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(54) **Ink jet recording apparatus**

(57) An ink jet recording apparatus comprising: an ink jet head (1) having an ink supply port (15), at least one pressurization chamber, (22), and at least one ejection nozzle (23); an ink tank (2) for storing ink; switching means (4), a first ink conduit (3-2) having one end connected to said ink supply port (15) and the other end to said switching means (4); a second ink conduit (3-1) connected between said switching means (4) and said ink tank (2); said switching means (4), being actuatable for selectively connecting said first ink conduit (3-2) to said second ink conduit (3-1) or venting said first ink conduit (3-2) to the atmosphere; suction cap means (6) capable of selective intimate contact with a front surface of said ejection nozzle (23) and having a space (6*a*) for drawing thereinto ink or air from said ejection nozzle (23) or nozzles; a drain tank (9); a third ink conduit (7) connecting said suction cap means (6) to said drain tank (9); suction means (8), disposed in said third conduit (7); and control means for controlling said switching means (4), and said suction means (8).

Fig.2.

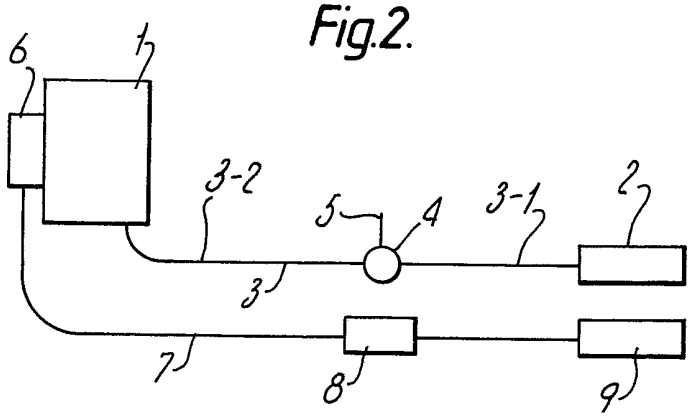

Fig.5.

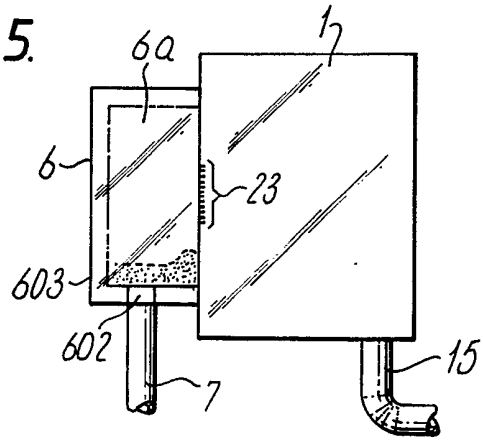

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Fig.1.

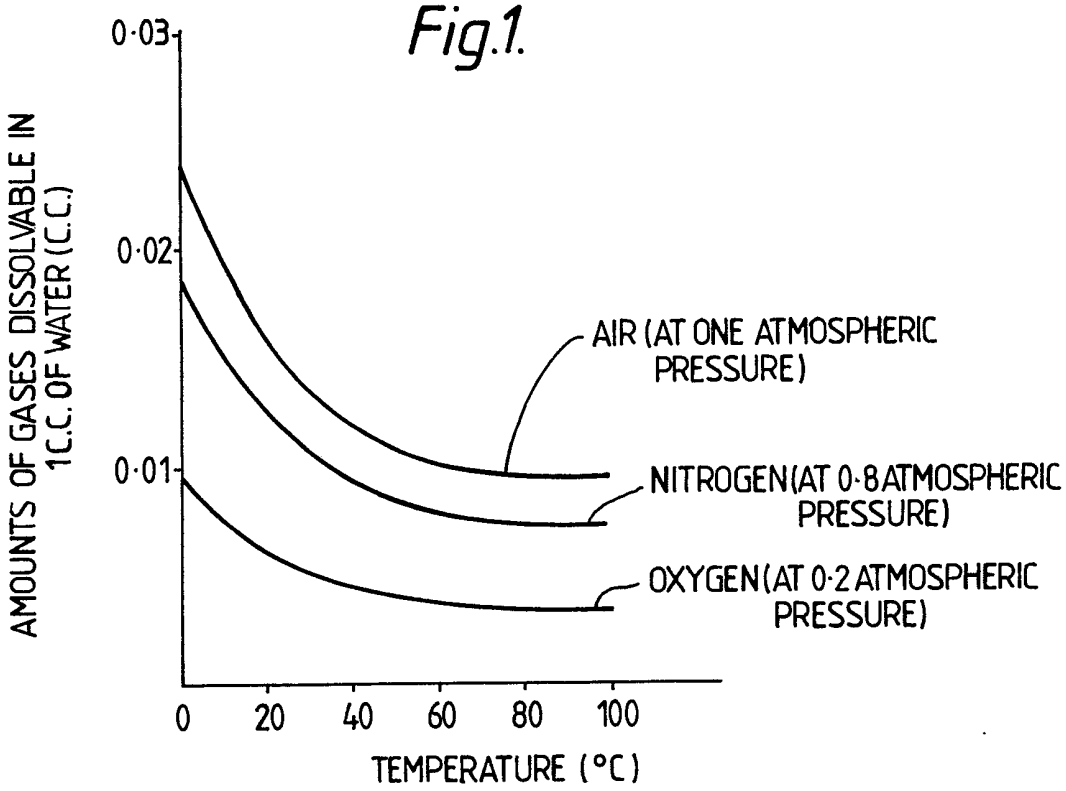

0·03
0·02
0·01
AMOUNTS OF GASES DISSOLVABLE IN 1C.C. OF WATER (C.C.)
AIR (AT ONE ATMOSPHERIC PRESSURE)
NITROGEN (AT 0·8 ATMOSPHERIC PRESSURE)
OXYGEN (AT 0·2 ATMOSPHERIC PRESSURE)
0
20
40
60
80
100
TEMPERATURE (°C)

Fig.2.

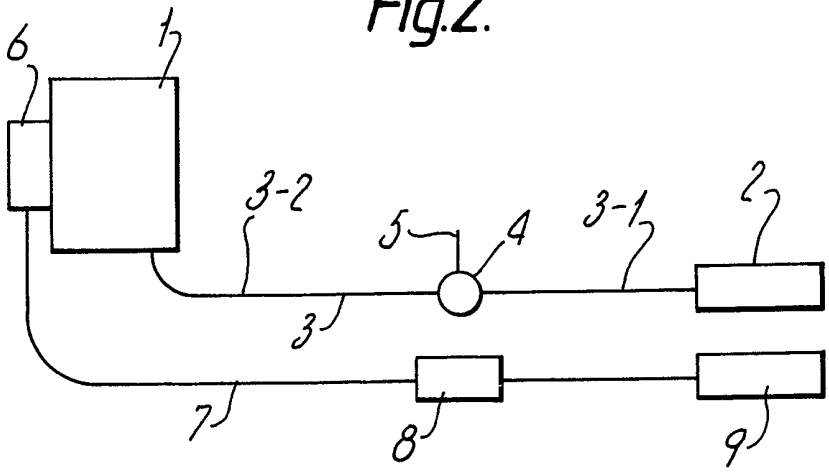

6
1
3-2
5
4
3-1
2
3
7
8
9

Fig.3a.

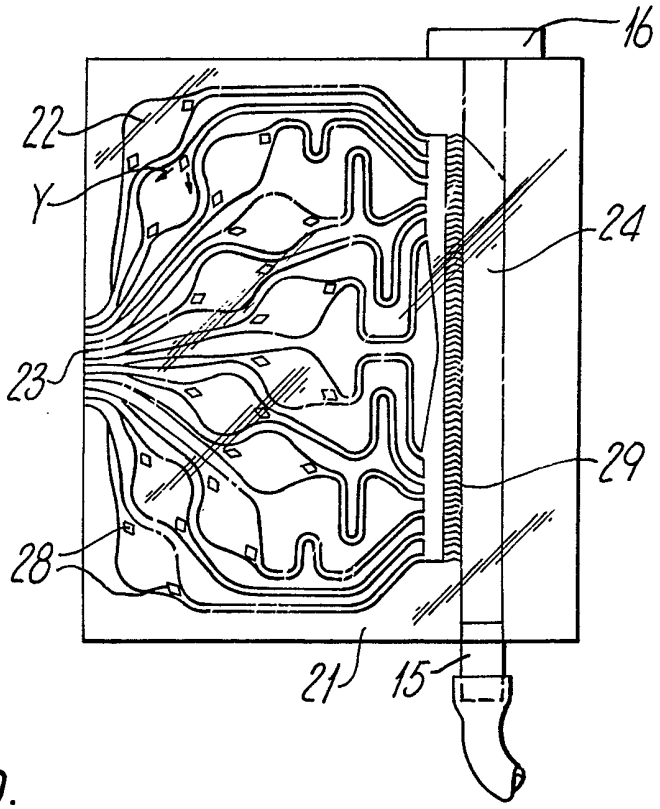


Fig.3b.

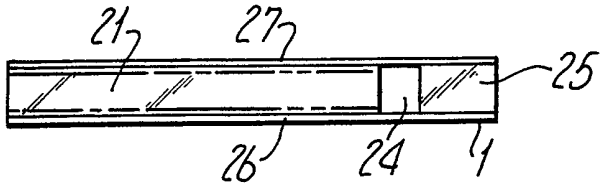


Fig.5.

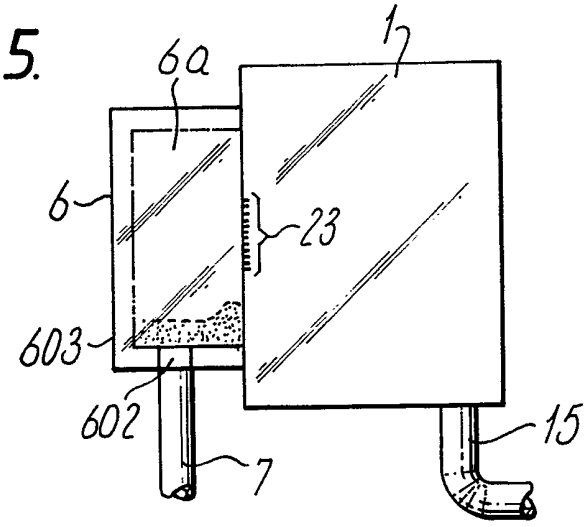


Fig.4(a).

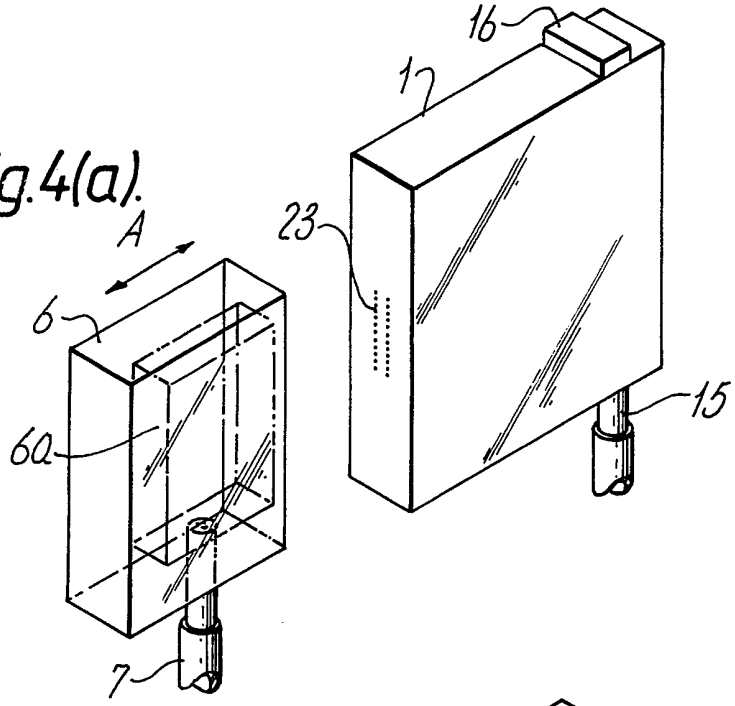


Fig.4(b).

