Feb. 16, 1960 R. HELL 2,925,463

METHOD OF AND APPARATUS FOR PRODUCING SCREENED PRINTING PATTERNS

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Fig.1

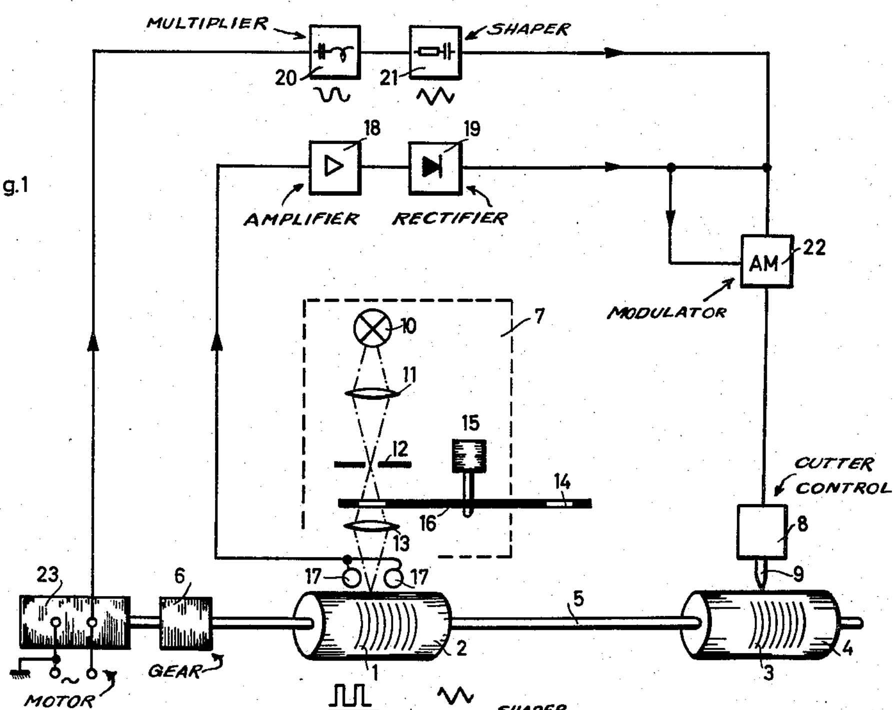

Fig.2

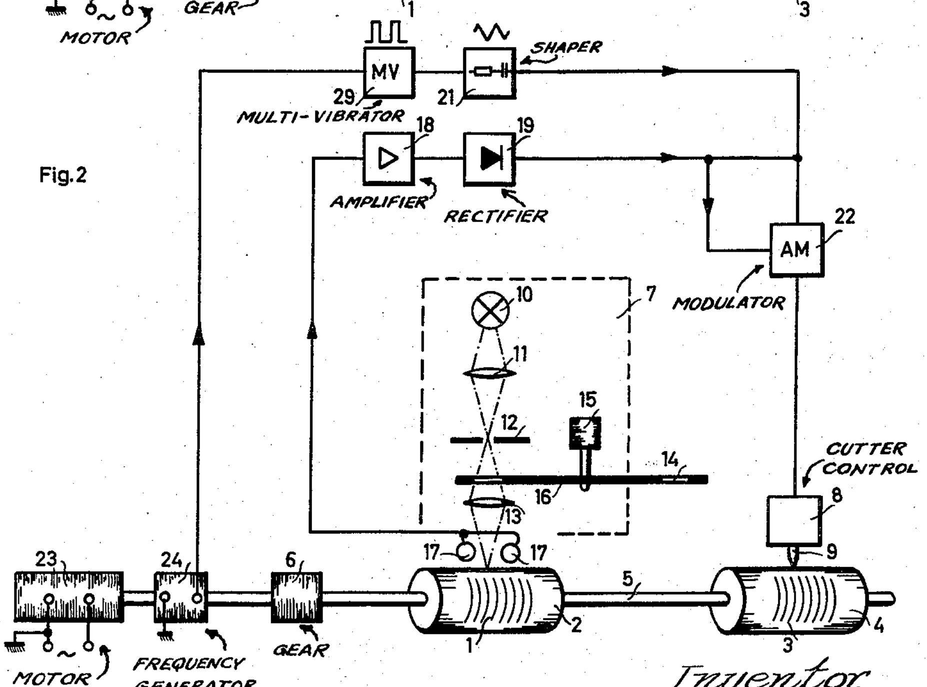

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Fig. 2a.

