APPENDIX
ACADEMY AWARDS

Listed below are the recipients of awards given by the Academy of Motion Picture Arts and Sciences, better known as Academy Awards or Oscars. From 1937 until 1964 Oscars were awarded jointly for both special photographic effects and sound effects, after which the categories received dedicated awards. In each case awards are given to the individuals who supervised or contributed most to the effects in each film. Sadly only the film titles can be listed here. For more information about Academy Awards see page 46. Full details of Oscar winners and the recipients of Technical, Scientific and Engineering awards can be found on the Academy's own website: www.oscars.org

Winners are listed in bold, the name of the award in italic.

1929
Engineering Effects
Wings

1937
Achievement in Special Effects
Spawn of the North

1939
Achievement in Special Effects
Gone with the Wind
Only Angels Have Wings
The Private Lives of Elizabeth and Essex
The Rains Came
Topper Takes a Trip
Union Pacific
The Wizard of Oz

1940
Achievement in Special Effects
The Blue Bird
Boom Town
The Boys from Syracuse
Dr. Cyclops
Foreign Correspondent
The Invisible Man Returns
The Long Voyage Home
One Million B.C.
Rebecca
The Sea Hawk
Swiss Family Robinson
The Thief of Bagdad
Typhoon
Women in War

1941
Achievement in Special Effects
Aloma of the South Seas
Flight Command
I Wanted Wings
The Invisible Woman
The Sea Wolf
That Hamilton Woman
Topper Returns
A Yank in the R.A.F.
Dive Bomber

1942
Achievement in Special Effects
The Black Swan
Desperate Journey
Flying Tigers
Invisible Agent
Jungle Book
Mrs. Miniver
The Navy Comes Through
One of Our Aircraft Is Missing
The Pride of the Yankees
Reap the Wild Wind

1943
Achievement in Special Effects
Air Force
Bombardier
Crash Dive
The North Star
So Proudly We Hail!
Stand by for Action

1944
Achievement in Special Effects
The Adventures of Mark Twain
Days of Glory
Secret Command
Since You Went Away
The Story of Dr. Wassell
Thirty Seconds Over Tokyo
Wilson

1945
Achievement in Special Effects
Captain Eddie
Spellbound
They Were Expendable
A Thousand and One Nights
Wonder Man

1946
Achievement in Special Effects
Blithe Spirit
A Stolen Life

1947
Achievement in Special Effects
Green Dolphin Street
Unconquered

1948
Achievement in Special Effects
Deep Waters
Portrait of Jennie

1949
Achievement in Special Effects
Mighty Joe Young
Tulsa

1950
Achievement in Special Effects
Destination Moon
Samson and Delilah

1951
Achievement in Special Effects
When Worlds Collide

1952
Achievement in Special Effects
Plymouth Adventure

1953
Achievement in Special Effects
The War of the Worlds

1954
Achievement in Special Effects
Hell and High Water
Them!
20,000 Leagues Under the Sea

1955
Achievement in Special Effects
The Bridges at Toko-Ri
The Dam Busters
The Rains of Ranchipur

1956
Achievement in Special Effects
Forbidden Planet
The Ten Commandments

1957
Achievement in Special Effects
The Enemy Below
The Spirit of St. Louis

1958
Achievement in Special Effects
Tom Thumb
Torpedo Run

1959
Achievement in Special Effects
Ben-Hur
Journey to the Center of the Earth

1960
Achievement in Special Effects
The Last Voyage
The Time Machine

1961
Achievement in Special Effects
The Absent-Minded Professor
The Guns of Navarone

1962
Achievement in Special Effects
The Longest Day
Mutiny on the Bounty

1963
Achievement in Special Effects
The Birds
Cleopatra

1964
Achievement in Special Visual Effects
Mary Poppins
7 Faces of Dr. Lao

1965
Achievement in Special Visual Effects
The Greatest Story Ever Told
Thunderball

1966
Achievement in Special Visual Effects
Fantastic Voyage
Hawaii

1967
Achievement in Special Visual Effects
Doctor Dolittle
Tobruk

1968
Achievement in Special Visual Effects
Ice Station Zebra
2001: A Space Odyssey

1969
Achievement in Special Visual Effects
Krakatoa, East of Java
Marooned

1970
Achievement in Special Visual Effects
Patton
Tora! Tora! Tora!

1971
Achievement in Special Visual Effects
Bedknobs and Broomsticks
When Dinosaurs Ruled the Earth

1972
Special Achievement in Visual Effects
The Poseidon Adventure

1973
No award

1974
Special Achievement in Visual Effects
Earthquake

1975
Special Achievement in Visual Effects
The Hindenburg

1976
Special Achievement in Visual Effects
King Kong
Logan's Run

1977
Achievement in Visual Effects
Close Encounters of the Third Kind
Star Wars

1978
Special Achievement in Visual Effects
Superman

1979
Achievement in Visual Effects
Alien
The Black Hole
Moonraker
1941
Star Trek: The Motion Picture

1980
Special Achievement in Visual Effects
The Empire Strikes Back

1981
Achievement in Visual Effects
Dragonslayer
Raiders of the Lost Ark

1982
Achievement in Visual Effects
Blade Runner
E.T. the Extra-Terrestrial
Poltergeist

1983
Special Achievement in Visual Effects
Return of the Jedi

1984
Achievement in Visual Effects
Ghostbusters
Indiana Jones and the Temple of Doom
2010

1985
Achievement in Visual Effects
Cocoon
Return to Oz
Young Sherlock Holmes

1986
Achievement in Visual Effects
Aliens
Little Shop of Horrors
Poltergeist II: The Other Side

1987
Achievement in Visual Effects
Innerspace
Predator

1988
Achievement in Visual Effects
Die Hard
Who Framed Roger Rabbit
Willow

1989
Achievement in Visual Effects
The Abyss
The Adventures of Baron Munchausen
Back to the Future Part II

1990
Special Achievement in Visual Effects
Total Recall

1991
Achievement in Visual Effects
Backdraft
Hook
Terminator 2: Judgment Day

1992
Achievement in Visual Effects
Alien 3
Batman Returns
Death Becomes Her

1993
Achievement in Visual Effects
Cliffhanger
Jurassic Park
The Nightmare Before Christmas

1994
Achievement in Visual Effects
Forrest Gump
The Mask
True Lies

1995
Achievement in Visual Effects
Apollo 13
Babe

1996
Achievement in Visual Effects
Dragonheart
Independence Day
Twister

1997
Achievement in Visual Effects
The Lost World
Starship Troopers
Titanic

1998
Achievement in Visual Effects
Armageddon
Mighty Joe Young
What Dreams May Come

1999
Achievement in Visual Effects
The Matrix
Star Wars: Episode I The Phantom Menace
Stuart Little

2000
Achievement in Visual Effects
Gladiator
The Hollow Man
The Perfect Storm

2001
Achievement in Visual Effects
Artificial Intelligence: AI
The Lord of the Rings: The Fellowship of the Ring
Pearl Harbor

2002
Achievement in Visual Effects
The Lord of the Rings: The Two Towers
Spider-Man
Star Wars: Episode II Attack of the Clones

2003
Achievement in Visual Effects
The Lord of the Rings: The Return of the King
Master and Commander: The Far Side of the World
Pirates of the Caribbean: The Curse of the Black Pearl

2004
Achievement in Visual Effects
Harry Potter and the Prisoner of Azkaban
I, Robot
Spider-Man 2

2005
Achievement in Visual Effects
Chronicles of Narnia: The Lion, the Witch and the Wardrobe
King Kong
War of the Worlds

GLOSSARY

ADDITIVE PROCESS
A method of creating colour pictures by combining two or three images, each of which contains one of the three primary colours (red, green and blue). Red, green and blue light will produce white light when mixed equally and can be combined in different quantities to produce any colour in the spectrum.

ALGORITHM
A set of instructions written in a computer language which instructs the computer to perform a specific task.

ALIASING
A phenomenon present in digital images when the number or size of pixels used to describe an image are insufficient to create enough subtlety or detail, with the result that edges of objects can appear jagged. Anti-aliasing algorithms used during rendering help to identify and reduce the effect of aliasing.

ALPHA CHANNEL
When a computer-generated object or scene is rendered the result is a 2-D image in which each pixel is represented by four values. Three of these values describe the amounts of red, green and blue that combine to produce the pixel's final colour. The fourth value represents how transparent the pixel is. This is known as the 'alpha channel'. When one computer-generated image is combined with another during compositing, the alpha channel is therefore used to define how objects will look when layered on top of one another. In the case of animated scenes, the alpha channel is a form of built-in travelling matte.

