

June 27, 1967

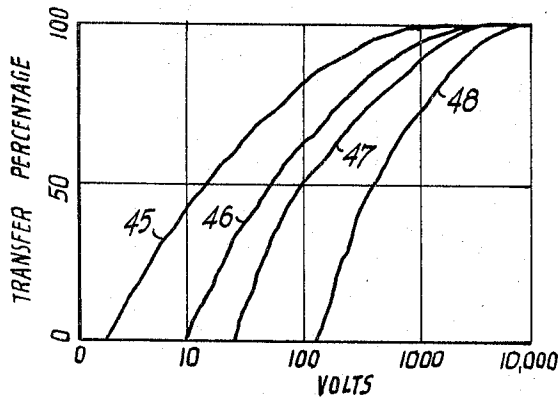
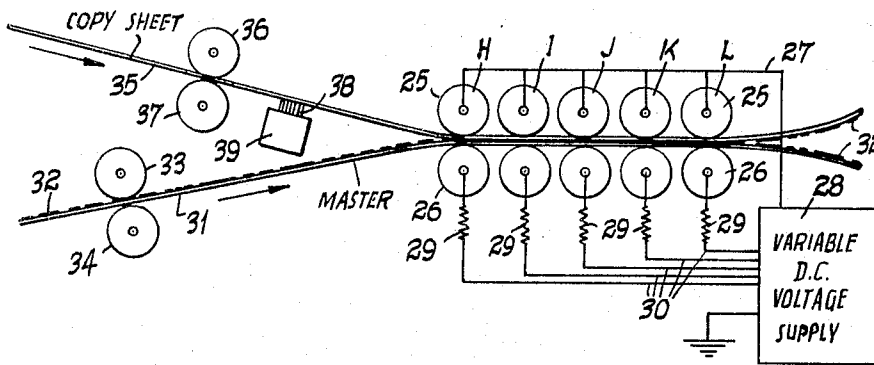
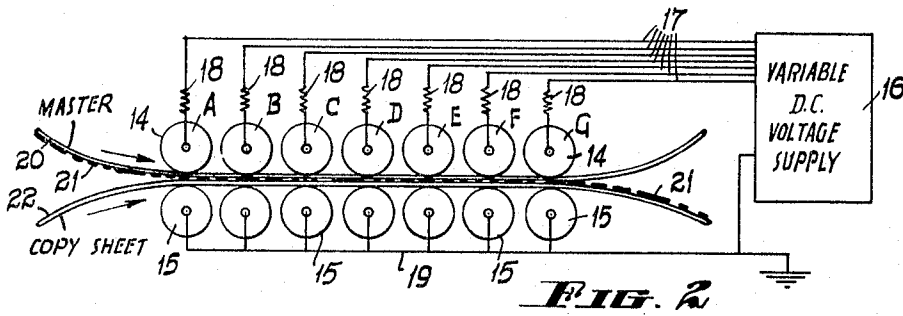
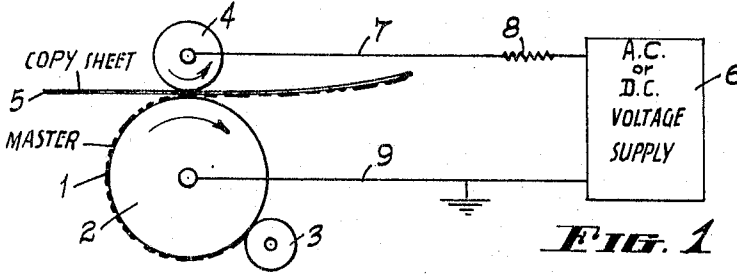
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3,328,193

