

July 13, 1965

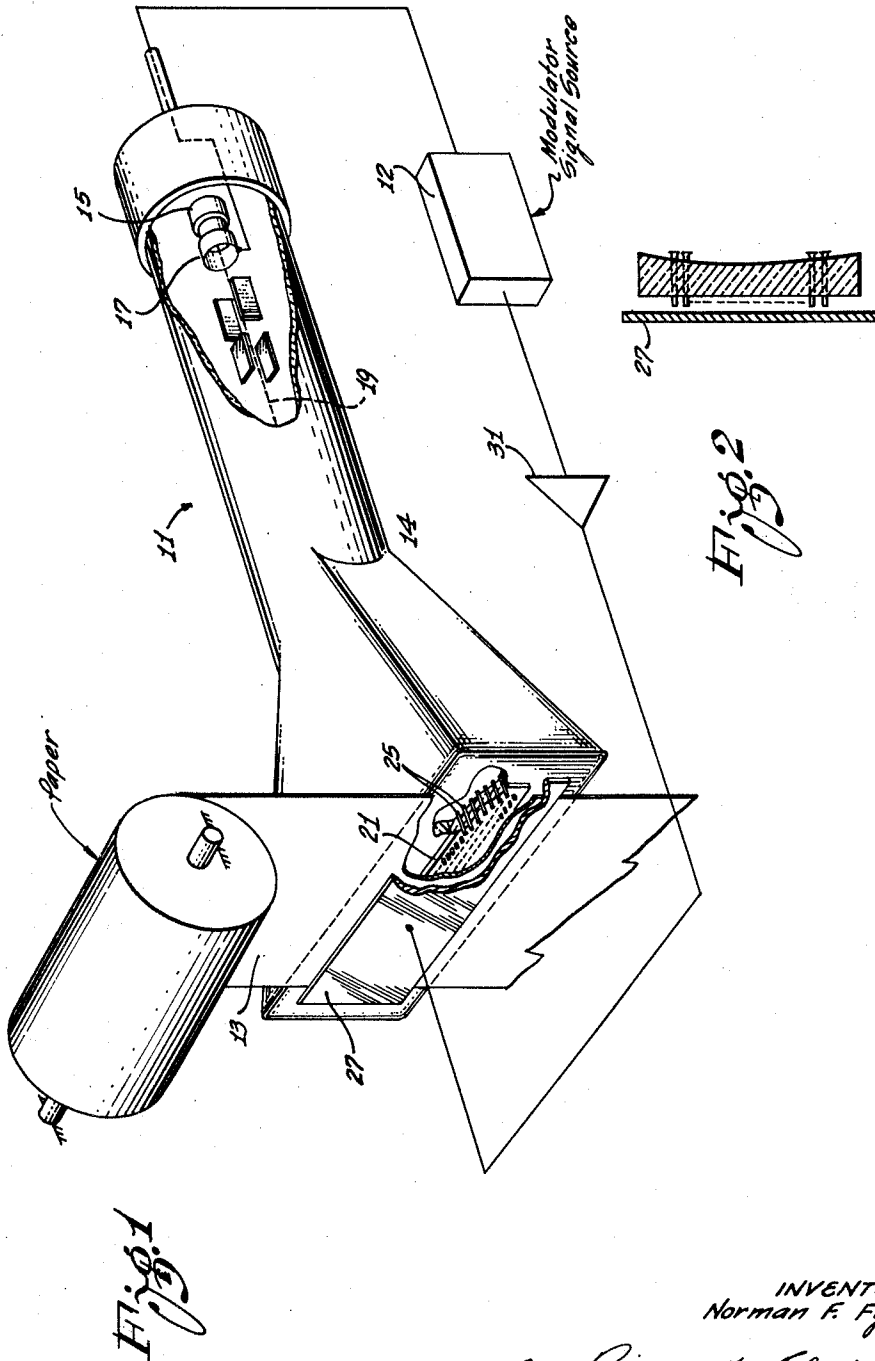
N. F. FYLER

3,193,907

HIGH SPEED CATHODE-RAY DIRECT WRITING TUBE

Filed March 22, 1960

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 3

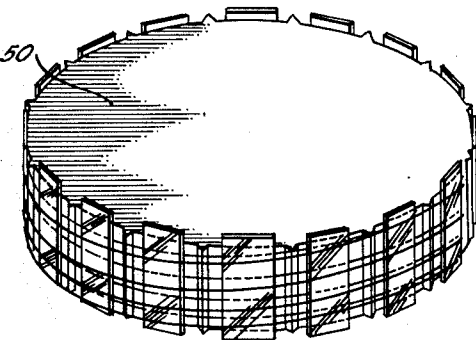


Fig. 4

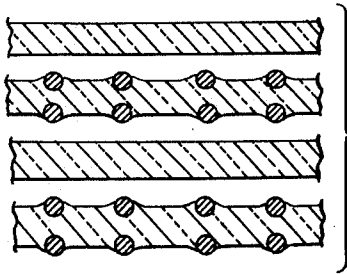


Fig. 5

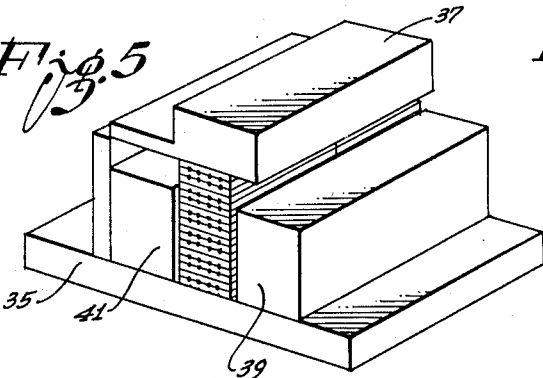


Fig. 6

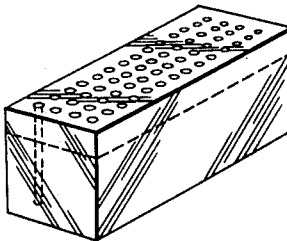


Fig. 8

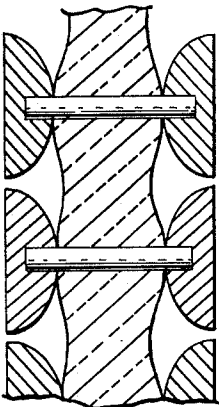
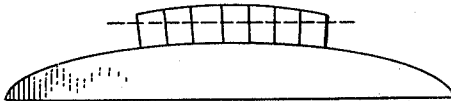


Fig. 7



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3,193,907 HIGH SPEED CATHODE-RAY DIRECT WRITING TUBE

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Filed Mar. 22, 1960, Ser. No. 16,734
11 Claims. (Cl. 29—25.17)

The present invention relates to a high speed cathode-ray direct writing tube and more particularly to a high speed cathode-ray direct writing tube having an improved face plate structure.

In modern high speed electronic computer applications as well as in modern communication systems, there is a constant need for high speed visual intelligible display of coded information. In the prior art, many mechanical and electro-mechanical printing devices have been utilized for this purpose. However, all of these devices have substantial inherent inertia which severely limits the speed of operation of the devices.

In order to avoid the foregoing described speed limitations inherent in the mechanical and electro-mechanical types of printing devices, the prior art has developed a cathode-ray xerographic printing system which converts coded electron beam or cathode-ray information into visual images by means of a phosphor screen positioned on the face of the cathode-ray tube. The visual image produced by the phosphor is, in turn, converted to a charge pattern which is transferred to a dielectric recording