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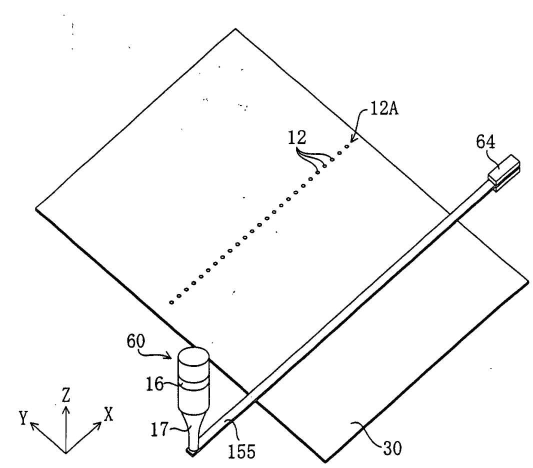
(54) IMAGE FORMING METHOD AND DEVICE

(57) Disposed on one side of a controlling plate (30) that is positioned opposite the other side across a row of orifices **(12A)** is an oscillation transmitting plate **(155)**. The other side of the controlling plate **(30)** is brought into contact with a toner conveying roller **(1).** One end of the oscillation transmitting plate **(155)** is connected to an oscillation generating body (60) and the other end has an oscillation absorbing body (64). A progressive wave is propagated parallel to the orifice row (12A) and a standing wave is formed in a direction orthogonal to the orifice row (12A).

Fig. 24



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Description

TECHNICAL FIELD

[0001] The present invention generally relates to copying machines, facsimile machines, and printers. This invention particularly relates to image forming devices capable of recording by jets of a developer such as toner onto a recording medium.

BACKGROUND ART

[0002] In recent years, with the improvement in the performance of personal computers, large amounts of documents are now being handled in many offices. Moreover, with the advance in network technology, printers and copying machines of extended processing capabilities have been applied widely. Color documentation also tends to increase.

[0003] There is an image forming device employing a direct marking technique capable of direct image formation on paper. For example, Japanese Patent Gazette No. S44-26333 shows an image forming device of the toner jet type as a direct marking technique. An accelerating electric field is created between the developer sleeve for charging and supplying toner and the opposing electrode, wherein the toner is carried through the air by the accelerating electric field. An image signal is input to an electrode of the print head having developer pass orifices, to control the charged toner's controlling lattice pass amount. The charged toner adheres onto the recording paper in front of the opposing electrode, thereby forming an image thereon. For example, in order to form dots of about 100 μm, the diameter of each developer pass orifice should also be miniaturized to around 100 μm.

[0004] However, in such a case, the size of resulting dots may become too small or dots themselves may not be shot at all because the developer pass orifice becomes clogged with dust scattered within the device or with toner particles.

[0005] That is, the entire toner on the developer sleeve cannot be charged uniformly. There is always a charge distribution. In addition to forward polarity-charged toner (i.e., toner which is forced into flight toward the opposing electrode from the developer sleeve by an electric field applied between the developer sleeve and the opposing electrode at image formation time), reverse polarity-charged toner and non-charged toner are present as a mixture. Toner useful for image formation is a forward polarity toner; however, a part of the reverse polarity toner is forced into flight along with the forward polarity toner by toner-to-toner cohesion and adhesion. An electric field, which is created between the opposing electrode and the print head at recording time, acts as a force that repels the reverse polarity toner back to the print head from the recording paper (the opposing electrode). As a result, the reverse polarity toner thus repelled comes to adhere to the surface of the print head and to the internal surface of the developer pass orifice. Moreover, the non-charged toner easily separates from the developer sleeve, so that the non-charged toner falls in the developer pass orifice and adheres thereto.

[0006] Such a phenomenon occurs repeatedly every time a voltage is applied to the print head. As a result, toner is deposited more and more on the print head as image formation is repeatedly carried out and the amount of deposit of the toner gradually increases. Moreover, contaminants such as dust also adhere to the print head, thereby promoting a buildup of toner deposits. As a result, the developer pass orifice may be clogged up strongly. These toner deposits and contaminants exert effects on an electric field that is formed by an electrode for toner pass control or physically prevent the passing of toner through the developer pass orifice, causing the thinning of dots and dot errors.

[0007] Accordingly, it is necessary to provide suitable cleaning means for providing protection against clogging of the developer pass orifice. In respect to such cleaning, various methods have been proposed. For example, the following methods have been known in the art.

(1) Method making utilization of an electric field (Japanese Unexamined Patent Gazette Nos. S58-104771 and S59-188450)
(2) Method making utilization of a stream of air (Japanese Unexamined Patent Gazette Nos. S58-122569 and H02-509789)
(3) Method in which an oscillation is applied to the printer head (Japanese Unexamined Patent Gazette Nos. H03-57658, H04-161353, and H04-257461)

[0008] However, the method (1) making utilization of an electric field finds it difficult to remove non-charged toner particles contained in the toner and contaminants such as dust scattered in the air. On the other hand, the method (2) which makes utilization of a stream of air is able to remove non-charged toner particles et cetera but finds it difficult to remove toner whose charge amount is large and which therefore strongly adheres to the print head. In other words, it is relatively easy to remove toner adhering to the surface of the print head. On the other hand, in order to remove strongly-adhered toner particles such as toner particles heavily charged and adhering to the inside of the developer pass orifice, it is required to subject the toner particles to an extremely fast air stream. This necessitates the provision of a large-sized pump.

[0009] In the method (3) making utilization of an oscillation, for the case of a standing wave, its node portion amplitude becomes smaller. Therefore it is difficult to remove toner and a spot may be formed. Furthermore, since the print head and the developer sleeve are located in very close proximity to each other or brought into contact with each other, toner may be emitted from the developer sleeve when an oscillation is applied. The print head will not be cleaned, rather contaminated, unless the emitted toner is collected positively.

DISCLOSURE OF THE INVENTION

[0010] Accordingly, an object of the present invention is to achieve sufficiently high cleaning power with a relatively small-sized device for the realization of an image forming device with an increased reliability in an oscillation cleaning method in which an oscillation is applied to the print head.

[0011] First and second inventions of the present application are image forming methods. More specifically, the first invention provides an image forming method comprising the steps of supporting a charged developer on a developer supporting body, applying a specified voltage to an opposing electrode positioned face to face with the developer supporting body, making use of an insulating substrate which is placed between the developer supporting body and the opposing electrode and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each developer pass orifice in the insulating substrate and to which a voltage according to an image signal is applied, and forcing the developer on the developer supporting body into flight so as to pass through a specified developer pass orifice for making a record on an image receiving body supported between the insulating substrate and the opposing electrode, and removing particles of the developer or contaminants adhering to around the developer pass orifice, wherein the developer particles/contaminants removing step is performed by applying to the insulating substrate an oscillation resulting from a combination of a progressive wave and a standing wave. In this case, it is preferable that the progressive wave propagates in a direction parallel to the developer pass orifice row and that the standing wave is formed in a direction orthogonal to the developer pass orifice row.

[0012] Since the progressive wave is made to propagate in a direction parallel to the developer pass orifice row, this avoids the generation of nodes and antinodes of an oscillation, thereby providing uniform oscillations. On the other hand, since the standing wave is formed in a direction orthogonal to the developer pass orifice row, this suppresses the damping of oscillation, thereby making it possible to cause the periphery of the developer pass orifice to be oscillated greatly.

[0013] On the other hand, the second invention comprises the steps of supporting a charged developer on a developer supporting body, applying a specified voltage to an opposing electrode positioned face to face with the developer supporting body, making use of an insulating substrate which is placed between the developer supporting body and the opposing electrode and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each developer pass orifice in the insulating substrate and to which a voltage according to an image signal is applied, and forcing the developer on the developer supporting body into flight so as to pass through a specified developer pass orifice for making a record on an image receiving body supported between the insulating substrate and the opposing electrode, and removing particles of the developer or contaminants adhering to around the developer pass orifice, wherein the developer particles/contaminants removing step includes the steps of causing an oscillation from an oscillation generating source positioned on one of sides facing each other across the developer pass orifice row to propagate to the insulating substrate, absorbing an oscillation propagating in a direction parallel to the developer pass orifice row, and reflecting, at the other side, an oscillation propagating in a direction orthogonal to the developer pass orifice row toward the developer pass orifice row.

[0014] As a result of such arrangement, a progressive wave is formed by absorption of an oscillation transmitted from the oscillation generating source on one side and an oscillation transmitted to the insulating substrate is reflected, giving rise to a standing wave by interference between a reflected wave and an incident wave. At this time, it is preferable that the position of the oscillation reflecting end is adjusted in such a way that a standing wave is formed having its antinodes in the vicinity of the developer pass orifices.

[0015] If the aforesaid method further comprises, prior to the step of propagating an oscillation from the oscillation generating source to the insulating substrate, the step of amplifying the oscillation from the oscillation generating source, this allows the periphery of the developer pass orifice to be oscillated sufficiently without having to increase the amplitude of the oscillation generating source.

[0016] It is preferable that prior to the step of absorbing an oscillation, the step of reducing the amplitude of the oscillation is carried out. This facilitates oscillation absorption.

[0017] It is preferable that the step of suppressing, while an oscillation from the oscillation generating source is absorbed, the damping of the oscillation is carried out. This ensures that oscillations from the oscillation generating source are positively propagated all over the developer pass orifice row.

[0018] A third invention of the present application relates to an image forming device. More specifically, the third invention provides an image forming device comprising a developer supporting body for supporting and, at the same time, conveying a developer, an opposing electrode positioned face to face with the developer supporting body, a developer pass controlling member, placed between the developer supporting body and an image receiving body and having at least one developer pass orifice row formed by arrangement of a plurality of developer pass orifices, for performing control so that in response to an image signal the developer conveyed by the developer supporting body is forced into flight so as to pass through a specified developer pass orifice for adhesion onto the image receiving body, and an oscillation applying member for applying an oscillation to the developer pass controlling member so that particles of the developer adhering to the developer pass controlling member are removed. The image forming device of the third invention is characterized in that the oscillation applying member is so configured as to achieve application of an oscillation to the developer pass controlling member by a combination of a progressive wave and a standing wave. Here, it is preferable that the oscillation applying member is configured so that the oscillation of the progressive wave propagates in a direction parallel to the developer pass orifice row and the oscillation of the standing wave is formed in a direction orthogonal to the developer pass orifice row.

[0019] The progressive wave is made to propagate in a direction parallel to the developer pass orifice row as described above, as a result of which arrangement the occurrence of formation of oscillation nodes and antinodes is prevented from taking place, thereby making it possible to obtain uniform oscillations. On the other hand, the standing wave is formed in a direction orthogonal to the developer pass orifice row, as a result of which oscillation damping is suppressed. This makes it possible to cause the periphery of the developer pass orifice to be oscillated greatly.

[0020] Fourth and fifth inventions of the present application are inventions suitable for forming a standing wave in the developer pass controlling member. More specifically, the fourth invention is directed to an image forming device comprising a developer supporting body which is formed rotatably about a rotation axis extending in a specified direction and which rotates about the rotation axis with a developer supported on its peripheral surface for conveying the developer, a developer pass controlling member, positioned face to face with the peripheral surface of the developer supporting body and having at least one developer pass orifice row in which a plurality of developer pass orifices capable of being passed through by the developer is arranged in the direction of the rotation axis of the developer supporting body, for performing control in response to an external image signal so that the developer is forced into flight from the developer supporting body so as to pass through a developer pass orifice, an image receiving body positioned opposite the developer supporting body across the developer pass controlling member, and an opposing electrode for guiding the developer, which has passed through the developer pass orifice of the developer pass controlling member, toward the image receiving body so that the developer is adhered to the image receiving body. The image forming device of the fourth invention further comprises an oscillation applying member for applying an oscillation to one of portions on both sides located opposite to each other across the developer pass orifice row in the developer pass controlling member, wherein the other of the side portions in the developer pass controlling member is in contact with the developer supporting body so that an oscillation, generated in the developer pass controlling member by application of an oscillation by the oscillation applying member and traveling from the oscillation-applied portion toward the developer pass orifice row, is reflected in the opposite direction.

[0021] As a result of such arrangement, an oscillation from the oscillation applying member is reflected at a contact portion at which the developer pass controlling member and the developer supporting body come into contact with each other, thereby giving rise to a standing wave between the developer pass controlling member and the oscillation applying member. If developer pass orifice portions or their neighboring areas are arranged not to correspond to nodes of the standing wave, this enables such portions to be oscillated at all times by the standing wave. Accordingly, the developer is effectively prevented from being built up within the developer pass orifices and around there. This positively prevents the developer pass orifices from being clogged up by a buildup of developer deposits.

[0022] In the fourth invention, preferably the other of the side portions in the developer pass controlling member is wound around the peripheral surface of the developer supporting body, so that it comes into surface to surface contact with the developer supporting body. In such a case, preferably it is set that $L3 > \lambda/4$ where λ is the wavelength of an oscillatory wave and L3 is the length of contact of the developer pass controlling member and the developer supporting body in the circumferential direction of the developer supporting body.

[0023] In this case, by the application of oscillation, the occurrence of swelling or the like in the developer pass controlling member is prevented, whereby the developer pass controlling member and the developer supporting body can be brought into contact with each other with increased stability. As a result, a reflected wave of the oscillation is stably formed, ensuring that a standing wave is positively formed in the developer pass controlling member. Further, if it is set that $L3 > \lambda/4$, this prevents an oscillation traveling from the oscillation applying member toward the developer pass orifice row from jumping over a contact portion of the developer pass controlling member and the developer supporting body, thereby ensuring that such an oscillation is reflected positively. As a result, the amplitude of the standing wave is increased to a further extent.

[0024] On the other hand, the fifth invention is directed to an image forming device comprising a developer supporting body which is formed rotatably about a rotation axis extending in a specified direction and which rotates about the rotation axis with a developer supported on its peripheral surface for conveying the developer, a developer pass controlling member, positioned face to face with the peripheral surface of the developer supporting body and having at least one developer pass orifice row in which a plurality of developer pass orifices capable of being passed through by the developer is arranged in the direction of the rotation axis of the developer supporting body, for performing control in response to an external image signal so that the developer is forced into flight from the developer supporting body so as to pass through a developer pass orifice, an image receiving body positioned opposite the developer supporting body across the developer pass controlling member, and an opposing electrode for guiding the developer, which has passed through the developer pass orifice of the developer pass controlling member, toward the image receiving body so that the developer is adhered to the image receiving body. The image forming device of the fifth invention further comprises an oscillation applying member for applying an oscillation to one of portions on both sides located opposite to each other across the developer pass orifice row in the developer pass controlling member, wherein the other of the side portions in the developer pass controlling member is in contact with the developer supporting body through a spacer member so that an oscillation, generated in the developer pass controlling member by application of an oscillation by the oscillation applying member and traveling from the oscillation-applied portion toward the developer pass orifice row, is reflected in the opposite direction. As a result of such arrangement, the same operation and effects as the fourth invention can be obtained. Further, the spacer member may be extendedly positioned along the rotation axis direction of the developer supporting body. In this case, the space defined between the developer pass controlling member and the developer supporting body is kept constant.

[0025] In the forth or fifth invention, the oscillation applying member may be made up of an oscillation transmitting body extendedly positioned along the rotation axis direction of the developer supporting body and an oscillation generating source disposed at at least one of lengthwise ends of the oscillation transmitting body. As a result of such arrangement, all the developer pass orifices of the developer pass orifice row are prevented from being clogged up by a buildup of developer deposits.

[0026] Further, the oscillation applying member may be configured so that a standing wave, whose node and antinode correspond to a reflecting end and to the developer pass orifice, respectively, in the developer pass controlling member, is obtained. As a result of such arrangement, the developer pass orifice portions of the developer pass controlling member undergo a greatest displacement and the effect of clogging prevention for the developer pass orifices is achieved to the full.

[0027] The position of the aforesaid reflecting end is preferably determined as follows.

[0028] That is, it is preferable that L1 is set such that $L1 < \lambda/2$ where λ is the wavelength of an oscillation and L1 is the distance between the developer pass orifice row and the reflecting end. In this case, in the developer pass orifice row the developer pass orifice portion or its neighboring area is oscillated at all times by a standing wave. Particularly, if L1 is set such that $L1 \approx \lambda/4$, this forms a standing wave whose antinodes correspond to the position of the developer pass orifice row.

[0029] Further, it is preferable that the position of the reflecting end is set to $L2 > \lambda/4$ where λ is the wavelength of an oscillation and L2 is the distance between the oscillation transmitting body and the reflecting end. That is, if the distance L2 is set below $\lambda/4$, this makes it difficult to produce a standing wave. In addition, the reflecting end portion is oscillated. As a result, there occurs a liberation of heat at that portion and the spacer member et cetera may wear away. On the other hand, if the distance L2 is set above $\lambda/4$, this efficiently generates a standing wave, therefore preventing the developer pass orifices from being clogged up by. a buildup of developer deposits.

[0030] Further, it is preferable that an oscillation reflecting means for reflecting an oscillation traveling from the oscillation applying member toward the developer pass orifice row in the opposite direction is positioned opposite the developer pass orifice row across the reflecting end in the developer pass controlling member and L4 is set such that $L4 \approx (2n + 1) \times \lambda/4$ where λ is the wavelength of an oscillation, L4 is the distance between the developer pass orifice row and the oscillation reflecting means, and n is an integer. That is, in addition to the reflecting end, a second reflecting end may be provided. Here, the oscillation reflecting means may be implemented by an oscillation reflecting plate fixed to the developer pass controlling means or by a holding member for holding the developer pass controlling member.

[0031] In such a case, an oscillation propagating downstream of the reflecting end in the oscillation propagation direction is reflected by the oscillation reflecting means. As a result, the developer pass orifice portions of the developer pass controlling member undergo a much greater displacement. Preferably, the position of the oscillation reflecting means is so determined that a standing wave is formed such that its antinode corresponds to a developer pass orifice.

[0032] Sixth and seventh inventions of the present application are inventions suitable for generating uniform oscillations in the row direction of the developer pass orifice row. More specifically, the sixth invention of the present application is directed to an image forming device comprising a developer supporting body for supporting and, at the same time, conveying a developer, an opposing electrode positioned face to face with the developer supporting body, a developer pass controlling member, placed between the developer supporting body and an image receiving body and having at least one developer pass orifice row formed by arrangement of a plurality of developer pass orifices, for performing control in response to an image signal so that the developer conveyed by the developer supporting body is forced into flight so as to pass through a specified developer pass orifice for adhesion onto the image receiving body, and an oscillation applying member for applying an oscillation to the developer pass controlling member so that particles of the developer adhering to the developer pass controlling member are removed. In the image forming device of the sixth invention, the oscillation applying member is equipped with an oscillating plate extending parallel to the row direction of the developer pass orifice row and fixed to a surface of the developer pass controlling member, a piezoelectric element extending parallel to the row direction so as to be superimposed on the oscillating plate and fixed to a surface of the oscillating plate opposite to a contact surface in contact with the developer pass controlling member, and a regulating body for regulating expansion and contraction of the piezoelectric element in the row direction, whereby oscillations of the same phase in the row direction can be applied to portions of the developer pass orifices of the developer pass controlling member.

[0033] With such arrangement, when a voltage is applied to the piezoelectric element, the piezoelectric element undergoes flexure and deformation together with the oscillating plate. At this time, since the expansion and contraction of the piezoelectric element in the row direction is regulated, this makes the oscillating plate flex exclusively in a direction orthogonal to the row direction. As a result, oscillatory waves transmitted to the developer pass controlling member from the oscillating plate become oscillatory waves of equal phase in the row direction, wherein oscillations of the same phase are applied to the respective developer pass orifice portions of the developer pass controlling member, and cleaning capability spots along the row direction are prevented. Accordingly, the developer is removed uniformly, thereby ensuring that the clogging of the developer pass orifices by a buildup of developer deposits is prevented positively. Stable image formation is realized accordingly.

[0034] Further, the seventh invention of the present application is directed to an image forming device comprising a developer supporting body for supporting and, at the same time, conveying a developer, an opposing electrode positioned face to face with the developer supporting body, a developer pass controlling member, placed between the developer supporting body and an image receiving body and having at least one developer pass orifice row formed by arrangement of a plurality of developer pass orifices, for performing control in response to an image signal so that the developer conveyed by the developer supporting body is forced into flight so as to pass through a specified developer pass orifice for adhesion onto the image receiving body, and an oscillation applying member for applying an oscillation to the developer pass controlling member so that particles of the developer adhering to the developer pass controlling member are removed. The oscillation applying member is equipped with an oscillating plate extending parallel with the row direction of the developer pass orifice row and fixed to a surface of the developer pass controlling member, an oscillation generating source for applying an oscillation to one end of the oscillation transmitting body so that an oscillatory wave is generated which travels parallel to the row direction from the one end of the oscillation transmitting body toward the other end thereof, and an oscillation controlling part for controlling the oscillation so that the oscillatory wave in the oscillation transmitting body becomes a non-standing wave.

[0035] As a result of such arrangement, a non-standing, oscillatory wave propagates to the oscillating plate extending parallel to the developer pass orifice row. As a result, oscillatory waves transmitted to the developer pass controlling member from the oscillation transmitting body become oscillatory waves of equal phase in the row direction, wherein oscillations of the same phase are applied to the respective developer pass orifice portions of the developer pass controlling member. Accordingly, the developer is removed uniformly, thereby ensuring that the clogging of the developer pass orifices by a buildup of developer deposits is prevented positively. Stable image formation is realized accordingly.

[0036] Furthermore, the oscillation controlling part may be equipped with a clamp means for catching therein the other end of the oscillation transmitting body while shifting its clamp position so that the position, at which an oscillation at the other end of the oscillation transmission body is reflected, is varied with time. In this case, an oscillatory wave traveling from one end to the other of the oscillation transmitting body is reflected at the clamp position at the other end. Then, a progressive wave and a reflected wave are superimposed with each other, giving rise to a standing wave on the oscillation transmitting body. Since the clamp means causes the clamp position to vary with time, the oscillatory wave formed on the oscillation transmitting body is momentarily a standing wave. However, it becomes non-standing with time and substantially becomes a non-standing wave.

[0037] Further, unlike the above, the oscillation controlling part may be equipped with an auxiliary agitating means for slightly disturbing an oscillation from the oscillation generating source in the oscillation transmitting body. In this case, an oscillation from the oscillation generating part in the oscillation transmitting body is disturbed slightly by the auxiliary agitating means. As a result, the oscillatory wave in the oscillation transmitting body becomes a non-standing wave.

[0038] Eighth and ninth inventions of the present application are image forming devices suitable for suppressing the damping of an oscillation from the oscillation generating source. More specifically, the image forming device of the eighth invention comprises a developer supporting body for conveying and, at the same time, supporting a charged developer, an opposing electrode positioned face to face with the developer supporting body, a developer pass controlling member having an insulating substrate which is placed between the developer supporting body and the opposing electrode and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each developer pass orifice in the insulating substrate and to which a voltage according to an image signal is applied, for forcing the developer on the developer supporting body into flight so as to pass through a specified developer pass orifice for adhesion onto an image receiving body supported between the developer pass controlling member and the opposing electrode, and an oscillation applying member having an oscillation generating source and an oscillation transmitting body which is connected, at at least one of ends thereof, to the oscillation generating source and disposed on the developer pass controlling member so as to extend parallel to the developer pass orifice row for transmitting an oscillation from the oscillation generating source to each developer pass orifice portion of the developer pass controlling member. The oscillation characteristic of the oscillation transmitting body varies along the propagation direction of an oscillation from the oscillation generating source for suppressing the damping of oscillation in the oscillation transmitting body. The oscillation gradually undergoes damping in the propagation direction. However, since the oscillation characteristic of the oscillation transmitting body varies along the propagation direction, this results in suppressing oscillation damping, thereby improving cleaning power.

[0039] Further, the image forming device of the ninth invention comprises a developer supporting body for conveying and, at the same time, supporting a charged developer, an opposing electrode positioned face to face with the developer supporting body, a developer pass controlling member having an insulating substrate which is placed between the developer supporting body and the opposing electrode and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each developer pass orifice in the insulating substrate and to which a voltage according to an image signal is applied, for forcing the developer on the developer supporting body into flight so as to pass through a specified developer pass orifice for adhesion onto an image receiving body supported between the developer pass controlling member and the opposing electrode, and an oscillation applying member having an oscillation generating source and an oscillation transmitting body which is connected, at one of ends thereof, to the oscillation generating source and disposed on the developer pass controlling member so as to extend parallel to the developer pass orifice row for transmitting an oscillation from the oscillation generating source to each developer pass orifice portion of the developer pass controlling member. The oscillation transmitting body decreases in rigidity from the one end toward the other end. As a result of such arrangement, the oscillation transmitting body has the characteristic that the oscillation transmitting body becomes readily oscillated as it extends from its one end toward the other end and the damping of oscillation from the oscillation generating source is suppressed.

[0040] The oscillation transmitting body may be implemented by an oscillation transmitting plate the plate width of which varies with the distance from the oscillation generating source. Alternatively, the plate thickness of the oscillation transmitting plate may vary with the distance from the oscillation generating source.

[0041] Further, a lateral face of the oscillation transmitting body on the side of the developer pass orifices may be formed into a wavy shape. This makes it possible to make the node and antinode of an amplitude dull at oscillation application time and uniform cleaning performance is obtained throughout the lengthwise direction of the developer pass controlling member.

[0042] The wave pitch of the wavy shape of the oscillation transmitting body may be substantially a half of the wavelength of an oscillation in the oscillation transmitting body. As a result of such arrangement, the amplitude node/antinode of the oscillation transmitting body becomes smaller. Further, the difference of level between a concave portion and a convex portion of the wavy shape may be substantially a quarter of the wavelength of an oscillation in the developer pass controlling member. As a result of such arrangement, an oscillatory wave traveling from the oscillation transmitting body toward the developer pass controlling member undergoes a phase difference of 90 degrees between a wave traveling from a convex portion (crest) of the wavy shape of the oscillation transmitting body and a wave traveling from a concave portion (trough) thereof, as a result of which the oscillatory wave becomes an oscillatory wave of relatively the same phase. Accordingly, uniform cleaning power is obtained.

[0043] The oscillation transmitting body, formed by an oscillation transmitting plate whose plate width or plate thickness becomes gradually smaller and having a wavy shape on the developer pass orifice side, is especially preferable.

[0044] A tenth invention of the present application is an invention suitable for amplifying an oscillation from the oscillation generating source and propagating it to the developer pass controlling member. More specifically, an image forming device of the tenth invention comprises a developer supporting body for conveying and, at the same time, supporting a charged developer, an opposing electrode positioned face to face with the developer supporting body, a developer pass controlling member having an insulating substrate which is placed between the developer supporting body and the opposing electrode and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each developer pass orifice in the insulating substrate and to which a voltage according to an image signal is applied, for forcing the developer on the developer supporting body into flight so as to pass through a specified developer pass orifice for adhesion onto an image receiving body supported between the developer pass controlling member and the opposing electrode, and an oscillation applying member having an oscillation generating source and an oscillation transmitting body which is connected, at one of ends thereof, to the oscillation generating source and disposed on the developer pass controlling member so as to extend parallel to the developer pass orifice row for transmitting an oscillation from the oscillation generating source to each developer pass orifice portion of the developer pass controlling member. The oscillation transmitting body is characterized in that a portion of the oscillation transmitting body connected to the oscillation generating source is greater in rigidity than a portion of the oscillation transmitting body disposed on the developer pass controlling member.

[0045] As a result of such arrangement, the oscillation of the oscillation generating source is amplified in the portion of the oscillation transmitting body disposed on the developer pass controlling member for propagation to the developer pass controlling member. As a result, high cleaning power can be obtained without increasing the oscillation of the oscillation generating source.

[0046] Further, an eleventh invention of the present application is an invention suitable for propagating a progressive wave to the oscillation transmitting body. More specifically, an image forming device of the eleventh invention comprises a developer supporting body for conveying and, at the same time, supporting a charged developer, an opposing electrode positioned face to face with the developer supporting body, a developer pass controlling member having an insulating substrate which is placed between the developer supporting body and the opposing electrode and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each developer pass orifice in the insulating substrate and to which a voltage according to an image signal is applied, for forcing the developer on the developer supporting body into flight so as to pass through a specified developer pass orifice for adhesion onto an image receiving body supported between the developer pass controlling member and the opposing electrode, and an oscillation applying member having an oscillation generating source and an oscillation transmitting body which is connected, at one of ends thereof, to the oscillation generating source, which is provided, at the other end, with an oscillation absorbing means for absorbing an oscillation from the oscillation generating source, and which is disposed on the developer pass controlling member so as to extend parallel to the developer pass orifice row for transmitting an oscillation from the oscillation generating source to each developer pass orifice portion of the developer pass controlling member. The oscillation transmitting body is characterized in that a portion of the oscillation transmitting body at which the oscillation absorbing means is disposed is greater in rigidity than a portion of the oscillation transmitting body disposed on the developer pass controlling member.

[0047] As a result of such arrangement, oscillatory energy propagated from the oscillation generating source is absorbed by the oscillation absorbing means positioned at the end of the oscillation transmitting body. This causes an oscillation input from the oscillation generating source to propagate in one direction, so that there exists no reflected wave from the side of the oscillation absorbing means. Because of this, no standing wave is formed on the oscillation transmitting body and the oscillation becomes a progressive wave.

[0048] Apart from the above, when the amplitude of an oscillation is great, it is difficult for the oscillation absorbing means to satisfactorily absorb the oscillation. If the portion at which the oscillation absorbing means is disposed is set greater in rigidity than the portion overlying the developer pass controlling member, this diminishes the amplitude of the oscillations of the portion having the oscillation absorbing means, ensuring that oscillatory energy is absorbed positively by the oscillation absorbing means. Particularly, if the plate width is increased for making a variation in the rigidity of the oscillation transmitting body, this increases the contact area of the oscillation absorbing means and the oscillation transmitting body. As a result, oscillatory energy per unit area is reduced. This especially facilitates the oscillation absorbing means to absorb an oscillation. As a result, uniform amplitudes are given to the developer pass controlling member, making it possible to achieve uniform cleaning.

[0049] In the tenth invention or in the eleventh invention, the plate width of the portion of the oscillation transmitting body disposed on the developer pass controlling member may be varied according to the distance from the oscillation generating source. In this case, the damping of an oscillation from the oscillation generating source is suppressed.

[0050] Further, in any of the inventions 7, 8, and 10, the other end of the oscillation transmitting body may be equipped with an oscillation absorbing means for absorbing an oscillation from the one end of the oscillation transmitting body. In this case, as described above, an oscillation input from the oscillation generating source propagates in one direction, so that there exists no reflected wave from the side of the oscillation absorbing means. Because of this, a progressive wave propagates on the oscillation transmitting body and no oscillation nodes and antinodes are created, thereby making it possible to achieve uniform cleaning of the developer pass controlling member.

[0051] Further, the oscillation absorbing means may be composed of two or more kinds of viscoelastic bodies having different characteristics.

[0052] That is, an oscillation in the oscillation transmitting body is transmitted, through the developer pass controlling member, to components having various natural frequencies and their reflected waves are returned to the oscillation transmitting body. Accordingly, it is required that the oscillation absorbing means absorbs not only oscillations of unitary frequency from the oscillation generating source but also oscillations of other frequencies. Dampers of rubber, PZT, or the like vary in the value of damping coefficient with respect to frequency if their configuration differs. To cope with this, if the oscillation absorbing means is composed of two or more kinds of viscoelastic bodies having different characteristics, this makes it possible to damp various frequencies input to the oscillation absorbing means.

[0053] Further, for example, if the oscillation absorbing means is composed of rubber hardened by addition of a metallic filler, this increases its weight, thereby increasing the coefficient of damping. It becomes possible to achieve effective oscillation damping. On the other hand, since the hardened rubber has a high spring constant, this produces the inconvenience that an input oscillatory wave becomes susceptible to being reflected. To cope with this, if the oscillation absorbing means is composed of two types of rubber materials such as soft rubber and hard rubber, the occurrence of oscillatory wave reflection is prevented by the soft rubber and oscillation damping is carried out by the hard rubber. This ensures that oscillatory energy input to the oscillation absorbing means is satisfactorily and positively absorbed and oscillations of uniform amplitude are applied to the developer pass controlling member.

[0054] Further, the oscillation transmitting body may be in tension in its longitudinal direction. In this case, the warping of the oscillation transmitting body is prevented, ensuring that oscillations are positively applied to the oscillation transmitting body. This is particularly effective when the oscillation transmitting body is formed of an oscillation transmitting plate.

[0055] Further, it is preferable that the image forming device further comprises a holding member for holding, on a side opposite to the developer pass orifice row across the oscillation transmitting body, the developer pass controlling member, and that the oscillation transmitting body is disposed so that $L5 > \lambda/2$ where λ is the wavelength of an oscillation and L5 is the distance between the oscillation transmitting body and the holding member. This prevents the holding member from being oscillated by the oscillation of the oscillation transmitting body, thereby making it possible to propagate an oscillation from the oscillation generating source to the developer pass controlling member without a damping of the oscillation of the oscillation generating source.

[0056] Further, when forming a non-standing wave oscillation in parallel with the developer pass orifice row as in the foregoing seventh to eleventh inventions, it is preferable that a standing wave is formed in a direction orthogonal to the developer pass orifice row so that the periphery of the developer pass orifice can be oscillated at greater amplitudes.

[0057] As a means for forming a standing wave in a direction orthogonal to the developer pass orifice row, the developer pass controlling member may be, on a side opposite the oscillation transmitting body across the developer pass orifice row, in line contact with the developer supporting body in parallel with the row direction of the developer pass orifice row so that a reflecting end for reflecting an oscillation from the oscillation transmitting body is formed. In this case, an oscillation transmitted from the oscillation transmitting body to the developer pass controlling member travels toward the developer pass orifice row and is reflected at the reflecting end. This progressive wave is superimposed with a reflected wave, forming a standing wave in a direction orthogonal to the row direction of the developer pass orifice row.

[0058] An arrangement may be made in which the developer pass controlling member passes around a peripheral face of the developer supporting body so that the developer pass controlling member is brought into surface-to-surface contact with the developer supporting body. Unlike this arrangement, another arrangement may be made in which a spacer means, disposed extendedly along the developer pass orifice row, is positioned at a reflecting end of the developer pass controlling member and the developer pass controlling member is brought into contact with the developer supporting body through the spacer means.

[0059] This ensures that a progressive wave is reflected accurately and positively in the developer pass controlling member, thereby facilitating the formation of excellent standing waves.

[0060] On the other hand, when providing the aforesaid reflecting end, it is preferable that the oscillation applying member is so configured as to apply an oscillation so that an oscillatory wave in a direction orthogonal to the row direction of the developer pass orifice row in the developer pass controlling member becomes a standing wave whose node and antinode correspond to the reflecting end and to the developer pass orifice row, respectively. In this case, the developer pass orifices undergo a greatest displacement, whereby removal of the developer can be carried out efficiently.

[0061] A twelfth invention of the present application is an invention suitable for providing protection against contamination by a removed developer. More specifically, an image forming device of the twelfth invention comprises developer supplying means for charging a developer and supplying the charged developer supported on a developer supporting body, an opposing electrode which is positioned face to face with the developer supplying means and to which a specified voltage is applied, an insulating substrate having a plurality of developer pass orifices and interposed between the developer supplying means and the opposing electrode, an image signal electrode which is disposed around the developer pass orifice of the insulating substrate and to which a voltage for controlling, in response to an image signal, the pass amount of the developer passing through the developer pass orifice, and an oscillation applying member, having an oscillation generating source and an oscillation transmitting body connected to the oscillation generating source and positioned in the vicinity of the developer pass orifice of the insulating substrate, for applying an oscillation to the insulating substrate, wherein the developer is adhered to an image receiving body placed between the opposing electrode and the insulating substrate or to the opposing electrode for forming an image. The image forming device of the twelfth invention further comprises a controlling means for bringing the operation of the developer supplying means to a halt and, at the same time, causing the oscillation applying means to operate, when no image formation is being performed.

[0062] As a result of such arrangement, application of an oscillation to the insulating substrate is carried out when no image is being formed (e.g., when the recording paper is being moved after the image formation), so that the already-formed image will not be disturbed even though the developer jumps out from the developer supporting body by the applied oscillation. Moreover, at such oscillation application time the operation of the developer supporting body is brought into a stop and no new developer is supplied, so that the amount of the developer jumping out from the developer supporting body becomes smaller.

[0063] Apart from the above, of the developer built up around the developer pass orifice of the insulating substrate, there exist not only developer particles of forward polarity but also developer particles of reverse polarity. If an oscillation is applied with the electric potential of the opposing electrode held at the same level as the image formation time, a force of flight from the opposing electrode toward the insulating substrate will act on such reverse-polarity developer particles. Therefore, even when the reverse-polarity developer particles are flown once from the insulating substrate toward the opposing electrode, these particles are forced into adverse flight toward the insulating substrate by the action force of an electric field, as a result of which the insulating substrate becomes contaminated. Moreover, if the opposing electrode remains at the same electric potential level as the image formation time, a developer that has jumped out from the developer supporting body by the oscillation application also returns to the insulating substrate and is likely to adhere thereto even when developer particles of reverse polarity of the developer are once moved toward the opposing electrode.

[0064] To cope with the above, an arrangement may be made in which, when no image formation is being carried out, the controlling means brings the operation of the developer supplying means to a halt while causing the oscillation applying means to operate and causes the opposing electrode and the developer supporting body to have the same electric potential at least at the early stage of an oscillation application operation by the oscillation applying member. As a result of such arrangement, at the time when an oscillation is applied, the opposing electrode and the developer supporting body are at the same electric potential level, thereby avoiding the returning of the reverse-polarity developer particles. As a result, the clogging of the insulating substrate is prevented. Further, another arrangement may be made in which the opposing electrode and the developer supporting body are at the same electric potential level during the entire period of oscillation application. Alternatively, the opposing electrode and the developer supporting body may be at the same potential level only at the early stage of oscillation application and thereafter their electric potential may be switched to an appropriate level. Even when such switching in electric potential is made, since an oscillation is applied with the operation of the developer supplying means stopped (i. e., without a new supply of developer), the jumping-out of a developer from the develop supporting body by the applied oscillation is almost completed at the early stage of the oscillation application. Therefore, a further jumping-out of the developer from the developer supporting body due to such electric potential switching, will be prevented.

[0065] Further, an arrangement may be made in which the opposing electrode is positioned movably so as to be able to change its face opposite to the developer supporting body, and when no image formation is being carried out, the controlling means brings the operation of the developer supplying means to a halt while causing the oscillation applying means to operate and causes the opposing electrode and the developer supporting body to have the same electric potential at least at the early stage of an oscillation application operation by the oscillation applying member while shifting the opposing electrode. As a result of such arrangement, a developer, flown from the insulating substrate toward the opposing electrode by application of an oscillation to the insulating substrate, moves to a position not facing the developer supporting body by movement of the opposing electrode. This therefore prevents the developer from adversely being brought back to around the developer pass orifice of the insulating substrate and facilitates collection of such a developer.

[0066] Further, an arrangement may be made in which, when no image formation is being carried out, the controlling means brings the operation of the developer supplying means to a halt while causing the oscillation applying means to operate, causes the opposing electrode and the developer supporting body to have the same electric potential at least at the early stage of an oscillation application operation by the oscillation applying member while shifting the opposing electrode, and thereafter changes the electric potential of the opposing electrode or the image signal electrode so as to form between the insulating substrate and the opposing electrode an electric field capable of aiding the flight of a charged developer from the insulating substrate toward the opposing electrode.

[0067] With this invention, since there is made a change in the electric potential of the opposing electrode or the image signal electrode while moving the opposing electrode, the face of the opposing electrode facing, at the early stage of the oscillation application, the developer supporting body, i.e., the developer pass orifice of the insulating substrate, will be placed in a different direction at the moment of such an electric potential change. This therefore prevents the developer, jumped out from the insulating substrate et cetera at the early stage of the oscillation application and then adhering to the opposing electrode, from being forced into adverse flight to around the developer pass orifice of the insulating substrate by a change in electric potential.

[0068] Further, since an electric field for aiding the flight of a charged developer from the insulating substrate toward the opposing electrode is formed between the insulating substrate and the opposing electrode by switching the electric potential of the opposing electrode or the image signal electrode, removal force by the electric field will act on the developer adhering to the insulating substrate in addition to mechanical removal force by the oscillation application. This facilitates removal of a developer strongly adhering to the insulating substrate. Moreover, it becomes possible to reduce oscillatory energy to be applied to the insulating substrate by enhancing the action force of the electric field, which is advantageous for avoiding troubles such as a liberation of heat by oscillation and debonding of the oscillation transmitting body.

[0069] An arrangement may be made in which an ac voltage is applied to the opposing electrode so that an electric field capable of aiding the flight of a charged developer from the insulating substrate toward the opposing electrode is formed between the insulating substrate and the opposing electrode. That is, there exist a developer of forward polarity and another of reverse polarity, so that the removal of developer particles overlying the insulating substrate is facilitated by application of an oscillation by the oscillation applying member and an alternating electric field by the aforesaid ac voltage.

