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Film 79

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FLYING WITH SUPERMAN

Film 79

Placing the ZOPTIC System within the context of other special effects methods of making a subject appear to fly, as was achieved with such extraordinary success in the recent filming of SUPERMAN

By ZORAN PERISIC

Of all special optical effects, the illusion of flying is probably the one most difficult to create convincingly. The key to this is to achieve a total freedom of movement of the object in flight within the background.

Standard optical process systems, which are used extensively at present, all have considerable limitations in this respect:

Colour difference—travelling matte process, usually referred to as blue-backing process, is not only very time-consuming and expensive, but has a major limitation in achieving a good coordination between the flying object and the background. Even with the use of Video to playback the background scene, it was difficult to achieve a good relationship between the background and the foreground.

A great number of shots were done in

this way for SUPERMAN, but only a few were used in the final film, because they could not be made to work successfully.

The image of Superman had to be reduced further on an optical printer from the point where the original move ended. This transition is difficult to achieve. Other standard drawbacks of this system are: loss of colour balance, lighting restrictions and the old familiar black line around the subject.

Blue is normally excluded from the wardrobe of artists when using blue backing—which of course was not possible in the case of Superman. The solution here was to make his tights out of a specific type of blue which was actually bordering on green in order to get a separation from the blue backing.

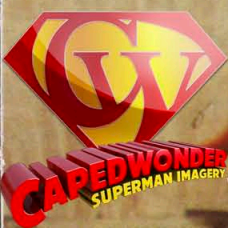
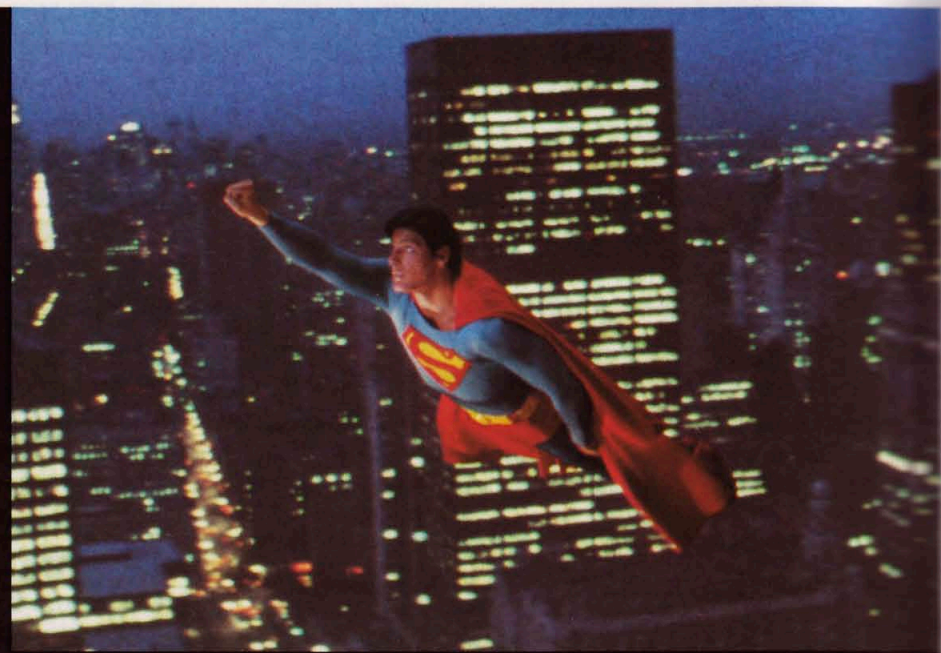
The only optical house which had been doing travelling matte work successfully closed down just at the time when

SUPERMAN was starting, so that all the work of this type had to be sent out to Los Angeles.

Back-Projection is another standard process which can be used for creating flying effects to a very limited extent. But because this system is the least flexible for this type of work it was not even attempted.

Front-projection, the natural successor to back-projection, offered much better possibilities. This process involves projecting a pre-filmed scene via a 2-way mirror onto a special screen. This screen is composed of a multitude of tiny glass spheres which are coated on the outside of one half and imbedded in the backing material with the clear half on the outside.

A light ray entering through this "window" undergoes total internal reflection and exits from the glass sphere along the



same axis as it entered. These light rays are picked up by the cameral lens behind the beam splitter. The nodal points of the projection lens and the camera lens must be in exactly the same relative position. The reflectivity of a screen made up of these tiny spheres is so great that even a white object placed in front of it will appear as a black silhouette in the projected background scene. This silhouette is, in fact, an instant matte of the subject. With the appropriate illumination, the subject can be made to blend in with the background.

When the projector and camera lenses are lined up correctly, the shadow created by the subject on the Front-Projection screen is not visible by the camera lens. If the alignment is incorrect, then a black fringe appears—the camera lens is seeing the shadow of the subject at that point.

Because Front Projection evolved from Back Projection, the equipment in use has consisted generally of the same heavy cumbersome projectors, modified so that the camera could be mounted onto the same base as the projector. This arrangement is perfectly satisfactory as long as the same type of work is attempted in Front Projection as had previously been done with Back Projection; i.e. static set-ups where the background is added to a suitable foreground action. The majority of standard process projector shots are of this type. However, when it comes to a flying effect, a different problem arises.

A subject such as an aeroplane or Superman, for that matter, has to be moved across the picture. Unfortunately, wires tend to show up in Front Projection. One way around this is to do an extra "cover" take of the background plate only and use this to eliminate the wires "optically".

