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(11) **EP 0 988 977 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**29.03.2000 Bulletin 2000/13**

(51) Int. Cl.<sup>7</sup>: **B41J 2/165**

(21) Application number: **99202982.7**

(22) Date of filing: **13.09.1999**

(84) Designated Contracting States:  
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE**  
Designated Extension States:  
**AL LT LV MK RO SI**

(30) Priority: **24.09.1998 US 159725**

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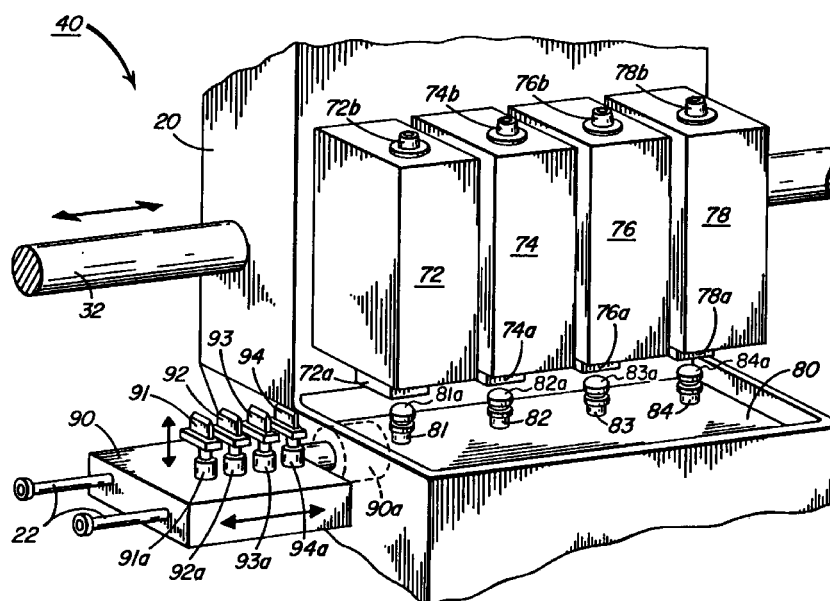
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(54) **Ultrasonic cleaning of ink jet printhead cartridges**

(57) Ink jet printing apparatus for receiving an ink cartridge (72,74,76,78) defining an orifice structure having at least one orifice plate (72a,74a,76a,78a) with a plurality of nozzles for ejecting ink droplets onto a receiver to form an image, cleaning of the orifice structure of debris is providing by at least one actuatable ultrasonic transducer (81,82,83,84) operatively associated with and spaced from the nozzles; and a thin layer

(meniscus) of viscous fluid (81a,82a,83a,84a) provided between and in contact with the ultrasonic transducer and the orifice plate to transmit the ultrasound energy through that fluid media. The actuatable ultrasonic transducer produce ultrasonic sound waves which pass through the thin viscous fluid layer and impinge upon the orifice structure and dislodges debris.



**FIG. 2**

**EP 0 988 977 A1**

## Description

[0001] This invention relates to a cleaning of ink jet printhead cartridges using ultrasonic transducers in contact with a thin layer of viscous fluid.

[0002] Typically, an ink jet printer has at least one printing cartridge from which droplets of ink are directed towards a receiver. Within the cartridge, the ink may be contained in a plurality of channels and energy pulses are used to cause the droplets of ink to be ejected on demand or continuously, from nozzles in a plate in an orifice structure.

[0003] In a thermal ink jet printer, the energy pulses are generally provided by a set of electrical resistors, each located in a respective one of the channels, each one of them is individually addressable by current pulses to instantaneously heat and form a droplet or bubble in the channels which contact the resistors. Operation of thermal ink jet printer is described in details in US-A-4,849,774; 4,500,895; and US-A-4,794,409.

[0004] On the other hand, a piezoelectric ink jet printing system includes a body of piezoelectric material defining a plurality of parallel open topped channels separated by walls. The walls have metal electrodes on opposite sides thereof to form shear mode actuators for causing droplets to expel from the channels. An orifice plate defining the holes through which the ink droplets are ejected is bonded to the open end of the channels. The electrical energy pulses are applied to the parallel electrodes causing the channels to shear actuating the expulsion of droplets from the orifice plate. Operation of piezoelectric ink jet print heads is described in details in US-A-5,598,196; US-A-5,311,218; and US-A-5,248,998.

