Sept. 14, 1937. G. E. LOSIER 2,092,765

ELECTRIC MACHINE

Filed Dec. 19, 1932 4 Sheets-Sheet 1

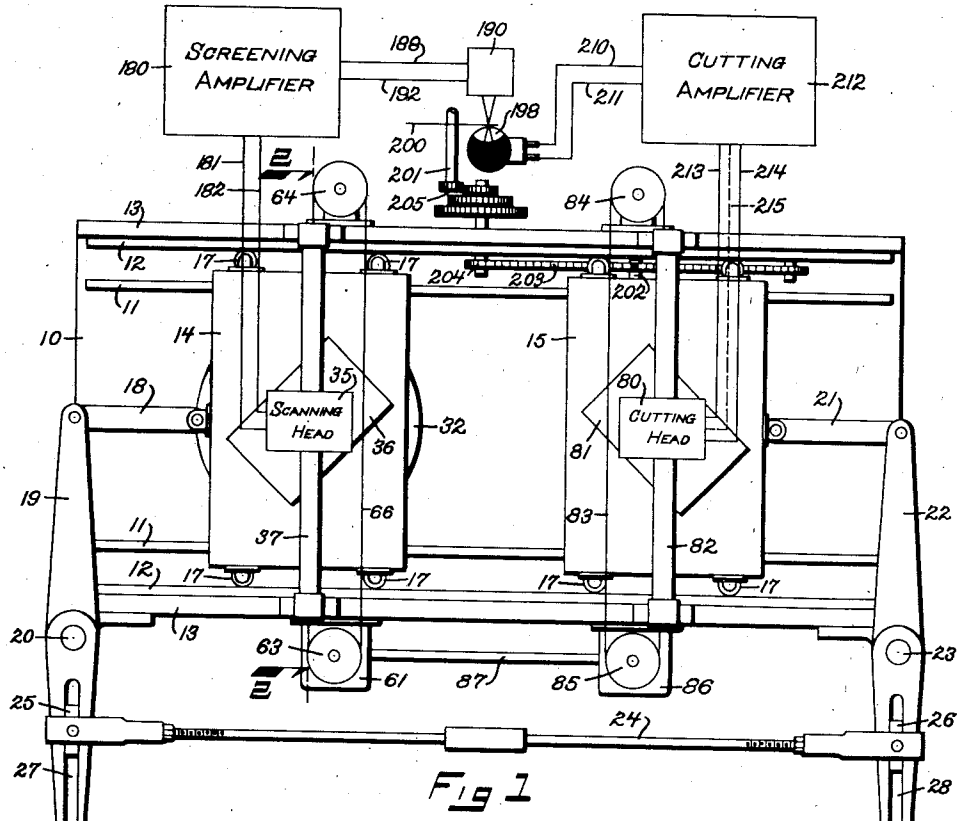


Fig 1

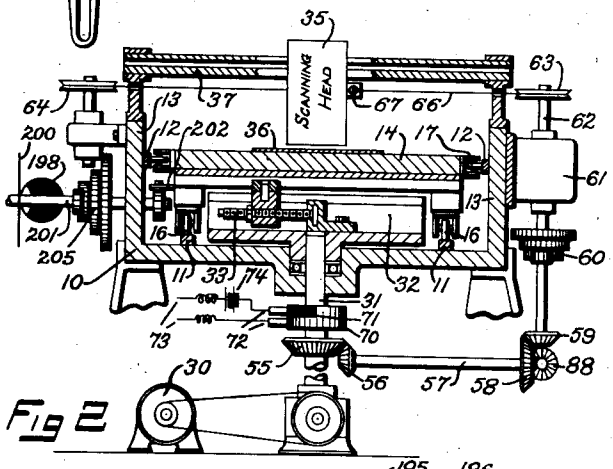


Fig 2

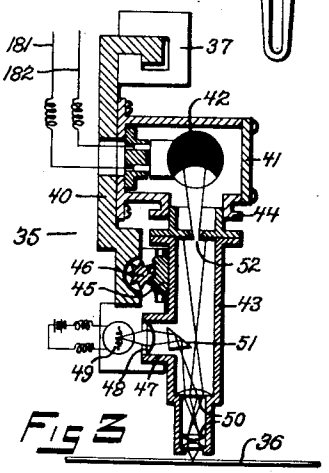


Fig 3

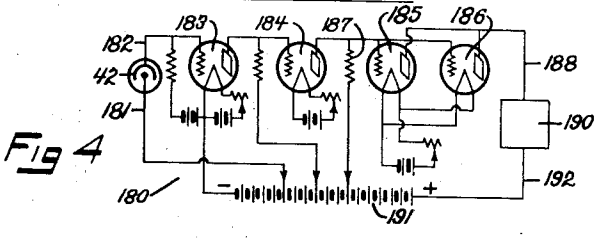


Fig 4