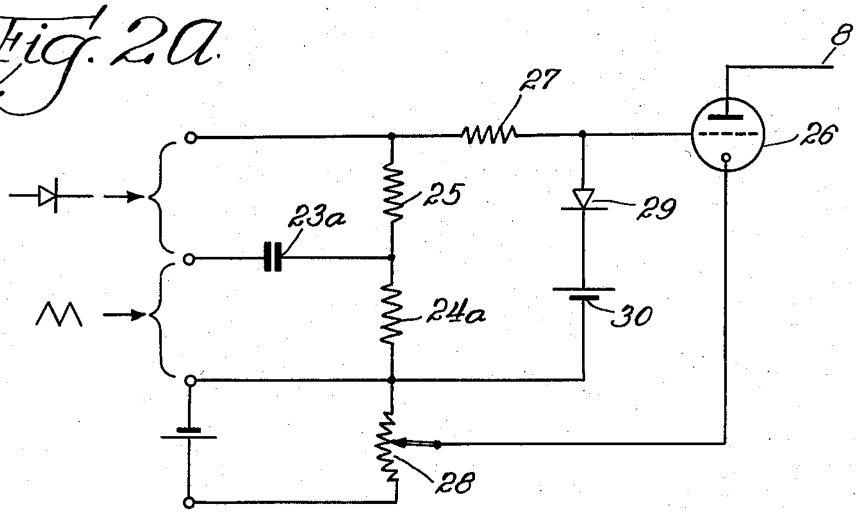

Fig. 6a.

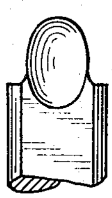

Fig. 6B.