METHOD OF AND MEANS FOR THE TRANSFER OF IMAGES

Filed Sept. 30, 1963

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

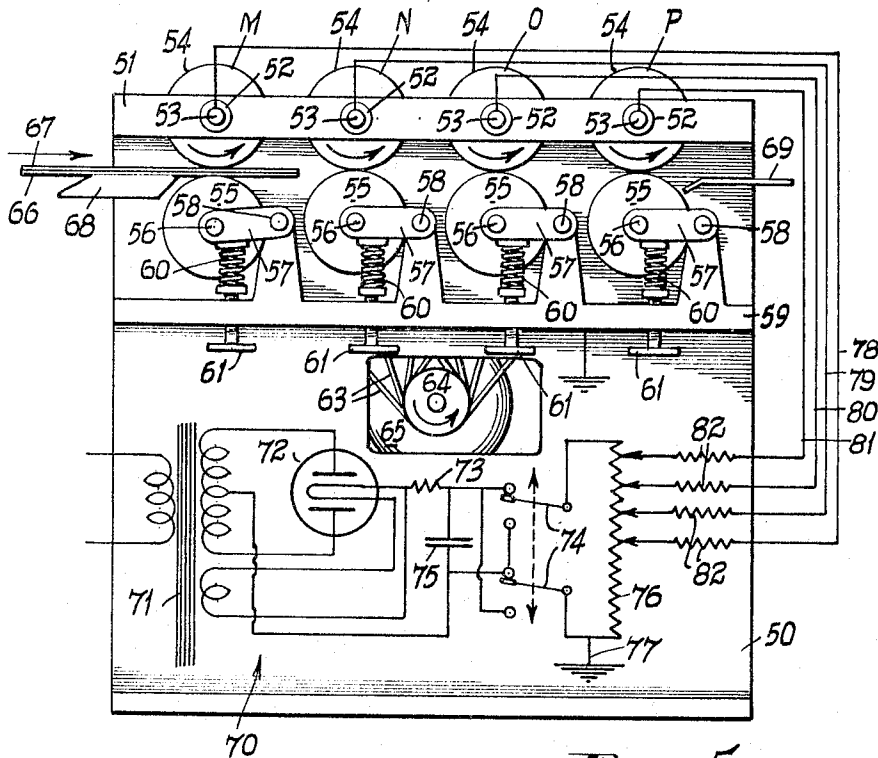


FIG. 5

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METHOD OF AND MEANS FOR THE TRANSFER OF IMAGES

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 8 Claims. (Cl. 117-37)

This invention relates to a method of and means for the transfer of images and in particular it relates to the transfer of images by electrostatic means.

It is already known, particularly in dry xerographic work, to transfer images from one surface to another by using an electrostatic force to effect the transfer, and while this invention also relates to the art of electrostatic transfer the object is to provide certain improvements in the method of and means for causing a transfer of a wet image from any source such as from a printed master or from a xerographic master or the like, the object being to obtain an improved result with relatively little distortion or smudging which can readily take place with the previously known methods when these are applied to wet transfer.

According to this invention the object is achieved by utilising a pair of conductive rollers between which the master image sheet (hereinafter referred to as the master) and the transfer-receiving sheet (hereinafter referred to as the copy sheet) are passed, or on one of which the master is formed, the rollers having a potential applied between them which causes the transfer to take place, or to be aided, electrostatically.

The loading of the rollers is such that only light contact with the master and the transfer-receiving sheet takes place, but the voltage whereby the transfer is effected is such that it is below the point where the dielectric formed by the sheet or sheets breaks down.

According to the preferred form of this invention a pair of rollers are spring-loaded together with a pressure which may be varied if required, and the potential is applied across the rollers by a suitable power pack which includes a limiting resistance in its circuit to avoid damage to the power pack when the rollers contact, such as when no material is being passed between them, the rollers being provided with driving means, either manual or mechanical, to cause the sheets to pass therebetween.

By using a pair of rollers and passing the image sheet and the transfer-receiving sheet between them it will be realised that good line contact is achieved with the result that linear scanning of the image sheet and the transfer-receiving sheet takes place in a plane where there is a substantial electrostatic field due to the proximity of the two rollers.

It has been found by experiment that spring-loading of one of the rollers towards the other is satisfactory, the rollers being adjusted so that the pressure between same is not excessive but there is just sufficient pressure to nip the paper or other sheets and keep them together in firm contact between the rollers in the actual transfer zone.

A multiplicity of pairs of rollers are provided through which the sheets move, the rollers being connected with an electrical supply in such a manner that, as the sheets move successively between the series of rollers, a progressive charging or transfer action will take place, the actual transfer action being controlled by ensuring that each pair of rollers has the correct voltage and current flow, which may vary from roller to roller.

In this way for instance the transfer can be effected

by commencing at a lower voltage and finishing at a higher voltage, or a higher voltage can be used at the start with a lower voltage subsequently acting on the sheet or sheets.

In order however that the invention may be more fully understood embodiments thereof will now be described with reference to accompanying drawings in which:

FIG. 1 is a schematic view showing how the invention can be applied between a single stage master and a copy sheet, the image on the master being wet during transfer,

FIG. 2 shows a further embodiment in which the transfer takes place between a master and a copy sheet, using a number of stations to effect the transfer, again using a wet master.

