July 27, 1965 M. H. M. ERNST 3,197,558

PROCESS FOR THE REPRODUCTION OF CONTINUOUS TONE PICTURES

Filed March 31, 1961 2 Sheets-Sheet 1

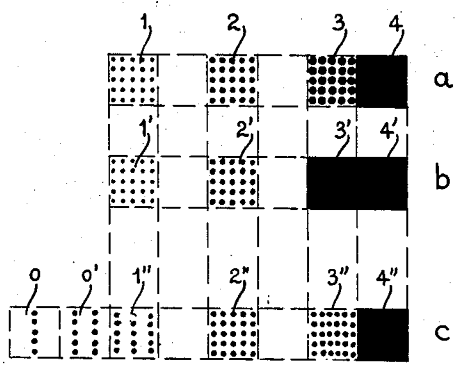

FIG.1

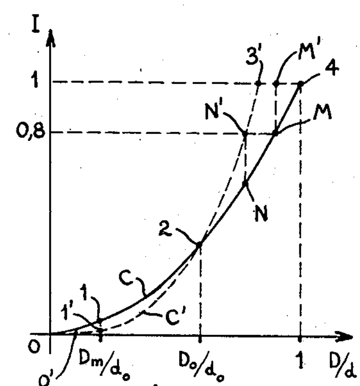

FIG.2

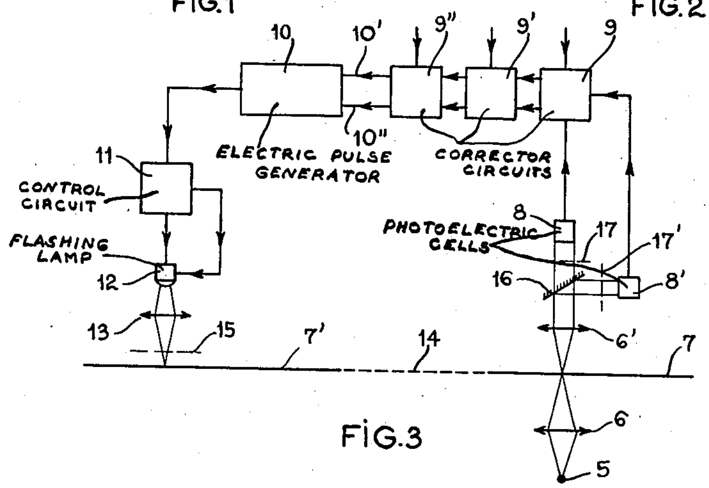

FIG.3

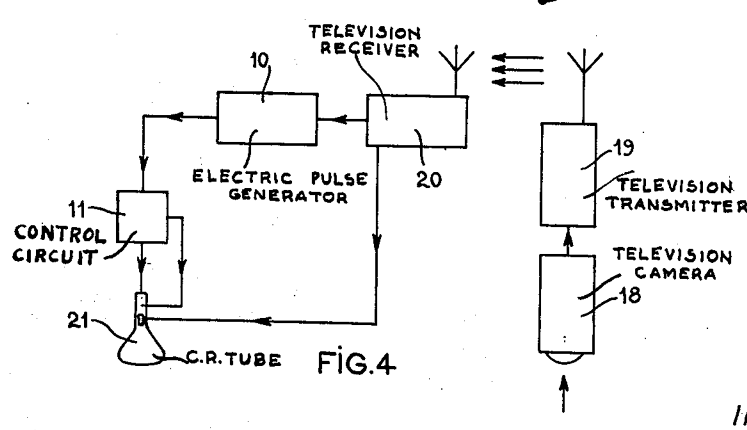

FIG.4

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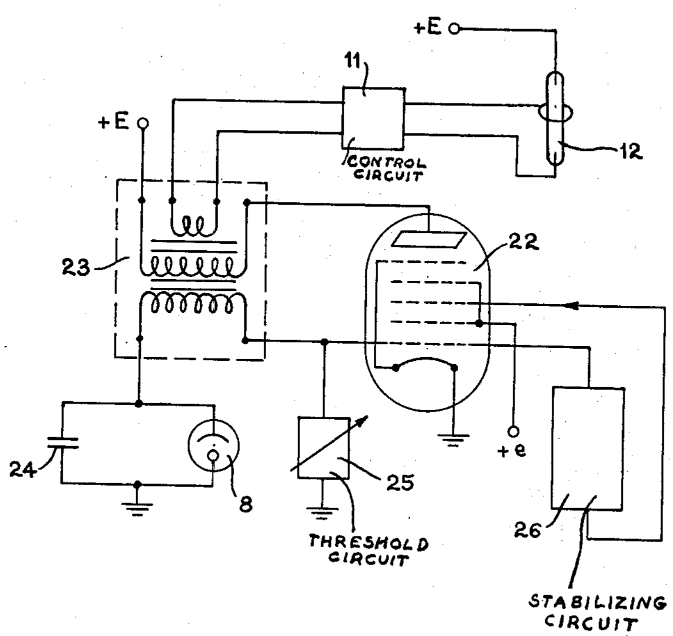
FIG. 5



