

July 29, 1969

P. A. STOWELL
METHOD AND APPARATUS FOR IMPROVING THE PERFORMANCE OF
ELECTROSTATIC PRINTING TUBES

3,458,752

Filed April 2, 1965

3 Sheets-Sheet 1

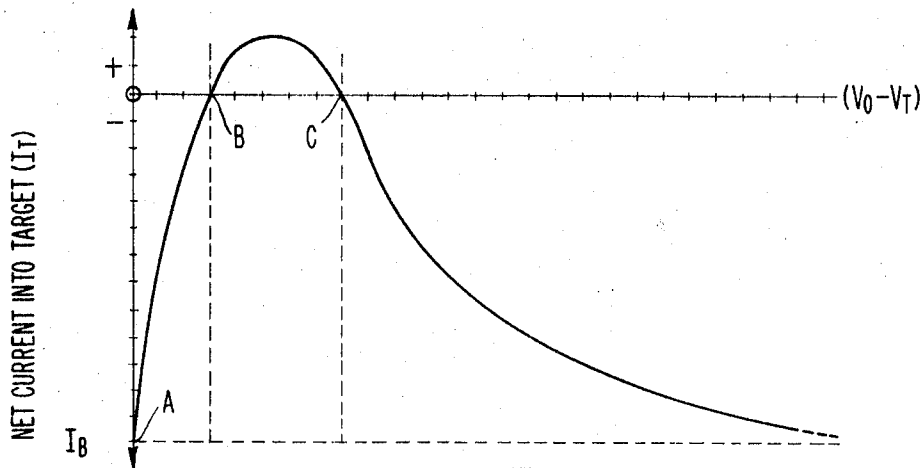


Fig. 1

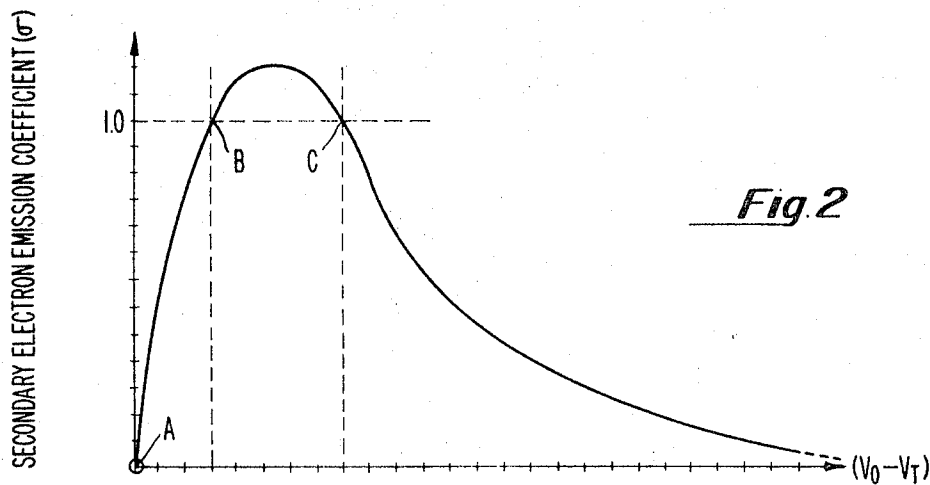


Fig. 2

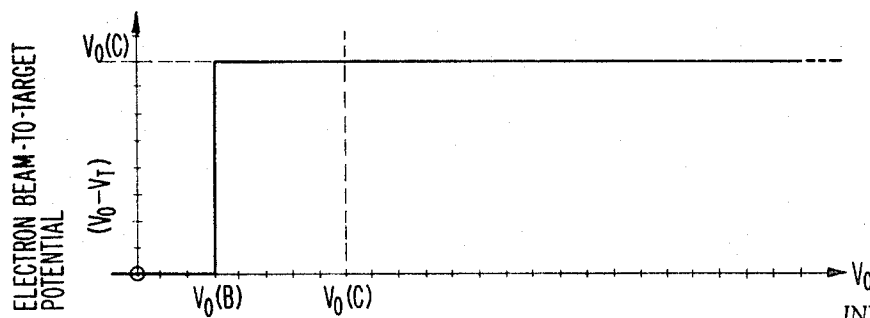


Fig. 3

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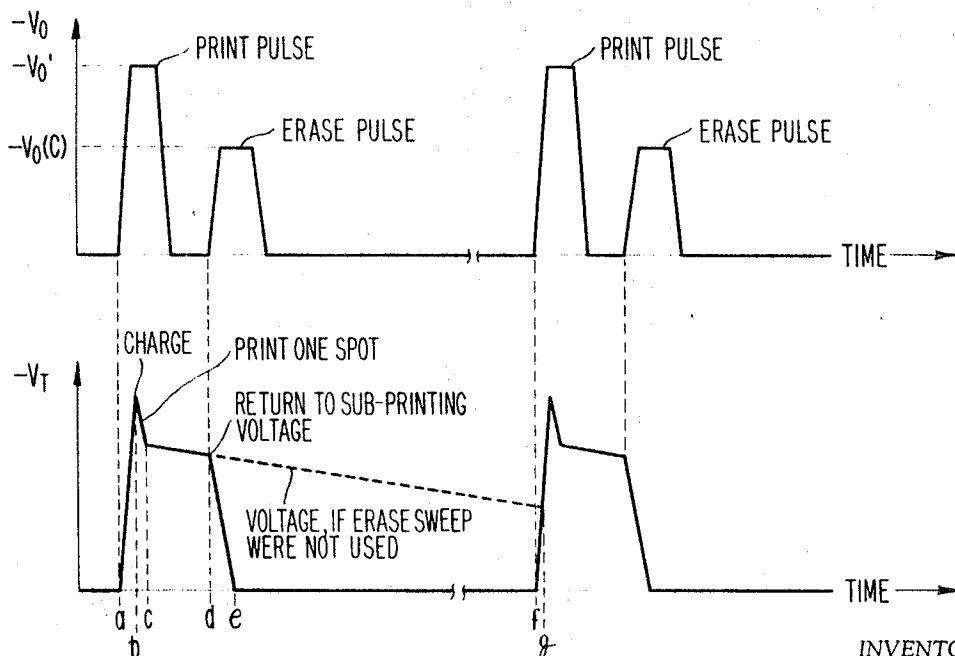
