Oct. 3, 1950 M. LANGE 2,524,531

APPARATUS FOR TRANSFORMING HALFTONE DOCUMENTS INTO A PRINTING WEFT

Filed May 7, 1947 4 Sheets-Sheet 1

FIG. 1

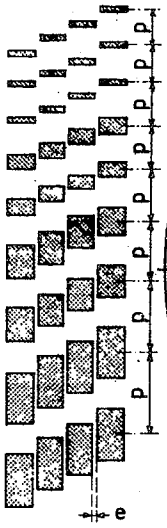


FIG. 2

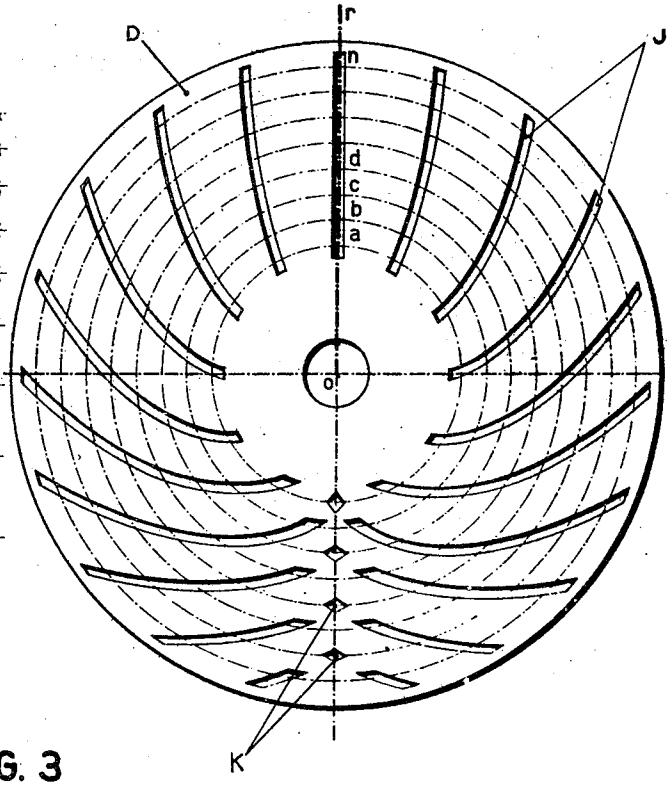


FIG. 3

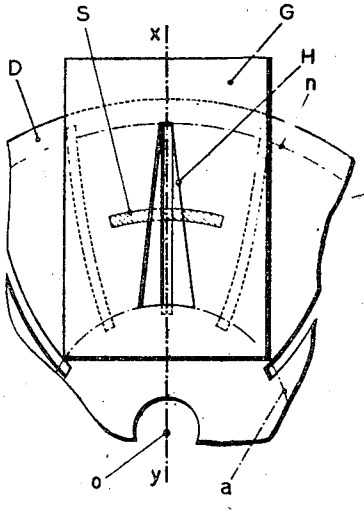
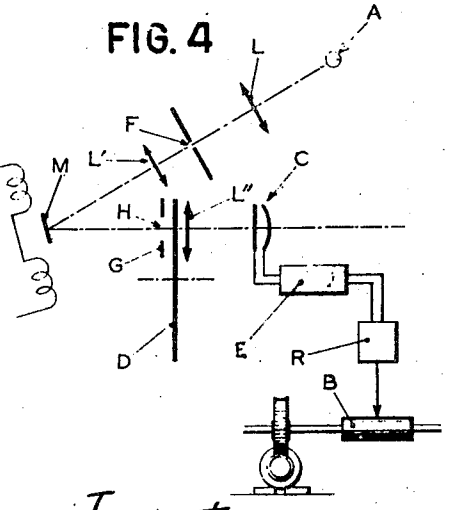