FIG. 3 is a similar multi-stage transfer arrangement between a master and copy sheet but using a method whereby the copy sheet is damped with a liquid to aid transfer from the master.

FIG. 4 is a graph showing the relation of the voltage to the transfer percentage, and

FIG. 5 is a schematic side elevation of a four stage machine according to the invention.

Referring first to FIG. 1, the master 1 is formed on the surface of a drum 2 which may contain any ink or developer accepting image surface, such as a xerographic sheet, the ink or developer being applied by the roller 3 and transfer being effected between the drum 2 and the loading roller 4, the loading roller 4 being urged towards the drum 2 by any suitable means such as its own weight to ensure that the copy sheet 5 is firmly held between the loading roller 4 and the drum 2 for effective transfer of the master. Where the drum surface is a xerographic sheet, the developer may comprise a pigment material, in particle form, in an electrical insulating liquid carrier, and a bonding material may be dissolved in the liquid carrier as a part of the developer.

A voltage generator 6 is coupled by means of the lead 7 through a resistance 8 to the loading roller 4, while the lead 9 connects the drum 2 to the voltage generator 6, this ensuring that there is an electrical field between the drum 2 and the loading roller 4 for the purpose of aiding the transfer. The purpose of the resistance 8 is to ensure that should the roller 4 touch the drum 2, there will be no short circuiting of the voltage generator 6, the resistance 8 having a value of perhaps 10 megohms where the voltage being used is say in the vicinity of 4 or 5 thousand volts.

It is to be noted from FIG. 1 that the voltage generator can be either of the alternating current or direct current type and in this regard it is of interest to mention that the transfer of the image from the master to the copy sheet may take place in some cases irrespective of the polarity of the field or the fact that it is alternating current.

It might seem at first that this should not be so and that the transfer should be a function of the direction of the field, but exhaustive tests have shown that a master can in some cases transfer to a copy sheet with enhanced effect even if the polarity is reversed during the actual transfer.

In explanation of this phenomena it is mentioned that when an image is transferred from a master to a copy sheet, the contact between the loading roller 4 and the master 1 of FIG. 1, tends to spread an image if it is wet and of course for transfer to take place the image must be wet.

Immediately there is any spread due to the contact between the master and the copy sheet, in view of the pressure of the loading roller 4, a somewhat inferior image results in which definition is lacking and also the problem is then encountered that the lines may some-

times be widened with consequent loss of depth of transfer.

When on the other hand a field exists at the point of transfer, the field appears to have the effect not only of maintaining the image and preventing spread, but also to aid transfer if the conditions are correct, which conditions vary greatly with the materials being transferred and other factors but which can readily be determined by doing a test run. It is noted for instance that when the inks or developers are near one of the electrodes, they tend to take the charge of that electrode and will be propelled towards the other electrode, while when they are at a point intermediate of the electrodes, the normal charge of the particles may be the predominant factor and in that case, when arranging conditions to give the correct polarity, movement of the particles can be enhanced in the required direction.

Again referring to FIG. 1 it will be realized that if the master 1 is formed directly on the drum 2 and the master itself is relatively conductive, then the interposing of a copy sheet which may be a relative insulator between the master and the loading roller 4 will ensure that the master is nearer the electrode formed by the drum 2 than it is to the loading roller 4 because of the interpositioning of the copy sheet therebetween, with the result that the pigment material and bonding medium of the wet image on the master 1 is given a charge corresponding to the drum 2 which may be positive or negative or alternating, and there is then a movement of this material away from the drum 2 against the copy sheet. If on the other hand the drum 2 had a zinc oxide sheet attached to it, the image material may become the dominating factor and for either a positive or negative characteristic material the drum may have to have similar polarity to effect a transfer, the opposite charge actually then preventing transfer.

For the purpose of obtaining the greater conductivity on the side of the master sheet to cause the material which is to be transferred to be urged away from it by the charge applied to it, the backing of the master may be conductive or relatively conductive, while a copy sheet can be ordinary paper or the like, but it will be realized that no exact formula can be set down for determining the actual polarity used. Using the above basis, however, those skilled in the art will have no difficulty in determining polarity, and in any case a simple trial run will show the most advantageous conditions.

