United States Patent

Buss

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[45] **May 30, 1972**

[54] ELECTRONIC SWITCH

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[52] **U.S. Cl.** **307/117**, 346/140

[51] **Int. Cl.** **H01h 47/24**

[58] **Field of Search** ..... 307/117; 250/209, 213 A; 340/173 LM; 346/74 P, 140

[56] **References Cited**

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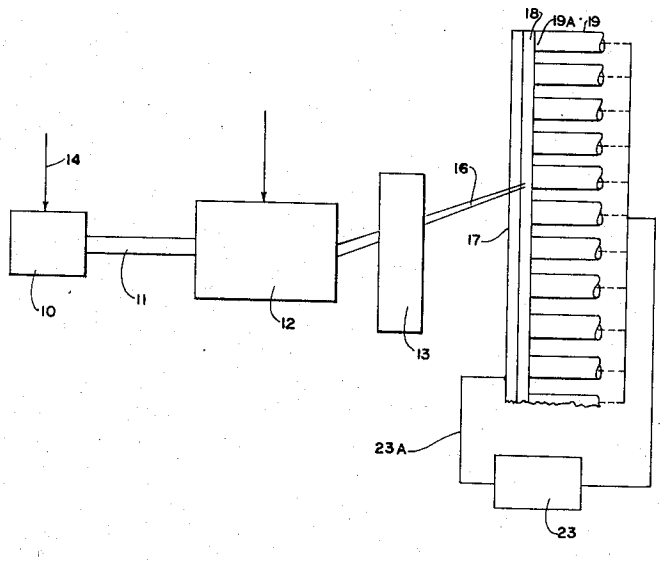
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[57] **ABSTRACT**

A device for connecting a conductor electrically to one out of a number of conductor by means of a photoconductive or semi-conductive material and a light or electron beam. The particular output to be connected to the common input is chosen by selecting the direction or the spatial position of a light beam. The resistance of the connection depends on the intensity of the beam.