[0070] Furthermore, an arrangement may be made in which, when no image formation is being carried out, the controlling means brings the operation of the developer supplying means to a halt while activating the oscillation applying means and reverse the relationship in electric potential size between the developer supporting body and the image signal electrode with respect to the relationship in electric potential size between the developer supporting body and the image signal electrode during the image formation. In this case, a change means for changing a voltage that is applied to the developer supporting body may be provided. This arrangement prevents, at the time of applying an oscillation, a developer from jumping out from the developer supporting body caused by such oscillation application. Moreover, by the action of the electric field, developer particles present between the developer supporting body and the insulating substrate are forced into flight toward the developer supporting body, thereby achieving effective developer removal.

[0071] A thirteenth invention of the present application is directed to an image forming device comprising a developer supplying means for charging a developer and supplying the charged developer supported on a developer supporting body, an opposing electrode which is positioned face to face with the developer supplying means and to which a specified voltage is applied, an insulating substrate having a plurality of developer pass orifices and interposed between the developer supplying means and the opposing electrode, an image signal electrode which is disposed around the developer pass orifice of the insulating substrate and to which a voltage for controlling, in response to an image signal, the pass amount of the developer passing through the developer pass orifice, and an oscillation applying member, having an oscillation generating source and an oscillation transmitting body connected to the oscillation generating source and positioned in the vicinity of the developer pass orifice of the insulating substrate, for applying an oscillation to the insulating substrate, wherein the developer is adhered to an image receiving body placed between the opposing electrode and the insulating substrate or to the opposing electrode for forming an image and, at the time when no image formation is being performed, the oscillation applying member is activated. Further, in the image forming device of the thirteenth invention, a plurality of image forming units, each units comprising a combination of the developer supplying means, the insulating substrate having the developer pass orifices and the image signal electrode, the oscillation applying member, and the opposing electrode, are provide, each of the oscillation applying members of the plurality of image forming units is driven independently of the other, and each of voltages of the opposing electrodes of the plurality of image forming units is controlled independently of the other.

[0072] As a result of such arrangement, it becomes possible to realize a multicolor image forming device by a plurality of image forming units of the present invention. Also in such a multicolor image forming device, each image forming unit operates independently of the other and there is no need for simultaneous oscillation application. Therefore, there is no need to provide individual driving circuits for the oscillation generating sources and individual power supplies for the opposing electrodes, which makes it possible to provide an inexpensive image forming device.

[0073] Further, the plural oscillation applying members are connected, through a drive switching means for sequential driving of the oscillation generating sources, to a single common driving circuit for driving the oscillation generating sources. This arrangement advantageously contributes to reducing the costs of the image forming device.

[0074] Furthermore, the driving circuit of the oscillation generating sources may be implemented by a frequency auto-following type circuit. That is, although a self-excited oscillator circuit can be employed as a driving circuit for the oscillation generating source, the natural frequency of an oscillatory system including the oscillation applying member and the insulating substrate varies greatly in some case because of, for example, the tension of the oscillation transmitting body and the insulating substrate. However, the use of a frequency auto-following type circuit makes it possible to apply stable oscillations to the insulating substrate without being affected greatly by the natural frequency.

[0075] Additionally, the plural opposing electrodes are connected, through a voltage switching means, to a single common power supply. In this case, there is no need to provide individual power supplies to the respective opposing electrodes, thereby advantageously contributing to lowering costs.

[0076] Further, preferably the oscillation applying member in the foregoing twelfth or thirteenth invention is formed as follows. That is, the plural developer pass orifices of the insulating substrate are arranged in a single row or in several rows, the oscillation transmitting body is disposed in parallel with the developer pass orifice row, the oscillation applying member is so configured as to apply an oscillation which becomes a progressive wave in a direction parallel to the developer pass orifice row and a standing wave in a direction orthogonal to the row direction of the developer pass orifice row.

[0077] Fourteenth and fifteenth inventions of the present application are particularly suitable for image forming devices with a transferring means. More specifically, an image forming device of the fourteenth invention comprises a developer supporting body for conveying and, at the same time, supporting a charged developer, an opposing electrode positioned face to face with the developer supporting body, an intermediate image holding member interposed between the developer supporting body and the opposing electrode, a developer pass controlling member, having an insulating substrate which is placed between the developer supporting body and the intermediate image holding member and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each developer pass orifice in the insulating substrate and to which a voltage according to an image signal is applied, for forcing the developer on the developer supporting body into flight so as to pass through a specified developer pass orifice for adhesion onto the intermediate image holding member, a conveying means for conveying the intermediate image holding member, a transferring means for transferring an intermediate image on the intermediate image holding member onto an image receiving body, and a developer removing means for removing particles of the developer adhering to the developer pass controlling member. In the image forming device of the fourteenth invention, the transferring means is characterized in that it is so configured as to enter the non-operation state when the developer particles, removed from the developer pass controlling member and then adhering to the intermediate image holding member, have been conveyed.

[0078] As a result of such arrangement, developer particles adhering to the developer pass controlling member are removed by the operation of the developer removing means. In this way, the developer pass controlling member is cleaned. At this time, even when such a removed developer adheres to the intermediate image holding member, the transferring means is placed in its non-operation state when the developer has been conveyed. Therefore, the developer adhering to the intermediate image holding member will not be transferred onto the transferring means, thereby providing protection against contamination of the transferring means.

[0079] Further, preferably the transferring means is so configured as to be pushed toward the intermediate image holding member with the image receiving body caught between itself and the intermediate image holding member when placed in the operation state whereas, when placed in the non-operation state, the transferring means moves away from the intermediate image holding member. As a result of such arrangement, in the non-operation state the transferring means and the intermediate image holding member are physically separated from each other, thereby ensuring that contamination of the transferring means is prevented positively.

[0080] On the other hand, the image forming device of the fifteenth invention comprises a developer supporting body for conveying and, at the same time, supporting a charged developer, an opposing electrode positioned face to face with the developer supporting body, an intermediate image holding member interposed between the developer supporting body and the opposing electrode, a developer pass controlling member, having an insulating substrate which is placed between the developer supporting body and the intermediate image holding member and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each developer pass orifice in the insulating substrate and to which a voltage according to an image signal is applied, for forcing the developer on the developer supporting body into flight so as to pass through a specified developer pass orifice for adhesion onto the intermediate image holding member, a conveying means for conveying the intermediate image holding member, a transferring means for transferring an intermediate image on the intermediate image holding member onto an image receiving body, and a developer removing means for removing particles of the developer adhering to the developer pass controlling member. The transferring means is characterized in that it includes a cleaning means for removing developer particles adhering to the transferring means. In this case, since the transferring means is kept clean at all times by the cleaning means, this provides protection against contamination of the inside of the device and contamination of the recording paper.

[0081] Each of the foregoing inventions can be applied to a device with a plurality of recording units. In such a case, the following configuration is preferable. That is, it is preferable that a plurality of recording units are provided, each recording unit including the developer supporting body, the opposing electrode, the developer pass controlling member, and the developer removing means, that the conveying means is so configured as to successively convey the intermediate image holding member between the developer pass controlling member and the opposing electrode of each recording unit, that the developer pass controlling members of the plural recording units are so configured as to operate one after another at intervals of a first time difference for forming on the intermediate image holding member an intermediate image resulting from superimposition of developers from the plural recording units, and that the developer removing means of the plural recording units are so configured as to operate one after another at intervals of a second time difference different from the first time difference for preventing respective developers removed from the plural recording units by the developer removing means from being superimposed on the intermediate image holding member.

[0082] As a result of such arrangement, the operation timing of the developer removing means differs for each recording unit, therefore causing the adhesion position of developers removed from the developer pass controlling members on the intermediate image holding member to be scattered. This therefore provides protection against accumulation of developer particles from the respective recording units at the same area in the intermediate image holding member. This provides positive protection against contamination caused by direct contact of the accumulated developer particles and the developer pass controlling member and against adverse flight of the developer toward the developer pass controlling member.

[0083] Further, it is preferable that the developer removing means comprises an oscillation applying member including an oscillation generating source for applying an oscillation to developer pass orifice portions of the developer pass controlling member.when the developer pass controlling member is in the non-operation state and an oscillation transmitting body connected, at at least one of ends thereof, to the oscillation generating source and disposed on the developer pass controlling member so as to extend parallel to the developer pass orifice row for transmitting an oscillation from the oscillation generating source to each developer pass orifice portion of the developer pass controlling member. Further, it is preferable that the oscillation applying member is so configured as to apply an oscillation which becomes a progressive wave in a direction parallel to the developer pass orifice row and a standing wave in a direction orthogonal to the developer pass orifice row.

[0084] A sixteenth invention of the present application is an invention suitable for multicolor image forming devices. More specifically, the sixteenth invention is directed to an image forming device comprising a developer supporting body which rotates with a developer electromagnetically supported on its peripheral surface, an opposing electrode, placed face to face with the developer supporting body, for electro-magnetically attracting the developer supported on the developer supporting body and a developer pass controlling member, interposed between the developer supporting body and the opposing electrode and having at least one developer pass orifice row arranged in the rotational axis direction of the developer supporting body, for controlling the passing of the developer through the developer pass orifices in response to an external image signal, wherein an image receiving body is interposed between the opposing electrode and the developer pass controlling member for adhesion of the developer thereonto. In the image forming device of the sixteenth invention, the image forming device further comprises a plurality of print heads each comprising a combination of the developer supporting body and the developer pass controlling member, the image receiving body is so positioned as to successively pass through between the developer pass controlling member and the opposing electrode of each print head, and the image forming device further comprises an oscillation applying member, positioned in the developer pass controlling member of each print head and extending along the developer pass orifice row, for applying an oscillation to the developer pass controlling members and an oscillation reflecting body, positioned in the developer pass controlling member of each print head and placed opposite the oscillation applying member across the developer pass orifice row, for reflecting an oscillatory wave transmitted from the oscillation applying member.

[0085] With this invention, it is possible to realize a multicolor image forming device with a plurality of print heads. Owing to the reflection of an oscillatory wave by the oscillation reflecting body, the transmission efficiency of oscillation is improved and it is also possible to form a standing wave between the oscillation applying member and the oscillation reflecting body. If the developer pass orifice portions or their neighboring areas are arranged not to correspond to nodes of the standing wave, this makes it possible to cause these portions to be oscillated greatly by the standing wave. This provides effective protection against a buildup of developer deposits in the inside of the developer pass orifices and therearound.

[0086] The plurality of print heads may be provided with individual oscillation generating sources each of which is driven independently of the other for driving its oscillation applying member. In this case, even when a multicolor image forming device is formed, each of oscillators of the print heads operates independently of the other and there is no need for simultaneous application of oscillations, therefore eliminating the need for the provision of individual driving circuits for driving these oscillation generating sources. This advantageously contributes to reducing the costs of the image forming device.

[0087] Further, an arrangement may be made in which each print head has the oscillation applying member and the oscillation reflecting body, the oscillation applying member and the oscillation reflecting body being positioned opposite to each other across the developer pass orifice so as to be disposed on the front side and on the far side, respectively, with respect to the traveling direction of the image receiving body.

[0088] That is to say, as stated above, of the toner deposited around the developer pass orifice of the developer pass controlling means there exist not only toner particles of forward polarity (toner particles which exhibit a polarity capable of electro-magnetically being attracted by the opposing electrode) but also toner particles of reverse polarity. Therefore, together with the toner particles of forward polarity, the toner particles of reverse polarity are forced into flight toward the image receiving body by toner-to-toner cohesion and adhesion. In such an arrangement that the image receiving body successively passes through the plural print heads, when a toner of reverse polarity, supplied from a print head which has previously been passed through by the image receiving body and adhering to the image receiving body, reaches the next print head, the toner is forced into adverse flight toward the developer pass controlling means of the next print head from the image receiving body by electro-magnetic force. This may result in contamination of the periphery of the developer pass orifice.

[0089] On the other hand, even when a toner of reverse polarity, supplied to the image receiving body from the previously passed-through print head and adhering thereto, is forced into adverse flight at an area of the next print head, if the oscillation applying member and the oscillation reflecting member are disposed on the front side and on the far side, respectively, with respect to the traveling direction of the image receiving body, this prevents the toner from readily adhering to around the developer pass orifice by an oscillation applied by the oscillation applying member to the developer pass controlling means of that print head and, even when adhered to around the developer pass orifice the adhered toner will be removed with ease. Accordingly, this provides protection against contamination of the developer pass controlling means of the next print head by toner particles of the previous print head.

[0090] Further, the oscillation applying members of the plural print heads may be connected to a single common oscillation generating source by which the oscillation applying members are oscillated. In this case, the single oscillation generating source is shared between the plural print heads, thereby advantageously contributing to reducing the costs of the image forming device.

[0091] Furthermore, it is preferable that an oscillation cutting-off means for cutting off the transfer of an oscillation from the common oscillation generating source to each oscillation applying member is interposed therebetween. In this case, even when the single oscillation generating source is shared between each print head, each of the oscillation applying members of the print heads can be operated independently of the other by the operation of the oscillation cutting-off means. This is useful when cleaning the developer pass controlling means by selectively causing the oscillation applying member of each print head to operate at the time when no image is being formed in any print head, i.e., at the time when no image is being formed by control of the developer pass controlling means, instead of causing the oscillation applying member of each print head to operate at all times.

[0092] Seventeenth to nineteenth inventions of the present application are inventions suitable for applying oscillations from both sides positioned opposite each other across the developer pass orifice row. More specifically, an image forming device of the seventeenth invention comprises a developer supporting body for supporting and conveying a charged developer, a developer pass controlling member, having a developer pass orifice row of a plurality of developer pass orifices through which the developer passes, for controlling, in response to an external image signal, the passing of the developer supplied from the developer supporting body through the developer pass orifices, and an image receiving body onto which the developer, which has passed through a developer pass orifice, adheres. The developer pass controlling member has an insulating substrate in which the developer pass orifices are formed, a pair of bar-like oscillation transmitting bodies are positioned opposite each other across the developer pass orifice row and extend along the developer pass orifice row, and oscillation generating sources are disposed at both ends of each of the pair of oscillation transmitting bodies.

[0093] Further, an image forming device of the eighteenth invention comprises a developer supporting body for supporting and conveying a charged developer, a developer pass controlling member, having a developer pass orifice row of a plurality of developer pass orifices through which the developer passes, for controlling, in response to an external image signal, the passing of the developer supplied from the developer supporting body through the developer pass orifices, and an image receiving body onto which the developer, which has passed through a developer pass orifice, adheres. The developer pass controlling member has an insulating substrate in which the developer pass orifices are formed, one ends of bar-like oscillation transmitting bodies, positioned opposite each other across the developer pass orifice row and extending along the developer pass orifice row, are connected together to form a U-shaped oscillation transmitting body, and an oscillation generating source is disposed in the oscillation transmitting body.

[0094] In such a case, oscillations from positions on both sides of the developer pass orifice row are transmitted to the developer pass orifice row, thereby causing the periphery of the developer pass orifice row to be oscillated greatly. This ensures that a buildup of developer deposits is prevented more positively.

[0095] Further, in the eighteenth invention, an arrangement may be made in which an oscillation generating source is disposed at each end of the oscillation transmitting body. In this case, oscillations by the oscillation generating sources positioned at the both ends of the oscillation transmitting body propagate through the oscillation transmitting body, as a result of which the oscillation transmitting body is oscillated greatly. This causes the insulating substrate to undergo much greater oscillation. This ensures that the buildup of developer deposits is prevented more effectively.

[0096] Further, in the eighteenth invention, another arrangement may be made in which the both ends of the U-shaped oscillation transmitting body are connected together to form an annular oscillation transmitting body. In this case, if a plurality of oscillation generating sources are provided at parts of the oscillation transmitting body, this causes the insulating substrate to be oscillated more greatly.

[0097] For the case of the provision of a plurality of oscillation generating sources as described above, it is preferable that the oscillation generating sources are so configured as to differ in oscillation phase from each other. In this case, there is generated a progressive wave in the oscillation transmitting body, thereby preventing formation of a portion that becomes a node in the insulating substrate. Because of this, the entire insulating substrate is uniformly oscillated, thereby eliminating the inconvenience that developer deposits build up in portions corresponding to nodes of oscillation mode.

[0098] The oscillation generating source may be so configured as to operate at all times when the developer pass controlling member is in operation and a detecting means for detecting whether the developer pass orifice becomes clogged may be provided in which the oscillation generating source is so configured as to operate according to the detection result. Here, the detecting means is so designed to directly detect clogging of the developer pass orifice or to detect whether the image is formed normally by test printing. More specifically, an arrangement may be made in which the detecting means is made up of a light emitting means capable of light emission toward the image receiving body and a light receiving means capable of receiving reflected light resulting from reflection of light emitted from the light emitting means by the image receiving body, and the detecting means thus configured detects whether the image is formed normally from the absence or presence of reflected light.

[0099] Further, an image forming device of the nineteenth invention comprises a developer supporting body for supporting and conveying a charged developer, a developer pass controlling member, having a developer pass orifice row of a plurality of developer pass orifices through which the developer passes, for controlling, in response to an external image signal, the passing of the developer supplied from the developer supporting body through the developer pass orifices, and an image receiving body onto which the developer, which has passed through a developer pass orifice, adheres. In the image forming device of the nineteenth invention, the developer pass controlling member has an insulating substrate in which the developer pass orifices are formed, an oscillation transmitting body, one end of which is fixed to the insulating substrate whereas the other end is oscillatably configured so as to cause the insulating substrate to be oscillated, is disposed on each side of the developer pass orifice row of the insulating substrate, extending along the developer pass orifice row, and an oscillation generating source is disposed on the oscillation transmitting body.

[0100] An arrangement may be made in which the oscillation transmitting body is formed into a flat plate-like shape extending along the developer pass orifice row and an end of the flat plate-like oscillation transmitting body on the far side with respect to the developer pass orifice row is fixed to the insulating substrate and a plurality of the oscillation generating sources are disposed along the developer pass orifice row.

[0101] Furthermore, an arrangement may be made in which the oscillation transmitting body is formed into a comb-like shape extending along the developer pass orifice row and an end of each of comb teeth of the comb-like oscillation transmitting body on the far side thereof with respect to the developer pass orifice row is fixed to the insulating substrate and the oscillation generating source is disposed on each of the comb teeth.

[0102] In this case, when the oscillation generating source oscillates, the other end of the oscillation transmitting body bends and strikes the insulating substrate. This causes the insulating substrate to be oscillated, thereby preventing a buildup of developer deposits. As a result, the clogging of the developer pass orifice is prevented and stable image formation is achieved.

[0103] An arrangement may be made in which the oscillation generating sources disposed on the oscillation transmitting bodies on both sides of the developer pass orifice row are arranged at the same pitch and oscillation generating sources on one side of the developer pass orifice row are so arranged as to be half-pitch deviated with respect to oscillation generating sources on the other side. If the oscillation generating sources on the oscillation transmitting bodies on both sides of the developer pass orifice row are arranged at the same pitch so that oscillation generating sources on the one side are positioned face to face with their corresponding oscillation generating sources on the other side, this creates regions not sandwiched between oscillators in the developer pass orifice row. In these regions, the magnitude of oscillation becomes relatively small. To cope with this, the oscillation generating sources on the oscillation transmitting bodies on the one side are arranged so as to be half-pitch deviated with respect to the oscillation generating sources on the oscillation transmitting bodies on the other side, which makes it possible to cause the entire developer pass orifice row to be oscillated uniformly. This prevents a buildup of developer deposits all over the developer pass orifice row.

[0104] An arrangement may be made in which each of the oscillation generating sources is oscillated by application of a voltage and the phases of voltages that are applied to the oscillation generating sources on the oscillation transmitting bodies on each side are the same. In this case, oscillations from each side are synthesized, thereby making it possible to cause the periphery of the developer pass orifice row to be oscillated more greatly. On the other hand, the phases of voltages that are applied to the oscillation generating sources on the oscillation transmitting bodies on each side may be deviated from each other. In this case, it is possible to cause every region in the vicinity of the developer pass orifice row to be oscillated uniformly and in each case it is possible to effectively prevent a buildup of developer deposits.

[0105] It is preferable that an oscillatory system, made up of the oscillation transmitting body on each side, the oscillation generating source on each side, and the insulating substrate, is so configured as not to causes a node of the oscillation at the position of each developer pass orifice. For example, it is preferable that the oscillatory system is so configured as to become either a primary oscillatory mode or a tertiary oscillatory mode. That is, if the position of a developer pass orifice corresponds to a node of the oscillation, this reduces the oscillation of the periphery of the developer pass orifice, resulting in being unsatisfactory for protection against a buildup of developer deposits. Accordingly, it is preferable that the position of each developer pass orifice is so arranged as not to correspond to a node of the oscillation. Particularly, if the oscillatory system is either a primary oscillatory mode or a tertiary oscillatory mode, this causes the position of each developer pass orifice to correspond to an antinode of the oscillation, thereby causing the periphery of the developer pass orifice to be oscillated greatly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0106]

Figure **1** is a diagram schematically showing an arrangement of an image forming device.

Figure **2(a)** is a cross-sectional view taken along line A-A of Figure **2(b)** and Figure **2(b)** is a top plan view of a print head.

Figure **3** is a perspective view of a print head in relation to a preferred embodiment (a first embodiment) for print head oscillation.

Figure **4** is a corresponding diagram to Figure **3**, showing a print head in relation to a variation.

Figure **5** is a corresponding diagram to Figure **3**, showing a print head in relation to another variation.

Figure **6** is a corresponding diagram to Figure **3,** showing a print head in relation to still another variation.

Figure **7** is a diagram showing an arrangement of an oscillation generating body in relation to a variation.

Figure **8** is a perspective view of a print head in relation to a preferred embodiment (a second embodiment) for print head oscillation.

Figure **9** is a top plan view of the print head.

Figure **10** is a cross-sectional view taken along line B-B of Figure **9**.

Figure **11** is a corresponding diagram to Figure **8**, showing a print head in relation to a variation.

Figure **12** is a cross-sectional view of the print head in relation to the variation.

Figure **13** is a perspective view of a print head in relation to a preferred embodiment for causing the periphery of a developer pass orifice to be oscillated at large amplitudes.

Figure **14** is a cross-sectional view of the print head.

Figure **15** is a corresponding diagram to Figure **14**, showing a print head in relation to a variation.

Figure **16** is a corresponding diagram to Figure **14**, showing a print head in relation to another variation.

Figure **17** is a corresponding diagram to Figure **14**, showing a print head in relation to still another variation.

Figure **18** is a corresponding diagram to Figure **14**, showing a print head in relation to a further variation.

Figure **19** is a corresponding diagram to Figure **14**, showing a print head in relation to a still further variation.

Figure **20** is a corresponding diagram to Figure **14**, showing a print head in relation to a variation.

Figure **21** is a diagram showing a relationship between the damping of an oscillation in a controlling plate and the space between an oscillation transmitting plate and a holding member.

Figure **22** is a perspective view of a print head in relation to a preferred embodiment (a first embodiment) for uniform oscillation in the direction of a row of developer pass orifices.

Figure **23** is a side view of an oscillation generating body.

Figure **24** is a perspective view of a print head in relation to a preferred embodiment (a second embodiment) for uniform oscillation in the direction of a row of developer pass orifices.

Figure **25(a)** is a top plan view of an oscillation absorbing body, Figure **25(b)** is a front view of the oscillation absorbing body, and Figure **25(c)** is a side view of the oscillation absorbing body.

Figure **26** is a perspective view of a print head in relation to a preferred embodiment (a third embodiment) for uniform oscillation in the direction of a row of developer pass orifices.

Figure **27** is a perspective view of a print head in relation to a preferred embodiment (a fourth embodiment) for uniform oscillation in the direction of a row of developer pass orifices.

Figure **28** is a cross-sectional view showing in detail an arrangement of an auxiliary oscillation agitator.

Figure **29** is a top plan view of an oscillation transmitting plate in relation to a preferred embodiment (a first embodiment) for oscillation-damping suppression.

Figure **30** is a perspective view of a controlling plate in relation to a preferred embodiment (a second embodiment) for oscillation-damping suppression.

Figure **31(a)** is a top plan view of a controlling plate in relation to a preferred embodiment (a third embodiment) for oscillation-damping suppression and Figure **31(b)** is a cross-sectional view taken along line C-C of Figure **31(a)**.

Figure **32** is a top plan view of an oscillation transmitting plate in relation to a preferred embodiment (a fourth embodiment) for oscillation-damping suppression.

Figure **33** is a diagram schematically showing an arrangement of an image forming device in relation to a preferred embodiment (a second embodiment) for protection against contamination by removed toner particles.

Figure **34** is a diagram schematically showing an arrangement of an image forming device in relation to a preferred embodiment (a third embodiment) for protection against contamination by removed toner particles.

Figure **35** is a diagram schematically showing an arrangement of an image forming device in relation to a preferred embodiment (a fourth embodiment) for protection against contamination by removed toner particles.

Figure **36** is a diagram schematically showing an arrangement of an image forming device in relation to a preferred embodiment (a first embodiment) for protection against contamination of a transfer mechanism by removed toner particles.

Figure **37** is a diagram schematically showing an arrangement of an image forming device in relation to a preferred embodiment (a second embodiment) for protection against contamination of a transfer mechanism by removed toner particles.

Figure **38** is a diagram schematically showing an arrangement of an image forming device in relation to a preferred embodiment (a third embodiment) for protection against contamination of a transfer mechanism by removed toner particles.

Figure **39** is a timing chart of the operation of a print head.

Figure **40** is a timing chart of the operation of a print head in relation to a variation.

Figure **41** is a perspective view of a print head unit.

Figure **42** is a schematic diagram of an image forming device in relation to a preferred embodiment (a first embodiment) for multicolor image forming device cleaning.

Figure **43** is a circuit diagram for driving of an oscillator in relation to a preferred embodiment (a second embodiment) for multicolor image forming device cleaning.

Figure **44** is an explanatory diagram of an oscillation applying member in relation to a preferred embodiment (a third embodiment) for multicolor image forming device cleaning.

BEST MODES FOR CARRYING OUT THE INVENTION

[0107] By making reference to the accompanying drawings, embodiments of the present invention will be described below.

[0108] Referring to Figure **1**, there is shown an arrangement of an image forming device according to the present embodiment. In Figure **1**, the toner conveying roller **1** supports and, at the same time, conveys a toner **4** as a developer. Further, the toner conveying roller **1** serves also as a charging electrode capable of charging the toner **4**. The toner conveying roller **1** can be composed of metal such as aluminum and iron and of alloy. Preferably, the outer diameter of the toner conveying roller **1** is from about 16 mm to about 20 mm. In the present embodiment, as the toner conveying roller **1**, a cylinder of aluminum, having an outer diameter of 20 mm and a thickness of 1 mm, is used. Further, the toner conveying roller **1** is connected to ground, which is however not to be deemed restrictive. For example, a dc voltage or an ac voltage may be applied to the toner conveying roller **1**.

[0109] The regulating blade **2** is for formation of from one to three layers of toner on the toner conveying roller **1**. The regulating blade **2** is composed of an elastic member such as urethane and its hardness, free end length (the length of a portion projecting from the installation part), and linear load to the toner conveying roller **1** are preferably from 40 degrees to 80 degrees (JIS K6301 A-Scale), from 5 mm to 15 mm, and from 5 g/cm to 40 g/cm, respectively. The regulating blade **2** may be placed electrically in the float state or connected to ground. Alternatively, a dc voltage or an ac voltage may be applied to the regulating blade **2**. In the present embodiment, the regulating blade **2** is used in the float state.

[0110] The toner **4** is caught between the toner conveying roller **1** and the regulating blade **2** and subjected to slight agitation there. Then, the toner **4** receives an electric charge from the toner conveying roller **1** and becomes charged. In the present embodiment, as the toner **4**, particles of a nonmagnetic substance, having a negative charge of - 10 μC/g and an average particle diameter of 8 μm, are used.

[0111] The supplying roller **3** is formed by applying, for about 2 mm to about 6 mm, synthetic rubber such as expanded urethane around a metallic shaft of iron or the like (a metallic shaft having a diameter of 8 mm is used in the present embodiment) and its hardness is 30 degrees (one processed in the form of a roller was measured using a method according to JIS K6301 A-Scale). The amount of penetration of the supplying roller **3** into the toner conveying roller **1** is preferably from about 0.1 mm to about 2 mm. Also, the supplying roller **3** may be configured to be connected to ground. Alternatively, a dc voltage or an ac voltage may be applied to the supplying roller **3**. The supplying roller **3** helps the charging of the toner **4**. In addition, the supplying roller 3 controls the supply amount of the toner **4**.

[0112] The opposing electrode **5** is for forming an electric field between itself and the toner conveying roller **1**. As a material to form the opposing electrode **5**, a metallic plate, a metallic roller, a film formed by dispersing conductive fillers in a resin, or the like is preferably used. Further, when such a film is employed as the opposing electrode **5**, its resistance is preferably from about 10^2 to about 10^{11} Ω/cm. Applied from a dc power supply **9** to the opposing electrode **5** is a dc voltage of from about 500 to about 2000 V. In the present embodiment, a dc voltage of 1000 V is applied to the opposing electrode **5**.

[0113] As the recording method, a method may be employed wherein the toner **4** is adhered onto a conveyor belt (not shown in the figure) for formation of an image thereon and the image thus formed is transferred to a sheet of recording paper for fixation thereon. However, in the present embodiment, a sheet of recording paper **6** is placed overlying the opposing electrode **6** and the toner **4** is adhered thereonto for direct image formation on the recording paper **6**, as shown in Figure **1**. Alternatively, an arrangement may be made in which the opposing electrode **5** is processed in the form of an endless film and an image is formed directly on the film and thereafter the formed image is transferred onto the recording paper. When forming an image, the recording paper **6** is fed at a specified rate by a paper feeding roller **7**. In the present embodiment, the rate at which the recording paper **6** is fed is 65 mm/s.

[0114] Referring to Figure **2**, there is schematically shown an arrangement of the print head **10** disposed between the toner conveying roller **1** and the opposing electrode **5**. Figure **2(a)** is a cross-sectional view of the print head **10.** Figure **2(b)** is a top plan view of the print head **10** when viewed from the side of the toner conveying roller **1**. Further, in Figure **2(b)**, the lateral direction of the drawing is the direction in which the recording paper travels (the Y direction) and the vertical direction is the crosswise direction of the recording paper (the X direction).

[0115] As shown in Figure **2**, a plurality of orifices **12** as developer pass orifices are formed through an insulating substrate **14** of the controlling plate **30**. These orifices **12** form an orifice row **12A** arranged along the recording paper crosswise direction. The number of the orifice rows **12A** is not limited to two. The number of the orifice rows **12A** may be one or three or more. Positioned at a surface of the toner conveying roller **1** of the insulating substrate **14** are a plurality of image signal electrodes **11** that are formed into a ring shape so as to enclose each orifice **12**. This is not deemed restrictive. For example, the image signal electrode **11** may be positioned on the internal wall of the orifice **12**. In the present embodiment, a ring-like electrode having an internal diameter of 150 μm and an outer diameter of 250 μm is used as the image signal electrode **11**. A thin insulating resin layer (not shown in the figure) having a thickness of 5 μm to 20 μm is formed on the surface of each electrode.

[0116] It is preferable that the insulating substrate **14** of the controlling plate **30** be formed of an insulating film having a thickness of 10 to 100 μm. Materials such as polyimide and polyethylene terephtalate are preferably used to form the insulating substrate **14**. In the present embodiment, an insulating film of polyimide having a thickness of 25 μm is used. The orifices **12** are arranged in staggered fashion for mutual interpolation in order that a full black image is formed when toner is emitted from all the orifices **12**. The diameter of the orifice **12** is preferably 50 to 200 μm. In the present embodiment, the diameter of the orifice **12** is 145 μm. The image signal electrode **11** is composed of metal such as copper and preferably has a thickness of 5 to 30 μm. Each image signal electrode **11** is individually connected, through a lead line **31A**, to an image signal power supply **13** which is an image signal voltage switching means. Further, a voltage of about 400 V is usually applied to the image signal electrode **11**. In the present invention, a voltage of 300 V is applied for the formation of dots. On the other hand, a voltage of -100 V is applied for the non-formation of dots. The distance between the opposing electrode **5** and the controlling plate **30** preferably ranges between 50 μm and 1000 μm. In the present embodiment, the distance is 250 μm. Further, the distance between the toner conveying roller **1** and the controlling plate **30** is preferably from 0 μm to 200 μm. In the present embodiment, the distance is 30 μm.

[0117] Further, an arrangement may be made, in which one end of the controlling plate **30** is fixed to the print head unit whereas the other end thereof is stretched by, for example, a spring so that tension is applied to the controlling plate **30**.

[0118] Next, the operation of the image forming device of the present embodiment will be described below.

[0119] When a voltage whose level is above a specified value is applied to the image signal electrode **11** in response to an external image signal, an acceleration electric field is created between the toner conveying roller **1** and the image signal electrode **11**. The toner **4** on the toner conveying roller **1** overcomes the toner conveying roller **1** in image force and starts flying toward the image signal electrode **11**. Then the toner **4**, forced into flight, passes through the orifice **12** enclosed by the image signal electrode **11**. Having passed through the orifice **12**, the toner **4** is pulled by a voltage applied to the opposing electrode **5** in the direction of the opposing electrode **5** and lands on the recording paper **6**. On the other hand, when a voltage of less than the specified value (including zero) is applied to the image signal electrode **11**, the toner **4** on the toner conveying roller **1** is not forced into flight. Therefore, the toner **4** remains supported on the toner conveying roller **1** because the intensity of an electric field formed between the toner conveying roller **1** and the image signal electrode **11** is insufficient. Further, in order to obtain the same effects as above, an arrangement may be made, in which a voltage of reverse polarity is applied to the image signal electrode **11** so that the direction of an electric field between the toner conveying roller **1** and the image signal electrode **11** is reversed.

[0120] Thereafter, the toner **4** adhering to the recording paper **6** is fixed by a fixing roller **8**, thereby making a record of the desired image on the recording paper **6**.

[0121] As image formation is repeatedly carried out, the toner **4** and contaminants will be built up in the vicinity of the orifice **12** of the controlling plate **30**. To cope with such a buildup of toner/contaminant deposits, the following step is taken. That is, during image formation, or in the period during which image formation is brought into a halt (for example, immediately after the power is applied to the device, and during the period from the time that a sheet of recording paper **6** passes through between the controlling plate **30** and the opposing electrode **5** to the time that a next sheet of recording paper **6** is fed when forming in succession an image on plural sheets of recording paper **6**), the controlling plate **30** is oscillated for removal of the toner **4** accumulated in the vicinity of the orifice **12**.

PREFERRED EMBODIMENTS FOR OSCILLATING CONTROLLING PLATE

[0122] Next, preferred embodiments for causing the controlling plate **30** to be oscillated will be described.

(EMBODIMENT 1)

[0123] Figure **3** shows the controlling plate **30** developed in plane. An oscillation transmitting plate **151** is disposed in parallel with the orifice row **12A** of the controlling plate **30**. In other words, the oscillation transmitting plate **151** is so disposed as to extend along the rotation axis direction of the toner conveying roller **1**. The oscillation transmitting plate **151** is formed into a bar-like shape and adhered to the controlling plate **30**. Such adhesion can be implemented by thermocompression bonding or by the use of epoxy adhesive or isocyanate adhesive. Provided at both ends of the oscillation transmitting plate **151** are oscillation generating bodies **60** and **60**.

[0124] The oscillation generating body **60** includes an oscillator **16** and an oscillation amplifier (horn) **17**. For example, as the oscillator **16**, a bolted oscillator of the Langevin type can be used. The oscillator **16** is attached to the horn **17**. The horn **17** is formed such that as it extends downward its cross-sectional area continuously and smoothly decreases and the oscillatory energy of the oscillator **16** is concentrated for transmission to the oscillation transmitting plate **151**.

[0125] The oscillation transmitting plate **151** should have such a rigidity that an oscillation is not absorbed but transmitted. For example, the oscillation transmitting plate **151** may be formed of metal. More specifically, stainless steel may be used to form the oscillation transmitting plate **151** and its plate width and thickness may be 5 mm and about 0.2 mm, respectively. The horn **17** also should have such a rigidity that an oscillation is not absorbed but transmitted. It is preferable that the horn **17** has the same natural frequency as the oscillator **16**. The horn **17** may be formed of metal. More specifically, it is preferable for the horn **17** to be formed of stainless steel or aluminum because of easy formation.

[0126] A sine wave of not more than 1 MHz (e.g., 20 kHz) is preferable for the oscillation frequency of the oscillator **16**. This is because that if the oscillating frequency becomes high it is impossible to ignore a liberation of heat in a surface where the controlling plate **30** and the oscillation transmitting plate **151** are adhered together and because that the degree of oscillation damping increases.

[0127] Next, the operation of applying an oscillation to the controlling plate **30** will be explained.

[0128] When a voltage is applied to the oscillators **16** and **16**, the oscillation of each oscillator **16** is transmitted, through the oscillation transmitting plate **151**, to the controlling plate **30**.

[0129] Since the insulating substrate **14** of the controlling plate **30** is formed of polyimide or the like, the insulating substrate **14** exhibits viscoelasticity. Because of this, if the oscillator **16** is disposed directly on the controlling plate **30**, the oscillation of the oscillator **16** will be absorbed by the time that the oscillations have reached the orifice row **12A.** However, if the oscillation transmitting plate **151** is disposed overlying the controlling plate **30** and the oscillation of the oscillator **16** is made to propagate to the oscillation transmitting plate **151**, this arrangement makes it possible to cause the oscillation of the oscillator **16** to be transmitted to the orifice row **12A.** Further, the oscillator **16** is attached to the horn **17**, thereby making it possible to amplify the oscillation of the oscillator **16** for propagation to the oscillation transmitting plate **151**. Moreover, if the phases of voltages that are applied to the pair of the oscillators **16** and **16** are so set as to differ from each other, this creates a progressive wave in the oscillation transmitting plate **151**. This therefore prevents a portion which becomes a node of the oscillation from being formed in the controlling plate **30**. As a result, the entire controlling plate **30** is oscillated, thereby eliminating the inconvenience that the toner **4** is deposited on the node portion.

[0130] Here, oscillation suitable for cleaning in the vicinity of the orifice **12** depends upon the oscillatory system. If the amplitude is 20 μm and the frequency is 20 kHz, this setting was found to achieve efficient cleaning. This value, when converted into oscillation accelerations (the single amplitude a = 10 μm; the frequency = 20 kHz), becomes a velocity maximum value v_{max} = 1.3m/s and an acceleration maximum value $\alpha max = 1.6 \times 10^5 m/s^2$, for the oscillation displacement $x = a \sin\omega t$, the velocity $v = a\,\omega\cos\omega t$, the acceleration $\alpha v = -a\,\omega^2 \sin\omega t$ (t: time; ω: angular speed = 2 πf; π: pi; f: frequency). This acceleration is compared with an acceleration by an electric field. An acceleration by an electric field acting on a toner at the time of printing is $F = qE = m \times (Q/M) \times E = m\alpha e$, where F is the electric field force, q is the charge amount, E is the electric field, Q/M is the charge amount per toner weight, m is the mass of a single toner particle, and αe is the acceleration. Accordingly, $\alpha e = (Q/M) \times E = (Q/M) \times Vc/Lk$ (Vc: the voltage applied to the signal electrode at the time of printing; Lk: the distance between the toner conveying roller and the signal electrode). Here, the charge amount per toner weight (Q/M) = 10 μC/g, Vc = 300 V, and Lk = 30 μm, so that $\alpha e = 10 \times 10^5 m/s^2$. That is, an oscillation acceleration greater than an electric field force acting on toner at the time of printing acts on the toner particles adhering to around the orifice, and efficient cleaning can be obtained.

(VARIATION)

[0131] Further, the oscillation transmitting plate **15** and the oscillation generating body **60** may be positioned opposite each other across the orifice row **12A**. Further, as shown in Figure **4**, a pair of bar-like oscillating plates are disposed opposite each other across the orifice row **12A** and one ends of the oscillating plates are connected together to form a U-shaped oscillation transmitting plate **152**. In this case, as shown in Figure **4**, the oscillation generating bodies **60** and **60** may be disposed at both ends of the U-shaped oscillation transmitting plate **152.** Furthermore, as shown in Figure **5**, a pair of bar-like oscillating plates are disposed opposite each other across the orifice row **12A** and one ends and other ends of the oscillating plates are connected together to form an annular oscillation transmitting plate **153**. In this case, as shown in Figure **5**, the oscillation generating bodies **60** and **60** may be disposed at curbed portions at both ends of the annular oscillation transmitting plate **153**.

[0132] Further, an alternative arrangement may be made in which the oscillation generating body **60** is disposed at only one end of a bar-like oscillation transmitting plate **154**, as shown in Figure **6**. In this case, the other end of the oscillation transmitting plate **154** may be fixed.

[0133] Additionally, the oscillation generating body is not limited to a combination of the oscillator **16** and the horn **17**. As shown in Figure **7**, the oscillation generating body may be implemented by a bimorph which is a combination of piezoelectric elements **18** and **19**. Employment of such an arrangement makes it possible to provide a down-sized oscillation generating body.

(EMBODIMENT 2)

[0134] Referring to Figure **8**, there is shown the controlling plate **30** according to the second embodiment. A pair of oscillation generating bodies **160** and **160**, positioned opposite each other across the orifice row **12A**, each extend along the orifice row **12A.** Note that one of the oscillation generating bodies **160** and **160** positioned opposite each other across the orifice row **12A** is not shown in the figure.