In the form of the invention shown in FIG. 2 of the drawings a series of pairs of rollers 14 and 15 are used, the rollers 14 being connected to the voltage generator 16 so that the first pair A of rollers 14 and 15 is given perhaps a lower voltage than the last pair G of such rollers, the intermediate pairs of rollers B, C, D, E and F being given the required voltage for most effective transfer which usually is a progressively varying voltage.

Either the roller 14 or the roller 15 of each of the pairs A, B, C, D, E, F and G are fixed in position while the opposite roller of each pair is loaded towards the other roller, the rollers 14 being connected to the voltage generator 16 by leads 17 each of which includes in it a resistance 18 corresponding to the resistance 8 of FIG. 1.

A lead 19 couples all of the rollers 15 of the pairs A, B, C, D, E, F and G to the voltage generator 16 and, as shown, this part of the apparatus may be earthed.

In this embodiment a flexible master 20 is used having an image 21 on it which is to be transferred, the copy sheet being designated 22.

Using the arrangement of FIG. 2, to obtain a satisfactory transfer from an image prepared on a zinc oxide resin bonded web of high quality to a bond copy paper, the voltage was found to be within the range of 50 volts to 2.5 kv., using 50 volts between the first pair of rollers A, 200 volts between the second pair of rollers B, 500

volts between the third pair of rollers C, and successively 1 kv., 1.5 kv., 2 kv. and 2.5 kv. between the pairs of rollers D, E, F and G.

Using the same machine, the voltages varied for different materials as follows:

- From zinc coated foil to bond copy paper 50 v. to 1000 v.
- From zinc coated foil to foil copy 5 v. to 200 v.
- From zinc coated art paper to cloth 10 v. to 1000 v.
- From zinc coated art paper to glass 500 v. to 7.5 kv.
- From zinc coated art paper to plastic sheet 200 v. to 4.5 kv.

In the embodiment shown in FIG. 3 pairs of rollers 25 and 26 are shown, there being five such pairs designated H, I, J, K and L, all of the rollers 25 of the pairs being connected to the lead 27 of the voltage generator 28, while the rollers 26 are connected through the resistors 29 and leads 30 to the voltage generator 28.

In this case the master 31 has the image 32 thereon, and is fed forward by means of rollers 33 and 34, the roller 33 engaging only the edges of the master so that it does not contact the image 32.

The copy sheet 35 is fed forward by rollers 36 and 37 which are driven by any suitable means, as are also the rollers 33 and 34, so that synchronised movement of the master 31 and the copy sheet 35 takes place.

In this case the copy sheet is damped by means of a brush 38 fed from a reservoir 39, the damping material which is applied by the brush 38 being a solvent for the image 32 on the master so that in this case the master itself does not have to be in a wet condition prior to transfer.

It is found using such an arrangement that it is convenient to so control the voltage and the pressure between the rollers 25 and 26 of each of the pairs H, I, J, K and L, that a master can have sufficient image 32 thereon that only part of it is transferred during each pass of the master, thereby allowing a number of copy sheets to be printed from the master by successively passing the master through the device with new copy sheets.

It is to be noted that in FIG. 3 part of the image 32 has been transferred to the copy sheet but part still remains on the master as shown on the right hand side of the drawing, this effect differing from the embodiment shown in FIG. 2 where a wet master used in which the whole of the image 21 has been transferred from the master 20 to the copy sheet 22.

This of course is selected at will because quite obviously the master could also be in a condition in FIG. 2 where more than one transfer can take place, but the embodiment shown in FIG. 3, because of the use of a brush 38 which applies the solvent to the copy sheet, facilitates this multiple transfer.

In FIG. 4 is shown how as the voltage applied to the rollers is increased so the amount of transfer is increased until, under ideal conditions, at the highest voltage possible a complete transfer can take place.

In applying such a voltage of course it must always be ensured that there is no breakdown of the field through the materials such as by arcing, because this would necessarily damage the transfer.

The maximum voltage which can in any case be applied is therefore that voltage at which a field will be maintained without breaking down through the master or the copy sheet.

Obviously this will vary according to the materials used and the voltage can therefore readily be determined by testing the material for breakdown and the voltage below this used.

In FIG. 4 the lines 45, 46, 47 and 48 represent the amount of transfer for different materials according to the voltage the materials are able to take without arcing through same, the line 45 representing a transfer from coated foil to foil, the line 46 showing the transfer from

coated art paper to cloth, the line 47 showing the transfer from coated art paper to bond paper, and the line 48 showing the transfer from coated art paper to glass.