FIG. 4



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APPARATUS FOR TRANSFORMING HALFTONE DOCUMENTS INTO A PRINTING WEFT

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FIG. 6

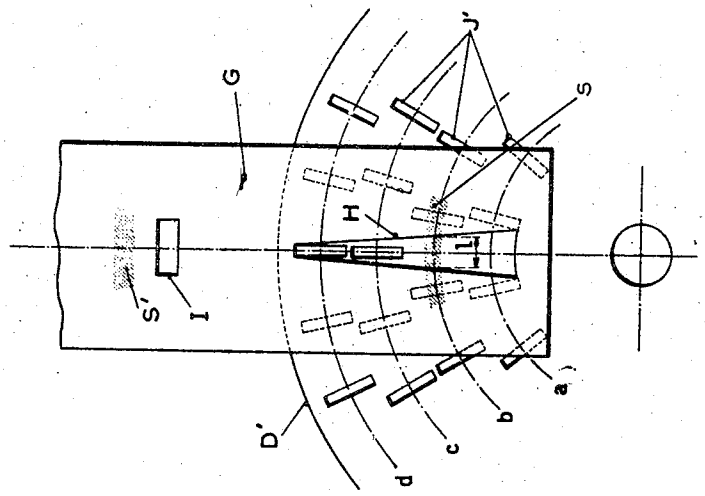
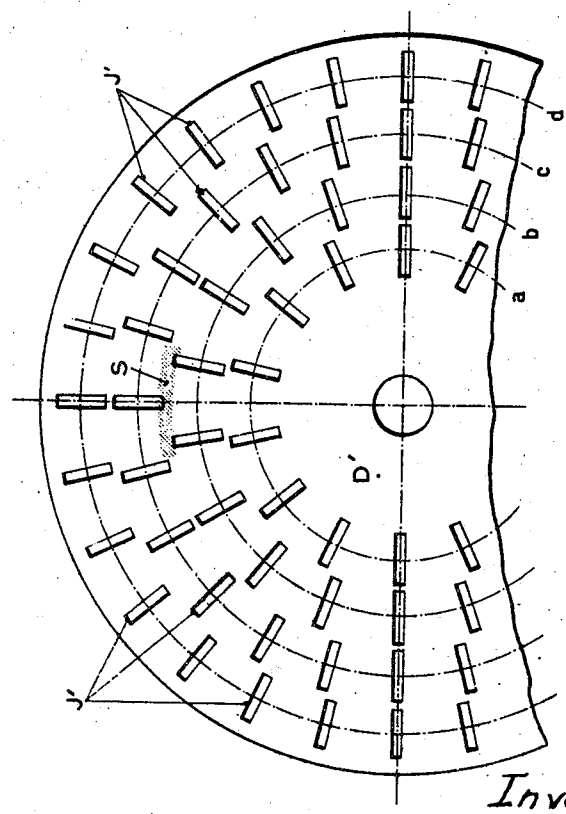


