March 31, 1959 R. HELL **2,880,270**

METHOD OF AND APPARATUS FOR ELECTROMECHANICALLY PRODUCING PRINTING FORMS FROM LINE-ORIGINALS

Filed July 10, 1953 2 Sheets-Sheet 1

Fig. 2

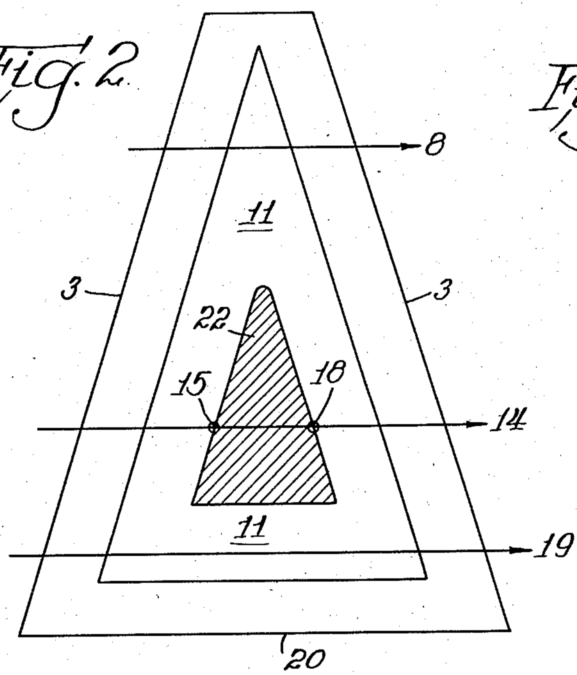


Fig. 1

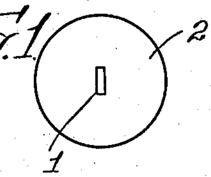
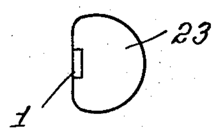


Fig. 8



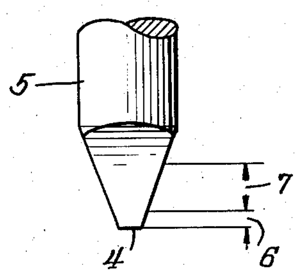


Fig. 3.

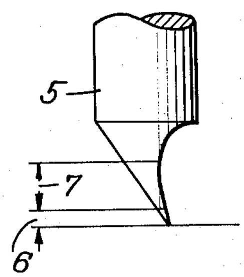


Fig. 4.

Fig. 5.

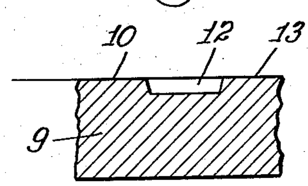


Fig. 6.

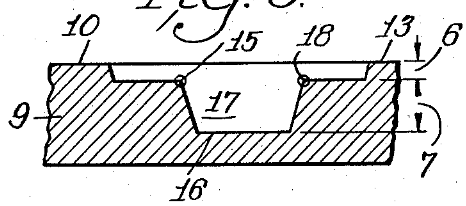


Fig. 7.