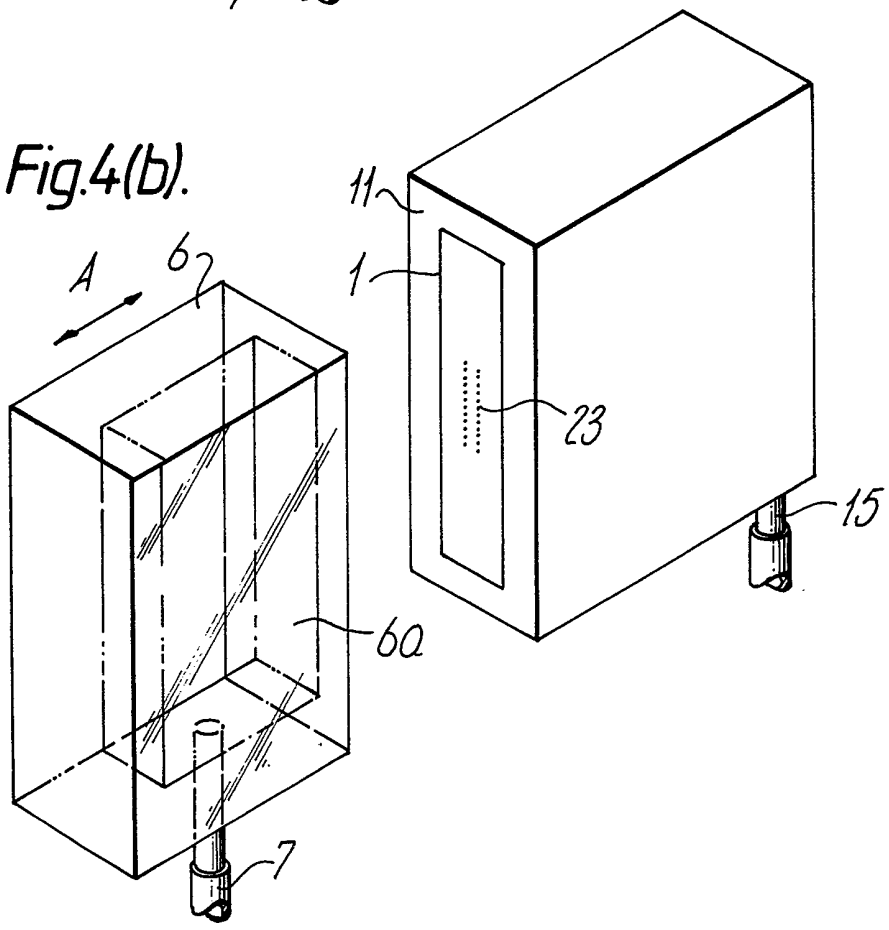


Fig.7(a).

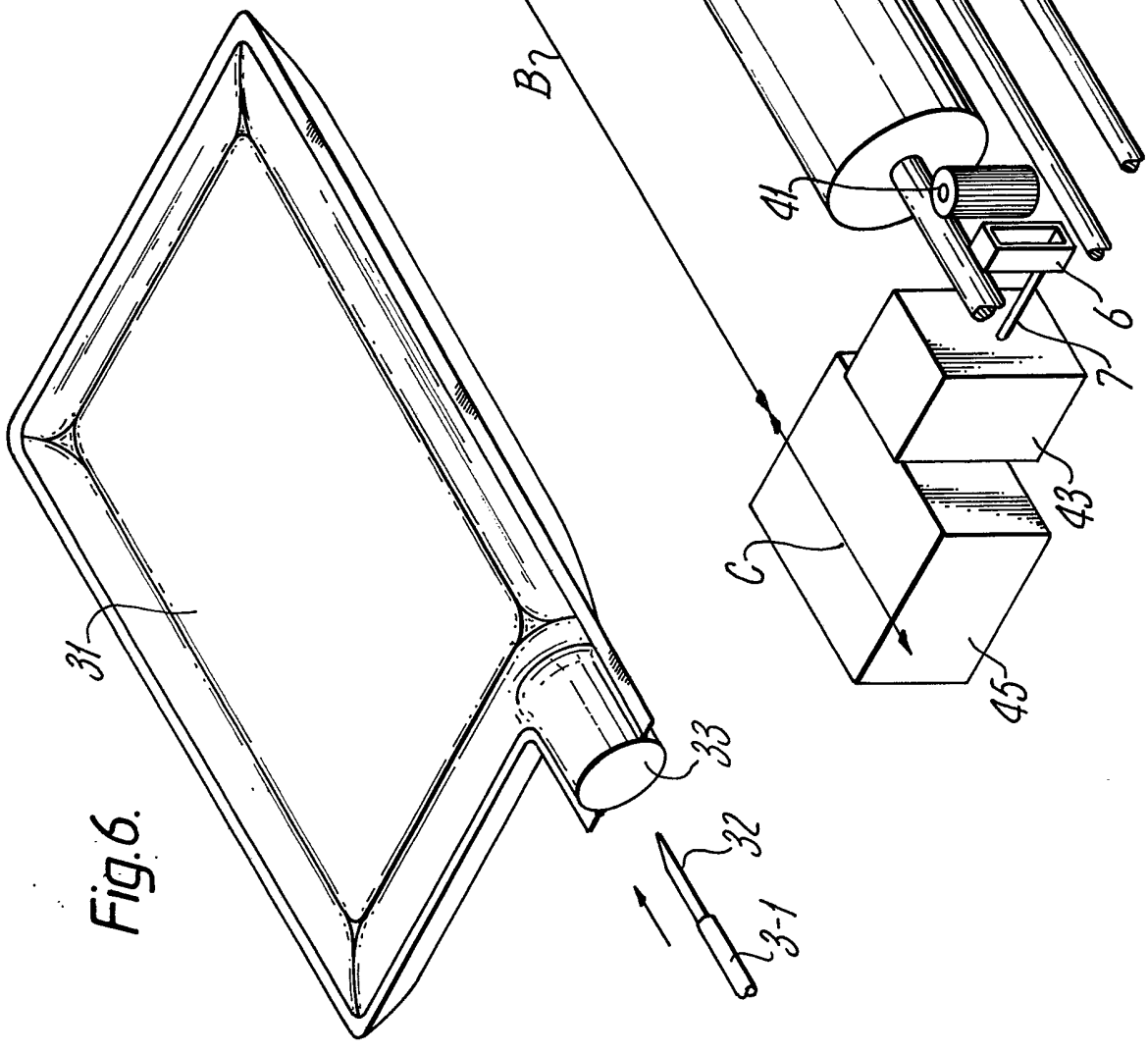


Fig.6.

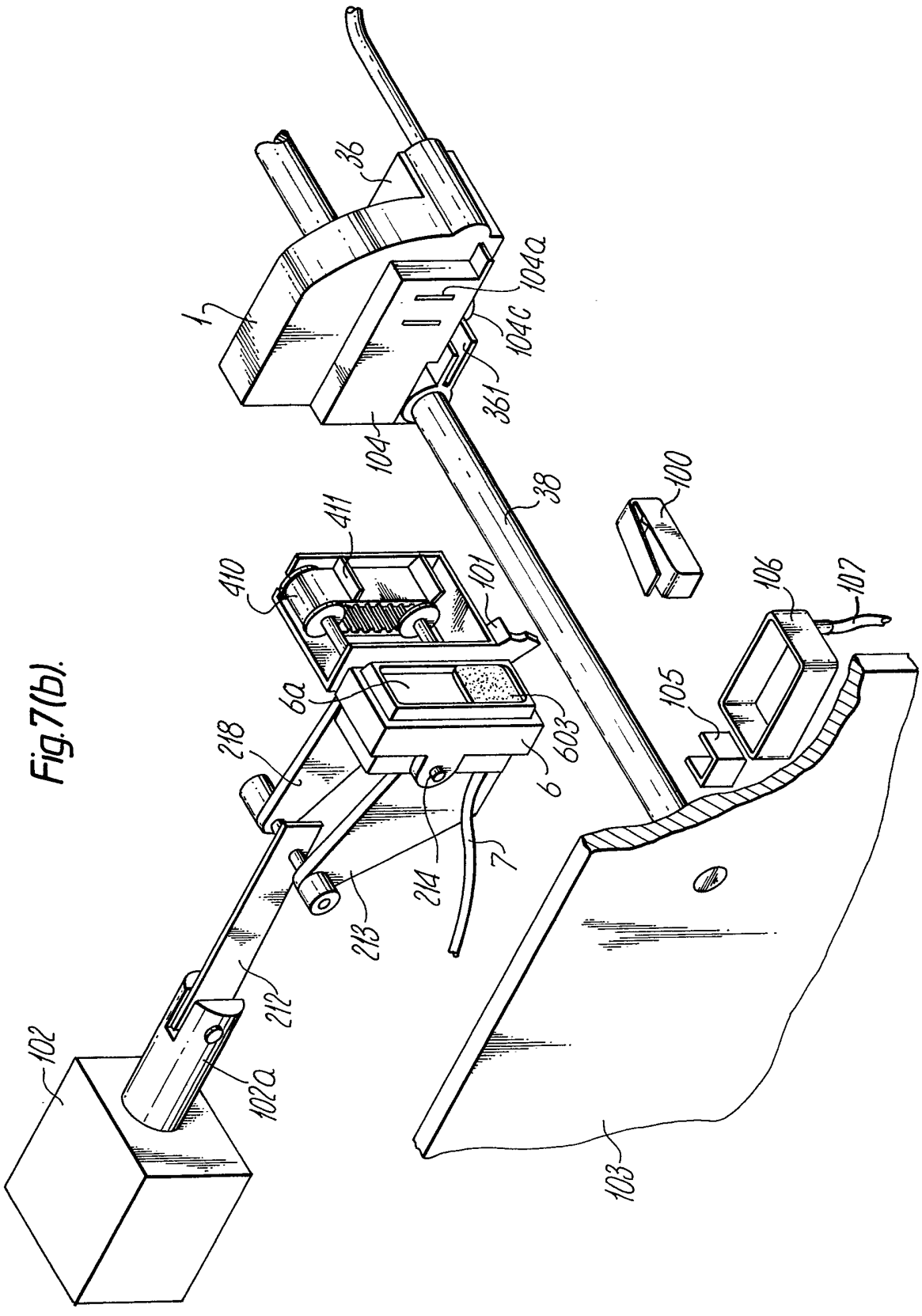

1
36
104a
104c
361
104
38
100
411
410
101
106
107
105
6a
603
6
218
214
7
213
212
102
102a
103

Fig.7(b).

Fig.9.

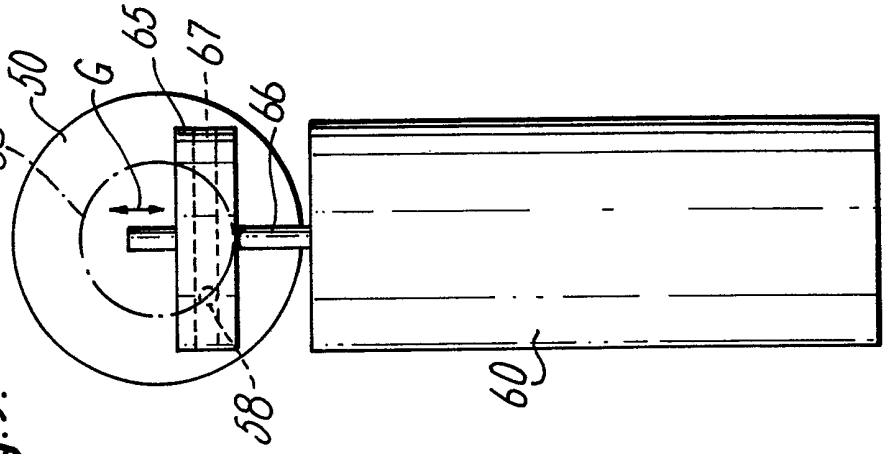


Fig.8.

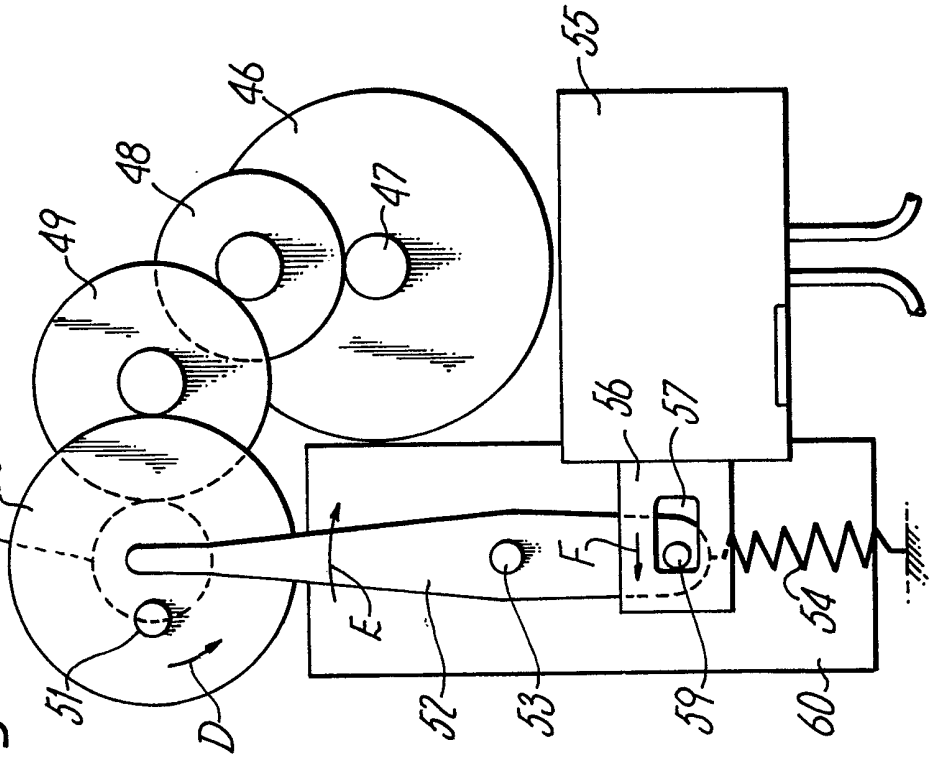


Fig.10.