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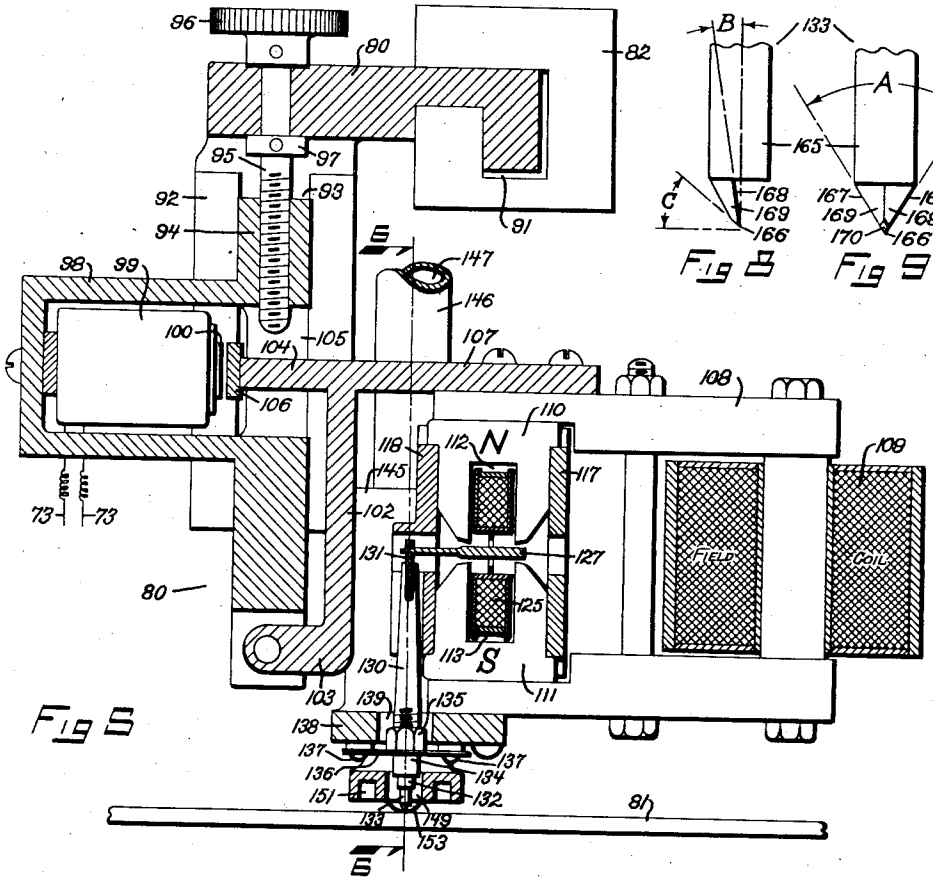


Fig 5

Fig 8 Fig 9

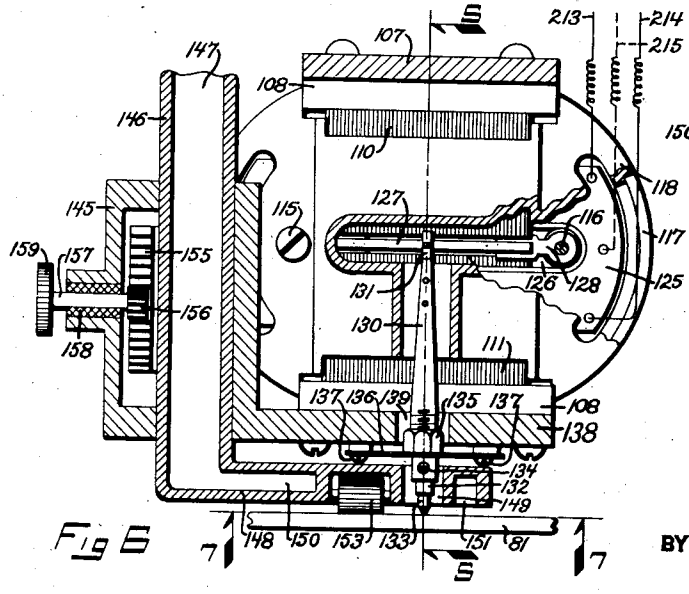


Fig 6

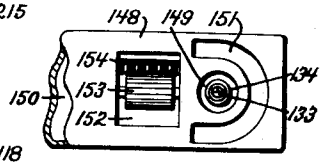


Fig 7

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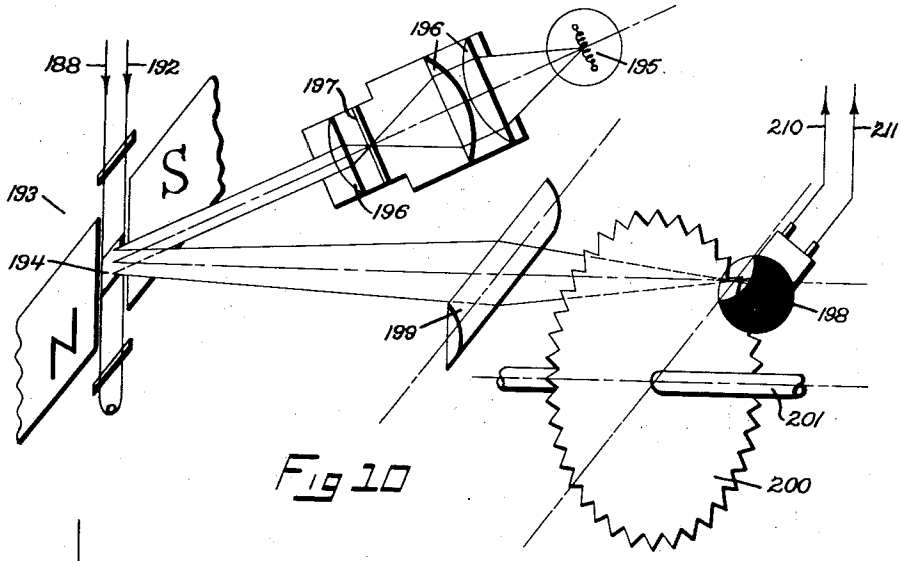