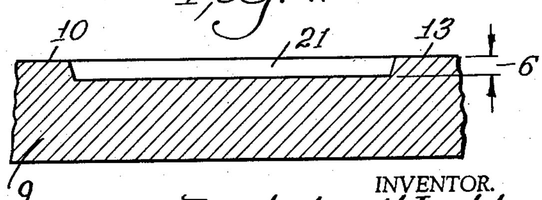


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Fig. 9

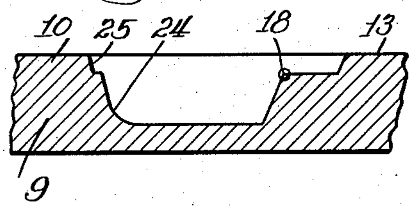


Fig. 10

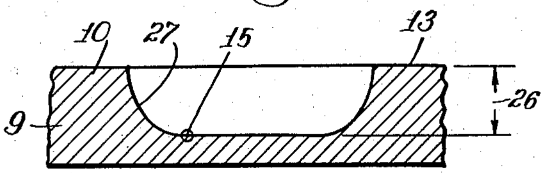


Fig. 11

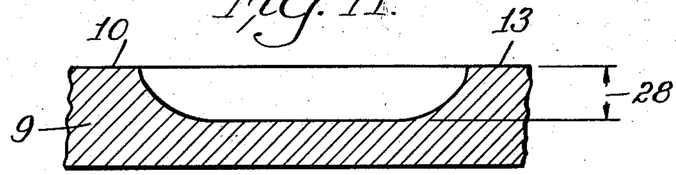
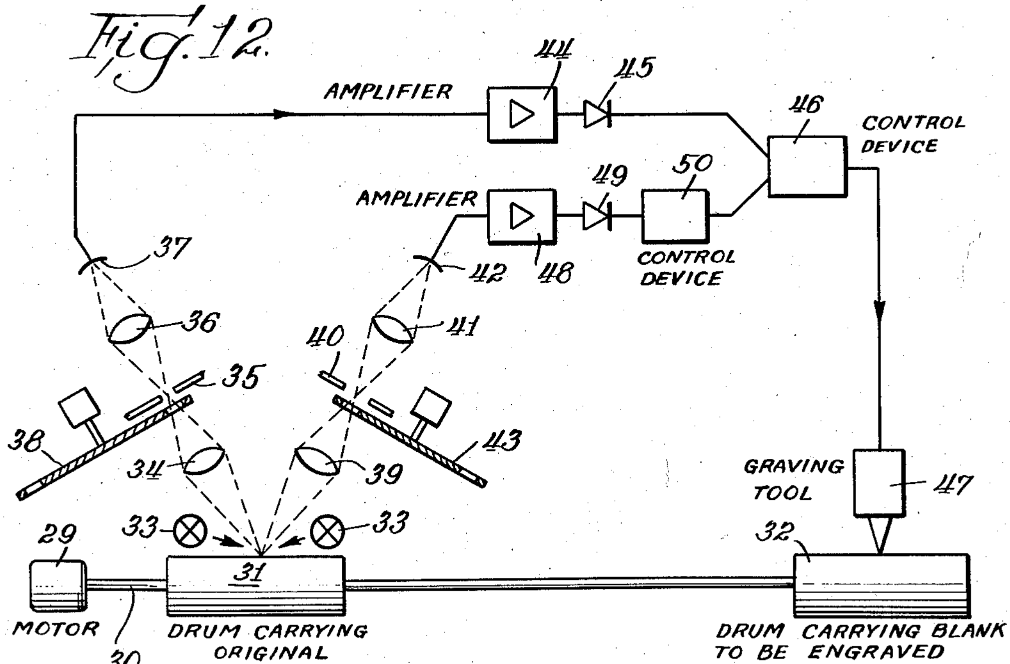


Fig. 12



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METHOD OF AND APPARATUS FOR ELECTROMECHANICALY PRODUCING PRINTING FORMS FROM LINE-ORIGINALS

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8 Claims. (Cl. 178—6.6)

This invention is concerned with apparatus for electromechanically producing printing forms from line originals.

In known apparatus employing the principles of picture telegraphy for the electromechanical production of printing forms, a line-bearing original, for example, a drawing, written matter or a map, which consists only of a light and a dark color—generally black and white—without any half-tones, is photoelectrically scanned line for line. To this end, a small area element of the original is isolated and its brightness is measured by a photoelectric cell. When the scanning spot scans a dark area element of the original, the photoelectric current actuates a graving tool which produces a corresponding depression in the material of the printing form. If, however, a light (white) portion is scanned, the graving tool does not operate. Portions of the original extending at an angle to the direction of scanning receive in this manner a stepped contour, but due to the smallness of the scanned area elements the steps are not apparent to the unaided eye.

These known methods have the disadvantage that large continuous depressions in the printing form, representing large white areas of the original and not intended for printing, are nevertheless inked by the resilient inking roller and apply ink to the slightly sagging paper. Consequently, white portions of the original appear partly black in the print. Moreover, the elastically deformed portions of the inking roller apply ink to the lateral end faces of the printing portions of the form, and this ink is likewise transferred to the paper and has the effect of widening the contours in the print. The latter, then, no longer corresponds exactly to the original.

