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(54) **TOILET AND METHOD FOR  
MANUFACTURE OF THE SAME**

(57)

## ABSTRACT

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To enable a low profile for a toilet, and provide more universal toilet installation.

A first principal flow **S1** is formed by convergence of flush water discharged from a first basal nozzle basal first nozzle hole **41** and a basal second nozzle hole **42**. By means of this convergence the first principal flow **S1** is generated with correct directionality and strong force, and converges with the bowl water **RS** diagonally rightward and forward from the left rear end of the toilet, as seen in the plan view. Flush water discharged from a left central nozzle hole **43** circles around the upper peripheral wall of the toilet bowl at the bottom edge of the rim, but during this time the discharge course thereof is corrected by means of converging flows of flush water discharged from the rim, to produce a second principal flow **S2** generated by means of this convergence with correct directionality and strong force. The second principal flow **S2** converges with the bowl water **RS** diagonally leftward and rearward from the right front of the toilet. This first principal flow **S1** and second principal flow **S2** converge substantially parallel to either long side of the bowl water **RS**, as viewed in the horizontal plane, and in the same circling direction. In this way circular flow is reliably produced in the bowl water **RS** and circulation thereof is accelerated.

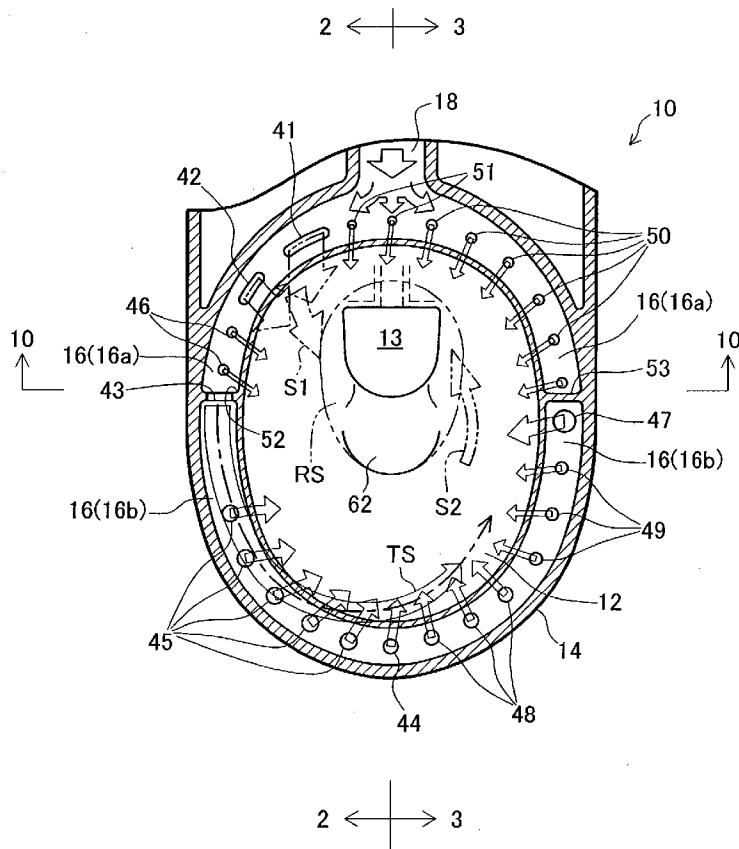


Fig. 1

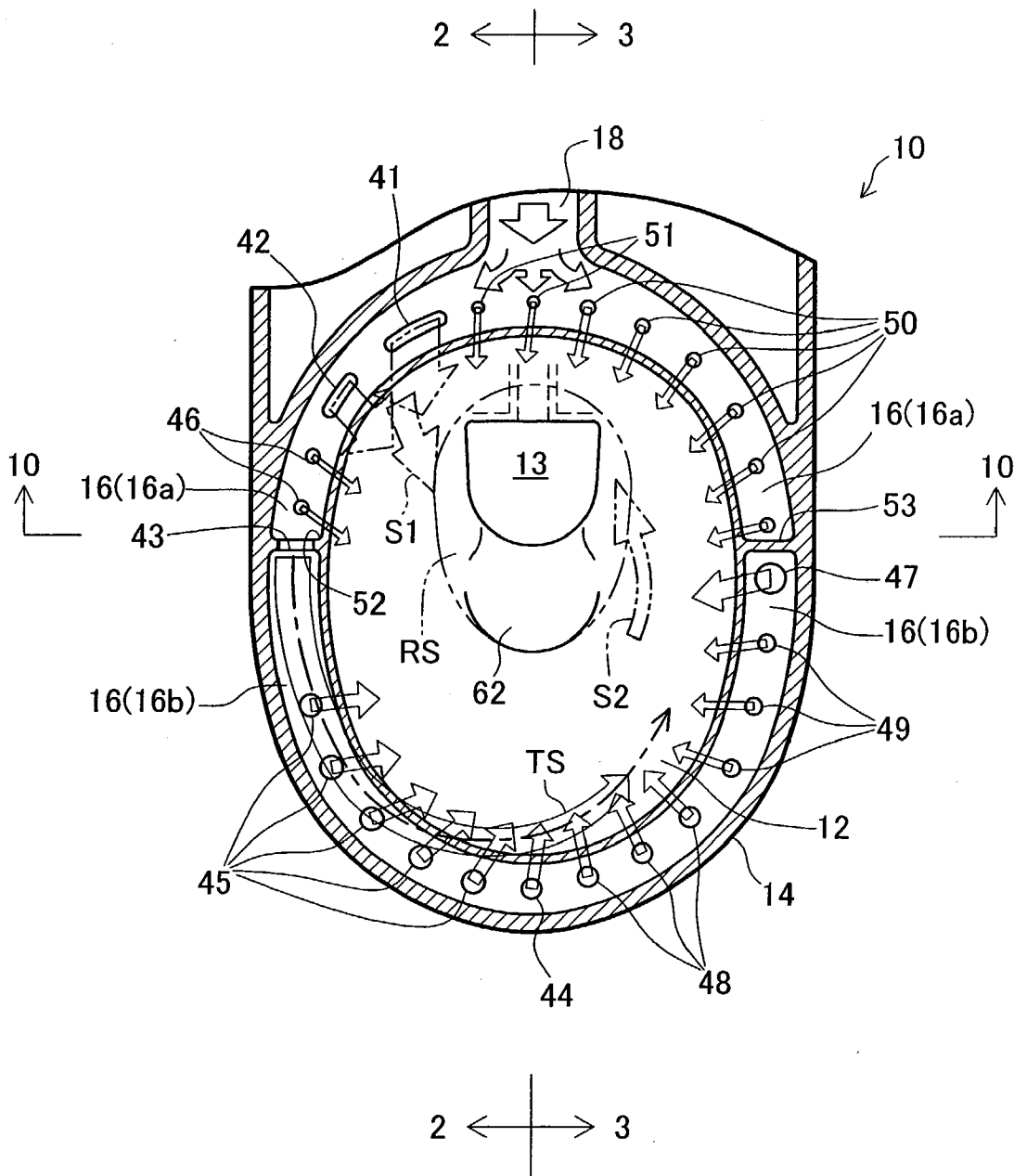
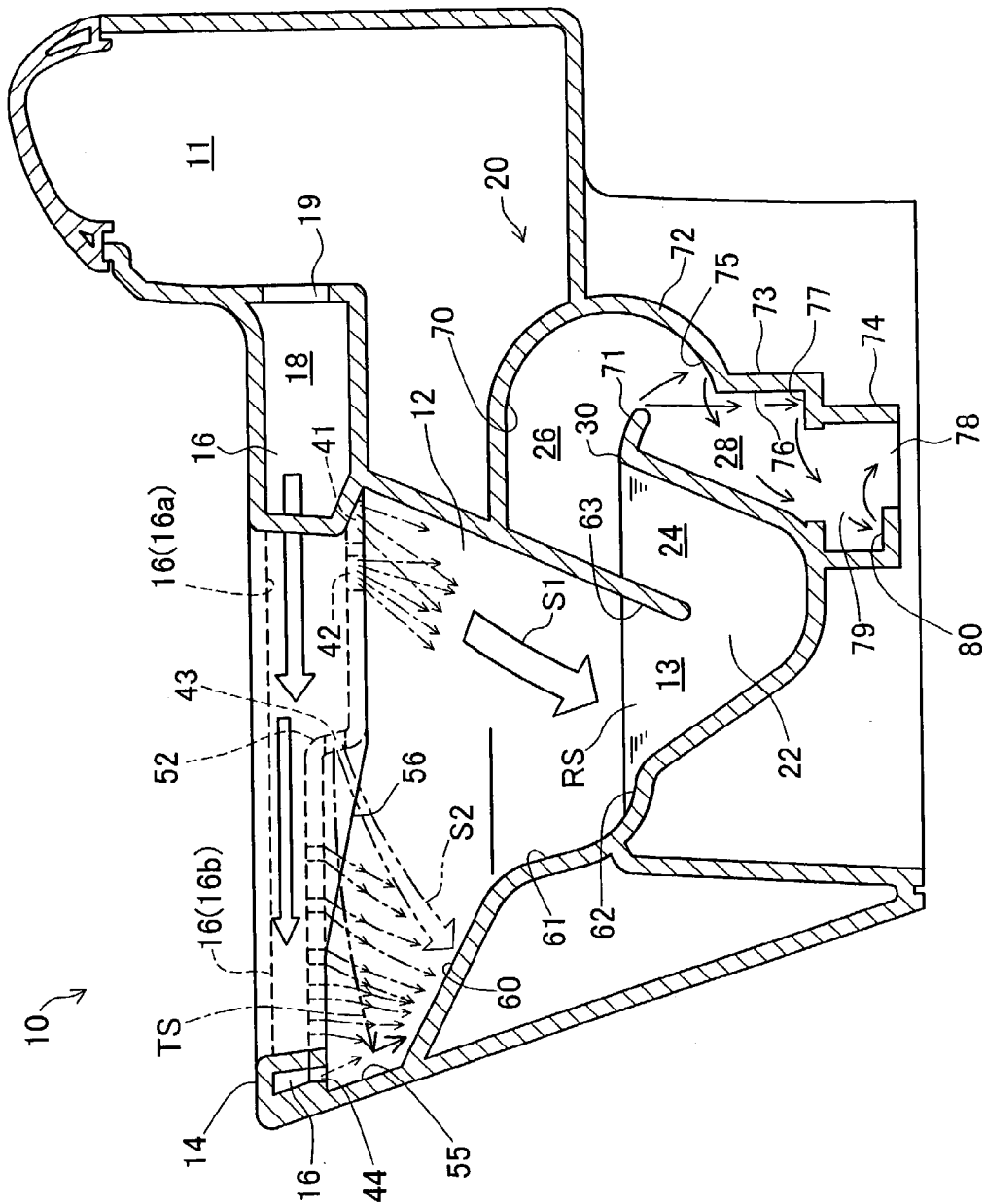