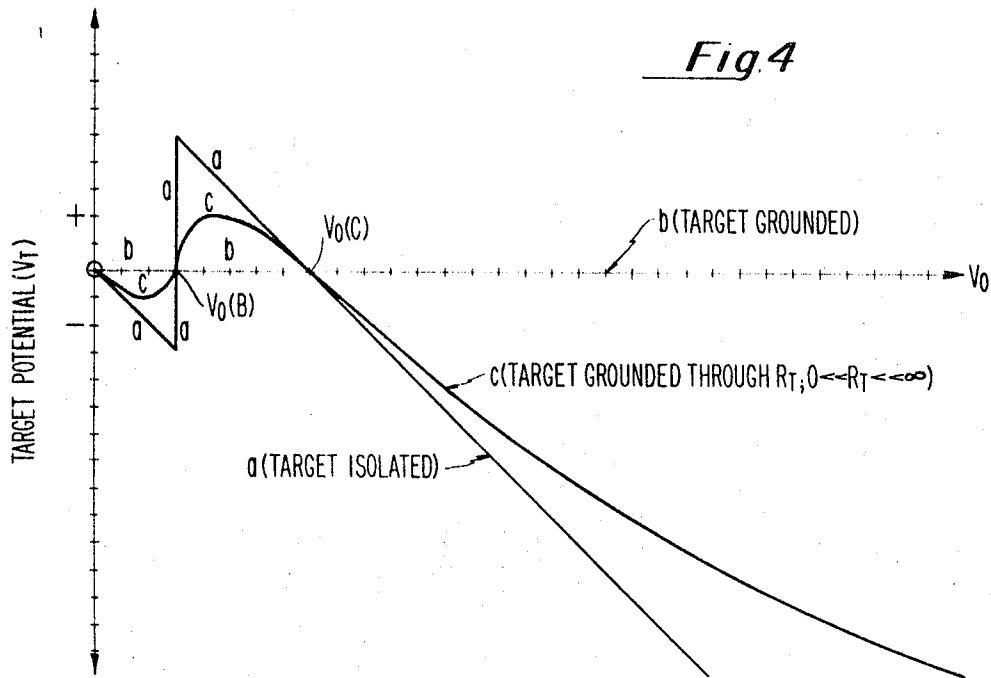


Fig 6

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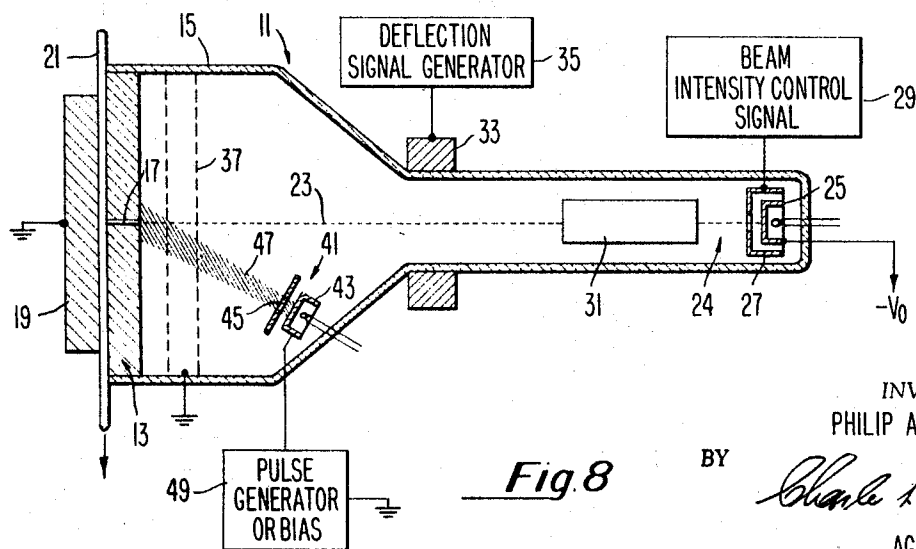
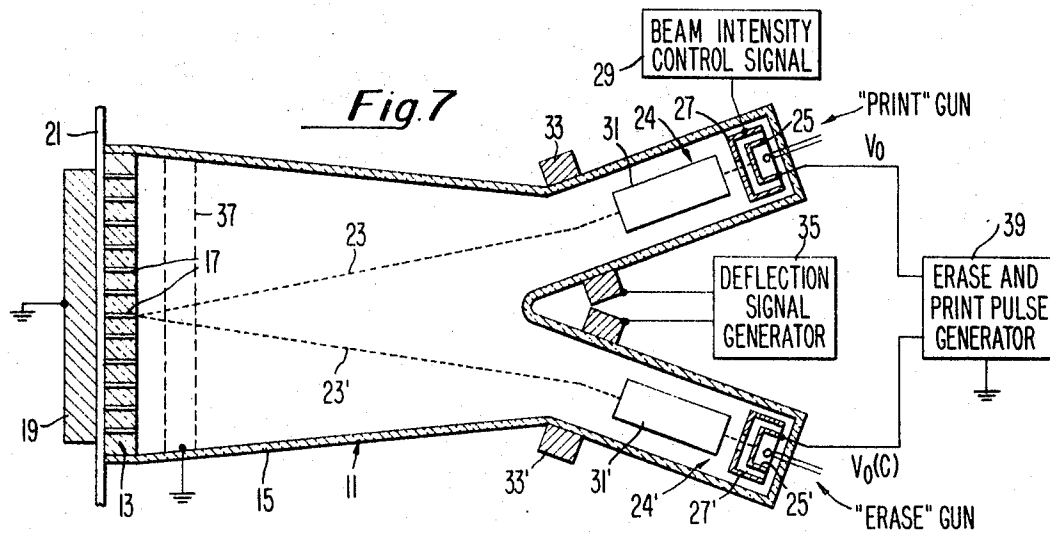
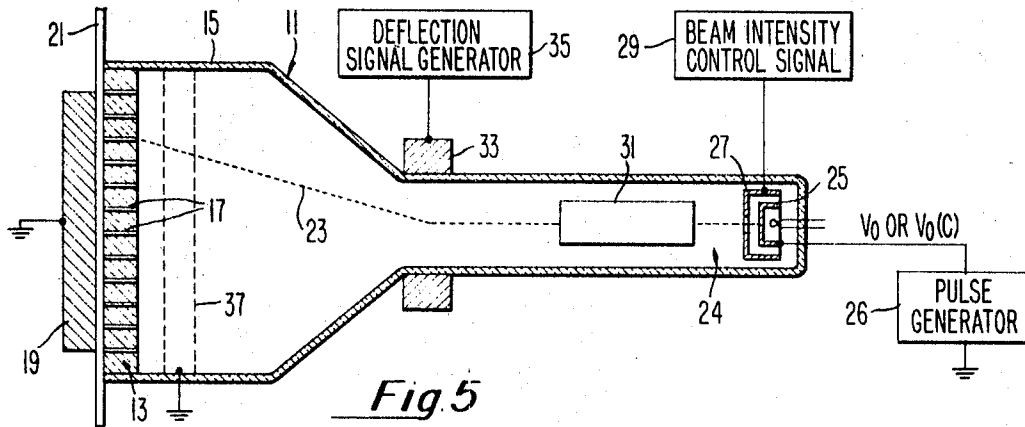
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METHOD AND APPARATUS FOR IMPROVING THE PERFORMANCE OF ELECTROSTATIC PRINTING TUBES