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PROCESS FOR THE REPRODUCTION OF CONTINUOUS TONE PICTURES

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4 Claims. (Cl. 178—6.6)

This invention relates to a process for the reproduction of continuous tone pictures by means of juxtaposed dots forming a half-tone screen.

Process-engraving is a known process for the reproduction by printing of the type indicated above. It utilises process blocks in which the image is formed by a pattern or screen of equidistant dots, the blocks being generally obtained by photo-engraving. In this known process local variations of tone of the picture to be reproduced are represented by corresponding variations in the dimensions of equidistant dots of the screen. It presents numerous disadvantages.

The process according to the present invention is likewise of the above-mentioned type but it has none of the disadvantages of process-engraving. It is characterized by the fact that local variations of tone of the picture to be reproduced are represented by variations in the mutual distances between the dots forming the screen.

According to one embodiment of the invention, the dots can also vary in size.

The process according to the invention has a wider application than process-engraving. In fact it not only allows the reproduction of continuous tone pictures in the form of a screened block of the same kind as, but of different structure from those obtained by photo-engraving, but it also makes it possible to reproduce a continuous tone picture in the form of a luminous screened picture, for example a fluorescent screened picture of the same kind as pictures formed of fluorescent screens used in cathode tubes, in radioscopy etc., but having a screened structure.

Finally, by means of the process according to the invention, continuous tone pictures can be reproduced at a considerable distance from the original, using the known techniques of signal transmission. Luminous pictures, for example fluorescent pictures, can be reproduced, and the process is thus applicable in particular to television, and especially to the additive process of colour television.

The invention likewise extends to apparatus for carrying out the reproduction process according to the present invention and includes apparatus for obtaining screened printing blocks, apparatus for the distant transmission of photographs, and finally apparatus for the production of luminous, screened pictures, for example television pictures.

One method of carrying out the process according to the invention and various embodiments of an apparatus for carrying out the process will now be described by way of example with reference to the accompanying drawings, in which:

FIG. 1 shows the various continuous tones which can be reproduced by process-engraving and by the process according to the invention;

FIG. 2 is a diagram intended to facilitate the setting out of the general principle of the invention;

FIG. 3 is a block diagram of one embodiment of an apparatus according to the invention for the reproduction of a continuous tone picture in the form of a screened block;

FIG. 4 is a block diagram of one embodiment of a television installation according to the invention;

FIG. 5 shows diagrammatically one embodiment of the main electrical circuits of the apparatus of FIG. 3.

Referring to the drawings in FIG. 1, *a* represents the range of continuous tones which can be theoretically reproduced by the known process of process-engraving. This process utilises dots and spots which stand out against a lighter background. All the tones to be reproduced are represented by dots which are equidistant from one another but of different dimensions. Dark grey (zone 3) can be reproduced by dots which are so close to one another as to be almost touching. Black (zone 4) can be reproduced by dots which are of still larger dimensions and which partially overlap. Medium grey (zone 2) and light grey (zone 1) can be reproduced by dots which are of smaller dimensions but still the same distance apart. The carrying out of this process in practice leads to the following two difficulties:

(1) It is impossible to reproduce the white areas of the picture other than by very light grey zones, even if the background of the dots is white, as in the case of printing on white paper by means of a block. This is due to the fact that the size of the dots or spots of the screen cannot be indefinitely reduced because, especially in the case of blocks formed by photo-engraving, the said dots must necessarily be of finite dimensions.

(2) Experience shows that dots printed by means of a screened block, obtained for example by photo-engraving, generally differ in size from those of the corresponding dots of the block, but under given printing conditions, for example using a paper and an ink of well-defined qualities, there exists a preferential size for the dots of the block for which the corresponding printed dots are of exactly the same size as the dots of the block.

