Special Effects Sourcebook

Special Report No.11, 1982
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FOREWORD

It is said - and it’s true - that a planetarium’s best special effect is its ability to display the starry night sky. But these days it is not the only special effect we employ. As we strive to present realistic astronomical phenomena, to visualize concepts, to create an environment, or simply to enhance a mood, special effects can be effective tools to educate, enlighten and delight.

This Special Effects Sourcebook is a reprint of the International Planetarium Society’s Special Publication No.11, compiled by David A. Aguilar, and first published in 1982. It includes some additions to the original publication, and has been guided to its new form by Publications Chair, Undine Concannon, and her able committee, to whom I offer our sincere thanks.

Even as we turn increasingly to computer graphics and video under our domes, the popularity of the original Sourcebook - which provides the impetus for this reprint - suggests that there is still a role to play for the clever planetarium professionals who have made magic for years with a motor, a lens, and the simplest of elements effectively used. We hope that this Sourcebook will become and remain a useful reference in your work - a source of ideas and inspiration as you continue in your worthy efforts to bring the universe down to earth for your varied audiences.

Special thanks to all whose contributions have made this publication possible.

James G. Manning
President, International Planetarium Society

Autumn 1996
CONTRIBUTORS

Where known, contributors' names appear beneath the title of their effect. In spite of our efforts, it has been almost impossible to trace most of the contributors to the original publication, as many seem to have left the Planetarium field; and some of those we have traced could not remember which effects they had produced! We therefore apologise to those whose contribution is included without credit. The institutions listed are those by whom the contributors were employed at the time of submitting their ideas.

Anderson Don H - Rochester, N.Y.
Andress J.R. - Warrensville Heights Planetarium, Ohio
Bernedo Tony - Madrid Planetarium, Spain
Bishop Jeanne - Westlake Schools Planetarium, Ohio
Bowman Maile - George Wallace Jr. Civic Centre, Fitchburg, Maryland
Canonaco Giuseppe - Europlanetarium, Genk
Carr Everett Q - Herkimer Boces Planetarium, Herkimer, NY
Coolbaugh John - Robert J. Novins Planetarium, Toms River, New Jersey
Dabrowski Jan Paul - Portland, Oregon
Deutschmann W.A - Bonisteel Observatory, Carlisle, Pennsylvania
Dutton William L - Edgerton Memorial Planetarium, Stamford, Connecticut
Dziedziech Carl - Strasenburgh Planetarium, Rochester Museum & Science Center, NY
Findlay John - Calgary Centennial Planetarium, Canada
Ford Harry - Caird Planetarium, Greenwich, London, UK
Friedman Alan J - William K. Holt Planetarium, University of California, Berkeley, California
Garland Don - Richmond College, Dallas, Texas
Godeaux Ashley - Wallace Fiske Planetarium, Boulder, Colorado
Grabowski Edward R. - Abrams Planetarium, Michigan State University, Ohio
Hall Don - Strasenburgh Planetarium, Rochester Museum & Science Center, NY
Hamilton Thomas - Wagner College, Staten Island, New York
Hurd David - H.R. MacMillan Planetarium, Vancouver, Canada
Jeff & Bob & Jeff Co.
Jenzano Tony - Morehead Planetarium, Chapel Hill, N.Carolina
Joseph Charles - Abrams Planetarium, Michigan State University, Ohio
Larranzio Stephen R - Orange Coast College, Costa Mesa, California
Littman Mark - Hansen Planetarium, Salt Lake City, Utah
Lober Bob - Chaffee College, Rancho Cucamonga, California
McColman Richard - Morehead Planetarium, Chapel Hill, North Carolina
McDonald Donald - Moinita Planetarium, DeAnza College, Cupertino, California
Michael Dwight E. - Jay County High School, Portland, Indiana
Nichol Steve - Morehead Planetarium, Chapel Hill, North Carolina
Percival Charles - Christa McAuliffe Planetarium, Pueblo, Colorado
Pounds Bill - Arlington Public Schools Planetarium, Virginia.
Rahunen Timo - Tampere Planetarium, Finland
Ryan Michael F. - Cernan Earth & Space Center, River Grove, Illinois
Sanford David - Shaker Heights Planetarium, Ohio
Schults William Jr. - Cranbrook School
Schwartz Herbert J. - Sargent Planetarium
Seebach James R - Charlotte Nature Museum, N.Carolina
Sessions Larry - Noble Planetarium, Museum of Science & History, Fort Worth, Texas
Smith Steven E. - Arlington Public Schools Planetarium, Virginia.
Stobbeleir D.Scott - Shiras Planetarium, Marquette, Michigan
Vann Marvin - Foothill College, Los Altos, California
Warren Don - City College Planetarium, San Francisco, California
Wieser Sig - Calgary Centennial Planetarium, Canada
Wilson Ken - Alexander Morrison Planetarium, San Francisco, California
Yankee James R. - Enrico Fermi High School, Enfield, Connecticut

We have kept both American and English spellings, according to the nationality of the contributor; and have converted measurements from or to metric where appropriate.
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ABLATION TRAIL

Use motors of different speeds to simulate either a passing rocket (1-2 rpm) or a bolide (5-10 rpm). Use a very heavy duty motor to move the projector, or you will get a jerky motion across the sky. A Hurst 600 inch-ounce reversible motor works well.

1/16" PLEXIGLASS
AIRBRUSHED WITH PAINT, OPAQUE
AT TOP, GOING GRADUALLY TO CLEAR.

150 WATT PROJECTOR
WITH THIN VERTICAL SLIT AS TRANSPARENCY

LIMIT SWITCH

WOOD STAND
Moving asteroid images seem to move in a continuous three-dimensional "belt" which extends across the dome from one horizon to the other.

The effect should be positioned near the star projector. It consists of a single-slide projector with a 75mm lens, and two large tuna cans partially covered with small mirror sections, rotated in front of the projection lens via two AC gearhead motors of different speeds.

A simple Kodalith slide with 10 to 20 asteroid "dots" is used in the projector gate. 10mm-square mirror sections are then removed from a small disco mirror ball, and glued around the tuna cans as shown. Each can has one continuous row of mirror sections, and a second row with the mirrors spaced more irregularly, to randomize the multiplied pattern of asteroid dots. The areas between the mirrors are painted flat-black.

Mount the cans on to two motors (1/2 rpm and 1/4 rpm) oriented with their shafts facing each other. Since they face each other but spin in the opposite directions, their cans effectively spin in the same direction. They are mounted so that the projector will aim into the mirrors on the tops of both cans - and a light mask is positioned behind to keep any stationary asteroid images from missing the mirrors and projecting on to the dome.
ASTEROID BELT IN MOTION

Two cylinders are used, one inside the other, both rotating in the same direction at different speeds. This is done using four gears, all of different sizes. The cylinders are of metal to avoid heat-warping or melting, and covered with aluminum foil, perforated in a random pattern by placing it in a telephone book with a sheet of medium-fine sandpaper and hammering on the book until the desired hole size and pattern is achieved. The aluminum foil is then cut to size and glued on to the hardware cloth cylinders. Enlarge the holes on the inner cylinder by punching holes at random with a sharp pencil.