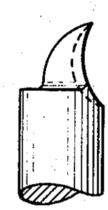

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Fig. 3

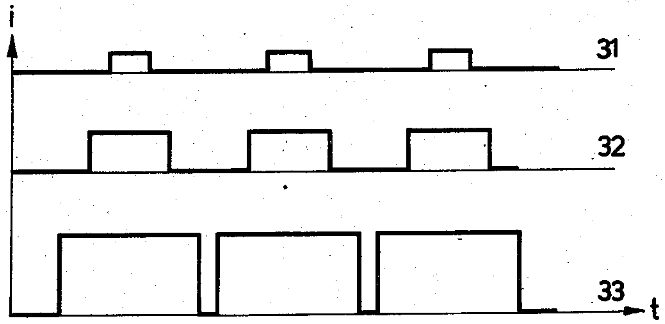

Fig. 4

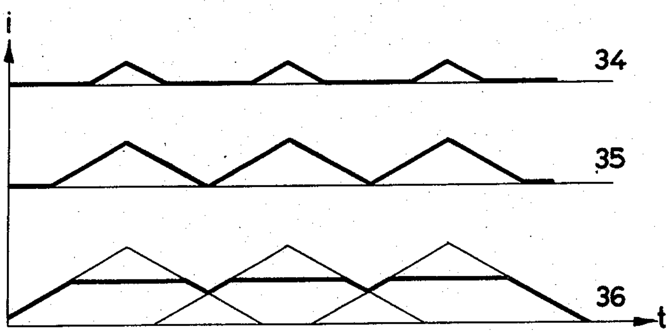

Fig. 5

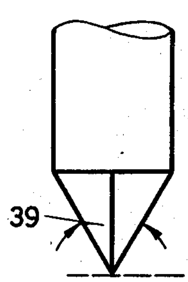

Fig. 6

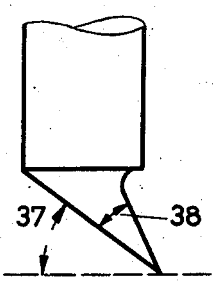

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Fig.7

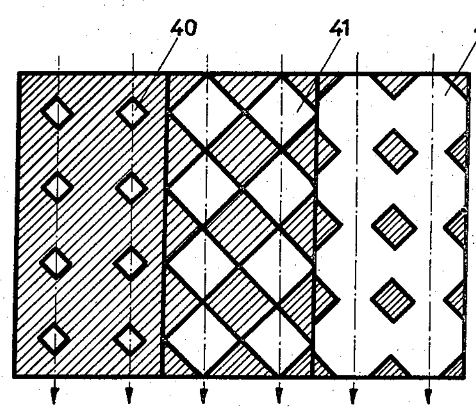


Fig.8

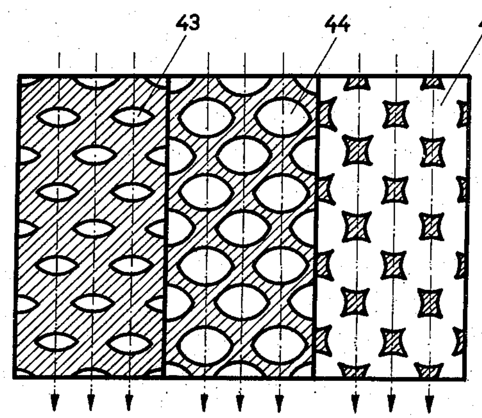
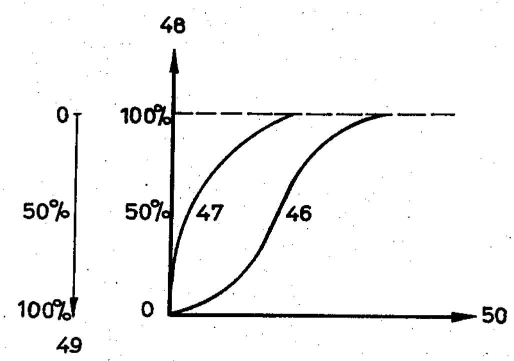


Fig.9



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METHOD OF AND APPARATUS FOR PRODUCING SCREENED PRINTING PATTERNS

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Application March 11, 1953, Serial No. 341,641

Claims priority, application Germany March 20, 1952

3 Claims. (Cl. 178—6.6)

This invention is concerned with apparatus for making screened printing blocks or plates.

Known apparatus for making screened printing plates provide means for photo-electrically scanning a picture or image hereafter briefly referred to as "copy" either upon a plane surface or upon a drum in adjacent parallel lines to produce amplified currents for controlling a tool, for example, a cutting, milling, drilling, impact or burning tool which produces the printing plate line by line. The control currents for producing the screen are usually periodically affected, the tool thus receiving impulses. These impulses are modulated by the photo-electric currents by either altering only the amplitude or only the impulse duration in accordance with the brightness of the copy pattern. In the amplitude modulation, the tool will in response to great brightness of the copy penetrate deeply into the material and of the blank from which the plate is to be formed and surface elements of variable width but uniform length will be worked from the blank incident to such impulse depending on the advance of the tool. In the time modulation, the advancing tool will responsive to each impulse penetrate the material of the blank to the identical depth but for intervals of different length depending on the brightness of the copy, thereby producing surface elements of variable length but constant or uniform width. This results in a preferential direction in the screen. In addition, the impulse flanks are in the known impulse methods not approximated to the operations of the engraving tool and to the flanks thereof, resulting in crowding effects and imperfect cutting planes and it is therefore impossible to accurately predict the way-time curve of the tool in the blank of plate material worked upon. The production of printing plates is thus attended with uncertainties which lead to great operational difficulties.

The object of the invention is to produce for the electro-mechanical control of a cutting tool periodic impulses which are modulated as to time and also as to amplitude. The amplitude and also the duration of an impulse can thereby be governed in accordance with the brightness of a copy. The frequency of the impulses represents the screen frequency in the direction of scanning. The modulation of the impulses as to time and also as to amplitude makes it possible, considering the tool advance, to work from the material of the blank for all brightness values in each screen point surface elements of identical length and width, thereby producing a screen without preferential direction.

