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INK JET CARTRIDGE, INK JET HEAD AND PRINTER

FIELD OF THE INVENTION AND RELATED ART

The present invention relates to an ink jet cartridge containing liquid ink, manufacturing method thereof, an ink jet head and printer using the cartridge, and is usable with a copying machine, a facsimile machine or another recording apparatus, communication apparatus, office equipment, combined machine or printer.

Heretofore, an ink cartridge for an ink jet recording apparatus is integrally formed with an ink jet head, and when the ink in the cartridge is used up, the unified end and the container are disposed of. The quantity of the ink remaining in the cartridge is decided by the ink retaining capacity of a sponge (vacuum producing material) occupying the entirety of the space in the cartridge, and it is relatively large. Japanese Laid-Open Patent Application No. 63242/1988 discloses such an ink container. The ink container contains a foamed material, and it is integral with an ink jet recording head having a plurality of ink ejection orifices. In such an ink container, in order to accommodate the ink in the porous material such as foamed polyurethane material, the production of the vacuum and the ink retention (prevention of the ink leakage from the ink container)

are accomplished by the capillary force of the foamed material. However, the foamed material is required to be filled in the entirety of the ink container, and therefore, the quantity of the ink therein is limited, and the quantity of the non-usable ink is relatively large. This means that the ink use efficiency is low. It is difficult to detect the remaining amount of the ink therein. In addition, during the ink consumption period, the negative pressure gradually changes, and therefore, it is difficult to maintain a substantially constant vacuum.

Japanese Laid-Open Patent Application No. 522/1990 discloses that the ink cartridge contains substantially only the ink. More particularly, it discloses an integral ink jet recording head and ink container, comprising a primary ink container for containing a large amount of the ink at an upper position, and a small porous material between the ink jet recording head therebelow. It is stated that the ink use efficiency is improved because only the ink is disposed in the ink passage without the porous material contained in the ink container. In addition, a secondary ink container capable of containing the ink is provided at a side of the porous material, which is effective to receive the ink flowed from the primary ink container due to expansion of the air in the primary ink container upon temperature rise

(pressure decrease), so as to maintain a substantially constant negative pressure of the recording head during the recording operation.

In this structure, when the recording operation is not carried out, the porous material is filled with a very large amount of the ink from the primary ink container containing a large amount of the ink above the porous material, and therefore, the porous material itself can hardly produce the negative pressure. For this reason, the ink leaks out of the orifice of the ink jet recording head by small impact, and therefore, it is not practical. If this container is used as a exchangeable ink cartridge to be mounted to an ink jet recording head, the ink can leaks out of the porous material, and therefore, it is still not practical.

In an ink cartridge, the ink is sealingly contained in a bladder, and the negative pressure of the bladder is maintained constant using a spring structure, but this is expensive, and it is difficult to mass-produce with the correct performance of the spring structure. In the field of the ink jet printing (non-contact type printing) inexpensive ink cartridge having proper performance has not been accomplished, and has long been desired.

The inventors have investigated from the standpoint of capability of properly supplying the ink

corresponding to the ejection of the ink from the recording head during the printing operation and also from the standpoint of capability of preventing ink leakage through the ejection outlet when the printing operation is not carried out. As a result, it has been found that the fundamental structure comprises a first container containing a vacuum producing material and provided with an air vent and a second container for containing substantially only the ink to be supplied to the first container, the second container being substantially hermetically closed with the exception of the communication with the first container.

Japanese Laid-Open Patent Application No. 16385/1985 discloses a recording pen having a recording tip which is contacted to a recording material during the recording operation. The recording tip has ink absorbing and retaining nature, and the ink is supplied thereto. Therefore, the recording tip is exposed to the ambience, as contrasted to the ink jet recording apparatus. The Japanese Laid-Open Patent Application is directed only to the overflow of the ink through the recording tip.

It comprises as essential elements a first liquid absorbing material, and a second absorbing material which absorbs less ink than the first absorbing material although it absorbing a small

amount of the ink, the second absorbing material being disposed above the first absorbing material at a position closer to the air vent, a central chamber from which the recording tip is projected downwardly, and hermetically closed in accommodating chamber to supply the ink to opposite sides of the chamber. With this structure, when the air in the closed ink container expands due to the ambient temperature rise with the result of the ink in the ink container into the first absorbing material, the ink incapable of being retained by the first absorbing material, is absorbed by the second absorbing material, so that the overflowing droplets of ink from the writing tip can be prevented. It also discloses provision of a constant width groove which is effective, when one of the two closed ink container contains only air, to permit the expanded air to escape through the air vent. The groove is extended from the bottom end to the top end on a side surface which is different from a partition wall between the central chamber and the closed ink container. When this structure is used for an ink jet recording head, the ink leakage through the air vent has been confirmed, as has been expected because of the fundamental difference between the contact recording and the non-contact recording. This problem is not recognized in the field of the recording pen. In addition, the constant width groove

serves to promote the discharge of the ink together with the air, and therefore, the leak of the ink through the air vent has been promoted.

Additionally, the ink consumptions of the two ink containers are not the same. If one of the containers becomes empty first, the ink jet recording operation became no longer possible despite the fact that a large amount of the ink is remaining in the other ink container. This is because a large amount of the air is introduced into the first absorbing material with the result of incapability of the ink supply. This is against the aim of this invention.

SUMMARY OF THE INVENTION

It is a first alternative object of the present invention to provide an improvement to the fundamental structure having the first container containing the vacuum producing material and provided with the air vent for communication with the ambience, and a second container for substantially only the ink to be supplied to the first container, the second container being substantially hermetically closed with the exception of the communication with the first container. The improvement is intended to effective use for the ink jet recording or printing.

It is another object of the present invention to provide an exchangeable ink cartridge, an ink jet

head and a printer using the same capable of effecting high speed recording, while the vacuum can be maintained substantially constant in a large part of the period from the start of the use to the end thereof of the ink cartridge.

