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de Vos et al.

[11] **3,770,888**

[45] **Nov. 6, 1973**

[54] **METHOD AND APPARATUS FOR CONTROLLING THE ENGRAVING PATTERN OF AN ELECTROMAGNETIC GRAVURE ENGRAVING**

[75] Inventors: **Ferdinand Allard de Vos**, Castricum; **Jan Hendrik ter Steege**, Breukelen, both of Netherlands

[73] Assignee: **N.V. Werkspoor-Amsterdam**, Amsterdam, Netherlands

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[21] Appl. No.: **185,946**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 823,389, May 9, 1969, abandoned.

[52] **U.S. Cl.** ..... **178/6.6 B**

[51] **Int. Cl.** **H04n 1/24**

[58] **Field of Search** ..... 178/6.6 B

[56] **References Cited**

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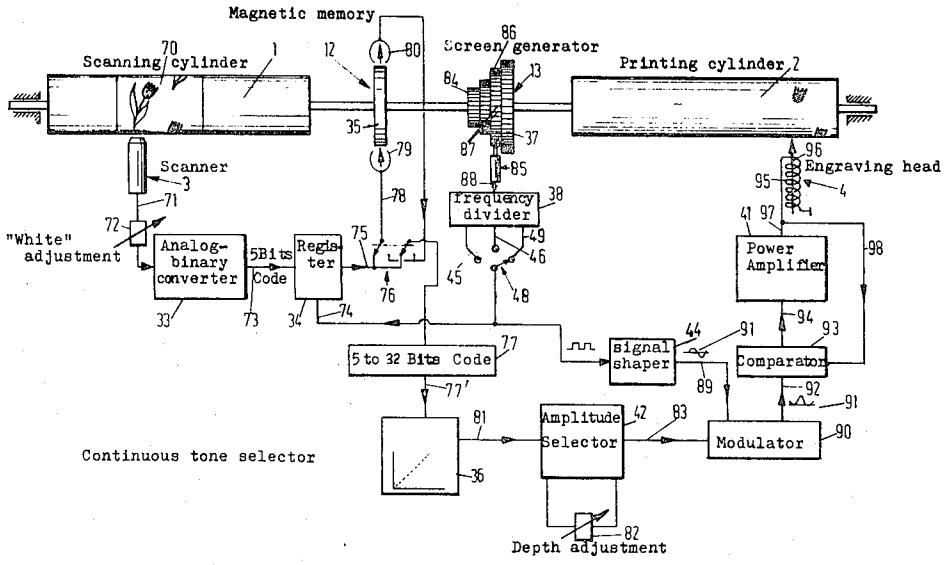
Primary Examiner—Howard W. Britton

Attorney—John P. Snyder et al.

[57] **ABSTRACT**

Method and apparatus for electromechanically engraving a pattern of diamond shape dot depressions on the surface of a cylindrical printing form in which the pattern predominantly produces lines of ridges particularly useful for textile printing. The pattern is obtained by engraving along successive, parallel, circumferential engraving line paths at an engraving dot rate per cylinder revolution which causes the placement of dots in adjacent lines to be out of phase with each other by an amount substantially different from 180°. The distance between adjacent lines is related to the width of a dot produced at the maximum engraving depth such that adjacent pairs of dots overlap at such engraving depth and produce, even at lesser non-overlapping depths, a pattern which is predominantly a line pattern, i.e., is essentially lineiform.

