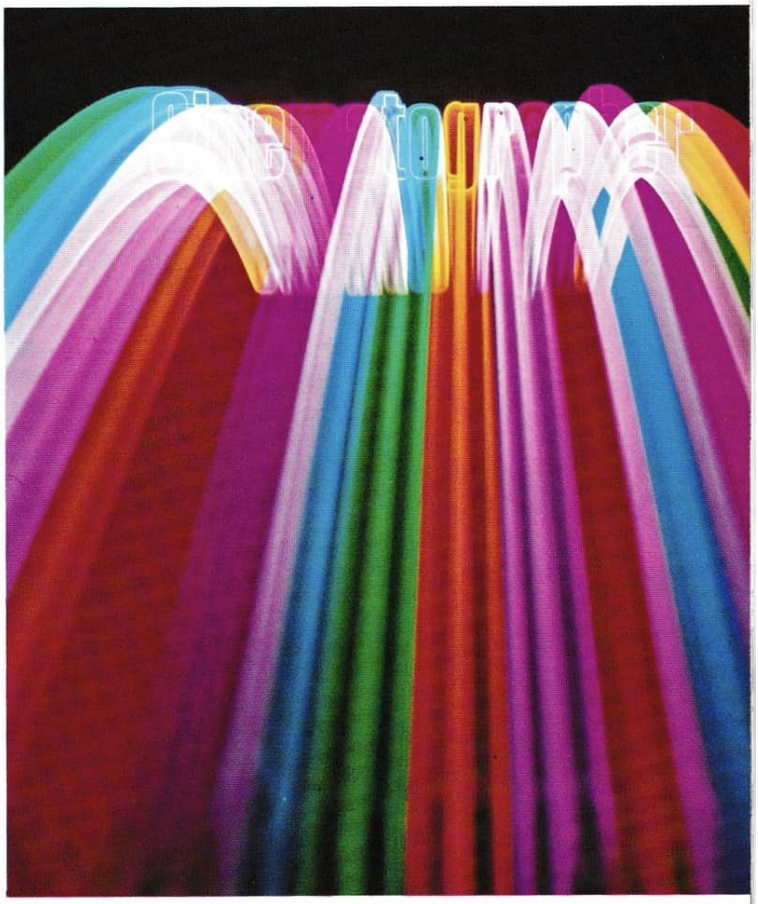
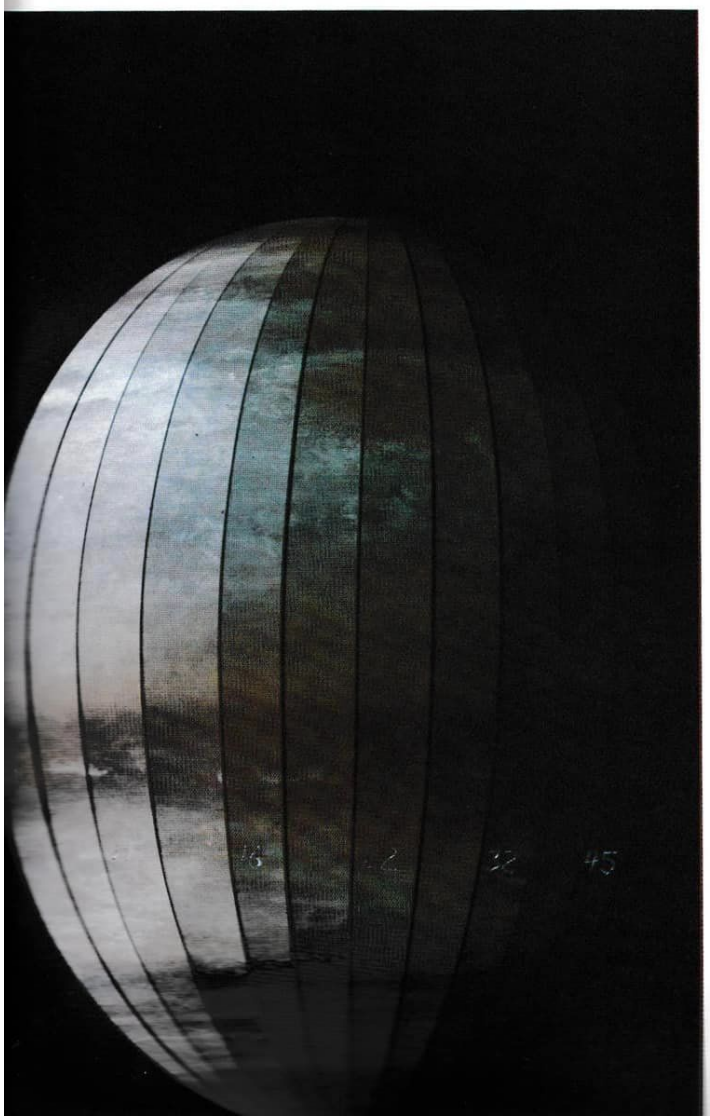
AMERICAN
Cinematographer
International Journal of Motion Picture Photography and Production Techniques