Strip *b* of FIG. 1 shows the tonal range effectively reproduced by printing by means of a block on which the continuous tones of the picture have been represented in accordance with the range *a* of FIG. 1. The dots of zone 2 of FIG. 1 are the only ones that retain their correct dimensions when printed (zone 2'). The dots of the other zones do not retain their proper size when printed. Printing has the effect of reducing the size of those dots which are smaller than the dots of the preferential zone 2, as shown for example by a comparison of the sizes of the dots of zones 1 and 1' of *a* and *b*, FIG. 1, which corresponds to light grey. Conversely, those dots which are larger than the dots of the preferential zone 2 are enlarged. The result is that the dots of zone 3 of the block, which almost touch one another and which are intended to reproduce a dark grey tone, are represented in the print by larger and therefore partially overlapping dots giving a zone 3' which is as black as the zone 4', corresponding to zone 4 of the block, which is formed by partially overlapping dots and is intended to reproduce a black area of the picture. This alteration of the dimensions of the dots of the block in printing results from the combined effect of two opposing physical phenomena, the relative importance of which varies according to the sizes of the respective dots of the block. One of these two phenomena is due to the effect of the surface tension between the ink deposited by the block on the printing support and the surface of the support itself. This effect tends to reduce the transverse dimensions of the deposited spot of ink. The other effect, which is of mechanical origin, results from the squashing of the spot of ink, due both to the pressure of the block on the printing support and the relative speed between the said printing support and the block, for example when the latter is carried on the cylinder of an offset printing press. This squashing effect naturally tends to increase the transverse dimensions of the spot of ink. The worst effect in the print of the change in the dimensions of the dots of the block is that a certain number of dark grey zones, such as 3, in the range of reproduced tones are replaced by absolutely black zones, such as 3'. The result is that the tonal range effectively reproduced by printing under the usual conditions of producing process-engravings comprises at the most 6 to 8 tones ranging from very light grey to dark grey. Not only is the rendering of the picture consequently imperfect, but in addition the process-engraving obtained has only a very limited tonal range. In order to overcome this disadvantage retouching work is generally carried out on blocks obtained by photo-engraving, before they are used in the printing process. The retouching work consists essentially in reducing the dimensions of the dots of the dark grey areas so as to prevent the mutual overlapping of the ink spots which result from the printing operation and the consequent production of black areas or at least areas which are much darker. Retouching is of course very fine work and is consequently time-consuming and costly, since it can only be carried out by hand by highly skilled workmen. This disadvantage is especially serious in the case of the reproduction of pictures in colours by colour photography. For example, the three-colour process utilises four screened blocks obtained by photographing the picture through complementary colour filters. Each of the four blocks requires special retouching, but the retouching work carried out on each block must take into account the retouching work carried out on the other three, and this particularly complicates the work.

Reproduction by process-engraving has two other disadvantages. If the dots used are smaller, the reproduction is finer, that is to say richer in detail occurring in the continuous tone picture. Therefore, in the case of a process-engraving, in which the dimensions of the dots of the screen vary according to the tone reproduced, the fineness varies according to the area under consideration, the light grey areas being richer in detail because they are formed by dots having the minimum dimensions. This is seldom an advantage because frequently the medium grey areas and dark areas of the continuous tone picture are the ones which are richest in detail. On the other hand, when complementary screened blocks bearing inks of complementary colours are superimposed as in colour processes, the resulting prints frequently have the defect known as the water-effect, resulting from the superimposing of different coloured structures which are of the same periodicity, when the screens of all the blocks are similarly orientated during the printing. These disadvantages are partly avoided in the usual colour process technique by orientating differently the screens of different blocks. This arrangement complicates production by photo-engraving and does not entirely remove the defects of the water-effect.

A preferred embodiment of the process according to the invention will now be described by which the whole range of continuous tones of a picture can be faithfully reproduced in the manner shown in strip *c* of FIG. 1. As in the case of process-engraving, each of the areas of uniform tone of the picture is reproduced by juxtaposed dots against a uniform and generally lighter background. However, while in the case of process-engraving, local tone variations of the picture are represented by variations in the dimensions of equidistant dots of the screen, according to the present invention the local tone variations of the picture are represented by variations in the mutual distance between the dots of each line of the screen and in particular the said dots may be all of the same size. The example shown in strip *c* of FIG. 1 corresponds to the latter conditions. In strip *c* all the dots which form the zones 0 to 4" of the tonal range are of the same size but their mutual distances have been caused to vary in each line of the screen in an opposite sense to that of the tone variations of the picture to be reproduced. The dots of each line of the dark grey zone 3" are closer together than those of each line of the medium grey zone 2", and these in turn are closer together than those of each line of the light grey zone 1". This results in the following two advantages:

(1) The fact that, at least theoretically, the various dots of each line of the screen can be an infinite distance apart makes it possible to reproduce the very light areas and even the absolutely white areas of the picture with great fidelity. In strip *c* of FIG. 1 the zone 0' shows how it is possible to reproduce a grey zone which is much lighter in shade than that of the lightest zone 1' which can be reproduced by ordinary process-engraving. In the zone 0 the dots, still of the same dimensions, are so widely spaced in each line that they may even be entirely absent from a zone of limited dimensions, so that an absolute white zone of the picture to be reproduced can be rendered by the uniform tone of the printing support, for example white paper, this being impossible in process-engraving.

