del rilasciamento elettrostatico uguaglia quella del rilasciamento meccanico; e la costante di tempo complessiva deve essere tale che la deformazione si mantenga più a lungo possibile (in modo da consentire l'accumulazione della luce) ma sia totalmente annullata in un periodo di quadro. Il pennello elettronico deve generare uno « spot » di forma rettangolare, all'incirca, con rapporto 1:4 o 1:5 col lato minore nella direzione del moto; il lato maggiore uguaglia lo spessore di una riga. Per evitare distorsioni che sarebbe troppo complicato descrivere (e per cui si rimanda alle memorie originali) il pennello non è modulato in intensità; al contrario, la corrente di pennello è tenuta costante, e il segnale completo (portante modulata del segnale visivo) viene impiegato a modulare la velocità di deflessione del pennello, essendo sovrapposto al segnale di deflessione normale. La deposizione della carica « a densità variabile » sull'eidophor avviene quindi in modo analogo ad una registrazione sonora a valvola di luce (Western).

La piastra portante l'eidophor è tenuta in rotazione lentissima per consentirne il raffreddamento. A tale scopo essa è per metà coperta da una piastra semicircolare di metallo raffreddata da circolazione d'acqua; uscendo dalla piastra essa viene « piallata » da un bordo tagliente situato in corrispondenza del semidiametro di uscita. Tutto il complesso è, naturalmente, sotto vuoto spinto; il pennello catodico, che è dallo stesso lato dell'obbiettivo di uscita, è deviato come nell'iconoscopio, e quindi la deflessione deve essere corretta per la distorsione trapezia. Una pompa a vuoto è costantemente in funzione durante l'esercizio.

Il liquido costituente l'eidophor, oltre ad avere i requisiti di viscosità, elasticità, costante dielettrica, e conduttività volumetrica richiesti deve anche avere una bassissima tensione di vapore (dato che lavora sotto vuoto) e deve resistere chimicamente al bombardamento elettronico.

Il prototipo dell'eidophor costruito dal Prof. Fischer aveva dimensioni enormi. Il diametro era circa m. 1,80 e l'altezza era tale da occupare due piani di uno stabile. Attraverso lo studio di un sistema ottico più compatto, le dimensioni dei futuri esemplari saranno sensibilmente ridotte e paragonabili a quelle di un proiettore ordinario da pellicola, a parte il peso (900 kg.). L'apparecchio potrà allora essere installato nella cabina di proiezione, e in questo potrà costituire un notevole progresso di fronte ai proiettori a tubo catodico che debbono di necessità essere installati in sala (dove possono, fra l'altro, costituire un pericolo, date le alte tensioni impiegate). L'altro punto di vantaggio dovrebbe essere nella maggiore disponibilità di luce, dato che la luce, generata da una lanterna ad arco, è limitata soltanto dal riscaldamento dell'eidophor, e dato che la proiezione perdura per tutto il tempo di rilasciamento.

Come per tutti i metodi di proiezione diretta sussiste per l'eidophor l'inconveniente già osservato della impossibilità di ripetere la proiezione, e della contemporaneità di questa con la trasmissione televisiva.

A parte i due sistemi di modulazione diretta (l'Eidophor, non ancora commerciale, e lo Scophony, che meriterebbe verosimilmente ulteriori sviluppi) la Televisione su grande schermo è già oggi una realtà pratica secondo due procedimenti di caratteristiche opposte, fra i quali la scelta deve essere effettuata dall'esercente. Le considerazioni precedenti possono valere soltanto ai fini di un orientamento generico, in quanto la comparazione definitiva dei vantaggi e dei difetti presentati dai due sistemi può essere compiuta soltanto attraverso un lungo periodo di impiego.

Discussione

Al termine della relazione Cambi il dott. SCHROTER fa alcune osservazioni sui dati di rendimento e di luminosità di tubi catodici dati da Cambi.

Interloquisce anche l'ing. MANDEL.

La produzione di film cinematografici con l'ausilio della televisione
Il film elettronico ad alta definizione

N. COLLINS e T. C. MACNAMARA

Viene esaminato un sistema di produzione di film cinematografici mediante la registrazione di immagini televisive ottenute da apparati elettronici da presa e da riproduzione. Il film così realizzato, detto film elettronico ad alta definizione, è tecnicamente superiore come grana e tonalità fotografiche al film cinematografico normale.

Inoltre col sistema televisivo elettronico si realizza una notevole economia nel costo complessivo di produzione.

Tale sistema è inoltre l'unica via oggi tecnicamente possibile per produrre dei film speciali a dinamica di contrasti ridotta come è richiesta per le trasmissioni televisive.