[0005] Ink jet printing cartridges, whether it is of thermal or piezoelectric kind, use a variety of functional components, all of which must cooperate in a precise manner to achieve maximum efficiency. One of the most important components is an orifice plate having a plurality of orifices referred to as nozzles therein. The nozzles are usually circular in cross section and the diameter of the nozzles may vary from 10 to 100  $\mu\text{m}$  as required by the specification of the printer. Higher the resolution of the printed output, smaller is the ink droplet thereby requiring smaller diameter nozzles. Ink is ejected through these openings during printing operation. To obtain defect-free printing output, the orifice plates and nozzles must be kept clean and free of debris and any kind of obstructions to ink flow at all times. If the orifice plate and nozzles are not clean, many problems can occur thereby undermining the performance of the printer. As for example, paper fibers and other debris accumulated on the orifice plate surface and inside the nozzles can affect the quality of the printed images. Similarly, debris can be dried ink crusts and paper dust on the orifice plate as well as in the ink channels and the nozzles can cause the printer to perform poorly.

[0006] The foregoing problems are overcome, as described in US-A-5,300,958, by providing "maintenance or service stations" within the main printer unit. The maintenance stations are designed such that when the printhead ink cartridge is not operating and is in a "parked" position, the cartridge is situated in the maintenance station outside the printing zone. The maintenance stations have many components which are designed to serve many functions. These functions include: (a) priming the printhead cartridge, (b) capping the orifice plate and nozzles therein when the printhead is not in operation, (c) wiping contaminants from the orifice plate, (d) preventing ink from drying out in the openings of the orifice plate, and (e) providing a receptacle for discarding the cleaned debris.

[0007] To accomplish this cleaning, the US-A-5,103,244 discloses a structure in which a multi-blade wiper is used. The desired cleaning is performed by dragging a printhead (cartridge) across the selected wiper blade. The wiper mechanism also includes a plurality of resilient blades each having an octagonal shape and rotatable about an axis.

[0008] Another cleaning structure disclosed in US-A-5,300,958, includes a printhead wiper unit consisting of a single or dual members positioned against each other to form a capillary pathway therebetween. The cartridge includes a compartment having an opening there-through and an absorbent member impregnated with cleaning solution.

[0009] Still another cleaning structure is disclosed in US-A-5,287,126 which includes a vacuum cleaner to help clean the orifice plate. The vacuum cleaner is comprised of a top cover plate, having a plurality of air passages, that is located over a channel surface by spacers. A vacuum means draws the pressure in the defined volume between the top cover plate, the channel surface, and the spacers below the external pressure, whereby air is drawn into the defined volume through the air passage. The resulting air flow removes ink, dust and debris from the vicinity thereby keeping the cartridge clean.

[0010] All the above mentioned prior arts have the following drawback: distortion of orifice plate, wear and abrasion of the orifice plate surface and inefficient cleaning of the printhead cartridges.

[0011] It is an object of the present invention to provide improved cleaning of ink jet printhead cartridges.

[0012] It is another object of this invention to provide a more efficient printhead cartridge cleaning system which not only provides a wiping unit but also permits a controlled dislodging of debris accumulated in the nozzles and the surface of the orifice plate and thereby cleaning the printhead cartridges.

[0013] It is another object of the present invention to provide an apparatus for cleaning an ink jet printhead cartridge which is compact, robust and efficient.

[0014] These objects are achieved in an ink jet printing apparatus for receiving an ink cartridge defining

an orifice structure having at least one orifice plate with a plurality of nozzles for ejecting ink droplets onto a receiver to form an image, means for cleaning the orifice structure of debris, comprising:

- (a) at least one actuatable ultrasonic transducer operatively associated with and spaced from the nozzles;
- (b) a thin layer (meniscus) of viscous fluid provided between and in contact with the ultrasonic transducer and the orifice plate to transmit the ultrasound energy through that fluid media;
- (c) means for actuating the actuatable ultrasonic transducer to cause such actuatable ultrasonic transducer to produce ultrasonic sound waves which pass through the thin viscous fluid layer and impinge upon the orifice structure and dislodge debris; and
- (d) means for wiping the orifice structure to clean it of loosened debris and the viscous fluid.

**[0015]** Advantages of the invention include:

**[0016]** The use of a thin high viscous layer facilitates the transmission of ultrasonic sound waves to the orifice structure which overcomes many of the disadvantages of the existing technology, such as damages of the orifice plates and orifices due to wear, abrasion and distortion.

**[0017]** Lower power consumption can be minimized because of the lower driving frequency and effective sound wave transmission.