Fig 10

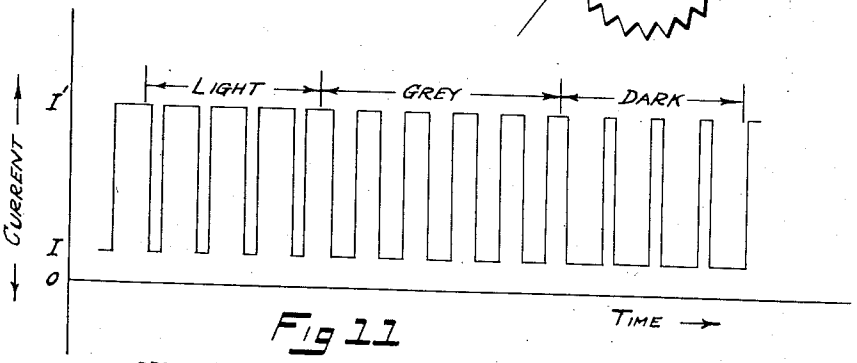


Fig 11

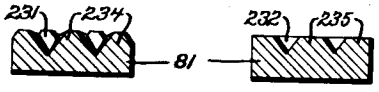


Fig 12

Fig 14

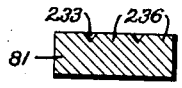


Fig 16

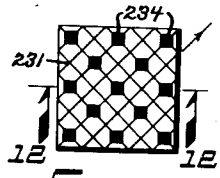


Fig 13

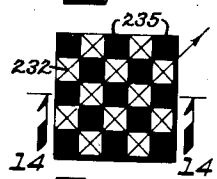


Fig 15

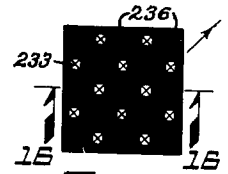


Fig 17



Fig 18

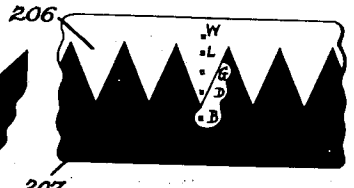


Fig 19

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Fig. 20

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Patented Sept. 14, 1937

2,092,765

UNITED STATES PATENT OFFICE

2,092,765

ELECTRIC MACHINE

George E. Losier, East Orange, N. J., assignor of one-fifth to William A. Hughes, Newark, N. J., and four-fifths to Marion L. Losier, East Orange, N. J.

Application December 19, 1932, Serial No. 647,884

7 Claims. (Cl. 178—5)

The present invention relates to a method and an automatic machine for cutting printing plates or other reproductions from an image, picture or pattern, and also to the printing plate or reproduction made with and according to the method and machine of the invention.

An object of the present invention is to provide a method and machine for performing the steps of the method for making reproduction of images, pictures and patterns such as making half-tone printing cuts or plates directly from the picture without the use of the chemical processes heretofore used.

Another object of the present invention is to provide a half-tone printing plate in which the printing points or elevations are substantially in the shape of frustums of pyramids whereby is obtained a printing plate which can be used for making thousands of copies of pictures without the "mushrooming" of such elevations such as occurs with the photo-chemically produced plates, but in which all the advantages of the photo-chemical half-tone are present, including the screen effect, the oblique rows of printing elevations and so on.

Another object of the present invention is to provide a half-tone printing plate which can be used with greater pressures and which will have a longer life than the heretofore used photo-chemically produced half-tone plates.

Other objects and advantages of the present invention will be apparent from the following description of the method, machine and plate of the invention and from the drawings and claims illustrating and describing the same.

The accompanying drawings, forming part of the present application, show, somewhat diagrammatically, an embodiment of the present invention, with alternative forms of certain parts, in which:

Figure 1 is a plan view, somewhat diagrammatic, of an apparatus embodying the invention;

Figure 2 is a section view in elevation, taken along the line 2—2 of Figure 1, looking in the direction of the arrows, and in part cut away;

Figure 3 is a vertical section of a scanning head;

Figure 4 is a diagram of the circuit of an amplifier used;

Figure 5 is a vertical elevation view in section of the plate cutting head, in place on a plate to be cut, taken along the line 5—5 of Figure 6, looking in the direction of the arrows;

Figure 6 is a section view, in part cut away, taken along the line 6—6 of Figure 5, looking in the direction of the arrows;

Figure 7 is a bottom plan view of a portion of Figure 6, looking from the position of arrows 7—7;

Figures 8 and 9 are, respectively, side and back elevation views of the end of the cutting tool;

Figure 10 is a diagrammatic illustration of a screen-effect producing unit of the apparatus, including a screening wheel;

Figure 11 is a graph of current against time, showing relative strengths of current used in reproducing light, grey and dark portions of the picture;

Figures 12 and 13, 14 and 15, and 16 and 17 are sets of section elevation and plan views, respectively, of parts of the cut plate corresponding, respectively, to light, grey and dark portions of the picture, and corresponding, respectively in sets, to the "light", "grey" and "dark" portions of the plotting of Figure 11; and

Figure 18 is a somewhat diagrammatic view of a screening wheel, in part cut away;

Figure 19 is a diagrammatic view of a scanning tape, alternate in form to the wheel of Figure 18; and

Figure 20 is a print made with a printing plate made with the apparatus and according to the method of the present invention.