Le rapport esamine un procédé de production des films cinématographiques moyennant enregistrements des images de télévision obtenues par des cameras de prise de vue TV. Le film réalisé par cette mèthode possède une graine très fine et une meilleures « dynamique » des contrastes. Le prix de production est moindre que celui d'une film normale. Le système éléctronique est le seul qui peut assurer la production rationnelle des films pour transmissions TV.

This paper reviews a system for the produetion of moving pictures films by means of recording high definition images obtained from an electronic TV camera. The film produced by this system owns many advantages against the ordinary cinematographic film, as well as finer grain and better photo « dynamic ».

Moreover, the production cost of an electronic film is lower than the in the ordinary film.

Fnally, the electronic system represents the sole suitable and rational way for making films devoted to TV transmissions.

This report reviews the current situation in the Film Industry, and draws attention to the unavoidably high costs of production, which in the authors' view derive in large part from the production methods at present employed.

As a result of these costs, the risks of picture-making have become very real, and for every picture which shows a substantial return on capitai invested, many only just break even and many make serious losses.

Attempts have been made to reduce production costs and many expedients have been tried, but without significant success.

The authors seek to suggest that the failure to reduce costs significantly without spoiling the product is above all due to the limitations imposed by the optical camera, which, despite improvement out of all recognition in technical detail, remains essentially the same instrument as in the days of Lumiere and Friese-Green.

As seen by the authors, the limitations of the optical camera centre on the fact that no-one except the camera operator can have a true picture of what is being shot during a take and the director is therefore compelled to rely on his powers of judgement and imagination to visualise the nature of the shots, which he cannot see until rushes are projected-probably the next day.

In consequence, he must at the expense of a great deal of footage safeguard himself by a repetition of takes to the point where he can be sure that he is hound not only to have at least one entirely satisfactory shot but that he has assembled sufficient material to cut into a finished sequence.

The employment of more than one orthodox camera in a continuity sequence is considered by the authors to be entirely impracticable — a view in which most film-workers concur — not least because of the artistic hazards that are involved, and because the lighting that some part of the exposed film depicts the action as he wishes it.

It is sometimes argued that the unavoidable period of waiting before being able to study the projected film is not injurious to the end-product but is, in fact, positively beneficial. The view has been expressed that the technical perfection of the finished film can be obtained only by these two distinct processes the totally undistracted shooting of individual and unrelated scenes in the studio, followed by the far more leisurely assessment of the "rushes" when they are projected upon the screen in the viewing theatre.

Such a view may well rest upon a confusion of cause and effect, and may indeed conceal a misconception of proper artistic method, for it can be argued that with the facilities offered by the present type of camera, no other procedure could possibly be employed.

It now becomes profitable to consider the relationship of the individual shots to each other. It will be accepted by most film-makers that a great—possibly the greater part of the artistic merit of the finished film, i.e. its effect upon the audience, will ultimately depend as much upon the juxtaposition of sequences as upon the merits of the individual shots themselves.

In film-making under present conditions, however, the director is denied the possibility of any prior judgment on this point. He is compelled to rely upon "assembly" or "rough-cut" of the rushes before he can begin to evaluate these juxtapositions properly. By then it is frequently too late, except at considerable expense, to add what is discovered to be missing or to put right what is found to be wrong; furthermore, it is not until this stage that it can be realized that certain shots which are satisfactory in themselves are nevertheless redundant.

Nor is it surprising that this state of affairs should be so; because of the nature of the medium in which he is working the director is in the position of an artist denied the facility of sketching-in the general outline of his picture and therefore forced to bring the various details to perfection as he proceeds. It should be recognized that the only outline to which the director can refer is his shooting script. This can, however, prove a false and misleading guide, inasmuch as the whole art of film-making consists of the translation of a literary form into a visual one, and it is only visually that the finished result can be judged.

THE TECHNIQUE OF THE ELECTRONIC CAMERA.

The use of the electronic camera—or rather a unit of three or four such cameras-will obviate many if not all of the difficulties which confront the fiim director who is employing single optical equipment. It is of the essence of the electronic method employing more than one camera that, during both rehearsal and during shooting, the director can view upon his monitor screen not merely isolated shots but complete sequences (i.e. the blended output of his several cameras) of whatever length he may desire. The director can thus study the "architecture" of the film whilst the construction of the whole is still being composed, and the element of artistic hazard intrinsic in multiple-camera working with purely optical cameras is entirely avoided.

The film industry has already shown its awareness of the contribution which the electronic camera can make to smoothrunning studio production by the introduction of an electronic aid in the form of a view-finder used in conjunction with multiple optical cameras. The advantages possessed by the combination of optical camera and electronic viewfinder may be roughly summarized as follows. First, the element of operational blindness is removed; the director can study a cameraview of the shot during both rehearsal and the actual shooting. He can satisfy himself that the *découpage*, i.e. the breakdown into shots and angles, is as effective visually as it appears to be on paper. He can, whilst there is still time to alter or modify his own intentions, watch continuous sequences, and he is no longer compelled to work in a series of discontinuous glimpses. Finally, the electronic image can be multiplied and distributed, so that other key workers—the producer, the lighting engineer, the make-up supervisor, etc., can exercise their own separate supervisions.