FIG. 5



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APPARATUS FOR TRANSFORMING HALFTONE DOCUMENTS INTO A PRINTING WEFT

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FIG.9

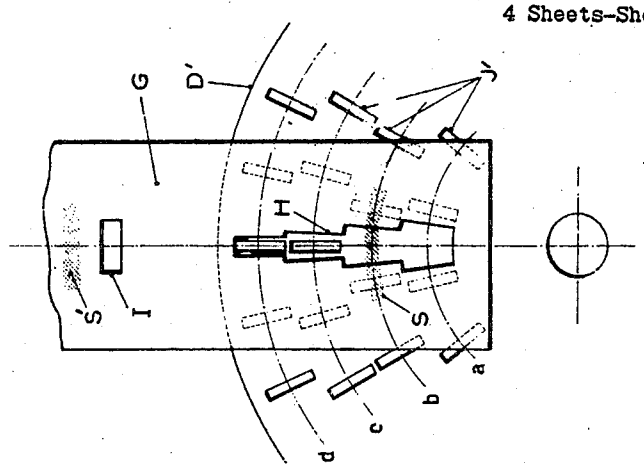


FIG.8

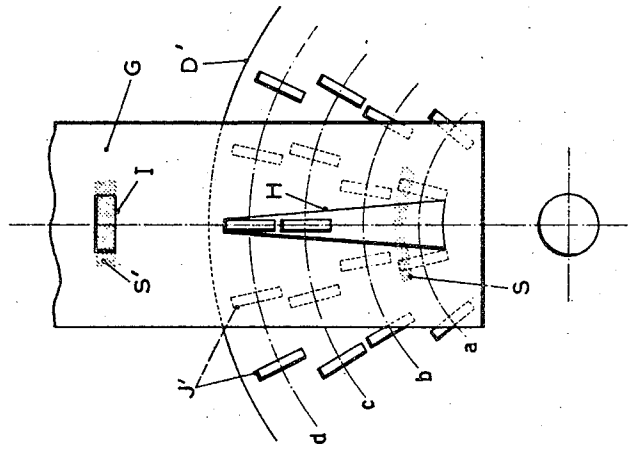
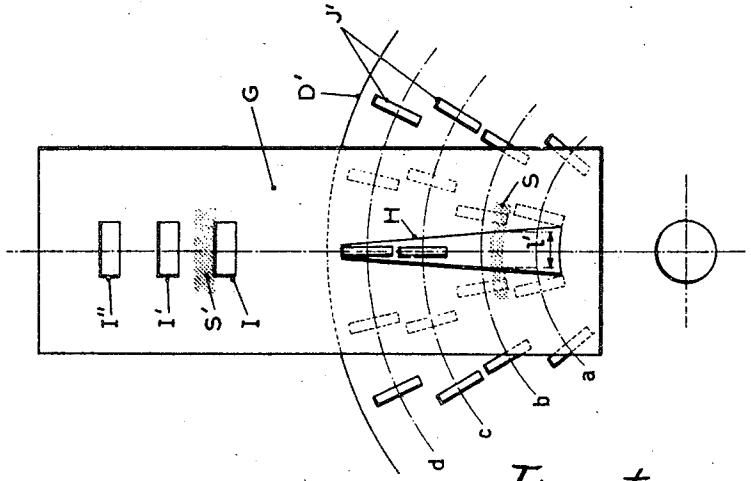


FIG.7



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APPARATUS FOR TRANSFORMING HALFTONE DOCUMENTS INTO A PRINTING WEFT

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4 Sheets-Sheet 4

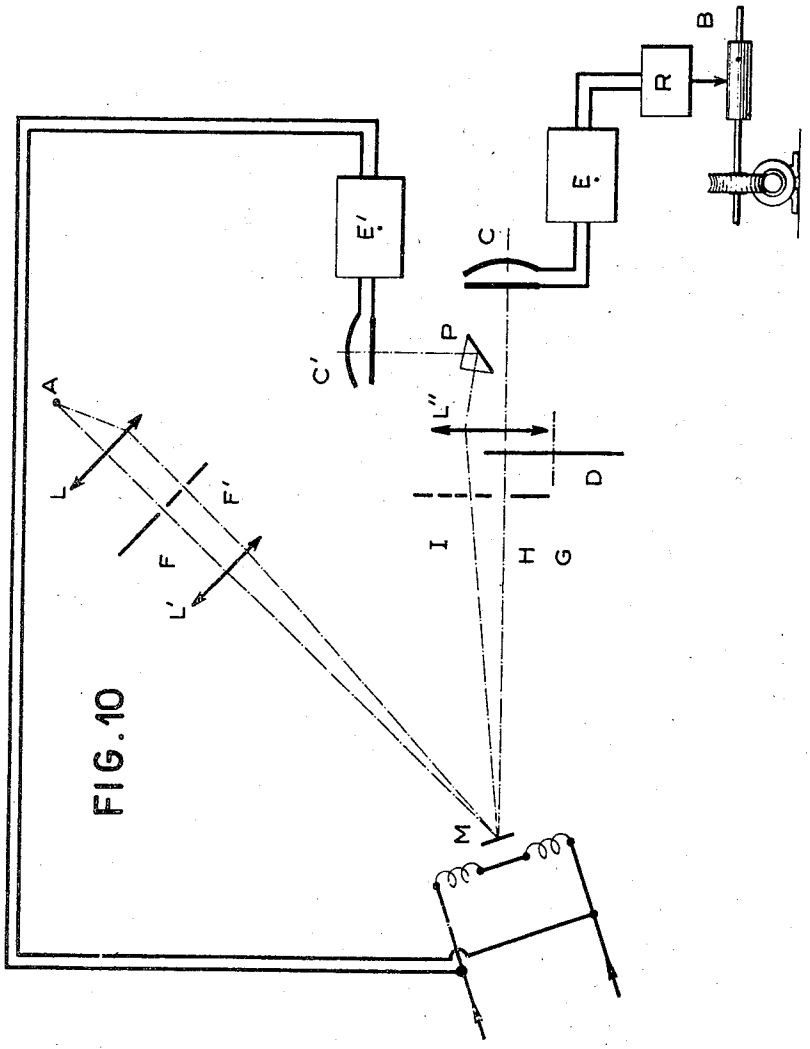

FIG. 10

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UNITED STATES PATENT OFFICE

2,524,531

APPARATUS FOR TRANSFORMING HALF-TONE DOCUMENTS INTO A PRINTING WEFT

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Application May 7, 1947, Serial No. 746,442
In France May 8, 1946

4 Claims. (Cl. 178—5)

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The invention has for its object to provide a process and an apparatus making it possible to obtain automatically and with high speed a screened or hatched reproduction, either on a film or on any other photosensitive surface, of an original document in outline or in half tone.