10 Claims, 4 Drawing Figures



BLOCK SCHEME ELECTRONIC ENGRAVING MACHINE

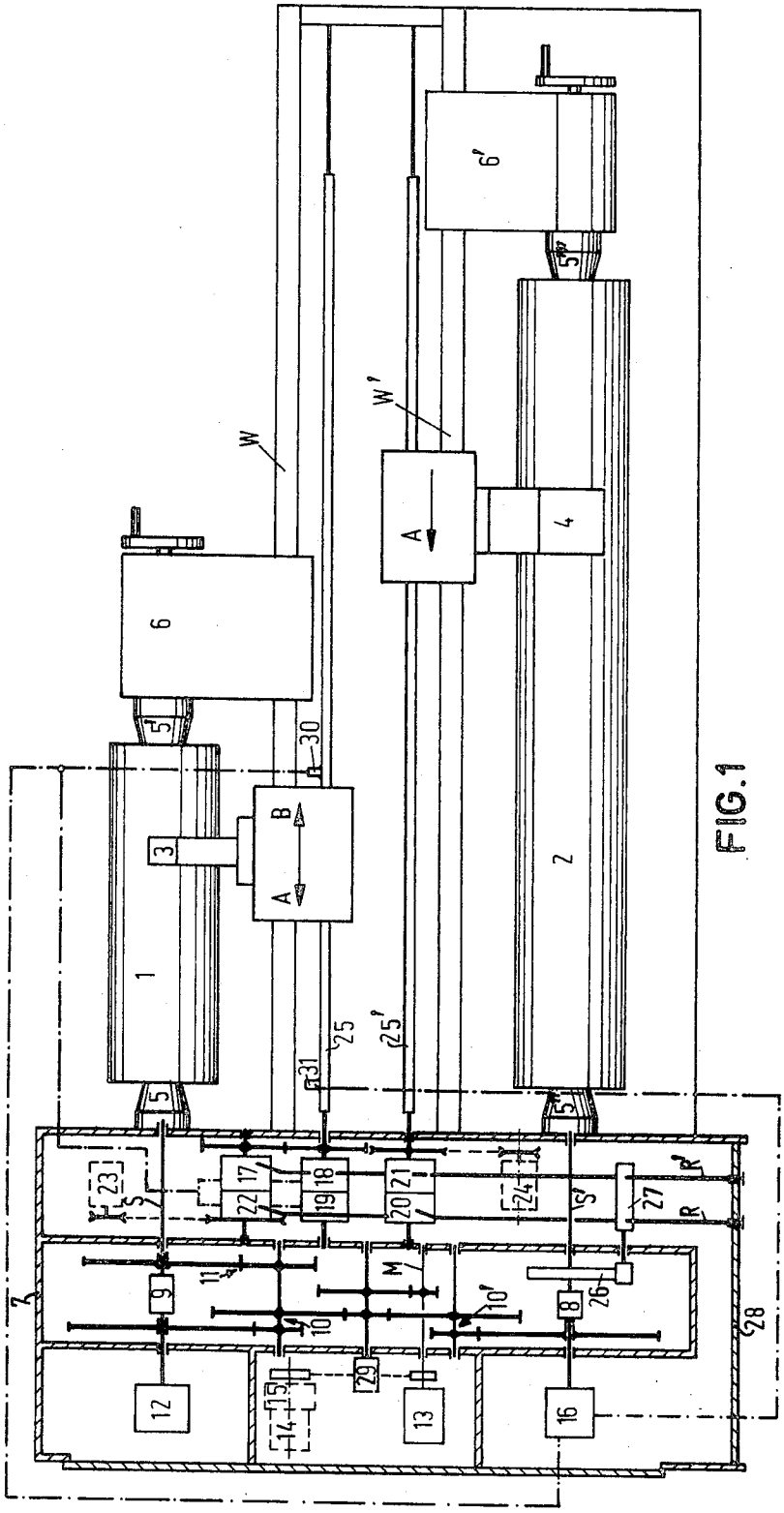

6'
5''
W'
W
A
4
6
5'
30
B
A
3
2
1
5
25
25'
31
23
17
18
21
24
27
22
19
20
S'
R'
R
11
M
9
10
10'
8
26
28
29
12
15
14
13
16

FIG.1

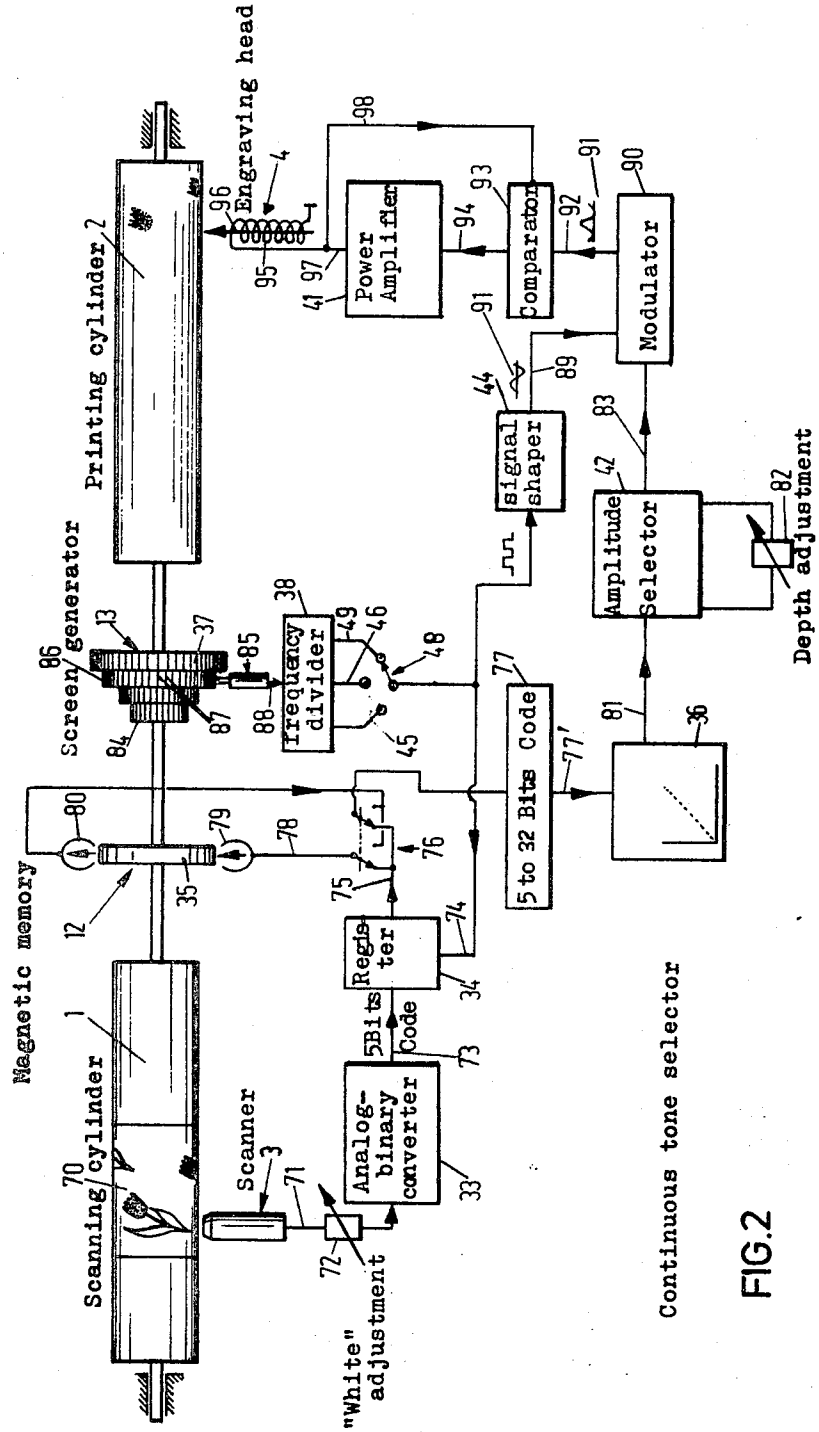


FIG.2

BLOCK SCHEME ELECTRONIC ENGRAVING MACHINE

FIG. 3

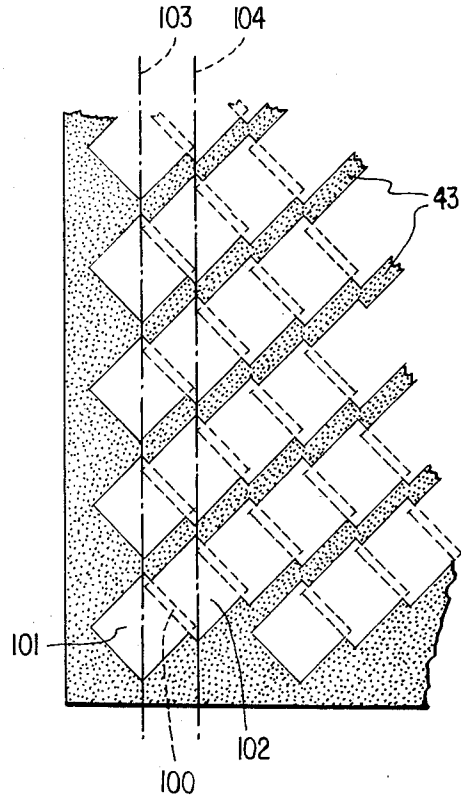
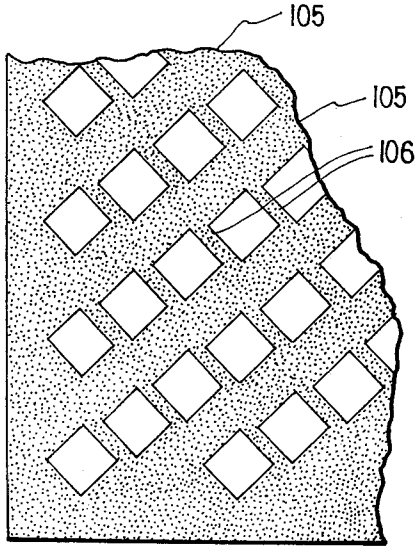


FIG. 4



METHOD AND APPARATUS FOR CONTROLLING THE ENGRAVING PATTERN OF AN ELECTROMAGNETIC GRAVURE ENGRAVING

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of copending U.S. Pat. application Ser. No. 823,389, filed May 9, 1969 now abandoned and claiming priority, under 35 USC 119, based upon Dutch Pat. application Ser. No. 6807334, filed May 7, 1968.

BACKGROUND OF THE INVENTION

In conventional half-tone engraving of a cylindrical printing form, the scanning and engraving heads are continuously moved axially of their respective cylinders as the cylinders are rotated synchronously. The resulting