May 12, 1953 C. E. ERNST 2,638,500

PROCESS AND APPARATUS FOR PHOTOELECTRIC ENGRAVING

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Fig. 1.

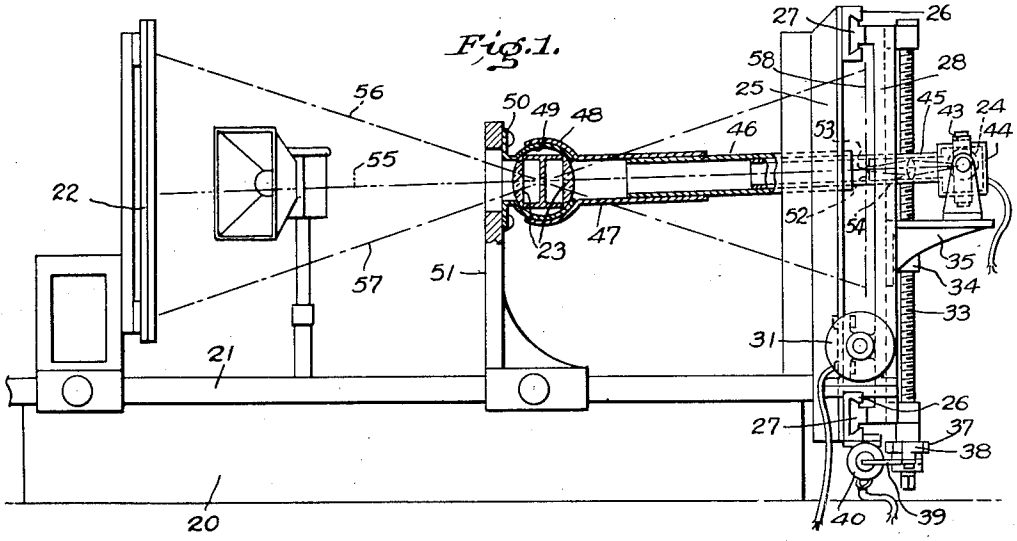
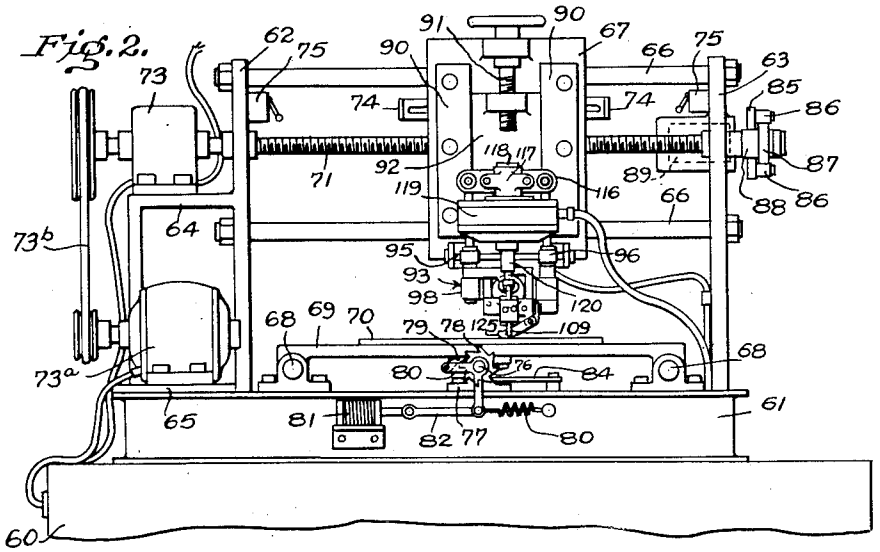


Fig. 2.



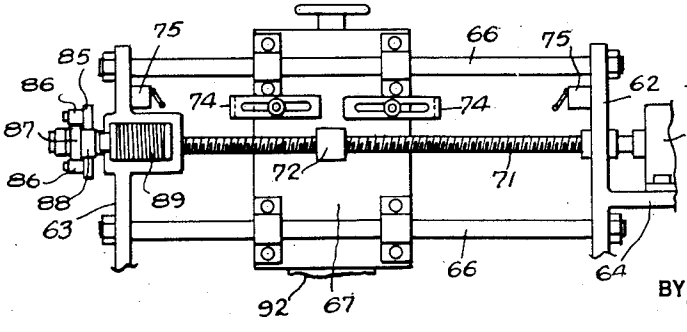


Fig. 3.

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PROCESS AND APPARATUS FOR PHOTOELECTRIC ENGRAVING

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Fig. 4.

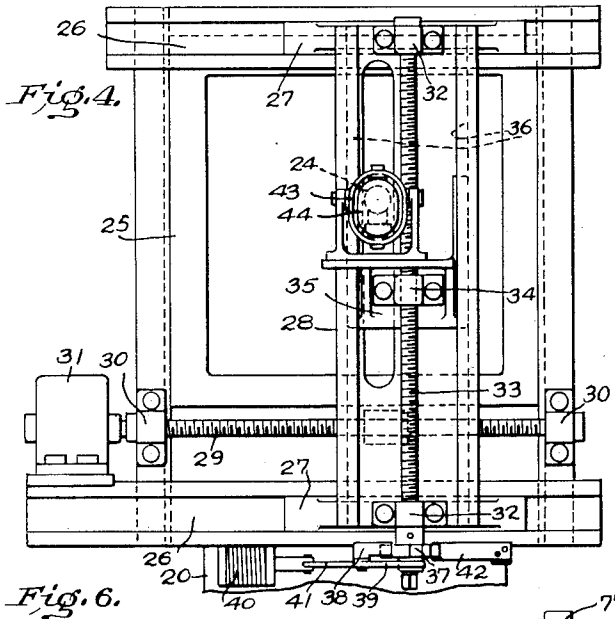


Fig. 5.