Special Issue: "FILMING MAN IN SPACE"
WITH FULL COLOR PHOTOS OF THE APOLLO 11 LUNAR FLIGHT

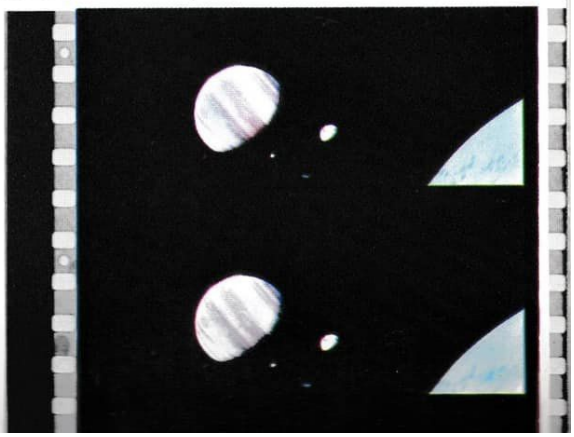
Cinematographer

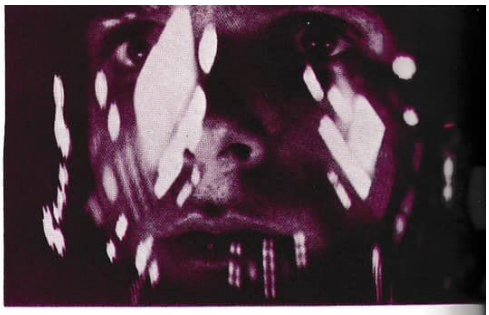
(ABOVE) The raw material from which Douglas Trumbull created the striking cover for this issue of AMERICAN CINEMATOGRAPHER, utilizing the slit-scan process. He began with nothing more than a high-contrast outline negative of the letters in the CINEMATOGRAPHER logo, then backed them up with various shades of tinted gelatin. (RIGHT) The high-contrast material, thus prepared, was placed on the slit-scan machine and made to rise up and fall back in a sine wave curve controlled by an eccentric cam. The camera recorded the spectacular "rainbow waterfall" of colored light generated from the logo as it travelled down the track of the machine. This is a variation of the same technique used in creating the "Star-gate" sequence in "2001: A SPACE ODYSSEY".





(LEFT) Exposure test for the creation of the planet Jupiter in '2001", utilizing the slit-scan process. The black lines indicate where the shutter was closed momentarily during the test to denote changes of exposure. (BELOW) Frame blow-ups from the final sequence of "2001" showing the slit-scan manufactured planet Jupiter in juxtaposition to other planets. Spherical shape was generated by projecting flat art onto a rotating arc of white card material only 1/16-inch wide.





THE "SLIT-SCAN" PROCESS

as used in

2001 A SPACE ODYSSEY

and beyond...

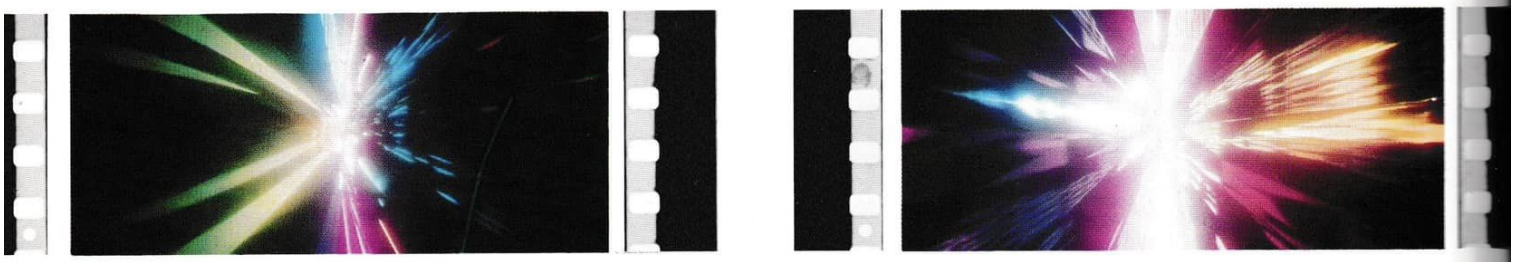
Details of an exciting new "light-in-space" technique for filming in the Space Age

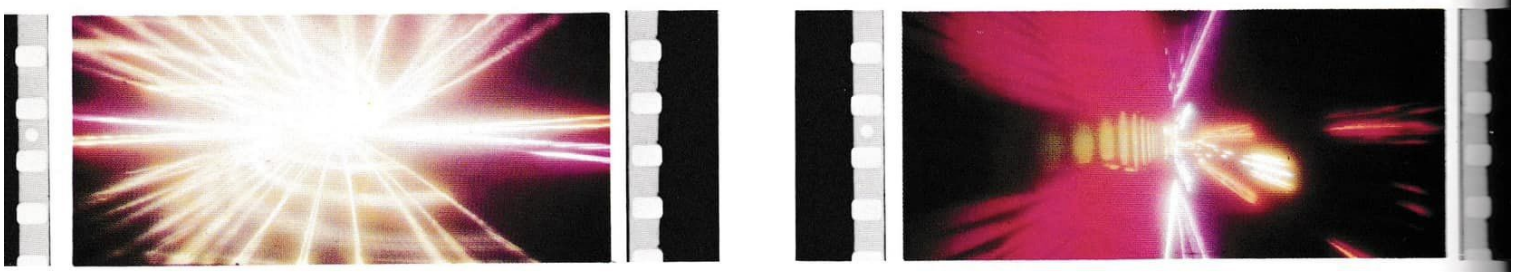
By DOUGLAS TRUMBULL

Toward the end of Stanley Kubrick's "2001: A SPACE ODYSSEY"—in that somewhat psychedelic sequence audiences like to call "the trip"—there are scenes in which the camera seems to be speeding through flat corridors having walls made up of multi-colored abstract patterns of light, an effect which we called the "Star-gate" while we were working on it.