Fig. 2



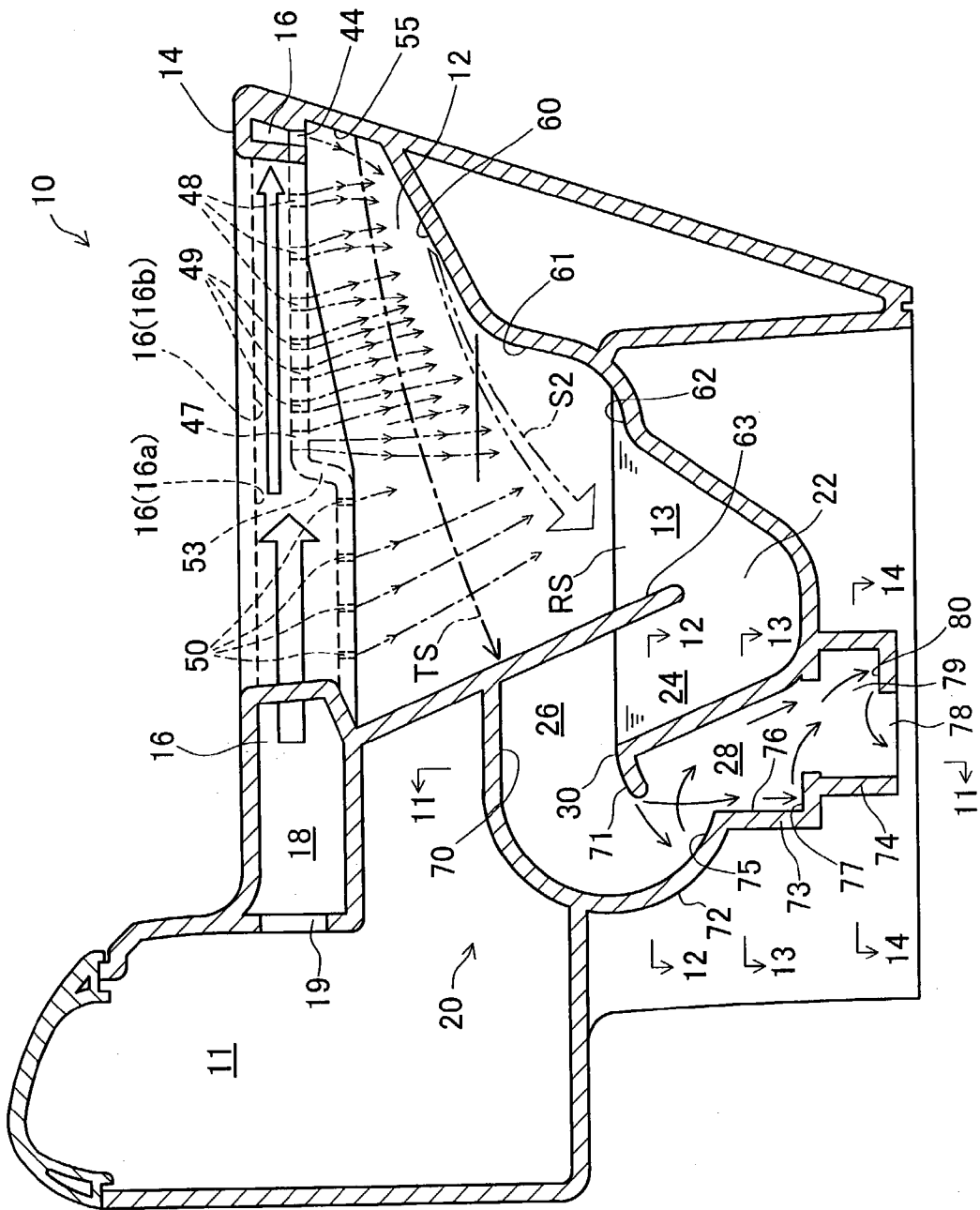


Fig. 3

Fig. 4

