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PRODUCING PRINTING BLOCKS, PREFERABLY INTAGLIO PRINTING BLOCKS

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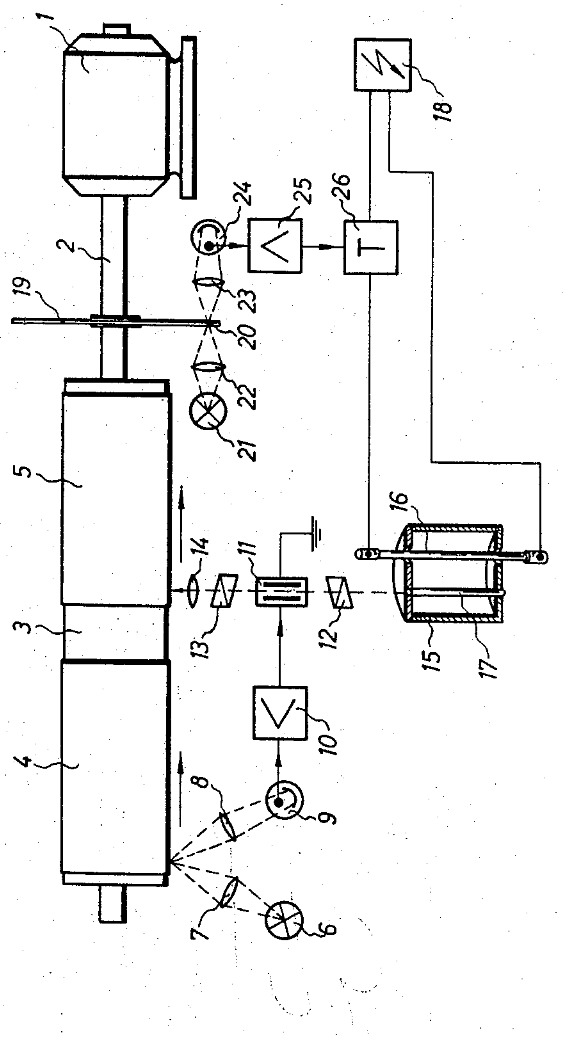

Fig. 1

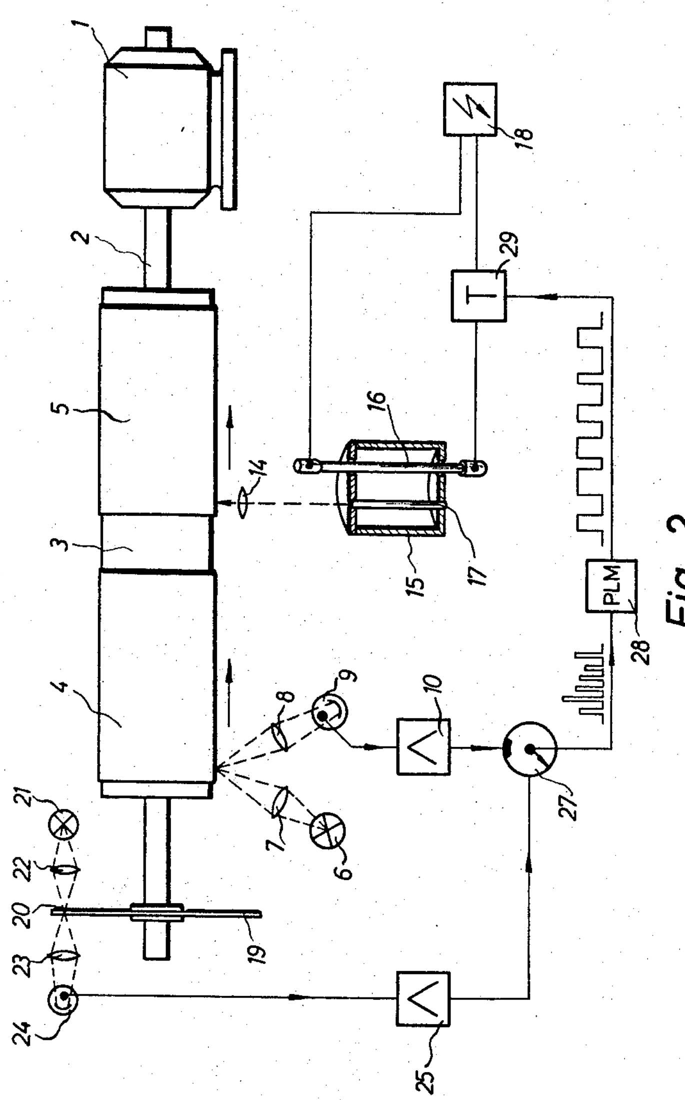

Fig. 2

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PRODUCING PRINTING BLOCKS, PREFERABLY INTAGLIO PRINTING BLOCKS

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The invention disclosed herein relates to the production of printing blocks, preferably intaglio printing blocks, from single-color or multi-color picture or text copies, by photoelectric scanning of the picture copy to be reproduced and, under the control of said scanning, removing material from the surface of the printing block.