scanning and engraving line paths are helical albeit of very slight pitch, and it is conventional so to control the locations of the engraving dots in adjacent lines that same are of 180° phase with respect to each other, giving rise to a 45° alignment of dots for purposes well known in the art. Depending upon the cross section of the engraving stylus used, the printing areas remaining for middle-tone values are either discrete areas aligned at 45° or are criss-cross lines aligned along 45° angles, see for example Levine U.S. Pat. No. 3,075,042, Jan. 23, 1963. Highlight areas in any case are in the form of discrete printing areas and shadow-tone areas are in the form of discrete dots within and surrounded by the printing area.

BRIEF SUMMARY OF THE INVENTION

The present invention is directed to an arrangement for producing a diamond dot pattern in which at the maximum depth of penetration of the engraving stylus, the non-excised areas left are linear or continuous due to the fact that pairs of dots in adjacent engraving lines are phase-shifted with respect to each other by an amount which is substantially less than 180° and that the spacing between adjacent lines is such as to cause overlap between such pairs of such maximum-penetration dots. As the depth of penetration decreases and the excised areas correspondingly grow smaller, the aforementioned linear non-excised areas become wider and, ultimately, are joined by much narrower cross bands as soon as dot pair overlap no longer prevails. Over a wide range of stylus penetration, however, the effect of the non-excised areas is predominantly lineiform. Such a pattern arrangement is particularly well suited for printing upon textile materials.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

FIG. 1 is a diagrammatic view illustrating the principles of the apparatus;

FIG. 2 is a schematic view showing the processing circuit arrangement;

FIG. 3 is a view illustrating the dot pattern at maximum cutting depth; and

FIG. 4 is a view illustrating the dot pattern for middle-tone values.