It is another object of the present invention to provide an exchangeable ink cartridge in which the vacuum is produced in the ink cartridge when the recording operation is not effected, thus preventing ink leakage through an opening upon small impact.

It is a further object of the present invention to provide an ink cartridge in which the remaining non-usable ink is minimized.

It is a yet further object of the present invention to provide an exchangeable ink cartridge which is less expensive and from which the ink does not leak out during transportation of itself.

According to an aspect of the present invention, a region of the vacuum producing material that adjacent to air introduction passage does not contain the ink. By doing so, the leakage of the ink through the air vent from the ink cartridge can be prevented against the ambient condition change. Particularly when a sealing member is used to seal the air vent, this aspect of the invention is effective to prevent removal of the sealing member. During the use of the ink cartridge, this region is effective to the

proper amount of the air is introduced into the ink cartridge, thus suppressing variation of the vacuum in the ink jet cartridge. The region adjacent the air introduction passage is completely free from being wetted by the ink, the ink seeping speed is reduced, and therefore, it is desirable. However, it is a possible alternative that the region is once wetted by the ink, and the ink is thereafter removed.

According to another aspect of the invention based on the above-described fundamental structure, the vacuum or negative pressure producing material is compressed or capable of being compressed in the region adjacent an ink supply opening or an ink supply pipe which is provided at a side opposite from the partition wall having a small communication part between the first container and the second container. By doing so, a stabilized ink path can be assured in the vacuum producing material from the second ink container. For the purpose of the further stabilization, the ink supply opening is disposed above the small communication part relative to the bottom surface of the ink cartridge. Here, the supply pipe includes an insertion pipe peculiar to the ink jet recording or printing, and a valve structure or connecting member mounted on the cartridge compressing the vacuum producing member. By doing so, the ink movement direction can be substantially stabilized, so

that all of the ink in the second container can be used up. After it is used up, the air moves from the partition wall toward the ink supply opening, thus permitting consumption of the ink in the vacuum producing material, and therefore, the amount of the non-usable remaining ink can be minimized.

According to a further aspect of the present invention, a region of the vacuum producing material not compressed by the supply pipe, and the region compressed by the supply pipe are formed in the order named from the partition wall forming the fine communication part to the opposite wall, by which one way ink supply path is formed in the non-compressed region, and in addition, the remaining non-usable ink amount can be further reduced by the ink retaining capacity in the compressed region.

The present invention includes a structure containing one or more of the above-described aspects.

The ink jet cartridge of this invention is usually handled by an operator, and therefore, it is possible that strong force is applied thereto with the result of deformation of the ink container wall. In view of this, it is preferable that an additional partition wall providing a larger clearance than the fine communication part in the ink container for containing substantially only the ink. When the cartridge is made of resin material, it is preferable

that the thickness of the wall containing substantially only of the ink is 0.8 mm (Ti, G in Figure 29) or more and that the wall thickness of the container containing the vacuum producing material such as sponge is 1.3 mm (Ts, J in Figure 20) from the standpoint of the prevention of the deformation. In the ink jet printer of this invention, the ink is forced discharged by sucking the ink by the sucking means and by ejecting the ink by ejecting means automatically or manually upon mounting of the cartridge on the ink jet printer. This is preferable because the state of the ink in the vacuum generating material can be adjusted before the start of the printing operation, and therefore, the printing function can be performed without influence of the ink cartridge keeping state.

In the manufacturing method of this ink cartridge according to this invention, the fine communication part can be provided between a partition wall and a covering member by fixing the covering member accommodating the vacuum producing material in a container, to the main body of the ink cartridge. Thus, the vacuum producing material can be stabilized adjacent the fine communication part, and therefore, the mass-production is easy.

The height of the fine communication part provided by the partition wall is larger than an

average pore size of the vacuum producing material (preferably the average pore size in the region adjacent the fine communication part) (practically not less than 0.1 mm), and it is preferably not less than 5 mm. If it is less than 3 mm, the further stabilization can be expected. The volume ratio of the vacuum producing material container and the ink container is not less than 1:1 and not more than 1:3, practically.

These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic partly broken perspective view of an ink container according to a first embodiment of the present invention.

Figure 2 is a sectional view of the ink container of Figure 1.

Figure 3 shows examples of connection between the cartridge and the supply pipe.

Figure 4 illustrates a comparison example.

Figure 5 illustrates ink supply part used in this invention.

Figure 6 illustrates a positional relationship between an ink supply portion and the fine communication part.

Figure 7 illustrates the structure of the fine communication part.

Figure 8 illustrates configuration of the partition wall at a side of the fine communication part.

Figure 9 illustrates state of the absorbing material at an end adjacent the partition wall.

Figure 10 illustrates the state of inside of the absorbing material against ambient condition change.

Figure 11 illustrates a manufacturing method according to an embodiment of the present invention, and illustrates an ink jet head.

Figure 12 illustrates an ink jet printer and an ink cartridge usable therewith.

Figure 13 illustrates modified embodiments of the present invention.

Figure 14 is a sectional view illustrating permissible inclination in use, of the ink cartridge.

Figure 15 shows configuration in an embodiment of the present invention.

Figure 16 illustrates the change in the printing operation.

Figure 17 illustrates pressure to the

external wall of the cartridge according to an embodiment of the present invention.

Figure 18 is a sectional view of a modified example of an ink cartridge according to an embodiment of the present invention.

Figure 19 is a perspective view of a color ink container according to an embodiment of the present invention.

Figure 20 is a graph showing a relation between the thickness of the wall and ink leakage by the external pressure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Figures 1 - 6, there is shown an ink container having an ink supply opening formed in a wall of a vacuum producing material container that is faced to a partition wall 5 which is cooperative with a bottom surface of the cartridge to form a fine communication part 8.

Figure 1 is a perspective view of the ink container according to a first embodiment, and Figure 2 is a sectional view of the ink container according to the first embodiment.

