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(54) Non-contact ultrasonic cleaning of ink jet printhead cartridges

(57) An ink jet printing apparatus for receiving an ink cartridge defining an orifice structure having at least one plate with a plurality of nozzles for ejecting ink droplets onto a receiver to form an image, cleaning the orifice structure of debris, including at least one non-contact actuable ultrasonic transducer operatively associated with and spaced from the nozzles. The non-contact actuable ultrasonic transducer produces ultrasonic sound waves which impinge upon the orifice structure and loosens debris. Wipers wipe the orifice structure to clean it of loosened debris.

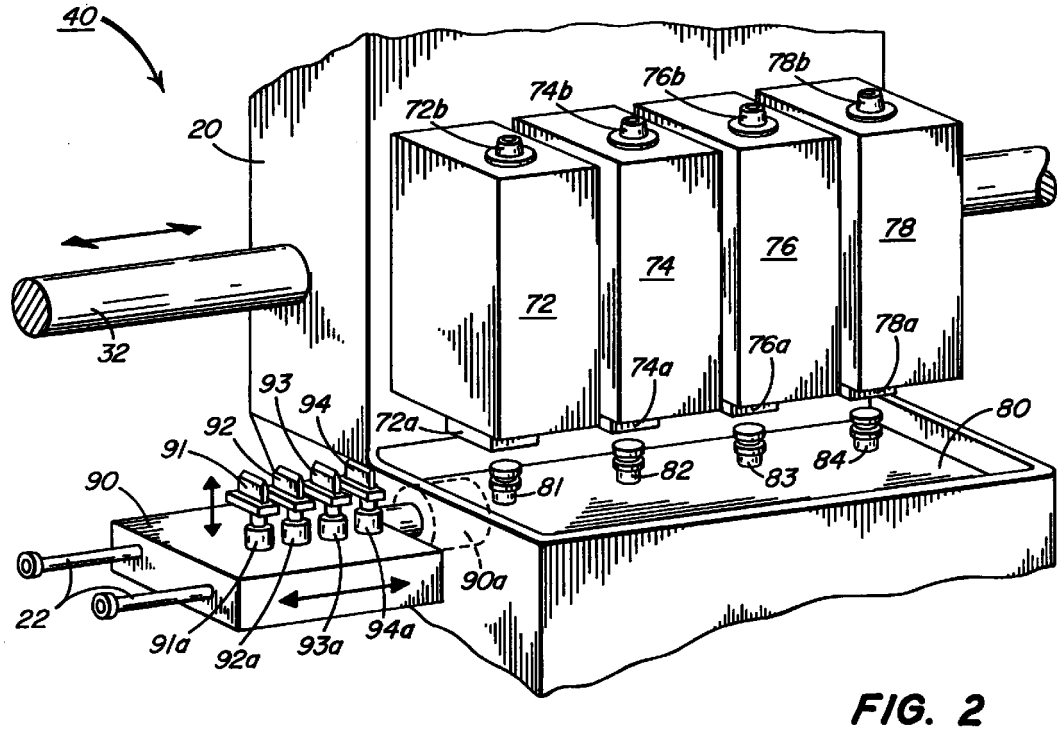

FIG. 2

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Description

[0001] This invention relates to a non-contact cleaning of ink jet printhead cartridges using ultrasonic transducers.

[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; US-A-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 openings or nozzles therein. The nozzles are usually circular in cross section and the diameter of the nozzles may vary from 10 to 100 μm 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 or orifices. 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 (openings) 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 therethrough 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 cartridge.

[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 in ink jet printing apparatus for receiving an ink cartridge defining

an orifice structure having at least one 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 non-contact actuable ultrasonic transducer operatively associated with and spaced from the nozzles;
(b) means for actuating the non-contact actuable ultrasonic transducer to cause such non-contact actuable ultrasonic transducer to produce ultrasonic sound waves which impinge upon the orifice structure and dislodges debris; and
(c) means for wiping the orifice structure to clean it of loosened debris.

