ILLUSTRATION TECHNIQUES FOR PALAEONTOLOGICAL EXHIBITS

by TERRY L. CHASE

ABSTRACT. Illustrations play a major role in the success of any palaeontological exhibit. To be effective they should be clear and simple, as well as aesthetically pleasing and durable. Techniques for preparing murals, diorama backgrounds, easel paintings, photographs, and drawings are discussed, with special emphasis on their use in palaeontological exhibits. Means for protecting illustrations from photodegradation, proper techniques for mounting illustrations for exhibition, and a procedure for printing illustrations directly on exhibit panels by means of silk screening are also described.

THE preparation of palaeontological exhibits almost always requires some form of illustration to supplement specimens or other materials comprising the exhibit. Illustrations for exhibits perform a very important function. Not only do they clarify or further explain other components, but often they must also carry the burden of conveying the idea or purpose of the entire exhibit. Since the average visitor spends less than a minute in front of any given display, it is unlikely that a lengthy text will be read; complicated and extensive information is more appropriately reserved for textbooks or printed guides. Instead, the visitor is likely to gain much more information from an exhibit if it is summarized graphically in a well-designed illustration or other visual aid. The most successful illustration, therefore, is clear and simple with not so much information as to confuse the visitor, and not so detailed as to disguise the important point. If, for example, a graph includes too many lines or a diagram of a fossil identifies too many parts, it becomes visually fatiguing and is generally more than the average visitor is willing to digest. The same effect can result from an excessive number of illustrations in any given exhibit, just as it can from too many labels or too many specimens.

An illustration should also be aesthetically pleasing and interesting so that it will attract viewers and entice them to investigate the exhibit further, creating a lasting impression. An illustration such as a palaeontological reconstruction can often bring to life what might otherwise seem to the visitor to be a display case of lifeless and meaningless bones and rocks. Such a reconstruction creates a visual image of prehistoric life which the visitor is more likely to remember than the fossil specimens on which the reconstruction is based.

Almost every graphic-art medium can be used for palaeontological illustration. The choice may depend on: the size of the visual image desired; whether the illustration will be displayed with a protective covering or left unprotected; the length of time the illustration will remain on exhibit; and the type of illumination to be used. Illustrations for exhibits should be sufficiently durable to perform their intended function without fading, discolouring, peeling off, cracking, wrinkling, or any of the other deleterious effects which can visibly affect them. The kinds of illustrations discussed in this paper are murals, diorama backgrounds, easel paintings, photographs, drawings, and silk screen prints.

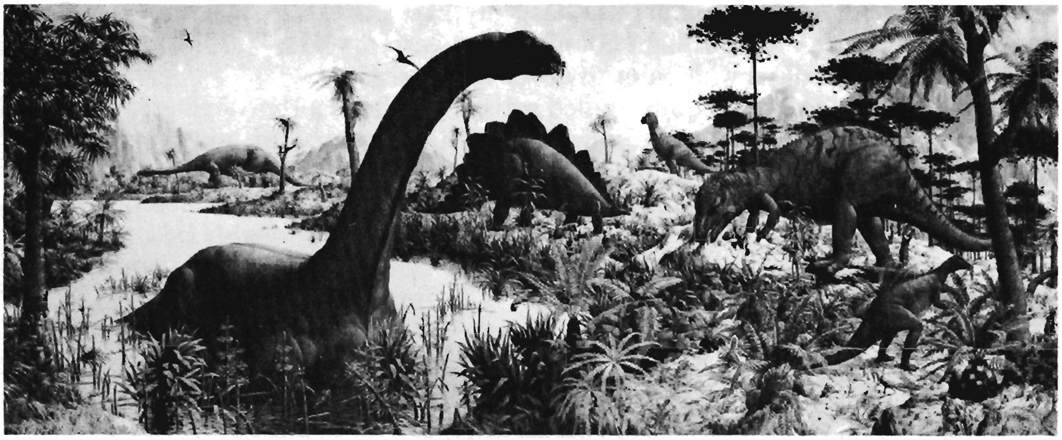
This brief introduction to materials and techniques is intended as a guide to palaeontologists and curators who are faced with the task of planning or preparing palaeontological exhibits. I have attempted to survey methods commonly used by skilled artists, as well as techniques which can be employed with some practice by the novice. While there is no substitute for artistic skill to prepare elaborate or detailed drawings and paintings, an inexperienced person can produce effective illustrations using a number of techniques described here. The inexperienced person should also find this summary of value in co-ordinating and preserving the work of professional illustrators. Some addresses for sources of materials are given at their first mention where it is felt that they will be useful, and further sources are given by Rixon (1976, pp. 275–282).

MURALS

Murals are one of the most commonly used forms of illustrations for palaeontological exhibits. In many large museums with lofty ceilings they have been painted high on the gallery walls above eye-level displays. It is currently fashionable, however, to lower ceilings, either physically or by painting them black, and to intersperse large photo or painted murals with the floor-level exhibits. In either case, murals should be designed to withstand the conditions to which they will be exposed, including the necessary washing and cleaning. They should also be designed so that they may be viewed from several angles, which necessitates a flat, glare-free finish.

Traditionally, mural painters have used the fresco process, i.e. painting on a moist, freshly prepared lime-plaster wall with pigments suspended in water. The advantages of a fresco painting are that it is durable, or at least as durable as the wall of which it is an integral part; it can be cleaned easily; and it is glare-free. The fresco technique also lends itself to a wide range of painted effects. Although a number of European museums have fresco murals (intended mostly as architectural decorations), the process is seldom used today for museum exhibits. However, a similar technique, the secco fresco process, has been used to produce the largest palaeontological mural ever attempted. This Pulitzer Prize-winning mural, *The Age of Reptiles*, was completed in 1943 by Rudolph Zallinger for the Peabody Museum at Yale University (text-fig. 1). It measures 110 ft long, 16 ft high, and took 4½ years to paint. Small-scale, preliminary drawings were prepared and transferred in charcoal by a proportional grid system to a lime-plaster wall. A clean, salt-free river sand was used in the plaster so that the paint pigments would not be affected by any saline compounds. The final colour, a mixture of casein glue and colour-fast 'earth' or chemical pigments (rather than the less stable coal-tar dyes) was applied directly to the dry plaster. Even though these fresco methods produce a relatively permanent and durable painting, such stationary murals do not allow flexibility in the display areas, should any future modifications to the exhibit halls be necessary or seem appropriate. It is naïve to think that the style and content of any exhibit hall will always be timely, even if the exhibits themselves lasted for ever.

Most well-known murals of palaeontological subjects have been painted on canvas



TEXT-FIG. 1. The Jurassic section of a secco fresco mural, *The Age of Reptiles*, painted by Rudolph Zallinger for the Peabody Museum, Yale University. Photograph courtesy of The Peabody Museum of Natural History.

