Feb. 27, 1962 R. E. BENN 3,023,070

ATMOSPHERE FOR ELECTROGRAPHIC PRINTING

Filed May 20, 1957

Fig. 1

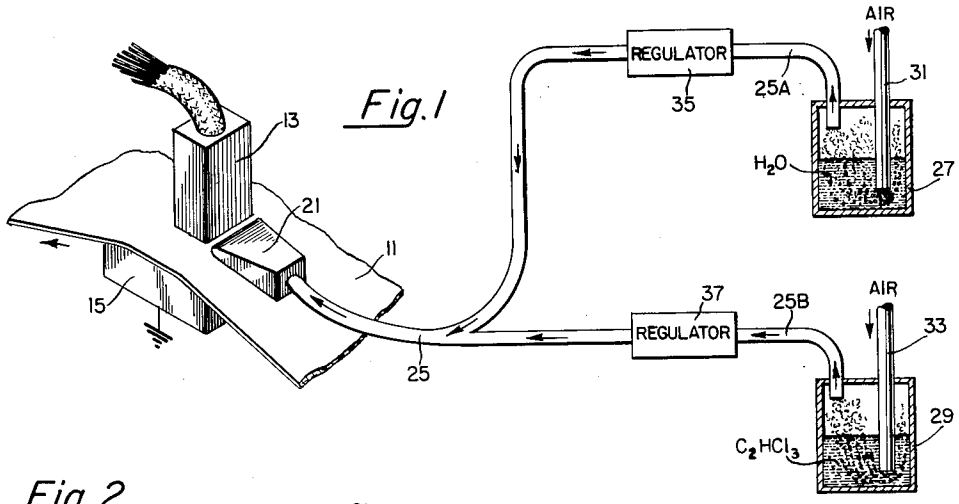


Fig. 2

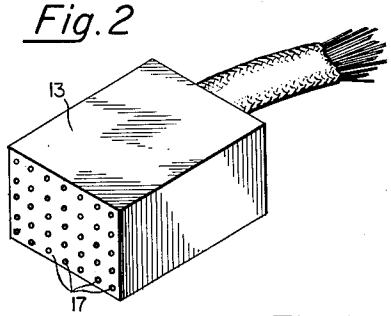
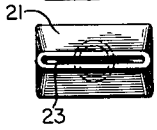


Fig. 3



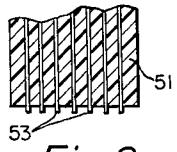
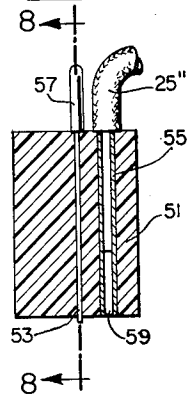


Fig. 8

Fig. 7



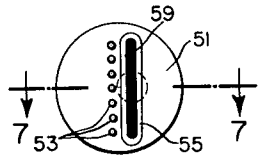


Fig. 6

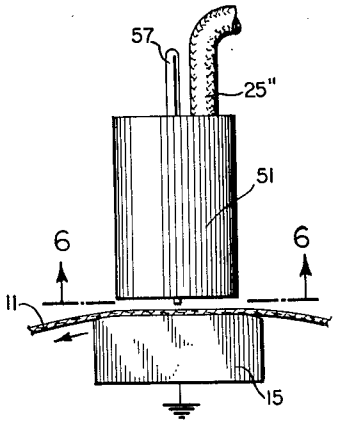
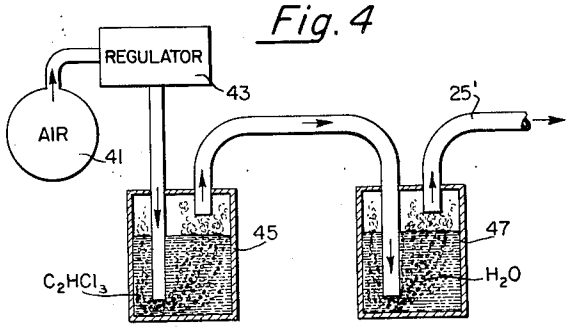


Fig. 5

Fig. 4



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3,023,070 ATMOSPHERE FOR ELECTROGRAPHIC PRINTING

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This invention relates to electrographic printing. More particularly it refers to an artificial atmosphere for the electrical printing discharges employed in this type of printing and to electrode means adapted to operate in conjunction with such an atmosphere.