[0015] Advantages of the invention include:

Overcoming many of the disadvantages of the existing technology, such as damages of the orifice plates and orifices due to wear, abrasion and distortion.
Cost-effective electronic integration of the non-contact actuable ultrasonic transducer to the ink jet printhead cartridge.
Use of solvents and other undesirable chemicals can be avoided.
The non-contact actuable ultrasonic transducers can be miniaturized and easily accommodated in a conventional maintenance station of a printer.

[0016] It is an important feature of the present invention to involve at least one non-contact actuable 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 an 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 non-contact actuable ultrasonic transducer of this invention;
FIG. 3 is an end view of an ink jet cartridge adjacent to an non-contact actuable ultrasonic transducer; and
FIG.4 is an enlarged partial isometric view of actuator platform.

[0017] 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. A wiper platform 30 containing plurality of wipers is provided in close proximity to the 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.

[0018] The present invention provides an apparatus for cleaning an ink jet printhead cartridge which uses a high frequency non-contact actuable ultrasonic transducer in conjunction with a plurality of conventional wipers for effectively cleaning the printhead cartridge. The non-contact actuable ultrasonic transducers can be kept in close proximity of the cartridges intended for cleaning without having any physical contact and transmitting the sound energy through air. Non-contact ultrasonic transducers marketed by Ultran Laboratories in Boalsburg, Pa. can be adapted to this cleaning operation.

[0019] 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.

[0020] 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. 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 cleaning purposes it is desirable that the wavelength, λ, of the incident acoustic wave be of the same orders of magnitude or smaller than the nozzle diameter so that the sound energy will penetrate the nozzle thereby dislodging debris therein. Thus if the nozzle diameter is 20 μm the required frequency, f, of the sound waves in air must be approximately 17 MHz as dictated by a general rela-

tionship: $\lambda f = c$, where c, the speed of sound in air, is 343 m/s at atmospheric pressure and 20 °C temperature. For the purpose of cleaning ink jet printhead cartridges, the ultrasonic frequency must range between 5 and 30 MHz. See Fundamentals of Physics, Revised Edition by David Halliday and Robert Resnick, John Wiley & Sons, Inc., New York (1974).

[0021] 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 non-contact actuable ultrasonic transducers 81, 82, 83, and 84 which transmit acoustic energy through air or gaseous medium. These ultrasonic transducers are mounted on a transducer platform 80. Four ink jet printhead cartridges 72,74,76 and 78 which are mounted on the printhead carriage 20 are shown here to describe fully the embodiment of the present invention. The printhead carriage 20 is moved bi-directionally on the carriage rod 32 through the printing zone. 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.

[0022] 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 close proximity to 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 a non-contact actuable ultrasonic transducer 81, 82, 83 and 84 concludes the cleaning action of a cartridge. As for example, cartridge 72 may move across non-contact 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 non-contact 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 non-contact 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).

[0023] The maintenance station 40 along with the wiper platform 90 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 as they are moved by the carriage rod 32 until they enter the maintenance station 40 where they engage the non-contact actuable transducers 81, 82, 83 and 84.

[0024] 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 a non-contact actuable ultrasonic transducer head 81 to provide a small air gap between the non-contact actuable transducer head 81 and the orifice plate 72a. For sake of convenience only a single printhead ink cartridge is shown. Also shown in FIG. 3 an electrical connector 86 which can be used for quickly connecting the non-contact actuable ultrasonic transducer 85 to a power supply 84a.