The result is a shimmering band of star-like and larger objects moving in a continuous stream across the dome.

Fig. 1
ALUMINUM FOIL
(FOILED OVER METAL CYLINDERS-
INNER CYLINDER WITH LARGER HOLES)

BALL BEARING

100W PROJECTOR BULB
FASTENS TO DIRECT DRIVE SHAFT
THROUGH BEARING IN OTHER CYLINDER

CYLINDERS OF 1/4"
HARDWARE CLOTH (ONE END
OPEN, ONE END OF 1/4" MASONITE*)
MAKE SHAFTS AS SHORT
AS POSSIBLE

CARDBOARD OR METAL TUBE
(SLOTTED AT FILAMENT LEVEL
THROUGH 180°)

1/2 RPM MOTOR

BALL BEARING

ASTEROID BELT IN MOTION
(continued)
This gives the impression of a meteorite impact just over the horizon. A bright moving dot gains speed as it crosses the dome. When it reaches the edge of the panorama, the dot disappears and an impact projector momentarily lights up and fades.

The Dot Projector can be made by mounting a piece of aluminum foil pierced with a needle (The image does not need to be circular) It is placed just in front of a 500w projector lamp - no condensers are needed. To form the image use a projection lens of about 100mm focal length. If you take care not to run the lamp for more than about 10 seconds, no fan will be needed. The dot image is bounced off a moving mirror to make it travel across the dome.

The projector lamp is controlled by a triac of sufficient voltage and current rating to handle the lamp used. We used an 8-ampere 400v device in a plastic tab package. No heat sink is necessary because the lamp is only on for about 10 seconds. The 15w horizon explosion lamp serves as a gate current limiting resistor for turning the triac on.

During the time the dot is travelling across the dome, the capacitor is charging up. R limits the charging current to avoid destruction of the diode. Its value will be determined by the diode used; but it must be small enough to allow the capacitor to charge fully. At impact the 15w lamp is switched out of the triac gate circuit and across the capacitor. It glows brightly and fades, giving the impression of an explosion.

The impact flare is placed in the cover right under the spot on the panorama where the impact occurs. Experiment with black tape, cardboard, scissors and gels to get a nice explosion.

Two power cords are required. One is connected to 110v all the time. The other is switched 100v from the console. It is thrown and held until impact takes place. The switch is then released and the projector resets itself using a microswitch.
This ATMOSPHERIUM is designed for a small 29ft (9m) dome. Two Bell & Howell Cube projectors are modified by substituting short focal-length fisheye camera lenses (7.5mm-17mm) for the projection lens module. Inexpensive lenses are advertised in photographic magazines (eg. *Modern Photography* and *Photography*).

Excellent allsky pictures are made from Eastman Kodak Ektachrome Infrared film, using a Wratten #12 yellow filter exposed at 100 ASA. The film should have continuous refrigeration before use to retain the color balance. The slides are made as time-lapse photographs at a picture-taking rate of 3 pictures per hour.

A ‘day’ of 13 hours 20 minutes can be recorded on a total of 80 slides. They can be played back at any desired rate using an automatic dissolve unit.

Against bright skies, it may be necessary to use a neutral-density filter to bring the exposure within the range of your shutter speed and aperture available. If a friendly cloud is not handy to mask the Sun, you will need to create an artificial eclipse to prevent fogging the frame to insensitivity. Kodak has information leaflets on the infrared film, and on creating artificial eclipses for photographic purposes.

When ordering the projection lens, make sure you can adapt it to your own camera body. It is convenient to make the originals in a standard 35mm camera.

When used as a projection lens, the format of the slides will have to be enlarged - some slide-processing laboratories will enlarge a standard 35mm slide to approximately 46mm on a superslide format.

*See over for illustrations*
Fig. 1

Schematic of the optical path that allows vertical adjustment of the projector to an horizontal projection position.

Wide Angle Lens Modification
Shows how the adjustment is accomplished, and how the lens is mounted.
This AURORA PROJECTOR utilizes a Pepsi bottle for the lens. When slowly rotated in front of three projected slits, a very realistic rayed arc aurora is produced.

The container box can either be constructed out of ¼" (30mm) plywood or corrugated cardboard. The slide is a 2"x2" (50mmx50mm) glass painted flat black, with three very fine lines scribed in the paint.

Place green gels in the bottle, one round the inside, the other across the diameter, to give the aurora color. A ⅛" (19mm) black stripe painted vertically on the bottle causes the aurora to die out and reappear very realistically. Baffles may be required in front of the lens to shape the aurora.
AURORA 2

PLASTIC CYLINDER WRAPPED IN BLACK TAPE

PLYWOOD BASE

CRUMPLED ALUMINUM FOIL

PLYWOOD DISC

12V PR-12 LAMP

TACK TO PLYWOOD ON PROJECTOR

12V D.C. MOTOR
(EDMUND #41,863)

WINDOW

CONSOLE SHROUD

WINDOW COVERED WITH RED AND GREEN GEL

CARDBOARD OR ALUMINUM
Place a motorized "ripple" wheel in front of a 100-150w slide projector with a 35mm slide of an aurora placed in the slide gate. Aurora pictures can be copied out of meteorological or astronomical books quite easily. The ripple wheel is made from a disc of clear plexiglass \( \frac{1}{16} \text{"} - \frac{1}{6} \text{"} \) (1.5mm - 3mm) thick, with either Duco cement or Vaseline dabbed randomly on its surface.

NOTE: TO EXCLUDE EXTRANEOUS LIGHT, MASK THE OUTSIDE EDGE OF THE RIPPLE WHEEL WITH \( \frac{1}{2} \text{"} \) BLACK TAPE...
A CURTAIN AURORA is produced when light from a 605 lamp is reflected from a crumpled-foil surface on to the dome. The foil is mounted on a cardboard turntable attached to a 1rpm motor. The moving reflecting surface causes the curtain to shimmer and change pattern. Color can be added by taping or pinning a skirt of multi-colored filters perpendicular to the disc’s surface. With a 605 lamp, only pale yellows, blues and pinks are suitable. Darker colors may reduce the light output too much. If you desire brighter colors or want to use the projector in a large dome, replace the 605 lamp with a GE 1424 6v lamp.

The projector’s enclosure can be made of sheet metal, wood, or black poster board. The latter is the simplest to build, and is durable provided it is not treated as a hands-on exhibit by the audience.

The projector is mounted horizontally on the pedestal. The light from the exit slit falls slightly above the horizon cut-off and extends 30° vertically and 70° horizontally. When in operation, the projector is not visible to the audience since the slit is at least 6" (150mm) above eye level.
This uses reflection grating material of the type found in holograms to produce a spectrum which can then be projected. At a distance of about 4 yards/metres a 2.5v 1w bulb produces a diffuse spectrum with red at one end and green at the other, just what the aurora often shows.