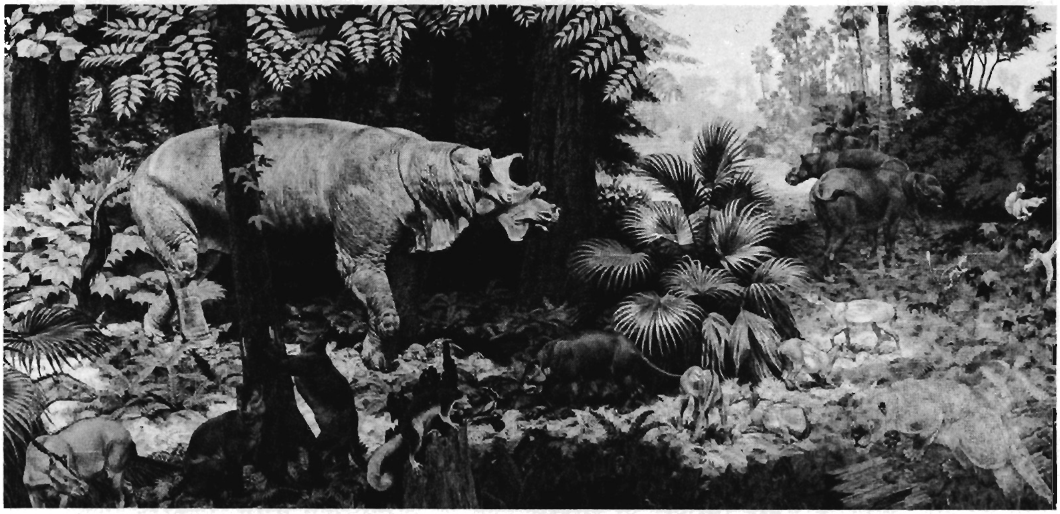
using oil colour. The murals are either painted on stretched canvas in the artist's studio and later fixed to the exhibit surface in the museum, or they are painted directly on a canvas-covered surface *in situ*. Occasionally, oil paint is applied directly to a plaster surface; however, bare plaster walls are technically ill-suited for oil unless carefully primed. Full discussions on the preparation of surfaces for oil paint are given by Mayer (1970) and Wehlte (1975).

Oil paint has become the universally accepted medium for murals, diorama backgrounds, and smaller paintings, because it is durable, versatile, and dependable. In addition, its relatively slow drying time allows ease in the application and manipulation of the paint, a wide variety of effects can be produced with relative ease, and freshly painted colours do not change to any great degree when dry.

Alternatives to oil have been developed within the last twenty years and are becoming increasingly popular for murals, dioramas, and smaller-scale paintings. The two most useful materials have a synthetic resin base. Polymer colours, or acrylic, have a number of advantageous qualities. They may be applied in a thick consistency so that, like oil, a textured or impasto effect can be achieved; they can also be thinned with water to the consistency of watercolour and applied in thin washes. Although moist polymer colour is soluble in water, it dries in a matter of minutes to form a tough, flexible coating that is impervious to water and most commonly used solvents. The rapid drying time alleviates the problem of waiting for layers of paint to dry before succeeding coats are applied; the tough, insoluble film allows the paintings to be easily cleaned when necessary. The pigments in polymer paints are identical to those used in oil, but the optical properties of the medium give them a more brilliant quality. Although inherently glossy, polymer paint can be made to have a matt lustre with the addition of a flatting agent.

A second resin-based medium, alkyd colour, has recently been introduced in tube form as a fine-art material (Winsor and Newton, Ltd., Wealdstone, Harrow, Middlesex HA3 5RH, England). It differs from acrylic in that it is soluble in turpentine and other oil-based solvents. Alkyd colours are basically like oils except that they dry faster and are available in more brilliant colours. They also dry to a flat finish and can be used together with alkyd wall paint to cover large areas.

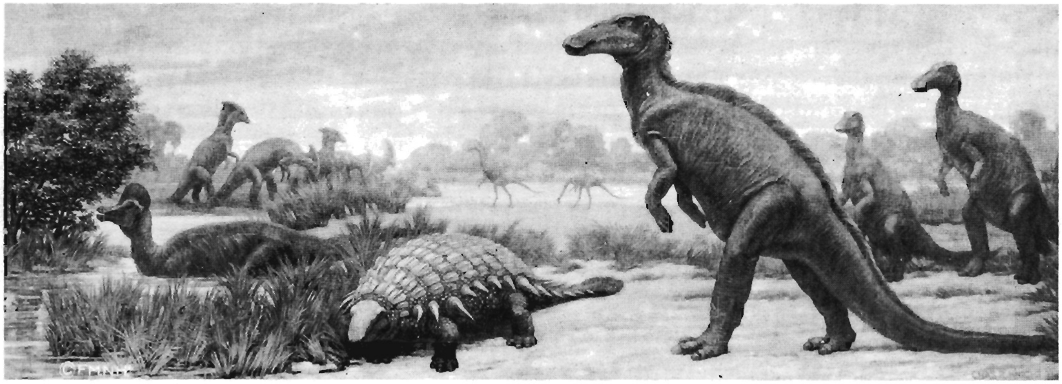
Murals of good quality require skilled artists who have a thorough knowledge of their subject-matter. Usually the finished painting is based on much preliminary effort and study. Jay Matternes, a sculptor and painter at the Smithsonian Institution, for example, begins with preliminary sketches of a reconstructed skeleton to which muscles are added in pencil and, finally, skin and fur. He is probably best known for a recently completed series of large murals for the Hall of Vertebrate Paleontology at the U.S. National Museum in Washington, D.C. (text-fig. 2).



TEXT-FIG. 2. Section of a mural depicting the fauna and flora of the Middle Eocene of Wyoming, painted in oil by Jay Matternes for the Museum of Natural History, Smithsonian Institution, Washington, D.C. Photograph courtesy of the Smithsonian Institution.

Perhaps the best-known palaeontological murals were painted by Charles Knight in the 1930s and 1940s for the Chicago Field Museum and the American Museum in New York (text-fig. 3). The paintings were done on canvas in Knight's New York studio and then transported to the museums. As an aid to proper distribution of light and shadow in his final paintings, Knight sculpted clay models based on mounted skeletons. These murals, numbering nearly fifty, have been widely reproduced in textbooks and have served as a basis for many later reconstructions.

In addition to the conventional brush-painting techniques used for preparing murals, two other methods have useful application for palaeontological subjects. The first is airbrushing, a technique for spray-painting that utilizes a pencil-sized spray-gun powered by compressed air. With this small sprayer it is possible to duplicate a photographic style or produce illustrations with a soft-edge quality unlike any other technique. Airbrush is also excellent for shading and tinting line drawings and photographs. Oil colour thinned with turpentine, amyl acetate, or naphtha works well for



TEXT-FIG. 3. Cretaceous mural painted in oil by Charles R. Knight for the Field Museum of Natural History. Photograph courtesy of the Field Museum of Natural History, Chicago, Illinois.

most purposes; however, dilute lacquers, watercolours, and inks may also be used with success. A full discussion of airbrush techniques is given by Tobias (1946).

A second technique which is sometimes useful for painting designs or enlargements of illustrations on exhibit panels involves the use of an opaque projector. Line drawings, wood engravings, or typeface, for example, can be projected on to a flat surface at any desired degree of enlargement. The image is then pencilled in directly on the panel, and later the outline is filled in with paint.

Another method for preparing murals is by enlarging black-and-white photographs. Photomurals can be prepared from any artwork or photographs of reasonable quality and can be enlarged to almost any size. They can also be prepared on a variety of surfaces, including canvas. If desired, colour may be added using polymer paints rendered transparent by the addition of clear polymer medium, or transparent inks and watercolours. The photograph should be securely glued to a hard surface using a permanent adhesive. If the photomural is pieced together in sections, care must be taken to assure that the adjoining sections are in register and match exactly in tone. The joints should be slightly overlapped rather than butt-jointed to compensate for shrinkage when the mounted photo is completely dry. To increase the durability of a photomural, the surface should be coated with matt varnish or acrylic lacquer.