[0025] 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 actuator 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

[0026]

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
72	black ink cartridge
72a	orifice plate for black ink
72b	inlet for black ink
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	non-contact ultrasonic transducer
82	non-contact ultrasonic transducer
83	non-contact ultrasonic transducer
84	non-contact ultrasonic transducer
84a	power supply
86	electrical connector
90	movable wiper platform
90a	actuator
91	wiper
91a	actuator
92	wiper
92a	actuator
93	wiper
93a	actuator
94	wiper
94a	actuator
100	ink jet printer

Claims

1. An ink jet printing apparatus for receiving an ink cartridge defining an orifice structure having at least one 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 non-contact actuable ultrasonic transducer operatively associated with and spaced from the nozzles;

(b) means for actuating the non-contact actuable ultrasonic transducer to cause such non-contact actuable ultrasonic transducer to produce ultrasonic sound waves which impinge upon the orifice structure and loosens debris; and

(c) means for wiping the orifice structure to clean it of loosened debris.

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.

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.

4. The ink jet printing apparatus of claim 1 wherein the non-contact actuable ultrasonic transducer produce ultrasonic sound waves about 5 to 30MHz.

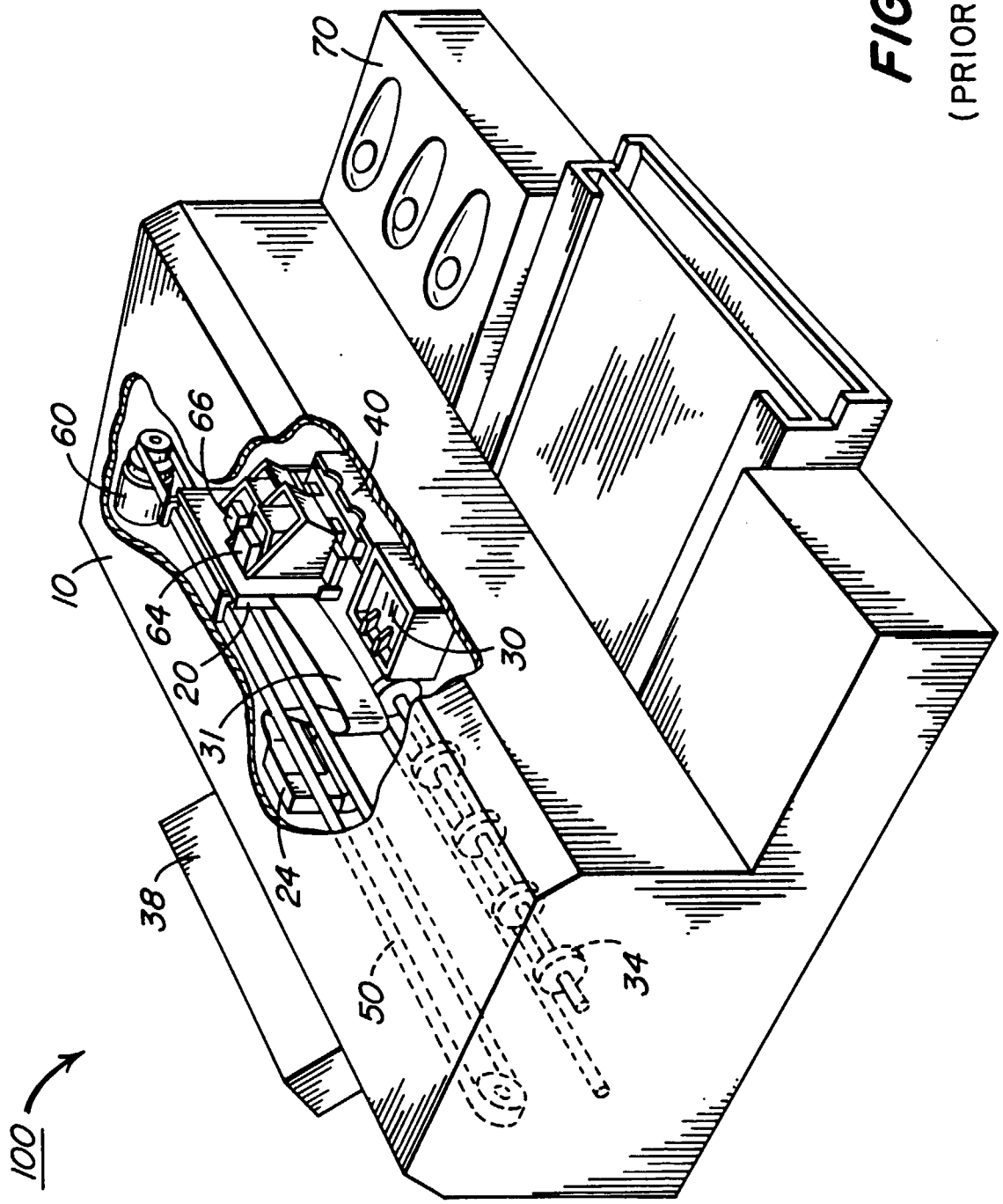

FIG. 1
(PRIOR ART)

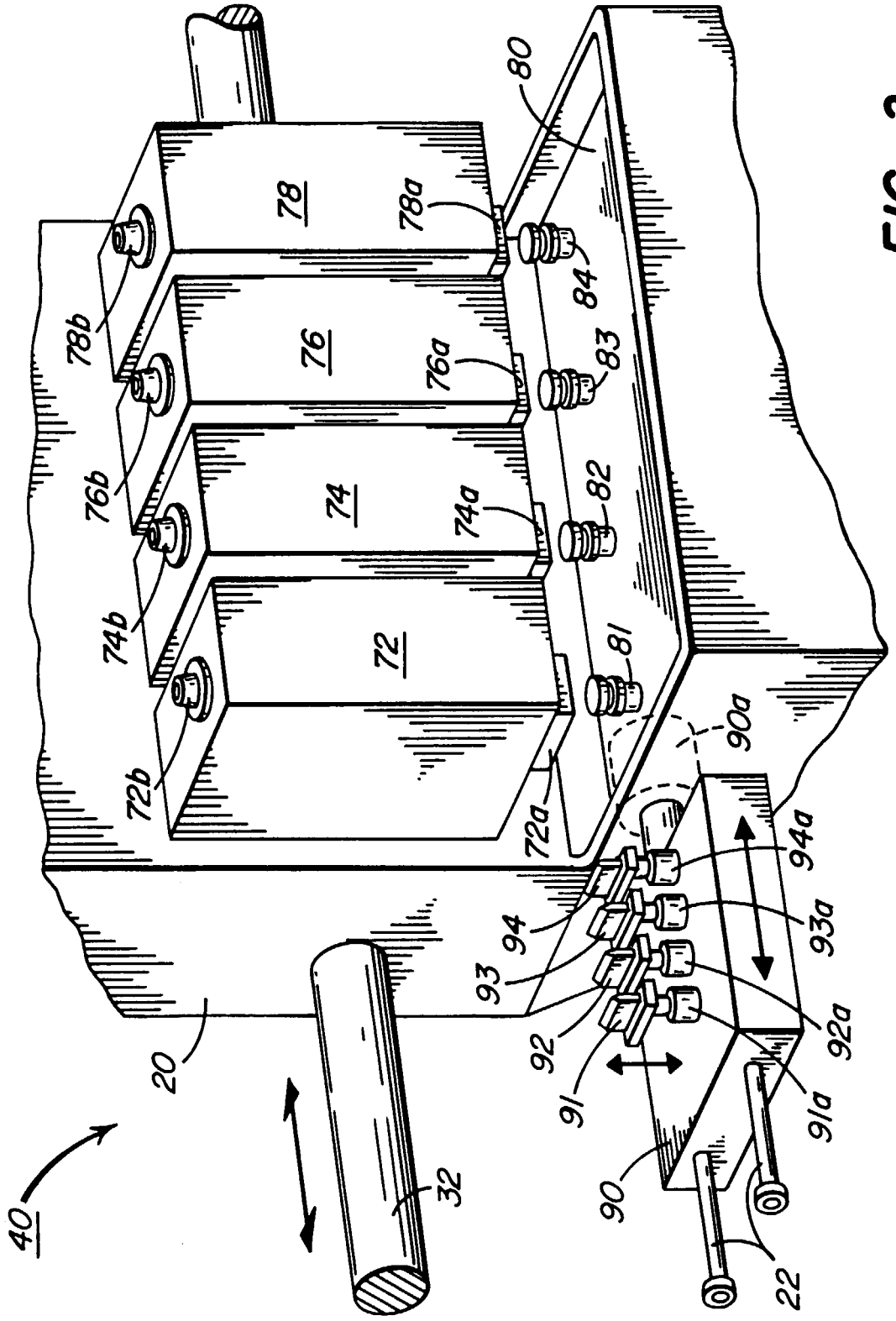
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FIG. 2

