United States Patent

Nakatani et al.

[15] **3,677,640**

[45] **July 18, 1972**

[54] ELECTROSTATIC CONTACT PRINTING DEVICE FOR USE IN A PHOTOGRAPHIC CONTACT PRINTER

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[22] Filed: **April 9, 1971**

[21] Appl. No.: **132,733**

[30] **Foreign Application Priority Data**

April 10, 1970 Japan.....45/34424
May 21, 1970 Japan.....45/49886

[52] **U.S. Cl.**.....**355/78,** 355/97, 355/99
[51] **Int. Cl.**.....**G03b 27/02**
[58] **Field of Search**.....355/12, 78, 97, 99; 96/1

[56] **References Cited**

UNITED STATES PATENTS

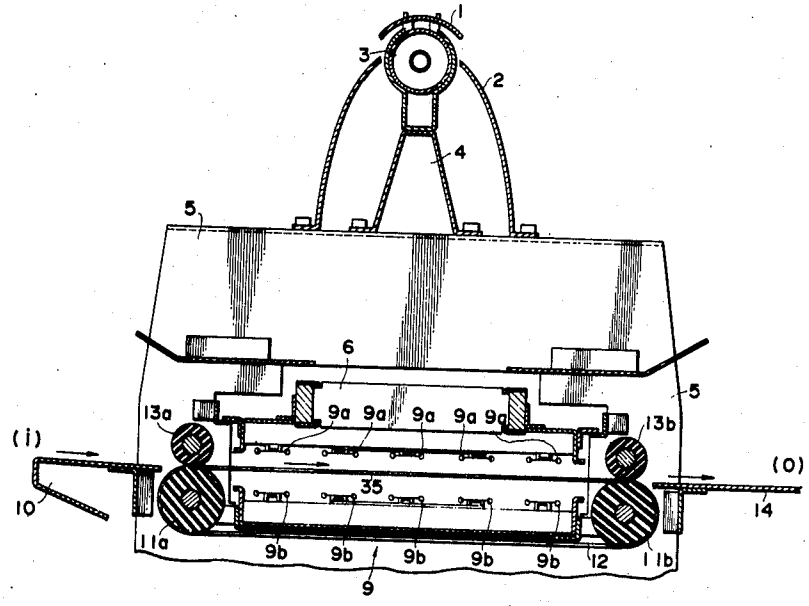
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Assistant Examiner—Richard M. Sheer
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[57] **ABSTRACT**

In a photographic contact printer, an electrostatic contact printing device comprises an electrode assembly consisting of several pairs of juxtaposed electrodes, each pair of electrodes being oppositely disposed so that an original sheet and a photosensitive sheet which have been superposed pass between. A high electric voltage is applied to the electrodes to create an electrostatic suction force therebetween, and an illuminating light source is located outwardly from the electrodes disposed on the original sheet side, whereby a high electric voltage is applied thereto simultaneously with the printing so that the original sheet and photosensitive sheet are electrostatically enforced to come into close contact with each other. A modification of the structure includes an additional set of electrodes which establish a pre-charge on the superposed original and photosensitive sheet of opposite polarity to the electrostatic charge of the adjoining electrodes.

