Jan. 26, 1954 W. C. HUEBNER 2,667,121

PRINTING METHOD AND APPARATUS

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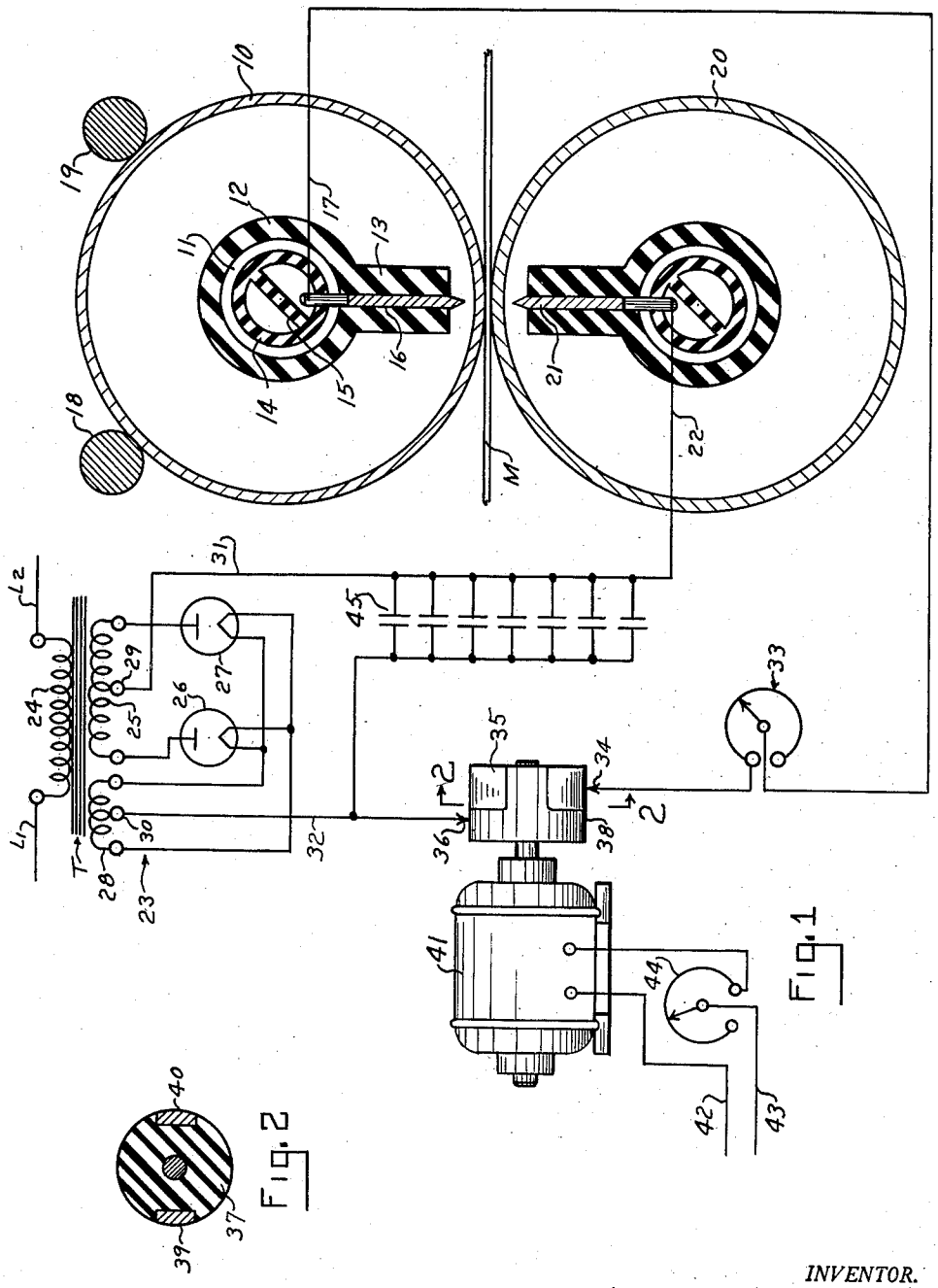