Because of these advantages the addition of the electronic view-finder to an orthodox camera is regarded as a progressive step; nevertheless, it is essentially a traditionalist solution to a problem which is amenable to more satisfactory solution by newer methods. If the electronic image produced by the view-finder on the camera (or rather the master image produced by the several view-finders on the various cameras in the unit) already exists in convenient form, the most rewarding course would be to improve the quality of that image until it attains technical parity with normal film, and then to photograph the master image itself rather than turn back to the individual cameras for the actual process of recording.

The advantages inherent in this method will already he apparent to any director who is familiar with modern television-studio technique. Once the electronic camera has been substituted for the optical camera within the studio the electronic image on the director's master-screen becomes not merely an accurate and helpful camera-eye view of the scene, but an identical reproduction, faithful in all respects with regard to lighting, focus, tonal gradation, brilliance, etc., of the picture which is to be, or is being, recorded. Moreover, the photography has taken place at the point where the contribution of the electronic unit and of the director's supervising intelligence are at their optimum Not only can the "cuts," "fades," and "wipes" be recorded precisely as the director wishes, but this facility extends automatically also to mixes and superimpositions. Thus, at the end of shooting it is a portion of the fully finished film, rather than a collection of shots needing processing and editing, which the director of an electronic camera-unit has in his possession.

It is not the purpose of the paper to consider the advantages, in terms both of financial economy and of improvement in acting standards, which sequence shooting provides in comparison with the separate-shot method. The main issue is the question of the technical quality of recordings made from an electronic image. It remains, therefore, to show the reasoning which leads to the belief that recordings made by this method can produce film of fully acceptable technical quality.

OVERALL TECHNICAL CONSIDERATIONS.

It is clear that, to be acceptable, motion pictures made by the process describeb in the paper must to all practical intents and purposes be indistinguishable from those made by ordinary optical methods. This being so, an assessment of the average technical quality of pictures intended for theatrical release must be made, in order to determine the standard of technical performance which has to be achieved to attain the requisite effect. This is a difficult process, complicated by the profound influence of the artistic and entertainment value of the product, but swhilst recognizing the overwhelming importance of these qualities in their proper sphere, the engineer must endeavour to disregard them and evaluate such purely technical quantities as he can. Even when he can assign objective values to the more measurable qualities, his task is still formidable, because the final result will be judged subjectively and no two people will agree what constitutes the most acceptable product when it comes to the portrayal of some particular scene. The most important qualities which must be assessed are, in order of relative importance, tonal range and fidelity of tonal reproduction, and picture definition.

Contrast Range.

Dealing first with tonal fidelity and excluding specialized shots where unusually small or distorted contrast ranges are used for special effects, it is generally conceded that the average motion-picture-film print has a useful detail-bearing contrast range of 0·2-1·5, expressed in terms of $\text{density} = \log 1/x$, where x is the transmission coefficient.

Extreme highlights, such as reflections from chromium-plated parts of motor cars, musical instruments, sequins and to a lesser extent glints in eyes, shine on hair, etc., are permitted to extend to a value of about 0·1, which is the density of the celluloid base and constitutes a burnt-out highlight which contains no detail, but the presence of which is essential to give sparkle to the picture. At the other end of the scale, there is usually no great advantage in reproducing dark areas of density greater than 1:5 with any detail, because the ambient light falling on the screen is sufficient to flatten them out, owing to requirements of safety lighting in theatres. Nevertheless, it is customary to permit extremely dark areas to reach a density substantially below 1:5 without, however, containing much detail.

It may thus be said that the detail-bearing contrast range in an average motion-picture film, expressed in linear terms, is antilog (1:5-0:2) = 20:1. Allowing for extension to burnt-out highlights at one end of the scale (density = 0·1) and extreme blacks at the other (density = 1·7), the total contrast range is probably some 40:1 in the print itself.

It does not follow that this range of contrast will always be realized on the screen when the film is projected, because the actual limits of reproduction will vary enormously with many factors. The quality of the illuminant and optical system of the projector, the amount of ambient light reflected on to the screen by different decorative schemes in the auditorium and many other things all contribute to reduce the effective contrast of the picture.

These considerations aside, however, it seems clear that, to be comparable with normal motion-picture film, the release prints of motion pictures made by the proposed electronic process must have a total maximum contrast-range of some 40 or 50:1.

