Nov. 17, 1964 J. D. KUEHLER 3,157,879

APPARATUS FOR PRINTING BY MEANS OF AN ELECTRON BEAM

Filed Dec. 28, 1959 3 Sheets-Sheet 1

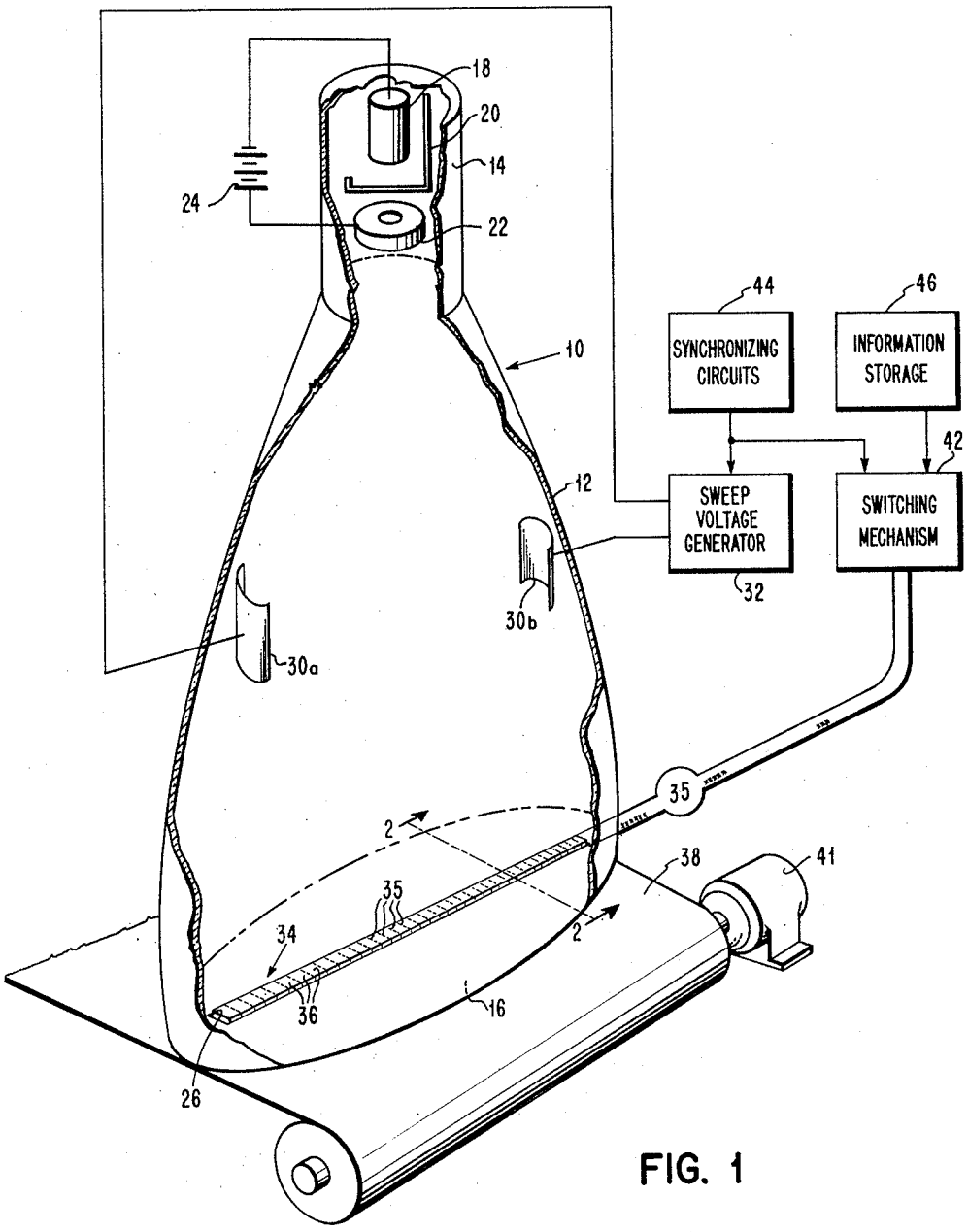


FIG. 1

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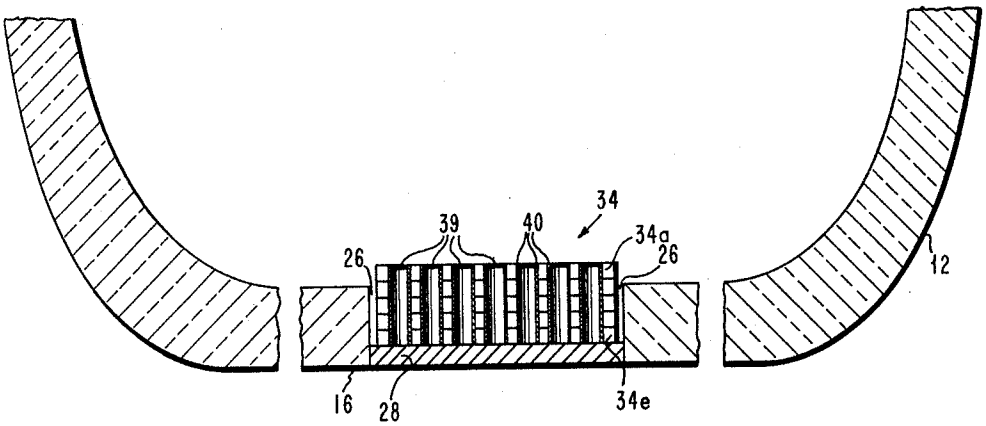