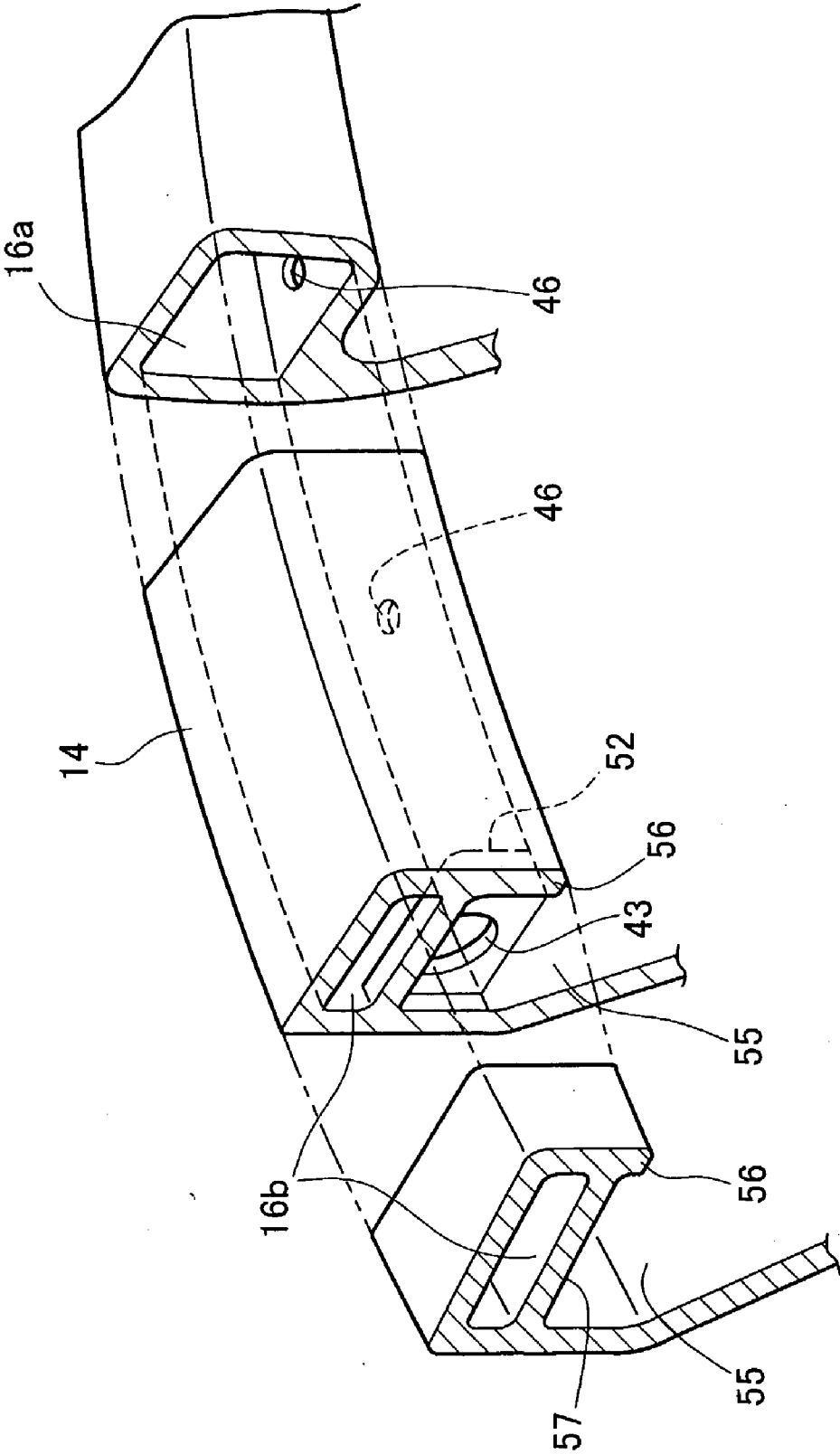
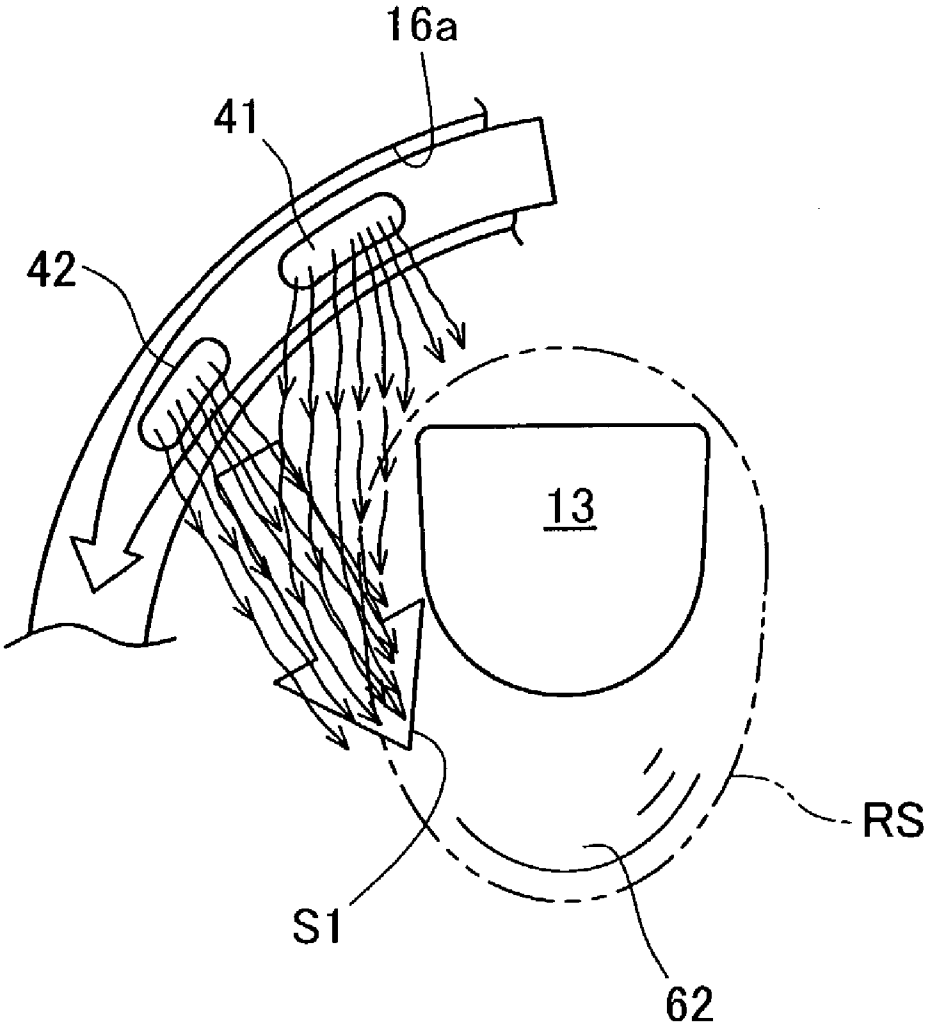