In accordance with another feature of the invention, the flanks of the time-amplitude modulated impulses are by delay means flattened so that they are approximated to the flanks of the tool, thus avoiding crowding effects incident to the motion of the tool into and out of the material of the blank which is being worked on. The way-time curve of the tool is therefore by an adjustable and governed current-time curve predetermined and executed by the tool since all factors that might hinder the tool operation are considered beforehand. It is possible,

for example, to flatten the leading flanks of the impulses more than their trailing flanks so as to equalize differences in the cutting resistance and differentiating crowding effects incident to the motion of the tool into and away from the material of the blank, and the tool can therefore be moved in either direction with the same speed.

The predetermined way-time curve of the tool makes simple adjustment possible.

The invention also makes it possible to predetermine the geometrical form of the screen elements. For example, with a given way-time curve, the wedge angle of a wedge-shaped cutting tool may be determined so as to produce rectangular screen elements, or the radius of a spoon-shaped cutter may be determined so as to produce round screen elements. It is possible therefore to calculate the size of the surface elements respectively cut from or retained in the material of the blank dependent on the photo-electrical control currents. This is particularly important because it is possible to obtain a linear dependence between brightness of the copy and a median brightness of the corresponding pattern on the printing plate by the introduction of correcting elements having a characteristic which is inverse to this calculated dependence.

In accordance with another feature of the invention, the amplitude of the time-amplitude modulated impulses may be limited to a value which corresponds to the beginning of the mutual overlapping of the cut away surface elements.

Examples of the invention will now be described with reference to the accompanying diagrammatic drawings, wherein

Fig. 1 shows an embodiment in schematic representation;

Fig. 2 indicates a circuit example illustrating one mode of time-amplitude modulation;

Fig. 2*a* illustrates the operation of the modulator;

Fig. 3 shows time-amplitude modulated current-time curves for dark, gray and bright tone values;

Fig. 4 illustrates time-amplitude modulated current-time curves with angular impulse flanks and amplitude limitation for the three tone values of Fig. 3;

Fig. 5 shows in schematic manner the rear view of an engraving tool as seen in the direction of cutting;

Fig. 6 shows the tool of Fig. 5 in side elevation;

Figs. 6*a* and 6*b* show a spoonlike engraving tool in side view and in front view, respectively;

Fig. 7 illustrates on a greatly enlarged scale a printing pattern produced on a plate by a tool according to Figs. 5 and 6 in accordance with the current-time curve of Fig. 4 at dark, gray and bright tone values, the shaded portions indicating the retained and the blank portions the cut away parts of the printing pattern;

Fig. 8 shows the pattern produced on a printing plate by a spoonlike tool such as shown in Figs. 6*a* and 6*b*, the successive lines being displaced by the space of one half point; and

Fig. 9 indicates the dependence of the mean brightness of the copy on the amplitude of the photo-electric control current resulting respectively for a screen according to Fig. 7 produced with a wedge-shaped tool and for a screen according to Fig. 8 produced with a spoonlike tool.

The operation of an embodiment of the invention is apparent from Fig. 1. In this embodiment are shown, as examples, rotating drums **2** and **4** and a cutting or engraving tool **9**. The copy **1** is placed on the drum **2** and the plate blank **3** on which the printing pattern is to be cut is similarly placed on the drum **4**. Both drums are disposed on a common shaft **5** which is over a suitable gear **6** rotated from a synchronous motor **23**. The scanning device **7** and the cutting control apparatus **8** and the cutting tool 9 are in known manner by means of a suitable spirally grooved spindle (not shown) moved with respect to the drums 2 and 4 either in identical or in opposite sense, depending on whether it is desired to produce on the printing plate a side-identical or side-reversed copy pattern. An illuminating source, for example, a suitable light bulb 10 illuminates over a lens system 11 a shutter 12 which is trained upon the copy 1 by way of the lens system 13. The light beam is periodically interrupted by a disk 16, having cutouts 14, which is rotated by a motor 15. The light reflected from the copy 1 falls into the two photo-cells 17 which convert the intermittent light pulses into current impulses. The latter are conducted to the amplifier 18 and subsequently rectified again in the rectifier 19. The frequency of the current impulses is higher than the screen frequency referred to below. The rectifier 19 demodulates these carrier frequency impulses, but the amplitude fluctuations which correspond to the brightness of the picture pattern are left unaffected.