Not all hologram material gives good spectra, so you will need to experiment till you find one that does.
This is a projector with a ragged-edge "starburst" side in it. A rapidly-spinning gelled color wheel rotates in front of the slide. The lens is fitted with a hexidoscope tube (from Edmund Scientific). The light path is folded by a prism or mirror and sent up an 8" (200mm) piece of plastic tubing lined with crumpled aluminized mylar or aluminum foil. A lens of 175mm focal-length is cemented on top of this tube. Supported on a motorized rail above this assembly is a 225mm focal-length large condenser lens smeared with Chapstick. This lens is arranged to drive from a point almost touching the 7" condenser lens to 8 to 10 inches (200mm - 250mm) away from it. Driving the two lenses closer together zooms the effect. The focal lengths are not critical: experiment with what you have.
This Double Star projector uses a 100-150w slide projector with a rotating star plate mounted inside the slide gate. Cut a circular star plate from a piece of \( \frac{3}{4} \) (6mm) clear plexiglass, and cover it with either a Kodalith mask, or thin sheet of aluminum, with one large red-gelled aperture and one small blue-gelled aperture glued to it with Duco cement. The star plate is bearing-mounted on an aluminum plate of \( \frac{3}{8} \) (3mm) diameter, driven by a \( \frac{1}{2} \) rpm motor. Since neither star is centered on the mask, both will seem to rotate around a common centre of gravity.
A face-on view of a double star system with one star appreciably more massive than the other. On cue, the more massive star disappears, leaving the smaller star orbiting an invisible companion.

Two plastic discs are used. *(Fig. 1)*. Disc 1 is grooved around the edge and mounted with two flanged ball-bearings and an O-ring motor-driven friction puck. At its centre is an axle on which is mounted Disc 2. The mask for Disc 1 *(Fig. 2)* is simply two round apertures, one smaller than the other, mounted and gelled to represent the two stars. Turning this disc causes the stars to orbit.

Disc 2 mounts on the axle with some spring-loaded washers so that it will turn with Disc 1 when unrestrained. A small solenoid is mounted to pull a wire braking-arm against the edge of Disc 2, stopping its motion on cue. Its mask *(Fig. 3)* consists of an opaque disc with a pie wedge cut out of it. By stopping the rotation of Disc 2, the inner star can be made to appear and disappear on cue. Once the desired effect has been achieved, release of the brake arm will cause the two discs to rotate back into the visible two star system.

*Fig. 1*
BINARY STAR DISAPPEARING (continued)

*Fig. 2* Disc 1 with large disappearing star and smaller companion

*Fig. 3* Disc 2 with occulting mask
BLACK HOLE 1

A small opaque projector with a small crumpled ball of aluminum foil turning slowly on the extended shaft of a motor. Place an occulting disc (eg. a small coin) in the light path, between the foil ball and the lens.

This projection, when properly light-shielded, and projected out of focus through a blue or purple filter, beautifully simulates a Black Hole.
BLACK HOLE 2

Made with an illuminated rotating drum turning inside a gelled cover. The drum can be made from a piece of clear plastic tubing, 2" (50mm) diameter, or a baby food jar. Wrap half-inch masking tape in a spiral pattern around the drum and paint it flat black. Strip off the tape to reveal the clear spiral areas.

Mount the drum on a motor shaft inside the base. The outside cardboard base cover should be sprayed flat black before it is mounted on the drum. Experiment with different pieces of colored gel over the opening on the cover to achieve the desired effect.
This BLACK HOLE projector uses a 500w Sawyer projector (from Edmund Scientific), a motorized colour wheel, and a special mylar lens tube to project one of the most beautiful effects ever seen. It never fails to be a crowd pleaser.

The lens tube is a piece of corrugated cardboard (such as used for bulletin boards in the USA, and not cardboard boxes). Line it for half its length with aluminized mylar or aluminium foil. Then roll and glue it into a piece of tubing that fits the lens opening of the projector. Cover the end of the tube with a piece of thin clear plexiglass with a small coin glued in the centre.

An additional tip - boxes to house projectors can be made from black Plasticard (UK) which can be bought at model shops. The sheets can be cut with a knife and glued with polystyrene cement; and the black color means no reflections, and it does not have to be painted matt black inside.
Black Hole Binary

This is created by having two sandwiched discs moving at slightly different speeds. Both discs with thin rims (¼" or 3mm), are bearing mounted together, and rim-driven.

The artwork discs are of ¼" (6mm) plexiglass. Disc A has Black Hole kodalith artwork cemented on to one side of it; the large star is dyed with red food coloring, but the stellar gas loop remains clear. Disc B has a purple mask cemented to it, with the emulsion side next to the plexiglass. A small piece of coathanger wire, flattened at one end, forms the Black Hole and joins the two discs together.
This uses a fabricated cardboard drum with a kodalith bolide image rotated over a smaller drum containing the light source. The slot on the inner drum is covered with various pieces of colored gel taped to the outside of the slot.

The adjustable support base is an added extra that makes positioning the projector an easy task. Make sure that you match up the adjustable base to the stand support BEFORE gluing the ¼" (6mm) bolts into the support. This is the only way to get the two support axles in place.
CEPHEID VARIABLE

Use a 100-150w slide projector with the slide gate enlarged to accept an iris diaphragm plate, driven by a rod and camshaft attached to a 1rpm motor. Also connected to the drive shaft of the motor is a rod that turns a color wheel in front of the projector lens. This color wheel is synchronized so that as the aperture opens the star turns from a white to a reddish-orange giant, and then shrinks back again as it closes.

This projector can also be used to simulate a NOVA or STAR EVOLUTION by replacing the colour wheel with another one of different colours.
CLOUDS

A simple but effective special effect made from a 6" (150mm) petrie dish, sprayed inside and out with flat black paint. The lid of the dish is smeared with black enamel to produce the clouds on the dome; its overlapping edge is also painted black. The lid is moved with a 1 rpm motor and the light source is a very common PR-12 lamp.

The projector should be mounted near the centre of the dome. Two projectors working together give the best results.
A multi-colored dome effect can be used to illustrate the Big Bang, a nebula or a planetary atmosphere. For best sky coverage, use two projectors positioned in the cove area 180° apart.
Dichroic 150w incandescent floodlights, simply mounted with mylar filters, provide inexpensive sources of quite pure light, which can illuminate a small planetarium. Additional lamps would be needed for a planetarium larger than 65ft (20m).

The floodlights are manufactured by General Electric (part numbers 150PAR/FLI B, G and R for blue, green and red colors respectively). They become quite hot and must be used in porcelain sockets. Some white light will leak out of the sides, so each should be enclosed in an opaque ventilated cylinder, larger in diameter than the bulb itself, so that the cylinders do not touch the hot glass. Mylar filters add to the purity of the color, if they are approximately the same color as the bulb. In fact, with proper selection of mylar filter, you can use regular white 150W incandescent floodlights instead of the much more expensive dichroic type mentioned above. The filters are glued in cardboard caps which fit loosely over the cylinders; the caps also serve as light baffles for the upper set of ventilation holes.