AMBIENT LIGHT
A constant level of light that falls on CG objects no matter what lighting effects are in the scene.

AMBIENT OCCLUSION
Each point on the surface of a computer-generated object fires beams out in all directions in order to discover if any other objects in the scene will prevent light from reaching that point of the surface. Ambient occlusion is calculated as a separate pass during rendering and the result is a model whose surface has a certain amount of shadow 'built in'.

ANALOGUE
Used to describe any method of recording or transmitting sounds, images or data by creating and storing modulations such as size, width or density that are directly analogous to the subject in question.

ANAMORPHIC LENS
A lens that horizontally squeezes images during filming so that a disproportionately wide picture can be recorded on the almost square frame of standard 35 mm film. During projection, a second anamorphic lens is used to unsqueeze the image to its normal proportions.

ANIMATIC *see* **PRE-VISUALIZATION**

ANIMATION
The process of creating the illusion of movement in either models, puppets, pictures, artwork or computer-generated objects by causing them to move incrementally from one image to the next. When the resultant images are viewed at the normal speed of 24 frames per second (for normal 35 mm film), the subject appears to move independently.

ANIMATION CAMERA
Camera capable of photographing a single frame at a time, which points down at a flat table where artwork is arranged. Also called animation stand, rostrum camera or down-shooter.

ANIMATRONIC
Any remotely controlled system that uses pneumatics, hydraulics, cables, rods, or motors to produce lifelike performances from puppets or models.

ANISOTROPIC SHADING
A method of shading CG objects that have many small grooves in their surface. Used for materials such as straight hair and brushed metals. A good example of this type of shading is the reflected highlights seen on the surface of a CD.

APERTURE
An opening through which light passes on its way to or from the film. In a camera, the aperture regulates how much light passes through the lens and is controlled by an adjustable hole called a 'diaphragm' or 'iris'. The amount of light is measured in 'f-stops' or 't-stops'. In a projector, the aperture is a changeable mask that determines the aspect ratio of the image being projected.

ARMATURE
The underlying framework or skeleton of a model or puppet. Armatures are extremely tough and carefully engineered to withstand the rigours of filming.

ASPECT RATIO
The relative width and height of an image when viewed on a cinema screen or television. Aspect ratios are measured in terms of width against height. A standard frame of 35 mm film has an aspect ratio of 1.33:1, which is known as 'Academy ratio' and is the same as with a traditional television screen. 35 mm cinema images are typically projected in one of two standard ratios: 1.85:1 ratio is usually produced by masking off the top and bottom of a normal 1.33:1 image during printing or projection. 2.35:1 is a much wider image that is the result of using anamorphic lenses to 'squeeze' a wide image onto a standard-sized piece of film and then decompressing it during projection. 70 mm films are normally projected with an aspect ratio of 2.2:1.

ATMOSPHERIC EFFECTS
Physically produced effects that alter the quality of atmosphere in a studio or on location. These include smoke, rain and snow.

AUTOMATED DIALOGUE REPLACEMENT (ADR)
The replacement of dialogue originally spoken and recorded during filming with new dialogue recorded at a later date. Also called dubbing or looping.

BALD CAP
A rubber cap stretched over a performer's head to create the illusion of baldness, or ensure that a wig fits snugly.

BALL-AND-SOCKET JOINTS
Small joints used in the construction of the armatures used for animation puppets. A ball on the end of one limb is fitted into a precisely fitting socket on the adjoining limb. The joint is loose enough to allow the easy manipulation of a puppet but tight enough to ensure that the puppet keeps its shape when posed.

BEAM SPLITTER
An optical device such as a prism or two-way, half-silvered mirror that divides and redirects the light that hits it. A single image projected into a beam splitter will be equally divided and exit as two identical images of the same scene. The device can work in reverse so that two separate images entering the beam splitter exit as a single beam of light. Used extensively in the creation of optical visual effects.

BEAUTY PASS *see* **PASS**

BI-PACK
Some optical effects shots required two separate films to be run through a camera simultaneously. Each reel of film was usually held in a separate magazine, but the two strips were sandwiched together or 'bi-packed' when they ran through the gate where they were exposed to light.

BITMAP
A file that describes a 2-D digital image. The information in a bitmap includes the number of horizontal and vertical pixels that make up an image, the number of bits per pixel, and the colour of each pixel.

BLACK POWDER
A fast-burning material that comes in grades ranging from a fine powder to small chunks and is the basis of most pyrotechnic explosions and fireworks.

BLUE SCREEN
A screen of a carefully balanced blue colour which is placed behind performers or objects during filming to allow the optical or digital creation of travelling mattes. Today's digital matting processes can produce a matte from a surface painted blue, green or any other consistent colour.

BLUE-SCREEN PROCESS
An optical process by which subjects filmed in front of a blue screen were combined with a separately filmed background. There were two basic systems, the blue-screen colour separation process and the superior blue-screen colour difference process. Now replaced by digital alternatives.

BLUE OR GREEN SPILL
Any blue or green light that is reflected onto the subject, and hence into the camera, during the filming of blue- or green-screen footage. If not corrected, these areas may become transparent during compositing.

BOOLEAN OPERATION
A method of creating a 3-D digital model by performing an addition, subtraction, union or intersection between two or more 3-D objects.

BREAKAWAY EFFECTS
Props designed to break easily and safely during the filming of action sequences. These include chairs made from lightweight balsa wood, which can be smashed over heads, and windows for stuntmen to jump through.

BUMP MAP *see* **TEXTURE MAPPING**

CABLE CONTROL
The remote-controlled operation of puppets or models via cables that are pushed and pulled either by hand or by small motors.

CAD (COMPUTER-AIDED DESIGN)
Specialized engineering or design software used in the planning and construction of models, props, sets, lighting set-ups and complex special effects equipment.

CAMERA MAPPING
A digital texturing technique by which a 2-D image is projected into a scene from the position of the virtual camera being used to view the scene. If simple 3-D objects are placed within the scene so that they line up with the 2-D image, the impression of fully textured 3-D objects will be created. Used to produce 3-D (or '$2^1/_2$-D') moves on 2-D digital matte paintings.

CANNON CAR
A specially modified vehicle which uses a pyrotechnic or pneumatic cannon to fire a projectile from its base in order either to propel it forwards or turn it over.

CARTESIAN COORDINATES
Named after the French mathematician and philosopher René Descartes (1596–1650), the coordinates that locate any point in space relative to at least two perpendicular axes. A point in 2-D space is defined by its X and Y coordinates, while a point in 3-D space also has a Z or depth coordinate.

CATHODE-RAY TUBE (CRT)
The component in a traditional television or computer monitor that enables an image to be displayed on its screen. Streams of electrons emitted by a cathode inside a vacuum bombard a phosphorous screen causing it to glow. Electromagnets are used to deflect the electrons so that they hit the correct part of the screen in order to form an image.

CCD (CHARGE-COUPLED DEVICE)
An electronic chip used in video cameras and film scanners to convert images into digital or analogue signals. Small light-sensitive cels (photosites) on the surface of the chip convert the light that hits them into an electrical charge proportional to the quality of the light. This electrical charge is either recorded as an analogue signal, or is converted and stored as a digital signal in the form of a series of binary digits.

CEL ANIMATION
The traditional method of creating hand-drawn 2-D 'cartoon' animation. Each changing frame of movement is drawn and painted on a clear cel (made from cellulose acetate). This cel is placed on top of a painted background before being photographed. Twenty-four cels are needed per second of action and there are some 130,000 in a typical animated feature.

CGI
Computer-generated imagery (or computer graphic images). Any 2-D or 3-D images created entirely within a computer. Often abbreviated as 'CGI' or 'CG'.

CINEMATOGRAPHER
The cinematographer designs the overall look of a film by choosing the type of camera, film, lenses, lighting, filters, and other equipment used during filming. He or she will work closely with the visual effects supervisor to ensure that effects shots conform to the overall style. Also called director of photography (DOP or DP) or lighting cameraman.

CLOUD TANK
A glass tank filled with saline solutions of various densities and used to film billowing cloud and smoke formations.

COLOUR SEPARATIONS
By copying a colour image onto black-and-white film through red, green and blue filters, it can be broken down into three black-and-white positive records of the red, green and blue content of the scene. These black-and-white records (called colour separation masters) can be successively printed back onto normal colour film stock through the same colour filters to produce another colour image. Colour separations were used in the creation of optical travelling mattes, to control colour balance during optical compositing, and are used as a method of archiving important films in a black-and-white format so that their colour detail will not fade over time.

