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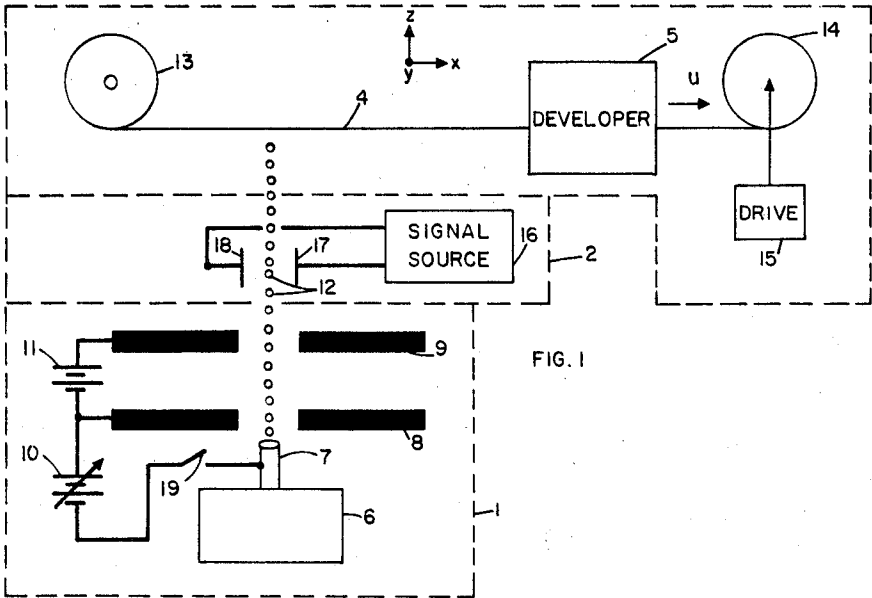
[54] ION BEAM PRINTER
15 Claims, 4 Drawing Figs.

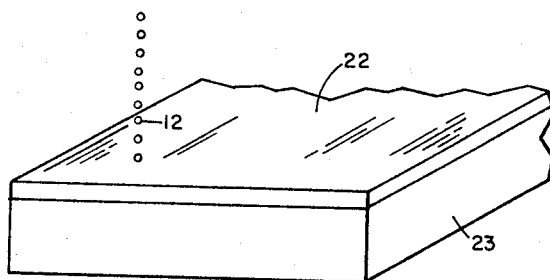
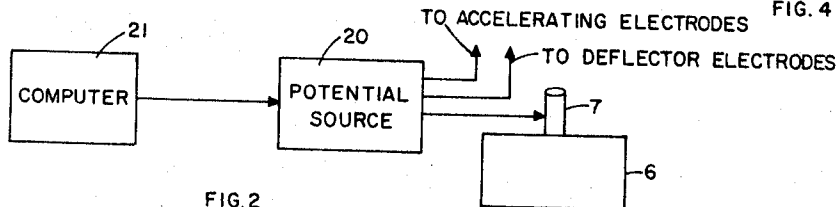
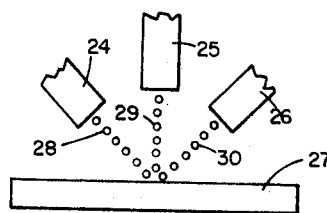
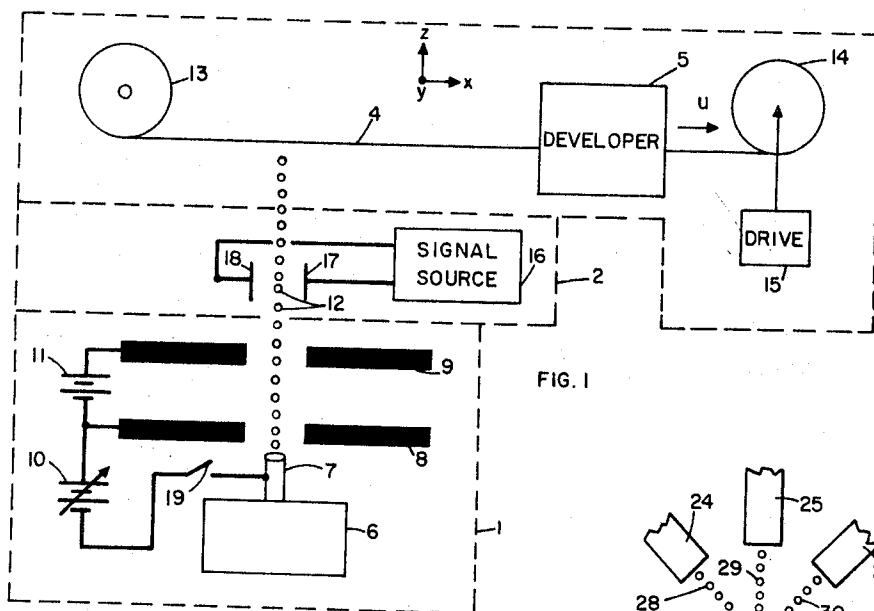
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ABSTRACT: Apparatus adapted to provide an ion beam of large or small, single or multiatomic ions, the beam being directed upon a web to impress a message upon the web. Means is provided to modulate the beam thereby to determine the form of the message.