[0135] Each oscillation generating body **160** is comb-shaped extending along the orifice row **12A**. A far-side end of each comb tooth **161** with respect to the orifice row **12A** is jointed to a fixing portion adhered to the controlling plate **30**. Each comb tooth **161** has a cantilever structure (see Figure **8** or Figure **10**).

[0136] Furthermore, as shown in Figure **9**, the comb teeth **161** of the oscillation generating bodies **160** and **160** on both sides of the orifice row **12A** are arranged at the same pitch and the comb teeth **161** of the oscillation generating body **160** on one side are arranged to be half-pitch deviated from their corresponding comb teeth **161** of the oscillation generating body **160** on the other side. Mounted on each comb tooth **161** is an oscillator **162**. It is designed such that the phase of voltages that are applied to the oscillators **162** of the oscillation generating body **160** disposed on one side of the orifice row **12A** is deviated from the phase of voltages that are applied to the oscillators **162** of the oscillation generating body **160** disposed on the other side.

[0137] Next, the operation of applying an oscillation to the controlling plate **30** will be described.

[0138] A voltage is applied to each oscillator **162**. When the oscillator **162** is oscillated, the comb tooth **161** having a cantilever structure undergoes flexure and its free end starts striking the controlling plate **30**. This causes the controlling plate **30** to be oscillated for protection against a buildup of toner deposits. As a result, the clogging of the orifice **12** is prevented, thereby making it possible to realize stable image-formation.

[0139] Further, since the comb teeth **161, 161**, ... are arranged along the orifice row **12A**, this makes it possible to cause the entire orifice row **12A** to be oscillated. This effectively oscillates the periphery of the orifice **12**.

[0140] Furthermore, since the pair of the oscillation generating bodies **160** and **160** are arranged opposite each other across the orifice row **12A**, oscillations are transmitted to the orifice row **12A** from both lateral directions thereof. This makes it possible to relatively increase the oscillation of the periphery of the orifice **12**. As a result, it becomes possible to provide effective protection against a buildup of toner deposits in the vicinity of the orifices **12.**

[0141] Further, if the oscillators **162, 162**, ... on the oscillation generating bodies **160** and **160** on both sides of the orifice row **12A** are disposed at the same pitch so as to be positioned face to face with each other, this results in producing a region in the orifice row **12A** that is not sandwiched between a pair of oscillators **162** and **162**. In such a region, the degree of oscillation becomes relatively small. However, if the oscillators **162, 162,** ... on the oscillation generating bodies **160** and **160** positioned on both sides of the orifice row **12A** are disposed at the same pitch and the oscillators **162** on the oscillation generating body **160** on one side of the orifice row **12A** are deviated half pitch from the oscillators **162** on the oscillation generating body **160** on the other side, this arrangement makes it possible to cause the entire orifice row **12A** to be oscillated uniformly, thereby making it possible to provide protection against a buildup of toner deposits all over the orifice row **12A**.

[0142] Further, if the phase of voltages that are applied to the oscillators **162, 162,** ... on the oscillation generating body **160** on one side of the orifice row **12A** is deviated from the phase of voltages that are applied to **162, 162**, ... on the oscillation generating body **160** on the other side, this makes it possible to cause the entire region in the vicinity of the orifice row **12A** to be oscillated uniformly. Accordingly, it becomes possible to provide effective protection against a buildup of toner deposits. An arrangement may be made in which voltages of the same phase are applied to the oscillators **162, 162**, ... on the pair of the oscillation generating bodies **160** and **160**. In this case, oscillations from each side are synthesized, thereby making it possible to cause the periphery of the orifice row **12A** to be oscillated greatly.

[0143] Furthermore, if, in an oscillatory system organized between the pair of the oscillation generating bodies **160** and **160**, the position of each orifice **12** corresponds to an oscillation node, this decreases the oscillation of the periphery of the orifice **12**. Therefore, it is impossible to provide effective protection against a buildup of toner deposits. To cope with such a problem, if the oscillation system is organized such that its oscillation mode is either a primary mode or a tertiary mode as indicated by chain single-dashed lines of Figure **10**, the position of the orifice row **12A** corresponds to oscillation antinodes, thereby increasing the amplitude in the vicinity of the orifice row **12A**. This therefore effectively prevents toner from adhering to around the orifice row **12A**. Setting the oscillation mode of the oscillatory system to a primary mode or to a tertiary mode can be made by, for example, changing the oscillating frequency of the oscillator **162**, changing the length, width, thickness or material of the oscillation generating body **160**, changing the thickness and width or material of the controlling plate **30**, or changing the placement position of the oscillation generating body **160**.

(VARIATION)

[0144] As shown in Figure **11**, an arrangement may be made in which a flat plate-like oscillation generating body **163** extending along the orifice row **12A** is employed and a plurality of oscillators **162, 162**, ... are provided on the oscillation generating body **163**. The oscillation generating body **163** may be disposed on only one side of the orifice row **12A**. Alternatively, the oscillation generating body **163** may be disposed on both sides of the orifice row **12A.**

[0145] Furthermore, as shown in Figure 12, the oscillation generating body **164** may be formed in such a manner that a fixing member **165** as a separate member from a comb tooth **166** is placed on the comb tooth **166** and a base of the comb tooth **166** is fixed.

PREFERRED EMBODIMENTS FOR CAUSING ORIFICE PERIPHERY TO BE OSCILLATED AT LARGE AMPLITUDE

[0146] Next, preferred embodiments for causing the periphery of the orifice **12** to be oscillated at larger amplitudes will be described.

[0147] As shown in Figure **13**, the oscillation transmitting plate **151** is disposed along the orifice row **12A** in the controlling plate **30**. An oscillation reflecting plate **71**, by which an oscillatory wave (generated in the controlling plate **30** by application of an oscillation by the oscillation generator **60** and the oscillation transmitting plate **151** and traveling from the oscillation transmitting plate **151** toward the orifice row **12A**) is reflected, is adhered by thermocompression bonding on one side of the orifice row **12A** opposite to the side where the oscillation transmitting plate **151** is positioned. Like the oscillation transmitting plate **151**, the oscillation reflecting plate **71** is also extendedly disposed along the rotation axis direction of the toner conveying roller **1**. In other words, the orifice row **12A**, the oscillation transmitting plate **151**, and the oscillation reflecting plate **71** are disposed in parallel with one another.

[0148] As a material to form the oscillation reflecting plate **71**, a material, which has a rigidity capable of transmitting an oscillation without absorbing it and whose oscillation characteristic greatly differs from the impedance of oscillation transmission of the controlling plate **30**, is especially preferable when improving the efficiency of reflection. When using a resin (e.g., polyimide) to form the insulating substrate **14** of the controlling plate

30, it is preferable to use a metal greatly differing in the value of ρc (i.e., a product of the density ρ and the sound velocity c). Specifically, stainless steel and spring steel are preferable. Further, the plate width and thickness may be set to 5 mm and to about 0.2 mm, respectively. Adhesion to the controlling plate **30** may be carried out by thermocompression bonding or by the use of epoxy adhesive or isocyanate adhesive.

[0149] Next, the operation of applying an oscillation to the controlling plate **30** will be described below.

[0150] When a voltage is applied to the oscillator **16** of each oscillation generating body **60,** the oscillation of the oscillator **16** is transmitted and applied to the controlling plate **30** through the horn **17** and the oscillation transmitting plate **151**. This generates in the controlling plate **30** oscillatory waves traveling from a portion to which the oscillation transmitting plate **151** (an oscillation applying portion) is adhered toward the orifice row **12A** (toward the oscillation reflecting plate **71**) and toward the side opposite the orifice row **12A**. Of these oscillatory waves, one that travels from the oscillation transmitting plate **151** toward the orifice row **12A** goes beyond the orifice row **12A** to arrive at an end (i.e., a reflection end **32**) of the oscillation reflecting plate **71** on the side of the oscillation transmitting plate **151** and is reflected by the reflection end **32**. Then, as shown in Figure **14**, a progressive wave and a reflected wave are superimposed with each other, thereby forming between the reflection end and the oscillation transmitting plate **15** a standing wave s (indicated by a chain double-dashed line in Figure **14**) whose node corresponds to the reflection end **32**.

[0151] In view of the above, if each orifice's **12** portion of the controlling plate **30** or its neighboring area is so arranged as not to correspond to a node of the standing wave s, this causes the portion to be oscillated at all times. This effectively prevents particles of the toner **4** which have not passed through the orifice **12** from adhering to the inside of the orifice **12** or to its peripheral edge portion. Even when particles of the toner **4** adheres to such a portion, it is possible to effectively remove them by the following arrangement. That is, a distance L1 along an oscillation progress route between the reflection end **32** and the orifice row **12A** is so set as to satisfy $L1 < \lambda/2$ where λ is the wavelength of the standing wave s. Particularly, if the distance L1 is set such that $L1 = \lambda/4$, this causes the orifice row **12A** to correspond to antinodes of the standing wave s, thereby subjecting each orifice's **12** portion to a greatest displacement. For example, the wave length λ when an oscillation is applied to the controlling plate **30** is about 4 mm for the oscillating frequency = 40 kHz. Accordingly, if the distance between the reflection end **32** which is a contact portion of the toner conveying roller **1** and the controlling plate **30** and the orifice **12** is so set as to fall below 2 mm, this ensures that the peripheral portion of the orifice **12** is oscillated positively. In the present embodiment, the distance is 1 mm.

[0152] Further, it is preferable that a distance L2 along an oscillatory wave progress route between the reflection end **32** and the oscillation transmitting plate **151** be so set as to satisfy $L2 > \lambda/4$. The reason is as follows. That is, if the distance L2 is λ/4 or less, this makes it difficult to form the standing wave s and further causes the reflection end **32** to be oscillated, which is accompanied by a liberation of heat, wear of the oscillation reflecting plate **71** or the like. It is more preferable that the distance L2 be so set as to satisfy $L2 > 3\lambda/4$.

[0153] As described above, the arrangement that in the controlling plate **30** the oscillation generating body **60** and the oscillation transmitting plate **151** for oscillation application are disposed on one side of the orifice row **12A** and the oscillation reflecting plate **71** for oscillatory wave reflection is disposed on the other side of the orifice row **12A**, makes it possible to form the standing wave s between the reflection end **32** and the oscillation transmitting plate **151.** The standing wave s provides protection against the clogging of each orifice **12** by a buildup of the toner **4**. Therefore, it is possible to form a stable image with a simplified arrangement over a long period of time.

(VARIATION)

[0154] The placement position of the oscillation transmitting plate **151** and that of the oscillation reflecting plate **71** with respect to the orifice row **12A** may be switched.

[0155] Further, as shown in Figure **15**, the oscillation reflecting plate **72** may be adhered to a surface of the controlling plate **30** on the side of the opposing electrode **5**.

[0156] Furthermore, as shown in Figure **16**, an arrangement may be made in which the toner conveying roller **1** and the controlling plate **30** come into contact with each other. As a result of such arrangement, an oscillation node is formed at a contact portion of the toner conveying roller **1** and the controlling plate **30** (i.e., at the reflection end **32**). As a result, the standing wave s is formed in the controlling plate **30**, thereby ensuring that the periphery of the orifice **12** is oscillated positively.

[0157] Further, as another arrangement of bringing the toner conveying roller **1** into contact with the controlling plate **30**, a spacer **73** may be disposed on the controlling plate **30** for protection against wear of the controlling plate **30** or reduction in friction force of the controlling plate **30**, as shown in Figure **17**. In addition to achieving the aforesaid purposes, the spacer **73** has a function of keeping a gap defined between the controlling plate **30** and the toner conveying roller **1** uniform in the row direction of the orifice row **12A**. Since the spacer **73** and the toner **4** rub against each other, this may cause the spacer **73** to become charged according to the material used to form the spacer **73**, thereby affecting the electric field of printing and the charge amount of the toner **4**. Preferably, the spacer **73** is coupled to a mechanism capable of electric charge elimination and its material is superior in conductivity and wear resistance. More specifically, resins such as polyamide, polyimide, and polyca filled with a conductive filler and metals such as stainless steel and aluminum are especially preferable. Moreover, the spacer **73** may be composed of metal or the like. In this case, any kind of metal can be used as long as it has a rigidity capable of reflecting an oscillatory wave without absorbing an oscillation. For example, the spacer **73** is formed of a metallic plate of stainless steel (preferably coated with diamond like carbon (DLC)) and its plate width and plate thickness are set to about 5 mm and about 0.2 mm, respectively. By the provision of such a spacer **73**, it becomes possible to make the position of the reflection end **32** with respect to each orifice **12** stable and the distance L1 between the reflection end **32** and the orifice **12** can be maintained constant. Further, also the distance between the toner conveying roller **1** and the controlling plate **30** can be maintained constant.

[0158] In addition to the above, as shown in Figure **18**, in order to provide protection against undulation of the controlling plate **30**, the controlling plate **30** may be wound around the toner conveying roller **1**. That is, when the contacting of the toner conveying roller **1** and the controlling plate **30** becomes unsteady because the controlling plate **30** undergoes an undulation, oscillatory wave reflection likewise becomes unsteady. As a result, the amplitude of oscillations around the orifice row **12A** diminishes. Moreover, if the controlling plate **30** undergoes an undulation, this contributes to variations in the landing position of the toner **4** on the recording paper **6**. In order to avoid these drawbacks, the foregoing arrangement of Figure **18,** in which the controlling plate **30** is passed around the toner conveying roller **1,** is preferable. With such arrangement, the contacting portion of the controlling plate **30** and the toner conveying roller **1** is made longer, thereby providing protection against the occurrence of undulation in the controlling plate **30**, and it becomes possible to reflect an oscillatory wave in a steady manner. Further, it is preferable that the contacting length L3, along which the controlling plate **30** and the toner conveying roller **1** are in contact with each other, is not less than about 1/4 of the oscillatory wavelength λ of the controlling plate **30**.

[0159] Further, in order to make the reflection of an oscillatory wave steadier, it is preferable that an oscillation reflecting member **81** be disposed in parallel with the orifice row **12A** and downstream of the reflection end **32** in the direction of oscillation propagation, as shown in Figure **19**. In other words, the oscillation reflecting member **81** and the orifice row **12A** are positioned opposite to each other across the reflection end **32**. Further, the oscillation reflecting member **81** may be disposed on a surface of the controlling plate **30** on the side of the opposing electrode **5**. Like the oscillation reflecting plate **71**, as a material to form the oscillation reflecting member **81**, a material, which has a rigidity capable of transmitting an oscillation without absorbing it and whose oscillation characteristic greatly differs from the impedance of oscillation transmission of the controlling plate **30**, is especially preferable in improving the efficiency of reflection. When resin (e.g., polyimide) is used to form the insulating substrate **14** of the controlling plate **30**, it is preferable to use a metal greatly differing in the value of ρc (i.e., a product of the density ρ and the sound velocity c). Specifically, stainless steel or spring steel is preferable. Further, it is preferable that the plate width and plate thickness be set to 5 mm and to about 0.2 mm, respectively. If the oscillation reflecting member **81** is free from warping and bending, this makes it possible to obtain the effect of providing protection against the occurrence of undulation in the controlling plate **30**, and the effect of reducing landing errors of the toner **4**. Adhesion of the oscillation reflecting member **81** to the controlling plate **30** may be done by thermocompression bonding or by the use of epoxy adhesive or isocyanate adhesive. When the oscillation reflecting member **81** is disposed in the way described above, its reflection end corresponds to a node of the oscillatory wave. As a result, nodes and antinodes of the oscillatory wave are formed in the controlling plate **30** at pitches of 1/4 of the oscillatory wavelength λ. It is therefore preferable that the distance L4 between the oscillation reflecting member **81** and the orifice row **12A** is set to $L4 \approx (2n + 1) \times \lambda/4$ (the number n is an integer) for causing the periphery of the orifice **12** to correspond to an oscillatory wave antinode. In the present embodiment, the wavelength λ is 4 mm, so that the distance L4 is selected from among values of 3 mm, 5 mm, 7 mm, 9 mm, and so on.

[0160] As shown in Figure **20**, an arrangement may be made in which, instead of providing the oscillation reflecting member **81**, holding members **82A** and **82B** for holding the controlling plate **30** are employed and the controlling plate **30** is sandwiched between the holding members **82A** and **82B** to form a reflection end.

[0161] Further, the orifice row **12A** and holding members **82C** and **82D** of the controlling plate **30**, positioned opposite each other across the oscillation transmitting plate **151**, are preferably separated by a distance of not less than $\lambda/2$ with respect to the oscillation transmitting plate **151**. The reason is as follows.

[0162] The ordinate of Figure **21** indicates the amplitude ratio of oscillation in the controlling plate **30** resulting from dividing an amplitude at a position 200 mm away from the oscillation transmitting plate **151** by an amplitude at a position 20 mm away from the oscillation transmitting plate **151**. In other words, the ordinate indicates the oscillation damping. On the other hand, the abscissa of Figure **21** results from division of a distance between the oscillation transmitting plate **151** and the holding members **82C** and **82D** (see L5 of Figure **20**) by the wavelength λ of an oscillatory wave in the controlling plate **30**. In this case, since the frequency of the oscillation source is 40 kHz, the wavelength λ is 4 mm. The amplitude was measured using a laser Doppler system.

[0163] As can be seen from Figure **21**, when the distance between the oscillation transmitting plate **151** and the holding members **82C** and **82D** is small, there is a significant oscillation damping. If the space between the oscillation transmitting plate **151** and the holding members **82C** and **82D** is increased above about λ/2, then the damping of oscillation is reduced because, when the space between the oscillation transmitting plate **151** and the holding members **82C** and **82D** is not greater than the distance at which oscillatory wave nodes and antinodes are formed, the holding members **82C** and **82D** are oscillated by the oscillation of the oscillation transmitting plate **151**. As a result, the oscillatory energy of the oscillation transmitting plate **151** is consumed by the oscillation of the holding members **82C** and **82D.** To cope with this, it is preferable that the space between the oscillation transmitting plate **151** and the holding members **82C** and **82D** is set to a value at which oscillatory wave nodes and antinodes are formed and that the oscillation transmitting plate **151** and the holding members **82C** and **82D** are so arranged as to be separated from each other by a distance of not less than λ/2.

PREFERRED EMBODIMENTS FOR UNIFORM OSCILLATION IN ORIFICE ROW DIRECTION

[0164] Next, preferred embodiments for causing each orifice 12 to be oscillated uniformly in the direction of the orifice row **12A** will be described below.

(EMBODIMENT 1)

[0165] As shown in Figure **22**, disposed on the controlling plate **30** is an oscillation generating body **167** which extends parallel with the row direction of the orifice rows **12A** (i.e., the X direction of Figure **22**) which is hereinafter referred to also as the row direction. Only one of the orifice rows **12A** is shown in Figure **22.** The oscillation generating body **167** is formed into a bar-like shape or into a plate-like shape and is fixedly adhered to the controlling plate **30**. Such adhesion may be implemented by thermocompression bonding. The oscillation generating body **167** is operable to generate a wave capable of causing the controlling plate **30** to undergo flexure and deformation, such as a transversal wave. In the present embodiment, the oscillation generating body **167** is implemented by a unimorph or bimorph formed by lamination of an oscillating plate **167b** and an oscillator **167a**. The oscillating plate **167b** extends parallel with the row direction of the orifice row **12A** and is adhered to the surface of the controlling plate **30**. The oscillator **167a** extends parallel with the row direction of the orifice row **12A** so that it is superimposed with the oscillating plate **167b** and is adhered to the surface of the oscillating plate **167b**. The length of the oscillator **167a** and that of the oscillating plate **167b** in the direction orthogonal to the orifice row **12A** are identical with each other. As the oscillating plate **167b,** for example, a plate of stainless steel having a plate width of about 5 mm and a plate thickness of about 0.3 mm can preferably be used. On the other hand, as the oscillator **167a**, for example, a piezoelectric element (PZT) can preferably be used.

[0166] Further, a rigid bar **167c** extending in the row direction is adhered to the surface of the oscillator **167a** as a regulating body by which the expansion and contraction of the oscillator **167a** in the row direction is regulated. As the rigid bar **167c**, a material with a high Young's modulus, such as stainless steel, can preferably be used. This suppresses the flexure of the controlling plate **30** in the row direction, as a result of which plane waves of the same phase (i.e., whose phases are aligned in the row direction) are applied to the respective orifices **12** of the orifice row **12A**.

[0167] That is, as shown in Figure **23**, owing to expansion and contraction of the oscillator **167a** in the Y direction, i.e., expansion and contraction in the direction indicated by an arrow A, the oscillation generating body **167** deflects in the direction indicated by an arrow B (i. e., in the Z direction orthogonal to the X and Y directions) because of the difference in rigidity between the oscillator **167a** and the oscillating plate **167b**. However, since flexure in the row direction is regulated by the rigid bar **167c**, the amounts of flexure in the B direction become equal in any cross section in the row direction. Therefore, by causing the oscillator **167a** to be expanded and contracted periodically, the controlling plate **30** is repeatedly subjected to periodical flexure/deformation, as a result of which it becomes possible to generate oscillations of the same phase at any point in the row direction.

[0168] Also in such a case, if the oscillating frequency is excessively high, it becomes impossible to ignore a liberation of heat in a surface where the controlling plate **30** and the oscillation generating body **167** are adhered together and the degree of oscillation dumping increases. A sine wave of not more than a frequency of 1 MHz (e.g., 20 kHz) is preferable for the oscillation of the oscillation generating body **167**.

[0169] Further, it is possible that plane waves of the same phase in the row direction (the X direction) propagate from the oscillation generating body **167** in the Y direction orthogonal to the row direction to the controlling plate **30**, thereby making it possible to cause each orifice **12, 12**, ... to be oscillated uniformly. This therefore prevents or cancels the clogging of each orifice **12, 12**, ... in a uniform manner.

(EMBODIMENT 2)

[0170] Referring to Figure **24**, there is shown the controlling plate **30** according to the second embodiment in which an oscillation transmitting plate **155**, which is formed into a bar-like shape or into a plate-like shape, is fixedly adhered to the controlling plate **30**, extending parallel with the orifice row **12A**.

[0171] Mounted at one end of the oscillation transmitting plate **155** is the oscillation generating body **60** having the oscillator **16** and the horn **17**. On the other hand, an oscillation absorbing body **64** is disposed at the other end of the oscillation transmitting plate **155** so that wave motion departed from the oscillator **16** is absorbed for providing protection against reflection of an oscillatory wave.

[0172] As the oscillation absorbing body **64**, for example, silicon rubber can preferably be used. However, the oscillation absorbing body **64** may be in the form of a fluid or may be formed using a piezoelectric element.

[0173] Since it is long and narrow in the row direction, the oscillation transmitting plate **155** is flexible in the row direction. Accordingly, the oscillation of the oscillation generating body **60** becomes a transverse wave, propagating through the oscillation transmitting plate **155**. However, since the transverse wave is absorbed by the oscillation absorbing body **64** at the other end of the oscillation transmitting plate **155**, there is generated no reflected wave from the other end. As a result, only a progressive wave in one direction is formed on the oscillation transmitting plate **155**, so that there is generated no standing wave along the row direction on the orifice row **12A**. This therefore makes it possible to cause each orifice **12, 12,** ... to oscillated uniformly, thereby preventing or canceling the clogging of each orifice **12, 12**, ... in a uniform manner.

[0174] The oscillation absorbing body **64** may be formed of a combination of oscillation absorbing plates **64a** and **64b** and rigid body plates **64c** and **64d**, as shown in Figure **25**. It is possible to obtain sufficient oscillation damping by interposing the oscillation absorbing plates **64a** and **64b** between the rigid body plates **64c** and **64d** so that the oscillation absorbing plates **64a** and **64b** are closely adhered to the oscillation transmitting plate **155**. Moreover, if the rigid body plates **64c** and **64d** are formed of a material having a sufficient heat transfer rate such as aluminum, this makes it possible to readily release heat, generated from the oscillation absorbing plates **64a** and **64b** in the course of absorbing an oscillation, to the outside. Further, as shown in Figure **25(c)**, in order to enhance the releasing of heat, a heat releasing fin **64e** may be disposed in the rigid body plate **64c**. Further, in order to promote the transmission of an oscillation from the oscillation transmitting plate **155** to the oscillation absorbing plates **64a** and **64b**, for example, silicon grease may be applied between the oscillation absorbing plates **64a** and **64b** and the oscillation transmitting plate **155**. Furthermore, the rigid body plates **64c** and **64d** may be tightened with screws for application of an appropriate pressure to the oscillation absorbing plates **64a** and **64b**. In order to promote the transfer of heat from the oscillation absorbing plates **64a** and **64b** to the rigid body plates **64c** and **64d**, for example, silicon grease may be applied between the oscillation absorbing plates **64a** and **64b** and the rigid body plates **64c** and **64d**. It is preferable that the length of the section of damping of the oscillation transmitting plate **155** by the oscillation absorbing body **64** be at least the half-wavelength of a flexual wave on the oscillation transmitting plate **155**, more preferably, not less than the quadri-wavelength of a flexual wave.

[0175] Further, as the oscillation absorbing plates **64a** and **64b**, any material may be used as long as it exhibits a viscoelasticity sufficient enough to damp oscillations. For example, butyl rubber and silicon rubber can preferably be used to form the oscillation absorbing plates **64a** and **64b**. Moreover, the paired oscillation absorbing plates **64a** and **64b** may be formed of the same material, but they may be formed of different materials. More specifically, ferrite rubber with a rubber hardness of 80 degrees according to JIS-K6301 A-scale (formed by adding powders of ferrite to butyl rubber), and silicon rubber with a rubber hardness of 10 degrees according to JIS-K6301 A-scale may be used for forming the oscillation absorbing plates **64a** and **64b**, respectively. The following effects will be obtained if the oscillation absorbing plates **64a** and **64b** are composed of different materials as described above.

[0176] That is, a transverse wave in the oscillation transmitting plate **155** is transmitted through the controlling plate **30** to components having various natural frequencies and their reflected waves are brought back to the oscillation transmitting plate **155**. Accordingly, the oscillation absorbing body **64** is required to absorb not only a single-frequency oscillation from the oscillation generating body **60** but also oscillations of other frequencies. For example, the damping coefficient of rubber varies with the frequency according to its molecular structure and composition. Therefore, if the oscillation absorbing plates **64a** and **64b** are formed of plural types of viscoelastic bodies, this makes it possible to damp oscillations of various frequencies which are input to the oscillation absorbing body **64**. Further, if the paired oscillation absorbing plates **64a** and **64b** are both formed of rubber hardened by addition of a metallic filler or the like thereto, their weight increases. As a result, the damping coefficient increases, thereby making it possible to effectively damp oscillations. However, since hard rubber is high also in spring constant, an input oscillatory wave is readily reflected. To cope with this, if the paired oscillation absorbing plates **64a** and **64b** are formed of soft rubber and hard rubber, respectively, this makes it possible to prevent reflection of an oscillatory wave by the soft rubber whereas oscillations are damped by the hard rubber.

[0177] The arrangement that the oscillation absorbing body **64** is formed of a plurality of dampers is applicable to an oscillation absorbing body using a fluid as well as to an oscillation absorbing body using a piezoelectric element, in addition to an oscillation absorbing body using rubber.

(EMBODIMENT 3)

[0178] Referring to Figure **26**, there is shown the controlling plate **30** according to the third embodiment in which the oscillation transmitting plate **155** is disposed in parallel with the orifice row **12A** and the oscillation generating body **60** having the oscillator **16** and the horn **17** is positioned at one end of the oscillation transmitting plate **155**.

[0179] Further, provided at the other end of the oscillation transmitting plate **155** is a clamp mechanism **65** as an oscillation condition changing means for changing the dynamic and geometric conditions of an oscillation. During excitation by the oscillator **16**, the oscillation transmitting plate **155** is caught in the clamp mechanism **65**, and the point, at which a flexual wave is reflected, is shifted by appropriately changing the clamp position along the longitudinal direction of the oscillation transmitting plate **155**. The clamp mechanism **65** is so arranged as to be movable in a free manner along the longitudinal direction of the oscillation transmitting plate **155**, i.e., along the row direction of the orifice row **12A**. As the material to form clamp portions **65a** and **65b** of the clamp mechanism **65**, a material having a rigidity capable of positively reflecting a flexual wave and a viscoelasticity capable of suppressing generation of abnormal sounds at clamp time. For instance, aluminum coated with vinyl can preferably be used. The clamp portions **65a** and **65b**, shown in Figure **26**, each have a pointed end. However, the clamp mechanism **65** may be formed into any shape as long as the oscillation transmitting plate **155** is supported positively. Shapes containing flat and curved surfaces are, of course, applicable.

[0180] Next, the operation of applying an oscillation to the controlling plate **30** will be described below.

[0181] When a voltage is applied to the oscillator **16**, the oscillation of the oscillator **16** is transmitted, through the horn **17** and the oscillation transmitting plate **155**, to the controlling plate **30**.

[0182] A flexual wave on the oscillation transmitting plate **155** departs from its one end at which the oscillation generating body **60** is disposed and is reflected at the other end at which the clamp mechanism **65** is positioned. At this time, superimposition of an incident wave and a reflected wave gives rise to a standing wave. The position of nodes of the standing wave differs depending upon the reflection condition of an extreme point, upon the length and thickness of the oscillation transmitting plate **155,** or upon the oscillating frequency. Therefore, during excitation, the clamp position of the oscillation transmitting plate **155** is changed by the clamp mechanism **65** so that at least one of the extreme point reflection condition and the oscillating length of the oscillation transmitting plate **155** is changed. Because of such arrangement, the positions of antinodes and nodes of the standing wave are made to vary appropriately, and it is possible to cause an oscillating wave in the oscillation transmitting plate **155** to become a non-standing wave. This therefore causes each orifice **12, 12**, ... to be oscillated uniformly, thereby preventing or canceling the clogging of each orifice **12, 12**, ... in a uniform manner. When excitation is carried out by a resonance system, there are changes in natural frequency with changes in oscillation condition. To cope with this, for example, an arrangement may be made in which a matching circuit (not shown) is inserted in a driving circuit (not shown) of the oscillator **16** for the following of a natural frequency to perform control according to the natural frequency .

(EMBODIMENT 4)

[0183] Referring to Figure **27**, there is shown the controlling plate **30** according to the fourth embodiment in which an auxiliary exciting unit **66** is provided at the other end of the oscillation transmitting plate **155**. The auxiliary exciting unit **66** is required just to disturb an oscillation from the oscillator **16**. For example, the auxiliary exciting unit **66** may be implemented by a bimorph of PZT plates **66a** and **66b** as shown in Figure **28**. In order to provide protection against destruction of the PZT plates **66a** and **66b** by self distortion at oscillation time, these PZT plates **66a** and **66b** may be sandwiched between the rigid body plates **66c** and **66d**. The reference numeral **66e** denotes a power supply for applying a voltage to the PZT plates **66a** and **66b.** As the material to form the rigid body plates **66c** and **66d**, any material serving as a sufficient load with respect to the PZT plates **66a** and **66b** may be used. For example, aluminum can preferably be used. An arrangement may be made in which the rigid body plates **66c** and **66d** are further tightened with a clamping means such as screws so as to apply an appropriate load to the PZT plates **66a** and **66b**.

[0184] Next, the operation of applying an oscillation to the controlling plate **30** will be described below.

[0185] When a voltage is applied to the oscillator **16,** a flexual wave on the oscillation transmitting plate **155** departs from one end thereof at which the oscillation generating body **60** is disposed and is reflected at the other end at which the auxiliary excitation unit **66** is positioned and, at this time, superimposition of an incident wave and a reflected wave gives rise to a standing wave. However, since an extremely small oscillation is applied by the auxiliary exciting unit **66**, this disturbs an oscillation from the oscillator **16**, thereby causing antinodes and nodes of the standing wave to appropriately shift without remaining at the same point. This therefore causes each orifice **12, 12**, ... to be oscillated uniformly, thereby preventing or canceling the clogging of each orifice **12, 12**, ... in a uniform manner.

[0186] In order to achieve the effect of disturbing an oscillation with the auxiliary exciting unit **66** with efficiency, it is preferable that the frequency of the oscillator **16** does not closely resemble that of the auxiliary exciting unit **66**. For example, by a setting that the frequency of the oscillator **16** is about 40 kHz and that of the auxiliary exciting unit **66** is about 55 kHz, it becomes possible to provide effective protection against generation of a standing wave.

[0187] As described above, if a non-standing wave is propagated parallel with the orifice row **12A** and, on the other hand, a standing wave is formed in a direction orthogonal to the orifice row **12A** as described in the part labeled "PREFERRED EMBODIMENTS FOR CAUSING ORIFICE PERIPHERY TO BE OSCILLATED AT LARGE AMPLITUDE", this makes it possible to cause the periphery of the orifice to be oscillated uniformly in the direction of the orifice row **12A** and at larger amplitudes.

PREFERRED EMBODIMENTS FOR SUPPRESSING OSCILLATION DAMPING

[0188] Next, preferred embodiments for suppressing the damping of oscillation will be described below.

(EMBODIMENT 1)

[0189] Referring to Figure **29**, there is shown an oscillation transmitting plate **156** according to the first embodiment. Formed at one end **41** of the oscillation transmitting plate **156** (shown on the left-hand side of the figure) is a U-shaped portion to which the horn **17** of the oscillation generating body **60** is fixed with screws, and the oscillation absorbing body **64** is fixed to the other end **42** (shown on the right-hand side of the figure). Further, instead of the provision of the oscillation absorbing body **64** at the other end **42**, an arrangement may be made in which a U-shaped portion similar to the one formed in the one end **41** is formed at the other end **42** and the U-shaped portion is fixed to a frame (not shown) which does not oscillate. The oscillation transmitting plate **156** is adhered, substantially at its mid section, to the controlling plate **30,** wherein the width of the adhesion portion is tapered, becoming thinner toward the right-hand side. In other words, the width of the oscillation transmitting plate **156** becomes narrower from the one end **41** toward the other end **42**. Such tapering suppresses the damping of oscillation in the oscillation propagation direction in the oscillation transmitting plate **156**. That is, when the one end **41** of the oscillation transmitting plate **156** is oscillated, an oscillation propagates on the oscillation transmitting plate **156** while at the same time oscillatory energy is absorbed. This results in a decrease in oscillation amplitude at the other end **42**. However, if the rigidity of the oscillation transmitting plate **156** is made to become smaller in the direction away from the oscillation generating body **60**, this results in an increase in amplitude of an oscillation energy even when it is small. Because of this, the damping of oscillation in the oscillation propagation direction in the oscillation transmitting plate **156** is suppressed, which makes it possible to cause even the periphery of the orifice **12**, the position of which is remotest from the oscillation generating body **60**, to be oscillated sufficiently.

[0190] In order to obtain the same effects as the above, the plate thickness of the oscillation transmitting plate **156** may be made to become thinner from the one end **41** toward the other end **42**. However, reducing the plate width is much preferable because it achieves considerable cost reduction in view of control of the etching time when employing techniques such as etching. That is, since the effect of the oscillation transmitting plate **156** can be obtained just by making its width smaller, this provides an easy manufacture and cost reduction. Further, it is preferable that the plate thickness of the oscillating plate ranges between about 0.2 mm and about 1 mm. The use of such a plate thickness range facilitates mounting of the oscillating plate in a narrow space.

(EMBODIMENT 2)

[0191] Referring to Figure **30**, there is shown the controlling plate **30** according to the second embodiment. In the second embodiment, a lateral face of an oscillation transmitting plate **157** on the side of the orifice **12** in an adhesion portion of the oscillation transmitting plate **157** and the controlling plate **30**, has a wavy shape **61.** The wave pitch of the wavy shape **61** is set to a value of about half the oscillation wavelength when an oscillation propagates on the oscillation transmitting plate **157**. Further, the wave level difference of the wavy shape **61**, i.e., the distance between a convex portion (a top portion) and a concave portion (a bottom portion) of a wave of the wavy shape **16**, is set to a value about a quarter of the wavelength of an oscillation propagating on the controlling plate **30**. By employing such a wave shape, the distance between the wave concave portion and the orifice **12** is made longer than that between the wave convex portion and the orifice **12** by a length of about a quarter of the wavelength of an oscillation propagating on the controlling plate **30**. Because of this, if the wave concave and convex portions corresponds to an antinode and to a node of the oscillation on the oscillation transmitting plate **157**, respectively, this causes an oscillation-propagation deviation of 90 degrees between the wave concave portion and the wave convex portion in the orifice's **12** portion. Accordingly, the node and antinode of the oscillation become sluggish in the vicinity of the orifice **12**, thereby making it possible to perform uniform cleaning in the row direction of the orifice row **12A**.

[0192] It is preferable that the oscillation transmitting plate **157** is prepared using stainless steel and its thickness is 0.2 mm.

[0193] Further, an arrangement, in which the plate width of the oscillation transmitting plate **157** becomes gradually narrower from one end thereof toward the other end, is further preferable because the damping of amplitude can be suppressed.

(EMBODIMENT 3)

[0194] Further, as shown in Figures **31(a)** and **(b)**, an arrangement may be made in which an electrode pattern **11B** is formed using the same material that the image signal electrode **11** is formed (e.g., copper) so that its width becomes gradually narrower along the orifice row 12A for variations in the oscillation characteristic. In other words, the electrode pattern **11B** whose width becomes gradually narrower from one end (the left-hand side end in Figure **31**) toward the other end (the right-hand side end in Figure **31**) may be so formed as to extend substantially parallel with the orifice row **12A** and an oscillation transmitting plate **158** of stainless steel or the like is fixed on the side of the one end . As a result of such arrangement, the damping of an oscillation propagating from the one end side to the other end side is suppressed based on the characteristics of the controlling plate **30** itself. There is no need for the oscillation transmitting plate to extend from the one end toward the other end.

(EMBODIMENT 4)

[0195] Referring to Figure **32**, there is shown an oscillation transmitting plate **159** according to the fourth embodiment.

[0196] Of the ends of the oscillation transmitting plate **159**, one end **43** (shown on the left-hand side of the figure) serves as an oscillation generating part to which the horn **17** of the oscillation generating body **60** is fixed and the other end **44** (shown on the right-hand side of the figure) serves as an oscillation absorbing part to which the oscillation absorbing body **64** is fixed. The oscillation transmitting plate **159** is adhered, at its mid section, to the controlling plate **30**. The plate width at the mid section is made smaller than the plate width at the one end **43** serving as an oscillation generating part. Such a reduction in plate width results in the drop in rigidity. Therefore, an oscillation by the oscillation generating body **60** is amplified at the mid section. As a result, it is possible to apply to the controlling plate **30** an oscillation at larger amplitudes.

[0197] Further, the mid section of the oscillation transmitting plate **159** becomes smaller in plate thickness from the one end **43** towards the other end **44**. Because of such tapering, the damping of oscillation in the oscillation transmitting plate **159** is suppressed. In order to obtain the same effects, the plate thickness of the oscillation transmitting plate **159** may be made to become thinner from the one end **43** toward the other end **44**.

[0198] On the other hand, the plate width of the other end **44** serving as an oscillation absorbing part of the oscillation transmitting plate **159** expands beyond that of the mid section thereof. By such improvement in the rigidity, the oscillation amplitude of the other end **44** becomes smaller than that of the mid section, thereby facilitating absorption of oscillatory energy in the oscillation absorbing body **64**. The same effects as above can be obtained by making the plate thickness of the other end **44** thicker than that of the mid section. However, increasing the plate width provides a greater area of contact between the oscillation absorbing body **64** and the oscillation transmitting plate **159**, resulting in a reduction in oscillatory energy per unit area. This further facilitates energy absorption in the oscillation absorbing body **64**. With the oscillation transmitting plate **159** having such a form, it becomes possible to apply oscillations of the same amplitude along the orifice row **12A**, thereby achieving uniform cleaning.

[0199] It may be arranged such that tension is made to act on the oscillation transmitting plates **151** to **159** in their longitudinal direction. Such tension application provides protection against warp of the oscillation transmitting plate **159**, thereby positively causing an oscillation to be propagated to the controlling plate **30**. In order to cause tension to act on the oscillation transmitting plates **151** to **159**, the following may be taken. That is, for example, with one end of the oscillation transmitting plate caught between the clamp members, the clamp members are pulled outwardly in the longitudinal direction of the oscillation transmitting plate.

PREFERRED EMBODIMENTS SUITABLE FOR PROTECTION AGAINST CONTAMINATION BY REMOVED TONER

[0200] Next, preferred embodiments for providing protection against contamination of an already-formed image by toner particles removed by oscillation application will be described below.

(EMBODIMENT 1)

[0201] An image forming device according to the first embodiment has the same basic configuration as the one shown in Figure **1** and its description is therefore omitted. The image forming device of the first embodiment has a controlling means (not shown) for cleaning of the print head **10**. If a voltage of - 100 V is applied to the image signal electrode **11**, in other words if no image formation is being carried out, the controlling means receives a cleaning signal and sends to a roller driving means (not shown) a rotation stop signal to stop the rotation of the toner conveying roller **1** and, at the same time, sends to an oscillation driving circuit (not shown) a driving signal, and further sends to a voltage switching means (not shown) a switch signal so that the opposing electrode **5** is placed in the grounded state.

[0202] Next, the cleaning operation of the image forming device will be described below.