**[0018]** Cost-effective electronic integration of the actuatable ultrasonic transducer to the ink jet printhead cartridge.

**[0019]** Use of solvents and other undesirable chemicals can be avoided.

**[0020]** The actuatable ultrasonic transducers can be miniaturized and easily accommodated in a conventional maintenance station of a printer.

**[0021]** It is an important feature of the present invention to involve at least one actuatable ultrasonic transducer in conjunction with an ink jet cartridge and resilient wipers for effectively cleaning the ink jet printhead cartridge of debris.

FIG. 1 is a perspective of a prior art ink jet printer depicting the prior art;

FIG. 2. is a partial isometric view of the maintenance station area of the ink jet printer containing the actuatable ultrasonic transducer of this invention;

FIG. 3 is an end view of an ink jet cartridge disposed adjacent to an actuatable ultrasonic transducer; and

FIG.4 is an enlarged partial isometric view of actuatable platform.

**[0022]** Referring to FIG. 1, a typical ink jet printer 100 of prior art is described. Ink jet printer 100 is of the type

in which the printing is done in a substantially horizontal plane, includes a printer housing 10, a printhead carriage 20, a carriage rod 32 (see FIG. 2), drive roller assembly 34, paper supply 38, and maintenance station 40. Drive roller assembly 34 feeds paper, or other print media of choice supplied to it from the paper supply 38 to a printing zone disposed between printhead carriage 20 and the platen (not shown) in a manner well known to artisans. Printhead carriage 20 travels back and forth on carriage rod 32 (see FIG. 2) through the printing zone. Printhead carriage 20 is moved bi-directionally typically by means of a drive belt 50 connected to a carriage motor 60. Printhead carriage 20 includes ink cartridges 64 and 66 (only two cartridges are shown here) which are connected by a flexible electrical interconnect strip 31 to a microprocessor 24 which also controls carriage motor 60. A control panel 70 is electrically associated with microprocessor 24 for selection of various options relating to printing operation. Such control operation and the printing mechanism of an ink jet printer is well known in the prior art and hereby form no part of this invention.

**[0023]** The present invention provides an apparatus for cleaning an ink jet printhead cartridge which uses a high frequency actuatable ultrasonic transducer in conjunction with a plurality of conventional wipers for effectively cleaning the printhead cartridge. The actuatable ultrasonic transducers can be kept in close proximity of the cartridges intended for cleaning in contact with a thin layer of viscous of fluid through which the sound energy is transmitted. Ultrasonic transducers marketed by Ultrason Laboratories in Boalsburg, Pa. can be adapted to this cleaning operation.

**[0024]** Components of a typical ultrasonic cleaner include a generator or power supply that converts conventional 50 Hz alternating current at 110 or 220 volts to greater than 10 MHz electrical energy at approximately 1,000 volts. This high frequency electrical energy is fed to a converter where it is transformed to mechanical vibration. The ultrasonic transducer has ceramic piezoelectric materials, for example, two or more PZT (lead zirconate titanate) bodies of any convenient shape which, when subjected to an alternating current, expand and contract. The piezoelectric bodies vibrate in the longitudinal direction and this motion is transmitted to the transducer head.

**[0025]** The ultrasonic transducer is formed of materials having a high mechanical Q, thus minimizing the attenuation experienced by the ultrasonic energy as it is transmitted through this transducer. Q is a measure of the efficiency of the transducer. It is defined as follows:  $Q = \text{energy stored by the material} / \text{energy input}$ . Preferably, aluminum, titanium or an aluminum or titanium alloy having a mechanical Q greater than 50,000 is used. Examples of suitable aluminum alloys include duralumin, aluminum alloy 7075, aluminum alloy 2024, and aluminum alloy 6061. An example of a titanium alloy which transmits ultrasonic energy efficiently is Ti-6Al-

4V. For the purpose of cleaning ink jet printhead cartridges, the ultrasonic frequency should preferably be in the range of between about 100 kHz and 1 MHz.

**[0026]** Now referring to FIG. 2, a detailed description of the maintenance station 40 of the present invention will now be provided. The maintenance station 40 incorporates one or more high frequency actuable ultrasonic transducers 81, 82, 83, and 84 which transmit acoustic energy through a viscous liquid (fluid) medium. These ultrasonic transducers are mounted on a transducer platform 80. The maintenance station 40 also incorporates means for providing few drops of viscous fluid to provide a thin viscous layer 81a, 82a, 83a, 84a on the transducers 81, 82, 83 and 84 respectively. The characteristics of the viscous liquid to form a viscous meniscus are as follows:

- (a) not chemically reactive such that it reacts with and contaminates the ink and chemically degrades the orifice plate;
- (b) viscosity must range from 100 to 500 centipoises;
- (c) must be able to transmit ultrasound efficiently;
- (d) thickness of the liquid layer (meniscus) must not exceed 1 mm and must be at least 0.1 mm; and
- (e) viscous liquids that can be used are ethylene glycol, propylene glycol and glycerol, commercially available, glycerine can be effectively used in accordance with this invention.