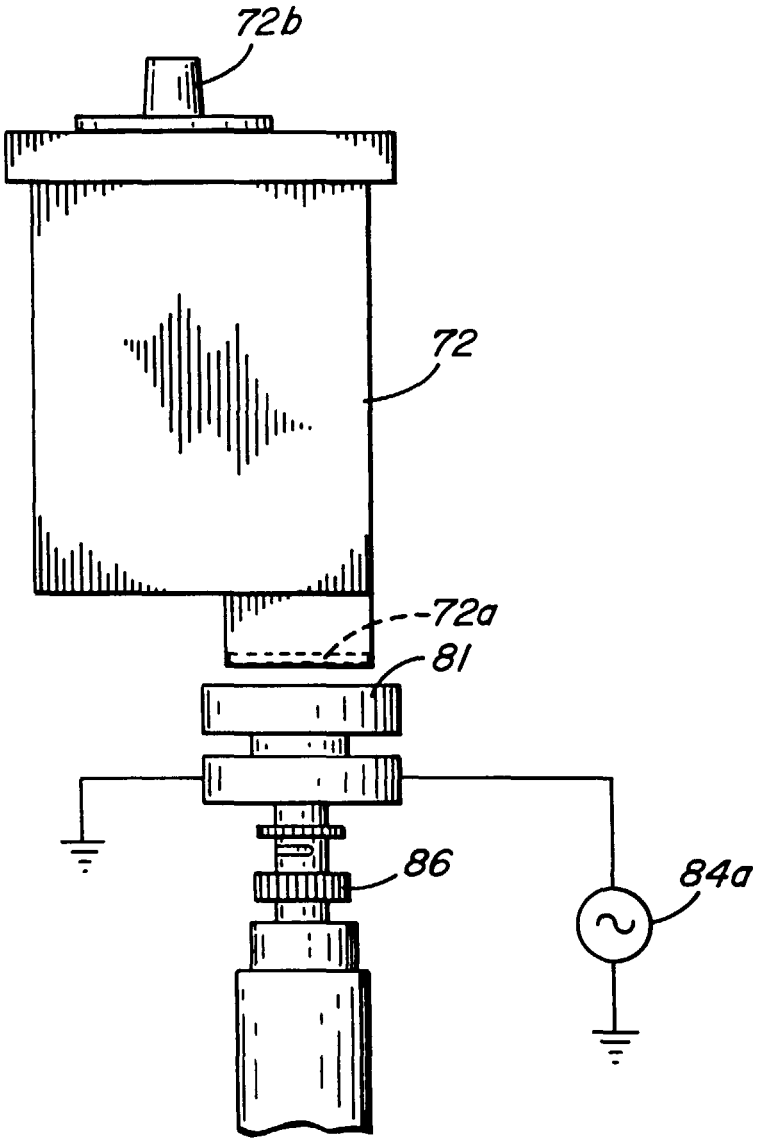

FIG. 3

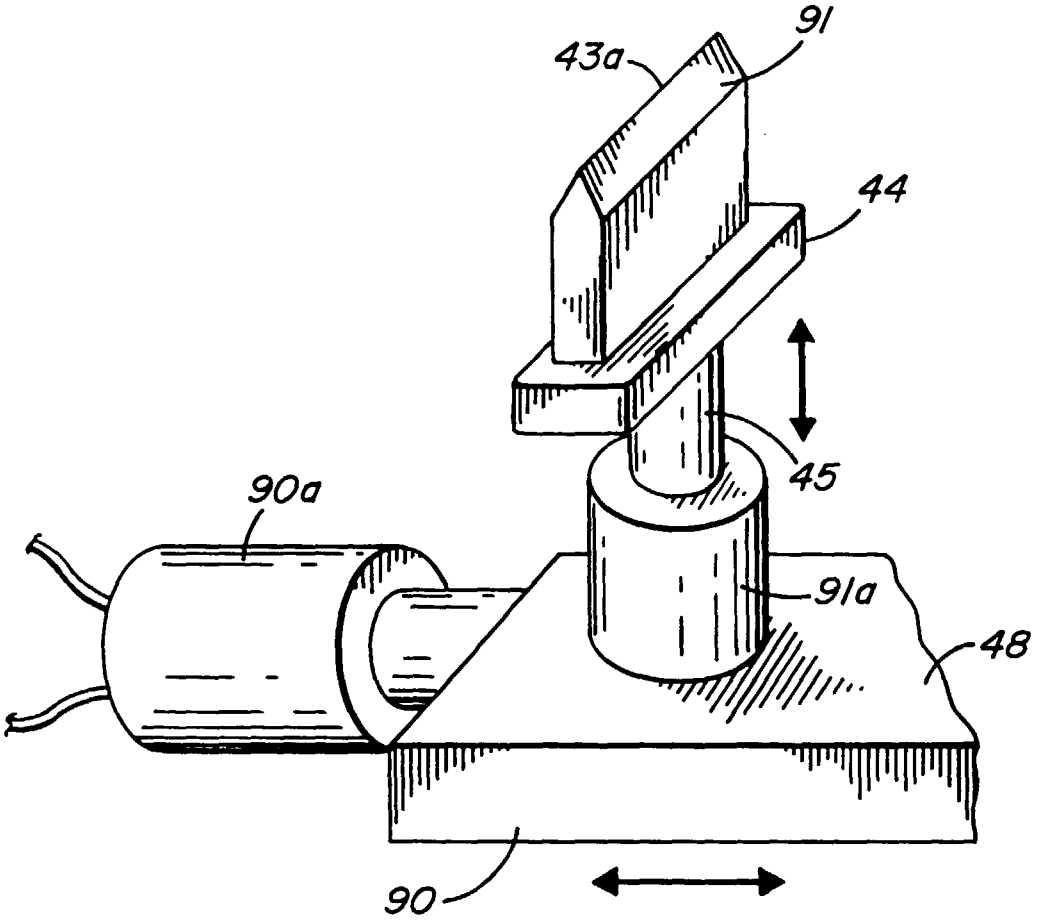

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 99 20 2364

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.7)
X	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 04, 30 April 1996 (1996-04-30) & JP 07 329310 A (ISHIZAKA SHOJI KK), 19 December 1995 (1995-12-19) * abstract *	1	B41J2/165
X	US 5 574 485 A (CHINNICI JOHN ET AL) 12 November 1996 (1996-11-12) * column 3, line 50 - column 8, line 44; figures 3,4 *	1	
A	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 04, 31 May 1995 (1995-05-31) & JP 07 025028 A (NEC CORP), 27 January 1995 (1995-01-27) * abstract *	1-3	
A	US 5 757 396 A (BRUNER DAN M) 26 May 1998 (1998-05-26) * column 5, line 38 - column 12, line 4; figure 1 *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.7) B41J
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22 November 1999	De Groot, R

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22-11-1999

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