ever, offer a fine substitute when nature has not been generous. Even when there are real clouds in the sky, the scenes may have to be photographed at angles that do not include the clouds. Edited together, scenes with and without clouds are inconsistent. This method fills in the gaps. Dramatic moods may be created by choosing suitable cloud formations regardless of the actual sky conditions at the time. Hazy skies, which are so difficult to control with color-correcting filters, make no difference to the transparency, which requires only a printing light whether it be hazy or otherwise. By using suitably toned or dye-toned transparencies the method may be applied to color-photography.

Rear-projection plates may be made at any time after or before the regular production long-shots have been made. Using the same transparency for both purposes guarantees that the identical cloud effects will prevail in each when the final scenes are edited in sequence. It is impossible to discuss here all the adaptations of this method. The method is constantly used in this studio, and extensions and improvements in the technic of using are occurring constantly.

Technicolor Cinematography

WINTON HOCH*

This essay does not in any way pretend to be a comprehensive coverage of the equipment, methods, and problems of the Technicolor cameraman at the present time, but is intended rather to present some of the items that might be of general interest. Inasmuch as the general technics of motion picture photography are well known and have been frequently discussed in the literature, there will here be presented some of those aspects that are peculiar to, or receive emphasis from, the fact that the camera is photographing in color.

These aspects arise in very large part before photography, and of all the preparation activities that take place before the actual start of photography, two that are very important to the Technicolor cameraman are color design of the sets and costume color selection. The

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importance of proper color design and costume color selection can not be overemphasized. The set colors should be chosen with care for hue, chroma, and value, and with a knowledge of the costumes to be used, the relative importance of the set, its cutting and physical relationship to the other sets, and the orientation of these factors with the script. While it is true that the cameraman can control the set effect to a large extent by his lighting of it, this color control work must be carefully handled or the screen result will not be optimum. Obviously the more adverse conditions the cameraman meets, the more the production is likely to suffer either in screen result or lost production time to correct those adverse conditions, or both. These two factors of set and costume color probably go farther than any other group of factors in representing the difference between a black-and-white production and a color production. The net result might be termed the "color score" of the picture. It might be compared to a musical score sometimes flashing and brilliant and at other times subdued. It follows that if the problem is ignored, discords usually occur.

Obviously, without sets and costumes in color, the only colors left are flesh tones. A very interesting color emphasis effect was demonstrated in the RKO picture, *Irene*, where an entire set was designed in neutral tones and the star wore the only color.

To handle this very important set and costume color contact, the Technicolor Motion Picture Corporation has available the services of a color control department to advise on the color design of the sets, the evaluation of costume colors, and allied problems. This department has a background of experience from all productions, and its experience and highly developed judgment are available, through the normal functioning of the department, to each new production as it comes along. This department is the spearhead of the Technicolor photographic activity.

The make-up problem is handled, as in black-and-white pictures, by the studio make-up departments, although the color cameraman does have the responsibility of requesting the "touching up" of the make-up as it may be necessary, and he very often has special problems that require close collaboration with the make-up man. For instance, on exteriors with the actors working in sunshine, they usually begin to sunburn, and make-up changes must be made in many cases to handle these gradually tanning complexions. Frequently this means a new make-up problem in order to keep the camera appearance of the flesh

tones the same. It can readily be seen that this can become a difficult job. The reverse is also true. As the troupe begins stage work after returning from the exteriors, their tanned skins will slowly fade and the problem of compensating by make-up continues. Occasionally we have had difficulty due to physical exertion on the part of the principals, causing faces to flush beneath the make-up, which effects the camera appearance.

The color camera is very discerning of flesh quality, and we find it necessary to include in the make-up area the neck and throat, and the hands and arms if they show. On rare occasions no make-up at all is used, and it is frequently omitted when photographing babies, as their clear smooth skin generally needs no correction.

It should be kept in mind that, generally speaking, the primary function of make-up is to correct extremes in colors, cover blemishes, and generally reduce the tone range observed in any average group of persons. If one will note the varying complexions of people, he will readily appreciate that if three or four persons were lined up side by side to be photographed, it would be highly desirable and probably very necessary to correct the flesh tones and greatly reduce the tone spread. This must not be interpreted as meaning that all flesh tones should appear alike. Variations of tone are very desirable. It is the extremes that are undesirable. Obviously a white man with a heavy tan who photographs like an Indian is not a very convincing white man. The most critical care is given to the close-ups, especially of the principals. The care and attention given to the problem are, of course, directly proportional to the screen importance of the skin tones.