In the production of printing blocks according to the picture telegraphy process, the picture copy to be reproduced is scanned photoelectrically dot by dot in successive lines. The resulting fluctuating photocell signals control the depth of penetration of an engraving tool, which, simultaneously with the scanning of the picture points, engraves the screen elements on the surface of the printing block material. In the production of screen-type printing blocks, as is the case with relief and intaglio printing, the engraving tool also performs a movement vibrating regularly up and down with the aid of a screen frequency. Cutting, drilling, milling, or burning tools can be used as engraving tools. Cutting tools which are adapted to engrave both, plastic foils and metals, and also burning engraving tools, the use of which however is restricted to decomposable materials such as plastic foils, dominate in practical use. The processes mentioned can be referred to as electromechanical or electrochemical processes.

The engraving speeds which can be achieved with the above mentioned procedures depend on the fineness of the screens, that is to say, on the number of screen dots per unit of length and the line density. In the case of relief printing it is possible to engrave up to 2,000, and in the case of intaglio printing up to 3000 screen dots per second. It is hardly possible to increase these engraving speeds, since there are limits to the speed at which the engraving tool can be introduced into and removed from the printing block surface, which limits may not be exceeded because of the pressure effects and the risk of breaking the engraving tool.

In addition, it is known to engrave printing blocks with the aid of focused electron beams. If this corpuscular radiation has a sufficiently high power density, which can easily be brought about by focusing on the small screen elements, the electron beam can be used as a tool, for example as a drill, metal being for example vaporized at the points attacked. Given the use of sufficient beam current intensities and power densities, a considerable increase of the speed of engraving can be achieved with such an "electronic engraving machine" as it is referred to. The difficulty consists in that the entire machine must be placed in an evacuated vessel (an intaglio printing cylinder of a length of 2 meters for example should be considered in this connection). Since the mere cost makes this impossible, and in addition the vacuum must be permanently regenerated because of the metal vapors produced, a multi-chamber pressure process has been proposed in which the electron beam is produced in a first chamber in a high vacuum by means of an electron gun, and then passed through a number of chambers with a vacuum decreasing in stages, until finally it is passed last of all through a short air gap at atmospheric pressure on the material to be treated. Efficiency however is lower than in a high vacuum, since in addition the ionization work for

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the air gap to be passed through must be provided, and sharp focusing becomes more difficult.

In this "electronic" engraving of printing blocks, the photocell signal modulates either the beam current intensity in the case of continuous operation or, in the case of pulse operation, the pulse frequency or the pulse amplitude or pulse length.

Entirely new possibilities now arise for a considerable increase of the speed of engraving of printing blocks, upon utilizing high energy wave radiation, which is not to any great extent absorbed by the atmosphere, thereby also avoiding the difficulties attendant upon high vacuum operation and the multi-chamber pressure process in electronic engraving.

According to the invention, "optical" engraving is effected by vaporizing the printing block material on its surface by focusing a very highly bunched, monochromatic bundle of light rays of high power density on to the surface of the printing block, and modulating said bundle of light rays by the photocell signals.

The laser, acronym for light amplification by stimulated emission of radiation, which has been discovered in recent years, is an optical maser, acronym for microwave amplification by stimulated emission of radiation, that is to say, a quantum-mechanical oscillator for the light wave range, particularly for the infrared range (about 1 μm.–100 μm.).

The laser is an extremely monochromatic light source which has very considerable bunching with aperture angles of less than 1 minute of arc, which emits coherent light, and which has a high power of several hundred watts (when pulse-wise operated). Solid-body lasers and gas lasers are to be distinguished. In the former, the active medium consists for example of synthetic ruby which is doped with chromium ions, or else of fluorspar doped with samarium or uranium ions. Crystal lasers have a cylindrical shape with a diameter of about 5 to 10 mm. and a length of about 5 to 20 cm. The circular end surfaces of the cylinder must be extremely plane-parallel in order to achieve good bunching, and are mirror surfaced. The crystal cylinder is at one and the same time the active medium and cavity resonator for the light wave trains produced by the forced emission. The excitation energy is radiated into the crystal by xenon flashlamps. In one convenient form of construction, the cylindrical flashlamp is situated in the one focal line and the cylindrical laser crystal in the other focal line of an internally mirrored elliptical cylinder. The entire light energy of the flashlamp is thereby focused into the crystal and thus particularly well utilized.