material. The recording material is then dusted with a pigmented powder which adheres to the charged areas on the recording medium. Hence, the visual image presented on the face of the cathode-ray tube is printed on the recording material. While this type of printing device possesses a substantially faster printing rate than the mechanical and electro-mechanical devices heretofore mentioned, the device is not capable of obtaining the speeds desired in many applications since the electron beam information must be converted first to a visual image, then reconverted again to a voltage pattern, and finally to a charge pattern on the recording material, each of these conversions, of course, decreasing efficiency and requiring a finite period of time. Further, as would be expected this form of device requires a substantial number of components and thus is cumbersome and expensive to manufacture.

In order to provide a printing system having a printing rate in excess of that which can be achieved by xerographic methods, the prior art has also attempted to develop a specialized type of cathode-ray tube including a face plate having a plurality of conducting wires embedded therein traversing the face of the tube, the conductive wires being insulated from one another and having their ends flush with the sides of the face plate. In theory at least the face plate permits the coded electron beam to be converted directly to a charge pattern which can be deposited on a recorded medium, a backing plate maintained at ground potential being positioned contiguous with the remote side of the record medium and adjacent the face plate of the tube for maintaining a uniform potential behind the record medium so that the charge deposited thereon in response to each charged conductor corresponds to the magnitude of the charge on each conductor.