A great deal of time and money has been spent in solving the make-up problem, and literally thousands of feet of film have been exposed and printed on various make-up tests to discover the best make-up materials and technics for the color camera. A proper make-up requires highly skilled artistry in its application.

Other important items to the cameraman are his lights. Here, color photography again introduces an important factor of which the cameraman must be cognizant, and which must be watched very closely on certain types of work. That factor is color-temperature. Our present three-strip Technicolor cameras are balanced to an average daylight color-temperature. For true color rendition, especially in the pastel shades and neutral grays, this temperature should not vary on the set by more than about $\pm 250°$.

There has been in the past some misconception regarding the status of incandescent lamps (designated in the studios as "inkies") with respect to Technicolor photography. Some people have understood that the Technicolor cameras are changed over by filters and prisms to accept an unfiltered incandescent-lamp color-temperature. Others have indicated that they thought that the camera automatically corrected any unfiltered inky light that might be added to an arc-lighted set. These conceptions are wrong.

The filters, prisms, and film of our present three-strip Technicolor camera are all balanced to daylight and this balance is used both for exteriors and interiors. This simplifies the production problem a great deal. First of all, there is manufactured and used only one set of film emulsions. This means that manufacturing, ordering, shipping, storing, exposing, and developing are all standardized for one system, with all the obvious attendant advantages, not the least of which is a lower negative cost.

This single standard also simplifies set-lighting problems, both interior and exterior. All regular Technicolor lighting units have been balanced to this daylight color-temperature by actual and repeated tests with the Technicolor camera. Therefore, they may all be used interchangeably as far as color-temperature is concerned. The only other factors governing their use are the very direct functional ones such as size of unit, light output of unit, operational characteristics of the unit, the type of light that it gives (that is, whether a "hard" light or "soft" light), and the unit efficiencies with respect to light output *vs.* current input, and with respect to light output *vs.* the throw required of the unit for the particular job in hand.

The more common units used for general production are (HI = high intensity):

The 150-ampere HI arc
The 120-ampere HI arc
The white-flame Twin Broad arc
Inky Sr. spotlight
Inky Jr. spotlight
Inky Baby spotlight

Among others less frequently used but in many cases no less important should be mentioned many special converted lamps, a 65-ampere HI arc spot, and a 10-kw corrected inky lamp.

The light-sources used for photography might be classed in four general groups as follows:

Daylight
High-intensity arc light
White-flame arc light
Incandescent light

The daylight, of course, is our standard for color-temperature. The HI arc lights are all corrected for normal work with a *Y-1* gelatin filter placed in front of the arc light. This filter was especially made for Technicolor, using a special non-fading yellow dye supplied by us. The exact filter strength is determined by camera test. The white-flame arcs were balanced to a daylight color-temperature by the National Carbon Company, and therefore require no filter of any kind. The incandescent lighting units must fulfill two requirements to meet the daylight color-temperature standard. They must first be equipped with incandescent bulbs burning at a color-temperature of 3380°K, and second, they must be fitted with a tested Macbeth glass filter. All General Electric bulbs marked *C.P.* will burn with a color-temperature of 3380°K when operated at their rated voltage. It should be emphasized that the rated voltage must be supplied, and in the case of the arcs, the proper amperages and proper gap lengths and positions must also be maintained.

Daylight as a source probably presents fewer troubles, although very early in the morning and very late in the afternoon trouble is frequently encountered. An interesting difficulty occurred early one afternoon when the smoke from a forest fire filtered the sunshine to such a brownish orange hue that it was necessary to abandon the location for that day.

The conditions just outlined do not have to be met at all times, but they should be adhered to if a pure white light is necessary and desirable for the work in hand. Certainly there is no limit to the effects obtainable with colored lights. For instance, frequently straight unfiltered flickering inky lights are used to produce a warm glow on the costumes and faces to simulate firelight. Artistic sense and experience must dictate the extent to which colored lights are used. The colored-light possibilities have been frequently used, perhaps most recently and extensively in the colored shadow and live action sequences in *Fantasia*. Its first featured use in three-color pictures was in the first three-color production, *La Cucaracha*.

The rigging and lighting of a color set is similar in many respects to that of a black-and-white set, with the exception that lighting units balanced for Technicolor are the units used, unless effects are in order Most Technicolor sets rely upon arc-light units for the bulk of the lighting. The large sets especially use the larger arc units. Some of the very small sets are from time to time lighted entirely by corrected inky light. Inky units are valuable also on big sets as auxiliary lighting units. They must be watched for age and cleanliness, as an aged bulb and a dirty reflector, filter, and lens can substantially reduce the lamp output. Needless to say, cleanliness is also an asset with arc-light lenses, and proper maintenance and servicing of all lighting units are important.