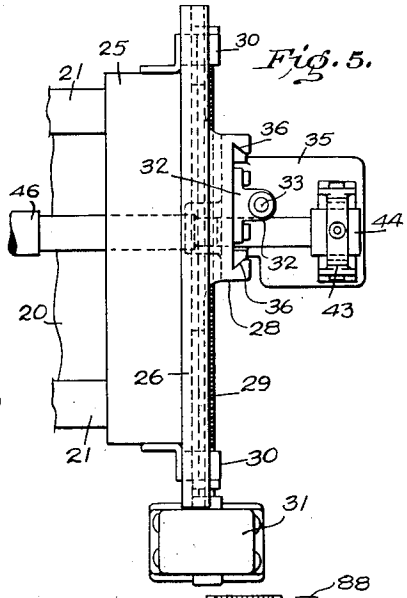
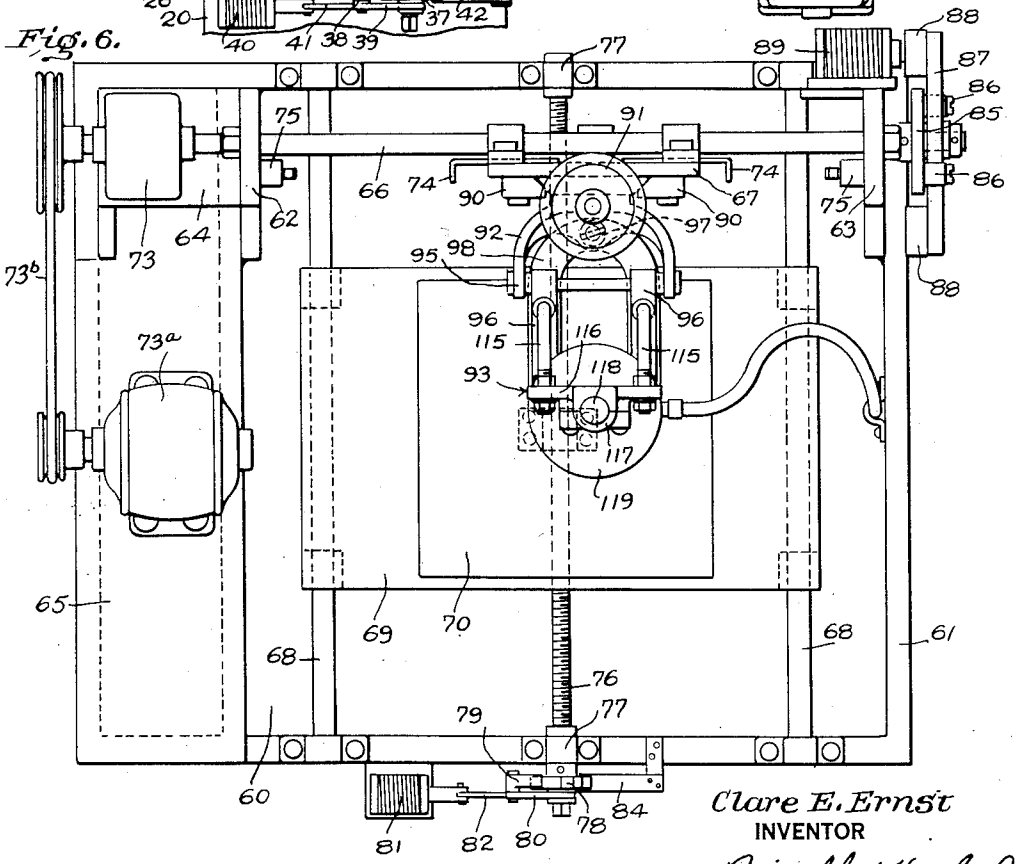


Fig. 6.



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PROCESS AND APPARATUS FOR PHOTOELECTRIC ENGRAVING

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Fig. 7.

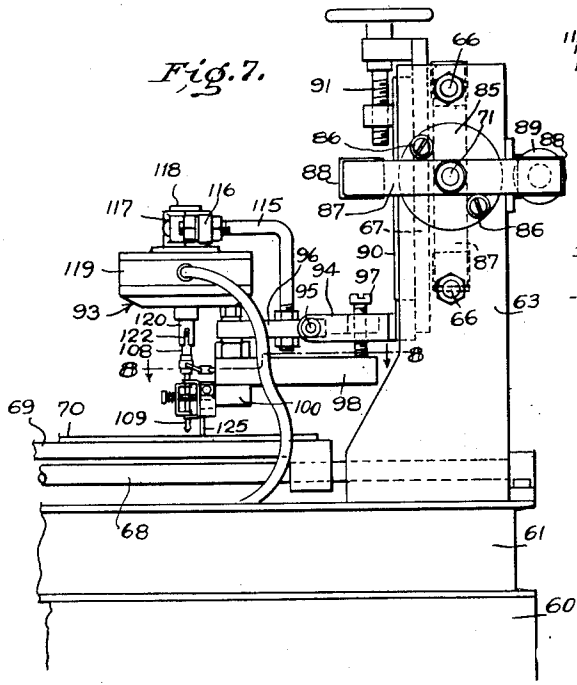


Fig. 9.

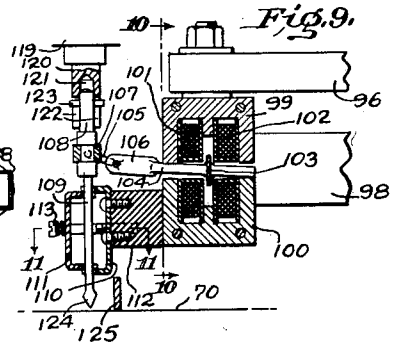


Fig. 10.

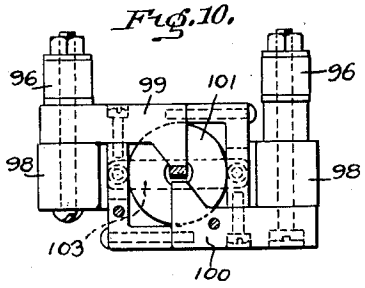


Fig. 8.

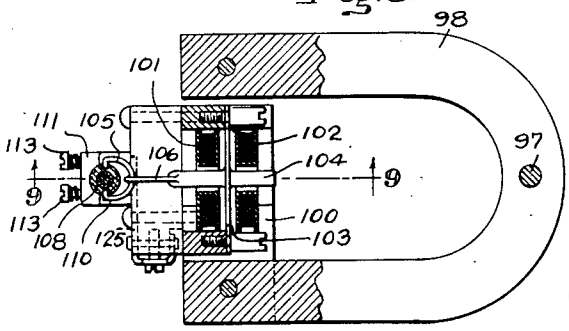


Fig. 11.

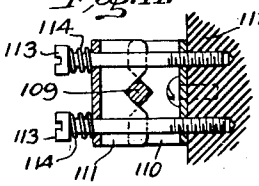


Fig. 12.