In order to produce a uniform screen, the screen points of the successive lines must always have the identical position relative to each other. The screen frequency therefore must be produced in dependence on the advance of the tool along the plate 3 on the drum 4. Current from a commercial source may be in known manner used for driving the synchronous motor and to serve as a source for the screen frequency. The frequency of the commercial current source is for this purpose multiplied in a multiplier 20. The screen frequency thus obtained is due to multiplication of the frequency of the commercial current synchronized with the rotation of the shaft 5 and therewith with the relative speed of advance of the tool 9.

In accordance with another feature of the invention, the screen frequency may be derived from the shaft 5, for example, by means of a suitable alternating current generator 24 having a rotor disposed on said shaft, such generator taking the place of the device indicated at 20. The screen frequency is in such manner again synchronized with the rotation of the shaft 5 and therefore with the relative speed of advance of the tool 9.

The impulse like screen frequency produced in the frequency multiplier 20 is shaped in a delay element 21 and conducted to the modulator 22. The rectified control current coming from 19 governs in one stage of the modulator 22 the duration of the time and in the next stage thereof the amplitude of these impulses. There are also means in the modulator 22 for additionally flattening the flanks of the impulses. At the output end of the modulator 22 are in this manner produced the time-amplitude modulated impulses with flattened flanks as they are contemplated by the invention. Known means may be used to construct the modulator 22 so as to carry out the indicated functions.

The modulated impulses from 22 are, as has been said before, conducted to the cutting control apparatus 8. This apparatus may be represented by a dynamic system; however, electromagnetic cutting or impact systems are preferred because of the greater forces obtainable. The cutting control apparatus 8 carries the cutting tool 9 which cuts in step with impulses surface elements from the material of the plates blank 3 the length and width of which, that is, the areas of which correspond to the brightness of the copy 1.

It is important for the invention that the duration of penetration and the penetration depth of the engraving tool 9 are controlled by the time-amplitude modulated screen impulses, but the kind of impulse generation and the special circuit arrangement are of subsidiary importance. The screen frequency coming from the multiplier 20 may, for example, be used for governing a multivibrator with means for adjusting the impulse duration. The multivibrator impulses also charge a capacitor disposed in 21, on which will appear a sawtooth voltage. The duration of the charging of the capacitor is selectable by the alteration of the duration of the multivibrator impulses, the screen frequency remaining constant, resulting as desired in a sawtooth curve with steep leading and flat trailing flank or vice versa, which is conducted to the modulator 22. The operation of the modulator is separately shown in Fig. 2.

Referring now to Fig. 2, the sawtooth voltage from 21 will appear at the resistor 24*a* by way of a coupling capacitor 23*a*, and the rectified photo-electric control voltage will at the same time appear at the resistor 25. The voltages are superposed. At the grid of the tube 26 will appear only signals, over the high ohmic resistor 27, which exceed the threshold value that had been adjusted by the potentiometer 28. Accordingly, the amplitude and the duration of these sawtooth impulses at the tube grid will be a function of the photo-electric control voltage. In accordance with the invention, there are therefore produced time-amplitude modulated impulses with angular flanks which are conducted from the output of the tube 26 to the cutting apparatus 8.

Fig. 3 shows the theoretical current-time curves for a combined time-amplitude modulation of impulses. With growing brightness of the copy pattern, the amplitude and duration of the impulses will increase as indicated by the curve 31 for a slight brightness value, 32 for gray tone, and 33 for a great brightness value.

Fig. 4 represents the corresponding current-time curves in which the flanks of the time-amplitude modulated impulses are flattened as contemplated by the invention. The curves 34, 35, 36 correspond respectively to the three brightness values of the curves 31, 32, 33. The limitation of the amplitude as indicated in the curve 36 may be disregarded for the moment. The flanks of the impulses are approximated to the tool and the working operations so that the tool can be moved into and away from the plate material at the same speed without producing crowding effects. The steepness of the flanks is with a given tool advance speed so adjusted that it corresponds to the steepness of the flanks of the tool, for example, the free angle 37 of a wedge-shaped engraving tool shown in Figs. 5 and 6 or to the shape of the spoon shaped cutting tool shown in Figs. 6*a* and 6*b*. The adjusted flank steepness and therewith the approximation to the tool is preserved for all brightness values due to the peculiarity of the previously explained modulation. Differences in the cutting resistance are equalized by different slope or steepness of the leading and trailing flanks of the impulses. It is possible to consider in this manner all factors in the current-time curve that may hinder the tool in its cutting operations and to produce symmetrical cutting figures.