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17 Claims

ABSTRACT OF THE DISCLOSURE

A method of and apparatus for rapidly discharging, immediately after latent printing, an array of printing electrodes embedded in the face of an electrostatic printing tube. Said rapid discharge precluding the selected printing electrodes from experiencing protracted discharge to a dielectric recording medium being printed upon thereby preventing streaking of latent images being printed and said rapid discharge precluding the unselected printing electrodes which accumulate excess charge from experiencing discharge to the dielectric thereby preventing disruption of the printed information. Said rapid discharge takes place as a result of an electron beam of energy being imposed upon said printing electrodes at a potential such that the secondary electron emission coefficient of the bombarded printing electrodes exceeds unity, said bombardment taking place immediately after printing and prior to said dielectric moving sufficiently to cause said printing electrodes to discharge repeatedly and thereby cause streaking and disruption of the printed image.

This invention relates to electrostatic printing tubes, and more particularly, to a method and means for improving the performance of such tubes.

Electrostatic printer type cathode ray tubes have been studied experimentally for many years and are now commercially available. Typically, such tubes comprise a cathode ray gun for generating an electron beam, a deflecting coil for aiming the beam, and a faceplate having an array of parallel printing electrodes such as plugs, wedges or pins embedded therein. The pins penetrate the faceplate, extending from the inner to the outer surface thereof. In such operation, electrostatic images are deposited upon a dielectric record medium, such as paper, drawn past the faceplate, by directing the electron beam upon selected printing electrodes or pins, which discharge onto the record medium.

The quality of the printing obtainable with such tubes has not been entirely satisfactory because of an unfortunate characteristic which has proven difficult to correct. This characteristic is a persistent trailing of the printed marks, which represents discharges that are protracted to times long after the electron beam in the tube has charged up the printing electrode and moved on. As the paper moves past charged electrodes, they print not once, as would be desired, but many times in rapid succession or continuously. The reason for this is that the capacitance of an individual electrode or "pin," is many times the capacitance of the small circular area of the dielectric printing medium under the pin if only a single discharge occurred.

The ratio of pin to dielectric spot capacitance has been calculated to be of the order of five to as high as 12.5 to one. Thus, a single discharge does not sufficiently reduce the pin potential to prevent its firing again when an uncharged area of dielectric replaces the charged area as the paper moves, and such firing will occur a number of times as the paper moves until, at last, the

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pin potential drops below the threshold level necessary for firing. Such tubes cannot print round spots at each pin position, but instead print streaks five to ten times as long as they are wide. Reduction of pin capacitance and/or increase of the capacitance of the dielectric printing medium to an extent sufficient to completely prevent this effect has not proven practical to achieve.

Another difficulty has been the practical impossibility of printing a single firing electrode or pin without adjacent unselected pins firing also. Although the beam sweeps across only a single pin and the glass near it, one or two of the next adjacent pins, although not swept, may also print due to being charged up by secondary electrons from the pin and glass which were swept over by the high energy beam.

It is therefore an object of this invention to improve the performance of electrostatic printing tubes.

It is still another object of this invention to discharge very rapidly the faceplate and printing pins of an electrostatic printing tube.

It is a further object of this invention to eliminate streaks and unwanted spots in the image produced by electrostatic printing tubes.

These and other objects are achieved by a method and apparatus whereby printing electrodes, typically plugs, wedges or pins, which have become charged for printing, are rapidly discharged by means of secondary electron emission induced by electron bombardment from an "erasing" beam of electrons. The "erasing" beam is set at a potential at which those pins which have just printed are caused, when hit by the "erasing" beam, to emit more electrons than they receive from it, until the net loss of electrons brings pin potentials below printing level.

According to a first embodiment of my invention, a single electron gun is pulsed on alternate sweeps between two potential levels—one for printing, the other for erasing. The erasing voltage level is considerably lower than the writing level, being designed to fall on that portion of the secondary coefficient ratio curve of the printing pins in which the ratio is greater than one.