COMPOSITE
Any image that is made up from a combination of two or more elements filmed at different times or places. Compositing, the process of combining these various images, can be done in camera, in an optical printer, or now almost exclusively using a computer. Also known as a composit.

CONTACT PRINTING
The copying of images from one exposed and developed piece of film onto raw stock by sandwiching the two together and shining light through them.

CYBERSCAN
A method of transcribing a real object into a digital model by accurately measuring its features with a laser.

DAILIES
The previous day's filming that has been developed and printed overnight. At the beginning of each working day, director and key crew members assemble to watch the 'dailies' or 'rushes'. Productions shot digitally have no need for dailies as footage can be reviewed as soon as it has been shot.

DENTAL ALGINATE
A quick-setting plaster made from seaweed extracts used to make life casts of faces and body parts for make-up purposes.

DEPTH OF FIELD
The distance in front of the camera over which objects appear to be acceptably in focus. When objects both near and far from the camera are in sharp focus, a shot is said to have a 'deep' depth of field. When objects near the camera are in focus but those just a few feet behind them are out of focus, a shot is said to have a 'short' (or 'narrow' or 'shallow') depth of field. Depth of field is affected by the focal length and aperture of the lens on the camera, the amount of light in a scene, the shutter speed of the camera, and the speed rating of film being used.

DEPTH PERCEPTION
The illusion of distance in shots of models or miniatures. Depth perception is artificially created by filling the set with a fine smoke, stretching large sheets of fine cloth or bridal veil between planes, or painting distant objects in dull colours.

DEVELOPING
The laboratory process during which chemicals are used to make visible the latent image on an exposed piece of film. Also called processing.

DIFFERENCE MATTE
A digital method of creating a matte by comparing two almost identical images. Changes detected in the second image, such as the movement of an object, can be used to create a matte to remove the object from the scene.

DIFFUSE INTERREFLECTION
A CG rendering process whereby light bounces from one object and then strikes other objects in the surrounding area, thus illuminating them with the reflected light. Light is reflected from non-shiny, diffuse surfaces such as the ground, walls or objects, to illuminate areas that are not necessarily in direct view of a light source. If the diffuse surface is coloured, its reflected light is also coloured, resulting in similar colouration of surrounding objects. Diffuse interreflection is an important component of global illumination (see below).

DIFFUSE REFLECTION
Light hitting a textured CG surface that is reflected at a number of differing angles. It is the complement to specular reflection (see below). An example of the difference between specular and diffuse reflection can be seen in surfaces painted with either matt or glossy paints. Surfaces painted with matt paint have a higher amount of diffuse reflection, making them look evenly lit, while those in gloss have a higher amount of specular reflection, making them look shinier.

DIGITAL
Used to describe methods of recording, storing and transmitting images, sounds and data through the conversion of analogue information into binary numbers (combinations of ones and zeros). Digital information can be copied and transmitted repeatedly with no loss of detail, making it ideal for visual effects production where images need to be copied and combined many times.

DIGITAL BACKLOT
3-D computer models used to replace or extend real film sets, reducing the time and money spent in physically constructing major sets. An extension of the art of matte painting.

DIGITAL CINEMA
The creation and distribution of movies by entirely digital means. Productions are filmed using high-definition video, edited and finished digitally and then displayed in theatres using a digital projector.

DIGITAL INTERMEDIATE
The digital post-production of a movie during which all processes once achieved optically are handled by a computer. Movies shot on film have their negatives scanned at a high resolution to create digital data that can be edited, colour-corrected and integrated with visual effects. The finished movie can be digitally projected, recorded back onto film for distribution to theatres, or mastered to DVD for home video release.

DIGITAL MATTE PAINTING
The extension, manipulation and improvement of filmed images using 2-D digital paint methods to create objects, buildings and locations that do not exist. Increasingly involves the creation and integration of 3-D objects and environments as well as animation and other effects.

DIGITAL PAINT
The digital equivalent of paint and brushes. Digital paint may be used to touch up individual frames of film, create texture maps for digital models, or paint entire scenes for digital matte paintings. As well as painting with colours, artists can paint with 'textures' that have been sampled from real photographs or paintings. The most widely used digital paint software is Adobe Photoshop.

DIGITIZE
To convert the characteristics of any object, sound, image or analogue recording into digital information so that it can be used or manipulated by a computer.

DISPLACEMENT ANIMATION
A method of animation in which parts of a model are physically moved between the photography of each frame. This differs from replacement animation in which the model is substituted with a new one in a different pose.

DISPLACEMENT MAP *see* **TEXTURE MAPPING**

DISSOLVE
Scene-changing technique in which one image slowly fades out as the new image fades in. Dissolves are normally used as a narrative device to indicate the passing of time between scenes.

DOLLY
The moving platform on which camera and camera crew are pushed around to create a moving camera or 'dolly' shot. The platform is usually mounted on tracks that are laid on the ground to ensure smooth movement.

DOUBLE EXPOSURE
Two overlaid images on a piece of film caused by running the film through a camera twice. The technique can be used to create in-camera dissolves or the appearance of transparent ghosts.

DUBBING
The process of laying down new dialogue and sound effects onto filmed images. The term is also commonly used to describe the copying of sound and images from one videotape to another.

DUNNING-POMEROY PROCESS
The first method to use the principles of coloured light to create travelling mattes on black-and-white film. The technique bi-packed an orange-dyed positive of the required background image on top of raw stock inside the camera. In the studio, an actor lit with orange light performed in front of a blue screen. The image of the actor passed through the orange-dyed background image film in the camera to be recorded on the new film, while the blue light had the effect of printing the orange background image into the areas around the actor.

DYNAMATION
The name given by Ray Harryhausen and producer Charles Schneer to their split-screen method of combining stop-motion animation with rear-projected live action in *The 7th Voyage of Sinbad* (1958). For later Harryhausen films the same basic technique was variously renamed as 'Superdynamation' and 'Dynarama', while non-Harryhausen animated films hailed similar effects as 'Regiscope', 'Fantamation' and 'Fantascope', among others.

DYNAMICS
Methods that create movement in computer-generated objects by applying a set of predefined rules (an algorithm). An example is the movement of digital fur on a CG creature's body. This could be key-frame animated by manually moving 'guide hairs' which affect the movement of all surrounding hairs, or by programming the hair to react 'dynamically' in response to the animated movement of the body to which it is attached and the movement of neighbouring hairs. Most fur movement is created with a combination of manual and dynamic methods. Also commonly used to produce the movement of fluids and particulate masses such as dust clouds.

EDGE DETECTION
Traditionally, complex objects that moved in a 3-D fashion in animated feature films had to be painstakingly drawn, frame by frame, by artists skilled at portraying changing perspective. Today, complex objects are first created as 3-D computer models and then animated to produce the desired movement. Edge detection software then analyses the image in each frame and produces a series of 2-D black-and-white outline cels as if drawn by hand. These are then coloured and integrated into the traditionally animated elements.

EFFECTS ANIMATION
In 2-D animated feature films, the animation of any form of complex moving object or substance other than the characters. Includes moving water, falling leaves, fire, smoke, clouds and shadows. In live-action feature films, effects animation is drawn, painted and composited optically and now digitally, to create lightning, the muzzle flash on guns, sparks and smoke.

ELEMENTS
Images assembled during compositing in order to create a finished shot. A typical visual effects shot may contain digitally created elements such as animated characters or matte paintings, as well as filmed elements such as live action or miniatures. Many elements are created solely to help the major components of a scene merge together more realistically. For example, a movie containing CG dinosaurs might need mud, dust and water splashes added when each foot touches the ground, showers of bark and leaves when the creatures smash through forests, and puffs of vapour that will be added to mouths when the weather is supposed to be cold. A separate unit will often film these separate elements to create a library for use during compositing.

EMULSION
The layer of photochemically sensitive gelatin mixture that coats a strip of clear flexible material to create photographic film. Colour film has three layers of emulsion, each being sensitive to one of the three primary colours.

ESTABLISHING SHOT
The first image in a sequence which is used to establish a location, time and mood before cutting to close-ups of the main action. Matte paintings are commonly used to create establishing shots of fictitious locations.

EXPOSURE
The act of directing light onto a piece of undeveloped film in order to record an image. When film receives too much light it is said to be 'overexposed'. When too little light makes an image too dark it is 'underexposed'.

EXTRUSION
A digital modelling method by which a 2-D template of an object's cross-section is first drawn before being extended to the desired depth to produce a 3-D model. An extruded circle creates a cylinder, for example.