The chief advantages that photomurals have over painted murals are that they can be prepared in a fraction of the time it takes to complete a painting, they can create a dramatic effect at a minimum cost, and they can be easily replaced if damaged. One of the main disadvantages is that the more a photograph is enlarged, the more fuzzy or grainy the image appears. This limits its usefulness when viewed at close range. Photographs for murals should be prepared from sharp-imaged, sheet-film negatives (at least 4×5 in.) to minimize this problem. Photographs of high contrast reproduce best.

Computer painting recently developed by the 3M Company (Decorative Products Division, 3M Center, St. Paul, Minnesota 55101, U.S.A.) can reproduce any photograph or artwork in full colour up to the size of an auditorium wall, if desired, and on a variety of surfaces. Unlike photographs, no graininess is produced as the size increases. In fact, the quality and detail actually improve by enlarging the image. The 'painting computer' scans a transparency of the original artwork and transmits the image to a series of micro-spray-painting guns. The guns move slowly over a rotating drum wrapped with paper or fabric and spray the four basic process colour paints on to the surface. Through the blending of these colours the finished mural is an amazingly accurate, four-colour copy of the original. The fade-resistant pigment used is similar to outdoor house paints and is apparently durable enough for most indoor uses. However, the application of this process to museum murals is still largely unexplored.

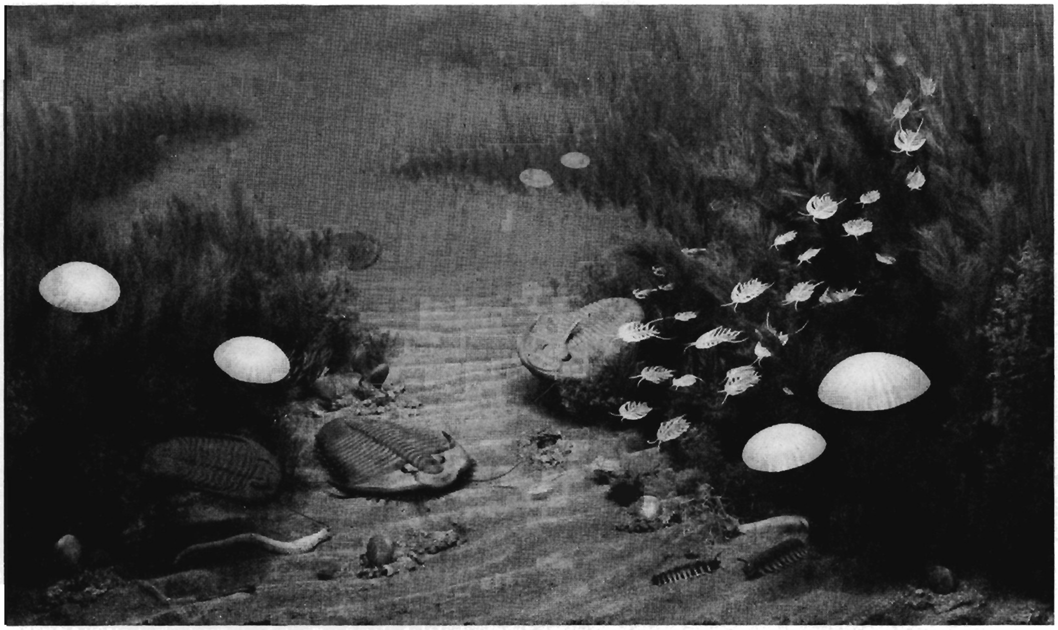
Although peripheral to the scope of this paper, explanatory text to accompany illustrations can also be quickly and effectively prepared photographically by means of a computer. The phototypesetting process can set type to any specifications (size, style, and spacing) and print it in black or white on a variety of papers. The paper is then fixed to the exhibit panel.

Another photographic method which has been used successfully for murals and smaller illustrations or explanatory text, involves preparing a transparent colour or black-and-white positive and backlighting it on the exhibit panel. This large transparency is especially useful in exhibit areas with subdued or directed lighting. Transparencies produced by the Cibachrome process (developed by the Ciba-Geigy Company) are the most fade-resistant. In addition, they are relatively easy and quick to prepare since they are produced by a direct-exposure method without the use of internegatives, as in the more complicated dye-transfer process. Cibachromes are also less expensive than transparencies of comparable quality produced by more time-consuming and technical procedures.

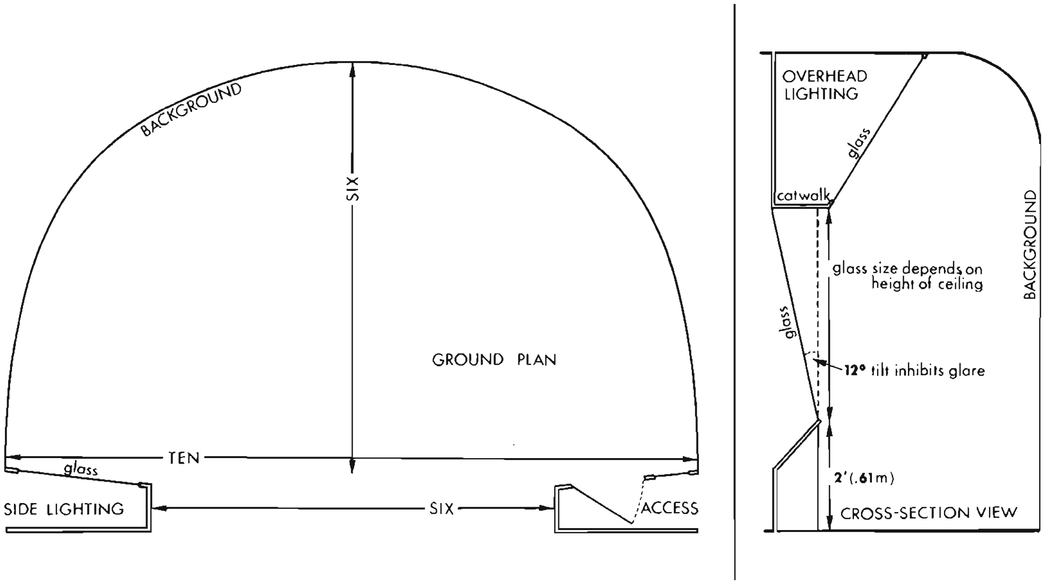
Large colour transparencies can be an effective and economical substitute for palaeontological dioramas. Many of George Marchand's famous Palaeozoic marine dioramas have been reproduced by this method and utilized by museums which either do not have the funds to commission a diorama or do not have the space to accommodate one. When reproducing any exhibit or illustration photographically, all copyright laws must be observed and permission must be obtained from the source.

DIORAMA BACKGROUNDS

Diorama backgrounds, although prepared with many of the same media as murals, present some special considerations. A diorama has two major parts, a foreground of three-dimensional models or specimens, and a painted background. The foreground should blend imperceptively into the background painting as viewed from the established vantage-point of the observer (text-fig. 4). Usually the background is curved so that there are no corners in the exhibit to destroy the illusion of gazing into a natural setting. Care must be taken that the case is not so deep that the sides of the painting are grossly distorted when viewed from the glass opening. An ideal shape for a diorama is 10 ft wide by 6 ft deep (text-fig. 5). The proportion for larger or smaller dioramas should remain the same. A good discussion on the construction of diorama backgrounds and the technical problems of diorama perspective is given by Jaques (1931).



TEXT-FIG. 4. Section of a diorama depicting the marine fauna and flora of the Cambrian Lake Superior Group (Munising Formation with some faunal elements from the Canadian Burgess Shale) of Upper Michigan, prepared by the author for the Chippewa Nature Center, Midland, Michigan. The background was painted in alkyd colours. The transition from the foreground to the background was aided by continuing the school of small crustaceans and seaweeds in the painting and using a ripple mark to hide the contact in the centre of the exhibit. As an additional aid to blending the foreground into the background, the substrate slopes upwards from the front to the back about fifteen degrees.