FIG. 2

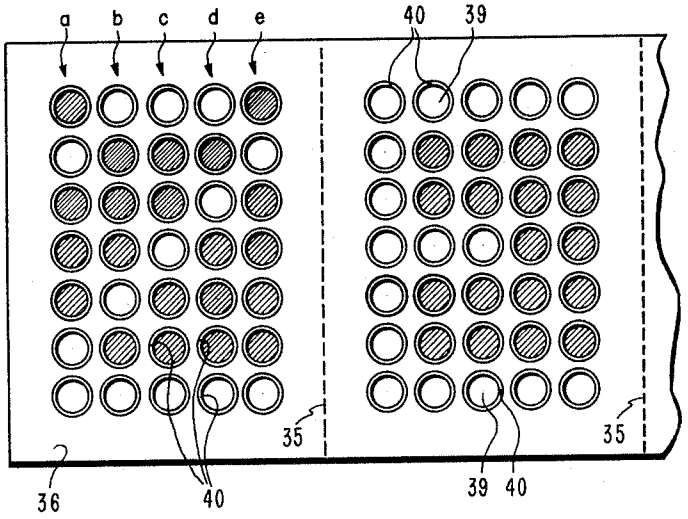


FIG. 3

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FIG. 4a

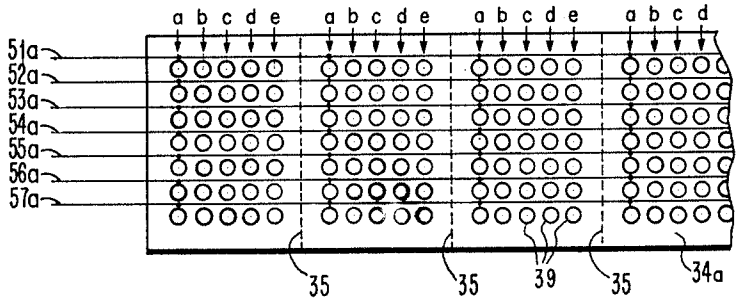


FIG. 4b

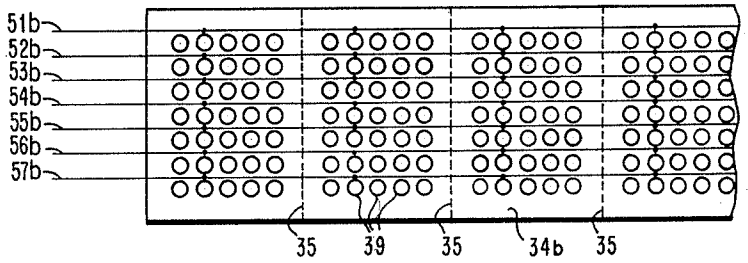


FIG. 4c

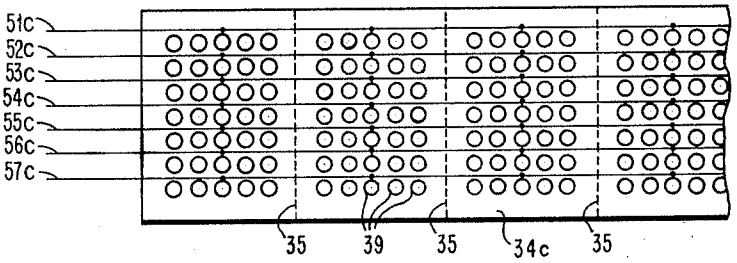


FIG. 4d

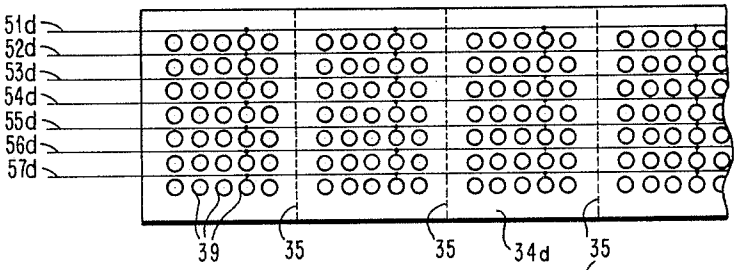
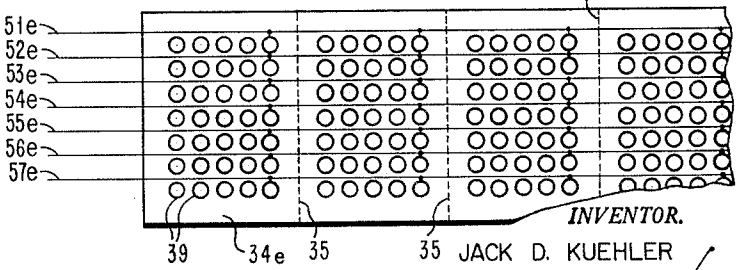


FIG. 4e



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United States Patent Office 3,157,879 Patented Nov. 17, 1964

3,157,879

APPARATUS FOR PRINTING BY MEANS OF AN ELECTRON BEAM

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Filed Dec. 28, 1959, Ser. No. 862,324
6 Claims. (Cl. 346—74)

The present invention relates to apparatus for printing letters, numerals and like symbols by means of an electron beam upon heat sensitive surfaces.

It is an object of my invention to provide a rapidly operating apparatus for printing information by means of an electron beam upon sensitized recording surfaces.

More particularly, it is an object of the invention to provide a cathode ray tube for printing information by means of an electron beam upon surfaces located exteriorly of the tube.

Still another object of the invention is to provide a device of the type referred to that may rapidly be set to print any desired symbol or any desired sequence of different symbols.

An additional object of the invention is to provide an apparatus of the type referred to, with means that may readily and rapidly be adjusted to cause the electron beam to print a selected symbol and/or a sequence of different selected symbols upon an exteriorly located recording surface.

In this connection it is another particular object of the invention to provide an adjustable stencil for printing by means of an electron beam, which is of simple construction and may rapidly be adjusted to different symbols.