As shown in Figures 1 and 2, the ink cartridge main body 1 of this embodiment is provided with an opening 2 for communication with an ink jet recording head at a position displaced toward the fine

communication part in the form of a clearance 8. It comprises a vacuum producing material container 4 for containing the vacuum producing material 3 and an ink container 6 for containing substantially only the ink, which communicates with the container 4 at a bottom portion 11 through the clearance 8 provided by the partition wall 5.

With this structure, the air is supplied through the opening 2. However, what is important is the ink is supplied assuredly from the ink container 6 through the communication part 8 toward the opening 2 along the bottom 11 of the ink cartridge. With the ink supply, the air is introduced in place of the ink in the ink container 6. The description will be made as to the compressing deformation of the vacuum or negative pressure producing material by the supply pipe in the compressing deformation capable region adjacent the opening. In Figure 3, a joint member 7 functioning as a supply pipe for supplying the ink to the ink jet recording head has been inserted into an exchangeable ink cartridge according to this embodiment. With this state, the joint member 7 is press-contacted to the vacuum producing member, and the ink jet recording apparatus is operable in this respect. A filter may be provided at an end of the joint member to remove the foreign matter in the ink cartridge.

When the ink jet recording apparatus is operated, the ink is ejected out through orifices of the ink jet recording head with the result of ink absorbing force in the ink cartridge. The ink 9 is supplied by the absorbing force from the ink container 6 through the clearance 8 between the bottom end of the partition and the bottom of the ink cartridge 11 to the vacuum producing material container 4, and to the ink jet recording head through the vacuum producing material 3 and the joint member 7.

By this ink supply, the internal pressure of the ink container 6 which is closed except for the clearance 8 reduces with the result of pressure difference between the ink container 6 and the vacuum producing material container 4. With the continuing recording operation, the pressure difference continues to increase. However, since the vacuum producing material is open to the ambience by a clearance 10 between the joint member and the opening. The air is introduced into the ink container 4 through the clearance 8 between the bottom end of the partition member 8 and the internal bottom surface 11 of the ink cartridge through the vacuum producing material. At this time, the pressure difference between the ink container 6 and the vacuum producing material container is canceled. During the recording operation, this action is repeated, so that a constant

negative pressure (vacuum) is maintained in the ink cartridge. Substantially all of the ink in the ink container 6 can be used up except for the ink deposited on the internal wall surface of the ink container, can be used up, and therefore, the ink use efficiency is improved.

When the recording operation is not performed, the capillary force of the vacuum producing material itself (meniscus force at the interface between the ink and the vacuum producing material) and the like are produced. Particularly, when the ink consumption from the ink container is started, the ink retaining state in the vacuum producing material becomes substantially constant. Since the air collected in the ink container is substantially in a certain degree of vacuum, and therefore, the pressure balance in the cartridge is extremely stabilized, so that the ink leakage from the ink jet recording head is suppressed.

If the vacuum producing material is properly selected in accordance with the ink jet recording head to be used therewith and if the volume ratio between the vacuum producing material container and the ink container, are properly determined, the structure shown in Figure 4 is possible.

As shown in Figure 19, in order to use the ink cartridge of this invention in a color ink jet

recording, various color inks (black, yellow, magenta and cyan) may be accommodated in separate exchangeable ink cartridges, respectively. These ink cartridges may be unified as shown in Figure 19A. The exchangeable ink cartridge may comprise a black container exchangeable ink cartridge which is frequently used and one another color exchangeable cartridge, as shown in Figure 19, (B). Any combination is possible in consideration of the ink jet apparatus. In the exchangeable ink cartridge according to this embodiment, in order to control the vacuum, the following is preferably optimized: material, configuration and dimensions of the vacuum producing material 3, configuration and dimensions of rib end 8, configuration and dimensions of the clearance 8 between the rib end 8 and the ink container bottom 11, volume ratio between the vacuum producing material container 4 and the ink container 6, configuration and dimensions of the joint member 7 and the insertion degree thereof into the ink container, configuration, dimension and mesh of the filter 12, and the surface tension of the ink.

The material of the vacuum producing member may be any known material if it can retain the ink despite the weight thereof, the weight of the liquid (ink) and small vibration. For example, there are sponge like material made of fibers and porous

material having continuous pores. It is preferably in the form of a sponge of polyurethane foamed material which is easy to adjust the vacuum and the ink retaining power. Particularly, in the case of the foamed material, the pore density can be adjusted during the manufacturing thereof. When the foamed material is subjected to thermal compression treatment to adjust the pore density, the decomposition is produced by the heat with the result of changing the nature of the ink with the possible result of adverse influence to the record quality, and therefore, cleaning treatment is desirable. For the purpose meeting various ink cartridges for various ink jet recording apparatuses, corresponding pore density foamed materials are required. It is desirable that a foamed material not treated by the thermal compression and having a predetermined number of cells (number of pores per 1 inch) is cut-into a desired dimension, and it is squeezed into the vacuum producing material container so as to provide the desired pore density and the capillary force.

In this embodiment, the clearance is provided between the joint member 7 and the opening 2 for the joint member 7 to permit introduction of the air into the ink cartridge. However, this structure is not limiting to the present invention. Other structure or configuration is usable for the joint member and the

joint opening. In the case that on the vacuum producing material is a porous material such as sponge, it is preferable that an end of the joint member 7 is inclined at a certain angle with respect to a joint member inserting direction, since then as shown in Figure 3(a) and (b), the parting of the porous material from the bottom of the ink cartridge is prevented upon insertion of the joint member, and the surface contact between the filter and the vacuum producing material is maintained assuredly. If the insertion amount of the joint member is too large, the tapered end portion might tear the vacuum producing material, and therefore, the surface structure shown in Figure 3, (c), is preferable.

It will be considered that an outer wall of the joint member is provided with grooves. As shown in Figure 5, the configuration of the opening 2 may be a slot (Figure 5, (a)), rectangular (Figure 5, (b)), triangular (Figure 5, (c)). The preferable configuration of the opening 2 provides a clearance between the joint member, or the configuration is such that it is in contact with the outer periphery of the joint member at the bottom of the opening (bottom of the ink cartridge) and that it is open at the upper portion of the opening.

