Oct. 23, 1951 D. D. WHITE ET AL 2,572,549

VOLTAGE MODULATED MARKING FLUID DEPOSITION DEVICE

Filed May 5, 1947 2 SHEETS—SHEET 1

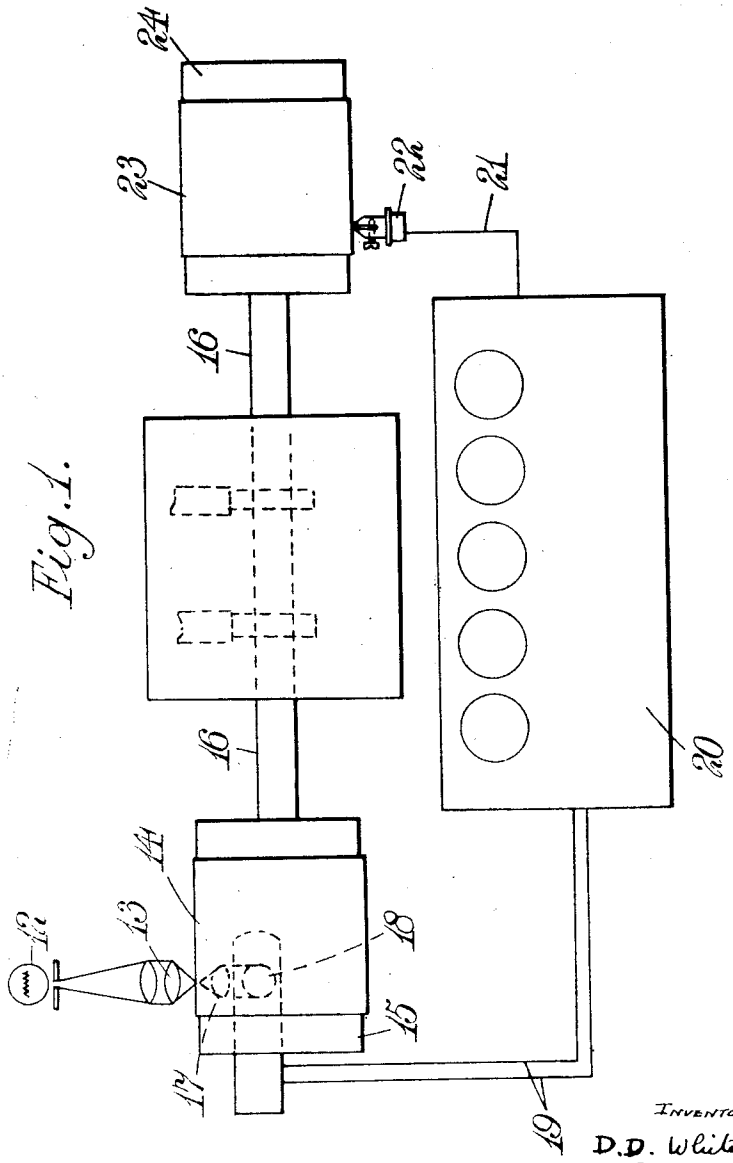


Fig. 1.

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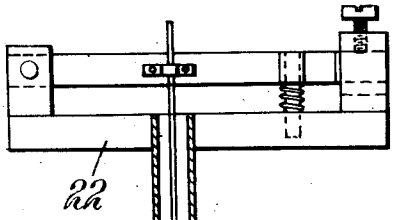


Fig. 2.



Fig. 5.

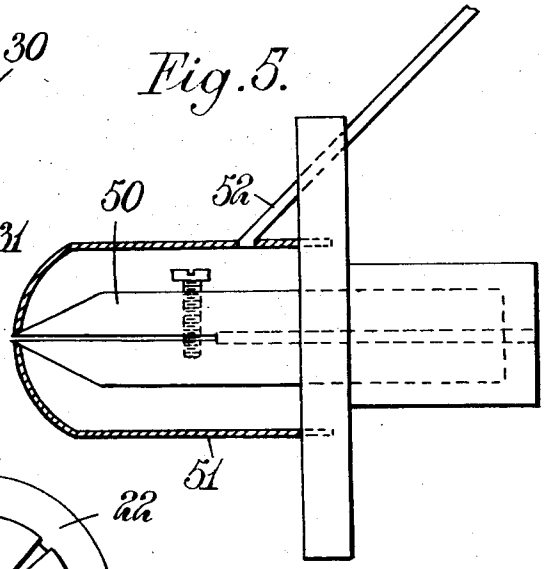


Fig. 4.