3 Claims, 8 Drawing Figures



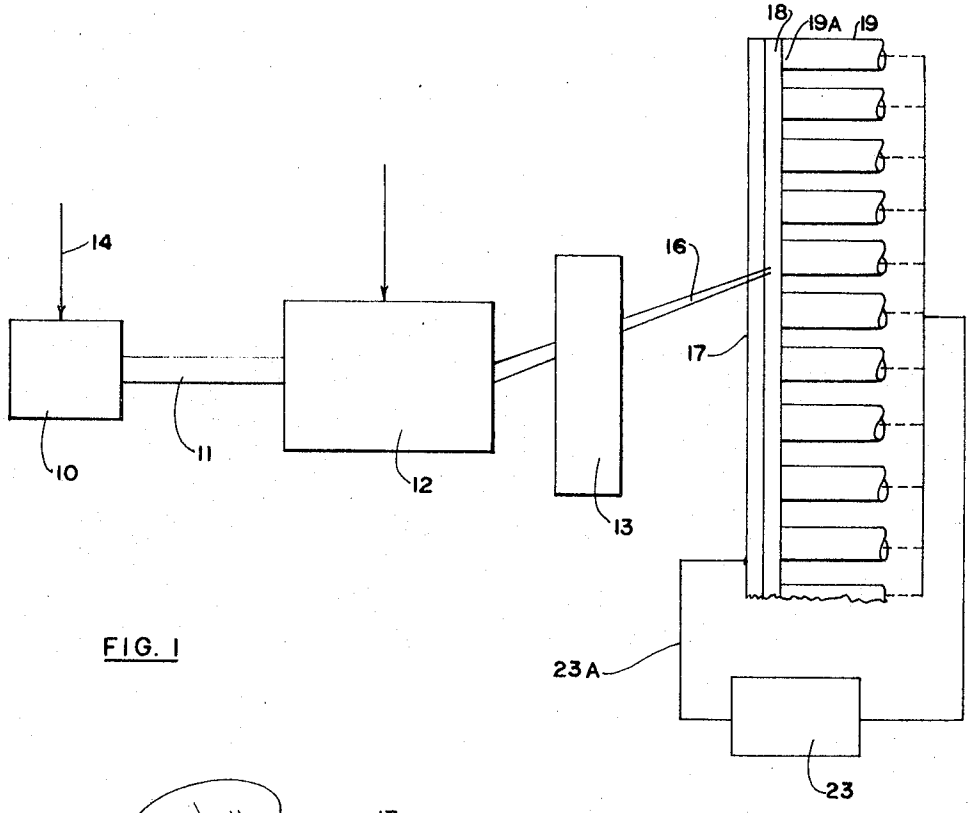


FIG. 1

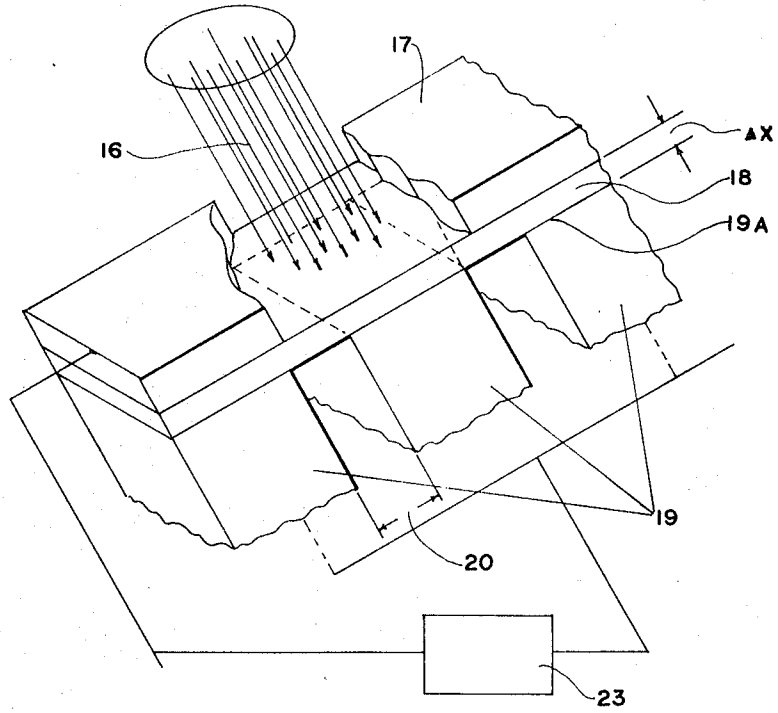


FIG2

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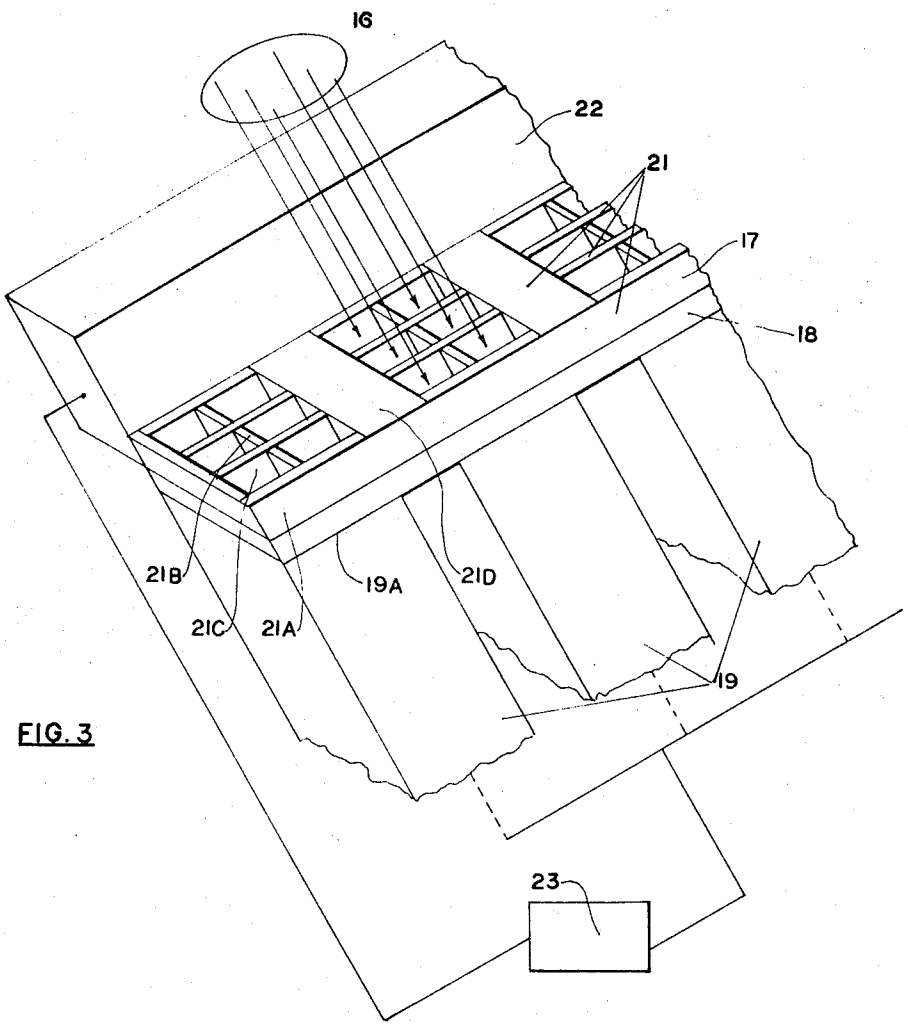