In the drawings a channel shaped bed 10 (see Figures 1 and 2) carries a pair of spaced apart bottom rails 11, 11 and a pair of side rails 12, 12, one on each of the channel sides 13, 13, which pairs of rails 11, 11, and 12, 12 respectively support and laterally guide a picture table 14 and a plate table 15 by means of the bottom rollers 16, 16 and side rollers 17, 17. Means for moving said tables 14 and 15 synchronously on said rails 11, 11 are provided comprising an arm 18 pivoted at one end to said table 14 and at its other end to a lever 19 which at an intermediate point pivots on a pin 20 fixed on a side 13 of said bed 10 at one end thereof. Similarly an arm 21 pivoted to said table 15 connects to a lever 22 which pivots on a pin 23 at the other end of said bed 10. A rigid turnbuckle arm 24 connects levers 19 and 22 in driving relation by means of slides 25 and 26, which are pivoted one to each end of said turnbuckle arm 24 and which are fixedly adjustable one in each of the slots 27 and 28, in the outer ends of said levers 19 and 22, respectively. By arranging the distance of said slide 25 from its corresponding pin 20 to be different from the distance of said slide 26 from said pin 23, the length of the stroke

movement of said table 14 can be made to be different from that of said table 15, either greater or less to suit the needs of reduction or enlargement from the picture to the plate, as desired. Obviously, when the reproduction is to unit scale these distances are arranged to be the same.

Movement of said tables 14 and 15 is secured by means of a motor 30 which drives the slow speed vertical shaft 31 which passes through said bed 10 and drives a Scotch yoke 32 (see Figure 2) which connects with the bottom of said table 14 in driving relation. The Scotch yoke, a well known form of adjustable mechanical movement, is used on account of its adjustability to secure different lengths of strokes of movement of said table 14 (and of table 15) to suit various sized pictures to be reproduced. In the present case adjustability of the distance of movement of said table 14 for each revolution of said shaft 31 is secured through the adjusting screw 33.

Directly over said table 14 is a scanning head 35 for scanning a picture 36 carried by said table 14. Said scanning head 35 rides on the bar 37, mounted transversely across said bed 10 and with its ends fixed to said sides 13, 13, for movement of said scanning head 35 across said picture 36 while said table 14 is carrying said picture 36 longitudinally, the relative movement of said scanning head 35 with respect to said picture 36 being along a diagonal across said bed 10, in a manner and by means hereinafter fully described. Said scanning head 35 comprises a support bar 40 which rides on said bar 37 and which carries a housing 41 within which is a photoelectric cell 42 which latter faces downward toward said table 14. A tube 43, slidably mounted on said support bar 40, extends vertically below said photoelectric cell 42 with its upper end fitting in sliding relation in a short tube 44 connecting with and extending downwardly from said housing 41. Said tube 43 has fixed thereto a rack 45 which engages with a pinion 46 mounted to said support bar 40 and having a thumb-piece (not shown) for moving said tube 43 up or down to adjust the position thereof. In its side adjacent said support bar 40 carries a laterally projecting short tube 47 in which is mounted a condensing lens 48 opposite which, on said support bar 40, is a source of light 49. At the lower end of said tube 43 is a set of condensing lenses 50, and between said lens 48 and lenses 50 is a reflecting prism 51 adapted to reflect light passing thereto from said lens 48 so that it passes through said lenses 50 to a picture 36 on said table 14 by which it is reflected upwardly back through said lenses 50 through an aperture 52 carried at the upper end of said tube 43 and thence to said photoelectric cell 42.

Means for moving said scanning head 35 on said bar 37 comprise a bevel gear 55, on said shaft 31, which drives a pinion 56 on a shaft 57 which drives a bevel gear 58 and pinion 59, which latter, through the set of interchangeable reduction gears 60 drives another set of reduction gears (not shown) in gear box 61 from the upper side of which extends the driven slow speed shaft 62 which carries a belt pulley 63 opposite which latter, on a side 13, is an idler pulley 64. Between said pulleys 63 and 64 there extends a belt 66 which connects with said scanning head 35 by a set screw 67 in driving relation. The driving gear train for said belt 66 is geared down to move said belt 66 at such a rate that said scanning head 35 is moved the distance of the size of the screen mesh to be simulated in the case of a one to one reproduction, or a predetermined coefficient thereof in case of reduction or enlargement, for each forward and back stroke of said table 14, that is, for each revolution of said shaft 31. Mounted on and insulated from said shaft 31 is a commutator 70 having one part cut away for half the distance around its circumference in which place is set an insulating piece 71, with brushes 72, 72 bearing on the commutator so that for one half of a revolution of said shaft 31 said commutator 70 makes a circuit between said brushes 72, 72 and for the other half it breaks the circuit. Said brushes 72, 72 connect to the leads 73, 73 one of which includes a source of electric energy 74 for a purpose hereinafter described.

Over said table 15 is mounted a cutting head 80 in operative relation to a plate 81 on said table 15, in similar relation to that of said scanning head 35 with respect to said picture 36. Said cutting head 80 rides on a bar 82 mounted to said sides 13, 13, across said bed 10 and receives its motion from a belt 83 mounted on idler pulley 84 and driving pulley 85 which latter connects through a set of interchangeable reduction gears (not shown) in gear box 86, through a connecting shaft 87 and pinion 88 to said bevel gear 58. Through these driving means, said cutting head 80 will move in synchronism with said scanning head 35 when the latter moves, either in unit ratio for exact size reproduction or greater or less if enlargement or reduction is desired; the ratio being changeable through the gears of said gear box 86, or of gear box 61, or of gears 60 or any or all of them.