4 Claims, 7 Drawing Figures



Patented July 18, 1972 3,677,640

4 Sheets-Sheet 1

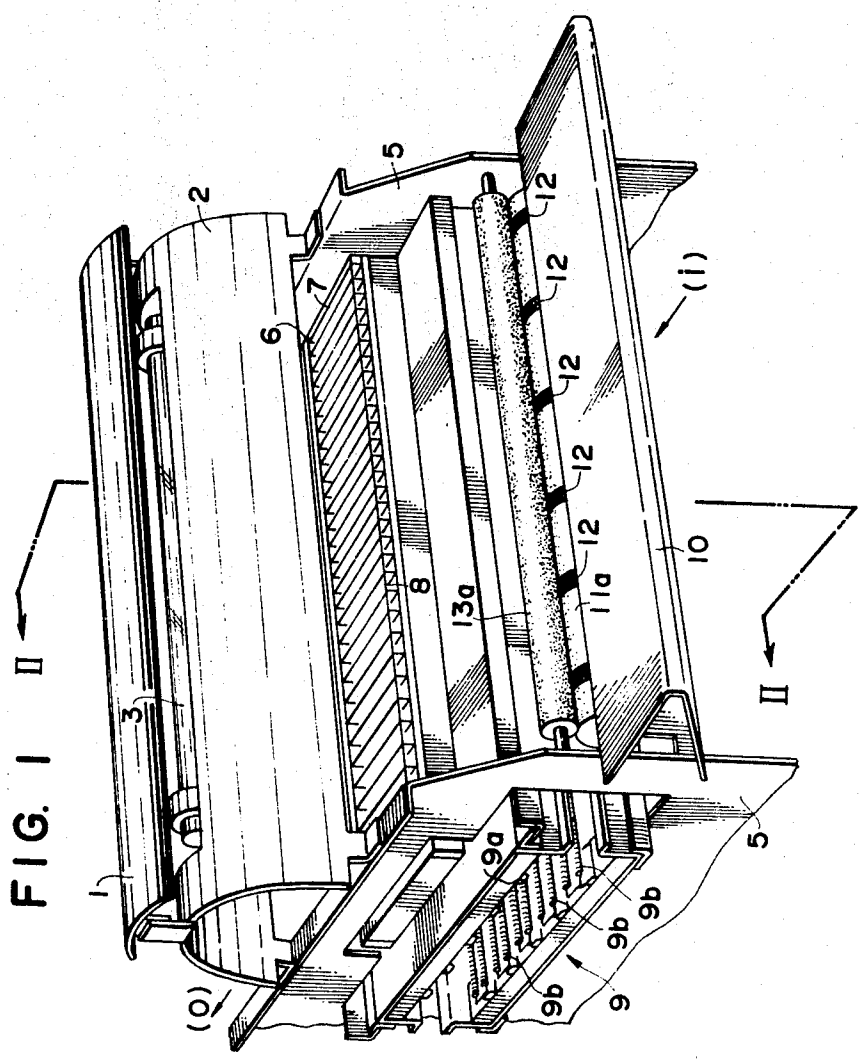


FIG. 1

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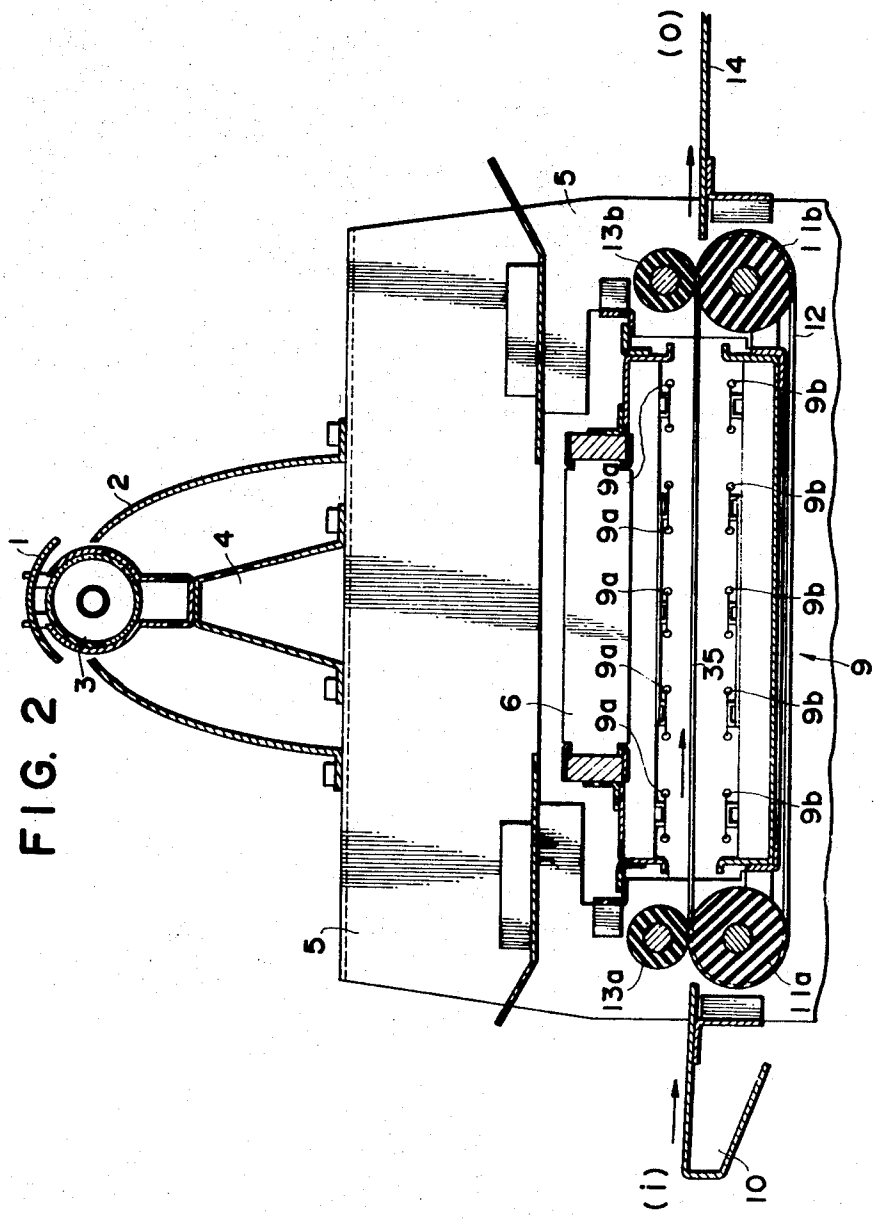