A number of activities relating to color perception can be done - for example,

- comparing pieces of fabric in different colored light with startling and dramatic changes in the appearance of the fabric
- investigating the properties of colored filters to show how they are used in analyzing astronomical objects, and making color images from black and white spacecraft cameras.

CAUTION! Ordinary cellophane or acetate filters will melt. Our local theater supply store carries mylar filters under the brand name “Roscolux”. The purest and best colours we found were Medium Red (Roscolux #27), Kelly Green (Roscolux #94) and Medium Blue (Roscolux #88)

See Illustration on next page
In a COLOR ORGAN, musical notes trigger circuits which automatically light colored lamps. Each circuit responds to a different tone group. Bass notes trigger one channel; high notes trigger another. Music or sound is introduced into the Color Organ through a microphone or sound source (radio, tape recorder, CD player etc) Once the sound enters the Organ, the highs, middles and lows are sorted out and used to modulate a colored light source or projector. It can also be used to translate the human voice into light and color.

Edmund Scientific offers an inexpensive 3-channel Sound to Light control (#42,309) that can handle up to 100w per channel. It is small enough to be placed on top of the control console, or mounted on a rack inside it.
COLORED RINGS

This effect supplies rings of slowly expanding shimmering colors. The color wheel is made by sandwiching large pieces of gel and black tape spirals between two discs of thin plexiglass. It is mounted in the slide plane of a projector, and motorized to turn slowly. The tube is made of cardboard, lined with heavy aluminized mylar. The angle at which the tube is mounted can be varied to change the size of the rings.
A unique Comet projector can be quickly made by bouncing a pinhole projection off a shiny ball-bearing. The pinhole should be quite small, and can be made by piercing a piece of aluminum foil with a sharp needle.

Ball Bearing

Pinhole - Slide mounted aluminum foil in a 100-300W slide projector
CONSTELLATION FIGURES

This uses a cardboard cylindrical container with a slip-on lid, that has a diameter and length of about 3½" (85mm). (An ice-cream container does well) To the bottom fix a right-angle of sheet metal about 1" (25mm) square on each flange, by bolting it through to a miniature screw base socket. To it is bolted a duplicate angle using a wing nut. The bottom flange of this second sheet metal angle is screwed to a wooden base.

Fix a piece of clear acetate over the cover opening with masking tape, and turn on the lamp in the darkened dome. Turn the stars up full, and point the projector towards the desired constellation. Dim the light as much as possible so that the stars can still be seen. With a red felt marker, sketch on to the acetate the rough outline of the constellation while looking back and forth from the dome to the lid. The red lines should be visible projected on to the dome. Once you have the rough dimensions to fit the constellation outline, transfer the drawing on to white paper, using black ink. Make a contact print using Kodalith Ortho film, and tape this to the top of the projector. The size of the projected image can be slightly changed by moving the cover in or out on the cylinder.
An effect for those planetaria with access to the space between the projection and outer domes, providing that the projection dome is perforated.

It uses the transparent cables with built-in flashing coloured lamps, such as you find everywhere at Christmas time. At Genk two have been used to accentuate the Big and Little Dippers. The hoses should be fixed about 4" (100mm) behind the perforated dome and are matched to the constellations in a pre-defined position. They can be plugged into the Sky Stepper made by Sky-Skan.

To avoid lighting up the background of insulation, trunking etc. it may be necessary to mask the "back" of the hose with tape. The intensity may be regulated by turning down the power, and the flashing speed can be adjusted with a small built-in oscillation box. The effect will be quite bright, even when the dome is lit.
This uses a 100-150w slide projector, a motorized Bubble Wheel in the slide gate, and a Colored Clouds lens. A conical light shield made out of black construction paper is placed over the Cloud lens to reduce the amount of light spread to the dome. Different colored wheels produce a variety of energy fields.
DIAPHRAGM 'GLOP' PROJECTOR

Strasenburgh Planetarium

MATERIALS:
One projector for light source directed into the mirrors
Sheet rubber 8" (200mm) diameter
Metal ring to hold it
Wood for plunger 1¼"x4" (30mmx100mm) diameter
Cardboard tube of 5¼" (130mm) diameter
Approx. 150 ¼" (6mm) mirror squares
Hurst motor with CMM wheel
½" (12mm) metal rod
Micro switch
Misc. Screws etc
DUST STORM

This can be created by painting the outside of a clear plastic dome with patches or blobs of brown and orange transparent paint. The dome is supported on a large-diameter ball-bearing from a lazy susan. A timing motor and O-ring belt are arranged to drive the bearing. Inside is mounted a 50-100w lamp.

A more elaborate way is to build an effect consisting of two contra-rotating cylinders (cardboard mailing tubes) covered with crumpled aluminum foil. Large pieces of black tape on the foil break up the reflection into cloud-like masses. The light source is a 100-150w slide projector with a color wheel rotating in front of it.

If you use a color wheel with blues and greens on it you can achieve an underwater effect.
EARTH CHORD

A clear plexiglass disc with a donut slide of the Earth glued to it. A wide-angle Buhl lens should be used to spread the image out as far as possible. The projector should be placed on the horizon of the dome just above cove.

If you substitute a round hole for the half-circle opening on the image plate, you will have an entire rotating planet instead of just a chord.
Use a Fresnel lens covered with a piece of black construction paper containing several pencil-punched holes at random points.

For domes up to 30ft. (9m), a PR-12 lamp will work quite well. For larger domes, or brighter images, substitute a GE 1424 lamp.

Place the Fresnel lens about 13" (330mm) above the light source so that a small area of concentrated light appears on the dome. By very slowly moving the Fresnel lens down toward the light source, you can obtain the effect of galaxies rushing outward from a central point until the entire dome is covered with galaxies.

By slowly moving the Fresnel lens upward, away from the light source, the effect is of a collapsing universe.

An alternative set up is to fix the lens to the open top of a box. Fasten the small lamp to the top end of a moveable cardboard tube placed inside a fixed cardboard tube, which is fixed in the centre of the box. Move the lamp toward and away from the lens, as above.
This EXPANDING FIREBALL effect uses a standard slide projector with a rotating color wheel focussed on a motorized mirror which bends the light beam up a cardboard tube, 24" (610mm) long, and 3 1/2" (90mm) diameter. Line the tube with smooth aluminized mylar and cap it with a plexiglass disc thickly spread with glue and tiny coloured gel fragments.
This gives the visual effect of being inside a raging inferno. It can be used to represent the interior of a star, or the catastrophic aftermath of a comet collision with Earth.