TEXT-FIG. 5. Proportions for a well-designed diorama (after Jaques 1931).

In full-scale dioramas the horizon line in the painting should be positioned at 5 ft from the floor level (the horizon line always appears at eye level, and 5 ft is the eye level of the average adult). To conform to the laws of perspective, horizon lines for miniature dioramas should be set at about the eye level of the tallest animal in the exhibit, and the exhibit should be installed with the horizon line at 5 ft from floor level. To facilitate viewing by children, a step can be built on the floor in front of the diorama.

EASEL PAINTINGS AND THE CONSERVATION OF COLOUR ILLUSTRATIONS

In addition to murals and dioramas, the preparation of palaeontological exhibit areas generally requires many smaller illustrations. Smaller, 'easel-sized' paintings can be prepared in the same way as large murals, using oil, polymer, and alkyd colours. Tempera, pastels, gouache, and watercolour also have some limited applications, but in general, illustrations prepared with these media should be displayed under glass or rigid acrylic sheets to protect them from handling. These media tend to be more unstable than oil, polymer, and alkyd, and for that reason have application for short-term use only. Some coloured dyes and inks, including felt-tip pen ink, tend to fade rather rapidly and should also be used only for temporary exhibits.

All colour illustrations should be protected from the damaging effects of illumination, or photodegradation. All light in and near the visible wavelengths has a destructive effect on pigments, their vehicles, and the surface on which the illustration is rendered. Ultraviolet light and the visible spectra, prominent in fluorescent lighting and sunlight, cause fading and discolouration. Infra-red light, prominent in incandescent lighting and sunlight causes heat damage. The rate of damage depends on the illustration medium used and the intensity of the light source. Some dyes fade completely in a matter of days under direct sunlight, whereas oil paints protected by varnishes are little affected after years of exposure under normal exhibit lighting conditions.

The damaging effects of light can be most easily deterred by blocking out sunlight or turning off artificial lights when the exhibits are not being viewed. Colour illustrations should never be displayed for any length of time near a window where they will be exposed to direct sunlight. Electric eyes and pushbutton or floor-mat switches can be utilized to activate lights when the exhibits are open to the public, and a variety of filters, absorbers, or reflectors can be used to combat the harmful effects of light.

Ordinary window glass and the glass used in light bulbs is a good filter for long-wave ultraviolet rays, but it does not screen out the more harmful short-wave ultraviolet radiation. Various chemical compounds have been formulated to absorb much of the ultraviolet light that remains unfiltered by glass. These compounds have been added to plastic to make thin, flexible films or rigid sheets (such as UF-3 Plexiglas, manufactured by Rohn and Haas Company, Independence Mall West, Philadelphia, Pennsylvania 19105, U.S.A.) which can be installed over glass windows, display cases, or directly over the illustration to prevent fading or discolouration. The same compounds have also been added to moulded plastic to make filter sleeves for fluorescent lights which emit as much as 50% ultraviolet radiation. Ultravioletabsorbing compounds (such as Tinuvin P, manufactured by Ciba-Geigy) may also be mixed with varnish for coating paintings.

Heat produced by infra-red radiation in sunlight and incandescent lighting causes discolouration in pigments; drying out of the paint vehicle resulting in cracking, crazing, or peeling; and deterioration of the paper or fabric on which the illustration is prepared. These effects can largely be controlled by displaying colour illustrations where they will not be exposed to direct sunlight or too close to lights in cases. The use of heat-removing dichroic lamps or special infra-red absorbers or reflectors on incandescent lamps also reduces the damaging effects of heat. Installation of air-conditioners and vents in display cases will help to regulate heat build-up, and humidity as well. Humidity can also be controlled through the use of humidifiers/dehumidifiers or by placing a quantity of moist silica gel inside the display case. More extensive discussions of methods for controlling the deleterious effects of light and heat on exhibits are given by Feller (1964*a*, 1964*b*, 1968), Hanlan (1970), Lusk (1975), and Weiss (1977).

PHOTOGRAPHS

One of the safest ways of preserving original artwork prepared for exhibits is to use photographic copies, whenever possible. Although photographs are as susceptible to the effects of light, heat, and moisture as painted illustrations, they can usually be replaced at less expense and trouble than can the original artwork. Most colour photographs are highly susceptible to fading, and the same precautions should be observed as for displaying colour paintings. Special care must be taken to thoroughly wash both colour and black-and-white prints after development, or the detrimental effects of light and heat on the photographs will be increased.

Photographs prepared for exhibits should be printed on a medium- to light-weight paper. Although heavy photographic paper is somewhat easier to handle, it develops enormous tension in drying, creating a greater tendency for warping. Medium-weight paper comes in the greatest variety of speeds and finishes and is most often used in preparing photos for exhibitions, including photomurals. Photographic papers also come in many different surfaces for various artistic effects, but a glossy paper dried on a matt print drier is best for showing detail without glare. Matt acrylic lacquer may be sprayed over a glossy print to reduce the undesirable glare and protect the surface.

Photographic paper with a matt finish is also best for any retouching that may be necessary. Retouching is done to emphasize particular details in a photograph, to alter the shading so that the image is more clear, or to rectify any fuzziness resulting from a limited depth of field in the camera lens. Most black-and-white retouching is done with water-based retouching paints applied either by hand or by airbrush. Light areas on a photograph can also be darkened by using a soft graphite pencil or a graphite-coated paper stomp made by rolling up a strip of blotting or kraft paper at a slight angle so that one end is pointed. Retouched photographs are generally rephotographed for use in the exhibit.

Photographs for exhibits should be mounted on a stiff backing such as acid-free mounting board, masonite, or sheet aluminium. Permanent adhesives such as polyvinyl acetate water emulsion glue or casein-based white glue thinned slightly with water may be used to mount the prints, but the paper should be tempered by allowing it to absorb some of the moisture and expand before it is applied to the backing or panel. To compensate for shrinkage when the prints dry, the photograph can be cut at least an inch larger than the backing and after it is glued to the surface, wrapped around the edges and pasted to the back. If the backing is somewhat flexible, an additional piece of heavy kraft paper can be glued to the back to prevent warping.

Another acceptable method for mounting photographs is by dry mounting. The adhesive used in this process is a sheet of dry-mounting tissue, onion-skin paper coated with sealing wax. The tissue is sandwiched between the print and backing, and slipped into a dry-mounting press which applies heat and pressure. The heat melts the wax, resulting in a smooth bond between the print and backing.

Photographs should never be mounted using impermanent adhesives such as rubber cement, contact cement, mucilage, starch paste, or two-way masking tape. Such adhesives are only temporary and will eventually lose their binding power. For a discussion of adhesives useful for exhibit purposes see Macbeth and Strohlein (1965).

To protect photographs and other illustrations mounted on exhibit panels that are touched or handled by visitors, the entire panel can be covered with a sheet of clear, rigid acrylic. Another method is to embed the graphic material in polyester resin reinforced with a single layer of fibreglass. This process is described by Conway (1972).

The photographing of palaeontological specimens involves a number of specialized techniques beyond the scope of this paper. For a discussion of the general principles see Rasetti (1946, 1965); techniques for the photography of microfossils are discussed by Whittington (1956, 1965), and Benson (1965); photomicrography of thin sections is covered by Douglass (1965); and techniques for coating fossils for photography are summarized by Kier *et al.* (1965).