DETAILED DESCRIPTION OF THE INVENTION

Reference is had at this time more particularly to FIG. 1 wherein a general outline of the machine is shown. The mechanical aspects of the machine are described in detail in our copending U.S. Pat. application Ser. No. 185,947, filed Oct. 4, 1971, (docket 329 Am) a continuation-in-part of U.S. Pat. application Ser. No. 809,643, filed Mar. 24, 1969. As shown in FIG. 1, the frame of the machine includes ways W and W' which may mount adjustable tail stock devices 6 and 6' and which also support a scanning head 3 and engraving head 4 which are adapted for movement longitudinally of the ways by means of the lead screws 25 and 25' respectively. A pair of chucks 5 and 5' cooperate with the centers 5'' and 5''' of the respective tail stock assemblies 6 and 6' to support a master cylinder 1 and a printing cylinder 2 for rotation about longitudinal axes of these cylinders. A main drive motor 14 and an associated eddy current clutch 15 for synchronizing the speed accurately drives the main shaft M of the machine which is coupled through the respective transmissions 10 and 10' synchronously to drive the shafts S and S' carrying the respective chucks 5 and 5' whereby to impart the desired synchronized rotation of the two cylinders 1 and 2. An alternate transmission arrangement 11 is provided to impart a 2:1 drive ratio as between the cylinders 1 and 2 for purposes well understood in the art, the clutch symbolically indicated by the reference character 9 being provided to select which of the transmissions 10 or 11 is in operation and the clutch symbolically indicated by the reference character 8 being utilized to couple the shaft S' to the output gear of the transmission 10'.

The main shaft M of the machine carries a screen generating unit 13 hereinafter more particularly described whereas the shaft S carries a magnetic memory unit 12 also hereinafter described and, associated with the shaft S' is a control assembly 16 for periodically or intermittently effecting axial displacements of the scanning and engraving heads 3 and 4.

The shaft S' also carries a cam 26 which operates, through a mechanism 27 to impart reciprocatory motions to the rods R and R'connected respectively to the clutch 20 and to the clutches 17 and 18. Brake assemblies are indicated by the reference character 19 and 21. The clutches 18 and 20 are respectively associated with the lead screws 25 and 25' whereas the brakes 19 and 21 are respectively associated with these two lead screws also. The operation of the device is such that reciprocation of the rods R and R' in one direction are coordinated with energizations of the clutches 20 and 18, while the respective brakes 19 and 21 are released, to impart partial rotations to the lead screws 25 and 25' cyclically during each rotation so that the scanning head 3 and the engraving head 4 are intermittently stepped axially along their cylinders 1 and 2. This causes the scanning line path and the engraving line path in each case to be in the form of a series of parallel and circumferentially extending lines disposed in a spaced axial relation along the respective cylinders 1 and 2 wherein these parallel lines encompass a major portion of the circumference of their respective cylinders and are joined, from the end of the preceding lines to the beginning of a subsequent line by a short helical line path. All of this is described in detail in conjunction with the aforesaid pending U.S. Pat. application Ser. No. 185,947. For mirror image engraving, the clutch 18 is not actuated but, instead, the clutch 17 is actuated so as to impart an opposite direction of rotation to the lead screw 25 causing the scanning head 3 to move in the opposite direction with respect to the engraving head 4. A quick return motor 23 is associ-

ated with the scanning head for returning the scanning head to an initial position when the clutch 22 is actuated and, likewise, a quick return motor 24 is provided in association with the lead screw 25' to return the engraving head 4 to an initial position.