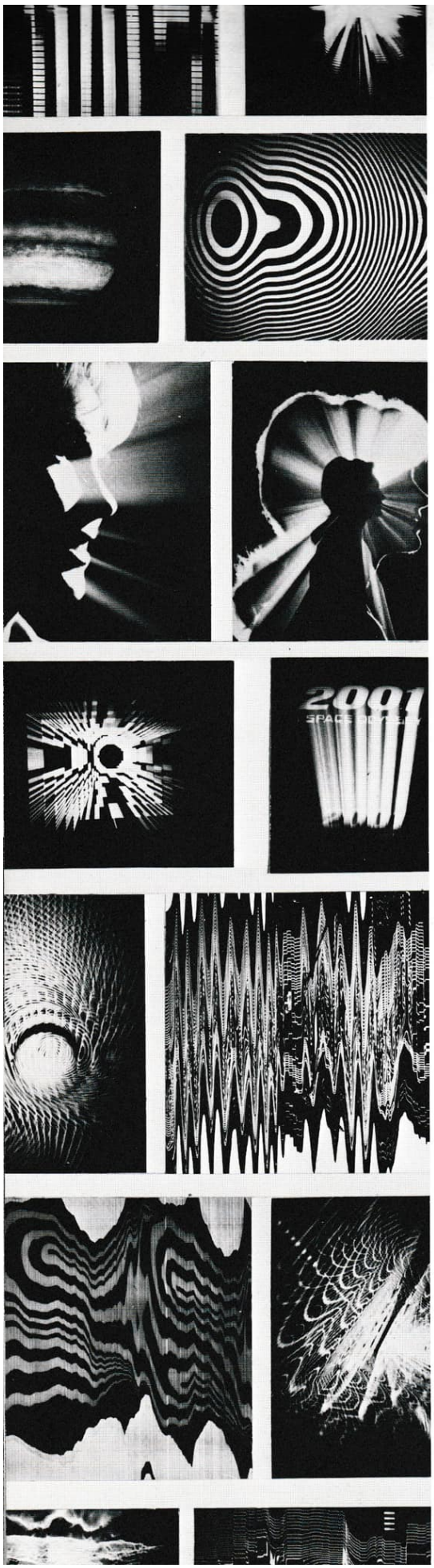
Many people have asked me how that effect came about. Kubrick had said that he wanted the camera to "go through something", but nobody knew quite what or how. As a Special Effects Supervisor working on the film I came up with one idea which is derived from some of the work of John Whitney, who, with his sons, has done some incredible things in combining completely abstract optical effects with computerized graphics.

I had just vaguely heard about something he had attempted involving a slit that moved across the frame while something moved behind it in a pattern that distorts in an odd way. I asked myself the question: "Why couldn't that pattern be made to move in depth—in *space*, so to speak?" There seemed to





(ABOVE) Frame blow-ups from several of the television spots made for the American Broadcasting Company by Trumbull Film Effects, involving slit-scan projections of the ABC logo. (BELOW) Frame blow-ups from the stunning Star-gate "psychedelic trip" sequence which enlivens the final portion of Stanley Kubrick's "2001: A SPACE ODYSSEY". The effect was created by the author using the slit-scan process which he developed while working as Special Effects Supervisor on that fabulous film of the future.



be no reason why it couldn't, so I decided to try it.

At the M-G-M Studio in England, where the picture was being made, we had a 70mm Oxberry animation stand which was rigged with a Polaroid camera that we used to run tests of animation artwork in register. I stopped the lens of the Polaroid down to about F/45, so that it would have a great depth of field. Then I got together some random *moiré* patterns, slit lines and abstract black and white transparent artwork. I would fit one of these patterns onto the register pegs, start the camera up at the top of the track, open the shutter, and then just sit there and crank the handles by hand, moving the slit across and moving the artwork around and trying out different kinds of effects.

I ended up with a stack of Polaroid pictures, each of which was a separate and fascinating effect. One of the simplest applications of the technique resulted in flat walls of exposed light. When Kubrick saw examples of this he really liked it, and he told me: "Do *that*. Go ahead with it!"

I designed a special rig to shoot these "slit-scan" sequences and started to build it on Stage 3 at M-G-M. We got it about half finished and then, for some reason, we had to vacate Stage 3. So we tore the whole thing down and moved it to another building where we finally got it put together. It involved panes of glass 5½ feet high and 12 feet long, mounted on huge tracks. We had to have large worm gears about 15 feet long, two inches in diameter and weighing 200 pounds, flown in from Detroit to move the camera up and down and drive the panes of glass back and forth in sync. It turned out to be a great, huge, clumsy rig—but it worked.