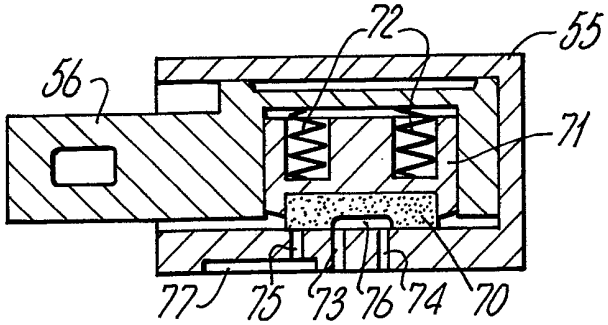


Fig.11.

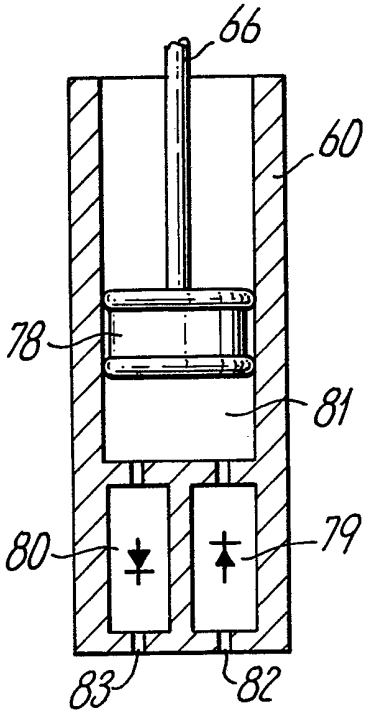


Fig.12.

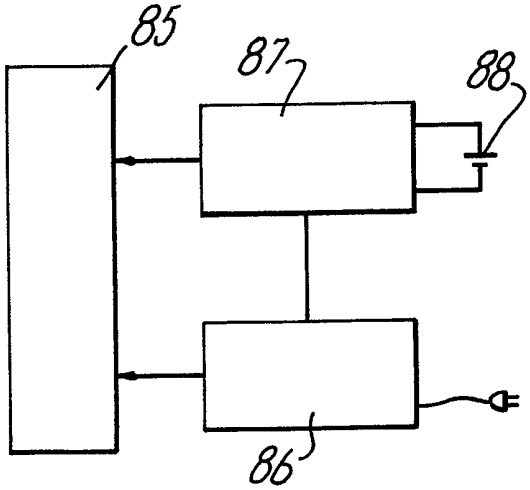


Fig.16.

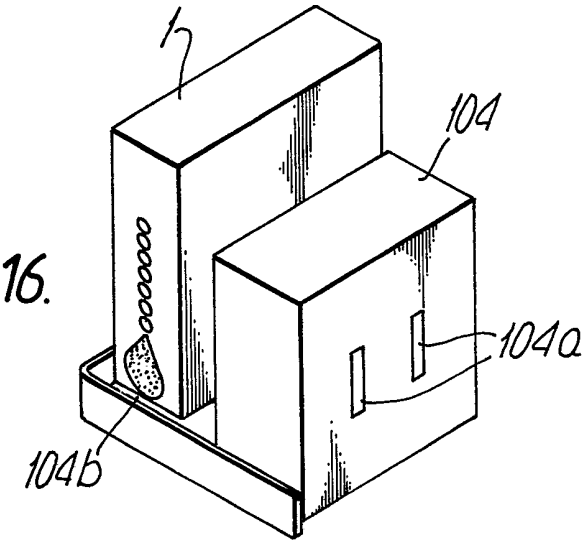


Fig.13(a).

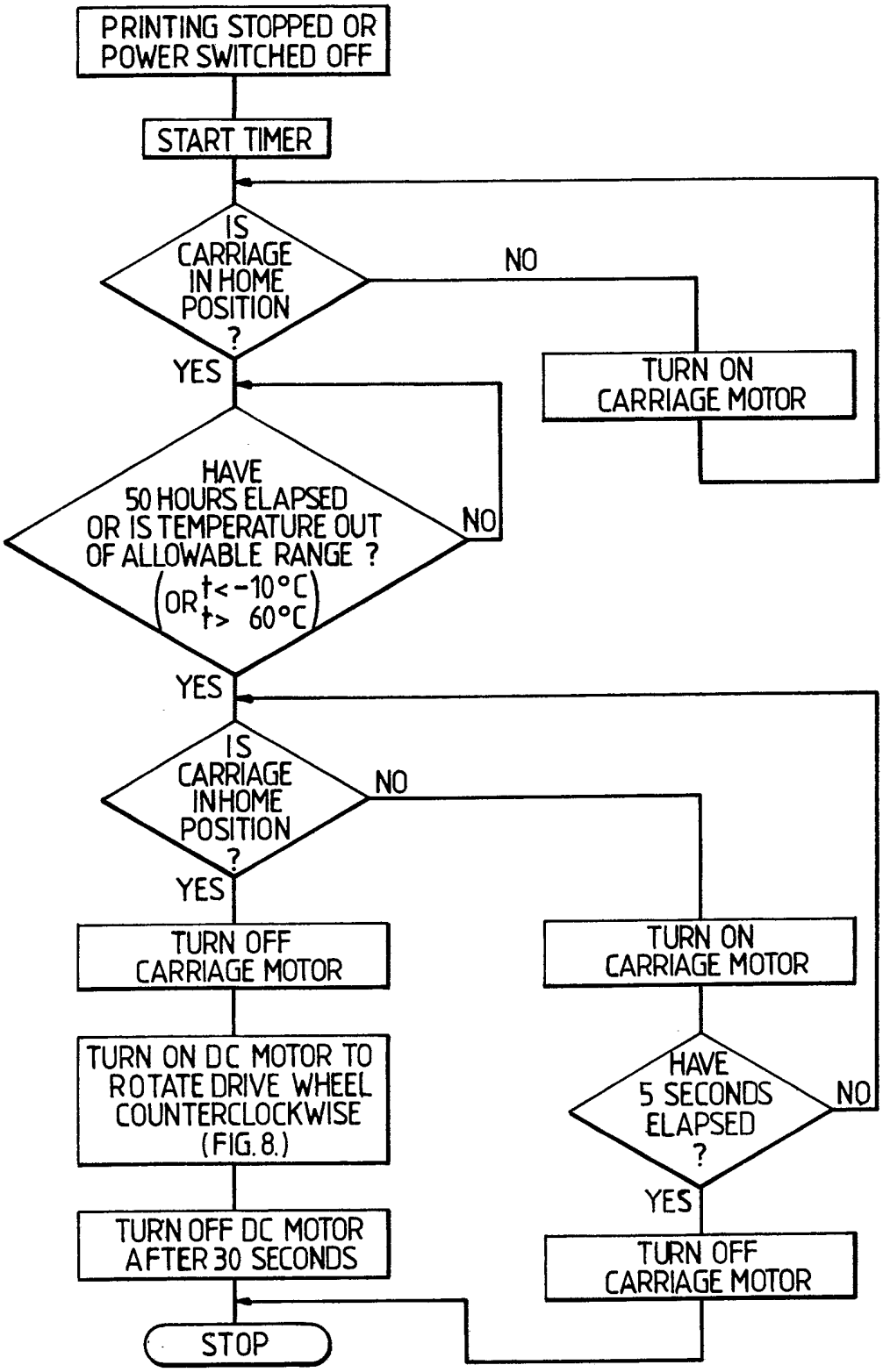

PRINTING STOPPED OR POWER SWITCHED OFF
START TIMER
IS CARRIAGE IN HOME POSITION ?
NO
YES
TURN ON CARRIAGE MOTOR
HAVE 50 HOURS ELAPSED OR IS TEMPERATURE OUT OF ALLOWABLE RANGE ? (OR t<-10°C t> 60°C)
NO
YES
IS CARRIAGE IN HOME POSITION ?
NO
YES
TURN OFF CARRIAGE MOTOR
TURN ON DC MOTOR TO ROTATE DRIVE WHEEL COUNTERCLOCKWISE (FIG. 8.)
TURN OFF DC MOTOR AFTER 30 SECONDS
STOP
TURN ON CARRIAGE MOTOR
HAVE 5 SECONDS ELAPSED ?
NO
YES
TURN OFF CARRIAGE MOTOR

Fig.13(b).

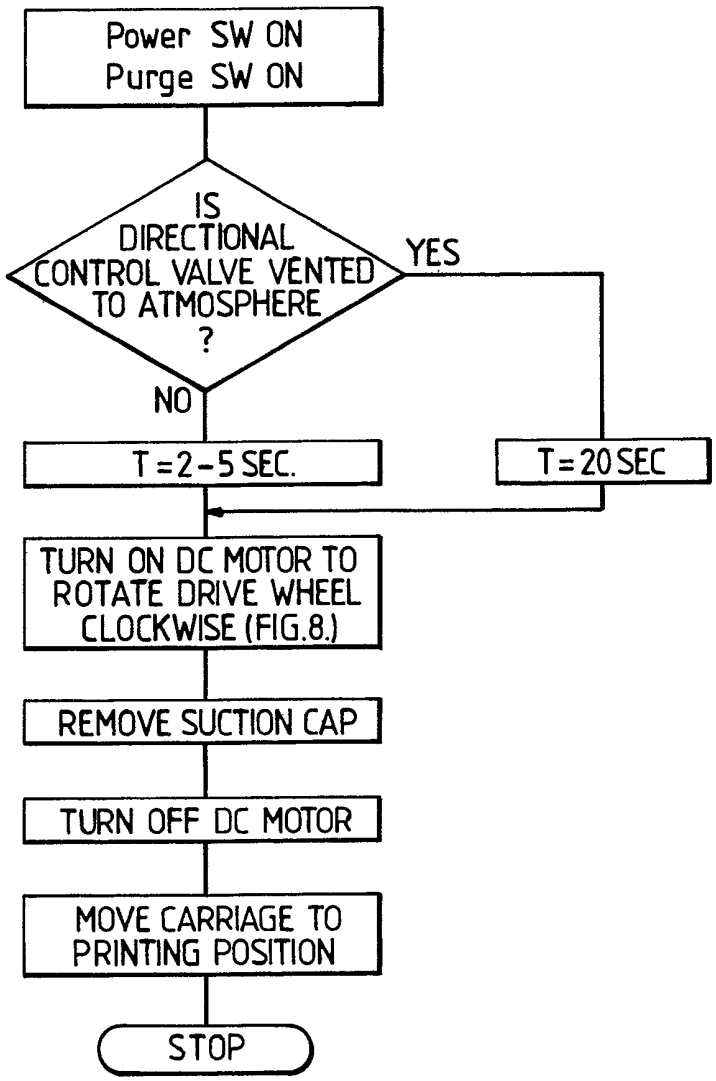

Power SW ON
Purge SW ON
IS DIRECTIONAL CONTROL VALVE VENTED TO ATMOSPHERE ?
YES
NO
T=2-5 SEC.
T=20 SEC
TURN ON DC MOTOR TO ROTATE DRIVE WHEEL CLOCKWISE (FIG.8.)
REMOVE SUCTION CAP
TURN OFF DC MOTOR
MOVE CARRIAGE TO PRINTING POSITION
STOP

Fig.14.