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ION BEAM PRINTER

The present invention relates to high-speed printer apparatus and, more particularly to apparatus wherein an ion beam is modulated, to provide a message upon a web, in accordance with a programmed output from, for example, a digital computer or the like.

In an application for Letters Patent entitled, "High-Speed Gas Discharge Matrix," filed herewith by the present inventor, there is described printer apparatus embodying a multiperforation matrix adapted to be programmed to provide a message that can be impressed upon a web. In the apparatus of the present invention, a modulated ion beam provides the means whereby a message is applied to a web.

In printout apparatus now available for use in connection with high speed computers, and the like, it is often necessary to provide days of printing time for information available from the computer in hours or minutes. An object of the present invention, accordingly, is to provide high-speed ion beam printing means adapted to present information in legible form at substantially the rate of a computer output.

While the invention is particularly adapted to use in connection with computers, it has, also, more general usefulness; another object, therefore, is to provide an ion beam printer of more general utility, as, for example, one adapted to operate as a facsimile machine to print characters on cardboard boxes or the like in response to punched tape, punched cards, or electronic controls.

A further object is to provide apparatus adapted to deposit ions in a predetermined pattern upon a surface, as a metal or semiconductor layer upon a substrate, to effect etching or other action upon the surface.

Other and still further objects will be evident in the application to follow and will be particularly pointed out in the appended claims.

By way of summary, the objects of the invention are attained in a printer having, in combination, an ion beam source adapted to direct an ion beam upon one major surface of a web, and a computer and potential source (or other signal source) in combination with appropriate control electrodes to modulate the beam in a determined pattern.

The invention will now be described with reference to the accompanying drawing in which:

FIG. 1 is a schematic diagram of an ion beam printer of the present invention;

FIG. 2 is a further schematic drawing showing one circuit arrangement whereby a computer may be used to modulate the beam;

FIG. 3 is an isometric partial view showing a modification of portions of the apparatus of FIG. 1; and

FIG. 4 shows a further modification.

Turning now to FIG. 1, a source of ions, shown generally at 1, is adapted to provide an ion beam 12 directed to strike a web 4 upon one major surface thereof. As will be explained more fully hereinafter, the direction of the beam 12 in the $x-y$ plane can be changed or modulated by the elements shown generally at 2, and the intensity of the beam can be changed by the electrical circuitry shown within the dotted box 1. In a broad sense, therefore, the beam modulation means can include the elements within both boxes 1 and 2; although, in other instances, either will suffice.