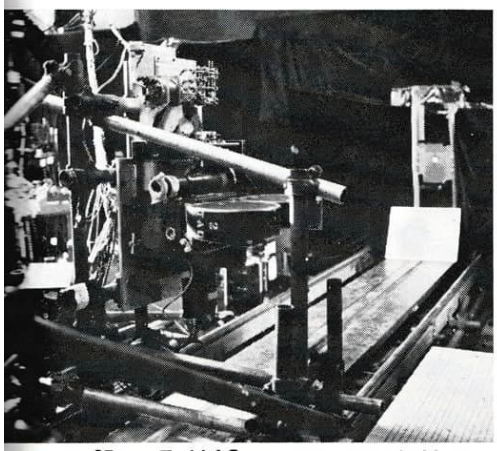
SUMMARY OF THE SLIT SCAN PROCESS

The term slit scan applies to only one form of a general process which would more accurately be called animated streak photography. Streak photography is used primarily in scientific flow and movement analysis, and consists of either extended time exposures or stroboscopic sequence multiple exposures to show changes in shape, direction, or velocity by exposing an entire movement onto a single film plate.

The animated streak photography technique, loosely called slit scan, consists basically of a mechanical or optical method of producing and exposing a controlled image movement onto mo-

(LEFT) A few examples of the infinite variety of design and special effect motifs possible with the slit-scan process. (RIGHT) Artwork being assembled for "psychedelic" Star-gate sequence which appeared in Stanley Kubrick's "2001: A SPACE ODYSSEY" and which was produced by means of the slit-scan technique.

Trumbull adjusts machine he built to "create" planet Jupiter for '2001". Special controls were needed to avoid speed fluctuations, which would have caused uneven exposure.



65mm Todd-AO camera mounted sideways on slit-scan track for shooting horizontal walls of light seen in end sequence of "2001".

tion picture film one frame at a time, each frame containing a complex streak exposure. The synthesis of movement as seen when the film is projected, is created by a controlled incremental change in the image from one frame of film to the next.

The mechanical arrangement of image and camera, as well as the electrical control apparatus, are probably not patentable ideas. However, the application of the streak photography technique to produce images which simulate reality, three-dimensionality, solid spacial relationships, and almost infinite photographic depth-of-field—is a major breakthrough in the creation of motion picture special effects which have heretofore been impossible.

The mechanism is simple. Either the image or object being photographed must move or change in some way relative to the camera during each exposure, or alternatively, the camera itself must move relative to the image being photographed. No matter what the specific relationships are, whatever movement takes place during the exposure must repeat itself exactly for each

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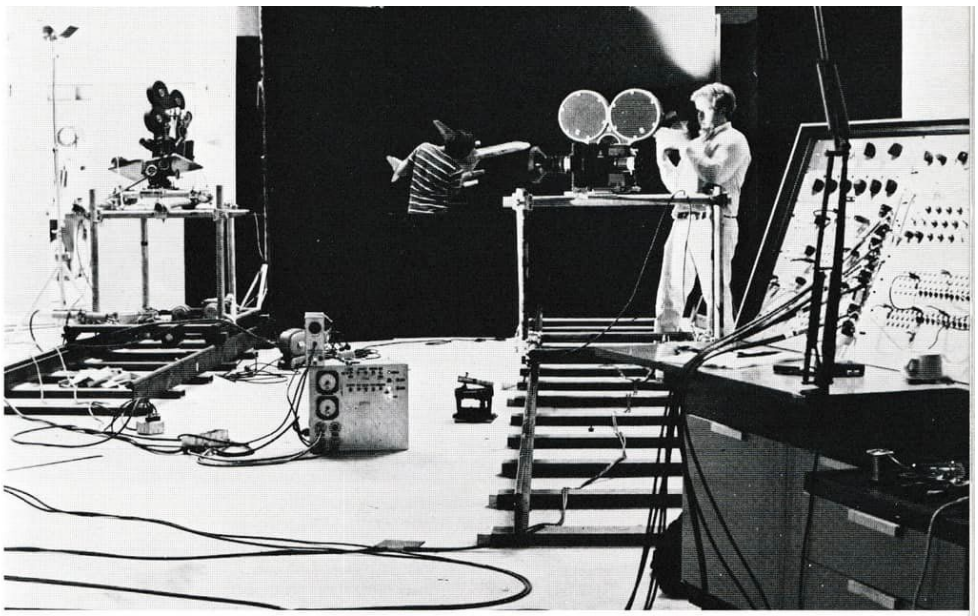
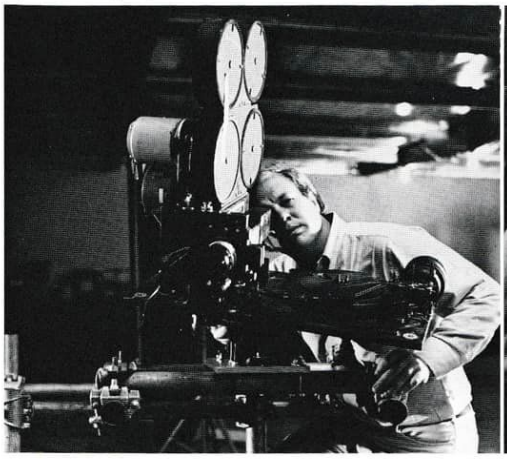
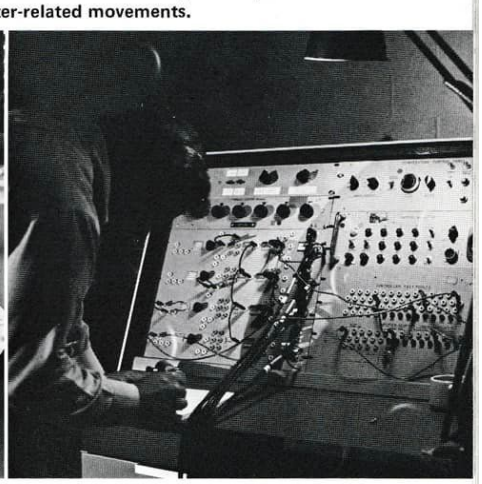