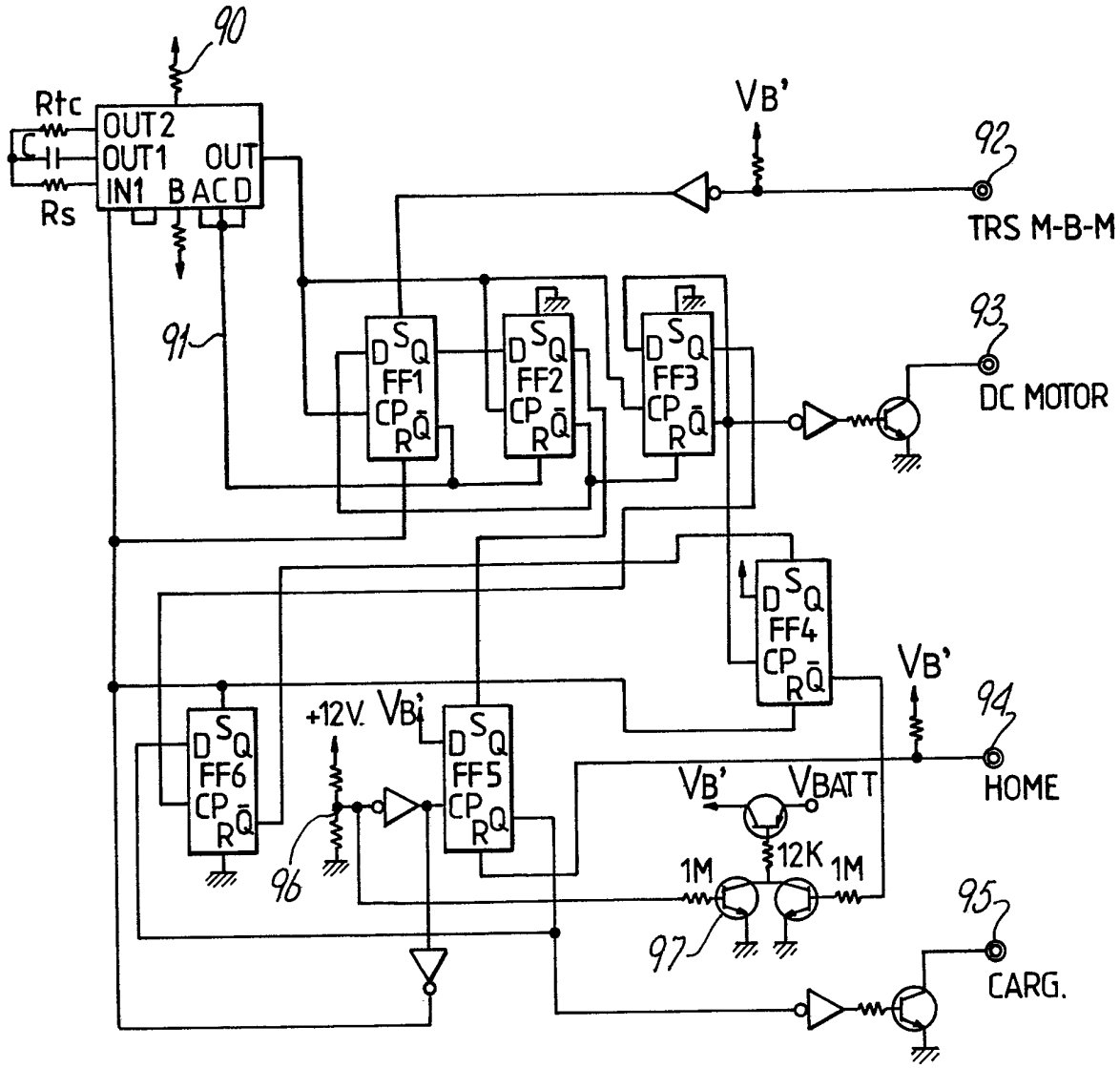

90
Rtc
C
Rs
OUT2
OUT1
IN1
OUT
B A C D
91
VB'
92
TRS M-B-M
93
DC MOTOR
FF1
FF2
FF3
FF4
FF5
FF6
D S Q
CP
R Q̄
+12V.
VBATT
1M
12K
96
97
94
HOME
95
CARG.

Fig.15(a).

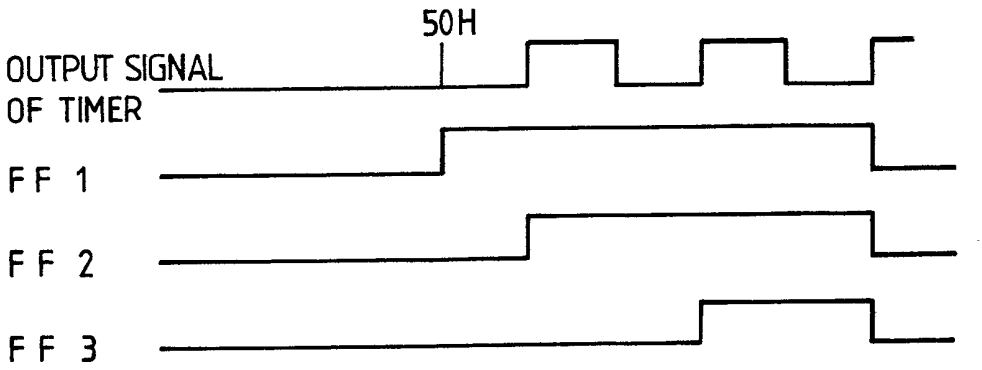


Fig.15(b).

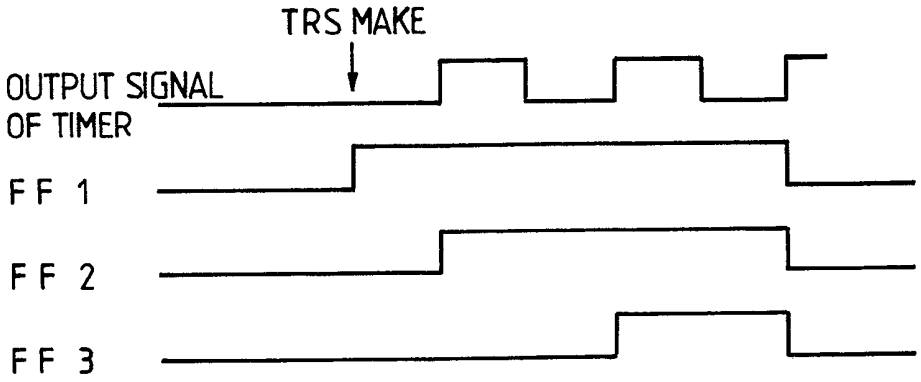


Fig.17.

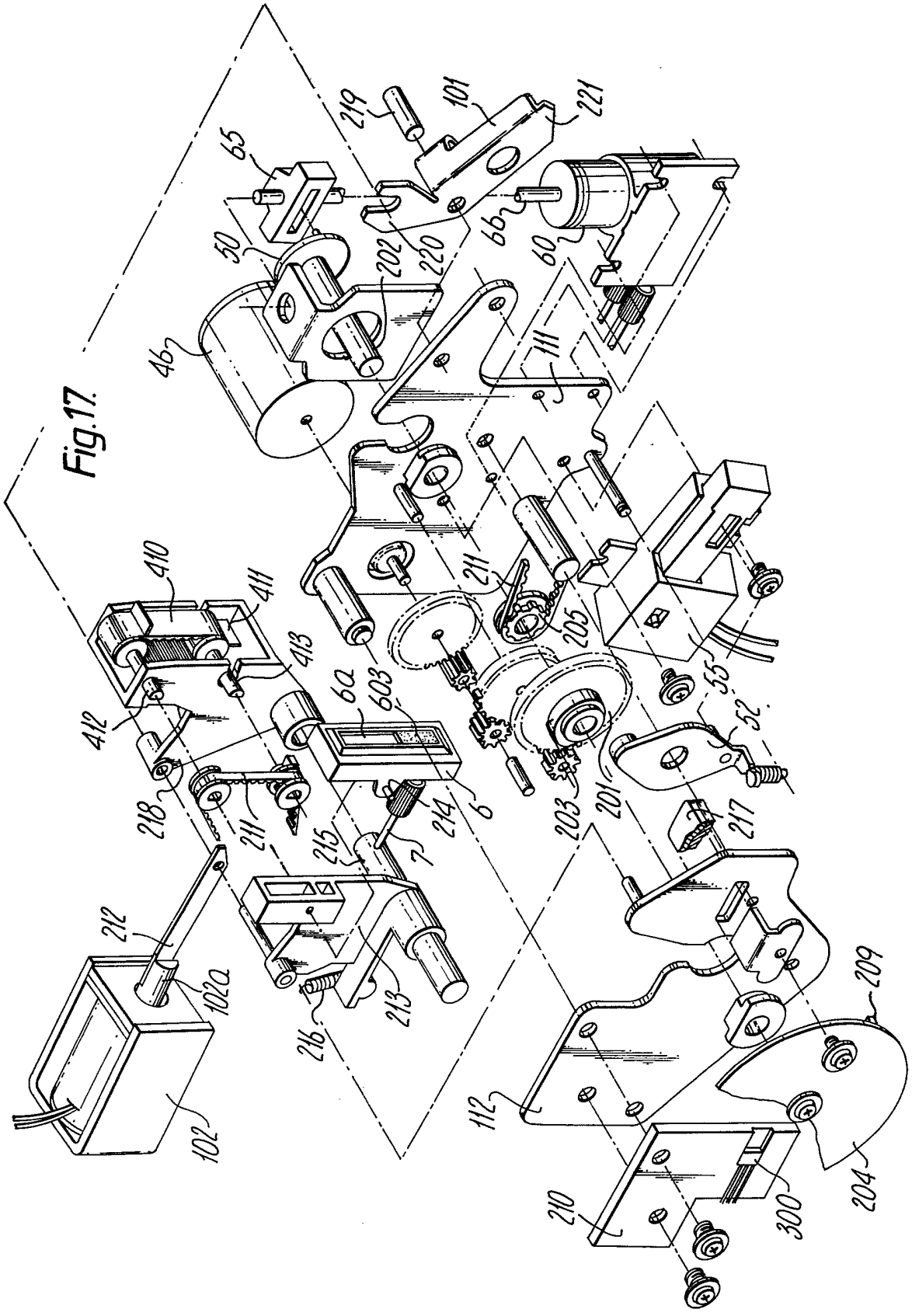

219
101
221
65
50
202
220
66
60
46
111
410
411
413
412
603
211
205
55
52
218
211
215
214
203
201
217
212
102a
213
216
209
112
210
300
204
102

Fig.18.

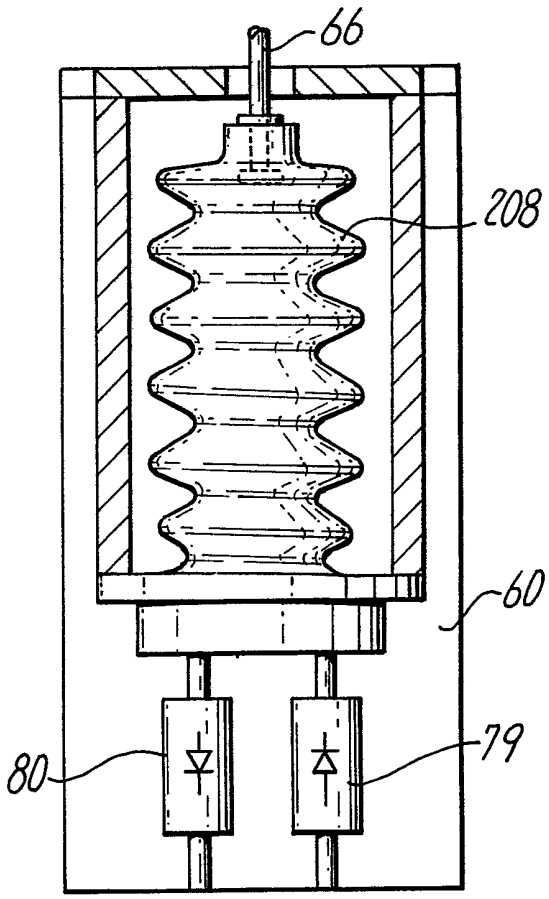
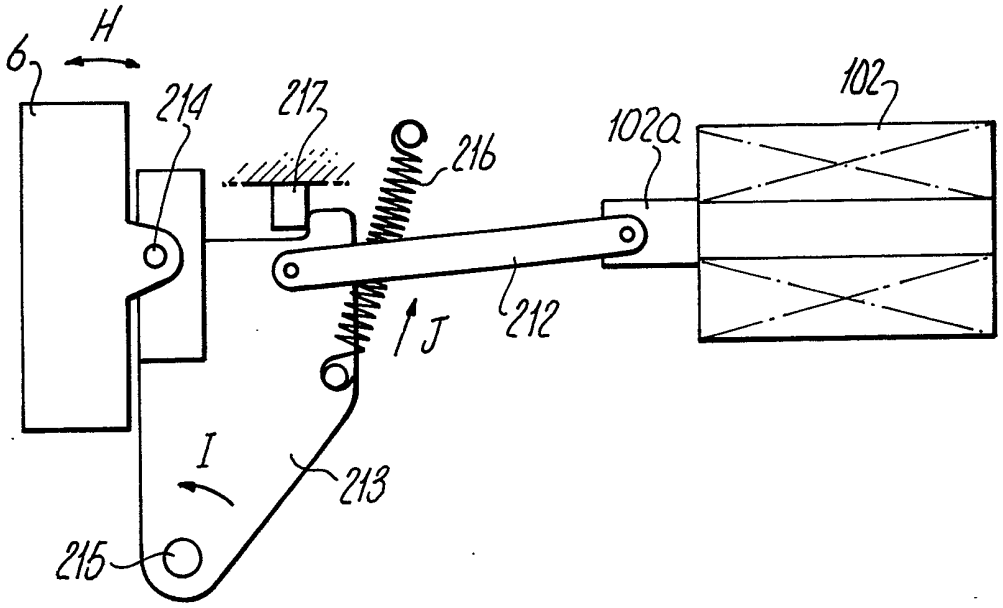


Fig.19.



SPECIFICATION

Ink jet recording apparatus

The present invention relates to an ink jet recording apparatus for ejecting ink directly onto paper or other record medium for recording thereon.