Said cutting head 80 (see Figures 5, 6 and 7) comprises a supporting rod 90, one end of which rides in locking engagement in the slot 91 in said bar 82. From the other end of said rod 90 there depends a bar 92 having a vertical slot 93 therein in which latter rides a slide rod 94 whose position in said slot 93 is fixed and vertically adjustable by means of the screw 95 which is threaded into said slide rod 94 at its lower end and has its upper end extending through an opening in said rod 90 where it has a knurled fixed head 96 bearing against the upper surface and a fixed washer 97 bearing against the lower surface of said rod 90.

Said slide rod 94 intermediate its ends carries a yoke 98 which extends transversely in the direction away from said bar 82 and which carries within itself an electromagnet 99 having a pole-piece 100 extending in the direction toward said bar 82. Said electromagnet 99 is energized by said source 74 through said leads 73, 73 in a manner and for the purpose hereinafter described. An armature bar 102, hinged to the lower end of said slide rod 94 through an offset 103, extends vertically upwards and carries at its upper end a transverse bar 104 which extends through an opening 105 in said slide rod 94 and carries an armature 106 in operative relation to said pole piece 100.

Extending oppositely from said bar 104 and fixed to said armature bar 102 is a support bar 107 which supports beneath it a permanent magnet yoke 108, which latter at its outer end carries an electromagnet 109 and at its inner ends carries the pole-pieces 110, 111 having therein, respectively, the oppositely facing slots 112, 113. Said field coil 109 is energized by direct current during operation of the mechanism. Clamped one on each side of said pole pieces 110 and 111, by means of the bolts 115 and 116, are the back

plate 117 and the front plate 116. Said bolts 115 and 116 also hold between them the oval shaped coil 125 which extends horizontally edgewise through said slots 112, 113. Extending centrally lengthwise in the longitudinal opening 126 of said coil 125 is the flat armature 127 which carries, one at each end, the flexible loops 128, 128, each of which is mounted on one of said bolts 115, 116 which loops 128, 128 allow a small rotative movement of said armature 127 about an axis which is the median of said coil 125. To be actuated by such rotative movement of said armature 127 is a vertical tool holder 130 which connects at its upper end through a flexible link 131 to said armature 127, said link 131 being flexible in a direction at right angles to said coil 125. At its lower end said tool holder 130 terminates in a chuck 132 which carries a cutting tool 133.

Clamped between a shoulder 134 and an adjustable nut 135 on said tool holder 130 is a flexible annular diaphragm 136 which serves to hold the lower end of said tool holder 130 and to steady it during movement. Said diaphragm 136 is attached by the four screw bolts 137, 137, near its edges, to a bar 138 fixed to the bottom of said yoke 108 under the pole piece end and extending outwardly therefrom with an opening 139 therein through which said tool holder 130 passes.

To one side from said tool holder 130, said bar 138 carries a vertical guide 145 through which extends a vertical slide bar 146 which has a longitudinal passageway 147 extending therethrough and carries a horizontal bar 148 projecting therefrom under said diaphragm 136 with an opening 149 therein into or through which said toolholder 130 passes. A longitudinal passageway 150 within said bar 148 connects at its inner end with said passageway 148 and at its other end terminates in a U-shaped opening 151 through the lower face of said bar 148 about said opening 149. In the bottom face of said bar 148 adjacent said opening 151 is another opening 152 which connects with said passageway 150 and which carries therein the supporting roller 153 which is adapted to ride on and to carry the cutting head 80 over a plate 81 to be cut by said tool 133. Means (not shown) for drawing a suction through said passageways 147 and 150 will draw chips cut from the plate and any dirt from under and through said openings 151 and 152. A brush 154 fixed in said opening 152 and bearing on said roller 153 will wipe off any chips or dirt adhering to the latter and release them to be carried away by such suction. A gear rack 155 fixed to said slide bar 146 engages a pinion 156 in said guideway 145 which latter carries a spindle 157 which passes through a friction bushing 158 in a wall of guideway 145 and terminates in a knurled head 159. By turning said knurled head 159 to move said pinion 156 on said rack 155, said cutting head 80 can be raised or lowered to suit the length of said tool 133 and to suit the length of the cutting stroke thereof.

In Figures 8 and 9 said cutting tool 133 is illustrated in detail in which the shank 165 carries at one end the cutting point 166 which has two cutting edges 167, 167 which taper to a point from said shank 165 and for making a plate of a given screen the angle A defined by said edges 167, 167 is predetermined the value of said angle A being smaller for fine screens than for larger ones. The bisecting line of said angle A is at right angles to the plate being cut. The face 168 of said cutting point 166 is cut upwardly and back from the perpendicular at an angle B to give the tool a bite, the back of the cutting point is cut backwardly from said two edges 167 to give them clearance and in the form here illustrated defines two faces 169, 169. To give bottom clearance, said cutting point 166 is cut upwardly and back from the tip at an angle C from the horizontal whereby a diamond shaped face 170 is defined in the embodiment of the tool illustrated in Figures 8 and 9.

Referring again to Figures 1 and 2 and others, said photo-electric cell 42 connects to the aperiodic screening amplifier 180 (see Figure 4) by the leads 181 and 182, which amplifier 180 comprises two high amplification tubes 183 and 184, which are connected in series with each other and with said photo-electric cell 42, and two power tubes 185 and 186 which are connected in parallel with each other and in series with said tubes 183 and 184, with a resistor 187 in parallel between said tubes 184 and 185. From the plates of said tubes 185 and 186 a lead 188 connects to one terminal of a screening system 190 and from the grids thereof through said resistor 187 and a source of electric energy 191 the lead 192 connects to another terminal of said screening system 190. The rest of the connections of said power amplifier 180 are conventional, as shown.