FADE
A technique by which an image gradually changes from a normally exposed picture into a solid colour – normally black – as a scene transition. A fade-out is where the picture turns black, while a fade-in is where the picture emerges from black.

FILM FORMAT
The type of film used for a project, either in terms of the physical width of the film as measured in millimetres (e.g. 35 mm or 70 mm), or by trade name (e.g. IMAX or VistaVision).

FILM RECORDER
A device used to record digital images from a computer onto the analogue medium of film. CRT film recorders use a camera to film the images from a high-quality computer monitor, while the now more common laser recorders shine a beam of coloured light directly onto a piece of film.

FILM SCANNER
A device that converts the analogue information held on film into digital information for manipulation within a computer. Light is shone through a frame of exposed and developed film and onto a CCD chip, converting the image into electrical signals which are recorded as digital information.

FILM SPEED
The 'speed' of photographic film refers to the sensitivity of its emulsion to light. 'Fast' film needs little light to record a correctly exposed image while 'slow' films need much more. Film speed is measured in terms of an exposure index, which is stated by film manufacturers and measured by a number of international standards.

FILTER
Any material such as glass or gauze that affects the quality of light passed through it. Filters can be attached to camera lenses, over lights, or within optical printers. In the digital world, filters are algorithms that are applied to digital images in order to affect the characteristics of groups of pixels, for instance by making them blurred or warped.

FLUID DYNAMICS
The study of how particulate matter and fluids flow under different circumstances. Such characteristics can be reduced to a number of mathematical rules, or algorithms, that may be used to create realistic computer-generated water and smoke.

FOLEY
The recording of synchronized sound effects to match silent images. Most noises heard in a film are created during a Foley session rather than being recorded during original filming. The process is sometimes called 'Foley walking' or 'footsteps' since a large part of the job involves reproducing the sound of walking. Named after Jack Foley (1891–1967; <345).

FORCED PERSPECTIVE
A false illusion of depth or size created during the

construction of models or sets by artificially shortening the distance over which objects would naturally appear to change in size. This means that exceptionally large-looking sets can be built in much smaller spaces and for less money than would otherwise be the case. Sets with dramatic forced perspective are sometimes peopled with tall people in the foreground and small people in the distance, as in the case of the engine room set of the *Enterprise* in *Star Trek: The Motion Picture* (1979).

FRAME RATE
The number of frames of film that are exposed per second during filming. Normal 35 mm motion picture photography is filmed and projected at 24 frames per second (fps).

FRONT PROJECTION
An optical method of simultaneously filming performers in a studio and pre-filmed background images which were projected onto a highly reflective backdrop from the front. The projector and camera were positioned at 90° to one another, yet were able to share the same optical path due to the positioning of a beam-splitting mirror at an angle of 45° between them. The method was also used to combine live action and matte paintings.

F-STOP
The amount of light that travels through the lens of a camera is controlled by opening and closing a diaphragm or iris. Each successive opening of a diaphragm lets in twice as much light as the last and is called an f-stop or just 'stop'. F-stop numbers range from f1, which allows all the light entering a lens to reach the film, to f32, where almost all the light entering the lens is blocked from the film. T-stops, sometimes confused with f-stops, are an electronic calculation of the actual amount of light that reaches the film plane.

GATE
The place behind the lens of a camera or projector where a frame of film stops momentarily to be exposed to light or, in the case of the projector, to be projected onto a screen.

GENERATION
Each time a filmed image is copied it is one generation on from the original negative. Since image quality is lost with each subsequent generation, film-makers try to ensure that images seen in the cinema are of a generation as close to the original negative as possible. Digital processes have removed the problems of generational loss since each subsequent copy of a digitized image (or sound) retains all the original information.

GEOMETRY
The geometric 'wire mesh' that forms the underlying structure of most computer-generated objects.

GLASS SHOT
A method of integrating painted image with live action by painting the desired additions to a scene onto a sheet of glass positioned in front of the camera. The camera films a combination of the image on the glass and the background scenery seen through the glass.

GLOBAL ILLUMINATION
A rendering method used to produce photorealistic CG images. Global illumination algorithms simulate the way that light energy is exchanged between all objects in a scene by taking into account both direct illumination (the light which has taken a path directly from a light source) and indirect illumination (the light that has undergone reflection from other surrounding surfaces).

GO-MOTION
A sophisticated variation of stop-motion animation in which the puppet is pre-programmed to perform each incremental move while the shutter of the camera is open. The result is an animated character that moves with lifelike motion blur.

GRAIN
The emulsion on photographic film is made of tiny grains of silver halide suspended in gelatin. The larger the size of these grains, the more sensitive the film is to light, but the more 'grainy' the image appears when projected. Grain can clump together in the emulsion of a film, becoming quite visible on a cinema screen. Grain becomes more noticeable the further away each generation is from the original negative.

GRAIN MANAGEMENT
Shots created by digitally compositing numerous images from different sources will need to have the grain (see above) in each element carefully managed. This may mean trying to suppress the appearance of grain in some filmed elements, or adding grain to digitally created elements which inherently contain no grain. The aim is to create multi-layered composite shots in which the final appearance of the grain matches that of the ordinary shots in the rest of the movie.

GRAPHICS TABLET
A sensitive desktop device which can be used by computer operators to draw using a special pen. Anything drawn on the tablet will simultaneously appear on the computer monitor. The graphics pen can also be used like a paintbrush – the amount of digital paint applied varies with the pressure applied by the pen. A graphics tablet can also be used like a mouse to give instructions to a computer.

HDRI (HIGH DYNAMIC RANGE IMAGES)
Photographs that capture a full range of exposure detail in both the lightest and darkest areas of the image. Created by combining over-, under- and correctly exposed images of a scene, often photographed in a highly reflective sphere. These are used as a light source when lighting CG objects that are to be composited into real-world environments.

HIERARCHY
A chain of interdependent elements in any jointed digital model – typically a limb of a computer-generated character's body. The position of an object in a hierarchical chain affects the way that it reacts when the objects to which it is linked are moved during animation, and how those other objects react when it is moved.

HIGH-CONTRAST FILM
A variety of black-and-white film that only records extreme contrasts of tone – converting most tones and colours into either black or white. Used in the production of optical mattes and titles.

HIGH-CONTRAST MATTES
A method of producing optical mattes that relied on the subject being separated from its background by extreme differences of contrast. Typically, a model spacecraft might be filmed by a motion-control camera in two passes. In the first pass, the model was lit perfectly (the 'beauty pass') but no light was allowed to fall on the backdrop, which remained dark. In the second pass, no light was allowed to fall on the model but the backdrop was lit brightly – making it a stark white. The model became a black silhouette against the white backdrop and, when filmed with high-contrast black-and-white film, was used to produce male and female mattes.

HIGH-DEFINITION VIDEO
High-definition (HD) video generally refers to any video system of higher resolution than standard-definition (SD) formats such as the NTSC and PAL systems normally used for broadcast and home video. The increased quality of images produced by HD video results from the additional number of horizontal lines used to record an image (e.g. 1080 as opposed to the 525 or 625 used by NTSC or PAL) and the methods used to process, compress and store image information.

HIGH-SPEED PHOTOGRAPHY
Filming at higher than normal frame rates will result in 'slow motion' images when the film is projected at the normal rate of 24 frames per second. High-speed photography is often used to create a sense of scale when filming miniature effects such as models, smoke or water. While most miniature photography is achieved at two to four times normal speed, some shots involve filming several thousand frames per second using highly engineered cameras made by the Photosonics corporation.

IMAGE-BASED LIGHTING
The use of photographs of real-world locations to generate the lighting used to illuminate CG scenes and objects. See HDRI.

IMAGE-BASED MODELLING
The creation of 3-D CG models by cross-referencing 2-D images of an object that has been photographed from several different angles.

IMAX
A large-format film process which uses 65 mm film horizontally, resulting in a frame that is three times larger than that in normal 65 mm photography and ten times the size of the frame in standard 35 mm photography. As a result, the image quality is superb and can be projected onto an enormous screen.

IN-BETWEENER
During the drawing of traditional 2-D animation, a lead animator draws only the key poses of a character in each scene – perhaps two or three key frames for every second of action. In-betweeners draw the stages of action between these frames.

IN-CAMERA EFFECT
Any visual effect that is achieved during filming without having to manipulate the film after processing. In-camera effects can include fast and slow motion, fades, dissolves, split-screen effects, glass shots and hanging miniatures. Though they can give superior results because they are achieved on the original negative, such effects are generally avoided since they risk damaging the original negative image. Now largely redundant due to digital processes.