DRAWINGS

Drawings for palaeontological exhibits may be subdivided into two major categories: renderings of three-dimensional subjects such as fossil specimens and restorations, and two-dimensional charts, graphs, and maps.

The preparation of most drawings representing three-dimensional objects begins with a preliminary outline or sketch on tracing paper. This preliminary drawing may be prepared either free-hand or by using a variety of mechanical or optical devices. With some practice the outline and major details of microfossils can be accurately drawn by use of a camera lucida, essentially a broken-beam prism and mirror attached to a binocular microscope. With one eye on the microscope and one eye on the camera lucida, the reflected image appears to be projected on to a drawing surface below, so that it is possible to trace the outline with a pencil. The image can be made larger or smaller by adjusting the microscope objective and eyepiece magnifications. A good discussion of techniques for illustrating microfossils is given by Hanna (1931). A helpful technique for drawing fossil thin sections is to project them on a flat surface by means of a microprojector. Perhaps the easiest way to begin a preliminary drawing of either microfossils or thin sections is to photograph them, and trace the photograph.

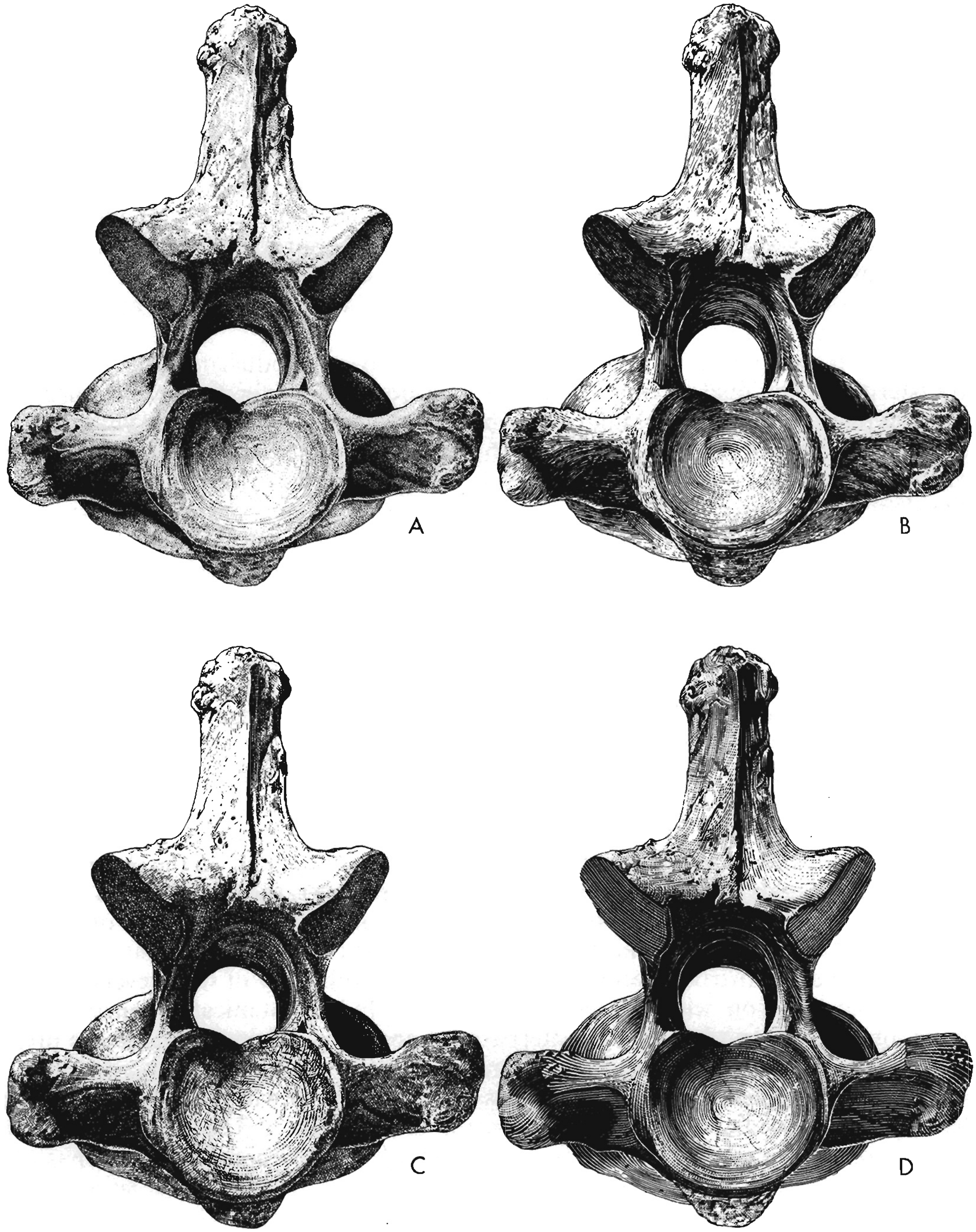
Preliminary drawings of megafossils can also be easily prepared by tracing a photograph or by drawing directly on the print with a waterproof ink and then bleaching out the photographic image to leave the drawing. If drawn free-hand, a direct comparison between measurements on the specimen and those on the sketch may be achieved by use of a proportional divider. This simple device consists of two legs with points on both ends and a sliding, adjustable pivot in the middle. It can be set so that the distance between points on one end is in direct proportion to that on the other end, allowing the desired magnification to be easily transferred. More complete discussions of mechanical drawing devices and their use are given by Zweifel (1961) and Ridgway (1938).

When an acceptable preliminary drawing has been produced, it may then be transferred to the final illustration board by a double transfer method. A piece of paper is placed over the preliminary drawing and the surface is burnished with a hard, smooth-edged tool such as a wooden burnisher. This transfers a mirror image, carbon copy of the sketch to the reverse side. The piece of paper is then removed from the sketch and placed over the illustration board. It is again burnished to transfer the image on to the illustration board. The process is facilitated if a soft-lead pencil is used for the preliminary sketch. Any marks or smudges which need to be removed from the illustration board may be easily erased with a kneaded rubber eraser.

