

June 6, 1961

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2,987,573

ENLARGING AND REDUCING PHOTOELECTRIC ENGRAVING MACHINE

Filed Aug. 3, 1956

2 Sheets-Sheet 1

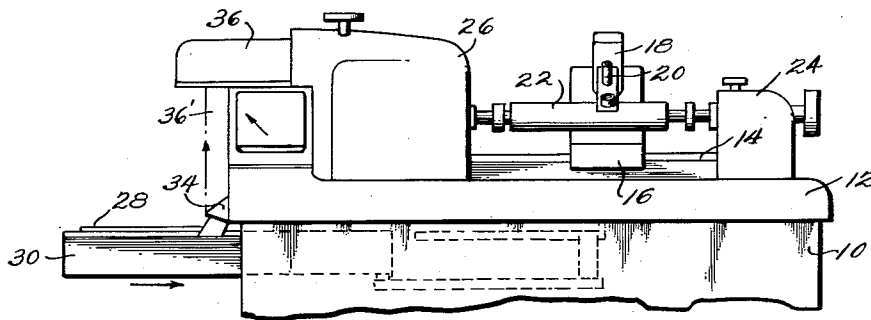


Fig. 1

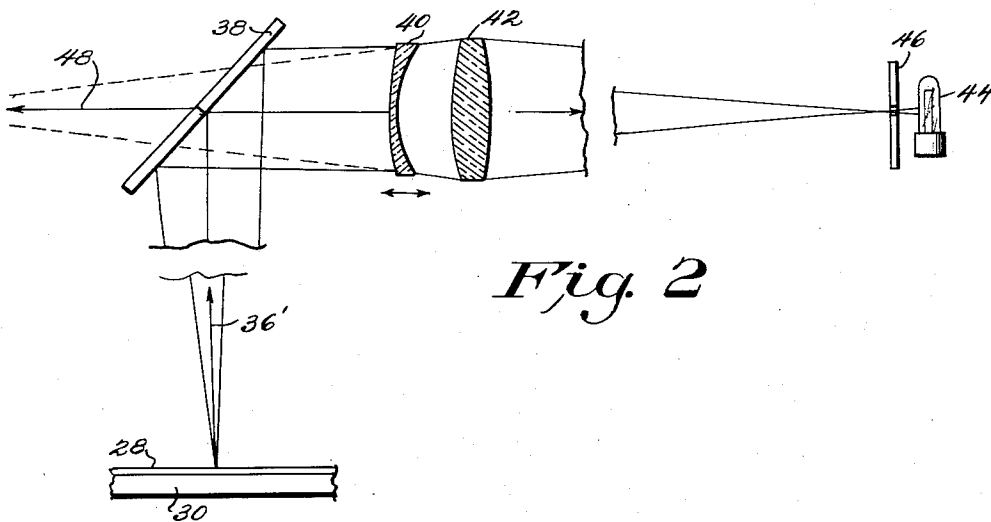


Fig. 2

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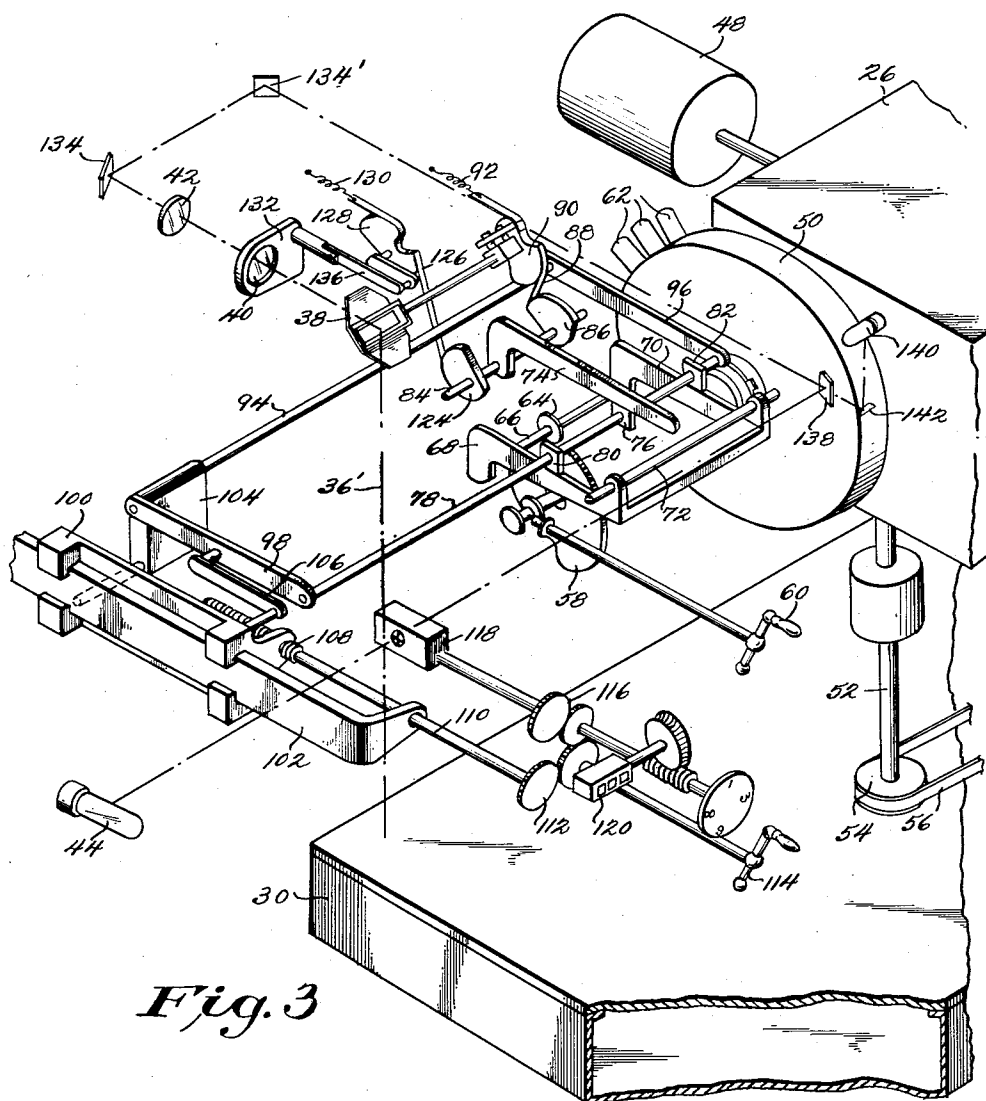


Fig. 3

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ENLARGING AND REDUCING PHOTOELECTRIC ENGRAVING MACHINE

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Filed Aug. 3, 1956, Ser. No. 602,013
3 Claims. (Cl. 178—6.6)

This invention pertains to automatic engraving machines, and especially to engraving machines of the type which provide an engraved plate or the like suitable for printing purposes, directly from original subject matter such as a photographic positive or negative desired to be reproduced by a printing process. More particularly, the present invention deals with an improved machine of this type in which the original picture can be given any desired enlargement or reduction.

The present invention represents improvements in an earlier form of automatic engraving machine, which is the subject matter of U.S. Patent No. 2,875,275 of February 24, 1959, and owned by the assignee of the present application. Reference is made to that patent for a detailed description of the background of the invention, including the technical characteristics required for successful commercial operation. The earlier form of the machine described in the prior patent has gone into commercial use, and has enjoyed considerable success. However, the mechanism required is relatively complicated, leading to higher costs and the like. The present invention aims to simplify the construction of the prior invention, and to produce a machine of that general type at lower cost, and one requiring relatively less maintenance.

Briefly stated, the simplification provided by the present invention is made possible by changes in the optical system of the scanning apparatus, and for that reason only so much of the mechanical and electrical structure is included herein as is necessary to an understanding of the improvements, so that those skilled in the art can practice the same. In the original machine as described in the cited patent, line-by-line scanning of an original subject was accomplished by means of a tilting mirror, so moved as to cause the optical system of the machine to "look at" a very small spot of the flat original which spot effectively moved back and forth in ordinary line scan fashion, while the original as a whole was moved more slowly in a direction perpendicular to the travel of the flying spot. As pointed out in the prior patent, the effective object distance necessarily varies as the scan is accomplished, because the fixed axis of the scan mirror is closer to the center-line of the original copy than it is to either of the lateral margins. Hence, the machine of the original patent provided an optical system comprising at least one focussing lens whose position in the optical path could be varied to keep the spot at all times in focus with respect to the photoelectric cell from which the engraving control signals are derived. Since the machine as built must be capable of handling original subject matter of substantial size (as large as 14 by 20 inches, for example), the focal length of the optical system has to be substantial, and for the same reason a considerable angular travel of the scanning mirror is required. These requirements combine to necessitate a focus-correcting motion of the movable lens of something of the order of two inches.