The other problem with wires is that it is difficult to get a smooth enough movement. It is, in fact, for this reason that most model shots involving wires are done at high camera speeds. However, most standard process projectors do not have the facility to run in sync with the camera at speeds above 24 FPS.

Vibrating wires were tried out extensively on Superman. The main problem with this was the uneven pressure on the wires as Superman leans to one side. Even if it had been possible to make the wires invisible, there would still be the problem of physically moving a man from point A to point B at incredible speeds. This is difficult enough in a straight line, let alone when the man is expected to execute complicated manoeuvres. There were occasions when Chris Reeve was thrown into a net placed at the end of the

track to stop him from going through the studio wall! The swing on a curved track is unpredictable and often he came to within inches of hitting parts of the set!

Ideally, the subject would be suspended in the air by some invisible means. One such method is to put a pole through a hole in the Front Projection screen which is fixed to a rigid base on the other side of the screen. The model is attached to the other end of the pole. The camera lens is placed in line with the pole and the model acts as a mask for it. A knuckle-type joint is used to make the model pitch and yaw. The pole can also be made to rotate.

This arrangement works very well in certain situations where the subject is seen stationary and the impression of speed and direction of flight is conveyed by the background. However, this is all that could be done with the standard Front Projection approach. The subject could not move across the frame because it is fixed to the pole, but if the entire Front Projection machine (i.e. projector and camera) is panned from side to side, the subject appears to travel across the frame. Tilting the camera/projector compound makes the subject appear to go up or down in the frame. This, coupled with manoeuvrability of the subject does make for a much more realistic flight effect. The projector/camera compound has to be sufficiently small to enable it to be manoeuvred in this way.

A lightweight projector was built by Jan Jacobson for SUPERMAN which could be mounted on a geared head. By using two geared heads crossways, panning, tilting and rocking movements could be accomplished. By this means, Superman could fly across the picture and up and down, but always in the same plane. He could not be made to fly "in depth" through the picture towards or away from the camera. In order to make him fly really convincingly he has to do just that—to move "in depth". This is, of course, physically impossible to any useful degree using the pole, even with a model, let alone a person. Flying him on wires was still the only way, despite all the drawbacks. However, the very idea of a physical movement in depth by whatever means is doomed to failure because it goes against the golden rule of Front Projection. The subject should be kept closer to the screen than to the camera wherever possible, otherwise serious "fringing" problems occur; the reason for this is quite simple—the shadow of the subject will have softer edges as the subject is moved away from the screen because it is related to the depth of field of the projection lens.

Since the shadow of the subject is, in fact, its matte, it is impossible to match a

soft edge of the shadow with the sharp clean edge of the subject, unless the subject is allowed to go out of focus proportionally also. However, this would be defeating the object of the whole exercise.

Therefore, the only way satisfactory results can be achieved is to keep the subject as near to the screen as possible and avoid any appreciable movement towards the camera. Yet on the other hand, without movement "in depth", the whole illusion of flying cannot be achieved successfully.

This is where ZOPTIC came in. This system makes the subject appear to move towards or away from the camera while it is in fact stationary. This is accomplished by using two matched zoom lenses in synchronisation—one on the projector and one on the camera. The size of the projected image is altered with the zooming action of the projector lens, but the corresponding zooming action of the camera lens cancels this out, so that through the camera viewfinder the background appears to be a constant size. Meanwhile, the subject is only affected by the zoom action of the camera lens and appears to grow in size as the lens zooms in. It is this apparent increase in the image size of the subject against a "constant size" background, which creates the illusion that the subject has moved closer to the camera, whilst the real physical distance between the two in effect remains unchanged.

The Neilson-Hordell projector, which was able to take the ZOPTIC system, proved to be too limiting for certain manoeuvres. The original rig, although quite small by normal standards, was really designed for general purpose Front Projection and not exclusively for flying. On the instigation of the Director of Photography, Denys Coop, and with the enthusiastic backing from Richard Donner, I designed the flying rig which can be mounted onto two geared heads set at 90° to each other. This way, Superman could be made to fly in any direction, as well as towards or away from the camera. He was at last free of any restrictions and virtually all Front Projection flying shots were done on this rig. Even for close-up shots, ZOPTIC was used constantly to produce subtle changes, adding more realism to the flight as though Superman was being photographed from an aircraft flying in front of him.

Following a series of tests, the first production shot to be done with ZOPTIC was the long shot of Superman and Lois Lane flying around the Statue of Liberty. Judging by the reaction of the director and the producer, it became obvious that the Flying Unit had made a breakthrough. Superman could really fly! ■

MODERN TECHNIQUES OF OPTICAL TRICK CINEMATOGRAPHY

Film 79

How basic optical illusions are created on film, and the methods of assuring that the most suitable rolls of film stock can be selected to obtain the best possible results in the field of special effects

By ROY FIELD and TONY ILES

What is Optical Trick Cinematography? It is the art of combining two or more images shot independently into one piece of film.