For the contrast characteristic required, normal practice in motion pictures is to work to an overall gamma of about 1:3. which correspond to a mean gamma of about unity. It is clearly desirable that films made by the electronic method should conform to this convention and there is no difficulty in achieving this result. In fact, the electronic process offers the possibility of improvement, because the extreme flexibility of the electronic chain through which the signals corresponding to picture are passed allows almost any shape of transfer characteristic to be contrived, within broad limits determined by the signal/noise ratio.

This is very significant, because it means that inherent defects in photographs, which are cumulative throughout the printing and processing and which result in a far from ideal characteristic in the final product, can be corrected by electronic compensation when the electronic camera is used, whereas they have to be tolerated when only the ordinary optical camera is available. As a result, the film produced by electronic means should ultimately be superior in tonal quality to that made by normal optical methods.

Definition.

The study of definition in a photographic image is a difficult subject, and too much adherence to conventional approaches con lead to erroneous conclusion. A somewhat novel approach to the problem has therefore been evolved, in the hope that methods of measurement may emerge which are capable of yielding more realistic results than some of the methods used in the past.

For example, the resolving power of a lens or a film stock, or a combination of the two, is usually defined as a limiting resolution of so many lines per millimetre. This means that an image composed of a pattern of that line density is just discernible, i.e. it is an extinction value. Any detail finer than this is lost, falling within the circle of confusion of the lens or the film grain size, or some combination of the two.

This definition by itself is misleading in assessing the effective sharpness of the resultant picture. The limiting resolution figure is analogous to the ultimate cut-off frequency of a low-pass filter, or, with certain minor reservations, of any piece of television equipment, such as a video-frequency amplifier or television broadcast transmitter. It gives no indication of the performance of the equipment at frequencies in the pass region below cut-off.

Obviously, many factors, such as lens aberrations, flare, internal reflections and diffusion of light and grain structure in the photographic emulsion, etc., must contribute to this fall-off in response as the detail fineness approaches the limiting resolution or extinction value, but a mere statement of the resolving power does not disclose the rate at which the fall-off takes place.

In an attempt to reconcile the television and optical points of view, the authors propose to use a term which has come to be used, namely "detail frequency," which is the product of the number of lines per millimetre into which the object is dissected and the scanning speed. Detail frequency in television is thus the electrical counterpart of detail fineness in photography and its use permits comparisons to be made. It must be recalled, however, that 1 line/mm in photographic practice conventionally represents one white and one black line, whereas in television the black and white lines are counted separately, i.e. one photographic line equals two television lines. It must be added, moreover, that the detail frequency is to be regarded as the fundamental frequency generated by scanning a repetitive pattern. No account is taken of harmonic development at this stage.

Fig. 1 shows an arbitrary comparison between the detail-frequency response of a television system and the detail response of a lens and photographic emulsion in comparable terms. To illustrate the point, the lens and film combination have been shown as having something approaching a normal aperture/distortion curve, whereas the television-system response has been maintained at 100% almost up to a sharp cut-off. The limiting resolution is the same in both cases.

It is believed that of the two reproducing systems, television will present a picture giving a greater subjective impression of sharpness and boldness of detail than the other, even though the detail cut-off frequencies are the same in both cases. The theory is advanced that subjective impression of definition can in some way be related to the ratio of the respective areas below the curves. The determination of this effect is complicated—like all comparisons of definition between television and photography—by the fact that television pictures are discontinuous in the vertical plane, whereas photographs are continuos in both planes. However, this does not necessarily invalidate the truth of the conception.

Another way of considering the same effect is to study the rate of change from black to white (and vice versa) attainable in photography. It is known that the transition from black to white in a photographic image is not infinitely rapid. In other words, the density change at the edge of an exposed area is gradual and not abrupt. Discounting contributions due to lack of sharpness in the lens, the main cause of the effect is hallation or dispersion in the grain of the emulsion. To demonstrate this effect, an image of alternate black and white bars of progressively smaller dimensions is explored by means of a microdensitometer, which is capable of measuring the density of areas small by comparison with the width of the narrowest bar.

The results of such an exploration are shown (greatly exaggerated) in Fig. 2. The full curve illustrates the ideal response, and the dotted curve the general shape of results attained in practice. It becomes apparent that the effect is precisely analogous with the distortion of a square wave which has been passed through an amplifier with an insufficiently short rise-time.

Investigation shows that the "rise-time" of different photographic emulsions varies greatly, for example, with grain size, etc., and it is not necessarily those emulsions that are capable of the greatest absolute resolution that posses the shortest rise-time for a black-and-white pattern of given fineness. It is believed that the picture which gives the best subjective impression of sharpness is the one that possesses maximum depth of modulation at higher frequencies and most rapid rise time, and that a figure of merit of apparent sharpness can be extracted, based on a mathematical combination of these two values. It will therefore be seen that to evaluate the quality of average motion-picture definition and to translate the result into terms of equal television definition is not a simple process. In consequence, it has been necessary to base the calculations on a simple conversion using such values as are generally accepted.