A further object of the invention is to provide an electrically controlled adjustable stencil of the type referred to that requires a minimum of control leads to set up any desired sequence of symbols such as are necessary to print a desired sequence of words.

These and other objects of the present invention will be apparent from the following description of the accompanying drawings which illustrate a preferred embodiment thereof and wherein

FIGURE 1 is a fragmentary perspective of an electron beam printing apparatus embodying my invention;

FIGURE 2 is a vertical cross section taken along line 2—2 of FIGURE 1 and viewed in the direction of the arrows associated with said line;

FIGURE 3 is an enlarged fragmentary plan view of the device for predetermining the symbols to be printed by the electron beam; and

FIGURES 4*a*, 4*b*, 4*c*, 4*d* and 4*e* are plan views of components of the device shown in FIGURE 3 illustrating its electrical connections, and the manner in which the device may be assembled in the manufacture thereof.

Having first reference to FIGURE 1, the apparatus of the invention is basically a cathode ray tube **10** and comprises an evacuated envelope **12** which has a narrow neck **14** and opposite said neck a flat bottom **16**. Located in the neck **14** is the electron discharge cathode **18**, which may be surrounded by a control electrode **20** to predetermine the intensity of the electron stream emitted by the cathode. Arranged in the front of the cathode is an apertured anode **22** which is held at a high positive potential relative to the cathode as indicated by the battery **24**, to direct the stream of electrons emitted by the cathode in a beam toward the flat bottom of the envelope.