For reasons elaborated in the prior patent, the output of the photoelectric cell is utilized only during travel of the scanning spot in one direction across the original copy, the retrace motion being an idle one. To achieve a reasonable speed of scanning, this retrace time must be reduced to a minimum; however, the increased speed

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of the moving mirror during retrace would involve accelerating and decelerating a considerable additional mass if the moving focus-correcting lens were to be rigidly linked to the scanning mirror drive. For that reason, the previous machine provided an arrangement for uncoupling the focussing lens from the moving system during retrace, and coupling it up again at the beginning of each useful scan line.

The present invention provides an improved optical system in which the necessary focus correction for this type of flat scan can be accomplished by a very much reduced motion of the single moving lens element of the optical system. Moreover, this moving lens element itself can be quite thin and light, so that it can be accelerated and decelerated rapidly without slowing down the retrace motion, and without undue strain on the mechanical parts. Thus, it becomes possible to maintain a solid connection between the scanning mirror, the moving lens and the driving mechanism, with considerable mechanical simplification. In addition, the retained parts are subject to less arduous strains and wear, and in general the machine is made more reliable and more economical both to produce and to maintain in optimum condition and adjustment.

With the above discussion in mind, the invention itself will be clearly understood from the following detailed specification of a preferred apparatus incorporating the desired improvements, taken in connection with the accompanying drawings, in which:

FIG. 1 is a side elevational view of the complete apparatus, showing the relationship of the major parts thereof.

FIG. 2 is a diagrammatic view illustrating the improved optical system of the invention.

FIG. 3 is a diagrammatic perspective view detailing the mechanism associated with this optical system and the remainder of the machine.

Referring now to FIG. 1 of the drawings, the general arrangement of the apparatus is shown. Numeral 10 designates a casing or cabinet in which are contained the principal electrical circuit elements, amplifiers and the like required for the machine, which cabinet serves also as a support for the major mechanical parts. Thus, the housing 10 is surmounted by a machine table or top plate 12 carrying a horizontal guide rail 14 upon which is slidably mounted the carriage 16 on which are supported the engraving head 18 and optical parts 20 constituting a stroboscopic illuminator and microscope for viewing the engraving during initial preparation or as the work proceeds. As in the prior application referred to above, the sheet being engraved is wrapped around a cylinder 22 mounted for rotation between end bearings carried by the tail stock assembly 24 and the machinery casing 26, both of which are mounted upon the table 12 and at opposite ends of the guide rail 14.

Provision is made for supporting the original copy 28 upon a flat rigid table 30 mounted for longitudinal sliding motion upon suitable guides within the housing 10. By means to be described, the scanning operation is preferably started with the copy mounted on table 30 in its most extended condition, and proceeds as the table is withdrawn into housing 10 by a tape drive mechanism as described in the earlier application. The scanning is accomplished in zig-zag fashion, a line at a time crosswise of the table 30, and the region being scanned at any one table position is illuminated as by lamps mounted above the moving table upon the top plate 12 and provided with suitable reflectors as generally indicated at 34, to throw their light downwardly and concentrate upon a laterally extending zone or strip of the original 28.

A scanning head containing the necessary optical parts and mechanical elements for the scanning operation is

indicated generally at 36, and this head is energized mechanically from the mechanism housing 26 by means to be described.

The parts which have just been referred to are substantially identical with the corresponding parts of the prior application, and they serve to produce the desired engraving from electric signals obtained from the scanning operation which is carried out by apparatus, now to be described.

As has been indicated above, the optical axis of the scanning system, designated by numeral 36' in FIG. 1, is caused to swing back and forth across the copy original on table 30, this motion therefore being in a plane perpendicular to the plane of the drawing. The mechanical axis of the scanning mirror is centered over the table 30, and hence the distance from the mechanical axis of the scanning mirror to the copy 28 varies during each scan traverse, being a maximum when the system is looking at either margin, and a minimum when the system is looking straight down at the center-line of the copy. In a typical machine, the distance from the copy center-line to the scanning mirror may be of the order of 20 inches; the optical path length from the scanning mirror to the photocell or its entrance pupil may be approximately of the same order. As has been stated, for a variation in object distance of as much as two inches, as when a wide original 28 is being scanned, the necessary motion of an ordinary focussing lens in this system had to be of the order of two inches.

The optical system of the present invention will be understood clearly from FIG. 2 of the drawings, in which the original copy is again represented at 28, and the table at 30. The rays from the small spot area being scanned at any instant travel generally upward along the optical axis 36' and are reflected from the oscillating scanning mirror 38 through the lenses 40 and 42 and thence to the photocell 44 behind the spot-size defining aperture element 46. Lens 42 is a fixed biconvex lens, while the movable lens 40 is a negative lens. Taken together, these components constitute a lens of variable focal length to accomplish the necessary correction.