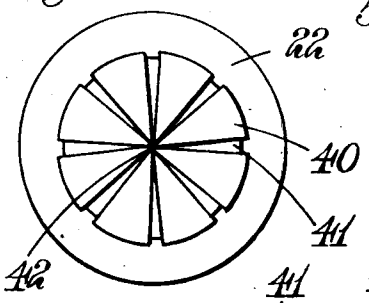
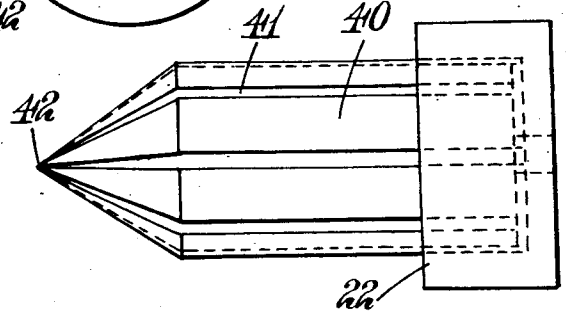


Fig. 3.



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UNITED STATES PATENT OFFICE

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VOLTAGE MODULATED MARKING FLUID DEPOSITION DEVICE

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2 Claims. (Cl. 346—74)

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This invention relates to improvements in apparatus for electric recording by deposition of dye, pigment, other colouring matter or the like of a suitable nature, and particularly to apparatus for using a modulated current to produce on a paper sheet or similar receiving surface deposits of liquids containing particles of dye, pigment, ink or other colouring matter (herein referred to as colour units) of area or amount or density varying proportionally with the modulated electric control. An illustrative example of the use to which this invention may be put is the production of prints on paper or the like from an original photograph or like picture, e. g. the production of three-colour prints from a three-colour photographic transparency.

It is an object of this invention to provide apparatus for electrical recording, that is simple in design and effective and speedy in operation.

According to the invention the apparatus comprises the following combination of elements:

A stylus located adjacent the recording surface, means for supplying coloring matter to the stylus surface at a pressure insufficient for the projection of the coloring matter from the stylus, means for setting up an electrical potential gradient between said stylus and the desired point of deposition on the recording surface and means for varying the intensity of potential gradient. The setting up of the potential gradient causes particles to be drawn from the stylus, disintegrated and deposited on the receiving surface, and by controlling the intensity of the potential gradient the intensity of the deposition of the coloring matter may be controlled.

Considering the simple case of a rotatable metallic drum carrying on its surface a sheet of paper which is to receive from a device of the general character of a pen a record the character of which is determined by an electric "signal," i. e. by a modulated electric current or voltage, the liquid-depositing device, stylus or "pen" does not touch the paper but is held at a slight distance therefrom while the drum is rotated. The modulated electric control current is led to an amplifier which gives an output of suitable voltage. This output is electrically connected to the liquid in the liquid-depositing device which terminates in a point which provides an exposed particle of liquid which therefore lies in the electric field between the liquid and the metallic drum (which may be earthed) and the liquid particle attains such an electric charge that it is disintegrated into a fine mist which is directed by the electric field on to the paper surface. The

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liquid contains a dye, pigment or ink and considering the particle at the outlet at any instant, the characteristic of this invention is that the area or amount or density of the record produced on the paper from that particle is proportional to the value at that instant of the modulated voltage.

