FRONT SCREEN PROJECTION AS A FILM PRODUCTION TECHNIQUE

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ABSTRACT

FRONT SCREEN PROJECTION AS A
FILM PRODUCTION TECHNIQUE

By

David L. Kelley

This thesis is a description and discussion of front screen projection used primarily as a film production technique. It is accompanied by a film entitled "MASKS," which demonstrates the use of front screen projection. The film also demonstrates some of the problems encountered in its use.

A definition of front screen projection is given (a method of achieving a high quality composite picture in which the background is projected from in front of the screen rather than from behind it), followed by a description of the primary elements that make up a front screen system, i.e., the screen, the beam splitter, and the beam splitter mount--camera/projection stand.

The author's experience with front screen projection is discussed in terms of a front screen system he helped set up for the Washington County Board of Education in Hagerstown, Maryland. Talked about are the reasons for setting up the system, along with the technical problems

encountered in doing so. An important element here is the discussion of the beam splitter mount that was designed and built by the author and his co-workers especially for this system.

Set up and operational procedures for a front screen system are discussed, including setting up and checking for proper alignment between the camera and projector, obtaining a proper exposure, lighting, talent, and camera movements.

In the Appendix is included a list of advantages and disadvantages of front screen projection as compared with rear screen projection, a short history of front screen projection, the major patents covering most of the front screen systems in use today, a set of drawings showing the beam splitter mount built in Hagerstown, some comments concerning the accompanying film, and a short list of companies that either sell, rent, or use front screen projection in actual production.

It is the author's opinion that front screen projection is indeed a valuable tool in film (and television) production. It does many of the things normally done before with rear screen projection, and does them as well, if not better, with a significant saving in costs.

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FILM PRODUCTION TECHNIQUE

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David L. Kelley

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Director of Thesis

An integral part of this thesis is the film entitled "MASKS," which is on file with the Department of Television and Radio, Michigan State University.

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INTRODUCTION

This paper is a discussion of a relatively new film production technique called Front Screen Projection.

The information contained herein is, to a large degree, based on personal experience. It includes a definition and description of front screen projection, set-up and operational procedures, a discussion of the author's exposure to front screen projection, some of the advantages and disadvantages of front screen projection as compared with rear screen projection, and a short history of front screen projection.

The paper is supplemented by a fifteen minute film entitled "MASKS." It is an instructional film used by the Washington County Board of Education, Hagerstown, Maryland, as part of their junior high and high school art curriculum.

I feel that the information contained in this paper will be of particular interest to the small film producer working with a limited budget, or in limited studio space. It provides him with information about a relatively simple and inexpensive technique for obtaining realistic settings and backgrounds, and/or special effects, through the use of composite photography. Front screen projection is much easier to use, much cheaper to use, and much less cumbersome than rear screen projection, and will give consistently good results with fewer potential problems than with rear screen projection.

CHAPTER I

FRONT SCREEN PROJECTION--DEFINITION AND SHORT DISCUSSION

Front screen projection is somewhat of a slang term used in the film industry to describe a method of achieving a high quality composite picture in which the background is projected from in front of the screen rather than from behind it.

A more technically accurate term would be "reflex projection composite photography."[1] This becomes rather unwieldy however, and I feel that the name front screen projection adequately describes the end result.

There are three basic elements that make up a front screen projection system:

1. A retro-reflective projection screen, in front of which actors perform, and which reflects a very high percentage of the projected image directly back towards the apparent light source.

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[1] Philip V. Palmquist, "Retro-Reflective Screen for Reflex Projection Composite Photography," American Cinematographer (July, 1969), pp. 688-690.

2. A beam splitter, which is in essence a two-way front surface mirror. It is placed at a 45^{o} angle in front of the camera and projector with the reflecting side facing the projector. Its basic purpose is to allow the projected image to be positioned along the optical axis of the camera lens. This is essential to the operation of a front screen system.

3. A sturdy support system for the camera, projector, and beam splitter. This system must allow precise adjustments of the camera and projector in all directions in order to maintain their positions along the same optical axis. Ideally, it should allow adjustment of the beam splitter also.

What are the requirements of a front screen projection screen? They are not many, but they are demanding. It must be a highly efficient screen, reflecting as bright an image as possible. It must be uniformly bright with no hot spots, reflecting light striking it from oblique angles as efficiently as it does light striking it at right angles. It must absorb as much ambient light as possible, from set lights etc., in order to minimize possible image wash out.

The standard projection screen, designed to reflect an image bright enough to be seen in a darkened theater by an audience viewing it from many different angles, cannot meet these requirements.

In the late 1940's, Minnesota Mining and Manufacturing (3M) introduced a new material called "Scotchlite." More recently they have developed "SCOTCHLITE" Brand High Gain Reflective Sheeting #7610, which is an improvement over the old "Scotchlite." 3M describes the product as follows:

> "SCOTCHLITE" Brand High Gain Reflective Sheeting #7610 is a plastic sheeting containing extremely small spherical glass lenses which are uniformly bonded at their equators. The optical glass lenses function as microscopic spherical mirrors which focus and return (retro-reflect) incoming light rays directly back to the light source. The reflective surface appears neutral gray under ambient light. The sheeting has a pressure sensitive adhesive on the reverse side which is covered with a removable paper liner.[2]

Table 1 demonstrates the optical properties of "SCOTCHLITE" Reflecting Sheeting #7610.

What all of this means, in terms of the requirements for a front screen projection screen, is that the screen material now available is extremely efficient. The gain over a perfectly diffuse white surface is approximately 1600. It means that the loss in gain at very oblique angles is negligible. It means that the image is only minimally affected by ambient set light. It means that there is now available a good front screen projection screen material. "SCOTCHLITE" Reflective Sheeting #7610 is the most widely used. There are other types, such as the Alekan-Gerard type, but their characteristics are essentially the same as #7610, so they need not be discussed separately.

The retro-reflective characteristics of these new screen materials accomplish three important things:

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[2]Minnesota Mining and Manufacturing Company Product Bulletin, <u>Remote Sensing Systems, "SCOTCHLITE" Brand High Gain Reflective Sheeting #7610</u> (March, 1971).

TABLE 1.--Optical Properties of "SCOTCHLITE" Reflective Sheeting #7610.[a]

TABLE 1 - LUMINANCE FACTOR VS. INCIDENCE ANGLE

Angle of Incidence	0°	10°	20°	30°	45°
Luminance Factor	590	595	620	660	710

TABLE II - LUMINANCE FACTOR VS. DIVERGENCE ANGLE

Angle of Divergence	0°	1/4°	1/3°	1/2°	3/4°	1°	1-1/2°
Luminance Factor	1610	1280	1090	590	195	115	55

Notes:

All readings in Table I were taken at an 0.5° divergence angle. All readings in Table II were taken at a 0° incidence angle.

The incidence angle is the angle formed by a light beam striking a surface at a point, and a line perpendicular to the surface at the same point.

The divergence angle is the angle between the line formed by a light beam striking a surface, and the line formed by its reflected beam.

"SCOTCHLITE" Brand High Gain Reflective Sheeting #7610 has the retro-reflectance values listed in the above tables. The values are expressed as a multiple of the brightness of a perfect [sic.] diffuse white surface. This multiple is shown as the luminance factor. These values were obtained from retro-reflective measurements of a typical sample of #7610 Sheeting.

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[a]Minnesota Mining and Manufacturing Company Product Bulletin, Remote Sensing Systems, "SCOTCHLITE" Brand High Gain Reflective Sheeting #7610 (March, 1971).

1. The gain is so high that those portions of the projected image that fall on foreground objects are not seen by the film.

2. The reflected image is bright enough to allow the camera to film at a relatively small aperture. This increases the depth of field, giving the actors much greater freedom.

3. Because the image is virtually unaffected by ambient set light, the problem of image washout is much less severe.

At this point it should be explained further just why that part of the image that is projected onto talent and other foreground objects is not seen. There are two elements involved here, both of which are the result of the characteristics of the retro-reflective screen.

First, the difference between the brightness of the image reflected from the retro-reflective screen and that reflected from the talent and most other foreground objects is greater than the latitude of the film, and hence generally beyond the capability of the film to record it.

If there are no set lights on, the talent and foreground set will be sillhouetted against the projected background. Under this condition it is possible that certain portions of the projected image would be visible on the talent and other parts of the set. They would probably appear as mottled splotches of light. This brings us to the second element, that being set lighting. Once the set is properly lit and balanced against the projected background, the combined effect of the above-mentioned difference in image brightness, and the bright set lights washing out what little image is reflected, will result in the fact that those portions of the projected image falling on talent and other foreground objects are invisible.

The second basic element in a front screen projection system is the beam splitter. As I said above, it is basically a two-way front surface mirror. It is placed in front of the camera and projector at a 45^{o} angle with the reflecting side towards the projector (see Figure 1). The projected image is reflected off the beam splitter onto the screen, and the camera shoots through the beam splitter to film that image. Its function is to allow the projected image to be positioned along the same optical axis as the camera lens. Put another way, it allows the camera and the projector to operate along the same optical axis so that the camera becomes the apparent light source. The precise alignment of the camera and projector along this common optical axis is extremely critical and important, for this is the basic principle upon which front screen projection operates. The beam splitter, by allowing the camera and projector to operate on a common optical axis, accomplishes two things. First of all it is the function of the retro-reflective screen to focus and reflect most of the light striking it, i.e., the image, directly back to the light source. The camera then, being the apparent light source, is able to film

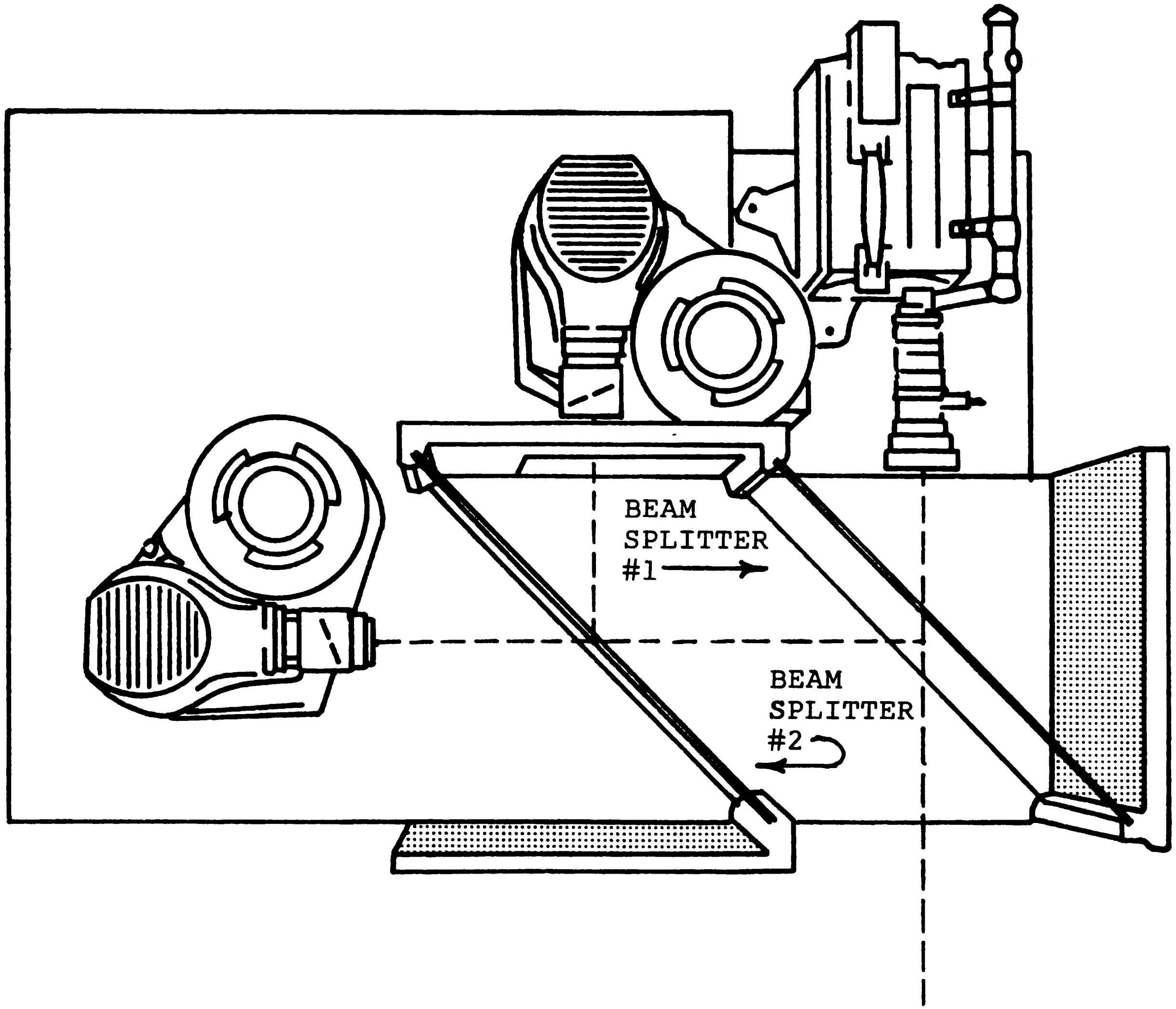

Figure 1.--Beam Splitter Mount--Camera/Projector Stand.

the brightest possible image. Secondly, proper alignment along this common axis insures that the shadow cast by foreground objects (talent etc.) is cast directly behind them, with no matt fringing of the shadow being visible. The visibility of a matt shadow immediately indicates that the system is out of alignment. It significantly lowers the quality of the composite picture, in most cases making it unacceptable.

A matt shadow is quite visible in one of the scenes in the film "MASKS" which accompanies this thesis. It occurs when the camera moves diagonally down and to the right and zooms all the way in to show a close-up of one of the masks sitting on a pillar. The narrator describes the mask as a skull that had been covered with plaster and then decorated. Another shadow occurs a little later when talking about a New Guinea mask. Again, the camera is in tight for a close-up. In both cases the shadow was the result of the camera movement throwing the system out of alignment. It was deemed acceptable because of other production problems, and because it was so far out of focus. But it seriously lowered the quality of the composite picture, and significantly compromised the quality of the final film.

There are various kinds of beam splitters ranging from a thin sheet of flashed plastic called a pellicle to to the standard two-way front surface mirror.[3] Theoretically almost anything that can reflect and transmit light at the same time can be used as a beam splitter so long as the reflectance-transmission ratio is within workable limits, so long as it is absolutely flat so that it doesn't distort the reflected image, and so long as it generally reflects a high quality image.

The reflectance-transmission ratio is an important factor. There is no specific ratio for all cases, but generally speaking it should probably be somewhere around 50 per cent reflectance, 50 per cent transmission. It should be tailored to the needs of the individual system however. Of course the more it reflects the less it will transmit, which means a larger exposure compensation either in the aperture setting or in the lighting. The reverse of this is also true. The more it transmits the less it will reflect.

This may create a need for a higher wattage projection bulb, which in turn leads to a possible noise problem due to the larger cooling fans required on the projector.

To a large extent the quality of the projected image is determined by the beam splitter. It is recommended that as high a quality beam splitter as possible be used, for the front screen projection system is

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[3] Raymond Fielding, The Technique of Special Effects Cinematography (New York: Communication Arts Books, Hastings House, 1965), p. 313.

highly analogous to the proverbial chain and its weakest link.

The third basic element in a front screen system is the beam splitter mount, which, in most cases, is also the camera/projector stand (see Figure 1). This is an important element because of the highly critical nature of the alignment between the camera, the projector, and the beam splitter.