While a prototype cathode-ray tube printing system of the foregoing type has been built which can achieve speeds which approach the speeds desired in present day computation and communication equipment, it still does not completely fulfill the desired speed requirements. Further, the system has proved to be extremely difficult to mechanize. For example, the individual wire conductors traversing the face plate must be uniformly spaced

and must be sealed to the insulating material vacuum tight, while the face plate itself must be affixed to the remainder of the tube envelope with a vacuum tight seal. In addition, for the system to print properly a dielectric material such as paper must pass adjacent the face plate in such a manner that it is always in contact with the exterior ends of all the wire conductors which are flush with the mosaic surface. However, because of the impossibility of producing an absolute planar exterior mosaic face many of the exterior ends of the wire conductors are not in contact with the dielectric material as it passes over the wires. As a result a clear image is not printed inasmuch as the electrostatic field established at the ends of the wire conductors attenuates rapidly even at rather small distances from the ends of the wires. Therefore, a distorted charge pattern is produced on those portions of the recording material not in contact with the ends of the charged wires, and the printing quality is inferior. In addition, the electron beam bombardment of the wire conductors tends to cause secondary emission of electrons within the tube which rain upon other wire conductors which have not been bombarded by the electron beam. Therefore, these wires also have a charge placed thereon which further reduces the clarity of the printed image.

It should also be noted that since the wire conductors must be placed a relatively substantial distance apart in order that the insulating material therebetween be of sufficient strength to resist the pressures exerted thereon as a result of the tube vacuum without cracking or developing leaks, a substantial portion of the electron beam will fall or impinge upon the insulating material rather than on the ends of the wire conductors. It is clear that the impinging of substantial portions of the electron beam on the insulating material rather than on the ends of the wire conductors extends the time necessary to build up a sufficient charge on the wire conductors to adequately charge the record material. Therefore, the overall speed of the cathode-ray writing tube is substantially limited.

However, the most important limitation of the cathode-ray writing tube of the prior art is that it is impossible to do half tone printing with the tube. In other words, only high contrast marks can be printed on the record medium. While this limitation may be of little importance in applications where it is desired to print only alphabetic or numeric characters, it renders the system incapable of reproducing or printing high quality pictures or photographs. Thus, the prior art cathode-ray writing tube cannot be used in applications requiring such uses.

As is apparent from the foregoing discussion, while the prior art cathode-ray writing tubes can print at a faster rate than mechanical printers, they still suffer from numerous limitations which seriously limit their usefulness. For example, they are extremely difficult and expensive to mechanize. Further, despite the fact that the printing speed of the cathode-ray writing tube is substantially improved, it is still substantially less than that required in a good number of present day applications. In addition, cathode-ray writing tubes of the prior art cannot be used in applications requiring the printing of half tones or in other words, where complete gray tone printing is required.

The present invention overcomes the foregoing enumerated and other limitations of the prior art devices by providing a mosaic face plate of novel design for use in mechanizing an improved high speed writing system capable of half tone printing as well as full contrast printing. The invention further provides a method of constructing a mosaic face plate which can be easily fabricated, the face plate having sufficient strength to withstand the pressures exerted thereon by the pressure dif-

ferentials between the exterior and the interior surfaces of the tube. In addition, in accordance with the present invention the conductive wires are affixed to the tube envelope with a highly reliable vacuum seal.

In accordance with one of the concepts of the present invention, the ends of the wire conductors traversing the face plate project out from the internal surface of the insulating material of the face plate whereby the secondary emission electrons which rain from the interior ends of the wire conductors are more easily attracted to an adjacent conductive wall on the inside surface of the tube envelope, thereby minimizing the probability that the secondary emission electrons will strike the surrounding wire conductors. Furthermore, projection of the interior ends of the wire conductors allows a much higher percentage of the electron beam to impinge upon the wire conductors rather than on the surrounding insulating medium. In this regard it should be noted also that the insulating material has a substantially longer life when protected from electron beam bombardment.

In accordance with another concept of the present invention, the percentage of the electron beam intercepted by the interior ends of the wire conductors is increased by building up the interior ends of the wire conductor ends. Accordingly, concomitant with the increase in the percentage of the electron beam impinging upon the wire conductors a smaller percentage of the beam impinges upon the insulating medium. Hence, the life of the insulating material is substantially increased.

In accordance with still another concept of the present invention, the exterior ends of the wire conductors project out from the exterior surface of the insulating material of the mosaic whereby the electrostatic field produced by the charged wires is restricted in radial dimension so that the electrostatic field projects out axially from the conductors. Hence, a charge is deposited upon the moving medium in accordance with the charges on the wire conductors regardless of the fact that the paper is not in contact with the conductors.