In the electrographic printing process the printing medium, usually in sheet form, receives electrostatic charges over limited surface areas as a result of silent, non-arcing electrical discharges induced between paired electrodes respectively positioned on opposite sides of the medium. Through the use of suitably shaped electrodes or groups of electrodes the charged areas of the medium, which collectively constitute a latent electrostatic image of the printed material, can be caused to have the form of characters, graphs, etc. The latent image is developed or "inked" by a pigmented powder applied to the surface of the medium which adheres to the charged areas by electrostatic attraction and thereby renders these areas visible. The developed or powder image may then be fixed, for example by the application of heat and pressure in the case of thermoplastic material. Details of the process as heretofore practiced are described, among other places, in co-pending patent applications Serial No. 320,592, filed November 14, 1952, and Serial No. 443,646, filed July 15, 1954, both assigned to the present assignee.

The gap between the paired electrodes that support the printing discharge, one electrode commonly being designated the printing electrode and the other the base or anvil electrode, usually is only a few thousandths of an inch in width but in spite of this short discharge path it has been found that the composition of the atmosphere in the gap in the immediate vicinity thereof has a marked effect on the formation of the latent electrostatic image on the printing medium. Certain aspects of the effect of this atmosphere have been discussed in another co-pending patent application assigned to the present assignee, Serial No. 478,602, filed December 30, 1954. This last-named application discloses the beneficial effect, under certain printing conditions, of a printing gap atmosphere comprising a small amount of electronegative gas, such as the vapor of trichlorethylene or carbon tetrachloride, for example. An electronegative gas may be generally defined as one which has the ability to attract and hold negative charges, that is, electrons. A discussion of this property of certain gasses is to be found in the book "The Nature of the Chemical Bond" by Pauling, Cornell University Press, 2nd edition, 1948. The present application discloses another desirable component, namely, water vapor, either as the sole additive to the normal atmosphere in which the apparatus, as a whole, operates or in combination with the previously disclosed electronegative gas.

The presence of water vapor in the printing gap atmosphere to a higher degree than in the ambient atmosphere has been found to have among other advantages that of improving the reliability of printing, also, that of lowering the voltage at which printing discharges occur and, in

combination with an electronegative gas or vapor, of further improving the definition of the printed latent image.

It is, accordingly, a general object of the invention to provide means for improving the performance of electrographic printing apparatus.

Another and more specific object is to provide an improvide artificial atmosphere for the electrical printing discharges occurring in electrographic printing.

Another object is to provide improved printing electrode means designed for operation with the above-mentioned artificial printing atmosphere.

Another object is to provide means which increase printing reliability and permit printing at reduced printing voltages.

A further object is to provide an improved method of electrostatic printing.

Other objects and advantages of the invention will be apparent upon consideration of the following specification and of the accompanying drawings in which:

FIG. 1 is a view, partly in perspective, showing a portion of an electrographic printing system, together with artificial atmosphere supply means therefor, in accordance with the invention;

FIG. 2 is an enlarged perspective view of the electrographic printing head of FIG. 1, showing the printing electrodes thereof;

FIG. 3 is an enlarged end view of a gas discharge nozzle seen in FIG. 1;

FIG. 4 shows a modification of a portion of the atmosphere supply means of FIG. 1;

FIG. 5 is an elevational view of a modification of another portion of the system of FIG. 1, including a modified electrographic printing head;

FIG. 6 is a view taken in the direction 6—6, indicated on FIG. 5;

FIG. 7 is a sectional view along the line 7—7 of FIG. 6, and

FIG. 8 is an enlarged fractional view along the line 8—8 of FIG. 7.