[0203] In the period that the operation of forming an image is brought into a halt, i.e., in the period that no image formation is being carried out (for example, immediately after the power is applied to the device or in the period from the time that a recording paper sheet is fed to the time that another recording paper is conveyed when a plurality of the recording paper **6** are conveyed at continuous image forming time), the oscillator **16** is operated to perform the following cleaning operations.

[0204] That is, the rotation of the toner conveying roller **1** is brought into a stop and an oscillation voltage is applied to the oscillator **16** to cause it to start oscillating. This applies an oscillation to around the orifice **12** of the print head **10** through the oscillation transmitting plate **151.**

[0205] Of the toner that is built up around the orifice **12**, there is not only the presence of toner particles of forward polarity but also the presence of toner particles of reverse polarity. If an oscillation is given to the opposing electrode **5** with its polarity remaining the same as the time of image formation, this causes a force of attraction to act on the reverse-polarity toner adhering to around the orifice **12.** As a result, the toner particles are drawn from the opposing electrode **5** toward the print head **10**. Therefore, even when the reverse polarity toner is once forced into flight toward the opposing electrode **5** by oscillation, it is again forced into adverse flight toward the print head **10** by the action of an electric field and spreads beyond around the orifice **12**, resulting in rather contaminating the print head **10** in some case. Moreover, when operated with the print head **10** and the toner conveying roller **1** brought into contact with each other or into extremely close proximity to each other, toner is forced out from the toner conveying roller **1** by a stream of air caused by oscillation application. Also in this case, of the forced out toner, there is the presence of toner particles of forward polarity in addition to the presence of toner particles of reverse polarity, so that if a voltage of either forward polarity or reverse polarity is applied to the opposing electrode **5**, this forces either one of the toner particles of forward polarity or the toner particles of reverse polarity into adverse flight toward the print head **10**. This may contaminate the print head **10**.

[0206] However, at the time when an oscillation is applied, the opposing electrode **5** is so switched as to enter the grounded state. Therefore, the toner conveying roller **1** and the opposing electrode **5** are identical in electric potential with each other, so that no electric field works on the toner **4** and contaminants. This positively forces the toner **4** to be flown toward the opposing electrode **5**. Further, at the time when an oscillation is applied, the rotation of the toner conveying roller **1** is brought into a halt, so that after an elapse of a certain period of time from the application of the oscillation, the toner **4** will not be forced out from the toner conveying roller **1**.

[0207] For example, an arrangement (not shown) may be made in which a power supply for applying a voltage to the toner conveying roller **1** and a switch for switching the toner conveying roller **1** between the voltage applied state and the grounded state are provided. When no image formation is being performed, a voltage is applied to the toner conveying roller **1** so that the relationship in electric potential size between the toner conveying roller **1** and the image signal electrode **11** is reversed with respect to the potential size relationship at the time when forming an image. In this case, at the time of applying an oscillation, it is possible to actively force the toner **4** present between the toner conveying roller **1** and the controlling plate **30** into flight toward the toner conveying roller **1**, thereby making it possible to achieve effective cleaning of the print head **10**. In addition to the above, it becomes possible to provide protection against discharge of the toner from the toner conveying roller **1** by a stream of air caused by oscillation application.

(EMBODIMENT 2)

[0208] Referring to Figure **33**, there is shown an image forming device according to the second embodiment. Its basic configuration and others are the same as the image forming device shown in Figure **1** and only differences therebetween will be described below.

[0209] That is, the opposing electrode **5** is a roller type and is so configured as to be rotatably driven by a driving means such as a motor (not shown). A cleaning blade **23A** is brought into contact with the opposing electrode **5** at a side thereof opposite to the print head **10**. Disposed beneath the opposing electrode **5** is a toner collecting container **23B**. A controlling means for cleaning (not shown) receives a cleaning signal and sends to a roller driving means (not shown) a rotation stop signal for stopping the rotation of the toner conveying roller **1** while at the same time sending a driving signal to an oscillation driving circuit (not shown), a switch signal to a voltage switching means **29** so that the opposing electrode **5** is placed in the grounded state, and a rotation driving signal to an opposing electrode driving means (not shown).

[0210] During image formation, the opposing electrode **5** stops rotating, being at rest. The opposing electrode **5** starts rotating when the print head **10** is cleaned. In the present embodiment, the opposing electrode **5** rotates counterclockwise. By virtue of the working of the oscillator **16**, the toner **4** adhering to around the orifice **12** is forced out toward the opposing electrode **5**. The voltage of the opposing electrode **5** at that time is switched from the image forming time voltage (+ 1000 V) and is connected to ground like the toner conveying roller **1**. The toner **4** and contaminants, which have been emitted toward the opposing electrode **5**, are collected in the toner collecting container **23B** by the cleaning blade **23A** when the opposing electrode **5** rotates.

[0211] The toner **4** emitted toward the opposing electrode **5** is collected in the way as described above, thereby providing protection against adverse flight of the toner **4** from the opposing electrode **5** toward the print head **10**. The print head **10** is prevented from being contaminated by the adversely-flown toner.

(EMBODIMENT 3)

[0212] Referring to Figure **34**, there is shown an image forming device according to the third embodiment. Its basic configuration and others are the same as the image forming device shown in Figure **33** and only differences therebetween will be described below.

[0213] Connected to the rotatable opposing electrode **5** is a voltage switching means **291** which allows the opposing electrode **5** to be switched between the state of being connected to a dc power supply **9**, the state of being connected to ground, and the state of being connected to an ac power supply **31B**. The frequency and the voltage of the ac power supply **31B** are 4 kHz and 1.5 kV (Vpp), respectively. A controlling means for cleaning (not shown) receives a cleaning signal and sends to a roller driving means (not shown) a rotation stop signal for stopping the rotation of the toner conveying roller **1** while at the same time sending a driving signal to an oscillation driving circuit (not shown), a switching signal to the voltage switching means **291** so that the opposing electrode **5** is placed in the grounded state in the first half (first stage) of an oscillation application operation and then in the state in which an ac voltage is applied to the opposing electrode **5** in the second half of the oscillation application operation, and a rotation driving signal to an opposing electrode driving means (not shown).

[0214] Accordingly, at the time of cleaning the print head **10**, the opposing electrode **5** is switched from the image forming voltage state (i.e., + 1000 V) to the grounded state (i.e., 0 V); however, after an elapse of a specified period of time from the start of the cleaning, the opposing electrode 5 is switched to the ac power supply **31B.**

[0215] Since application of an oscillation is carried out when the operation of the toner conveying roller **1** is at rest, this provides protection against emission of toner from the toner conveying roller **1** in the second half of the oscillation application operation. At this time, the opposing electrode **5** is switched to the ac power supply **31B** so that an alternating voltage is applied to the opposing electrode **5**. The resulting alternating electric field will work only on removal of toner remaining around the orifice. The alternating electric field and oscillation together force toner of forward polarity as well as toner of reverse polarity into flight from the print head **10** toward the opposing electrode **5** for achieving cleaning. As has been describe above, cleaning is carried out with the aid of electric field force, which makes it possible to remove toner particles and contaminants even with small oscillation acceleration. Since the opposing electrode **5** is shifted, the toner flown onto the opposing electrode **5** is collected in the collection container **23B** by the cleaning blade **23A**. This accordingly provides protection against adverse flight of the toner from the opposing electrode **5** toward the print head **10**.

[0216] That is, an ac voltage is applied to the opposing electrode **5** in the second half of the oscillation application operation, which allows a cleaning electric field force to work between the opposing electrode **5** and the print head **10**. As a result, it is possible to remove strongly adhered toner. Further, if such a cleaning electric field force is enhanced, this makes it possible to reduce oscillatory energy to be applied, providing the advantage of avoiding the occurrence of troubles such as the destruction of the print head **10**.

(EMBODIMENT 4)

[0217] Referring to Figure **35**, there is shown an image forming device according to the fourth embodiment. This is an example when the present invention is applied to a multicolor image forming device. The present image forming device comprises four image forming units for colors of yellow, magenta, cyan, and black, each image forming units including a head unit **25** having components such as the toner conveying roller **1** and the supplying roller **3**, the print head **10** having the oscillation transmitting plate **151** and the oscillation generating body **60**, and the opposing electrode **5.** These four image forming units are arranged in a single row and a conveyor belt **20** is positioned between the print head **10** and the opposing electrode **5** of each image forming unit so that the carrier side of the endless belt travels in the row direction. The conveyor belt **20** travels in the direction indicated by an arrow in the figure by the rotation of a driving roller **21A**. The conveyor belt **20** is a conductive seamless belt formed by filling a resin such as polyimide, polycarbonate, and polyethylene with a conductive filler. In the present embodiment, the conveyor belt **20** is formed of polyimide.

[0218] In the present embodiment, the recording paper **6** is fed to the conveyor belt **20** by a paper feeding roller **7.** In a paper adsorbing brush **20A** connected to ground, static charge is applied to the conveyor belt **20** and the recording paper **6** is statically adsorbed onto a surface of the conveyor belt **20** facing the print head **10**. The recording paper **6** is conveyed as the conveyor belt **20** travels and the four colors are image-formed one after another. A toner image, which has been image-formed on the recording paper **6**, is heated, pressurized, and fixed on the recording paper **6** in the fixing roller **8**.

[0219] Driving of the oscillation generating bodies **60** is carried out as follows. That is, only the oscillation generating body **60** of the image forming unit for the color in the image forming operation stop timing, is driven. Accordingly, only one driving circuit **31** is provided for the four oscillation generating bodies **60** and they are selectively driven in color order by a changeover switch **33**. The voltage of the opposing electrodes **5** is also switched in synchronization with the operation timing of the oscillation generating bodies **60**. Such switching is made also by the changeover switch **291**. Accordingly, the one dc power supply **9** and the one ac power supply **31B** are shared between each image forming unit.

[0220] In the way described above, the oscillation driving circuit **31**, the high voltage power supply **9**, and the ac power supply 31B are shared between each image forming unit, which contributes to preventing device costs from increasing beyond allowable limits even for the case of multicolor image forming devices.

[0221] If the oscillation generating bodies **60** of the image forming units are in disagreement in their natural frequency with each other, this causes the oscillation generating body **60** to vary in their amplitude. Accordingly, it is preferable to control the natural frequency of the oscillation generating bodies **60** and to perform design so that the natural frequency band Q of the oscillator **16** becomes narrow. In other words, it is preferable that the natural frequency band Q of the oscillator **16** be made narrow for accelerating the start of the oscillator **16**. In the present embodiment, the natural frequency band Q is about 1000 and the oscillation frequency is 40 kHz. In this case, the start rate of the oscillator **16** is 1000/40000 = 25 ms. In this case, the experiment result proves that if the amplitude around the orifice row **12A** is 10 μm, then the time necessary for cleaning is 50 ms. On the other hand, the oscillation generating body **60** is driven when no image formation is being carried out, so that a period of drivable time is found by dividing the distance between each image forming unit by the traveling velocity of the recording paper **6**. For example, if the distance between each image forming unit is 50 mm and the traveling velocity of the recording paper **6** is 100 mm/s, then the drivable time is 500 ms which is much longer than the time necessary for completing a cleaning operation (50 ms). Accordingly, if the natural frequency band Q is set narrow, this makes it possible to employ the common driving circuit **31**.

[0222] Further, it is preferable that the driving circuit **31** for the oscillation generating bodies **60** be implemented by a frequency auto-following circuit so that variations in natural frequency can be absorbed on the circuit side.

[0223] If the voltage switching means **291**, such as a switch and a relay, is used for controlling the voltage of the opposing electrodes **5,** the two power supplies **9** and **31B** for image formation and cleaning suffice. When using a relay, due to the switching of a high voltage, there occurs noise at the time of such switching. This may cause the malfunction of peripheral circuits. In this case, it is preferable that a filter such as ferrite is placed at the high voltage output side for cutting off the noise.

PREFERRED EMBODIMENTS FOR PROTECTION AGAINST CONTAMINATION OF TRANSFER MECHANISM BY REMOVED TONER

[0224] Next, preferred embodiments for providing protection against contamination of a transfer mechanism or the like by toner particles removed from the print head will be described below.

(EMBODIMENT 1)

[0225] Referring to Figure **36**, there is shown an arrangement of an image forming device according to the first embodiment. In the image forming device of the first embodiment, the toner **4** is adhered onto the conveyor belt **20** for formation of an intermediate image. Thereafter, the intermediate image is transferred onto the recording paper **6**. The basic configuration and others of the image forming device of the first embodiment are the same as the image forming device shown in Figure **1** and only differences therebetween will be explained below.

[0226] The conveyor belt **20** is formed by an endless type belt and wound around the roller-like opposing electrode **5** and around a backup roller **21.** For the convey belt **20** to be conveyed continuously, at least one of the opposing electrode **5** and the backup roller **21** is formed as a driving roller. The opposing electrode **5** and the backup roller **21** together form a conveying means for conveying the conveyor belt **20.** The conveyor belt **20** may be formed of conductive carbon-scattered polycarbonate, having a thickness of about 150 μm. Further, its peripheral length may be set to about 340 mm for recording paper according to the JIS A4 standard.

[0227] A transfer mechanism **40** includes the backup roller **21** and a transfer roller **22** capable of approaching to and moving away from the backup roller **21**. In other words, the transfer mechanism **40** applies, at operation time (at transfer time), a voltage of a specified level to the transfer roller **22** and, at the same time, causes the transfer roller **22** to approach the backup roller **21** so that the conveyor belt **20** and the recording paper **6** are caught between the transfer roller **22** and the backup roller **21**, and the intermediate image on the conveyor belt **20** is transferred onto the recording paper **6.** The applied voltage to the transfer roller **22** depends upon various characteristics such as the amount of charge of a toner that is used, the humidity of environment, and the like. Preferably, the applied voltage to the transfer roller **22** is the 600-1500 V range. In the present embodiment, the applied voltage is 1000 V. On the other hand, at non-operation time (at non-transfer time), the transfer roller **22** is connected to ground and forced to move away from the backup roller **21**.

[0228] The transfer roller **22** is formed preferably of a metallic roller which is coated, for about 2-6 mm, with conductive filler-scattered foamed urethane. Preferably, the rubber hardness of the foamed urethane on the surface of the transfer roller **22** ranges between 30 degrees and 60 degrees. Pressing force of the transfer roller **22** against the backup roller **21** is preferably from about 50 N to about 200 N and such pressing starts before the recording paper **6** is inserted and conveyed between the transfer roller **22** and the backup roller **21**.

[0229] The recording paper **6**, onto which the intermediate image has been transferred, is conveyed by the rotation of the backup roller **21** to the fixing roller **8** serving as a fixing means. Thereafter, the image on the recording paper 6 is fixed by the fixing roller **8.**

[0230] After the recording paper **6** has passed through the transfer mechanism **40**, the transfer roller **22** is moved away from the backup roller **21** by a mechanism **22A** capable of causing the transfer roller **22** to approach and move away from the backup roller **21**. In the present embodiment, the paper feed rate is 65 mm/s. Residual toner left on the conveyor belt **20** after transfer by the operation of the transfer roller **22** is removed by the cleaning blade **23A** of the conveyor belt cleaning unit **23** and collected in the toner collecting container **23B**. Here, the cleaning blade **23A** is formed of urethane rubber, having a thickness of 3 mm. Other than urethane rubber, the cleaning blade **23A** may be formed of rubber such as silicon rubber and butyl rubber, resin such as polyester resin and acrylic resin, and metal such as stainless steel. When the collection container **23B** is completely filled with collected toner particles, the toner collecting container **23B** is replaced with a new one.

[0231] Particles of the toner **4**, emitted when the orifice **12** of the controlling plate **30** was cleaned by application of an oscillation by the oscillation generating body **60** and the oscillation transmitting plate **151**, adhere once to the conveyor belt **20**. However, if the transfer roller **22** remains pushed against the backup roller **21**, this causes the toner particles to be transferred onto the transfer roller **22** itself. As a result, the transfer roller **22** becomes contaminated. Particularly, such contamination becomes significant when the transfer roller **22** remains in the voltage-applied state. To cope with this, switching control is performed so that the transfer power supply to the transfer roller **22** is turned off in the timing that the toner adhering to the conveyor belt **20** comes into contact with the transfer controller **22**.

[0232] That is to say, the toner adhering to the conveyor belt **20** is conveyed to the transfer mechanism **40** at a time difference according to the travel velocity of the conveyor belt **20**. Therefore, taking into consideration such a time difference, after an elapse of a specified length of time from the time that the cleaning operation of the controlling plate **30** is carried out, the applied voltage to the transfer roller **22** is turned off.

[0233] Further, as described above, there exist toner particles of forward polarity and toner particles of reverse particles in the toner emitted at the time when the orifice **12** is subjected to cleaning. Accordingly, it is preferable that the voltage polarity of the transfer roller **22** is reversed with respect to the voltage polarity when the toner image is transferred to a sheet of recording paper and, in addition, that the transfer roller **22** is moved away from the backup roller **21**. Therefore, in the present embodiment, in order to ensure that the transfer roller **22** is prevented from being contaminated, the transfer power supply is subjected to switching control and, in addition, the transfer roller **22** is forced to move away from and approach the backup roller **21** so that the transfer roller **22** is prevented from coming into physical contact with the toner image.

[0234] That is, the transfer mechanism **40** is placed in the non-operating state when a specified length of time has been elapsed since the oscillation generating body **60** was operated and thereafter the non-operating state of the transfer mechanism **40** is maintained as long as the operating continuous time of the oscillation generating body **60**.

[0235] Thereafter, the toner on the conveyor belt **20** which has passed through the transfer mechanism **40** is scraped away by the cleaning blade **23A** and collected in the toner collecting container **23B**.

[0236] As described above, the application of a voltage to the transfer roller **22** is brought into a halt and the transfer roller **22** is moved away from the backup roller **21** during the period that the toner blown away toward the conveyor belt **20** when the print head is oscillated is facing the transfer roller **22**, thereby making it possible to provide positive protection against contamination of the transfer roller **22**.

(EMBODIMENT 2)

[0237] Referring to Figure **37**, there is shown an image forming device according to the second embodiment. In the second embodiment, the transfer roller **22** is so configured as to come into contact with the conveyor belt **20** (more precisely, in contact with the recording paper **6** at transfer time) at all times and the transfer roller **22** is equipped with a transfer roller cleaning device **24**. The basic arrangement and others of the second embodiment are the same as the image forming device shown in Figure **36** and only differences therebetween will be described below.

[0238] The transfer roller cleaning device **24** is made up of a blade **24A** of urethane rubber having a thickness of 3 mm and a toner collecting container **24B**. The edge of the cleaning blade **24A** comes into contact with the transfer roller **22,** and as the transfer roller **22** rotates toner particles and contaminants are scraped away from the surface of the transfer roller **22**. Other than urethane rubber, rubber such as silicon rubber, butyl rubber and resin such as polyester resin and acrylic rubber, and metal such as stainless steel may be used to form the cleaning blade **24A**. It is preferable that the surface uneveness of the transfer roller **22** be small. In the present embodiment, as the transfer roller **22**, urethane rubber covered with a fluorine tube is used.

[0239] The toner collecting container **24B** is formed integrally with the toner collecting container **23B** of the conveyor belt cleaning device **23**, and if the collected toner is discarded and replaced at the same time, this preferably reduces the frequency of maintenance. In such a case, it is preferable that the capacity of the toner collecting container **23B** of the conveyor belt cleaning device **23** be set larger than that of the toner collecting container **24B** of the transfer roller cleaning device **24**. Further, it may be designed such that the toner that is collected from the transfer roller cleaning device **24** is delivered to the toner collecting container **23B** of the conveyor belt cleaning device **23** and only the toner collecting container **23B** of the conveyor belt cleaning device **23** is discarded for replacement with a new one. Further, conversely, an arrangement may be made in which the toner that is collected by the conveyor belt cleaning device **23** is delivered to the toner collecting container **24B** of the transfer roller cleaning device **24** and only the toner collecting container **24B** of the transfer roller cleaning device **24** is discarded for replacement with a new one. That is, it is possible to omit either one of the toner collecting container **24B** of the transfer roller cleaning device **24** and the toner collecting container **23B** of the conveyor belt cleaning device **23** by toner collecting container sharing.

[0240] The toner, emitted at the time of cleaning the orifice **12** of the controlling plate **30** and adhering onto the conveyor belt **20**, once adheres to the transfer roller **22**; however, the toner on the transfer roller **22** is removed by the transfer roller cleaning device **24**. This accordingly makes it possible to provide protection against contamination of the recording paper **6** and the drop in performance of the transfer roller **22**. Particularly, the transfer roller **22** is not required to perform approaching/moving-away operations, thereby providing a configuration suitable for high-speed printers.

[0241] With the present embodiment, toner particles and contaminants adhering to around the orifice **12** of the print head are removed by applying an oscillation to the print head. Then, the toner particles and contaminants thus removed are once adhered to the conveyor belt **20** and then to the transfer belt **22** and thereafter removed by the cleaning means **23**. This ensures that the transfer roller **22** is positively maintained clean. Because of this, it is possible to provide protection against the drop in transfer efficiency, recording paper contamination, and in-device contamination. Furthermore, if the toner collecting container **24B** is so configured as to serve also as the toner collecting container **23A** of the conveyor belt cleaning device **23**, this makes it possible to provide the transfer roller cleaning device **24** without increasing the number of times that the toner collecting container **24B** is replaced.

(EMBODIMENT 3)

[0242] Referring to Figure **38**, there is shown an image forming device according to the third embodiment. The third embodiment is an example in which the present invention is applied to a multicolor printer. Four sets of head units **25** shown in Figure **36** are provided. First to fourth image forming units **51, 52, 53**, and **54** for four colors of yellow, magenta, cyan, and black, respectively, are arranged in succession. Each image forming unit **51, 52, 53**, and **54** is made up of a set of the toner conveying roller **1**, the controlling plate **30**, the oscillation generating body **60**, the opposing electrode **5**, et cetera.

[0243] The conveyor belt **20**, wound around the roller **21A** and around the backup roller **21**, travels successively between the controlling plate **30** and the opposing electrode **5** of each of the first to fourth image forming units **51-54**. More specifically, the conveyor belt **20** travels in the direction indicated by an arrow of the figure (e.g., in the clockwise direction in Figure **38**) by the rotation of the backup roller **21**. The conveyor belt **20** is a conductive, seamless belt and is preferably formed of resin, such as polyimide, polyca, and polyethylene, filled with a conductive filler. In the present embodiment, polyimide is used to form the conveyor belt **20**.

[0244] In synchronization with the movement of the conveyor belt **20**, the first to fourth image forming units **51-54** operate so that images of four colors are printed in successive on the conveyor belt **20**. The intermediate image formed on the conveyor belt **20** is sandwiched, together with the recording paper **6**, between the transfer roller **22** and the backup roller **21** and is transferred onto the recording paper **6**. The toner image transferred on the recording paper **6** is heated and pressurized in the fixer **8**, whereby it is fixed on the recording paper **6**.

[0245] Next, by making reference to Figure **39**, the formation of an image and the operation timing of the oscillator **16** will be described. In Figure **39**, the first to fourth image forming units **51-54** are referred to as a first, a second, a third, and a fourth color image forming unit, respectively.

[0246] As shown in Figure **39,** in each of the image forming units of the first to fourth colors, the applied voltage of the image signal electrode **11** is switched in synchronization with that of the opposing electrode **5**. On the other hand, the oscillator **16** is given a voltage in the period during which the applied voltage of the image signal electrode **11** and that of the opposing electrode **5** are turned off.

[0247] The image signal electrodes **11** of the image forming units operate one after another at intervals of a specified, first time difference T1 so that toner particles from the plural image forming units are superimposed on the conveyor belt **20** to form thereon an intermediate image. In other words, the second image forming unit **52** starts its image forming operation after an elapse of the first time T1 since the first image forming unit **51** started its image forming operation. The third image forming unit **53** starts its image forming operation after an elapse of the first time T1 since the second image forming unit **52** started its image forming operation. The fourth image forming unit **54** starts its image forming operation after an elapse of the first time T1 since the third image forming unit **53** started its image forming operation.

[0248] On the other hand, the oscillators **16** of the image forming units operate one after another at intervals of a second time difference T2 greater than the first time difference T1 so that toner particles removed from the respective image forming units are not superimposed on the same position on the conveyor belt **20**. That is, there is a specified time difference between the time interval T2 according to which each oscillator **16** starts its operation and the time interval T1 according to which each image forming unit starts its image forming operation.

[0249] More specifically, the oscillator **16** of the first color is driven upon completion of the first color image formation (at the time when the applied voltage of the image signal electrode **11** and that of the opposing electrode **5** are switched from ON to OFF). On the other hand, the oscillators **16** of the second to fourth colors are each driven after an elapse of a specified delay time ΔT since the image formation of each color was completed. In other words, the delay time ΔT (note that the delay time of the first color is zero) is provided between the time that the image formation of each color is completed and the time that the oscillator 16 starts operating. The delay time ΔT differs among the four colors. If the same delay time ΔT is set for all the four colors, then the position on the conveyor belt **20** at which toner is emitted by the operation of each oscillator **16** becomes the same for all the four colors. In this case, when a larger amount of toner is emitted from the print head **10**, each emitted toner sequentially lies upon another. Accordingly, particularly in the fourth color image forming unit, the toner **4** accumulated on the conveyor belt **20** comes into mechanical contact with the print head **10** and the toner **4** is forced into adverse flight toward the print head **10** by an electric field generated by the accumulated toner **4,** resulting in contamination of the print head **10** in some case. To cope with such problems, in the present embodiment, there is provided a difference between the time interval according to which each oscillator **16** starts operating and the time interval of the image formation of each image forming unit, thereby dispersing the position of toner emission by oscillation for forestalling contamination of the print head **10** and improving device reliability.

[0250] Further, also in the present embodiment, it is preferable that the toner collecting container **23B** of the conveyor belt cleaning device **23** is so configured as to serve also as the toner collecting container **24B** of the transfer roller cleaning device **24.**

(VARIATION)

[0251] The operation of each oscillator **16** may be performed before the operation of forming an image begins (e.g., immediately after the power of the image forming device is turned on and immediately after a series of image signals is received). For example, as shown in Figure **40**, after the power is turned on, a voltage may sequentially be applied to the oscillators **16** of the first to fourth colors for pre-cleaning. In this case, in the initial cleaning, there is no need to cause each oscillator **16** to operate at intervals of the second time difference T2 (in the example of Figure **40** the oscillators of the respective colors are operated sequentially and continuously), thereby making it possible to complete cleaning of all of the image forming units **51-54** in a short time.

PREFERRED EMBODIMENTS FOR CLEANING MULTICOLOR IMAGE FORMING DEVICE

[0252] Next, preferred embodiments for efficiently causing the periphery of developer pass orifices of a developer pass controlling means of each head unit at the time of performing multicolor image formation by successive passing between each head unit and each opposing electrode, will be described below.

(EMBODIMENT 1)

[0253] The basic arrangement and others of the present embodiment are the same as the image forming device shown in Figure **38** and only differences therebetween will be explained. That is, the image forming device of the present embodiment comprises first to fourth head units **25, 25**, ... in which four colors of the toner **4** (i.e., yellow (Y), magenta (M), cyan (C), and black (B)) are stored for forming a color image.

[0254] Figure **41** illustrates one of the head units **25**. Provided face to face across the orifice row **12A** on the controlling plate **30** are the oscillation transmitting plate **151** and the oscillation reflecting plate **71**, which is the same as described above. The oscillation transmitting plate **151** is positioned on the front side in the traveling direction of the conveyor belt **20** with respect to the orifice row **12A**, and provided on the far side in the traveling direction is the oscillation reflecting plate **71**. Referring to Figure **42**, there is shown the position relationship between the oscillation transmitting plate **151**, the oscillation reflecting plate **71**, and the oscillation generating body 60 in each of the head units **25(Y), 25 (M), 25(C)**, and **25(B)** of the colors of yellow, magenta, cyan, and black. Note that some members are omitted in Figure **42**.

[0255] If a voltage is applied to the oscillator **16** when an image is being formed or when the formation of an image is being stopped, the oscillation of the oscillator **16** is transmitted and applied, through the horn **17** and the oscillation transmitting plate **151**, to the controlling plate **30**.

[0256] Here, the toner **4** causes clogging and contamination in the controlling plate **30**. More specifically, the toner **4** is accumulated in the inside of the orifice **12**, causing clogging of the orifice **12**. Further, the toner **4** is accumulated on a surface of the controlling plate **30** on the side of the conveyor belt **20**, causing contamination. In the latter cause, the toner **4** adhering to the controlling plate surface is charged, so that the electric field created between the controlling plate **30** and the conveyor belt **20** is disturbed. The toner **4** may not be flight-controlled successfully. Accordingly, it is required that the toner **4** adhering to the surface of the controlling plate **30** on the side of the conveyor belt **20** be cleaned thoroughly.

[0257] Adhesion of the toner **4** to a belt-side surface of the controlling plate **30** is attributed to the fact that there is coexistence of toner particles that are charged negatively and toner particles that are charged positively in the toner **4**. Of the toner **4** which has been once forced into flight toward the intermediate image holding belt **2**, particles of the toner **4** charged positively are pulled back to the controlling plate **30**. That is, during image formation, an electric field created between the controlling plate **30** and the opposing electrode **5** forces particles of the toner **4** of negative polarity into flight from the controlling plate **30** toward the conveyor belt **20** and, at the same time, forces particles of the toner **4** of positive polarity into flight from the conveyor belt **20** toward the controlling plate **30**.

[0258] Accordingly, with the arrangement of the present embodiment for color image formation in which images of yellow, magenta, cyan, and black are formed in that order, when the conveyor belt **20** is delivered from the yellow head unit **25(Y)** to the magenta head unit **25 (M),** in the magenta head unit **25(M)** a magenta image is formed overlying a yellow image already formed on the conveyor belt **20**. At this time, if the toner **4** of yellow adhering to the conveyor belt **20** contains therein positively-charged particles, these toner particles are attracted to the controlling plate **30** of the magenta head unit **25(M)**. As a result, the controlling plate **30** of the magenta head unit **25(M)** is contaminated. Such contamination is likely to take place in areas of the controlling plate **30** of the magenta head unit **25(M)** in the vicinity of the yellow head unit **25(Y)**.

[0259] On the other hand, for the case of the present embodiment, the oscillation transmitting plate **151** of each head unit **25** is positioned on the front side of the orifice **12** with respect to the traveling direction of the conveyor belt **20** so that an oscillation is extensively applied to the front side of the orifice **12** in the controlling plate **30** by the oscillation transmitting plate **151**. Because of this, even when the positive polarity toner **4** supplied from one head unit **25** and adhering to the conveyor belt **20** is forced into flight toward the controlling plate **30** of the next head unit **25**, the toner **4** will not readily adhere to the controlling plate **30**. Even when the toner **4** adheres to the controlling plate **30**, the toner **4** can be removed readily.

(EMBODIMENT 2)

[0260] Only major parts of the second embodiment are shown in Figure **43**. The oscillators **16(Y), 16(M), 16 (C),** and **16(B)** of the head units **25(Y), 25(M), 25(C)**, and **25(B)** are coupled, through a switching circuit (for example, a relay et cetera), to a single common driving circuit **80**. The switching circuit **81** is for selective driving of the oscillators **16(Y), 16(M), 16(C)**, and **16(B)** of the head units **25.**

[0261] When forming a color image, the conveyor belt **20** is delivered from the left-hand side to the right-hand side in Figure **42** and the image is formed by gradually shifting in timing the colors of yellow, magenta, cyan, and black in that order. As a technique of providing protection against clogging or of cleaning a clogging, there is a method in which an oscillation is applied after the formation of an image is completed or before the formation of an image begins to eliminate a clogging created during image formation, and there is another method in which an oscillation is applied when an image is being formed so as to provide in advance a state free from the occurrence of clogging.

[0262] Generally, clogging is seldom occurs during formation of an image on one sheet of recording paper. It is therefore possible to eliminate clogging by applying an oscillation between the time that an image is formed on a sheet of recording paper and the time that the formation of an image on the next recording paper starts (hereinafter called the paper-to-paper cleaning). When applying an oscillation also during image formation, such an oscillation should not be the one with a large amplitude which itself has adverse effects on the flight control of the toner **4.**

[0263] When thinking of a case of performing paper-to-paper cleaning, in the operation of formation of a color image the head units **25(Y), 25(M), 25(C),** and **25(B)** deviate from each other in image forming timing. That is, the image forming position of the intermediate image holding belt **2** is delivered in front of each head unit **25 (Y), 25(M), 25(C),** and **25(B)** at time intervals so that recording is effected by signals delayed for such an interval. Accordingly, the timing at which paper-to-paper cleaning is performed differ among the head units **25(Y), 25(M), 25(C),** and **25(B)** and the oscillators **16(Y), 16 (M), 16(C)**, and **16(B)** can be driven at different timings for performing cleaning.

[0264] For the case of the present embodiment, as described above, the provision of the switching circuit **81** makes it possible for each of the oscillators **16(Y), 16(M), 16(C)**, and **16(B)** of the respective head units **25** to be driven at an appropriate timing independently of another. Additionally, the driving circuit **80** is shared between each head unit **25**, thereby being advantageous for the aspect of costs.

(EMBODIMENT 3)

[0265] With respect to the third embodiment, its only major parts are shown in Figure **44.** That is, the horn **17** of a single oscillation source **60** is coupled, through a branching member **82,** to the oscillation transmitting plates **151(Y), 151(M), 151(C)**, and **151(B)** of the head unit **25(Y), 25(M), 25(C)**, and **25(B).** The oscillation source **60** (comprised of the oscillator **16** and the horn **17**) is shared between each head unit **25.** Positioned at branching portions of the branching member **82** are oscillation cutting-off means **83(Y), 83(M), 83(C)**, and **83 (B).** Each oscillation cutting-off means **83**, formed of oscillation absorbing material such as silicon rubber, is disposed so that each branching portion of the branching member is caught therein for preventing an oscillation from being transmitted therebeyond.

[0266] As a result of such arrangement, with respect to the controlling plate **30** of the head unit **25** not subjected to cleaning, the oscillation of the horn **17** is prevented from being transmitted to the oscillation transmitting plate **151** by the oscillation cutting-off means **83**, thereby making it possible to perform paper-to-paper cleaning. Additionally, the oscillation source **60** is shared between each head unit **25**, being advantageous in the aspect of costs.

Claims

1. An image forming method comprising the steps of:

supporting a charged developer on a developer supporting body;
applying a specified voltage to an opposing electrode positioned face to face with said developer supporting body;
making use of an insulating substrate which is placed between said developer supporting body and said opposing electrode and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each said developer pass orifice in said insulating substrate and to which a voltage according to an image signal is applied, and forcing said developer on said developer supporting body into flight so as to pass through a specified developer pass orifice for making a record on an image receiving body supported between said insulating substrate and said opposing electrode; and
removing particles of said developer or contaminants adhering to around said developer pass orifice;
wherein said developer particles/contaminants removing step is performed by applying to said insulating substrate an oscillation resulting from a combination of a progressive wave and a standing wave.

2. The image forming method of claim 1, wherein said progressive wave propagates in a direction parallel to said developer pass orifice row and wherein said standing wave is formed in a direction orthogonal to said developer pass orifice row.

3. An image forming method comprising the steps of:

supporting a charged developer on a developer supporting body;
applying a specified voltage to an opposing electrode positioned face to face with said developer supporting body;
making use of an insulating substrate which is placed between said developer supporting body and said opposing electrode and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each said developer pass orifice in said insulating substrate and to which a voltage according to an image signal is applied, and forcing said developer on said developer supporting body into flight so as to pass through a specified developer pass orifice for making a record on an image receiving body supported between said insulating substrate and said opposing electrode; and
removing particles of said developer or contaminants adhering to around said developer pass orifice;
wherein said developer particles/contaminants removing step includes the steps of causing an oscillation from an oscillation generating source positioned on one of sides facing each other across said developer pass orifice row to propagate to said insulating substrate, absorbing an oscillation propagating in a direction parallel to said developer pass orifice row, and reflecting, at the other of said sides, an oscillation propagating in a direction orthogonal to said developer pass orifice row toward said developer pass orifice row.

4. The image forming method of claim 3 further comprising, prior to said step of propagating an oscillation from said oscillation generating source to said insulating substrate, the step of amplifying said oscillation from said oscillation generating source.

5. The image forming method of claim 3 or claim 4 further comprising, prior to said step of absorbing an oscillation, the step of reducing the amplitude of said oscillation.

6. The image forming method of claim 3 or claim 4 further comprising the step of suppressing, while an oscillation from said oscillation generating source is absorbed, the damping of said oscillation.

7. The image forming method of claim 6 further comprising, prior to said step of absorbing an oscillation, the step of reducing the amplitude of said oscillation.

8. An image forming device comprising:

a developer supporting body for supporting and, at the same time, conveying a developer; an opposing electrode positioned face to face with said developer supporting body;
a developer pass controlling member, placed between said developer supporting body and an image receiving body and having at least one developer pass orifice row formed by arrangement of a plurality of developer pass orifices, for performing control in response to an image signal so that said developer conveyed by said developer supporting body is forced into flight so as to pass through a specified developer pass orifice for adhesion onto said image receiving body; and
an oscillation applying member for applying an oscillation to said developer pass controlling member so that particles of said developer adhering to said developer pass controlling member is removed;
wherein said oscillation applying member is so configured as to achieve application of an oscillation to said developer pass controlling member by a combination of a progressive wave and a standing wave.

9. The image forming device of claim 8, wherein said oscillation applying member is configured so that the oscillation of said progressive wave propagates in a direction parallel to said developer pass orifice row and the oscillation of said standing wave are formed in a direction orthogonal to said developer pass orifice row.

10. An image forming device comprising:

a developer supporting body which is formed rotatably about a rotation axis extending in a specified direction and which rotates about said rotation axis with a developer supported on its peripheral surface for conveying said developer;
a developer pass controlling member, positioned face to face with said peripheral surface of said developer supporting body and having at least one developer pass orifice row in which a plurality of developer pass orifices capable of being passed through by said developer is arranged in the direction of said rotation axis of said developer supporting body, for performing control in response to an external image signal so that said developer is forced into flight from said developer supporting body so as to pass through a developer pass orifice;
an image receiving body positioned opposite said developer supporting body across said developer pass controlling member; and
an opposing electrode for guiding said developer, which has passed through said developer pass orifice of said developer pass controlling member, toward said image receiving body so that said developer is adhered to said image receiving body;
said image forming device further comprising:

an oscillation applying member for applying an oscillation to one of portions on both sides located opposite each other across said developer pass orifice row in said developer pass controlling member;
wherein the other of said side portions in said developer pass controlling member is in contact with said developer supporting body so that an oscillation, generated in said developer pass controlling member by application of an oscillation by said oscillation applying member and traveling from said oscillation-applied portion toward said developer pass orifice row, is reflected in the opposite direction.

11. The image forming device of claim **10**, wherein the other of said side portions in said developer pass controlling member is wound around said peripheral surface of said developer supporting body, establishing surface to surface contact with said developer supporting body.

12. The image forming device of claim **11,** wherein it is set that L3 > $\lambda/4$ where λ is the wavelength of an oscillatory wave and L3 is the length of contact of said developer pass controlling member and said developer supporting body in the circumferential direction of said developer supporting body.

13. An image forming device comprising:

a developer supporting body which is formed rotatably about a rotation axis extending in a specified direction and which rotates about said rotation axis with a developer supported on its peripheral surface for conveying said developer;
a developer pass controlling member, positioned face to face with said peripheral surface of said developer supporting body and having at least one developer pass orifice row in which a plurality of developer pass orifices capable of being passed through by said developer is arranged in the direction of said rotation axis of said developer supporting body, for performing control in response to an external image signal so that said developer is forced into flight from said developer supporting body so as to pass through a developer pass orifice;
an image receiving body positioned opposite

said developer supporting body across said developer pass controlling member; and
an opposing electrode for guiding said developer, which has passed through said developer pass orifice of said developer pass controlling member, toward said image receiving body so that said developer is adhered to said image receiving body;
said image forming device further comprising:

an oscillation applying member for applying an oscillation to one of portions on both sides located opposite each other across said developer pass orifice row in said developer pass controlling member;
wherein the other of said side portions in said developer pass controlling member is in contact with said developer supporting body through a spacer member so that an oscillation, generated in said developer pass controlling member by application of an oscillation by said oscillation applying member and traveling from said oscillation-applied portion toward said developer pass orifice row, is reflected in the opposite direction.

14. The image forming device of claim 13, wherein said spacer member is extendedly positioned along the rotation axis direction of said developer supporting body.

15. The image forming device of any of claims 10-14, wherein said oscillation applying member is made up of an oscillation transmitting body extendedly positioned along the rotation axis direction of said developer supporting body and an oscillation generating source disposed at at least one of lengthwise ends of said oscillation transmitting body.

16. The image forming device of claim 15, wherein said oscillation applying member is configured so that a standing wave, whose node and antinode correspond to a reflecting end and to said developer pass orifice, respectively, in said developer pass controlling member, is obtained.

17. The image forming device of claim 15, wherein L1 is set such that $L1 < \lambda/2$ where λ is the wavelength of an oscillation and L1 is the distance between said developer pass orifice row and said reflecting end.

18. The image forming device of claim 17, wherein said distance L1 is set such that $L1 \approx \lambda/4$.

19. The image forming device of claim 15, wherein L2 is set such that $L2 > \lambda/4$ where λ is the wavelength of an oscillation and L2 is the distance between said oscillation transmitting body and said reflecting end.