In chemigraphic methods of making line etchings, in which the same problem also arises, the non-printing areas are generally re-cut by hand, or deep-milled in a graving machine. These subsequent treatments require considerable experience and are time-wasting since it is necessary in addition to round off, by a subsequent etching step, any ridges left over after the cutting operation. Other known methods employ a succession of etching steps to deepen the large non-printing areas of the printing form. These repeated etching steps render this method cumbersome and time-wasting. If these methods were to be applied to the electromechanical graving of printing forms, it would entail foregoing the main advantage of this process, which resides in the rapid and automatic production of the printing form.

According to the present invention, the large continuous non-printing areas of the printing form are deepened during the graving operation, to such an extent as to reliably prevent any contact of the inking roller or of the paper with the bottom of the depressions during printing. This is done by increasing the stroke of the graving tool at these points, so that the tool penetrates more deeply into the material being treated than was the case in conventional graving methods. The extra steps

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of subsequently deepening the depressions by milling or cutting operations are thus eliminated.

The type of graving tool employed is immaterial to the present invention; cutting, drilling, milling or heated tools may be employed; alternatively, electrodes graving by means of an electric arc may be used, which burn off or chemically decompose the material to be removed. Therefore, the term "graving" is intended hereinafter to comprise any kind of treatment of the printing form with any desired tool. It is also immaterial whether the line original and the form are mounted on a flat carriage or on a drum, and whether the original is scanned across its thickness or on its surface, that is, whether it is transparent or reflective.

The deepening of a large non-printing area—hereinafter termed "deep-graving"—raises a special problem. As is known, the graving tool performs two movements at right angles to each other: first, a relative displacement in the direction of scanning, which may consist of movement of a tool-supporting carriage, or alternatively of a displacement of the form, with the tool remaining stationary; and secondly, a stroke perpendicular to the surface of the printing form. When the scanning of a black portion of the original terminates, the printing area remaining in the material of the form should likewise be terminated by penetration of the tool into the material to remove this material, that is, to produce the non-printing area. The edge of the remaining, that is, the printing area, should be correctly positioned and have a steep side face so that the latter will not be inked, in order to insure a sharply defined and accurately positioned contour in the printed reproduction of the line drawing. This requires as abrupt a penetration of the tool as possible.

For practical reasons, only the extreme end portion of the tool may be made slender; the tool will always be wider toward the top and will present a larger cross-section than the area being scanned. As long as the depth of penetration of the tool is small, rapid penetration of the slender tool tip is possible without causing crowding effects. This is true of the graving method heretofore employed. However, with the great depths of penetration required for the deep-graving contemplated herein, the wide stem of the tool would damage the edge of the remaining (unrelieved) printing area during its working stroke. Even if no printing element (that is, dark portion) lies ahead in the direction of scanning, so that from this point of view the tool could indeed be permitted to penetrate deeply, such deep-graving might still damage printing areas that remained at opposite sides of the path of the tool. Therefore, in accordance with one feature of the invention, the initial portion of the depression is graved with the normal depth of penetration, and the deep-graving starts only after the tool has traveled a certain distance away from the unrelieved printing area.

As the scanning member approaches a dark portion of the original, which is to produce an unrelieved printing portion in the form, the graving tool can be withdrawn from the material only at a finite speed. Thus, the tool would clear the surface of the material only after the scanning spot had already left the contour of the corresponding portion of the original, so that the contour of the printing area would not exactly correspond as to its position to the contour of the original.

To avoid this difficulty, according to the invention, the tool is raised ahead of time by the amount corresponding to the increased depth of deep-graving, so that it thereafter graves only at a small depth of penetration until it is finally withdrawn from the material, that is, up to the point where a new printing area starts. In this manner, the area subjected to deep-graving is smaller than the non-printing area, just as is the case in methods employing subsequent deep-milling or deep-etching operations. Similar principles apply to electrode-type graving tools which remove the material of the printing form with the aid of an arc. In this case, the additional depth of graving according to the present invention is accomplished by an abrupt increase in the arc current.