Materials: clear tubular lamp and lamp-socket; 10 rpm AC motor, pulley; rubber drive belt; "lazy-Susan" bearing; plywood base; transparent lens-faceted dome from "Rainbow of Light" party effect (Radio Shack #42-3018)

Cut out a plywood base, including openings for the lamp-socket and motor, and mount the lazy-Susan bearing centrally over the lamp-socket opening. The faceted dome is then glued on the bearing with a bead of silicone adhesive/sealant. Once the silicone is fully cured, mount the motor in the base with the output shaft facing up. A ½" (13mm) pulley is then mounted on the motor and a drive belt of suitable length stretched around the pulley and the clear dome. The tubular lamp (with a long, linear filament) is painted red with lamp or stained-glass paint, and mounted with the lamp-socket for a diagonal orientation inside the clear dome.

Two of these projectors, placed on opposite sides of the star projector, will cover the entire planetarium dome. Vignettes of black paper or aluminium roof-flashing (painted black) mounted on the instrument side of each will eliminate silhouettes of star projector on the dome.

Alternatives: Lamps with differently-shaped filaments and colours can generate different effects. For instance, a transparent-blue (but not tilted) bulb with looped filaments, plus slower motors, can turn the dome into a convincing underwater scene, complete with watery ripples and currents.
A brute force projector constructed around a set of four spur gears, the larger the better. Tape Kodalith transparencies of galaxies to the lids of two large coffee cans. The light source is a 605 lamp. The angle-iron support bars are either soldered or glued to the bottom of the cans.
GLOBULAR CLUSTER

Paint a transparent acrylic dome opaque flat black. Drill out star holes using the smallest possible drill bits. The base ring is formed from a piece of thin cardboard 6" (150mm) wide and approximately 24" (610mm) in length. It is rolled and taped together at the edges to form a cylinder, which is then glued to the lip of the plastic dome. Five-minute epoxy or silicon glue works best. The base is made from a piece of ¼" (6mm) plywood glued to the other end of the cylinder. There you have it - a chance to see what it's like living on the outskirts of M13!
HYDROGEN/HELIUM ATOM

This projector uses a 100-150w slide projector. Enlarge the slide gate to accommodate a rotating Kodalith mask, closely located next to a stationary Kodalith slide of the electron orbits of the atoms. The rotating slide disc is bearing-mounted at the sides and driven by a friction puck.

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FRICTION PUCK DRIVE

GLASS PLATE with SLIDES A or B MOUNTED TO IT

6-10 RPM MOTOR

3/8" CLEAR PLEXIGLASS DISC WITH SLIDE REVEALER ARTWORK GLUED TO IT.

ROLLER BEARINGS (3)

BEARING MOUNTING PLATE - 1/8" ALUMINUM

150-500 W PROJECTOR

#A - HYDROGEN ATOM (KODALITH MASTER)

#B - HELIUM ATOM

SLIDE REVEALER
IMAGE ROTATOR

Image rotation is achieved by using a dove prism. To eliminate any light spill or possible double images, include a cardboard light baffle around the edges of the prism. Since image rotation speed is twice the rotation speed of the driving motor, anything rotated with a 10 rpm motor or faster will have a very fast spin rate. For a rotating satellite, a 1 rpm motor is recommended.
The all-dome effect gives the audience the illusion of being suspended within a gas giant's atmosphere. A transparent ceiling-fan light-fixture globe is painted with stained glass paint to create belts and zones, and then rotated around a transparent 75-100w lamp. It should be positioned on or near the star projector.

The globe is glued with epoxy glue to a metal hub - a slightly dish-shaped and modified door knob works well - and fastened on to the shaft of a 1 rpm AC motor. The motor is then mounted above a plywood base via an aluminum-bar and angle-stock support. The lamp-socket mount is similarly designed, and can be quickly and easily removed for lamp changes. Stained-glass paint (available from hobby stores) creates the needed coloration and refraction as light passes through the globe; and a straight-filament lamp adds to the natural appearance of the cloud belts when the lamp is tilted over and the filament is parallel to the belts.

A semi-circular aluminum mask is mounted behind the lamp-socket to prevent light leaks from the globe's open end. A horizon-cutoff mask can be made from thin aluminum roof-flashing and attached around the plywood base's perimeter, with wood and metal parts then painted flat-black to minimize stray reflections.
This kaleidoscope consists of three pieces of glass about the size of microscope slides, two of which are aluminized with first-surface mirrors. They are assembled, along with the uncoated glass, to form a triangular tube of glass with the reflecting surface facing inward. The edges are cemented with epoxy glue.

Small objects are dropped into the box and strongly lit with a slide projector through the clear piece of glass. A projection lens placed above the box projects an enlarged image of the pattern on the dome.

See also Illustration on next page

A second modification consists of cementing the kaleidoscope through a light framework of cardboard to the paper cone of an inexpensive speaker. Power from the tape deck or phonograph drives the speaker and jiggles coloured fragments of plastic which are projected on to the dome. The small colored spheres (known to confectioners as French’s nonpareils) together with short lengths of colored plastic insulation stripped from copper wire (No.28 gauge), make an effective fragments for opaque projection.

A alternative kaleidoscope can be mounted on a transparent base, such as the 2" (50mm) cover glass of a slide mount. Mount the glass slide to a speaker cone with silicon glue. Place a piece of polarizing material over the
projection lens of the light source. Charge the kaleidoscope chamber with small crumpled wads of cellophane or other highly birefringent materials. Place another piece of polarizing material on top of the kaleidoscope projection lens. When the speaker is energized and the polarizing sheets are adjusted, the details of the projected patterns change continuously in both form and color.
KALEIDOSCOPE 2

A beautiful and fascinating DRY KALEIDOSCOPE projector can be made by inserting a motorized striped color wheel into the slide gate of a 100-150w slide projector, with a Kaleidoscope lens in place of the regular lens. By rotating the lens, three different patterns and motions may be obtained.
LASERS & GRAPHIC DESIGNS

The Laser Projection System requires two mirrors that can be rotated electronically at high frequencies (~900 Hz) and a set of oscillators to drive them. If we want stationary patterns or patterns that repeat themselves in time, the oscillators must be locked to some integer multiple of a common reference frequency and maintain a constant phase relationship.

Many two-dimensional geometric forms such as stars and looped figures can be generated by superimposing four such sinusoidal waveforms with the correct frequency, amplitude and phase relationships. The method of maintaining these relationships will be discussed later. Given a device which can supply all the necessary frequencies, amplitudes and phase shifts, it is tempting to think that twirling knobs in almost random fashion will create many patterns. This is not the case. The control settings are delicate enough to require some degree of programming.

The basic building block of our system is a phase-locked oscillator which will lock on the first 10 harmonics of a given reference frequency with zero phase error.

We used a conventional edge triggered phase lock loop design, using CMOS logic for the divide by N and phase comparator. The VCO is the constant amplitude square wave section of an EXAR 2206. The unusual marriage of linear & digital circuitry works for power supply voltages between 10 & 15 volts.