(2) As the dots which form all the shades of the tonal range are all of the same size on the block, the corresponding printed dots will also be all of the same size, although the printed dots may differ in size from the dots of the block, in consequence of the inaccurate tone rendering of the printing process, as explained above. However, the dots of the block may be given the preferential dimensions corresponding to the zones 2 and 2' of the strips *a* and *b* of FIG. 1, so that the printed dots are exactly the same size as the corresponding dots of the block. In any case, in the process according to the present invention the dots which are to reproduce the dark grey areas of the picture can be so spaced that the corresponding printed dots do not overlap, and the corresponding zone of the reproduced picture is then a true dark grey (zone 3") and not black (zone 3') as in the case of ordinary process-engraving. This possibility results from the fact that the dots of the screen are all the same size, and consequently the tone rendering obtained in the print is uniform for the whole block. By means of the process according to the invention the continuous tones of the picture can be reproduced with great fidelity and moreover, reproductions obtained by the process can have a great richness of tonal range, for example up to 15 or 20 shades of grey ranging between pure white and dark grey or black.

Another advantage of the process of reproduction according to the invention lies in the fact that the fineness of the reproduction is independent of the depth of tone of the reproduced areas, since the said fineness depends only on the dimensions of the dots of the screen, and since the latter are identical for all the reproduced tones. Thus by choosing dots of sufficiently small dimensions, all the details included in the medium grey areas and the dark grey areas of the continuous tone picture can always be reproduced. The essential advantage of the process according to the invention, however, lies in the fact that owing to the uniformity of the tone rendering obtainable in the print retouching of the blocks which is essential in the case of process-engraving is no longer necessary, since the risk of reproducing a dark grey area of the picture by a black of darker area is removed. This advantage is especially appreciable in the case of colour photography. In this particular case, another advantage lies in the fact that complementary screened blocks obtained by the process according to the invention do not possess a repeating structure since the dots of their screens are not equidistant. "Watering" defects are thus avoided without having to take into account the relative orientations of the screens of the different blocks.

The particular embodiment of the process of reproduction according to the invention which has just been described, makes it possible to standardize the tone rendering of the print in a simple manner by making all the dots of the screen the same size and by making local tone variations of the picture correspond to corresponding variations of the mutual distances between the dots of each line of the screen.

According to a more general embodiment of the process of reproduction according to the invention, local tone variations of the picture to be reproduced are made to correspond to the corresponding variations not only in the mutual distances between the dots of each line of the screen, but also the mutual distances between the lines of the screen.