Four ink jet printhead cartridges 72, 74, 76 and 78 are shown here to describe fully the embodiment of the present invention. For purposes of the illustrative embodiment described in this invention, cartridge 72 utilizes black ink while cartridges 74, 76, and 78 could use only cyan, yellow, and magenta ink, respectively. The cartridges 72, 74, 76 and 78 are each provided with orifice structure that can define ink channels but will necessarily include orifice plates 72a, 74a, 76a, and 78a respectively, through which ink droplets are ejected to a receiver. Furthermore, any number of different colored ink cartridges could be used, as warranted by the application of the printer. Typically, ink jet cartridges 72, 74, 76, 78 are thermal ink jet printheads, but other kinds of cartridges, as for example, piezoelectric cartridges may also be acceptable and useful in this invention. Each cartridge orifice structure is provided with inlets 72b, 74b, 76b, and 78b for black, cyan, yellow, and magenta inks respectively, being delivered from reservoirs (not shown) located somewhere else. The maintenance station 40 is also equipped with resilient wipers 91, 92, 93, 94 which are mounted on a movable wiper platform 90 for wiping off debris from the orifice structure after ultrasonic cleaning operation of the orifice structure. The details of the operation of the wiper is described later.

**[0027]** At least four wipers 91, 92, 93 and 94, as shown in FIG. 2, are provided on the movable wiper

platform 90 which is located in the maintenance station 40. An actuator 90a provides the bi-directional translation motion of the wiper platform 90. Wipers 91, 92, 93, 94 are equipped with actuators 91a, 92a, 93a, 94a for motion in the vertical direction. The wiper platform 90 moves slidably on two sliding rods 22 as the actuator 90a is prompted by the microprocessor 24. Alternatively, the wiper platform 90 can also be moved bi-directionally by a motor directly connected to the platform 90a or through a belt. Each wiper is dedicated to orifice structure of a specific cartridge. The microprocessor 24 (see FIG. 1) controls the motion of the wipers 91, 92, 93 and 94 through the actuators 91a, 92a, 93a, 94a in such a manner that a specific wiper engages in wiping action of a cartridge immediately after an actuable ultrasonic transducer 81, 82, 83 and 84 concludes the cleaning action of a cartridge. As for example, cartridge 72 may move across actuable ultrasonic transducer 81 for necessary cleaning action after which is moved to wiper 91 for wiping and can be capped immediately after wiping. The wipers 91, 92, 93 and 94 and actuable ultrasonic transducers 81, 82, 83 and 84 each are dedicated to corresponding cartridges 72, 74, 76, 78, respectively, for the purpose of eliminating any cross contamination of debris. In other words, the actuable ultrasonic transducers 81, 82, 83 and 84 and the actuators 90a, 91a, 92a, 93a and 94a are controlled electronically by the microprocessor 24 through a feedback circuit (not shown).

**[0028]** The maintenance station 40 of FIG. 2 will be understood by those skilled in the art to be located in a region outside the printing zone at one end of the bi-directional movement of carriage 20. Cleaning is accomplished when the cartridges 72, 74, 76, 78 are moved by the carriage rod 32 to the maintenance station 40 where the wipers 91, 92, 93, and 94 are engaged in cleaning action.

**[0029]** Referring to FIG. 3, a printhead ink cartridge 72 which includes an inlet for ink 72b and orifice plate 72a is shown in close proximity to but space from an actuable ultrasonic transducer head 81 to provide a thin high viscous layer of glycerin 81a between the actuable transducer head 81 and the orifice plate 72a. By use of the term "thin" is meant that the thin high viscous layer has a thickness in the range of 0.1 to 1.0 mm thick. Also shown in FIG. 3 an electrical connector 86 which can be used for quickly connecting the actuable ultrasonic transducer 81 to a power supply 88.