In the very early days of cinematography, film-makers were super-imposing images in original photography by double-exposing the negative to achieve a composite result. These appeared as ghost images, which although very acceptable for certain effects, did not meet every requirement. Gradually, more sophisticated optical effects were dis-

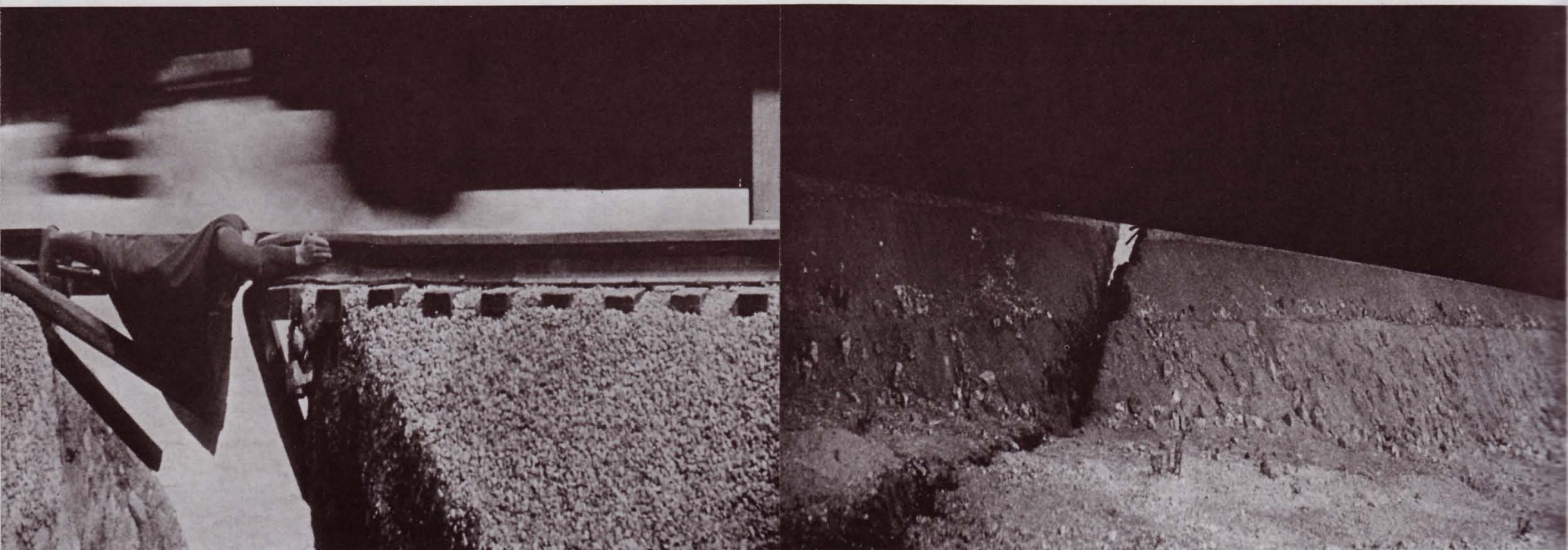
covered and used. In recent years there had to be an improvement in the techniques used for optical effects, as the quality and resolution of the film, and the sudden increase in screen sizes, made the work of the optical specialist more and more difficult.

Nowadays, with techniques such as travelling matte, rotoscoping, forcing high contrast mattes for bright objects, etc., it is possible to get more and more sophisticated opticals using the optical printer. With the fine-grain stocks avail-

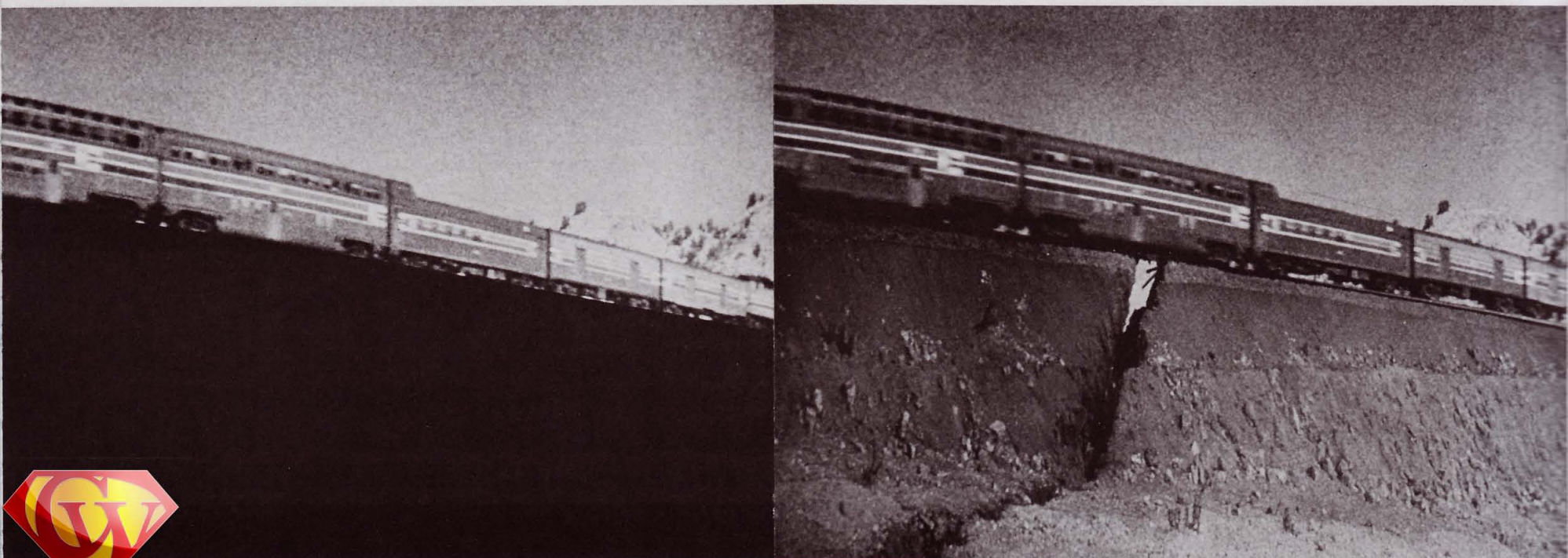
able (both negative and print) and modern high-resolution lenses, improved lens coatings, and projection onto large screens, it has become increasingly important to achieve the highest possible quality duplicate negatives for the preparation of optical special effects.