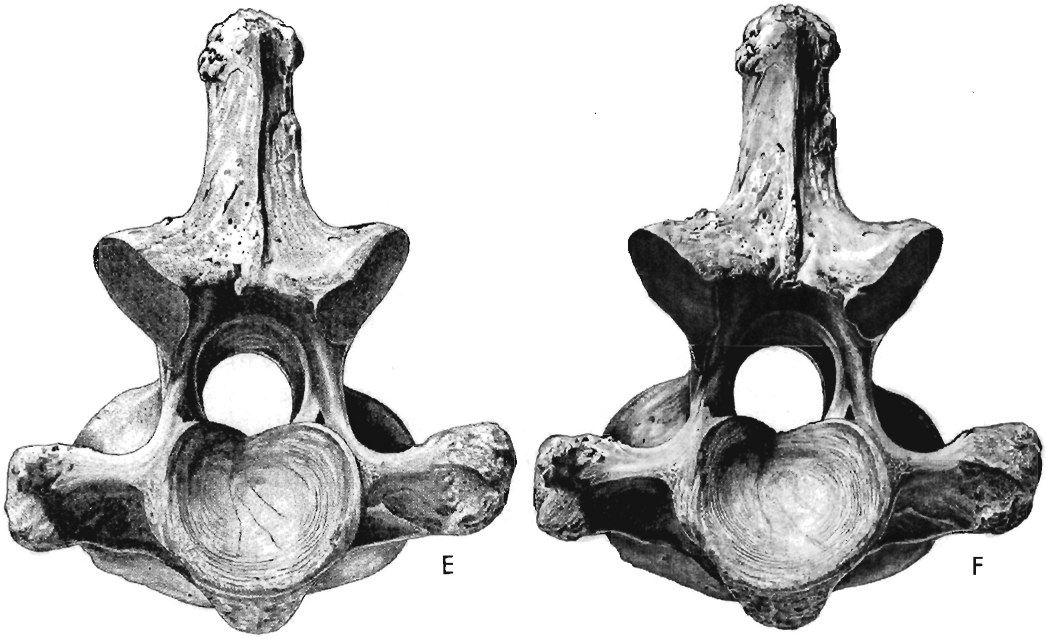
Successful drawings of palaeontological reconstructions, like drawings of living animals and plants, require thorough knowledge of the subject-matter. This entails not only an understanding of the skeleton, muscular structure, and skin patterns of vertebrates, for example, but also their behaviour and environment. Palaeontological reconstructions of vertebrates must obviously rely heavily on the skeleton, but additional information from associated trace fossils (such as footprints), casts of skin, carbon impressions of the body outline, associated fossils, and even the depositional environment itself, may prove useful. Study of living counterparts or allied forms is an additional, and usually invaluable aid for reconstructing flesh on the skeleton and for gaining insights into the habits of the animal. However, the artist should not rely so heavily on living counterparts that the restoration unjustifiably takes on a false similarity. There is generally no trace of the soft parts in fossil invertebrates, so their body must be reconstructed using the functional morphology of the preserved hard parts in comparison with modern-day relatives. Palaeobotanical reconstructions must also rely on modern-day counterparts as an aid to piecing together the often fragmented and scattered pieces of evidence.

The ability to illustrate fossil specimens can be mastered with a knowledge of the techniques and media, along with a certain amount of practice. The ability to prepare illustrations of fossil reconstructions, on the other hand, requires not only a mastery of techniques and practice, but also an intimate familiarity with the subject and 'artistic ability'.

The choice of a drawing medium depends, to a large extent, on the texture of the subject-matter and also how it will be used in the exhibit. One of the most versatile and durable media for palaeontological drawings is pen and ink. An opaque black, waterproof ink such as India drawing ink and a fine pen point with some flexibility,



TEXT-FIG. 6. Bison vertebra from the Pleistocene of Minnesota showing a comparison of various drawing techniques. A, stipple drawing with a crow-quill pen; B, hatching with a stiff mapping pen; C, cross-hatching with a crow-quill pen; D, scratchboard; E, stipple board; F, pencil drawing. Drawings prepared by the author; all figs. approx. $\times 0{\cdot}4$.



such as a crow-quill or mapping point, are best for this purpose. A flexible pen point allows the artist to change the angle and amount of pressure on the point to produce variations in the width and character of a line or dot. A fine-pointed fountain-pen such as a Rapidograph may be used and has some advantage over a crow-quill or mapping pen point in that it is not necessary to dip the pen in a bottle of ink continually to replenish the supply. However, a dense India ink cannot be used in a fine-pointed fountain-pen, and the fountain-pen inks tend not to be as opaque or stable as India ink. In addition, a fountain-pen does not allow for as much variation in the width or quality of a line as does a flexible pen point.

The pen work is prepared over the preliminary drawing beginning with an outline. The shading is then added by a stipple or line technique. The more dense the dot or line pattern, the darker the shading. Shading by stipples, or dots (text-fig. 6A), is the easiest for obtaining satisfactory results and may also be used to duplicate almost any surface texture. Smooth textures may be represented by evenly spaced dots that do not touch one another. Rougher textures may be simulated by unevenly spaced dots of various sizes. In either case, the dot pattern is ordinarily applied in a random fashion. Other textural effects may be achieved by using a linear series of dots, dots in circles, or dots in combination with lines.

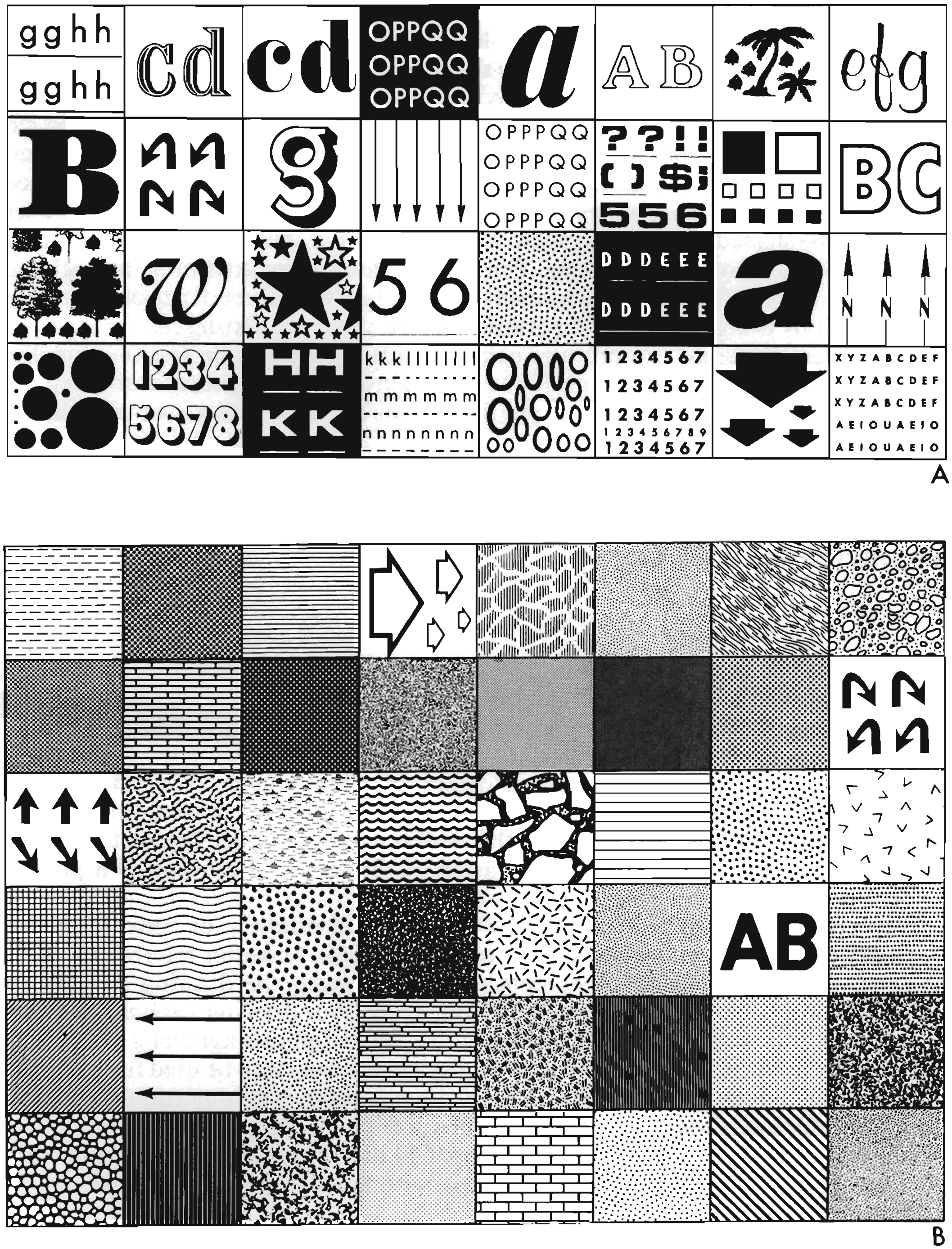
Hatching, or shading with lines, may be done in three basic ways. Using a relatively stiff pen, lines of equal width may be drawn, more closely spaced for darker areas, and more widely spaced or broken for lighter areas (text-fig 6B); or, using a flexible pen, lines of varying width can be drawn, wider for darker areas and thinner for lighter areas. A third method, called cross-hatching, may produce a shaded effect by criss-crossing lines (text-fig. 6C). The more times the lines cross in different directions and overlap, the darker the shading.