FIG. 3

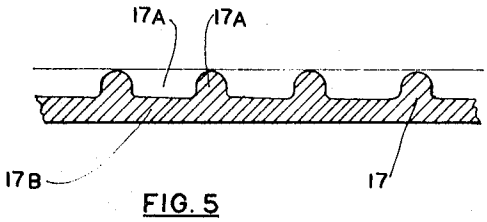


FIG. 5

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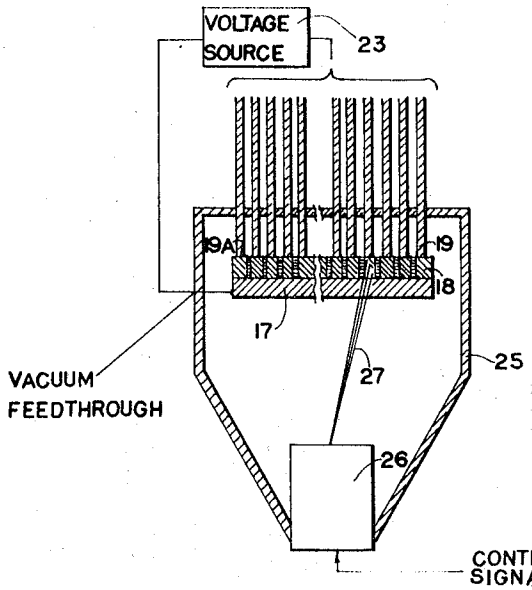