Before proceeding to numerical values it seems desirable to recognize that motion-picture technicians have, over a long period, arrived empirically at an order of definition which is adequate to satisfy the most discerning member of the public, even when sometimes projected through rather mediocre equipment. There is little doubt that twice or even four times the definition could be realized, but it would be quite unnecessary and uneconomic to do so. The generally accepted standard seems to comprise a lens and negative-stock combination having a limiting resolution under best conditions of about 40 lines/mm on the axis, and some 30 lines/mm over the whole field of a frame (22·55 mm x 16·03 mm.)

After processing, the release print has a limiting resolution of about 25-30 lines/mm on the axis. This is not a very high standard of definition, and a single-35 mm frame projected statically to normal screen dimensions generally appears fairly soft. Under running conditions, however, "dynamic resolution" makes its effect apparent and helps to produce an impression of adequate sharpness.

The mechanism of the dynamic-resolution effect lies in the fact that surface noise is random and adds from frame to frame in quadrature. The image, on the other hand, is repetitive and therefore tends to add arithmetically over a number of frames; moreover, the sharpness of edges is improved because a random succession of film grains, as it were, scan them and sharply delineate them.

For the choice of standards of electronic-image definition to give results comparable with motion-picture film produced by normal methods, it is necessary to consider the order of resolution required and that realizable in the present state of electronics. So far as image dissection is concerned, the only variable quantity is the number of lines, since the picture repetition frequency is fixed by motion-picture standards at 24 frames/sec. The decision regarding the number of lines controls many factors, of which the bandwidth of the system, the signal/noise ratio and the size of the scanning spot at both camera and reproducing tube are of cardinal importance. It is well known that, for a given number of lines, there is a calculable bandwidth which must be used in order to produce definition which is equal in both vertical and horizontal directions. It is worth remembering that the use of many more lines than the available bandwidth justifies can result only in progressive deterioration of the picture detail, since the detail frequency increases as the square of the number of lines.

The effect of increasing the number of lines, however, has a meretricious appeal, because of the finer resultant structure of the picture, but, whilst easier on the eye, it has no advantage for photography, where the linear structure is going to be eliminated in any case by one of the known expedients and out-and-out detail resolution is all that counts.

Considering, in the absence of anything better, a direct translation from optically produced film-definition standard to television, the following assembly of facts is arrived at:

The resolution of a normal motion-picture negative has been assessed, at best, to be about 40 lines/mm, which represents 80 television-picture points per millimetre.

Since the frame is 22·05 mm wide, the definition along the line is equivalent to a total of 80x22·05 = 1 764 picture points.

This, however, is based on photographic limiting-resolution values, so that it seems possible, in the light of the foregoing arguments, that appreciably less television picture points would suffice to produce a picture of acceptable sharpness. In this connection, Kemp (1) has suggested that it would be permissible to introduce a factor *C*, of which he considers the value to be about 0·75, to compensate for the more rapid decay of response of the photographic system with increasing fineness of detail, as opposed to the maintenance of a high level of television modulation up to the frequency of cut-off. Application of this factor gives the definition along the lines as the equivalent of 1764x0·75 = 1323 picture points. Direct translation of this value into the number of lines from top to bottom of the picture gives 1323x0·75 = 992 lines. The bandwidth required to transmit this detail, given by the familiar $L^2RP/2$ formula, is therefore $(992^2 x4x24)/(3x2)$ = 15·75 Mc/s.

It will be argued that it would not give a balanced picture, i.e. one in which vertical and horizontal definitions are equal, because of the line scanning factor, *K*. Various values have been assigned to *K*, but taking it at 0·75, the number of lines is increased to 992/0·75 = 1 320.

To sum up, therefore, a definition along the line corresponding to one-hundredth of the picture height, but to take account of diversity in the discontinuous vertical direction, the number of scanning lines may have to be increased to 1 300 with a 25 % increase in bandwidth to cater for the increased scanning speed.

However, because of the probably greater incidence of vertical than horizontal lines in a natural scene, it may not prove necessary to go much above 1 000 lines, and, since there is a tremendous advantage in keeping the writing speed as low as possible, this figure has been taken as a basis for first experiments.

It must be emphasized that the whole of the foregoing is advanced with extreme reserve and is, moreover, the subject of experiments currently being made, as much of it is based on pure supposition and on theories which have always been the subject of fierce controversy. Doubtless, calculations on other bases would yeld widely divergent results, but the authors feel that it is essential to make some attempt to determine numerical values, as a starting point for practical investigation.

Quite apart from the foregoing, there remain the possibility of introducing novel means of picture dissection—which may prove more adaptable than scanning of the orthodox variety—to the production of motion-picture film by television methods. It is too early, however, to make more than a passing reference to such possibilities, and for the purpose of the paper the authors have confined their consideration to scanning of the conventional type.