What are the requirements for such a stand? First of all it should be sturdy. Any movement or vibration of the camera and/or the projector and/or the beam splitter is unacceptable. If the system should move, or vibrate, out of alignment it will cause a visible matt shadow. This could create the rather novel effect of the background moving, which can be shocking in some cases. Secondly it must allow for the easy adjustment in all directions of the camera and projector. Ideally it will also allow for the adjustment in all directions of the beam splitter, but this type of mount can get to be a bit complicated.

Generally speaking it is probably better to have the beam splitter mount and the camera/projector stand combined into one unit. This allows for more precise adjustments, and fewer potential alignment problems.

An additional element that needs some consideration at this point is the type of equipment to be used in terms of cameras and projectors. Almost any kind of camera can be used, so long as it will take a picture, and so long as it will fit on the stand so that it comes into proper alignment. Naturally the better the camera and lens, the better the end product, but this choice is best left up to the individual producer.

To a large extent the same holds true for the projectors. First of all we will assume that 2x2 slides are to be used for the background, rather than motion pictures. Provided it will fit on the stand properly almost any projector will work. The amount of gadgetry on the projector to help accomplish dissolves, supers, etc. is up to the individual producer. Again, the better the quality of the projector and the projection lens the better the end product.

A point to keep in mind is that the smaller the wattage requirements for the projection lamp are, the smaller the cooling requirements for the projectors are, which might possibly solve a serious sound problem. Unlike rear projection, the projector in front screen projection operates from the same place the camera does, which is generally quite close to the talent. If large cooling fans are required, and the projectors are not mounted in sound conditioned boxes, these fans will be picked up on mike. This, obviously, is undesirable.

I mentioned above that we would make the assumption that 2x2 slides would be used for the backgrounds rather than motion pictures. Motion picture backgrounds are entirely possible, and have been used in many films. But it is rather more complicated, and quite a bit more costly than the design of the system under discussion allows for. To be done properly the camera and projector must be interlocked on a frame for frame basis. This requires the use of a sylsen interlock system which is quite expensive, as is adapting a camera to such an interlock system. Motion picture projectors are also rather noisy creatures, and this noise factor must be taken into account.

CHAPTER II

HAGERSTOWN FRONT SCREEN SYSTEM

For the two years prior to June, 1970, I was involved in an experimental film project with the Washington County Board of Education, Hagerstown, Maryland. The project was funded under a Title III grant from the Department of Health, Education, and Welfare. Its basic goal was to experiment, on film, with different types of television teaching techniques in an attempt to improve television instruction. The target audience for the final two years of the project, which ended in June of 1970, was the seventh, eighth, and eleventh grades of the Washington County public school system.

The project produced a film series called ART--A REFLECTION OF MAN. It dealt primarily with art in the humanities, covering such areas as the origins of art, art history and philosophy, the effect of art on society, and the effect of society on art. A few basic "how to" type programs were also produced.

The series was produced and used as supplemental instruction in the county's basic art curriculum. However, because of the very broad approach to the subject matter, the series also served in a cross-curriculum capacity as supplemental instruction in English and social studies.

One of the major problems, as is the case with most visual presentations, was how to present the visual information in an interesting and informative way. This was a rather all-inclusive problem, ranging from the presentation of art examples to sets within which to place talent.

For the most part the problem was handled in the traditional manner, i.e., the use of cut-aways, copying slides and pictures onto film, location shooting, and use of models and miniatures, etc.

Approximately eight months before the end of the project we became aware of front screen projection and its potential application to our particular problems. We were able to get enough money approved to purchase a large screen and two beam splitters. The catch was that the project would have to design and build its own beam splitter mount.

The project already had the necessary camera gear and projection equipment. The camera was an Auricon Pro-600, with an Angenieux 12-120 zoom lens. This was mounted on an NCE fluid tripid head, which would in turn be mounted on the beam splitter mount by means of a standard high hat. The projectors were made by Spindler and Sauppee. They were controlled by a special control unit that allowed supering, timed dissolves, etc. Each projector had a two and a three inch lens.

The screen was 10' x 14', and covered one whole wall of the studio. It was bound and grommeted on all four sides, and was hung from a special framework that had been attached to both side walls, the ceiling, and the floor of the studio. This allowed for the screen to be laced on all four sides, providing tension in all directions. With the proper tension, and a couple of days hanging time, all the wrinkles pulled out and it hung perfectly flat.

The beam splitter mount was the difficult part, because all we really had to go on for the design were some basic drawings in an article in American Cinematographer.[1] Figure 1 shows the basic mount with the equipment in position. In Appendix IV I have included a complete set of drawings. These drawings show the mount from various angles, with the camera and projectors in position. One of the illustrations gives some rough dimensions. Not all dimensions are given however, for it is not the purpose of these drawings to act as blue

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[1]"A Double Front Projection Set-up that Uses Slides for Backgrounds," American Cinematographer (April, 1970), pp. 340, 369.

prints. There are a couple of problems with the mount that I will get to shortly. The drawings are included simply to show what kind of a mount we built in Hagerstown, and to perhaps give some direction to other producers who may want to design and build their own mount.

When first put into operation the mount was placed on a sturdy projection table. Since I left Hagerstown they have moved it to an even sturdier table, but one that they can move in and out of the studio more easily. Obviously the best support would be one that is especially built for it. Hagerstown tells me that this is in the works, but there are other more pressing items, so it will be some time before it is a reality. In the meantime the table top will suffice. This points up the fact that nearly any table can act as a base for the stand, so long as it gets the camera and projector to the necessary height, and so long as it is good and sturdy and doesn't wobble around.

Because of the fact that the camera and the projector are both positioned on the mount, and because the optical alignment between them is critical, sturdiness was an important consideration in construction. We used 3/4" plywood, with all joints first being glued together and then screwed down tight. When it was finished, the whole mount was painted a flat black. The reason for this was to eliminate any secondary reflections that might cause ghost images. This was particularly important in the light traps, indicated by the shaded areas in Figure 1.

When the mount was finished, the whole system was set up and tests were run. It was at this point that we discovered two bad design faults. As I mentioned above, the screen was 10' x 14', and we knew that in some productions we would want to fill that screen with an image. A maximum projection throw of about 20' meant that we would have to use wide angle projection lenses. A 2 inch lens filled the screen nicely, except when on the mount. Here we soon discovered that the opening in the front of the mount through wich the image was reflected, and through which the camera filmed that image (see Figure 1), was not wide enough. It cropped a significant portion of the projected picture area. This resulted in having to use 3 inch lenses and living with a smaller image size, the compromise here being that we could live more easily with a smaller image size than we could with an actual loss of picture information.

The second problem was that the design allowed for almost no along-axis adjustment of the camera position. It is important that the front nodal points of both the camera and projection lenses be equidistant from the number 1 beam splitter (see Figure 1). If this distance is not equal a matt shadow appears. There was some degree of along-axis adjustment and we were able to minimize the shadow, but as the talent moved further away from center screen the shadow became increasingly apparent, resulting in an unacceptable picture.

The proper solution to both of these problems was to redesign and rebuild the mount. If we wanted the system in operation before the end of the project, however, this was an impossibility. So, for the time being, we had to accept a smaller image size and very limited talent movement.

The people in Hagerstown tell me that they are still working with these same limitations, but that they are designing a new mount. Their indications are that the new mount will have an extension where the camera is mounted that will allow axial movement of the camera along the common optical axis. The beam splitters will be mounted closer to each other, and the projectors will be mounted closer to the beam splitters. They feel that this will create only a slightly smaller image, but one that will project through the front of the mount without being cropped when using 2 inch projection lenses (see Figure 1 as a reference for understanding these changes).

A problem that became immediately and painfully apparent was the very limited camera movement when there was talent in the shot. This is due to the fact that the alignment between the camera and projector is extremely critical. They must operate along the same optical axis or a matt shadow is created. When panning or tilting on a standard tripod head it is impossible to maintain this alignment because the lens is way out in front of the center of rotation; which means that it must swing through an arc in order to accomplish the move. We found that with no talent or foreground object in the shot we could pan and tilt to a rather large degree with only a minor loss in image brightness. This is because the arc through which the lens moved stayed within an acceptable angle of reflectance from the retro-reflective screen without an objectionable loss of image brightness. This is demonstrated early in the accompanying film in those shots where the camera moves in on the large world map used as a background.

Panning and tilting are indeed possible with foreground objects in the shot, but they require a special nodal point pan head that moves the lens back to the center of rotation of the head. This means that the camera body swings through the arc rather than the lens, thus maintaining proper alignment. These heads are specially designed and built, and are rather expensive, so that they were unavailable to us in Hagerstown.

The system, with these limitations, functions quite well, however. The film accompanying this written portion of the thesis will demonstrate this. It allowed us to present the visual information in a much more interesting, informative, and creative manner. They are now using it in Hagerstown as an integral part of their instructional television system, using it both in television and film production to enhance their daily lessons.

CHAPTER III

OPERATIONAL PROCEDURES

This section will deal with the set up and operation of a front screen system. It assumes that the screen is already up. There is one further thing I might say about the screen, however, and that is that it is important that it be perpendicular to the axis of projection. Although, to a large extent this is a function of projector placement, it is important that the screen be hung properly. It must be hung in such a way as to be perpendicular to the axis of projection, and with enough tension all the way around so that the wrinkles pull out and the screen hangs flat.

The first thing to check when setting up a front screen system is whether or not the projection axis is perpendicular to the projection plane. It is difficult to say just how to do this as it will depend on the shape and design of the individual beam splitter mount-projection stand. Generally speaking however, it can be accomplished by running a tape measure from the corners of the leading edge of the mount to the corners of the screen, and adjusting the mount until the proper measurements are obtained.

Perhaps the most important and critical adjustment to be made is that of bringing the camera and projector into proper alignment. Fortunately it is a relatively simple thing to accomplish.

One method is to place the reflected image of the projection lamp filaments in the center of the camera lens.[1] By standing in front of the mount and looking through the number one beam splitter, one looks directly into the camera lens (see Figure 1). One also sees the reflected image of the projection lamp filaments. Proper coaxial alignment then becomes a matter of panning and tilting the projector until the reflected image of the lamp filaments falls exactly in the center of the camera lens. It is suggested that a neutral density filter be placed over the projection lens to bring the light intensity down to an acceptable level for this operation. In some cases, if one is using a projector control unit such as we had in Hagerstown, he can accomplish the same thing as with the neutral density filter by putting the control unit in the ready or hold position. With some units this setting allows just enough voltage to pass through the lamp to cause the filaments to glow slightly,

[1]Instructions for the operation of a Retro-Reflective Front Screen Projection System, prepared by the Telesync Corporation, 20 Insley Street, Demarest, New Jersey, 07627. (Mimeographed.)

but with enough intensity for their reflected image to be clearly seen in the beam splitter.

The problem with this method is that it doesn't indicate proper along-axis alignment. Mr. L. F. Rider, in an article in American Cinematographer entitled The Alekan-Gerard Process of Composite Photography,[2] explains a method to determine both the proper along-axis and the proper coaxial alignment.

> A piece of beaded screen material about nine inches square should be mounted on a thin stiff board of the same size which, in turn, is fixed to the end of a rod of convenient length. This device is used as a probe, to be inserted into the camera field approximately where the foreground subject is to be located. If the optical alignment is correct, then the probe target, as seen through the camera, will merge almost indistinguishably into the background and will be free from shadow fringing. Sould an all-round shadow fringe be seen, then either the camera is too far back along the common axis, or the projector is too near the mirror. Should the camera be too far forward, then a fringe will be seen on that edge of the target which is nearest the optical axis, but this effect is only observed when the target is wholly off-axis.

I did not become aware of this technique until after I had left Hagerstown. It would have been a great help to us in setting up that system.

The proper alignment between the camera and the projector is extremely critical. If these two elements are not in proper alignment the system will not function

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[2] L. F. Rider, "The Alekan-Gerard Process of Composit Phctography," American Cinematographer (July, 1962). p. 430.

properly, and there will be a matt shadow that cannot be eliminated.

Obtaining the correct exposure for the background is rather important, for it is this exposure that will determine the exposure for the talent and other foreground objects.

This reading must be taken from the position of the camera lens. There are a number of reasons for this, the first of which has to do with the basic principle upon which front screen projection is based. As I mentioned earlier, this principle requires that the camera and projector operate on a common optical axis, and that it is function of the beam splitter to allow this. It does so by reflecting the projected image onto the screen and, being a two-way front surface mirror, allowing the camera to shoot through it to film that image. If one stands in front of the beam splitter then, he blocks out the projected image.

Secondly, the highly directional characteristics of the retro-reflective screen require that the reading be taken from the camera lens position (see Table 1 under the discussion of screen material in Chapter I). The second table shows us that as the angle of divergence increases, the luminance factor falls off quite rapidly. Since the basic principal upon which front screen projection is based requires that the camera and projector operate along a common optical axis, and since it is the purpose of the retro-reflective screen to focus and reflect most of the light striking it directly back to the light source, and since the camera becomes the apparent light souce, the brightest image is seen from the camera position. A light meter held at the position of the camera lens then, will see and read exactly what the camera will film. But as the light meter moves away from this position, and hence away from the common optical axis, the brightness of the image it is reading falls off quite rapidly, as Table II shows, and an incorrect reading will be obtained.

Also, again because of the highly directional characteristics of the screen, it is almost impossible to see the projected image from anywhere except the camera position.

Because the most accurate reading is taken from the camera position, a reflected reading must be used rather than an incident reading. We found in Hagerstown that a meter with a normal angle of acceptance, one that read the whole image and automotically averaged the exposure, was more convenient. This will depend on the individual system however. In some cases it might be easier to use a spot meter to read many small areas of the image, and then average the exposure manually after all readings are taken.

Another method to be considered is to use a 35mm single lens reflex still camera with interchangeable lenses, and a through-the-lens metering system. The camera could be set up in place of the motion picture camera, with the nodal point of the lens in the proper place. The operator could then see exactly what his meter is reading, and could change lenses to make it read exactly what he wants it to.

One important point to keep in mind is the necessity for maintaining a consistant exposure in all background slide. If the density of these slides varies more than about 15 per cent, the brightness of the projected background will vary from slide to slide and the quality of the final composite picture will be greatly decreased, or even be unacceptable.

Once the basic exposure for the background slides is determined, one can begin to light the set. This can be done with an incident meter, remembering always to allow for the light loss through the beam splitter. As I mentioned earlier, the beam splitter is basically a two-way front surface mirror that reflects part of the light striking it and transmits the rest of it. This is usually expressed in terms of a percentage. The beam splitters used in Hagerstown reflected 30 per cent of the light and transmitted 70 per cent. This means simply that unless the light loss was taken into consideration when taking the reading, the picture will be 30 per cent underexposed. It has the same effect as putting a neutral density filter on the camera lens, and then not allowing for the filter factor when taking the picture. It is a good idea to run some tests when setting up the system to determine the exact amount of this loss. This can be accounted for, then, when taking the reading by either adjusting the aperture, or adjusting the ASA rating of the film.

A color correction filter on the camera may be necessary to compensate for a possible color shift caused by the reflective coating on the beam splitter. All coatings vary slightly, but a 10, 20, or 30cc magenta filter should take care of most situations.[3] Again, some tests should be run. If the shift is slight, it can be corrected at the lab during printing, doing away with the need for a filter.

Lighting set ups can be pretty much standard, but even with the retro-reflective screen materials it is a good idea to keep the ambient set light falling on the screen as low as possible. But this is not the absolute requirement that it is in rear screen projection. Lights should be high and at a side angle of about 40°. This allows ambient light rays from the set lights to strike the screen from an oblique angle, and for shadows created by these lights to fall on the floor rather than the screen.

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[3]Letter from Mr. Bob Swanson, Telesync Corporation, 20 Insley St., Demarest, New Jersey, 07627, to Mr. Blair L. MacKenzie, Title III ETV Project, Washington County Board of Education, Hagerstown, Maryland, 21740, December 26, 1969.