Many ink jet recording apparatus have heretofore been devised. One such ink jet recording apparatus, which ejects ink selectively only on demand, is described in Japanese Laid-Open Patent Publication No. 51-35231 and is simple in construction. However, although ink jet recording apparatus of this type have been improved they remain unreliable. Those apparatus which have been commercially available have been difficult to use because of the problems of air bubbles in the ink and the clogging of ink passages. As can be understood from the principles of recording described in the above-mentioned Japanese Laid-Open Patent Publication No. 51-35231, no ink can properly be ejected when air bubbles are trapped in a pressurization chamber which is used for pressurizing the ink. Ink passage clogging happens not only in the ink jet recording apparatus under consideration, but also in all forms of ink jet recording. However, this problem is particularly pronounced in the case of ink jet recording apparatus of the ink-on-demand type as the ejection nozzle thereof has a relatively small cross section.

Several ways have been suggested of removing the air bubbles that tend to be introduced when ink is initially loaded in the apparatus or a cartridge of ink is replaced. Representative of such suggestions are a device for removing air bubbles through ink circulation (as disclosed in Japanese Laid-Open Patent Publications Nos. 54-159227 and 54-160242, for example), and an air bubble remover disposed in a passage of ink (as described in Japanese Laid-Open Patent Publication No. 51-88224). Although Japanese Patent Publication No. 53-20882 suggests a way of removing the air bubbles which are formed within ink due primarily to cavitation, substantially no consideration has been given to coping with such air bubbles. Attempts to prevent an ink passage from being clogged include improved ink, a cover for an ejection nozzle, and means for forcibly releasing the clogging of the ink passage, for example as described in Japanese Laid-Open Utility Model Publication No. 54-66853. However, these suggestions have proved unsatisfactory for the reasons described below.

It is believed, however, that the air bubbles which are formed and the clogging of the ink passages cannot be eliminated completely unless provision is made to cope with the following difficulties. As described above, air bubbles can either be introduced into ink from the exterior or can be formed in the ink due to cavitation. It has been found that air bubbles formed by cavitation result from minute air bubbles in the ink. Cavitation normally takes place under a high negative pressure. Where there are minute air bubbles in the ink, the threshold value of the negative pressure beyond which cavitation occurs becomes quite low, and hence cavitation can easily be created under a small negative pressure which is developed immediately after the ink is ejected. Such a condition cannot be avoided though it is subject to differences dependent on the size and shape of a recording head for ejecting ink. The minute air bubbles are formed mainly from the air (primarily oxygen and nitrogen) dissolved in ink. For example, 1.6% of air is dissolved in aqueous ink at 20 degrees Celsius. The solubility of air in ink becomes smaller as the temperature rises. Therefore, as the temperature rises during a recording operation, more air which has been dissolved in the ink is formed as air bubbles in the ink.

The ink circulation described above is effective in removing relatively large air bubbles, but causes the foundation of fine air bubbles when ink with air bubbles is circulated back into an ink tank. Mere vibration or movement of the ink tends to produce minute air bubbles in the ink. Moreover, although the device for removing air bubbles as described above can trap relatively large air bubbles, it is ineffective for trapping fine air bubbles having a diameter of a few microns.

The arrangement for preventing cavitation, which is described in Japanese Patent Publication No. 53-20882, removes oxygen from the ink, but allows the nitrogen to remain dissolved in the ink and to be formed into fine air bubbles upon temperature changes, since removal of only the oxygen still leaves the nitrogen which forms 2/3 by volume of the bubbles in the ink.

To prevent the ink passages from getting clogged, improvements have been made towards making the ink more volatile. However, the problem of incompatibility between easy volatility and quick drying of ink upon recording has not been fully solved. Furthermore, improved wet-type and dry-type covers for covering the front face of an ejection nozzle have been proposed, but are much less effective at high temperatures than at normal temperatures. An ink conduit for delivering ink into a recording head is made of high-polymer material because of required flexibility which allows free movement of the recording head. The best high-polymer material is vinylidene chloride resin which however permits ink to evaporate through the wall of the ink conduit at high rates, especially at high temperatures. Even with a nozzle designed to prevent evaporation of ink therefrom such ink evaporation from the ink conduit eventually causes the ink passage to be clogged. Once the ink conduit or nozzle is clogged, it is difficult for the apparatus disclosed in Japanese Laid-Open Utility Model Publication No. 54-66855 to completely remove solid particles from the ink conduit or to do no damage to the nozzle which is extremely thin. With solid material left in a portion of the nozzle, for example, the linearity of travel of the ink droplets is lost. In addition, air which has passed through the wall of the ink conduit causes ink to

become saturated, a condition which renders recording unstable during an initial period.

According to the present invention there is provided an ink jet recording apparatus comprising: an ink jet head having an ink supply port, at least one pressurization chamber and at least one ejection nozzle; an ink tank for storing ink; switching means; a first ink conduit having one end connected to said ink supply port and the other end to said switching means; a second ink conduit connected between said switching means and said ink tank; said switching means being actuatable for selectively connecting said first ink conduit to said second ink conduit or venting said first ink conduit to the atmosphere; suction cap means capable of selective intimate contact with a front surface of said ejection nozzle and having a space for drawing thereinto ink or air from said ejection nozzle or nozzles; a drain tank; a third ink conduit connecting said suction cap means to said drain tank; suction means disposed in said third conduit; and control means for controlling said switching means and said suction means.

Preferably said switching means and said suction means are drivable by one source of power.

The said control means may include means for detecting set conditions. Thus the latter means may include a timer for detecting an interval of time which has elapsed after a printing operation has ended, the timer being arranged to actuate said suction means upon detection of the elapse of a predetermined interval of time after printing operation has been finished. It may also include means for detecting ambient temperatures, the last-mentioned means being arranged to actuate said suction means upon detection of an ambient temperature outside a set range of temperatures. It may also include means for detecting switching off of a main power supply, in which case said control means and said suction means are preferably actuable by a secondary battery serving as a power supply upon detection of the switching off of said main power supply, the arrangement being such that ink is drawn out of said ink jet head and said first ink conduit and through said ejection nozzle or nozzles when the set conditions are detected by said means for detecting set conditions.

A switch may be provided for controlling a power supply to said apparatus said suction means being arranged to draw ink out of said ink jet head and said first ink conduit when said switch is turned off, and thereafter the power supply is turned off.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:–

Figure 1 is a diagram showing the amounts of various gases that can be dissolved in water at various temperatures,

Figure 2 is a schematic diagram showing a first embodiment of an ink jet recording apparatus according to the present invention,

Figures 3(a) and 3(b) are respectively plan and side elevational views of a recording head forming part of the said first embodiment,

Figures 4(a) and 4(b) are perspective views of an ink suction cap forming part of the said first embodiment,

Figure 5 shows an ink suction cap of a second embodiment of an ink jet recording apparatus according to the present invention,

Figure 6 is a perspective view of an ink tank which may be used with either the first or second embodiment,

Figure 7(a) is a perspective view of a serial printer in which an ink jet recording apparatus according to the present invention is incorporated,

Figure 7(b) is a diagrammatic perspective view of another arrangement in which an ink jet recording apparatus according to the present invention is incorporated in a serial printer,

Figures 8 and 9 are elevational views of an ink supply system forming part of an ink jet recording apparatus according to the present invention,

Figure 10 is a cross-sectional view of a directional control valve forming part of an ink jet recording apparatus according to the present invention,

Figure 11 is a cross-sectional view of a pump forming part of an ink jet recording apparatus according to the present invention,

Figure 12 is a block diagram of the serial printer of Figures 7(a) and 7(b),

Figures 13(a) and 13(b) are flowcharts of operations of the ink supply system according to an embodiment of the present invention,

Figure 14 is a circuit diagram of an ink supply system circuit according to an embodiment of the present invention,

Figures 15(a) and 15(b) are timing charts illustrating the operation of the circuit shown in Figure 14,

Figure 16 is a perspective view of part of another embodiment of the recording head,

Figure 17 is an exploded perspective view showing in detail a driver for the unit body of the cleaner 410 and ink suction cap 6 shown in Figure 7(b),

Figure 18 is a sectional view of another embodiment of a pump forming part of an ink jet recording apparatus according to the present invention, and

Figure 19 is a diagram illustrating the operation of the said suction cap.

Terms such as "left" and "right" as used in the description below are to be understood to refer to directions as seen in the accompanying drawings.

As shown in Figure 1, the amounts of air, nitrogen and oxygen which can be dissolved in water reduces as the temperature rises. Thus at 20°C, 1.6% of air at 1 atmospheric pressure will be dissolved in water, while at 80°C only about 1.0% of such air will remain dissolved in the water. As also indicated in Figure 1, if only the oxygen is removed from such dissolved air, about 2/3 by volume of the air will remain in the ink in the form of dissolved nitrogen.

FIG. 2 schematically shows a recording apparatus according to the present invention. The recording apparatus comprises a recording head 1, an ink tank (such as a cartridge) 2, and an ink conduit 3 for delivering ink from the ink tank 2 into the recording head 1. A directional control valve 4 is disposed in the ink conduit 3 and has one port 5 vented to the atmosphere and another port connected to the ink tank 2. An ink suction cap 6 is attached to a front face of the recording head 1 and has a cavity or space 6a. FIGS. 4 and 5 for covering a nozzle 23. The ink

suction cap 6 is connected through a conduit 7 and a pump 8 to a drain tank 9. Prior to describing the operation of the recording apparatus thus constructed, the recording head 1 will first be described in detail.

As shown in FIG. 3 the recording head 1 comprises a substrate 21 of glass having on its opposite surfaces a plurality of pressurization chambers 22 and nozzles 23, the nozzles being constituted by etched grooves, and an ink reservoir 24 having a relatively large volume for supplying ink from a pipe 15 which constitutes an ink supply port to the pressurization chambers 22. A piece 25 of glass having the same thickness as that of the glass substrate 21 is positioned in juxtaposed relation to the substrate 21, as shown in FIG. 3(b). The substrate 21 and the glass piece 25 are sandwiched at their opposite surfaces between a pair of plates 26, 27 of glass which are relatively thin and serve as vibratory plates (flexible walls). The glass plates 26, 27 are bonded to the substrate 21 and to the glass piece 25 as by fusion. The ink reservior 24 is defined by a space which is formed jointly by the glass substrate 21, the glass piece 25, and the glass plates 26, 27. The reservoir space is therefore sufficiently large in volume as compared with the grooves which form the pressurization chambers 22 and the nozzles 23, and which have depths ranging from 10 to a few hundred microns.

One end of the ink reservoir 24 is closed off by a plug 16. A filter unit 29 may be formed between the ink reservoir 24 and the pressurization chambers 22 by etching at the same time that the latter are formed. Piezo-electric elements (not shown) are mounted on the vibratory plates 26, 27 over the pressurization chambers 22 for ejecting ink out of the nozzles 23 in response to applied electric pulses. For better loading of ink, the pressurization chambers 22, which are substantially circular in shape, may have land-shaped projections 28 positioned at inlet and outlet ends of the chambers 22 for causing ink to flow along the walls of the chambers 22 in the directions of the arrows Y.

Figure 4(a) shows the way in which the ink suction cap 6 is engageable with the nozzle 23 of the recording head 1. The ink suction cap 6 with the cavity 6*a* therein is movable in the directions of an arrow A, the cavity 6*a* being such that ink or air from the nozzle 23 may be drawn into the cavity 6*a*. The ink suction cap 6 can be brought into intimate contact with the front surfaces of the nozzle 23 as desired. The cavity 6*a* in the ink suction cap 6 is in communication with the conduit 7. As shown in Figure 4(b) the ink suction cap 6 with the cavity 6*a* may be engageable closely with the front face of a head cover 11 mounted on the head 1 for protecting the latter.

The ink conduit 3 comprises an ink conduit 3-1, which is connected between the directional control valve 4 and the ink tank 2, and an ink conduit 3-2 having one end connected to the ink supply port 15 and the other end to the directional control valve 4. The directional control vlave 4 is thus actuable for selectively connecting the ink conduit 3-2 to the ink conduit 3-1 or venting the ink conduit 3-2 to atmosphere.

Figure 5 shows an ink suction cap 6 according to another embodiment. Parts of Figure 5 which are the same as those of Figure 4 are given the same reference numerals. The ink suction cap 6 has a cavity 6*a* containing a porous moisture absorbent 603 which is held in contact at one end thereof with a portion of the nozzle face of the head 1 below the nozzles 23 when the ink suction cap 6 is brought into intimate contact with the nozzle face. The porous moisture absorbent 603 has a portion covering a suction port 602 connected to the conduit 7. With this arrangement, an ink layer attached to the nozzle face can quickly be removed by being absorbed into the porous moisture absorbent 603. The ink absorbed by the porous moisture absorbent 603 is discharged through the conduit 7 so that the porous moisture absorbent 603 is kept ready at all times for continued absorption of ink from the nozzle face.

Since the porous moisture absorbent 603 covers the suction port 602, it also serves as a filter to prevent impurities such as dust in the ink from flowing into the conduit 7. Therefore, no clogging takes place in the ink passage constituted by the conduit 7 which extends to the drain tank 9.

The operation of the recording apparatus shown in FIGS. 2 to 4 will now be described.