The laser activity occurs only when the exciting pump power exceeds a certain threshold value. This threshold value can be reduced by about 1/3 if the ruby is cooled with liquid air. From the threshold value onwards the induced emission increases proportionally to the energy introduced. The excitation powers required for exciting the laser activity in the case of crystal lasers are at the present time still so great that they can be produced only in pulse form with xenon flashlamps. For continuous operation, overheating of the laser crystal would occur.

In accordance with the pulse-wise excitation of the laser, the emission also proceeds pulse-wise in the form of light flashes. It is remarkable that the ruby laser exhibits the phenomenon of relaxation oscillations, that is to say the light pulse radiated off is broken up, in accordance with the light pulse of the exciting light source of, for example, 1 millisecond duration, into a plurality of individual light flashes each of a duration of a few microseconds. In the ruby laser, the time spacing of the micro flashes decreases with increasing pump power. It is interesting to note that the fluorspar laser doped with samarium ions exhibits no relaxation oscillations, but a continuous emission during the irradiation time. The fluorspar laser has good prospects of working in continuous operation if it is cooled with liquid air in order to reduce the pump power.

The gas laser consists of a quartz tube of a length of about 1 meter and a diameter of about 2 cm., which is filled with a helium-neon gas mixture. The quart tube is closed by two highly plane-parallel, mirrored Fabry-Perot quartz plates. Excitation is effected here not by means of a light source, but by a gas discharge which is maintained by a high frequency generator with a frequency of about 30 mc./s. In contrast to the crystal laser, the gas laser has continuous emission of rays, so that it can be operated continuously. A disadvantage is its low emitted light power, which amounts to only some millwatts.

With the aid of a small lens of short focal length, the laser bundle of light rays can easily be concentrated on a surface of 0.1 mm.$\times$0.1 mm.$=10^{-4}$ cm.^{2}. If we assume an emitted power of 100 watts (with the ruby laser radiation powers of several kilowatts with an aperture angle of 1° have already been achieved), this gives a power density of 16 watts per cm.^{2}=1 mw. per cm.^{2}. At this high power density, metals and even high temperature oxides evaporate. The above mentioned area of 0.1mm.$\times$0.1 mm. is approximately the area of the screen cup in conventional intaglio printing with a line density of 100 lines per centimeter.

There would be no point in using the continuously emitting laser for continuous operation except in the case of printing blocks which have no screen, that is to say for line blocks and line-screened intaglio printing blocks (without dot screening). In such cases the laser light beam would engrave juxtaposed furrows of uniform width and variable depth. The amplitude modulation of the laser light beam is effected in the manner known from picture telegraphy with the aid of a Kerr cell or similar devices, which are brought into the path of the rays between an analyer and a polarizer. Apart from the fact that continuously working lasers at the present time still provide insufficiently high light powers for optical engraving, the interest in line-screened intaglio printing blocks is only slight, because of defective sharpness and lack of detail.

The crystal laser working pulse-wise with its high pulse powers, provides great advantages for the production of dot-screened intaglio printing blocks. For this purpose the pulse frequency of the exciting flashlamp must be equal to the screen frequency, which can be achieved by suitable dimensioning of the discharge circuit, which is controlled by a screen frequency generator. The screen frequency must be derived from the rotation of the intaglio printing cylinder, since the latter must be in a fixed relationship to the former.

When the screen dot frequency in electromechanically enrgraved intaglio printing blocks is increased tenfold, that is to say to 30 kc./s., for optically engraved intaglio printing blocks using a laser as engraving tool, a pulse frequency of the flashlamp likewise equal to 30 kc./s. is required. The light pulses of the exciting flashlamp and hence also the light flashes of the laser (without relaxation phenomena) accordingly have a time spacing of about 30 microseconds. In order that there may be no appreciable blurring, that is to say lengthing of the screen elements removed by evaporation in the direction of engraving, since the printing block continues to move during the time of action of a light flash, the pulse length must be small in relation to the pulse spacing, namely about 10%, so that there is a maximum pulse duration of about 3 microseconds.