INTERLACING *see* **PROGRESSIVE SCAN**

INTROVISION
An intricate variation of front projection which effectively enabled the 2-D projected background image to be split into various planes. Performers could be made to appear as if they were actually acting within the environment of the projected image.

INVERSE KINEMATICS
A method of digital character animation by which only the end joints or limbs in a hierarchical skeleton are moved to the desired position. The way that the rest of the body moves in response is calculated automatically by the computer according to pre-set rules.

KEY FRAME
In traditional 2-D animation, the most important images are drawn by lead animators to indicate the major changes in character movement. (Less experienced animators complete the in-between frames.) In computer animation key frames are still used, with the animator setting the position of any object every few frames, and the computer calculating the transitions in between (interpolating). Key-framing is the most common method of controlling all aspects of a computer-generated scene and is used to control lights, cameras and other aspects of the virtual environment.

KEYING
The digital process of selectively laying one image on top of another involves producing a matte or 'key' that is derived from some quality of the image to be overlaid. A 'key' can be 'pulled' from a number of attributes in an image including its luminance (luma-keying), and its chrominance (chroma-keying).

KICKER PLATE
A pneumatically operated springboard used to fling stunt performers or objects into the air when filming action sequences.

LATENT IMAGE
The invisible image that lies dormant on a piece of film after it has been exposed to light and before it has been developed. Some optical visual effects processes involved keeping an exposed but undeveloped piece of film in the camera, or in storage, before re-exposing it to other elements, for instance a matte painting, at a later stage. Such methods are called 'latent image' or 'held take' processes.

LATEX RUBBER
A liquid produced from the sap of the rubber tree. When combined with fungicides and other chemicals, it is used to create various densities of solid rubber including the foam rubber for prosthetic make-up and animatronics.

LATHING
A digital modelling method by which a basic 2-D shape is rotated about an axis to create a 3-D object with the same profile. A circle lathed around a nearby axis would create a torus (doughnut shape), for example.

LIFE CAST
A mould bearing the exact features of a performer, used for the creation of prosthetic make-up and costumes to ensure a perfect fit. The process usually involves covering the performer's body and face in quick-drying plaster to produce a negative mould from which a positive cast can be taken. Instead of the traditional method of producing a life cast, which can be unnerving for the subject, a cyberscan (see above) can now be used to create an accurate replica of a performer's features in a computerized milling process.

LOCKED-OFF CAMERA
A camera which has been rigidly secured to ensure that it will not move or shake during filming.

LOFTING
A digital modelling technique in which a number of differing 2-D shapes are arranged along a path (a spline) and then linked together to create an object with a changing profile.

LYDECKER TECHNIQUE
A method of suspending and flying models from tensioned wires. Perfected by brothers Howard and Theodore Lydecker in the 1930s (<145).

MAGAZINE
The detachable light-proof compartment which holds the film for a movie camera. Magazines generally have two chambers, one containing a reel of unexposed film, the other a take-up chamber which receives the film after it has been exposed in the camera.

MAPPING
The fitting of 2-D textures and images to the surface of a 3-D object in order to create natural-looking CG models.

MASSIVE
Artificial intelligence software used to control the complex movement of thousands of CG objects. Originally written by Stephen Regelous to create the battle scenes for *The Fellowship of the Ring* (2001) but now available commercially.

MATCH MOVING
When computer-generated elements need to be placed into a live-action scene that has been filmed with a moving camera, the CG elements must be

'filmed' with an identical camera move so that they can be merged realistically with the live action during compositing. Match moving is the process of matching the movements of the computer's virtual camera to those of the live-action camera. Also known as 3-D camera tracking.

MATTE
Any form of mask that prevents light from reaching and exposing areas of film. The area of film left unexposed is usually filled with an image from another source at a later stage. Mattes always exist in two complementary parts: one matte allows exposure on one part of the film and prevents it in another, while a counter-matte covers the already exposed area and allows the rest of the frame to receive a different image. A matte and its counter-matte are often referred to as a male and female matte. Today, mattes are produced digitally using a number of processes.

MATTE BOX
A slotted frame that is attached to the front of a camera in which metal or cardboard mattes can be inserted to prevent the film's exposure to parts of an image.

MATTE LINE
The place in a composite image where two separately created elements meet. When the combination of elements is not entirely successful, a discernible black line may be visible between them. With optical printing, matte lines were virtually impossible to avoid completely but the precision of digital compositing techniques means that matte lines are generally a thing of the past.

MATTE PAINTING
A painting, usually of a location, which is combined with live-action footage, animation or models to produce a realistic composite image. Paintings were traditionally done on large sheets of glass and combined with other images through a variety of optical processes, such as rear or front projection. Matte paintings are now usually painted directly within a computer before being digitally combined with live-action and animated elements.

MESH
The vertices, segments and polygons which collectively create the structure, or geometry, of a digital model.

MINIATURE
Any object or location that is reproduced at a smaller scale for filming purposes.

MODEL
Any object or location that has been reproduced for filming purposes. Models are not necessarily smaller than the real thing – they may be the same size or, when actors need to look small by comparison, larger than the real object. Though models are usually perfect re-creations of the exterior of an object, they are often dummies that lack interior details such as motors or mechanisms.

MORPHING
The process by which one image appears to transform seamlessly into another. Digital morphing can merge one 2-D image into another, or change one 3-D model into another. Morph sequences often involve a series of objects that will be transformed into one another over a set period of time. Each object in the sequence is called a 'morph target' or 'blend target'. Often used in action sequences to transition between a real or computer-generated stunt performer and the star of the film in time for a close-up.

MORTAR
A pipe, funnel or dish used to control the characteristics of pyrotechnic explosions.

MOTION BLUR
The blurring that occurs if an object moves when the shutter is open during photography. Though it is actually a technical shortcoming, motion blur helps moving images to look more natural to the human eye by preventing the strobing that would occur if objects moved from frame to frame without blur.

MOTION CAPTURE
Methods of capturing the natural movement of bodies or faces so that it can be used for the animation of computer-generated characters. Often called 'mo-cap'.

MOTION CONTROL
A method of recording or programming the movements of a film camera so that a shot can be achieved exactly as required, and repeated whenever necessary. Particularly useful for filming a number of different elements in separate takes or 'passes' so that they can be effectively combined at a later date.

MULTIPLANE EFFECTS
Naturalistic changes in focus and perspective in 2-D animation achieved by arranging artwork in a number of layers or 'planes' in front of the camera. Such effects were first successfully used after the construction of Disney's multiplane camera in 1937, and are now achieved by arranging layers of artwork in a computer.

NEGATIVE
When an image has been photographed and the film from the camera developed, the result is normally a negative image – in the case of black-and-white photography the dark and light areas are reversed, while in colour photography dark and light are reversed and the colours are 'complementary' to the original. When copied or 'printed' onto print film, the negative image is reversed into a normal positive image.

NODAL HEAD
A special tripod head that tilts or pans a camera around the nodal point of a lens so that the view of a scene changes but the perspective from which it is seen does not.

NODE
A point at which any decision is made during the creation of procedural computer-generated animation. For example, when a procedurally animated character reaches a chasm they could decide either to jump, fall, or turn around. This decisional 'node' is written into the character's set of operating rules and the final choice will be made by referencing all available information and options.

NOISE
A random signal generated by the computer that can be used for a number of digital imaging purposes. Noise added to a texture map will add a more mottled appearance and a naturalistic appearance of randomness. Noise added to any form of animation, such as the movement of a virtual camera or the motion of a character, can also help to modify the smooth performance sometimes produced by automation.

NURBS (NON-UNIFORM RATIONAL B-SPLINE)
A digital modelling technique which generates model surfaces as a number of separate square patches, each of which is influenced by a set of continuous curves (or splines).

OPACITY MAP *see* **TEXTURE MAPPING**

OPTICAL EFFECTS
Visual effects that were created with an optical printer. Strictly speaking, only effects actually created using an optical printer were 'opticals', but the phrase is widely used to distinguish any process that involves using the properties of light, film and lenses (such as front and rear projection) from physical effects that are achieved on the set, or digital effects that are produced in the computer.

OPTICAL PRINTER
A device used to create optical visual effects by manipulating photographic images while copying (printing) them from one film onto another. At its simplest, the optical printer was simply a projector and a camera facing one another; the projector shone its image through a lens and onto the new film held in the camera. Effects achieved using an optical printer included the compositing of travelling matte photography, split-screen effects, dissolves, fades and wipes. Optical printers have now been entirely replaced by digital alternatives.