When recording is to be started, or ink is initially to be loaded into the recording head 1, or the ink cartridge 2 is to be replaced, the ink suction cap 6 is moved toward the recording head 1 until the cavity 6*a* covers the nozzles 23. Then the directional control valve 4 is switched to connect the recording head 1 to the ink tank 2 and the pump 8 is actuated. A vacuum is developed in the cavity 6a through the conduit 7 to draw ink from the ink tank 2 until the ink reservior 24, pressurization chambers 22, and nozzles 23 in the recording head 1 are filled with ink. For removal of air bubbles and complete ink loading, an excessive amount of ink is drawn from the nozzles 23 and drained into the drain tank 9.

Such a process of drawing ink from the nozzles 23 under vacuum is better than pressurizing the ink tank 2 to force ink out of the nozzles 23 in that less ink remains in the ink reservoir 24 and the pressurization chambers 22, ink can be smoothly loaded, and air bubbles can be discharged efficiently. The amount of ink which is discharged from the nozzles 23 is less than 1 c.c., and hence no appreciable amount of ink is wasted.

After the recording head 1 has been filled up with ink the recording head 1 is moved by a carriage (not shown) away from the suction cap 6 and to a recording position to start a recording operation. When the recording operation is completed, the recording head 1 returns to the position in which the ink suction cap 6 is located.

The directional control valve 4 is now switched to vent the ink conduit 3 to the atmosphere through the port 5. The pump 8 is actuated to draw air through the ink conduit 3-2 into the recording head 1. Ink in the conduit 3-2 and the recording head 1 is drained via the ink suction cap 6, the conduit 7, and the pump 8 into the drain tank 9, whereupon no ink whatever remains in the recording head 1 and in the conduit

3-2. Thus, ink is completely removed from the recording head 1 by the foregoing operation. The recording head 1 is free from clogging in whatever conditions it may be placed. There is no danger that small dust particles, such as dye particles, will become deposited around the nozzles 23. Therefore, ink droplets can be stably ejected from the nozzles 23.

The directional control valve 4 is disposed in the ink conduit 3 by which the ink tank 2 and the recording head 1 are interconnected, thus dividing the ink conduit 3 into the conduits 3-1, 3-2. The ink conduit 3-2 is made of high-polymer material so as to be able to move flexibly in response to movement of the recording head 1. The ink conduit 3-2 therefore allows ink to evaporate therefrom and air to pass thereinto. Since the directional control valve 4 is disposed in the conduit 3 it also permits removal of ink both from the conduit 3-2 and from the recording head 1. The conduit 3-1 may be made of metal such as stainless steel since it does not need to move about. After the ink has been discharged, the first ink conduit 3-2 is vented to the atmosphere and the second ink conduit 3-1 is closed off by the directional control valve 4. There is no possibility of the second ink conduit 3-1 allowing evaporation therethrough of ink in the conduit 3-1 and in the ink tank 2 and of introducing therethrough. Assuming that the conduit 3-2 has an inside diameter of 1 mm and a length of 500 mm, the amount of ink consumed by the conduit 3-2 during such an ink discharging operation is about 0.4 c.c., and the amount of ink consumed by the recording head 1 including the reservoir, pressurization chambers and nozzles is about 0.1 c.c. Hence, the total amount of consumed ink is about 0.5cc. The ink discharging operation is thus not wasteful of ink. When it is desired to start printing again, the directional control valve 4 is switched to load ink into the recording head 1 in the manner described above.

Clogging can be completely removed by the foregoing ink discharging and loading operations. Air bubbles which have been trapped via the nozzles 23 upon initial ink loading, replacement of the ink tank, and accidental shocks, can reliably be removed by the ink drawing operation.

As described above, it is necessary to remove the air completely from ink. To this end, the ink needs to be fully de-aerated and it should be kept de-aerated for a long period of time. Therefore, the ink tank 2 shown in FIG. 2 should shield the ink from the air. As shown, therefore, in FIG. 6, the ink cartridge may be composed of a bag 31 made of aluminium foil laminated with a high polymer film e.g. of polyethlene or nylon. The bag 31 has a joint 33 e.g. of rubber, to which a needle-shaped pipe 32 attached to the distal end of the conduit 3-1 is connectable.

An ink cartridge is known which is made of laminated films of a vinylidene chloride resin, this ink cartridge having an extremely low evaporation co-efficient or air permeability. The air permeability of the material, however, is increased at high temperatures. Theoretically, the air permeability P can be expressed by the equation $P = P_0 \exp(-E/RT)$, wherein E is the activation energy, T is the absolute temperature and R is the gas constant, which indicates the temperature dependency of the air permeability. Stated differently, the higher the temperature, the larger the air permeability. As an example, a composite film of vinylidene chloride resin sold under the name "Saranex #26" by K.K. Asahi Dow and having a thickness of about 60 microns, is capable of transmitting therethrough oxygen in the amount of 7 c.c./m^2. 24 hr. 1 atm. at normal temperature. when the ink cartridge shown in FIG. 6 is made of such a composite film and has a surface area of 200 cm^2, and 200 c.c. of aqueous ink is contained therein, the ink in the cartridge is fully saturated in about 40 days. At a high temperature (65 degrees Celsius), the air permeability becomes from a few to ten times larger, and the ink cannot be kept for an extended period of time.

The ink cartridge of FIG. 6 is therefore in the form of a bag of laminated aluminium foils each having a thickness of a few microns. Although the aluminium foil may be constituted by a deposited film of a few hundred Å for a reduced air permeability, it should preferably be composed of a thin film of a few microns to prevent the formation of pin holes. With an aluminium foil of a few microns, the air permeability and the evaporation coefficient are substantially nil, allowing ink to be stored for a long period of time. Since the aluminium foil of a few microns in the form of a bag has an increased rigidity, it is necessary to prepare a flat closed bag having a relatively large surface area as illustrated in FIG. 6. More specifically, the bag needs to become progressively more flattened as the ink is consumed, and should not be so shaped that it is freely deformable.

FIG. 7(a) shows an arrangement in which the recording apparatus of the foregoing construction is incorporated in a serial printer. The serial printer comprises a platen 34, a carriage 36 supporting the recording head 1 thereon and two guide shafts 37, 38 along which the carriage 36 is movable by a motor or drive belt (not shown) in parallel relationship to the platen 34. With a recording sheet of paper (not shown) mounted on the platen 34, the carriage 36 is driven along the guide shafts 37, 38 to effect printing on the recording sheet on the platen 34. The recording head 1 has twenty four nozzles to record characters and picture images by means of twenty four dots at each printing position.

The carriage 36 is moveable with respect to the platen 34 in confronting relation thereto throughout a space B which is referred to as a recording position, and the recording head 1 is moveable to a home position C in which to load ink into the recording head 1 and draw ink from the recording head 1. Various devices are located at the home position C to carry out the ink loading and drawing operations. When paper particles or other foreign matter is deposited on the nozzle surface, the head 1 is brought into the home position C in alignment with a brush 41 located in the home position C. The brush 41 is then rotated to remove the dust from the nozzle surface of the head 1.

The ink suction cap 6 shown in FIGS. 2 and 4 is movable into and out of engagement with the head 1

which is held in alignment with the ink suction cap 6. An ink supply system 43, which is disposed in the home position C, includes the directional control valve 4, the pump 8 shown in FIG. 2, and a mechanism for actuating the valve 4 and the pump 8. The ink supply system 43 will be described in detail later on, and is shown in the form of a block in FIG. 7(a). The ink suction cap 6 and the ink supply system 43 are interconnected by the conduit 7 for drawing ink or air from the recording head 1. As can be understood from FIG. 2, the conduit 7 is connected to a pump in the ink supply system 43. An ink tank 45 contains the ink tank 2 and the drain tank 9 (FIG. 2) which are assembled together. From the ink tank 45 there extend conduits to the directional control valve 4 and pump 8 in the ink supply system 43 as shown in FIG. 2. Such conduits however are not shown in FIG. 7(a). The ink supply system 43 is connected by a conduit (not shown in FIG. 7(a)) to the recording head 1.

Operation of the serial printer thus constructed is as follows. While the serial printer is at rest, the carriage 36 is in the home position C with the nozzle surface of the recording head 1 being covered by the ink suction cap 6, and ink is removed from the recording head 1. When the power supply for the serial printer is turned on, the ink supply system 43 is actuated to load ink into the recording head 1. Upon supply of a printing command, the carriage 36 is moved to the printing position B and effects printing in accordance with the printing command. When the power supply for the serial printer is turned off, the carriage 6 is moved back to the home position C, and the nozzle surface of the recording head 1 is covered by the ink suction cap 6. Ink can then be withdrawn from the recording head 1. The amount of ink consumed in one cycle of the ink drawing and loading operations is about 1 to 2 c.c., which is not appreciable if ink is drained only in one cycle a day.

However, when the power supply is turned on and off frequently during the day, the amount of ink consumption will not be negligible. Accordingly, conditions which could lead to clogging of the nozzles with ink have been studied, and there is employed a system for drawing ink out only when there is imminent danger of clogging. The operation of such a system will be described later in detail. Briefly summarized, however, the system is actuated to unload ink when (1) a certain period of time has elapsed after the power supply for the printer has been switched off or a printing operation has been completed, (2) the printer is subjected to a temperature higher than a certain level, and/or (3) the printer is subjected to a temperature lower than a certain level. The condition (1) arises from the fact that when left unused for a prolonged period of time, water evaporates from ink, which then tends to clog the nozzles. The period of time after which the system should be actuated may range from one day to one week with a safety margin. For example, where the printer is operated every day, no ink loss is caused if the period of time is selected to be one day, and such a one-day safety period poses no problem in practice. Although ink is subjected to a small rate of evaporation at normal temperatures due to wetting, the ink will evaporate at an accelerated rate at high temperatures. Under the condition (2), ink is drained from the recording head 1 at a temperature in the range of from 50 to 60 degrees Celsius. The condition (3) arises when the printer is at a temperature below the freezing point of ink, in which case the ink in the ink head and in the other conduits is liable to damage the ink head and the conduits. Therefore, when there is a danger that the printer will be subjected to a temperature lower than the ink freezing point, the ink is drained to keep the printer free from damage.

In order to carry out the foregoing operations with reliability, the carriage 36 should be placed at a predetermined location in the home position C. To detect arrival at the location of the carriage 26, a position sensor is required which, although not shown in FIG. 7(a) may comprise a commercially available reed switch or a switch incorporating a photo-detector, for example. In addition, other devices such as a timer and a temperature sensor are needed as described later on.

Figure 7(b) is illustrative of another arrangement in which the present invention is incorporated in a serial printer, the view showing parts around cleaning means and an ink suction cap. When the carriage 36 is moved from a printing position to a non-printing position, a projection 361 on the carriage 36 engages a microswitch 100 attached to a printer frame to actuate the microswitch 100, whereupon the carriage 36 is stopped by a stopper 101 mounted on a unit body composed of the ink suction cap 6 and a cleaning means or head cleaner 410. At this time, the head 1 is positioned in confronting relationship to the head cleaner 410. The head cleaner 410, when actuated, cleans the nozzle face of the head 1. The stopper 101 serves to stop the carriage 36 accurately in position. The carriage 36 can be stopped by de-energizing a drive source such as a motor for the carriage 36 slightly after the microswitch 100 has been actuated. When the cleaning operation is completed, a solenoid 102 is energised to retract the ink suction cap 6 together with the stopper 101 from the position in which the carriage 36 is stopped. The carriage 36 then moves to the left until it abuts against a left frame member 103, whereupon the head 1 faces the ink suction cap 6. De-energization of the solenoid 102 allows the ink suction cap 6 to move under the returning force of a spring (not shown) into sealing contact with the nozzle face of the head 1. A pump (described later) is then actuated to charge ink into or discharge ink from the head 1. When ink charging is about to finish, excessive ink is liable to flow out of the nozzles as ink has been excessively introduced through the nozzles for reliable ink charging. Such a difficulty can be avoided by opening the ink suction cap 6 slightly after the pump has been de-energized, as described later on. However, some ink remains attached to the nozzle face, and there is a danger that such attached ink will drop onto the bottom of the printer while the latter is in operation. To cope with this problem, the head 1 has an ink absorbing container 104 including an ink receiver 104*b* (FIG. 16) for receiving ink flowing off the nozzle face of the head 1, the received ink being

absorbed into the ink absorbing container 104 e.g. by a porous absorbent, not shown in FIG. 7(b), contained in the container 104. The ink absorbing container 104 has slots 104*a* in its left-hand wall. When the carriage 36 is moved to the left-hand end, arms 105 attached to the frame member 103 enter the slots 104a to compress the porous absorbent in the container 104 to squeeze ink out of the porous absorbent. The squeezed ink is discharged through a discharge port 104*c* in a lower portion of the container 104 into an ink receiver 106, from which the ink is led by a conduit 107 into a drain ink container. Therefore, the ink can be discharged reliably even when the absorbent in the container 104 is saturated with ink after use over a long period of time.