To get the proper balance between the projected background and the foreground subjects will take some practice. Because the new retro-reflective screens have such a high gain, the reflected image can easily overpower the scene, and the talent becomes lost in the background. This should generally be avoided as it looks unreal. It looks as though someone is standing in front of a projected image, and this is neither the purpose of front screen projection, nor does it demonstrate the quality that it is capable of.

In the accompanying film there are a number of scenes in which this occurs. It is perhaps best demonstrated in the scene in which the background slide is a stage coach robbery. Talent is both poorly lit and poorly balanced against the background, and as a consequence, tends to become lost in it.

In my judgment it is better to keep the background light level down anywhere between 1/4 and one full stop below what the foreground subjects are lit for, dependent upon the requirements of the individual production. It may be necessary to put a neutral density filter on the projection lens to bring the background intensity down to an acceptable level.

Talent should be placed approximately six to eight feet in front of the screen. This gives separation between talent and background, generally allows any shadows created by set lights to fall on the floor rather than the screen, and keeps any intensely concentrated rays of light from striking the screen. In spite of the highly directional characteristics of the retro-reflective screen material, some part of the light rays are reflected in all directions and are bound to find their way into the camera lens. This is more likely to be a problem with a highly concentrated ray of light directly striking the screen than with ambient set light.

Talent may have some trouble working in front of a front screen system for the first time due to the fact that the camera lens becomes a rather bright spot of light. This is because of the projection lamp filaments being supered over the center of the camera lens, and although there is generally a slide up they still create a very bright spot of light. The other problem is that the talent can not see the image on the screen. As I mentioned earlier, about the only place the image can be seen is from the camera position. This problem is significant only when the talent must make reference to certain elements within the image. In most cases a solution can be found during rehearsal. In any event they are not serious drawbacks, and most talent will adjust quite readily.

Camera movements, at least in terms of trucking and dolly shots, are obviously out. To accomplish this type of movement would require moving the camera, which in turn means moving the projector, which just wouldn't work.

Pans and tilts are possible, but only by using a special pan head that is designed for front nodal point panning and tilting. A head of this nature, because the point of rotation is at the front nodal point of the lens rather than at the camera body, does not throw the lens out of alignment when a move is made. Even without this special nodal point pan head some movements can be made, but they are extremely limited. If there is no talent in the shot somewhat more freedom is allowed as there is no shadow problem to content with; only a loss in light level, and here there is a bit more latitude. This is demonstrated in the accompanying film when the camera pans and zooms in on the large map used as a background.

Zooms are also possible, but they introduce some special problems all their own. The major problem is in maintaining proper perspective. In theory, the same focal length lenses should be used in the camera and projector as were used on location to shoot the background slides. This is not an absolute rule however, and can be hedged quite a bit if one is very careful. The major problem with perspective begins when one is using a three-dimensional or real scene for a background and tries to make a long zoom. The established perspective is destroyed, and the scene begins to look unreal. In Hagerstown we found that short zooms were generally acceptable, but that one had to be extremely careful. In general a cut is better for long movements, in which a new slide can be put up with the proper perspective to match the new camera position and field of view.

The other major problem is that of throwing the system out of alignment and creating a matt shadow. As long as one zooms straight in or out there is very little problem. But if one is using talent and wants to zoom, it is very difficult, if not impossible, to make a straight in or out movement and maintain a properly composed picture. It is generally necessary to pan and/or tilt to maintain proper composition. In Hagerstown this was quite difficult, but, as I said above, limited moves were possible if one was very careful. Obviously, a nodal point pan head would have solved the problem.

APPENDICES

APPENDIX I

ADVANTAGES AND DISADVANTAGES OF FRONT SCREEN PROJECTION AS COMPARED WITH REAR SCREEN PROJECTION

ADVANTAGES AND DISADVANTAGES OF FRONT SCREEN PROJECTION AS COMPARED WITH REAR SCREEN PROJECTION

Some of the advantages of front screen projection are as follows:

1. Due to the technical requirements of rear screen projection, it needs as much studio space behind the screen as it does in front of it. Front screen projection can cut this space requirement in half.
2. Good rear screen projection requires a powerful light source, and it generally uses 4x5 glass mounted transparencies. This means heavy, bulky, noisy projection equipment. Front screen projection can get satisfactory results with a 35mm slide, and a standard slide projector with only a 500 watt lamp. The projection equipment required is small and light, and the noise problems are greatly reduced.
3. Rear screen projection has a problem with a hot spot in the projected image. This problem does not exist in front screen projection.

4. The image in front screen projection is generally as good as, if not better than, rear screen projection. This is because it is not compromised by diffusion and transmission through the screen. This generally also means more highly saturated colors.

5. Because of the characteristics of the front screen projection screen, lighting is greatly simplified over the lighting set ups required in rear screen projection. Standard lighting set ups can be used, or the lighting director can be as creative as he wants or needs to be without fear of bad image wash out.

6. Front screen projection is considerably less expensive to set up and operate than rear screen projection. Savings are noted primarily in the areas of basic equipment costs, and in studio and power requirements.

7. By covering portions of the foreground set with reflex-screen material, the actor can be made to appear to walk behind objects which appear in the background plate or stereo.[1]

Some of the disadvantages of front screen projection are as follows:

1. Camera movements are rather limited. Trucking and dolly shots are out. Pans and tilts are limited.

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[1]Raymond Fielding, op. cit., p. 322.

2. Because of the proximity of the talent's microphone to the projector there is a potentially serious sound problem.

The advantages of front screen projection over rear screen projection are obvious. In most cases it gives quality equal to that of rear screen projection, and is generally cheaper and easier to use than rear screen projection. This should be of particular significance to the small producer working with limited budgets.

The first disadvantage can be crippling for some kinds of shows. It can be easily dealt with however, if the director is absolutely certain of his shot requirements before going into production.

APPENDIX II

HISTORY

HISTORY

Throughout the history of both still and motion picture photography many attempts have been made to achieve a high quality composite picture through the use of a reflected image projected from in front of the screen rather than from behind it. A couple of days of digging around the patent files in the Detroit Public Library unearthed some rather interesting and potentially good ideas. For those interested in further research along these lines, I have included in the bibliography the numbers of some of these patents. Many of them have no direct relevance to the development of front screen projection to any greater extent than that they served as sources of ideas. They served well in this capacity however, and from this point of view it is indeed an interesting area of research.

In Appendix III I have reproduced the three major patents under which most front screen projection systems in use today operate. They are U.S. patent numbers 2,727,427, and 2,727,429, and British patent number 768,394.

As I said above, many attempts have been made to achieve a high quality front screen projection system. Despite these attempts, most of the efforts went into rear screen projection, which has become an industry standard.

The main problem facing front screen projection seems to have been technological, with the most important element being the lack of a good high quality, high gain retro-reflective screen material. This meant that cameramen had to work with wide open apertures giving them a very shallow depth of field, particularly with longer lenses. In some cases the reflected light level was so low it could not be filmed. It also meant that talent had very little freedom of movement towards or away from the camera. This resulted in having to place talent very close to the screen, causing shadows and image wash out due to light on the screen.

There seems to have been one other element involved. It is rather subjective, and I'm not certain just how much it really affected the development of front screen projection. This is a seeming reluctance and slowness on the part of the film industry to accept and utilize front screen projection, even after the technology was available. Their attitude seems to have been that this new technique is untried and has many problems that need to be worked out. Our old system of rear screen projection works, the problems have been worked out, it gives consistently high quality results, so why change?

The needed technology became available in the late 1940's with the introduction of "Scotchlite" by the Minnesota Mining and Manufacturing Company. This was a new development in projection screen material, being retro-reflective and having a very high gain. Shortly after the introduction of this new screen material, the Motion Picture Research Council, in association with the Stanford Research Institute, began research and development of the front screen projection technique.[1]

Beginning in 1950 the Motion Picture Research Council Bulletin began publishing reports of their work on the front screen technique.[2] In December of 1955, two patents, number 2,727,427 and number 2,727,429 were granted to an independent inventor by the name of Will F. Jenkins.[3]

At about the same time a process very similar in nature to that of Jenkins was being developed in Europe by two Frenchmen named Alekan and Gerard. In 1957 a British patent, number 768,394 was issued to Henry Albert Alekan, and has since been acquired by the J. Arthur Rank Organization.[4]

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[1]Raymond Fielding, op. cit., p. 306.

[2]*Ibid.*

[3]*Ibid.*

[4]*Ibid.*

It wasn't until the middle 1960's that Hollywood finally began to take a hard look at front screen projection. It is generally felt that the film that caused them to look was Stanley Kubricks' "2001: A Space Odyssey." In the film Mr. Kubrick uses front screen projection throughout the whole opening sequence to tell the story of the evolution of man. Since "2001" other films, such as "Tora Tora Tora," have also made much use of the technique.

Television also began finding uses for it, and its use has increased many times in both mediums. Today there are companies that either sell or rent complete systems. The sales do not generally include a camera, but they do include slide projectors, beam splitters, the beam splitter mount, and what ever size screen is needed. Rentals on the other hand, generally include everything, from the camera through the screen, plus a crew to run it. There are also a few film production companies and television studios which have installed front screen systems and use them for contract jobs. I have included the names of some of these companies in Appendix VI.

Front screen projection is a good tool. Mr. Kubrick demonstrated that it was indeed a viable and creative technique. I doubt that it will ever totally replace rear screen projection, nor is there a need to. They are both usable tools, but used properly front screen projection can now assume many of the jobs that formerly had to be done with rear screen projection, and do so with a significant saving in costs, and with a level of quality that is at least equal to rear screen projection, if not better.

APPENDIX III

IMPORTANT PATENTS

PATENT SPECIFICATION

768,394

Date of Application and filing Complete Specification: Jan. 3, 1955.

No. 56/55.

Application made in France on Jan. 7, 1954.

Complete Specification Published: Feb. 13, 1957.

Index at Acceptance:—Classes 40(3), F2E4; 97(1), C; and 98(2), D17.

International Classification:—G03b,d. H04n.

COMPLETE SPECIFICATION

Improvements in and relating to Apparatus for Taking Composite Pictures by Photography or Television

I, HENRI ALBERT ALEKAN, a citizen of the French Republic, of 46 rue de la Tourelle, Boulogne-sur-Seine (Seine), France, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a process and device for taking composite shots for the cinema, photography or television which permits associating in the same shot persons and material objects which are illuminated by a natural or artificial light, and an image, projected on to a screen of flat subject matter executed by hand (drawings, pictures) or by photography (photos on paper, transparencies, cinema films). The usual process employed in obtaining this type of shot, known as "transparency" or "background", consists in placing the people and the illuminated material objects in front of a translucid screen on which the images are projected by means of a projector placed on the other side of the screen relative to the camera.

This process has two main disadvantages. It requires, firstly, the use of a very bright projector in order to enable a fairly large screen to be utilized and thereby obtain a sufficiently deep field and, secondly, the use of a vast studio owing to the great distance between the projector and the camera.

For remedying these disadvantages it has already been proposed to utilize processes in which the camera and the projector are placed on the same side of a reflecting screen. For example, it is known to use a screen consisting of a large spherical concave mirror which is of one piece or comprises juxtaposed elements. This process is too delicate in operation, the slightest accidental displacement of any element marring the result. This problem is solved by the present invention which consists in taking the shot by disposing the projector, the camera and the objects, whether they are persons or material objects, on the same side of the screen and in utilizing a screen having a reflecting power which is considerably greater than that of said material objects, whereby the projection on this screen may be obtained with a lighting which is of such power that it is not reflected in the portion thereof which strikes the material objects and subsequently appears only on the background and not on said objects or persons.

To this end, it has been proposed to utilise for the screen a self-collimating surface constituted by a large number of self-collimating elements of very small size supported on a suitable support, and to dispose a projecting apparatus, a recording camera and a reflecting device in such manner that the virtual image formed by said reflective device, of one of the objectives of the projecting apparatus and recording camera coincides with the other of these objectives.

Fig. 1 is a diagrammatic view of such a self-collimating surface or a reflex reflector on which a beam or ray obliquely impinging thereon produces a concentrated cone of reflected light in a reflex manner returning towards the source of ray or beam.

Many types of self-collimating elements are known. The property of these elements is to return an incident ray as a cone of very small angular spread and whose axis coincides with the direction of the incident ray. These self-collimating elements consist for example of pyramids having three perpendicular faces, elements each formed of two spherical elements having different radii but substantially the same centre of curvature, or simple balls or spheres of a refractive material (of suitable refractive index) etc., combined with a reflecting or semi-reflecting surface.

Many applications of these surfaces are

known, notably for rendering publicity panels visible at night, highway signals, vehicle signals, path beacons at the bottom of underground caves or pits, etc.

Pearly screens have already been utilized for the projections of cinema scenes. These screens comprise a layer of fine balls of ordinary glass, whose index of refraction is about 1.5.

The use of such screen for taking photographic shots proved unsatisfactory. In fact the balls of this kind are practically not self-collimating but diffuse, that is the beam of reflected rays forms a very diverging cone, this being necessary to ensure that the projection is seen by the entire audience. The problem for a projection for a photographic shot is the reverse, since in this case the reflected beam must be concentrated as far as possible towards the lens of the camera. Thus such ordinary pearly screens cannot be utilized in the process of the invention for, firstly, their reflecting power is insufficient and requires a too strong source of light for projection and this would cause the image to appear on the persons and material objects. Secondly, the white appearance of these pearly screens drowns the projected image in a white haze, the screen receiving and diffusing the ambiant light illuminating the persons.

The invention has for its object an installation for taking combined views by still-photography, cinematography or television, in which persons or material objects illuminated by a source of light and optically projected images are photographed simultaneously, comprising a camera and an optical projector located on the same side of a projection screen, and an optical reflecting device so disposed with respect to said camera and said projector that the virtual image formed by said reflecting device, of the objective of one coincides substantially with the objective of the other, said projection screen being formed of a layer of spherical beads made of transparent material, the rear portion of each bead being embedded in a reflecting layer which supports the beads, characterized in this that the transparent material has a refraction index between 1.7 and 2.

A screen made of beads of material of this kind is known and is not claimed *per se*.

Plastic materials are known which satisfy this condition and, furthermore, recent discoveries have permitted the manufacture of glasses having an index of refraction as much as 2.05. Experiments carried out by Applicant with screens comprising glass balls of this nature and having an index of refraction increasing from 1.7, have given excellent results. The best results were obtained with ball screens made of beads whose index of refraction is between 1.8 and 1.95. Such surfaces have a reflecting power of the order of more than 200 times greater than that of a white surface and the Applicant has observed that in utilizing these surfaces as a projection screen for a photographic shot, it becomes very easy to obtain a projection which is reflected by the screen without, however, being reflected by the material objects placed in front of it, even if these objects consist of white surfaces.

The invention will be more fully understood from the ensuing description with reference to the accompanying drawing, which shows by way of example one embodiment of the invention and in which:

Fig. 2 is a sectional view of an embodiment of the surface of the self-collimating screen;

Fig. 3 is a diagrammatic plan of an embodiment of the shooting device.

With reference to Fig. 2 it is seen that the self-collimating surface comprises a support 1 on which is applied a reflecting layer 2 in which transparent balls 3 are embedded, for example over a part of their surface. These balls have a small diameter, for example of the order of 0.05 1.5 mm but preferably 0.10-0.25 mm. These balls are of glass or of a refractive plastic material having a high index of refraction. An index of refraction between 1.7 and 2, and, preferably, between 1.8 and 1.95 is perfectly suitable for obtaining maximum reflecting power.

Above the reflecting layer, the balls are interconnected by a binder 4 comprising for example a resin and preferably coloured black. These balls are thus embedded in the layer to the extent of a little more than one-half their surface.