Provided in the flat bottom **16** of the envelope is a linear elongated slot **26** that extends diagonally across said bottom but terminates at either end a limited distance removed from the peripheral edge thereof. Said slot is of a transverse width about equal to the height of a printed line, and flush with the outer surface of the flat bottom

16 of envelope **12** the slot is closed in an air-tight manner by a thin sheet or plate **28** (FIGURE 2) to maintain the interior of the envelope in evacuated condition. Said sheet **28** is made of a conductive material, such as aluminum or beryllium, and is extremely thin, for instance .00025 inch, to form an electron window through which the electrons emitted by the cathode **18** and accelerated toward the bottom of the envelope by the anode **22** may readily pass.

Means are provided in the form of a pair of deflection plates **30***a* and **30***b* and suitable control circuitry for said plates, indicated by the block **32**, to sweep the beam of electrons emitted by the cathode **18** continually over and along the slot **26**. Located in said slot above the electron window **28** is a strip **34** of a dielectric material, such as glass or mica, which forms a row of symbol-forming units **36** of identical size and construction. Said units are comparable to stencils used in the art of brush painting or spraying and may be set to permit passage of electrons from the interior of the envelope through the window **28** onto an exteriorly located sheet **38** of heat sensitive paper in such locations only as will form a selected symbol thereon.

Having particular reference to FIGURES 2 and 3, each of said symbol-forming units is formed by a section of the strip **34** as indicated by the vertical phantom lines **35** in FIGURES 3 and 4*a* to 4*e*, and each such section of the strip **34** is provided with an array of holes or passages **39** extending from the top to the bottom surface thereof (FIGURE 2). In the embodiment of the invention illustrated in the accompanying drawings each such section **36** contains five juxtaposed rows *a*, *b*, *c*, *d* and *e* of seven holes each, as best illustrated in FIGURE 3, so that each symbol-forming unit is actually provided with thirty-five holes **39**. By permitting selected ones of said thirty-five holes to pass electrons emitted from the cathode **18** while blocking the remaining holes, any letter of the alphabet or any character from 0 to 9 may be formed as illustrated in FIGURE 3 wherein holes blocked to the passage of electrons are identified by shade lines. In the first symbol-forming unit illustrated in FIGURE 3 the holes left open to the passage of electrons form the character "2"; in the second symbol-forming unit they form the letter E.

To be able to selectively control the passage of electrons through the holes **39** I furnish each hole with an electrically conductive lining such as a thin metal tube **40** and I provide means for applying individually to every one of the tubes **40** (FIGURE 3) in each unit a potential that blocks the hole effectively against passage by the electrons emitted from the cathode **18** or slows them down sufficiently so that they will not penetrate the electron window. Thus, as the electron beam emitted by the cathode **18** is swept over and along the inner surface of the row **34** of symbol-forming units **36**, the presence or absence of appropriate electrical potentials upon selected tubes **40** of each symbol-forming unit determines where the electrons may pass through said units and the electron window **28** to impinge upon the heat sensitive sheet **38** and form selected symbols thereon, and the heat sensitive sheet may be moved past the window **28** in synchronism with the sweeping speed of the electron beam. This may be accomplished by an electric motor such as indicated at **41** in FIGURE 1.

To control every one of the holes in the row of symbol-forming units individually would ordinarily require as many individual leads as there are holes in all the symbol-forming units comprised in the stencil strip **34**, and since a line of printed information may require as many as one hunder letters and/or letter-sized spaces, it would require as many as thirty-five hundred individual leads to control every one of the symbol-forming units **36** in the row **34** individually. In accordance with my invention, however,

I provide an arrangement for the control of all the symbol-forming units in row 34, that requires no more leads than the number of leads necessary to control the holes in a single symbol-forming unit. For this purpose I connect the identically located tubes of all the symbol-forming units comprised in the apparatus in parallel to common control leads 51 as illustrated in FIGURES 4*a* to 4*e*, which show individual plan views of five vertically superposed strata of strip 34 and which will be described in greater detail hereinafter. When the identically located tubes of all the symbol-forming units comprised in row 34 are all connected in parallel to common control leads, the total number of control leads for all the symbol-forming units in said row 34, no matter how many there may be, will always be equal to the number of holes 39 provided in each symbol-forming unit, and blocking potentials applied to selected ones of said control leads to set up a selected symbol in any one of said units will automatically and simultaneously set every one of the symbol-forming units comprised in the row to the same symbol. To enable the apparatus of the invention to print information composed of different symbols as the electron beam sweeps over the row of symbol-forming units, it is necessary therefore that the operation of the sweep circuitry 32 which controls the speed with which the electron beam is swept over the row of symbol-forming units be synchronized with the speed of operation of the switching mechanism which applies blocking potentials to selected ones of the common control leads of the symbol-forming units to establish the selected symbols, so that the blocking potentials which are to form a directly consecutive symbol be applied to the common control leads by the time the electron beam sweeps over the next symbol-forming member.