In accordance with a further concept of the present invention, half tone printing is accomplished by varying the magnitude of the charge deposited on the record medium as a result of each individual wire whereby the size of the spot printed on the medium varies from a little smaller than the diameter of the wire conductor to a size larger than the spacing between conductors. It is clear, of course, that this latter condition produces a blending of the charged areas or spots produced by each of the conductors in proximity to one another so that a pattern is printed having the highest contrast. On the other hand, it is clear that when the spot having the charge deposited thereon is smaller than the diameter of the individual charged wire, an area having a substantial gray tone is printed.

In accordance with another of the teachings of the present invention, a voltage is applied to the backing face plate positioned contiguous with the remote side of the recording medium and adjacent the face plate corresponding to the magnitude of the electron beam so that the transportation of the charges induced on the interior ends of the wire conductors in response to the modulating electron beam is assured to the exterior ends of the conductors. As a result, the magnitude of the charge induced on the ends of the wires adjacent the record medium can be varied over a wide range whereby full gray tonal scale printing is insured.

In accordance with another concept of the invention, there is provided a cathode-ray writing tube mosaic wherein the exterior ends of the wire conductors projecting out from the surface of the insulating material flare outwardly to increase the cross-sectional area of the ends whereby highest contrast printing is favored. This conductor configuration is highly desirable in writing tubes primarily designed to print alphabetic and numeric characters.

In accordance with the method of the invention, the

mosaic target structure may be fabricated by placing a plurality of fine wires on a sheet of vitreous insulating material, applying tension to the wires, heating the vitreous material, and embedding the wires in the vitreous sheet.

In accordance with another step of the present invention, the thin sheets of vitreous material are stacked one upon the other and are fused into a solid mass by application of heat and pressure to create a matrix array. Thereafter the fine wires may be made to project out from the surface of the insulating material by the additional step of etching the insulator back from the ends of the fine wires and flaring the projecting ends through a plating process whereby the ends of the wires are built up in size by metal deposits.

In accordance with one embodiment of the present invention a mosaic target structure is mechanized which is particularly suitable for producing the full gray scale tonal range. In this embodiment of the invention, the exterior and interior ends of the wire conductors traversing the mosaic insulating material project out from the insulating material and the interior ends of the conductors flare outwardly to provide a cross-sectional area at the interior ends which is substantially greater than the cross-sectional area of the conductor.

In a second embodiment of the invention a mosaic target structure is mechanized that is particularly suited for full contrast printing such as is desirable in printing alphabetic and numeric characters. This embodiment of the invention is substantially similar to the first embodiment of the invention except that the exterior ends of the conductors also flare outwardly to provide the exterior ends of the conductors with cross-sectional areas substantially greater than the mean cross-sectional area of the conductors.

It is therefore an object of the present invention to provide a mosaic face plate for use with a direct writing cathode-ray tube which permits full gray scale printing.

It is another object of the present invention to provide a mosaic face plate having a plurality of fine conductive wires embedded in and traversing an insulating body, the wires being affixed to the insulating body in a vacuum tight manner.

In accordance with a further object of the present invention, the ends of a plurality of wire conductors traversing a face plate project beyond the surfaces of the face plate, both interiorly and exteriorly.

In accordance with still another object of the present invention, the interior ends of the conductive wires projecting through the face plate flare outwardly so that they have a cross-sectional area greater than the mean cross-sectional area of the conductors whereby a higher percentage of the electron beam impinges upon the ends of the wire conductors.

It is still a further object of the present invention to flare outwardly the projecting exterior ends of the wire conductors to increase the cross-sectional area of the exterior ends whereby highest contrast printing is favored.

It is still another object of the present invention to provide improved gray scale tonal printing by modulating the conductive backing plate with a voltage corresponding in amplitude to the magnitude of the electron beam.

It is still another object of the present invention to provide a method of fabricating the mosaic face plate of the present invention.

The novel features which are believed to be characteristic of the invention, both as to its organization and methods of operation and fabrication, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawings in which several embodiments of the invention are illustrated by way of example. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only, and are not intended as a definition of the limits of the invention.

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FIGURE 1 is an isometric view, partly in section, of a high speed cathode-ray direct writing tube in accordance with the invention;

FIGURE 2 is a side elevational view of the mosaic face plate of the tube shown in FIGURE 1;

FIGURE 3 is a three-dimensional view of a fretted drum illustrating one of the steps in the method of fabricating a mosaic face plate in accordance with the present invention;

FIGURE 4 is a side elevational view of a stack of insulating sheets used in fabricating a mosaic face plate of the invention;

FIGURE 5 is an isometric view of a jig used in one method of fabricating the mosaic face plate;

FIGURE 6 is an isometric view of a mosaic face plate of the present invention illustrating the mosaic face plate after it has been molded but prior to finishing;

FIGURE 7 is a side view depicting one manner in which the face plate may be curved prior to incorporation of the tube; and

FIGURE 8 is a side view of a portion of an alternative form which the mosaic face plate may take in accordance with the invention.