(1) W. D. KEMP, *Television Recording*, Television Convention, 1952, Session 3, Paper No. 1351.

INTERLACED AND SEQUENTIAL SCANNING

For the purpose in hand the choice between interlaced and sequential scanning involves several important considerations. Interlaced scanning is universally used for broadcast television and, in this connection, is an extremely useful expedient. By interlacing, the apparent flicker frequency of the reproduced picture is doubled, without, however, any increase in the bandwidth required to transmit it. The principle of interlacing therefore possesses outstanding advantages for broadcasting in that its use transforms a television picture of comparatively low repetition frequency, which would exhibit considerable flicker if sequentially scanned, into one which within acceptable limits of brightness is effectively flicker-free.

On the other hand, the introduction of interlacing is generally held to reduce the apparent definition of the picture as viewed by the eye. A number of effects are involved, of which three may be cited. First, slight inaccuracies of registration of the interlace raster result in " pairing " of the scanning lines, or, in extreme cases, superimposition of the lace and interlace lines. This is bound to reduce the definition progressively as the pairing effect becomes worse, until complete superimposition occurs, when the definition is theoretically halved. It is only fair to record that advances in design of scanning circuits have greatly reduced this defect in the last year or so.

Secondly, the movement of the viewer's eye when following vertically-moving objects strobes the line structure and momentarily breaks the picture as seen into half the number of lines, giving the impression of a coarse line-structure. A similar effect occurs in the television camera, where strobing can take place between the line scanning and objects moving up or down the vertical axis of the picture. Tilting of the camera can produce the same effect. It must be noted that in the recording of a television picture strobing effects are confined to the electronic pick-up camera and do not occur at the photographing point, because the photographic camera has a fixed viewpoint. Nevertheless, even in its reduced form, the result of " line crawl " introduced by the camera can be quite serious.

Thirdly, the use of interlacing gives rise to a particularly objectionable form of movement blur, because two discrete and separate images of a fast-moving object appear on the screen, displaced from one another by the distance through which the object has moved in the 1/48-sec interval between the writing of the two superimposed rasters. This is a form of movement blur which finds no counterpart in the natural response of the eye or in normal cinematography.

On the question of recording television images on film, however, it will be immediately apparent that the need for interlacing fundamentally does not exist, because the standard picture repetition rate is 24 frames/sec, elimination of flicker being effected at the film projector, where the light is obdurated twice, or preferably three times, during the projection of each picture frame.

Freedom to use sequential scanning leads to a consideration of its advantages, which may be stated as follows:

(*a*) It is appreciably easier to obtain accurate registration of the lines in a sequential than in an interlaced raster.

(*b*) Movement blur, due to the formation of double images, and line crawl are eliminated.

(*c*) The obligation to produce an exact number of lines per frame no longer exists, which opens up possibilities of the introduction of advantageous effects analogous to the dynamic-definition effect.

(*d*) The number of frame-suppression periods per picture is reduced from two to one, thus materially increasing the "time efficiency" of the system.

It is thus suggested that sequential scanning presents so many advantages that its use is to be preferred. The only serious disadvantage lies in the fact that the pictures viewed by eye, during production, suffer from the severe disadvantage of 24-c/s flicker. There seems some hope, however, that the effect of flicker may be to a large extent reduced by the use of reproducing cathode-ray-tube screens having long decay times.

THE ELECTRONIC CAMERA

Brief Description of System

To summarize the foregoing, it would appear that the use of a 1 000- to 1 300-line sequentially-scanned electronic image with a bandwidth of 15 to 20 Mc/s will suffice to give adequate definition for the production of acceptable motion-picture film, provided that the whole system is sufficiently free from loss and distortion. The contention is advanced that definition of this order is within range of modern electronic equipment and that within a short time, equipment which has been developed in the laboratory will be available in a form which will be suitable for use on the studio floor.

Optical Performance

No limitation in definition is imposed on the system by the taking lens of the electronic camera, since good-quality 35-mm lenses of to-day are capable at full aperture of resolving from 8 to 10 times the fineness of detail normally required for making a film optically. The use of a standard range of 35-mm lenses also ensures that depth of focus, taking angles and so on, are exactly similar to those to which film technicians are accustomed.

Handling Characteristics

Electronic cameras can be made in conventional shape, but much smaller and lighter than their optical counterparts. No form of "blimp" is necessary, because the electronic camera is completely silent. No necessity for reloading exists, and the cameras will operate for long periods without attention.

Apart from this, the camera handles in exactly the same way as any film camera, and the camera operator, if he so wishes, may adopt entirely conventional methods of view-finding, focus-pulling, etc. On the other hand, he has open to him entirely new features, such as cathode-ray view-finder, remote turret and iris operation, as well as facilities for remote or even automatic focusing, including splitting focus.