Exterior sets and set-ups are also handled in a very similar manner to black-and-white set-ups. Scrims, nets, reflectors, and booster light all play their part. It should be noted that the so-called gold reflector is not acceptable in color work (unless for effect) for obvious reasons.

The color-temperature factor is once more introduced when reflectors are extensively worked. The term *daylight* has been advisedly used. By definition daylight is the light from the entire sky, including direct sunlight if the sky is clear. Sunshine has a color-temperature of about 5,500°K, while blue sky has a color-temperature varying from 10,000° to 20,000°K. When reflectors are used as lighting aids they select only the sun, which is reflected into the scene, and introduce a filler light that is warmer in tone than daylight. In addition, it must be remembered that the so-called silvered suface, which is usually aluminum or tin, reflects slightly less blue than it does red and green. This factor also adds slightly to the effect of a lower color-temperature. For these reasons reflectors are not considered as desirable as booster light for some purposes. This is especially true of close-ups where flesh quality is of critical importance.

Process photography in Technicolor is now largely a matter of routine. The scenes selected for process work are, of course, subject to the usual limitations for that type of work, but astonishing results have been obtained. Progress in this field can be largely attributed to two factors: improvement in plate quality, and improvements in background projector equipment. As Technicolor production film is processed day by day the technical crews improve in skill and the

research groups add their contributions, to the end that the process plates now furnished to the studios are specially printed for the optimum contrast, color-quality, and density required for this type of work. The equipment combinations of each studio have been photographically tested for color-balance, and this color-balance is also taken into account when the plates are printed.

It has been found that background projectors vary appreciably in the color-quality of the projected light. Generally speaking, the projectors using reflectors have a little more blue in the light than the condenser projectors, although this color-quality varies appreciably depending upon the condition of the reflector and the nature of its surface, or upon the glass used in the particular condenser set-up in use. Some condenser lenses have a very pronounced yellowish cast that is not very desirable for color work.

There has been appreciable pressure in the last few years aimed at increasing the background projector outputs. The present high outputs have resulted from improvements in carbons, objective lenses, projector optics behind the objective lens, and lamp house, and in the successful combination of several projectors for throwing superimposed, matched, and synchronized images onto the process screen. Astonishing progress has been made toward increased output, and fortunately these developments reached the point where they were incorporated into production equipment before the present war appreciably curtailed progress in this line.

The Academy of Motion Picture Arts & Sciences and many studios and equipment companies have all contributed to this projector improvement problem. As a result, we very frequently photograph screens in color more than 20 feet wide, and have photographed, in color, process screens approximately 28 feet wide. This size was used in the Paramount-de Mille production *Reap the Wild Wind*. A shot has recently been made by the same studio using a split screen including a total camera spread of 50 feet. This was accomplished with the aid of two triple relay projectors incorporating the recent improvements previously mentioned. In this emphasis on large screens it should not be forgotten that miniature screens also have their uses, and can be successfully handled on the same general basis as the large screens.

The problems faced by the color cameraman in handling process photography are generally about the same as those found in all process work. However, he must be very color-conscious and on his

guard against an off-color projector light and improperly burning foreground lights. He must also be very careful of his foreground-to-background balance, as a background that is carried too high will often present a burned-out appearance that greatly alters the color values of the plate, and destroy the illusion of realism that he is striving to create.

Modern Technicolor camera equipment closely parallels the black-and-white studio equipment in its principal operational features and functions. There are available, for the camera, lenses of 25, 35, 40, 50, 70, 100, and 140-mm focal-lengths. They are all in carefully calibrated mounts that fit onto a master focusing mount on the camera. In almost all cases focusing is accomplished by actual measurement to the focal plane desired, and then the lens is set on this indicated calibration. Repeated tests have shown that this method is more accurate than eye focusing. Eye focusing is seldom resorted to unless the focal distance is so short that it exceeds the lens calibrations. The stop calibrations on the lenses are all photometrically determined and calibrated on an arbitrary arithmetic scale. These lenses have all been specially corrected for Technicolor work. A very interesting and very valuable follow-focus aid, which has been standard equipment since the manufacture of the cameras, is available to the assistant or technician in the form of a pair of selsyn motors. One is attached to the lens mount, and the controlling motor is held in the technician's hand, or fastened to some support if desirable, permitting the technician to be 50 feet or more away from the camera, and yet maintain accurate control over the lens focus. This is of especial value when the camera is put into the sound "blimp," making actual rigid mechanical connection with the lens-mount un necessary. This is very helpful on sound shooting inasmuch as the camera unit inside the blimp is actually floating in rubber and has no direct mechanical contact with the blimp except through this sponge rubber.