Fig. 5



*Fig. 6(a)*

Fig. 7

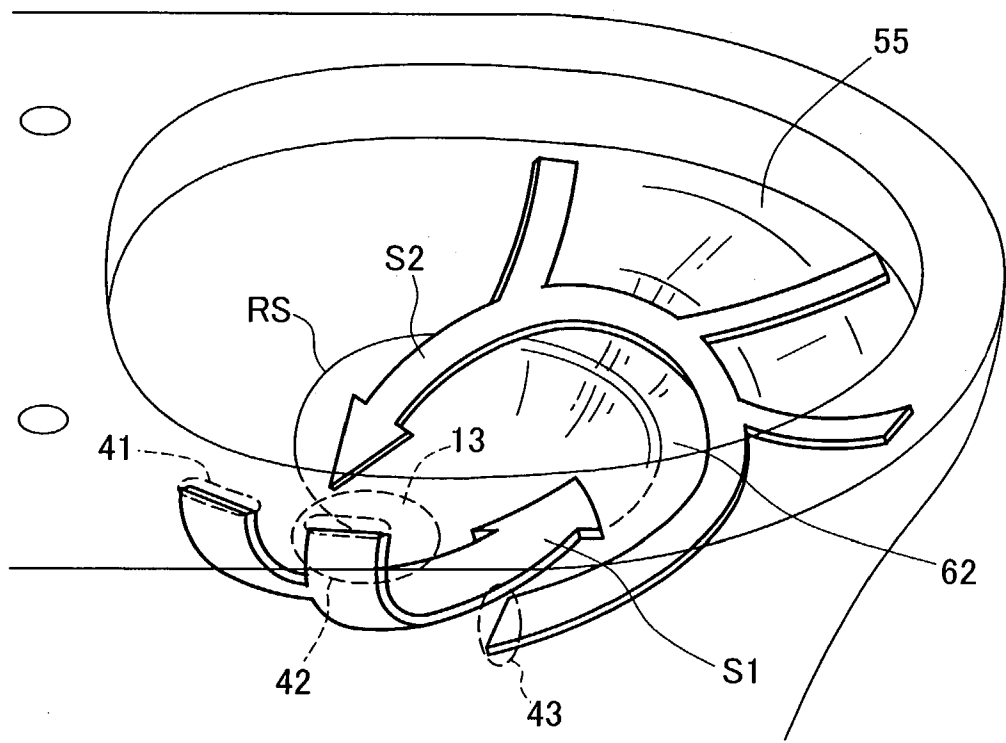


Fig. 8