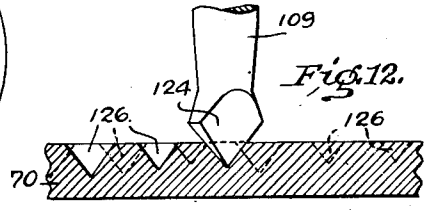
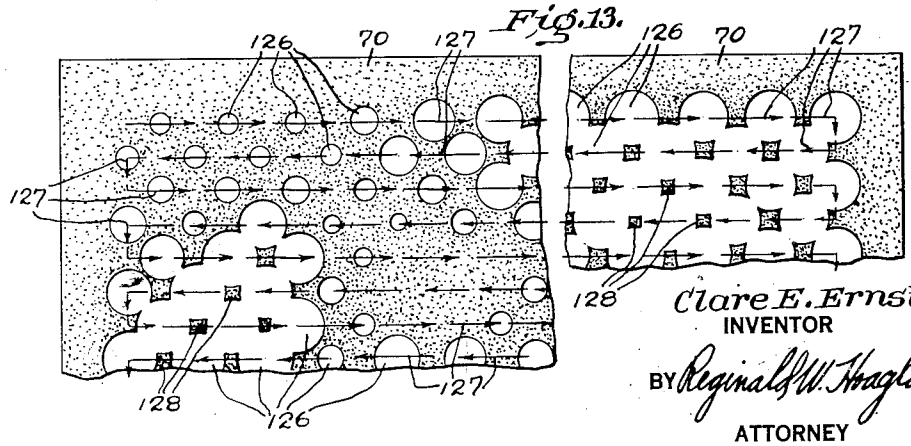


Fig. 13.



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PROCESS AND APPARATUS FOR PHOTOELECTRIC ENGRAVING

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Fig. 15.

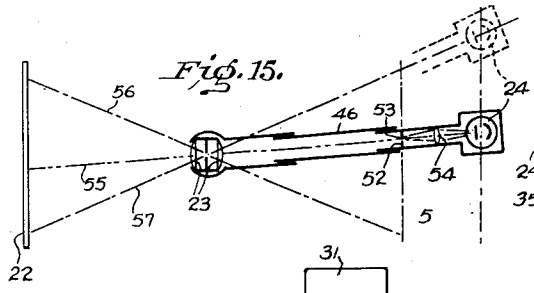


Fig. 14.

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PROCESS AND APPARATUS FOR PHOTOELECTRIC ENGRAVING

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Fig. 16.

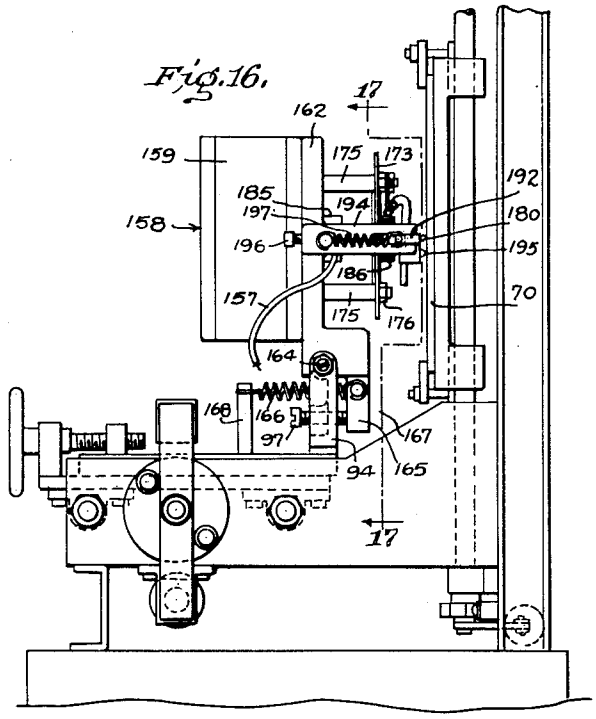


Fig. 19.

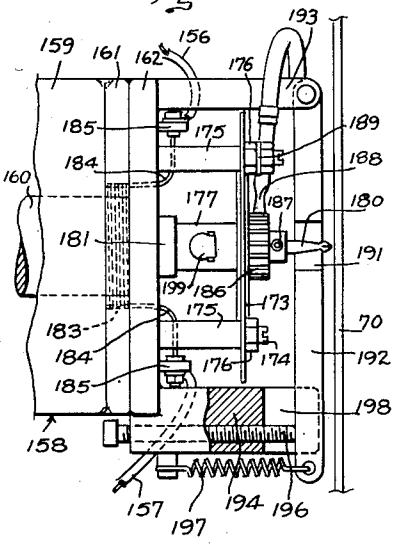


Fig. 17.

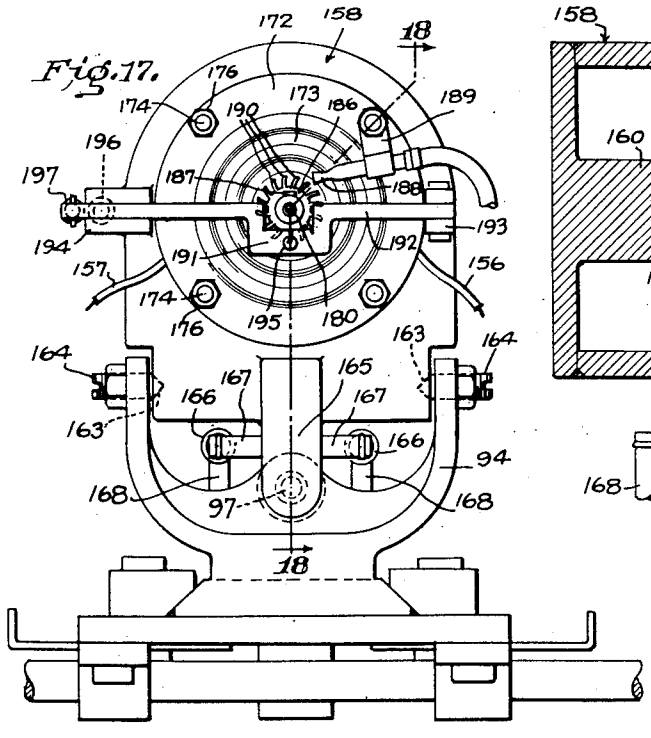
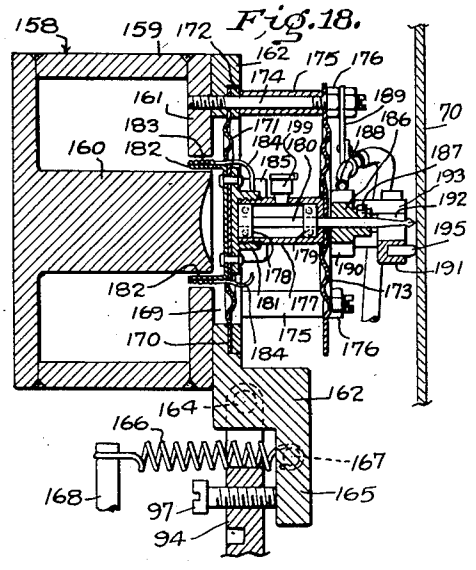


Fig. 18.