FIG. 2

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FIG. 3

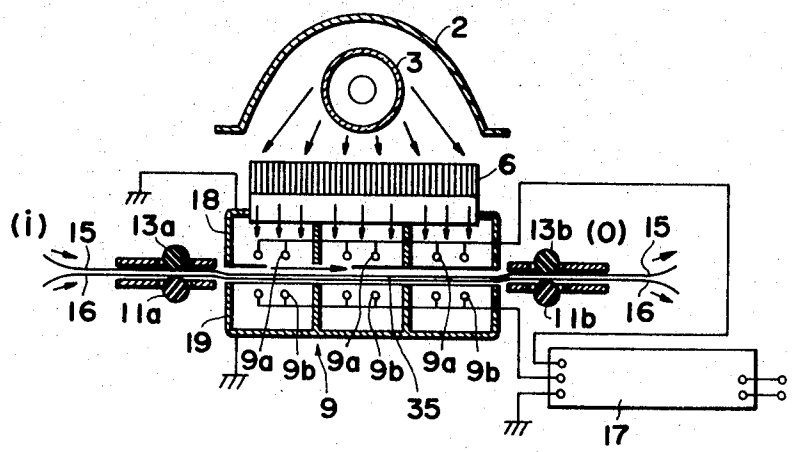
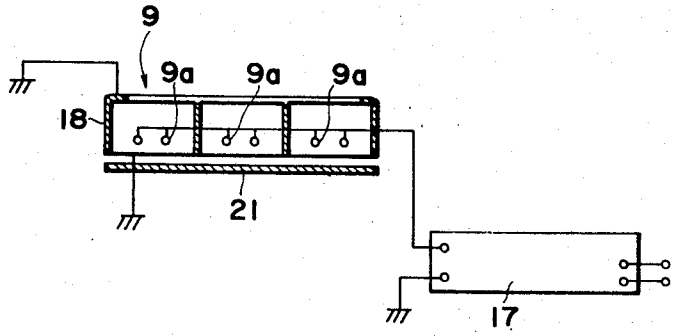