Referring now to FIG. 5 of the drawings which illustrates somewhat diagrammatically a machine for effecting the transfer according to this invention, a base 50 supports on it an insulated bar 51 on which are carried bearings 52 for the spindles 53 of driven rollers 54, these rollers being paired with rollers 55 in groups designated M, N, O and P.

Each of the rollers 55 has its shaft 56 carried on an arm 57 connected by means of a pivot 58 to the carrier 59 which, like the insulated bar 51, is supported on the base 50, these rollers being therefore free to move towards or away from the rollers 54 but being normally urged towards the rollers 54 by means of springs 60 confined between the arms 57 and adjusting screws 61 which engage the member 59.

The rollers 55 are not driven, but the rollers 54 are connected by means of belts 63 to a multiple pulley 64 of a motor 65, all of the rollers being driven in the same direction and at the same speed so that they move the master 66 and the copy sheet 67 through the transfer stations in a uniform manner, 68 representing a platform to guide the master 66 and copy sheet 67 into the first pair of rollers M, the platform 69 receiving the master 66 and the transfer sheet 67 from the last pair of rollers P.

In this case the voltage generator 70 is shown as comprising a transformer 71 and rectifier 72, the output of the rectifier 72 being passed through a resistor 73 to a polarity changing switch 74, a smoothing condenser 75 being included.

The resistor 76 has its one end connected to earth at 77, which is the frame 50 of the machine, and the rollers 54 of the pairs M, N, O and P are fed respectively from leads 78, 79, 80 and 81 through independent resistors 82 from the main resistor 76, this arrangement then allowing the voltage to be selected as required. It will be noted that in this case a lower voltage is applied to the rollers 54 and 55 of the first pair M with a progressively higher voltage being applied to the successive pairs N, O and P, the voltage being variable by moving the ends of the leads 78, 79, 80 and 81 along the resistor 76.

It is to be noted also that because of the polarity changing switch 74 the rollers 54 can be given either a positive or a negative voltage as required, this selection being made when the transfer is taking place and the position of the polarity changing switch depending purely on which gives the best transfer with the particular materials used, if in fact there is any difference in transfer.

As stated earlier herein it is to be appreciated that one of the most important factors in transferring from a master to a copy sheet by actual contact, is to avoid spread of the image due to the pressure used, and in the present case the spread is limited by two factors, the first being that only a low pressure need be used between the rollers 54 and 55, which pressure can be selected by operating the adjusting screws 61, and secondly the field between the rollers 54 and 55 is such that direct transfer of the image results along the plane of the field.

As pointed out earlier herein, the polarity in each particular case will have to be determined and will vary according to such factors as the inherent particle charge of the developer, or the charge of the developer or ink as a whole, or to the conductivity of the materials from which and to which transfer is taking place, and in the case of photoconductor images on the rectification effect which photoconductors can introduce when subjected to alternating current fields, but as stated earlier herein, the determination of polarities and voltages is well within the capabilities of persons skilled in the art when applying the principles set out herein as the polarities of the developers and inks are generally known, and if not known can be readily determined by simply trying both polarities to

ascertain whether under the conditions obtaining there will be a difference and if so which will give the best transfer.

For maximum transfer the best voltage to use is usually that which approaches the electrical breakdown of the material without actual breakdown taking place, but where only a partial transfer is to take place this voltage may be considerably lower. Here again, simple practical tests will readily give the best operating conditions.

What we claim is:

1. The method of transferring images from a master to a copy sheet comprising:

applying a medium to be transferred to the master in accordance with a predetermined pattern;

bringing the master into contact with the copy sheet so that the medium to be transferred is in contact with the copy sheet;

with the medium to be transferred in a wet condition, passing the master and the copy sheet together between a pair of rollers which press the copy sheet to the master;

establishing an electrical field of given relative polarity, transversely of said master and said copy sheet, between said rollers to transfer a part of said medium from the master to the copy sheet;

with the medium to be transferred still in a wet condition and with the master and the copy sheet maintained in contact registry, passing the master and the copy sheet together between at least one additional pair of rollers; and

establishing and electrical field of said given relative polarity, transversely of said master and said copy sheet, between each additional pair of rollers to transfer a further part of said medium from the master to the copy sheet as they pass between each additional roller pair;

the electrical fields between successive roller pairs being of progressively increasing intensity.

2. The method of transferring images from a master to a copy sheet according to claim 1 in which said medium is applied to the master in a wet condition and remains in a wet condition throughout the transfer process.

