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Method and apparatus for image recording.

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A method of vapour jet printing is described, along with several embodiments of apparatus for practicing such method. The vapour phase of a sublimable dye is mixed with a carrier gas. The resulting mixture is then jetted toward a recording medium. The carrier gas is indirectly heated by the sublimable dye to maintain the latter in its vaporous state during its travel to the recording medium. One embodiment of the apparatus includes a removable cartridge for the sublimable dye which enables colour interchange-ability and a limited downtime for dye recharging.

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METHOD AND APPARATUS FOR IMAGE RECORDING

The present invention relates to the production of images or representations, such as in high-speed printing. More particularly, it relates to a method and apparatus for effectively applying a coloring agent to a recording medium.

Most printing of alphanumeric characters is now accomplished by impact printing. That is, in general, a mechanical member of one sort or another which defines all or part of each of the characters to be imprinted, is used to impact an ink or coloring agent medium, such as a ribbon, on to a recording medium. However, because of a desire for high-speed printing, less noise, etc., much effort has been expended toward non-impact printing. Some of this effort has been devoted to attempting to provide a commercially successful vapor jet printing mechanism. Such a mechanism is one in which a vaporous coloring agent is transferred via a jetting action to a recording medium.

The approach used most often in vapor jet printing, has been to attempt to print dots which can be arranged to define desired alphanumeric characters. For such a method to provide quality printing with the high resolution necessary, the dots which are provided on the recording medium must be quite small. Moreover, the location of such dots on the recording medium must be accurately controllable.

It will be appreciated that the manner of transferring the coloring agent to the recording medium is an important part of vapor jet printing, particularly in connection with assuring small dot size and accurate control over printing location. Many vapor jet printing arrangements considered in the past have utilized electrical deflection means to provide the transfer. In these schemes the coloring agent is charged and then deflected to a desired location. Such schemes have various disadvantages, a primary one being decomposition of the coloring agent if it is as in most situations, the vapor state of a sublimable dye. Moreover, most of such arrangements require relatively large spacing between the jet from which the coloring agent emanates and the recording medium, to accommodate the deflection and charging mechanism. The coloring agent, if it is heated such as is typical for a sublimable dye, can be cooled by the atmosphere in such space and solidified before it reaches the recording medium. This, of course, results in a degraded image. Also, most applications for vapor jet printing require multiple jets of one or more coloring agents. The necessity with this approach

of controlling the individual jets of coloring agent results in added complexity. Examples of this approach are disclosed in Japanese Patent Publication Nos. 56-2020; 54-71636; and 54-71637.

Other arrangements which have been considered rely simply on the vapor pressure of the coloring agent itself to provide a jetting action, i.e., there is no means for forceably jetting the vaporous coloring agent. Such a method is described, for example, in Japanese Patent Publication No. 57-1771. One problem with this approach is that in periodic passes of a coloring agent through a jetting nozzle, the coloring agent of one pass may be left in the nozzle because of the low pressure or force used to eject the same. This earlier coloring agent is mixed with the subsequent coloring agent passed through the nozzle and thus changes the amount which is jetted. This deleteriously affects the parameters of printing. Moreover, when the coloring agent is a condensable vapor, it may condense in the nozzle and restrict the same. While heating of vapors has been employed to raise the vapor pressure of the coloring agent, such heating has not solved the nozzle problems.

It also has been proposed to use a gas such as air as a carrier to transport vaporous dyes to the recording medium. Japanese Patent Publication No. 59-22759 is an example of such an arrangement. U. S. Patent No. 3,950,967 discloses such an arrangement designed for coloring a textile material. Mechanisms which have relied upon this procedure have been less than ideal. One major problem is that it is difficult to control the amount of coloring agent which is transferred during any selected period, i.e., the amount of coloring agent within the gas carrier stream varies. This lack of control, interferes of course, with color proportioning, obtaining desired color densities, etc. Moreover, the use of a gaseous stream of this nature can result in solidification of vaporous coloring agents, (such as sublimable dyes in their vapor state.) It also should be mentioned that the system of Japanese Patent Publication No. 59-22759 utilizes a relatively expensive laser optical system to form a vaporous coloring agent from solid, sublimable dye rods. It is difficult to incorporate such a system into a multi-head arrangement because of the relatively complex optical and delivery systems utilized in such arrangement, and also to control the gating "on and off" of the formation of the desired vaporous dyes.