OPTICAL SOUND
A system of reproducing film sound which involves converting electrical sound signals into an analogue pattern that is printed as a continuous strip alongside the images on a piece of film. This signal is read optically and converted back into sound during projection.

ORIGINAL NEGATIVE MATTE PAINTING
A method of combining paintings and live action by exposing both onto the same original negative film without any additional processes. Also known as 'latent image matte painting'.

OVERCRANKING
Running a film through a camera faster than the normal speed of 24 frames per second. When the developed film is projected at the normal speed, the action appears in slow motion. Running a camera slower than the normal speed to create speeded-up images is called 'undercranking'.

PARTICLE SYSTEM
A digital method of generating and animating the random movement of large numbers of particles for the creation of swarms, clouds, tornados, fireworks, water and so on. Particle systems control various parameters such as the number of particles in a shot, where they come from, how they move in relation to one another, their velocity and drop-off. Changing any one aspect will change the entire pattern of movement. The particle flow in a shot is determined using basic particles before they are replaced with the objects required for the scene – which may in themselves be animated, such as swimming fish.

PASS
During the photography of models or miniatures, an image is often filmed in several 'passes'. Each one captures a specific aspect of the image, usually on a separate piece of film. In the case of a model spaceship, separate passes might be used to film the model's internal lighting, the glow from its engines, a smoky atmosphere, and a silhouette for the production of a travelling matte. In a 'beauty pass' the model in question is lit to look its best. The different passes are combined optically or digitally. The result is a shot in which all elements are balanced to produce an image difficult or impossible to achieve in a single take. When a shot involves a moving camera, motion control is essential for ensuring that the camera movement is identical for each pass. Different passes are also produced when rendering computer-generated models and animation.

PHOTOSHOP
Leading 2-D image creation and editing software used by most companies to create digital matte paintings and texture maps for CG models.

PHYSICAL EFFECTS
Any effects that are physically achieved on set during filming. Includes the use of pyrotechnics, atmospherics and large-scale mechanical props. Also known as 'mechanical effects' and 'special effects'.

PILOT PIN REGISTRATION
Most visual effects processes require every image in a sequence to be positioned in exactly the same place on each subsequent frame of film. This allows elements held on separate films to be precisely combined, ensuring production of a successful composite image. To ensure perfect 'pin registration', cameras and projectors used in visual effects use special pilot pins which fit snugly into the perforations in a piece of film, holding it absolutely steady in the aperture during photography or projection.

PIXELS
An abbreviation of 'picture elements'. Pixels are the tiny squares of colour which make up a digital image. Each image comprises many thousands of pixels – the more used to describe a picture, the higher its resolution. For film images the appearance of each pixel is the result of a combination of four channels of information. Three channels specify the amounts of red, green and blue that combine to produce the pixel's colour. The fourth channel, known as the alpha channel, contains information about the transparency of the pixel and is used during compositing.

PLATE
Any still or moving image used as a background for front or rear projection, optical travelling matte processes, or in a digital composite shot. To ensure that backgrounds will be suitable for use later in production, plate photography is often overseen by visual effects supervisors who travel to locations with the film's main crew. Lighting and camera movement in a plate are carefully planned so that effects elements can be effectively matched to them. The word 'plate' originates from the early days of still photography when negatives were made of plates of glass with photographic emulsion on their surface.

POLYGON
A simple two-dimensional geometric shape. Polygons are the building blocks of 3-D digital models.

PRE-VISUALIZATION
The planning of complex action sequences by first animating them using 3-D software. 'Pre-viz' allows visual effects supervisors to design shots, physical effects supervisors to plan what equipment they will need, stunt coordinators to calculate distances and speeds, cinematographers to plan lighting and camera angles, and editors and directors to pre-cut a scene to achieve the best result.

PRIMACORD
A high-explosive 'rope' that can be wrapped or taped around objects in order to destroy them on detonation. Also known as det cord.

PRIMITIVES
Basic 3-D geometric objects that are often used as a basis for the construction of more complicated digital models within the computer. Primitives such as spheres, cubes and pyramids may be squashed, squeezed, distorted or intersected to create other more interesting forms.

PROCEDURAL MODELLING/PROCEDURAL ANIMATION
Time-saving digital modelling and animation techniques by which the form or movement of objects is calculated by the computer according to pre-programmed mathematical formulas (algorithms).

PROCESS CAMERA/PROCESS PROJECTOR
A camera or projector which uses pin registration to ensure that each frame of film is held absolutely steady during the photography or projection of visual effects elements.

PROCESS SHOT
Usually describes composite shots achieved using rear projection. The term is sometimes also used to describe a shot achieved using optical travelling matte processes.

PRODUCTION/PRE-PRODUCTION/ POST-PRODUCTION

The process of creating a film is divided into three distinct phases. Pre-production refers to the parts of the film-making process that occur before principal photography begins. This includes scriptwriting, the design and construction of props and sets, casting of actors, financing and scheduling. Production is the actual phase of shooting a film in a studio or on location, and is usually the shortest part of the film-making process. Post-production refers to the processes that occur after shooting. This includes editing, the creation of visual effects, dubbing and sound effects, and recording the musical score. The actual timing of these phases may overlap somewhat – editing usually begins during the production phase, for example.

PROGRESSIVE SCAN

A video recording method in which the picture information for each frame is recorded, stored and displayed one line after another (progressively) to produce a whole image. Traditional video systems instead use a system by which alternate lines of picture information are recorded separately and later interlaced to form a complete picture during display. Progressive scan technology is analogous to the way whole frames are photographed by traditional film cameras. Video shot in this way can therefore be transferred directly to film on a frame-by-frame basis.

PROPRIETARY SOFTWARE

Most computer-generated imagery is created using standard 'off the shelf' software. Larger visual effects studios often write their own software to achieve unusual or difficult effects. This 'proprietary' technology is often widely promoted but carefully guarded, being one asset that sets a studio apart from its rivals.

PROSTHETICS

False limbs, noses or other appendages which are seamlessly affixed to the face or body of a performer.

PYROTECHNICS

The creation of explosions and bullet hits by using real explosives and other highly flammable materials. Non-pyrotechnic alternatives are available – using compressed air to blow debris into the air, for example.

RADIOSITY

A method of creating realistic lighting for 3-D digital images by calculating the diffuse interreflection of light between every surface in a scene. Radiosity produces convincing digital images but is extremely time-consuming and machine-intensive.

RAW STOCK

Unexposed and undeveloped film.

RAY TRACING

A method of calculating physically accurate lighting in 3-D digital scenes by tracing the path of light beams emanating from the camera as they bounce around an environment before reaching sources of light.

REAR PROJECTION

A method of combining live-action foregrounds with pre-filmed background scenery. Actors perform in front of a translucent screen which has still or moving images projected onto it from behind. A camera films the composite image. Animation, models and matte paintings can also be combined with background footage in this way. Also called rear-screen projection, back projection or process photography.

REGISTRATION PINS

Metal pins that precisely fit into the sprocket holes in a piece of film in order to position each frame exactly and hold it absolutely steady during exposure in a camera or projector.

RELEASE PRINT

The final version of a film, produced in large quantities for distribution to cinemas.

RENDERING

The final process in the production of computer-generated images. During rendering, every instructional aspect of a 3-D scene (lighting, camera, geometry, texture maps, shaders, animation, etc.) is studied by rendering software in order to calculate the final 2-D image.

REPLACEMENT ANIMATION

A method of stop-motion model animation in which puppets to be animated have all or part of their body replaced between photography of each frame, rather than being moved and repositioned by hand, as in displacement animation.

RE-RECORDING

The process of copying and mixing various pre-recorded sound effects and dialogue to create the final soundtrack for a film.

RESOLUTION

The quality of a digital image expressed in terms of pixels or pixels per unit area.

REVERSE BLUE SCREEN

An unusual method of creating blue-screen travelling mattes used in the early 80s. Rather than using a blue background screen to create a matte of a foreground object, the object was painted with a special translucent ultraviolet paint. The model was first filmed with normal lighting in front of a black screen. Using separate film, another identical pass was then filmed. This time the model was lit with ultraviolet light which turned the model blue, resulting in an image of a blue model against a black background. This film was used to create the travelling mattes. The reverse blue-screen process was first used for shots of a model fighter aircraft in *Firefox* (1982).

RIGID BODY DYNAMICS

A method of procedurally animating supposedly solid CG objects so that they collide and interact automatically, according to the laws of physics. Typically used to show objects crashing or disintegrating.