FIG. 4

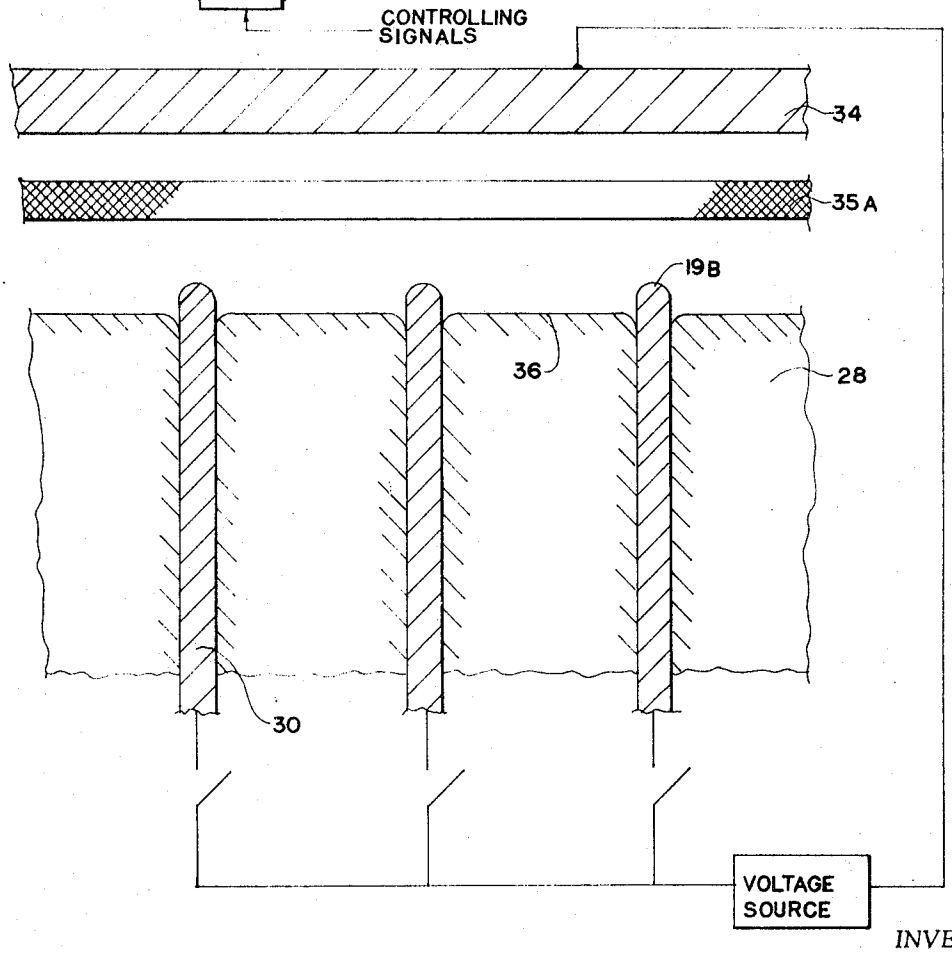


FIG. 8

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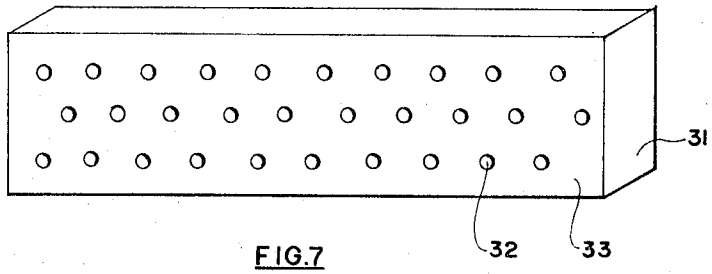


FIG.7

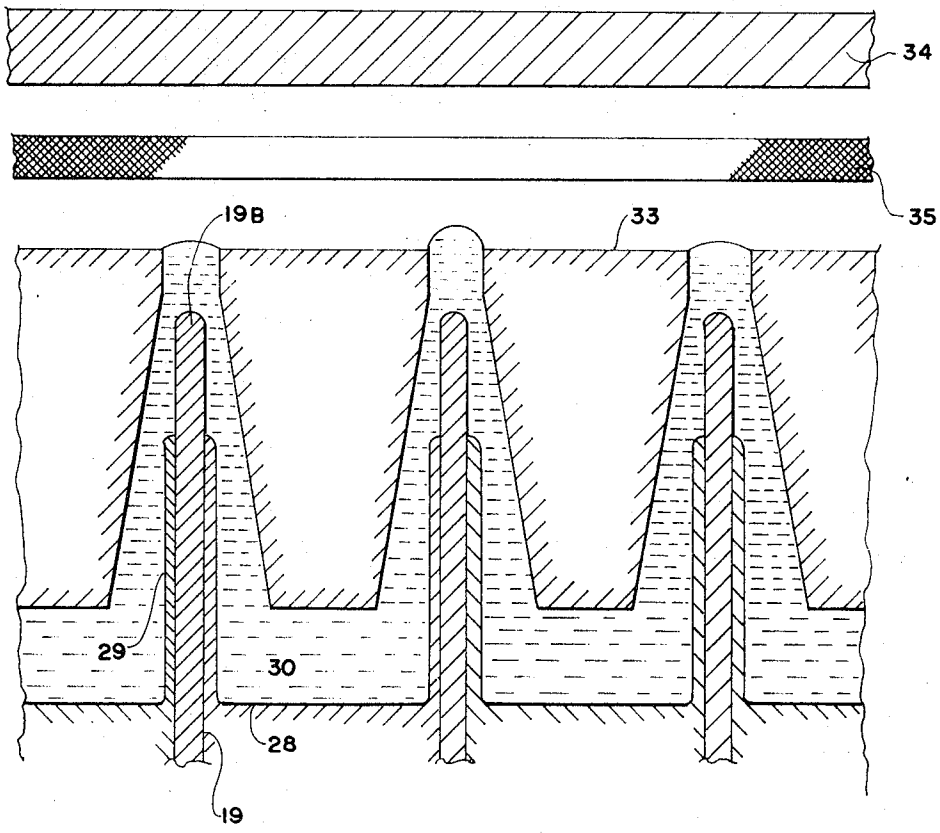


FIG. 6

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ELECTRONIC SWITCH

This invention relates to new and useful improvements in electro-optical switches, particularly switches adapted to be actuated by coherent light beams or electron gun systems.

Semi-conductor devices like transistors, can be used as fast switches, but it will be appreciated that one transistor can only switch on one connection and if more connections are required, then more transistors can be utilized.