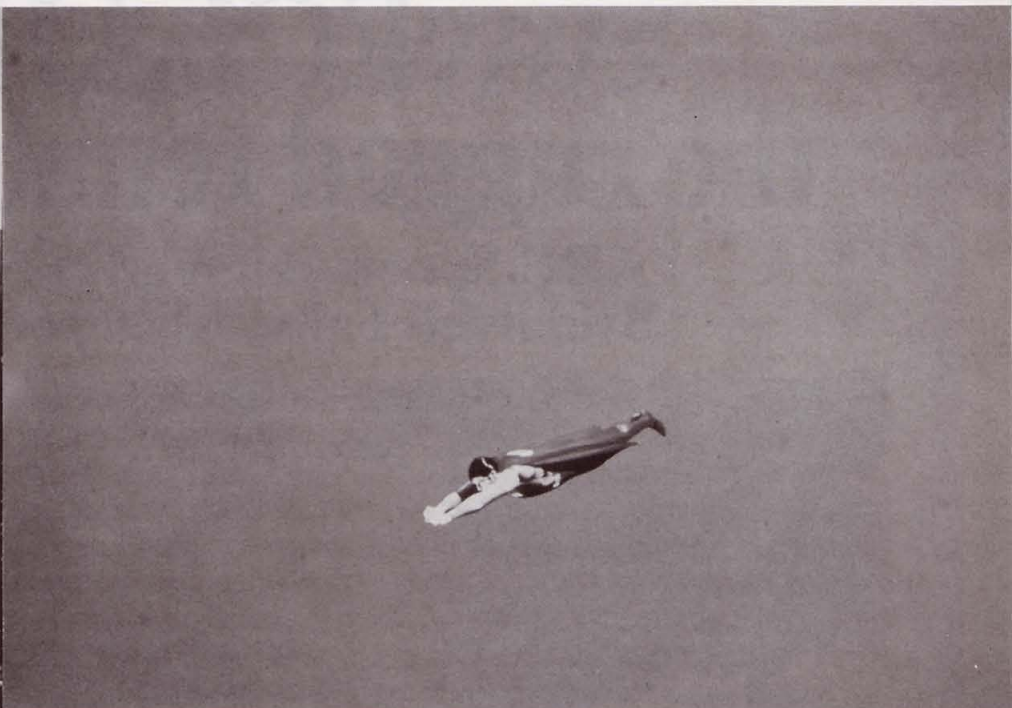
A fundamental technique in optical trick cinematography is that of the travelling matte. In this, typically, an actor in the foreground can be superimposed on a background scene, in a way that could be

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(LEFT) During the making of **SUPERMAN**, a scene was shot involving Christopher Reeve as Superman, bridging a gap in the railroad track with his body to save the train from derailing. (RIGHT) The lower sections of the scene were shot on the stage at Pinewood Studios. (BELOW LEFT) The top half was shot by an entirely different crew in America many months later. By locking down both cameras rock-steady and paying precise attention to lens angles and other details, the two scenes could be "married" successfully in the optical printer.



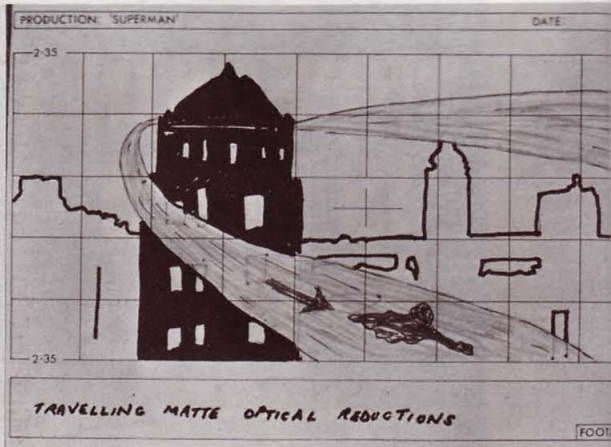
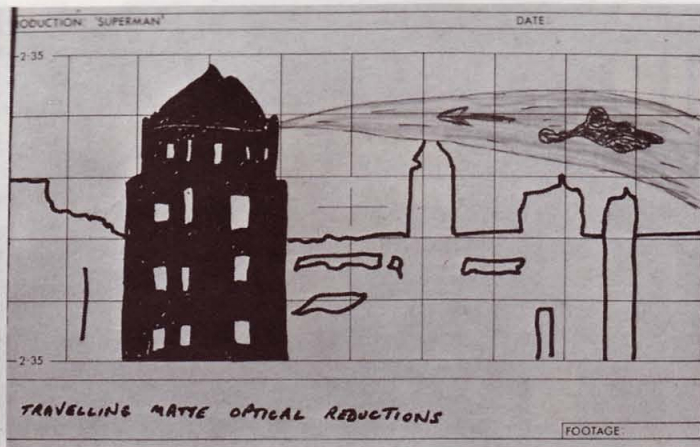


(LEFT) A fundamental technique in optical trick cinematography is the travelling matte. It was used to produce the illusion of Superman flying over the city of New York, and the progression started with this background scene of the skyline. (RIGHT) Next, Christopher Reeve was photographed "flying" against a special blue background. Great care had to be taken to make the blue of his costume sufficiently different from that of the background so that separation could be achieved.