As above referred to, the use of a very small amount of a highly electronegative gas, such as the vapor of trichlorethylene, in the atmosphere in which the electrical printing discharges occur has been found to have a decided effect in improving the definition of the electrostatic latent image produced in the electrographic printing process. This is particularly the case where this image is made up of small dot-shaped elemental charges of negative polarity printed from pin-type electrodes which may be energized in suitable groupings and sequences to form characters, etc., in the manner described in the aforementioned patent applications. As described in more detail in application Serial No. 478,602, the use of such a gas diminishes the tendency of the electrostatic image to spread beyond an area corresponding to that of the discharge surface of the printing electrode or electrodes. In addition to the more active gases and vapors, water vapor is to a certain degree electronegative and appreciable improvement in printing quality can be realized by the use of humidified air, alone, as a printing atmosphere, especially in systems which operate at relatively low speeds. The principal advantage of water vapor as a component of the printing atmosphere, however, is that its use results in more reliable printing, that is, with repetitive printing pulses substantially all of

such pulses result in printing dicsharges. Used together, therefore, with air, to form an artificial printing gap atmosphere, the combination of water vapor and an electronegative gas is found to result in reliably printed, well defined eletcrostatic images in the electrographic printing process.

Water vapor may also permit operation at a reduced difference in potential between the printing and anvil electrodes. Heretofore, under commonly obtaining conditions, a potential difference of over 1000 volts has been required for printing, which, in the case of small multi-electrode printing heads of the size used to print characters of the dimensions of typewriter characters, for example, has posed problems of surface leakage and undesirably high potential gradients. Even with a voltage of this order of magnitude, unexplained periods of irregular printing have occurred. It has been found that the introduction of a small amount of water vapor into the printing gap atmosphere above that existing in the surrounding air, as by the addition of a suitable amount of nearly saturated air, permits the voltage applied to the printing electrodes to be lowered while at the same time it increases the reliability of printing.

Although a full explanation of the above described effects cannot be given here, it appears that the presence of water vapor, which may condense to a certain extent on the electrodes, increases electron emission from the discharge surfaces of the printing electrodes. Thus, at a given printing voltage and with a printing pulse of a given period, the probability of the emission from a printing electrode of the requisite number of electrons to start a printing discharge during this period is increased. Certain precautions must be taken in connection with the use of water vapor, however, particularly when employed with small printing heads in which the printing electrodes are arranged as a matrix of closely spaced pins encapsulated in plastic or other insulating material. Heretofore, it has been common practice to terminate the pins flush with surface of the head at its print face and this construction operates satisfactorily when the percentage of water vapor used in the printing gap is kept in the lower part of its useful range. With larger percentages there may be a tendency, in spite of the velocity of the supplied gaseous mixture and the displacement of the medium, for a film of water to form on the surface of the head which not only provides current leakage paths between pin electrodes at different potentials but also provides a partially conductive layer on the surface of the insulation of the head from which discharges can occur to the opposed anvil electrode, thereby causing the printing of electrostatic charges outside of the areas on the printing medium which correspond to the discharge areas of the pin electrodes. Thus, the latent electrostatic image is distorted or spurious printing occurs. While the amount of water vapor used is not critical, it may be desirable in some instances in order to operate at low printing voltages to use a percentage of vapor which causes condensation on some portions of the head. To overcome this disadvantage the pin electrodes, or other forms of printing electrodes, may project beyond the surface of their insulating support or, as an equivalent, the insulation between electrodes may be undercut. In this manner if a film of water forms on the surface of the insulation the gap between it and the anvil electrode will be greater than that between the printing electrodes and anvil, so that discharges from this film are minimized.

Referring now to the figures, and first to FIGS. 1–4, there is shown a printing medium 11 in sheet form which can be transported (by means not shown) in the direction indicated by an arrow through a gap between a printing head 13 slightly spaced from the medium and an anvil electrode 15 on which the medium rides. Head 13 as illustrated in FIG. 2 comprises a 5x7 matrix of pin-type printing electrodes 17 with the body of the head formed of an insulating material, such as a cast plastic, which supports and spaces the pins. A pin diameter of 0.003 inch and a pin spacing of 0.017 inch have been used in some heads. The surface of medium 11 which faces electrodes 17 is spaced from the ends of the electrodes by a few thousandths of an inch and this surface is adapted to retain electrostatic charges produced as a result of silent, non-arcing electrical discharges between one or more pin electrodes 17 and common anvil electrode 15. The selective energization of groups of pin electrodes to print indicia of various forms, is fully described in the cited co-pending patent applications. The ends of pin electrodes 17 may either be flush with the end surface of the head, as shown in FIG. 2, or may project slightly therefrom for purposes earlier referred to herein.