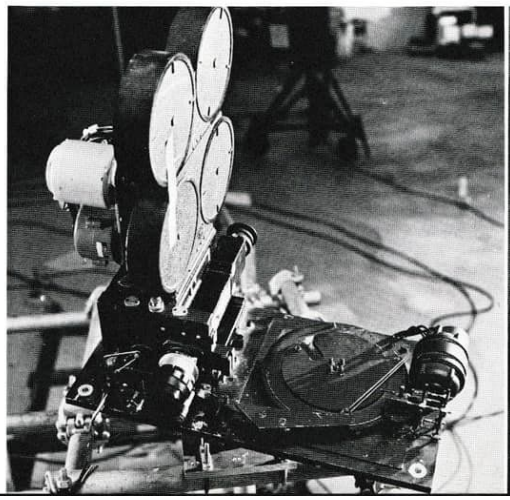
Work in process at Trumbull Film Effects, showing tracks, camera mounts and dollies used for slit-scan and other effects. Artist is painting airplane model matte white so that automatically matched movement can be shot to produce high-contrast, bi-pack matte.

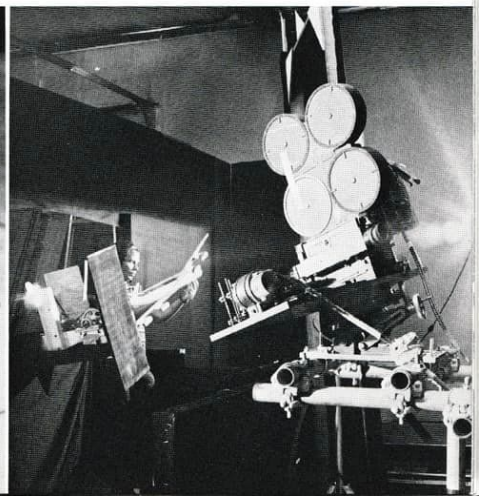
(LEFT) Trumbull lines up automated camera equipped with pulse motor drive system and selsyn-operated automatic focus. Bi-pack shooting allows matted foreground and background elements to be exposed onto the original negative for maximum quality. (RIGHT) Control console for pulse motor system, which is driven by sequences recorded on magnetic tape and can repeat exactly any number of takes involving complex inter-related movements.





(LEFT) 35mm standard Mitchell camera equipped with pulse drive and selsyn-driven focus cam. This camera is capable of copying over a range from 1-to-1 to infinity, using a 28mm Nikkor lens in bellows mount. (RIGHT) Rigid camera mounts and rigs are readily constructed using 2-inch steel pipe and scaffolding clamps, as shown.





THE SLIT-SCAN PROCESS

Continued from Page 1001

frame of film—except for the incremental change needed to produce cinematic movement.

More specifically, if during one frame of exposure a hypothetical image moves from point A to point B, the exact same exposure may be made by movement from B to A. By this means, recycling time between frames is eliminated, and the frame by frame sequence is A to B, B to A, A to B, and so on. The incremental change to produce motion takes place between frames, and is usually a small fraction of the total A to B movement, the size of the increment determining the speed of cinematic movement.

The following ideas show the progression of the streak photography technique to produce a photographic image of something that does not actually exist; a point light source moved during exposure produces a line in space—an intermittent light produces a dotted line. A line moved in space produces a plane of exposure—variations in the appearance of the line produce a pattern on the plane. Variations in the pattern of the plane produces a solid of varying density and pattern. Variations in the shape of the plane itself, produce a solid of complex and variable shape.

Obviously, these examples are extreme simplifications of the basic idea—for instance, an extremely complex spacial structure of lines and points may be created by the interrelated movements of the points of light on a back lit moire pattern. Complex multiple planes may be produced in the same way, depending upon the construction of the moire. An almost infinite plane may be created by moving an illuminated image behind a very narrow, long slit opening, while the entire mechanism moves toward the camera—we call this the slit scan.

A great variety of effects may be achieved by moving a flat surface, upon which are projected variable images, through space during the exposure—thus creating a solid effect from a flat image.

The permutations of movement relationships, exposure time, shapes, colors, etc. are endless, but the mechanism needed is fairly simple and adaptable to most situations.

There are usually only two axes of movement: (1) movement of the camera relative to the image, and (2) movement and change of the image itself. These movements are directly linked through a differential mechanism which provides the incremental displacement between the two, thus creating the cinematic movement. Since the camera is usually the least bulky part of the whole mechanism, it moves relative to the image via a simple track and gear system. The image is usually produced by projections or other light and pattern producing mechanisms on a plane relative to which the camera moves. Since the distance between the image and camera varies during the exposure, another mechanism is incorporated which automatically keeps the camera lens focussed upon the image plane at all times. Therefore, the image on one frame of film may include an infinite number of focal distances at once, keeping the image sharp from the most extreme foreground to infinity.

For consistency and evenness of exposure, all movements must be smooth and repeatable. High precision bearing tracks, anti-backlash gearing, synchronous motor drives, and selsyn links are used for this purpose. Synchronous sequencers and timers are used to control the overall system.