Said leads 188 and 192 connect and carry power to a reflecting galvanometer 193 of the type commonly known in the art as the vibrator element of an oscillograph. The mirror 194 of said galvanometer 193 is in operative relation to a constant source of light 195 and an optical system comprising three condensing lenses 196, 196 and a light slit 197, which latter is arranged to permit a vertical beam of light to be projected by said lenses 196, 196 onto said mirror 194. In operative relation to receive reflected light from said mirror 194 is a second photoelectric cell 198, with a horizontal cylindrical lens 199 between for concentrating the reflected vertical beam from said source 195 into a point at a toothed light interrupting disc 200 positioned between said cylindrical lens 199 and said photoelectric cell 198 and mounted on a shaft 201 (see also Figure 1) which latter is driven by said cutting table 15 through a stud 202, fixed to the latter and connected to a chain 203 (which can be a rack and pinion or other equivalent) through a sprocket 204 and a gear train 205. An alternate to said disc 200 is a toothed ribbon 206 (see Figure 19) which can be driven in back and forth movement by said table 15 and which can be a notched opaque strip or a transparent strip 206 having an opaque portion 207 running lengthwise thereof with one edge describing serrations or a series of uniform notches which come to points at their tops and bottoms like a saw edge.

Said light interrupting disc 200 (also ribbon 206) is opaque and is positioned in relation to said galvanometer mirror 194 so that the light reflected by the latter passes midway between the top and bottom of the notches of the disc 200 as at G in Figures 18 and 19 (at which point the width of the teeth and of the notches is the same) when said photoelectric cell 42 is passing over a portion of a picture which is midway in tone between black and white.

From said photoelectric cell 198 leads 210 and 211 connect with the cutting amplifier 212 which can be a transformer, resistance or impedance coupled amplifier of types generally well known and its purpose is to amplify the current passed through said photoelectric cell 198 to sufficient strength to operate said cutting head 80. Leads

213 and 214 connect said cutting amplifier to said coil 125 (see Figures 5 and 6). When a push-pull type amplifier is used the lead 215 connects from the source of high potential of the amplifier to the midpoint of said coil 125.

In the operation of the above described embodiment of my invention for making a printing plate from a picture or other delineament, a picture 36 is place on said table 14 laterally within the movement range of said scanning head 35. The said picture 36 can be aligned with the direction of movement of said table 14 or transverse thereto, but preferably for black and white printing it is placed at an angle of about forty-five degrees so that the black (or white) printed dots in adjacent rows are alternate or staggered (see Figures 13, 15 and 17 which show sections of the printing plate) whereby adjacent dots of a given shade, black or white, are adjacent only at the corners thereof thereby avoiding continuous bands of black or white of more or less continuous width in the longitudinal direction which produces an optical illusion which detracts from the desired effect in the picture. The manner of cutting is more fully explained hereinafter.

When a positive plate 81 is to be made from a positive picture 36, or a negative printing plate 81 is to be made from a negative picture 36, then said scanning head 35 and said cutting head 80 are moved in opposite directions across said bed 10; and, if a negative printing plate 81 is to be made from a positive picture 36, or a positive plate 81 is to be made from a negative picture 36, then said scanning head 35 and said cutting head 80 are moved in the same direction across said bed 10.

Said picture 36 and plate 81 being properly placed and fixed on their respective tables 14 and 15 by suitable means not shown, said scanning head 35 is brought to lower end of said bar 37 as shown in Figure 1 and the table 14 is moved to the right in Figure 1 far enough for the left hand corner of said picture 36 to be to the right beyond the line of travel of said scanning head 35. If said picture 36 is a positive and a negative plate is to be cut then said cutting head 80 is moved to the upper end of said bar 82 in Figure 1 and said table 15 is far enough to the right to bring the left hand corner of said plate 81 to the right of the line of travel of said cutting head 80.

The various electric circuits and sources of light are now energized and said motor 30 is set in motion, whereupon said tables 14 and 15 begin their synchronous rapid forward and backward movements and said scanning head 35 and cutting head 80 commence their comparatively slow movement across the picture 36 and plate 81, respectively. During forward movement of said table 14 said commutator 70 is in the "open circuit" part of its rotation and said electro-magnet 99 is de-energized leaving said cutting head 80 down in the plate cutting position, and during the backward movement of table 14 the circuit between said source of electric energy 74 and said electro-magnet 99 is closed through said commutator 70 and said cutting head 80 is lifted out of the plate cutting position. This movement of said cutting head 80, by said electro-magnet 99, into and out of plate cutting position is through movement of said armature bar 102 on its hinged connection at the lower end of said slide rod 94.

Light from said source of light 49 is reflected from a point on said picture 36 to said photoelectric cell 42, the amount of light reaching the latter being proportional to the degree of light or shade at the point of reflection. Likewise the value of the current which flows through said photoelectric cell 42 and the circuit connected thereto, including said screening amplifier 180 and oscillograph unit 193 is proportional to the amount of light reaching said photoelectric cell 42.