Adjacent head 13 there is shown a nozzle 21 having an elongated discharge orifice 23 (FIG. 3) preferably co-extensive with or longer than the linear arrays of pin electrodes 17 in head 13 which it parallels. Nozzle 21 preferably is positioned relative to head 13 so as to deliver a stream of gas to the printing gap or gaps in the direction of displacement of the medium, the flow of gas to the gaps being aided by this displacement, which may be quite rapid. To nozzle 21 is connected a bifurcated tube 25 having branches 25A and 25B each of which supplies a mixture of air and another gas for joint discharge from orifice 23. As sources of these mixtures there are shown a closed container 27 partially filled with water and another closed container 29 partially filled with trichlorethylene (CH_2Cl_3), exemplifying a liquid whose vapor is strongly electronegative. Other examples of liquids possessing this property are referred to elsewhere herein. Air under a slight pressure (from a source not shown) is bubbled through the liquids in containers 27 and 29 by way of input tubes 31 and 33, respectively, having their discharge ends in each case below the liquid surface. A mixture of air and water vapor is thereby supplied to branch 25A of tube 25, having its inlet above the liquid surface in container 27, and a mixture of air and the vapor of trichlorethylene is supplied to branch 25B, similarly positioned relative to container 29. Regulators 35 and 37 in tube branches 25A and 25B, respectively, may be employed to adjust both the absolute and relative flow in these conduits.

The amounts of water vapor and of electronegative gas added to the printing gap atmosphere by these means are small percentages of the complete atmosphere and may vary over wide ranges of values. The effluent air from container 27 has a relative humidity which probably approaches saturation so that its discharge from nozzle 21 increases the percentage of water vapor in the gap atmosphere relative to that in the air surrounding the apparatus as a whole, the latter percentage being well below a saturation value for normal operation of the apparatus. It has been the practice to use the control of water vapor, through control of the discharge of substantially saturated air, principally to lower the necessary printing voltage, without supplying an amount that results in an excessive deposit of water on the printing head, while control of the electronegative gas has been used to obtain satisfactory image definition. Owing to the small dimensions of the discharge gap it has not been feasible, so far, to obtain a reliable analysis of the gap atmosphere for optimum results. It is estimated that the content of electronegative gas does not exceed a few percent, at most, and may be a fraction of one percent in some cases.

Various modifications of the artificial atmosphere supply means of FIG. 1 are possible and have been employed. In FIG. 4 air under pressure from storage container 41 first passes, by way of regulator 43, to container 45 holding trichlorethylene with the resulting mixture of air and vapor passing to container 47 holding water. Since trichlorethylene (together with related compounds) has a low solubility in water very little of its vapor is

lost in passing through the water in container 47 and a mixture of vapor and humidified air is thus delivered to tube 25', which may connect with nozzle 21 in place of tube 25 of FIG. 1.

Alternative gas supply means, also taking advantage of the fact that trichlorethylene, and certain other halogen substitution compounds in liquid form whose vapors are strongly electronegative, are substantially immiscible with water, may comprise a single container (not illustrated) in which both liquids are present and wherein separation into two layers occurs in accordance with their respective specific gravities. Air may then be bubbled in sequence through these layers.

When the electronegative agent is a gas at ordinary temperatures and pressures instead of a liquid, this gas can be supplied directly from any suitable storage source (not illustrated) for combination with water vapor and air. Some of the mixtures of gases sold under the proprietary name of "Freon" and largely used as refrigerants, are highly electronegative and have been successfully employed in this manner.

FIGS. 5–8 illustrate a printing head having a built-in conduit through which the gases constituting the artificial atmosphere of the invention are introduced to the printing gap. Head 51, the body of which again may be of an insulating plastic, is shown in this case as mounting a single row of printing electrodes 53 each having an external terminal 57, although this is not a significant feature of the invention. The use of pin electrodes which project beyond the surface of the printing head is illustrated in these figures. Conduit 55 (FIG. 7) has a tubular upper section with which tube 25'', corresponding to tube 25 of FIG. 13, connects and a flared lower section having an orifice 59 (FIG. 6) wide enough to supply a uniform flow of gas to the several printing gaps bounded by pins 53. Again, it is desirable that the flow of gas to the printing gaps be in the direction of and aided by the motion of medium 11, which, in the case of a continuously transported medium, may travel at a high speed, 100 inches a second in some applications. In addition, the flared section of conduit 55 may be at an angle to the axis of the tubular section suitable to direct the effluent gas toward the printing gaps.