As described in the foregoing, the exchangeable ink cartridge has a joint opening

functioning also as the air introduction opening, and therefore, the structure is simple. The amount of insertion of the joint member 7 into the exchangeable ink cartridge is properly determined by the ordinary skilled in the art so as to provide a compression region of the vacuum producing member to prevent ink leakage upon the insertion and to prevent ink supply stop during the recording operation, in consideration of the configuration of the joint member, the vacuum producing material and the configuration of the ink cartridge.

In the foregoing embodiment, it is effective to provide an air vent in the vacuum producing material container, since then the region of the vacuum producing material that does not contain the ink is easily located adjacent the air introduction passage. The reliability in the ink jet recording apparatus against the ambient condition change is improved. The configuration and dimensions of the clearance 8 between the end of the partition wall and the ink cartridge bottom, are not limited. However, if it is too small, the meniscus force with the ink is too strong, and although the ink leakage can be prevented through the joint opening, but the ink supply to the vacuum producing material container is difficult, with the possible result of ink supply stop during the use. If it is too large, the opposite

phenomenon occurs, and therefore, the height to the partition wall of the fine communicating part is preferably larger than an average pore size of the vacuum producing material (average pore size adjacent the fine communication part, preferably) (practically not less than 0.1 mm), and not more than 5 mm. For the purpose of further stabilization, it is preferably not more than 3 mm. Figure 7 shows an example of the configuration of the clearance 8. Figure 7, (a), shows the structure and configuration most stabilized in the present invention, used in the foregoing embodiment. It is formed with a constant height over the entire width of the cartridge. Figure 7, (a), (b) and (c), shows an example in which the communication part is formed only a part of the entire width of the cartridge, and is waved. This structure is effective when the entire volume of the cartridge is large. Figure 7, (d) shows an example having tunnel-like communicating parts with which the ink is easily moved to the inside of the cartridge, and the air introduction can be concentrated. In the examples of Figure 7, (e) and (f), a recess is formed along a vertical direction on the partition wall in the ink container. With this structure, the air having come to the bottom end of the partition wall is effectively introduced into the ink container by the recess, thus increasing the air tracking efficiency.

The clearance 8 is also determined in consideration of the position of the joint opening. Referring to Figure 10, (a) and (b), the partition wall end is at a position lower than the bottom end of the joint opening in Example (a), and the ink retained in the vacuum producing material is lower than the bottom end of the joint opening, and therefore, the leakage preventing effect is sufficient. In Example (b), the end of the partition wall is at a position higher than the bottom end of the joint opening, and the ink retained in the vacuum producing material is above the bottom end of the joint opening, and therefore, the ink leakage suppressing effect is not sufficient. Therefore, it is preferable to stabilize the advantageous effect of the present invention that the position of the end of the partition wall is not higher than the bottom end of the joint opening by properly determining the dimension of the clearance 8. Although it is dependent on the configuration and dimensions of the exchangeable ink cartridge, the height of the clearance 8 is selected in the range of 0.1 - 20 mm. Further preferably it ranges from 0.5 - 5 mm approximately. The configuration of an end of the partition wall may be any if the consideration is paid to the position relative to the joint opening, as will be understood from Figure 8, (a) - (h).

As regards the boundary between the end of the partition wall 5 and the vacuum producing material 3, various structures are considered. This is shown in Figure 9. In the structure of Figure 9, (a) - (d), the vacuum producing material is not compressed by the end of the partition wall, and the density of the vacuum producing material is not locally increased, and therefore, the flow of the ink and the air is relatively smooth, and for this reason, it is preferable for a high speed recording or color recording. On the other hand, the examples of Figures 9, (e), (f), the vacuum producing material 3 compressed by the end of the partition wall, and the density of the material is increased, and therefore, the flow of the ink and the air is obstructed, but the ink leakage or the like can be effectively prevented against slight ambient condition change. Therefore, they are properly determined by one skilled in the art, on the basis of the ink jet recording apparatus with which the ink cartridge is used and the ambient condition under which the ink cartridge is used.

The volume ratio between the vacuum producing material container 4 and the ink container 6, is determined in consideration of the ambient condition under which the ink cartridge is used and the ink jet recording apparatus with which it is used. Also, the relation with the used vacuum producing material is

important. In order to improve the use efficiency of the ink, it is desirable to increase the volume of the ink container. In that case, a vacuum producing material capable of producing high vacuum (high compression ratio sponge), is effective. Therefore, the preferable ratio ranges from 1:1 - 1:3 practically. In this case, the vacuum producing performance of the vacuum producing member is increased with increase of the relative volume of the ink container.

The configuration, dimension and mesh of the filter 11 can be properly determined by one skilled in the art depending on the ink jet recording apparatus with which the ink cartridge is used. However, in order to prevent the nozzle from being clogged by the foreign matter introduced from the ink cartridge, the passing area thereof is smaller than the size of the orifice.

The quantity of the ink in the ink cartridge is not limited except for the internal volume of the ink cartridge. In order to maintain the proper negative structure immediately after the exchangeable ink cartridge is unpacked, the ink may be contained to the extent of the volume limit in the ink container. However, the vacuum producing material is preferably lower than the ink retaining capacity of the material. Here, the ink retaining capacity which can be retained

solely by the material when the ink is contained therein.