The point of commencement of deep-graving, and the moment of premature (as it were, anticipating) raising of the tool when approaching a dark image portion, which two factors determine the size of the deep-graved area of the printing form, are determined according to the invention by resorting to an additional pre-scanning of the original simultaneously with the graving operation. Thus, two simultaneously effective scanning systems must be distinguished from each other: On the one hand, an area element of the original is isolated, having the smallest possible dimension in the direction of scanning and having a width corresonding to the width of the scanning lines. The brightness of this area element controls the stroke of the graving tool in known manner and with normal amplification; the width of the tool equals that of the lines, so that successive scanned lines and successive graved lines abut. For identification, this area element will be referred to as "scanning element." On the other hand, an auxiliary scanning system simultaneously isolates an area of the original which is larger than the scanning element and which will be designated hereinafter as "auxiliary area." This area scans the surroundings of the scanning element. The brightness of this auxiliary area is measured by an auxiliary photoelectric cell independently of the scanning cell. As long as dark portions of the line drawing near the scanning element lie within the auxiliary area, the photoelectric current of the auxiliary cell is insufficient to exceed a threshold value in the amplifier of the auxiliary systems. However, if both the scanning element itself and its surroundings within the larger auxiliary area are free of dark picture portions, the light reflected by the auxiliary area is so bright, and the photoelectric current in the auxiliary cell so strong, as to exceed the threshold value of the amplifier and to initiate an additional control of the graving tool, that is, deep-graving. Numerous techniques for establishing the threshold value are known. For example, the amplifier of the auxiliary cell may have a negatively biased thyratron tube connected thereto which becomes conductive and causes deep graving only when the controlling voltage exceeds the fixed bias potential.

In the method just described, the line-bearing original is uniformly illuminated. The area elements for scanning are obtained by projecting an image of the original thorugh a lens systems and limiting the effective image area by means of apertured diaphragms of different sizes. Thus, the brightness of the diaphragm aperture controls the photoelectric cell arranged in back thereof. Alternatively, only one scanning system may be used, which successively and alternately scans small and large area elements. For this purpose, known pulsating shutters may be employed in connection with changeover switching devices, for example electronic switches. As a further alternative it is possible to project two diaphragms of different aperture size, each illuminated by a separate light source, onto the original to produce a small light spot serving as the "scanning element," and a larger area of light acting as the "auxiliary area" for scanning the environment of the light spot. Illumination is effected intermittently, with the frequency of illumination of the "scanning element" differing from that of the "auxiliary area." The brightness of the two areas, which may be scanned by two photoelectric cells or by single common cell, can then be separated by filters or by electrical screeners or gates in accordance with the different frequencies, to control different functions.

The intermittent illumination may be effected by periodically ignited gaseous discharge lamps or by the use of rotary sector disks. In the last mentioned case, each path of light may have incorporated therein a separate sector disk whose frequency differs from that of the other disk, or a common disk having two circular rows of apertures, with different numbers of apertures in the two rows, may be used with each row arranged in one of the light beams. The frequency of illumination at the same time constitutes the carrier frequency for the amplification of the photoelectric currents.

While the size of the auxiliary area depends upon the shape and size of the graving tool and upon the stroke speed and rate of scanning of the tool, its shape is of less importance. It may be circular or rectangular, with the scanning element situated at its center. However, as the prescanning or auxiliary scanning is the more sensitive, the smaller the auxiliary area is in proportion to the details of the original, it is preferable to have the auxiliary area cover only that portion of the environment of the scanning element which is situated forwardly and on the sides of the scanning element when considered in the direction of scanning. In this manner, the size of the auxiliary area may be reduced by one-half. Since deep-graving in that case would be initiated as soon as the scanning element left a dark portion of the original, it is necessary to delay the commencement of the deep-graving by incorporating circuit elements having a substantial time lag. If resistance-capacitance combinations are used, the graving operation sets in sharply at the contour of a printing area and penetrates into the material with a gradually decreasing speed in accordance with the exponential function by which the condenser is charged. Finally, another possibility is that of illuminating the auxiliary area non-uniformity in a known manner. The effect of a light area with intensity distribution will be discussed later with reference to the drawings.

The invention thus affords the possibility of deep-graving the printing form already during its electromechanical production with the aid of an additional scanning operation which is relatively easy to carry out, thus avoiding the need for any subsequent graving treatment with its concomitant time consumption and expense.