FIG. 1

FIG. 2

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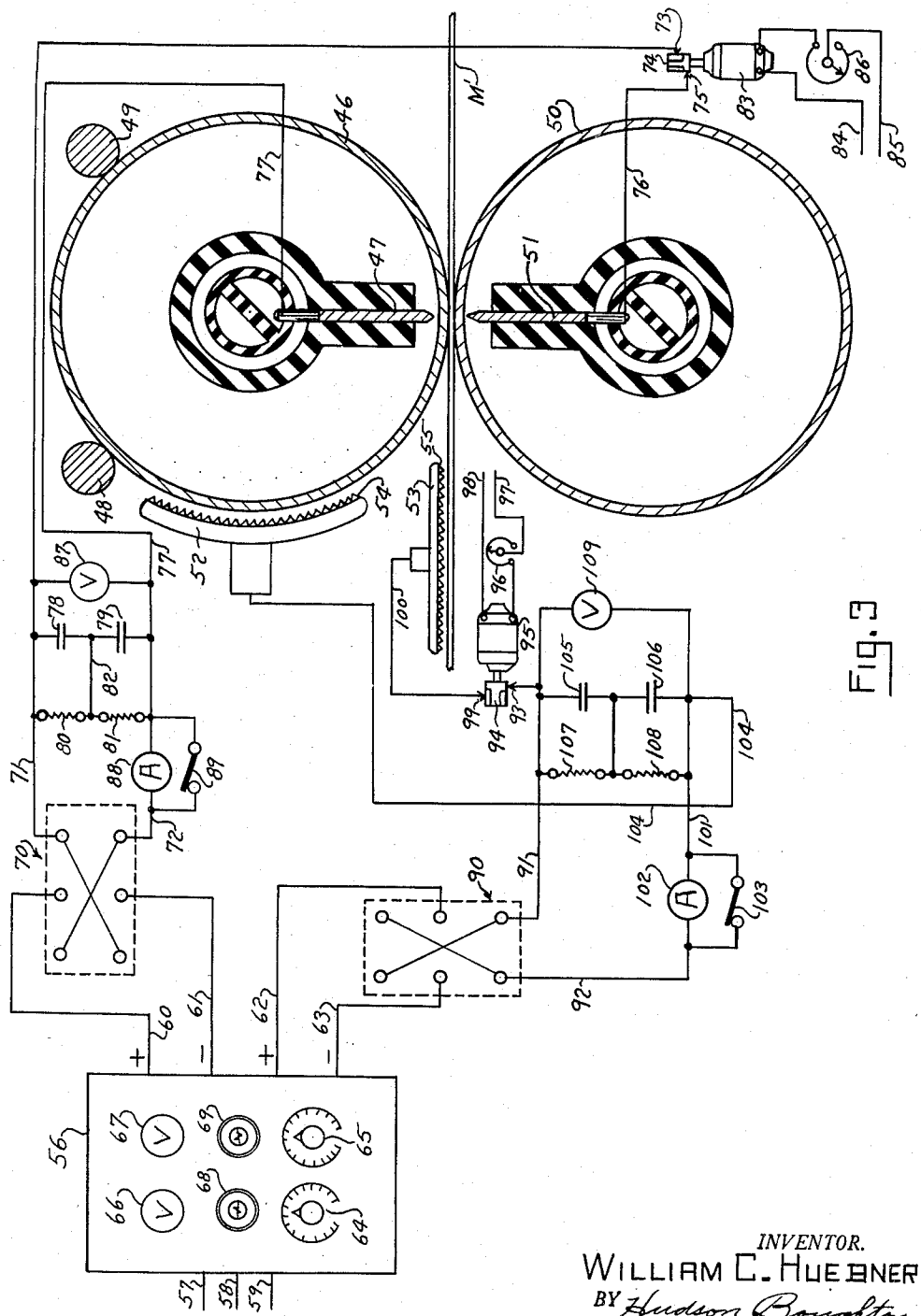

Fig. 3

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PRINTING METHOD AND APPARATUS

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6 Claims. (Cl. 101—219)

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This invention relates to a method and means for transferring a fluid to material and, more particularly, to a method and means for printing material with a fluid by the action of an electrostatic field of force.

Processes and apparatuses have been developed in recent years for printing a fluid, such as ink or the like, upon sheet or web material, such as paper or cloth, by employing an electrostatic field of force to effect the transfer of the fluid to the material. Examples of such processes and apparatuses are disclosed in my prior patents: 1,820,194, issued August 25, 1931; 2,224,391, issued December 10, 1940; 2,408,143 and 2,408,144, both issued September 24, 1946. In these patents there are disclosed processes and apparatuses for printing wherein the ink is transferred from an image carrying member to the print receiving material without appreciable pressure therebetween, the transfer being effected by the action of an electrostatic field of force extending through the image area and the print receiving material. When employing such processes and apparatuses, improved results, namely better transfer of the fluid with sharper and better defined images, are secured when the fluid and/or the print receiving material have been electrically precharged prior to their introduction into the electrostatic field which effects transfer of the fluid to the material. This precharging is fully disclosed and claimed in my patent application S. N. 591,739, filed May 3, 1945, entitled "Process and Apparatus for Electronographic Printing," and which issued on October 4, 1949, as Patent No. 2,483,462.