With the above general background, the system according to the present invention as is shown in FIG. 2 will be better understood. In FIG. 2, the scanning cylinder 1 will be seen to be provided with a pattern or image section 70 which is desired to be reproduced on the printing cylinder 2. The scanner 3 is of conventional construction and optically scans the pattern 70 as the cylinder 1 is rotated with respect thereto and produces an analog output electrical signal at the conductor 71 as a result of the optical scan. The circuit 72 is provided to compensate for variation in the intensity of the scanning lamp which occurs naturally as same ages. The output at the conductor 71 is applied to the analog-to-digital converting device 33 which is of entirely conventional form and in the specific example shown, converts the analog signal applied thereto into a five bit word in which the bits appear in parallel at the output 73, which is shown as a single line in FIG. 2 for the sake of convenience. Thus, the five bit word allows for 32 different tone levels to be represented although in the preferred embodiment, only twenty-five levels are necessary. This five bit parallel word is applied to a shift register device 34, such register having a shift input conductor 74 which simultaneously shifts out a stored five bit information word and stores the next work for subsequent shifting. The five bit parallel word which is shifted out of the register 34 appears at the conductor 74 and is stored on the magnetic memory 12 and, in particular the periphery of the wheel 35 thereof and is also applied directly to the circuit 77 through the switch 76. The circuit 77 may have as many as 32 outputs, one for each of the levels which may be represented by the 5-bit words and has one conductor for each output, one of which is shown at 77'. As stated before, however, only 25 levels are used and hence only 25 conductors 77' are necessary. The circuit 77 is merely a logic circuit which produces one output only in response to a 5-bit word input, corresponding to the level represented by the input word.

The input to the magnetic memory 12 is over the conductor 78 and, through the recording head 79, to the material forming the surface of the wheel 35. It simply stores the master pattern in the position of the switch 76 as shown, but may be used later to repeat the master pattern, the switch 76 then being in its other position.

The tone selector 36 may be used and may be of construction according to pending U.S. Pat. application Ser. No. 135,732, filed Apr. 20, 1971, which is a Streamlined Continuation of U.S. Pat. application Ser. No. 776,320, filed Nov. 18, 1968. The selector 36 has 25 output conductors 81 which may be connected to the input conductors 77' in desired manner for tone selection as is disclosed in U.S. Pat. Ser. No. 135,732. The amplitude selector circuit 42 has a single output at 83, the analog level of which is controlled by which of the inputs at 81 is active. Thus, the circuits 77 and 42 form, in effect, a digital-to-analog conversion, the amplitude of the analog signal being a function of the level indicated by the 5-bit input words to the circuit 77. The over-all level of the analog outputs at 83 may be adjusted by means of the circuit 82 so as to obtain the desired depth of engraving tool penetration for the various analog levels. It will be appreciated that the extremes of the amplitude levels at the conductor 83 will represent the "black" and "white" conditions and the 23 levels in between will represent gray tone values lying between the two extremes. The depth adjustment control 82 of the amplitude selector circuit 42 is provided simply to produce at the output conductor 83 the desired *e* reference level for modulation characteristics related to the operation of the engraving head 4 so as to obtain the proper maximum depth of penetration of the engraving head assembly for the "black" regions and progressively less for decreasing darkness gray regions until, at the "white" condition, no penetration will be effected by the engraving head 4.

The screen generator 13 as shown in FIG. 2 will be seen to consist of a plurality of wheels, the largest of which is indicated by the reference character 37 and the smallest of which is indicated by the reference character 84, each of the wheels being provided with a different number of equidistantly spaced teeth or other signal-generating means so that for each revolution of the printing cylinder 2, a specific whole integer number of pulses will be produced from the transducer 85. In FIG. 2, the transducer 85 is shown associated with the screen generator wheel 86 and the teeth thereof are indicated by the reference character 87. The transducer 85 may be of magnetic type, producing a series of pulses at a frequency determined by the number of teeth or elements 87 and the speed of rotation of the printing cylinder 2. And thus producing at its output conductor 88 a number of pulses *n* per revolution of the printing cylinder 2 which is a whole number. This signal is applied to a frequency divider circuit 38 having a plurality of outputs at the conductors 45, 46 and 47, one of which is selected by means of the rotary switch 48. The frequency divider may be of any conventional configuration and construction and produces a square wave output at each of the conductors 45, 46 and 47 and each having a different frequency which is a fraction of the frequency at the input conductor 88, all as is conventional and well known.