FIG. 4



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FIG. 5

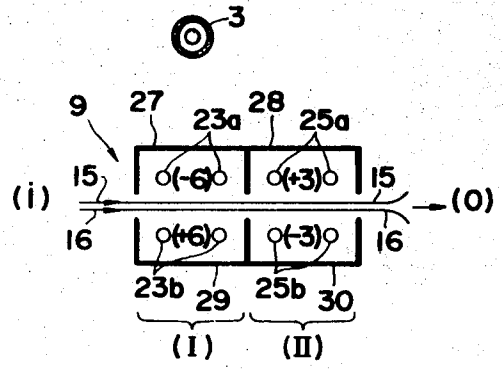


FIG. 6

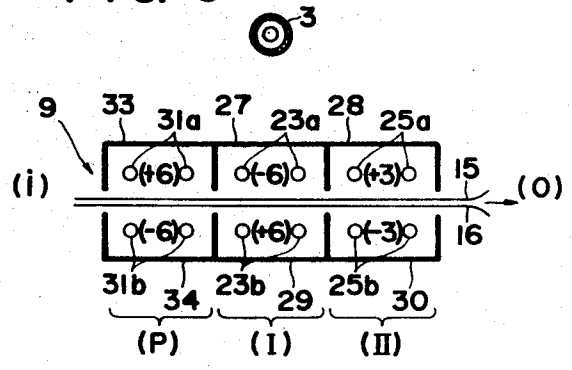
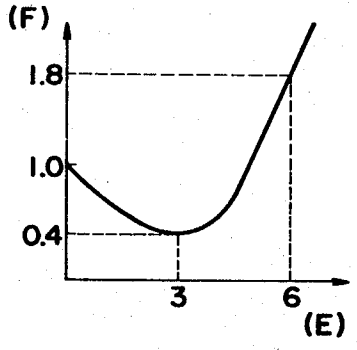


FIG. 7



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ELECTROSTATIC CONTACT PRINTING DEVICE FOR USE IN A PHOTOGRAPHIC CONTACT PRINTER

BACKGROUND OF THE INVENTION

The present invention relates to a device, in a photographic contact printer, in which an original sheet and a photosensitive sheet are electrically forced to come into close contact to each other when they are printed.

Since contact printing devices of the prior art are of a mechanical contact type wherein a press contact member, a photosensitive sheet and an original sheet superposed thereon are apt to shift their relative position due to slippage between respectively pressed contact portions thereof. As a result the photosensitive substance may be damaged, as well as its overall contact face can not be uniformly pressed, thereby reducing the resolving power of a copy printed in the printing operation. original

There is another contact apparatus which maintains the contact portions in a vacuum condition while bringing them into close contact, however, it has the disadvantage that it requires incidental appliances such as a suction device which is not only expensive but also renders the overall construction large and complex.

SUMMARY OF THE INVENTION

The present invention relates to an electrostatic contact printing device in a photographic contact printer, wherein, in order to apply an electrostatic suction force simultaneously with printing, positive and negative electrodes are juxtaposed so that they are respectively confronting against an original sheet and a photosensitive sheet superposed with each other. The original sheet and the photosensitive sheet are forced to come into close contact with each other, by applying a high electric voltage to the electrodes, as well as the force is released, if necessary, after the completion of the printing carried out under the forced contact, by providing two electrode layers each consisting of plural electrodes opposing each other, and by applying a high voltage having opposite polarities to the opposed electrode layers and the abutting electrode layers during separate successive time intervals.

An object of the present invention is to provide, in a photographic contact printer, an electrostatic contact printing device in which an original sheet and a photosensitive sheet are exposed to an electrostatic field, and both sheets are capable of coming into close contact with each other to form an improved therebetween.

Another object of the present invention is to provide, in a photographic contact printer, an electrostatic contact printing device in which an original sheet and a photosensitive sheet are not likely to be damaged.

A further object of the present invention is to provide, in a photographic contact printer, an electrostatic contact printing device in which an original sheet and a photosensitive sheet are easily separated from each other after the completion of printing.

Still another object of the present invention is to provide, in a photographic contact printer, an electrostatic contact printing device which is capable of affording an adherent force of the identical grade as that in cases where an extremely high voltage is applied, by applying a comparatively low voltage by virtue of a previous charge layer provided in the electrode assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an outside perspective view showing an embodiment of an electrostatic apparatus is accordance with the present invention.

FIG. 2 is a sectional view along a line II—II in FIG. 1 in the direction of the arrows thereon.

FIG. 3 is an illustrative elevational section view showing the first embodiment of an electrode assembly in the electrostatic apparatus.

FIG. 4 is an illustrative diagram showing the second embodiment of the electrode assembly.

FIG. 5 is an illustrative diagram showing the third embodiment of the electrode assembly. FIG. 6 is an illustrative diagram showing the fourth embodiment of the electrode assembly, and

FIG. 7 is a graph showing the relationship between the applied voltages (E) and the adherent forces (F).

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. 1 and FIG. 2, a tubular lamp (light source) 3 surrounded by an arcuate mirror 1 and a parabolic mirror 2 is rigidly fixed to a body frame 5 by means of a support 4, and the heated air flow due to the light source is discharged through gaps between the mirrors 1 and 2. In this case, they may be constituted so that the lamp 3 is continuously cooled by a draught fan which is not shown in the drawings.