Although the above-mentioned processes and apparatuses have generally proved satisfactory, it has been found that even when utilizing precharging of the ink and the print receiving material, the transfer is not always entirely uniform especially with certain types and/or colors of ink. Thus, it has been found that, in general, blues will migrate or transfer freely with a given potential gradient of the electrostatic field, whereas yellows move less freely, particularly the finer particles comprising the lighter tones of an image, so that there is a somewhat spotty migration or transfer. The composition of the ink or other fluid employed, of course, greatly affects the ease of migration and, while, as stated above, generally blues migrate more freely than yellows, the degree of migration depends upon the solvents, the nature of the particles used for color, and/or upon other considerations. The characteristic effect where transfer is not uniform is that small specks or flecks of the print receiving material show in the areas where the migration is not completely uniform. Also, in some cases the outline of the image is not sufficiently sharp and distinct.

An object of this invention is to provide an improved process and apparatus for printing by means of an electrostatic field of force wherein migration of the printing fluid subjected to the field of force is improved for a given potential gradient of the field, and fluids which are difficult to migrate may be uniformly transferred, thereby producing an image of improved characteristics.

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Another object of the invention is to provide an improved process and apparatus for printing by means of an electrostatic field of force wherein the potential gradient of the field is pulsated to produce a more effective migration of the printing fluid.

A further object of the invention is to provide an improved process and apparatus for printing by means of an electrostatic field of force wherein the printing fluid and the material which is to receive the fluid are precharged with electrostatic charges of opposite polarities before introduction into the electrostatic field which effects migration or transfer of the fluid, and the potentials creating the said electrostatic field are rapidly pulsated, thereby producing a more effective migration of the printing fluid.

A still further object of the invention is to provide an improved process and apparatus for printing as defined in the preceding paragraph and wherein the electric potentials employed to precharge said fluid and material are also pulsated.

A more specific object of the invention is to provide an improved process and apparatus for printing by means of an electrostatic field of force wherein the printing fluid and the material which is to receive the fluid are precharged with electrostatic charges of opposite polarity by movement adjacent to electrodes of an electric circuit, which is periodically rapidly interrupted, prior to introduction of the fluid and material into the electrostatic field which effects the migration or transfer of the fluid, the said electrostatic field being created between spaced electrodes connected in an electric circuit which is also periodically interrupted, thereby pulsating the said electrostatic field.

A still more specific object of the invention is the provision of an improved apparatus as defined in the preceding paragraph and wherein means are provided for varying the speed of interruptions in the electric circuit providing the said electrostatic field and/or in the circuit providing the said precharge potentials.

The invention further resides in certain novel steps of procedure, features of construction and combination and arrangements of parts of the apparatus, and further objects and advantages thereof will be apparent to those skilled in the art to which the invention pertains from the following description of a simplified form of ap-

paratus, and the present preferred embodiment thereof, as utilized in effecting the method; the invention being described with respect to the accompanying drawings in which similar reference characters represent corresponding parts in the several views and in which:

Fig. 1 is a diagrammatic view of a printing couple disclosing a simplified form of an apparatus embodying the invention and by means of which the process can be effected;

Fig. 2 is a sectional view through the circuit interrupting or pulsating switch shown in Fig. 1, the view being taken substantially on the section indicating line 2—2 of Fig. 1;

Fig. 3 is a diagrammatic view of a printing couple disclosing the present preferred form of apparatus embodying the invention and by means of which the process can be effected.

In Fig. 1 there is diagrammatically illustrated a printing couple comprising a moving image-carrying member 10 shown in the form of a cylinder, the wall of which is a thin section. This cylinder is rotatably mounted at its opposite ends on and insulated from tubular supports 11 carried by the frame of the printing couple and extending into the cylinder. The inner ends of the supports 11 are surrounded by and support an insulating sleeve 12, extending substantially the length of the cylinder, and having connected thereto radially extending parallel, but spaced apart, bars 13 which may be formed integral with the sleeve 12 and have their free ends adjacent the inner circumference of the cylinder 10. An insulating sleeve 14, extending through the cylinder, is mounted within the tubular supports 11 and its opposite ends project beyond the frame, the said sleeve 14 being shown as having a diametrical partition 15 dividing the sleeve into two compartments. The cylinder 10 is therefore rotatably mounted upon and electrically insulated from the frame of the press in the manner disclosed in my said Patent 2,408,144 to which reference may be had for further details of the construction since it forms no part of the present invention.

A discharge element or electrode is contained in the cylinder 10 and is here shown in the form of a blade 16 extending longitudinally of the cylinder and located in the space between the insulating bars 13 being supported therein in any suitable manner. The inner end of the blade 16 is electrically connected to a wire or cable 17, a portion of which extends through one of the compartments within the insulating sleeve 14, the other portion of the wire being lead externally of the cylinder at an end thereof, as disclosed in my said Patent 2,408,144. The outer end of the blade 16 is adjacent the inner circumference of the cylinder but spaced therefrom and the mounting of the blade within the bars is preferably such as to permit adjustment of this space to thereby vary the width or gap of the electrostatic field hereinafter described.