The invention will now be described with reference to the drawings, in which

Figs. 1 and 8 diagrammatically illustrate two scanning area systems according to the principles of this invention;

Fig. 2 shows a portion of a line original that is scanned by systems according to Fig. 1 or Fig. 8;

Figs. 3 and 4 are a front view and a side elevation respectively of a cutting graver;

Figs. 5 to 7 and Figs. 9 to 11 diagrammatically represent profiles produced in the printing form with the aid of a graver such as that shown in Figs. 3 and 4; and

Fig. 12 is a diagram illustrating apparatus for carrying out the present invention.

In Fig. 1, numeral **1** designates the scanning element, while **2** designates the circular auxiliary area in which the vicinity of the scanning element **1** is scanned. The extent or dimension of the scanning element in the direction of scanning is small, while at right angles thereto the dimension equals the width of a line. Scanning areas of this nature can be obtained, for example, by projecting virtual images of apertured diaphragms arranged in the optical path of photoelectric cell systems, and causing these images to travel along the original; alternatively, limited illuminated areas are projected by a lens system onto the original and are moved along the latter.

A scanning area system such as that shown in Fig. 1 is moved along a line original, a portion of which is illustrated in Fig. 2 on an enlarged scale. In this figure, **3** designates the line elements of the line drawing. The degrees of brightness occurring upon scanning within areas **1** and **2**, are converted in a known manner into photoelectric currents which control the operations of a graving tool such as shown, for example, in Figs. 3 and 4 in front and side views.

The cutting graver is designated as a whole by numeral **5**. The width of the cutting edge **4** of this tool equals the height of the scanning element **1** as viewed in Fig. 1, that is, it equals the width of a scanning line. Normally, the graver is used in such a manner that its stroke, or depth of penetration, equals the distance 6, but in deep-graving according to the invention, this stroke is increased by the amount shown at **7**. When the scanning area combination **1, 2** travels across the original in the line direction designated **8** in Fig. 2, the graver **5** will cut into the printing form a profile such as that shown in Fig. 5. Numeral **9** designates the remaining, unrelieved portion of the form, which is effective in printing. The scanning element **1** first scans the dark portion **3** of the original in the direction indicated by arrow **8** in Fig. 2. The edge **4** of the graver thus overlies the surface of the printing form and leaves the printing area **10** (Fig. 5) intact. As the scanning element **1** leaves portion **3** of the original and begins to scan the white area **11** (Fig. 2), the graver **5** becomes operative and penetrates the material of the printing form, producing a depression **12** (Fig. 5). When the scanning element **1** reaches the next-succeeding dark portion **3** of the original, the graver **5** is withdrawn from the material so that a further printing element **13** remains in the material.

During this entire period, the auxiliary area **2** always partly extends into dark portions **3** of the original so that the brightness of the auxiliary area is insufficient to initiate deep-graving.

If, however, the same scanning system moves across Fig. 2 at the level and in the direction of arrow **14**, the graver will produce a profile such as that shown in Fig. 6. In this figure, numeral **9** again designates the unrelieved portion of the form. The scanning element **1** again first scans a dark portion **3** of the original, corresponding to the printing element **10** in Fig. 6. When the scanning element **1** leaves the area **3** and enters upon the white portion **11** of the original, the graver starts to cut material out of the form with the stroke (or depth) **6**. As soon as the auxiliary area **2** leaves the dark portion **3** of the original and covers only white portions thereof, the brightness of the auxiliary area **2** becomes sufficient to initiate deep-graving and to increase the stroke of the graver **5** by the additional amount 7. This takes place at the point marked **15** both in Figs. 2 and 6. Accordingly, the non-printing portion of the form is deepened, in its central area, to such an extent that ink cannot reach the bottom **16** of the depression **17** during the inking operation. Starting at point **18**, the auxiliary area **2** again begins to include a dark portion **3** of the original while the scanning element **1** still remains in the white area **11**. The prescanning with the aid of the auxiliary area **2** causes the deep-graving to terminate at point **18**, the graver **5** being raised by the amount 7 so that it thereafter continues to grave at the normal cutting depth **6** until also the scanning element **1** enters upon the dark drawing portion **3**; the graver is then moved completely out of the form material so that printing area **13** is formed.