The action of the system can be seen by reference to FIG. 2. The negative lens 40 forms a virtual reduced image of the plane to be scanned which virtual image acts as the object image for the positive lens 42. The lenses and distances are so chosen that the final real and inverted image of the plane to be scanned is formed in the plane of the aperture 46. If the scanning mirror 38 is now rotated, the apparent distance to the scanned plane increases, say by an amount A, then the virtual image of the scanned plane moves away from the negative lens 40 by an amount A/M^2 where M is the linear magnification between the virtual image of the plane being scanned and the plane itself. The virtual image location is indicated on axis 48. If the negative lens 40 is now moved toward the positive lens 42 by an amount approximately equal to A/M^2 , the virtual image will be returned to its original position relative to the positive lens, and the point being scanned will be in focus at the aperture. Consequently, by proper choice of lens characteristics, the compensating motion can be reduced to a small fraction of the apparent change in object distance.

The constants for a typical and preferred system are as follows:

	Inches
Distance from aperture 46 to positive lens 42	26.5
Separation of positive and negative lenses	1.000 to .800
Distance from scanned plane to negative lens	
40	23 to 25

The preferred optical data for the lenses are as follows:

Positive lens 42—biconvex: Radii 169 mm.; thickness 14 mm.; diameter 61.60 mm.; glass BSC-2; index of refraction 1.517; dispersion 64.5.

Negative lens 40—concave meniscus: Radii 121.52 mm. and 311.04 mm.; thickness 6 mm.; diameter 53.98 mm.; glass EDF-3; index of refraction 1.720; dispersion 29.3.

In the above example, it was noted that the total travel of the negative lens 40 need be only 0.2 inch; that is, corresponding to the separation of from 0.8 to 1.0 inch from positive lens 42. The reason for this small travel will now be clear, because the travel of the lens need be only $1/M^2$ of the change in apparent object distance of about 2 inches, and M is the magnification of the negative lens only.

The negative lens is preferably chosen as the moving lens, because it will be lighter than the positive lens; however, the reverse arrangement is equally feasible, as is also an equivalent system in which the positions of the two components are interchanged. The glasses for the components are selected to minimize chromatic and spherical aberrations, but cemented or air-spaced doublets can be substituted if additional correction is required. These have not been found necessary for the purposes of the present invention.

The mechanical simplification will be well understood by referring now to FIG. 3 of the drawings, and comparing it with the corresponding figure of the prior application. Inasmuch as the parts of FIG. 1 which lie within and to the right of the housing 26 are the same as in the previous case, these have not been duplicated in FIG. 3. Briefly, a drive motor 48 supplies the power for operation of all of the mechanical parts via a transmission in housing 26, as fully described in the earlier case. The magnetic tone wheel 50 is driven constantly in one direction at an appropriate speed, as is the shaft 52 carrying the tape wheel 54 which drives the tape 56 and table 30 in the direction of the arrows therebeside in FIG. 1.

The shaft protruding from housing 26 to drive the tone wheel 50 extends further and drives a scanning drive cam 58. A clutch is provided so that the scanning drive can be disengaged while the engraver continues to operate, with the tone wheel turning, to enable preliminary adjustments of the machine, as described in the prior application. This clutch is manually operated as by a control handle 60. Magnetic tone-wheel reproduce heads are indicated at 62.

Cam 58 engages a follower roller 64 mounted on an axle 66 between spaced arms 68, 70 forming a yoke pivoted on fixed axle 72.

The vertical motion of cam follower 64 is transmitted into rotation of a lever 74 by reason of the sliding engagement of one end of said lever with a slide block 76 mounted on a shaft 78. The upper edge of each of arms 68, 70 forms a sliding support surface for a respective follower block 80, 82, carried upon the common shaft 78.

Between slide follower blocks 80 and 82, the shaft 78 carries slide block 76 which will therefore also partake of the substantially vertical motion of shaft 78, and this slide block 76 rides along the under surface of the lever 74 to rotate the latter and thereby the shaft 84 secured to said lever, said shaft being in fixed position on the machine frame. At one end, the shaft 84 carries a drive sector 86, one point on whose periphery has attached thereto a short flexible and inextensible (metal) strap or belt 88 whose other end is secured to a point on the periphery of a driven sector 90. The sector 90 transmits the rotation of shaft 84 to the scanning mirror 38, and it will be observed that the movable axle 78 operates as an adjustable fulcrum between the axles 72 and 84. A tension spring 92 pulls on another tape connected to sector 90 to maintain the belt 88 taut and prevent back-lash.