Said galvanometer 193 is now energized by current passing through said photoelectric cell 42 by virtue of light reflected to the latter from said picture 36 on said table 14 and said mirror 194 is deflected at an angle from a predetermined normal energized position in one direction or the other in ratio to the degree of light or shade of the picture above or below the predetermined medium or normal tone. Said angle is zero, of course, when the said photoelectric cell 42 is scanning those parts of the picture 36 which are of medium or normal shade. Said light interrupting disc 200 is now rotating and entirely cutting off successive portions of the light passing from said mirror 194 toward said photoelectric cell 198 whereby the current flowing through the latter and through said coil 125 of said cutting head 80 and the circuit therebetween varies in alternate succession from a minimum in accordance to the "dark" conductivity of said photoelectric cell 198 when the light is cut off therefrom, to a maximum which occurs when light from said mirror passes through the notches of said disc 200. The graph in Figure 11 indicates the changes in value from minimum to maximum of this current as the light is interrupted by said disc 200, and also the time duration of the minimum and maximum current values as determined by the position of said mirror 194 and the path of the light from the latter to said photoelectric cell 198. It is seen that for "light" portions of the picture the time duration of the maximum value of the current in the graph of Figure 11 is greatest and of the minimum value the least. For the "dark" portions the maximum value of the current is of the least duration and the minimum of the greatest duration. For the "grey" portions the time duration of the maximum and minimum current values are substantially equal.

During periods of the greatest time duration of the maximum current value said cutting tool 133 will reach its greatest depth in said plate 81 because it will have time to reach further, for although it is actuated into and out of cutting position from several hundred times to several thousand per second, said table 15 and plate 81 are moved at a corresponding speed to give the required number of actuations of said cutting tool 133 per inch of movement of said table 15 and plate 81, for example, to simulate a sixty-five mesh screen, the number of complete up and down movements of said cutting tool 133 per inch movement of plate 81 will also be sixty-five. The number of actuations of said cutting tool 133 in a given unit of time depends on the number of interruptions of light made by said disc 200, and, of course, on the mechanical characteristics of the moving parts, for example, of said cutting head 80. An actual working example is in cutting pictures in a Babbitt metal plate at the rate of ten lineal inches per second to simulate a sixty-five mesh screen under which conditions the actuations of said cutting tool 133 are thirteen hundred per second, regard being had for the fact that half of the one second period is used in the forward or cutting movement and half in the return movement of said cutting head over said plate 81.

Figures 12, 14 and 16, respectively, show enlarged cross-sections of parts of said plate 81 hav-

ing cut therein, respectively, the depressions **231**, **232** and **233** by said tool **133**, the depths of these said depressions being proportional to and the areas of the horizontal or printing faces of the elevations **234**, **235** and **236** between said depressions **231**, **232** and **233**, respectively, being directly proportional to the time durations of the maximum value of current at those parts of the current curve in Figure 11 marked, respectively, light, grey and dark. Face views (also enlarged) of the plate parts shown in Figures 12, 14 and 16 are shown, respectively, in Figures 13, 15 and 17, with the printing faces of the elevations **234**, **235** and **236** blackened in with ink to indicate the relative degree of shading and light on those parts of an image or picture printed from a plate **81** having elevations **234**, **235** and **236** thereor of various areas of horizontal or printing surface. The slanting arrows indicate the direction of movement of the cutting tool **133** in going over the plate **81** during the cutting operation. Where the depressions in the plate **81** run in together as Figures 12, 13 and 14, 15 the elevations (**234**, **235**) are in the forms of frustums of four-sided prisms, with the top faces of the frustums forming the ink receiving areas. The depressions **231**, **232**, and **233** have their lower portions (if not all) in inverted four-sided hollow pyramidal contour. Figures 14 and 15, for example, illustrate a section of printing plate of the invention in which the area cut away was equal to the printing area (made up of the faces of elevations **235**, **235**) which is left. Here the depressions **232**, **232** are in the form of inverted four-sided pyramids. In Figures 12 and 13 the depressions **231**, **231** are in the form of inverted four-sided pyramids which run in together at their bases, the cut-away surface area being greater than the printing area left. In Figures 16 and 17, the form illustrated has the printing area greater than the cut-away surface area. Here again the depressions **233**, **233** are in the form of inverted four-sided pyramids. In some cases the lateral faces of said depressions **231**, **232** and **233** are not true planes but can be slightly concave, due to the shape of the energy curve of the current supplied to said coil **125** and the resultant movement of said tool **133** with respect to said plate **81** as the two are moved, the former up and down and the latter horizontally.

The operation of said cutting head **80** to give an average light and shape effect, for example, to compare with that of the picture being reproduced, in several ways as for example, by adjusting the light slit **52** in the scanning head **35**; by raising or lowering the cutting head **80** as by thumb adjustment **159** to adjust the depth of cut; by adjusting the median of the angle of movement of the beam of light from the galvanometer mirror **194** with respect to said interrupter **200**; by running the whole apparatus faster or slower whereby the depth of cut is shallower or deeper; or by using harder or softer metal for the plate to be cut to control the depth of cut or in various other ways.

The method and apparatus of the present invention, in addition to use in a unit machine, are applicable to use in an arrangement in which the cutting head is at a point distant from the scanning transmission of current from one to the other being accomplished by wire connection or by a radio system, with suitable amplifying units when required and with suitable means for synchronizing the scanning head and the cutting head. In such case a number of cutting heads could be set up in operated relation to one scanning head and several reproductions made simultaneously. In such case positives and negatives could be made at the same time on different cutting heads governed by the same scanning head.