Toward the end of the scanning operation, the line indicated at **19** in Fig. 2 is scanned in the direction indicated. When the scanning element **1** leaves the dark portion **3** of the drawing, the graver **5** penetrates the material with stroke **6** (Fig. 7). Although the scanning element **1** thereafter scans only white portions **11** of the original, deep-graving nevertheless will not be initiated, as the auxiliary area **2** continuously includes parts of a dark area **20** located close to the line of scanning **19** (Fig. 2). The graver **5** will accordingly operate at the normal depth of penetration **6** and will cut the depression **21** (Fig. 7) without damaging the portions of the form remaining unrelieved adjacent to the scanning line **19**.

It will thus be seen that the additional deepening in the printing form extends over the area **22** indicated by shading in Fig. 2.

Fig. 8 represents a scanning system in which **1** again designates the scanning element. The auxiliary area **23** in this instance includes only that portion of the environment of **1** which is located forwardly of the scanning element **1** in the direction of scanning. Assuming that the original represented in Fig. 2 is again scanned along the three scanning lines **8, 14** and **19**: The graver **5** will produce a printing form, whose profile corresponding to scanning line **8** is identical with that shown in Fig. 5. On the other hand, for scanning line **14**, a profile different from that shown in Fig. 6 is obtained which is illustrated in Fig. 9. The reason is that very shortly after the scanning element **1** has left the dark portion **3** of the original and entered the white area **11**, the auxiliary area **23** likewise will no longer include dark portions of the original. Consequently, initiation of the deep-graving operation with stroke **6** plus **7** takes place immediately; however, in order to prevent the deeply penetrating tool from damaging the edge of printing element **10**, the electrical connections involved in deep-graving have control means with a substantial time lag incorporated therein. When using resistance-capacitance combinations for this purpose, the graver will penetrate into the material in accordance with an exponential function and will thus first dig steeply into the material, with its rate of penetration decreasing continuously, so that the profile **24** of Fig. 9 is produced. Withdrawal of the tool from the material takes place in the same manner as shown in Fig. 6. Scanning along line **19** corresponds exactly to Fig. 7, as the auxiliary area **23** includes regions located laterally of the scanning element **1**.

In the embodiments thus far described, the slope of wall **25** (Fig. 9) is determined by the unretarded cutting speed of the tool.

As a further feature, the auxiliary area **2** of Fig. 1 may be given a non-uniform intensity distribution, with the intensity of illumination decreasing from the center (where **1** is located) toward the margin of area **2**. If the original of Feb. 2 is scanned with such a system along scanning lines **14** and **19**, the profiles shown in Figs. 10 and 11 respectively will be obtained. Conditions for scanning along line **8** will remain unchanged. In this modification, the threshold value for releasing deep-graving must be lower whereby the additional stroke **7** of the tool becomes variable and dependent upon the over-all brightness of area **2**.

When the scanning element **1** leaves area **3** of the original along line **14**, the brightness of the auxiliary area **2** gradually increases up to point **15** and thereafter remains constant. Thus, the depth of penetration of graver **5** gradually increases as shown in Fig. 10 until the full stroke **26** is reached. The contour **27** of the profile is governed by the brightness distribution in area **2**. The edges **27** of the printing elements **10** of the form are slanted in a manner corresponding to that heretofore obtained by subsequent milling followed by etching in chemigraphic processes.

When scanning in direction **19**, the auxiliary area **2** continuously includes a region **20** of the original. In this case, the brightness of area **2** is less than in the preceding case so that also the depth of penetration **28** for deep-graving is less than the depth **26** of Fig. 10, while still exceeding the stroke **6** of the normal cutting operation. Withdrawal of the tool takes place in a corresponding manner.

To insure that the deep-graving responsive to the brightness of auxiliary area **2** will be positively prevented as long as the scanning element **1** scans dark portions **3** of the original, the circuit associated with the scanning element **1** includes means for preventing pre-scanning by auxiliary area **2**; for example, the control current of the first circuit may serve to block an amplifier included in the second circuit.