Calling the VCO frequency \( F \), a frequency \( F/N \) is applied to the phase comparator which adjusts the VCO frequency until \( F/N \) is the same as the reference frequency. The 2206 simultaneously generates sine waves of the same frequency which can be amplitude modulated with a control voltage.

Phase shift can be introduced between two such oscillators with this circuit. We generate a triangle wave with the desired reference frequency and apply it to a voltage comparator. The voltage at which the comparator switches determines the phase of the reference pulse relative to the triangle wave. Since the phase comparator is edge triggered, no complications arise from the variable duty cycle.
No special circuitry details are necessary other than those normally associated with high impedance CMOS logic. A block diagram of the apparatus is shown below. Four phase-lock oscillators are mixed in pairs to generate X and Y scanner signals. Two control oscillators are available to modulate amplitudes.

Let us now discuss some methods of obtaining graphic designs. Using just two oscillators, we start with a simple geometrical form like a straight line or an ellipse. The amplitude on each mirror is separately and rapidly changed up and down. This will create a beautiful abstract form. The persistence of the eye causes one to see an abstract form with many lines even though we are only drawing them one at a time. To create another class of patterns we use all four oscillators. The X-axis oscillators are locked to 2 and 3 times the reference frequency and the Y-axis oscillators are locked to the same harmonics with a 90° phase difference. With some adjustment of the amplitudes a five-pointed star will be created. Other patterns are obtained by changing the oscillators locked on 3F to some other harmonic. Of course there are other patterns which use different principles, but often a wealth of patterns can be obtained with only a slight variation of one or two controls.
LASER LUMIA

To make a Laser Lumia projector, make a box with an insert to hold the laser almost exactly perpendicular to twin spinning discs. One disc consists mainly of liquid cement, a JUPITERSCOPE, and some pre-popped bubbles from bubble-wrap packing material. The other disc has that plus some diffraction gratings and a piece of lamp diffuser. One disc rotates at 2 rph and the other at 6 rph. This means that the pattern repeats itself every half hour.

The biggest cost in this effect is the laser. Any rpm motor will do, but slower ones are better able to catch the more delicate and subtle patterns. The Jupiterscopes are pocket-sized holographic diffraction discs of clear flexible plastic (available from Functional Products Inc. in San Francisco).
A hand-held Lightning projector can be made using a cheap strobe (K-Mart) as the power source. Position and tape a Kodalith lightning slide over the diffusion lens of the strobe unit with black photographic tape so that no light can leak out around the slide. Mount a 100-150mm focus PC or Achromat lens on the end of a cardboard tube and attach to the strobe unit over the Kodalith slide with tape or glue. Experiment first to obtain the proper focus before cutting the tube.

Two hand-held projectors pointed randomly around the dome, can provide quite a convincing lightning storm.
This Lightning projector uses a rotating wheel made from various Kodalith slides of lightning bolts sandwiched between two pieces of ½" (3mm) plexiglass. As the disc rotates, changing lightning bolts are flashed on to the dome. With the addition of the oscillating mirror assembly in Fig. 2, the lightning bolts are randomly placed around the dome.
Copy these Kodalith Master Graphics images on to 35mm Kodalith Ortho film and mount on to a clear plastic disc.
LIGHTNING POWER SUPPLY

C1 10mfd 400volt electrolytic
C2 0.5mfd 400volt mylar
D1, D2 1 ampere, 1000volt
R1, R2 ½ watt, 2 megohm
T1 Photoflash transformer
C-ESU These capacitors are large value, high-voltage electrolytics. Be sure that their working voltage is at least 350 volts for 110 volt input. The necessary capacitance is computed with the formula \( E = \frac{1}{2} CV^2 \) where \( E \) is energy in watt seconds, \( C \) is capacitance measured in microfarads, and \( V \) is volts measured in kilovolts. Make sure that the total capacitance and voltage used do not exceed the voltage and power capabilities of the flashtube used.
K1 Relay is DPDT used to trigger strobe and disconnect charging current.

CAUTION - THE CAPACITOR VOLTAGE CAN BE LETHAL!!
LIGHTNING (DISTANT)

Use a piece of clear plastic tubing 14" (355mm), capped at both ends with pieces of flat plastic. The tube should be sanded with #120 sandpaper until it is translucent. In the middle of the tube, drill a ¾" (19mm) hole into which you can insert tightly, a 110v 7w night-light and holder, wrapped in electrical tape.

Another type of DISTANT LIGHTNING projector can be made by using a baby food jar, masked off and gelled blue in place of the plastic tubing.

Both projectors should be positioned in the cove area and controlled by momentary contact switches back on the console.
LUNAR ECLIPSE 1

The Moon can be seen moving in and out of the penumbra and umbra. The eclipse will occur wherever you wish, even if you have moved the star projector in latitude or daily motion.

The occulting disc is made out of two discs of clear plastic. The smaller disc is gelled red and mounted on a larger, semi-opaque disc used for the penumbral shadow. The occultor is mounted to the star projector in any convenient place with a thin flexible wire.

To operate, place the Moon where you want the eclipse to occur. Place the occulting device so that the moonlight will shine through it, producing the eclipse effect. Back the Moon off and you are set.

Diagram:
- TO DOME
- 1/8" - 1/4" CLEAR PLASTIC - GELLED LT. GREY
- 1/8" - 1/4" CLEAR PLASTIC - GELLED RED/ORANGE
- PIANO WIRE SUPPORT CONNECTED TO STAR PROJECTOR AT ANY CONVENIENT POINT
- FROM MACHINE'S LUNAR PROJECTOR MIRROR
A simple Lunar Eclipse projector is made from a 100-150w slide projector with an enlarged slide gate modified to accommodate a rotating disc.

The disc is made from 1/8" (3mm) clear plexiglass with two pieces of orange gel taped to it. Be careful to keep the tape on the outside edges of the coloured gel so that it will not be picked up as part of the projected shadow image. If you have extra-steady hands, thin crescent sections of light grey gel may be placed on either side of the orange umbral shadow to create a penumbral effect.
MARS - TELESCOPIC VIEW

Rotate a clear disc of glass or plexiglass in front of a slide projector containing a photograph of Mars. To create atmospheric disturbances, lightly dab Vaseline on the surface of the glass, adding or removing as needed.
A very realistic representation of a meteor shower, with randomly-spaced and timed meteors appearing at a rate close to that seen in nature.

The optical assembly is made up of a long lens (175-225mm focal length) a tube, low-voltage lamp and a light baffle. It is important to choose a lamp with a tiny filament (like a mini-Maglite) as its projected image will become the meteor. The baffle keeps scattered light off the tube’s inner walls. The lamp end of the projector tube points up toward the radiant of the shower.

Aim the projector downward into an assembly of two small mirrors, cemented back to back, and attached to the shaft of a 5-rpm AC motor. Fix a black-paper tube (not shown in diagram) to the mirror-motor mount bracket, surrounding the spinning mirrors and lower end of the projector. It should have a cut-out in one side, allowing for visible meteor motion away from the radiant only.