FIGS. 8 and 9 show in detail the ink supply system 43 illustrated in FIG. 7(a) and FIGS. 10 and 11 show in detail the directional control valve and the pump. FIG. 8 is a side elevational view of the ink supply system. The ink supply system includes a d-c motor 46 for powering the directional control valve and the pump. The motor 46 may be an inexpensive one since it is energized only for short intervals of time and does not need to have a durable construction. The d-c motor 46 has a rotatable shaft supporting thereon a gear 47 from which rotative power is transmitted through a train of speed-reducer gears 48, 49 to a drive wheel 50. The drive wheel 50 has on one side a pin 51 for actuating a directional control valve 55 and on the other side a pin 58 for actuating a pump 60. When the drive wheel 50 rotates, the pin 51 rotates along a circular path 61, shown by a dot-and-dash line, into engagement with a valve actuation lever 52. The valve actuation lever 52 is angularly movable about a shaft 53. The valve actuator lever 52 is acted on by a tension spring 54 attached to an end of the lever 52 remote from the drive wheel 50 so as to be urged into a position in which the lever 52 engages the pin 51 in alignment with the central axis of the drive wheel 50. The end of the valve actuation lever 52 to which the tension spring 54 is attached has thereon a pin 59 received in an opening 57 in a slider 56 of the directional control valve 55. As will be described in detail with reference to FIG. 9, the directional control valve 55 is responsive to movement of the slider 56 for changing paths of fluid flow therein. When the d-c motor 46 is energized to rotate the drive wheel 50 in the direction of an arrow D, the pin 51 is brought into engagement with the valve actuation lever 52 and rotates the latter in the direction of an arrow E. Angular movement of the valve actuation lever 52 causes the pin 59 to push against an end of the opening 57 in the slider 56 so as to displace the latter towards the left in the direction of an arrow F, until fluid paths in the directional control valve 55 are changed. Conversely, when the d-c motor 46 is rotated in the opposite direction to rotate the drive wheel 50 in a direction opposite to the direction of the arrow D, the slider 56 is caused to be shifted towards the right, i.e. in a direction opposite to the direction of the arrow F, whereupon the original path of fluid flow is established again in the directional control valve 55. Therefore, the directional control valve 55 can be changed over in response to the direction of rotation of the d-c motor 46. The slider 56 is displaced by the pin 51 through the valve actuation lever 52 upon the first revolution of the drive wheel 50. Since the slider 56 remains displaced unless subjected to applied external forces only the valve actuatio lever 52 is continuously actuated when the drive wheel 50 makes successive revolutions. When the pin 51 is moved out of engagement with the lever 52, the latter is brought back to the illustrated central position under the action of the spring 54. At this time, the slider 56 does not move back since there is enough play around the pin 59 within the opening 57.

The drive wheel 50 serves to actuate the pump 60 through a pump actuator unit which is mounted on the other side of the drive wheel 50. Figure 9 shows such a pump actuator unit. The pin 58 secured to the drive wheel 50 is received in a slot 67 in a pin follower 65 secured to a piston shaft 66. The slot 67 extends perpendicularly to the axis of the piston shaft 66. When the drive wheel 50 rotates, the pin 58 also rotates along a circular line 68 indicated by the dot and dash line to actuate the pin follower 65, whereupon the piston shaft 66 reciprocates in the directions of an arrow G. The pump 60 has an internal construction as shown in Figure 11, and effects its pumping action upon reciprocating movement of the piston shaft 66. The piston shaft 66 can be driven by the drive wheel 50 irrespective of the direction of rotation of the drive wheel 50.

With the illustrated embodiment, the directional control valve 55 and the pump 60 can be actuated by the single d-c motor 46. The manner in which ink is loaded into and drained from the recording head by actuation of the directional control valve and the pump will now be described. For loading the recording head with ink, the directional control valve 55 needs to connect the recording head to the ink tank. Assuming that the slider 56 of the directional control valve 55 is required to be pushed in a direction opposite to that of the arrow F in Figure 8 so as to connect the recording head to the pump, the d-c motor 46 is energized to rotate the drive wheel 50 in a direction opposite to that of the arrow D. Upon the first revolution of the drive wheel 50, the slider 56 is caused to move in the direction opposite to that of the arrow F, connecting the recording head to the ink conduit coupled to the ink tank. As the drive wheel 50 rotates further, the pump 60 is actuated to draw ink from the ink tank into the recording head to fill the latter with ink. To drain ink from the recording head, the d-c motor 46 is rotated in the opposite direction to rotate the drive wheel 50 in the direction of the arrow D, whereupon the slider 56 is shifted in the direction of the arrow F to thereby vent the conduit coupled to the printing head to the atmosphere.

Continued rotation of the drive wheel 50 causes the pump 60 to be actuated for drawing air into the recording head until ink in the head is replaced with air and hence is drained from the head. Thus, the same function as that illustrated in FIG. 2 can be performed.

FIG. 10 is a cross-sectional view illustrative of the

internal construction of the directional control valve. The valve comprises a packing 70 moulded of rubber and supported on a packing holder 71 that is mounted in the slider 56. The packing 70 is pressed against an inner wall of a body of the directional control valve 55 under the resiliency of a spring 72 acting between the slider 56 and the packing holder 71. The inner wall of the valve body has a port 73 connected to the conduit coupled to the recording head, a port 74 connected to the conduit coupled to the ink tank, and a port 75 vented to the atmosphere. The ports 73-75 are mutually aligned in the direction in which the slider 56 is movable. The distance between the ports 73, 74 is substantially equal to that between the ports 73, 75. The packing 70 has a recess 76 which is so sized and located to interconnect the ports 73, 74 when the slider 56 is displaced to the rightmost position as shown in FIG. 10. When the slider 56 is moved to the left, the packing 70 is also displaced to the left to enable the recess 76 to connect the port 73 to the port 75. The space through which the slider 56 is movable is selected so as to be equal to the distance between any adjacent two of the ports. Thus, movement of the slider 56 to the right causes the ports 73, 74 to be interconnected, allowing fluid communication between the recording head and the conduit coupled to the ink tank. Conversely, when the slider 56 is moved leftward, the ports 73, 75 are interconnected to thereby vent the conduit coupled to the recording head to the atmosphere. The above-mentioned performance of the directional control valve can be effected in this manner. An air filter 77 may be attached to an outer wall covering the port 75 vented to the atmosphere for preventing dust from being introduced from the atmosphere into the recording head.

FIG. 11 is a cross-sectional view of the internal construction of the pump 60. The pump 60 comprises a cylinder in which a piston 78 fixed to the piston shaft 66 is slidably movable. Vertical reciprocating movement of the piston shaft 66 therefore causes repeated alternate pressurization and non-pressurization of a cylinder chamber 81. The pump 60 also includes a pair of one-way valves 79, 80 directed in opposite directions. The one-way valve 79 serves to allow a fluid to flow from the exterior into the cylinder chamber 81 upon non-pressurization of the latter. The one-way valve 80 serves to allow a fluid to flow from the cylinder chamber 81 to the exterior when the cylinder chamber 81 is pressurized. The one-way valves may be of the well-known type utilizing a rubber body or a ball, and its description will be omitted here. The pump 60 is actuated when the piston shaft 66 reciprocates up and down for repeated alternate pressurization and non-pressurization of the cylinder chamber 81. The pumping action can be carried out by such intermittent pressurization of the cylinder chamber 81 to introduce the fluid via an inlet 82 of the one-way valve 79 and to discharge the fluid via an outlet 83 of the one-way valve 80. The inlet 82 is connected via the conduit to the ink suction cap 6 (FIG. 7), and the outlet 83 is connected via the conduit to the drain tank to perform the function described above.

FIG. 17 is an exploded perspective view showing in detail a driver for the unit body of the cleaner 410 and ink suction cap 6. FIG. 17 corresponds to FIGS. 8 to 11 which show in detail the ink supply system 43 illustrated in FIG. 7(a). Parts shown in FIG. 17 which are similar to those of FIGS. 8 to 11 are given the same reference numerals. The motor 46 serves as a drive source for driving the pump 60, the directional control valve 55, the cleaner 410, and other parts. The ink suction cap 6 and the cleaner 410 are actuated by the solenoid 102. All of these parts are mounted on first and second subframes 111, 112 to form a single unit which is attached to the left-hand frame member 103 (FIG. 7 (b)) of the printer.

Rotative power from the motor 46 is transmitted through a train of speed-reducer gears to a gear 201 having a shaft 202 on which there are mounted the actuator plate 50 for driving the pump 60, a cam 203 for driving the directional control valve 55, a detector plate 204 for detecting a lower limit of the stroke of the pump 60, and a belt wheel 205. The pump 60 has the piston shaft 66 which is reciprocatable for pump operation by the pin follower 65 with which the pin 58 on the actuator plate 50 engages. The pump 60 includes a piston fitted in a cylinder with an airtight seal, the piston and cylinder being of a low coefficient of friction. According to this embodiment, the piston is made of rubber to provide airtightness under its own resiliency, and is coated on its surface with a layer of a fluorine-containing resin so that there is a small coefficient of friction. Such fluorine-containing resin may preferably be a coating agent of bound rubber such as "DAI-EL Latex" manufactured by Daikin Kogyo K.K.

The pump of the piston-cylinder type as shown in FIG. 8 may be replaced by a bellows pump as shown in FIG. 18. The bellows pump of FIG. 18 includes a bellows 208 of rubber having the piston shaft 66 on one end thereof and mounted on the pump body 60 with an airtight seal. The bellows 208 can be compressed and expanded by reciprocating the piston shaft 66 so as to effect a pumping action through the one-way valves 79, 80. Since the bellows pump has no sliding parts, it is more reliable in operation than a piston cylinder type pump.

The cam 203 mounted on the shaft 202 serves to actuate the directional control valve 55. The cam 203 is equivalent to the pin 51 shown in FIG. 8, and its operation will not be described here as it is the same as that of the pin 51. However, although not shown in FIG. 17, the directional control valve 55 includes a packing slidable for changing the flow through the valve. The packing should be of a low coefficient of friction and provide a desired degree of airtightness, and for this reason is coated with a layer of fluorine-containing resin.

The detector plate 204 serves to detect a lower stroke limit of the piston of the pump 60. A permanent magnet 209 is fixed to the detector plate 204. The second subframe 112 has a base plate 210 which is attached thereto and which supports thereon a magnetic detector 300 for detecting a particular part of the detector plate 204 while the latter makes one revolution. The lower stroke limit of the piston of the pump 60 can be detected by bringing this part of the detector plate 204 into alignment with the

magnetic detector 300 at the lower stroke limit. When the ink suction cap 6 is disengaged from the head 1 upon de-energization of the motor 46 during the expansion stroke of the piston at the time of charging ink into the head 1, the ink is ejected from the nozzles. This ink ejection can be avoided by stopping the pump 60 and hence the motor 46 and opening the ink suction cap 6 during the compression stroke of the piston, or most reliably at the lower stroke end of the piston. In reality, however, pressurization and de-pressurization in the ink suction cap 6 is slightly delayed because ink flows through the conduit 7 between the pump 60 and the ink suction cap 6. Therefore, there still remains a danger even during the compression stroke of the pump piston that ink will be ejected when the ink suction cap 6 is removed from the head 1 immediately after the motor has been de-energised. This shortcoming can be eliminated by stopping the motor during the compression stroke of the piston and releasing the ink suction cap 6 a few seconds (1 to 5 seconds according to experiments) thereafter. In the ink charging operation, therefore, it is necessary to effect control of the de-energization of the motor 46 by detecting the compression stroke and lower stroke limit of the piston with the detector plate 204.

A belt 211 which travels around the belt wheel 205 mounted on the shaft 202 is provided for operating the cleaner 410. The cleaner 410 is composed of a flat ring having a plurality of scraper projections 411 and extending around two cleaner shafts 412, 413. The belt 211 also extends around ends of the cleaner shafts 412, 413. When the gear 201 rotates upon energization of the motor 46, the belt 211 operates the cleaner 410 to enable the scraper projections 411 to scrape dust, fibrous matter and other impurities off the nozzle face when the cleaner 410 faces the head 1.

Operation of the solenoid 102 for actuating the ink suction cap 6 and the cleaner 410 will now be described with reference to FIGS. 17 and 19. The solenoid 102 has a movable iron core 102*a* held in engagement with a cap support 213 through an actuator lever 212. The ink suction cap 6 is pivotably mounted by a pin 214 on the cap support 213 for slight angular movement about the pin 214 in the direction of an arrow H. Such movement of the ink suction cap 6 serves to keep the same airtight when in engagement with the head 1. The cap support 213 is supported on a shaft 215 and urged by a tension spring 216 to move in the direction of an arrow J. Thus, the cap support 213 is urged to move angularly in the direction of an arrow I into abutment with an abutment stopper 217. When the solenoid 102 is energized, the movable iron core 102*a* is pulled into the solenoid 102 to cause the actuator lever 212 to turn the cap support 213 in a direction opposite to the direction of the arrow I against the force of the tension spring 216. Such angular movement of the cap support 213 causes the ink suction cap 6 to disengage from the nozzle face of the head 1, and allows the head 1 to move to a position facing the ink suction cap 6. The cleaner 410 is selectively movable into or out of contact with the head as described below in detail.