A second form of my method involves the use of two electron guns, the first for printing and the second for erasing. Both guns are caused to sweep the array of pins in the faceplate, the "erasing" gun beam lagging slightly behind the printing gun's beam, the lag being so designed as to allow selected pins to transmit their charge onto the printing medium for a predetermined short period of time, after which they are discharged by the "erasing" beam.

The third and preferred embodiment of my invention also involves the use of two electron guns. However, in contrast to the previous embodiment, the "erasing" gun generates a stationary ribbon-shaped beam covering the whole array of pins with a shower of electrons at the appropriate voltage level. The erasing gun in this embodiment may either be left on at all times to act as a constant drain of electrons, the effect of which is temporarily overridden by the writing gun, or, alternately, the erasing gun may be turned on shortly after the writing gun has operated.

While some of the objects and a brief description of the invention have been given above, the invention and its objects will be best understood by referring to the following detailed description and to the accompanying drawings wherein:

FIG. 1 is a plot of net current into a target vs. the difference between target and electron beam potential;

FIG. 2 is a plot of the secondary electron emission coefficient vs. the difference between target and electron beam potential;

FIG. 3 is a plot of the difference, at equilibrium, between target and electron beam potential vs. electron beam potential;

FIG. 4 is a plot of target potential, at equilibrium, vs. electron beam potential;

FIG. 5 illustrates one embodiment for practicing my invention, a cathode ray printing tube, employing a single cathode gun;

FIG. 6 is a plot of voltages applied to the apparatus illustrated in FIG. 5, and a plot of the voltage levels of charged printing pins;

FIG. 7 is an illustration of a second type of cathode ray tube for practicing my invention, employing two cathode guns;

FIG. 8 is an illustration of a third type of cathode ray tube for practicing my invention, having an erasing gun with a "ribbon" type cathode.

To understand the phenomenon of secondary emission utilized by my invention, consider a surface of some material onto which an electron beam is impinging in a vacuum. As long as this surface is less negative than the cathode from which the electron beam is being emitted, the beam will have sufficient energy to hit the surface if aimed at it and most of the incident beam electrons will "stick" to the surface after hitting it. But it is known that some electrons may be re-emitted from this surface while it is under bombardment by the beam; these electrons, which are known as secondary electrons are emitted with energies low compared to the energy of the primary electrons in the incident beam.

Whether and to what extent secondary electrons are emitted depends upon the composition and physical state of the surface layer of material and the energy (voltage) of the primary electrons. For a given combination of conditions, a particular ratio between secondary and primary electron currents will exist; this ratio is known as the secondary electron emission coefficient.

If the secondary electron emission coefficient were zero, all the electrons striking a surface would remain there and no "secondaries" would be emitted. If it were unity, the secondary electron current from the surface would equal the primary electron current into it, so there would be no net current either way across the surface. If the secondary emission coefficient lies between zero and one, there will be a net electron current into the surface which is less than the beam current. It is possible for the secondary electron emission coefficient to exceed one, in which case the secondary emission current exceeds the beam current and a net electron current out of the surface results.

If the object whose surface is under consideration be electrically isolated so that there can be no paths for current flow to or from it other than those primary and secondary electron currents, then the object will gain or lose charge as necessary until its electrical potential with respect to the cathode of the electron gun reaches the value for which the secondary electron emission coefficient of its surface exactly equals unity. If a surface has a net gain of electrons, its potential will become more negative; if it suffers a net loss of electrons, it will become less negative. For a given material surface the secondary electron emission coefficient can be measured and will be found to vary significantly with voltage.

In order to print electrostatically, with a cathode ray tube designed for this purpose, it is desirable that the pins in the faceplate be driven to a high negative voltage. It is from this voltage that the pins discharge to the dielectric which is being imaged. Such a discharge is extremely fast and occurs very soon after the pin reaches printing potential.

Paper motion while the pin is being charged by the electron beam and during the printing discharge is negligible. No further printing occurs at the same spot, since the potential on the charged dielectric reduces the net potential from pin to dielectric at that point to a value

below the threshold for breakdown of the air gap between the pin and the dielectric. However, as previously stated, printing will occur as the paper moves past the pin to bring uncharged dielectric into position for printing, because the pin capacitance is comparatively high relative to the dielectric capacitance of a single spot so that a single printing discharge does not sufficiently reduce pin potential to prevent its firing again over uncharged dielectric.

According to my invention, protracted discharging of selected pins is prevented by showering the pins with electrons which are at an energy for which the pins' secondary electron emission coefficient is greater than unity. After selected pins have been charged up negatively with the printing beam and allowed to print, the excess negative electrical charge remaining on the pins after printing will be re-emitted and the pin voltage will be driven down so they will not print again. When paper motion under the pins becomes appreciable so that uncharged dielectric is brought into printing position, no printing will occur because, by this time, pin voltage will be too low to initiate a discharge. Thus, the undesirable protracted printing effect will have been prevented by "erasing" the excess charge from the pins from within the tube, instead of relying on the external discharge to the dielectric to bleed it off. Using this technique, it is possible to print small, round spots instead of elongated streaks.

Firing of unselected pins due to secondary electron coupling is prevented by dropping the pin and glass potential as quickly as possible after printing. To this end, pins and glass are showered with lower energy electrons so as to cause them to re-emit their excess charge. By so doing, the accumulation of charges on unselected pins may be kept from becoming high enough for these pins to print. This technique provides improved printing resolution by preventing printing of unselected pins as well as by eliminating protracted discharges.

The following is a more detailed description of the behavior of the secondary electron emission phenomenon and its effect on the current into, and potential of, a surface which may be one end of a printing pin, under electron bombardment. V_0 is the negative potential with respect to ground of the cathode from which an electron beam is being drawn. The beam current I_B is assumed to be held constant regardless of V_0 .