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UNITED STATES PATENT OFFICE

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PROCESS AND APPARATUS FOR PHOTO-ELECTRIC ENGRAVING

Clare E. Ernst, Flint, Mich.

Application June 28, 1951, Serial No. 234,006

5 Claims. (Cl. 178—6.6)

1

This invention relates to methods and apparatuses for photoelectrically engraving half-tone plates, having particular reference to automatic mechanical removal of printing surface from plates according to graduations of tone of images being reproduced.

Half-tone plates made according to the customary photoengraving method wherein acid is used for attacking areas of the plate have not proven satisfactory as acid cannot be properly controlled and often results in uneven contours and undercuts. Furthermore, the cost of producing half-tone plates by this method is very expensive due to time requirements and the necessity of employing highly skilled labor.

Efforts have previously been made to intermittently and individually remove or displace surface areas from half-tone plates of varying sizes in accordance with the density of tone in pictures by prick-punching, etching, and drilling processes with the use of pointed tools that are controlled as to their depth of engagement into the plate during each individual removal or displacement operation. For different reasons, such mechanical dispersement of surface areas of plates have not produced half-tone plates acceptable to the trade.

It is therefore the primary object of this invention to provide a novel and improved method and apparatus for efficiently and accurately producing from pictures half-tone plates for use either in the making of stereotype mats or for printing directly from the plates.

Another object of the invention is to provide an apparatus of the above-indicated character wherein a photoelectric tube and picture-reflecting lenses are encased by a telescopic tube and aligned with a restricted aperture therebetween located on the focal plane of an image reflected from a picture by said lenses, said telescopic tube being provided to prevent outside light from entering through the aperture to the photoelectric tube and to permit variations in the spacing of the lenses relative to the picture and restricted aperture for varying the size of the reflected image from which a half-tone plate is produced and for movement of the photoelectric tube relative to the lenses and picture during scanning operation.

A further object of the invention is to provide a photoelectric engraving apparatus wherein the voltage and current from a picture-scanning photoelectric tube that controls depths of engagement of a cutter into a half-tone plate can be varied at different intensities of illumination of the photoelectric tube for lightening gray portions without changing black or darkened portions when producing a half-tone plate from a picture, thereby obtaining greater contrast between light and dark tones in pictures produced with the half-tone plate than the tone contrast of the original picture.

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A further object of the invention is to provide a novel manner of obtaining a screen effect with a mechanically produced half-tone plate wherein cuts of adjacent rows of cuts in the surface of a plate are in staggered relation to one another.

It is also an object of the invention to provide an apparatus as set forth having a high-speed, air-operated rotor attached directly to the shank of a cutting tool, both being of extremely lightweight construction and rotatably mounted as a unit on a sensitive, flexible support which is magnetically flexed according to tone graduations of a picture being reproduced to move the cutting tool into and out of a half-tone plate being produced, said air rotor being of a width that air pressure directed thereto substantially tangent to its diameter continually actuates said rotor independent of the position of the cutting tool relative to the plate and without influencing the position of the cutting tool.

These, together with various auxiliary features and objects of the invention which will later become apparent as the following description proceeds, are attained by the present invention, preferred embodiments of which have been illustrated, by way of examples only, in the accompanying drawings, wherein:

Figure 1 is a side elevation, with parts broken away and shown in section, of the scanning unit;

Figure 2 is a side elevation of the engraving unit;

Figure 3 is a fragmentary rear elevation of the engraving unit shown in Figure 2;

Figure 4 is an end elevation of the scanning unit;

Figure 5 is a fragmentary plan view showing the rear portion of the scanning unit;

Figure 6 is a plan view of the engraving unit;

Figure 7 is an end elevation of the engraving unit with the forward portion thereof broken away;

Figure 8 is a horizontal section taken on line 8—8 of Figure 7;

Figure 9 is a vertical section taken on line 9—9 of Figure 8;

Figure 10 is a vertical section taken on line 10—10 of Figure 9;

Figure 11 is a horizontal section taken on line 11—11 of Figure 9;

Figure 12 is an enlarged sectional view through a half-tone plate in the process of being made, showing the cutting end of a tool relative to said plate;

Figure 13 is a plan view of fragments of a half-tone plate made with the apparatus;

Figure 14 is a diagrammatic view of both the scanning and the engraving units showing electrical symbols and wire connections to various elements of the apparatus;

Figure 15 is a diagram of the picture-reflecting mechanism;

Figure 16 is a side elevation of a modified form of engraving unit;

Figure 17 is a vertical section on line 17—17 of Figure 16 showing a face view of the transducer;

Figure 18 is a vertical section taken on line 18—18 of Figure 17; and

Figure 19 is a fragmentary plan view of the modified form with a portion broken away and shown in section.

Referring now more specifically to the accompanying drawings, wherein like numerals designate similar parts throughout the various views, attention is directed first to Figures 1, 4, and 5 illustrating the scanning unit which is shown for the purpose of illustration, separate from the engraving unit, and being connected thereto only by electric wires.

The scanning unit has a base 20 with a track 21 on which a copyboard 22 and focusing lenses 23 are slid towards and away from each other and adjusted relative to a photoelectric cell 24 on a frame 25 fixed to said base. Different adjusted positions of the copyboard and focusing lenses along the track for reflecting an image of a picture attached to the copyboard on a focal plane relative to the photoelectric cell permit the making of enlarged and reduced reproductions, as well as reproductions of the same size.

Mounted in horizontally extending dovetailed guide members 26 of the frame 25 are slides 27 at both the upper and lower ends of a transversely movable member 28 which is threadably engaged by a horizontal feed screw 29 mounted in bearings 30 on the frame and rotated by a synchronous motor 31 which is operated in opposite directions for imparting reciprocal motion to said member 28. Journaled in upper and lower bearings 32 on the member 28 are the opposite end portions of another feed screw 33 arranged at right angles to the screw 29 and threaded through a lug 34 on a vertical, movable carriage 35 guided in its vertical movement by a beveled way 36 formed in the member 28. On the lower end of the feed screw 33 below the lower bearing 32 is secured a ratchet 37 engaged by a pawl 38 mounted on an end of a bell crank lever 39 which is also connected to a solenoid 40 by a link 41. An end of a spring 42 engages the teeth of the ratchet to prevent turning of the ratchet upon return of the pawl 38 to engage the next tooth of the ratchet. Thus, it can be seen that each time the solenoid is energized, the feed screw will lower the carriage a slight distance.