The non-rigid relationship between camera and blimp suggests another problem that has been solved in a very successful manner. That is the problem of attaching a finder for the use of the camera operator. Obviously, if it were attached to the outside of the blimp, the camera, inasmuch as it is floating, could be framed differently from the way indicated by the finder. This was solved by designing a very compact finder, and attaching the main optical elements to the camera. Auxiliary optical elements are available for use depending

upon whether the camera is used with or without the blimp. This compact design has the additional advantage that this same finder is used with the camera for almost 100 per cent of the work; thus only one finder and one set of mattes are necessary for each camera, and the camera operator has only one set of finder conditions for which to make allowances. Auxiliary finder allowances are *always* necessary to compensate for the parallax errors both in front of and behind the focal plane for which the camera is adjusted.

The camera motor arrangement is highly flexible and worthy of special note. There are eight types of motors and eight combinations of motor-to-camera gears, all of which can be changed in the field. The only requirement of the cameraman is to specify the kind of shooting expected and the electrical current or the kind of distributor system to be used. The regular cameras can also be successfully operated running backward at full speed. Speeds higher than 24 pictures per second, either forward or backward, are not permitted with the standard cameras.

The camera unit has available all the standard camera mounts to which the industry is accustomed. The wild camera can be mounted on anything from a camera spider to a high tripod, and on any other piece of equipment as may be desired, such as dollies, three-wheel perambulators, four-wheel velocilators, booms, rotating mounts, *etc.* The camera, incidentally, has been successfully operated in all possible positions.

For sound shooting the standard camera is used in connection with either a "barney" or a blimp. The barney is necessarily not so efficient from a sound standpoint as the blimp, but it is very useful in a great many places. The regular blimp is a highly efficient piece of equipment, and of course requires heavier mounts than the wild camera, but it can be accommodated on all types of mounts. Those most popularly used are the blimp "high-hat," four-wheeled "velocilator," and a variety of booms.

There are many items of special equipment available to the Technicolor photographer that are far too numerous to mention in detail. Among them should be mentioned, however, the variety of equipment and mounts used for air photography; the camera blimp and mounts used for underwater photography; and the speed-cameras capable of consistent operation at so-called six times normal speed, or 96 pictures per second.

The question has been asked if an extra standby camera was kept

on the set at all times to replace the camera in use when the film ran out, because it took so long to thread the Technicolor cameras. This is not true. The actual threading time of a Technicolor camera is only about three minutes, for a skilled technician, and many units work with only one camera. On major production units, however, an extra camera is usually kept on hand, threaded, to prevent any possible loss of production time due to many reasons. Sometimes a reduction of the three-minute threading time is desirable, and when sound shooting is involved and a certain emotional tempo or mood has been established with the principals, unnecessary mechanical interruptions are highly undesirable. Frequently the director requires two cameras on a shot, and the fact that the supply of extra cameras is often many miles from the stage has an important bearing upon the desirability of this extra camera. The additional cost of the extra camera is a very minor item and the camera usually saves much more than its cost by the saving of production time.

This equipment has been in service for many years, and has successfully met the test of almost all climates, altitudes, and conditions. The cameras have been in all parts of the world—into the crater of Mt. Vesuvius, under the sea near Nassau, almost 20,000 feet above the Andes in South America, in tropical climates, and in subzero temperatures.

Cartoons and all types of animation photography also should be mentioned. The bulk of the cartoon and animation work is now handled by adapted black-and-white cameras using the successive-exposure method. These cameras are set up with a balanced set of three-color filters in the optical system at some point, the filters either rotating or sliding, and the color-exposures are made by exposing one frame of film through each filter successively. At the head end of each roll of film a special chart is photographed, permitting the laboratory to identify the various frames. This negative, after development, is printed on a step printer that prints each third frame only. Thus the records are separated and the prints handled in a manner similar to other standard prints. This method is limited to work where no movement takes place during the exposure, and great care must be exercised in the lighting, exposure, registration, development, and color-balance of the film. The cameras must be serviced to rigid mechanical specifications, and the lenses should be color-corrected. A great deal of careful work must be done to set up such a system, and reasonable care observed in the shooting. Once the

system is set up, however, these items are handled largely on a routine basis and with reasonable facility. This type of photography can not be intercut with the standard three-strip negative unless dupe negatives are made.