FIG. 1 represents I_T , the net current flowing into the target surface is receiving the electron beam. The negative potential with respect to ground of this target is V_T . Its net potential relative to the cathode is $(V_0 - V_T)$. With increasing values of $(V_0 - V_T)$, the current I_T , in terms of conventional current flow, rises from a negative value, at $(V_0 - V_T) = 0$, to zero. It then flows in a positive direction, i.e., into the target, increasingly and then decreasingly, crosses zero again, and goes negative, coming back toward I_B as a limit.

Since I_B is constant, the variation of I_T with different values of $(V_0 - V_T)$, as shown in FIG. 1, must be attributed to the variation with $(V_0 - V_T)$ of the current I_s , representing secondary electron emission. The current I_s can therefore be calculated as the algebraic sum

$$(I_B + I_T)$$

The curve of FIG. 1 could also represent I_s if the zero axis (abscissa) were shifted downwards to the level marked I_B and the present axis were assigned the value I_B . Thus when I_T is positive, I_s is greater than I_B . The ratio (I_s/I_B) may be called σ , the secondary electron emission coefficient; this quantity is plotted in FIG. 2, and because I_B is assumed to be a constant, the shape of the plots of FIGS. 1 and 2 match.

The abscissae of FIGS. 1 and 2 are the same and are plotted in register, so points on the same vertical line in both curves correspond to the same voltage. At point A of FIG. 2, $(V_0 - V_T) = 0$, $I_s = 0$, $I_T = I_B$, and $\sigma = 0$. At point

B, $I_T=0$, the slope of I_T with respect to (V_o-V_T) is positive, $I_s=I_B$, and $\sigma=1$. Finally, at point C, $I_T=0$, the slope of I_T with respect to (V_o-V_T) is negative, $I_s=I_B$ and $\sigma=1$.

If the target is perfectly insulated from ground, it will become progressively charged up by I_T until its potential becomes such that $I_T=0$. This will be a point of stable equilibrium. Consider FIG. 2 as it applies to such a case: If (V_o-V_T) lies between points B and C, I_T is positive and the target potential V_T tends to become more positive with respect to ground. This increases (V_o-V_T) since V_o is negative with respect to ground. As (V_o-V_T) increases, the operating point of the target will move to the right along the curve until it reaches point C, where it will remain, since at that point $\sigma=1$ and $I_T=0$, so that further charging of the target ceases.

Now consider any point to the right of C, in FIG. 2. By the above reasoning, I_T is negative, V_T becomes more negative, (V_o-V_T) decreases, and the operating point will shift to the left along the curve until point C is reached, where again charging will stop and the target will remain. Thus point C is a point of stable equilibrium, to which the isolated target will always go, if the initial value of (V_o-V_T) is to the right of point B.

Finally, consider a point to the left of B. Again I_T is negative, V_T moves negatively, (V_o-V_T) decreases, and the operating point shifts to the left along the curve until $(V_o-V_T)=0$. Now, since the target and cathode potentials are the same, the beam current hits the target with zero velocity, theoretically. There is a discontinuity at this point, however. If V_T becomes any more negative the beam velocity into the target becomes negative, i.e., the beam is repelled from the target by its potential and cannot hit it at all. Therefore I_T abruptly becomes zero at $(V_o-V_T)=0$, and remains zero for all more negative values of V_T . Consequently the target must remain at cathode potential, at point A. Point A is thus another point of stable equilibrium.

If (V_o-V_T) were placed exactly at point B, the target would remain there, but if any net charge whatever leaves or enters the target, the target will move to the right to C or to the left to A, respectively. Thus B is a point of unstable equilibrium.

From these facts the equilibrium potential difference between the cathode and an isolated target may be plotted as a function of cathode potential under the conditions that $V_T=0$ initially, and that the beam is not turned on the target until the cathode is at its intended potential. FIG. 3 is such a plot, and shows that (V_o-V_T) can have either of two values only, zero or $V_o(C)$, depending on whether V_o is less or greater than $V_o(B)$.

The straight curve *a* of FIG. 4 was derived from FIG. 3 by subtracting (V_o-V_T) from V_o , and is therefore a plot of isolated target potential V_T versus cathode potential V_o . Except at the discontinuity at $V_o(B)$, the slope of the curve $dV_T/dV_o=1$ for all values of V_o .

If the target is firmly grounded, $V_T=0$, noted as straight curve *b* lying on the horizontal axis. But if the target is grounded through a significantly great but not infinite resistance R_T , I_T flowing through R_T will generate a voltage drop that will put the target at some intermediate potential. This is represented in FIG. 4 by the intermediate, smooth curve *c*. Curve *c* represents the most practical case, since a grounded target is of no practical use and a truly isolated target is nearly impossible to achieve.

As an application of FIG. 4 according to my invention, assume that each division represent negative 1,000 volts on both ordinate and abscissa. Then $V_o(B)=-3,000$ volts and $V_o(C)=-8,000$ volts. If initially the printing beam potential V_o is set at $-12,000$ volts and the target is hit, V_T will go to $-3,300$ volts. If the target, a printing pin, is allowed to print to one spot on the dielectric, its voltage may drop about 400 volts, to $V_T=-2,900$ volts, as illustrated in FIG. 6. The pin voltage will continue to drop even if further printing does not occur, because of

the pin's resistive connection to ground. The rate of drop will be determined by the pin's capacitance and resistance to ground. Ordinarily, this drop will be sufficiently slow to be negligible for purposes of this discussion. Hence, if the paper moves under the pin, the pin will print again and again until pin voltage has dropped to perhaps -500 volts, which is too low for further printing. It is this repeated or protracted discharge which is undesirable. However, if before the paper has moved, the pin is scanned again with the beam, the pin may move to a new operating point.