ROTOSCOPE

A combined camera and projector that is mounted on a rostrum and points down at a table. Images from a film can be projected downwards and traced onto paper or cels, which can then be used to create artwork for lightning, ghosts, or other hand-animated effects. The artwork is then rephotographed and optically combined with the original footage. The digital version of rotoscoping is mainly used for dividing each frame of a sequence into areas that will become either background or foreground when additional elements are composited into the scene.

SCALE

The comparative size of a model compared to the real object on which it is based. A 1 m model of a 4 m car has a scale of 1:4. Solid objects can be effectively re-created at smaller scales, while certain natural elements such as fire and water are difficult to miniaturize convincingly.

SCOTCHLITE

Trade name for a highly reflective material manufactured by the 3M company. With 250,000 tiny glass beads on each square inch of its surface, Scotchlite is 'retroreflective' – the majority of light hitting it is reflected directly back to its source. Generally used for reflective road signs and safety clothing, Scotchlite was also used in the effects industry for front-projection processes.

SEGMENT

A basic piece of geometry that links vertices during the construction of a digital model.

SHADER

An algorithm used by computers during rendering to calculate the way that light interacts with the surface of a digital model. Shaders determine the final look of computer-generated objects and scenes. Also called surface shaders.

SHAPE INTERPOLATION

A method of creating movement by instructing the computer to interpolate, or 'morph', between a number of fixed shapes. It is commonly used to create facial performances by interpolating between a number of pre-made facial expression models. Also called shape blending or blend-shape animation.

SHOWSCAN

A high-quality film format that moves 65 mm film vertically through the camera and projector at a speed of 60 frames per second. Showscan is also the name of a corporation that uses the process to create theme-park film attractions.

SHUFTAN PROCESS

A traditional method of using mirrors to combine full-scale live action and miniatures in camera.

SHUTTER

The device inside a camera that intermittently allows light to enter and expose the film within. Shutters are normally rotating discs with openings that let light reach the film while it is held motionless in the gate for exposure, and block light while the film is being advanced to the next frame. The shutter on a film projector prevents light from reaching the screen while each frame is being pulled into place.

SIMULATION

Methods of computer animation or modelling that draw on predetermined rules (algorithms) to generate the models' appearance or behaviour. Usually used to produce shots that would be too complicated or time-consuming to animate or model manually.

SLIT SCAN

A type of optical animation that produced images of streaking light. The effect was achieved by exposing a single frame of film, over a long period, to artwork seen through a slit in a screen. The camera, artwork and even the slit could be in motion during photography.

SLOW MOTION

Slowing the apparent speed of filmed objects by running film through the camera faster than the 24 frames per second normally used for filming and then projecting the resulting images at the normal speed. A scene filmed at 48 frames per second and projected at 24 will move at half its original speed. Some visual effects shots may be filmed at speeds as high as 500 frames per second, making a one-second event stretch to over 20 seconds on screen. Slow motion can now be created digitally by interpolating frames to produce artificial in-between frames that extend the sequence. Also called overcranking.

SODIUM VAPOUR PROCESS

A travelling matte process that used two films mounted in a single camera simultaneously to produce both the foreground element of a shot and its complementary travelling matte during original filming. The matte was created by placing the foreground element (e.g. an actor) in front of a yellow backdrop lit by sodium vapour lamps. A beam-splitting prism inside the camera sent the light from the yellow backdrop to one film to produce the matte, and all other light to the second film to record the image of the foreground element.

SPECULAR REFLECTION

The brightest areas of highlight on the surface of a computer-generated object. Created by light from external sources being reflected directly toward the camera.

SPLINE

A path created within the computer by joining two or more vertices. Although straight lines can be used to connect the vertices, more commonly the connecting lines can be influenced to produce a series of smoother curves. A spline could control the movement of a virtual camera by manually defining various key camera positions in a sequence and allowing the computer to calculate the path that links them. Spline-based modelling defines the surface of a digital model by using a relatively small number of control points, which are linked to produce a shape that influences the contours on the surface of the model.

SPLIT SCREEN

Any optical or digital process that allows an image to contain two or more elements that were photographed at separate times. Typically used to allow the same actor to appear twice in the same frame. To achieve the effect photographically, one side of the screen is matted off during exposure before the film is rewound. The matte is reversed, the film re-exposed. Some split-screen effects try to hide the fact that the image is produced by more than one exposure, others use the technique for dramatic effect – for instance, to show two people in different locations speaking on the telephone. Split screens need not be stationary – the line dividing the two exposures can be moved from frame to frame.

SPROCKET HOLES

Small perforations along the edges of a film strip that are engaged by the teeth of sprocket wheels to move film through a camera or projector.

SQUIB

A small pyrotechnic device used to simulate bullet hits. Squibs come in various sizes and are detonated electrically – either directly through a wire or occasionally by radio control.

STOP-MOTION

A method of animating models by physically altering their position in between the photography of each frame. When the resulting images are projected at the normal speed, there is the illusion of autonomous movement. Also called stop-action.

SUBDIVISION SURFACES

A method of selectively subdividing the polygons that form the mesh of a digital model in order to create more refined surface detail. Pioneered by Pixar in their short animated film *Geri's Game* (1997).

SUBSURFACE SCATTERING

A method of rendering realistic translucent materials by calculating the way that light penetrates their surface and is absorbed and diffused before exiting at different angles. Developed in the late 90s by Pat Hanrahan, Henrik Wann Jensen and Stephen Marschner.

SUBTRACTIVE PROCESS

A method of creating colour photographic images by combining three images, each of which contains just one of the three primary 'complementary' colours of cyan, magenta and yellow. Individually, these colours work to filter out the other colours in the spectrum that make up white light; when the separations are projected together they therefore produce a resulting image that is the desired colour. This method is used in all modern colour film processes.

SUPERIMPOSITION

The layering of two or more filmed images so that they are transparently visible at the same time. Also called double or multiple exposure.

SUPERVISOR

The senior effects technician responsible for overseeing the production of effects for a film.

Most major films have two types of effects supervisor: the special effects supervisor works on the physical and mechanical effects in a film, while the visual effects supervisor oversees the production of visual effects such as matte painting, animation, travelling mattes and miniature photography. Supervisors begin working on a film during pre-production, when they study the script and plan how each effect can be best achieved using the allocated budget. This is followed by a period of research and development during which techniques are tried, materials tested, and specialized equipment or software created. During production, supervisors oversee the safe and efficient filming of scenes in which physical effects are used, or the shooting of plates to which visual effects will be added during post-production. The special effects supervisor's job normally ends when shooting finishes, while the bulk of the visual effects supervisor's work takes place during post-production when the live action has been filmed and is ready for any changes. A film normally has an overall visual effects supervisor who is hired by the production to plan and budget each effects shot. They then contract visual effects studios, or vendors, to create the work. Each effects studio will have its own visual effects supervisor to oversee its own work.

SURFACE NORMAL
The surfaces of CG models are normally made up of thousands of triangular polygons. The flat surface of each polygon usually faces a slightly different direction in order to describe the contours of the model. The direction in which each polygon faces is its 'surface normal'. This information is used when calculating the way that light bounces off the model during rendering.

TAKE
Each time the camera is started and then stopped to film a shot. Several takes of each shot are normally filmed and the best is selected and used during editing. After the first take, each subsequent version of a shot is called a retake.

TANK
A large area of water in a film studio that is used for the filming of scenes involving boats and water. Tanks normally have a large painted backdrop and contain underwater tracks and pulleys for the manoeuvring and sinking of boats, plus equipment for creating waves.

TECHNICAL DIRECTOR
Though different visual effects facilities tend to give their staff different titles, technical directors, or TDs, usually have a highly specialized role in the production of computer-animated sequences. Ordinary animators or modellers create the basics of each shot before handing it over to TDs, who will deal with any out-of-the-ordinary requirements such as interactive water effects, the behaviour of hair, or any unusual lighting conditions. TDs will often need to write new software applications in order to achieve the desired effect.

TECHNICOLOR
An American company formed in 1915 by Herbert T. Kalmus, Daniel F. Comstock and W. Burton Wescott, who invented a number of pioneering colour film processes. Their first system was a 'two-strip' additive process (see above) that used a beam splitter in the camera to send two copies of an image to two separate strips of negative film, each filtered through a red or green filter. The two resulting black-and-white prints were then projected back through a red or green filter to produce a colour image. A later two-strip process used the subtractive process (see above) to combine cyan and magenta to create a colour image. In 1932 the company introduced the three-strip Technicolor process for which it is best known. This system used a special camera that held three films to record the red, blue and green colour components of a scene. All three colour records were then used to print their complementary colour onto a single positive film for projection. The colour produced using this system was bold and lush, as seen in *Gone with the Wind* (1939), for example. The system became outmoded after 1952 when Kodak introduced its single-strip Eastman Color film, which could be used in ordinary cameras. Technicolor still exists as a company that processes and develops movie film, duplicates consumer video and DVD and operates major digital intermediate facilities (see above). It also owns the visual effects facility The Moving Picture Company (MPC).