When a beam of incident light impinges on the front semi-sphere of a spherical self-collimator, the reflected light flux is unequally distributed according to whether the incident rays impinge on the pole or on a region near the equator of the sphere, this distribution varying furthermore with the index of refraction of the material. Generally the reflected light flux is maximum in respect of the polar dome and minimum in respect of the equatorial zone. As this unevenness is noticeable on the image obtained it may be necessary to soften it down by varying the reflecting power of the rear semi-sphere, which acts as a mirror. For this purpose, the rear of the self-collimating balls may be coated with a material composed of layers having varying properties of reflection disposed on a support or constituting this support. Thus there may be used a composite reflecting layer which permits diminishing the reflex reflecting power for the rays striking the screen perpendicularly or substantially perpendicularly. To this end the posterior pole of the spheres may lie in a subjacent surface having a poor reflecting power, on top of which is disposed a layer of binder having a high reflecting power, containing for example flakes of aluminium in suspension. This layer may be itself covered by a black binder which prevents the light penetrating the subjacent layers from re-emerging other than through the self-collimating spheres.

This description is of course not intended to be limitative, and the screen may be formed in a different way, provided that the self-collimating character of the unit comprising the balls 3 and the reflecting element is retained. For example, the balls united by the binder may be disposed on a reflecting surface and not embodied therein, or a dark binder may be utilized for the balls, this dark binder being itself reflecting by incorporating in it as in the case of the intermediate layer, metallic flakes in suspension, or there may be utilized any binder covered with a black or dark coating, etc.

The resultant screen does not have a black appearance but is merely dark grey owing to the fact that the glass, having a high index of refraction, produces a very considerable parasitic reflection of the ambient light on the uncovered surface of the balls. In order to diminish this parasitic reflection, an anti-reflecting layer may be advantageously applied on the surface of the glass balls. The reflecting power will thereby be slightly increased.

Fig. 3 shows by way of example an optical device permitting use of a screen of the kind described above.

Reference numeral 5 designates the self-collimating screen, 6 the camera, 7 the projection apparatus and 8 a person or material object placed in front of the screen 5 and illuminated in any manner, care being taken, however, to ensure that there is no light coming from the immediate vicinity of the camera, since this light is liable to be returned by the screen and mar the projection.

The axes of the camera 6 and projector 7 are disposed for example at 90° from one another and interposed between them is an obliquely disposed semi-transparent mirror 9. Owing to this arrangement the beam of light issuing from the projector 7 and impinging on the screen 5 seems to issue from the camera 6 towards which it is returned by the self-collimating screen 5. It is obvious that the two apparatus 6 and 7 may be reversed relative to the semi-transparent mirror, or may occupy in space such positions that the beam of light always appears to issue from the lens of the camera by utilizing multiple combinations of reflecting mirrors or semi-reflecting mirrors, the projector and the camera being placed, if desired, in parallel, perpendicular or oblique positions. Similarly, the subject 8, instead of being placed, as illustrated, between the screen 5 and the mirror 9, may be advantageously placed between the latter and the camera 6 for taking close-up shots.

In any case the beams of incident light and of reflected light must appear to emanate from the same point, which is the centre of the aperture of the lens of one of the apparatus and the optical image of the centre of the aperture of the other apparatus. If it were otherwise the shadow cast by the object 8 on the screen 5, due to the occultation of the incident light, would be visible from the lens of the camera and would produce an undesirable black ring around the object 8.

Other combinations of these two apparatus may be visualized. For example, the projector may be directed towards the ground, the beam of light being reflected by the mirror in a direction parallel with the optical axis of the camera.

The utilization of lenses having a variable focal length either in the camera or in the projector would permit obtaining impressions of approaching or receding from the subject, comparable to movements termed travelling movements in the cinema industry.

For panoramic motion of great amplitude, a screen of concave curved form would be adopted, the projection being obtained by means of a projector provided with a lens pivotable with respect to itself or a lens having a wide angle of operation or by means of a combination of several associated projectors. In such panoramic motion the camera as well as the mirror or mirrors would be rendered movable on a special support, so that whatever the position, the projection light beam would always appear optically to issue from the lens of the camera.

The process of the invention may also be utilized when it is desired to cause a material object to appear in front of a very bright background which enables a positive film to be used as a mask, the positive film being obtained by printing with very sharp contrasts in which the subject stands out as an entirely dark silhouette on a bright background on which there may be applied, in accordance with the well-known technique, any fixed or animated background. In this case the projection onto the screen at the moment of taking the shot would be limited to a beam of light.

What I claim is:

1. Installation for taking combined views by still-photography, cinematography or television, in which persons or material objects illuminated by a source of light and optically projected images are photographed simultaneously, comprising a camera and an optical projector located on the same side of a projection screen, and an optical reflecting device so disposed with respect to said camera and projector that the virtual image

formed by said reflecting device, of the objective of one coincides substantially with the objective of the other, said projection screen being formed of a layer of spherical beads made of transparent material the rear portion of each bead being embedded in a reflecting layer which supports the beads, this installation being characterized in this that said transparent material has a refraction index between 1.7 and 2.

2. Installation as claimed in claim 1, characterized in that said transparent material has a refraction index between 1.8 and 1.95.

3. Installation as claimed in claim 1 or 2, characterized in that said spherical beads have a diameter smaller than 1.5 mm.

4. Installation as claimed in any one of claims 1 to 3, characterized in that a dark colour binding layer is superimposed on said reflecting supporting layer and between said beads, whereby said beads are interconnected on a portion of their sides.

MARKS & CLERK.

Belfast: Printed for Her Majesty's Stationery Office, by The Universities Press.—1957. Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

768,394 COMPLETE SPECIFICATION
1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

Fig. 1

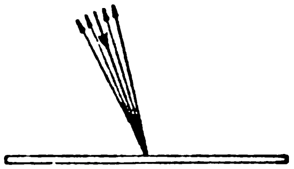


Fig. 2

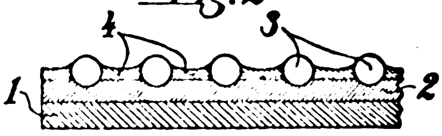
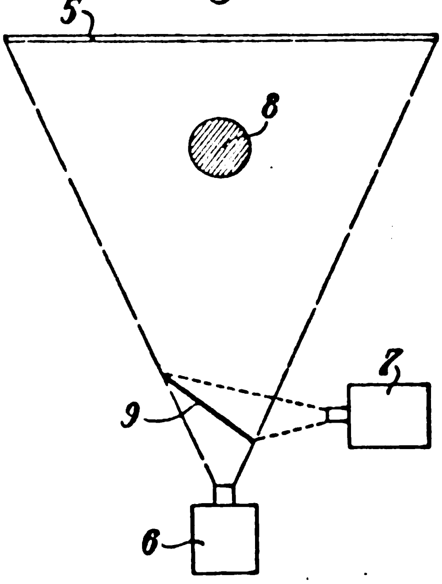


Fig. 3



Dec. 20, 1955 W. F. JENKINS 2,727,429
APPARATUS FOR THE PRODUCTION OF
COMPOSITE PHOTOGRAPHIC EFFECTS
Filed Nov. 30, 1953

FIG. 1.

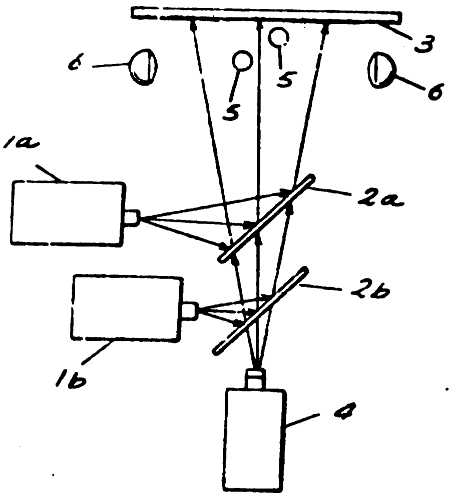


FIG. 2.

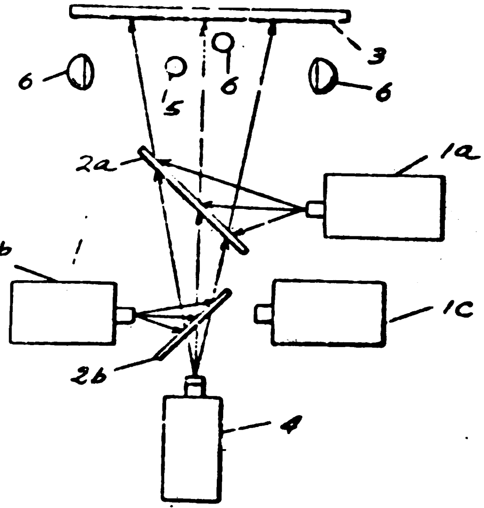


FIG. 4.

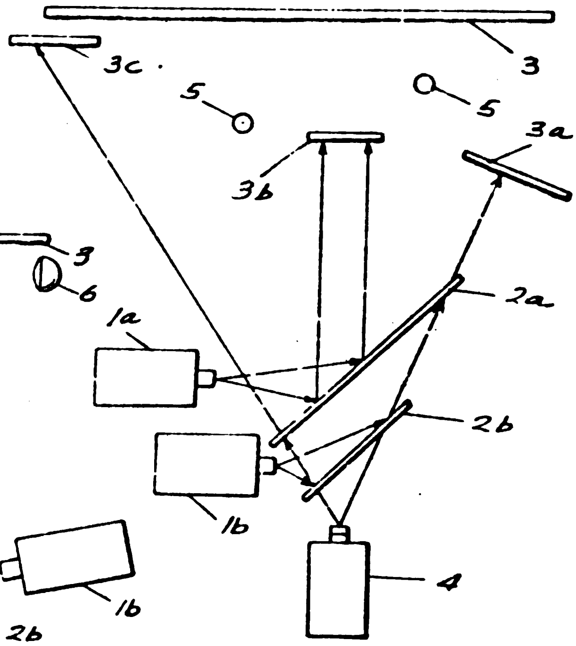
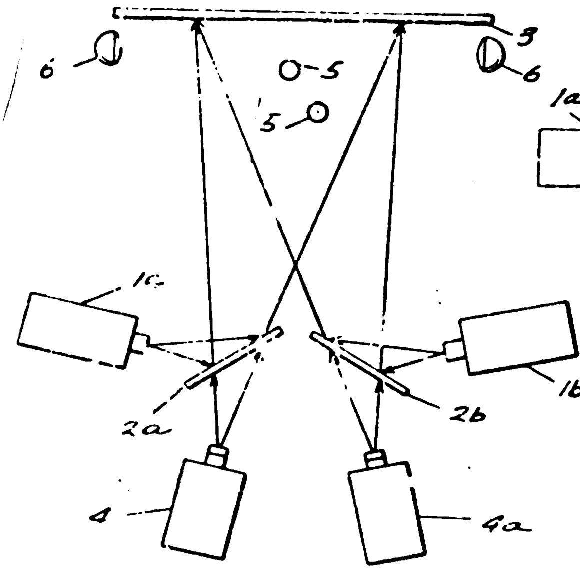


FIG. 3.



INVENTOR
WILL F. JENKINS

BY

Greene, Pineles & Durr
ATTORNEYS

United States Patent Office

2,727,429

Patented Dec. 20, 1955

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2,727,429

APPARATUS FOR THE PRODUCTION OF COMPOSITE PHOTOGRAPHIC EFFECTS

Will F. Jenkins, Gloucester, Va.

Application November 30, 1953, Serial No. 395,043

3 Claims. (Cl. 88—16)

This application is a continuation-in-part of my application Serial No. 274,638, filed March 3, 1952.

This invention relates to apparatus for the production of composite photographic effects. More particularly it relates to apparatus whereby realistic scenes may be photographically recorded in which the building, handling, and maintenance of stage scenery may be largely dispensed with.

The handling of scenery has always been a major problem in the staging of any kind of show. The advent of television made the problem even worse since live scenes cannot be repeated and corrected. Furthermore split second timing is often necessary in staging a quarter hour or half hour television show, hence the cost of handling scenery can be enormous. The advertiser pays the cost of the show, but the high cost of television production has made the medium too expensive for many advertisers. Reduction or elimination of constructive scenery has up to now lowered the quality of the show. Thus the progress of television broadcasting has been seriously impeded.

It is an object of this invention to provide apparatus for the simplified, cheap and efficient, production of still pictures, and of motion picture or television performances. It is a further object to provide apparatus whereby unusual effects may be readily and cheaply produced on motion picture or television sets.

These objects are obtained in a surprisingly simple and efficient manner. The apparatus of the invention includes at least one back-drop having a surface covered with a reflex reflecting surface. The staging of the show takes place on the acting-set in front of this backdrop. One or more cameras for recording the performance are located at a convenient place in front of the backdrop so that the lens of the camera takes in the action on the acting-set. Two or more sheets of plane transparent material are positioned at spaced intervals in front of the camera lens or lenses and between the camera and backdrop. Two projectors or more are so located that their light first strikes the plane transparent sheets; the light from each projector first strikes a single plane transparent sheet. A portion of the light from each projector is thus reflected to the reflex reflecting surface that serves as a backdrop. The relative positions of the camera or cameras, the projectors, and the plane transparent sheets are so adjusted that the lens of the camera or cameras receive both the reflected light from the projectors and the light from the scene being enacted.

In the accompanying illustrative drawings:

Fig. 1 is a simplified diagrammatic representation of a stage showing a single camera with two projectors and two plane transparent sheets in operation;

Fig. 2 shows an alternate arrangement of the apparatus in Fig. 1, and in addition shows how additional projectors may be incorporated into the apparatus;

Fig. 3 shows two cameras in operation with two projectors and two plane transparent sheets; and

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Fig. 4 shows an arrangement utilizing a plurality of backdrops.

Referring to Fig. 1 two projectors are shown at *1a* and *1b*. The light from projector *1a* strikes plane transparent sheet *2a*, while light from projector *1b* strikes plane transparent sheet *2b*. A portion of the light from the projectors striking the plane transparent sheets passes on through the sheets and is unused here. The remaining portion of the projectors light however is reflected from the plane transparent sheets to the backdrop or reflecting structure **3** which has an extended reflecting surface facing the camera **4**. The reflecting surface of the reflecting structure **3** is a reflex reflecting surface of the type described in connection with Fig. 4 of my copending application Ser. No. 274,638, filed March 3, 1952. Such reflex reflecting surfaces having been long known to the art, having been described for instance in Palmquist Patents Nos. 2,294,930 and 2,379,741. In such reflex reflector screens, an outer layer of adjacent transparent bead or sphere-like lens elements with underlying light reflecting elements which are in optical connection therewith cause beams of light incident on the outer layer to be refracted and reflected as brilliant cones of light in a direction generally coaxial with the incident light beams throughout the range of angular relations of the layer surface and the direction of the incident light between 90° and about 50°. Any of the reflex reflector screens operative in the manner described above may be used for the reflector surface of the reflector structure **3** of the systems of the invention shown in the drawing, including the similar reflex reflector screens shown in Figs. 2, 3 and 4, at **3**, *3a*, *3b* and *3c*.

The light from the backdrop **3** is reflected to the two plane transparent sheets *2a* and *2b*. A portion of this reflected light passes through the plane transparent sheets and is recorded by the camera **4** which can be a still camera, a motion picture camera, or a television camera. The camera **4** will not record the light from the projectors that strikes the actors **5**. The actors **5** are diffuse reflectors as far as the camera **4** is concerned and extra side lighting **6** masks the projector's light. Hence any images thrown by the projectors do not show up on the actors **5**.