Referring now to the drawings wherein like or corresponding parts are designated by the same reference character throughout the several views, there is shown in FIGURE 1 a high speed direct printing cathode-ray tube 11 which is operable in response to a code modulated signal generated by a modulated signal source 12 to produce visually the coded information by printing on an insulating material 13, such as paper.

As shown in FIGURE 1, tube 11 includes an envelope 14 which encloses an electron beam generator comprising a cathode 15 and a control grid 17 for producing an electron beam 19, and, in addition, two pairs of deflection plates operable for deflecting the electron beam to impinge at predetermined points upon a mosaic face plate 21 affixed to the front portion of tube envelope 14. As further shown in FIGURE 1, the code modulated signal from modulated signal source 12 is applied to grid 17 for selectively generating electron beam 19 having an intensity corresponding to the modulated signal. The deflection plates, are, of course, energizable from a source, not shown, to deflect the electron beam to scan the complete surface of mosaic 21 whereby the electron beam selectively bombards the surface of the mosaic in accordance with the modulated signal.

As indicated in FIGURE 1, mosaic target 21 includes an insulator having a plurality of fine conductive wires 25 embedded therein and traversing the face plate. When the ends of conductors 25 inside the envelope, hereinafter referred to as the interior ends, are bombarded by electron beam 19, an electrostatic charge is developed on the interior ends and this charge is transported to the exterior ends of the conductors. As shown in FIGURE 1, dielectric paper 13 is moved at a constant rate past the exterior ends of conductors 25, and is backed by a conductive backing plate 27 which is positioned contiguous with the remote side of paper 13 and adjacent face plate 21. As will be apparent to one skilled in the art, the charged exterior ends of conductors 25 generate an electro-static field which induces a charge on those portions of paper 13 which pass adjacent the charged conductors. Hence, the charge pattern produced on the face plate conductors is transferred to paper 13.

It will be recognized that the charged pattern induced on the surface of paper 13 can be developed or processed to produce a visual image in a number of ways. For example, a pigmented powder or dust can be automatically or manually sprinkled over the surface of paper 13 whereby the pigmented particles will adhere to the charged areas. To further insure that the particles adhering to the charged areas on paper 13 remain affixed to the paper, the paper can be heated and a thin molten layer of wax can be applied to the paper surface. Upon

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cooling and hardening the wax will thus mechanically affix the pigmented particles to the paper and a permanent printed image will be produced on paper 13 corresponding to the code modulated signal.

Referring now more particularly to mosaic face plate 21, attention is directed to FIGURE 2 wherein there is shown a side elevational view of the mosaic structure and backing plate 27. As indicated in FIGURE 2, the exterior surface of face plate 21 is substantially planar while the interior surface of the face plate is curved, the interior side of the face plate being curved, of course, so that it can better resist the pressures exerted on the face plate due to the lack of internal air pressure resulting from the tube vacuum. As is shown in FIGURE 2, the ends of conductors 25 on both the interior and exterior sides of the face plate project out from the surfaces of the face plate a predetermined distance. Further, as shown in FIGURE 2, the interstitial spacing of the conductors is substantially greater than the wire diameters in order that there be sufficient insulating material between the embedded conductors so that the insulating material can resist the pressure differentials exerted thereon without developing vacuum leaks.

In accordance with the invention each of the projecting interior ends of the conductors is outwardly flared so that the perimeters of the interior ends of each of the conductors almost touches the perimeters of the ends of the adjacent conductors in order to prevent the electron beam from impinging on the space that would exist between the interior projecting ends of the conductors were they to have the mean or average cross-sectional area of the conductors. Hence, the interior surface of the face plate is shielded from bombardment by the electron beam and concomitantly substantially all the electron beam impinges upon the selected wire conductors thereby decreasing the time necessary for the conductors to develop charges of sufficient magnitude to print on paper 13. Accordingly, the speed of operation of the printing system of the present invention is substantially greater than that of prior art devices.

Directing attention now to the physical properties of the insulating material which generally comprises the body of the face plate, the insulating material should have a low dielectric constant and minimum hysteresis effects. Furthermore, the dielectric material should be complementary in its physical characteristics with those of the metal conductors especially with respect to the coefficient of thermal expansion, which should be substantially the same. In addition, the insulating material should be so chosen that a true molecular seal can be achieved between metallic conductors 25 and the insulating material.