If swept again at $V_o=-12,000$ volts, the pin will recover to $-3,300$ volts. If swept at about $V_o=-11,500$ volts, I_T will just equal the leakage current to ground through R_T and the pin will hold at an equilibrium voltage of $V_T=-2,900$ volts as long as the beam is on the pin. Finally, if the pin is scanned with the beam at $V_o'=V_o(C)=-8,000$ volts, $(V_o'-V_T)=-5,100$ volts, which in FIG. 1 is in the B-C region of the curve in which I_T is positive and I_s exceeds I_B . In this case, the pin will lose charge and move positively up and to the left along the curve *c* of FIG. 4 from $V_T=-2,900$ volts until $V_T'=0$ and the pin voltage is again in equilibrium. At $V_T'=0$, no printing can occur when the paper moves.

It should be noted that beam current I_B , together with R_T determines the curve *c* of FIG. 4. For a very small I_B and/or a small R_T , the curve *c* will deviate little from the axis, and will approximate curve *b*. On the other hand, for a large I_B and/or a very large R_T , curve *c* will more closely approximate curve *a*. The reason for this is that in FIG. 4, curve *c*, $V_T=I_T R_T$, where I_T is determined, as before, from FIG. 1.

FIG. 5 illustrates a method and apparatus for carrying out my invention. Cathode ray printing tube 11 comprises a nonconducting faceplate 13 set in a glass envelope 15. A row of equidistant parallel printing pins 17 penetrates the faceplate 13. It should be noted, however, that my invention is equally adapted to printing tubes having an array of printing pins in several rows or columns. A back electrode 19 is positioned in front of the faceplate 13 at a distance suitable to admit the record medium 21, which may be paper, to be printed on. Back electrode 19 is connected to a reference potential, which is usually ground.

Electron beam 23, with which printing is accomplished, is generated by an indirectly heated cathode 25. Cathode 25 is tied to the output of pulse generator 26. Situated in front of and partially surrounding the cathode is control electrode 27 connected to beam intensity control signal source 29. Situated in the neck of the tube 11 between the faceplate and the control electrode is accelerating and focusing electrode assembly 31. A deflecting coil 33 surrounds the neck of the tube 11 at a point between the electrode assembly 31 and the faceplate 13 and is powered by deflection signal generator 35. A post deflection accelerating electrode 37 is located within the tube 11 near the faceplate 13. Accelerating electrode 37 is connected to a reference potential, typically ground.

In operation, the beam potential is pulsed between print and erasing levels by duplexing the cathode 25 alternately, and in synchronism with the sweep of beam 23 across the pins 17, between signal voltage V_o and a suitable D-C level $V_o(C)$. As illustrated in FIG. 6, on the first and every alternate succeeding sweep, full accelerating voltage V_o is applied to cathode 25 and the beam intensity, that is, beam current I_B is modulated with the signal to be recorded, so as to "blank" the beam during its passage over nonselected pins. This sweep, therefore, results in printing of selected pins only. The second and every alternate succeeding sweep follows very closely in time, so that paper motion is negligible since the prior recording trace, and is at a substantially lower accelerating voltage $V_o(C)$ and at a constant beam current so that all swept

pins emit electrons and drop to a lower voltage which is insufficient to cause printing.

The time between a printing sweep and the erasing sweep next succeeding it, indicated on FIG. 6 as the interval $a-d$, should be short compared to the time between two successive sweeps, indicated on FIG. 6 as the interval $a-f$, since in the former case it is necessary that paper motion between the two sweeps shall be negligible, while in the latter case it is necessary that appreciable paper motion occur so that fresh, uncharged dielectric can be brought into printing position under the pins. It may be necessary, depending on tube design, to pulse other electrodes and the deflection coil, as well, in synchronism with these successive sweeps, in order that satisfactory focus and spot positioning be maintained as the accelerating voltage is pulsed up and down.

FIG. 7 illustrates a variation upon the method and apparatus discussed in connection with FIG. 5. A cathode ray printing tube 11 is shown which comprises parts identical with those comprising the tube 11 illustrated in FIG. 1 except that two electron guns, 24 and 24', are provided, each gun having an individual deflecting coil, and each gun comprising parts which correspond to the parts that constitute the electron gun 24 illustrated in FIG. 5. Electron gun 24 of FIG. 7 functions as a "print" gun and is assigned part numbers corresponding to those assigned to the electron gun 24 of FIG. 5. Electron gun 24' of FIG. 7 functions as an "erase" gun and its parts are given primed numbers which correspond to numbers given to similar parts of the "print" gun 24.

A deflection signal generator 35 is provided for powering both deflecting coils 33 and 33'. An erase and print pulse generator 39, operating at two voltage levels V_0 and $V_0(C)$, is provided for energizing the cathode 25 of the print gun and the cathode 25' of the erase gun. Print gun 24' of FIG. 7 is operated at a high voltage V_0 and is modulated by the signal to be recorded, as described previously in connection with FIG. 5. The erase gun 24' is operated at a lower voltage $V_0(C)$ and a constant beam current I_B .

In operation, beams 23 and 23' are swept at the same rate with a small time lag between the beam 23 from the print gun 24 and beam 23' from the erasing gun 24'. First the print beam 23 sweeps across the pins 17 which are to be printed, causing them to charge up and discharge to the record medium 21. Then the erase beam 23' sweeps across the pins and causes them to re-emit their excess electrons and to drop to a potential which will not print when the paper moves.

FIG. 8 illustrates the preferred embodiment of my invention. It shows a tube of the type illustrated in FIG. 5. Where applicable, parts of the tube illustrated in FIG. 8 are assigned the same number as their counterparts illustrated in FIG. 5. In addition to these parts, there is provided a second, "spray" type of electron erase gun 41. This gun comprises a straight filament or ribbon cathode 43 and a collimating slit 45 rather than circular collimating apertures employed in the other cathode ray guns heretofore discussed.

The electron beam 23, generated by electron gun 24, is swept over the pins 17 by deflection coil 33 under the influence of a current produced by deflection signal generator 35. As described previously in connection with FIGS. 5 and 7, unselected pins are prevented from printing by reducing the intensity of beam 23 during its passage over pins during its sweep.