Since this technique deals with an accumulated exposure, only a fraction of which exists at any single point in time, light meter readings are relatively useless, and a desired exposure can only be obtained by a trial and error process. Otherwise, exposure is the same as normal photography, being dependent upon image brightness, lens aperture, film sensitivity, and total exposure time.

Description of Slit Scan Camera Mechanism

The slit scan camera mechanism incorporates a normal motion picture camera equipped with a stop motion motor, along with various selsyn motors and timers, to produce the streak photograph frame by frame as mentioned in the summary of the slit scan technique. The most important part of the mechanism is the motion picture camera. The normal shutter mechanism within the camera is taken 180° out of phase so that between frames in the stop motion sequence, the shutter remains in the open position. The exposure is then controlled by the auxiliary diaphragm-type shutter in front of the lens which is activated by the main sequencer.

The focus of the lens is controlled by a cam, which is driven by a slave selsyn linked with the main drive system. The camera and its mechanisms are driven along the track via another slave selsyn, which is also controlled by the main drive system. On the camera dolly are microswitches which determine the

Continued on Page 1016

THE SLIT-SCAN PROCESS

Continued from Page 1013

positioning and reversing of the entire camera mechanism via the automatic sequencing mechanism.

The camera faces towards a plane of glass at the end of the track and remains focused on that plane at all positions along that track. Directly behind this plane of glass is another sliding plane of glass which is driven by a slave selsyn, controlled by the main drive unit. The main drive unit consists of a reversible, ¼-horsepower, synchronous motor, a solenoid type brake on the motor and a master selsyn driven by the motor. The master selsyn drives all of the slave selsyns at the camera dolly, the camera focus and the sliding glass plane.

During the exposure of one frame of film, the camera dolly traverses a length of track approximately 12 ft. and, in this time, the focus selsyn provides a cam rotation of approximately ¾ of a rev., which keeps the lens focused upon the glass plane. In addition, the selsyn driving the sliding glass plane provides a movement of approximately 10 inches. At the forward and back positions on the main track are cams which trigger the microswitches on the camera dolly which, in turn, operate the main sequence control unit. The sequencer stops the main motor, engages the brake, closes the shutter, advances the film to the next frame, provides the incremental advance to the sliding glass frame, restarts and reverses the main motor and re-opens the shutter.

Using a 35mm. lens on a 65mm. camera, the area covered in the back position on the track is roughly 14 ft. in width. At the closest position on the track, the area covered is roughly 4 inches. At this point, the front lens element and shutter mechanism are extremely close to the glass plane and, for this reason, the brake has been added to the main drive motor to stop the camera dolly before it coasts into the glass. Emergency overrun microswitches are also provided to cut off the main power supply in case the camera dolly overruns its normal stopping position. During the normal sequence of photography, shooting may be stopped at any time by turning off the auto restart switch which allows the camera to carry on its normal exposure until it reaches the microswitches, at which point the sequencer will provide all of the normal sequences including film advance, artwork incremental advance, etc., without restarting or opening the shutter. At this point, the sequencer stops and waits until the auto restart switch is turned to the 'On' position. In this way, various checks of the camera and other functions may be made during a shot and lights may be turned on since the shutter remains closed during this time.

In slit scan photography, the entire shooting area must be kept completely dark, except for the back-illuminated artwork. A track light is incorporated in the system which is basically a darkroom safe light which comes on only during the time that the shutter is closed. This allows various checks to be made on camera positioning and artwork during shooting.

The artwork is made of various types of light transmitting materials such as color transparencies, black and white transparencies, and colored celluloid gels, and is attached to the sliding glass plane. On the static glass plane is a very narrow slit opening, through which only a small segment of the artwork can be seen at any one time. With the camera in its closest position, the slit is positioned at a point just slightly outside the frame area seen by the camera, so that as the camera moves away from the glass, the slit comes into view and when the camera is in the farthest back position, the slit is in almost exactly the center of the frame. During this movement from front to back positions while the camera shutter is open, the artwork is sliding on the glass frame and is therefore being exposed behind the slit as the slit image travels across the film plane. In this way the artwork is literally scanned onto the film, creating a receding plane of exposure. Since the camera is traversing a distance of 12 ft. and the artwork is only traversing a distance of 10 inches behind the slit, this has the effect of stretching the artwork over the 12-foot distance. To create the effect of movement along the plane of exposure, the incremental change is applied between each frame which displaces the position at which the artwork intersects the slit. Different amounts of incremental change produce different apparent speeds of movement and multiple slits provide the effect of multiple planes of exposure.

Other effects can be produced by using moire patterns interacting between the static glass plane and the sliding glass plane.

Since widely varying speeds may be called for in the apparent motion of the slit scan effect, the incremental advance is controlled as a function of time rather than as a function of gear ratios, so that the art advance timer may be set at any amount of time depending on the speed desired—more time producing a greater

Continued on Page 1020

THE SLIT-SCAN PROCESS

Continued from Page 1017

amount of incremental advance each frame. The film advance timer gives a controlled one-second pulse which is required to advance the film one frame. Other timers may be added to the circuit to provide more complex advancement or incremental change in the image. Extra slave selsyns may also be added for this reason.