3. The method of transferring images from a master to a copy sheet comprising:

applying a medium to be transferred to the master in accordance with a predetermined pattern;

bringing the master into contact with the copy sheet so that the medium to be transferred is in contact with the copy sheet;

with the medium to be transferred in a wet condition, passing the master and the copy sheet together between a pair of rollers which press the copy sheet to the master;

connecting said rollers to a unipotential electrical supply to establish an electrical field of given relative polarity, transversely of said master and said copy sheet, between said rollers to transfer a part of said medium from the master to the copy sheet;

with the medium to be transferred still in a wet condition and with the master and the copy sheet maintained in contact registry, passing the master and the copy sheet together between at least one additional pair of rollers; and

connecting the rollers of each additional pair to a unipotential electrical supply to establish an electrical field of said given relative polarity, transversely of said master and said copy sheet, between each additional pair of rollers to transfer a further part of said medium from the master to the copy sheet as they pass between each additional roller pair;

the electrical voltage differences between the rollers of successive pairs being of progressively increasing amplitude.

4. The method of transferring images from a master to a copy sheet comprising:

applying a medium to be transferred to the master in accordance with a predetermined pattern;
wetting the copy sheet with a solvent for the medium to be transferred;
bringing the master into contact with the copy sheet 5 so that the medium to be transferred is in contact with the copy sheet;
with the medium to be transferred in a wet condition due to contact with the wetted copy sheet, passing the master and the copy sheet together between a pair of rollers which press the copy sheet to the master; 10 establishing an electrical field of given relative polarity, transversely of said master and said copy sheet, between said rollers to transfer a part of said medium from the master to the copy sheet;
with the medium to be transferred still in a wet condition and with the master and the copy sheet maintained in contact registry, passing the master and the copy sheet together between at least one additional pair of rollers; and 20 establishing an electrical field of said given relative polarity, transversely of said master and said copy sheet, between each additional pair of rollers to transfer a further part of said medium from the master to the copy sheet as they pass between each additional roller pair; 25 the electrical fields between successive roller pairs being of progressively increasing intensity.

5. The method of transferring xerographic images from a master to a copy sheet comprising: 30 forming an electrostatic image on a master comprising a photoconductor surface on a base;
applying a developer to the electrostatic image, which developer consists of pigment particles in an electrically insulating liquid in which is contained a dissolved bonding medium; 35 bringing the master into contact with the copy sheet so that the developer is in contact with the copy sheet;
with the developer in a wet condition, passing the master and the copy sheet together between a pair of rollers which press the copy sheet to the master; 40 establishing an electrical field of given relative polarity, transversely of said master and said copy sheet, between said rollers to transfer a part of said developer, including both pigment particles and bonding medium, from the master to the copy sheet; 45 with the developer still in a wet condition and with the master and the copy sheet maintained in contact registry, passing the master and the copy sheet together between at least one additional pair of rollers; and 50 establishing an electrical field of said given relative polarity, transversely of said master and said copy sheet, between each additional pair of rollers to trans-

fer a further part of said developer from the master to the copy sheet as they pass between each additional roller pair;
the electrical fields between successive roller pairs being of progressively increasing intensity.

6. The method of transferring xerographic images from a master to a copy sheet according to claim 5, and including the additional step of wetting the copy sheet with a solvent for the developer before the copy sheet is brought into contact with the master.

7. A machine for transferring wet images from a master to a copy sheet comprising: a series of transfer stations each including a pair of electrode rollers mounted in aligned relation to each other; means for driving at least one roller in each pair, in synchronism with the rollers in each other pair, to advance the master and the copy sheet through said series of transfer stations, the spacing between pairs of rollers being close enough to maintain the master and the copy sheet in continuous contact registry as they pass between each pair of rollers; means biasing at least one roller in each pair toward contact with the other roller of the pair; means for adjusting the pressure between the rollers of each pair; an electric voltage supply; and circuit means for electrically connecting said voltage supply to each pair of rollers to establish an electrical field between the rollers of each pair and thereby transfer a part of a wet image from said master to said copy sheet at each transfer station; said circuit means including means for establishing the voltage differences across successive pairs of rollers at progressively higher amplitudes but with the same relative polarity to afford a progressive variation in the intensity of the electrical fields between successive pairs of rollers; said circuit means including current-limiting means for limiting the flow of current between said rollers.

8. A machine according to claim 7 and further including means for individually adjusting the voltage applied to each roller pair.

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