On a rearwardly projecting platform of the carriage 25 is secured a bracket 43 of universal movement construction which is connected to a casing 44 that houses the photoelectric cell 24. Opening into the casing 44 and aligned with the photoelectric tube is the smaller end section 45 of a telescopic tube 46 that has its larger opposite end section 47 formed with an enlarged socket 48 which receives and is turned about a substantially ball-shaped casing 49 that houses the focusing lenses 23, there being oppositely arranged openings in the ball-shaped casing at the focusing lenses and an opening from the socket into the section 47 through which light enters the telescopic tube. The casing 49 is flanged, as at 50, where it is attached to a bracket 51 that slides on the track 21 which provides the previously mentioned slidable connection for the focusing lenses 23 along the track.

In the smaller tube section 45 of the telescopic tube 46 is a closed off wall 52 with a small, square opening 53 centrally of the tube section for restricting the amount and shape of light rays from the focusing lenses that are permitted to pass said closed off wall. Between the closed off wall 52 and the photoelectric cell 24 and also arranged in the tube section 45 is a small lens 54 which reflects light passing through the opening 53 to the photoelectric cell.

The controlling of the direction of rotation of a synchronized motor 31 and the energizing of the solenoid 40 for turning the horizontal and vertical feed screws 29 and 33, respectively, for moving the carriage 35 on which is supported the photoelectric cell 24 that scans during such movement a picture on the copyboard will be described as the description proceeds. However, it can be assumed that the synchronized motor reciprocates the carriage horizontally and that the solenoid lowers the carriage slightly at the end of each stroke of reciprocal motion, thereby scanning the entire surface area of a picture. The telescopic tube, while shutting off outside light to the photoelectric cell, pivots at its opposite ends about the housing of the focusing lenses and on the carriage and compensates for lengthening and shortening of the distance between the focusing lenses and the photoelectric cell during scanning movement of the carriage. Also, the use of a telescopic tube permits adjustment of the distance between the focusing lenses and the photoelectric cell when reducing or enlarging a reproduction of a picture, as it is essential that the focusing lenses be adjusted relative to the picture on the copyboard and the opening 53 in the closed off wall 52 so that the focal plane on an image reflected from the picture is at the opening 53 in the closed off wall 52. In Figures 1 and 15, the dash and double-dot line 55, centrally of the focusing lenses 23, telescopic tube 48, and photoelectric cell 24, and extended to the copyboard 22, indicates the portion of a picture reflected to the photoelectric cell, while the crossed-dash and dot lines 56 and 57 indicate extreme positions the photoelectric cell is capable of moving during a scanning movement. The vertical dash and dot line 58 represents the focal plane of a picture reflected by the focusing lenses as being directly on the restricted opening 53 in the closed off wall 52.

Attention is now directed to Figures 2, 3, 6, and 7 illustrating the engraving unit of the apparatus wherein the number 60 indicates the upper portion of a cabinet on which a rectangular base frame 61 constructed of channel members rests. Secured to the base frame are spaced uprights 62 and 63, a motor seat 64 on the upright 62, and a motor-supporting plate 65 across one end of said base frame. Attached to and extending between the uprights 62 and 63 is a pair of guide rods 66 that slidably supports a carriage 67, while mounted on the base frame and extending

at right angles to the pair of guide rods 66 is another pair of spaced guide rods 68 that slidably supports a table 69 to which is clamped the plate 70 to be made into a half-tone plate. A feed screw 71 rotatably mounted adjacent opposite ends thereof on the uprights 62 and 63, extending parallel to the guide rods 66 and threadably engageable with the carriage 67, as at 72, reciprocates said carriage on said guide rods when rotated in opposite directions by a synchronous motor 73 mounted on the motor seat 64.

Adjustable extensions 74 on opposite sides of the carriage 67 are adapted to engage limit switches 75 attached to the inner sides of the uprights at the ends of desired movement of the carriage in both directions. The limit switches 75 are connected to a reversible motor 73a mounted on the plate 65 of the base frame 61 and reverse the direction of rotation of the motor upon each actuation of either switch. The reversible motor 73a is connected by a belt and pulley drive 73b to the synchronous motor 73 which is electrically connected to the synchronous motor 31 for reversing the direction of rotation of the synchronized motors 31 and 73 to move the carriages 35 and 67, respectively, in directions opposite to that previously moved.

Another feed screw 76, mounted at its opposite ends in bearings 77 attached to the forward and rear sides of the base frame 61, as shown in Figure 6, and threadably engageable with the table 69, slides the table on the guide rods 68 upon turning movement of said feed screw. On the forward end of the feed screw 76 is attached a ratchet 78 which is engaged by a pawl 79 mounted on one arm of a bell crank lever 80 that has its other arm connected to a solenoid 81 by a link 82. A spring 83 returns the pawl to engage the next tooth of the ratchet after each time the solenoid is energized, while a free end of a leaf spring 84 prevents turning of the ratchet in the wrong direction during return of the pawl to an operative position.

The solenoid 81 and the solenoid 40 on the scanning unit have circuits closed thereto by actuation of the limit switches 75 during the period of reversing the directions of reciprocal motions of the carriages 67 and 35. Thus, when the table 69 and photoelectric cell 24 have reached an end of a stroke of their reciprocal motion, the table and the photoelectric cell are slightly moved at right angles to their reciprocal motion for cutting and scanning along other adjacent areas of the plate and picture, respectively.

On the end of the feed screw 71 that is rotatably mounted on the upright 63 is secured a disk 85 with a pair of parallel and oppositely spaced lugs 86 which project outwardly therefrom for engaging a cross bar 87 at opposite sides of a pivotal connection of said bar to the feed screw 71 to cause said bar to be rotated with said feed screw. Secured to each end of the cross bar 87 is a permanent magnet 89 arranged so that the path of movement of both magnets will place said magnets at predetermined spaced intervals of time in close proximity to a pulse generator coil 89 stationary on the upright 63 for exciting said pulse generator coil. The width of the magnets determines the length of time of each impulse, while the space between the two magnets determines the time between impulses, thus; by using magnets of greater or lesser widths, length of time of each impulse may be increased or decreased. The purpose of the impulses will be set forth as the description proceeds. The locations of the lugs 86 relative to the cross bar 87 are such that a lost motion of ninety degrees of rotation of the cross bar with respect to the feed screw 71 is present upon the reversing of the direction of rotation of the feed screw, which, together with the locating of the permanent magnets 88 one hundred eighty degrees apart, causes an even staggering of the spaced intervals of the time of excitement of the pulse generator coil 89 during reciprocal motion of the carriage 67 in opposite directions.