Among the materials suitable for use as the insulating material are ceramic or glazed materials. For example, a lead-potash glass, No. 8871, manufactured by the Corning Glass Company, has been used on a number of occasions as the insulating material of the face plate with satisfactory results.

Continuing with the description of FIGURE 1, the operation of backing plate 27 in conjunction with face plate 21 to enhance full gray scale printing will now be discussed. As has been hereinbefore mentioned, the interstitial spacing between the conductors is a number of times greater than the size of the conductors. Hence, the resultant charge pattern produced by an individual wire conductor can be made to vary in size from a condition where the pattern is somewhat smaller than the wire itself to where the image is substantially larger than the interstitial spacing between the wires. Of course, the size of the image corresponds to the charge positioned on the exterior end of each individual conductor so that the greater the range of variation of charge magnitude that can be obtained on the exterior ends of the wires the greater will be the range variation in the size of the individual image pattern produced on paper 13.

In prior art printing tubes the structure equivalent to

backing plate 27 has been maintained at a fixed potential, such as ground potential. However, with a fixed potential on backing plate 27 it has been found that it is impossible to achieve the full range of variation of charge magnitude on the exterior ends of the conductors necessary to obtain the full range of image sizes needed for full gray scale printing. For example, if the potential on the backing plate is determined in such a manner that the system is capable of printing images somewhat smaller than the wire conductors, it has been found that the potential will not be of sufficient magnitude to insure that the charge deposited on the interior ends of the conductors by a high intensity electron beam will be transported to the exterior ends of the conductors with sufficient speed to print the enlarged size image corresponding to high intensity electron beam. Moreover, it has been found that excessive secondary emission is experienced when charge is not transported from the interior ends of the conductor to the exterior ends with promptness. Hence, the clarity of the printing is impaired.

As shown in FIGURE 1, in accordance with the present invention, the modulated signal which controls the intensity of the electron beam is applied to the backing plate through a non-inverting amplifier 31. Therefore, when a small intensity electron beam is generated and it is desired to produce an image somewhat smaller than the diameter of the conductive wire, the voltage applied to backing plate 27 is reduced. However, when a large intensity electron beam is generated and it is desired to produce an image pattern substantially larger than the spacing between conductors the voltage applied to backing plate 27 is substantial so that the prompt transportation of the charge from the interior ends of the conductors to the exterior ends is insured. Hence, the full range of tones from slight gray to high contrast black can be printed with a system mechanized in accordance with the teachings of the present invention. Further, since the movement of charge along the conductors is faster than in prior art devices the printing speed of the system is substantially increased.

In view of the foregoing, it is clear that the unique geometry of the conductors and the face plate as taught by the present invention not only permits full tone printing but decreases the time necessary to build up a sufficient charge on the exterior ends of the conductors to print an image on paper 13 whereby the overall printing speed of the present invention is substantially greater than that of prior art devices. Further, in conjunction with the foregoing features the application of a modulated voltage to backing plate 27 further increases the clarity of the printed image as well as increasing the printing speed and the overall tonal range capability of the system.

Referring now to one method of fabricating face plate 21 of the invention, a number of thin sheets of vitreous insulating material are thoroughly cleaned to remove therefrom foreign materials such as grease, adherent oxides, and dusty chemical residues. Furthermore, a roll of fine conductive wire is also thoroughly cleaned to remove all foreign matter therefrom. The exact manner of cleaning will vary somewhat depending upon the nature of the contaminants and the basic atmosphere to which the raw materials have been exposed. Electro-polishing has been found to be a satisfactory method of cleaning the wire if preparatory to the electro-polishing, standard de-greasing procedures are used. In the case of the vitreous sheets, if glass, for example is used, a simple fluid bath is usually satisfactory.

It should be noted, that both the vitreous sheets and the wire are cleaned because foreign materials tend to prevent the proper oxide conditions from being achieved as well as preventing the proper intimate contact between the sheet and the conductors. Thus, if the materials are not cleaned the metallic oxides in the vitreous sheet would

be reduced and voids or bubbles would be formed in the mosaic structure.

As indicated in FIGURE 3, the cleaned fine wire is wrapped in a helix around a fretted drum 50 and then cut. Next as shown in FIGURE 3, one sheet of vitreous material is positioned on top of the wire between each pair of frets on drum 50. Then, the remaining wire is wrapped in a helix around the fretted drum on top of the sheets of vitreous material whereby the sheets are affixed to the drum.