It will be understood that the cylinder 10 is provided on its exterior with image areas and non-image areas and that the image areas may be inked by any suitable means; for example, by inking rollers 18 and 19, while the non-image areas will not have ink applied thereto as is well known in the art. The cylinder may be adapted for intaglio, planographic, relief, or other types of printing, the image areas of the cylinder being such as to allow passage of electrostatic fields of force therethrough and the type of inking means employed will, of course, be in accordance with the type of printing the cylinder is to perform, as is well known in the art.

A second cylinder 20 is rotatably supported adjacent the image cylinder 10 to provide a support for the print receiving material M in the printing zone, the space between the cylinder being sufficient to allow passage of the material M without appreciable pressure thereon. The cylinder 20 is preferably formed of conductive material and is rotatably supported upon, and insulated from, the frame of the printing press in the same manner as is the image cylinder or element 10. The cylinder 20 is therefore provided with tubular supports and insulating sleeves of the type mentioned above in the description of the cylinder 10 and hence need not be again described in detail. Likewise, within the cylinder 20 is disposed an electrode in the form of a longitudinally extending blade 21, similar to the electrode or blade 16, and constituting the attraction element of the electrostatic field for the printing apparatus.

The blade 21 is connected by a wire or cable 22 in a circuit providing electrical energy for creating and electrostatic field of force at the printing or fluid transfer zone between the discharge element 16 and the attraction element 21. This electric circuit comprises a source of high potentil direct current, generally designated 23, and which in the illustrated form includes a transformer T, the primary 24 of which is connected to alternating power supply lines L1 and L2. The transformer T is provided with a main secondary winding 25 the ends of which are connected to the plates of rectifier tubes 26 and 27, the filaments of which are energized from a second secondary winding 28. The secondaries 25 and 28 of transformer T are each provided with central taps 29 and 30, respectively, to which are connected wires 31 and 32 constituting the output of the power supply unit 23. There is thus provided a conventional transforming and rectifying device capable of producing a high potential, low amperage current. The wire 31 is connected to the wire 22 which is in turn connected to the attraction element 21, while the wire 32 is connected, as hereinafter described, to the discharge element 16, thereby providing a potential gradient between the discharge and attraction elements for producing an electrostatic field of force therebetween. This electrostatic field of force defines a printing or fluid transfer zone since it acts upon the ink or other fluid supplied to the image cylinder 10 to effect transfer of that fluid on the image areas to the material M as the latter and the image areas pass through the field of force between the discharge and attraction elements. It will be understood that the material M is moved by means, not shown but which are disclosed in my prior patents, in timed relation with the rotation of the cylinders 10 and 20.

As mentioned above, it has been found that all inks and other printing fluids do not readily migrate completely when subjected to the same electrostatic potential gradient and that it is therefore necessary to vary the potential gradient in accordance with the type of ink or other fluid employed. Therefore, the wire 17, which is connected with the discharge element 16, is connected with the movable arm of a rheostat 33, the stationary portion of which is in turn connected, as hereinafter described, to the wire 32. Consequently, by varying the setting of the rheostat 33, the potential gradient or the strength of the field of force between the discharge and attraction

electrodes may be selected in accordance with the type of fluid and/or the print receiving material employed for printing.

It has been further found that even with relatively high potentials certain fluids do not readily transfer or migrate completely when passed through the electrostatic field of force. However, it has been further found that these fluids can be readily migrated or transferred at a given potential or strength of field if that field be pulsated rather than maintained at a constant potential gradient. In addition, fluids which can be relatively easily transferred at a given constant potential gradient may be more effectively transferred at that potential or even at a lower potential gradient when the potential gradient or strength of field is periodically varied or pulsated. Therefore, the circuit for applying electrical energy to the electrodes 16 and 21 for the electrostatic field of force is, in accordance with this invention, periodically pulsated or interrupted. This is effected by connecting the rheostat 33 to a brush 34 which cooperates with one portion of a rotatable pulsating switch or commutator 35, a second brush 36 cooperating with another portion of the switch or commutator 35 being connected to the output terminal 32 of the power supply 23.

The rotating pulsating switch or commutator 35 may be constructed in any desired manner for effecting circuit interruptions when the member is rotated. As here illustrated, however, the member 35 comprises a substantially cylindrical body of insulating material 37 which has a continuous cylindrical band 38 of electrically conductive material adjacent one end thereof, this band being provided with diametrically opposed projecting portions 39 and 40 projecting longitudinally with respect to the insulating material 37 on opposite sides thereof. The brush 34, as will be seen in Fig. 1, cooperates with the portion of the switch member 35 provided with the longitudinally extending projections 39 and 40, while the brush 36 rides continuously upon the cylindrical portion or band of the conductive member 38. Consequently, as the switch or commutator 35 is rotated, the circuit to the electrodes 16 and 21 is made and broken twice during each revolution of the rotating switch or commutator member. It will be readily apparent that the switch or commutator member may be otherwise constructed to provide for one, or any desired number of circuit interruptions, during each revolution thereof.