Since this streak photography process deals basically with the idea of image movement during exposure, any photographical image or object may be used to create a streak image effect and the type of effect created will depend upon the manner in which the image is moved relative to the camera. Therefore, the arrangement of the camera, dolly, track, and artwork plane may be altered to any number of different combinations. For this reason, master and slave drive selsyns were chosen for ease of adaptation to different setups.

The film advance and art advance timer start switches must be in the 'On' position to complete the microswitch-operated circuit which energizes the timers.

The motor and brake contactor switch must be in the 'On' position to complete the circuit which energizes the contacter, which in turn, provides power to the main motor and main motor brake. This switch may be used to stop progress of the camera dolly at any point along the track.

The auto restart switch completes the circuit to restart the main motor at the end of the cycle between frames.

The emergency stop switch on the camera dolly is wired in series with the motor and brake contactor switch and is useful for checking the camera focus at points along the track as well as an emergency stop in case of trouble.

Functions of the three microswitches on the camera dolly are as follows:

1. To disconnect the main camera drive.
2. To start the cam sequencer unit.
3. To reverse the direction of dolly movement.

The main motor is a single-phase, ¼-h.p. synchronous motor.

The art advance motor is a capacitor inductance, 1/75th-h.p. motor.

The art and film advance timers are normal darkroom timers incorporating a continuous running synchronous clock motor and provide a timed pulse depending on the dial setting whenever the timer start circuit is energized.

The cam sequencer motor is a 1/75th-

h.p. capacitor inductance motor equipped with a disc type electric brake.

The cam sequencer unit consists of the cam motor, the cam motor brake, and a set of five rotary cams which activate microswitches to perform various functions during the cycle between frames.

The auxiliary shutter is a standard diaphragm type still photography shutter, with an internal diameter sufficient to cover the front element of the motion picture camera lens.

The shutter solenoid is a small slug type D.C. solenoid which activates a normal still photography cable release to operate the shutter.

APPLICATIONS OF SLIT-SCAN BEYOND "2001"

Our main problem in creating the slit-scan effects for "2001: A SPACE ODYSSEY" had nothing to do with the machine we built, because that worked just fine; it had to do with the actual artwork.

Stanley Kubrick was very concerned about what would be seen in that sequence, and with good reason—so we went through a great deal of experimentation to get the correct visual patterns.

One of the things we tried involved pure texture and the result looked like giant carpets going by. When Stanley saw it, he said: "That looks too much like carpets going by." So we junked it.

We built a huge opal-glass light board about 6 feet wide and 8 feet long to use in building up the artwork. We got a huge roll of acetate and stretched it across the light board as a base for the materials we would use. These materials included high contrast Op-art paintings, *moiré* scientific kits and just about any other kinds of patterns we could find.

I also put artists to work making my own *moiré* patterns and designing special curves and loops. One of the most interesting techniques of creating artwork to shoot on the slit-scan camera involved a return to shooting with the polaroid on the animation stand. I would take a pattern and then, with the slit abstracting it onto polaroid, create new weirdly exciting patterns. For example, a high-contrast photograph of a printed circuit, when run through the slit-scan process, would become quite a different design, an abstract pattern only vaguely suggestive of a printed circuit. Even a straight pattern of concentric circles could be distorted by the slit to become an intricate Op-art design—something that would be very difficult to draw or paint. We also used enormously blown-up electron micro-

photographs of molecular structures and crystal patterns that resulted in very attractive designs.

Using the slit-scan itself to make artwork for the final slit-scan sequences, we would shoot a great many designs on 4 x 5 Polaroid material. Then we would select about 100 of these and paste them all up together and re-photograph the combination onto a single large high-contrast negative. This would be combined with a lot of other high-contrast negatives to build up a huge mosaic.

Color was added by cutting sheets of colored plastic into shapes to match segments of the design. In each slit-scan exposure the camera traveled a distance of about 15 feet from the farthest point to the nearest point. The vertical slit creates a plane of exposure 15 feet long, and it is exactly the equivalent of shooting a wall 15 feet long from a distance of about one inch from the wall. The odd thing is that during the time the camera moves that distance, the artwork, which is behind the slit, has moved only 4 or 5 inches. Optically, therefore, you have taken a very small segment of artwork and stretched it over a long distance. This optical stretching results in a very streaked effect, so that even a single frame of film (which is a very static thing) looks like it is going very fast. When shooting a piece of artwork 12 feet long and multiplying that by the ratio of 5 inches to 15 feet, you are essentially traveling over a piece of artwork that seems to be many, many yards long—which is why it is possible to get such long takes.

In creating the "Star-gate" effect, there would be one wall on one side of the frame and one wall on the other (or above and below), each photographed with a separate exposure. It was not possible to shoot two walls at the same time because of the angle at which the camera has to shoot the artwork.

It was necessary, therefore, to make two exposures for each of the "Star-gate" scenes. In some cases we used two completely different pieces of artwork. At other times, we would use the same piece of artwork, flopped, with the colors changed. This produces an odd effect that seems like a mirror-image, but it isn't really that. The two exposures don't actually match up, even though the images are symmetrical in form.

The slit-scan machine I built for "2001" was absolutely enormous. The whole thing was constructed of heavy structural steel and sat about two feet off the ground.

Continued on Page 1024

THE SLIT-SCAN PROCESS

Continued from Page 1022

Since then I have built a much more sophisticated machine. It is much lighter and more compact, although the track is much longer than that of the first machine. It has smaller panes of glass, automatic follow-focus and the main elements are interlocked by means of pulse motors which are quite powerful, absolutely positive and much more efficient than selsyns.