Pen and ink may also be used on scratchboard, an illustration board with a smooth, chalk surface (text-fig. 6D). When the ink has dried, a sharp tool can easily scratch through the inked areas producing a fine, white line or dot. The same methods used for stipple or line shading may be used on scratchboard. With the scratchboard method, however, it is possible to block in the darkest areas with solid ink and scratch in white lines or dots so that the background is black and the detail is white. This can be blended into a white-background area with a black line or dot shading pattern prepared in the conventional manner. Another advantage of scratchboard over regular illustration board is that mistakes can be easily scraped away and shading patterns can be altered, if desired. This is a good material for illustrating subject-matter with suture lines, hair, small spines, or other linear details. Scratchboard is somewhat fragile and care must be taken not to bend it or cut with scissors, or it will crack. Instead, it should be cut with a matt knife or razor blade and mounted on a stiff backing, especially when used for exhibit purposes. Scratchboard also absorbs oil from the skin and tends to stain rather easily. When on exhibit it should be protected by a sheet of rigid acrylic or glass.

Stipple board is another kind of illustration board, and has a textured surface consisting of raised dots, lines, or small irregular ridges (text-fig. 6E). A lithographic crayon or china marker can be applied with varying pressure to the surface, so that the finished result very much resembles a stipple or line drawing. Stipple board is also available with a chalk coating, like scratchboard, so that white lines may be scratched in after the drawing is shaded. Darker shaded areas may be coated with India ink, and when dry, scraped to produce white dots on a black background. As with scratch-boards, stipple board drawings should be protected with a covering when on exhibit.

Pencil drawing has limited usefulness for exhibit purposes, but when well executed, pencil can be used to duplicate photographic realism (text-fig. 6F). The procedure for making a pencil drawing is to first prepare a preliminary sketch, much the same as for an ink drawing. This is transferred to a smooth, but not glossy, illustration board or bristol board. For maximum effectiveness a pencil drawing should have as much contrast as possible. A very soft pencil such as 4B can be used for dark shadows; high-lights can be produced by leaving the paper blank in the brightest areas. A kneaded rubber eraser is useful to lighten small areas after the illustration has been shaded. Pencil grades of B and 2B are useful for areas intermediate in value. Details and delicate shading can be done with a hard 2H pencil. To smooth out pencil strokes for a softer, more gradual shading effect, a paper stomp is generally used. The artist's finger should not be used for this purpose because skin oil mixed with the graphite will make any subsequent erasure difficult. For very smooth areas the graphite can be applied by brush. A pencil rubbed on a sheet of sandpaper will produce dust that can be applied in small amounts with a soft, red sable brush. A fixative such as acrylic spray applied to the finished illustration will help protect it. More complete discussions of drawing techniques applicable to palaeontological subjects are given by Ridgway (1938) and Isham (1965).

Charts, maps, and graphs are often used in palaeontological exhibits. Their preparation has been greatly facilitated by the development of dry-transfer ink symbols and lettering (text-fig. 7A) as well as adhesive-backed shading and pattern films (text-fig. 7B). With these preprinted aids it is possible to get highly professional



TEXT-FIG. 7. A, examples of dry-transfer ink symbols and lettering; B, examples of adhesive-backed shading and pattern films.

results in a relatively short time. The dry-transfer symbols and letters are printed on vinyl or acetate sheets coated with a wax-like adhesive. By burnishing over the letters or symbols they can be transferred to any smooth surface. They are available in a wide variety of sizes and styles. One company (Chart-Pak, Incorporated, Leeds, Massachusetts 01053, U.S.A., or Didcot, England) supplies blank sheets which may be fed into an ordinary office copy machine to produce custom sheets of dry-transfer images. The shading and pattern films are also printed on clear vinyl or acetate sheets coated on one side with a contact adhesive and protective backing. The film is placed over the area to be shaded, and using a sharp knife, the desired shape is cut out, care being taken not to cut through the backing. The cut-out area is then lifted from the backing, positioned on the artwork, and burnished down smooth with a wooden tool. Examples of illustrations using shading and pattern film are shown in text-fig. 8.

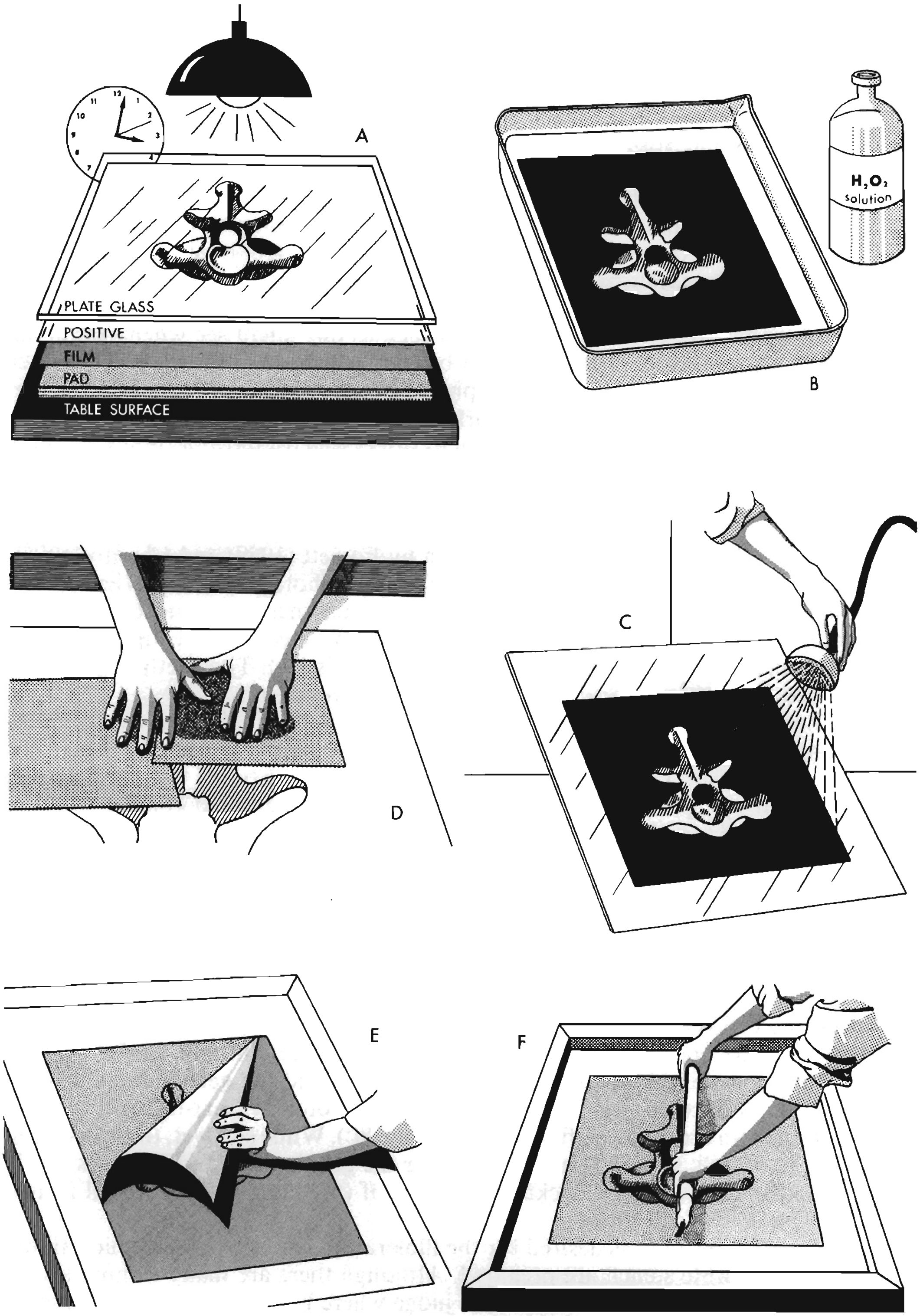
While these materials can produce camera-ready artwork of professional quality in a short time, they are not suitable for actual use in an exhibit, except for some short-term applications. The dry-transfer lettering begins to crack after a year or so as the wax adhesive dries out and eventually the lettering curls and peels off the background. This can be postponed by coating the letters with a clear plastic spray. The impermanent adhesives used on most shading films also makes them unsuitable for exhibit use. Illustrations prepared with these materials can, however, be photographed or silk screened for exhibit use.