In the foregoing described manner a "sandwich" consisting of two layers of wire imprisoning individual insulating sheets is formed between each of the frets on the drum. It should be noted that the drum should be constructed of a material having a higher coefficient of expansion than the wire and the insulating material comprising the sheets. More particularly, the diameter of the drum and the coefficient of expansion thereof should be so selected that when the drum, wire, and vitreous sheets are heated, the wire is stretched almost to the yield point so that during the critical interval wherein the wire and the vitreous material of the sheets are intersealed, the individual wires are taut and in a true cylindrical condition.

In accordance with the next step in fabricating the mosaic, the drum with the sandwiches thereon is placed in an air atmosphere oven, heated to a predetermined temperature range which is sufficient for fusing the metal and the vitreous insulating material. After fusion, or in other words, after the metal to vitreous sealing, the drum is allowed to cool gradually to room temperature and the metal and vitreous material sandwiches are stripped from the drum. Next, the individual sandwiches are separated by cutting the wires interconnecting them, and they are stacked alternately with sheets of vitreous material not having wires embedded therein, as shown in FIGURE 4.

The stack of vitreous sheets shown in FIGURE 4 is next invested or wrapped in thin aluminum foil. As shown in FIGURE 5, the invested package is placed in a forming jig 35 which includes a hinged weighted top 37 which tends to compress the package in the direction indicated in FIGURE 5 and a pair of restraining bars 39 and 41 which tend to apply a limited amount of restraint to the sides of the package adjacent the bars.

Continuing with the discussion of the invention, jig 35 is placed in an air atmosphere oven which is gradually heated until the vitreous material becomes soft whereby the package is compacted. In this regard, jig 35 is operable to apply pressure to two surfaces of the invested package and restraint to two other surfaces whereby a compact resultant of uniformly distributed wire in a homogeneous base of insulating material is obtained. It should be noted that if too much restraint is exerted on the package a non-uniform distribution of wire will result. Further, if inadequate pressure is applied air trapped between the vitreous sheets will not bleed out of the structure and voids in the insulating structure will occur which will ultimately lead to vacuum leaks. In addition, it should be pointed out that an excess of pressure or an excess of restraint or no restraint and no pressure will produce a poor geometric configuration. After the package has been compacted it is allowed to gradually cool to room temperature and as indicated in FIGURE 6 the package is sliced to produce a rectangular portion having a predetermined width.

Continuing with the description of the process of the invention it should be noted that while the subsequent steps in fabricating the face plate can be performed in any order, the order herein now described has been found to produce quite satisfactory results. In accordance with this order, one of the sides of the sliced portion having wire embedded therein is etched with an etching solution so that the vitreous material is removed away from the ends of the wire conductors embedded therein whereby the ends project out from the insulating material. The etched

face should then be rinsed thoroughly with a passifying solution to arrest the corrosive action of the etching solution.

The mosaic thus produced is then curved by heating and placing the mosaic on a cylindrical mold as shown in FIGURE 7. After the cylindrical shape has been achieved, the outer or exterior surface is then made planar by cutting the spherical surface away, as indicated by the dash line in FIGURE 7. The planar surface of the mosaic is then etched away in the same manner heretofore described so that the ends of the conductors associated therewith project out from the exterior mosaic surface.

In order to achieve the outward flare on the interior ends of the conductors described in connection with the invention, the projecting ends of the conductors associated with the curved surface of the mosaic are placed in a plating solution and built up in size by plating. After the plating operation has continued for a period of time sufficient to increase the projecting ends of the wire sufficiently in size they are milled so that the ends have the general configuration shown in FIGURE 2.

The completed mosaic face plate is then sealed to the rest of the tube envelope by use of a vitreous material having a melting point lower than that of the face plate. In this regard it should be noted that it is preferable to place a supplemental layer of the low melting point vitreous material on the inner and outer surfaces of the mosaic face plate before sealing it to the tube envelope to insure the vacuum tightness of the fit.

It is evident that numerous modifications and alterations may be made to the foregoing described embodiment of the invention as well as in the foregoing described process without departing from the scope of the invention. For example, the embodiment may be modified so that it is more suitable for use in applications where full contrast printing is favored, as for example, in systems which are to print mainly alphabetic or numeric characters.

In this regard, attention is directed to FIGURE 8, wherein there is shown a side elevational view of a modified face plate 21 for use in a second embodiment of the invention which is mechanized to print primarily alphabetic and numeric characters. As is shown in FIGURE 8, face plate 21 of the second embodiment of the invention differs from that of the first embodiment in that the exterior ends of the conductors as well as the interior ends flare outwardly to increase the cross-sectional end area of the exterior ends. It is apparent that with conductors having this geometry, images will be produced whose sizes are equal to or greater than the spacing between conductors. Therefore, the individual images produced by the individual conductors will tend to blend with one another so that full contrast printing is assured.