Fig. 2 illustrates another way to set up the apparatus of Fig. 1. In Fig. 2 projector *1a* is located on the other side of the camera **4** from projector *1b*. Such an arrangement in no way changes the operation of the apparatus as shown in Fig. 1. The sheets *2a* and *2b*, the projector *1b*, the backdrop with the reflex reflecting surface **3** and the actors **5** all function as before. Fig. 2 also shows how a third projector *1c* may be brought into use. In Fig. 2 as shown projectors *1a* and *1b* are each throwing images to the backdrop **3**. Projector *1c* is capped. In order to cut out projector *1b* and cut in projector *1c* the plane transparent sheet *2b* is revolved 90° on its vertical axis so that it is parallel to plane transparent sheet *2a*. At the same time projector *1c* is uncapped and projector *1b* is capped. By this method each plane transparent sheet may utilize a pair of projectors, one located on each side of the sheet, and adapted to alternatively throw an image to the backdrop **3**. It must be pointed out that the location of the projectors is not critical. They may be located above or below the plane transparent sheets. It is only necessary that the light from each projector impinge on the plane transparent sheet and then be reflected to the reflex surface on the backdrop. In order for the camera to see a useable image on the reflex reflecting screen the projector's light must be focused on the screen. The camera should be located so that the light path from the backdrop to the camera lens is approximately the same length as the light path from the projector lens to the backdrop via the plane transparent sheet; the camera should be same optical distance from the screen as the projector.

The use of two projectors with one camera as shown in Fig 1 allows the production of some interesting effects. The background scenery may be easily changed while the actors continue a scene. Changes are made by turning on one projector or uncapping its lens at the same time that the other projector is turned off or capped. If the change is slow it amounts to a fade. If it is abrupt it is a dissolve. Much laboratory processing is eliminated in this way. Many effects impossible in the laboratory may now become possible, for instance, as fading a character from one scene into another, making montages of sequential backgrounds while the actors move uninterruptedly. One or both of the projectors can be a motion picture projector. By masking part of one slide in one projector and a corresponding other part of the other slide in the other projector parts of two projections can be combined into one. For example one projector may show a still slide of the interior of a room with a window. A slide in the other projector can then fill in the exterior view. Thus it is possible to use a slide of a room interior with a summer scene through the window, and later to use the same slide with a winter scene visible through the window. If the projector showing the exterior scene is a motion picture projector it is possible to show trees blowing about, waves in motion or such matter as automobiles passing by. By combinations of the scenes from both projectors it is also possible to show such scenes as a river flowing through the Sahara Desert.

The projectors may be adapted so that the slide being used in the projector moves according to the turning of the camera. The slide will move laterally in the projector. With this ararngement the projected image seems to stay fixed while the camera pans.

Fig. 3 illustrates a modification of the apparatus wherein two or more projectors may be used each with its corresponding plane transparent sheet in conjunction with two or more cameras. The great significance of this modification is that the same backdrop serves two or more of the projector-sheet-camera systems. The reflex reflecting characteristics of the backdrop are such that the light from each projector is returned to its point of origin with a minimum of straying. Thus in Fig. 3, camera 4 and camera 4a may each record action of the actors 5 set against a different background and the light from projector 1a will not interfere with camera 4a and the light from projector 1b will not interfere with camera 4. When the cameras are equipped with proper filters, and are properly spaced, this arrangement can be used to produce 3-dimensional shows.

The apparatus of the present invention is such that the camera-screen-projector system need not remain fixed in position. The system may move in toward the actors for close-ups and it may back off for long shots. It may also move to one side for angle shots. As the system moves both the camera and the projectors are kept in focus by means well known in the art. As mentioned earlier the slide in a projector may be moved laterally so that the camera sees the actors in a changing position relative to the background. The entire system may be mounted on a dolly for ease of movement. When the modification as shown in Fig. 3 is used each of the systems preferably would be mounted on its individual dolly.

Although the drawings show only two plane transparent sheets with their accompanying projectors it is entirely feasible to use 3, 4 or more plane transparent sheets each with its own projector. The intensity of a projector's light may be increased should it become necessary for the light from that projector to pass through a whole series of plane transparent sheets as it returns from the backdrop to the camera.

Fig. 4 illustrates an arrangement with a plurality of backdrops. The reflex surfaces can be used not only as the backdrop 3, but anywhere on the acting-set as illustrated by backdrops 3a, 3b, and 3c. Part of the scenery may be projected on backdrop 3, but another part may be projected on backdrop 3a in the middle ground, and a third part on backdrop 3b in the foreground. The necessary depth of focus for sharp projection can be had by special lens design or by stopping down the projector aperture. Or the image from any one projector may be confined to any one backdrop. With backdrops like 3a, 3b, and 3c, in use, an actor as seen by the camera actually disappears behind the piece of scenery depicted by the projected image. Various props and microphones may be concealed behind any of the additional backdrops. The backdrops themselves are invisible to the cameras since they merely appear as a piece of scenery; an object behind them will be invisible too. It is not necessary that the additional backdrops be parallel to the main backdrop 3. They may be at any angle as illustrated by backdrop 3a.

The main backdrop 3 or any of the backdrops need not be in the form of a plane surface. As seen by the camera they may be concave or convex or irregular. The reflex properties of the surface of the backdrops return incident light to its source whether or not the path of the incident light is normal to the surface of the backdrop.

I claim:

1. In a photographic arrangement for photographing a performance on acting-set elements situated in the front of a background, at least one background structure having an extended reflecting surface, at least two photographic cameras each having its optical axis crossing said reflecting surface and so positioned that the angle between the optical axis of one camera and said reflecting surface is different from the corresponding angle between the optical axis of the other camera and said reflecting surface and as to record both an image focused on said reflecting surface and a performance on an acting-set situated between said reflecting surface and said camera lens, the exterior of said reflecting surface directly facing said cameras having a light returning layer of adjacent transparent minute lens elements and underlying light reflecting elements in optical connection with said elements for causing beams of light incident on said reflecting surface from the region facing said reflecting surface to be refracted and reflected as brilliant cones of light in a direction generally coaxial with said beams, at least one plane transparent mirror body extending with its plane at an angle to the optical axis of one of said cameras between said one camera and said reflecting surface for reflecting incident light received from a lateral direction transverse to said one axis toward said reflecting surface and thereby causing said so reflected incident light to be in turn reflected as brilliant cones of light towards said one camera, at least one image projector for said one mirror body so positioned relatively thereto that the projector's light impinges on said one mirror body from said lateral direction and is focused thereby on said reflecting surface for causing said reflecting surface to return the projector's light as brilliant cones of light in the direction generally parallel to said one optical axis towards said one camera throughout the angular positions of said one camera to said reflecting surface ranging between 90° and at least 60°, and a further similar mirror body and similar image projector similarly positioned relatively to said other camera for causing the light from said further projector to be returned by said reflecting surface as brilliant cones of light in a direction generally parallel to the other optical axis toward said other camera, the angles between said reflecting surface and said two optical axes being sufficiently different as to cause one camera to record an image projected on said reflecting surface by one of said projectors and the other camera to record an image projected on said reflecting surface by said further projector.

2. In a photographic arrangement as claimed in claim 1,

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said one camera and its associated mirror body and image projector having a movable common supporting structure constituting therewith one camera set movable as a unit to different photographing positions relatively to said reflecting screen.

3. In a photographic arrangement as claimed in claim 1, said one camera and its associated mirror body and image projector having a movable common supporting structure constituting therewith one camera set movable as a unit to different photographing positions relatively to said reflecting screen, said other camera and its associated mirror body and image projecting having another movable common supporting structure constituting therewith a further camera set movable as a unit to digerent photographing positions relatively to said reflecting surface.

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Dec. 20, 1955 W. F. JENKINS 2,727,427

APPARATUS FOR PRODUCTION OF LIGHT EFFECTS IN COMPOSITE PHOTOGRAPHY

Filed March 3, 1952

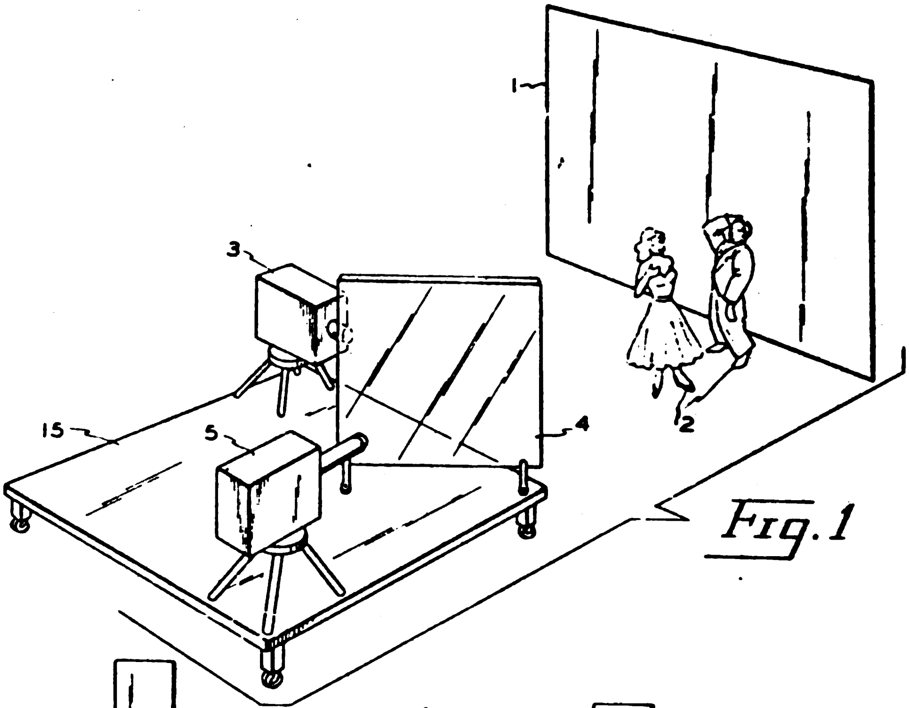


Fig. 1

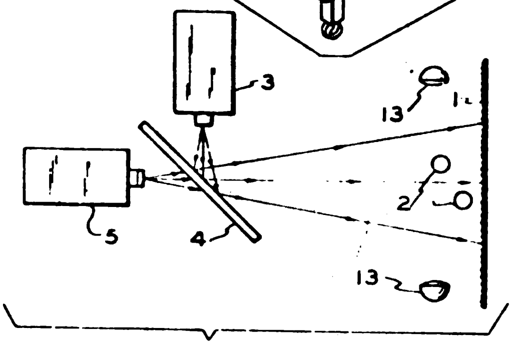


Fig. 2

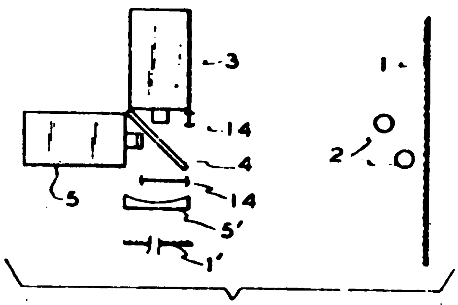


Fig. 3

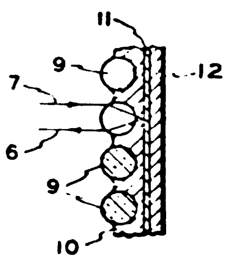
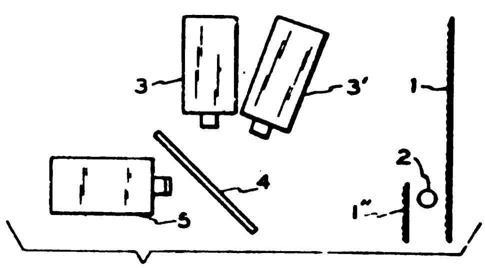


Fig. 4



INVENTOR

Fig. 5

Will F Jenkins

United States Patent Office

2,727,427

Patented Dec. 20, 1955

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APPARATUS FOR PRODUCTION OF LIGHT EFFECTS IN COMPOSITE PHOTOGRAPHY

Will F. Jenkins, Gloucester, Va.

Application March 3, 1952, Serial No. 274,638

8 Claims. (Cl. 88—16)

This invention relates to apparatus for the production of light effects. More particularly it relates to apparatus for the production of television shows, or motion picture shows. More particularly it relates to apparatus whereby the building, handling, and maintenance of stage scenery may be largely dispensed with.

The handling of scenery has always been a major problem in the staging of any kind of show. The advent of television made the problem even worse since live scenes can not be repeated and corrected. Furthermore split-second timing is often necessary in staging a quarter-hour or half-hour television show hence the cost of handling scenery can be enormous. The advertiser pays the cost of the show, but the high cost of television productions has made the medium too expensive for many advertisers. Reduction or elimination of constructed scenery has, up to now, lowered the quality of the show. Thus the progress of television broadcasting has been seriously impeded.

The prior art offers several partial solutions to the scenery problem. One system has been to project a scene or motion picture on a screen and then to photograph a live performance against the background of the projected scene. This system is useful in some applications but it often does not give the desired effect. Great difficulty has been encountered in maintaining the projected scene at the necessary brilliance and sharpness and at the same time maintaining the rest of the stage-set at the degree of illumination necessary for good photography.

Other systems use lenses and mirrors in varying arrangements in order to combine a live scene with either a projected scene or a miniature scene. Perhaps the most representative of the optical systems is that disclosed in U. S. Patent 2,076,103 to Walter Thorner.

In the Thorner system a projected image is reflected from a semi-transparent surface. The reflected image then strikes a large spherically-curved concave mirror which reflects the image back through the semi-transparent surface and focuses the image on the objective lens of a film-containing camera. A live performance takes place in front of the large concave mirror so the camera records the live performance against the background of the projected image.

Although the Thorner system serves very well for photographing short scenes under certain conditions, it suffers from three serious shortcomings. First, the cost of the large-sized, optically perfect, concave mirror, is so large as to be prohibitive. Second, any stray light striking the concave mirror is reflected to various points on the acting-set, thus the lighting of the live performance becomes a serious problem. Third, and perhaps most important, neither the camera nor the projector can be moved away from the focal point of the mirror; the position of both camera and projector are rigidly fixed at the focal point of whatever concave mirror is in use. Now in the staging of most performances it is essential that the camera have a certain freedom of movement. If viewer-interest is to be maintained the scene must not become monotonous; it must vary. Further, the build-up of suspense, the enhancing of dramatic values, and the emphasizing of certain characters, depends largely on the camera's ability to move in and out for close-ups and long shots, and to take up positions that will produce a maximum emotional impact on the viewer. A rigidly fixed camera can destroy whatever merit lies in a given scene. The talents of director and cameraman in trying to achieve the desired effects are largely rendered nugatory.

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Accordingly, it is an object of this invention to provide apparatus whereby the above-mentioned shortcomings of the prior art are overcome.

It is a further object to provide apparatus for the simplified, cheap, and efficient production of motion picture or television performances.

It is a further object to provide apparatus whereby unusual effects may be readily and cheaply produced on motion picture or television sets.

Other objects will appear in the following description.

The apparatus, in accordance with the invention, includes at least one backdrop including a directionally reflecting surface known as a reflex light reflector. The staging of a show takes place on the acting-set in front of this backdrop. A camera for recording the performance is located at a convenient place in front of the backdrop. A sheet of plane transparent or semi-transparent material is positioned in front of the camera lens and between the camera and backdrop. A projector is so located that its light first strikes the plane transparent sheet. A portion of the light from the projector is thus reflected to the reflex reflecting screen that serves as a backdrop. The relative positions of the camera, the projector, and the plane transparent sheet are so adjusted that the lens of the camera receives both the reflected light from the projector and the light from the scene being enacted.

In the accompanying illustrative drawings:

Fig. 1 is a perspective view of a stage on which one arrangement of the apparatus of the present invention is shown in operation;

Fig. 2 is a diagrammatic representation of the stage showing the apparatus employed in its simplest form;

Fig. 3 is a diagrammatic representation showing another modification of the apparatus;

Fig. 4 is an enlarged section of the reflex reflecting screen showing the preferable type of reflecting units;

Fig. 5 is a diagrammatic representation showing another modification of the apparatus.