Axle 78 actually forms one member of a movable carriage which comprises a rod 94 paralleling axle 78, the two being connected at one end by a rigid arm 96 and at the other (forward) end by an arm 98. This

carriage is suitably guided for tilting and lateral sliding movement, and the transmission ratio between the movement of follower 64 and rotation of the scanning mirror 38 will thus be adjusted by the position of such carriage. At its forward end, the carriage is arranged to be moved by reason of its connection to a slide 100 slidable along a fixed guide 102, the carriage being connected to the slide 100 by links 104 and 106. The carriage assembly is thus permitted to tilt as required by vertical motions of the follower 64, but maintains its lateral position until altered by the means now to be described for the adjustment of the transmission ratio.

Slide 100 is moved in its path as by a lead screw 108 on shaft 110, the latter being driven by gears 112 from a ratio-selecting handle 114. Additional gears 116 operate, from the same handle, an optical aperture device 118 which serves to establish the scanning spot size in a manner detailed in the prior application. The actual aperture is designated by numeral 46 in FIG. 1. An indicator 120 indicates the selected value of the scanning sweep determined by the ratio adjustment.

The cyclic movement of the focus-correcting or compensating lens 40 will now be described. Shaft 84 carries a second driving sector 124 opposite to sector 86, and sector 124 is also connected by a flexible inextensible tape 126 to a driven sector 128. The shaft connected to sector 128 is thus rotated in accordance with the rotation of shaft 84, and back-lash is eliminated by a tension spring 130 and a tape also connected to sector 128. The sector shaft moves a crank link pivotally connected to a crosshead 136 which is pivoted to a post or otherwise connected with the mounting 132 of negative lens 40. The mounting is suitably guided for motion only along the optical axis.

It will be observed that, as compared with the construction of the previous application, the scanning and compensating mechanisms are quite simple, due not only to the absence of any necessity for the latch and unlatch arrangements of the prior case, but also to the fact that the small motion required of the compensating lens 40 eliminates the need for exact straight-line linkages of which two sets were needed in the previous construction. That is, the amount of movement required throughout the compensating lens drive is such that, for example, the movements of cam follower 64 while actually taking place about the axis of shaft 72, are sufficiently truly vertical for all practical purposes.

The complete optical system can readily be traced in FIG. 3, the scan spot on the original copy emitting rays along the optical axis 36', thence from the scanning mirror 38 to the lenses, the fixed flat reflectors 134 and 134', the reflector 138 and to the photocell 44. As in the earlier case, an auxiliary light source 140 is provided to direct a beam via prism 142 (reflector 138 then being turned out of the path) through the lens system and scanning mirror onto the original copy for isolating a

particular region of interest on the copy for test or adjustment purposes. These features are not elaborated herein because they form no essential part of the invention.

It will be seen that the construction disclosed herein is simple and efficient, and accomplishes the objects of the invention in an effective way. However, the details of construction are of course subject to alterations within the ability of the ordinary worker in this art, and it is intended to cover all such modifications as fall within the proper scope of the appended claims.

What is claimed is:

1. An automatic photoelectric engraving machine of the variable enlargement and reduction type for reproducing flat copy upon a sheet wrapped about a continuously rotating cylinder, comprising an oscillating scanning mirror mounted to scan successive lines of flat copy, a cam driven in synchronism with said cylinder, an adjustable-ratio linkage in operative relation to said cam for oscillating said mirror through successive cycles respectively corresponding to the successive rotations of said cylinder, each cycle consisting of a relatively slow working rotation of said mirror in one direction followed by a relatively rapid idle retrace rotation thereof; and an optical system arranged to image rays reflected by said scanning mirror upon a fixed photoelectric cell; said optical system comprising a fixed lens and a movable lens having optical powers of opposite signs and in combination producing a focal length substantially greater than the absolute values of the focal lengths of said individual lenses; means driven by said linkage for moving said movable lens in synchronism with said mirror throughout each scanning cycle thereof to maintain the focus on said photoelectric cell of rays proceeding from the flat copy, regardless of the selected degree of enlargement or reduction, and means controlled by the output of said cell for engraving a sheet on said cylinder in accordance with the tone value of subject matter being scanned.

2. The invention in accordance with claim 1, in which said movable lens is a diverging lens.

3. The invention in accordance with claim 1, in which the powers of said lenses are such as to produce an effective change in object distance, for focussed conditions, of approximately two inches, upon axial motion of the movable lens in the amount of substantially two-tenths of an inch.

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