20. The image forming device of claim 15,

wherein oscillation reflecting means for reflecting an oscillation traveling from said oscillation applying member toward said developer pass orifice row in the opposite direction is positioned opposite said developer pass orifice row across said reflecting end in said developer pass controlling member; and
wherein L4 is set such that $L4 \approx (2n + 1) \times \lambda/4$ where λ is the wavelength of an oscillation, L4 is the distance between said developer pass orifice row and said oscillation reflecting means, and n is an integer.

21. The image forming device of claim 20, wherein said oscillation reflecting means is implemented by an oscillation reflecting plate fixed to said developer pass controlling means or by a holding member for holding said developer pass controlling member.

22. An image forming device comprising:

a developer supporting body for supporting and, at the same time, conveying a developer;
an opposing electrode positioned face to face with said developer supporting body;
a developer pass controlling member, placed between said developer supporting body and an image receiving body and having at least one developer pass orifice row formed by arrangement of a plurality of developer pass orifices, for performing control in response to an image signal so that said developer conveyed by said developer supporting body is forced into flight so as to pass through a specified developer pass orifice for adhesion onto said image receiving body; and
an oscillation applying member for applying an oscillation to said developer pass controlling member so that particles of said developer adhering to said developer pass controlling member are removed;
wherein said oscillation applying member, equipped with an oscillating plate extending parallel with the row direction of said developer pass orifice row and fixed to a surface of said developer pass controlling member, a piezoelectric element extending parallel with said row direction so as to be superimposed on said oscillating plate and fixed to a surface of said oscillating plate opposite a contact surface thereof in contact with said developer pass controlling member, and a regulating body for regulating expansion and contraction of said piezoelectric element in said row direction, whereby

oscillations of the same phase in said row direction can be applied to portions of said developer pass orifices of said developer pass controlling member.

23. An image forming device comprising:

a developer supporting body for supporting and, at the same time, conveying a developer;
an opposing electrode positioned face to face with said developer supporting body;
a developer pass controlling member, placed between said developer supporting body and an image receiving body and having at least one developer pass orifice row formed by arrangement of a plurality of developer pass orifices, for performing control in response to an image signal so that said developer conveyed by said developer supporting body is forced into flight so as to pass through a specified developer pass orifice for adhesion onto said image receiving body; and
an oscillation applying member for applying an oscillation to said developer pass controlling member so that particles of said developer adhering to said developer pass controlling member are removed;
wherein said oscillation applying member is equipped with an oscillating plate extending parallel with the row direction of said developer pass orifice row and fixed to a surface of said developer pass controlling member, an oscillation generating source for applying an oscillation to one end of said oscillation transmitting body so that an oscillatory wave is generated which travels parallel to said row direction from said one end of said oscillation transmitting body toward the other end thereof, and an oscillation controlling part for controlling said oscillation so that said oscillatory wave in said oscillation transmitting body becomes a non-standing wave.

24. The image forming device of claim 23, wherein said oscillation controlling part is equipped with clamp means for catching therein said other end of said oscillation transmitting body while shifting its clamp position so that the position, at which an oscillation at said other end of said oscillation transmission body is reflected, is varied with time.

25. The image forming device of claim 23, wherein said oscillation controlling part is equipped with auxiliary agitating means for slightly disturbing an oscillation from said oscillation generating source in said oscillation transmitting body.

26. An image forming device comprising:

a developer supporting body for conveying and, at the same time, supporting a charged developer;
an opposing electrode positioned face to face with said developer supporting body;
a developer pass controlling member having an insulating substrate which is placed between said developer supporting body and said opposing electrode and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each said developer pass orifice in said insulating substrate and to which a voltage according to an image signal is applied, for forcing said developer on said developer supporting body into flight so as to pass through a specified developer pass orifice for adhesion onto an image receiving body supported between said developer pass controlling member and said opposing electrode; and
an oscillation applying member having an oscillation generating source and an oscillation transmitting body which is connected, at at least one of ends thereof, to said oscillation generating source and disposed on said developer pass controlling member so as to extend parallel to said developer pass orifice row for transmitting an oscillation from said oscillation generating source to each developer pass orifice portion of said developer pass controlling member;
wherein the oscillation characteristic of said oscillation transmitting body varies along the propagation direction of said oscillation from said oscillation generating source for suppressing the damping of oscillation in said oscillation transmitting body.

27. An image forming device comprising:

a developer supporting body for conveying and, at the same time, supporting a charged developer;
an opposing electrode positioned face to face with said developer supporting body;
a developer pass controlling member having an insulating substrate which is placed between said developer supporting body and said opposing electrode and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each said developer pass orifice in said insulating substrate and to which a voltage according to an image signal is applied, for forcing said developer on said developer supporting body into flight so as to pass through a specified developer pass orifice for adhesion onto an image receiving body supported be-

tween said developer pass controlling member and said opposing electrode; and
an oscillation applying member having an oscillation generating source and an oscillation transmitting body which is connected, at one of ends thereof, to said oscillation generating source and disposed on said developer pass controlling member so as to extend parallel to said developer pass orifice row for transmitting an oscillation from said oscillation generating source to each developer pass orifice portion of said developer pass controlling member;
wherein said oscillation transmitting body decreases in rigidity from said one end toward the other end.

28. The image forming device of claim 26 or claim 27, wherein said oscillation transmitting body is implemented by an oscillation transmitting plate the plate width of which varies with the distance from said oscillation generating source.

29. The image forming device of claim 26 or claim 27, wherein said oscillation transmitting body is implemented by an oscillation transmitting plate the plate thickness of which varies with the distance from said oscillation generating source.

30. The image forming device of claim 26 or claim 27, wherein a lateral face of said oscillation transmitting body on the side of said developer pass orifices is formed into a wavy shape.

31. The image forming device of claim **30,**

wherein the wave pitch of said wavy shape of said oscillation transmitting body is substantially a half of the wavelength of an oscillation in said oscillation transmitting body; and
wherein the difference in level between a concave portion and a convex portion of said wavy shape is substantially a quarter of the wavelength of an oscillation in said developer pass controlling member.

32. An image forming device comprising:

a developer supporting body for conveying and, at the same time, supporting a charged developer;
an opposing electrode positioned face to face with said developer supporting body;
a developer pass controlling member having an insulating substrate which is placed between said developer supporting body and said opposing electrode and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each said developer pass orifice in said insulating substrate and to which a voltage according to an image signal is applied, for forcing said developer on said developer supporting body into flight so as to pass through a specified developer pass orifice for adhesion onto an image receiving body supported between said developer pass controlling member and said opposing electrode; and
an oscillation applying member having an oscillation generating source and an oscillation transmitting body which is connected, at one of ends thereof, to said oscillation generating source and disposed on said developer pass controlling member so as to extend parallel to said developer pass orifice row for transmitting an oscillation from said oscillation generating source to each developer pass orifice portion of said developer pass controlling member;
wherein a portion of said oscillation transmitting body connected to said oscillation generating source is greater in rigidity than a portion of said oscillation transmitting body disposed on said developer pass controlling member.

33. An image forming device comprising:

a developer supporting body for conveying and, at the same time, supporting a charged developer;
an opposing electrode positioned face to face with said developer supporting body;
a developer pass controlling member having an insulating substrate which is placed between said developer supporting body and said opposing electrode and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each said developer pass orifice in said insulating substrate and to which a voltage according to an image signal is applied, for forcing said developer on said developer supporting body into flight so as to pass through a specified developer pass orifice for adhesion onto an image receiving body supported between said developer pass controlling member and said opposing electrode; and
an oscillation applying member having an oscillation generating source and an oscillation transmitting body which is connected, at one of ends thereof, to said oscillation generating source, which is provided, at the other end, with oscillation absorbing means for absorbing an oscillation from said oscillation generating source, and which is disposed on said developer pass controlling member so as to extend parallel to said developer pass orifice row for transmitting an oscillation from said oscillation gen-

erating source to each developer pass orifice portion of said developer pass controlling member;

wherein a portion of said oscillation transmitting body at which said oscillation absorbing means is disposed is greater in rigidity than a portion of said oscillation transmitting body disposed on said developer pass controlling member.

34. The image forming device of claim 32 or claim 33, wherein the plate width of said portion of said oscillation transmitting body disposed on said developer pass controlling member varies according to the distance from said oscillation generating source.

35. The image forming device of any of claims 23, 27, and 32, wherein the other end of said oscillation transmitting body is equipped with oscillation absorbing means for absorbing an oscillation from said one end of said oscillation transmitting body.

36. The image forming device of claim 33 or claim 35, wherein said oscillation absorbing means is composed of two or more types of viscoelastic bodies having different characteristics.

37. The image forming device of any of claims 23, 26, 27, 32, and 33, wherein said oscillation transmitting body is in tension in its longitudinal direction.

38. The image forming device of any of claims 23, 26, 27, 32, and 33,

wherein said image forming device further comprises a holding member for holding, on a side positioned opposite said developer pass orifice row across said oscillation transmitting body, said developer pass controlling member; and wherein L5 is set such that L5 > $\lambda/2$ where λ is the wavelength of an oscillation and L5 is the distance between said oscillation transmitting body and said holding member.

39. The image forming device of any of claims 23, 26, 27, 32, and 33, wherein said oscillation applying member is so configured as to apply an oscillation which causes a standing wave in a direction orthogonal to the row direction of said developer pass orifice row.

40. The image forming device of claims 23, 26, 27, 32, and 33, wherein said developer pass controlling member is, on a side located opposite said oscillation transmitting body across said developer pass orifice row, in line contact with said developer supporting body in parallel with the row direction of said developer pass orifice row so that a reflecting end for reflecting an oscillation from said oscillation transmitting body is formed.

41. The image forming device of claim 40, wherein said developer pass controlling member is wound around a peripheral face of said developer supporting body so that said developer pass controlling member is brought into surface-to-surface contact with said developer supporting body.

42. The image forming device of claim 40, wherein spacer means, disposed extendedly along said developer pass orifice row, is positioned at a reflecting end of said developer pass controlling member and said developer pass controlling member is brought into contact with said developer supporting body through said spacer means.

43. The image forming device of claim **40**, wherein said oscillation applying member is so configured as to apply an oscillation so that an oscillatory wave in a direction orthogonal to the row direction of said developer pass orifice row in said developer pass controlling member becomes a standing wave whose node and antinode correspond to said reflecting end and to said developer pass orifice row, respectively.

44. An image forming device comprising:

developer supplying means for charging a developer and supplying said charged developer supported on a developer supporting body;

an opposing electrode which is positioned face to face with said developer supplying means and to which a specified voltage is applied;

an insulating substrate having a plurality of developer pass orifices and interposed between said developer supplying means and said opposing electrode;

an image signal electrode which is disposed around said developer pass orifice of said insulating substrate and to which a voltage for controlling, in response to an image signal, the pass amount of said developer passing through said developer pass orifice; and

an oscillation applying member, having an oscillation generating source and an oscillation transmitting body connected to said oscillation generating source and positioned in the vicinity of said developer pass orifice of said insulating substrate, for applying an oscillation to said insulating substrate;

wherein said developer is adhered to an image receiving body placed between said opposing electrode and said insulating substrate or to said opposing electrode for forming an image; and

wherein said image forming device further comprises controlling means for bringing the operation of said developer supplying means to a halt while activating said oscillation applying means, when no image formation is being performed.

45. The image forming device of claim 44, wherein, when no image formation is being carried out, said controlling means brings the operation of said developer supplying means to a halt while activating said oscillation applying means and causes said opposing electrode and said developer supporting body to have the same electric potential at least at the early stage of an oscillation application operation by said oscillation applying member.

46. The image forming device of claim 45,

wherein said opposing electrode is positioned movably so as to be able to change its face opposite to said developer supporting body; and wherein, when no image formation is being carried out, said controlling means brings the operation of said developer supplying means to a halt while activating said oscillation applying means and causes said opposing electrode and said developer supporting body to have the same electric potential at least at the early stage of an oscillation application operation by said oscillation applying member while shifting said opposing electrode.

47. The image forming device of claim 46,

wherein, when no image formation is being carried out, said controlling means brings the operation of said developer supplying means to a halt while activating said oscillation applying means, causes said opposing electrode and said developer supporting body to have the same electric potential at least at the early stage of an oscillation application operation by said oscillation applying member while shifting said opposing electrode, and thereafter changes the electric potential of said opposing electrode or said image signal electrode so as to form between said insulating substrate and said opposing electrode an electric field capable of aiding the flight of a charged developer particle from said insulating substrate toward said opposing electrode.

48. The image forming device of claim 47, wherein an ac voltage is applied to said opposing electrode so that an electric field capable of aiding the flight of a charged developer particle from said insulating substrate toward said opposing electrode is formed between said insulating substrate and said opposing electrode.

49. The image forming device of claim 44, wherein, when no image formation is being carried out, said controlling means brings the operation of said developer supplying means to a halt while activating said oscillation applying means and reverse the relationship in electric potential size between said developer supporting body and said image signal electrode with respect to the relationship in electric potential size between said developer supporting body and said image signal electrode during image formation.

50. The image forming device of claim 49 further comprising change means for changing a voltage that is applied to said developer supporting body.

51. An image forming device comprising:

developer supplying means for charging a developer and supplying said charged developer supported on a developer supporting body;
an opposing electrode which is positioned face to face with said developer supplying means and to which a specified voltage is applied;
an insulating substrate having a plurality of developer pass orifices and interposed between said developer supplying means and said opposing electrode;
an image signal electrode which is disposed around said developer pass orifice of said insulating substrate and to which a voltage for controlling, in response to an image signal, the pass amount of said developer passing through said developer pass orifice; and
an oscillation applying member, having an oscillation generating source and an oscillation transmitting body connected to said oscillation generating source and positioned in the vicinity of said developer pass orifice of said insulating substrate, for applying an oscillation to said insulating substrate;
wherein said developer is adhered to an image receiving body placed between said opposing electrode and said insulating substrate or to said opposing electrode for forming an image and, at the time when no image formation is being performed, said oscillation applying member is activated;
wherein a plurality of image forming units each comprising a combination of said developer supplying means, said insulating substrate having said developer pass orifices and said image signal electrode, said oscillation applying member, and said opposing electrode are provided; and
wherein each of said oscillation applying members of said plurality of image forming units is driven independently of the other and each of

voltages of said opposing electrodes of said plurality of image forming units is controlled independently of the other.

52. The image forming device of claim **51,** wherein said plural oscillation applying members are connected, through drive switching means for sequential driving of said oscillation generating sources, to a single common driving circuit for driving said oscillation generating sources.

53. The image forming device of claim 44 or claim 52, wherein said driving circuit of said oscillation generating sources is a frequency auto-following type circuit.

54. The image forming device of claim 51, wherein said plurality of opposing electrodes are connected, through voltage switching means, to a single common power supply.

55. The image forming device of claim 44 or claim 51,

wherein said plurality of developer pass orifices of said insulating substrate are arranged in a single row or in several rows;
wherein said oscillation transmitting body is disposed in parallel with said developer pass orifice row; and
wherein said oscillation applying member is so configured as to apply an oscillation which becomes a progressive wave in a direction parallel to said developer pass orifice row and a standing wave in a direction orthogonal to the row direction of said developer pass orifice row.

56. An image forming device comprising:

a developer supporting body for conveying and, at the same time, supporting a charged developer;
an opposing electrode positioned face to face with said developer supporting body;
an intermediate image holding member interposed between said developer supporting body and said opposing electrode;
a developer pass controlling member, having an insulating substrate which is placed between said developer supporting body and said intermediate image holding member and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each said developer pass orifice in said insulating substrate and to which a voltage according to an image signal is applied, for forcing said developer on said developer supporting body into flight so as to pass through a specified developer pass orifice for adhesion onto said intermediate image holding member;
conveying means for conveying said intermediate image holding member;
transferring means for transferring an intermediate image on said intermediate image holding member onto an image receiving body; and
developer removing means for removing particles of said developer adhering to said developer pass controlling member;
wherein said transferring means is so configured as to enter the non-operation state when said developer particles, removed from said developer pass controlling member and then adhering to said intermediate image holding member, have been conveyed.

57. The image forming device of claim 56, wherein said transferring means is so configured as to be pushed toward said intermediate image holding member with said image receiving body caught between itself and said intermediate image holding member when placed in the operation state whereas, when placed in the non-operation state, said transferring means moves away from said intermediate image holding member.

58. An image forming device comprising:

a developer supporting body for conveying and, at the same time, supporting a charged developer;
an opposing electrode positioned face to face with said developer supporting body;
an intermediate image holding member interposed between said developer supporting body and said opposing electrode;
a developer pass controlling member, having an insulating substrate which is placed between said developer supporting body and said intermediate image holding member and through which a plurality of developer pass orifices are formed in a row and an image signal electrode which is arranged around each said developer pass orifice in said insulating substrate and to which a voltage according to an image signal is applied, for forcing said developer on said developer supporting body into flight so as to pass through a specified developer pass orifice for adhesion onto said intermediate image holding member;
conveying means for conveying said intermediate image holding member;
transferring means for transferring an intermediate image on said intermediate image holding member onto an image receiving body; and
developer removing means for removing particles of said developer adhering to said devel-

oper pass controlling member;
wherein said transferring means includes cleaning means for removing particles of said developer adhering to said transferring means.

59. The image forming device of any of claims 56-58,

wherein said developer removing means comprises an oscillation applying member including an oscillation generating source for applying an oscillation to developer pass orifice portions of said developer pass controlling member when said developer pass controlling member is in the non-operation state and an oscillation transmitting body connected, at at least one of ends thereof, to said oscillation generating source and disposed on said developer pass controlling member so as to extend parallel to said developer pass orifice row for transmitting an oscillation from said oscillation generating source to each said developer pass orifice portion of said developer pass controlling member; and
wherein said oscillation applying member is so configured as to apply an oscillation which becomes a progressive wave in a direction parallel to said developer pass orifice row and a standing wave in a direction orthogonal to said developer pass orifice row.

60. The image forming device of any of claims 56-58,

wherein a plurality of recording units are provided, each said recording unit including said developer supporting body, said opposing electrode, said developer pass controlling member, and said developer removing means;
wherein said conveying means is so configured as to successively convey said intermediate image holding member between said developer pass controlling member and said opposing electrode of each said recording unit;
wherein said developer pass controlling members of said plural recording units are so configured as to operate one after another at intervals of a first time difference for forming on said intermediate image holding member an intermediate image resulting from superimposition of developer particles from said plural recording units; and
wherein said developer removing means of said plural recording units are so configured as to operate one after another at intervals of a second time difference different from said first time difference for preventing respective developer particles removed from said plural recording units by said developer removing means from being superimposed on said intermediate image holding member.

61. The image forming device of claim 60,

wherein said developer removing means comprises an oscillation applying member including an oscillation generating source for applying an oscillation to developer pass orifice portions of said developer pass controlling member when said developer pass controlling member is in the non-operation state and an oscillation transmitting body connected, at at least one of ends thereof, to said oscillation generating source and disposed on said developer pass controlling member so as to extend parallel to said developer pass orifice row for transmitting an oscillation from said oscillation generating source to each said developer pass orifice portion of said developer pass controlling member; and
wherein said oscillation applying member is so configured as to apply an oscillation which becomes a progressive wave in a direction parallel to said developer pass orifice row and a standing wave in a direction orthogonal to said developer pass orifice row.

62. An image forming device comprising:

a developer supporting body which rotates with a developer electro-magnetically supported on its peripheral surface;
an opposing electrode, placed face to face with said developer supporting body, for electromagnetically attracting said developer supported on said developer supporting body; and
a developer pass controlling member, interposed between said developer supporting body and said opposing electrode and having at least one developer pass orifice row arranged in the rotational axis direction of said developer supporting body, for controlling the passing of said developer through said developer orifices in response to an external image signal;
wherein an image receiving body is interposed between said opposing electrode and said developer pass controlling member for adhesion of said developer thereonto;
wherein said image forming device further comprises a plurality of print heads each comprising a combination of said developer supporting body and said developer pass controlling member;
wherein said image receiving body is so positioned as to successively pass through between said developer pass controlling member and said opposing electrode of each said print head;

wherein said image forming device further comprises:

an oscillation applying member, positioned in said developer pass controlling member of each said print head and extending along said developer pass orifice row, for applying an oscillation to said developer pass controlling members; and

an oscillation reflecting body, positioned in said developer pass controlling member of each said print head and placed opposite said oscillation applying member across said developer pass orifice row, for reflecting an oscillatory wave transmitted from said oscillation applying member.

63. The image forming device of claim **62**, wherein said plurality of print heads are provided with individual oscillation generating sources each of which is driven independently of the other for driving its oscillation applying member.

64. The image forming device of claim 62, wherein each of said plurality of print heads has said oscillation applying member and said oscillation reflecting body, said oscillation applying member and said oscillation reflecting body being positioned opposite each other across said developer pass orifice so as to be disposed on the front side and on the far side, respectively, with respect to the traveling direction of said image receiving body.

65. The image forming device of claim 62, wherein said oscillation applying members of said plural print heads are connected to a single common oscillation generating source by which said oscillation applying members are oscillated.

66. The image forming device of claim **65**, wherein oscillation cutting-off means, operable to cut off the transfer of an oscillation from said common oscillation generating source to each of said oscillation applying members, is interposed therebetween.

67. An image forming device comprising:

a developer supporting body for supporting and conveying a charged developer;

a developer pass controlling member, having a developer pass orifice row formed of a plurality of developer pass orifices through which said developer passes, for controlling, in response to an external image signal, the passing of said developer supplied from said developer supporting body through said developer pass orifices; and

an image receiving body onto which said developer, which has passed through a developer pass orifice, adheres;

wherein said developer pass controlling member has an insulating substrate in which said developer pass orifices are formed;

wherein a pair of bar-like oscillation transmitting bodies for oscillating said insulating substrate are disposed on said insulating substrate, said oscillation transmitting bodies being positioned opposite each other across said developer pass orifice row and extending along said developer pass orifice row; and

wherein oscillation generating sources are disposed at both ends of each of said pair of oscillation transmitting bodies.

68. An image forming device comprising:

a developer supporting body for supporting and conveying a charged developer;

a developer pass controlling member, having a developer pass orifice row formed of a plurality of developer pass orifices through which said developer passes, for controlling, in response to an external image signal, the passing of said developer supplied from said developer supporting body through a developer pass orifice; and

an image receiving body onto which said developer, which has passed through said developer pass orifice, adheres;

wherein said developer pass controlling member has an insulating substrate in which said developer pass orifices are formed;

wherein bar-like oscillation transmitting bodies for oscillating said insulating substrate are disposed on said insulating substrate, said oscillation transmitting bodies extending along said developer pass orifice row and being positioned opposite each other across said developer pass orifice row; and

wherein one ends of said bar-like oscillation transmitting bodies on said both sides are connected together to form a U-shaped oscillation transmitting body.

69. The image forming device of claim 68, wherein an oscillation generating source is disposed at each end of said oscillation transmitting body.

70. The image forming device of claim 68, wherein the both ends of said U-shaped oscillation transmitting body are connected together to form an annular oscillation transmitting body.

71. The image forming device of claim 70, wherein a plurality of oscillation generating sources are disposed at respective parts of said oscillation transmitting body.

72. The image forming device of any of claims 67, 69, and 71, wherein said oscillation generating sources are so configured as to differ in oscillation phase from each other.

73. The image forming device of any of claims 67-71, wherein said oscillation generating source is so configured as to operate at all times when said developer pass controlling member is in operation.

74. The image forming device of any of claims 67-71 further comprising:

detecting means for detecting whether said developer pass orifice becomes clogged;
wherein said oscillation generating source is so configured as to operate according to the result of said detection.

75. An image forming device comprising:

a developer supporting body for supporting and conveying a charged developer;
a developer pass controlling member, having a developer pass orifice row formed of a plurality of developer pass orifices through which said developer passes, for controlling, in response to an external image signal, the passing of said developer supplied from said developer supporting body through a developer pass orifice; and
an image receiving body onto which said developer, which has passed through said developer pass orifice, adheres;
wherein said developer pass controlling member has an insulating substrate in which said developer pass orifices are formed;
wherein an oscillation transmitting body, one end of which is fixed to said insulating substrate whereas the other end is oscillatably configured so as to cause said insulating substrate to be oscillated, is disposed on each side of said developer pass orifice row of said insulating substrate, extending along said developer pass orifice row; and
wherein an oscillation generating source is disposed on said oscillation transmitting body.

76. The image forming device of claim 75,

wherein said oscillation transmitting body is formed into a flat plate-like shape extending along said developer pass orifice row and an end of said flat plate-like oscillation transmitting body on the far side thereof with respect to said developer pass orifice row is fixed to said insulating substrate; and
a plurality of said oscillation generating sources are disposed along said developer pass orifice row.

77. The image forming device of claim 75,

wherein said oscillation transmitting body is formed into a comb-like shape extending along said developer pass orifice row and an end of each of comb teeth of said comb-like oscillation transmitting body on the far side thereof with respect to said developer pass orifice row is fixed to said insulating substrate; and
wherein said oscillation generating source is disposed on each of said comb teeth.

78. The image forming device of claim 76 or claim 77, wherein said oscillation generating sources disposed on said oscillation transmitting bodies on said both sides of said developer pass orifice row are arranged at the same pitch and oscillation generating sources on one side of said developer pass orifice row are so arranged as to be half-pitch deviated with respect to oscillation generating sources on the other side.

79. The image forming device of claim 76 or claim 77,

wherein each of said oscillation generating sources is oscillated by application of a voltage; and
wherein the phases of voltages that are applied to said oscillation generating sources on said oscillation transmitting bodies on each side are the same.

80. The image forming device of claim 76 or claim 77,

wherein each of said oscillation generating sources is oscillated by application of a voltage; and
wherein the phases of voltages that are applied to said oscillation generating sources on said oscillation transmitting bodies on each side are deviated from each other.

81. The image forming device of claim 76 or claim 77, wherein an oscillatory system, made up of said oscillation transmitting body on each side, said oscillation generating source on each side, and said insulating substrate, is so configured as not to cause a node at the position of each said developer pass orifice.

82. The image forming device of claim 81, wherein said oscillatory system is so configured as to be either a primary oscillatory mode or a tertiary oscillatory mode.