In FIG. 1 the ion beam source 1 illustrated consists of a container 6 having ions in solution with a conductive capillary tube 7 extending into the solution. A source of variable electric potential 10, connected between the capillary tube 7 and an apertured electrode 8 serves to effect removal of ions from the upper opening in said tube and initial acceleration thereof. A further potential source 11 is connected between the electrode 8 and a further apertured electrode 9 which serves as an accelerator electrode for the ions which emit to form a beam 12 of large or small, single or multiatomic ions. The web 4 is positioned to have its lower major surface in the path of the beam 12 to receive ions from the source 1. The web 4 may be made of an insulating paper (treated or untreated) which is

rolled as a sheet from a roll 13 along a path substantially perpendicular to the direction of the beam 12 and onto a roll 14 which is driven by a drive means 15.

Modulation of the ion beam 12 to effect translational movement thereof in the $x-y$ plane in FIG. 1 may be accomplished by signals from a signal source 16 to deflector or control electrodes represented by the electrodes 17 and 18 but including additional like electrodes disposed in quadrature with the electrodes 17 and 18. In this manner the beam 12 may be moved about in the $x-y$ plane as the web 4 moves along at some velocity U . The intensity of the beam 12 can be affected by changing the output voltage of the potential source 10 or by removing the voltage entirely, as by opening a switch 19.

In actual practice the sources of electric potential shown at 10 and 11 in FIG. 1 can be replaced by an electric potential source 20 in FIG. 2 with control thereof by a computer 21. The potential source 20, in fact, can replace the signal source 16 and both electric potential sources 10 and 11 in FIG. 1 by having the output thereof connected to the accelerating electrodes 8 and 9 and to the deflector electrodes 17 and 18, etc., as shown, with appropriate programming.

The ions, which may be of positive or negative potential, remain on the insulating web 4 where deposited to be developed by a developer material applied in a developer 5 to provide an image. The relaxation time of the material of which the web is made must be long compared to the time lapse between the instant the ions impinge or are received by the web 4 and the instant the ions are reacted with the developer material. However, the web 4 can be treated as with ferric chloride, for example, and if the ions of the beam 12 are of a multiion material, as tannic acid, a reaction takes place on the web beginning as soon as the ions reach there, and no further development is necessary. Or the tannic acid ions can be retained on the web and the ferric chloride applied in the developer 5 in the form of a spray, aerosol, solution or the like. Further ions may be gallium, indium, mercury, woods metal, or other nonvolatile conductors which will leave conducting letters on the web. If the ions deposited on the web are of an oil, the charges will attract carbon dust, paint pigment, or the like so that either can be applied in the developer 5 by dusting or other means to adhere to the oily surface. The oil thus applied may be, for example, 2 ethyl hexyl phthalate, dibutyl phthalate, a suitable silicone oil (as DC-703 manufactured by Dow Corning Corporation of Midland, Michigan) or any light petroleum oil.

In FIG. 3 the web shown is a plate that comprises a conductive layer 22 on an insulating substrate 23. The layer 22 may be copper or some other conductive material. The ion beam 12 can consist of, for example, ferric chloride and, by appropriate programming, the beam can be caused to deposit ions at regions on the surface of the copper layer 22 thereby to remove in a determined fashion portions of the layer. In this manner an electronic printed circuit board can be fashioned. Similarly, if the layer 22 is semiconductive (such as appropriately doped silicon, germanium, or the like) and the beam is a suitable etchant (such as hydrofluoric acid), the resulting etched layer may form the basis for an integrated circuit or other semiconductive device. In the latter case, the substrate 23 may be a conductor or a semiconductor or an insulator, as required.

The embodiment of FIG. 4 includes a plurality of three focused particle emitters 24, 25, and 26 adapted to provide monatomic or multiatomic ion beams 28, 29, and 30, respectively, which converge, as shown, to deposit particles at one region on the web. The beams 28 and 29, for example, may be respectively cadmium and sulfur, in which event a cadmium sulfide pattern can be deposited on a substrate 27. Also by using three emitters, gallium, arsenic and phosphorous can be deposited at the same location on the substrate 27, the ratio of the three being maintained to provide proper appropriate properties of the deposited material. In addition, the multibeam embodiment of FIG. 4 is adapted to allow the simultaneous deposition of the reactant materials to provide instant