Furthermore, there is a galvanic connection between the controlling circuitry and the output making it difficult to provide for an output at a potential different from the controlling input.

The principal object of the present invention is to provide a device of the character herewithin described which utilizes the characteristics of laser beams to actuate a multiple switch device rapidly and which also can be used to amplify the signal passing through the switch.

Lasers (light amplification by stimulated emission of radiation) provide highly parallel light beams which can be deflected and focused onto relatively small areas and furthermore which permit rapid modulation of the intensity of the beam and an object of the present invention is to provide a switch having a relatively fast response with many switch positions utilizing the properties of the laser light beams.

A further object is to provide a device of the character herewithin described in which a relatively fast switch can be operated remotely by controlling the intensity of the light beam used or its direction or both.

A yet further object of the present invention is to provide a switch that is relatively fast and which furthermore has no galvanic connection to the controlling source.

Another object of the invention is to provide a device of the character herewithin described which provides improved apparatus for amplifying signals, specially when the driving source is spatially separated from the amplified output, or electrically insulated therefrom.

A still further object of the invention is to provide a device of the character herewithin described which can be utilized in many different environments which may require rapid switching without the necessity of providing a plurality of semi-conducting devices such as transistors.

In one embodiment of this invention, a beam of light is used as the controlling element of the switch. The intensity and direction of the beam of light can be changed at will and the response is extremely fast. Furthermore, the beam of light can be focused onto a small area. A number of wires or conductors are arranged perpendicularly to a common conductor such as a wire or metal bar defined in the specification and claims as a conducting layer.

The ends of the wires or conductors are separated from the conducting layer by a relatively short distance and the space defined between the conducting layer and the ends of the conductors is filled with photoconductive material. The light beam can be directed so that it strikes the photoconductive material through the conducting layer and immediately above one of the conductors, thereby rendering the photoconductive material at this point, conductive thus establishing a galvanic connection between the conducting layer and that particular conductor.

The intensity of the light beam determines the resistance of the photo-conductive material and accordingly the current flowing therethrough. It will therefore be appreciated that a switch of this kind can also serve as an amplifier with one input and a number of outputs, only one of which is activated at any one time. It will, of course, be appreciated that while the selection of the particular connection or switch position can be done easily by properly deflecting and focusing a light beam, the present invention is also adapted to the selection of the switch position by other means as desired.

With the foregoing in view, and such other or further purposes, advantages or novel features as may become apparent from consideration of this disclosure and specification, the present invention consists of, and is hereby claimed to reside in, the inventive concept which is comprised, embodied, embraced, or included in the method, process, construction, composition, arrangement or combination of parts or new use of any of the foregoing, of which concept, one or more specific embodiments of same are herein exemplified as illustrative only of such concept, reference being had to the accompanying figures in which:

FIG. 1 is a schematic view of a complete switch construction incorporating the present invention.

FIG. 2 is a fragmentary partially sectioned perspective view of one embodiment of the invention.

FIG. 3 is a view similar to FIG. 2, but showing a further embodiment of the invention.

FIG. 4 is a schematic view showing a further embodiment of the invention.

FIG. 5 is an enlarged fragmentary sectional view of one form of the conducting layer.

FIG. 6 is a sectional fragmentary view showing one of the uses to which the invention can be placed.

FIG. 7 is an isometric underside view of the counter electrode of FIG. 6.

FIG. 8 is a view similar to FIG. 6, but showing a still further utilization of the invention.

In the drawings like characters of reference indicate corresponding parts in the different figures.

Proceeding therefore to describe the invention in detail, reference should first be made to FIG. 1 in which reference character 10 illustrates a light source such as a laser which produces a parallel beam of light illustrated by reference character 11 which may then be deflected by a light beam deflector 12, focused by an optical system 13 thus providing a focused beam of light 16.

The intensity of the light beam 11 is controlled by an intensity signal illustrated at 14 which controls the light source 10.

The laser 10 operates on well-known principles and it is not believed necessary to describe the production of the beam of light 11 in this specification.

By the same token, many devices are available to provide the necessary deflection signal and as an example, U.S. Pat. No. 3,458,247 shows a deflection apparatus for a light beam which may be utilized in the present embodiment.