A 10-rpm AC motor rotates this entire assembly about the centre axis of the meteor projector, and changes meteor direction. Construct a small slip-ring-and-contact arrangement round the rotational shaft to pass current to the mirror motor. Mount projector and dual-motor assembly on a large U-shaped bracket with enough space for the mirror motor to clear as it spins round. A third motor (½-rpm) drives a cam with 8 irregularly-spaced lobes against a microswitch. This alternately activates the lamp, and the meteor-direction motor, while the mirror motor runs continuously with the effect. No dimmer is needed.
MOON ZOOM

A brute-force projector to create the illusion of a landing on the Moon. It is made from two pieces of cardboard tubing that fit one inside the other like a telescope. Both are spray-painted flat black inside and out. At the top of the outer tube, a 2"x2" (50mm x 50mm) transparency of the Moon is glued on. A PR-12 lamp is fixed by its socket inside the top of the inner tube. When the inner tube is pushed up, the lamp is kept from hitting the transparency by a stop-ring made of masking tape fixed to the outside of the smaller tube.

The bottom tube is fixed to the console and the projector is pointed towards the centre of the dome. By pushing or pulling the small tube back and forth, the Moon will zoom up and down almost filling the entire sky.
MULTIPLE IMAGES

Used for passage through Black Holes, Time warps, and various other light show effects. Many different multi-image lenses are available from any large photographic store.

The lens can be attached to the front of the projector lens with a piece of tape, or can be motorized in front of the projector lens, to bring a rotating motion into effect.
The full sky nebula uses a 100-150w slide projector with a multi-colored gelled slide in the slide gate. The motorized wheel is made from either a disc of ¼" (6mm) plywood or corrugated cardboard. Crumple the aluminum foil first before glueing it down on the disc.

The projector lens should be adjusted for best coverage, or can be removed altogether. The light pattern should scatter to all parts of the dome.
An effect produced with simple lenses and bulbs, which deliberately introduces aberrations into a projection system. This only works in a small planetarium.

Get hold of a low-current light bulb and a plastic magnifying glass with handle (in England they can be obtained at Woolworths or W.H. Smith). The over-correction produces a ring-shaped image of a pin-point bulb if the image is defocussed. Tilt the lens off the optical axis to obtain the telescopic appearance of the Ring nebula (M57).

A similar telescopic view of the Orion Nebula, with bright areas and extended wisps of gas, can be obtained by using a larger bulb where the filament is a distinct horseshoe shape between the two prongs.

A similar system can also produce a short-tailed comet.
A Nova may be quickly made by placing a 605 lamp through an enlarged hole in the dome. The brightness can be varied by a power supply located near the console.

These bulbs are so small that they go unnoticed and several can be placed at various locations around the dome. One dipped in yellow transparent paint works quite well as the Sun seen from Pluto.

A small but efficient four-lamp CONTROL BOX can be made out of 1/4 " (6mm) plywood, and five SPST switches. Attach the box to the side of the console and run a short power line from the pointer Jones plug on the console to the switches inside the box. Add another female Jones plug to one end of the control box for your pointer to plug back in to. The first SPST switch controls the pointer. By flipping the pointer off and one of the other switches on, the pot on the main control console can be used to vary the brightness of the other 605 lamps around the dome.

For a SUPERNOVA, project a Crab Nebula slide over the lamp. As you zoom up the nebula, increase brightness and turn down the bulb to illustrate the explosion of the star.

See also under CEPHEID VARIABLE.
SEASONS CHANGING

Any slide projector can be used, with a special color wheel placed behind a Kodalith nature scene. The color wheel is painted with transparent paint and mounted on a \( \frac{1}{2} \)-rpm motor; as it turns the color change indicates the seasonal changes. If the wheel is placed in front of the slide it will distort the image as it rotates.

KODALITH NATURE SCENE MASTER 2x
SHADOW PROJECTOR
Strasenburgh Planetarium

A brute force projector.

NOTE Roughening the metal drawer slider with a file or emery board will increase wheel grip.

See p.75 for Control Diagram
The UTILITY SLIDE PROJECTOR provides an inexpensive method of obtaining a set of auxiliary projectors.

It is made out of a simple wood- or sheet-metal housing. With the addition of a removable slide-holder, the projector gate becomes accessible for color wheels, image rotators, and other special effects that require the modification of a standard projector. The top metal ventilator may be found in some building supply stores. If you want to boost the lamp to 150w, be sure to include some sort of fan so you won’t end up cooking your slides.
There are occasional times when a planetarium operator-mechanic wishes for a few more Slip Rings in some part of his instrument. It is possible to double-up two circuits on one slip ring if both the circuits control only light bulbs.

Below is a typical control circuit for a bulb with variable brightness (such as a Meridian projector).

By using a new transformer and four diodes, two bulbs may be controlled separately; but only one slip ring is necessary.

NOTE: The direction of the diodes in the circuit is important, and a transformer with twice the voltage of the original is required. This circuit has been used successfully on a Nova instrument to give separate controls for the sun, moon and planet groups, where they were all on a single control originally.
SOLAR/STELLAR PROMINENCES

This LOOP PROMINENCE projector gives the appearance of large amounts of gas being exploded out from the Sun, and then falling back to the surface along a curved path.

On the concave side of 5" (125mm) watch glass, glue a 6" (150mm) square of ¼" (6mm) mirrors. (Any type of epoxy glue will do). Trim off excess mirrors. Next, glue a suction cup to the back of the watch glass with silicone glue and then screw the cup on to the motor.

Locate the mirrored watch glass with a single-slide projector in the cove just below an image of a portion of the solar disc. Use a slide with mottled yellow or red colors, such as can be found in the Edmund Psychedelic Slide Sets. Place the slide projector so that its projected light just covers all the mirror surfaces.
SOLAR WIND STREAM

This is placed near the projected image of the burning Sun - tilted at a high angle along the dome so that streams spread away from the Sun. Twisted, fluted clear plastic rods are available at most plastic suppliers. A Sawyer’s Rotodisk projector is used for the basic system and housing. The projector lens should be replaced with a cheap wide-angle single lens or an Erfle short focus eyepiece. The color wheel is brushed with transparent paint in light blue, green, purple etc. The Solar Wind Streams are taped or painted on to the square piece of plexiglass.
As an alternative to using a color wheel, place stops of red gel inside the projector lens itself. Stops A and B are located just out of focus. The closed iris in focus gives a small white sun. As the iris opens, the image becomes larger and turns into a red giant.

When setting up the throw of the eccentric cam shaft make sure that it is not greater than the throw of the iris arm.

See also CEPHEID VARIABLE
This BURNING SUN effect uses two slide projectors. One has a regular slide of the Sun. The other is an opaque projector, using a rotating aluminum foil ball (motion upwards). A Sawyer's Rotodisk projector from Edmund Scientific) can be used for this. The lens track portion is cut out and repositioned to the side.