The present invention is a method and apparatus for applying a coloring agent to a recording medium which does not have the disadvantages of prior art approaches discussed above. While a car-

rier gas, such as air, is used to transport the coloring agent to the recording medium, in accordance with the invention it is mixed with the coloring agent while the latter is in its vaporous state before being ejected toward the recording medium. Most desirably, the coloring agent and gas are intimately mixed together to form a generally uniform mixture prior to being ejected. It will be recognized that this will assure that a selected known amount of coloring agent will be ejected toward the recording medium. Also most desirably, the mixture is pressurized to be ejected with force toward the recording medium. This pressurization simply is achieved by providing the carrier gas itself under a desired pressure when it is mixed with the coloring agent.

The carrier gas is heated to maintain the coloring agent in a vaporous phase during use of such gas to transport the coloring agent to the recording medium. This is most easily accomplished by passing the gas mixture through a channel the temperature of which is maintained at an appropriate level. Most simply and desirably the coloring agent is a sublimable dye in solid form which is heated to form a vaporous dye which is then mixed with the carrier gas to form the desired, heated mixture.

As another salient feature of the instant invention, the coloring agent is provided in a stand-alone cartridge which can be interchangeably connected with the remainder of the apparatus, including the ejection nozzle, to complete the arrangement. It will be recognized that the provision of such a cartridge simplifies the operation of providing new coloring agent or changing colors, and significantly reduces the downtime associated therewith.

As will be appreciated from the more detailed description of a preferred embodiment, the simplicity of the method and apparatus of the invention lends itself well to multi-head arrangements, i.e., arrangements having a plurality of sources of coloring agents and a plurality of nozzles. Moreover, it is particularly applicable to use of sublimable dyes as the coloring agents.

Brief Description Of The Drawings

With reference to the accompanying three sheets of drawing:

Fig. 1 is a perspective view of a schematic representation of a first embodiment of the instant invention;

Fig. 2 is a sectional view of the embodiment of Fig. 1;

Fig. 3 is a second sectional view of such embodiment taken on a plane indicated by the lines 3-3 in Fig. 2 and including a representation of a recording medium and an image signal source;

Fig. 4 is another sectional view of the embodiment of Fig. 1, taken on a plane indicated by the lines 4-4 in Fig. 2;

Figs. 5 and 6 are enlarged sectional and broken-away views of gating mechanisms for the nozzles of the embodiment of Fig. 1;

Figs. 7 and 8 are schematic graphic representations of image signals;

Fig. 9 is a view similar to the view of Fig. 2, showing an alternate embodiment;

Fig. 10 is a sectional view similar to Fig. 3 of a third embodiment of the instant invention; and

Fig. 11 is a sectional view of a schematic representation of a fourth embodiment of the invention.

Detailed Description Of The Preferred Embodiment

The first preferred embodiment of the apparatus of the invention is illustrated in Figs. 1 -5. A recording head for applying four differing coloring agents to a recording medium is generally referred to by the reference numeral 11. As is best illustrated in Figs. 1 and 2, such recording head 11 includes four chambers 12 -15 individually containing sublimable dyes in solid form to produce desired vaporous coloring agents. While in the drawing the sublimable dyes in solid form are schematically illustrated in the chambers 12 -15 as blocks 16 -19, respectively, it is preferred that they be provided as is typical in powder form. The dyes could be of any desired color which is available. The sublimable dye 16 could be, for example, a cyan dye, the sublimable dye 17 could be a magenta dye, the sublimable dye 21 could be a yellow dye, and the dye 19 could be a black dye. A blocked entrance for supplying dye in powder form is provided for each of the chambers, and is schematically represented at 21 in Fig. 3 for chamber 13.

A source of heat in the form of a heater 22 is included within the base wall of the recording head 11 to provide simultaneous heating of the sublimable dyes in the four chambers 12 -15. Such heater is preferably an electrical resistance heater electrically insulated from the recording head material.

The amount of heat energy applied to the dyes and, hence, the temperature to which the heater is raised will depend upon the particular sublimable dyes which are used, as well as the desired vapor pressures. As is indicated by the dots in the figure, the dyes will sublime and form a vaporous state in

the upper portion of the respective chambers 12 - 15. In accordance with the invention, means are provided for furnishing a carrier gas to the upper portion of such chambers for mixture with the dyes. A reservoir 23 is schematically illustrated for this purpose, containing a pressurized gas, such as air. Such reservoir is individually communicated with each of the chambers 12 -15, as is represented in Fig. 2. The result is that a gas under pressure (in this case air) is mixed with the sublimable dyes in the individual chambers. The carrier gas is heated to a temperature which will maintain the dye with which it is mixed in a vaporous state. Most simply, the dye itself is provided with sufficient thermal energy to heat the carrier gas with which it is mixed before being ejected as described below. The structure communicating the reservoir with the chambers is, in essence, means connecting the sources of coloring agents with the source of carrier gas.