**[0030]** Referring to FIG. 4, a detailed description of the wiper platform 90, includes the actuator 90a for horizontal bi-directional motion of a wiper base 48 and an actuator 91a for vertical motion of the wiper 91, is given. For sake of convenience only a single wiper 91 is shown. The wiper 91 shown in FIG. 4 has a razor like edge 43a for effective wiping action, but other shapes can also be applicable in this invention. The wiper 91 is mounted on a base 44 which is fastened to the actuator shaft 45. The wiper base 48 is moved bi-directionally by the actu-

ator 90a and the motion is controlled by the microprocessor 24 (see FIG. 1). Other alternative means may be used to move the platform such as a motor directly connected to the wiper base 48 or through a belt or a lead screw (not shown).

## PARTS LIST

### [0031]

10 printer housing  
 20 printhead carriage  
 22 sliding rod  
 24 microprocessor  
 30 wiper platform  
 31 electrical interconnect strip  
 32 carriage rod  
 34 drive roller assembly  
 38 paper supply  
 40 maintenance station  
 43a wiper edge  
 44 wiper base  
 45 transducer shaft  
 48 wiper base  
 50 drive belt  
 60 drive motor  
 64 ink cartridge  
 66 ink cartridge  
 70 control panel  
 71 ink cartridge  
 72 black ink cartridge  
 72a orifice plate  
 72b inlet for black ink  
 73 orifice plate  
 74 cyan ink cartridge  
 74a orifice plate for cyan ink  
 74b inlet for cyan ink  
 76 yellow ink cartridge  
 76a orifice plate for yellow ink  
 76b inlet for yellow ink  
 78 magenta ink cartridge  
 78a orifice plate for magenta ink  
 78b inlet for magenta ink  
 80 ultrasonic transducer platform  
 81 ultrasonic transducer  
 81a viscous liquid (fluid) layer  
 82 ultrasonic transducer  
 82a viscous liquid (fluid) layer  
 83 ultrasonic transducer  
 83a viscous liquid (fluid) layer  
 84 ultrasonic transducer  
 84a viscous liquid (fluid) layer  
 86 electrical connector  
 88 power supply  
 90 wiper platform  
 90a actuator  
 91 wiper  
 91a actuator

92 wiper  
 92a actuator  
 93 wiper  
 93a actuator  
 5 94 wiper  
 94a actuator  
 100 ink jet printer

## Claims

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1. In ink jet printing apparatus for receiving an ink cartridge defining an orifice structure having at least one orifice plate with a plurality of nozzles for ejecting ink droplets onto a receiver to form an image, means for cleaning the orifice structure of debris, comprising:

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(a) at least one actuatable ultrasonic transducer operatively associated with and spaced from the nozzles;

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(b) a thin layer (meniscus) of viscous fluid provided between and in contact with the ultrasonic transducer and the orifice plate to transmit the ultrasound energy through that fluid media;

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(c) means for actuating the actuatable ultrasonic transducer to cause such actuatable ultrasonic transducer to produce ultrasonic sound waves which pass through the thin viscous fluid layer and impinge upon the orifice structure and dislodge debris; and

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(d) means for wiping the orifice structure to clean it of loosened debris and the viscous fluid.

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2. The ink jet printing apparatus of claim 1 wherein the wiping means includes a plurality of resilient wipers for engaging the orifice structure to clean it of loosened debris.

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3. The ink jet printing apparatus of claim 2 further including actuator means for causing bi-directional movement of the wipers as they engage the orifice structure.