In the printing technique, screens are preferred for printing patterns which lie obliquely to the edge of the screened replica of the image on the printing plate. This means that the screen points lie upon the two diagonals of a rectangular image replica. There are two possibilities of producing such screens.

First, the image may be scanned at 45° to its edge and the printing plate blank is worked accordingly. The image copy 1 and the plate blank 3 are therefore mounted at an angle of 45° to the developed lines of the drums 2 and 4, respectively. The screen points of successive lines will then lie side by side. When the screened plate 3 is rotated back by 45° into its normal position, the screen points will appear displaced relative to one another. For the screen frequency there is in such a case the requirement that the number of screen points per rotation of the drum 4 is an even number. This requirement is automatically fulfilled due to the synchronization of the screen frequency with the advance of the engraving tool.

The second possibility for producing a screen lying obliquely to the edge of the screened replica resides in scanning the copy parallel to its edge and working the printing pattern on the plate blank similarly parallel to its edge. The copy 1 and the plate blank 3 are therefore respectively mounted on the drums 2 and 4 perpendicular to the developed lines of the drums. The screen points of each line should in such a case be displaced by one half point spacing relative to the screen points of the preceding line. The requirement is therefore posed for the screen frequency that the number of screen points for two drum revolutions must be an uneven number. This screen displacement, that is, the shifting of the screen frequency by one half phase per drum rotation may also be carried out by the gear 6 after switching of the gear ratio. A printing pattern cut in this manner will therefore exhibit an angular or oblique screen. This method of working is referred to as parallel cutting.

The two cutting methods exhibit outside of these external features very considerable differences as to principle which are essential for the cutting operation. In the diagonal cutting, for which a wedge-shaped engraving tool corresponding to Figs. 5 and 6 is preferred, the wedge angles 38 and the spur angle 39 may be determined so that rectangular cutting figures result for all brightness values at a given way-time curve. Such a screen is characterized by the absence of preferential directions.

Fig. 7 shows on a greatly enlarged scale a portion of the surface of a printing pattern on a plate that had been worked in such manner. The direction of working extends in the figure from the top to the bottom. It will be seen from the figure that the screen points of successive lines lie next to one another and that the line spacing and the point spacing are identical in the line direction. The elements 40 are cut out from the plate material for a small brightness value based on the current-time curve 34. The impulses of the current-time curve 34 and the cut out surface elements 40 are separated from one another. The surfaces 41 are cut out for a 50% brightness value based on the current-time curve 35. The individual impulses of the current-time curve 35 and the cut out surfaces 41 are in abutment and the result is a chessboard pattern. Cut out elements and retained surface areas are of identical size. The surfaces 42 have been cut out for a great brightness value based on the current-time curve 36. The impulses for the current-time curve 36 and the cut elements 42 merge one into the other while the retained surface areas (shown shaded) are individual separate rectangles lying at both sides of the line center. Due to the overlapping, the cutting tool is not moved out of the material with its point, but is caused to cut out a continuous portion so long as great brightness values are reproduced although surface areas which are separated from one another are left standing. Therein resides the great advantage of the diagonal cutting as compared with the parallel cutting. The photo-electric control amplitudes therefore are in the three brightness values smaller, equal or greater than the amplitudes of the time-amplitude modulated impulses.

In the region in which the cut out elements mutually overlap, the width which is effective for the printing will remain constant, that is, equal to the line spacing. For this portion of the way-time curve, its amplitude may be limited to a value which corresponds to the line spacing and therewith to the peak amplitude for 50% brightness value. In this interval, the sideways limitation of the cut out elements will correspond to the touching line (dot-dash lines) of two neighboring elements. By this amplitude limitation is obtained the advantage that the tool does not cut deeper into the plate material than is required by the line spacing and the cutting work is thus reduced. The current-time curve 36 of Fig. 4 has in this manner been limited as to amplitude.