Fig. 12 diagrammatically illustrates an embodiment of apparatus for carrying out the method, so as to further explain the invention. Motor **29** is drivingly connected by shaft **30** to a drum **31** on which the original is adapted to be mounted. Shaft **30** carries a further drum **32** receiving the blank, that is, the foil or plate which is to be cut to produce the printing form. The drums are moved both in the direction of scanning and in line-shifting directions. A plurality of light sources **33** illuminate the original on drum **31**. The scanning element **1** of Fig. 1 is "spotted" on the original with the aid of a lens system **34** and a small-apertured diaphragm **35**, and an image thereof is projected through the further lens system **36** into the photoelectric cell **37**. The rotating perforated disk **38** renders the exposure of cell **37** intermittent. The auxiliary area **2** of Fig. 1 is defined on the original with the aid of a lens system **39** and a larger-apertured diaphragm **40** and is intermittently projected into photoelectric cell **42** through a further lens system **41** and a perforated disk **43**. In lieu of the optical systems **34** to **37** and **39** to **42**, a single scanning system comprising a single perforated disk may be used in which the beam of rays is divided in front of the apertured diaphragms by means of a semitransparent mirror.

The photoelectric current produced in cell **37** and varying with the drawing of the original, is amplified in amplifier **44** and demodulated in rectifier **45**. The rectified current is transmitted through a control device **46** to the graving tool **47** which cuts into the blank of the printing form, mounted on drum **32**, a faithful reproduction of the original. The photoelectric current emanating from cell **42** and corresponding to the brightness of the auxiliary area **2** is amplified in amplifier **48** and demodulated in rectifier **49**. Control device **50** includes means having a threshold value, for example, a thyratron with negative bias, which value is exceeded only if the auxiliary area **2** is free of dark portions of the original.

Upon excitation of the control device **50**, a control current is transmitted to control device **46** and is there superimposed over the current coming from **37**, **44** and **45**. Such superimposition may, for example, take the form of a mere addition of the control voltages, or may involve mixing in a multiple-grid tube. This superimposition causes the stroke of tool **47** to be increased by the amount 7 (Fig. 3) so that deep-graving is effected. If device **50** is not excited because area **2** includes dark portions of the original, the tool **47** will either grave at the smaller depth 6 (Fig. 3) or will be positioned entirely out of engagement with the material of the blank of the printing form.

In the place of device **46**, the graver system may include two energizing coils which are connected, independently of each other, to devices **45** and **50** respectively.

Changes may be made within the scope and spirit of the appended claims.

I claim:

1. Apparatus for electromechanically working a blank to produce a printing form for the reproduction of a line original, comprising a graving tool operable relative to said blank, first light-electrical scanning means for producing signals for the actuation of said graving tool to penetrate into the material of said blank to a predetermined depth along areas corresponding to white area elements of said original which are relatively close to respectively adjacent toned areas, second light-electrical scanning means for the actuation of said graving tool to penetrate into said material to a predetermined greater depth along areas corresponding to white area elements which are relatively remote from the corresponding toned areas, control means for receiving said signals, and means connected to receive the signals from said control means for actuating said graving tool in accordance with said signals.

2. Apparatus according to claim 1, wherein one of said scanning means scans the vicinity of toned area elements only in a region lying in scanning direction ahead thereof.

3. Apparatus according to claim 1, wherein said first scanning means is effective to scan toned area elements, said second scanning means being effective to scan the regions adjacent said toned area elements.

4. Apparatus according to claim 3, comprising photocell means forming respectively part of said first and second scanning means, said photocell means being effective to produce signal currents according to the brightness of the respective area elements scanned on said original, the photocell current produced by the photocell means of said second scanning means exceeding an adjustable threshold value only if the area scanned thereby is free of toned area elements.

5. Apparatus according to claim 4, comprising separate signal-receiving means cooperating with each photocell means, means for connecting said signal-receiving means with said control means, the current from said photocell means which exceeds said threshold value being operative to effect the operation of said graving tool to penetrate into the material of said blank to said predetermined greater depth.

6. Apparatus according to claim 4, comprising separate signal-receiving means cooperating with each photocell means, means for connecting said signal-receiving means with said control means, the current from said photocell means which exceeds said threshold value being operative to effect the operation of said graving tool to penetrate into the material of said blank by a constant amount constituting said predetermined greater depth.

7. Apparatus according to claim 4, comprising means for inhibiting the operative actuation of said control means by said second scanning means for the duration of scanning toned area elements by said first scanning means.

8. Apparatus according to claim 4, wherein said signal-receiving means cooperating with the photocell means of said second scanning means comprises switching means having a relatively great time constant for interposing a delay in the operative actuation thereof.

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