TEXTURE MAPPING
A method of adding colour or surface detail to digital models. To create texture maps, photographs or artwork of surfaces and patterns can be scanned into the computer, or created using digital paint software. Texture maps are then applied to the model using mapping coordinates to ensure that they fit correctly. As well as adding 2-D detail to a model, certain texture maps can change the appearance of a model's shape. Bump maps are greyscale maps that can make a flat surface look bumpy by the way that light is reflected from it. Alternatively, displacement maps can be applied to a model's surface to physically alter its shape during rendering. Opacity maps can be applied to a 'solid' model to make areas of its surface appear see-through.

THREE-DIMENSIONAL/3-D
Most images that we see have the two-dimensional aspects of height and width. Stereoscopic photography (using two cameras) can create images that, when combined, appear to have the third dimension of depth. Traditional cartoon animation is 2-D, since characters and backgrounds are flat pieces of artwork that can only be viewed and filmed from one angle. Model animation is 3-D because the camera and the models are able to move in all dimensions during animation. However, unless filmed stereographically, the resulting filmed images are two-dimensional. Computer-generated animation is often called 3-D animation because the models and environments are constructed in three-dimensional space within the computer, allowing the computer's virtual camera to roam around and 'film' them from any angle. Like normal motion picture photography, the usual result is, however, a 2-D image of a 3-D scene. Some computer-generated films have been rendered in both normal 2-D and stereographic 3-D versions, including *The Polar Express* (2004) and *Chicken Little* (2005).

THREE-STRIP PROCESS *see* **TECHNICOLOR**

TIME-LAPSE PHOTOGRAPHY
A method of filming slow-moving events to produce a sequence in which they appear to occur far more quickly. Once a camera is set up it can be programmed to photograph one frame every second, every hour or even every week. Usually used to create speeded-up images of naturally slow processes such as the growth of plants or the movement of clouds.

TIME-SLICE PHOTOGRAPHY
An effect produced by editing together images of the same subject that have been photographed simultaneously from different perspectives. The effect is of a motion picture camera moving through a moment that has been 'frozen in time'. Also called bullet time.

TIP TANK
A large tank of water that can be tipped or emptied to create waves during the filming of floods and storms. Also called tipper tank or dump tank.

TRACKING SHOT
A shot in which the camera moves in a linear fashion either towards, away from, or past the subject. The camera is normally mounted on a crane, track or wheels to allow smooth movement. Also called dolly shot, trucking shot or travelling shot.

TRAVELLING MATTE
Travelling mattes are used to combine two separately filmed elements when the foreground element (e.g. a person) changes shape or position from frame to frame – necessitating a new matte for each frame. Many methods of producing travelling mattes have been used – most rely on the foreground object being filmed in front of a coloured background. Traditional techniques such as the sodium vapour process and the blue-screen colour difference process created mattes optically. Today, all travelling matte shots are created digitally. *See* mattes

TWO-STRIP PROCESS *see* **TECHNICOLOR**

UNIVERSAL CAPTURE
A form of motion capture that uses the facial performance of a live actor as recorded by multiple video cameras to drive the performance of a computer-generated character with identical facial features. Pioneered for use in *The Matrix Reloaded* (2003).

UV MAPPING
The process of producing a 2-D image or 'map' that represents the surface of a 3-D model. U and V refer to the horizontal and vertical coordinates of the image. Once they have had colour and texture applied in 2-D, UV maps are reapplied to a 3-D model to produce its final appearance.

VERTEX
A single point in two- or three-dimensional digital space. By linking three or more vertices, basic shapes called polygons can be created and used to construct complex digital models.

VIRTUAL CAMERA
The hypothetical camera used to film animation and environments created within the computer. The virtual camera is not a physical camera but rather the 'device' used to determine the viewpoint that the computer will use when deriving information about the digital world during the process of rendering. Virtual cameras have been designed to replicate the abilities of real cameras and can be programmed to use different types of lenses and animated to move like real cameras.

VIRTUAL REALITY
Images of computer-generated environments and characters that are displayed to a single viewer using a form of headset or projected directly onto the retina of the eye (Virtual Retinal Display) to give the viewer the impression that he or she is immersed within a scene. VR systems react to the movements and actions of the viewer, allowing him or her to directly influence events. Used for military, medical and gaming purposes, they have the potential to develop into new forms of interactive entertainment.

VIRTUAL SETS/VIRTUAL STUDIO
Photorealistic computer-generated environments that replace the need for large film sets or location filming. Actors perform within an empty studio using minimal sets and props. During filming, cameras that move freely around actors relay their exact movements to a computer, determining how the virtual camera reacts. Filmed live action and computer-generated backgrounds are then composited to produce the final sequences.

VISTAVISION
35 mm film that is run horizontally through the camera (rather than vertically, as is normally the case) to create a negative that is eight perforations wide – twice the size of a normal 35 mm image. First developed in the 50s, VistaVision produces images that are sharper and less grainy than those in normal 35 mm photography, making them ideal for optical visual effects processes that require the repeated copying and therefore degradation of an image.

VOLUME RENDERING
The rendering of large numbers of often semi-transparent computer-generated particles used to simulate snow, rain, dust, clouds, etc. The computer studies the 3-D volume of particles at various depths from the camera in order to calculate a final 2-D image of the combined effect.

WEDGE
A strip of identical images, each of which has been photographed at different exposure levels. It is used to find the best exposure or balance.

WILLIAMS PROCESS
Early travelling matte process that filmed foreground images against a black or white backdrop and used high-contrast film to produce a matte.

WIPE
The replacement of one image with another through some form of decorative transition rather than by a straight cut, dissolve or fade. The second image normally replaces the first by appearing to 'wipe' across the screen.

WIRE-FRAME MODEL
The most basic visual form of a computer-generated model before it has had any textures applied to it. Also called a mesh.

WIRE REMOVAL
The removal of wires or rigs used to hang or support characters or objects during filming, as well as other unwanted elements, from a scene. A painstaking task when attempted optically, it is now achieved digitally with relative ease. Also called rig removal.

Z-DEPTH
During the rendering of computer-generated objects, a Z-depth pass (also called an 'ID pass' or simply 'depth pass') renders information about the distance of parts of an object from the camera in a visual form. Typically, distance from camera (or from the top to the bottom of an object) is denoted using greyscale (parts of an object that are nearest to the camera are white and furthest are black, with shades of grey in between) or hue (bands of colour that travel through the spectrum). This 2-D representation of an object's 3-D characteristics is used during compositing in order to relight an object, change focus on it, or allow the realistic addition of depth cues such as mist or fog.

ZOOM
The process of altering a shot during photography so that the camera appears to get closer to or further from its subject. In fact, a camera does not actually move during a zoom in or out, it is only the focal length of the zoom lens that is altered.

ZOPTICS
A variation of front projection in which the zoom lens on a camera was linked with the zoom lens on a projector. By simultaneously increasing the size of the projected image and the field of view of the camera, the projected image would appear to remain the same size when rephotographed while any foreground object would appear to shrink. Invented by Zoran Perisic and first used in *Superman* (1978) to make Superman fly towards or away from the camera without actor Christopher Reeve having to physically move.

SPECIAL EFFECTS

The History and Technique

RICHARD RICKITT

Foreword by **RAY HARRYHAUSEN**

Aurum

First published in Great Britain 2006 by Aurum Press Ltd
25 Bedford Avenue, London WC1B 3AT
www.aurumpress.co.uk

A catalogue record for this book is available from the British Library.

ISBN-10 1 84513 130 4
ISBN-13 978 1 84513 130 2

10 9 8 7 6 5 4 3 2 1
2010 2009 2008 2007 2006

Design by Ashley Western
Printed in China

FRONTISPIECE: *King Kong* (2005), Weta's extraordinary creation.

BELOW: Special effects have played a prominent part in many movies during cinema's first century: *Santa Claus* (1898), *T2: 3-D – Battle across Time* (1996), *Manslaughter* (1922), *When Worlds Collide* (1951), *The Living Daylights* (1987), *The Godfather* (1972).