The specific means described herein are to be considered as illustrative of the invention, only, and not by way of limitation of the scope thereof, which is defined in the appended claims.

What is claimed is:

1. In electrostatic printing apparatus having a pair of electrodes forming a gap, means adapted to position a charge retentive medium therebetween, and means for inducing across the said gap between the said electrodes non-arcing electrical discharges adapted to print electrostatic charge patterns on such charge retentive medium positioned between the said pair of electrodes; the improvement comprising means for supplying to the region in and about the said gap air having a higher water vapor content than the normal atmosphere in which the said apparatus as a whole operates.

2. In electrostatic printing apparatus having a pair of electrodes forming a gap, means adapted to position a charge retentive medium therebetween, and means for inducing across the said gap between the said electrodes non-arcing electrical discharges adapted to print electrostatic charge patterns on a charge retentive medium positioned between the said pair of electrodes; the improvement comprising a container holding a body of water, means for passing a stream of air through said water to humidify the said air, and means for supplying air thus humidified to the region in and about the said gap.

3. Apparatus as defined in claim 1 wherein the means for supplying to said region air having an increased water vapor content comprises a source of air substantially saturated with water vapor, and means for adding a controllable amount of said saturated air to the normal atmospheric air in said region.

4. In electrostatic printing apparatus wherein non-arcing electrical discharges are induced across a gap between a pin-type electrode having a discharge surface of limited extent and an anvil electrode opposing a surface of relatively greater extent thereto to form electrically charged areas on a charge retentive medium adapted to be located between said pin type electrode and said anvil electrode, means for producing a stream of air substantially saturated with water vapor, and means directing at least a portion of said stream to the region in and about said gap to condition the atmosphere in said region.

5. In electrostatic printing apparatus having a pair of electrodes spaced apart to form a gap adapted to receive a recording medium between said pair of electrodes, and means for supplying substantially fixed amplitude printing pulses to said electrodes, said pulses creating a difference of potential across the gap insufficient, when said gap is filled with ambient atmosphere, to reliably produce printing discharges between said electrodes to establish electrically charged areas on a recording medium to be located in said gap; the improvements comprising means for substantially filling said gap with a modified atmosphere containing substantially more water vapor than that contained in the ambient atmosphere; whereby said printing pulses reliably produce electrically charged areas on a recording medium located in the gap.

6. In electrostatic printing apparatus having at least a pair of electrodes spaced apart to define a printing gap, moving means adapted to move a charge retentive medium through the said gap, and means adapted to establish a pattern of electrically charged areas on a charge retentive medium moved by the said moving means through said gap: the improvements comprising means for modifying ambient air by passing said air through a body of water and through a liquid whose vapor is electronegative, and means for introducing said modified air into said gap, whereby the voltage difference across said electrode at which said charged areas are reliably established on the recording medium is lowered.

7. In electrostatic printing apparatus having a pair of electrodes spaced apart to form a gap adapted to receive a recording medium between said pair of electrodes, and means for supplying substantially fixed amplitude printing pulses to said electrodes, said pulses creating a difference of potential across the gap insufficient, when said gap is filled with ambient atmosphere, to reliably produce printing discharges between said electrodes to establish electrically charged areas on a recording medium to be located in said gap: the improvements comprising means for substantially filling said gap with a modified atmosphere including an electronegative gas and containing substantially more water vapor than that contained in the ambient atmosphere; whereby said printing pulses reliably produce electrically charged areas on a recording medium located in the gap.

8. In electrostatic printing apparatus having: a back electrode adapted to receive a charge retentive medium substantially in contact with the said back electrode, a plurality of print electrodes spaced from said back electrode and defining between said print electrodes and said back electrode a gap adapted to receive said charge retentive medium in said gap, and means for producing between said back electrode and said print electrodes electrical discharges adapted to establish electrically charged areas on a charge retentive medium located in said gap; the improvements comprising: means for modifying the ambient atmosphere by substantially increasing the water vapor content of the atmosphere and means for causing said modified atmosphere to flow through the printing gap between the recording medium and the print electrodes, whereby the voltages at which said electrically charged

areas are established on the medium in said gap are lowered.

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