In the ink cartridge having a closed system ink container, when an external ambient condition change such as temperature rise or pressure reduction, occurs when it is loaded in the ink jet recording apparatus, the air and the ink expands in the ink container to push the remaining ink out of the ink cartridge with the possible result of ink leakage. However, in the exchangeable ink cartridge of this invention, the volume of air expansion in the closed ink container, including ink expansion (although the amount is small) in accordance with the worst ambient condition change, is estimated, and the amount of the displaced ink from the ink container is to be accommodated in the vacuum producing material container. In this case, it is very effective to provide the vacuum producing material container with an air vent in addition to the joint opening, as shown in Figure 10, (c) and (d), since then the ink displaced into the vacuum producing material from the ink chamber by the expansion of the air can be guided toward the air vent. The position of the air vent is not limited if it is upper than the joint opening of the vacuum producing member container. However, in order to make the ink flow in the vacuum producing material under the ambient condition change remote

from the joint opening, it is preferably away from the joint opening. The number, configuration and size of the air vent are properly determined by skilled in the art in consideration of the ink evaporation or the like.

During transportation of the ink cartridge itself, it is preferable that the joint opening and/or the air vent is hermetically shield by a sealing member to prevent ink evaporation or to be prepared for the expansion of the air in the ink cartridge. The sealing member may be a single layer barrier which is so-called barrier material in the packing field, a compound plastic film having several layers, or such material reinforced by paper or cloth or another reinforcing material or aluminum foil, are preferable. It is further preferable that a bonding layer of the same material as the main body of the ink cartridge is used to fuse fixing the barrier material, thus improving the hermetical sealing property.

In order to suppress the evaporation of the ink from the ink cartridge and the introduction of the air thereinto, it is effective that the air in the pack is removed after the ink cartridge is inserted therein. The packing member may preferably of the same barrier material as described with respect to the sealing member in consideration of the permeabilities of the liquid and the air.

By such proper selection of the packing, the ink does not leak out during the transportation of the ink cartridge itself.

The material of the main body of the ink cartridge may be any known moldable material if it does not have any adverse influence to the ink jet recording ink or if it has been treated for avoiding the influence. The productivity of the ink cartridge is also considered. For example, the main body of the ink cartridge is separated into a bottom portion 11 and an upper portion, and they are integrally molded from plastic resin material, respectively. The vacuum producing material is inserted thereinto, and thereafter, the bottom portion and upper portion are fuse-bonded, thus providing the main body of the ink cartridge. If the plastic material is transparent or semitransparent, the ink in the ink container can be observed externally, and therefore, the timing of ink cartridge change may be expected. In order to facilitate the fusing of the bonding material or the like, it is preferable to provide a projection shown in the Figure. From the standpoint of design, the outer surface of the main body of the ink cartridge may be grained.

The ink can be loaded through pressurizing or pressure-reduction method. Provision of ink filling opening in either of the containers of the containing

main assembly is preferable since then the ink cartridge opening is not contaminated. After the filling, the ink filling opening is plugged by plastic or metal plug.

The configuration, dimension or the like of the ink cartridge according to this invention can be modified without departing from the sprit of the present invention.

As described in the foregoing, the exchangeable ink cartridge is reliable during the transportation thereof, and a high use efficiency ink cartridge can be provided with simple structure.

The proper vacuum is maintained from the start to the end of the use can be maintained when the recording operation is carried out or is not carried out, while permitting high speed recording. Under the use ambient condition of the ink jet recording apparatus, the possibility of the ink leakage can be minimized.

The exchangeable ink cartridge of this invention is easy to handle so that the ink does not leak out when it is loaded into the ink jet recording apparatus, and the possibility of erroneous operation can be avoided.

Figure 11 illustrates a manufacturing method of an ink container cartridge. A main body of the cartridge (left down hatching) comprises a partition

plate 61 and two containers separated by the partition wall 5. An ink absorbing material 4 functioning as the vacuum producing material is inserted into the container portion which is close to the opening 2. Thereafter, a bottom member 11 functioning as the covering member is unified to the main body. This Figure also shows the state in which the recording head HD is loaded in the ink container 1. The ink container 1 is constituted by a container partitioned into two chambers by a partition wall 5, and the bottom portion is covered by a flat bottom member 11 constituting the bottom of the ink container. Thus, by the simple structure, the fine communication part 8 can be provided by the end of the partition wall.

The air vent 10 is disposed on the same surface as having the opening 2, but above the opening.

The joint portion 7 functioning as the supply pipe is inserted into the opening of the ink container, and the recording head is mounted thereto. The joint portion 7 is inclined so that the top portion is more front than the bottom portion. The ink passage in the joint is in the form of a horn opening upwardly in the Figure. With this structure, the ink can be properly supplied to the recording head from the ink absorbing material.

The ink jet recording apparatus comprises

heat generating element 72 for producing thermal energy to eject the ink through ejection outlets 71 of the nozzles 73, wherein the thermal energy is effective to cause state change in the ink. In this case, a high density and fine images can be provided by the stabilized ink supply performance, particularly in the case of color recording.

As described in the foregoing, the ink cartridge according to this invention, the high reliability is maintained during the transportation thereof, and the use efficiency of the ink is high.

In addition, the proper vacuum is maintained from the start to the end of the use thereof when the recording operation is carried out or is not carried out, when permitting high speed recording operation. In addition, the ink leakage can be prevented under the use condition of the ink jet recording apparatus.

Additionally, the exchangeable ink cartridge according to this invention is easy to handle, and the ink does not leak out when it is mounted or demounted relative to the ink jet recording apparatus. Therefore, the erroneous operation in the mounting thereof can be avoided.

The manufacturing method of the ink cartridge will be described further. When the closed structure ink container (although there is fine communication part between the ink containing chamber or container

and the negative pressure producing material containing chamber, but the ink is discharged only when the air and the ink are exchanged with each other), and the vacuum producing material containing chamber are integrally molded, the ink is filled through an opening 13 at the ink container chamber side in the covering member 11. When the ink is supplied in this manner, a substantial part of the vacuum producing material 4 receives the ink through the fine communication part.

However, the region of the vacuum producing material 4 adjacent the air vent is not supplied with the ink to provide ink-free region. Thereafter, the opening 13 is sealed by a ball 14. Then, the opening 2 and the air vent are sealed by the same sealing member S (it may be separate members).