Fig. 1

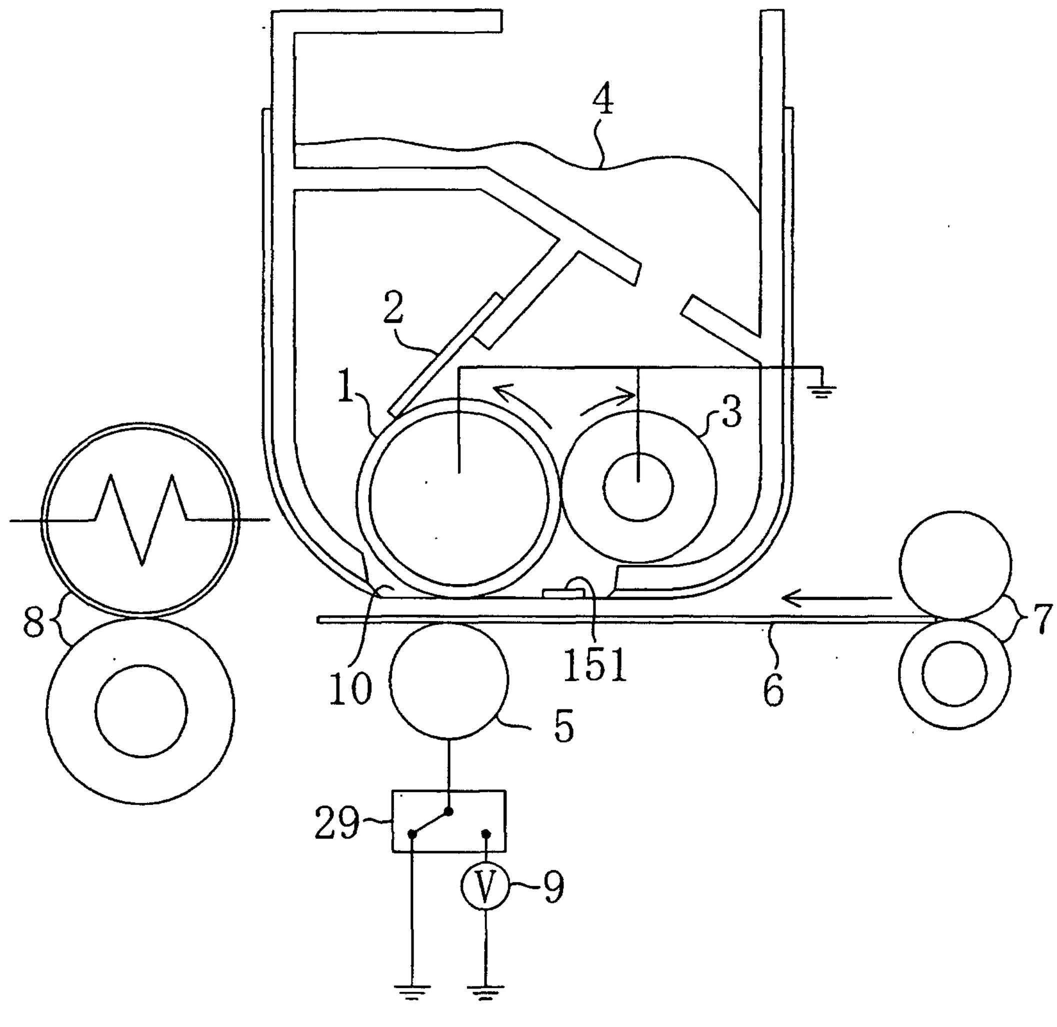

Fig. 2A

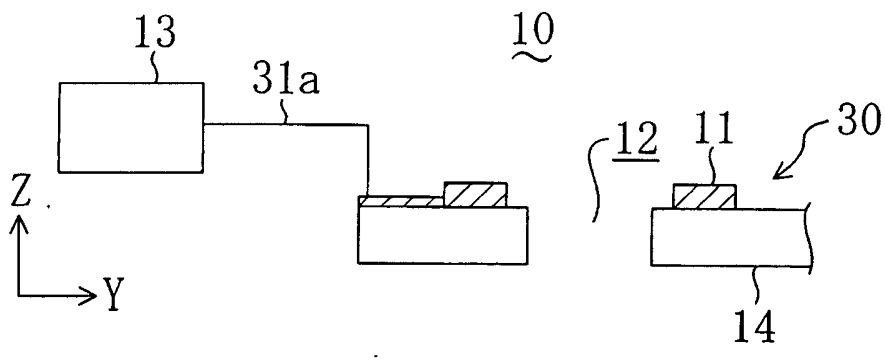

Fig. 2B

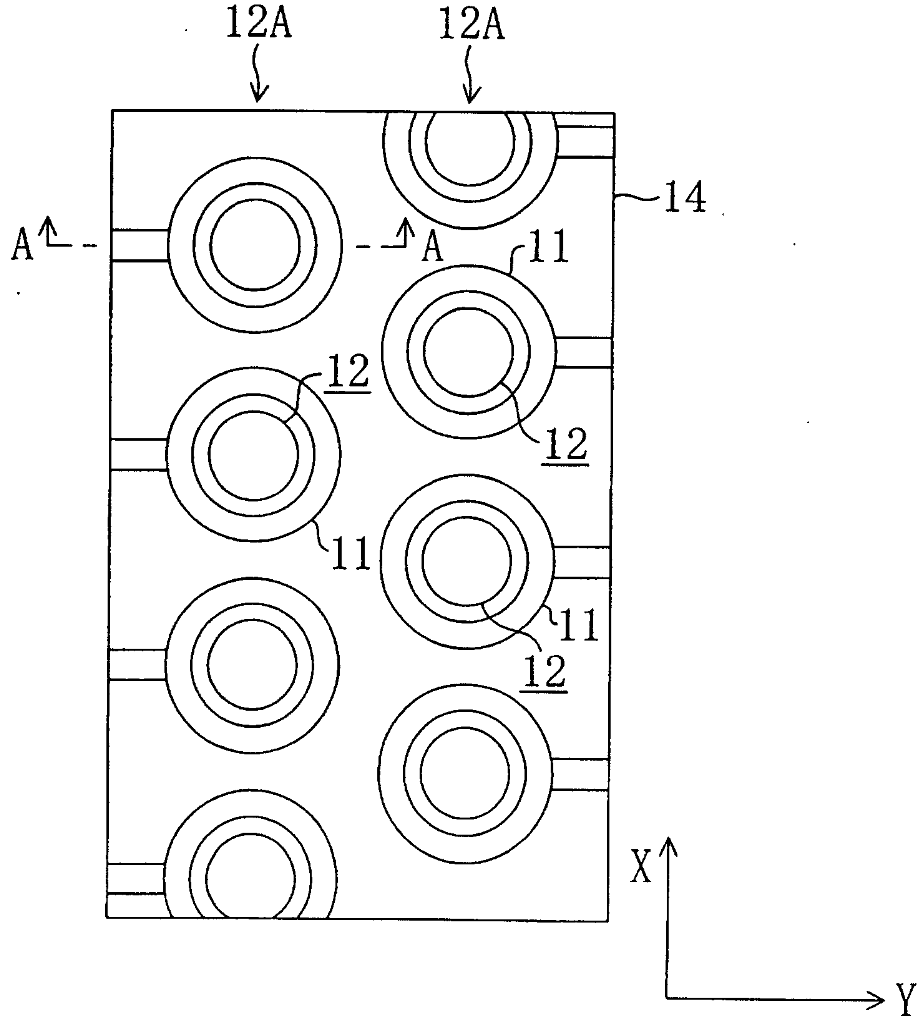

Fig. 3

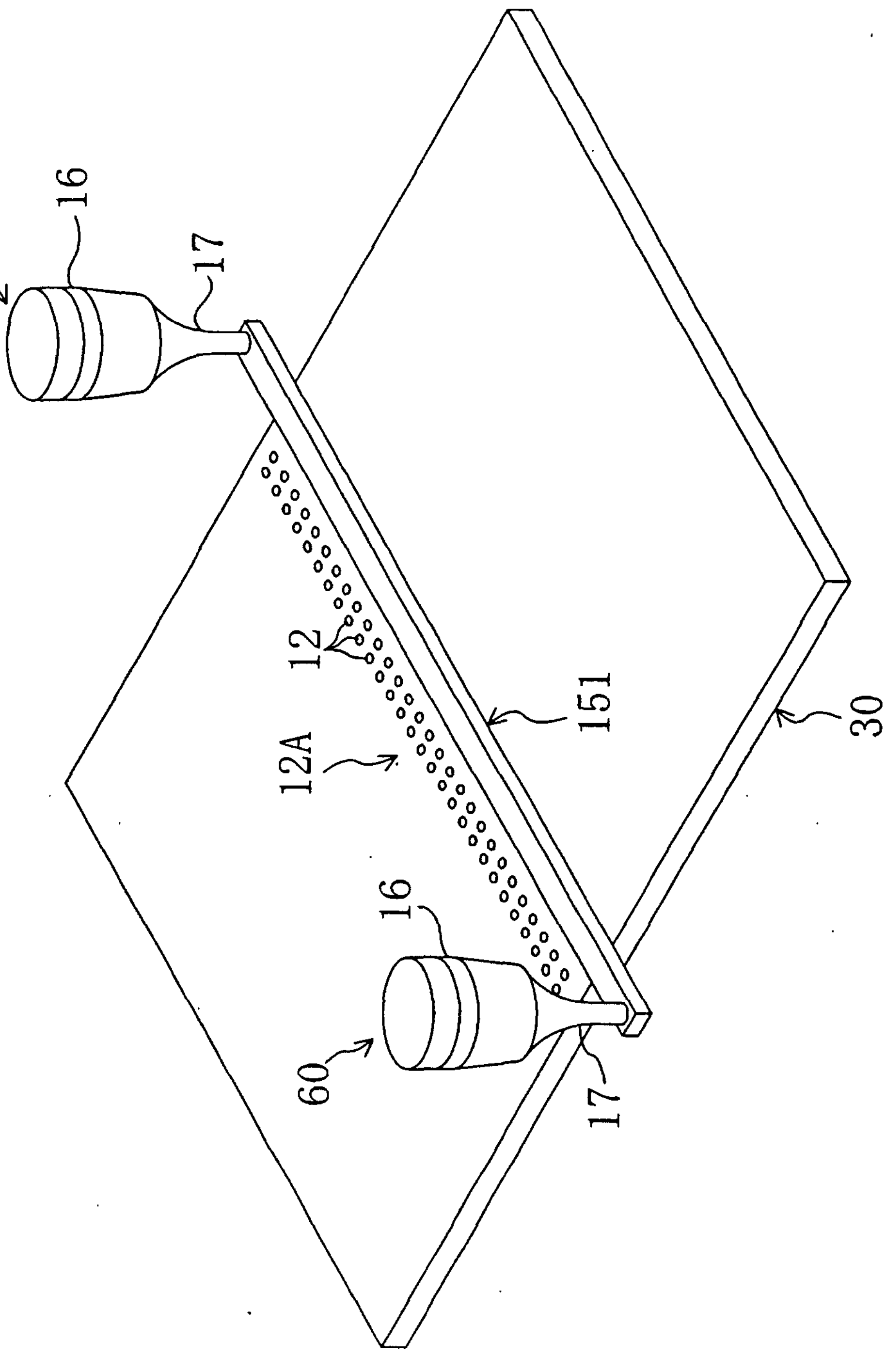

Fig. 4

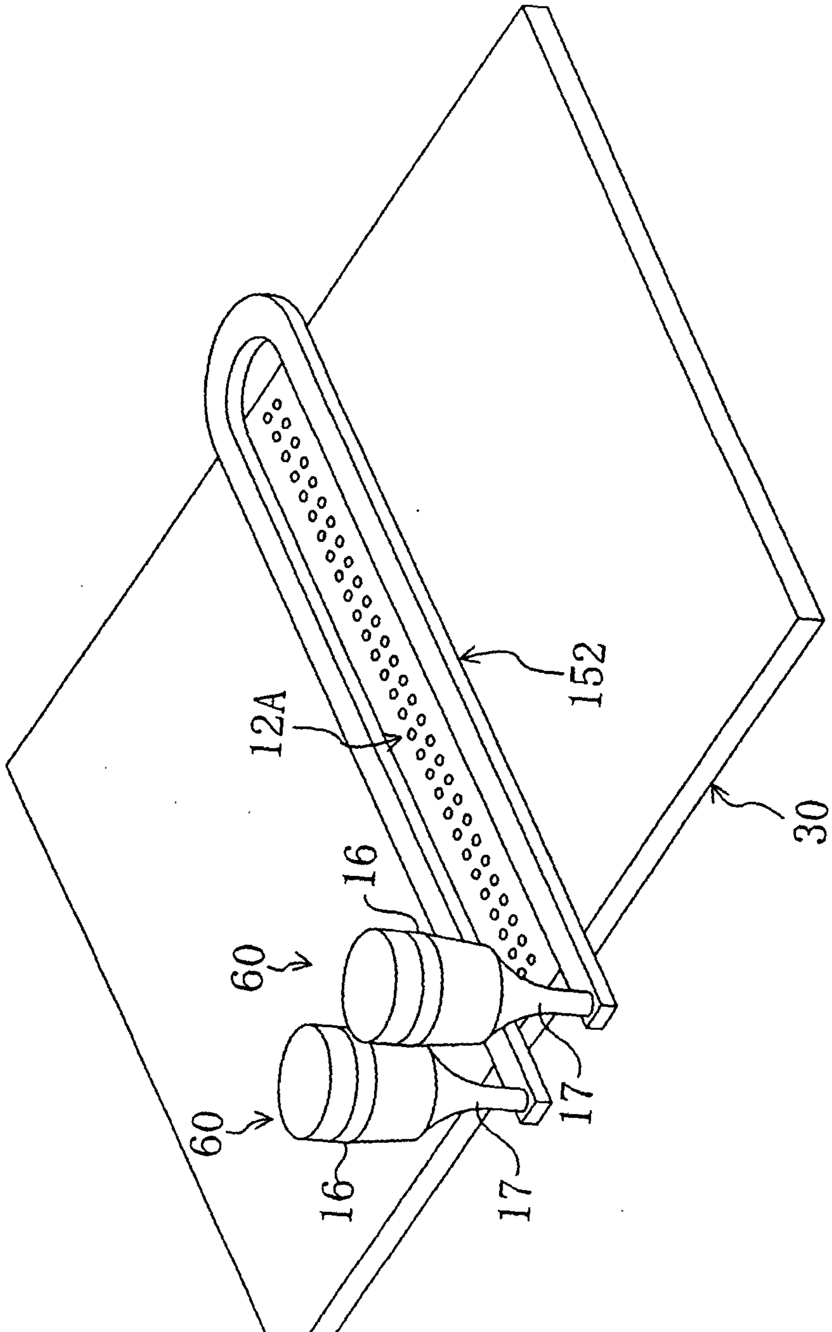

Fig. 5

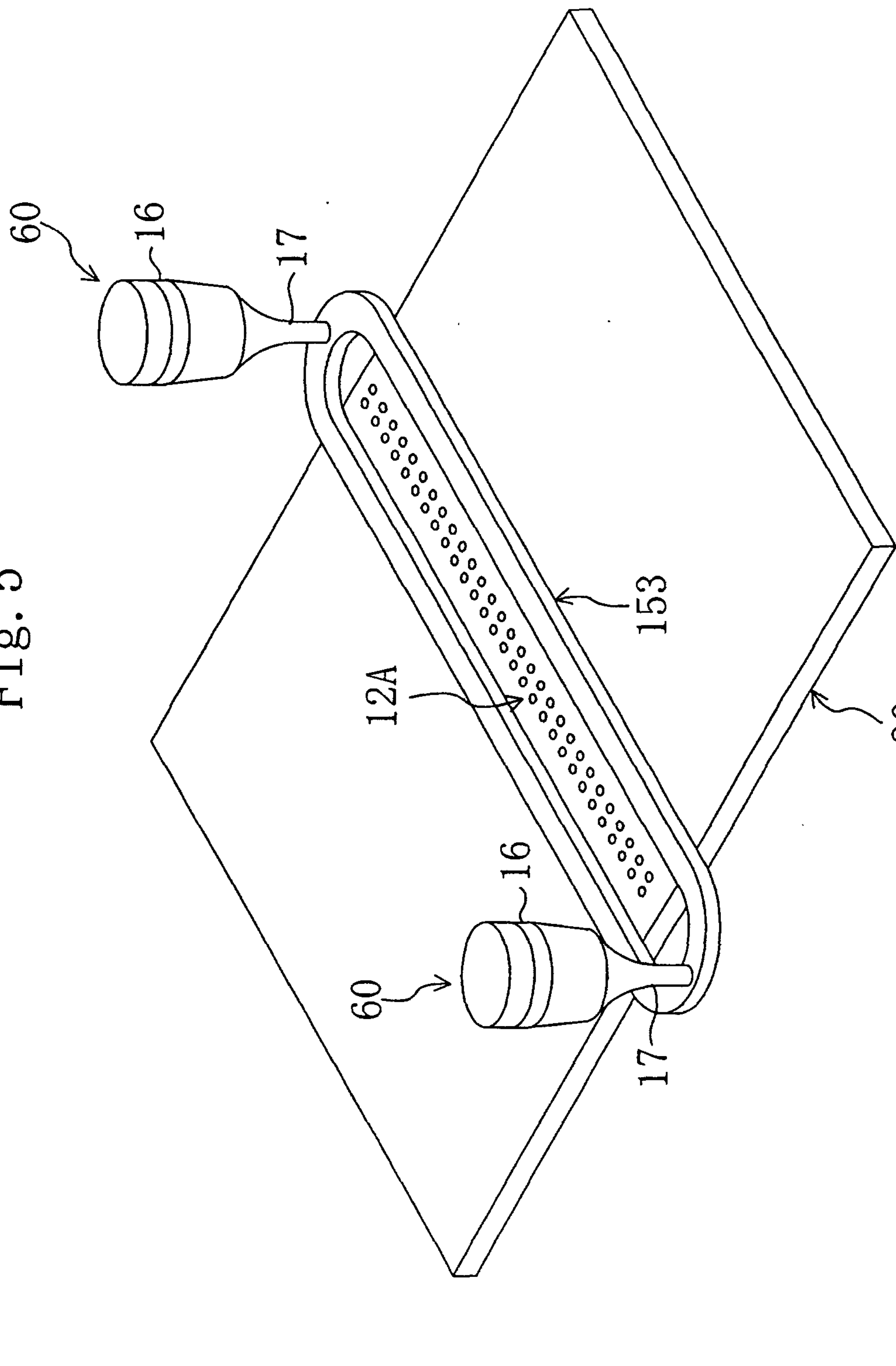

Fig. 6

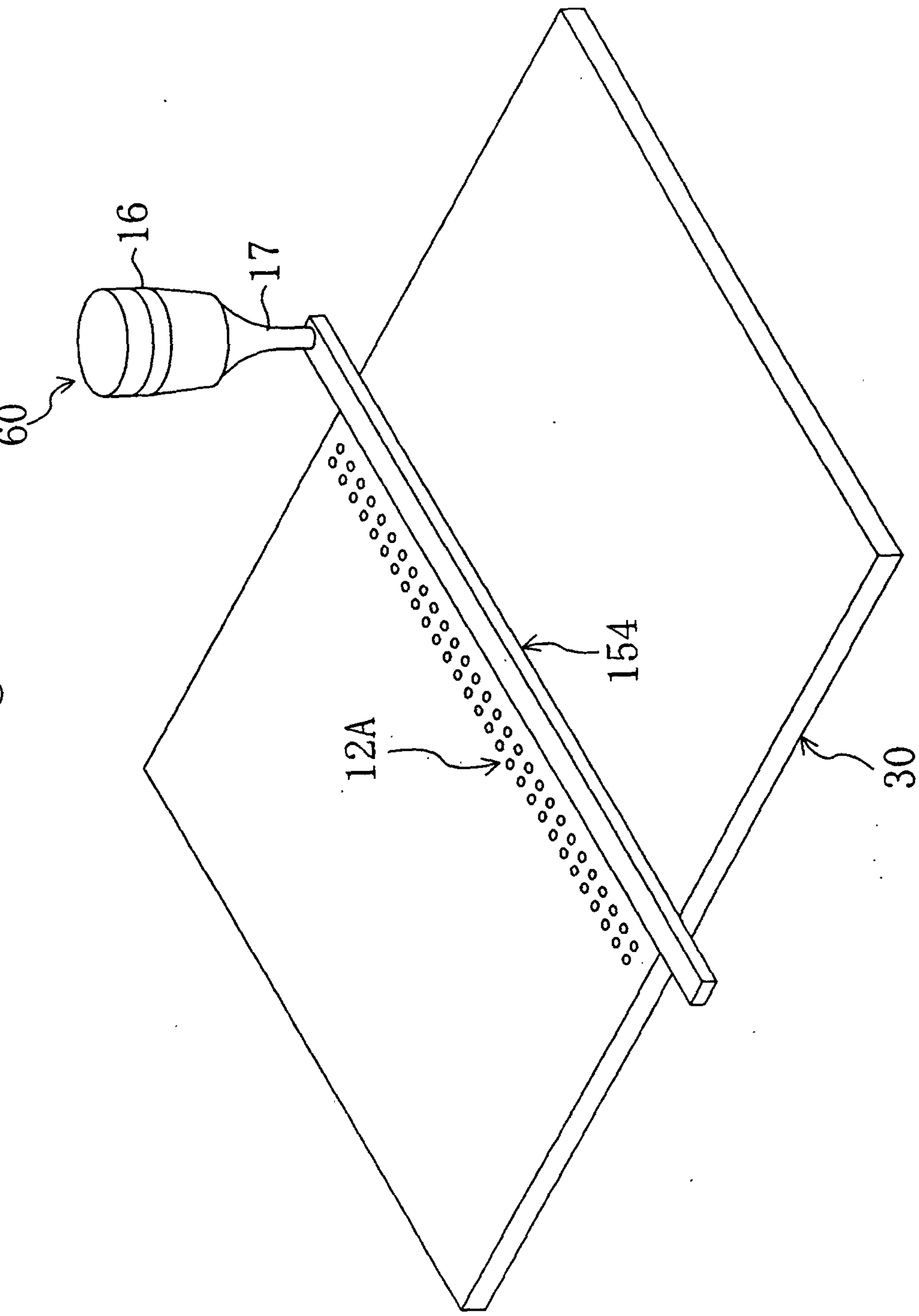

Fig. 7

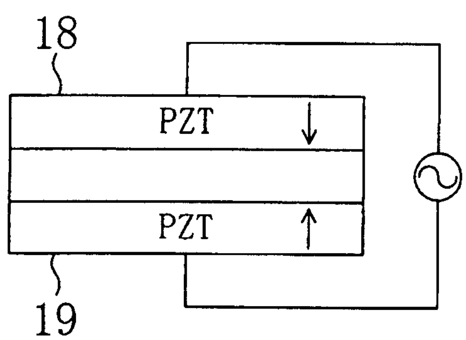

Fig. 8

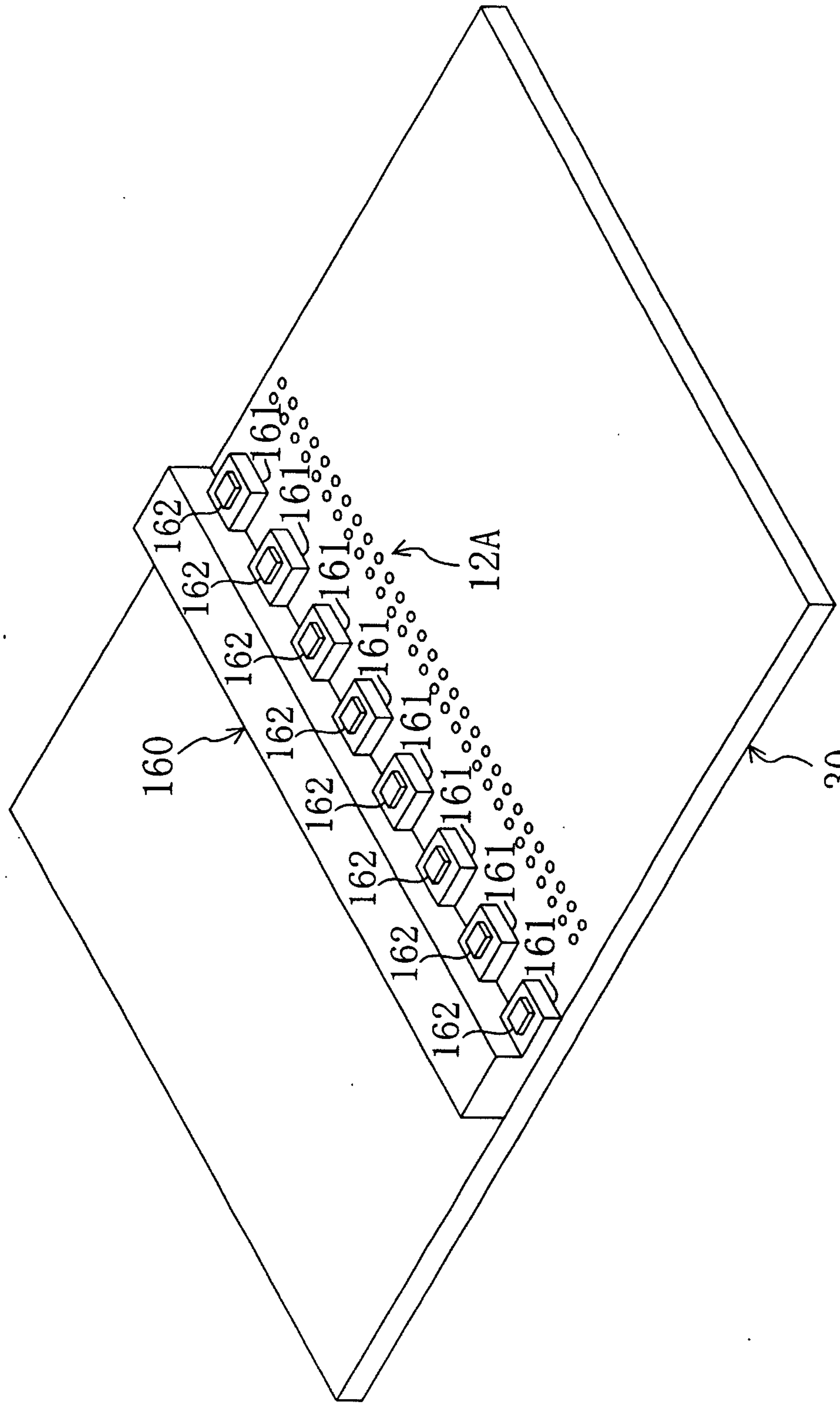

Fig. 9

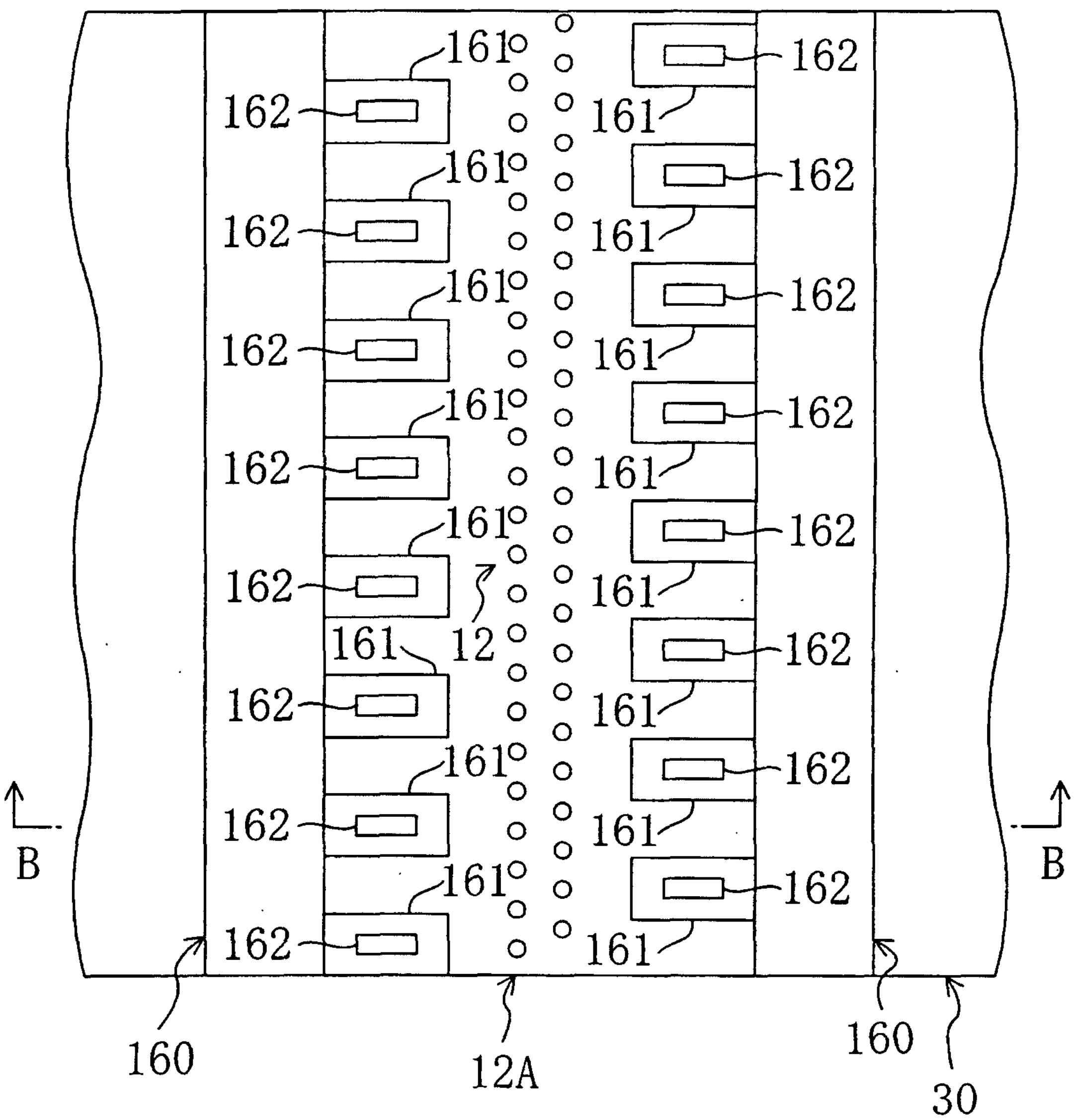
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Fig. 10