The process and apparatus according to the invention may in particular be used for obtaining engraved surfaces designed for printing on fabrics.

The engraving of such surfaces involves hatches wherein the spacing or pitch and the ratio between the sunk and solid area are varied with the intensity of the tint to be reproduced; said hatches simply provide means to retain a more or less large amount of ink, which, being distributed in the fibres of the fabric, reproduces the flat or shaded tones of each one of the tints in the original drawing.

The method of the invention is characterized by the following sequence of operations:

The original image is analyzed or scanned by known means actuating a movable mirror in such a way that the angular orientation of said mirror is at any instant a function of the tint analyzed on the original document at the same instant.

A fixed luminous beam of constant intensity is created and is caused to be reflected from the mirror controlled by the analyzing device, so that the reflected beam or pencil of light occupies a position which at any instant is a function of the tint analyzed upon the original document.

The reflected pencil of light is periodically intercepted and during the periods where it is not so cut off it acts on the photosensitive surface either directly or through the medium of a special device which is controlled by it, and in such a way that there is obtained on the photosensitive surface a pattern corresponding to the design to be reproduced.

In a modification of the process, the periodically intercepted pencil of light is caused to act on a device controlling an engraving tool or punch thereby making it possible directly to obtain an engraved surface.

The apparatus according to the invention comprises in combination:

A device of known type to analyze or scan the original image, which device at each instant determines the angular orientation of a mirror as a function of the tint at the point analyzed at that instant;

A device for periodically intercepting a luminous pencil reflected from the above-said movable

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mirror and derived from a pencil of incident light of fixed intensity and direction, said intercepting device being characterized in that the luminous beam acting periodically between the cut-off periods directly or through the agency of intermediate means, provides on a photosensitive surface a succession of photographic impressions reproducing a pre-determined pattern or screen as determined by the various shadings on the original document and thereby making it possible to reproduce said document.

In one specific embodiment of the apparatus the periodically cut off pencil of reflected light may be made to control, through a photo-cell and an amplifier a mechanical or electrical device actuating an engraving tool or punch directly engaging the cylinder to be engraved.

The method of the invention is operated by means of an apparatus whereof the accompanying drawings diagrammatically illustrate two embodiments by way of indication only and without in any way limiting the scope of the invention.

Fig. 1 shows an enlarged view of one specific form of screen pattern.

Fig. 2 shows a form of disk providing for the periodic interception of the pencil of reflected light which at each passage thereof determines the recording of one element of the screen pattern.

Fig. 3 shows a screen provided with a triangular aperture therein and placed in front of the intercepting disk between the latter and the reflected pencil of light.

Fig. 4 is a diagram showing a screening apparatus cooperating with a disk and a screen such as shown in Figs. 2 and 3.

Fig. 5 is a view partly broken away of another type of disk comprising rings of radially extending slots.

Fig. 6 shows a portion of the disk and the slotted screen covering the same for one particular position of the principle and secondary spots obtained with the screening assembly or stand of Fig. 10.

Fig. 7 shows a portion of the radially slotted disk and the screen covering it when the main luminous spot is positioned at the boundary of the slots of one ring of slots.

Fig. 8 shows a position of the secondary spot corresponding to the screening assembly or stand of Fig. 10 at the passage of the main spot from one ring of slots to the adjacent ring of slots.

Fig. 9 shows one specific form of the large

triangular slot of the screen placed in front of the disk.

Fig. 10 shows a diagram of the layout of a screening assembly or stand with a disk comprising rings of slots.

As shown in Fig. 4 an oscillograph or more generally a galvanometer including a mirror M is actuated by the analyzing device analyzing the original document to be reproduced, which analyzing device may be such as are used in photo-telegraph transmitter equipment of any known type.

The mirror M is movable about an axis perpendicular to the plane of the figure; it is illuminated by a lantern comprising a source of light A, a condenser L, an arcuate slot F and an objective lens L' adapted to form upon the mirror M the image of the luminous source A.