Turning to the construction of the liquid-depositing device or "pen," this may comprise a tube of fine bore ground externally to a point at its outlet end. An insulated fibre (say of glass) passes through said bore and carries a bead at its extremity (external to the outlet orifice) which bead forms an outlet valve. This tube may be arranged vertically and above the receiving surface with the point downwards and close to the paper or alternatively the tube may be arranged below the receiving surface with the point upwards. In either case the bead has a film of the liquid on its surface. The modulated current from some transmitting device is led to an amplifier which gives an output of a suitable voltage. There is an electric conductor leading from the output of the amplifier to the depositing device. It may lead to a metal wire dipping into the liquid with the interposition of a suitable limiting resistance if necessary. Alternatively, the conductor from the amplifier may lead to a metallic sleeve on the outside of the tube or jet. The tube may itself be of metal which will act as a conductor. It may or may not be provided with a tip of insulating material made of glass, plastic or other suitable substance. If the liquid is a dye dissolved in butyl alcohol, the voltage from the amplifier may vary between 1,000 and 4,000 volts. The operation is a peculiar one. The metallic drum carrying the paper being earthed or at a fixed voltage, there is an electric field between the liquid and the drum. A film of liquid spreads over the bead and the liquid is drawn to a point by the electric field and the electric charge on the liquid particle at this point is sufficient to cause the particle to disintegrate and a minute spray or mist of the liquid is formed and is directed to the paper. The position of the bead in relation to the nozzle may be manually adjusted through the fibre which carries the bead or alternatively the position of the bead in relation to the nozzle (i. e. the extent of opening of the outlet valve) may be controlled from the amplifier so as to take care of extensive changes in the modulated output.

In one form of liquid-depositing device a pointed member somewhat of the shape of a rifle bullet but having external capillary grooves run-

ning axially towards the point is mounted at the end of a liquid conduit in such a way that the liquid from such conduit passes into the capillary grooves (which may vary in number from say 2 to 12).

The position of the pointed member or nose in relation to the receiving surface may be varied by the electric control, but this system of control of the colour units is not preferred.

Where the original is a colour transparency and it is desired to produce a colour print, the receiving drum is operated as above described but there are three or more separate scanning beams, three or more separate photocells of appropriate sensitivity, three or more separate electric circuits and three or more separate depositing devices, the disposition of these parts in relation to the drums being such as to ensure the proper relationship of the three deposits both in relation to the original and to one another.

It is well known that when using an amplifier of a modulated current it is possible to inject into the input of the amplifier compensating or correcting voltages. It is within the present invention to effect contrast control, density control, colour control or corrections for various aberrations by injecting into the amplifier input voltages designed to modify the output for any of these purposes.

In the case where the electric control is effected by the use of a photo-electric cell activated by an optical scanning device, the invention ensures that the area or amount of the deposited colour unit is responsive to the modulation of the scanning light by the original.

In one modification of this invention whether the liquid-depositing device or "pen" be hollow (like a stylographic pen) or has external capillary grooves, the spray discharge may be focussed on to the receiving surface by suitably disposed electrodes carrying control potentials acting on the minute particles of the mist to determine their course (in a manner analogous to that in which a beam of electrons in a cathode ray tube is focussed on a screen or on an "exit pupil").

Again the liquid-depositing device or "pen" (and particularly the nose or pointed end) may be surrounded by a conducting sleeve or shroud to stabilize the electric field or to assist in determining its shape.

When a highly concentrated solution of dye is used, the conducting sleeve or shroud may be used for conducting over the liquid-depositing device, a gas, (e. g. air or carbon-dioxide), saturated with a vapour of the solvent being used, to prevent evaporation of the dye-containing solvent.

It has been stated above that an amplifier may be used in the electric control system. Such an amplifier may be provided with means for limiting the upper and lower values of the output voltage.

It is desirable to prevent the accumulation on the receiving paper of undesired electric charges and the paper may be treated to control its electric conductivity. Thus it may be impregnated with a solution of a salt (e. g. lithium chloride) or with a hygroscopic agent such as glycerine. The conductivity of the liquid to be deposited may also be controlled.

To maintain a check on the light and shade in the deposited picture, the picture as it is formed may be optically scanned and an electric "signal" generated by the scanning device (e. g. by the use of a photo-electric cell) is fed back to the amplifier in such a way as to correct automatically any errors in reproduction.