The recording head 11 includes a nozzle structure 24 on its front face, having individual nozzles 26 -29 communicating respectively with the dye chambers. 12 - 15. Such nozzles face a recording medium 31 (Fig. 3) at a relatively close spacing. As is conventional, the recording medium can be, for example, a sheet of paper or plastic upon which it is desired to impart graphical representations.

Because the coloring agent-carrier gas mixture is under pressure, it is important that the individual nozzles 24 -29 be gated. Fig. 5 illustrates an embodiment of a gate or shutter arrangement which can be used to provide such gating. With reference to such figure, a gate 32 is shown in the outlet port of the illustrated nozzle. Such gate includes not only an annulus 33 restricting the size of the nozzle orifice, but an electrostriction vibrator 34 for controlling opening and closing of the nozzle orifice. It should be noted that the carrier gas, sublimable dye mixture will be at a relatively high temperature of between 200 and 250 degrees C. Thus it is important that the vibrator 34 be one which is capable of withstanding and operating under such high temperature conditions.

A voltage is applied to the electro restriction vibrator to open and close the same, the application of which voltage is controlled by an image signal source. Such source is schematically represented in the figures by block 36. Each of the nozzles includes a gate for controlling the flow of the mixture in its associated dye chamber therefrom. This is schematically represented in Fig. 4 by the illustration of flow lines extending from the source 36 to each of the nozzles.

Fig. 6 illustrates another type of nozzle gating device that may be used with the instant invention. It is similar to the gating device shown in Fig. 5 and like reference numerals are used for common

parts. Such device, generally referred to by the reference numeral 37, includes an electromagnet 38 for vibrating a gate 39. Again, because the carrier gas, sublimable dye mixture is at a relatively high temperature, it is desirable that the Curie temperature of the core portion of the electromagnet be above 300 degrees C.

It is believed that the method of the invention is readily apparent from the above description of the apparatus of the first embodiment. The coloring agents in the individual chambers (in this case, sublimable dyes in their vaporous state) are mixed with a carrier gas and thereafter the mixture is ejected toward the desired location on the recording medium. The configuration of each of the chambers assures that there is an intimate mixture of the coloring agent and gas to form a generally uniform mixture prior to it being ejected. Moreover, the carrier gas is provided under pressure. This results in the mixture also being pressurized. The carrier gas is indirectly heated to assure that it will maintain the coloring agent in vaporous form between the time the individual mixtures are jetted from the nozzles and they strike the recording medium. In this particular arrangement in which the coloring agent is a sublimable dye, sufficient thermal energy is provided to each solid dye both to form and maintain its vaporous state and also to heat the carrier gas with which each is mixed. The carrier gas should be heated to a temperature at or above the temperature at which the sublimable dye will maintain its vaporous phase during travel to the recording medium. Ejection of the mixture toward the recording medium is controlled to occur only when it is desired, by the gating devices.

Figs. 7 and 8 are timing charts which indicate how with vibration of the gates of one of the respective nozzle gating devices, the amount of mixture ejected from a nozzle can be controlled. Periodic time demarcations or intervals are represented in such figures by uniformly separated lines, the distance between any two of which is the same, as is represented by T_D . The vibration rate provided by a gating device of a nozzle is represented in the figures by pulses 40. Each of these pulses represents an "open" state of a gate and the frequency and amplitude of all of such pulses are the same, with the result that each represents a predetermined amount of carrier gas-coloring agent mixture which is allowed to eject. (This is assuming, of course, that the pressure within each of the dye chambers remains relatively constant.) It thus will be seen that during any selected time interval T_D , the number of pulses which are applied to a gating device will control the amount of mixture which actually is ejected during such time interval.

Various colors can be obtained on the recording medium by mixing the vaporous dyes. To this end, the directions of the nozzles may be set so that the carrier gas -coloring agent mixture of a plural number of them will be converged to the same spot on the recording medium. Alternatively, the vaporous dye can be made to impinge at different locations on the recording medium. It will be appreciated that sequential passing of a recording head by the same spots on the recording medium can be used to mix different colors at a single spot to form a desired color.