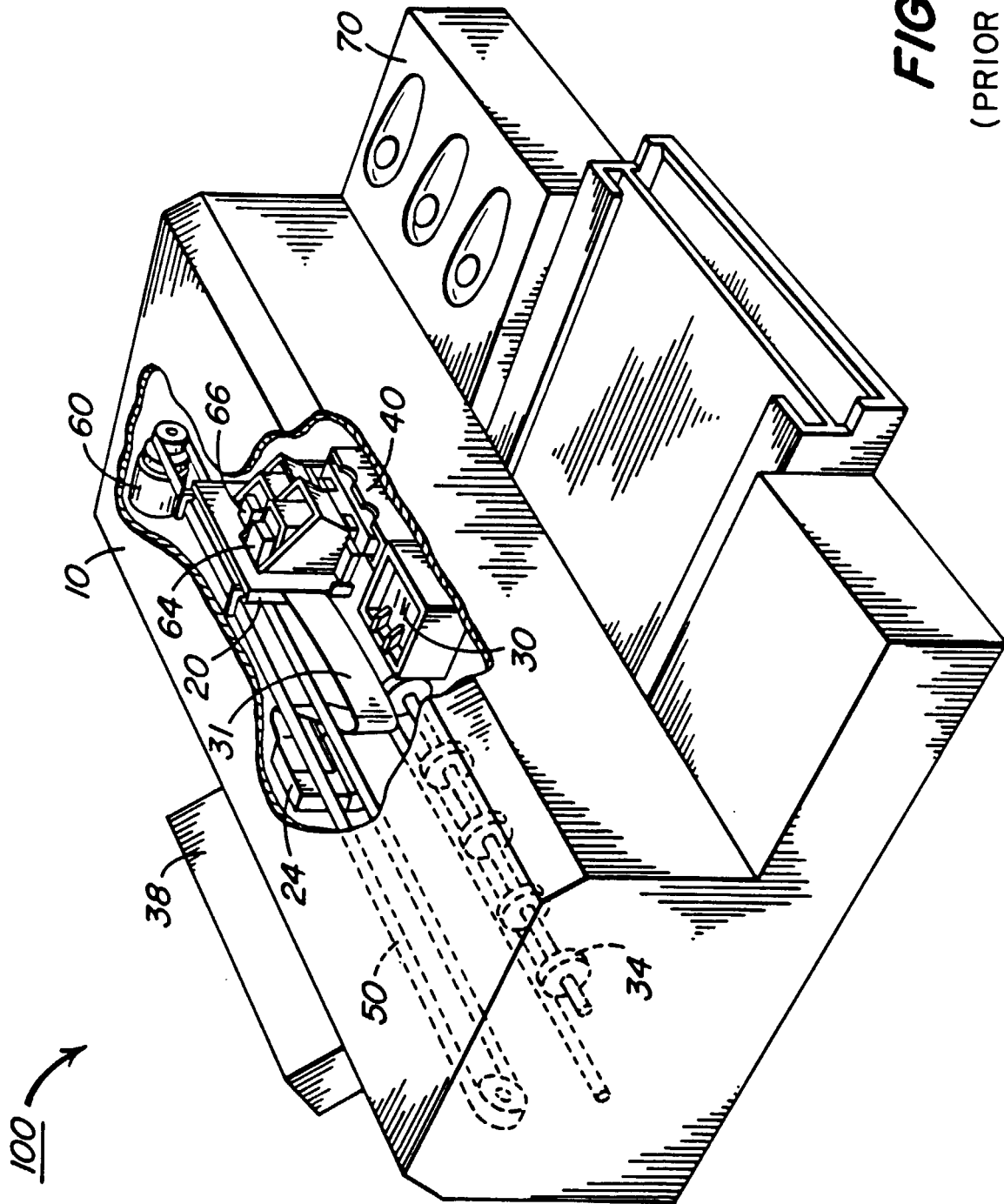
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4. The ink jet printing apparatus of claim 1 wherein the actuatable ultrasonic transducer produce ultrasonic sound waves in the range of about 100 kHz to 1 MHz..

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5. The ink jet printing apparatus of claim 1 wherein the thin high viscous layer is formed of glycerin.

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**FIG. 1**  
(PRIOR ART)