Only time can show how he will choose to employ these facilities, but it seems very probable that a technique can be built up using some or all of them with a material increase in efficiency of working.

Technical Performance Requirements

The electronic camera must be capable of resolving some 1 000-1 300 lines and generating a substantial amplitude of signal up to the highest detail frequency.

The photometric response must be such that a substantially linear characteristic can be obtained, with correction, if necessary, for a 50:1 range of light intensity.

The signal/noise ratio of the whole system must be not worse than —30 db on peak white.

The camera must be free from shading and vignetting effects and spurious signals generally, and it must maintain constant illumination over the field and a constant black level under the exacting conditions of practice.

The sensivity of the whole system must be at least equal to or greater than that of a normal film camera used with fast negative stock, and the scanning geometry must be of a very high order of accuracy, say within 1% in terms of velocity.

The associated equipment must have sufficient gain for the purpose in hand and a handling capacity large enough to allow for pre-emphasis at the higher frequencies, if necessary. It must be free from phase distortion or overshoot generally.

Facilities must be provided for gain adjustment, shaping of amplytude characteristic and the introduction of pre-emphasis.

Finally, means must be provided for cutting, fading, mixing or superimposing the pictures from a number of cameras and introducing electronic wipes, overlays, matte and other process shots, as well as programme material derived by telecine scanning of film taken elsewhere of exteriors, etc.

RECORDING CATHODE-RAY-TUBE UNIT

As in the camera, the scanning geometry of the recording unit must be of unimpeachable accuracy and the spot size sufficiently small to resolve the requisite definition without appreciable loss.

The tonal response must be either linear or capable of being shaped to compensate for the film-gradation characteristics. The maximum available peak brightness must be sufficient to reproduce the highest burnt-out highlight without "white flattening" or defocussing.

Steps must be taken to reduce dispersions or reflections of light so as to preserve the maximum contrast range, and the recording tube must be set up *vis-à-vis* the motion-picture recording camera in such a way as to minimize the effects of vibration.

The Mechanism of Photographic Recording

The choice of a means of photographing the image on film in the form of a motion picture poses a number of serious questions. Numerous methods have been proposed to bring about the desired result, but, broadly speaking, practicable methods tend to fall into one of two main categories, namely intermittent of continuous motion. The relative merits of the two systems, in their various applications to television recording are discussed by Kemp *(loc. cit.)*, and there is therefore no need to enlarge upon them here.

It must be noted, however, that Kemp's approach to the problem is conditioned by the fact that his treatment concerns the problems of recording broadcast television, where the worker is presented with a composite signal intended for reception on a normal television receiver. The form of this signal is fixed and he cannot in any way vary it.

The authors, on the other hand, are at liberty to make any changes in signal waveform that they see fit and consequently their conclusions are influenced by the greater degree or freedom open to them, as well as by the fact that they are working to much higher standards of definition, which in turn bring special problems.

Whilst there can be no doubt that continuous motion is exceedingly attractive from many points of view and may prove to be the ultimate solution, the accuracy of registration which can be realized in the present state of development is insufficient for recording pictures of the order of definition required. In consequence, attention has been directed to the intermittent system, which has been proved by many years' use in the motion-picture industry to give a very high degree of accuracy of registration.

The application of the intermittent movement to the problem or recording high-definition electronic images has, of course, been greatly eased by the freedom to adapt the signal waveform to suit the operating conditions of the photographic camera.

To illustrate the degree of this easement, consider the case of recording broadcast television with an intermittent camera. If the maximum picture information is to be recorded, the film shift must take place completely within every other frame-suppression interval. This means that the film must be accelerated, decelerated, brought to rest and registered in a period of 14 television lines, which represents a time interval of about 1:4 millisec, or 12° rotation of the film-camera mechanism.

Expert opinion indicates that a film shitf of this speed is on the limits of possibility, and that even if improved designed enabled it to be realized, the strain on both film perforations and mechanism would be such as to make frequent jams and stoppages unavoidable and to render maintenance extremely difficult and costly.

No such mandatory condition exists in the requirements of the proposed system of high-definition recording, and it is possible to choose a frame-suppression interval of any length desired. Any increase would, of course be made at the expense of the time efficiency of the system i.e. the ratio of the time during which information is passing to the time during which the system is inoperative during suppression. Nevertheless, a useful compromise may be struck in which the gains accruing from the use of a longer frame-suppression period outweigh the loss in terms of time efficiency.

As stated earlier, the use of sequential scanning gives a substantial gain over interlaced scanning, since there is only one frame-suppression period per frame in the former as against two in the latter. The authours, therefore, advocate an intermittent camera with an accelerated film-shift operating during the frame-suppression period.