The rotating member or switch 35 is connected with the armature shaft of a motor 41 which is of the variable speed type energized through power supply lines 42 and 43. The speed of the motor 41 may be varied in any conventional manner but is here illustrated as employing a rheostat 44 in the power supply lead 43 to thereby vary the strength of the electrical energy supplied to the motor and thus alter the rate of rotation. By adjusting the rheostat 44, it will be apparent that the number or frequency of circuit makes and breaks may be varied so that the rate of pulsation or interruption of the electrostatic field of force may be readily selected for a given type of fluid employed with printing. That is to say, having determined the electrical properties of a fluid to be utilized, the settings of the rheostat 33 and the rheostat 44 are then effected to provide a potential gradient of proper value for that fluid and circuit interruptions at a frequency most advantageous for transfer of that fluid. In view

of the great variety of printing inks or other fluids utilized, it will be readily apparent that a list of the potentials and frequencies employed would exceed practical limits for inclusion in this application.

Connected in parallel between the output wires 31 and 32 are a plurality of electrical condensers 45. These condensers serve to eliminate the ripple in the electrical energy, provided by the power supply 23, and to maintain the potential difference or gradient applied to the discharge and attraction elements 16 and 21 at a predetermined constant value for a given setting of the rheostat 33 at all times when the circuit thereto is closed. Consequently, the electrostatic field comprises repeated pulses or impulses at substantially full potential separated by intervals at zero potential through action of the switch 35 as it repeatedly closes and opens the circuit.

It should be noted at this point that the spacing between the discharge and attraction electrodes 16 and 21 and the maximum potentials applied thereto are at all times such that no sparking therebetween is effected nor is there any corona or similar current discharge occurring between the electrodes.

An explanation of why the pulsation or interruption of the electrostatic field of force effects more complete transfer or migration of the fluid to the printing material is beyond the scope of this application, but it is believed that the effect is similar to that which is evidenced by the mechanical analogy of striking the interior of a cylindrical member with repeated hammer blows to dislodge material clinging on the exterior thereof. Be that as it may, repeated tests have shown that, for a given potential gradient of the electrostatic field and a given type of printing fluid, the fluid is more completely transferred to the print receiving material and sharper image outlines are secured upon the print receiving material when pulsation or circuit interruption of the electrostatic field is utilized.

While one simplified form of an apparatus for pulsating the electrostatic field of force for effecting the transfer or migration of the fluid to the print receiving material has been disclosed, it will be readily apparent that numerous means other than the specific circuit arrangements heretofore illustrated and described may be employed for effecting the same result. For example, if a source of sufficiently high potential direct current be readily available, the power supply 23 can, of course, be omitted. Moreover, means other than the motor driven switch or commutator 35 may be employed for interrupting or pulsating the electrostatic field. Likewise, the printing apparatus illustrated in Figs. 1 and 2, and described with respect thereto, may be employed with electrical precharge of the printing fluid and/or the print receiving material prior to their introduction into the electrostatic field or printing zone and this electrical precharge may itself be pulsated in a suitable manner; for example, similar to that utilized for the transfer field above described. Furthermore, in certain instances, it has been found that the electrical characteristics of the fluids employed are such that they move more readily in one direction in an electrostatic field than in another; that is to say, certain inks or other fluids are self-ionized or more readily receive charges of one polarity, whereas other fluids or ink are ionized or more readily receive charges of an opposite polarity. Therefore, provisions may be made for readily reversing the

polarities of the potentials applied to the discharge and attraction elements and similar provisions may be made for the precharge circuit or circuits when the latter are employed.

A present preferred form of an apparatus constructed in accordance with the invention and capable of performance the method thereof is illustrated in Fig. 3. This form of the apparatus, in addition to pulsation of the transfer electrostatic field, includes the electrical precharge of the ink or fluid and of the print receiving material, pulsation of these precharges and provisions for reversing the polarities of the precharge and transfer potentials as suggested above.

The apparatus illustrated in Fig. 3 is provided with an image cylinder 46 which is constructed and supported in the same manner as described above with respect to the image cylinder 10 of Fig. 1. This cylinder is likewise provided with a discharge electrode 47 similar in nature and construction to the electrode 16 of Fig. 1 and ink or other fluid is supplied to the cylinder 46 by inking rollers or other similar means 48 and 49 corresponding with the inking rollers 18 and 19 previously described. Also, the print receiving material M', corresponding with the material M in Fig. 1, is supported within and moved through the printing zone in the same manner as in Fig. 1, a cylinder 50 corresponding with the cylinder 20 being provided to support the material in the printing or transfer zone. The cylinder 50 has an attraction element 51 therein, corresponding with the attraction element 21 of Fig. 1, so that an electrostatic field of force may be established extending through the image portions of the cylinder 46 and the print receiving material M' in the same manner as in the form of the device previously described.