developing in the previously discussed embodiments. Modifications of the invention herein disclosed will occur to those skilled in the art and all such modifications are deemed to be within the spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. An ion beam printer comprising, in combination, an ion beam source that includes a container adapted to hold a liquid in which ions may be formed and removed therefrom, a conductive capillary tube adapted to extend into the liquid, a source of electric potential connected between the tube and an electrode to effect removal of ions from the opening in the tube and initiate acceleration thereof, a web positioned to have one major surface thereof in the path of the beam to receive ions from said ion beam source, means adapted to modulate the beam in a determined pattern, means for driving the web along a path substantially orthogonal to the beam direction, and a developer positioned along the path, the developer being adapted to develop an image as the web moves therealong.

2. A printer as claimed in claim 1 in which the relaxation time of the material of which the web is made is long compared to the time lapse between the instant ions are received by the web and the instant the ions are reacted with a developer material in the developer.

3. A printer as claimed in claim 1 in which the modulation means is a digital computer in combination with a source of electric potential.

4. A printer as claimed in claim 1 and in which the modulation means is adapted to effect translation movement of the ion beam and which is further adapted to vary the intensity of the beam.

5. A printer as claimed in claim 1 in which the modulation means is adapted to effect at least one of translational movement and variations of the intensity of the ion beam.

6. A printer as claimed in claim 2 in which the ions are of a material from the group consisting of gallium, indium, mercury, woods metal, or other nonvolatile conductors.

7. A printer as claimed in claim 2 in which the ions are tannic acid ions and the developer material is ferric chloride.

8. A printer as claimed in claim 2 in which the ions are of an oil and the developer material is a pigment or dust which will adhere to the oily surface.

9. A printer as claimed in claim 8 in which the oil is one of 2 ethyl hexyl phthalate, dibutyl phthalate, a silicone oil, and light petroleum oil.

10. An ion beam printer comprising, in combination, an ion beam source that includes a container adapted to hold a liquid in which ions may be formed and removed therefrom, a con-

ductive capillary tube adapted to extend into the liquid a source of electric potential connected between the tube and an electrode to effect removal of ions from the opening in the tube and initiate acceleration thereof, a web positioned to have one major surface thereof in the path of the beam to receive ions from said ion beam source, means adapted to modulate the beam in a determined pattern, and in which the web is a thin conductive layer on an insulating substrate and the ion beam comprises multiatomic particles adapted to remove portions of said layer in a determined fashion.

11. An ion beam printer comprising, in combination, an ion beam source that includes a container adapted to hold a liquid in which ions may be formed and removed therefrom, a conductive capillary tube adapted to extend into the liquid, a source of electric potential connected between the tube and an electrode to effect removal of ions from the opening in the tube and initiate acceleration thereof, a web positioned to have one major surface thereof in the path of the beam to receive ions from said ion beam source, means adapted to modulate the beam in a determined pattern, and in which the web comprises a semiconductor layer on a substrate and the ion beam comprises a multiatomic particles adapted to etch portions of said layer in a determined fashion.

12. An ion beam printer comprising, in combination, an ion beam source that includes a container adapted to hold a liquid in which ions may be formed and removed therefrom, a conductive capillary tube adapted to extend into the liquid, a source of electric potential connected between the tube and an electrode to effect removal of ions from the opening in the tube and initiate acceleration thereof, a web positioned to have one major surface thereof in the path of the beam to receive ions from said ion beam source, means adapted to modulate the beam in a determined pattern, and in which the ion beam source comprises a plurality of particle emitters focused to deposit simultaneously at the same location on the web particles of various reactant materials which interact with one another upon the web, thereby to form on the web a chemical compound of deposited material formed from said reactant materials.

13. Apparatus as claimed in claim 12 in which the particles emitted are monatomic or multiatomic ions.

14. Apparatus as claimed in claim 12 in which two particle emitters are provided, one of which emits cadmium ions and the other of which emits sulfur ions which combine on the web to form cadmium sulfide.

15. Apparatus as claimed in claim 12 in which three particle emitters are provided: one of which emits gallium ions, another of which emits arsenic ions, and still another of which emits phosphorus ions.

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