In all of the drawings the reflex reflecting screen is at 1. Since this screen constitutes an essential feature of the invention, and since the surprisingly great versatility of the present system depends on this screen, it will be discussed in some detail.

The screen should be large enough to encompass whatever projected background is desired. In some cases the screen may be long enough to serve as a backdrop for two or more adjoining sets; this application will be discussed later. If the screen is built so as to be flexible it will merely hang in the same way as any other flat curtain. Supports for the screen are not shown in the drawings.

The screen is so constructed that any light that strikes it is reflected back to the source. This can be accomplished in several ways. Fig. 4 shows an enlarged section of the screen illustrating the preferable way in which this can be done. Clear glass or resinous beads 9 of suitable index of refraction are imbedded in a binder coating 10. A reflector coating 11 reflects incident light rays 7 back through the refracting glass beads 9 to the source as shown by reflected ray 6. The back coating 12 strengthens the screen. Such a catadioptric system will return both paraxial and normal rays to their source.

Construction details may be varied to achieve maximum reflex reflection brilliancy consistent with wide angularity. Since the glass or resinous beads 9 can measure about 3 to 10 mils in diameter there are over 10,000 of them per square inch of screen surface.

Screens of the type described above in connection with Fig. 4, have been long known in the art as reflex reflector screens, having been described, for instance, in Palmquist Patents Nos. 2,294,930 and 2,379,741. In such reflex reflector screens, an outer layer of adjacent transparent bead or sphere-like lens elements with underlying light reflecting elements which are in optical connection therewith cause beams of light incident on the outer layer to be refracted and reflected as brilliant cones of light in a direction generally coaxial with the incident light beams throughout the range of angular relations of the layer surface and the direction of the incident light between 90° and about 50°. Any of the reflex reflector screens operative in the manner described above may be used for the reflector surface of the reflector structure 1 of the system of the invention.

In Fig. 1, the projector 3 throws light on a sheet of plane transparent or semi-transparent material 4. A portion of the light passes right through the sheet and is unused in this arrangement. The remainder of the light however is reflected to the reflex reflecting screen 1. With the proper focus on the projector 3 an image will be formed on the screen 1. This image will appear clear and sharp to the camera 5 since the camera 5 is positioned to the rear of the sheet 4 and is located near the apparent source of light from the projector 3. Thus the actors 2 can be photographed in action against whatever background scene is desired. The light reflected from sheet 4 does not adversely affect the photography of the actors 2 even though the light strikes the actors 2 on the side that is being photographed. The light is not in sharp focus on the actors 2 and is diffusedly reflected from them. Hence the effect of this reflected light is negligible; in practice it is unnoticeable.

The apparatus functions just as well when the projector 3, the sheet 4, and the camera 5 move in toward the actors 2 for a close-up, or back away from the actors 2 for a long shot. The focus of projector 3 and camera 5 are easily adjusted by means well-known in he art. If a projector possessing a considerable depth of focus is used, it may be unnecessary to vary the focal adjustment of the projector at all. In any case the image reflected from the screen 1 presents a startling illusion of depth. Thus the actors 2 appear to perform in the midst of actual scenery. In Fig. 1 the projector 3, the sheet 4, and the camera 5 are all shown mounted as a unit on the dolly 15. Hence close-ups, long shots, and angle shots may readily be taken without interrupting the photography.

Under some conditions it may be necessary to prevent the back side of the plane transparent sheet 4 (the side nearest the camera 5) from receiving extraneous light from other portions of the set. This can easily be done when necessary by putting up a curtain or drop to block off stray light.

Not only may the camera 5 move in and out from the screen 1 in accordance with the present system, it may also move to one side or the other for angle shots. Thus the camera 5 records excellent scenes when light reflected from the sheet 4 strikes the reflex reflecting screen 1 at an angle of 40° to the normal. Even greater angles may be used but care must be taken not to exceed the angle at which the brilliancy of the reflected image falls below that required for good photography. This maximum angle depends on the characteristics of the particular reflex reflecting screen in use; it usually runs around 40° to normal.

The apparatus of the present invention possesses another important advantage. Fig. 2 is a diagrammatic plan view of Fig. 1, showing the employment of stage lights 13. The lights 13 may be used freely as the director sees fit since they will not adversely affect the photography so long as they do not shine directly into the objective lens of the camera 5. Light from the stage lights 13 that strikes the reflex reflecting screen 1 will not be reflected to the camera 5, but rather back to the stage lights 13. Light striking the sheet 4 will not be reflected to that portion of the screen 1 that is being photographed by the camera 5. Thus in addition to reducing the problem of handling scenery, the present invention does away with many lighting problems.

Fig. 3 is a diagrammatic plan view showing the apparatus of the present invention set up in a modified arrangement that utilizes the entire beam from the projector 3, instead of merely a portion. The screen 1, projector 3, sheet 4, and camera 5, function in the same way as described before. In addition a smaller reflex reflecting screen 1' reflects an image focused on it by lens 5'. This image originates from the unreflected light that passes through sheet 4 from the projector 3. Thus the camera 5 sees two matching images, a large one from the acting-set screen 1 and a small one from the miniature-set screen 1'. If necessary, the brightness of the two images may be matched by means known to the art.

With such an arrangement it becomes possible to achieve unusual realism without resort to the actual handling of scenery. For example shutters 14 mask the left-hand quarter of the acting-set and the right-hand three-quarters of the miniature set. Instead of the shutters 14 as shown it may be advisable to position black masks directly over the surface of screens 1 and 1'. In this way a sharp dividing line may be obtained in the final composite image. The camera 5 still sees a complete set. The dividing line between the two scenes that make up the composite image may be the projected image of, say, a doorway seen from an angle. Now an actor 2 positioned on the portion of the acting-set masked by shutters 14 will be invisible in the composite image until he walks over to the unmasked portion of the acting-set. When he does so he will appear to have entered the set through the door. The shutters 14 may then be shifted to fully expose the acting-set and completely mask the miniature-set. The actor may then return to his original position, only this time he will appear to be in front of the door through which he has just entered. Thus realism is obtained without the necessity of constructing a room complete with doors. At the same time appropriate props like desks, chairs, tables, beds, and the like, may be placed on the acting-set as part of the scene whenever necessary. Since these objects are diffuse reflectors the light reflected from sheet 4 does not cause the objects to look mottled when photographed by the camera 5.

In similar fashion it is possible to obtain a composite image made up of the top portion of the miniature-set and the bottom portion of the acting-set. In fact any portion of the acting-set can be masked so long as the corresponding portion of the miniature-set is unmasked. Thus if it is desirable to show an actor going behind a building and coming out on the other side, the central portion of the acting-set can be masked while the miniature-set supplies the image of the building that apparently occupies the masked portion of the acting-set. Many other modifications will be obvious to those skilled in the art. Suitable shutters may be installed whenever the matching of opposing portions becomes desirable.

The addition of a miniature-set as described above in no way affects the ability of the camera 5 to move to the most suitable position; close-ups, long shots, and angle shots can still be taken. For this purpose it may be well to have the projector 3, sheet 4, camera 5, lens 5', miniature-set 1', and shutters 14, all mounted on the same dolly. Thus the installation can move as a unit

If desired, the screen 1' may be the same size as the screen 1, and located the same distance from sheet 4 as is screen 1. The lens system 5' thus becomes unnecessary.

Two full-size acting-sets become available, one in front of screen 1 and one in front of large-size screen 1'. This arrangement may be particularly desirable where weird effects are needed as in the production of a science-fiction shown. For example, performers can be shown to walk through one another.

Fig. 5 shows two other modifications of the apparatus of the present invention. Reflex reflecting screen 1" may be positioned as a wing partly in front of the reflex reflecting screen 1; both screens are of the same construction. An actor 2 will be unseen until he steps out from behind screen 1". Such an arrangement provides still another method that enables an actor 2 to enter the acting-set through a projected door, in which case the projected door should coincide with the on-stage end of screen 1". Projector 3 should have sufficient depth of focus so that the images reflected from screens 1 and 1" are matching in clarity and sharpness.

At the same time that projector 3 is supplying a background scene visible to the camera 5, projector 3' may also supply a different background scene. Since the light from projector 3' strikes the sheet 4 at an angle different from that of projector 3, the camera 5 will not see the image from projector 3' unless the camera 5 shifts its position relative to sheet 4, that is, unless the camera 5 rotates counterclockwise on its vertical axis. Thus an actor may perform against the background of an image from projector 3. He may then move along the set parallel to screen 1 and away from screen 1". The camera 5 rotates independently to keep him in view. When the actor 2 reaches the proper position the camera 5 will see the actor against the background of an image from projector 3' instead of from projector 3. Thus the set has been changed with a minimum of effort and expense. The camera 5 has been continuously trained on the actor: there is no necessity for a fade-out.

Although Fig. 5 shows the projectors 3 and 3' positioned to the left of camera 5 they need not be placed there. A projector may be positioned anywhere on the set so long as sheet 4 is so located that the projected image appearing on screen 1 can be seen by the camera 5. A projector may be positioned near one end of screen 1, or at the top of screen 1 for that matter. If a battery of projectors is used each projector of necessity must be located at a different position just off-stage from the acting-set. The apparent distance between a projector and the image on the reflex reflecting screen should be approximately the same as the actual distance between the camera and the image on the reflex reflecting screen.

A projector in the apparatus of the present invention may be of any convenient type. In its simplest form it may simply be a source of light, as when a performance against a gleaming background is desired. A projector may also consist of either a still or motion picture projector, depending on the type of background desired. The projector may contain means for the rapid changing of the slides to be projected as scenery. The slides can be changed sufficiently rapidly that a viewer is not aware of the change until it is an accomplished fact. Thus, if necessary, as the projector, camera, and plane transparent sheet move forward for a close-up the slides may be changed to show a successively smaller area of the same background scene. In this way proper perspective is maintained; the size relationship between the actors and the projected background scene is maintained at a proper ratio. The projector may also contain means for varying the angularity of the slides, that is, the slides may be partially rotated around their vertical axis in order to prevent fuzziness around the edges of the image on the reflex reflecting screen when the projector throws an image to the screen at an angle thereto. Or a projector may consist of a television tube confronted with a lens system to focus the tube's image on the reflex reflecting screen. By "television tube," as used in the claims, is meant the type of cathode-ray tube commonly used in television receivers. By means of this last arrangement a composite picture can be made up from two distinct sets on each of which action or movement takes place. By way of example, one television camera may be focused on a bowl of water into which has been dropped some solid carbon dioxide. The resulting dense white fog will appear on the television tube that serves as a projector for the present invention. Thus the actors on the acting-set can be photographed in the midst of a swirling fog by using the arrangement illustrated in Fig. 3; the shutters 14 are unnecessary in this application.

The plane transparent sheet in the apparatus of the present invention may be of any convenient size. A too-large sheet works no hardship since the portion not used for reflection does not interfere with operations. The sheet may be made of glass or suitable resinous material. Although preferably the sheet is perfectly transparent it may be lightly silvered so as to render it semi-transparent. In fact if a projector is positioned near the center and top of the reflex reflecting screen the sheet should preferably be lightly silvered in order to reflect sufficient light to form an image on the reflex reflecting screen. Any suitable means may be used for holding the sheet in the desired position; adjustable or fixed mounts may be employed. If a thick sheet is used one face of it may be coated with a non-reflecting coating to avoid the possibility of a double image, although this difficulty has not been encountered in practice. The phrase "plane transparent sheet" as used in the claims is meant to include a plane semi-transparent sheet.

Several types of cameras may be used in the present invention. A still picture camera can be used for the taking of publicity or advertising stills. A motion picture camera can be used and the film that is obtained can be later displayed in the usual way either in a motion picture theater or in a television broadcast. Or the camera may be a television transmitter that instantly televises the scene being photographed. The phrase "camera having an objective lens" as used in the claims is meant to include a television transmitter, a motion picture camera, and a still picture camera.

In some applications of the present invention it may be expedient to exchange the positions of the camera and the projector. With this arrangement the projector throws an image through the plane transparent sheet and on to the reflex reflecting screen. The camera then photographs the image that is reflected to it by the plane transparent sheet. Since the camera can also see through the plane transparent sheet, a blank drop of some kind may be positioned in the camera's line of sight beyond the plane transparent sheet when a miniature-set is not in place.

The composite images obtained by the apparatus of the present invention are blended optically, not electronically, thus eliminating the disastrous phenomenon known as halo. The composition of the final image is completely under the control of the cameraman who is in the best position to exercise judgment as to the merits of the final image.

Further applications of the present invention may readily be found without departing from its spirit and scope. The versatility of the invention allows numerous embodiments, therefore the invention should not be limited by the specific applications described herein, but only by the appended claims.

I claim:

1. In combination: at least one reflecting structure having an extended reflecting surface, a camera having an objective lens with an optical axis crossing said reflecting surface and so positioned as to simultaneously record both an image focused on said reflecting surface and an image of a performance or an acting-set situated between said reflecting surface and said camera, a substantially plane transparent mirror body extending at an angle to said optical axis between said camera and said reflecting

surface for reflecting incident light received from a lateral direction transverse to said axis toward said reflecting surface, at least one image projector so positioned that the projector's light impinges on said mirror body from said lateral direction and is focused by said mirror body on said reflecting surface, and an acting-set situated between said reflecting surface and said mirror body, the exterior of said reflecting surface directly facing said camera having a light returning layer of adjacent transparent minute lens elements and underlying light reflecting elements in optical connection with said lens elements for causing beams of light from said projector incident on said layer to be refracted and reflected as brilliant cones of light in a direction generally coaxial with said beams toward said camera for causing said camera to record said brilliant cones throughout the angular positions of said reflecting surface relatively to said optical axis ranging between 90° and at least 60°.

2. In the combination as claimed in claim 1, a further reflecting structure having a further reflecting surface of similar light reflecting properties as said extended reflecting surface and positioned to receive light of said projector passing through said transparent mirror body and arranged to reflect received light back onto said mirror body, said camera having an objective lens system arranged to record a composite image comprising a performance taking place on said acting-set and the projected light reflected by said two reflecting surfaces.

3. In the combination as claimed in claim 2, a further acting-set positioned between said mirror body and said further reflecting surface, said camera having an objective lens system arranged to record a composite image comprising performances taking place on said two acting-sets and the projected light focused on said two reflecting surfaces.

4. In the combination as claimed in claim 1, a further reflecting structure of substantially smaller size than said one reflecting structure having a further reflecting surface of similar light reflecting properties as said extended reflecting surface, a lens arrangement positioned between said mirror body and further reflecting surface for focusing a portion of the projected light passing through said mirror body onto said further reflecting surface, said camera having an objective lens system arranged to record a composite image comprising a performance taking place on said acting-set and the projected light reflected by said two reflecting surfaces.

5. In the combination as claimed in claim 1, a further reflecting structure of substantially smaller size than said one reflecting structure having a further reflecting surface of similar light reflecting properties as said extended reflecting surface, a lens arrangement positioned between said mirror body and said further reflecting surface for focusing a portion of the projected light passing through said mirror body onto said further reflecting surface, a miniature-set positioned between said lens system and said further reflecting surface, first masking elements arranged to mask a portion of said acting-set, further masking elements arranged to mask that portion of said miniature set that corresponds to the unmasked portion of said acting-set, said camera having an objective lens system arranged to record a composite image comprising performances taking place on said acting-sets and the remaining projected light focused on said further reflecting screen.

6. The combination according to claim 1 wherein the said projector comprises a motion picture projector.

7. The combination according to claim 1 wherein the said projector comprises a still picture projector.

8. The combination according to claim 1 wherein the said projector comprises a television tube confronted by a lens system.