In addition to the transfer electrodes, the instant apparatus is provided with precharging electrodes 52 and 53 for respectively precharging the printing fluid and the print receiving material before these are moved adjacent each other in the printing zone between the discharge and attraction elements or electrodes 47 and 51. The electrode 52 preferably comprises a curved member, substantially concentric with the image cylinder 46 and adjacent the surface of the latter but spaced therefrom, the concave surface of the electrode being preferably provided with a plurality of projections or points 54. The electrode 53 extends transversely of the print receiving material M' and substantially parallel therewith, the lower surface of this member likewise being provided with projections or points 55 adjacent to but spaced from the print receiving material.

In the instant form of the apparatus, electrical energy for the transfer and precharge potentials is preferably provided by independent circuits, each connected with a power supply source 56 of conventional type available on the market for converting alternating current to high potential, low amperage direct current. In the form of the power supply shown, alternating current is supplied thereto through the power supply lines 57, 58 and 59 while two separate direct current outputs are provided by the wires 60, 61 and 62, 63. The unit 56 preferably includes separate adjustable potentiometers or rheostats 64 and 65 for varying the voltage output of the separate circuits connected with the output leads 60, 61 and 62, 63. Likewise, separate voltmeters 66 and 67 are provided to indicate the voltage supplied to these separate circuits and lights 68 and 69 may be provided to indicate that the corresponding portions of the power supply are in operation.

The power output lines 60 and 61 are connected with the movable blades of a reversing switch 70, one of the stationary terminals of the switch being connected with a wire 71 and the corresponding other stationary terminal being connected with a wire 72, these connections being adapted to be reversed by operation of the switch 70. The wire 71 is connected with a brush 73 cooperating with a circuit interrupting switch or commutator 74, similar to the previously described switch or commutator 35, the brush 73 riding upon the portion of the switch or commutator provided with the spaced conductive portions. Also cooperating with the switch or commutator 74 is a brush 75 running upon the continuous conductive portion of the switch or commutator. The brush 75 is connected by a wire or cable 76 to the attraction electrode 51 of the transfer electrostatic field while the discharge electrode 47 is connected to a wire or cable 77 which, in turn, is connected with the wire 72.

Connected in series between the wires 71 and 72, intermediate the switch 70 and the electrodes 47 and 51, are condensers 78 and 79. Connected in parallel with the condensers 78 and 79 between the wires 71, 72, intermediate switch 70 and electrodes 47, 51, are resistances 80 and 81. Intermediate the resistances 80 and 81 is connected one end of a wire 82, the other end of which is connected between the condenser 78, 79. The switch or commutator 74 is connected for rotation by a motor 83 energized from power supply lines 84, 85. The motor 83 is of the variable speed type, the speed of which, and hence the speed of the switch 74, being varied by means of a rheostat 86 provided in the power supply line 85 for the motor.

It will be apparent, therefore, that an electrostatic potential gradient is established between the discharge electrode 47 and the attraction electrode 51 which potential gradient is periodically pulsated or interrupted by rotation of the switch or commutator 74, the frequency of the pulsations or interruptions being selected, in accordance with the nature of the fluid to be transferred, by adjustment of the rheostat 86. Moreover, the potential of the energy supplied to the electrodes 47 and 51 may be varied by operation of the potentiometer or rheostat 64. Consequently, the circuit thus far described, with the switch 70 set in one position thereof, operates as previously described for the circuit in Fig. 1, it being understood that the condenser 78, 79 and the resistances 80, 81 correspond in function to the condensers 45 in the previously described circuit, the purpose of the resistances 80, 81 being to provide a small "bleed" current as is well known in the electrical art. The direction of the potential gradient, i. e., the polarities of the transfer electrodes 47, 51, may be readily reversed by simply throwing the switch 70 to its other position thereof, thereby enabling the apapratus to be utilized for transfer of fluids which more readily migrate under influence of an electrostatic field whose potential gradient is reverse to that utilized with fluids of different electrical characteristics.

In addition to the features of the circuit described in Fig. 1 and which are incorporated in the instant transfer circuit, a voltmeter 87 may be provided between the wires 71 and 77 to indicate the potentials applied between the elec-

trodes 47 and 51. Also, an ammeter 88 may be inserted between the wires 72 and 77 to indicate the current flowing in the circuit through the bleeder resistances 80, 81, a switch 89 being preferably bridged about the ammeter 88 to short circuit the latter when indication of the current flow is not desired.

The electrical energy for effecting the precharge of the fluid and of the print receiving material is substantially identical with that described for providing the potentials for the transfer electrostatic field. Thus, the power output wires 62, 63 are connected with the blades of a reversing switch 90, the stationary terminals of the switch being in turn connected with wires 91 and 92 so that the switch is effective to reverse the connections of the wires 62, 63 to the wires 91, 92 as will be readily understood. The wire 91 is connected with a brush 93 riding upon the continuous conductive portion of a reversing switch or commutator 94, similar to those designated 35 and 74. The switch 94 is driven by a variable speed motor 95, the speed of rotation being preselected by a rheostat 96 connected in one of the power supply leads 97, 98 for the motor. A second brush 99 rides upon that portion of the switch or commutator 94 which is provided with the spaced conductive portions, this brush being connected by a wire 100 with the previously mentioned electrode 53 for effecting precharge of the print receiving material M'.