In FIGURE 1 the switching mechanism which applies blocking potentials to the appropriate control leads is represented by the block 42, and the mechanism which supervises both the sweep circuitry 32 and the switching mechanism 42 so that they may operate in synchronism is indicated by the block 44. The switching mechanism 42 in turn may be controlled from and activated by an information storage device in which the information to be printed is stored and which is represented by the block 46. Switching arrangements, information storage devices, information recovery arrangements and synchronizing circuitry such as represented by the blocks 42, 44 and 46 are well known in the art of recording information and recovering recorded information, they do not by themselves constitute part of the present invention so that it is unnecessary to describe them in greater detail.

The best way to produce a strip of symbol-forming units with its many holes and electrical connections is to assemble it from as many component strips as there are juxtaposed rows of holes in each unit. In the embodiment of the invention illustrated in the accompanying drawings, each unit 36 has five juxtaposed rows of holes identified by the letters *a*, *b*, *c*, *d* and *e*, respectively, as illustrated in FIGURE 3 and as pointed out hereinbefore. Accordingly, the symbol-forming stencil strip 34 is assembled from five component strips 34*a*, 34*b*, 34*c*, 34*d* and 34*e* which are illustrated in FIGURES 4*a* to 4*e* respectively. The holes in the strips may be drilled or etched in any suitable manner into said strips prior to assembly thereof.

In strip 34*a* the top holes in the leftmost row *a* of all the sections are all connected to a longitudinally extending control lead 51*a* and the second, third, fourth, fifth, sixth and seventh holes in the leftmost row *a* of all the sections are all connected to common longitudinally extending control leads 52*a*, 53*a*, 54*a*, 55*a*, 56*a* and 57*a* respectively. These control leads and the short branches leading from the holes to the control leads may be produced by conventional printed circuit methods or by evaporation of metal through masks. In the second component strip 34*b* the top holes in the second row *b* (counted from the left) of all the sections are all connected to a

longitudinally extending control lead 51*b*, and similarly the second, third, fourth, fifth, sixth and seventh holes in said second rows *b* of all the sections are all connected to longitudinally extending control leads 52*b*, 53*b*, 54*b*, 55*b*, 56*b* and 57*b*, respectively, as illustrated in FIGURE 4*b*. In the third component strip 34*c* identically located holes in the third row of holes *c* are connected to longitudinally extending control leads 51*c*, 52*c*, 53*c*, 54*c*, 55*c*, 56*c* and 57*c*, respectively, as illustrated in FIGURE 4*c*, and in the fourth and fifth component strips identically located holes in the fourth and fifth rows *d* and *e*, respectively, of all the sections are all connected to common longitudinally extending control leads 51*d*, 52*d*, 53*d*, 54*d*, 55*d*, 56*d* and 57*d* and 51*e*, 52*e*, 53*e*, 54*e*, 55*e*, 56*e* and 57*e*, respectively, as illustrated in FIGURES 4*d* and 4*e*. When the described connections have been established, the five component strips 34*a*, 34*b*, 34*c*, 34*d* and 34*e* are superposed and suitably secured to each other in such a manner that the holes in the corresponding groups of holes of the five strips are perfectly aligned vertically and form passages 39 extending from the top to the bottom surface of the resulting composite strip 34 (FIGURE 2). A metal may now be evaporated through these passages to provide conductive linings inside these passages corresponding to the hereinbefore described conductive tubes 40.

In the composite strip thus produced the conductive linings 40 of identically located holes 39 in every one of the consecutive symbol-forming units of the strip are connected to common longitudinal leads 51*a* to 57*a*, 51*b* to 57*b*, 51*c* to 57*c*, 51*d* to 57*d* and 51*e* to 57*e*, that project from one end edge of the strip. These leads are connected to the hereinbefore described switching mechanism represented by the block 42 in FIGURE 1, that energizes appropriate ones of said leads under control of the information storage device 46 to establish in rapid succession selected characters in all the symbol-forming sections of the strip as the electron beam sweep across the inner surface of said strip in synchronism with the speed with which the means for recovering information from the storage device 46 establishes new settings of the voltage distributing switching mechanism 42.