Figure 12 shows such an ink jet cartridge before start of use. In this Figure, the ink container 6 is filled with an ink.

Figure 12 shows the closed state ink jet cartridge 1 with the printer which is used therewith. A region 3A of the vacuum producing material adjacent to the air vent portion 10 does not contain the ink at an upper portion of the cartridge. A region 3B of the vacuum producing material below the region 3A is compressed by insertion of the ink supply pipe (not shown). The vacuum producing material portion other

than those regions 3A and 3B, are not externally influenced and simply functions to retain the ink. The region 3B is faced to the opening 2 for the ink supply to the recording head provided on the same surface but below the air vent 10. The opening is above the fine communication part 8, and the above-described structure is used. The cartridge 1 of Figure 12 becomes usable by removing the sealing member S. Since the region A does not retain the ink, the ink does not leak out even if the vibration or pressure change is imparted upon the removal of the sealing member.

In the ink container of this invention, the ink is not retained in the region of the vacuum producing member that is close to the air vent or air communication part, irrespective of whether the ink cartridge is being used or not used. By doing so, the leakage of the ink from the ink cartridge through the air vent can be prevented even when the ambient condition varies. Particularly, when the sealing member closes the air vent, the sealing member can be prevented from peeling off. During the use, the region is effective to permit air supply corresponding to the consumption of the ink, so that the change of the vacuum in the ink cartridge can be suppressed. If the region of the vacuum producing material adjacent to the air vent has never been wetted by the ink at

all, it is preferable to decelerate the ink seeping speed. However, the region thereof may be wetted by the ink beforehand, and thereafter, the ink may be removed from this region.

In the embodiment of this invention, the ink supply opening or the compressed part of the vacuum producing material (compressible) by the ink supply pipe is present at a side opposed to the partition wall constituting the fine communication part, by which the effective ink supply path can be stably provided in the vacuum producing material in the second accommodation chamber. This can be further stabilized by placing the ink supply opening above the fine communication part relative to the bottom surface of the ink cartridge.

Because of this arrangement, the ink moving direction can be substantially made constant, and therefore, the ink can be completely consumed from the second chamber, that is, the ink container chamber. After the use-up of the ink in the ink container chamber, the air exist so as to move the ink toward the opening from the partition wall in the direction for canceling the vacuum in the ink container chamber, as a result, the ink in the vacuum producing material can be consumed further, thus minimizing the non-usable remaining amount of the ink.

There are provided a region of the vacuum

producing material not compressed by the supply pipe and the region thereof compressed by the supply pipe in this order in a direction from the partition wall constituting the fine communication part to the side face thereto, and therefore, the non-compressed region provided one-way ink path, and the ink retaining capacity of the compressed region can further reduce the remaining amount of the ink.

The ink jet printer is provided with a recording head recovery means HR which carries out ink ejection or ink sucking by sucking means automatically or manually in response to mounting of the cartridge 1 thereto. By doing so, the state of the ink in the vacuum producing material can be corrected before the start of the printing operation. Therefore, the cartridge performance can be used form the start of the printing irrespective of the state in which cartridge has been placed.

In Figure 12, the ink container 1 mounted to the ink jet head HD mounted on a scanning type carriage CR has been deprived the sealing tape. The container mounted on the carriage CR receives through the opening 2 the ink supply pipe, by which the vacuum producing material 3 is compressed in the compressible region 3b. In this embodiment, the vacuum producing member 3 is deformed toward the fine communication part 8. At this time, the mounting of the container

is detected by detecting means (not shown) in the form of mechanical or electrical detecting means, which produces mounting signal IT into the printer control means CC. In response thereto, the recovery means HR is actuated before the start of the recording operation to discharge the ink in the ink container, thus improving the state of the ink in the ink container.

In Figure 13, (A), there is shown an ink jet cartridge which is a modification of that of Figure 12 in which the inside surface of the ink accommodating chamber is modified, and the top part thereof is correspondingly modified into a space 22. The inside surface 20 provides a curved surface which rises away from the fine communication part 8. This structure is effective to supply into the vacuum producing material 3 fine droplets of ink remaining on the wall of the inside surface 20 by the surface tension of the ink, and also to provide a grip 21 for the operator, thus preventing deformation of the ink container upon manipulation thereof.

Figure 13, (B) shows another modification in which the partition wall 51 is inclined so that the capacity is larger in the ink accommodating chamber or ink container than in the vacuum producing material container. Figure 13, (C) shows an embodiment which has been produced by the manufacturing method

described hereinbefore. A covering member 11 constituting the clearance or gap 8 with the partition wall 5 is inserted and fixed between side plates 101 and 100 of the cartridge main body. Designated by a reference 5E is an end of the covering member 11. In the case of Figure 13, (C), the clearance SP is not constant if the bonding is not uniform.

In view of this, it is preferable that spacers 110 contacting to the end 5E of the partition wall, as shown in Figure 13, (D), at the opposite ends. The spacer 110 is preferably provided on the covering member 11. Projections 30 in the space SP may be provided on the covering member to enhance the collection of the air into the ink container.

Figure 14, (A) and (B) show an inclination range capable of printing operation or ink supply. Designated by a reference numeral 40 is a horizontal line. It is preferable that the fine communication part is at a lower position. Ideally, bottom surface of the cartridge is parallel with the horizontal plane 40. Practically, however, in the case of two chamber structure as in this embodiment, the inclination is permissible in the range $0 \leq \theta \leq 15$ degrees. When it is reciprocated on a scanning carriage, it is preferably $0 \leq \theta \leq 5$ degrees.

The vacuum producing material used in this embodiment may be constituted by a plurality of vacuum

producing material members. However, in that case, the resultant interface between the members might permit movement of the air at the interface, as the case may be. In view of this, single porous material member is preferable for the vacuum producing material.

The ink container (chamber) performs it function if it has an ink capacity larger than that of the vacuum producing material accommodating chamber.