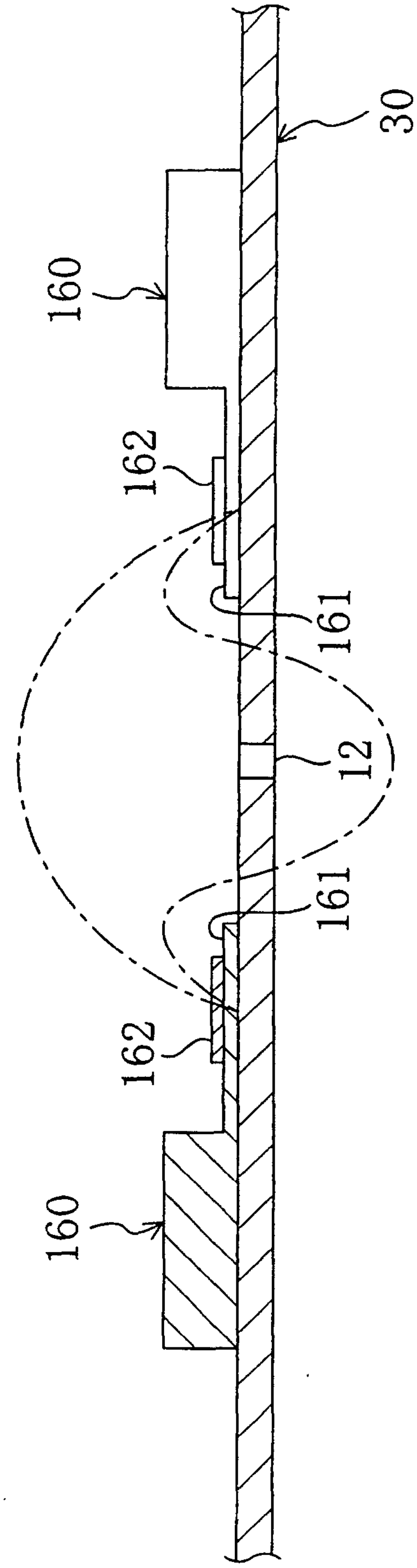


Fig. 11

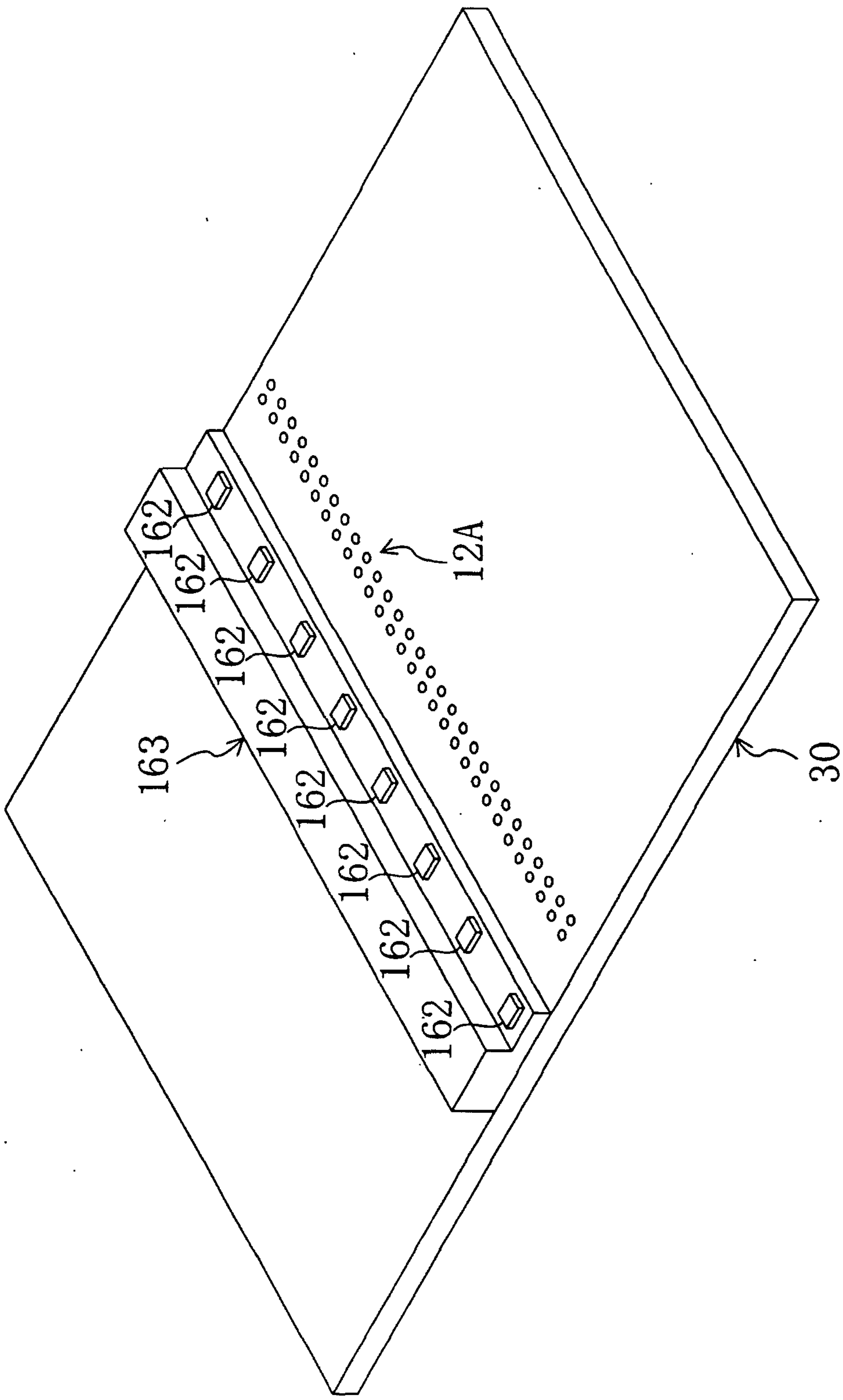


Fig. 12

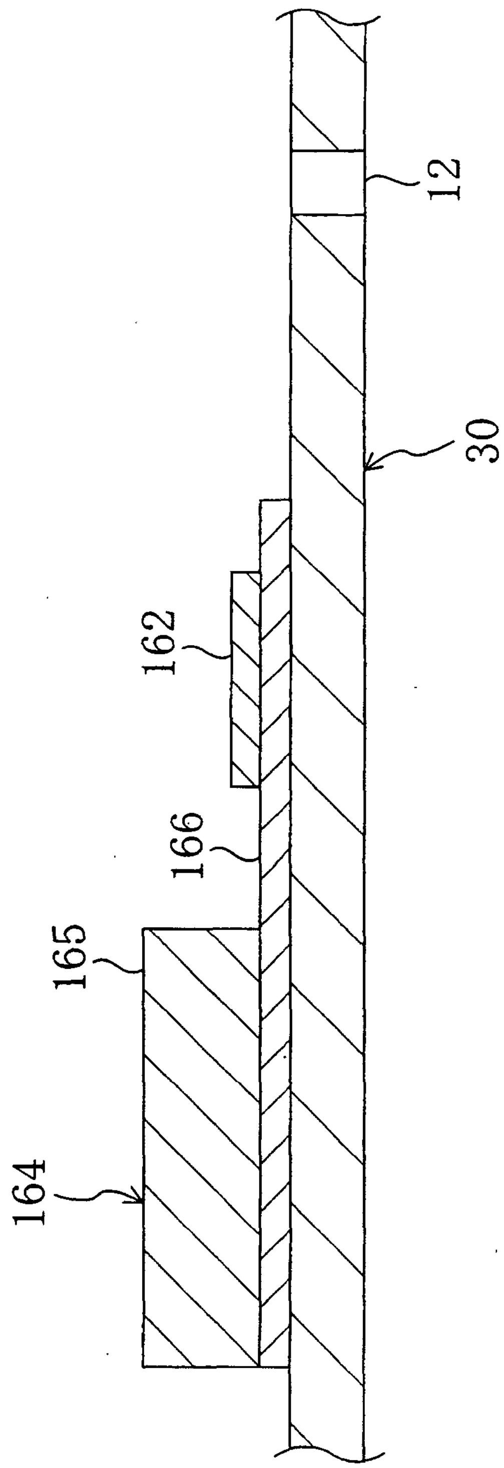


Fig. 13

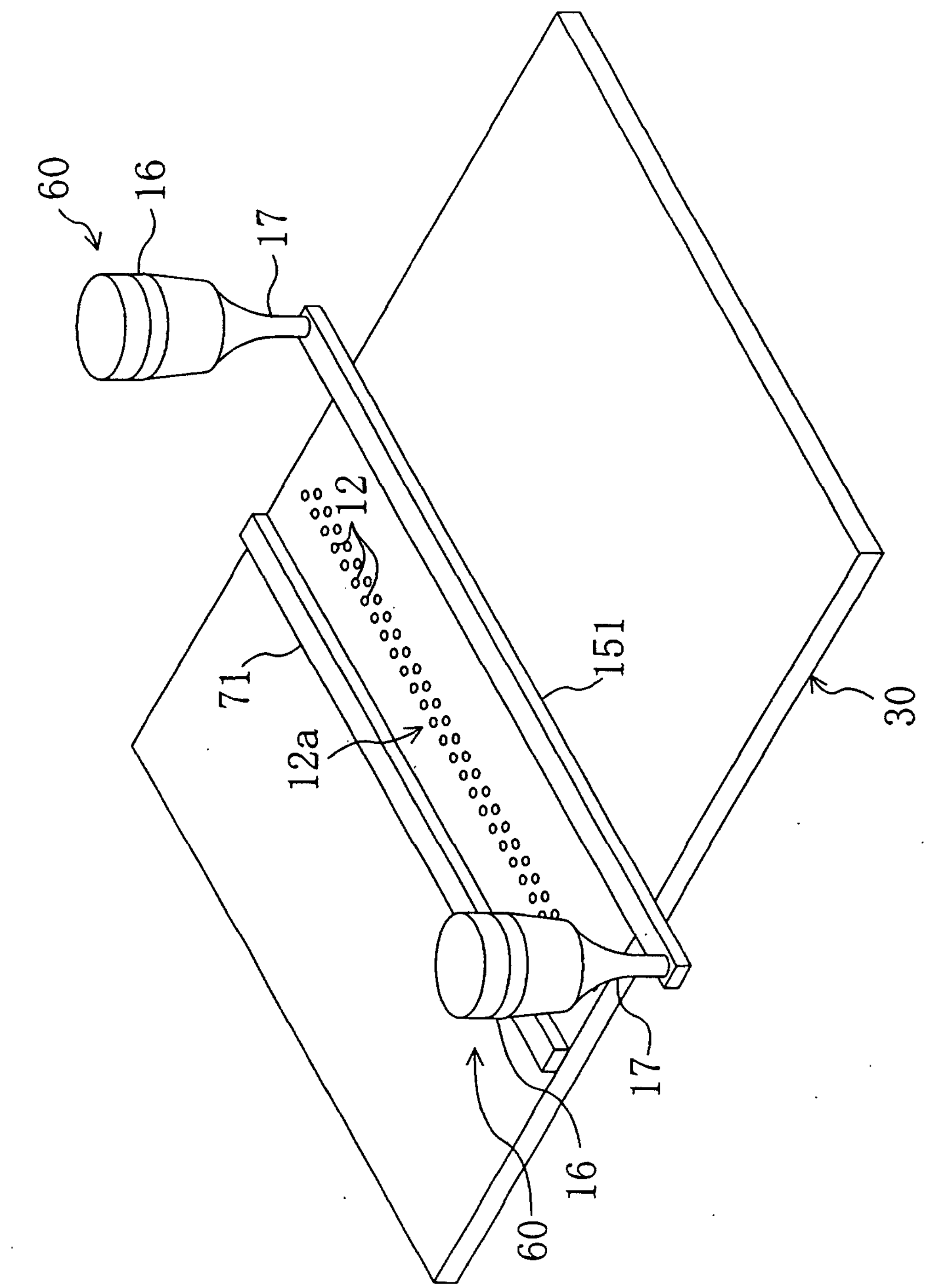


Fig. 14

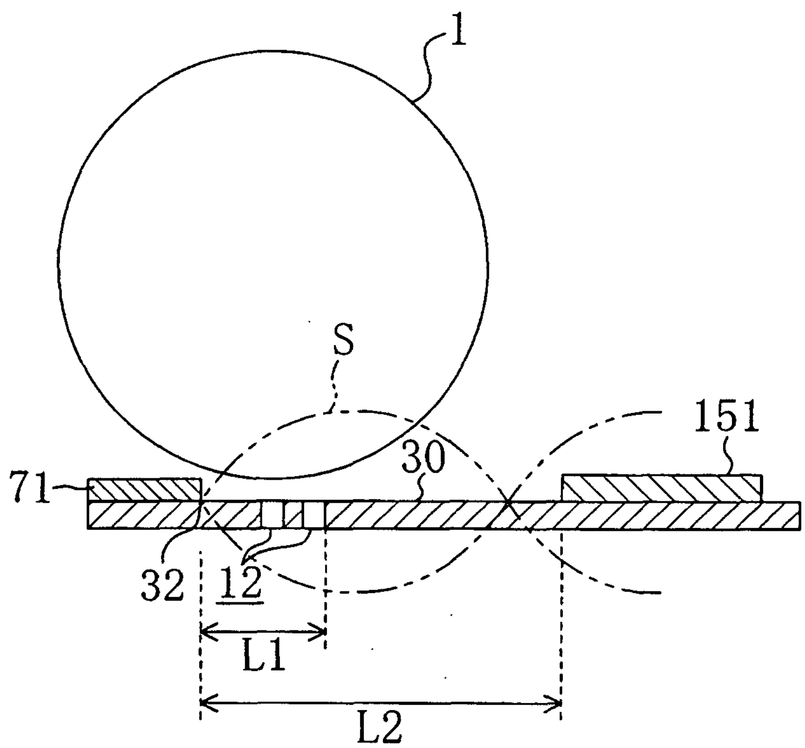


Fig. 15

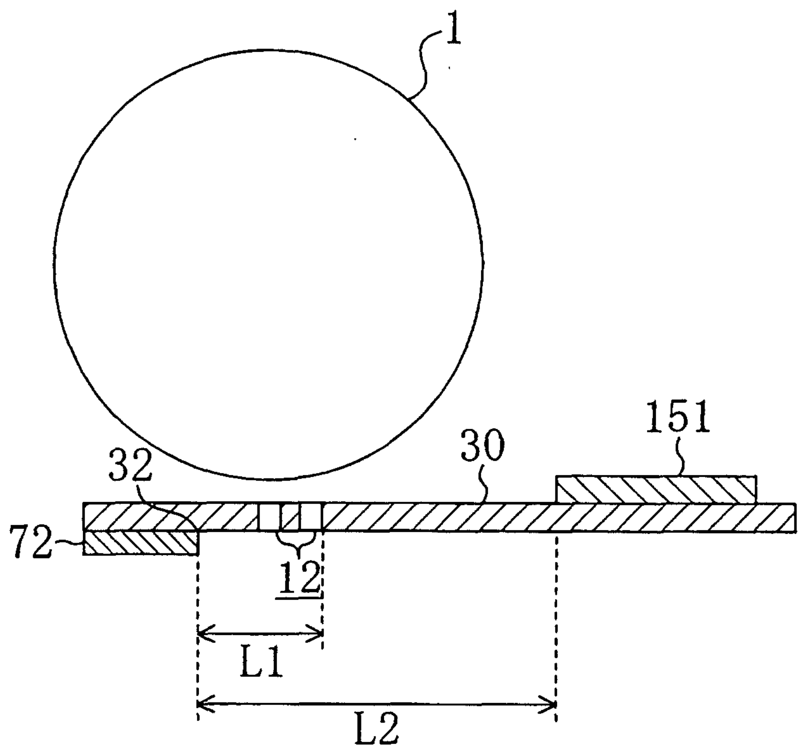


Fig. 16

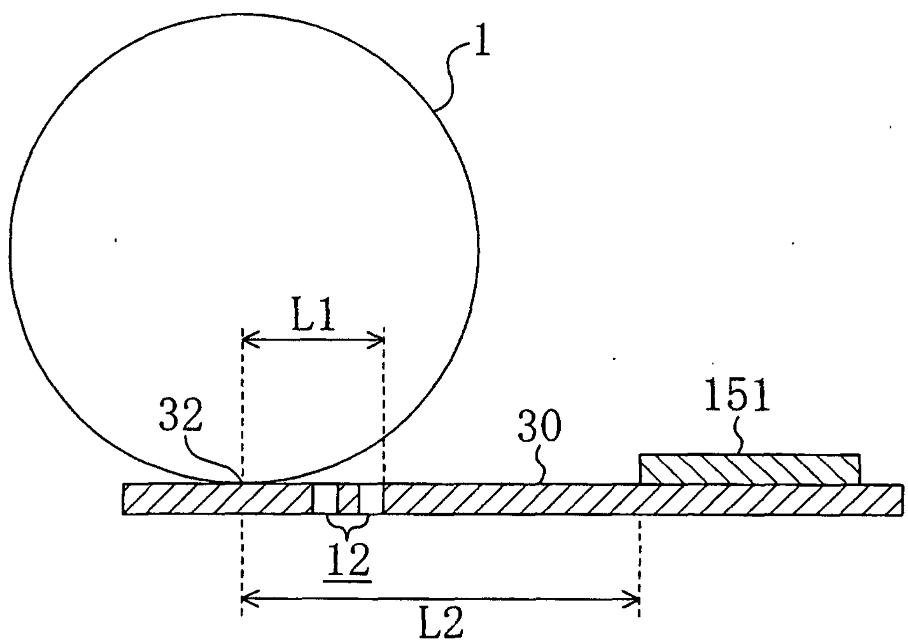


Fig. 17

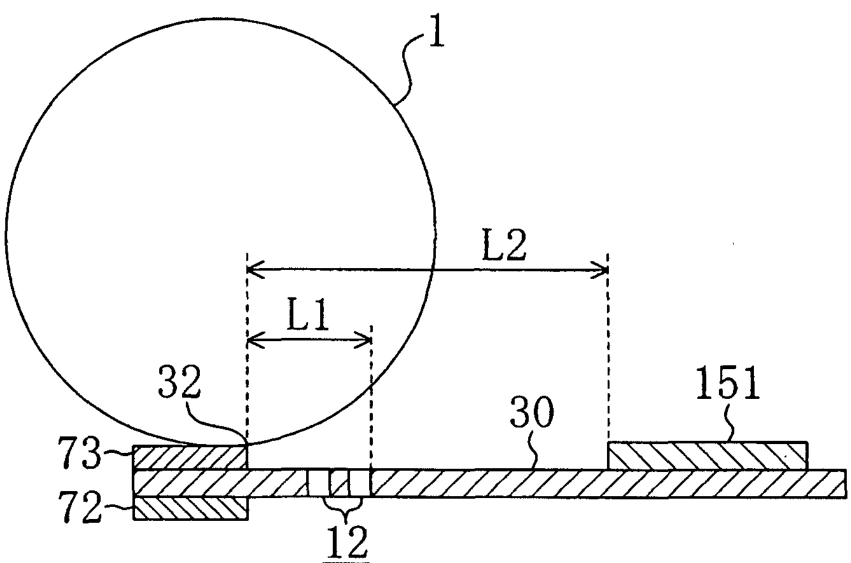


Fig. 18

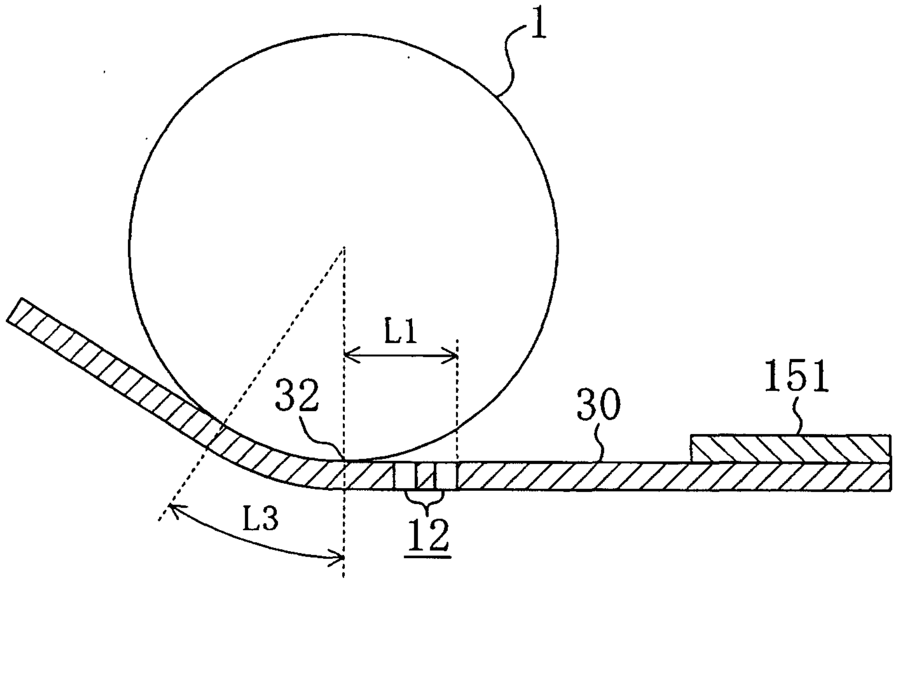


Fig. 19

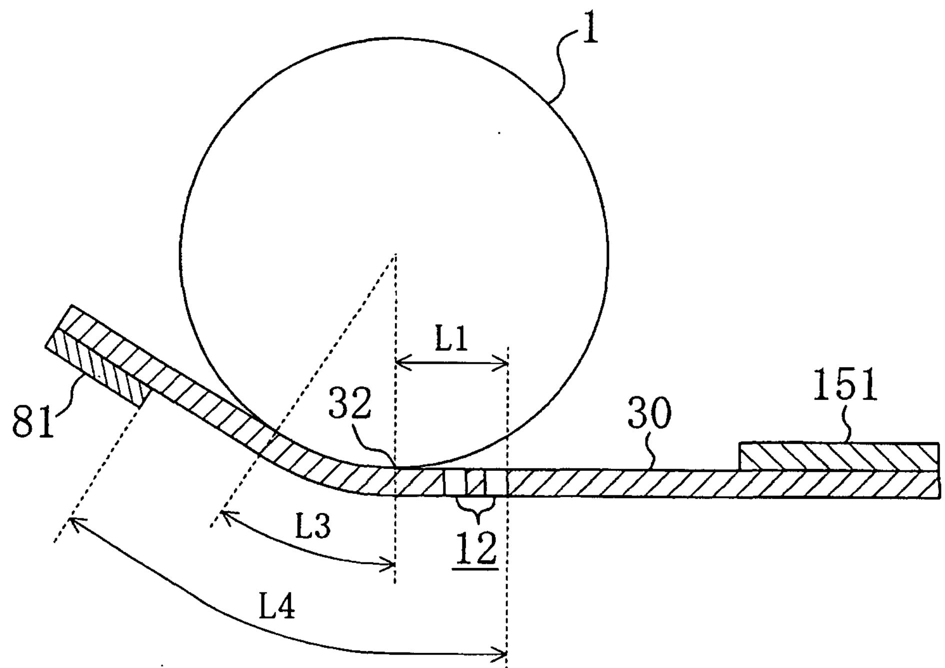


Fig. 20

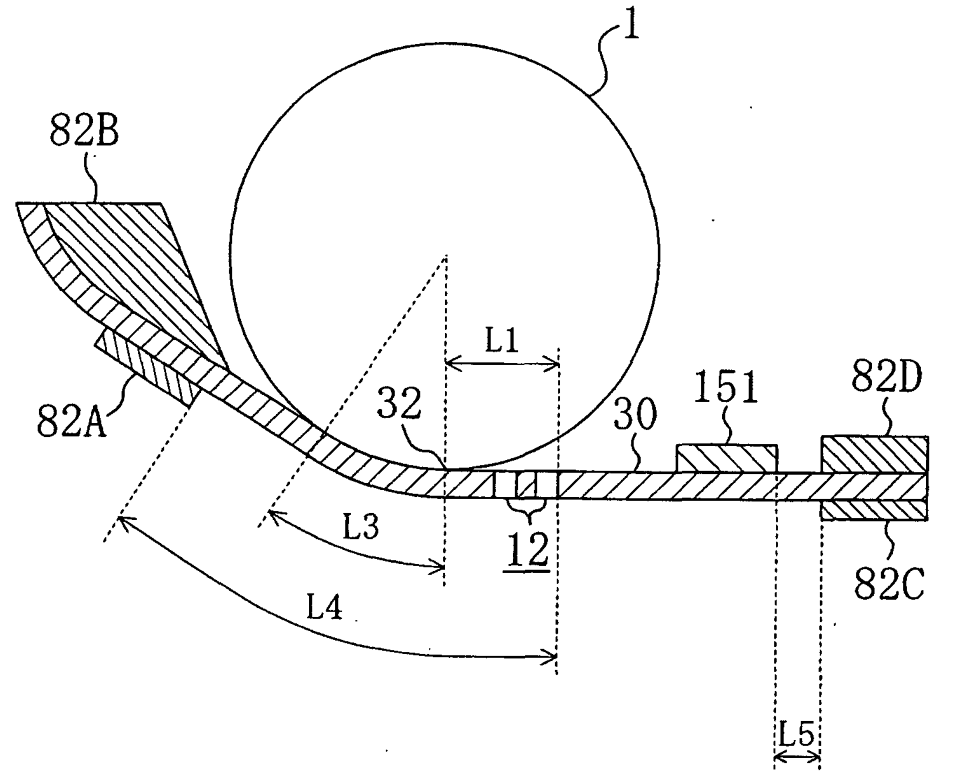


Fig. 21

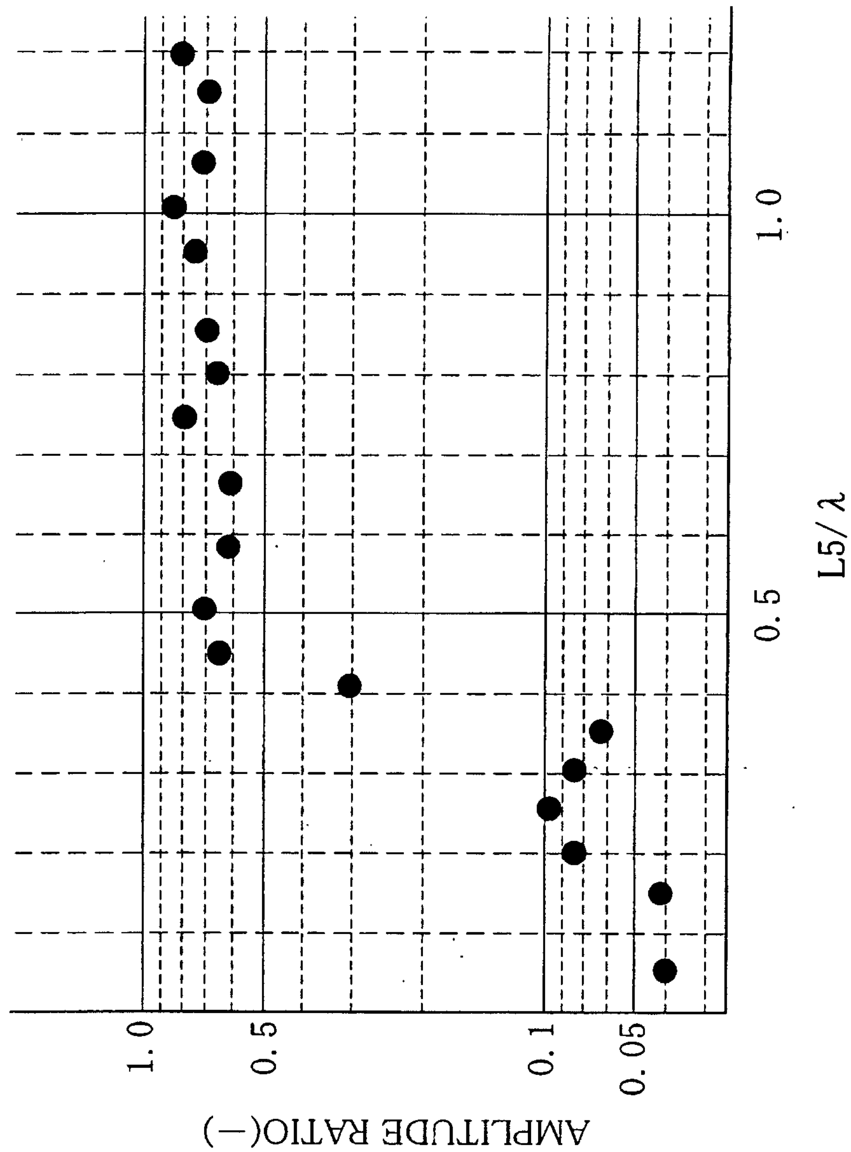


Fig. 22

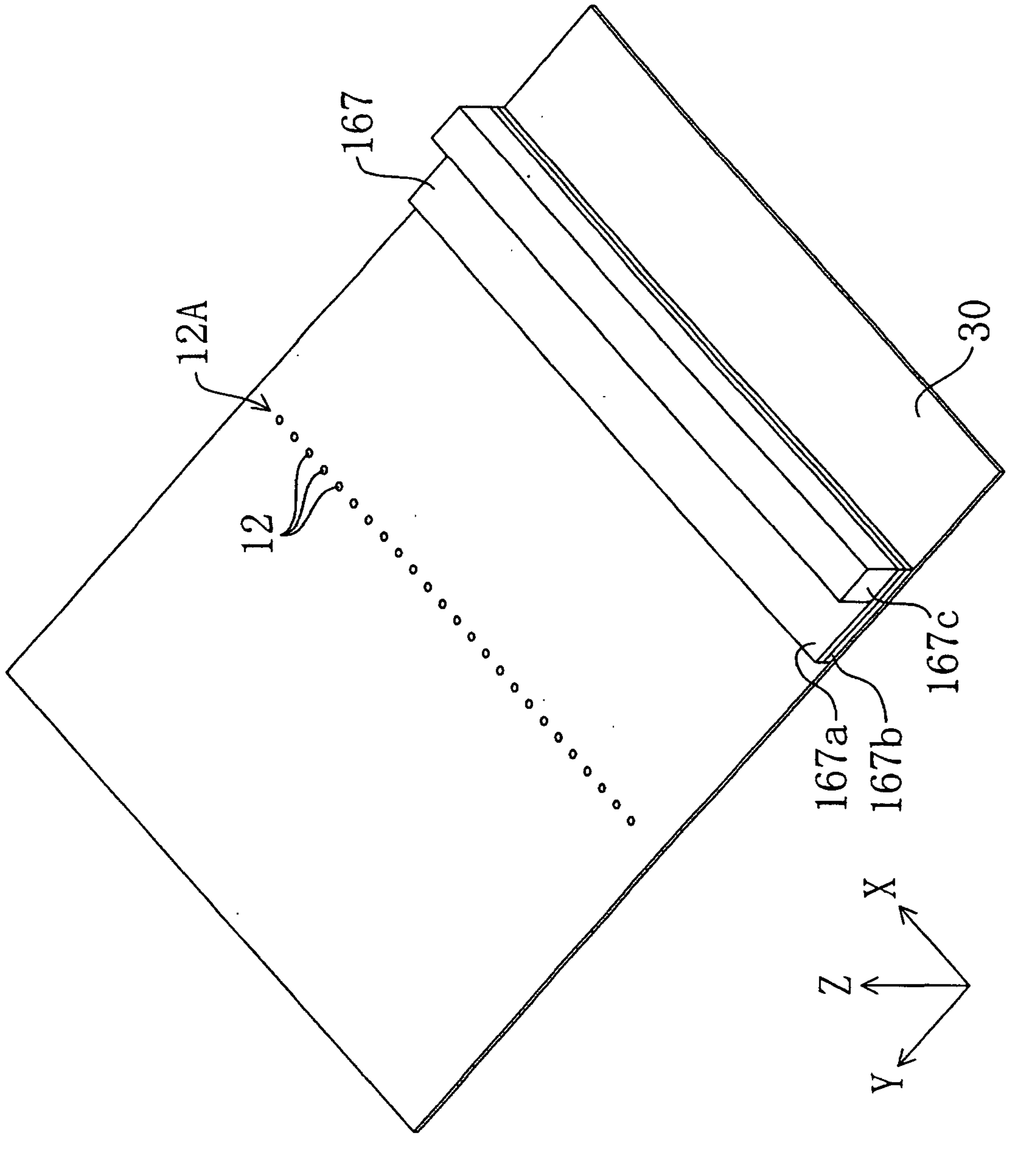


Fig. 23

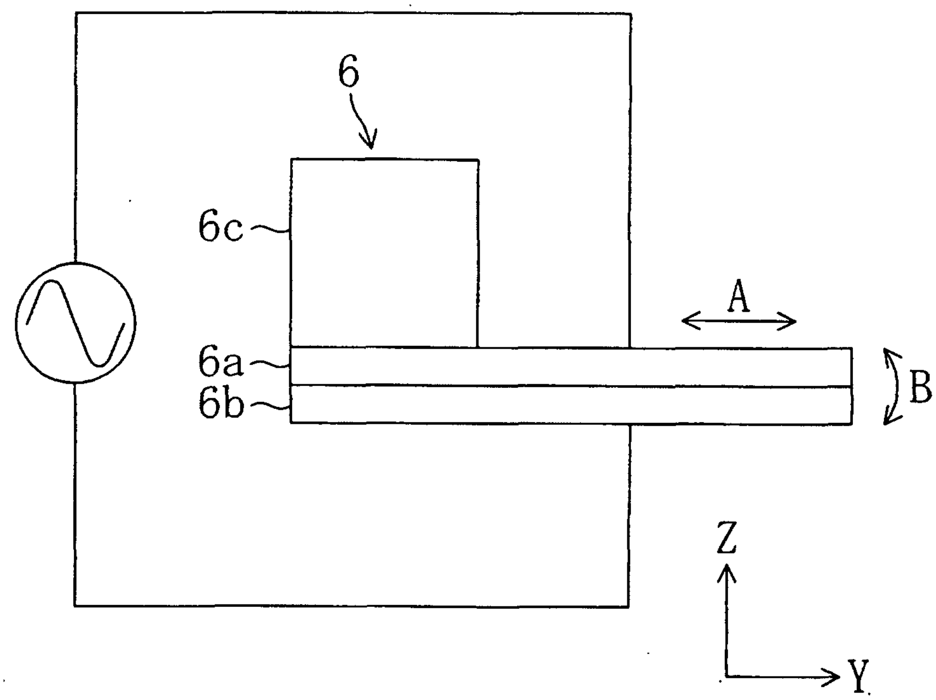


Fig. 24

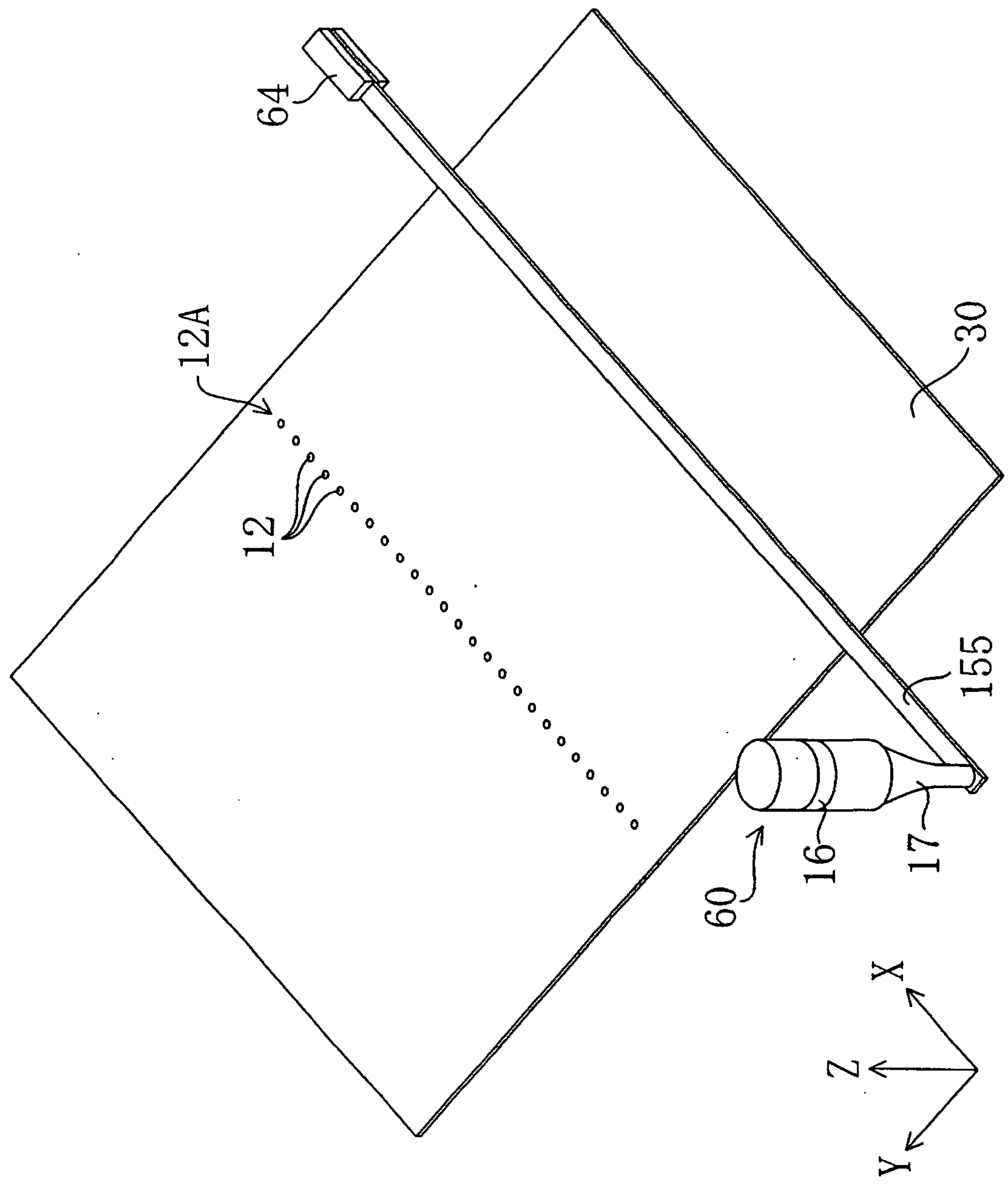


Fig. 25A

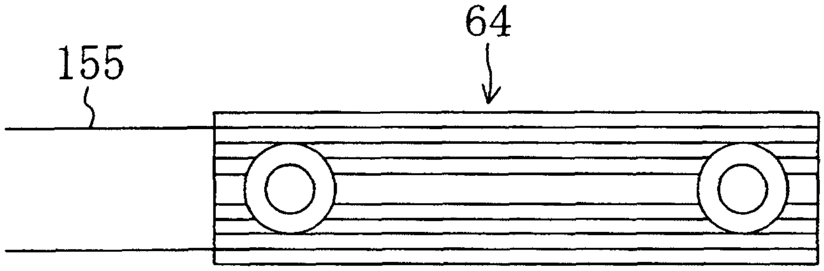


Fig. 25B

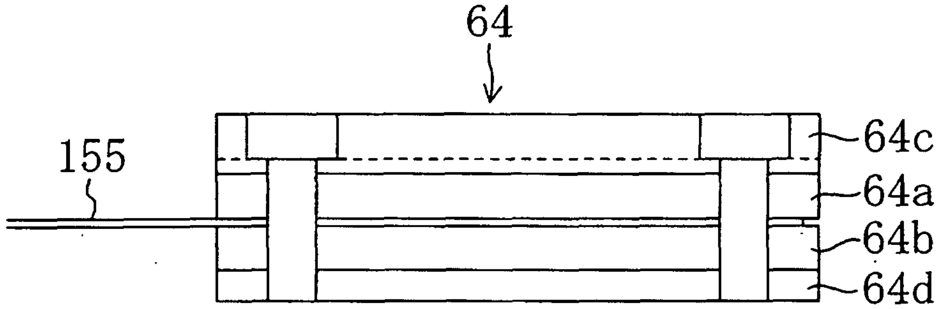


Fig. 25C

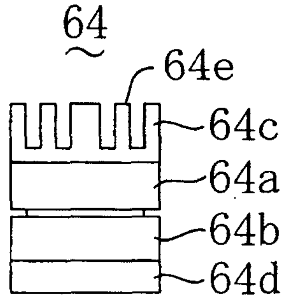


Fig. 26

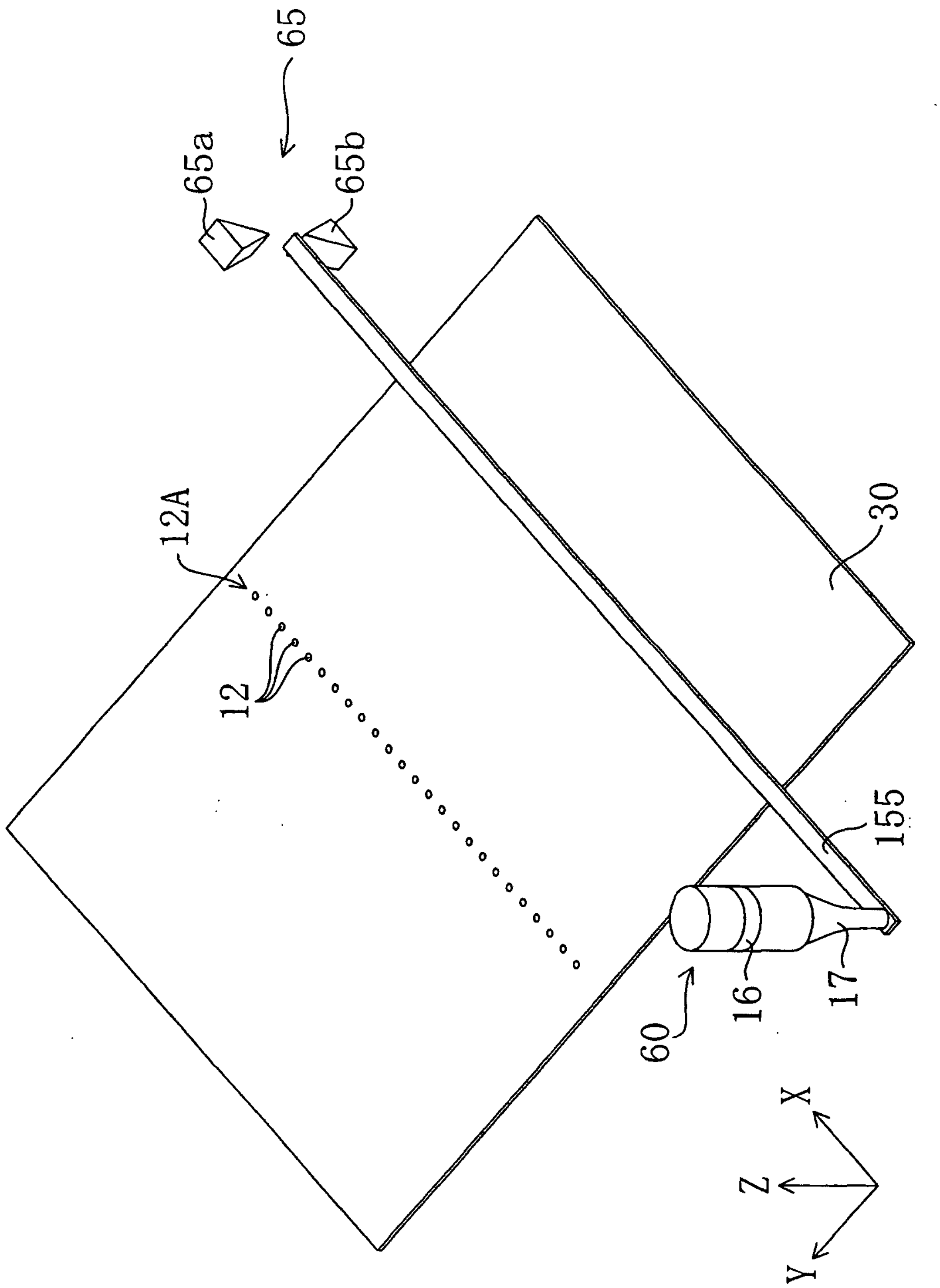


Fig. 27

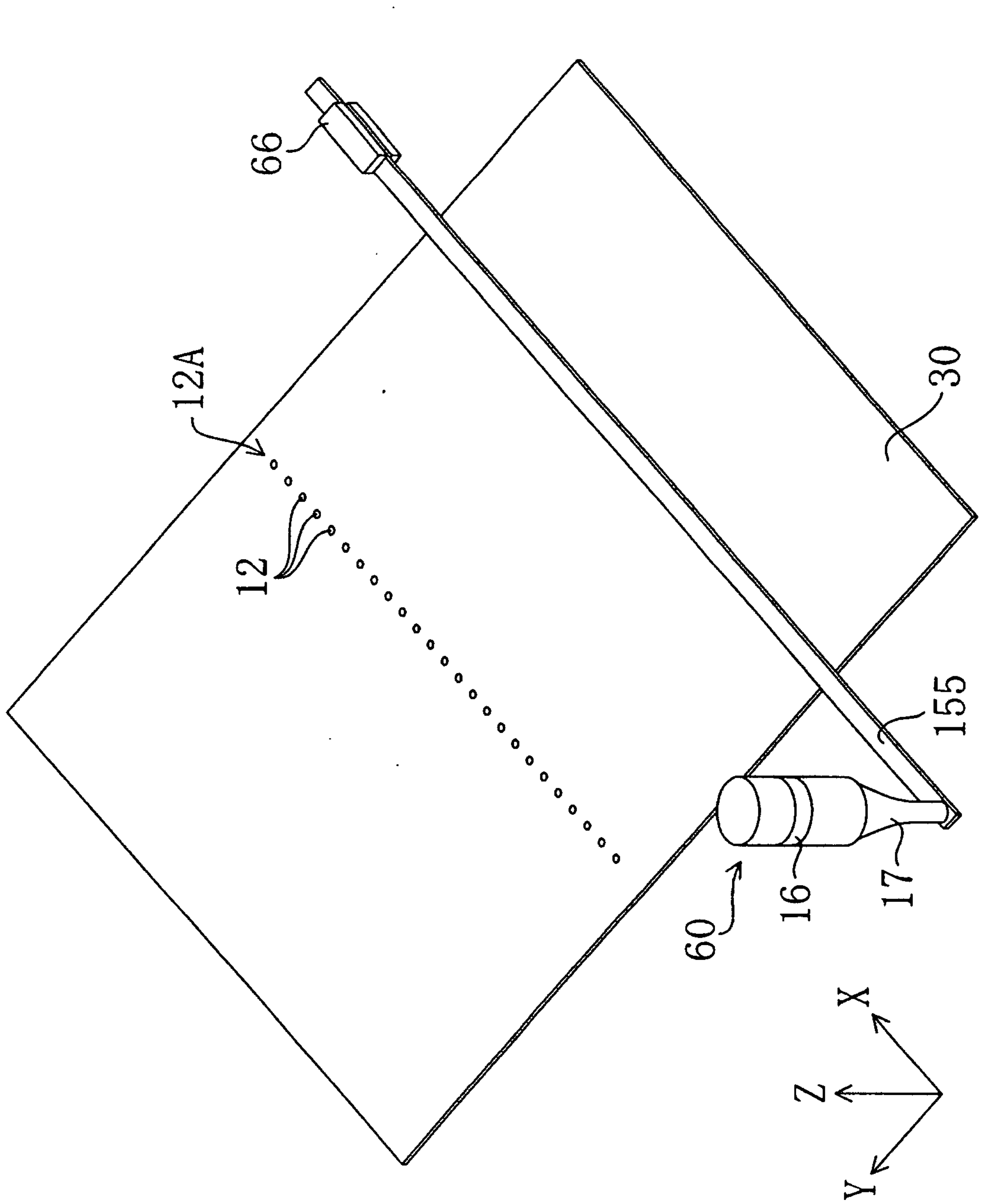


Fig. 28

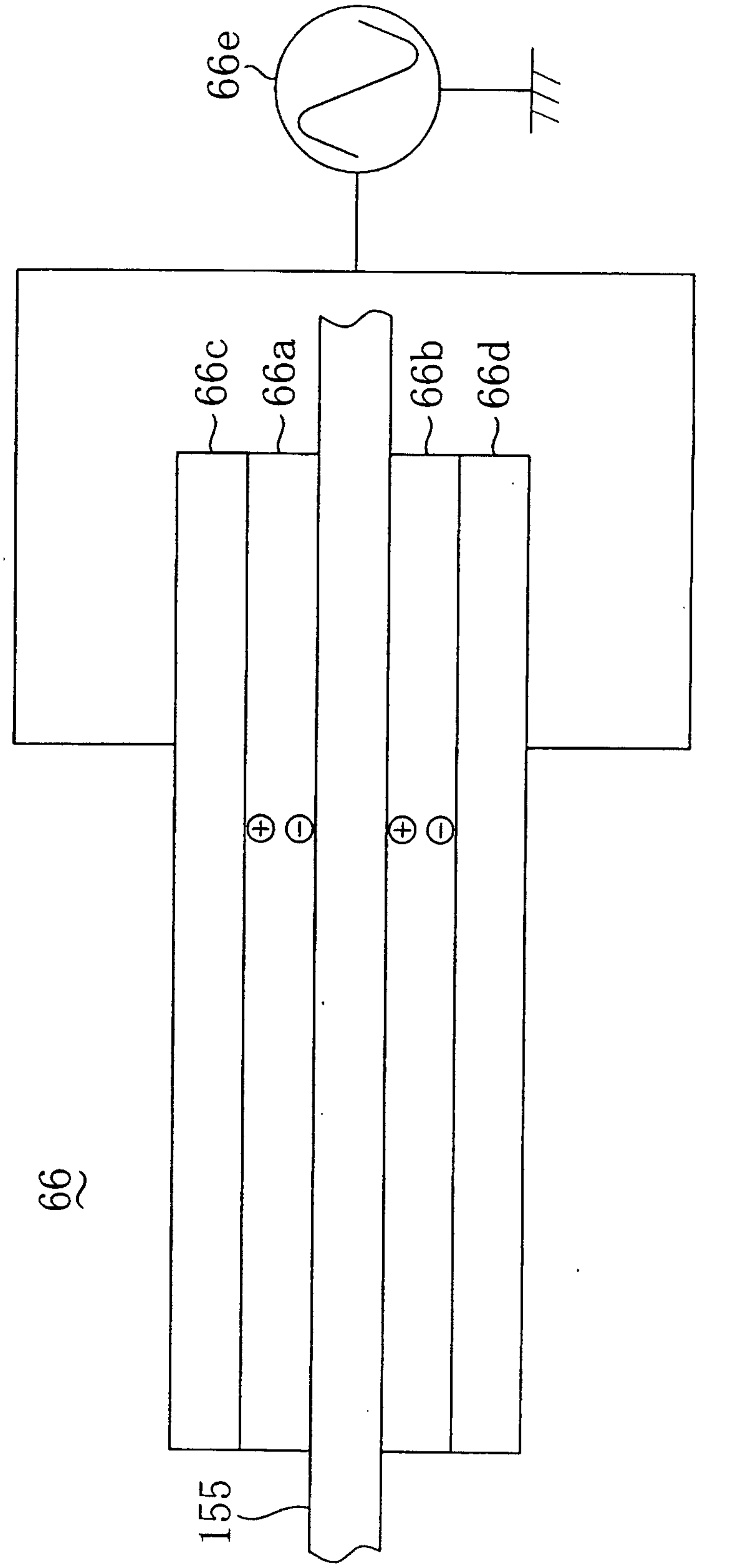


Fig. 29

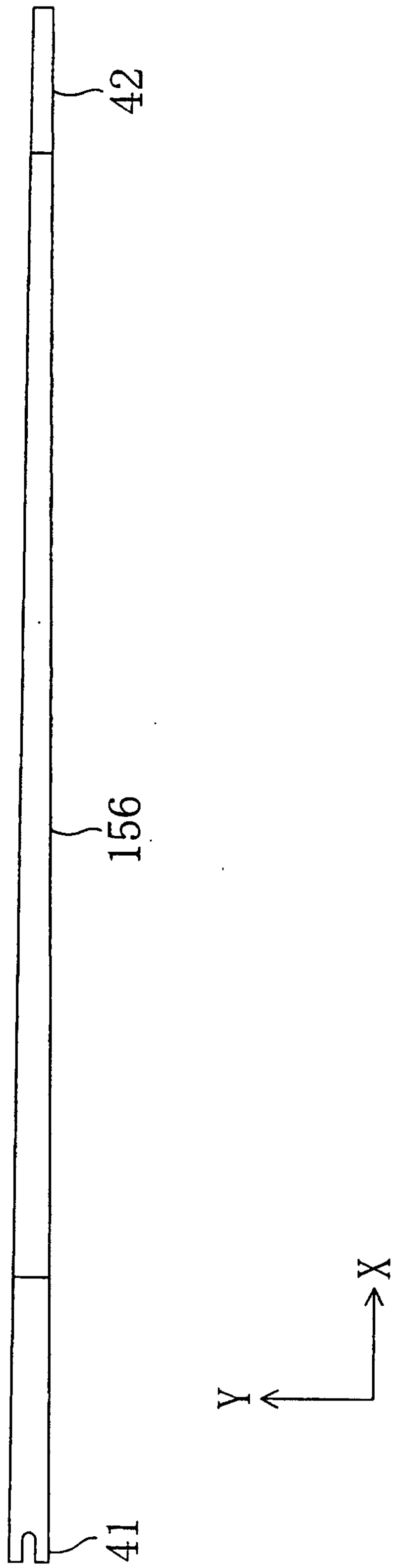


Fig. 30

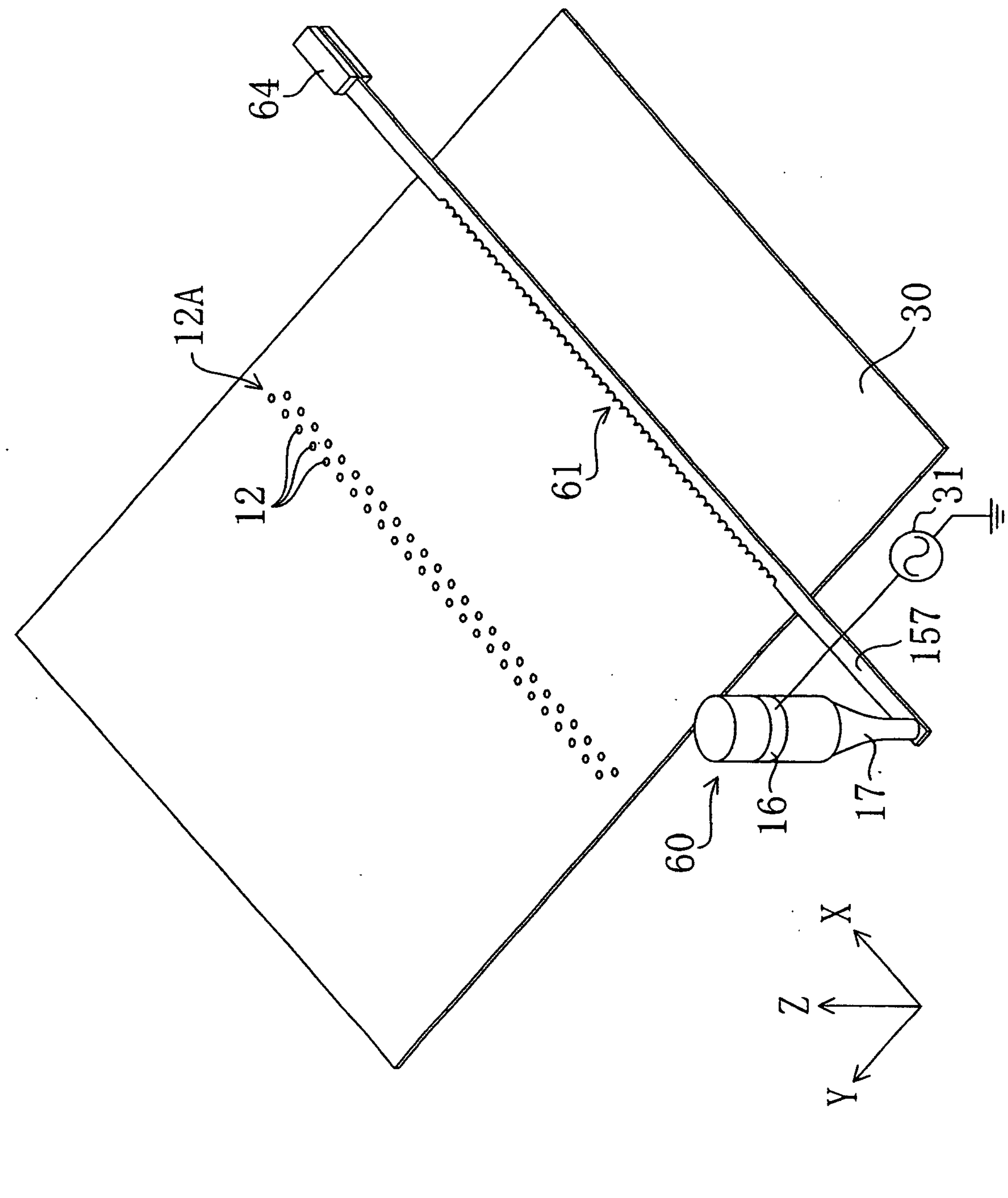


Fig. 31A

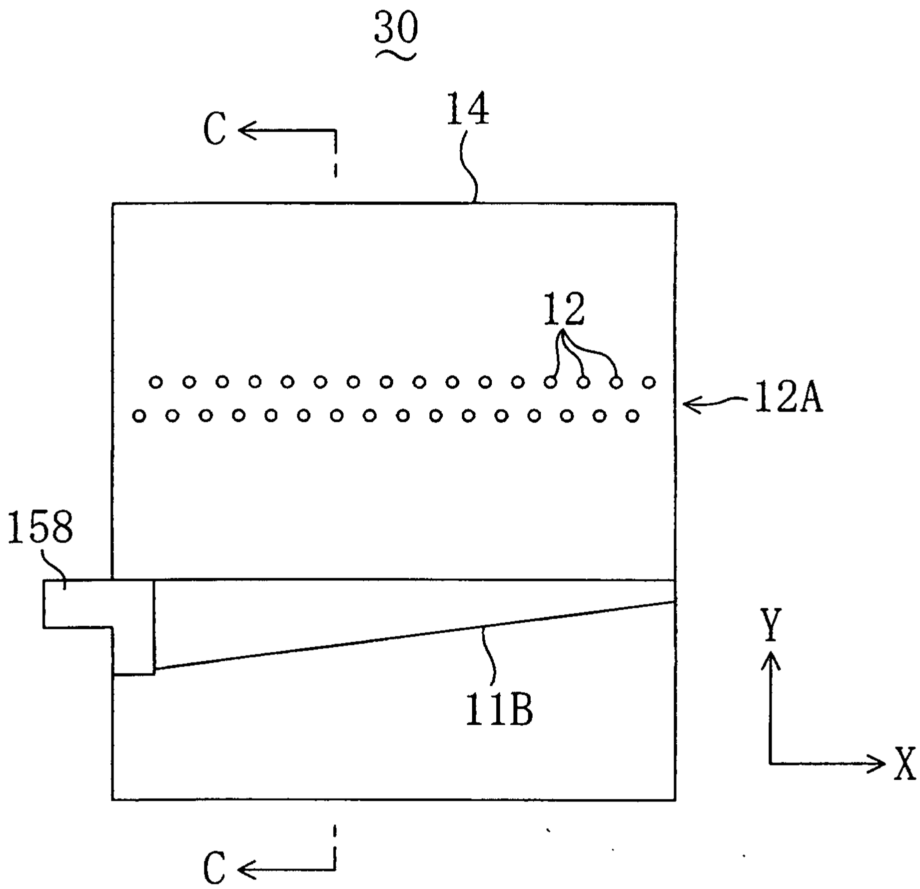
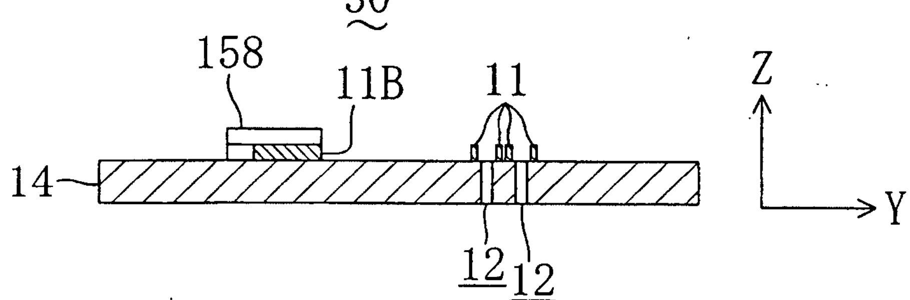