The printing apparatus of the invention may be capable of extremely rapid operation. When a flood beam of a size appropriate to cover a single unit 36 and of a current strength of .5 milliampere is swept over the stencil strip, the strength of the electron current that reaches the heat sensitive paper held against the window 28, through the individual holes 39, is of the order of 7 microamperes, which is sufficient to produce a distinct mark upon heat sensitive paper, such as Chalkley paper, in a time interval of the order of 10 micromicroseconds. At the same time, the blocking potentials applied to selected ones of the linings 40 of the stencil holes 39 may be established and abolished with utmost rapidity. As a result thereof, the apparatus of the invention is capable of printing one hundred lines each of one hundred letters per second. As an added advantage the printing apparatus of the invention and particularly the adjustable electron stencils employed therein may be made very small so that the symbols established by said stencils may equal typewritten characters in size. Furthermore, in spite of the fact that the stencil strip may be set to establish a whole line of different symbols in a minimum of time, its construction and especially its control connections are rather simple in that the total strip with its many symbol-forming units requires no more control leads than ordinarily required for a single symbol-forming unit.

While I have described my invention with the aid of an exemplary embodiment thereof, the invention is not limited to the specific constructional details shown and described by way of example which may be departed from without departing from the scope and spirit of the invention.

I claim:

1. A printing apparatus comprising an evacuated en-

velope, an electron-emitting electrode provided within said envelope, an electron-permeable window provided in said envelope opposite said electrode, a member of dielectric material having a plurality of channels adapted to pass electrons arranged over said window, means for blocking selected ones of said channels to the passage of electrons to establish electron passing areas of desired conformation, and means for sweeping the electrons emitted by said electrode over said member.

2. A printing apparatus comprising an evacuated envelope, an electron-emitting electrode provided within said envelope, an electron-permeable window provided in said envelope opposite said electrode, a member of dielectric material having a plurality of channels adapted to pass electrons arranged over said window within said envelope, means for blocking selected ones of said channels to the passage of electrons to establish electron passing areas of desired conformation, means for conducting a sensitized sheet past said window exteriorly of said envelope, and means for sweeping the electrons emitted by said electrode over said window.

3. A printing apparatus comprising an evacuated envelope having a flat bottom, an electron-emitting electrode provided within said envelope opposite said flat bottom, an electron-permeable window provided in said bottom, a strip of a dielectric material disposed over said window within said envelope, said strip having a plurality of channels adapted to pass electrons, means operable to block selected ones of said channels to the passage of electrons so that those left unblocked may form desired symbols, and means for sweeping the electrons emitted by said electrode over said strip.

4. A printing apparatus comprising an evacuated envelope having a flat bottom, an electron-emitting electrode provided within said envelope opposite said flat bottom, an electron-permeable window provided in said bottom, a strip of a dielectric material disposed over said window within said envelope, said strip having a plurality of channels extending normal to said window and adapted to pass electrons, means operable to place electrostatic charges to selected ones of said channels to block them effectively to the passage of electrons so that those left unblocked may form desired symbols, means for passing a sensitized sheet along said window exteriorly of said

envelope and means for sweeping the electrons emitted by said electrode over said strip.

5. A printing apparatus comprising an evacuated envelope, an electron beam emitting electrode arranged within sad envelope, an elongated window of electron-permeable material provided in said envelope in an area opposite to said electrode, a strip of dielectric material placed over the inside of said window, said strip having a sequence of groups of channels extending from the interior of said envelope to said window to permit electrons emitted from said electrode to pass to and through said window, means for applying electron flow blocking potentials to selected channels of said groups to block the passage of electrons through said selected channels so that the unblocked channels may establish desired symbols, and means for sweeping the electron beam emitted by said electrode across the inner surface of said strip.

6. A multi-symbol stencil for electron beam printing comprising a plurality of superposed strips of a dielectric material having vertically aligned arrays of holes arranged in juxtaposition longitudinally of said strips, each of said arrays being comprised of transverse rows of holes equal to the number of superposed strips and each of said strips carrying a number of longitudinally extending leads equal to the number of holes comprised in each of the transverse rows of said arrays, electrically conductive linings in the passages formed by the vertically aligned holes of said superposed strips, and means on said strips connecting the linings of identically located holes in identically located vertical rows of the array of holes provided in said strips to identical ones of the longitudinal leads passing through said strips.

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