The wire 92 is connected to a wire 101 with an ammeter 102 interposed therebetween, the ammeter being normally bridged by a switch 103. The wire 101 is in turn connected with a wire 104 connected to the precharge electrode 52 for precharging the fluid upon the image cylinder 46. Between the wires 91 and 101 are connected the condensers 105, 106 and resistances 107, 108, these elements being connected in the same manner and serving the same purpose as the corresponding condensers and resistors 78, 79, 80 and 81 in the transfer circuit. Likewise a voltmeter 109 may be connected between the wires 91 and 101 to indicate the potential applied in the precharge circuit in the same manner as does the voltmeter 87 for the transfer circuit.

It will be apparent, therefore, that with the reversing switch 90 in one position thereof, the precharge electrode 52 for the fluid will be provided with an electrical charge of one polarity while the precharge electrode 53 for the sheet or web material M' will be provided with an electrical charge of opposite polarity. By reversing the position of the switch 90, the polarities applied to the precharge electrodes 52 and 53 may be reversed. In all cases, however, the polarity of the charge upon the precharge electrode 52 should correspond with the polarity of the discharge electrode 47 and the polarity of the charge upon the precharge electrode 53 should correspond with the polarity of the attraction electrode 51. In other words, when one reversing switch 70 is actuated to a different position to alter the potential in the transfer circuit, the reversing switch 90 should likewise be actuated to reverse the polarities in the precharge circuit. If desired, the switches 70 and 90 may be ganged together so that both are actuated simultaneously as indicated in my aforementioned application S. N. 591,739, now Patent No. 2,483,462.

It will also be evident that the precharging potentials may be pulsated or interrupted in the same manner as the transfer potentials and the speed of these interruptions may be varied by adjusting the setting of the rheostat 96 controlling the speed of rotation of the motor 95 and hence of the switch or commutator 94. Likewise, the value of the potentials applied in the precharging circuit may be adjusted or varied by altering the setting of the potentiometer or rheostat 65. The speed of pulsation or interruptions of the precharge potentials need not be the same as that employed in the transfer potential circuit and will be selected in accordance with the characteristics of the particular fluid or fluids employed. In certain cases, pulsation of the precharge circuit may be eliminated and a steady potential employed. This may be readily effected by deenergizing the motor 95 and positioning the switch 94 so that both brushes 93, 99 rest upon conductive portions of the switch or commutator 94.

The method of this invention and the mode of operation of the apparatus herein described should now be fully apparent. By way of brief recapitulation, however, it may be mentioned that printing upon sheet or web material is effected by passing the latter through a printing zone in which a pulsating electrostatic field of force extends through the image and the print receiving material. The image and print receiving material are moved simultaneously, in register, by suitable means rotating the image cylinder and the supporting cylinder, such as 10, 20 or 46, 50, in timed relation with the operation of the driving means for the print receiving material and ink or other fluid for reproducing the desired image is supplied to the image cylinder 10 or 46, as the latter rotates, by suitable means such as the inking rollers diagrammatically illustrated.

As the image cylinder is rotated after having received a supply of ink upon the image areas, this ink receives a precharge of predetermined polarity and intensity as it moves adjacent the precharge electrode 52, this precharge being received prior to the introduction of a given image area into the printing zone. Likewise, the print receiving material M' receives a precharge of predetermined polarity, opposite to that of the ink and prior to introduction of a given portion of the print receiving material into the printing zone, by passing adjacent the precharge electrode 53. The precharge potentials thus applied are preferably pulsated to effect a more ready precharging of the ink and material, this pulsation bing effected by operation of the switch 94 in the precharge potential circuit. As the image cylinder and print receiving material, conditioned by precharge of the inked image areas and precharging of the print receiving material, pass in register through the transfer or printing zone, the electrostatic field of force between the transfer and attraction electrodes, such as 47 and 51, causes migration or transfer of the ink or other fluid to the material, this migration being effectively and completely achieved by pulsating the transfer potential through operation of the pulsating switch or commutator 74.

The potentials employed for effecting transfer of the ink or other fluid at the printing zone, and for precharging of the ink and print receiving materials, are selected in accordance with the characteristics of the paritcular ink or other fluid utilized. These potentials, however, are at all times less than the values which would produce sparking or corona discharge between the transfer electrodes 47 and 51 for a given spacing

therebetween. Likewise, the precharge potentials are selected in accordance with the nature of the fluid and print receiving materials employed and these potentials likewise are less than those productive of sparking or corona discharges. The speed of pulsation or interruption of the precharge and transfer potentials is preselected in accordance with the known characteristics of the printing fluid and the print receiving material employed and this speed will, of course, vary for different types of inks or other fluids. The polarities of the precharge and transfer potentials are reversed whenever the nature of the ink or other fluid requires this action, it being remembered that the transfer and precharge potentials must be simultaneously reversed.