(LEFT) From the shot of Superman against the blue background, an exposure was made to generate an opaque mask, or matte, of the figure against a clear background. (RIGHT) This matte was bi-packed in contact with the background scene of New York and printed onto a piece of internegative film. (BELOW LEFT) The blue background was held back by bi-packing it with a reverse mask, known as a *counter matte*. (RIGHT) The finished composite optical effect, with Superman printed into the "hole" in the background scene.





(LEFT) To shoot a scene of Superman zipping behind buildings, a background "plate" of New York with the tower block in the mid-distance was shot. (CENTER) Superman was reduced in size by a combination of zoom lens and optical printer, and he had to be panned in the optical printer to create the illusion of his sideways flight. (RIGHT) The third stage was his flight back to the camera, after having disappeared behind the tower, reappearing in front of it.

TRICK CINEMATOGRAPHY

Continued from Page 892

difficult or inconvenient to arrange as a real situation: as, for instance Superman flying over New York. Here we would take a picture of the background scene, and a picture of Superman, flying against a special blue background. From this, we would expose to make an opaque mask, or matte, of the figure, against a clear background. This would be bi-packed in contact with the scene of New York and printed onto a piece of internegative film.

If a print were made from it at this stage, it would show a replica of the scene, but with exposure held back in the shape of Superman. In fact, the picture of Superman is printed into this unexposed area, the blue background being held back by bi-packing it with a reverse mask—known as the counter-matte. The final result is the required composite picture.

In practice travelling mattes are often much more complex than the simple case illustrated, with ten or more separate elements combined onto different areas of the field of view within a sequence.

The background colour is chosen as one that is unlikely to occur—or can be avoided—in the foreground subjects, so that the background can be eliminated when the matte is made. Of the colours that can be used, red, green or blue, the blue is the most suitable in relation to the film emulsion characteristics. This led to some delicate work in choosing the exact shade of material for Superman's costume, that could be separated from the background.

Picture negative steadiness has its part to play in obtaining a high-resolution result. If exact registration does not occur the result will be unsatisfactory and the effect spoiled.

Let us consider a famous sequence in the film *SUPERMAN*, where Superman is flying across New York looking for



To select perfectly perforated holes for special effects work, four consecutive pairs of punched holes are gauged, using a standard Mitchell pin. The film is held horizontally in a special clamp. Then the pin is carefully inserted from below. Holes are sought that will grip the pin snugly and prevent it from slipping under gravity. (BELOW) If one such pair are found, they are marked and the camera assistant will thread the camera so that the register pin enters the marked hole.



Luthor, who is hiding in his lair. He enters frame top camera right passing the camera very closely and then flies away to become a very small figure in the distance. Then he disappears behind a large tower block, reappears on the other side coming toward us and flies right into camera and dives at the last moment out of frame, camera right. This complex optical was a combination of travelling mattes of Superman, and optical moves.

The shot was broken down into sections. First of all, the plate of New York with the tower block in the mid distance. Secondly, Superman flying away from camera against a blue backing, basic flying moves here being obtained by using a zoom lens. A Panavision 50-500 anamorphic was use which gave a 10-to-1 reduction. Then on an optical printer we started reducing on a colour reversal internegative (CRI) from the first frame that Christopher Reeve was completely in frame and carried on the reduction on the optical printer getting a further 7-to-1 reduction until the point where he disappeared behind the tower block. Also during this optical move, we had to pan the optical printer to make his sideways flight. The third stage was his flight from the tower back to camera which was achieved by using the same process in reverse. After that, a matte was made of the tower, by delineation, so that Superman disappeared behind the tower which was on the background. When all these sections had been completed, the normal travelling matte process was carried out to superimpose Superman onto this background.

On SUPERMAN, many different systems of special effects were employed: front projection, back projection, high-speed photography, micro-photography, double-exposure techniques, and so on. Travelling matte was just one of the composite cinematography systems used.

It is obvious when considering the number of moves both in the original photography and on the optical printer, that complete control must be enforced at all times. A closed-circuit video system for overlaying Superman against the plate at the time of shooting the travelling matte photography was found to be a tremendous help, particularly for judging the angle of incline of Superman during his flight. These inclines, attitudes and banking movements cannot be changed later. On many occasions, to get Superman small enough, it was necessary to make a double CRI on the optical printer.

During the making of SUPERMAN, a scene was shot involving Christopher Reeve as Superman, lying in the railway track bridging a gap in the line so that the wheels of the train passed safely over his body. The lower sections of the scene