A light flux control grid 6 positioned at an optimum distance apart from the lamp 3 is provided with regulating plates 7 which are perpendicularly directed with respect to the axis of the lamp 3 and other regulating plates 8 which are axially directed with respect thereto. Thus the light flux emitted radially from the light source is converted to a parallel light flux and introduced in parallel onto the printing surface 35 within an electrode assembly 9.

Also, the electrode assembly 9 is constituted in such a manner that electrodes 9*a* located on the original sheet side do not project their own images on the original sheet 15 when they are irradiated, and any reflected images can be fully neglected by virtue of the mutual influence among the light flux control grid 6, the electrodes 9*a* and the original sheet 15.

The electrode assembly 9 comprises a pair of sets of electrodes, the sets being located respectively above and under the printing surface 35 interposed therebetween, and formed between feeding rollers 11*a* and 13*a* which are disposed at the entrance side (*i*) and delivery rollers 11*b* and 13*b* which are disposed at the exit side (0), wherein respectively juxtaposed electrodes 9*a*, 9*b*, ... *confront each other, each electrode being composed of a tungsten wire or the like, and the electrodes 9a, 9b*, . . . are connected to a high voltage power source which is shown in FIG. 3 and FIG. 4.

A pair of rollers consisting of feed roller 11*a* and delivery roller 11b at one side are bridged with a plurality of belts made of nylon threads as shown in FIG. 1 and FIG. 2, and driven together with another pair of rollers consisting of the rollers 13*a* and 13b at the other side by means of a drive mechanism not shown in the drawing. They are constituted so that an original sheet 15 and a photosensitive sheet 16 are fed from the entrance side (*i*) and sent out through the exit side (0), and a printing thereof is carried into effect between the pairs of rollers.

A feeding table 10 is mounted to body frame 5 in front of the feed rollers 11*a* and 13*a* at the entrance side (*i*), and a guide plate 14 is disposed at the rear of the delivery rollers 11*b* and 13*b* on the exit side (0), the photosensitive sheet 16 is thereby sent through the guide plate 14 to a developing device not shown in the drawings.

The first embodiment of an electrode assembly 9 of the device shown in FIG. 1 and FIG. 2 is schematically illustrated in FIG. 3 in which like components have the same notations as those in FIG. 1 and FIG. 2.

The electrodes 9*a*, 9*b*, ... are electrodes confronting each other, and plural electrodes are respectively juxtaposed on both sides so that they are connnected to a suitable high voltage power source 17, both electrodes 9*a* and 9*b* are each thereby applied with respectively opposite polarities of a direct current high voltage. Notations 18 and 19 indicate shielding plates which are respectively grounded.

FIG. 4 illustrates the second embodiment of the electrode assembly 9, in which electrodes 9a are solely applied with a high voltage as shown in the drawing, and a grounded electrode plate 21 is disposed on the other side, being thereby constituted so that the electrostatic field generated therebetween will afford the same contact force effect as that of the first em-

bodiment. It is a matter of course that in this case alternating current may also be used as well as direct current. The notation **18** indicates a grounded shielding plate similar to that in FIG. **3**.

FIG. **5** illustrates the third embodiment of the electrode assembly **9**, which comprises the first electrode subset (I) and the second electrode subset (II) adjacent each other, and is constituted so that electrodes of the first layer (I) and the second subset (II) adjacent each other are capable of being applied respectively with opposite polarities of a high voltage. In other words, when the electrodes **23***a* of the first subset (I) are negative high voltage electrodes, and the electrodes **23***b* confronting therewith are positive high voltage electrodes for instance, the electrodes **25***a* of the second subset (II) are positive high voltage electrodes, and the electrodes **25***b* confronting therewith are negative high voltage electrodes.

Shielding plates **27**, **28**, **29** and **30** surrounding these electrodes shield them as a whole for the purpose of defining the functional region of the electrodes.

FIG. **6** illustrates the fourth embodiment of the electrode assembly **9**, wherein a previously charging electrode subset (P) is additionally disposed in front of the first subset (I) and the second subset (II).

It is constituted in such a manner that the electrodes **31***a* and **31***b* confronting each other within the charging subset (P) and the electrodes **23**a and **23**b of the subset (I) are applied respectively with opposite polarities of a high voltage.