In guide ways 90 on the carriage 67, and movable by an adjusting screw 91, is a bracket 92 that supports an engraving head, generally indicated by the numeral 93. Said support consists of a right-angled, projecting, forked portion 94 between which are pivotally connected, as at 95, parts 96 of the head 93, while an adjusting screw 97 on the bracket engages a part 98 of the head and determines the position of the head on its pivotal connection relative to the bracket.

The engraving head 93, shown more in detail in Figures 8, 9, 10, and 11, has a horseshoe-type permanent magnet which is the part 98 previously referred to and which has connected to its ends pole pieces 99 and 100 that are forked and directed towards one another for receiving in the combined forks of both a pair of spaced coils 101 and 102 between which is a flexible blade 103 that supports for slight rotary movement an armature 104 that extends through openings in the coils and between the push and pull ends of the pole pieces 99 and 100, said armature being normally held by said flexible blade in a position contrary to its position of actuation by said pole pieces upon current impulses of said pulse generator.

To one end of the armature 104 a yoke 105 is mounted by a laterally flexible leaf connection 106 and is provided with inturned ends that engage in holes in opposite sides of a collar 107 rotatably connected against end movement on an arbor 108 which holds a cutting tool 109. The shank of the cutting tool 109 is supported for rotation and endwise movement in V-shaped notches in the free ends of a pair of oppositely directed and telescoping U-shaped brackets 110 and 111 supported by the lower pole piece 100 and insulated therefrom by a block 112. The attaching screws 113 that retain the U-shaped bracket 111 in place have coil springs 114 under the heads thereof which engage the bracket 111 for yieldably forcing said bracket in position with bearing surfaces of the V-shaped notches of both brackets in engagement with the shank of the cutting tool.

Mounted on the parts 96 that pivotally connect the head 93 to the bracket 92 are the lower ends of a pair of angled arms 115 that extend upwardly and then forwardly. To said forward ends are attached the opposite ends of one of a pair of clamping members 116 and 117 that engage about a stub extension 118 on the casing of a lightweight, high speed air motor 119 of the 75,000 to 100,000 R. P. M. type. The drive shaft 120, to which is attached the rotor of the motor, depends from the motor casing, and besides having a central bore 121 extending upwardly from its lower end to slidably receive the upper end of the arbor 108, has slots 122 therein into which extend the ends of a cross pin 123 on the arbor for forming a slidable drive connection between the air motor and the arbor. The point 124 of the cutting tool 109, which is substantially in the form of a drill point for cutting tapered holes of varying depths in the

plate 70 according to the value of the current which flows through the photoelectric cell 24, is adjusted relative to the plate 70 by the adjusting screws 91 and 97; but in order to further retain proper relationship of such parts, a shoe 125, adjustable on the head 93, rides over the plate 70 during cutting operation in advance of the area of the plate being cut for slightly raising the head on the pivot 95 should higher areas in the plate be encountered.

Figures 12 and 13 show tapered holes 126 of varying diameters cut into the upper surfaces of the plate 70 for removing areas from the plate surfaces to obtain light and dark tones in a picture printed either directly or indirectly from said plate.

Arrows 127 indicate the direction of travel of the cutting tool produced by the coordination of rotation of the feed screws. Also shown is the staggered relation of adjacent rows of holes cut in the plate produced by the lost motion in the connection of the cross bar 87 to the feed screw 71 when rotating said feed screw in opposite directions. It will be observed that in the removal of surface from the plate, some of the individual, circularly cut holes are of such large diameter that they coalesce, leaving small, substantially rectangular, unconnected surface areas in the form of islands which are indicated by the numeral 128.

Referring now to Figure 14 which shows an electric wiring diagram of the entire apparatus and diagrammatic illustrations of certain elements of the apparatus, there is indicated both an alternating current circuit and a direct current circuit. The alternating current circuit, which times and coordinates movement of the photoelectric cell 24, engraving head 93, plate 70, and pulse generator magnets 88, has a source of current, indicated at 129, with wires 130 leading therefrom to a reversing switch relay 131 from which the usual three-line connection 132 is made to the reversing motor 73a. Also from the reversing switch relay 131, wires 133 connect to the two limit switches 75, while other wires 134 connect to the solenoids 40 and 81. The synchronous motors 31 and 73 are connected together by the usual five-wire connection 135, while the synchronous motor 73 receives current through the wires 136 from the source 129.

The direct current circuit, which supplies pulses of varying currents to the mechanism which actuates the cutting tool, consists of the scanning photoelectric cell 24 for producing varying currents according to the density of tone of pictures, the coil 89 of a pulse generator for producing timed electrical pulses, an adjustable mixer for receiving current variations from the photoelectric cell and timed pulses from the coil of the pulse generator, an amplifier for amplifying timed pulses mixed with varying currents, and the mechanism which actuates the cutting tool that is operated according to the value of pulses from the amplifier.

The adjustable mixer has therein a 6L7 mixer tube 137 with a potentiometer 138 adjustably connected through a 100-megohm resistor 139 by a wire 140 to a control grid of the mixer tube and connected by wire 141 to the cathode of the photoelectric cell 24 for varying the bias voltage of the grid and for partially varying the sensitivity of the photoelectric cell. The other control grid of the mixer tube is connected by a wire 142 to one end of another potentiometer 143 which has the adjustable connection thereof wired, as at 144, to the pulse generator coil 89, while the other ends of the potentiometer and pulse generator coil are grounded. A 250-volt battery 145 with the negative terminal grounded is tapped at 90 volts for connection by a wire 146 to the plate of the photoelectric cell 24, at 100 volts by a wire 147 through a resistor 148 to the screen grid of the mixer tube, and at 250 volts by a wire 149 through a resistor 150 to the plate of the tube. The cathode-heating filament of the tube is supplied with current from a 6-volt battery 151, while the cathode is grounded by a wire 152. To the lead 149 between the resistor 150 and the plate of the mixer tube a wire 153 is connected and leads through a condenser 154 and an amplifier 155 after which said wire is grounded.

Connected to the output of the amplifier 155 are a pair of wires 156 and 157 which lead to opposite ends of the series-connected coils 101 and 102 of the mechanism which actuates the cutting tool. The pulses of varying current from the amplifier 155 to the coils 101 and 102 cause magnetism to be set up in the armature 104 which then repells itself from the magnetic pole of the permanent magnet of the same polarity causing the armature to swing on its flexible support 103 according to the values of current impulses.