A cleaner support 218 for the cleaner 410 is mounted on the shaft 215 and hence is biased by the tension spring 216. Thus, the cleaner 410 moves with the ink suction cap 6 in response to energization of the solenoid 102. When the solenoid 102 remains de-energized while the head 1 is facing the cleaner 410, a projection 411 of the cleaner 410 is held against the nozzle face of the head 1 to scrape dust off the nozzle face in response to the energization of the motor 46. When the solenoid 102 is energized, the projection 411 is retracted out of contact with the nozzle face.

An advantage arising from such an arrangement will be described with reference to FIG. 7(b). The solenoid 102 is not energised when the carriage 36 is displaced away from the printing region to the position which faces the cleaner 410. Since the projections 411 are made of rubber, they are resiliently deformed to allow the head 1 to move toward the cleaner 410. After the head 1 has been cleaned in this position, the solenoid 102 is energized to retract the ink suction cap 6, and then the head 1 is moved to a position facing the ink suction cap 6. The solenoid 102 is now de-energized to allow the ink suction cap 6 to engage the head 1 in an airtight manner. The pump 60 is now actuated to replenish the head 1 with ink. Thereafter, the solenoid 102 is energized once more to retract the ink suction cap 6 and the cleaner 410, and the carriage 36 is quickly moved back to the printing region. At this time, the nozzle face of the head 1 is kept out of engagement with the scraper projections 411 of the cleaner 410. More specifically, after the cleaner 410 has scraped dust, paper powder fibrous matter and the like off the nozzle face, the scraper projections 411 carry such foreign matter. If the projections 411 of the cleaner were brought into contact with the nozzle face after the head 1 has been replenished, the nozzle face would be smeared again with impurities. In the illustrated embodiment, the solenoid 102 is actuated to keep the projections 411 of the cleaner 410 out of contact with the nozzle face after the head 1 has been replenished, while the head 1 is being displaced into the printing region.

Operation of the stopper 101 for stopping the head exactly opposite to the cleaner 410 will now be described. The stopper 101 is angularly movably mounted on the first subframe 111 by a pin 219, and has one end 220 held in engagement with the actuator lever 212. When the solenoid 102 is energized, the stopper 101 is angularly moved about the pin 219 to displace the other end 221 of the stopper 101. When the solenoid 102 remains de-energized, the end 221 of the stopper 101 serves to stop the carriage 36 for bringing the head 1 and the cleaner 410 into accurate mutually facing relationship. Energization of the solenoid 102 displaces the stopper 101 out of abutting engagement with the carriage 36.

FIG. 12 is a block diagram, including an electrical circuit of the serial printer illustrated in FIG. 7. Designated at 85 is a printer mechanism and at 86 an electrical circuit for controlling the printer mechanism 85, the electrical circuit 86 being powered by a commercial power supply. Ordinary printers are of the foregoing construction. In the construction

shown in FIG. 12, however, there is also provided an ink supply system circuit 87 for actuating the ink supply system to drain ink from the recording head after the power supply has been turned off and to effect other operations, the ink supply system 87 being powered by a chargeable secondary battery 88. The electrical circuit 86 will not be described here, but the ink supply system circuit 87 will be described with reference to FIGS. 12 to 14.

FIG. 13(a) is a flowchart illustrating operations of the ink supply system during an ink draining process, and FIG. 13(b) is a flowchart illustrating operations of the ink supply system during an ink loading process. In FIG. 13(a), a timer in the ink supply system circuit starts when the power supply for the printer is turned off. If the carriage is not in the home position, a carriage motor is energized to bring the carriage back to the home position, in which the nozzle surface of the recording head is capped by the ink suction cap. It is then ascertained whether a time period of 50 hours has elapsed on the timer or not and whether the temperature is within an allowable range or not (i.e. whether $t < -10°C$ or $t > 60°C$). Thereafter, as a precaution, the carriage motor would be energised to return the carriage to the home position if the carriage were not in the home position. Then the d-c motor is energized to rotate the drive wheel in the direction of the arrow D (FIG. 8) for 30 seconds, during which time the directional control valve and the pump are actuated to drain ink from the recording head.

The operations shown in FIG. 13(b) will now be described. When the power supply switch is turned on, or a purge switch is turned on upon printing failure, the timer is set for different time intervals dependent on whether the directional control valve is switched for the atmosphere or the tank. The d-c motor is then energized to rotate the drive wheel in the opposite direction for the period of time set by the timer. The reason for such an operation is that when the directional control valve is vented to the atmosphere, ink has already been discharged from the recording head, and the d-c motor needs to be energised for 20 seconds in order to refill the recording head with ink. Conversely, when the directional control valve is connected to the tank, ink has not been drained from the recording head, and the d-c motor is driven for a short period of time say, 2 to 5 seconds, for replenishing the recording head. Subsequently, the ink suction cap is removed, the d-c motor is de-energized, and the carriage is moved to a printing position.

The operations for ink loading as shown in FIG. 13(a) are effected while the power supply is turned on, and can be performed by the printer circuit 86 illustrated in FIG. 12. A circuit arrangement for effecting the operations of FIG. 13(a) will now be described with reference to FIG. 14. A timer 90 is composed of an oscillator and a frequency divider. The timer 90 is set to produce an output having a period of 100 hours when a frequency-divider selection terminal 91 is high, and to produce an output having a period of 30 seconds when the terminal 91 is low. A temperature detection terminal 92 is connected to a temperature sensor comprising a thermal reed switch composed of a reed switch and a thermosensitive magnetic material, the temperature sensor being operable on transition between property changes marked by the Curie temperature of ferrite. The temperature sensor is of the type which is actuatable differently in two temperature ranges, or the make-break-make-type which makes the circuit at $-10°C$ or below and at 60° or higher, and breaks the circuit at the other temperatures. A terminal 93 is connected to the d-c motor, which is energizable by the circuit shown to rotate the drive wheel in the direction of the arrow D only for draining ink from the recording head. A circuit for driving the motor to fill the recording head with ink is incorporated in the printer circuit. A terminal 94 is connected to a detector for detecting when the carriage is in the home position. When the carriage is in the home position, the terminal 94 breaks the circuit. A terminal 95 supplies a signal to the carriage motor for moving the carriage to the home position. Designated at 96 is a detector for the power supply switch, to which a voltage of 12V is applied when the power supply is turned on and no such a voltage is applied when the power supply is off. A switching circuit 97 for the chargeable secondary battery allows the latter to be charged while the printer power supply is on, and to serve as a power supply when the printer power supply is off in order to carry out the following operation: while the voltage of 12V is being applied, the timer and flip flops FF1, FF4 are reset, the timer 90 is not actuated, and the battery switching circuit 97 is turned on. When the voltage of 12V is absent, the timer starts operatiing. When the carriage is not in the home position, the terminal 94 makes the circuit to cause the output $\overline{Q}$ of flip flops FF5 to go low, thereby driving the carriage through the terminal 95. When the output of the timer 90 is changed from the low level to the high level upon elapse of 50 hours, FF1 is set and the timer 90 is changed over to set itself for producing the output of 30 seconds. The timer 90 is also set to produce the 30-second output when the terminal 92 makes the circuit to set FF1. (See the timing charts of FIG. 15) FF2 is set at the leading edge of a next output from the timer 90. When the carriage is not in the home position, FF5 is set by FF2 to bring the carriage back to the home position. If the carriage is not in the home position, or the carriage is not brought back to the home position regardless of energization of the carriage motor for 30 seconds, when FF3 is set at the leading edge of a next output of the timer 90, FF6 is reset, FF4 is set, and the circuit is in a power-down mode, whereupon no ink is drained from the recording head. When the carriage is in the home position, FF6 is reset and FF3 is set to energize the d-c motor while the output $\overline{Q}$ of the latter is low. At the trailing edge of a next output from the timer 90, FF3 is reset to de-energize the d-c motor, and at the same time FF4 is set to render its output $\overline{Q}$ low, whereupon the battery switching circuit 97 is turned off. Accordingly, the circuit shown in FIG. 14 serves to perform the operations shown in the flowchart of FIG. 13(a). The timer may be actuated from the exterior so that it can be started when the power supply is not cut off. For example, the timer may be started when the printing

operation is stopped for effecting ink drainage 50 hours after the printing operation has been finished (even while the power supply is on).

In the foregoing embodiment, the secondary battery is used after the main power supply has been turned off to drain ink from the recording head upon elapse of a certain interval of time. However, the secondary battery may be dispensed with, and a delay (time lag) relay may be employed instead to cut off power supply to the control circuit and the mechanical moving parts at a predetermined interval of time after the main power supply switch has been turned off. Such a modification can easily be made, and is advantageous where it is necessary to drain ink for a short period of time after the main power supply switch has been turned off.

Upon turning off the switch, the suction means begins to be operated to draw ink out of the ink jet head and the first ink conduit. After this operation, the power supply is stopped.

While the embodiments of the present invention have been described, the present invention should not be interpreted as being limited to the illustrated embodiments, but improvements and modifications may be made without departing from the scope of the present invention as defined in the claims. For example, the recording apparatus may be incorporated in other devices than the serial printer. The pump and the directional control valve may be modified, and the conditions set for ink drainage may be changed. Furthermore, the invention is applicable to ink jet heads of other types.

With the present invention, as described above, a directional control or switching means is disposed in a conduit extending between an ink jet head and an ink tank, and can be selectively changed over to connect an ink head conduit to an ink tank conduit or to vent the ink head conduit to the atmosphere. An ink suction cap is movable into intimate contact with the nozzle surface of the ink jet head. The ink suction cap is connected to a suction means. Such an arrangement allows ink to be drained from the ink jet head as desired, thus preventing the nozzles from becoming clogged with ink, a problem which is particularly serious with the ink jet head. The ink jet head can easily and reliably be refilled with ink for a next printing operation. The switching means and the suction means can be driven by one source of drive, resulting in a simpler arrangement. The foregoing construction may be combined with an ink tank which comprises an ink cartridge of laminated films of aluminium with de-aerated ink sealed therein. This combination can solve the problem caused by air bubbles in ink jets. The recording apparatus of the invention can be used under various conditions and is of great advantage.

CLAIMS

1. An ink jet recording apparatus comprising: an ink jet head having an ink supply port, at least one pressurization chamber, and at least one ejection nozzle; an ink tank for storing ink; switching means; a first ink conduit having one end connected to said ink supply port and the other end to said switching means; a second ink conduit connected between said switching means and said ink tank; said switching means being actuatable for selectively connecting said first ink conduit to said second ink conduit or venting said first ink conduit to the atmosphere; suction cap means capable of selective intimate contact with a front surface of said ejection nozzle and having a space for drawing thereinto ink or air from said ejection nozzle or nozzles; a drain tank; a third ink conduit connecting said suction cap means to said drain tank; suction means disposed in said third conduit; and control means for controlling said switching means and said suction means.

2. An ink jet recording apparatus according to claim 1 wherein said switching means and said suction means are drivable by one source of power.

3. An ink jet recording apparatus according to claim 1 or 2 wherein said suction means is capable of drawing ink out of said ink jet head and said first ink conduit.

4. An ink jet recording apparatus according to any preceding claim wherein said control means includes means for detecting set conditions.

5. An ink jet recording apparatus according to claim 4, wherein said means for detecting set conditions includes a timer for detecting an interval of time which has elapsed after a printing operation has ended, the timer being arranged to actuate said suction means upon detection of the elapse of a predetermined interval of time after the printing operation has been finished.

6. An ink jet recording apparatus according to claim 4 or 5 wherein said means for detecting set conditions includes means for detecting ambient temperatures, the last-mentioned means being arranged to actuate said suction means upon detection of an ambient temperature outside a set range of temperatures.

7. An ink jet recording apparatus according to any of claims 4 to 6 wherein said means for detecting set conditions includes means for detecting switching off of a main power supply.

8. An ink jet recording apparatus according to claim 8, wherein said control means and said suction means are actuatable by a secondary battery serving as a power supply upon detection of the switching off of said main power supply, the arrangement being such that ink is drawn out of said ink jet head and said first ink conduit and through said ejection nozzle or nozzles when the set conditions are detected by said means for detecting set conditions.

9. An ink jet recording apparatus according to any preceding claim comprising a switch for controlling a power supply to said apparatus, said suction means being arranged to draw ink out of said ink jet head and said first ink conduit when said switch is turned off, and thereafter the power supply is turned off.

10. An ink jet recording apparatus according to any of claims 1 to 8 wherein said switching means is actuatable to vent said first ink conduit to the atmosphere, and said suction means is actuatable for drawing ink out of said ink jet head and said first ink conduit.

11. An ink jet recording apparatus according to any of claims 1 to 8 wherein said switching means is actuatable to connect said first ink conduit to said

second ink conduit, and said suction means is actuatable for reloading ink into said ink jet head.

12. An ink jet recording apparatus substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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