THE SILK-SCREEN PROCESS

Silk screen is one of the most effective ways to reproduce any illustration or lettering on an exhibit panel in every detail and in any colour. The method involves a simple stencil process (text-fig. 8). A gelatin stencil, prepared in the manner described below, is attached to a piece of silk stretched taut on a wooden frame. The silk acts as a support for keeping the stencil in a fixed position and as a reservoir for the printing ink. The ink, forced through the silk fabric with a squeegee, passes through the unmasked portions of the screen on to the exhibit panel or surface below, but it does not pass through the gelatin-protected areas of the screen. The result is a printed design corresponding to the openings in the stencil.

To prepare the stencil for the screen, the original illustration, or copy, must first be transferred on to a transparent sheet of film or tissue, hereafter referred to as the positive. This is most easily accomplished by preparing the drawing directly on a sheet of clear acetate or tracing vellum using an opaque drawing medium. A dense India ink works well for dot and line patterns, while a photoengraver's retouching paint is best for large, solid areas. Lithographic crayon may also be used for a fuzzier, more sketchy image. Whatever drawing medium is used, it is important to keep in mind that the image must be completely opaque. Dry-transfer symbols and letters or shading and pattern films may also be applied to a transparent surface and work very well when labels, graphs, or drawings with shaded areas are needed on an exhibit panel.

If the desired illustration cannot be prepared by drawing directly on a transparent surface or using the preprinted patterns and type, then a photographic process may be employed. With this method any black-and-white image can be transferred to a



TEXT-FIG. 8. The photographic silk-screen process. A, schematic view of a simple contact method for exposing the gelatin-coated stencil film with the positive using an overhead light source; B, developing the stencil film in a hydrogen peroxide solution; C, washing the stencil film to remove soft emulsion from the image; D, adhering the stencil film to the silk screen; E, peeling off the vinyl backing from the dried gelatin coating to open up the stencil; F, printing the design on the exhibit panel.

transparent film, and at any degree of enlargement or reduction. Drawings of any type, inked lines and stipples, scratchboard, or even pencil drawings and photographs with grey areas may be reproduced with precise fidelity.

To prepare a photographic positive suitable for the silk-screen process, the illustration must be photographed to produce a black-and-white negative with good contrast. The negative is then exposed in an enlarger to a high-contrast orthochromatic positive film to make a transparent positive on which appears the image of the original illustration. If the illustration has grey areas, or halftones, it must be converted during this photographic process into a dot pattern such as one might see when examining a newspaper photo at close range. This may be accomplished by sandwiching together the negative with a magenta screen in the photographic enlarger. The magenta screen is a sheet of film on which a fine grid-work of red lines is printed. A 133-line screen (133 red lines and white spaces per linear inch) works well for most purposes in which the final enlargement will be less than 85 lines per linear inch. When this is exposed along with the negative to a high-contrast orthochromatic film, the halftone areas are translated into a grid system of dots on the positive. More detailed discussions of photographic silk-screen techniques are given by Fossett (1959) and Chieffo (1967).

Another way to make a positive, which requires no photographic experience, is to use a machine for making overhead projector transparencies. Again, the image on these transparencies must be opaque and all halftone areas broken up into a dot pattern, or the finished print will appear fuzzy and indistinct. This method may only be employed when enlargement of the original is not necessary.

Once the positive is made, it is placed in contact with a light-sensitive, gelatin-coated vinyl film (such as 'Ulano Green' manufactured by the Ulano Company, 210 East 86th Street, New York, N.Y. 10028, U.S.A.) which is exposed to a light source, usually carbon arc, photo flood, or fluorescent. A photographic contact printing frame may be used to hold the films in contact during exposure; a simpler and usually adequate method is to sandwich the two films between a thin rubber or foam mat on a smooth surface for a backing, and a sheet of plate-glass as a covering (text-fig. 8A). Positives which have been screened are best exposed in a vacuum frame. This consists of a light table and a flexible vinyl-covered frame which is lowered over the film. With the addition of a vacuum, the positive is held in tight contact with the light-sensitive film.

During the exposure time, which varies according to the light source used, the clear areas of the positive allow the light to reach the gelatin and harden it. The opaque areas, on the other hand, block out the light and the gelatin remains soft. After the film is developed in a hydrogen peroxide solution (text-fig. 8B), the soft areas of the gelatin are washed off the film (text-fig. 8C). While still wet, the film is then pressed on to the silk screen (text-fig. 8D). After the gelatin dries and becomes firmly attached to the silk, the vinyl backing is peeled off (text-fig. 8E). The stencil is now complete and ready for printing.

If more than one colour is desired for the illustration, a positive for the additional colour and a separate stencil are prepared. Although there are many techniques for registering one colour over another, or to judge where the initial image will appear when it is printed, the easiest way is by manipulating the screen over the printing surface. A copy of the original design or the positive itself can be taped to the printing surface, and the screen with the stencil can be aligned to coincide with the taped-on image. The corners of the screen can be marked with pencil or chalk on the printing surface as a gauge for repositioning the screen during the inking process. This method is generally adequate for exhibit purposes since usually only one printing is required.

The silk-screen printing may be done either on a horizontal or vertical surface by placing a small amount of ink on one end of the screen. The ink is then carried across the screen by means of a rubber squeegee grasped firmly in the hand (text-fig. 8F). The printing process is described in more detail in Biegeleisen (1971) or any basic book on silk screening.

The term 'photographic silk screen', sometimes applied to the above described technique, is misleading, since the whole operation can be employed without the use of standard photographic equipment. While a positive prepared photographically may be desirable for producing some graphic images, it is not a requirement. Positives prepared without the use of photography by one of the other methods described can be used to produce graphic designs in a wide variety of styles. The major advantages of the silk-screen process are that it is one of the simplest ways of producing high quality and durable graphic designs or type on exhibit panels, it requires only a few inexpensive supplies, and it can be mastered by persons who have no 'artistic ability' or special training.

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T. L. CHASE

Exhibit Department
James Ford Bell Museum of Natural History
The University of Minnesota
Minneapolis, Minnesota 55455
U.S.A.

and

Chase Studio
Star Route 3, Box 133
Cedar Creek, Missouri 65627
U.S.A.