The frequency dividing signal in square wave form is applied to a signal shaping circuit 44 which converts the square wave pulses to a sinusoidal output at the conductor 89 which is also applied to the modulator circuit 90. The output of the signal shaping circuit 44, which may be of entirely conventional configuration, is a sinusoidal signal symmetrical about some reference voltage as indicated at 91 which, for sake of convenience, may be ground potential, and the effect of the modulator circuit 90 having the input from the amplitude selector 42 at the conductor 83 is to shift the reference of the signal from the signal shaping circuit 44 in the manner indicated at the output conductor 92 of the modulator 90 so as to shift the sinusoidal signal up or down with respect to the reference level 91. This signal is applied to a comparator circuit 93 whose output at the conductor 94 is applied, through a power amplifier 41, to the actuating winding 95 of the engraving head 4 so as to cause reciprocation of the stylus 96 thereof. Obviously, as the sinusoidal signal is shifted with respect to the reference voltage 91, the stylus 96 will be caused to penetrate more or less with respect to the printing cylinder and thereby to control the depth of engraving achieved thereby. The comparator circuit is simply for the purpose of limiting the amplitude of

current through the amplifier 41 and to stabilize the same and, for this purpose, the output of the power amplifier at the conductor 97 is fed back through the conductor 98 to the comparator 93 in conventional fashion.

As has been stated hereinbefore, the basic concept of the present invention is to provide the engraving dot pairs in adjacent engraving lines to be out of phase with respect to each other by an amount substantially different from 180° and it is for this reason that the frequency divider 38 is provided. To illustrate, assume that the wheel 86 of the screen generator contains 215 individual elements 87 which will produce 215 output pulses from the transducer 85 per revolution of the printing cylinder 2. Obviously, if this signal were to be used without modification, the engraving dots in adjacent engraving lines on the printing would be exactly in phase with one another. However, the frequency divider 38 produces at its output conductors 45, 46 and 47, frequency outputs which are, for example, respectively at one-fourth, one-twelfth and one-eighteenth of the rate of the input at the conductor 88. Thus, the output to the signal shaper 44 will be at a rate of 22 5/18 pulses per revolution of the printing cylinder 2 and, consequently, there will be a 100° phase shift between adjacent engraving dots in adjacent engraving line paths on the printing cylinder 2. It will be noted that the phase shift is determined by the fractional portion of the number of pulses per revolution of the printing cylinder 2, the fraction five-eighteenths representing exactly 100° of the phase shift. Preferably, the phase shift is in the order of 100° but is, in any event, substantially different from 180° and is sufficient to produce edge overlapping between adjacent engraving excisions of maximum amplitude as is indicated by the area 100 enclosed within the dashed lines in FIG. 3 caused by overlap of the two adjacent excised areas 101 and 102 when such excised areas are of maximum penetration corresponding to "black" condition of the engraving head 4. In FIG. 3, the two adjacent engraving line paths along which the excised areas 101 and 102 occur are indicated by the dashed lines 103 and 104 and it will be seen that the ,spacing therebetween is substantially equal to one-half the width of the maximum depth incised areas 101 or 102. With this condition prevailing, the ridges left between the excised areas at maximum penetration, as are indicated by the reference character 43, are continuous, i.e., of lineiform characteristic and the pattern produced is not one of isolated areas such as is the case with the prior art constructions wherein the phase difference between excised areas in adjacent engraving line paths are displaced by 180°, see particularly Levine U.S. Pat. No. 3,075,042.

FIG. 4 illustrates that this generally lineiform characteristic is carried through even at lesser penetration depths of the engraving stylus, FIG. 4 illustrating the essentially lineiform areas 105 which are joined by the relatively narrow bands 106. The over-all pattern characteristic is, as has been stated, essentially lineiform even at decreased penetration of the engraving stylus and is, in any event, purely lineiform at the maximum engraving depth.

It is to be noted that in prior art arrangements wherein there is 180° phase shift between pairs of dots and adjacent engraving lines, the overlap, at best, will be a corner overlap and will produce the essentially lineiform pattern characterized in the present invention.

It is to be understood that the aforesaid copending U.S. Pat. application Ser. No. 185,947 filed concurrently herewith (docket No. 329 Am) is incorporated herein by reference.