A plurality of substantially linear conductors or wires 19 are situated in spaced and parallel relationship relatively close together with one end 19A of each conductor being in a common plane. A conducting layer 17 is situated spaced from the ends 19A and the space defined by the ends 19A and the inner surface of the conducting layer 17, is filled with a semi-conducting or photo-conductive layer 18. It will be observed that the one surface of this photo-conductive layer 18 is in contact with the ends 19A of the conductors 19 and the other surface is in contact with the conducting layer 17.

FIG. 2 shows a perspective fragmentary view of this arrangement enlarged considerably for clarity.

The conducting layer 17 is relatively thin and is transparent to the light beam 16 at least in the areas immediately adjacent to the ends of the conductors 19. This can be fabricated from an evaporated layer of gold and this layer may be thicker in some areas than others.

As an example, FIG. 5 shows ribs 17A situated at right angles to one another and of a relatively thick formation defining therebetween a relatively fine layer 17B which is situated above the individual ends 19A of the conductors 19 and is transparent to the light beam 16 focused thereupon.

The conductive layer 17 is connected to a voltage source 23 by conduits 23A and as the deflection device 12 moves the focused beam 16 from one position to another, the beam penetrates the conductive layer 17 and strikes the photo-conductive layer 18. This photo-conductive layer or semiconducting layer can be constructed from any well-known material having these characteristics, and as an example, medium resistance silicone yields good results. The effect of the beam 16 striking the photo-conductive layer is to produce charge carriers and as the conducting layer 17 produces an electrical potential difference between this layer and the conductors 19,

an electric field across the photo-conductive layer 18 is formed. This causes the charge carriers in the layer 18 to migrate along the field lines, thus constituting an electrical current. An electrical connection is therefore established between the conducting layer 17 and the individual conductor 19 upon which the light beam 16 is focused.

The resistance of this connection depends upon the density of the charge carriers of the photo-conductive layer 18 and thus on the intensity of the light beam 16. If the distance 20 between two of the conductors 19 is relatively large compared with the thickness of the photo-conductive layer 18 and if further light beam 16 is focused onto an area on the layer 17 which is equal to or smaller than the cross-section of a conductor 19, and furthermore if the light beam is directed towards the end face of one of the conductors 19 only, then the resistance between the conductive layer 17 and one of the conductors 19 is small compared to the resistance between the conductive layer 17 and the remaining conductors 19. It will be appreciated that this is exactly what a switch is supposed to do, namely establish an electrical connection between an input and one out of a number of outputs by selectively lowering the resistance between the input and the particular output being utilized.

FIG. 3 shows an alternative construction of the conducting layer 17 which is in the form of a mesh or lattice grid including lattice members 21A and 21B thereby defining interstices 21C situated over the end 19A of the individual conductors 19. This grid is provided with relatively thick dividers 21D between adjacent conductors and it is preferable that a relatively heavy metal bar 22 be connected to one side of the grid in order to prevent voltage losses, especially if layer 17 is relatively thin and many conductors 19 are utilized.

Due to the extremely rapid response of a laser beam and the accuracy by which it may be moved and focused, the switch hereinbefore described is particularly suitable for use in many environments.

Furthermore, an electron beam can be utilized for similar results as shown in FIG. 4.

In this embodiment, reference character 25 illustrates a vacuum tube having electron gun 26 at one end thereof producing an electron beam which can be controlled by controlling signals insofar as acceleration, deflection, focusing and intensity are concerned.

The conducting layer 17 is similar to that hereinbefore described with the exception that it needs to be transparent to the action of the electrons illustrated as a beam by reference character 27. These electrons strike the semi-conductive layer 18 with some of the results hereinbefore described causing a galvanic connection between the conductors 17 and individual conductors 19.

It will, of course, be appreciated that the conducting layer 17, the semi-conducting layer 18 and inner portions of the conductors 19 together with the inner end of the electron gun are sealed within the vacuum tube and that necessary vacuum feed throughs are provided for all of the conductors.

The electron beam is focused, accelerated and directed towards the conducting layer 17 passing therethrough and striking the semi-conductive layer 18 where it is stopped and produces charge carriers thus rendering the semi-conductive material conductive while the electron beam lasts and for some time thereafter until the charge carriers that have not been swept away by the electric field, have recombined. FIGS. 6, 7 and 8 show one use to which such a switch operated by a laser beam, can be directed.

For example, in FIG. 6, the individual conductors 19 are embedded within an insulating block 28 and extend upwardly to insulating sleeves 29 into a liquid 30.