In general a perfectly faithful reproduction of all the continuous tones of a picture precisely by making use of the lack of uniformity of the tone rendering of the print, in the case in which the dots of the screen of the block are not all of the same dimensions, can be obtained in order to arrive at this result, in the process according to the invention local variations of tone of the picture to be reproduced are represented not only by corresponding variations in the mutual distances between the dots forming the screen, but also by variations in the dimensions of the dots. Thus variations in the mutual distances and in the dimensions of the dots forming the block screen must be co-ordinated in such a way as to compensate for the differences in dimensions between the dots of the block and the corresponding printed dots, by modifications which are proportional to their mutual distances. The general principle of the invention can be more readily understood by considering the diagram of FIG. 2. The abscissas of the diagram represent the different values of the ratio of the dimension D of the dots of a zone of the block screen (for example their diameter if the dots are round) to the mutual distances d between the dots. The ordinates of the diagram represent the different values of the density I of a zone of the reproduction. In other words, every point on this diagram has an ordinate which represents the density of the resulting tone of a zone of the reproduced image formed by juxtaposed dots, the dimensions D of which bear a ratio to their mutual distances d equal to the abscissa of the point in question. The full line curve C corresponds to the range of tones represented by strip a of FIG. 1. If the constant mutual distance between all the dots of an ordinary process-engraving screen is designated by d_0, the curve C extends from the point 1 having an abscissa D_m/d_0 which corresponds to the lightest strip 1 of the strip a of FIG. 1 (D_m being the diameter of the smallest technically obtainable dots of the block) to the point 4 having an abscissa 1 which corresponds to the black zone 4 of strip a formed by dots, the dimension D of which is substantially equal to the constant distance d_0, that is to say dots which touch or even slightly overlap. The broken line curve C' corresponds to the range of tones effectively obtained by printing, which is shown in strip b of FIG. 1. It extends from a point 1' having an ordinate slightly less than the ordinate of point 1 and corresponding to the zone 1', to a point 3' having an abscissa of less than 1 and an ordinate equal to 1, correspondings to the black zone 3', by which the dark grey strip 3 is reproduced in the print. The curves C and C' intersect at a point 2 having an abscissa D_0/d_0, which corresponds to the zones 2 and 2' of the ranges a and b of FIG. 1, D_0 being the particular dimension of the dots of the block which are reproduced in the print without any change in dimensions. As the value 1 of the density I of the tone corresponds to black, the diagram of FIG. 2 readily shows that all the dark grey zones of the picture, which theoretically could be reproduced by screened zones formed of dots having dimensions intermediate between those corresponding to the abscissae of the points 3' and 4, are replaced by black zones. In ordinary process-engraving, retouching of an area of the block intended to reproduce a zone of the picture of density 0.8 for example (dark grey) which could be reproduced in the print by black (point M' of the horizontal segment 3' to 4 of the curve C') consists, if the mutual distance d_0 between the dots of the screen are maintained constant, in reducing the dimensions D of the dots of the said zone so as to substitute for the point M on the curve C a point N of the same curve, with which is associated on the curve C' a point N' having the same abscissa, which has exactly the same ordinate as the point M, that is to say, $I=0.8$. In the process according to the present invention this retouching operation, which is intended to counteract the lack of uniformity of tone rendering of the print, is effected systematically. In the preferred embodiment described above, the retouching operation is effected systematically, not by reducing the dimensions D of the dots of the screen, as in the case of retouching by hand in process-engraving, but on the contrary by maintaining constant the dimension D of the said dots and increasing the distance d between the dots so as to reduce the abscissa of the point M of the curve C sufficiently to bring it to the position N. However, in its most general embodiment the process according to the invention consists in varying simultaneously the dimension D of the dots of the block screen and their distance apart d in a co-ordinated manner so as to reduce the abscissa of the point M to the value of that of the point N. Process-engraving can thus be regarded as a particular case of the general process according to the invention in which the distance d between the dots of the screen is maintained at a constant value d_0. The preferred embodiment of the invention shown in strip c of FIG. 1 corresponds to the symmetrical case of process-engraving in which the dimension D of the dots of the screen is maintained constant but the distance d between the dots, at least in each line of the screen, is caused to vary. In general, the process according to the present invention only utilises the simultaneous and co-ordinated variations of the dimensions of the dots of the screen and the distance between them, in the case of relatively dark tones, that is to say tones corresponding to densities I of a value relatively near to 1, so as to facilitate the reproduction of very dark tones and flat tones. For lighter tone areas the dimensions of the dots of the screen will be maintained constant and preferably equal to the preferential dimensions for which the dots of the block are reproduced in the print without change of dimensions. However it is clear that at the other end of the tonal range, that is to say for reproducing very light and pure white areas, it is equally possible to reduce the dimensions of the dots of the screen down to the minimum which is technically obtainable, in order to facilitate the reproduction of pure white. This corresponds to the portion 0' between the point 0 and the point 1 on the curve C of FIG. 2 and to the zones 0' and 0 of strip c of FIG. 1c.