What is claimed Is:

1. In a machine for electromechanically producing a gravure form which simulates a master form, a first cylinder having the master form thereon, a second cylinder upon which the master form is to be simulated, means for rotating said cylinders at a selected speed ratio, scanning means associated with said first cylinder for producing instantaneous outputs indicative of the local intensity of the master form as the first cylinder revolves with respect to the scanning means, engraving means associated with said second cylinder for effecting periodic penetration of the surface of the second cylinder in which the depth of penetration is in accord with discrete instantaneous outputs of said scanning means, and control means for effecting translation of said scanning means and of said engraving means axially with respect to their associated cylinders during only a minor portion of each revolution thereof whereby consecutive scanning and engraving line paths swept past the scanning means and the engraving means respectively each are in the form of a circumferentially extending major portion disposed in a plane normal to the rotation axis of the associated cylinder and a helically extending minor portion connecting the end of each major portion with the beginning of the next consecutive major portion, the improvement comprising:

pulse generating means for providing pulses at a rate n per revolution of said second cylinder in which $n=m+a$ where m is an integer and a is a fraction substantially different from one-half;

means for actuating said engraving means at said pulse rate n to engrave depressions in consecutive engraving line paths which are shifted circumferentially with respect to each other by an amount dependent upon said fraction a; and

the maximum circumferential extent of each depression at maximum penetration depth of said engraving means and said pulse rate n being such as to assure separation of said depressions in each engraving line, and the axial translation of said engraving means between consecutive engraving lines together with the value of said fraction a being such as to assure partial overlap of such maximum depressions in consecutive engraving lines.

2. In a machine as defined in claim 1 wherein said fraction a is such as to produce a phase shift between adjacent excised areas in consecutive engraving lines which is in the order of 100°.

3. In a machine as defined in claim 1 wherein said pulse generating means includes circuit means for producing pulses at one of a number of rates, each of which is higher than said rate n, and means for dividing down said higher rate to produce said rate n.

4. In a machine as defined in claim 3 wherein said means for actuating said engraving means includes means for producing a sinusoidal carrier signal at said rate n, and means for modulating said carrier according to said discrete instantaneous outputs of said scanning means.

5. In a machine as defined in claim 1 wherein said pulse generator means includes circuit means for producing pulses at a rate r per revolution of said second cylinder in which r is a whole number greater than n, and means for dividing down the pulses produced by said circuit means to provide said n pulses per revolution of the second cylinder.

6. In a machine as defined in claim 5 wherein said pulse generator means includes means for actuating same at a plurality of rates per revolution of said second cylinder, each of which is a whole number greater than n, said means for dividing down having a plurality of outputs each of which is of different rate and one of which is said rate n.

7. In a machine for electromechanically engraving gravure forms, in combination:

cylinder means and engraving means associated therewith for excising discrete areas along a number of side-by-side circumferential paths along said cylinder means;

means for generating a plurality n of discrete engraving signals per revolution of said cylinder means, the number n being a whole number plus a fraction which is substantially different from one-half whereby adjacent excised areas in successive paths are out of phase by an amount which is substantially less than 180°;

means for actuating said engraving means in response to said engraving signals;

means for controlling the depth of successive penetrations by said engraving means according to a predetermined pattern whereby the discrete excised areas may range between a maximum and a minimum area; and

means for controlling the spacing between adjacent paths so that adjacent excised areas in successive paths overlap when the areas thereof are maximum.

8. In a machine as defined in claim 7 wherein said means for generating comprises pulse generator means having an output which is of a rate r per revolution of said cylinder means in which r is a whole number greater than n, and means for dividing down the output of said pulse generator means to provide said n engraving signals per revolution.

9. In a machine as defined in claim 7 wherein said engraving signals are of sinusoidal form and said means for controlling modulates said engraving signals.

10. In a machine as defined in claim 9 wherein said means for generating comprises pulse generator means having an output which is of a rate r per revolution of said cylinder means in which r is a whole number greater than n, and means for dividing down the output of said pulse generator means to provide said n engraving signals per revolution.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,770,888 Dated November 6, 1973

Inventor(s) Ferdinand Allard de Vos and Jan Hendrik Ter Steege

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

---Foreign Application Priority Data

[30] May 24, 1968 Dutch.....68,07334---.

Signed and sealed this 23rd day of July 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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