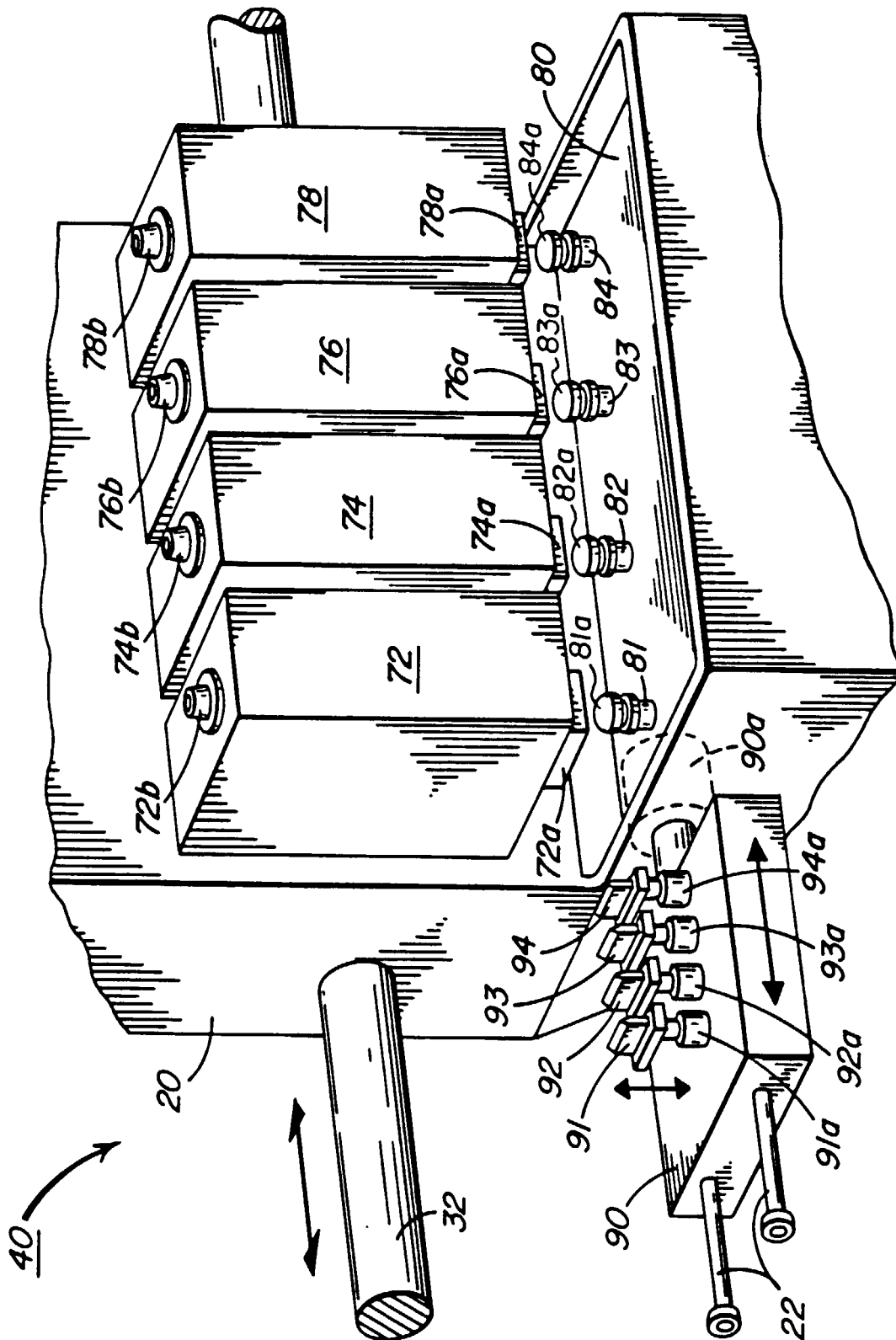
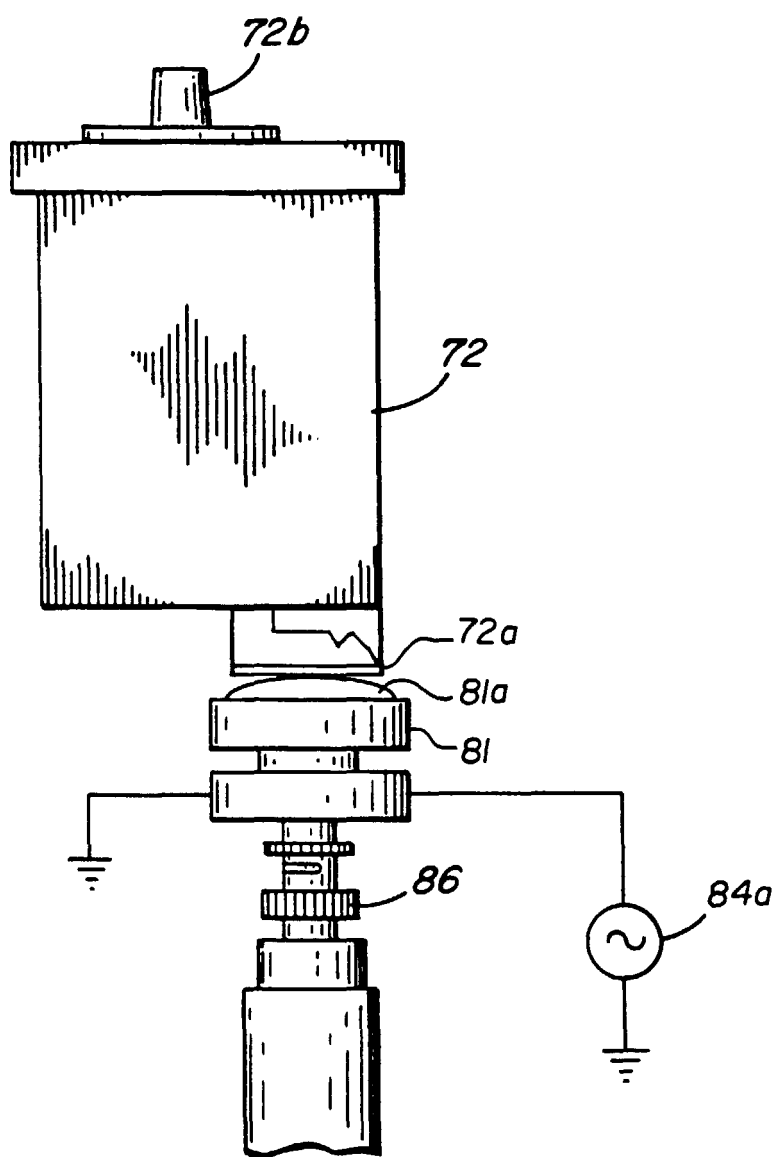
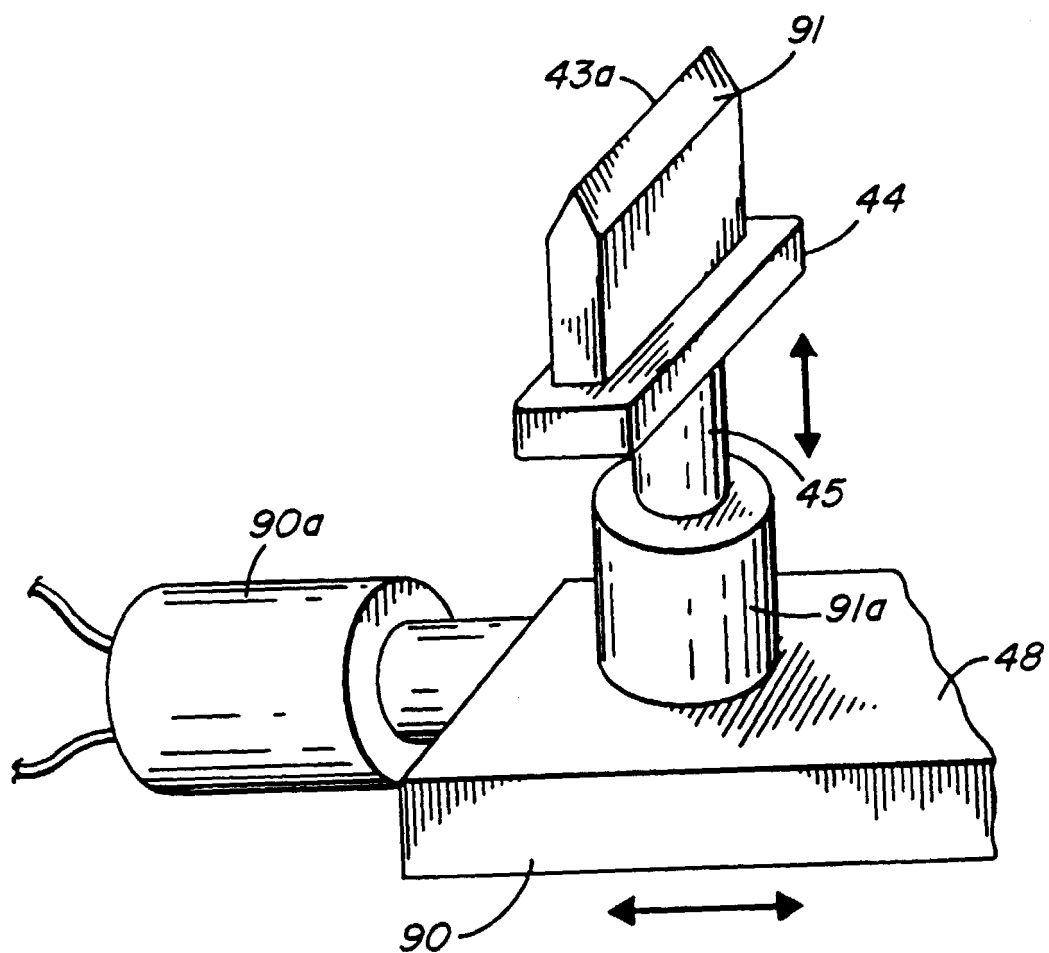


FIG. 2



**FIG. 3**



**FIG. 4**



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Application Number  
EP 99 20 2982

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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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Place of search		Date of completion of the search	Examiner
MUNICH		10 December 1999	Widmeier, W
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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
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