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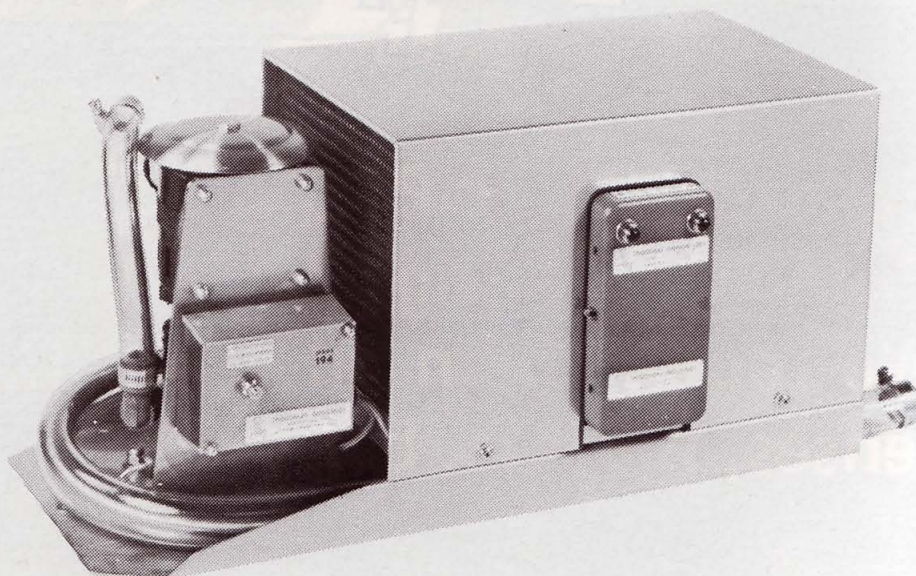
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were shot on the stage at Pinewood. The top half was shot by an entirely different crew in America many months later. Now, it was essential that, not only should both halves be rock steady but also both components should match in perspective, lighting, contrast and detail. To achieve this, measurements were recorded during the first shooting, of lens

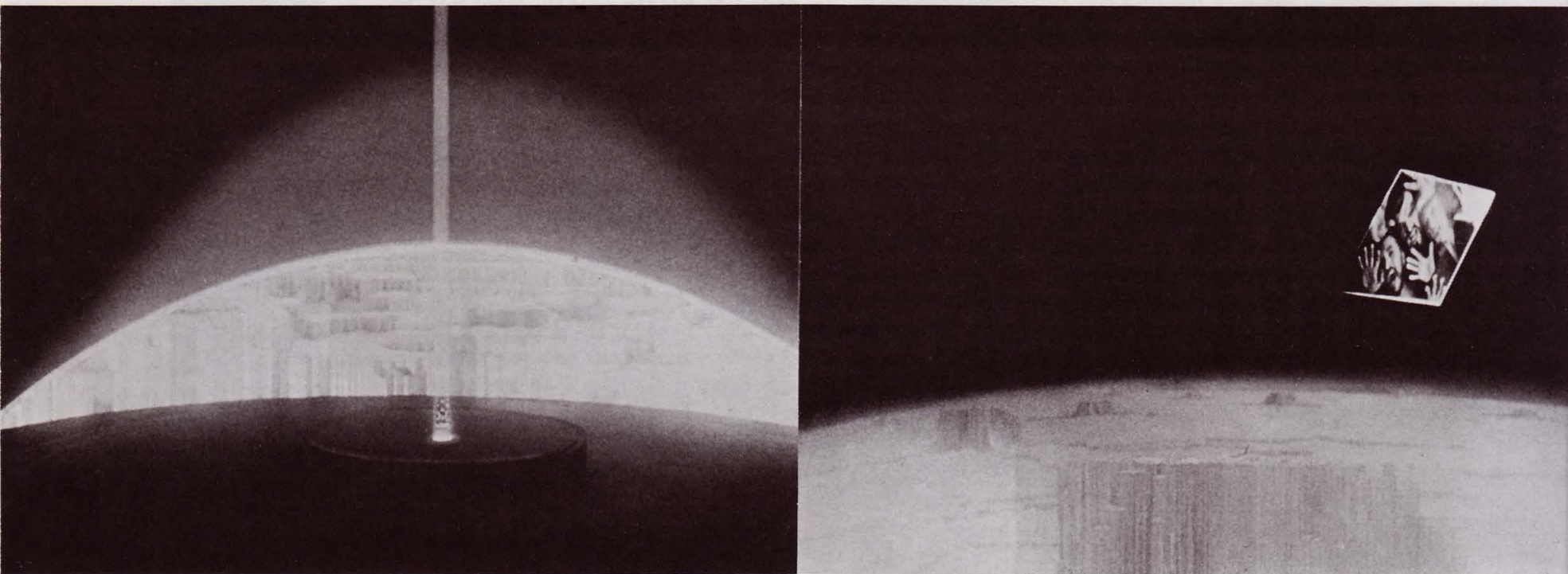
heights, distance from camera to railway, elevation and tilt of camera, lens angles, key light direction and any other relevant information. All these facts were then used in America to line up and shoot the real train speeding along the railway-line and the job in the optical printer was then comparatively easy.

It is obvious that strict control must be

maintained over all components of an optical shot. It must also be noted that if there is any picture negative unsteadiness on either component, the final composite will not be satisfactory and the whole illusion ruined. It can be seen from this that steadiness in the original photography is of the utmost importance.