The gun 41 generates a ribbon-shaped beam 47 which bathes the entire row of pins 17 in electrons at a suitable voltage to cause them to lose charge by high secondary emission after they have printed. The erase gun 41 may be left turned on at all times by setting the rate at which the print gun 24 charges them. In this case the beam 23 from the print gun 24 would simply override the discharging effect of the superposed erasing beam 47.

Alternatively, if faster erasing is necessary, the erasing beam 47 could be pulsed on by pulse generator 49, just after a recording trace 23 has been swept, then off again before the next recording trace. By proper selection of flood gun potential and current, as indicated in the discussion of FIG. 4, pins with high potentials on them due to charging by the writing gun 24 will lose electrons at a greater rate than that at which they receive them from the erase, or flood gun 41.

Proper selection of potential is achieved when $(V_0 - V_T)$, the potential of the flood gun cathode 43 with respect to the potential of charge printing pins 17, falls between the first and second crossover points B and C of the secondary electron coefficient curve, FIGS. 1 and 2. In such a case the pins will be discharged (charged less negatively) until their potential with respect to the flood gun cathode-to-pin potential $(V_0 - V_T)$ is above (to potential $V_0(C)$) of FIG. 2.

Flood gun current I_B to the pins 17 must be sufficient to cause discharge below printing potential before the record medium 21 has moved substantially, and before the next charging cycle by the recording beam 23 has commenced.

Referring to FIG. 4, note that upon initial operation the flood gun cathode-to-pin potential $(V_0 - V_T)$ is above (to the right of) the second crossover point C, since the pins are initially uncharged. This condition results in charging of the pins by the flood, or erase, beam 47 to the second crossover potential $V_0(C)$, which is the desired nonprinting bias point. When the pins are still further charged, by the beam 23 from the writing gun 24, the flood gun cathode-to-pin potential shifts to a place between the first and second crossover points B and C where the pin potential is high enough to cause printing. In this region the flood gun beam 47 causes rapid discharge of the pins back down to the bias point $V_0(C)$ at the second crossover point C.

In using the preferred embodiment of my invention it is important to avoid charging the pins so high with the writing beam that their potential relative to the flood gun cathode, $(V_0 - V_T)$, falls to the left of the first crossover point B, since in this event, the flood gun will tend to charge them further, replacing charge removed by printing on the dielectric, and holding the pins at printing potential. This would aggravate the streaking problem sought to be eliminated. This undesirable voltage relationship between pin potential V_T and flood gun potential V_0 may be avoided by cutting off the flood gun current or raising its cathode potential momentarily so as to bring $(V_0 - V_T)$ to the right of crossover point B. Alternatively, writing gun voltage or current may be controlled to prevent overcharging.

Thus, there have been provided several related methods and apparatus for rapidly ridding printing pins of their charges after a single printing, thereby eliminating a common, troublesome cause of streaking and of poor pin selectivity in cathode ray type printing tubes.

What is claimed is:

1. In an electrostatic printing tube having a faceplate transpierced by an array of printing electrodes periodically swept by a current modulated electron beam for depositing through selected ones of said printing electrodes a charge pattern upon a printing medium backed by an electrode confronting said faceplate and biased positively relative to said beam, the improvement comprising:

means for bombarding said printing electrodes with electrons at a potential whose magnitude with respect to the potential assumed by said printing electrodes after printing is selected to make the secondary electron emission coefficient of said electrodes exceed one, so that said electrodes, due to a net loss of electrons sustained as a result of said bombardment, are rapidly discharged thereby preventing protracted discharge.

2. In an electrostatic printing tube having a faceplate transpierced by an array of printing electrodes periodically swept by a current modulated electron beam, the improvement comprising:

means for causing the electric potential of said electron beam to alternate between a first negative potential, for selective charging of individual screen areas, and a second, less negative potential, for rapidly reducing the potential of said individual screen areas.

3. In an electrostatic printing tube having a faceplate transpierced by an array of printing electrodes periodically swept by a current modulated electron beam for depositing, through selected ones of said printing electrodes, a charge pattern upon a printing medium, the improvement comprising:

means for causing the electric potential of said electron beam to alternate between a first negative potential sufficient to cause a selected printing electrode hit by the beam to discharge onto said printing medium; and

a second negative potential whose magnitude with respect to the potential assumed by printing electrodes after a single printing is such as to make the secondary electron emission coefficient of said electrodes exceed one.

4. In an electrostatic printing tube having a faceplate penetrated by an array of conducting pins, for depositing a charge upon a printing medium backed by an electrode confronting said faceplate, the combination comprising:

means for generating a cathode ray beam; electron deflecting means for sweeping said beam over said pin;

modulating means for causing, during every other sweep a momentary rise in beam current during passage of said beam over selected pins; and

means for causing the electric potential of said beam to alternate between a first potential, maintained during said every other sweep, and sufficiently negative relative to said electrode to cause said selected pins hit by the beam to discharge onto said printing medium, and a second, less negative potential, for rapidly reducing the potential of said selected pins after printing.

5. In an electrostatic printing tube having a faceplate penetrated by an array of printing electrodes for depositing a charge upon a printing medium, the combination comprising:

means for generating a cathode ray beam; means for sweeping said beam over said electrodes; means for causing, during every other sweep, a temporary rise in beam current during passage of said beam over selected electrodes; and

means for causing the electric potential of said beam to alternate between a first potential, maintained during said every other sweep, and sufficient to cause said selected electrodes hit by the beam to discharge onto said printing medium, and a second potential whose magnitude with respect to the potential assumed by electrodes after a single printing is selected to make the secondary electron emission coefficient of said electrodes exceed one.