The mirror M reflects a pencil of light which finally forms a spot or image S of the slot F on a screen G (see Fig. 3) formed with a triangular aperture H. The expression "triangular aperture" is used to designate an aperture having a generally triangular outline but the sides of which may be either rectilinear, curved or more or less broken or irregular.

A disk D is disposed against the screen G; said disk D which is movable about its center O is provided with slots such as J or perforations K or transparent portions corresponding to such apertures or perforations which ride in front of the aperture H of the screen G as the disk D revolves.

The disk D is driven in rotation from an electric motor or any equivalent device; said disk may be made of any suitable opaque material wherein slots or perforations are cut out or may be constituted by a photographic film wherein the slots or perforations may appear by transparency.

Behind the disk D is arranged an aplanatic converging lens L'' adapted to concentrate the light of the narrow-beam or pencil passing through the triangular slot H and one of the slots in the disk D upon a photo-electric cell C.

As the disk D rotates the photo-electric cell C therefore receives a succession of luminous signals; said photo cell C is connected with the amplifier E or any suitable conventional type the output of which provides a current whereof the magnitude may thus assume one of two predetermined values, the one corresponding to darkness and the other to illumination as the pencil traverses any one of the apertures in the disk D.

The output current from the amplifier E is (when necessary after having been rectified) conveyed to a receiver device R which comprises an oscillograph the mirror of which oscillates when said oscillograph is traversed by the variable current from the output of the amplifier E. Said mirror is illuminated by a luminous source through an optical system and provides upon a slotted screen a movable image or spot; when this spot falls upon a slot in the screen the pencil of light traverses an optical system adapted to form a light spot upon the photo-sensitive surface of the recording or reproducing cylinder B.

The disk D may be formed with slots in widely varying dispositions or patterns.

In the case of Fig. 2 said disk D has drawn thereon a number of equi-spaced circumferences *a, b, c, d, . . . n*, eight in number for example. The innermost circumference *a* is subdivided, starting from the upper vertical diameter, into N equal portions, 12 in the instant case, the circumference

b is divided into N+1 portions, i. e. 13, the circumference *c* will include N+2, i. e. 14 portions, etc. . . . ; that is the number of divisions is increased by one digit from any one circumference to the next larger one. The slots and perforations are formed through those points of subdivision and in such a way that, were the spot S to fall through the slot H onto the circumference *a*, it would provide, at each revolution of the disk, 12 luminous signals on the cell C whereas upon the circumference *b* it would give 13 signals; the number of said luminous signals being regularly increased by one digit as the spot S is displaced outwardly of the disk.

The disk D' of the type shown in Fig. 5 is of much simpler construction; it comprises rings of radical slots J' starting from equi-spaced circumferences *a, b, c, d*, each respectively comprising 14, 18, 24 and 28 slots of equal height.

In other words, the variation in the number of luminous signals transmitted through said disk D' towards the photo-cell C for each revolution of the disk is discontinuous as the spot passes from the innermost circumference *a* to the outermost circumference *b*.

The screen G used with the disk D' comprising radial slots further includes three additional rectangular slots I, I', I'', and the screen of the lantern is in this case provided with an additional slot F' which forms upon the screen G after reflection from the mirror M of the oscillograph a second light spot S'.

Whenever said light spot S' passes through one of the slots I, I', I'' it is picked up by the aplanatic lens L'', then by a total reflection prism P which directs the light pencil back upon a photo-electric cell C'. The direct current output of the cell C', as amplified by a tube E' having a high-slope amplifying characteristic is fed back into the circuit of the oscillograph actuating the mirror M.

Said oscillograph circuit normally receives the output current from the modulating amplifier controlled by the photo-cell which scans the original document and the current generated by the secondary photo-cell C' is thus added to the normal current.

The stepped form of the slot H (Fig. 5) is desirable in the case of a flat-tint document, that is such as does not comprise continuously shaded tints; the aperture H has as many steps as there are rings of radial slots in the disk D'.

The screened pattern obtained through the use of a disk such as D (Fig. 2) enabling the number of luminous signals to be varied in a continuous or progressive manner is constituted by rectangular elements (sunk and solid areas) of constant width, variable in length and also in pitch or spacing *p* (Fig. 1). The spacing *e* between the rows of rectangular elements may be totally suppressed so that the merging of said rectangular elements will determine the production of hatches.