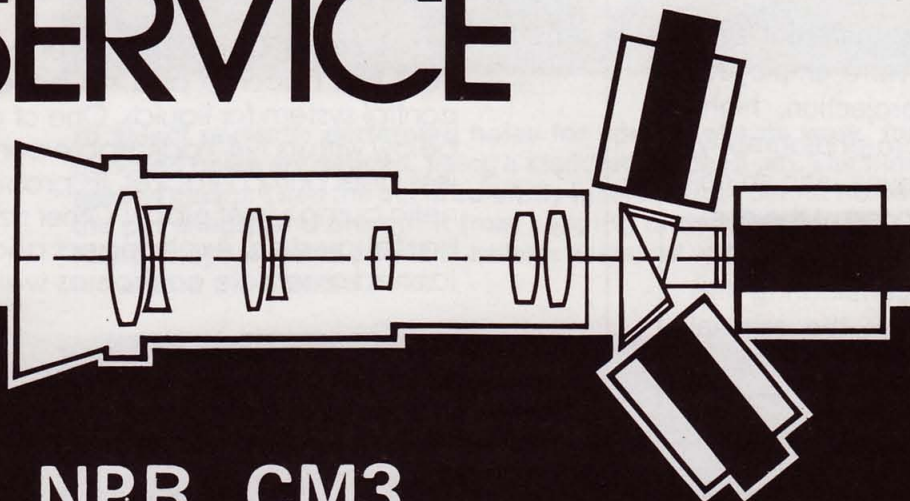
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(LEFT) A complex early sequence in **SUPERMAN** showed three villains being held captive by the council of elders of Krypton in a beam of light with revolving rings. (RIGHT) When they were sentenced to eternal imprisonment, a strange diamond-shaped object had to descend from space, collect them and take them into orbit around Krypton. This involved optically printing together five separate scenes, with their respective mattes.



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TECHNIQUES OF OPTICAL TRICK CINEMATOGRAPHY

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The camera must be steady tested. The Mitchell camera with its pin registration system is an ideal camera. This system holds the film firm, located on registration pins, positively steady at the moment of exposure. Many high-speed S35 Panavision cameras from Samuelsons were used in the making of SUPERMAN with excellent results. The sequence on the railway line was a relatively simple optical involving only two elements which had to be split-screened with the use of complementary mattes. Many other opticals in the picture involved numerous components which, on occasion, had to be moved, tracked, zoomed or faded on the optical printer.

One of the most complex opticals made was the sequence early in the picture where the three villains were held captive by the council of elders of Krypton in a beam of light with revolving rings. When they were sentenced to eternal imprisonment a strange diamond-shaped object had to descend from space and collect them and take them into orbit around Krypton. John Barry's design for this, the Phantom Zone, was a diamond-shaped, flat object with immense depth. To create the effect of the actual collection meant shooting it in separate parts. Firstly, the villains waiting in the rings. Secondly, the empty Phantom Zone; thirdly the Krypton surface; fourth, the villains shot for their containment in the Zone after the collection and finally a spinning shot of the villains. This was done by spinning the camera, as to spin optically in an anamorphic process does not work. All these components had to be mixed together with rotoscope mattes to print the Phantom Zone over the Krypton landscape, dissolving one to another. This optical was achieved with CRI techniques which resulted in the highest possible quality.

Let us now consider how the film stock is manufactured, and how this can affect the making of optical special effects. An understanding of this can considerably assist the special effects cinematographer.

Eastman Colour Negative film is coated onto rolls of triacetate base which are about five feet wide and in multiples of 2000 feet long. Normally five or more rolls are coated in sequence, as a batch. Each of these parent rolls is slit into either 35mm or 16mm strips—the familiar strip number is the position of the strips across the original parent roll. The slit rolls are then distributed around a bay of perforating machines, (maybe up to twelve separate machines), where they

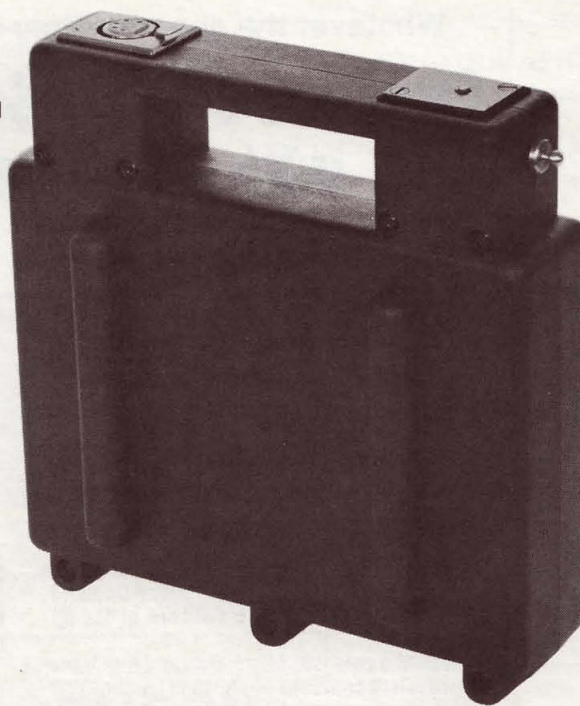
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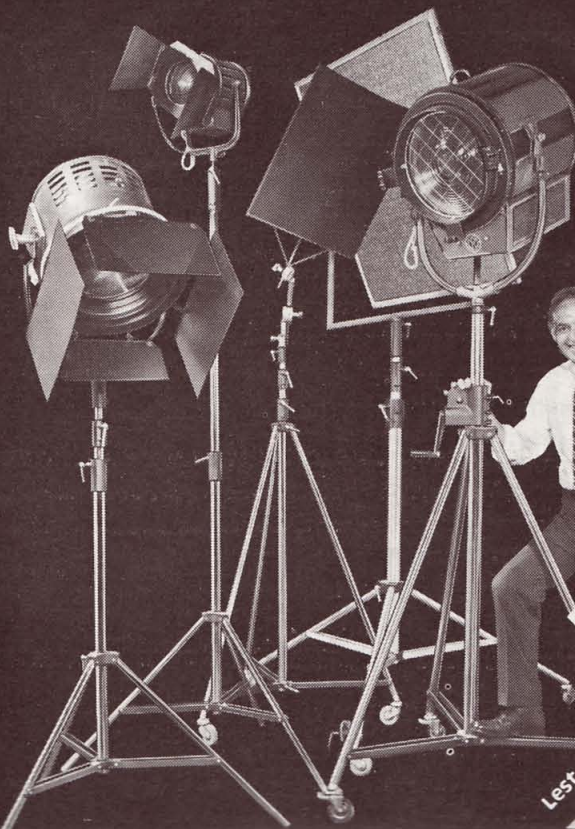
In this partial view of Charger, red and green lights are both on, showing trickle-charge mode.