Referring to the block diagram shown in FIG. 3, the apparatus according to the invention for the reproduction of a continuous tone picture in the form of a screened block consists essentially of a light source 5 from which by means of a suitable optical system 6 a parallel light beam is directed on to a point of the continuous tone picture 7 which is to be reproduced, it being assumed that the picture is transparent. In the embodiment considered it is assumed that the assembly 5 and 6 is stationary and the picture 7 is given a movement of translation in its place in such a way that every point is caused to pass successively through the light beam from the optical system 6. Of course, the scanning of the surface of the picture 7 which is to be reproduced can be effected in accordance with any law (rectilinear scanning, spiral scanning, etc). The light beam transmitted through the transparent picture 7 is focussed by an optical system 6' on to a light-energy detector 8, for example a photo-electric cell. By way of modification the picture 7 to be reproduced can be maintained fixed, the assembly 5, 6, 6' and 8 being then displaced as a whole so as to scan every point on the surface of the picture. The continuous electrical signal from the photoelectric cell 8 passes through adjustable corrector circuits 9, 9' and 9'' each of which has the effect of modifying the instantaneous amplitude of the signal in accordance with a predetermined law, but is capable of being adjusted and the precise functions of the said circuits will be described in detail below. The continuous signal thus corrected actuates an electrical pulse generator 10 so as to modulate the recurrence frequency and amplitude of the pulses which it produces, in accordance with its own variations of amplitude, through connections 10′ and 10″ respectively. In other words, during a time interval which corresponds for example to the scanning of a given line of the picture along which the tone varies in accordance with a certain law, the said generator 10 procures a series of electrical pulses, of which on the one hand the recurrence periods, that is to say the time intervals between successive pulses of the series, vary for example in accordance with the law of variation of the amplitude of the continuous signal supplied by the cell 8, that is to say, precisely in accordance with the law of variation of the tone along the line scanned during the time interval in question. On the other hand the amplitudes of the electrical pulses of the said series are likewise modulated, but in accordance with a law which is inverse to the law of the variations of tone along the corresponding line of the picture to be reproduced. Thus the light areas of the picture will be represented by series of pulses which are widely spaced from one another and the amplitudes of which will be relatively small. Dark areas of the picture on the other hand will be represented by series of fairly closely spaced pulses of relatively great amplitudes. The electrical pulses from the generator 10, thus modulated, are used to energise a flashing lamp 12 through the intermediary of a control circuit 11. Owing to the latter the durations of the successive light flashes produced by the flashing lamp 12 are exactly equal to the durations of the successive electrical pulses produced by the generator on one hand, and on the other hand the intensities of the light pulses are exactly proportional to the amplitudes of the said electrical pulses. The light flashes emitted by the flashing lamp 12 are concentrated by an optical system 13 on to a sensitised surface 7′ which is given a movement of translation in its plane in synchronism with the picture 7 to be reproduced, as indicated diagrammatically by the broken line 14 which connects 7 to 7′. Each of the light flashes emitted by the flashing lamp 12 falls on a given point of the sensitised surface 7′ which on development produces at this point a black spot on the clear background of the negative. From the latter a counterpart can be printed, on the white background of which the various dark spots form a screen, the different dots of which are located at varying distances from one another. The modulation of the intensity of the successive flashes of the lamp 12 can be converted into variations of dimension of the spots produced on the sensitised surface, for example by inserting a filter 15 having a bell-shaped absorption curve between the sensitised surface and the lamp 12. The filter, which has not been shown, can consist for example of a substance having a uniform absorption coefficient, but the thickness of which increases from the centre towards the edges. By breaking the connection 10′ through which the tone variations of the picture to be reproduced cause the intervals between successive flashes emitted by the lamp 12 to vary, a screened block having uniformly spaced dots similar to that obtained by photo-engraving can be obtained. Similarly by breaking the connection 10″ through which tone variations of the picture to be reproduced modulate the intensities of successive flashes from the lamp 12, a block 7′ can be obtained, the screen of which is formed by non-equidistant dots which are all of the same dimensions, using a preferred embodiment of the process according to the invention, which is shown in strip *c* of FIG. 1. In general the apparatus is arranged so that the continuous analysing signal which actuates the electrical pulse generator 10 through the connection 10′ can modulate the amplitude of the electrical pulses which it emits, only when its own amplitude is at least equal to a predetermined minimum value, having a threshold function, in order to facilitate the reproduction of dark greys and flats as previously indicated.

The functions of the various corrector circuits 9, 9′ and 9″ are as follows:

One of the circuits, for example circuit 9, makes it possible to improve the contrasts of the picture to be reproduced, if there is insufficient contrast, by modifying the law connecting the variations of continuous tone of the picture to be reproduced and the variations in the recurrence frequency, and possibly in the amplitude, of the electrical pulses emitted by 10. Another circuit, for example circuit 9′ compensates for variations in the dimensions of the dots of the screen which are produced during printing in such a way as to reduce the abscissa D/d of the point M on curve C of FIG. 2, so as to transfer this point to a position N by increasing the uniform distance d in the case of dots which are all of the same dimensions, and by co-ordinated variations of D and d in the case of dots of varying dimensions D. In the case of an apparatus intended for the production of screened colour blocks, an additional corrector circuit 9″ for example, makes it possible to correct the tones effectively recorded on the block 7′ with a view to obtaining a better colour rendering of the pictures to be reproduced. Other corrector circuits, not shown, could correct for certain defects of the document to be reproduced, such as for example the presence of fogging, or a prevailing colour in the case of a coloured picture. By inverting the phase of the continuous picture-analysing signal which actuates the pulse generator 10, it is also possible to obtain a screened block 7′ representing at will a positive or a negative of the block 7 to be reproduced. For the production of colour blocks of better quality, the apparatus shown diagrammatically in FIG. 3 is provided with an improvement consisting in a second light detector 8′, for example a photo-electric cell, to which a part of the light beam from the optical system 6′ is deflected by a suitable device, for example a semi-reflecting mirror 16. The selection filter 17 corresponding to the fundamental tone of the block to be reproduced is inserted between 16 and 8. A complementary colour selection filter 17′ is inserted between 16 and 8′. The continuous analysing signals from the photo-electric cells 8 and 8′ respectively actuate the pulse generator 10 in opposite phase and with relative amplitudes controlled by means of the corrector circuits such as 9 and 9″. This device thus makes it possible to subtract from the intensity of the fundamental tone selected by the filter 17, the whole or at least part of the intensity of the complementary tone which is generally superimposed on the said fundamental tone in the colour of the area of the picture which is analysed. This correction has the same effect as the retouching operation known as masking which is currently carried out on screened colour blocks, and consequently renders such retouching operations unnecessary.

Most of the circuits indicated by blocks in the diagram of FIG. 3 are capable of various arrangements some of which are well-known to technicians; for example, the electrical pulse generator 10 can be an asynchronous multi-vibrator, the recurrence frequency and possibly the amplitude of the pulses of which can be modulated by the continuous analysing signal owing to conventional arrangements. Similarly the corrector circuits 9, 9′ and 9″ are capable of very varied embodiments, the most simple of which utilise potentiometric lay-outs.

The circuit diagram of the principal electrical circuits of the apparatus of FIG. 3, which is shown in FIG. 5 will now be described.

The electrical pulse generator (10 in FIG. 3) is of the "blocking oscillator" type, and is adapted to produce very short pulses of high recurrence frequency. It comprises essentially a multielectrode electronic tube 22, between the anode circuit and grid circuit of which a strongly reactive coupling is provided by a transformer 23. A condenser 24 is connected between the grid circuit of the tube 22 and its cathode (earthed in the example shown), and the photo-electric cell 8 is connected in parallel with the condenser 24. The tube 22 is initially locked by the potential of the condenser 24 which is strongly negative in relation to earth, but it becomes conductive as soon as the condenser 24 has discharged sufficiently through the cell 8 (which is made conductive by the exploring light beam) for the control grid of the tube 22 to exceed its cut-off potential. A single pulse then appears in the anode circuit of the tube 22, the condenser 24 being immediately negatively recharged so as to again lock the tube 22. The more conductive the cell 8 becomes, that is to say the greater the intensity of the exploratory light beam, the shorter the time intervals between the successive electrical pulses thus produced. The said pulses are fed to a third winding of the transformer 23, which transmits them to the control circuit 11 of the flashing lamp 12. The purpose of the circuit 25 is to allow adjustment of the minimum value of light intensity to which the apparatus is sensitive (threshold of sensitivity). As it is merely a question of limiting the positive range of the grid potential of the tube 22, it is capable of numerous known embodiments which do not need to be described.

The circuit 26 connected between the control grid of the tube 22 and another grid of the said tube is intended to stabilise the cut-off potential of the tube so as to improve the linearity and the stability of its operation.

The reproduction apparatus shown in FIG. 3 is capable of numerous modifications. For example the light source 5 can be replaced by a source of other radiant energy, for example an X-ray generating tube, 7 being in that case a body analysed by transparency by the beam of X-rays emitted by 5. In this case the apparatus has the valuable possibility of modifying the contrast of the picture 7 and has a function similar to the known contrast intensifiers, the reproduced picture 7′ however having a screened structure. Similarly the flashing lamp 12 can emit flashes of radiant energy of any other kind, for example infra-red, ultra-violet or X-rays. The device for analysing the picture 7, which consists of the members 5, 6, 6′ and 8, can be replaced entirely by a television camera. In this case the camera feeds a continuous electrical analysing signal directly to the corrector circuits and to the pulse generator 10 and furnishes synchronising signals which can be used either for controlling the synchronous displacement of the sensitised surface 7′ or for controlling the scanning of the electronic beam of a reproducing cathode ray tube which replaces the flashing lamp 12. In the latter case the block 7′ can be obtained simply by photographing the fluorescent screen of the reproducing cathode ray tube. The luminous, i.e. fluorescent, image itself which appears on the fluorescent screen of the reproducing cathode ray tube could be of importance in certain applications, such as radioscopy, the source 5 being in that case an X-ray generating tube, and especially in telephotography and television. The modification of the apparatus in FIG. 3 in which the device for analysing the picture is replaced by a television camera, and the reproducing device is replaced by a cathode ray tube constitutes in fact a closed circuit television apparatus in so far as the various components which constitute it are connected together by conductors.