The following parameters are suggested as guidelines for the design of specific equipment utilizing air as a carrier gas and sublimable dyes:

Temperature: 400 degrees F (204 degrees C)

Orifice: 20- μ m diameter

Carrier gas pressure: 0.1 psi (700 Pa)

Printing speed: 1 cm/s

Full-width array: 250 lines (nozzles)/inch

Gating frequency: 2000 Hz

In some situations, depending largely on the sublimable dyes which are selected, it is desirable to be able to control the thermal energy imparted to each separately, in spite of the fact that a plurality of chambers are provided. Fig. 9 illustrates a simple modification which can be made to the embodiment which is described above, to facilitate such separate heat control. The individual dye chambers 12A--15A are separated from one another by thermally insulating walls 41 -43. The single heater 22 of the earlier embodiment is replaced by individual heaters 46 -49 associated with the individual chambers and controllable separately. It thus will be seen that different amounts of thermal energy can be transmitted to the separate chambers.

Sublimation of the dyes can be enhanced by including high thermal conductivity material in the chambers with the solid form of the same. As previously mentioned the sublimable dye is preferably provided in powder form, and Fig. 10 illustrates metal (steel) shot 51 combined with the same. It is important that the high thermal conductivity material mixed with the solid sublimable dye be stable or inert with respect to such dye at the temperatures and pressures of operation.

The embodiment illustrated in Fig. 10 also includes a schematic illustration of a power source 52 and an adjusting mechanism 53 for controlling the pressure of gas to be injected into the illustrated dye chamber. It will be appreciated that

adjustment of such pressure will change the mixture pressure and, thus, the color density or proportion obtainable in the ultimate image. Such figure also illustrates a power source 54 and an adjustment mechanism 56 for the heater 22. This representation is included to bring out the fact that the mixture pressure and hence the density of the image also can be adjusted by changing the amount of thermal energy applied to the sublimable dye. A change in the thermal energy changes the pressure of the dye in the vaporous state, the ultimate mixture pressure, and hence, the density of the image.

It is desirable to be able to replenish or change the coloring agent associated with each nozzle in a rapid manner. The embodiment of the invention illustrated in Fig. 11 facilitates such an arrangement. The sublimable dye is provided within a stand-alone cartridge 61 which is removably securable to the remainder of the apparatus. That is, the remainder of the apparatus include a leaf-spring 62 which resiliently urges the cartridge 61 into a pocket of the apparatus sized to fit the same. Such apparatus includes means for ejecting a carrier gas -vaporous coloring agent toward a recording medium. In this connection, the apparatus is provided with a tubular needle 64 that communicates with its nozzle and is designed to register with and penetrate through an appropriate seal in the cartridge to provide a passage to the nozzle for the gas mixture.

The cartridge itself includes a tubular connection 66 extending from a gas inlet through the volume of the cartridge that may contain the sublimable dye in solid form to that portion of the cartridge designed for the vaporous phase of the dye. The apparatus is provided with a second tube 67 which is designed to penetrate an appropriate seal into the cartridge for communication with the tubular connection 66. Means are thus provided for conveying gas under pressure from a source 68 in the remainder of the apparatus to the sublimable dye in the cartridge when the dye is in its vaporous state.

It will be seen that a plurality of standalone cartridges can be provided designed to cooperate with the remainder of the apparatus to apply desired dye to a recording medium 31. Such cartridges can have differing coloring agents. In this connection it will be appreciated that because the gas mixture is under pressure and the passage through the apparatus to the output end of the nozzle is relatively short, there will be very little mixture of color when cartridges having differing coloring agents are used sequentially. The apparatus, can be said to include the nozzle, the cartridge, and means (the heater, gas source nozzle, passage way etc.) for conditioning the coloring

agent for impingement at a desired location on the recording medium. This embodiment otherwise is similar to the earlier described embodiments and like reference numerals are used to refer to common parts.

While the invention has been described in connection with preferred embodiments, it will be appreciated by those skilled in the art that various changes can be made. For example, although the coloring agent is described in the preferred embodiment as being a sublimable dye, it will be recognized that other types of coloring agents may also be used appropriately with the invention. Such coloring agent may itself not provide a desired color. -It may be an acid or other material which will react with the recording medium to provide a selected color.

Claims

1. A method of applying a colouring agent to a recording medium, characterised in that said method comprises:

(i) mixing the colouring agent with a carrier gas while the colouring agent is in a vaporous state; and

(ii) thereafter ejecting the mixture toward a desired location on the recording medium.

2. A method as claimed in claim 1 characterised in that said step comprises intimately mixing said colouring agent and gas together to form a substantially uniform mixture prior to ejecting the mixture.

3. A method as claimed in any preceding claim characterised by pressurizing said mixture of said carrier gas and colouring agent.