When reproducing a picture on a plate that does not have sufficient contrast between light and dark tones, and it is desired to lighten gray portions of the picture without changing black or darker portions, the bias voltage on the control grids of the mixer tube 137 can be varied by adjusting the two separate potentiometers 138 and 143 to allow more current to flow from the cathode to the plate in the mixer tube. The potentiometer 143 on the second control grid is adjusted for dark or black tones, while the potentiometer 138 on the first control grid is adjusted for lightening gray tones.

Figures 16, 17, 18, and 19 show a modified form of engraving unit wherein a different type of engraving head, generally indicated by the numeral 158, is used, and other parts of the unit are turned ninety degrees on the cabinet 60, thereby arranging some elements that were in vertical positions on horizontal planes and other elements that were in horizontal positions on vertical planes. By turning the unit on its side, both the plate 70 that is acted upon by the engraving head 158 and the right-angled projecting forked portion 94 that supports the engraving head 158 are arranged vertically instead of horizontally.

In this case, the permanent magnet 159 is of a circular type with a core pole 160 projecting through and spaced from an opening in an end plate 161 which constitutes the other pole. Attached to the end plate 161 of the permanent magnet 159 is a supporting bracket 162 provided with pivot holes 163 into which the pointed ends of trunnions 164 on the ends of the forked portion 94 of the adjustable bracket 92 extend. An offset leg 165 depends from the bracket 162 and is engaged by the adjusting screw 97 of the bracket portion 94 for limiting movement of the head 158 towards the plate 70, while coil springs 166 attached to said leg, as at 167, and to the bracket by pins 168 yieldably hold the head in position with the leg 165 in contact with the adjusting screw 97.

The bracket 162 has a circular opening 169 therein aligned with and of greater diameter than the opening in the end plate 161 of the

magnet. Around said opening, the bracket is annularly recessed, as at 170, to provide a seat for the marginal portion of the diaphragm 171 and to receive a clamping ring 172. Spaced from and aligned with the daiphragm 171 is another diaphragm 173 that is supported by pins 174 which also attach the bracket 162, diaphragm 171, and ring 172 to the plate 161 of the magnet by extending said pins through all of said parts. The pins 174 have one of each of their ends threaded into the plate 161, have spacer sleeves 175 thereabout between the ring 172 and diaphragm 173, and have nuts 176 threaded on their other or outer ends.

Attached to and arranged centrally of the diaphragm 173, by brazing or the like, and extending towards the center of the diaphragm 171 is a small, sleevelike housing 177 containing in each end thereof bearings 178 and 179 that rotatably receive a cutting tool 180 that projects forwardly through holes in the ends of the housing 177 and diaphragm 173. The end of the housing 177 adjacent the diaphragm 171 is threaded into a flanged socket 181 riveted or otherwise attached to the forward side of the diaphragm 171. These same rivets attach the bottom of a thin-walled, cup-shaped armature 182 to the rear side of said diaphragm with the annular wall thereof reposed in the space between the pole pieces 160 and 161 of the magnet 158 and out of engagement with said pole pieces. Wound around and insulated from the annular wall of the cup-shaped armature 182 is a coil 183 with leads 184 extending through holes in the diaphragm 171 to terminal blocks 185 supported and insulated from the ring 172. Connected to the leads 184 at the terminal blocks are the wires 156 and 157 that lead to the armature 155 shown in the other form of engraving unit illustrated in Figure 14.

On the forward portion of the shank of the cutting tool 180 projecting through the diaphragm 173 is detachably secured an air wheel or rotor 186 by a set screw 187 in a collar thereof. A Venturi-type nozzle 188 is shown as being supported by a hanger 189 from one of the pins 174 and is directed substantially tangent to the outer ends of radial vanes 190 of the rotor, as best shown in Figure 17. The vanes 190 are slightly arced, being undercut on their faces that are engaged by a blast of air from the nozzle and are of a width across their faces sufficient to remain in contact with said blast of air in all endwise positioning of the rotor and cutting tool.

Extending across the engraving head forward of the rotor 186 and offset, as at 191, for permitting the cutting tool to pass thereby is a bar 192 pivoted at one end to an arm 193 on the bracket 162 and detachably connected to another arm 194 on the bracket 162 at its opposite end. Below the point of the cutting tool and at the offset 191, the bar 192 has thereon a rounded end shoe 195 that engages the surfaces of the plate 70 along an area thereof in advance of the cutting apparatus to said plate for properly positioning the head relative to the surface of the plate being cut. The end of the bar 192 detachably connected to the arm 194 is also adjustable on said arm for properly locating the shoe 195 with respect to the depth of engagement of the point of the cutting tool into the plate upon different endwise motion of the cutting tool. Said adjustment consists of an adjusting screw 196 on the arm against which the bar 192 is held by a coil spring 197, the end of said arm 194 being slotted, as at 198, for supporting the detachable end of the bar against up and down movement.

It will be observed that the two diaphragms 171 and 173 support a high-speed, rotatable cutting mechanism of extremely light weight for sensitive end movement produced by pulses varying current to the coil 183. As the permanent magnet 159 has a constant magnetic field of constant polarity, impulses of like polarity from the transformer in the amplifier 155 through the coil 183 repel each other, thereby pushing the coil out or away from the magnet to engage the cutting tool into the plate according to the value of each pulse. When pulses through the coil are of opposite polarity which attract the coil to the magnet, and when there is no current through the coil and the coil is returned to the position held by the diaphragms 171 and 173, the cutting tool is out of engagement with the plate.

Due to the lightweight and high-speed requirements of the cutting mechanism, the small precision ball bearings 178 and 179 used for rotatably supporting the shank of the cutting tool must be lubricated. Therefore, the sleevelike housing 177 is also used as an oil reservoir and is supplied with oil through the filler cap 199.

While there are shown and described separately a scanning and an engraving unit for the purpose of locating the units a distance from each other, it is to be understood that certain elements of the apparatus may be eliminated, and parts of both the scanning and the engraving unit may be mounted on the same movable members for movement in unison.

In view of the foregoing description taken in conjunction with the accompanying drawings, it is believed that a clear understanding of the construction, operation and advantages of the apparatus will be quite apparent to those skilled in this art. A more detailed description is accordingly deemed unnecessary.

It is to be understood, however, that even though there are herein shown and described preferred embodiments of the invention, various changes may be made without departing from the spirit and full intendment of the invention.