On recent projects I have been using the slit-scan process in much the same way that I employed it for "2001"—and that is basically with the camera on a track moving toward a pane of glass onto which various kinds of material have been pasted. In the series of promotional spots which we recently completed for the American Broadcasting Company, the material used was simply a series of little ABC logos, all photographed through the slit. In one of these spots the letters of a circular logo turn into translucent tubes that look like they're made out of plastic. They have perspective and appear to be solid, three-dimensional objects. But they have no physical structure at all, because they're created from pure light.

In another of the ABC spots the camera seems to be rushing between flat planes of multiplying logo designs, very much like the "Star-gate" sequence from "2001". In yet another spot I simply took a line version of the ABC logo, photographed it flat to the camera, but stretched it on every frame so that it appears to be about a foot deep.

A similar technique was used in shooting the cover photograph for this issue of AMERICAN CINEMATOGRAPHER. It started with an outline version of the CINEMATOGRAPHER logo, each letter being backed up with a different color. Then, using the pulse motor-driven rig, the typography was stretched and made to rise up and then fall back down in a sine wave curve generated by an eccentric cam as the camera approached it.

A quite different technique from that used in the "Star-gate" sequence was the application of the slit-scan process employed to create the planet Jupiter for "2001: A SPACE ODYSSEY". Several painters had tried to paint Jupiter, but none of them was able to really articulately paint a perspective change around the edge of something spherical—the way clouds, for example, might change in shape, color and tone.

What was needed was a way to transfer a flat painting to a sphere, so as

to give it that accurate perspective. I decided to use a variation of the slit-scan process to get the effect.

Starting from scratch, if you want to make a line on a piece of film, you simply take a point of light and move it through the frame. If you have a line already generated and you traverse it through the frame, you can create a plane of exposure. Creating Jupiter was based on the principle of the lathe, in that if you have a semi-circular line of light mounted on a pivot so that it goes around in a circle, it will form a complete sphere on the film.

The line in this case was formed by a very thin piece of paper, trimmed down with a razor blade to a width of 1/16 of an inch and pasted onto the edge of a disc of black aluminum. A flat painting of Jupiter's surface (in color transparency form) was projected onto that little thin line of paper, so that only a very slender fragment of the painting was reflected at any one time. But as the whole machine rotated, the line traversed around and the projected picture traversed across the line simultaneously—just as the flat pane of glass traverses behind the slit in producing the "Star-gate" effect.

We wanted to reproduce the banding that extends around the planet, as well as the spot that is called "the Red Eye of Jupiter"—a sort of oval-shaped reddish area which we know exists on the face of the planet. I painted the Eye in realistic colors and textures, but in a perfectly circular form, knowing that when it was projected onto the spherical "surface" of Jupiter it would be stretched into an oval shape. As the machine rotated in a full 180° arc, the projected transparency moved only 90 to 100 degrees, which means that the image was stretched around Jupiter, giving a very new feeling to the painting. It became sweeping, as if there were terrific wind forces about the planet.

That was probably one of the first uses of slit-scan to create something that didn't look transparent. I could have continued the slit all the way around to show simultaneously the front and back surfaces of Jupiter, but in this case I only went 180 degrees, so that the planet would appear solid. The most pleasing thing about the result is that nobody has ever questioned that it was anything but Jupiter. The fact is that the very best actual photographs ever taken of Jupiter are very bad. They're extremely fuzzy and you can hardly see any distinguishing features. In that respect, I had very little to work with.

There are almost limitless possibilities to the use of the slit-scan process in

cinematography, but many people think of it solely in terms of creating something like a light-show. I feel that a light-show, per se, is a pretty aimless approach to any sort of dramatic effect. But just by using the method we employed to create Jupiter, you can develop many other spectacular things that don't actually exist.

I'll be using this and other applications of the process in a picture I'll be starting quite soon with James Coburn called "MAXIGASM" which will require the creation of very super-realistic natural phenomena, including things like the *aurora borealis,* heat lightning, sheet lightning and different kinds of fire balls. The story takes place in the future and these weird phenomena that are going on all the time are just part of the environment. They won't be treated as featured effects, but simply as things that are happening in the corner of the frame or in the background.

There will also be "flying saucers"—but not like any that have been seen on the screen before. Everyone who makes a flying saucer film gets a spun aluminum hub-cap and sails it through the scene by means of little rockets or something like that. The flying saucers will not be the "stars" of our film, but merely elements that exist in this environment. The creation of these saucers is going to be a fantastic thing, because they won't be models or anything made out of metal. They will be forms composed purely of light, shaped like saucers or globes, but able to change shape as well as appear and disappear. Sometimes when they disappear they just shatter into linear energy or suddenly expand and become pure light. I think that working with them will be very interesting.

The slit-scan process is uniquely applicable to certain kinds of requirements. "2001" was probably the ultimate perfect requirement, because what Stanley Kubrick needed in that picture is what slit-scan provides best. It is considered a new photographic technique, but it's not all that new. The basic method has been used in scientific work for some time now. However, it's the present applications that are new, stemming from the work of people like John Whitney.

Slit-scan is applicable to only a certain few special situations, but what it means to the modern film-maker is that he can take something that is essentially dull, flat and static and turn it into something dimensional, with movement and depth and color—something that is visually much more exciting on the screen. ■

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