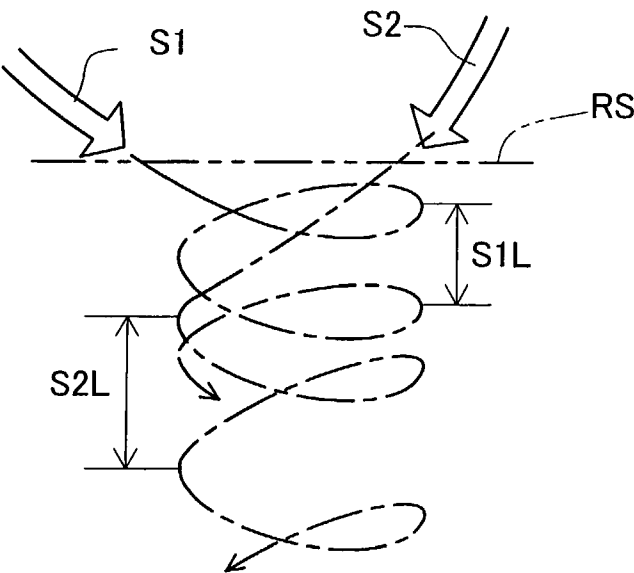


Fig. 9

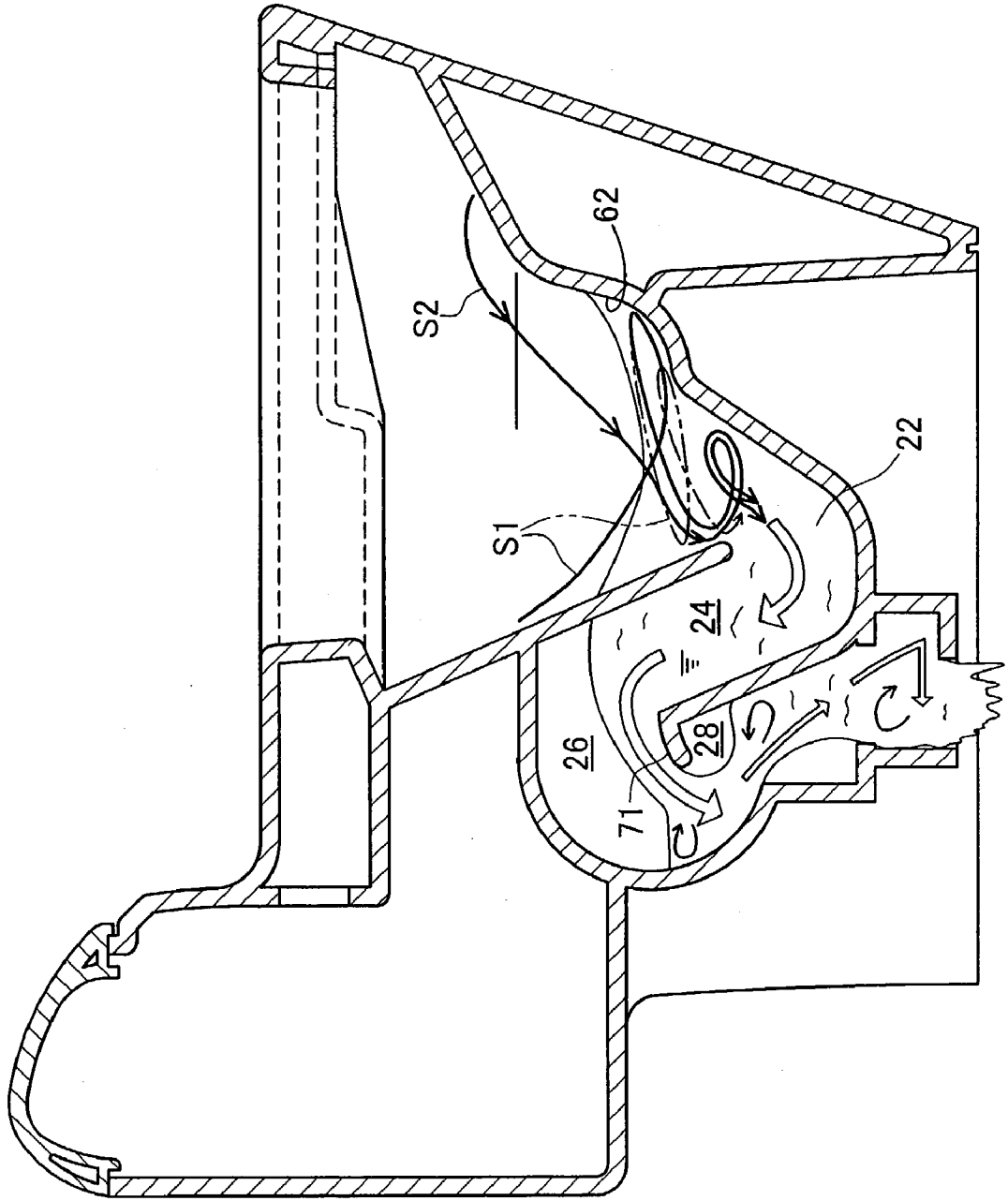