When there is used the disk D of the type involving a continuous variation in the number of light signals and starting from a design drawn in Indian ink comprising shaded or washed tints, the apparatus operates as follows:

The document to be screened is spread over a cylinder which is photo-electrically scanned just as if it were desired to transmit a photograph over a telephotograph system; the modulated current output of the amplifier is fed to a galvanometer such as an oscillograph placed upon the screening stand.

The light spot S directed from the mirror M of

said oscillograph impinges on the screen G formed with the triangular aperture H and which is arranged in front of the disk D, the axis *x y* of the triangle H lying in a vertical plane passing through the axis of rotation *o* of the disk, and its base being level with the circumference *a*, while its apex is level with the circumference *n*. The displacement of the mirror M is adjusted so that the spot will start from the base of the triangle for a dark area of the original document and will rise towards the apex of said triangle for the lighter shades of grey. Pure white will cause the spot to be projected beyond the apex of the triangle, because it then is unnecessary to screen it.

Assume by way of example that the circumference *a* has been divided into 12 portions and the outermost circumference *n* into 19 portions. The base of the triangle H which is structurally arranged to be positioned in front of the innermost circumference *a* comprising twelve apertures per revolution will therefore allow the spot of light to pass twelve times per revolution of the disk, each time said spot impinges on that point. The apex of the triangle H positioned in front of the outermost circumference which includes nineteen apertures per revolution will allow the spot to pass nineteen times per revolution. Any intermediate position will correspond to successive "on" and "off" conditions of the light spot in a number comprised between twelve and nineteen. It follows then that a black area of the document will be hatched twelve times and the intermediate tints will be hatched a number of times included in the range of from twelve to nineteen. At each passing of the aperture, photo-cell C (or the cylinder B as the case may be) will be struck by a luminous signal of constant intensity but the duration of which is a function of the position of the spot upon the triangle H. It is obvious that when the spot impinges on a point located towards the base of the triangle the duration of the signal is greater than when it falls upon a point near the apex.

The process forming the subject of the invention presents a remarkable flexibility inasmuch as it is simply necessary to modify the contour of the triangle H in order to shorten or lengthen the duration of the signals. There is thus provided a simple and practical means to compensate or correct certain shadings, and the sides of the triangle may be provided with curved or broken lines restricting the length of the signals.

Also it is sufficient to adjust the length of the stroke and the position of the spot on the triangle to transmit the shading with a more or less great number of points. Such number of points will be determined by the quality and thickness of the material to be ultimately printed.

The electric signals supplied from the output of the amplifier of the photo-electric cell on the screening stand (see Fig. 4) are directed towards the device R controlling recording on the cylinder B or reproducing cylinder housed in a light-tight box and which may for example be mounted on the same shaft as the cylinder supporting the original document, which in this particular instant will ensure positive synchronism of operation without the provision of any special means.

If the apparatus is devised in such a manner that, structurally, each revolution of the disk B will correspond to a linear displacement of one centimetre when the disk transmits twelve signals per revolution, it may be said that the screen pattern comprises twelve points per centimetre.

If the disk transmits nineteen points, the screen will be said to have nineteen points per centimetre and so on.

The rates of rotation of the cylinder and the driving motor for the disk D may be electrically interlinked by being electrically "in step" with each other to enable an accurate definition of the number of points per centimetre to be obtained.

The disk D' comprising a ring of radial slots (Fig. 5) is used in a number of cases where a continuous or progressive variation in the pitch step is unnecessary, and where a limited number of different screen patterns is sufficient to give a shades impression, because the triangle cut out in the screen, which is positioned in front of the disk, already has for its function to thicken or conversely to reduce the length of the luminous points impressing the photographic film placed on the recording cylinder.

A screened document may for example be formed by four different kinds of hatches. By way of indication, fourteen hatches per centimetre may be used for background tints, eighteen for dark tints, twenty-four for medium tints and twenty-four for pale tints. Naturally the above figures are given merely by way of indication and the number of hatches as well as their pitch step or spacing may be varied according to the nature of the support to be printed and also the composition of the colour which is to be used or the effect to be provided.

The disk D' may for instance comprise, starting from the circumference, *a, b, c, d,* four rings of slots of similar height, the first ring having fourteen slots, the second ring eighteen, the third twenty-four and the fourth twenty-eight.

It will be seen that the spot S may be so positioned as to overlap the slots of two successive rings, for instance the second and third rings *b, c,* and in this position there would be 18+24 luminous signals transmitted.