In the circuit according to Fig. 2, the limitation is carried out by the rectifier 29 which receives a fixed bias from the source 30. The amplitude limitation may however be carried out at another point of the transmission channel.

A spoonlike engraving tool as shown in Figs. 6*a* and 6*b* is preferably used in the parallel cutting method. The radius of such tool is such that oval cutting figures result at a predetermined way-time curve, which have for 50% brightness value approximately identical length and width. Fig. 8 shows in schematic greatly enlarged view a portion of the surface of a printing plate worked in this manner.

From Fig. 8 will be seen how the screen points of successive lines are displaced relative to one another. As distinguished from the diagonal cutting, the line spacing is in this case equal to half of the screen point spacing in the direction of the line. The elements 43 are cut from the plate blank material for a slight brightness value based on the current-time curve 34. The elements 44 are for a brightness value of 50%, in which case the cut out elements and the retained surface areas are of equal size. The elements 45 are cut out for a great brightness value, in which case the cutting planes overlap. The retained surface areas are now disposed at the line center so that the impulses of the current-time curve and the cut out elements are separated for all three cases. This means that the current-time curve must be of the type of the curve 34 and that it goes into the form of curve 35 only at a brightness value of 100% because only at 100% brightness will the cutting elements and the impulses of the current-time curve border one against the other. As distinguished from the diagonal cut, the cutting tool must therefore always be moved out of the material upon reproduction of great brightness values. For a brightness value of 100%, the cutting width will be equal to twice the line spacing, as distinguished from the diagonal cutting in which the maximal cutting width approaches only the single line space due to the amplitude limitation. The control amplitude of the photo current is therefore smaller than the amplitude of the time-amplitude modulated impulse or at the most equal thereto.

As will be seen from Fig. 7, the cut out elements overlap in the diagonal cutting for brightness values which exceed 50%. The same holds true for Fig. 8. Therefore, while the cut out rectangular elements become with increasing brightness of the image pattern larger by the square and the retained surface areas correspondingly smaller, such a relationship is not present at brightness values exceeding 50%. Due to the mutual overlapping of the surfaces, the retained areas become smaller at a slower rate than square and the cut out elements do not grow by the square.

This relationship is illustrated in Fig. 9 in which 48 indicates the brightness and 49 the darkening of the image pattern while 50 indicates the amplitude of the control current. The curve 46 represents the conditions of Fig. 7. Up to the brightness value of 50%, the curve 46 follows the square requirement and beyond that it grows slower. The curve 47 corresponds to similar conditions of Fig. 8. The amplifier 18 (Figs. 1 and 2) has a characteristic that is inverse of the dependency indicated in Fig. 9. The effect of the overlapping of the surfaces can be compensated by including in the amplifier 18 in generally known manner circuit means comprising electronic tubes adapted to produce a correcting or anti-distortion effect, and the result will be a linear dependence between photo-electric control current and the mean brightness of the screened printing pattern. Electronic correction means suitable for this purpose and including if desired resistor and rectifier combinations are well known.

Other non-linear distortions of the transmission channels 17, 18, 19, 22, 8 may be in similar manner compensated by the inclusion of known correcting or anti-distortion means so that an image produced from the printing pattern is reproduced correctly in all tone values, Changes may be made within the scope and spirit of the appended claims.

I claim:

1. In apparatus for making screened printing plates having means for respectively photoelectrically scanning pointwise in consecutive lines a copy to be reproduced to produce control impulses and for simultaneously engraving under control of screen frequency impulses a blank which is to form a printing plate, the improvement which consists in the provision of means for modulating said screen frequency impulses both in time and in amplitude as a function of the brightness values of scanned copy elements as reflected in said control impulses produced incident to said photoelectric scanning of said copy.

2. The improvement according to claim 1, comprising an alternating current source, and means for multiplying the frequency of said source to produce said screen frequency impulses.

3. The improvement according to claim 2, comprising means for amplifying said control impulses, and means for superimposing said amplified control impulses upon said screen frequency impulses.

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