Set both images to the horizon with the lower edge of the Sun masked off.
A series of suns, sized to match your star projector's Sun. Fit a 15w lamp inside a 4" (100mm) tube (the kind used for sending posters), sprayed black. In front of the tube attach a piece of paper to diffuse the light. To avoid getting a blotchy Sun, attach to the front of the tube an extra piece of plastic sheet thin enough to see through it when held up against the light, eg. from a shopping bag. The plastic should be sprayed or painted matt black, or dark grey. You can make three separate circuits (for spring/autumn, summer and winter) each with a dimming switch. You can even plug it into the Sky Stepper made by SkySkan. Remember that you must line up the Suns with the arcs.
UNDERWATER EFFECT

See under DUST STORM
FIRESTORM

UNVEILER PROJECTOR (DOUBLE)
Strasenburgh Planetarium

SIDE VIEW

110 VOLT SUPPLY

75
This is a simple and cheap way to have your video projectors aimed at different heights in the dome, and move them even while an image is being projected. We built three in 1990, and they have worked ever since without any problems.

A unit like this has several advantages:
1. Simplicity - it does not need counterweights
2. Size - it needs only 16"x22" (400x560mm) floor space
3. It uses a normal a.c. motor, controllable by any system
4. Reliability - there are no big forces or torques involved and no complicated parts or electronics.
5. Price - it is cheap!

The structure is steel plate 1/16" (2mm) thick, plied and welded. (This is strong enough to hold the heavy projectors, and flexible enough to absorb possible vibrations) The rotation axis is fitted with ball-bearings to make a smooth movement. The motor is a heavy duty crouzet, moving a crankshaft which pushes an arm driving the balancing tray. A directly on-shaft-mounted cam with microswitch ensures correct positioning.

The secret is to get the weight balance of the projector-tray system right, since the rotation axis will pass through its centre of gravity. The weight of the tray must be taken into consideration as part of the total weight to be balanced; and accurate calculation of the axis position in relation to the tray is fundamental to balance the system vertically.

The horizontal balance is achieved by two adjustable nuts which are also the sockets for the projector legs’ bolts.
VIDEO PROJECTION STAND (continued)

SIDE VIEW

FRONT VIEW

Rigidizing plate

Ball bearing

Rigidizer

Rigidizer

Rigidizing plate
I use a Digital Pentium DEC 60MHz PC with Autodesk 3D Studio software. I started with a 486 DX 66MHz PC which was OK - but you need as fast as PC as possible because the rendering of animations takes a lot of computing power. As well as the computer you need a video output card. I have a Matrox Illuminator Pro which has composite, S-video and RGB outputs. For good quality you need at least S-video output, but RGB or component output is better.

Silicon Graphics INDY workstation is an excellent machine for animation, and image-processing work. (UNIX machines are much more expensive, as is the software) INDY has many built-in audio and video features. In this machine I have an INDY video card which has composite and S-video in/outputs. The latter is especially good quality.

Software: Autodesk 3D Studio is a good animation software for PCs; or Softimage Creative Environment is a high-end software package for Silicon Graphics workstations. It is much more expensive than 3D Studio, but in some respects it is superior; the newest version, for example, includes a particle animation system which can simulate clouds, smoke, comet tails etc.

I make 3D animations first on hard disk using 24-bit full colour and 768x576 pixel PAL resolution. Then I record the sequences on to video tape, frame by frame. I have used a Sony EVO-9650P Hi8 PAL video cassette recorder so far, but a broadcast quality SP Betacam PAL format (Sony UVW-1800P editing recorder/player) gives better results.

With this system I can produce photo-realistic moving, zooming or rotating objects (such as planets, stars, nebulae, galaxies) by using real images of these objects and mapping them on 3D models. I can also create spaceships, rockets or UFOs and make them fly in space or against any kind of background image.

I can capture images from video tape or disc and I can use scanned (TIFF, TGA, GIF, BMP, JPEG etc) or Photo CD images. The better the original images are the better are the final animations. For Image processing I use Corel Photo Paint, Picture Publishers and Photoshop.
To make an Extendable Sample Arm for the Viking Lander, the slide holder of a TMC projector is made to hold two different slides together. Moving the slide holder through the slide gate alternately reveals each slide. When used as a single slide projector, this dual slide-holder is usually removed. The movement of the slide-holder in the gate is quite smooth, especially if lightly lubricated. With this slide gate and slide-holder, it is only necessary to motorize the slide-holder to move the slide across the projection field.

The slide-holder can be easily motorized with various pieces of scrap hardware arranged to make a cam and push-rod. The longer the push-rod is made, the smoother the movement should be. We recommend that it be at least twice as long as the cam. The motor and slide-holder should be at the same level for smooth operation.

The Viking Lander and its sample were positioned on the panorama so that the sample arm appeared to telescope from behind the lander as its slide entered the slide gate.
This is a spectacular effect for "galactic travel" sequences, and covers the whole dome when placed in the cove. It is bright even in large theatres. It uses the lamp-housing of an overhead projector and the double-Fresnel condenser from another (or Edmund Scientific #71,316) for its projection lens.

Use a special glass-drilling bit to drill a hole in the OHP’s glass platen big enough for the spindle. Then paint it black on top, and score the paint with a knife and straight-edge (ruler) to create radii. Best results are achieved by making multiple parallel scores for each radius, tilting the knife slightly on each pass, but keeping the final radius-width to less than $\frac{1}{10}$" (0.2mm).

Press very thin strips of tape on to the top of the acrylic disc as shown, and then paint the disk black. The tape can then be removed. (Alternatively, a large-format litho film of the disk pattern can be photographed and sandwiched between two unpainted disks)
The disk and spindle are mounted on the glass platen via a spindle, constructed from the shaft bushing of a used rotary potentiometer, a nylon spacer and small machine fasteners. The disk is edge-driven by a small 30-rpm 12VDC motor (Edmund Scientific #41,333) and 2"-diameter (50mm) rubber drive roller - cut from a replacement spindle for an oscillating spindle sander using a band saw. The motor and roller are coupled via an aluminum hub.

This assembly is fixed to a bent aluminum-bar pivot arm, which is drilled and coupled to a machine bolt with shaft collars above and below the arm. The bolt is mounted on to the lamp-housings' stage-frame. Tension the arm against the disk's edge with a small extension spring and two small machine screws and nuts.

The projection lens is mounted on a sheet of plywood with a centre hole cut for light passage. To mount this lens board on the projector make a triangulated support of three lengths of threaded rod and machine nuts, which are fastened to the stage-frame. Wing nuts above and below the board on each rod adjust for lens focus. Horizon cut-off is achieved with a black paper mask, which can be taped over a portion of the glass platen.
ZODIACAL LIGHT

OIL CONTAINER, TIN CAN, #C. WITH 6-VOLT #605 LAMP CENTERED ON SLOT

BASE AND TRANSFORMER

BLUE GEL FILTER