The description will be made as a partition plate 61 in the ink accommodating chamber. When the ink container (cartridge) is handled by the operator, or during the transportation thereof, the external wall of the cartridge may be deformed with the possible result that the ink is leaked through the orifice from the ink jet recording head or that the ink is leaked out through the air vent provided for equalizing the pressure in the cartridge with the ambient pressure.

In this embodiment, this problem is solved, thus preventing the ink leakage during the handling or during the transportation or even if the temperature or the pressure changes. In addition, the use efficiency is still high.

Figure 15, (A) is a perspective view of the ink container of this embodiment, and Figure 15, (B), is a sectional view thereof. Figure 16 illustrates

ink supply operation of this embodiment. Figure 17 illustrates deformation of the side wall when it receives load.

As shown in Figure 15, (A) and (B), the main body of the ink cartridge 1 comprises an opening 2 for communication with the ink jet recording head and an air vent 10 for permitting introduction of the air, disposed above the opening 2, vacuum producing material 3 for retaining the ink for the recording, a vacuum producing material container 4 for containing the vacuum producing material 3 and provided with the opening 2 and the air vent 10, and an ink container (chamber) 6 for containing the ink in communication with the vacuum producing material container 4 through a clearance below a rib 5. The ink container 6 and the vacuum producing material container 4 communicate with each other through a clearance 8 formed between an end of the rib 5 and the bottom surface. A partition plate 61 connects the opposite side walls leaving a gap not less than the clearance 8 at the bottom. Figure 16, (a) is a sectional view in the state in which the ink jet recording apparatus is operable after a joint member 7 for supplying the ink to the ink jet recording head is inserted into the opening 2 of the ink cartridge main body 1 to press-contact the vacuum producing material 3. The end opening of the joint member 7 may be provided with a

filter to remove foreign matters in the ink cartridge.

When the ink jet recording apparatus is operated, the ink is ejected through the orifice of the ink jet recording head, so that ink absorbing force is produced in the ink container. The ink 9 is supplied to the ink jet recording head from the ink container 6 through the clearance 8 between an end of the rib 5 and the bottom of the ink cartridge 11 to the vacuum producing material container 4, and through the vacuum producing material 3 to the joint member 7. By this, the pressure of the ink container 6 which is closed except for the clearance 8, reduces with the result of pressure difference between the ink container 6 and the vacuum producing material container 4. With the continued recording operation, the pressure difference continues to increase, however since the vacuum producing material container 4 is open to the air through the air vent 10. As shown in Figure 16, (b), the air enters the ink container 6 through the vacuum producing material 3 and the clearance 8. By this, the pressure difference between the ink container 6 and the vacuum producing material container 4 is removed. During the ink jet recording operation, this is repeated, so that a constant certain level of vacuum is maintained in the ink cartridge. All of the ink in the ink container 6 can be used up, except for the ink deposited on the

internal wall surface of the ink container 6, and therefore, the ink use efficiency is high (Figure 16, (C)).

When the recording operation is not carried out, the capillary force of the vacuum producing material 3 itself (or the meniscus force at the interface between the ink and the vacuum producing material) appears to prevent the leakage of the ink from the ink jet recording head.

Figure 18 shows a further embodiment in which the ink container 6 is provided with a plurality of partition walls 61, in consideration of the volume ratio between the vacuum producing material container 4 and the ink container 6 and the selection of the material of the vacuum producing material 3 in accordance with the ink jet recording head used with the ink container.

The description will be made as to the reinforcement of the side wall.

In the ink cartridge, it is desirable that the ink cartridge is durable against external force and the ambient condition change during the transportation, while maintaining high use efficiency.

In this embodiment, the amount of deformations are equivalent in the vacuum producing member container 4 and the ink container 6 when the external forces are applied to the side walls 12a, 12b

and 12c. For example, the cartridge is usually made by molding a plastic material. As shown in Figure 15, (B) and 17, the thickness of the side wall 12a of the vacuum producing material container 4 is larger than the thickness of the side walls 12b and 12c of the ink container portion 6, and a partition wall (rib) 61 is disposed to extend between the opposite side walls, leaving the clearance at the bottom, at a position to divide the space into two equal space in the ink container 6. In addition, the deformation δt6 of the wall responsive to the equivalent loads per unit area is made small, and the deformations of the side walls 12b and 12c at the opposite ends of the rib 61, are equivalent. By making the amount of deformation δt4 of the vacuum producing material container 4 equivalent thereto, the leakage of the ink due to the deformation of the wall can be prevented.

In the ink cartridge shown in Figure 15, (B) and Figure 17, the material of the wall is polypropylene (PP), and the outer dimensions are as follows: 48 mm in length, 35 mm in height, 11 mm in thickness. In this case, it is divided into the vacuum producing material container 4 and the ink container 6 substantially at the center of the length of 48 mm. The side wall 12a of the vacuum producing material container 4 has a thickness of 1.5 mm, and the side walls 12b and 12c of the ink container 6 have

a thickness of 1 mm, and the rib 61 of the ink container 6 is disposed approx. 10 mm away from the wall surface. By doing so, more than twice margin can be provided against the handling load (approx. 2 kg). Simultaneously, the sufficient strength can be provided against the pressure change during the transportation and the temperature range.

In this embodiment, only one rib 61 is provided in the ink container 6 because of the size of the ink container. However, the number thereof is not limited, and to ribs 61 may be provided as shown in Figure 18 in accordance with the size of the ink cartridge. Furthermore, the number, position and the wall thickness of the rib can be properly determined by skilled in the art.

Figure 20 shows a relation of the ink leakage during the handling and the transportation with the wall thickness of the vacuum producing material container 4 and wall thicknesses of various walls, investigated for the purpose of determining the wall thickness of the ink container 6.

Increase of thickness of any wall results in increase of the resistance against the ink leakage. However, from the standpoint of size reduction and high use efficiency of the ink, the smaller wall thickness is preferable to increase the internal volume. On the basis of the data show in the Figure,

a wall thickness of 1.5 mm was used for the side wall of the vacuum producing member container 4, and the side wall thickness of 1.0 mm was used for the ink container 6.