4. A method as claimed in claim 3 characterised in that the ejection of the pressurized mixture is controlled to occur only when it is desired.

5. A method as claimed in claim 3 characterised in that said mixture is pressurized by mixing said colouring agent with a carrier gas which is under pressure.

6. A method as claimed in any preceding claim characterised in that said colouring agent is in the vapour phase which can be maintained in such phase by maintaining its temperature above a predetermined temperature appropriate for its pressure and in that said carrier gas is provided at a temperature to retain said colouring agent above said predetermined temperature.

7. A method as claimed in claim 6 characterised in that said carrier gas is heated to said temperature above said predetermined temperature by being mixed with said colouring agent while the latter is in said vaporous phase.

8. A method as claimed in any preceding claim characterised in that said colouring agent is a sublimable dye in a vaporous state.

9. A method as claimed in any preceding claim characterised in that the step of mixing the colouring agent with a carrier gas comprises separately mixing a plurality of colouring agents with a carrier gas, and said step of ejecting the mixture toward a desired location includes separately ejecting each of said mixtures.

10. A method as claimed in any preceding claim characterised in that the colouring agent is a sublimable dye in solid form; and in that said dye is heated to a temperature above said predetermined temperature.

11. Apparatus for applying a colouring agent to a recording medium characterised in that said apparatus comprises:-

colouring agent supply means,

carrier gas supply means,

means for mixing colouring agent in the vapour state with carrier gas; and

means for ejecting the mixture so formed towards a desired location on a recording medium in juxtaposition thereto.

12. Apparatus as claimed in claim 11 characterised in that the colouring agent supply means comprises a removable cartridge containing a colouring agent, and securing means for securing said cartridge for the supply of colouring agent to said mixing means.

13. Apparatus as claimed in claim 11 or claim 12 characterised in that said colouring agent is a sublimable dye, and said mixing means includes a heating source for raising the temperature of said sublimable dye from one maintaining said dye in solid form to one maintaining said dye in a vaporous state.

14. Apparatus as claimed in any one of claims 11 to 13 characterised in that the ejection means includes a nozzle for ejecting a mixture of said carrier gas and colouring agent toward a desired location on the recording medium.

15. Apparatus as claimed in any one of claims 11 to 14 characterised in that a gate means associated with said ejection means for controlling the ejection of said mixture toward said recording medium.

16. Apparatus as claimed in any one of claims 11 to 15 characterised in that said colouring agent supply means includes a plurality of sources of colouring agents and said ejecting means includes a plurality of nozzles, each one of which is associated with one of said sources of colouring agents.