It is therefore necessary to provide means such that the spot S will be incapable of occupying such a position and will pass suddenly from one ring to the next one.

The mirror M of the oscillograph (Fig. 10) is adjusted so that the spot S will be positioned over the aperture H (Fig. 6) in the total absence of any current (white areas) and at the base of said aperture when there is a maximum current (black areas).

When said current passes from a minimum to a maximum the spot S occupies positions intermediate between the apex and the base of the aperture H.

Assume the original document is in one color drawn in Indian ink in shaded tints. If a given shade or tint causes the main spot S (see Fig. 6) to be stopped upon the ring of slots *b*, that particular tint being shaded, the spot will move along that ring of slots.

The spot S' is structurally positioned at a certain distance from the aperture I. The photo-cell C (Fig. 10) or the film will record the luminous impulses provided by the spot S through the aperture H and the slots of the ring of slots *b*. The duration of said impulses will be proportional to the width "1" of the triangle (Fig. 6) at the place where the spot passes therethrough since any one of the slots of the ring *b* requires a period of time "*t*" to travel over the distance "1."

If the shade becomes darker, the main spot S (Fig. 6) moves downwards and the secondary spot S' moves with it because they are both controlled by the mirror of the oscillograph. When the

main spot is at the base of the ring of slots *b* (Fig. 7) the width "1'" of the triangle at this point is greater than "1." Because the screen pattern has not changed there will be the same number of luminous impulses per centimetre of cylinder travel, but the duration of each impulse will be greater since each slot of the ring requires more time to travel through "1'" than it did to traverse "1," and the net result will be that there will be more colour deposited upon printing.

For this position of the main spot S, the secondary spot S' will have moved closer to the aperture I to the point of touching it, but should both spots continue to move downwards by a few tenths of a millimetre further, that is should the spot S tend to move towards the ring of slots *a*, the light from the secondary spot S' would begin to pass through the aperture I, the photo-cell C' is slightly illuminated and generates a small amount of current which is fed back to the oscillograph, the mirror M of which causes the spots S and S' to move still further down. The spot S' passes through the aperture I to a greater extent, and there is therefore an increase in the current supplied to the oscillograph. The spots S and S' will thus move further down and so on, until S' is allowed to completely pass through the aperture I. The spot S is then positioned at the upper part of the ring of slots *a*. At that time a state of balance sets in, because if the spot S' were to move down any further, it would move out of the slot I and the photo-cell being less strongly illuminated would generate less current which in turn would cause the spots to move upwards.

The above-described movement is effected very rapidly and the main spot S jumps very fast from one ring of slots to a next one without being allowed to stop astride a pair of different rings.

After the spot S has reached the position illustrated in Fig. 8, one of the following two conditions may occur:

1. If, as a result of a change in shading in the document, the spots S and S' have a tendency to rise, the secondary spot S' will no longer entirely pass through the aperture I, and the photo-cell C' shown in Fig. 10 will supply less current to the oscillograph. As a result the spots S and S' will rise yet further and the cell C' will receive less and less light until it remains completely in the dark and the spots S and S' will again be restored to the position of Fig. 7.

2. If on the other hand the shading of the document being scanned is such as to cause the spots S and S' to move down rather than up, the secondary spot S' will move away from the aperture I, the photo-cell C' of Fig. 10 will receive less light thus feeding less current to the oscillograph which in turn will be effective to retard the downward movement of the spots. This is manifested by a slight flattening in the modulation which will prevail as long as the secondary spot S has not entirely left the aperture I.

In the case of "flat-tinted" documents and with the stepped form of aperture H (Fig. 9), the operation of the light spots will be the same as previously described, but the displacements of the main spot S over a given ring of slots provide on the main cell C of Fig. 10 periods of illumination of equal duration. Said displacements being simply due to the slight irregularities which may occur in the "flat" tint corresponding to that particular ring of slots, correction is therefore automatically effected. The spot S moves from one ring to another only when there is a change in the shade of the "flat" tint.

The displacement of the mirror of the oscillograph with respect to the current fed to the latter is generally not strictly proportional to said current.

It follows that if it is desired always to obtain a similar displacement for the spot S as it jumps from the ring *a* to the ring *b*, then from *b* to *c* and later from *c* to *d*, the three apertures I, I', I'' should not be identical. Their height dimension is left unchanged, but, in the case of Fig. 7 for instance, the slot I will be provided longer than I' which in turn will be longer than I''. In other words, to obtain a similar displacement for the spot S, it is necessary that the photo-cell should receive more light when the spot S is positioned towards the base of the aperture H than when S is positioned towards the top. The length dimensions for I, I' and I'' are determined experimentally once for all according to the type of oscillograph used.