FIG. 4 is a block diagram of a television installation according to the invention which comprises essentially a television camera 18 which produces a continuous signal for analysing the picture as well as synchronising signals. These signals are used for modulating the carrier wave of suitable frequency emitted by a television transmitter 19. The said carrier wave can be demodulated by a conventional television receiver 20, which could be placed a great distance from the transmitter 19. The demodulated analysing continuous signal energises the electrical pulse generator 10 as in the case of the apparatus of FIG. 3. The electrical pulses emitted by 10 are used in the control circuit 11 to release the electronic beam of the cathode ray tube 21. The spot width of the electronic beam can be modulated by the amplitudes of successive electrical pulses. The cathode ray tube 21 receives directly from the television receiver 20 signals which deflect its electronic beam. The luminous picture which is formed on the fluorescent screen of the tube 21 has a screened structure according to the invention. According to a modification the continuous analysing signal could directly energise the electrical pulse generator 10 accommodated in the transmitting station, the carrier wave being in this case modulated by the pulses produced by the generator 10. The present invention also allows the production of television pictures in colour having a screened structure in accordance with the additive process. In this application the present invention has the advantage that watering defects are appreciably suppressed.

The reproduction of continuous tone pictures or documents by slow analysis as carried out by the apparatus of FIG. 3, can be effected at a distant station, without departing from the scope of the invention. For this purpose it is only necessary to transmit, preferably by means of a carrier current or carrier waves of suitable frequency propagated through conductors or through an insulating medium, either the continuous signal for analysing the picture to be reproduced, or the electrical pulses emitted by the generator 10.

It will be apparent that the various devices described above have been shown diagrammatically and only in their essential parts. Certain component parts, for example amplifiers, have not been shown for the reason that they do not fulfill an essential functional role, and their construction is well within the scope of those versed in the art.

What I claim is:

1. An apparatus for the reproduction of a continuous tone picture, including a television camera, adapted to generate an electric video signal, the picture to be reproduced being placed before said television camera so as to be scanned thereby, a generator of electric pulses, means to modulate the recurrence frequency of said electric pulses according to the modulation of the video signal generated by said television camera, a cathode-ray tube with an electron beam releasing electrode, on which said frequency modulated electric pulses are applied, and means to synchronize the electron beam sweeping of said cathode-ray tube with the scanning of said television camera.

2. An apparatus according to claim 1, including further means to modulate also the amplitude of the electric pulses, according to the modulation of the video signal generated by the television camera, the cathode-ray tube being further provided with a control electrode for adjusting the size of the electron beam spot, on which the frequency and amplitude modulated pulses are also applied.

3. An apparatus according to claim 2, including further means to photograph the screen of the cathode-ray tube, so as to obtain a screened block for the reproduction of the continuous tone picture by a printing process.

4. An apparatus for obtaining a monochromatic screened block from a continuous tone colour picture, including means to sweep the picture to be reproduced with a light beam, whereby said beam is modulated by the variations in tone of the picture along each sweeping strip, means to divide the modulated light beam into two partial beams, two complementary colour filters disposed so as to be respectively passed through by said partial beams, two photoelectric cells arranged to collect respectively the filtered partial beams, whereby said photoelectric cells respectively deliver continuous electric signals, with modulation following the respective modulations of said partial beams, a differential circuit adapted to subtract from one of said continuous signals, an adjustable part of the other continuous signal, a generator of electric pulses, means to modulate the recurrence frequency and the amplitude of said electric pulses according to the differential electric

signal, a flashing lamp adapted to be energized by the frequency and amplitude modulated electric pulses, a screen, and means to sweep said screen with the successive flashes of said lamp, in synchronism with the sweeping of the picture to be reproduced by the light beam, so as to produce juxtaposed dots on said screen.

References Cited by the Examiner

UNITED STATES PATENTS

1,683,894	9/28	Ivew	178—6.7
2,032,541	3/36	Losier	101—401.1
2,041,882	5/36	Dowd	178—6.7
2,294,643	9/42	Wurzburg	178—6.7
2,294,645	9/42	Wurzburg	101—401.1
2,818,465	12/57	Brink	178—6.7
2,962,548	11/60	Taudt	178—6.6

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