The modulation of the light flashes by the photocell signal can be effected in two ways, namely, by modulating either the amplitude or the length of the pulses. The two types of modulation are equivalent, since the quantity of material evaporated depends upon the product of amplitude and time duration, that is to say upon energy density. Pulse length modulation, particularly when symmetrical, is more complicated than pulse amplitude modulation, and for both types of modulation a number of methods are known from pulse and radar techniques. In addition, the modulation can be effected both electrically in the discharge circuit of the exciting flashlamp and optically on the emitter laser light by means of Kerr cells or similar devices. Since the latter are also electrically controlled, the modulation at the input or output side is in any case of electrical nature.

The modulation of the light by the photocell signal is very sensitive. Similarly to electronic engraving by means of corpuscular beams, the degree of modulation of the amplitude or time amounts to only a few tenths per thousand in order to cover the entire tone value range between black and white, which corresponds to a variation of cup depth between zero and about 0.05 mm.

Further details of the invention will appear from the description which is rendered below with reference to the accompanying drawings showing embodiments thereof.

FIG. 1 shows an embodiment in which the intensity of the light impulses is modulated by the photocell signals; and

FIG. 2 shows an embodiment in which the duration (length) of the light impulses is modulated by the photocell signals.

Corresponding parts are identically referenced in FIGS. 1 and 2.

In FIG. 1, the motor **1** drives the shaft **2** and therewith the cylinder **3** upon which are fastened the picture copy **4** which is to be reproduced as well as the printing form material **5**. A photoelectric scanning devise (to be presently described more in detail) and a laser, are respectively moved along a peripheral line of the cylinder in the direction indicated by arrows, respectively within the range of the copy **4** and the range of the printing form **5**, such movements being accomplished with the aid of supports (not shown) engaged by a lead screw such as used, for example, in connection with lathes, the advance per revolution of the lead screw amounting to the desired line spacing (about 0.1 mm.).

In practice, two separate machines are preferably used in the case of very long cylinders, one machine for the copy cylinder and the other for the printing form cylinder. It is understood that both machines must operate synchronously. Separate machines respectively for the copy and the printing form, with exchangeable cylinders of different diameter, must be used in the event that enlargement or reduction in size of the copy is to be accomplished. The speeds of advance must be appropriately adjusted at the two machines in accordance with the desired reproduction scale and the screen number employed.

It is also feasible to use a plurality of scanning devices as well as lasers so as to accelerate the operation.

In the embodiment shown in FIG. 1, the photoelectric scanning device comprises a point-light source **6** which illuminates by means of the optic **7** a small dot upon the picture copy **4**, and an optic **8** which collects the light reflected from the surface of the picture copy and concentrates it on the cathode of the photocell **9**. The photocell currents, which fluctuate according to the brightness of the picture copy, are amplified in the direct current amplifier **10** and conducted to the capacitor plates of a Kerr cell which is disposed between two mutually crossing polarization prisms **12** and **13** in the laser ray path, thus obtaining a modulation of intensity of the light impulse emanating from the laser. The laser ray bundle is by means of an optic **14** concentrated upon the area of the printing form which is to be prepared. The laser comprises an elliptical interiorly mirrored cylinder **15** in the focal lines of which are respectively disposed the cylindrical flashlamp **16** and the cylindrical laser crystal **17**.

The impulse frequency of the flashlamp **16** which is fed from the high voltage generator **18**, must be, as previously noted, equal to the screening frequency. This is obtained with the aid of a disk **19**, fastened to the shaft **2** and provided with a circular area **20** which is concentric with the shaft axis, such area being formed of transparent slots cut out from the disk material and alternating with opaque portions of disk material lying therebetween, these portions and slots forming sections which are of identical length. The number of these sections is such that the light emanating from the point-light source **21** and passing through the objective **22** and the slots **20** is chopped in timing with the screening frequency, collected by the objective **23** and concentrated upon the cathode of the photocell **24**. The pulsating direct current delivered by the photocell **24** is amplified in the amplifier **25** and the respective impulses are utilized for the purpose of successively momentarily opening the scanning stage **26**, thus successively extending high voltage impulses of constant duration from the generator **18** to the flash lamp **16**.

The elements **19** to **26** shown in FIG. 1 are omitted in an embodiment serving for the production of unscreened printing forms, the lamp **16** thus operating continuously and the light ray bundle being continuously radiated from the laser crystal **17**. The intensity modulation of the light ray bundle is however accomplished in the above described manner.

Parts used in the arrangement shown in FIG. 2 which correspond structionally and functionally to parts shown in FIG. 1 are identically referenced and therefore need not be separately described. The operation of the embodiment according to FIG. 2 is as follows:

The picture signal delivered by the amplifier **10** is, with the aid of the scanner **27**, which may be a rotating or electronic switch, momentarily, impulsewise and periodically read, with a frequency which is derived from the screening frequency produced in the same manner as in FIG. 1.