It will of course be understood that various alterations, improvements and additions may be made in the embodiments described and illustrated and certain devices therein may be replaced by equivalent ones without the general principle of the invention being thereby altered.

Thus in particular the rings of slots may be provided with varying heights if required, in the case of "flat tints"; the location of the additional slots and the secondary spot on the screen may differ from that shown, as for example it may be at one side of said screen.

As previously stated, the intermittent luminous signals produced from the pencil of light issuing from the source of light A through the slot F after reflection from the mirror M and through the screen G, disk D and lens L'' may if desired be caused directly to engage the reproducing cylinder B.

Finally any mechanical or electrical device controlling an engraving tool or punch may be operated from the amplifier of the main photocell; also, the optical device controlled from the same amplifier and acting on the same photocell may be of any suitable type.

What I claim is:

1. A reproducing arrangement for transforming half-tone documents into a printing weft, of the type wherein the document to be transformed is scanned by photoelectric means and wherein a light beam reflected by a galvanometer mirror responsive to the electrical current from said scanning means passes through slots in a rotating obturator disc and is caused to sweep said disc from the center to the periphery thereof in accordance with the shade of the scanned area in the document, wherein said slots are regularly spaced angularly along circumferences coaxial with said disc with a number of said slots varying from the center to the periphery of said disc, and said reflected light beam passes through a fixed, substantially triangular aperture arranged in the vicinity of said disc and whose main axis extends radially with respect to said disc with its base in regard to that portion of said disc provided with the lesser amount of said slots, whereby light signals are produced whose number and cross-sectional area at any time are functions of the shade of the area scanned at that time in said document.

2. A reproducing arrangement as set forth in claim 1, wherein said slots are of constant width throughout and extend along a curved path in a

general direction from the center to the periphery of said obturator disc, the number of said slots progressively increasing from said center to said outer periphery and the interspacing of said slots, as measured along circles coaxial with said disc, being constant along any given one of said circles.

3. A reproducing arrangement for transforming half-tone documents into a printing weft of the type in which the document to be transformed is scanned by photoelectric means and in which a light beam reflected by the mirror of an oscilloscope having a galvanometer responsive to the electrical currents from said photoelectric scanning means passes through slots in a rotating obturator disc and is caused to sweep said disc from the center to the periphery thereof in accordance with the shade of the scanned area in said document, comprising in combination: an axis about which said mirror is adapted to swing; means for striking said mirror with a pair of light beams of constant intensity thereby forming a pair of separate reflected light beams the angular spacing of which remains constant; a screen in the path of both said reflected light beams, formed with a substantially triangular aperture therein in the path of a first one of said reflected light beams, the main axis of said aperture being perpendicular to said swinging axis, said screen further being formed with a plurality of slits each extending in a direction parallel to the direction of said first-mentioned axis, said slits being arranged in the direction of said main axis for said triangular aperture in the path of the second one of said reflected light beams; said slots in said obturator disc being distributed in series of slots having a constant circumferential width and regularly spaced along circumferences coaxial with said disc, the number of the slots in each of said series increasing from a central circumference to an outer circumference, and the number of said series of slots being greater by one digit than the number of said slits in said screen; said obturator disc being positioned beyond said substantially triangular aperture with respect to said mirror with a radius parallel to said main axis of said aperture and with the base of said aperture lying in regard to the central

portion of said disc; second photoelectric means adapted to be struck by said second reflected light beam when passing through any one of said slits; means for connecting said second photoelectric means with said galvanometer thereby imparting to the same an additional angular displacement; and said slits in said screen and said series of slots in said obturator disc being so positioned with respect to each other that said second reflected beam only completely sweeps a related one of said slits when said first reflected beam impinges on said obturator disc substantially between two radially consecutive series of slots, whereby the additional angular displacement imparted to said mirror through said second photoelectric means at any time insures that said first reflected light beam only rests on an annular area of said obturator disc provided with a related series of circumferential slots.

4. In a reproducing arrangement as in claim 3, said substantially triangular aperture in said screen being formed with stepped lateral edges whose straight portions are arranged respectively in front of said disc circumferences provided with said series of slots.

MAURICE LANGE.

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