And the electrodes within the first subset (I) and the second subset (II) are also applied respectively with opposite polarities of a high voltage in like manner as in the case of the third embodiment.

Shielding plates **33** and **34** shield the charging subset (P) for the same function as that of the third embodiment.

FIG. **7** is a graph showing experimental values of electrostatic contact force (F) within the electrode assembly **9** comprising two electrode subsets having a of the first subset (I) and the second subset (II) as shown in FIG. **5**, wherein the ordinate (F) represents adherent forces, and the abscissa (E) represents voltages (V) applied to the second subset. For example, when the electrodes **23***a* on one side of the first subset (I) are applied with −6 KV and the electrode **23***b* on the other side thereof with +6 KV, if the index of the electrostatic adherent force (F) corresponding therewith is assumed as **1**, when the voltage applied to the abutting second subset (II) with the polarity opposite to the first subset (I) is varied in order from a low voltage to a higher voltage, then the initial adherent force **1** is gradually decreased until its minimum value of about 0.4 is shown approximately around ±3 KV. The force is thereafter increased gradually by still applying higher voltages, thus it can be observed that when ±6 KV (I) is applied thereto, the adherent force becomes stronger than its initial value and reaches a value of nearly 1.8 times as much as its starting value.

With the constitution in accordance with the present invention as described hereinabove, in the first embodiment shown in FIG. **3**, the original sheet **15** and the photosensitive sheet **16** inserted from the entrance side (*i*) are introduced between feed rollers **13***a* and **11***a* in a superposed status, thereafter they are transferred by means of the belt **12** shown in FIG. **2** in the direction indicated by arrows. Also the original sheet face is irradiated by the tubular lamp **3** so that a printing thereby is carried into effect, and then both sheets **15** and **16** are sent out by means of the delivery rollers **11***a* and **13***a* to continue any further process such as development or the like.

In the electrode assembly **9**, the electrodes **9***a*, **9***b*, ... are applied with respectively opposite polarities of a direct current voltage, for instance, 3 KV through 5 KV so as to generate an electrostatic suction force. The original sheet **15** and the photosensitive sheet **16** passing through the electrode assembly **9** are effected by the suction force within the electric field so that their overall surfaces within the field are forced to come into close contact with each other, and a printing thereof can be carried out under this excellent contact status as they are simultaneously irradiated by the tubular lamp **3**. In addition, these sheets are never mechanically pressed into contact with each other, therefore the photosensitive substance etc. is not damaged.

In the second embodiment shown in FIG. **4**, a high voltage is applied solely to the electrodes **9***a* on one side, and the electrode **21** on the other side is grounded, thereby the identical contact effect can be obtained on account of the electrostatic field created therebetween. In this case alternating voltages are also capable of being used, as well as a direct current as described above.

The third embodiment of the electrode assembly **9** shown in FIG. **5**, utilizes a variation of adherent forces due to two electrode subsets as seen from the graph shown in FIG. **7**, wherein the original sheet **15** and the photosensitive sheet **16** which are put one upon another are fed into the electrode assembly **9**, in which the electrodes **23***a* and **23***b* of the first subset (I) are then applied with a high voltage of −6 KV and +6 KB respectively. An electrostatic suction force is thereby generated within a space between the electrodes **23***a* and **23***b*, therefore the original sheet **15** and the photosensitive sheet **16** intervening therebetween are effected by the suction force so that the overall interior faces of both sheets within that space are forced to come into close contact with each other. Accordingly a printing thereof can be carried out under excellent conditions as they are simultaneously irradiated by the lamp **3**. Subsequently the original sheet **15** and the photosensitive sheet **16** are, for their successive steps of processing, transported into a space between the electrodes **25***a* and **25***b* of the second subset (II), and within that space a high voltage of + 3 KV and −3 KV is respectively applied to the electrodes **25***a* and **25***b*, resulting in the neutralization of electrostatic charge provided by the electrodes of the first subset (I). In accordance with the decreasing electrostatic suction force, the adherent force is eliminated or mitigated so that only a slight adherent force is left therebetween on account of any electric charge still remaining, thereby the original sheet **15** and the photosensitive sheet **16** are separated from each other.