On the basis of the size of the ink cartridge, the above-described dimension may be determined on the basis of the data of this Figure. It is preferable that the wall thickness of the vacuum producing material container 4 is 1.3 - 3 times the wall thickness of the ink container 6.

While the invention has been described with reference to the structures disclosed herein, it is not confined to the details set forth and this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims.

CLAIMS

1. A printing liquid container connectable to an ink jet head for an ink jet recording apparatus, comprising:

a first chamber accommodating negative pressure producing material and provided with an air vent for communicating with ambient air; and

a second chamber which is substantially closed except for a communication port communicating with said first chamber at a position away from said air vent wherein said second chamber provides a printing liquid reservoir for said first chamber and the container is filled with printing liquid so as to leave a region of said negative pressure producing material adjacent said air vent free of printing liquid.

2. A container according to claim 1, wherein said communication port is formed between a partition wall for defining said first and second chambers and an inside surface of said container, a wall of said first chamber facing said partition wall being provided with an opening for supplying printing liquid and means being provided for sealing the ink supply opening and said air vent.

3. A container according to claim 1, wherein said communication port is formed between a partition wall for defining said first and second chambers and an inside surface of said container, a printing liquid supply

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opening is formed in a wall of said first chamber facing said partition wall and is arranged to permit insertion of a supply pipe for supplying printing liquid to an ink jet recording head, said negative pressure producing material being provided in said first chamber so as to be compressed adjacent the supply opening toward the communication port by the insertion of the supply pipe.

4. A container according to claim 1, wherein said communication port is formed between a partition wall for defining said first and second chambers and an inside surface of said container, a printing liquid supply opening is formed in a wall different from the partition wall and is arranged to permit insertion of a supply pipe, said negative pressure producing material adjacent the ink supply opening being capable of being compressed towards the communication port by insertion of the supply pipe of an ink jet head, but not being compressed by the insertion of the supply pipe adjacent the communication port.

5. A container according to claim 4, wherein said different wall has a surface facing said partition wall, and the supply opening is located at a position which is displaced toward the communication port, and is disposed above the communication port.

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6. A container according to any one of claims 1 to 5, wherein said second chamber comprises a partition plate which provides a clearance with the inside surface of the container, which is larger than the communication port.

7. A container according to any one of claims 1 to 5, wherein the volume ratio of said first chamber to said second chamber is 1:3 - 1:1.

8. A container according to any one of claims 1 to 5, wherein the height of said communication port is larger than an average pore size of said negative pressure producing material in said first chamber, and is not less than 5mm.

9. A container according to claim 1, wherein said communication port is formed between a partition wall for defining said first and second chambers and an inside surface of said container, a printing liquid supply opening is formed on a wall different from the partition wall and is arranged to permit insertion of a supply pipe, said negative pressure producing material being capable of being compressed but said negative pressure producing material not being compressed adjacent the communication port by the insertion of the supply pipe.

10. A container assembly comprising a plurality of

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containers in accordance with claim 1 integrated together.

11. An ink jet head assembly comprising a container in accordance with claim 1, wherein said communication port is formed between a partition wall for defining said first and second chambers and an inside surface of said container and a printing liquid supply opening is formed in a wall of said first chamber which is different from said partition wall; and

an ink jet head having a supply pipe for insertion into said supply opening, said supply pipe being arranged, upon insertion into said supply opening, to compress said negative pressure producing material, said negative pressure producing material being arranged so as not to be compressed by the insertion of the supply pipe adjacent said communication port.

12. An ink jet head assembly comprising:

a container in accordance with claim 1 wherein said communication port is formed between a partition wall defining said first and second chambers and an inside surface of said container and a wall of said first chamber different from said partition wall is provided with a printing liquid supply opening; and

an ink jet head having an ink supply pipe for insertion into the supply opening, said negative pressure

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producing material being arranged to be compressed by insertion of said supply pipe.

13. A printer using an ink jet head assembly according to claim 12, wherein said different wall has a surface facing said partition wall and wherein, when said assembly is mounted to the printer, said supply opening and said communication port are located at a lower part of said container and said communication port is located below said ink supply opening, and said part of said negative pressure producing material is located at an upper position.

14. A printer comprising a container in accordance with claim 1, wherein when said container is mounted to said printer, said air vent is at an upper position, and said communication port and a printing liquid supply opening of the container are at a lower position and wherein, in response to mounting of said container to said printer, printing liquid from said negative pressure producing material is discharged through said supply opening, prior to the start of a printing operation.

15. A printer according to claim 14, wherein said supply opening is provided on a wall of said first chamber facing said partition wall.

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16. A printer according to claim 14, wherein said supply opening is arranged to permit insertion of a supply pipe of the ink jet head, and said negative pressure producing material is arranged to be compressed adjacent said supply opening by insertion of the supply pipe but not to be compressed adjacent said communication port.

17. A printing liquid container according to claim 1 and substantially as hereinbefore described with reference to the accompanying drawings.

18. An ink jet head assembly comprising a container in accordance with any one of claims 1 to 10 or 17.

19. A printer comprising a container in accordance with any one of claims 1 to 10 or 17 or an ink jet head assembly in accordance with claim 11 or 12, and means for mounting the container to the printer to enable supply of printing liquid to an ink jet head.

20. A process for producing a printing liquid container connectable to an ink jet head for an ink jet recording apparatus, which process comprises:

providing a container comprising a first chamber containing negative pressure producing material and having an air vent for communicating with ambient air and a second chamber which is substantially sealed apart from

a communication port communicating with the first chamber away from the air vent; and

supplying printing liquid to the container so as to fill the second chamber to provide a printing liquid reservoir for the first chamber but so as to leave a portion of the negative pressure producing material adjacent the air vent free of printing liquid.

21. A process for producing a printing liquid container according to claim 20 and substantially as hereinbefore described.