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APPENDIX IV

DRAWINGS OF PROJECTION STAND BUILT

IN HAGERSTOWN

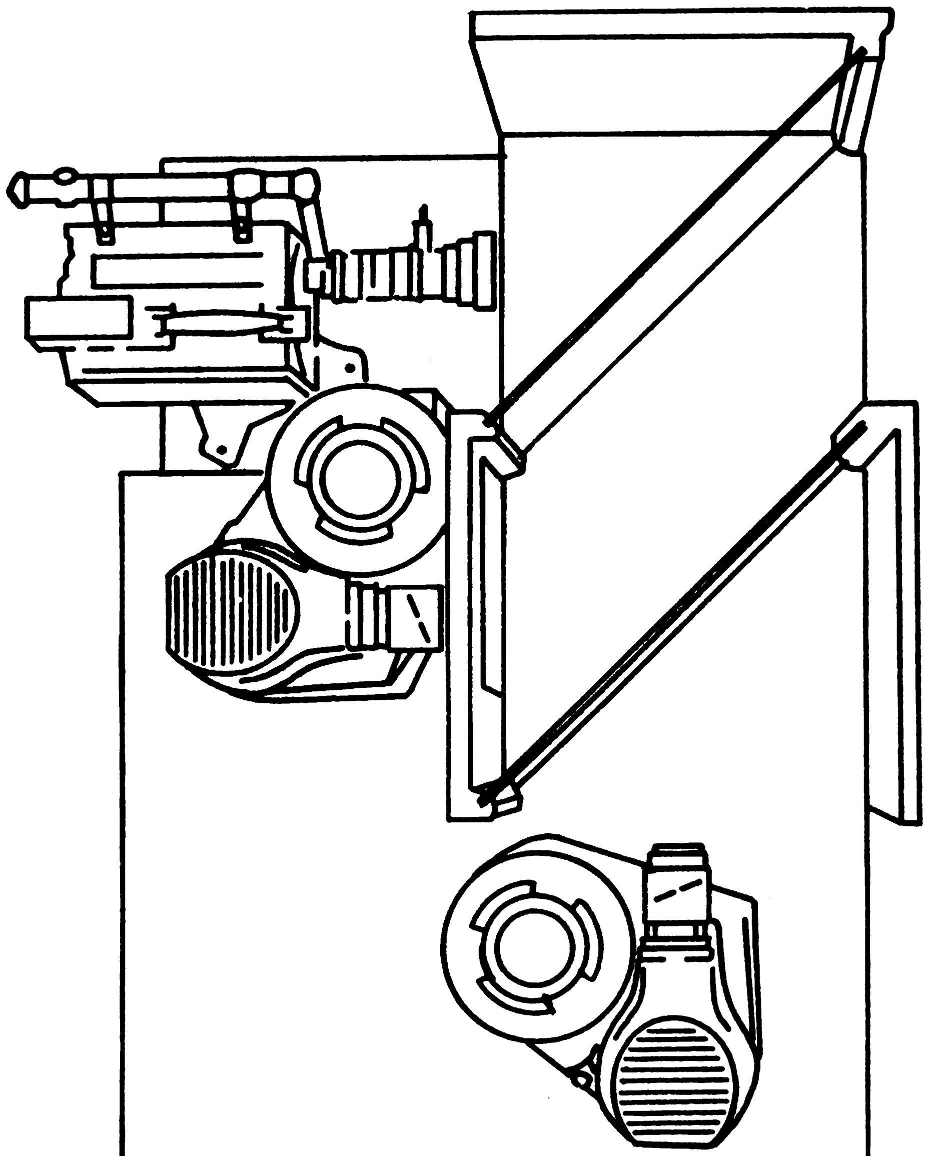

Figure 2.--Top View of Beam Splitter Mount.

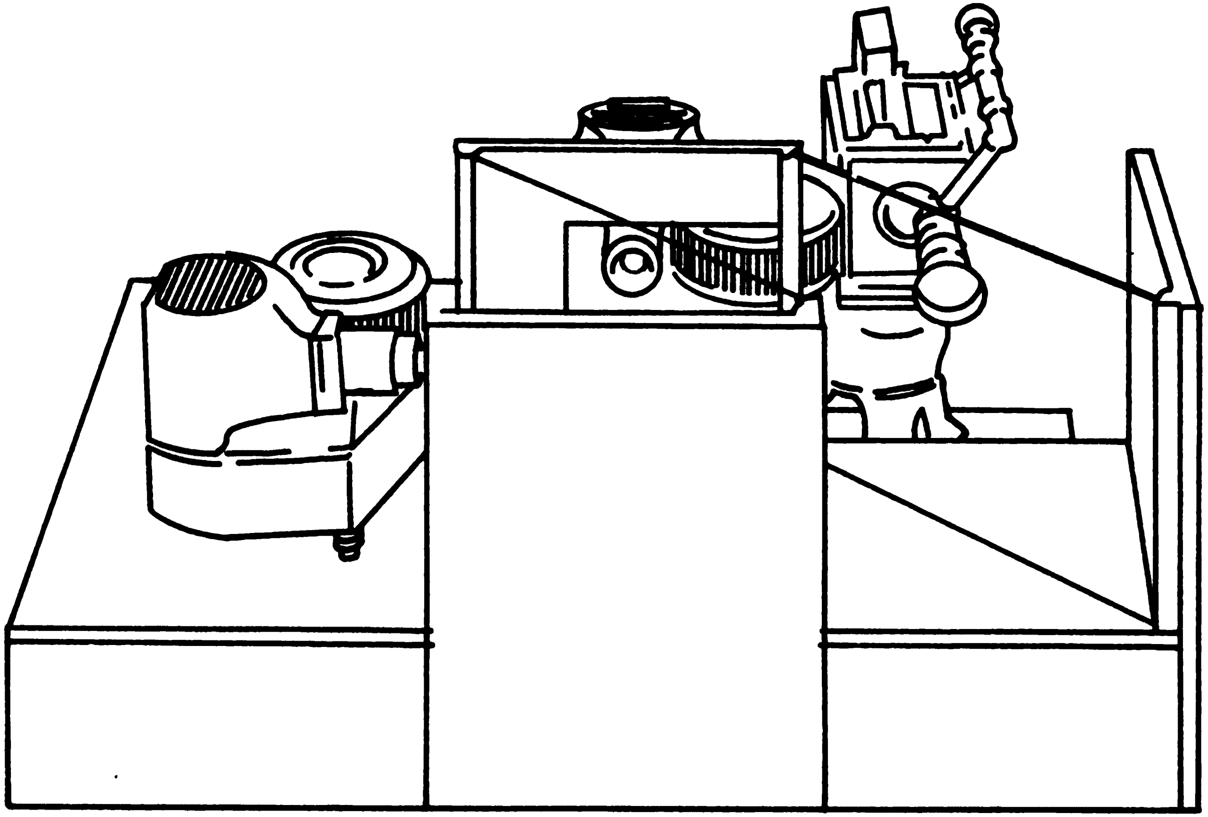

Figure 3.--Front View of Beam Splitter Mount.

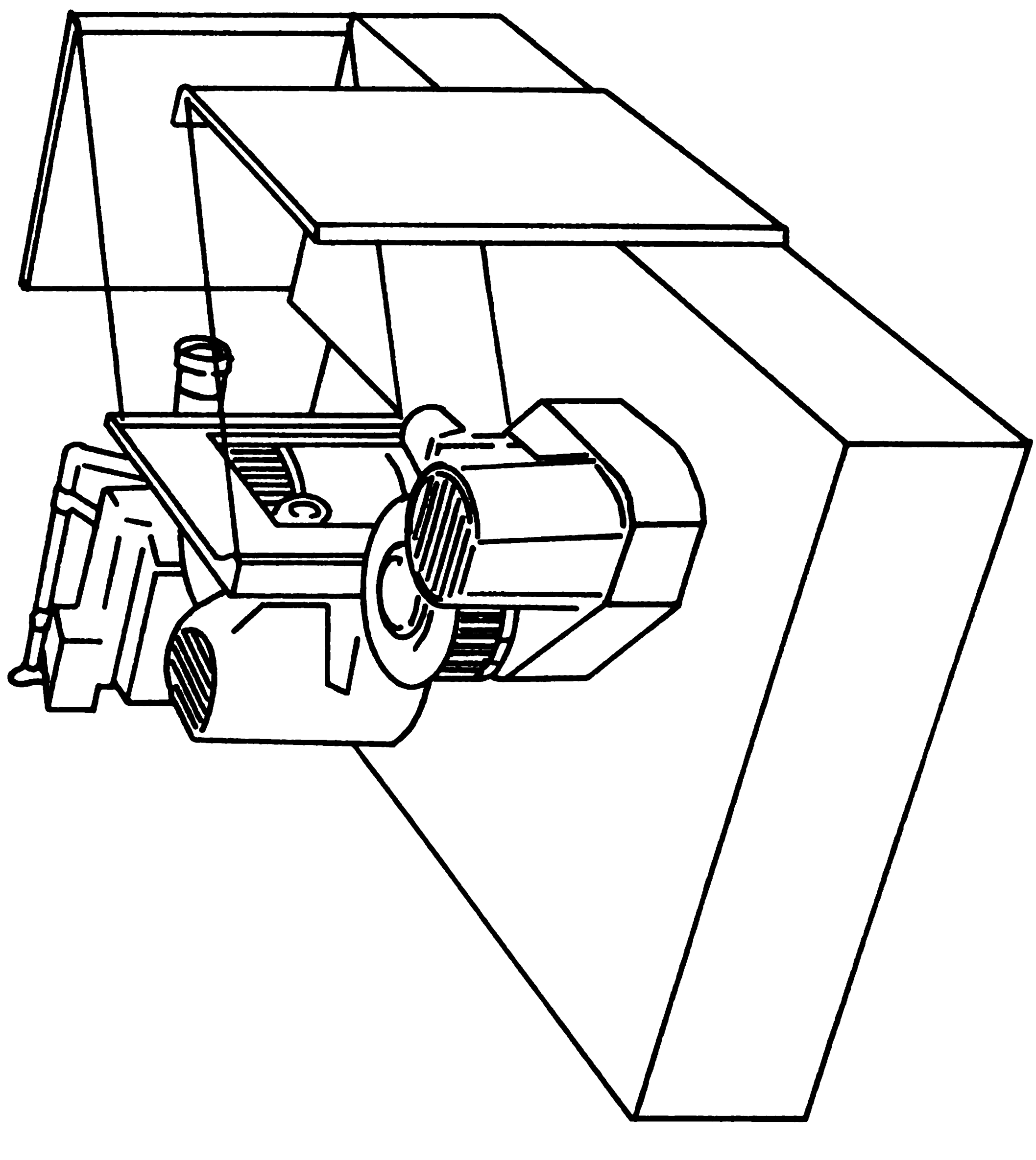

Figure 4.--Left Hand View of Beam Splitter Mount.

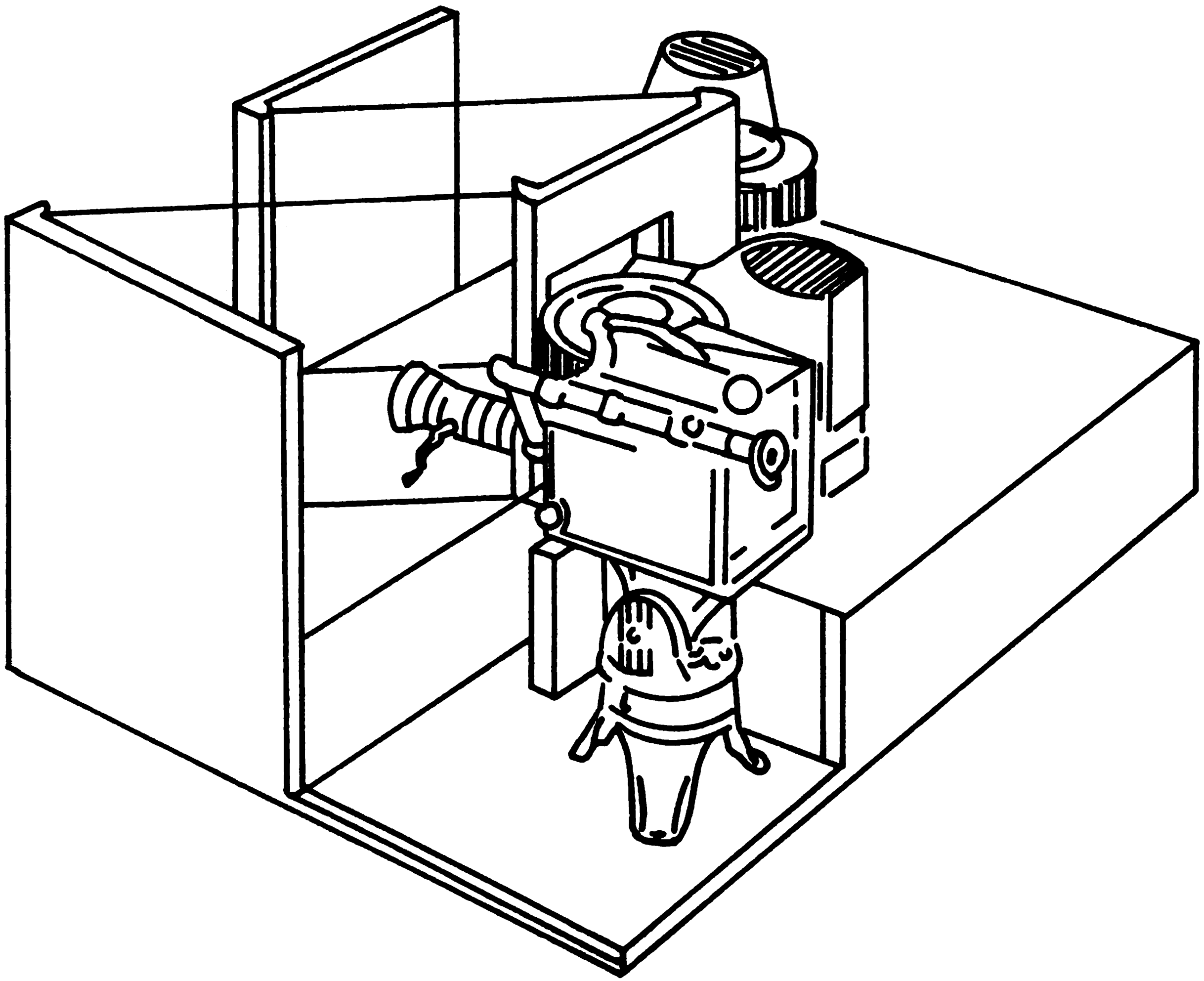

Figure 5.--Right Hand View of Beam Splitter Mount.

APPENDIX V

THE ACCOMPANYING FILM

THE ACCOMPANYING FILM

The film that accompanies this written portion of the thesis is entitled "MASKS". It is one of the final lessons filmed in the series done for the Title III ETV project. It is the first and only lesson filmed on the front screen projection system.

There are some obvious production problems. We had very little time to produce the lesson, and we were just beginning to learn how to use the front screen system, which still had some bugs to be worked out. But it clearly demonstrates some of the potential of front screen projection. It also demonstrates a few of the problems discussed in the thesis.

The important thing to remember is that the costs were not prohibitive. The whole system, less camera and projectors, was in operation for under $1600. Equipment to achieve comparable quality in rear screen projection, even if we had had the studio space for rear screen work, would have been significantly higher.

Front screen projection allowed us to present material in a manner that would have otherwise been

possible only through the use of rear screen projection or a matt process, neither one of which was available to us in Hagerstown. It allowed us to present information in a creative and informative way that broke away from cliched traditional methods, and at a cost that most small producers could manage.