Fig. 31B



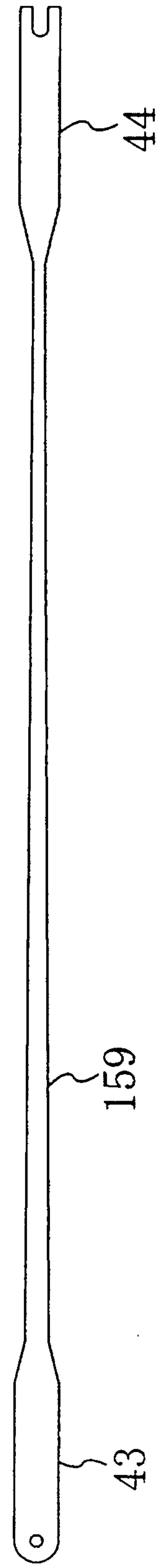


Fig. 32

Fig. 33

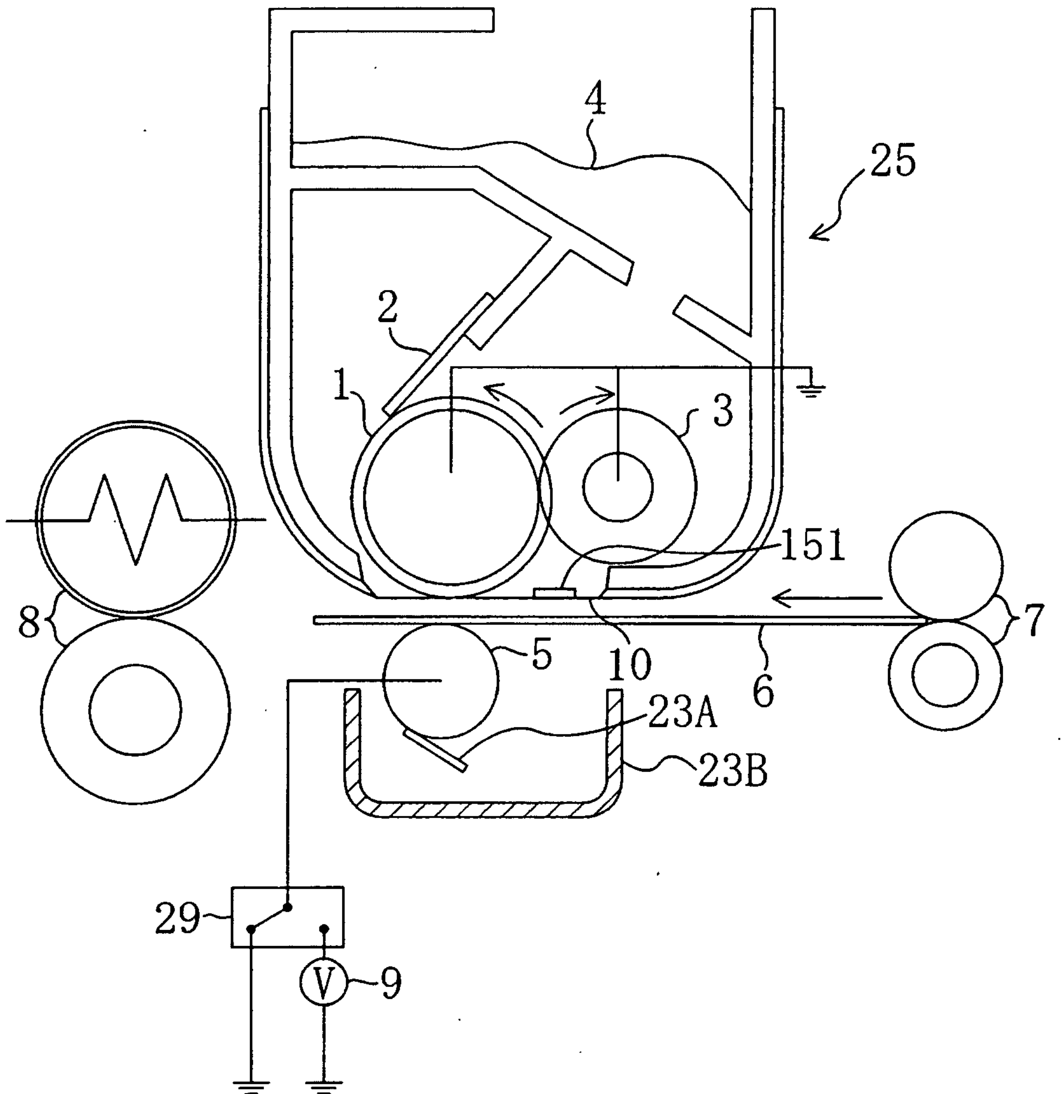


Fig. 34

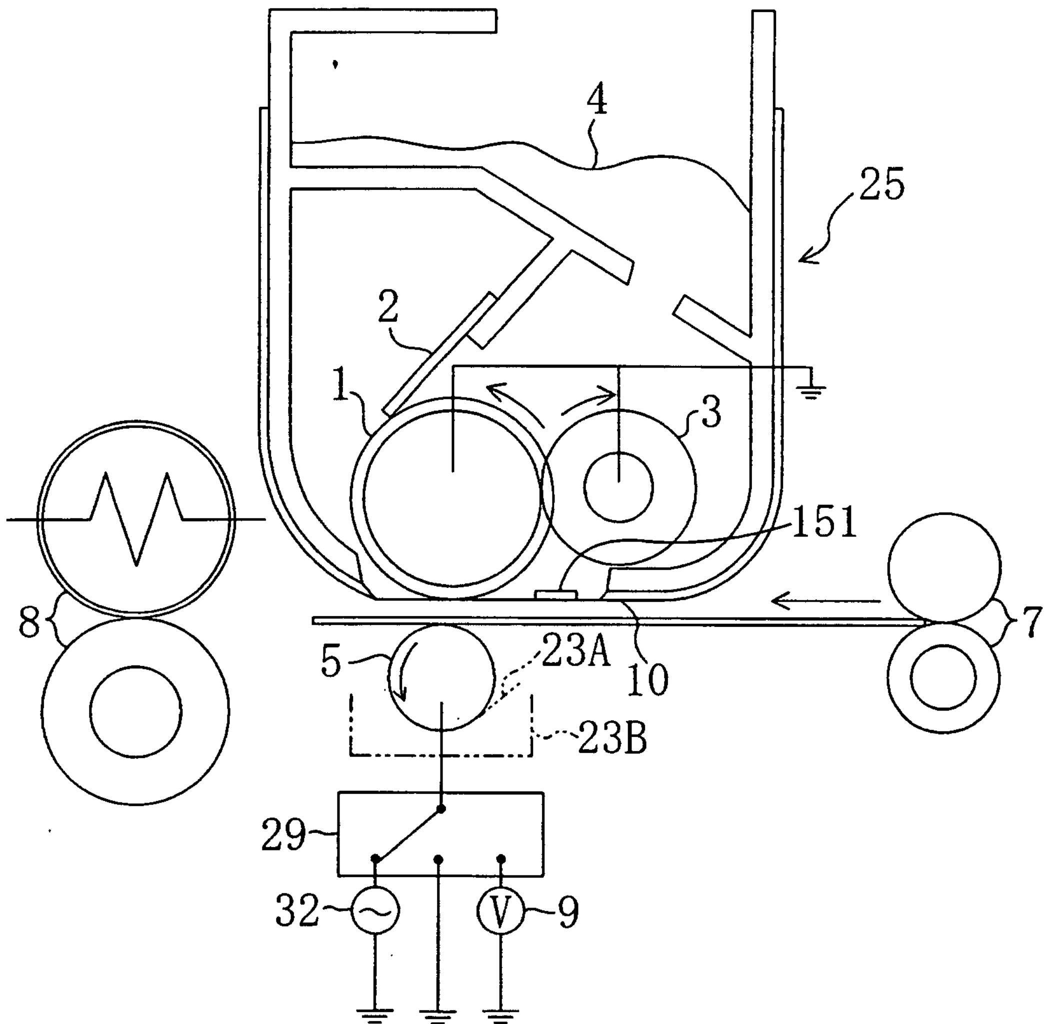


Fig. 35

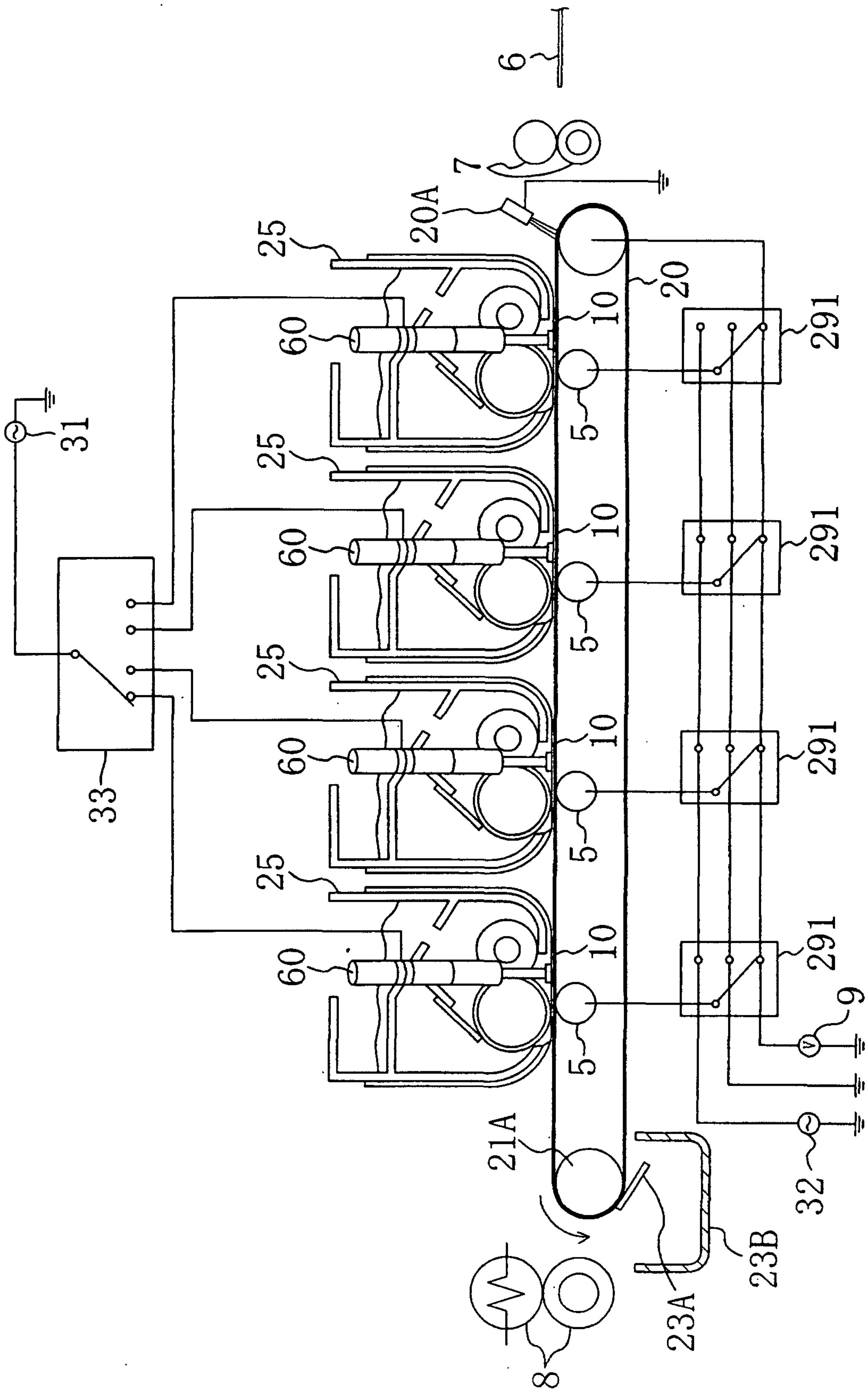


Fig. 36

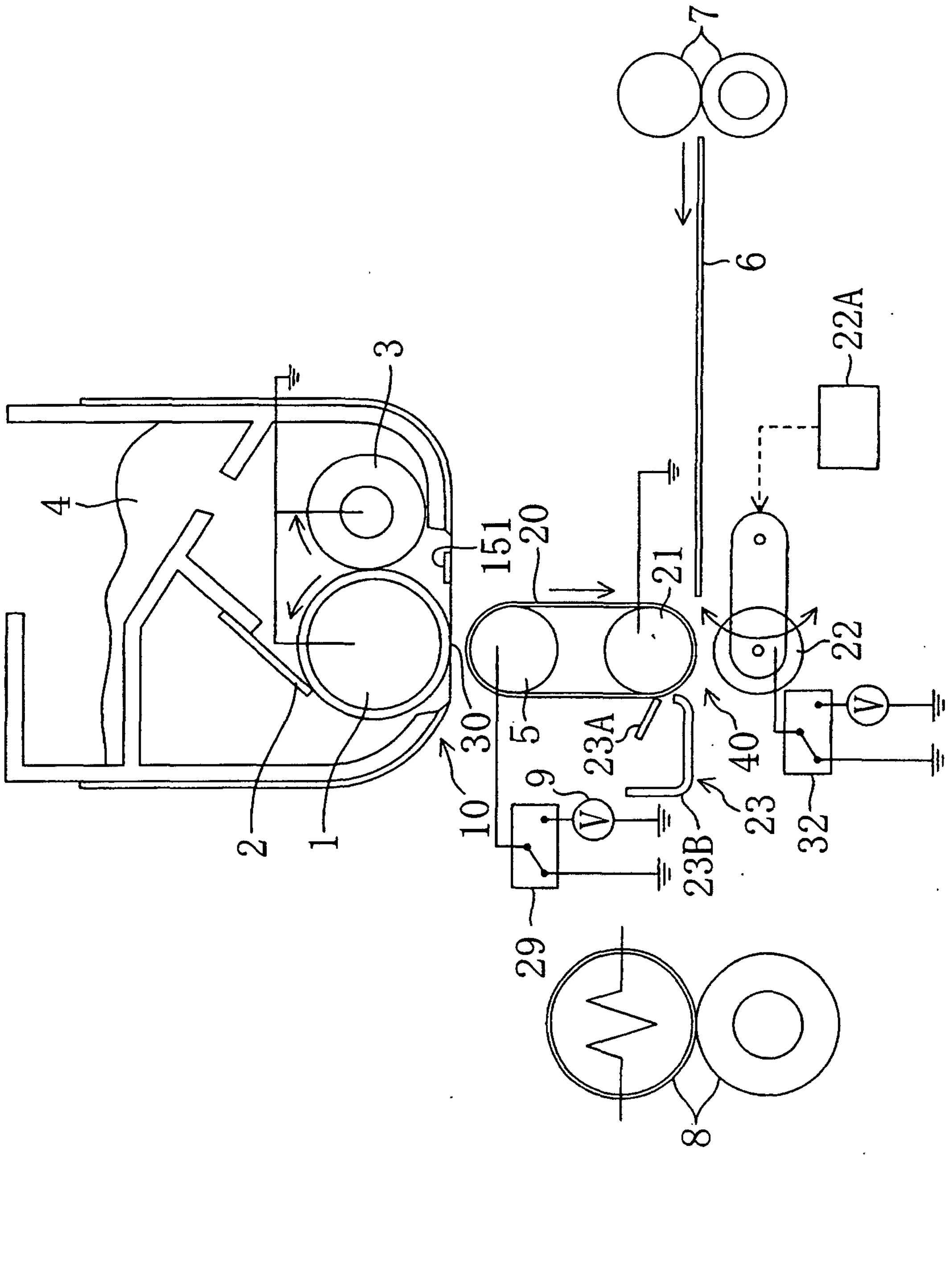


Fig. 37

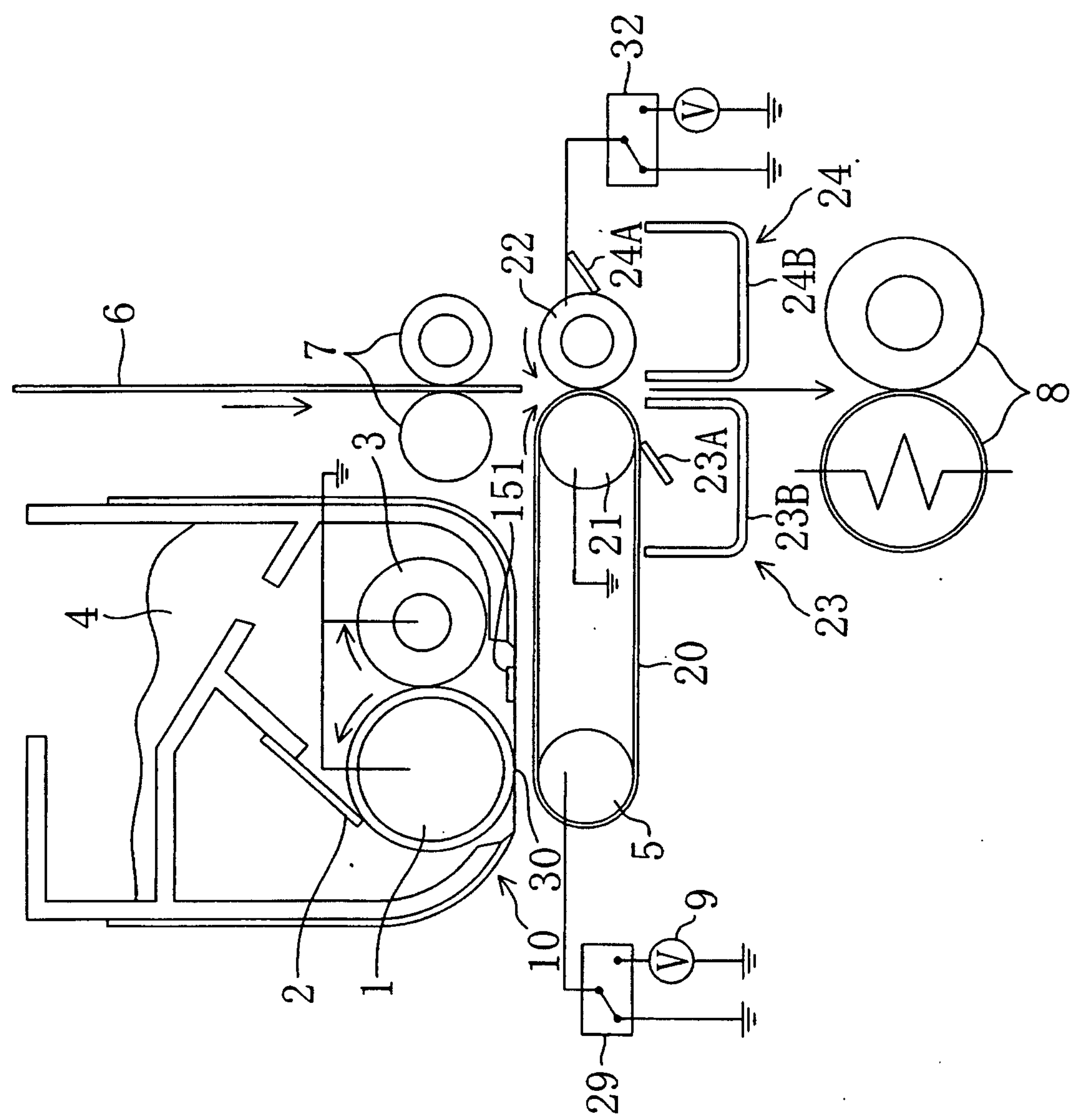


Fig. 38

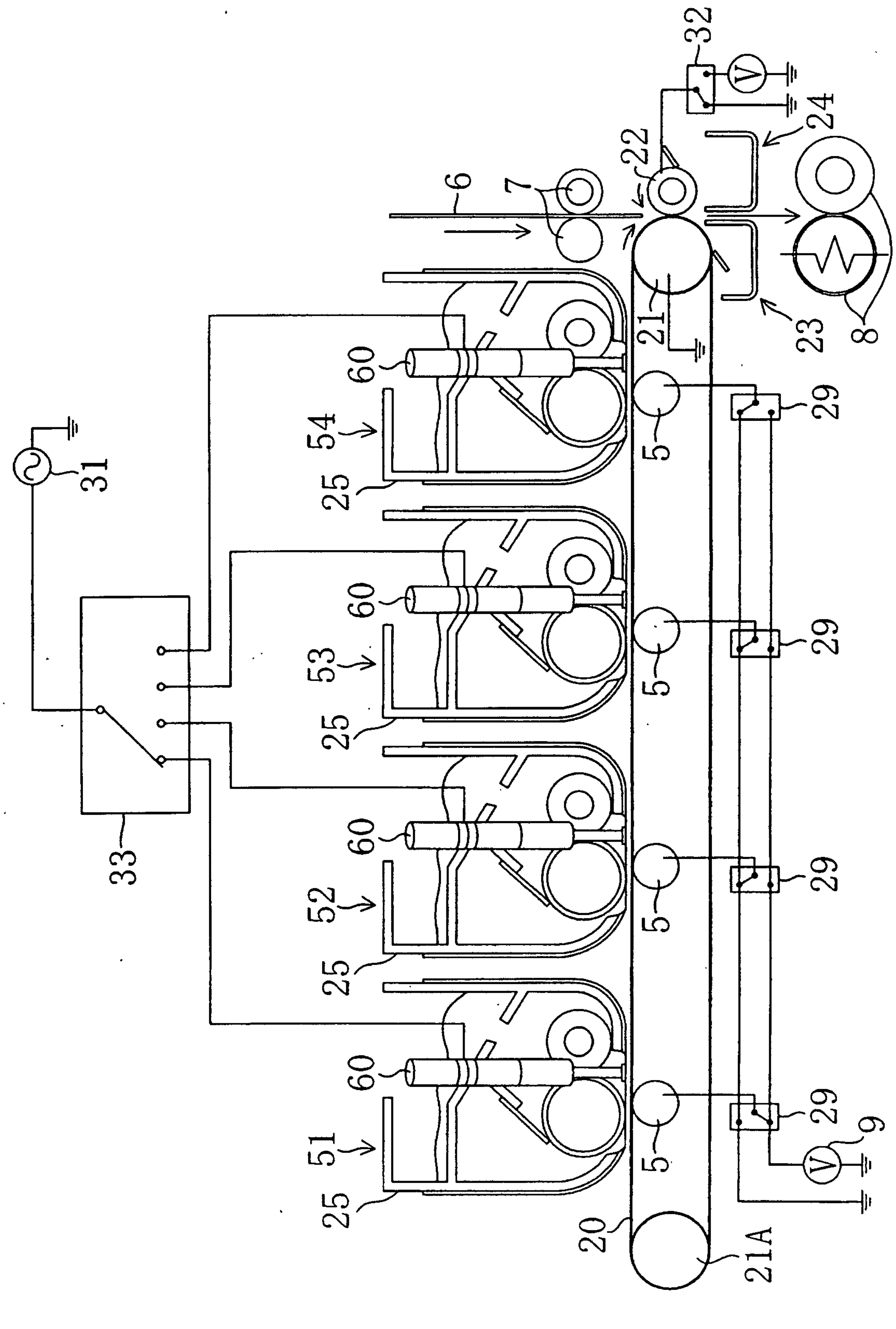
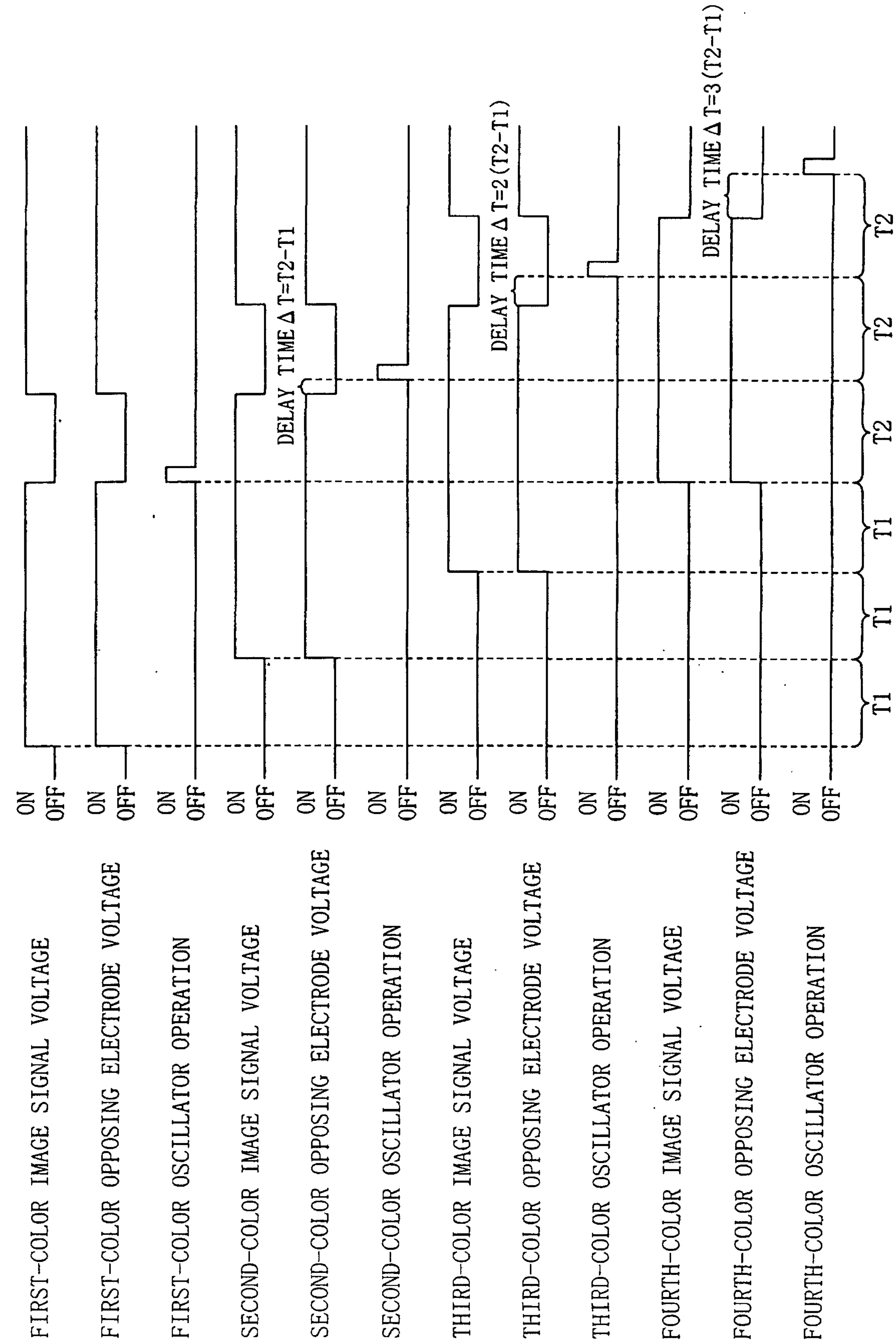


Fig. 39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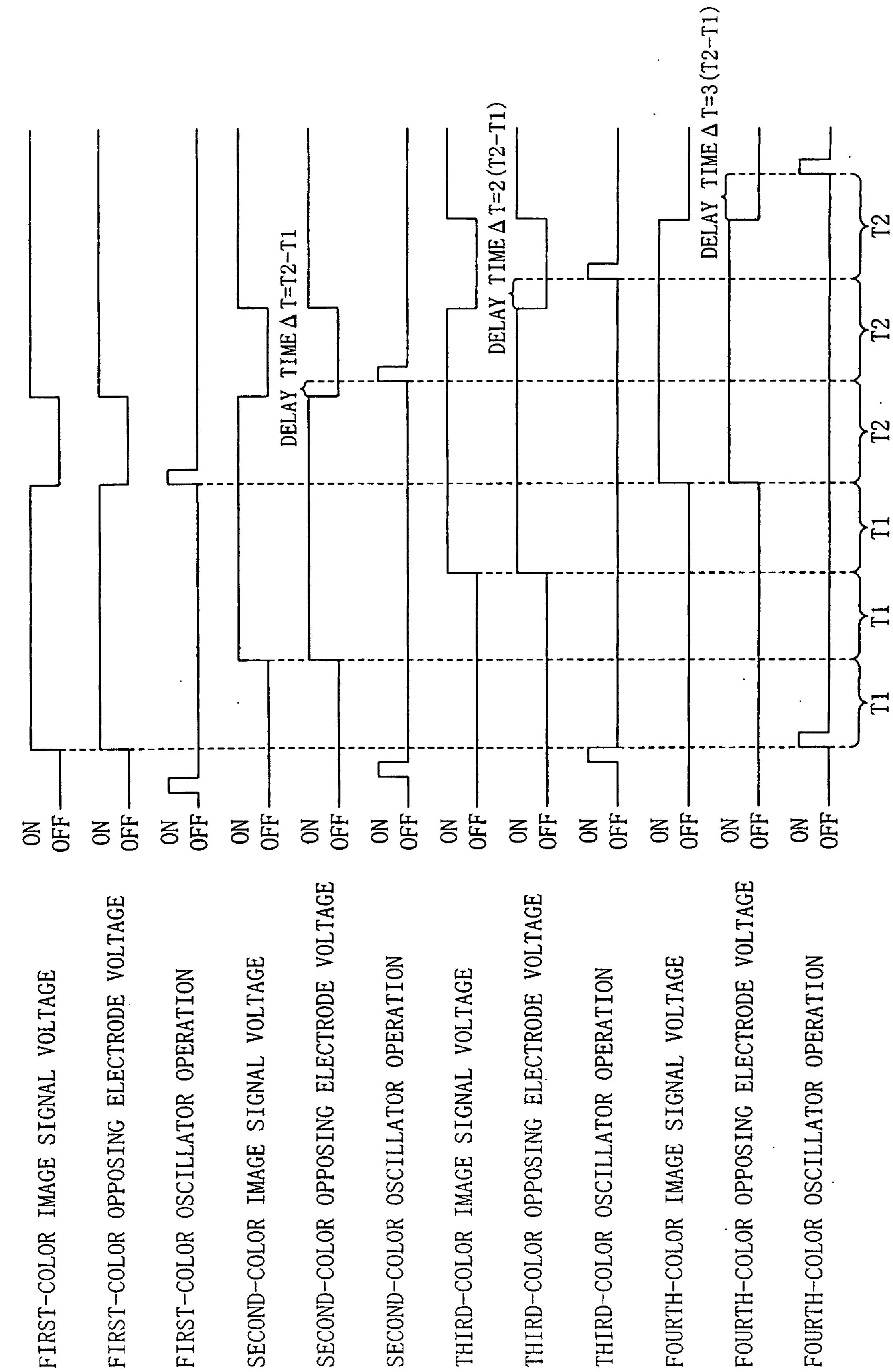
FIRST-COLOR OSCILLATOR OPERATION
SECOND-COLOR IMAGE SIGNAL VOLTAGE
SECOND-COLOR OPPOSING ELECTRODE VOLTAGE
SECOND-COLOR OSCILLATOR OPERATION
THIRD-COLOR IMAGE SIGNAL VOLTAGE
THIRD-COLOR OPPOSING ELECTRODE VOLTAGE
THIRD-COLOR OSCILLATOR OPERATION
FOURTH-COLOR IMAGE SIGNAL VOLTAGE
FOURTH-COLOR OPPOSING ELECTRODE VOLTAGE
FOURTH-COLOR OSCILLATOR OPERATION
ON
OFF
DELAY TIME Δ T=T2-T1
DELAY TIME Δ T=2(T2-T1)
DELAY TIME Δ T=3(T2-T1)
T1
T1
T1
T2
T2
T2

Fig. 40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FIRST-COLOR OSCILLATOR OPERATION
SECOND-COLOR IMAGE SIGNAL VOLTAGE
SECOND-COLOR OPPOSING ELECTRODE VOLTAGE
SECOND-COLOR OSCILLATOR OPERATION
THIRD-COLOR IMAGE SIGNAL VOLTAGE
THIRD-COLOR OPPOSING ELECTRODE VOLTAGE
THIRD-COLOR OSCILLATOR OPERATION
FOURTH-COLOR IMAGE SIGNAL VOLTAGE
FOURTH-COLOR OPPOSING ELECTRODE VOLTAGE
FOURTH-COLOR OSCILLATOR OPERATION
ON
OFF
DELAY TIME Δ T=T2-T1
DELAY TIME Δ T=2(T2-T1)
DELAY TIME Δ T=3(T2-T1)
T1
T1
T1
T2
T2
T2

Fig. 41

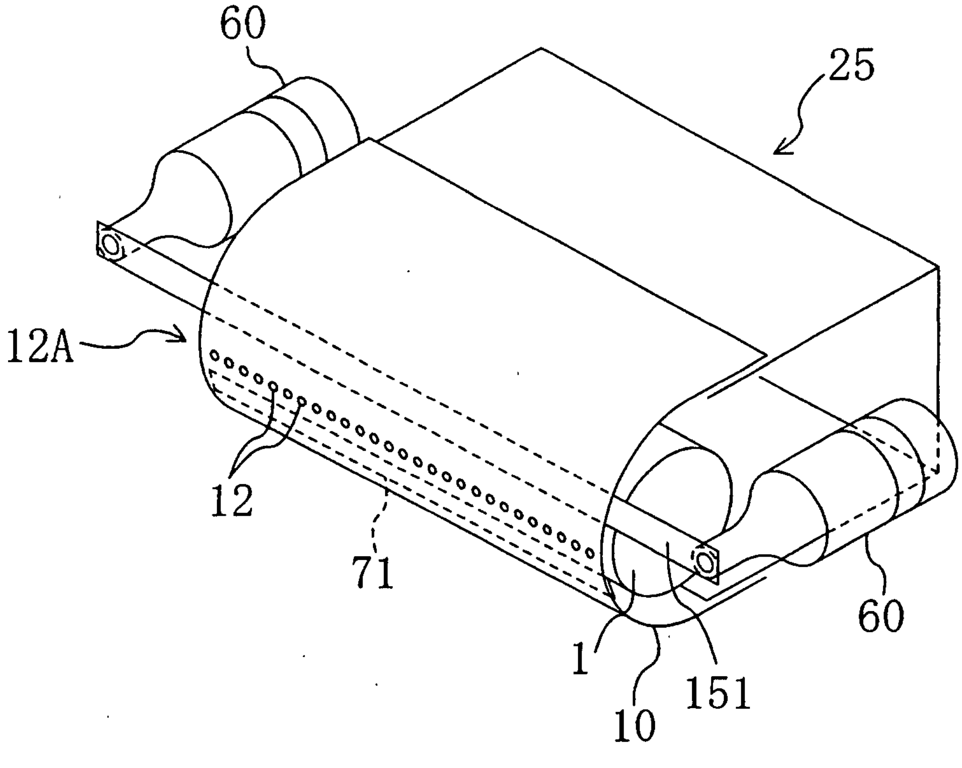


Fig. 42

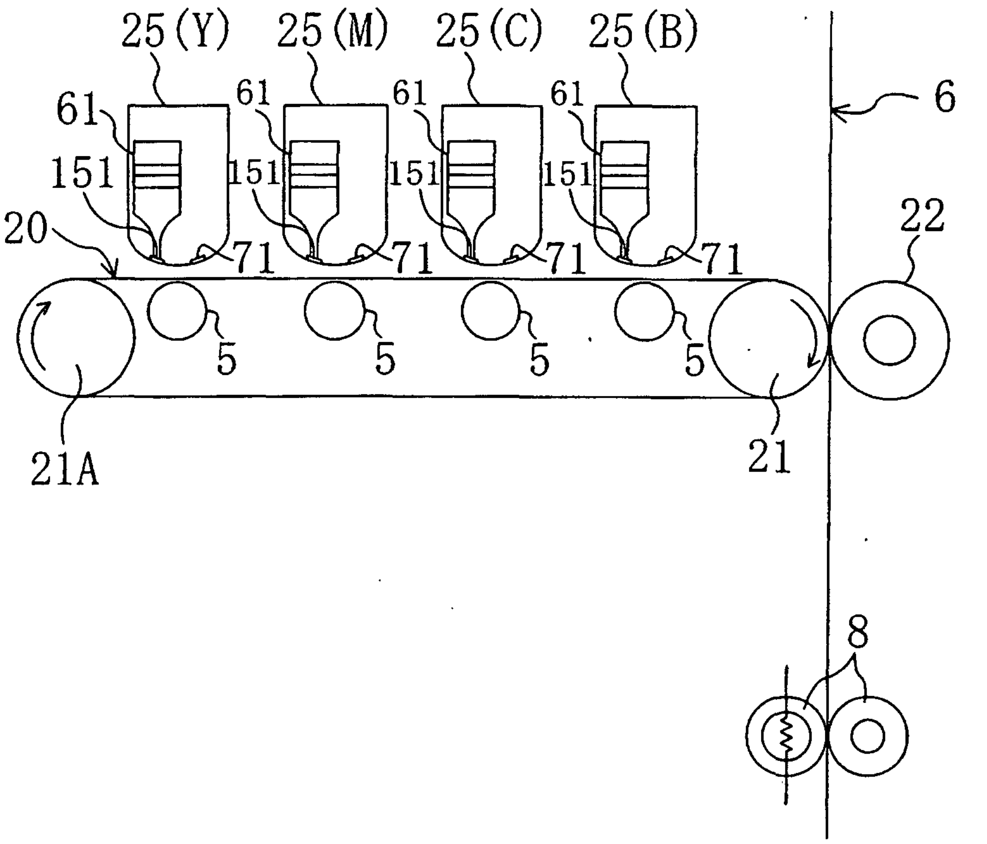


Fig. 43

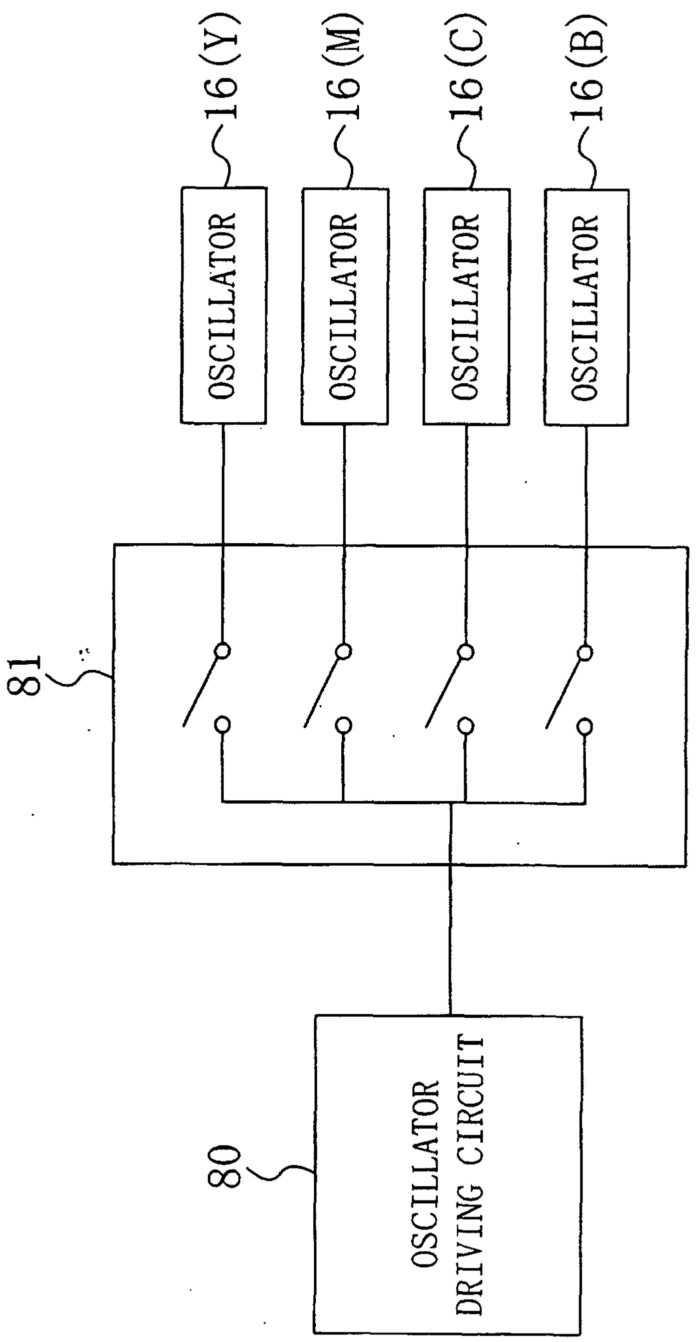
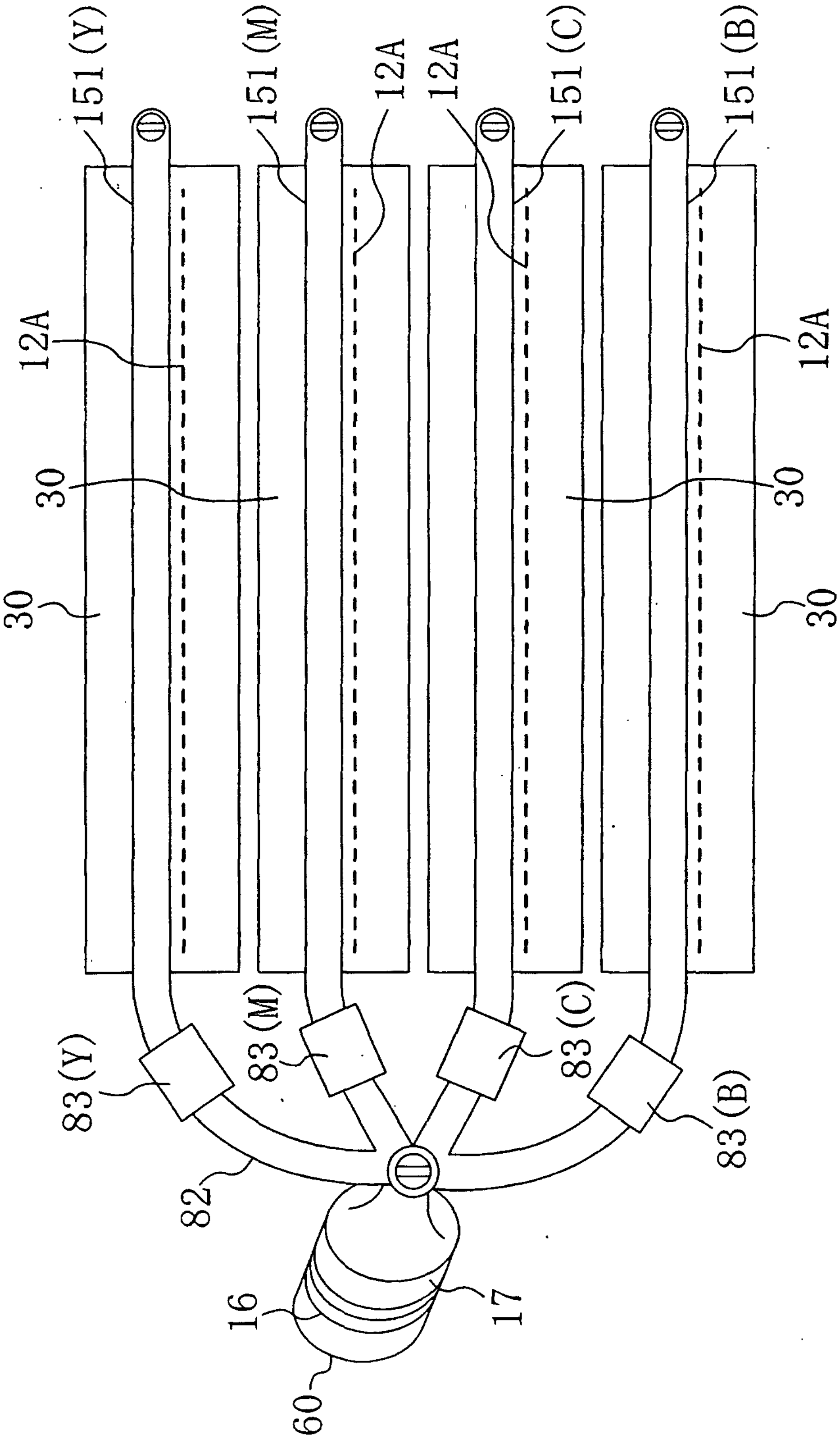

16(Y)
16(M)
16(C)
16(B)
OSCILLATOR
OSCILLATOR
OSCILLATOR
OSCILLATOR
81
80
OSCILLATOR DRIVING CIRCUIT

Fig. 44


151(Y)
151(M)
12A
12A
151(C)
151(B)
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30
30
30
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83(Y)
83(M)
83(C)
83(B)
82
16
17
60

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP99/06127

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] B41J2/385

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] B41J2/385

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Toroku Jitsuyo Shinan Koho	1994-2000
Kokai Jitsuyo Shinan Koho	1971-2000	Jitsuyo Shinan Toroku Koho	1996-2000

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 4-216963, A (BROTHER INDUSTRIES, LTD.), 07 August, 1992 (07.08.92), Full text; Figs. 1 to 5 (Family: none)	1-82
A	JP, 7-227994, A (Mita Industrial Co., INC.), 29 August, 1995 (29.08.95), Full text; Figs. 1 to 9 (Family: none)	1-82
A	JP, 6-262798, A (BROTHER INDUSTRIES, LTD.), 20 September, 1994 (20.09.94), Full text; Figs. 1 to 4 (Family: none)	1-82
A	JP, 5-84961, A (BROTHER INDUSTRIES, LTD.), 06 April, 1993 (06.04.93), Full text; Figs. 1 to 5 (Family: none)	1-82
A	JP, 61-174560, A (NEC Corporation), 06 August, 1986 (06.08.86), Full text; Figs. 1 to 4 (Family: none)	4
A	JP, 6-71932, A (BROTHER INDUSTRIES, LTD.), 15 March, 1994 (15.03.94),	5,6,7

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 January, 2000 (28.01.00)	08 February, 2000 (08.02.00)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP99/06127

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Full text; Figs. 1 to 4 (Family: none)	
Y	JP, 6-127014, A (BROTHER INDUSTRIES, LTD.), 10 May, 1994 (10.05.94), Full text; Figs. 1 to 4 (Family: none)	23,26,28-30,32,33,35
A	JP, 4-80053, A (BROTHER INDUSTRIES, LTD.), 13 March, 1992 (13.03.92), Full text; Figs. 1 to 2 (Family: none)	44-50
A	EP, 0266960, A (XEROX CORPORATION), 11 May, 1988 (11.05.88), Full text; all drawings, (Family: none) & JP, 63-123060, A & CN, 87107672, A & US, 4755837, A	47,48
A	JP, 58-96570, A (Canon Inc.), 08 June, 1983 (08.06.83), Full text; Figs. 1 to 5 (Family: none)	49,50
Y	JP, 5-309864, A (BROTHER INDUSTRIES, LTD.), 22 November, 1993 (22.11.93), Full text; Figs. 1 to 2 (Family: none)	51,54
A	Full text, Figs.1 to 2 (Family: none)	52,53,62-66
A	JP, 5-127515, A (Kyocera Corporation), 25 May, 1993 (25.05.93), Full text; Figs. 1 to 5 (Family: none)	56-61
A	JP, 9-314888, A (BROTHER INDUSTRIES, LTD.), 09 December, 1997 (09.12.97), Full text; Figs. 1 to 3 (Family: none)	60-66
A	JP, 8-142394, A (BROTHER INDUSTRIES, LTD.), 04 June, 1996 (04.06.96), Full text; Figs. 1 to 4 (Family: none)	64
A	JP, 7-266606, A (Mita Industrial Co., INC.), 17 October, 1995 (17.10.95), Full text; Figs. 1 to 10 (Family: none)	75-82

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