Exposure Time and Movement Blur

Some consideration must be given to exposure time in an electronic, as opnosed to a photographic, camera. In normal motion-picture work, the maximum available exposure is usually 180°, and although practice varies, the usual run of pictures is shot a full exposure. Shorter exposures, obtained by reducing the shutter opening angle, are generally used only for scientific investigations.

The effect of using a comparatively long exposure of, say, 1/48 sec in a photographic motion-picture camera is to produce a measure of movement blur, which is usually regarded as beneficial in smoothing out movement and preventing the formation of discrete separate images of a fast-moving object in successive frames. Picture-goers are used to this effect, and it enhances the impression of movement as portrayed on the screen.

In the high-definition electronic camera, the actual time the scanning beam is traversing each picture point is about 1/48 micro-sec, or a million-times shorter exposure, since this would be the effective exposure if the camera had no memory effect. Fortunately all electronic cameras have some "memory" , and it is possible to proportion the memory to give an adequate impression of movement.

In the early days of television broadcasting some cameras had a very short memory, and a fast-travelling ball for instance, appeared as a line of white dots. An exceptionally long memory, on the other hand, is equally disadvantageous, because under these conditions very serious blurring will occur on moving objects and when the camera is panned.

A compromise is therefore necessary, and motion-picture experience indicates that a storage memory of 0·25-0·5 frame in lenght is likely to be satisfactory. It is not thought that the effect is particularly critical, and most television cameras in use to-day do not show any unpleasant effects in this connection under any reasonable conditions of working.

CHOICE OF FILM STOCK

A considerable degree of latitude exists in the choice of film stock for the recording camera, by virtue of the fact that the amount of light emitted by the recording cathode-ray tube is independent of studio illumination and may be kept constant under all conditions. Processing to constant gamma as opposed to constant density is facilitated by this.

Moreover, much more light is available at the film than when it is exposed in an optical camera, not only because the intensity of lights emitted by the cathode-ray tube may be made several times that of the light reflected from a studio scene, but also because the optical system used with the photographic recording camera can be made more efficient than that which it is possible to use on a studio floor. Magnification is constant and negligible depth of focus is required, because the cathode-ray screen is a flat field.

In consequence, comparatively slow film stocks can be used, with advantage in terms of resolution, rise time, absence of granularity and linearity of tonal characteristic. Moreover, images on fine-grain negative are known to suffer proportionately less in processing and printing than those on more sensitive and coarser-grained emulsions.

CONCLUSION

Whilst encouraged by the results of laboratory and studio tests to date, the authors are conscious that the paper is necessarily tentative in its conclusions and is in many respects lacking in precise data. However, in view of the rapidly developing interest in electronic film-making, they felt that an interim paper of this nature would nevertheless be of interest.

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Televisione inglese 1952

C. EGIDI

Sulla base delle notizie apprese in occasione del recente Convegno I.E.E. di Londra (primavera del 1952) e di alcune visite alle principali industrie britanniche di televisione, viene delineato un panorama aggiornato sugli aspetti fondamentali di questa tecnica.

Dopo avere rilevato le caratteristiche generiche della televisione inglese e la loro importanza nei riguardi dell'ltalia, vengono brevemente analizzati gli argomenti specifici, ossia la costruzione dei tubi catodici, dei tubi da presa e delle valvole riceventi, la radiodiffusione televisiva (produzione dei programmi, stazioni trasmittenti, propagazione delle onde, collegamenti fissi e mobili), i ricevitori, la televisione professionale e industriale.

Si conclude affermando l'estrema utilità, per i tecnici italiani di televisione, di scambi d'informazioni e notizie con i tecnici inglesi.

Sur la base des nouvelles et des informations données au cours du Congrès Anglais de Television du dernier mois de Mai, l'Auteur donne un panorama du developpment actuel de la télévision en Angleterre.

Le rapport touche touts les principaux arguments techniques du secteur.

On the basis of news and informations collected through the British Television Convention of May last, the paper gives a general view of the present development of the television in England.

The main technical subjects of the TV sector are examined through the report.

Premessa.

Scopo della presente nota è di riassumere in forma sintetica i principali aspetti tecnici della televisione inglese odierna e di metterne in luce qualche particolare di speciale interesse.

Essa è quindi principalmente diretta a completare le informazioni gia possedute sull'argomento dai tecnici dei Paesi che si accingono ad iniziare l'esercizio televisivo e quindi, in particolare, è rivolta ai tecnici italiani. II testo integrale di essa comparirà entro poche settimane sulla stampa tecnica [1].

Tra la fine di aprile e i primi di maggio ebbe luogo a Londra, come tutti ricordano, una IEE Convention dedicata a « The British Contribution to Television »; avendo avuto il piacere di se-

[1] Atti e rassegna tecnica della Societa degli Ingegneri e degli Architetti in Torino, agosto-settembre 1952.