In addition, the electric voltage applied to the electrodes of the first subset (I) and the second subset (II) is not restricted to the values shown by the example set forth above, but it can be optionally selected so that, as seen by the graph in FIG. **7**, when a high voltage suitable for providing an electrostatic suction force in a space between the electrodes of the first subset is applied thereto and a voltage between the electrodes of the second subset is suitably selected, the electric charge is neutralized so as to decrease the adherent force. When another voltage is suitably selected, the adherent force is increased in reverse. For instance, in the third embodiment shown in FIG. **5**, if the second subset of the electrode assembly **9** is applied with a voltage which neutralizes the electric charge, the voltage is capable of, as a matter of course, providing any neutralization effect, even if it is not necessarily of a value which provides the minimum adherent force.

In the fourth embodiment of the electrode assembly **9** shown in FIG. **6**, the functional effect of the electrode subset (I) and the second electrode subset (II) is identical with that in the third embodiment however, if the electrodes of the charging electrode subset (P) are applied with a voltage of any suitable value, for example, in a case where the electrodes **23***a* and **23***b* of the first subset (I) are respectively applied with −6 KV and +6KV of a high voltage, if the electrodes of the charging subset (P) are charged with reverse polarities thereof, namely, with +6 KV to the electrodes **31***a* and with −6 KV to the electrodes **31***b*, the electrostatic adherent force (F) of the first subset (I) is increased up to nearly 1.8 times as much as compared with the case where the charging subset (P) is not provided. This is based on the principle that, as clearly seen in FIG. **7**, if a high voltage having reverse polarities as compared to subset the first and with an adequate range thereof is applied to the second subset, the electrostatic adherent force is increased thereby.

Moreover, if a voltage of ±3 KV is applied to the electrodes **25***a* and **25***b* of the second subset in the like manner as that of the third embodiment shown in FIG. **5**, the electric charge is neutralized so as to lower the electrostatic adherent force to 0.4, enabling the original and the copy to be easily separated after printing.

Since there exists an upper limit for the extremely high voltage which is directly applied to the first subset (I) in the case where the charging subset (P) is not provided, charging subset (P) provided therewith is advantageous in that the object above can be attained by applying a comparatively low voltage.

We claim:

1. In a photographic contact printer, an electrostatic contact printing device comprising:

feed rollers for superposing an original sheet and a photosensitive sheet and feeding the superposed sheets into the printing device; and delivery rollers spaced from said feed rollers for delivering said superposed original and photosensitive sheets from the printing device;

a belt bridged between said rollers for transferring said superposed original and said photosensitive sheets from said feed rollers to said delivery rollers;

an electrode assembly between said rollers comprising plural sets of electrodes oppositely spaced from each other and confronting said superposed original and said photosensitive sheets within a printing space formed between said feed rollers and said delivery rollers as said sheets pass through said printing device;

means for applying a high electric voltage of opposite polarities respectively to each set of electrodes of said electrode assembly to produce an electrostatic suction force for holding said superposed original and photosensitive sheets in contacting relationship; and

an illuminating light source located outwardly of the set of electrodes positioned on the original sheet side for exposing said photosensitive sheet.

2. The photographic contact printer as set forth in claim **1**, wherein said electrodes comprise conductive wires connected to said means for applying a high electric voltage, and said electrode assembly further comprising shielding plates for supporting said wires in parallel relationship with respect to the superposed original and photosensitive sheets and in perpendicularly crossed relationship relative to the direction of transfer of said sheets.

3. The photographic contact printer as set forth in claim **1**, wherein each set of said electrode assembly confronts each other and comprises a first subset of electrodes and a second subset of electrodes abutting each other and juxtaposed in the transfer direction of the superposed original sheet and the photosensitive sheet; means for applying a high voltage of opposite polarity between electrodes of said first subset in order to create an electrostatic suction force and for applying a high voltage having a reverse polarity from said first subset between electrodes of said second subset for neutralizing said electrostatic suction force.

4. The photographic contact printer as in claim **3**, wherein said electrode assembly comprises a third electrode subset and forming a charging electrode subset, said first subset and said second subset are juxtaposed in the advancing direction of the superposed original sheet and the photosensitive sheet, and wherein said means for applying a high voltage also provides a high voltage having a polarity reverse to the polarity applied to said first subset between respective electrodes of said charging subset for increasing said electrostatic suction force and the reverse polarity applied to said second subset with respect to said first subset neutralizes said electrostatic suction force.

* * * * *