What is claimed is:

1. A plate-engraving apparatus comprising a photoelectric cell for scanning a picture, a cutting tool, a plate positioned for engagement of said cutting tool therewith, means for imparting reciprocal motion and movement at right angles to said reciprocal motion at the end of each stroke of reciprocal motion to said photoelectric cell relative to the picture and to said cutting tool relative to said plate in unison, said means for imparting reciprocal motion including a feed screw rotatably mounted and reversed in its directions of rotation, a pulse generator including a stationary pulse generator coil and at least one permanent magnet connected to said feed screw and rotatably moved in close proximity past the coil for producing electrical impulses, said permanent magnet having a lost motion in its connection to the feed screw upon rotation of the feed screw in opposite directions for producing impulses staggered relative to reciprocal motion in opposite directions, a mixer tube receiving current variations from said photoelectric cell and timed pulses from said pulse generator, an amplifier receiving timed pulses of varying currents from said mixer tube, and a cutting tool activating mechanism for moving said tool into said

plate according to the value of the pulses from said amplifier.

2. A plate-engraving apparatus including a scanning unit and an engraving unit, each of which is comprised of a support, and a carriage slidable on said support; means for synchronized reciprocal motion of said carriages on said supports; a picture-reflecting member on said scanning unit adjustable for varying the size of an image reflected from a picture; an encased photoelectric tube on the carriage of said scanning unit, said encasement having an aperture therein arranged on the focal plane of an image reflected from a picture; means for moving the carriage with the photoelectric cell relative to said reflected image and at a direction at right angles to said reciprocal motion of the carriage at the end of each stroke of the reciprocal motion for progressively scanning the image along spaced, parallel, imaginary lines; a work plate on said engraving unit; a high speed, power-driven cutter supported on the carriage of said engraving unit and mounted for movement into and out of engagement with said work plate; means for moving the carriage of said engraving unit relative to said work plate in a direction at right angles to the reciprocal motion of said carriage at the end of each stroke of the reciprocal motion for progressively moving the cutter along spaced, parallel rows over the surface of the plate; means for varying the amplitude of movement of said cutter into said plate in accordance with variations in the intensity of illumination of said photoelectric tube; and means intermittently actuating said means of variable movement at constant intervals during both directions of reciprocal motion of the engraving carriage and at intervals staggered relative to movement of the carriage in opposite directions.

3. A plate-engraving apparatus including a scanning unit and an engraving unit, each of which is comprised of a support, a carriage slidable on said support, and a threaded shaft rotatably mounted on said support and threadably engageable with said carriage; reversible, synchronized motors connected to said threaded shafts for sliding said carriages on said supports, limit switches on one of said supports operated by the carriage supported thereby for reversing said synchronized motors for reciprocating the carriages in unison; a picture-reflecting member on said scanning unit adjustable for varying the size of an image reflected from a picture; a photoelectric cell on the carriage of said scanning unit; a casing enclosing said photoelectric tube with an aperture therein arranged on the focal plane of an image reflected from a picture; means for movement of the carriage with the photoelectric cell relative to said reflected image in a direction at right angles to said reciprocal motion of the carriage at the end of each stroke of the reciprocal motion for progressively scanning the image along spaced, parallel, imaginary lines; a work plate on said engraving unit; a high speed, power-driven cutter supported on said carriage of said engraving unit and mounted for movement into and out of engagement with said work plate; means for movement of the carriage of said engraving unit relative to said work plate in a direction at right angles to the reciprocal motion of the carriage at the end of each stroke of the reciprocal motion for progressively moving the cutter along spaced, parallel rows over the surface of the plate; means for varying the amplitude of movement of said cutter into said plate in accordance with variations in the intensity of illumination of said photoelectric cell; a permanent magnet on one of said threaded shafts and rotated therewith; and a pulse generator coil fixed to one of said supports and arranged in close proximity to the path of movement of said permanent magnet and electrically connected to said means of variable movement for intermittently actuating said means of variable movement at constant intervals upon continued passing of said permanent magnet thereby in each direction of reciprocal motion of said carriage.

4. A plate-engraving apparatus including a scanning unit and an engraving unit, each of which is comprised of a support, a carriage slidable on said support, and a threaded shaft rotatably mounted on said support and threadably engageable with said carriage; reversible, synchronized motors connected to said threaded shafts for sliding said carriages on said supports, limit switches on one of said supports operated by the carriage supported thereby for reversing said synchronized motors for reciprocating the carriages in unison; a picture-reflecting member on said scanning unit adjustable for varying the size of an image reflected from a picture; a photoelectric cell on the carriage of said scanning unit; a casing enclosing said photoelectric tube with an aperture therein arranged on the focal plane of an image reflected from a picture; means for movement of the carriage with the photoelectric cell relative to said reflected image in a direction at right angles to said reciprocal motion of the carriage at the end of each stroke of the reciprocal motion for progressively scanning the image along spaced, parallel, imaginary lines; a work plate on said engraving unit; a high speed, power-driven cutter supported on said carriage of said engraving unit and mounted for movement into and out of engagement with said work plate; means for movement of the carriage of said engraving unit relative to said work plate in a direction at right angles to the reciprocal motion of the carriage at the end of each stroke of the reciprocal motion for progressively moving the cutter along spaced, parallel rows over the surface of the plate; means for varying the amplitude of movement of said cutter into said plate in accordance with variations in the intensity of illumination of said photoelectric cell; a permanent magnet on one of said threaded shafts and rotated therewith; and a pulse generator coil fixed to one of said supports and arranged in close proximity to the path of movement of said permanent magnet and electrically connected to said means of variable movement for intermittently actuating said means of variable movement at constant intervals upon continued passing of said permanent magnet thereby in each direction of reciprocal motion of said carriage, said permanent magnet having lost motion in its connection to said rotatable shaft for staggering the constant intervals of actuation of said means of variable movement relative to travel of the carriages in opposite directions.

5. A plate-engraving apparatus comprising a picture-reflecting member adjustable for varying the size of an image reflected from a picture, a photoelectric cell for scanning the image, a cutting tool, a plate positioned for engagement of said cutting tool therewith, means for imparting reciprocal motion and movement at right angles to said reciprocal motion at the end of each stroke of reciprocal motion to said photoelectric cell

relative to the picture and to said cutting tool relative to said plate in unison, a casing enclosing said photoelectric cell and having an aperture therein arranged on the focal plane of an image reflected from a picture, a telescopic tube connected at opposite ends to said casing and picture-reflecting member, so as to retain alignment of the aperture in the casing with the photoelectric cell and the picture-reflecting member during movement of said photoelectric cell and means for varying the amplitude of movement of the cutting tool into said plate in accordance

with variations in the intensity of illumination of said photoelectric cell.

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