A sheet or layer of insulating material 31 is provided with apertures 32 within the outer face or wall 33 extending inwardly so that when it is placed into position upon the insulating block 28, the ends 19B of the conductors are situated below and in alignment with these apertures 32. The insulated layer or block 31 is provided with a relatively low dielectric constant not much greater than 2 and the liquid 30 should also have a low conductivity and a dielectric constant of between 5 to 20.

Each conductor or pin 19 is provided with an individual aperture 32 and the surface 33 of the insulating sheet or block 31 will not become wetted by the liquid inasmuch as the liquid suffers capillary depression in the holes of apertures 32 and will not fill them unless a hydro-static pressure is applied which provides enough energy to form the almost "free" surface of the liquid in the holes.

If now, through means of the switch hereinbefore described, any one of the conductors or pins 19 is brought to a high voltage with respect to the counter electrode 34 spaced therefrom, most of the electric field lines will stay in the liquid rather than enter into the insulating material and reach the air through the aperture in the insulator producing a large field at the mouth or opening of the aperture 32.

Providing the liquid has just sufficient conductivity, charge will be collected on the surface of the liquid towards the air, causing the liquid to bulge out due to the electric field forces. Liquid will continue to be poured out of the hole into the air as long as the energy gained in the field overwhelms the surface tension of the liquid minus the work done by the hydro-static pressure.

Eventually, if the electric field is high enough, a liquid drop will be formed and due to the net charge it carries, be accelerated away from the hole towards the counter electrode. This process will repeat itself as long as the pin voltage exceeds the threshold value for drop formation. If the liquid is a dye or contains a dissolved or finely dispersed dye, and if a sheet of paper, for example, given reference character 35 is interspersed between the block 31 and the counter electrode 34, the charged dye carrying droplets will be deposited on the paper. By removing the charge from the droplets and evaporating the solvent, a printed dot will remain on the paper.

FIG. 7 shows the insulating sheet or block 21 from the paper side or side 33, which is made up in the form of a mask which can be removed from the part carrying the wires or conduits 19, for cleaning purposes.

Such an electrostatic printer would offer considerable advantages over present day printers as it involves no mechanically moving parts except for the paper feed. It can be used to print anything from letters or graphs to pictures directly from an electronic input and therefore is almost ideally suited as a peripheral attachment for a computer. It is also capable of very high resolution down to 20 points per mm., which is sufficient to print newspapers and medium quality journals. Printing speed depends on the resolution and can be almost as high as present day computers can handle, and is comparable to the speed of conventional printing machines which require long and costly procedures to produce the printing plates.

Needless to say, the same principle can be applied to office copy machines if desired.

FIG. 8 shows a similar arrangement with the exception that the liquid or ink 30 is not utilized. The conductors or pins 30 are embedded within the insulating material 28 with the upper ends 19B extending from the surface 36.

The counter electrode 34 is similar to that hereinbefore described and the paper 35A is situated between the counter electrode and the ends 19B of the pins or conductors 19. Under these circumstances, by switching the voltage to various conductors 19 as hereinbefore described, electric charges can be deposited upon the surface of the paper 35A to produce a latent pattern which may be processed subsequently and developed into a visible picture or used otherwise as desired.

The latent pattern may last for a fraction of a second although it can last for several minutes depending upon the kind of paper used and many means are well known in the art for developing this latent pattern so that details are not believed necessary in this disclosure.

Various modifications can be made within the scope of the inventive concept which is herein disclosed and/or claimed.

What I claim as my invention is:

1. An electronic switch comprising in combination a plurality of essentially linear conductors arranged in relatively close spaced and parallel relationship with one another one end of each of said conductors being in the same plane a layer of semi-conducting material, one side of which is in contact with the said one end of said conductors, a conducting layer in contact with the other side of said semi-conducting layer, on the one hand, and connected to the said plurality of conductors on the other hand, a source of electrical energy connected to said conducting layer, and laser beam means focusible and movable onto the area of said conducting layer immediately spaced from any one of said conductors thereby establishing a galvanic connection between said conducting layer and the said conductor immediately spaced therefrom, the resistance of said connection being controlled by the intensity of said laser beam means.

2. The device according to claim 1 in which said conducting layer comprises a relatively thin light transparent sheet of metal.

3. The device according to claim 2 in which said sheet of metal is provided with ribs of relatively thick material having areas of relatively thin material therebetween, the areas of relatively thin material having light transmitting qualities and being situated over the said one ends of said conductors.

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