As mentioned before, the condensers such as **78, 79, 105** and **106** provide a low impedance path for the ripple in the direct current output of the power source **56** as well as providing an energy storing system for maintaining constant voltage output. The resistors such as **80, 81, 107, 108** provide a "bleed" or constant flow of current of small amperage to serve as a constant fixed load. The regulation of the power supply is thereby improved and the voltage is maintained at a substantially constant value. Consequently, the transfer and precharge potentials applied to the several precharge and transfer electrodes when the switches **74, 94** are in circuit closing relationship are always at full value and potentials at these electrodes sharply drop to zero when the circuits are interrupted by operation of the switches **74** and **94**, the electrodes again being restored substantially simultaneously to full potential when the switches **74** and **94** move to circuit making positions during their rotation. Therefore, sharp pulses of electrical potential are applied to both the transfer and precharge electrodes with the result that the printing fluid and print receiving material are more effectively precharged and the fluid is substantially completely migrated or transferred in the printing zone thereby producing sharper and better defined images upon the material and elimination of the flecks or specks of the material which heretofore sometimes appeared in the image areas when steady potentials were employed in the printing or transfer zone.

As will be understood by those skilled in the art, the term "image" and related terms as used heretofore in the specification and hereinafter in the subjoined claims includes words, letters, delineations, drawings, pictures, illustrations and the like which may be reproduced on the print receiving material from relief, intaglio, planographic or any other known type of printing member and that such terms are used as embracing any of these items or any combination thereof. It will be also understood that the term "ink" or "fluid" employed in this application is intended to refer to ink in the ordinary sense and also to any other substance, such as solid material suspended in liquids or gases, or any other substance which may be employed in reproducing in color, or otherwise, on print receiving material an image carried by the printing member of a printing apparatus.

While the method of this invention has been described with reference to the manner in which it may be practiced with two specific forms of apparatus, it will be readily apparent that the method is capable of use with other types of apparatus than those herein shown and described. Likewise, the details of the specific forms of apparatus herein illustrated and described may be varied by those skilled in the art without departing from the spirit of the invention. Therefore, it is to be understood that the detailed description and illustration are solely for the purpose of complete disclosure of the nature of the invention and are not intended as limitations thereon.

Having thus described the invention, I claim:

1. The method of printing comprising providing a printing element having an image thereon which is to be reproduced, providing a film of the printing liquid upon said image, creating a high potential unidirectional cyclically pulsating electrostatic field of force extending through said image at a printing zone, and bringing the material which is to receive said image closely adjacent said element in said pulsating field of force at the printing zone so that the electrostatic charges of the field of force effect transfer of the liquid on said image to said material thereby reproducing the image on the material.

2. The method as defined in claim 1 and further comprising precharging said film of printing liquid and said material with unidirectional electrostatic charges of opposite polarities from a source of cyclically pulsating unidirectional electrical energy prior to bringing the said film and material adjacent each other in said pulsating field of force at said printing zone.

3. In a printing apparatus, an image carrying member adapted to have printing relationship with print receiving material at a printing zone, means for inking the image on said member, means for impressing an electrical precharge of certain polarity on said ink prior to the member and the material being brought into printing relationship at the printing zone, means for imparting an electrical precharge of opposite polarity on the print receiving material before the latter is introduced into the printing zone, means for supporting the print receiving material in printing relationship to said member in the printing zone, and means for creating at the printing zone an electrostatic field of force extending from said member through said material, the last-mentioned means comprising a pair of spaced electrodes, a source of high potential direct current, a circuit connecting said source to said electrodes, a rotary switch in said circuit adapted to repeatedly make and break said circuit when rotated, and means for rotating said switch whereby the said electrostatic field is cyclically pulsated and the potentials of said pulses are substantially constant.

4. The combination as defined in claim 3 and further comprising means to vary the speed of said means for rotating said switch whereby the rate of pulsation of said electrostatic field may be varied.

5. The combination as defined in claim 3 and wherein the means to precharge said ink and the means to precharge said material each comprise an electrode respectively adjacent said member in advance of said printing zone and adjacent said material in advance of said printing zone, and means supplying the two last-mentioned electrodes with cyclically pulsating unidirectional electric potentials of opposite polarities.

6. The combination as defined in claim 3 and wherein the means to precharge said ink and the means to precharge said material each comprise an electrode respectively adjacent said member in advance of said printing zone and adjacent said material in advance of said printing zone, means supplying the two last-mentioned electrodes with cyclically pulsating unidirectional

electrical potentials of opposite polarities, and means to vary the frequency of the pulsations of said precharge potentials.

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