FIG. 1

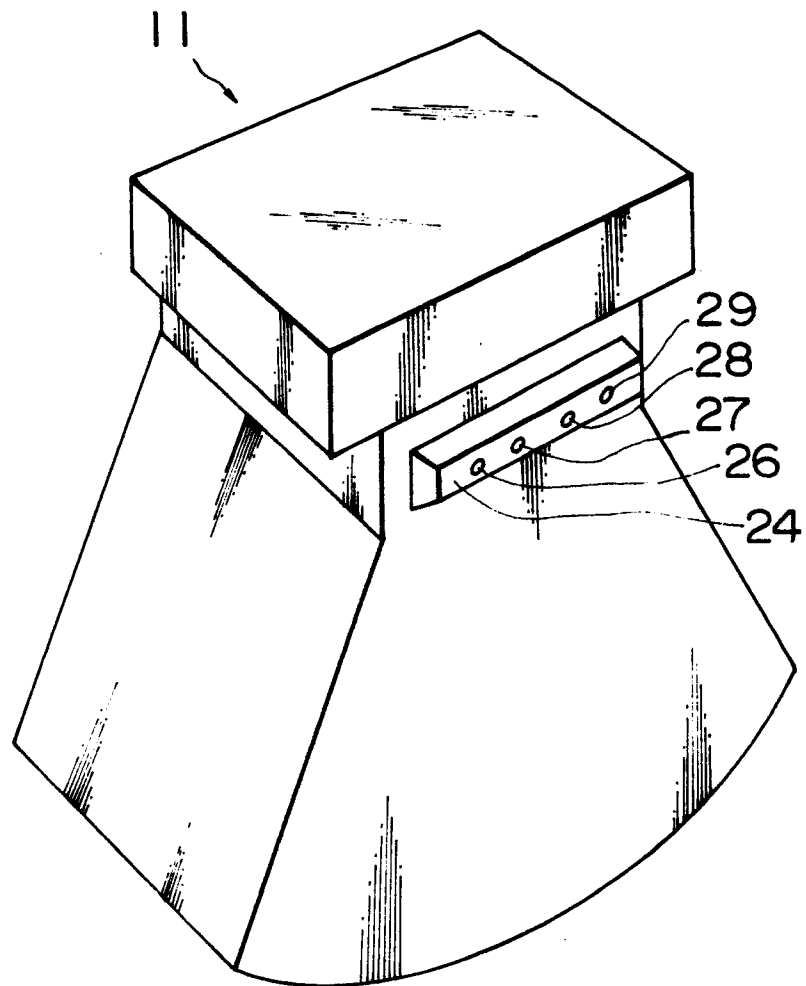


FIG. 2

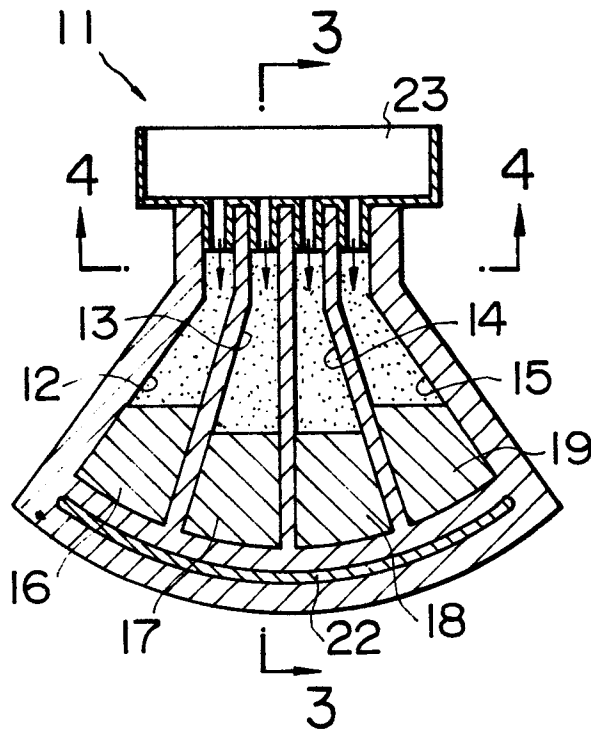


FIG. 3

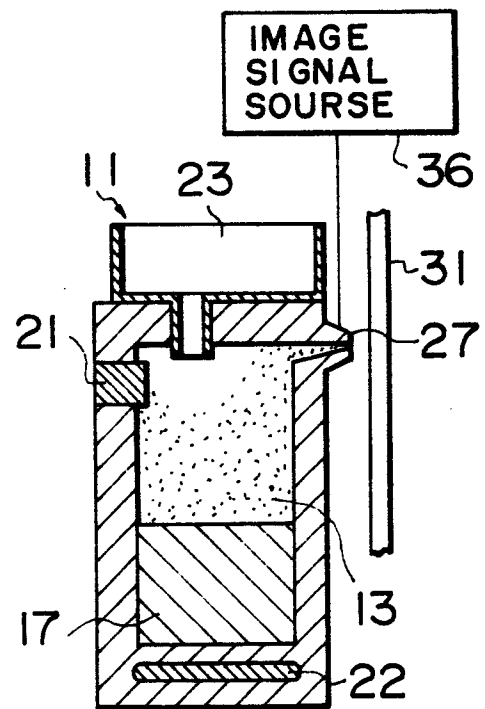


FIG. 4

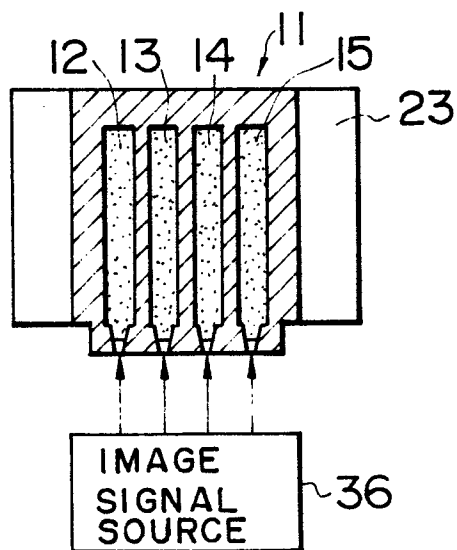


FIG. 5

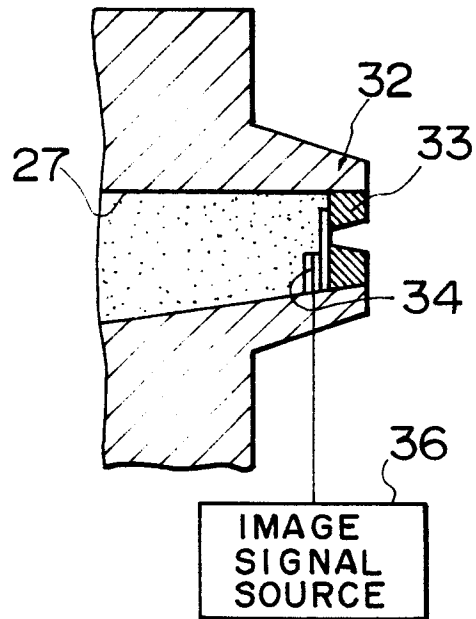


FIG. 6

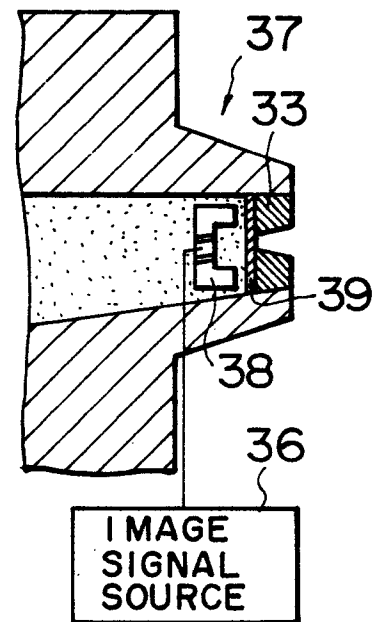


FIG. 7

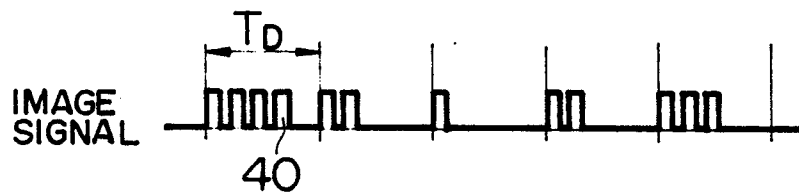


FIG. 8

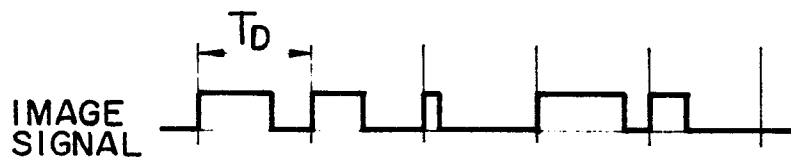


FIG. 9

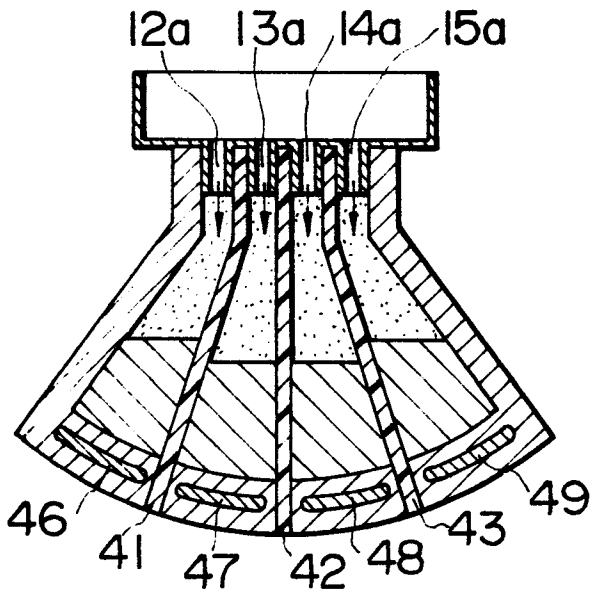


FIG. 11

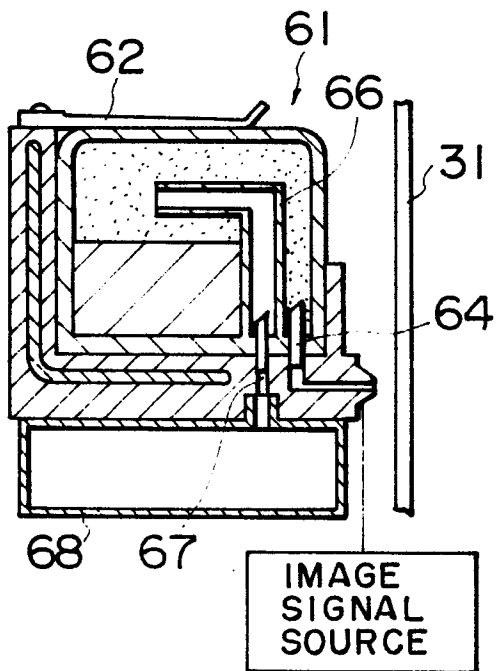
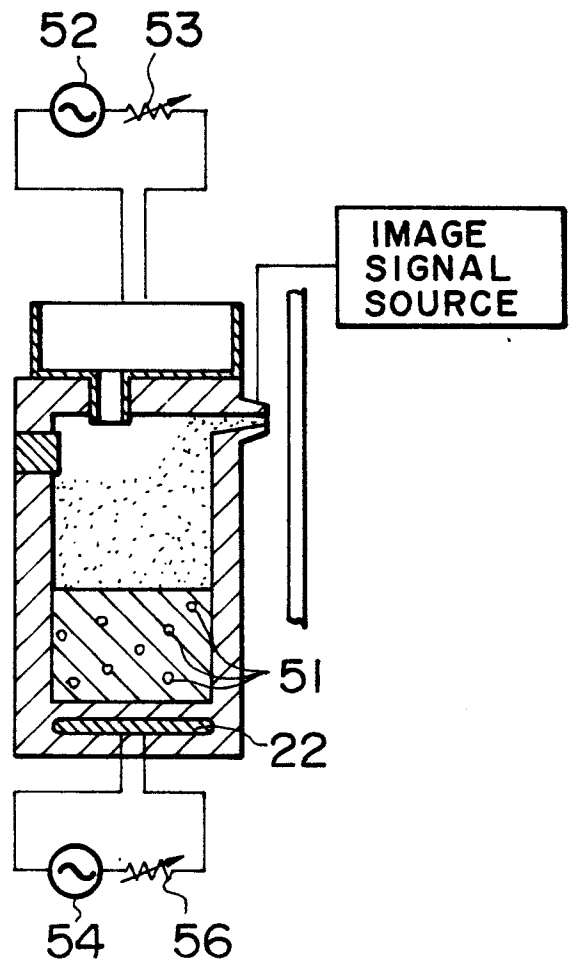


FIG. 10





EP 86304531.6

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
D,X	US - A - 3 950 967 (DAVIES)	1,2,6, 7,8,10, 11,13, 14	B 41 J 3/04 B 41 J 27/00 G 01 D 15/18
D,A	* Fig. 1; abstract * --	12	
X	US - A - 4 019 188 (HOCHBERG)	1-5,11, 14,15	
Y	* Fig. 1; column 2, line 36 - column 3, line 68 * --	6-10,13	