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are punched one frame (four pairs of holes, for 35mm) at a time. Finally, after a rigorous inspection, the perforated strips are cut down to length as required, and packed into cans. The labels are marked with the emulsion batch and parent roll, and the individual strip number.

The perforating process is extremely accurate—accuracies being of the order of tenths of thousandths of an inch, as defined by the international standard for Bell and Howell 1866 negative perforations, and the eight hole at a time punching operation is deliberately chosen to be consistent with the frame-by-frame camera operation.

In practice most of the perforating dimensions remain the same throughout the life of a manufacturing machine set-up. However, the hole size increases progressively throughout the life of the machine, as the back surface of the film wears away the die during the cutting process. The hole is therefore started at the lower end of the Standard tolerance range, and the machine is taken out for resetting before the top end of the tolerance range is reached.

From experience it has been found that the lower half of the permissible hole size is best for critical optical combination printing. Part of the control system that we have developed over the years involves visual checks of the perforations carried out in the camera room to select the best fit onto the pins of the camera.

The roll of film is put into a camera magazine, with the end protruding. Perforating machine information may be stamped onto this, and this information is noted. Four consecutive pairs of punched holes are then gauged, using a standard Mitchell pin, in the following manner. The film is held horizontally in a special clamp, and the pin is carefully inserted from below, a lens being used to ensure that the pin is presented with its sides parallel to the perforation walls. Holes are sought that will grip the pin snugly, and prevent it from slipping down under gravity (a small brass weight is fitted to its base). If one such pair of holes are found, these are marked and the film is returned to its can. When the roll is to be used, the camera assistant will lace it in the camera so that the register pin enters the actual marked hole.

Obviously, within the same consignment of film, there will be no point in gauging other rolls from perforating machines that gave large holes only, while those with "all o.k." holes will be gauged for preference.

Similarly, when 400' rolls are being used, those with the same roll and strip numbers will have been cut down from the same parent strip, and can be considered to be identical.

The method described is very much a "craft" operation, and is a form of go/no-go gauging, rather than an attempt at precise measurement, but its effectiveness has been very well borne out in practice.

It is well known that changes in humidity can affect the film dimensions, although the gauging system evidently incorporates sufficient latitude for the variations encountered in normal working conditions where humidity control equipment is a rarity, but an inexpensive relative humidity indicator is a good investment, to avoid gauging during periods of extreme humidity conditions.

Checking the rolls is a tedious process but extremely worthwhile, and we are indebted to Jack Greenfield, chief mechanic at Pinewood Studios, who so patiently advises on the stock. It has been found that about 80% of the stock checked gave snug-fitting perforations on at least one pair of holes. No stock that has been checked has fallen outside the British Standard, which is of great credit to the manufacturers and terms such as "good film" and "bad film" are at the very least misleading, as what we are referring to is the smaller fraction of the hole size distribution, which is found to be necessary for travelling matte work.

Clearly it is going to be safest to select the estimated number of rolls required for critical optical work as soon as possible after the batch of film has been received, as later in the production schedule you may easily be left with only the larger-hole fraction.

The nature of optical work relies upon the fact that, when two films are double-exposed together, neither one moves against the other. Our experience is that the full range of the British Standard tolerances for perforation hole size does not guarantee suitable stock for this kind of work unless some system of pre-selection is used. In the past the manufacturers have made attempts to select rolls of film destined for optical effects work at the time of manufacture. With the increasing demands for opticals this proved to be very difficult to control and give a guaranteed result, and each roll still required a test before use. Furthermore, by the time that a production has been planned it often happens that the batch of film that is to be used has already been finished and packed some months before.

In the course of work carried out during the making of SUPERMAN, a series of measurements on hundreds of perforating machine outputs indicated that with the general improvements in production controls that have come about in the last ten years, stock from any particular perforating machine (which can be identified

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from the information stamped and printed on the films) can be tested by gauging or by optical camera testing, and the result will be totally representative of all the output of the same machine in that production consignment, as this represents only a short time in the total life of a perforating machine set up. Furthermore, an analysis confirms that, on average, the 80% success rate of finding stock with at least one pair of holes in the lower half of the Standard tolerance range is supported.

It is comforting to know that a simpler and less tedious system is possible, i.e. testing one roll from each perforating machine used, and accepting without further tests all other rolls from a machine that gave a roll with "all-o.k." holes. For expensive set-ups like those involved in SUPERMAN, we are likely to stay with the assurance of gauging every roll, although the perforator identity can certainly be used to assist "pre-selection" of the rolls which will be gauged. The operation would become very much easier if the manufacturers could find a method of marking perforator identity on the outside of the can, thereby eliminating the need to open every one and sometimes even to have to process a piece from the end, to identify the machine. It certainly seems reasonable, however, that work with slightly less critical subject matter could be successful with the simpler selection method, and for scenes without optical combination work all film within the Standard tolerance is perfectly satisfactory. ■

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