The nature of this invention and the manner in which the same is to be performed will be appreciated from the following description of examples, reference being made to the accompanying drawings, in which:

Figure 1 is a diagram of a reproducing arrangement;

Figure 2 is a sectional elevation of one form of liquid-depositing device;

Figure 3 is a side elevation and Figure 4 an end elevation of a modified form of liquid-depositing device; and

Figure 5 is a sectional elevation of a shrouded form of liquid-depositing device.

Referring to Figure 1, a projection lamp **12** is used to produce a beam of light which passes through a lens system **13** to bring the beam to a fine point at the transparency **14**. The transparency **14** is mounted on a rotary drum **15** carried on a horizontal shaft **16** which can be rotated and axially moved at rates suitable for scanning, thus giving helical scanning. The rotary drum **14** may be of glass or transparent plastic which gives the minimum of interference to this scanning beam or the drum may be metal with orifices at those places where the original picture lies. After passing through the transparency the light beam is collected by a lens system **17** and focussed on to the sensitive portion of a photoelectric cell **18** which gives an electric output proportional to the intensity of the light falling on it and the current from the cell is led through conductors **19** suitably screened from external influences to an amplifier **20** (D. C. or A. C.) which produces an output of high voltage which varies proportionally to the intensity of the light falling on the cell. This output is led by conductor **21** to a liquid depositing device **22** of the type above described. The paper or like receiving surface **23** is mounted on an earthed metallic drum **24** which is rotated and moved axially identically with the scanning drum **15**. Preferably the metallic drum **24** for the receiving sheet **23** is mounted on the same shaft **16** as the scanning drum **15** and therefore partakes of identical movements. The important fact is that the area or amount or density of the colour unit or deposit on the paper at any instant is proportional to the electric output from the amplifier and the reproduction which is built up on the paper is a faithful reproduction of the original.

Referring to Figure 2, the liquid-depositing device or "pen" **22** comprises a tube **30** of fine bore ground externally to a point **31** at its outlet end. An insulating fibre **32**, say of glass, passes through said bore and carries a bead **33** at its extremity, which bead forms an outlet valve.

Referring to Figures 3 and 4, the liquid-depositing device **22** may comprise a pointed member or nose **40** having fine external grooves or channels **41** leading to the point **42** and the liquid may be retained by capillary action. Such a pointed member or nose may have its axis horizontal or inclined slightly downwards towards the point.

Referring to Figure 5, the "pen" **50** is surrounded by a shroud **51** which may be of electrically-conducting material so as to stabilise the electric field. This sleeve or shroud **51** is provided with an inlet conduit **52** so that a gas (e. g. air or carbon dioxide) saturated with the vapour of the solvent being used may be conducted over

the liquid-depositing device to prevent undue evaporation of the dye-containing solvent.

We claim:

1. Electric recording apparatus comprising a recording surface, an electrode located behind said surface, a stylus located adjacent to and in front of said surface, means for supplying coloring matter to the stylus surface at a pressure insufficient for the projection of the coloring matter from said stylus, said stylus being an electrically conducting pointed member having fine external grooves or channels leading to the point, in which channels the liquid coloring matter is retained by capillary action, means for setting up an electric potential difference between said stylus and said electrode, and means for varying said potential difference, whereby the particles of said coloring matter are attracted from said stylus surface and are disintegrated and the coloring matter is deposited in intensity on said surface in accordance with said variable potential difference.

2. Electrical recording apparatus comprising in combination, a recording surface, a liquid-depositing device for supplying coloring matter to the recording surface, means for producing a continuous relative movement between the liquid depositing device and the recording surface whereby the liquid depositing device traces a line over the recording surface, said device having a tip which is located out of contact with but close to the recording surface and which is fed with liquid cloring matter through a capillary opening, means for feeding the liquid coloring matter

to the liquid depositing device, means for setting up a high voltage potential gradient between the recording surface and the liquid depositing device sufficient to project coloring matter from the tip of the liquid depositing device on to the recording surface across the intervening gap, and means controlled by the said modulated electric current for varying the intensity of the said potential across the gap between the tip of the liquid depositing device and the recording surface in accordance with the intensity of the modulated electric current, whereby the intensity of deposit of the said liquid coloring matter varies from point to point along the line traced by the liquid depositing device on the recording surface.

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