6. In an electrostatic printing tube having a faceplate penetrated by an array of printing electrodes periodically swept by a current modulated electron beam for depositing through selected ones of said printing electrodes a charge pattern upon a printing medium backed by an electrode confronting said faceplate and biased positively relative to said beam, the improvement comprising, in combination:

means for generating a second electron beam; means for maintaining said second beam at a potential less negative relative to said electrode than said modulated beam, for rapidly reducing through secondary electron emission the potential of said selected printing electrodes after they have printed; and

electron deflecting means for sweeping said second beam over said printing electrodes closely lagging in time behind said first beam.

7. In an electrostatic printing tube having a faceplate containing an array of conducting pins transpiercing said faceplate for depositing a charge pattern upon a printing medium backed by an electrode confronting said faceplate, the combination comprising:

means for generating first and second electron beams; beam current modulating means for reducing the intensity of said first beam during its passage over unselected pins;

means for maintaining said first beam at a first potential, negative relative to said electrode and sufficient to cause a selected pin hit by said beam to discharge onto said printing medium;

means for maintaining said second beam at a second, less negative potential relative to said electrode, for rapidly reducing, upon impact, the potential of said pin after it has printed; and

electron deflecting means for rapidly sweeping said first and second beams over said pins, said second beam closely lagging in time behind said first beam.

8. In an electrostatic printing tube having a faceplate penetrated by an array of printing electrodes periodically swept by a current modulated electron beam for depositing through selected ones of said printing electrodes a charge pattern upon a printing medium backed by an electrode confronting said faceplate and biased positively relative to said beam, improvement comprising, in combination:

means for generating a second, stationary electron beam blanketing said array of printing electrodes with electrons; and

biasing means for maintaining said second electron beam at a potential less negative relative to said backing electrode than said modulated beam, for rapidly reducing the potential of said selected printing electrodes after they have printed.

9. In an electrostatic printing tube having a faceplate penetrated by an array of printing electrodes periodically swept by a current-modulated electron beam for depositing through selected ones of said printing electrodes a charge pattern upon a printing medium backed by an electrode confronting said faceplate and biased positively relative to said beam, the improvement comprising, a combination:

means for generating a second, stationary electron beam blanketing said array of printing electrodes with electrons; and

biasing means for maintaining said second electron beam at a potential whose magnitude with respect to the potential assumed by printing electrodes after a single printing is such as to make the secondary electron emission coefficient of said printing electrodes exceed one.

10. The apparatus of claim 9 wherein said biasing means is a pulse generator for bringing said second electron beam to said second potential temporarily, after said printing electrodes have printed.

11. In an electrostatic printing tube having a faceplate penetrated by an array of printing electrodes transpiercing said faceplate for depositing a charge upon a printing medium backed by an electrode confronting said faceplate, the combination comprising:

means for generating a first electron beam; electron deflecting means for sweeping said first beam over said printing electrodes;

means for reducing the intensity of said first beam during its passage over unselected printing electrodes; means for generating a second stationary electron beam blanketing said array of printing electrodes with electrons;

means for maintaining said first beam at a first potential negative relative to said backing electrode sufficient

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to cause a selected printing electrode hit by said beam to discharge onto said printing medium; and means for maintaining said electron beam at a second, less negative potential for rapidly reducing the potential of said printing electrode after it has printed.

12. A method for preventing the streaking of charges deposited upon a printing medium by an electrostatic printing tube of the type having a faceplate with an array of printing electrodes intermittently swept by a signal modulated cathode ray beam and having a back electrode confronting said faceplate and biased positively with respect to said beam, comprising:

discharging said electrodes below the voltage required for printing with a beam of electrons at a potential less negative than that of the modulated cathode ray beam.

13. A method for rapidly discharging the printing electrodes of an electrostatic printing tube, comprising: bombarding said electrodes with a beam of electrons having a potential which causes an electrode which has printed to emit more secondary electrons in response to said beam than impinge upon it from said beam.

14. A method for rapidly discharging areas of a cathode ray printing tube faceplate charged by a signal modulated cathode ray beam comprising:

altering the potential of said beam during alternate sweeps from a printing level to a level for which the secondary electron emission coefficient of said areas exceeds one.

15. A method for preventing the streaking of charges deposited upon a printing medium by a electrostatic printing tube of the type having a faceplate with an array of printing pins intermittently swept by a signal modulated cathode ray beam and having a back electrode confronting said faceplate and biased positively with respect to said beam, comprising:

altering the potential of said beam during alternate sweeps from a printing level to a level for which the secondary electron emission coefficient of said pins after a printing discharge exceeds one.

16. A method for preventing the streaking of charges deposited upon a printing medium by an electrostatic print-

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ing tube of the type having a faceplate with an array of printing electrodes intermittently swept by a signal modulated cathode ray beam and having a back electrode confronting said faceplate and biased positively with respect to said beam, comprising:

sweeping said printing electrodes with a second electron beam closely lagging in time but following the path of said first electron beam and having a potential with respect to said back electrode at which said second beam causes, through secondary emission, a net loss of electrons from, and rapid discharge of, those printing electrodes that have printed.

17. A method for preventing the streaking of charges deposited from a printing medium by an electrostatic printing tube of the type having a faceplate with an array of printing pins intermittently swept by a signal modulated cathode ray beam and having a back electrode confronting said faceplate and biased positively with respect to said beam, comprising:

subjecting said array of pins to a stationary, ribbon-shaped electron beam at a potential for which the secondary electron emission coefficient of a pin after a predetermined number of printing discharges exceeds one.

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CERTIFICATE OF CORRECTION

Patent No. 3,458,752

Dated July 29, 1969

Inventor(s) Philip A. Stowell

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 8 "printing" should read --firing--and "firing" should read --printing--. Column 2, line 35 "altermate" should read --alternate--. Column 8, line 17 "cathode-to-pin potential (V_O-V_T) is above (to)" should read --cathode 43 reaches the higher crossover point--.

SIGNED AND
SEALED

DEC 2 - 1969

(SEAL)

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