It should be noted that in the prior art the foregoing was a serious problem since the spacing between conductors must necessarily be a number of times greater than the size of the conductors in order that the insulating material therebetween will have sufficient strength to maintain a vacuum seal. Thus, since the conductors were spaced at such relatively great distances apart, relatively large magnitude charges had to be placed on the exterior ends of the conductors in order to insure full contrast printing. However, as has been heretofore explained, the placing of relatively large magnitude charges on the exterior ends of the conductors of prior art writing tubes was exceedingly difficult and relatively time consuming.

It will, of course, be recognized that numerous modifications and alterations may be made in the cathode-ray direct writing tube herein disclosed without departing from the spirit or scope of the invention. For example, cathode-ray tube 11 of FIGURE 1 could be modified by inserting a character stencil therein so that a very high speed character printing tube could be mechanized.

What is claimed as new is:

1. In the method of treating a mosaic vitreous target

structure having a plurality of fine wires imbedded therein running from a first side of the structure to a second opposite side, the combination of steps comprising: heating the vitreous structure to make it flexible; bending the structure to make the first side convex and the second side concave; and cutting the first side to provide a planar surface.

2. The combination of steps defined in claim 1 which further includes etching back the first and second sides of the vitreous structure whereby the wires project from the sides.

3. The combination defined in claim 2 which further includes the step of plating the projecting portions of the wires.

4. In the method of treating a mosaic glass structure having a plurality of spaced transverse wires therein, the combination of steps for affixing the structure to the face of a cathode-ray tube in such a manner that the tube is sealed vacuum-tight, said steps comprising: fusing a low melting point sheet of glass on the mosaic surface of the glass structure; positioning said glass structure next to the face of the tube; applying frit glass to the structure and to the face of the tube; fusing the glass structure to the tube by melting the frit glass.

5. In the method of making a mosaic glass target structure having a plurality of wire arrays therein, each including a plurality of fine wires, the combination of steps comprising: placing first and second arrays of fine wires across first and second strips of glass, respectively; establishing tension on the wires; heating the glass strips to embed the arrays of wires in the strips of glass; and sandwiching a third strip of plain glass between the first and second strips of glass.

6. In the method of making a mosaic glass target structure having a plurality of rows of fine wires therein, the combination of steps comprising: placing a first row of fine wires across a first strip of glass; putting tension on the wires, heating the glass to embed the wires in the glass; placing a second row of fine wires across a second strip of glass; putting tension on the wires; heating the second strip of glass to embed the second row of wires in the second strip of glass; placing a third strip of glass between said first and second strips; and combining under pressure the three strips to produce a composite mosaic structure.

7. The method of making a mosaic target structure for a cathode-ray tube, the combination of steps comprising: cleaning a plurality of thin sheets of vitreous material; cleaning first and second lengths of fine wire; winding the first length of wire around the circumference of a fretted drum a predetermined number of times; placing one of the plurality of sheets of vitreous insulating material on the first wire between a different pair of drum frets; winding the second length of wire around the drum and the sheets of vitreous insulating material; heating the drum and the sheets of insulating material to embed the first and second lengths of wire in the plurality of sheets of insulating material; and cutting the first and second lengths of wires at predetermined points to separate the sheets of insulating material from one another.

8. The combination of steps defined in claim 7 which further includes the steps of stacking the thin sheets of insulating material with wires embedded therein on top of one another and sandwiching a thin sheet of vitreous material between each of the stacked sheets having wires embedded therein.

9. In the method of making a mosaic target structure having a plurality of fine wires embedded therein, the combination of steps comprising: cleaning a plurality of fine wires; cleaning a sheet of vitreous insulating material; placing the plurality of fine wires on the sheet of vitreous insulating material; applying tension to the wires; heating the vitreous sheet to embed the wires in the vitreous sheet.

10. The combination of steps defined in claim 9 includ-

ing the additional steps of sandwiching a plain sheet of vitreous insulating material between two sheets of vitreous material having wires embedded therein.

11. In the method of making a mosaic vitreous target structure having a plurality of rows of fine wires therein, the combination of steps comprising: placing a first row of fine wires across a first strip of vitreous material; putting tension on the wires, heating the vitreous material; embedding the wires in the vitreous material; placing a second row of fine wires across a second strip of vitreous material; putting tension on the wires; heating the second strip of vitreous material to embed the second row of wires in the second strip of vitreous material; placing a third strip of vitreous material between said first and second strips; and combining under pressure the three strips to produce a composite mosaic structure.

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