The print which is Figure 20 of the accompanying drawings was made with a printing plate which was made by the method of the present invention and by the apparatus illustrated in the drawings hereof and described in the foregoing specifications, as an illustrative embodiment of the apparatus of the present invention. In Figure 20 there are various degrees of shading from pure white to solid black and through the intermediate shades corresponding to the "light" portions of the plate illustrated in Figures 12 and 13, the "grey" portions illustrated in Figures 14 and 15, and the "dark" portions illustrated in Figures 16 and 17 of the drawings. The pure white is shown in Figure 20 in the upright post under the rail on which the figure is leaning, the "light" shade is shown in the collar of the overcoat held by the figure, the intermediate shade is shown in the shadow which appears adjacent the figure's right shoulder, the dark shade is shown in various degrees in the derby hat held by the figure, and solid black is shown in the derby and also in a portion of the figure's hair.

The engraved plate cut by the machine and according to the methods of the present invention and herein described is claimed in my copending application Serial No. 742,715, filed Sept. 5, 1934, and allowed August 3, 1935.

Having thus described my invention what I claim and wish to protect by Letters Patent is:—

1. In combination with a photoelectrically controlled relief engraving tool, a light-interrupting member having a given portion thereof movable along a given line and having a light passage therein in said given portion and of a width which varies in a direction substantially transverse to said line, a light directing galvanometer having its light directing element in operable relation to said given portion and mounted to move a beam of light across said given line, means for concentrating said beam of light into a point at that part thereof which passes through said light passage, and a photoelectric cell in operative relation to receive light directed by said galvanometer through said light passage.

2. In combination with a photoelectrically controlled engraving tool, a light interrupter having light-directing and light-interrupting portions arranged alternately along a given line and movable along said given line, said light interrupting portion being of a dimension which varies substantially transverse to said given line, a light-directing galvanometer having its light directing element in operable relation to move a beam of light across said given line, means for concentrating said beam of light into a point at that portion thereof which passes through the light-directing portions of said interrupter and a photoelectric cell in operative relation to receive light passing from said galvanometer to the light-directing portion of said light interrupter.

3. In a machine for reproducing a given picture on the surface of a printing plate, in combination, a scanning head; a reflecting galvanometer; an aperiodic amplifier connected between said scanning head and said galvanometer; means for directing a beam of light to the mirror of said galvanometer in a plane at right angles to the axis of movement of said mirror; a photoelectric cell in operative relation to receive

light reflected from said light directing means by the mirror of said galvanometer at various positions of the movement of the latter; a light interrupter adapted to move a succession of light passages and light interrupting portions across the path of light between said galvanometer and said second photoelectric cell, said light passages being of varying width across said light path; and an electrically controlled engraving tool connected in controlled relation to said second photoelectric cell.

4. The method of producing cameo relief engraving with a half-tone screen effect from a picture to be reproduced, comprising scanning with a photoelectric cell to produce flow of electric current whose strength varies proportionally to the degree of light and shade of the picture being scanned; operating an engraving tool with a second electric current of constant value; operating on said second electric current with the aid of first said electric current to produce pulsations in the former which vary in time duration proportionately with the degree of light and shade in the picture being scanned and producing relative movement between said engraving tool and a plate to be engraved which is in operative relation thereto.

5. The method of producing a screen effect printing plate with a tool having two cutting edges which taper away from each other from a common point and with a photosensitive scanning element in controlling relation to said tool which comprises synchronously scanning an image with said photosensitive element and moving said tool in successive, parallel paths across a plate to be cut with its said cutting edges in a plane substantially transverse to the direction of movement in said parallel paths, and simultaneously moving said tool in an up and down movement at a given rate in relation to the rate of speed of movement in said parallel paths into successive cutting engagements with said plate to such depth and in such number in each of said parallel paths of movement that a plurality of substantially tetrahedral cuts are formed which are aligned longitudinally and transversely and which vary in length, width and depth in proportion to the degree of shading of the image being scanned.

6. In a machine for cutting any given image in reproduced relation into a printing plate with a screen effect, in combination, means for scanning an image; a screen effect producing system comprising a light transmitting galvanometer in controlled relation to said scanning means, a photosensitive element to receive light transmitted by said galvanometer, a light interrupter having a light passage which is tapered and which is substantially transverse to a beam of light transmitted by said galvanometer to said photosensitive element, means for directing a beam of light to said light transmitting galvanometer and for defining said beam of light into a small point at said light interrupter, said light transmitting galvanometer being so related to said other parts of said screen effect producing system that said beam of light at its small point is movable along the length of said tapered light passage, and means for causing relative movement between said beam of light at its small point part and said tapered light passage in a direction substantially transverse to said beam of light; and a plate cutting tool which is in controlled relation to said photosensitive element and which has two cutting edges which taper away from each other from a common point.

7. In a machine for reproducing a given picture on the surface of a printing plate, in combination, a scanning head; a reflecting galvanometer; an aperiodic amplifier connected between said scanning head and said galvanometer; means for directing a beam of light to the mirror of said galvanometer in a plane at right angles to the axis of movement of said mirror; a photoelectric cell in operative relation to receive light reflected from said light directing means by the mirror of said galvanometer at various positions of the movement of the latter; a light interrupter adapted to move a succession of light passages and light interrupting portions across the path of light between said galvanometer and said second photoelectric cell, said light passages being of varying width across said light path; a cylindrical lens having its axis substantially in the plane of movement of the light beam reflected from said reflecting galvanometer and to focus the light at said light interrupter; and an electrically controlled engraving tool connected in controlled relation to said second photoelectric cell.

GEORGE E. LOSIER.