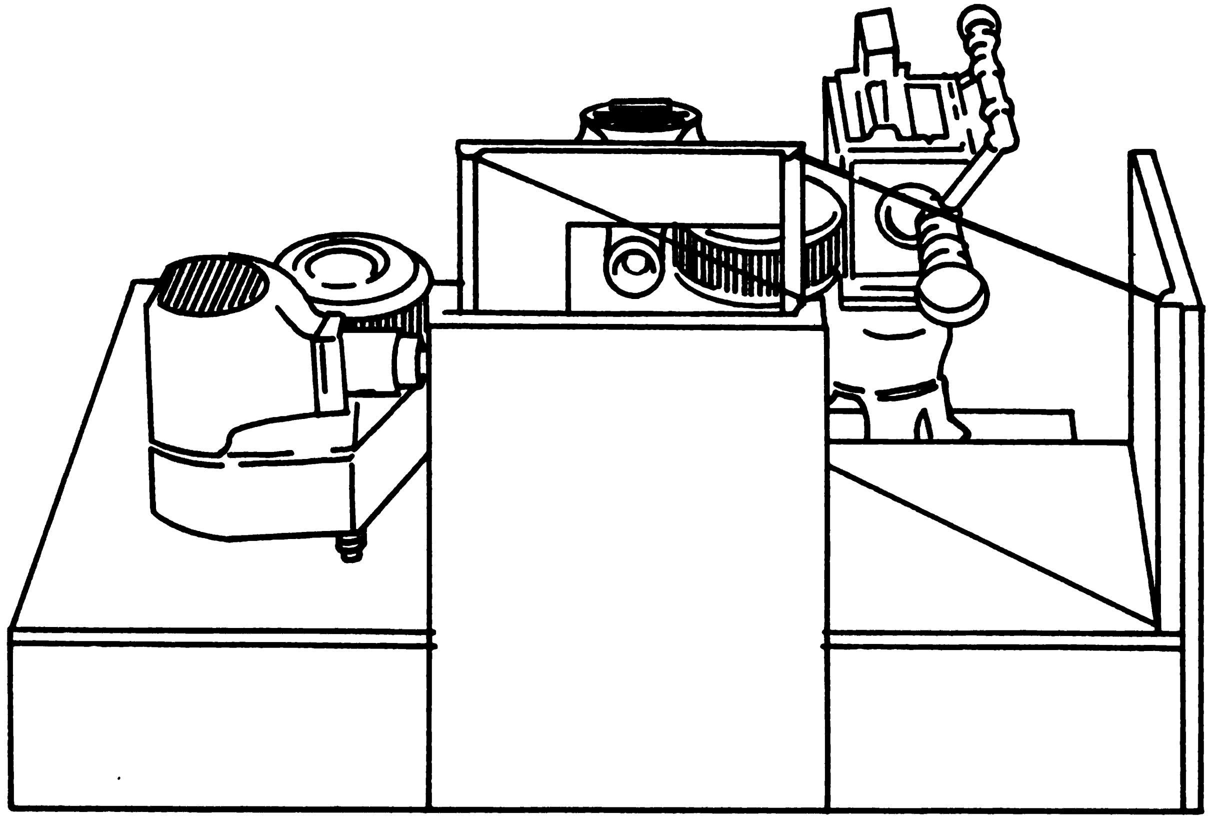

Figure 3.--Front View of Beam Splitter Mount.

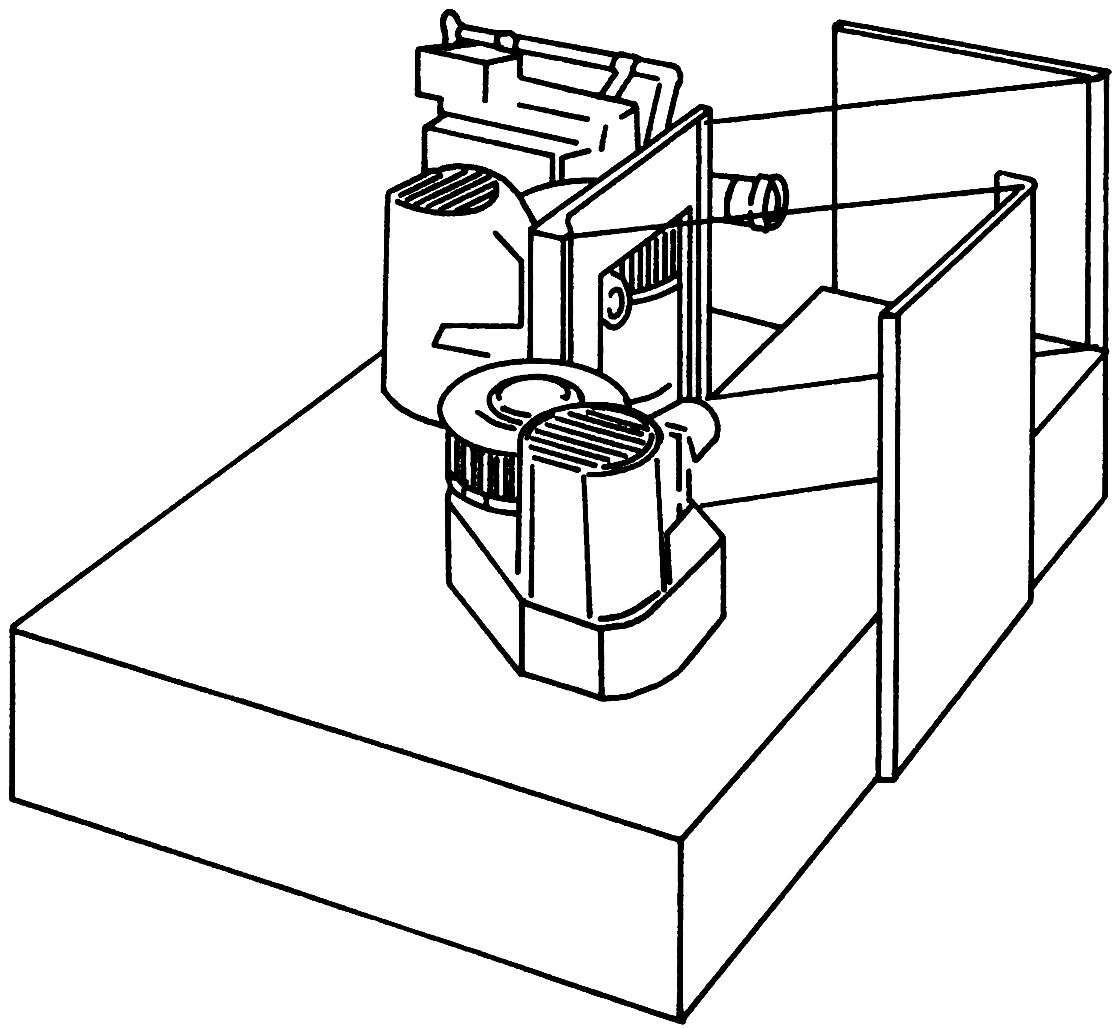

Figure 4.--Left Hand View of Beam Splitter Mount.

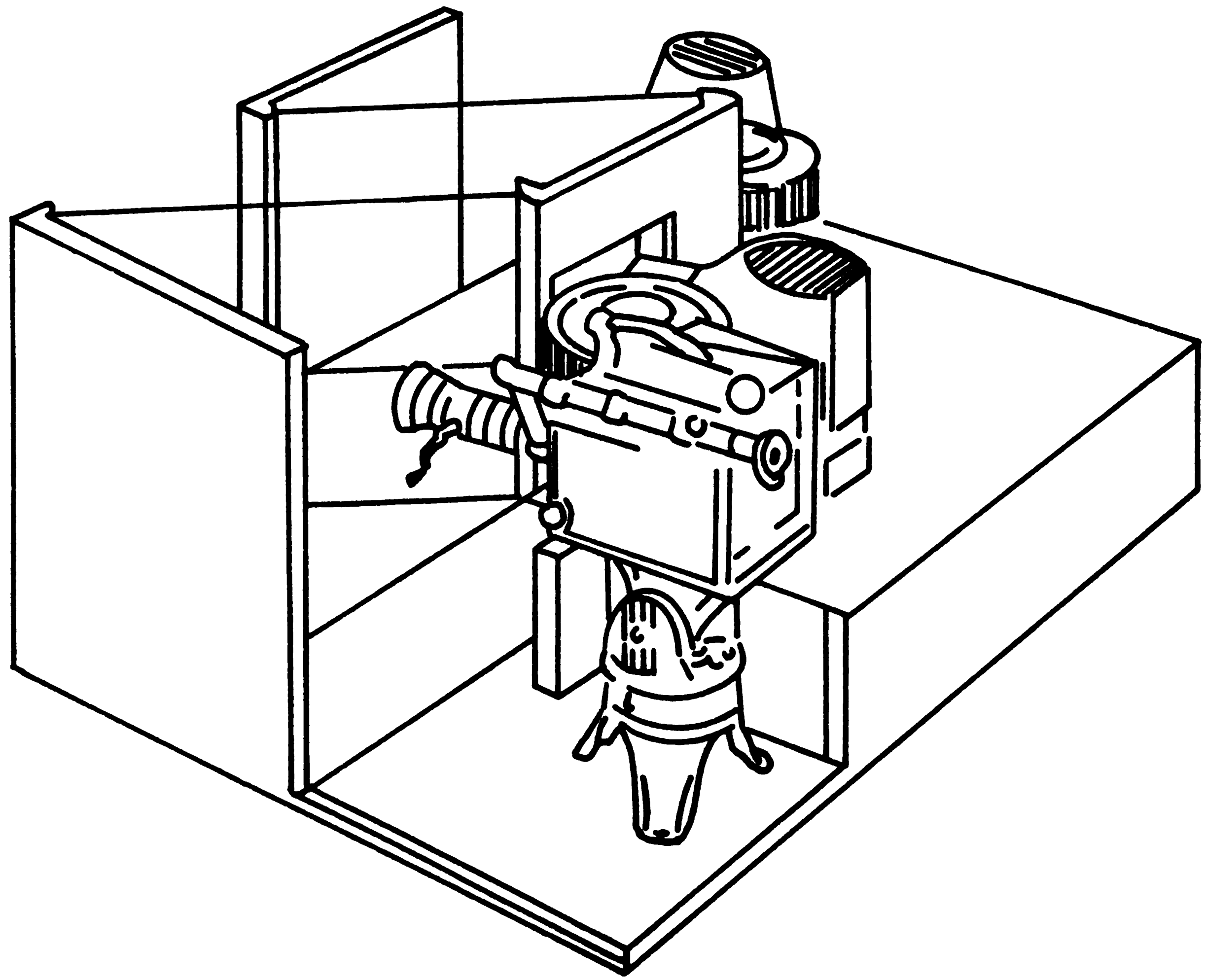

Figure 5.--Right Hand View of Beam Splitter Mount.

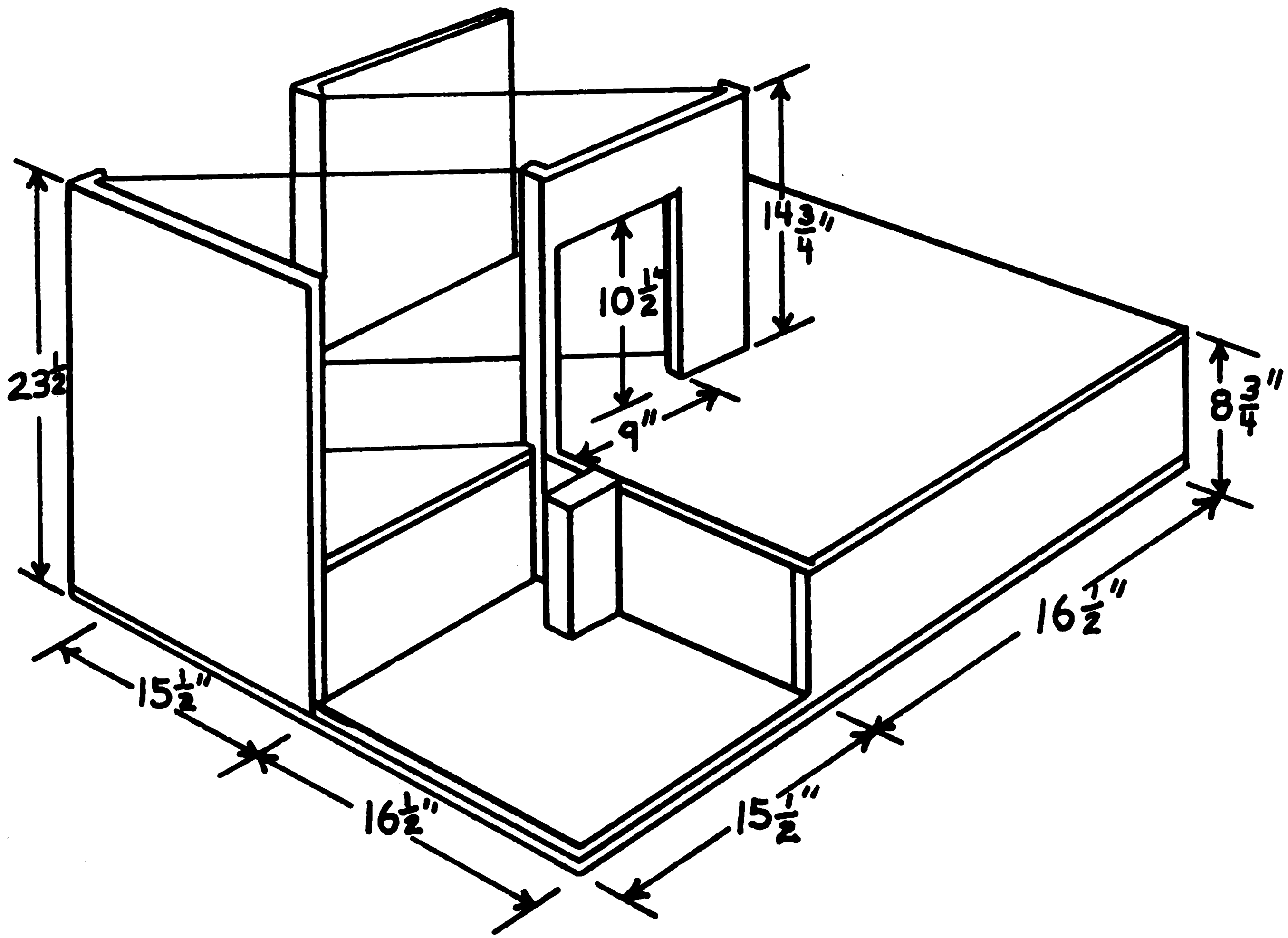

Figure 6.--Right Hand View of Beam Splitter Mount Showing Dimensions.

APPENDIX V

THE ACCOMPANYING FILM

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Front screen projection allowed us to present material in a manner that would have otherwise been possible only through the use of rear screen projection or a matt process, neither one of which was available to us in Hagerstown. It allowed us to present information in a creative and informative way that broke away from cliched traditional methods, and at a cost that most small producers could manage.

APPENDIX VI

SALES, RENTAL, AND PRODUCTION COMPANIES

SALES, RENTAL, AND PRODUCTION COMPANIES

Sales:

TELESYNC CORPORATION
20 Insley Street
Demarest, New Nersey 07627

CO/AX GRAPHIC SYSTEMS LTD.
902 Wentworth Avenue
North Vancouver, B.C.
Canada

Rental or Sales:

FRONT PROJECTION COMPANY
6647 Matilija Avenue
Van Nuys, California 91405

Production Companies:

CALVIN PRODUCTIONS/CALVIN CINEQUIP, INC.
1105 Truman Road
Kansas City, Missouri 64106

THE JAM HANDY ORGANIZATION
2843 East Grand Blvd.
Detroit, Michigan

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