D,Y	PATENT ABSTRACTS OF JAPAN, unexamined application, section E, vol. 1, no. 103, September 12, 1977 THE PATENT OFFICE JAPANESE GOVERNMENT page 3315 E77 * Kokai-no. 52-36 033 (MATSUSHITA) *	6-8,10, 13	
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D,A		1-5,11, 14	B 41 J G 01 D
D,Y	PATENT ABSTRACTS OF JAPAN, unexamined application, field M, vol. 6, no. 58, April 15, 1982 THE PATENT OFFICE JAPANESE GOVERNMENT page 160 M122 * Kokai-no. 57-1 771 (CANON) *	9	
D,A		16	
The present search report has been drawn up for all claims			
Place of search VIENNA		Date of completion of the search 25-09-1986	Examiner MEISTERLE
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			



DOCUMENTS CONSIDERED TO BE RELEVANT			EP 86304531.6
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ⁴)
A	<p><u>US - A - 4 415 910</u> (REECE)</p> <p>* Fig. 4; column 4, lines 17-43 *</p> <p style="text-align: center;">--</p>	4,15	
A	<p><u>EP - A2 - 0 124 116</u> (BROWN, BOVERI)</p> <p>* Fig. 1,2 *</p> <p style="text-align: center;">-----</p>	12	
The present search report has been drawn up for all claims			<p>TECHNICAL FIELDS SEARCHED (Int. Cl.⁴)</p>
Place of search		Date of completion of the search	Examiner
VIENNA		25-09-1986	MEISTERLE
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone</p> <p>Y : particularly relevant if combined with another document of the same category</p> <p>- A : technological background</p> <p>O : non-written disclosure</p> <p>P : intermediate document</p> <p>T : theory or principle underlying the invention</p> <p>E : earlier patent document, but published on, or after the filing date</p> <p>D : document cited in the application</p> <p>L : document cited for other reasons</p> <p>& : member of the same patent family, corresponding document</p>			