The amplitude modulated impulses of constant length (duration), which are read out, are extended to the pulse-length modulator (PLM) indicated at **28** in which they are converted into time modulated impulses of constant amplitude, the length of which (duration) is proportional to the amplitude of the readout impulses.

Such a pulse length modulator consists substantially of a capacitor which is by the readout impulse rapidly charged to a voltage which is proportional to that of the readout pulse, and thereupon via a resistor slowly discharged to a constant residual voltage. The longest discharge time corresponds thereby to the greatest impulse amplitude. The respective discharge time elapsing until the variable capacitor voltage has dropped to the constant residual voltage, is proportional to the respective charging voltage, that is, proportional to the impulse amplitude. The variable sawtooth voltage thus obtained is thereupon, by means of a maximum value limiter, cut to the residual voltage, thus resulting in the time modulated impulses of constant amplitude.

These time modulated impulses of constant amplitude are in the present case utilized for opening the scanning stage **29** for a time corresponding to the respective impulse length, while the high voltage from the generator **18** is extended to the lamp **16**. Accordingly, the lengths of the light flashes produced by the lamp **16** and therewith the lengths (duration) of the light impulses from the laser crystal **17**, are equal to the lengths of the time modulated impulses which control the operation of the scanning stage **29**, thus resulting in a modulation in time of the length (duration) of the light impulses by the photocell signals.

It may be mentioned that printing blocks or forms without dot-screens, that is to say, line blocks or line-screened intaglio printing forms, could also be engraved by means of a laser working pulse-wise. In the case of line-screened intaglio printing blocks or forms which reproduce half-

tones, although in an unsatisfactory manner, the impulse density would have to be modulated spatially, that is to say, the pulse frequency would have to be modulated by the photocell signal in respect of time. Although methods of pulse frequency modulation are known, the frequency of light pulses of flashlamps could be modulated only with difficulty, since, in order to avoid screen-like structures, the frequency would already come within the high frequency range. Line blocks on the other hand could be produced with greater chances of success by means of a laser operating pulse-wise. The pulse frequency is in this case, although very high, nevertheless constant so that, corresponding to the signals black and white, it would merely have to be gated and blocked. A possibility of producing (unmodulated) pulse high frequencies would comprise continuous signal operation of a ruby laser with relaxation phenomena. In this case pulse frequencies of the emitted light flashes of about 1 mc./s. could be obtained.

Color separation printing blocks for multicolor printing can also be engraved by the optical engraving method. Since, however, in this case a different screen angle is required for each color separation printing block, the screen frequency undergoes, after each drum revolution, a constant phase displacement the amount of which being different for each color separation printing block, so that the preferential directions of the screening are given a different angular position for each color separation printing block.

In all embodiments of the invention, provision must be made of adequate cooling of the intaglio printing cylinder. In addition, the metal vapor produced must be continuously exhausted.

Changes may be made within the scope and spirit of the appended claims which define what is believed to be new and desired to have protected by Letters Patent.

I claim:

1. A system of producing printing blocks, preferably intaglio printing blocks, from single-colored or multicolored picture or text copies, by photoelectrically scanning such originals to be reproduced and removing continuously variable and controllable amounts of material from the surface of such blocks under the control of such scanning, comprising evaporating the material on the surface of such blocks in atmospheric pressure by a very highly bunched, monochromatic bundle of light rays of high power density being focused on to said surface of said blocks, and modulating said bundle of light rays by the photocell signals.

2. A system according to claim **1**, wherein, for the production of printing blocks without screening, the bundle of light rays is emitted continuously, and the light intensity is modulated by the photocell signals.

3. A system according to claim **1**, wherein, for the production of printing blocks without screening, the bundle of light rays is emitted pulse-wise, and the frequency of the light pulses is modulated by the photocell signals.

4. A system according to claim **1**, wherein, for the production of screened printing blocks, the bundle of light rays is emitted pulse-wise with a frequency which is equal to the screen dot frequency, and the intensity of the light pulses is modulated by the photocell signals.

5. A system according to claim **1**, wherein, for the production of screened printing blocks, the bundle of light rays is emitted pulse-wise with a frequency which is equal to the screen dot frequency, and the duration (length) of the light pulses is modulated by the photocell signals.

6. A system according to claim **1**, wherein a laser is utilized as the light source.

7. A system in accordance with claim **1** wherein the modulating of said bundle of light rays includes polarizing the said light rays, doubly refracting said light rays in accordance with said photcell signals and further cross polarizing said light rays relative to said first polarization thereof.

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