Other very valuable technics and facilities that are available and are very successfully executed in current production today are glass shots; double and multiple exposures; double and multiple printing; wipes, fades, and lap dissolves made in the laboratory; and many combinations of these. The possibilities are numerous.

While speaking of effects photography, fluorescent materials, paints, inks, *etc.*, should be mentioned. This is a field that has not received much attention due to lighting equipment limitations; however, it can be accomplished in Technicolor. A very simple test was recently made to indicate some of its possibilities. Fabrics colored with fluorescent materials were photographed using as an ultraviolet source a Type *170* M. R. HI arc, covered by a 12-inch ultraviolet Corning filter. The arc unit was positioned 12 feet away from the illuminated subject and the spread obtainable with the filter was about $6^1/_2$ feet at this distance. The brightness of the fluorescent fabrics were sufficient to give an acceptable Technicolor negative with the camera operating at the normal speed of 24 pictures per second.

Routine studio Technicolor photography has long since passed the experimental stage. It is now handled with the same efficiency and dispatch as many black-and-white units. The negative is developed at night and the negative reports, negative clippings, and estimated printer points are delivered to the Technicolor cameraman on the set the following morning. Black-and-white rush prints, if ordered, are generally delivered the following afternoon, and the color rush prints are delivered the following evening.

The negative reports and all laboratory contacts are handled for the cameraman through the Technicolor camera department, which also checks the daily log sheets, and by these log sheets keeps a very complete record of every production and of every scene photographed on that production. The records have proved invaluable, not only to the cameraman, but on many occasions to the director and others participating in the production. This most excellent coördinating agency is extremely valuable.

Further production flexibility would be available if a single film capable of being exposed in any ordinary black-and-white camera could be used for a full color record. Technicolor's Research Labora-

tory has spent many years in the development of a monopack type of film that would fulfill this requirement. Progress on the project was reported by Dr. Herbert T. Kalmus, President of Technicolor Motion Picture Corporation, to its stockholders in his Annual Report for 1940, as follows:

"Your company's research engineers have also been engaged in cooperation with Eastman Kodak Company on a process of photography employing a single negative or monopack instead of the three strips, and on which three emulsions are superimposed on a single support. Your company's officers and technicians are frequently asked when Technicolor monopack prints will be available. Their current interest in the monopack process is not primarily for release prints because the triple-layer raw film appears inherently to be so expensive that it could hardly compete in cost with Technicolor imbibition prints in the long run.

"But your company's officers and engineers do believe that monopack will be developed to be satisfactory for use as originals from which Technicolor imbibition prints can be made. Such an original could be exposed through any standard black-and-white motion picture camera and should thus have mechanical and cost advantages over three-strip negative.

"Work on this monopack process for originals has been in progress for several years, and has lately reached a point of decided encouragement for certain purposes. At present the monopack research program includes a number of experiments of semi-commercial character which are promising for photography where camera size, mobility, operating speed, or other special considerations are of extreme importance. The expectation is that it will first be tried in a limited way for the special purposes indicated, to be matched and cut in with the larger part of a picture photographed by the three-strip method. It should be borne in mind that Technicolor three-strip photography is constantly improving in quality so that imbibition prints from monopack have not yet overtaken the present quality of imbibition prints from three-strip."

The expectation outlined in Dr. Kalmus' report has been largely realized, and since that time monopack has been used in several pictures, including *Dive Bomber* and *Captains of the Clouds*, where shots from airplane wing-tips and other difficult locations were required; in the industrial field; in military training films; and in special-effects photography where mobility and high speed are important. These

uses of monopack are considered as commercial experiments serving the dual purpose of fulfilling a special need of increased flexibility in the field of color photography and of pointing up production requirements which are not easily determined even on the large-scale test basis that characterizes Technicolor's research program.

Technicolor does not consider that the quality of prints from the monopack method of photography has reached the level of quality of prints from its three-strip process. This resides in part not in the absence of progress with monopack research but in the rapid improvement of three-strip Technicolor which, like all phases of Technicolor's process, receives emphasis from its research group.

The present monopack process, in latitude, visibility, and tone rendition is satisfactory, but the picture texture, in grain and uniformity, has not attained the smooth, fine texture of three-strip. The problems involved in correcting these deficiencies are receiving attention and progress is being made.

Technicolor is now and has been for some time definitely on a routine production basis, with almost all the technics used in black-and-white available in color also. The experimental phases have definitely long since left the production field, and have taken their place in the Technicolor research department, which is currently very active and from which the results flow quietly but efficiently to the production field without disturbing changes.