Fig. 10

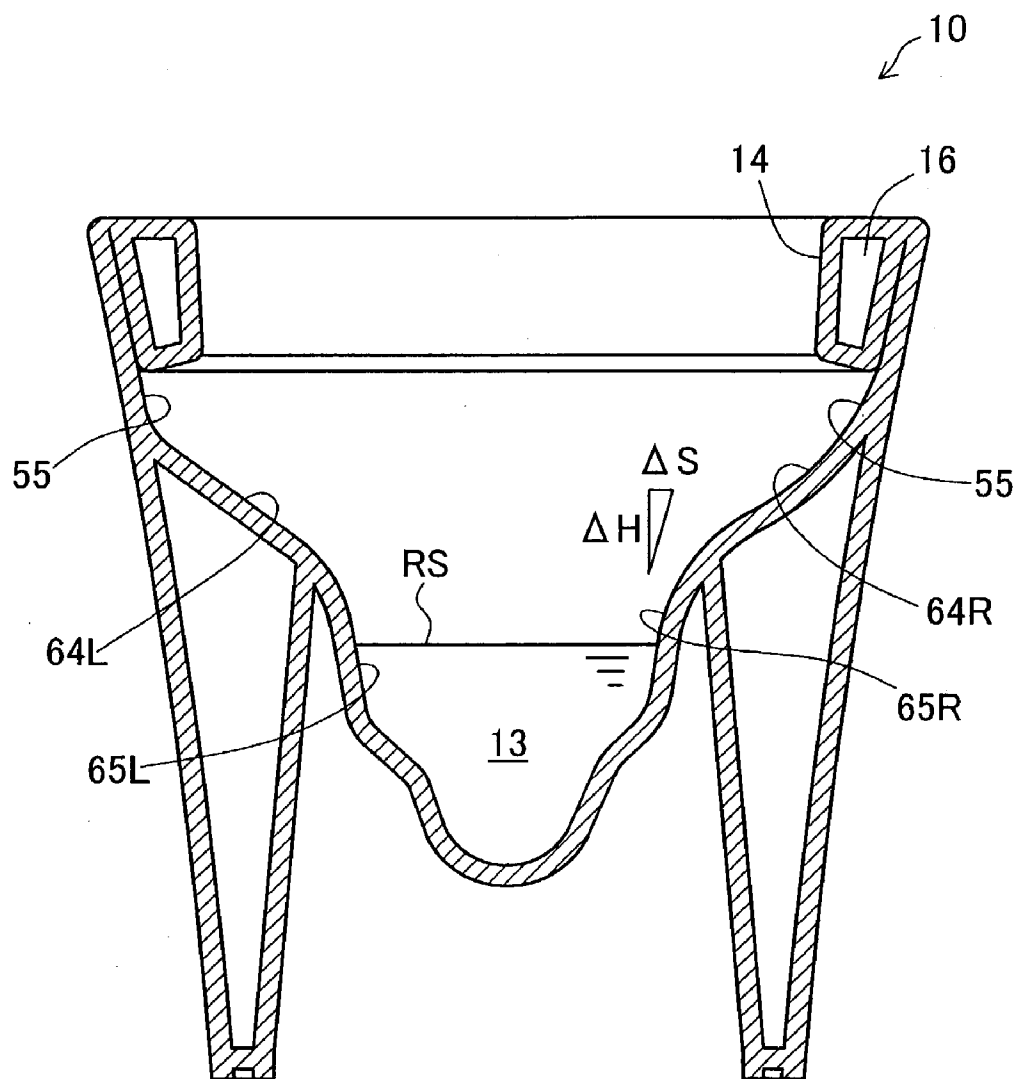


Fig. 11

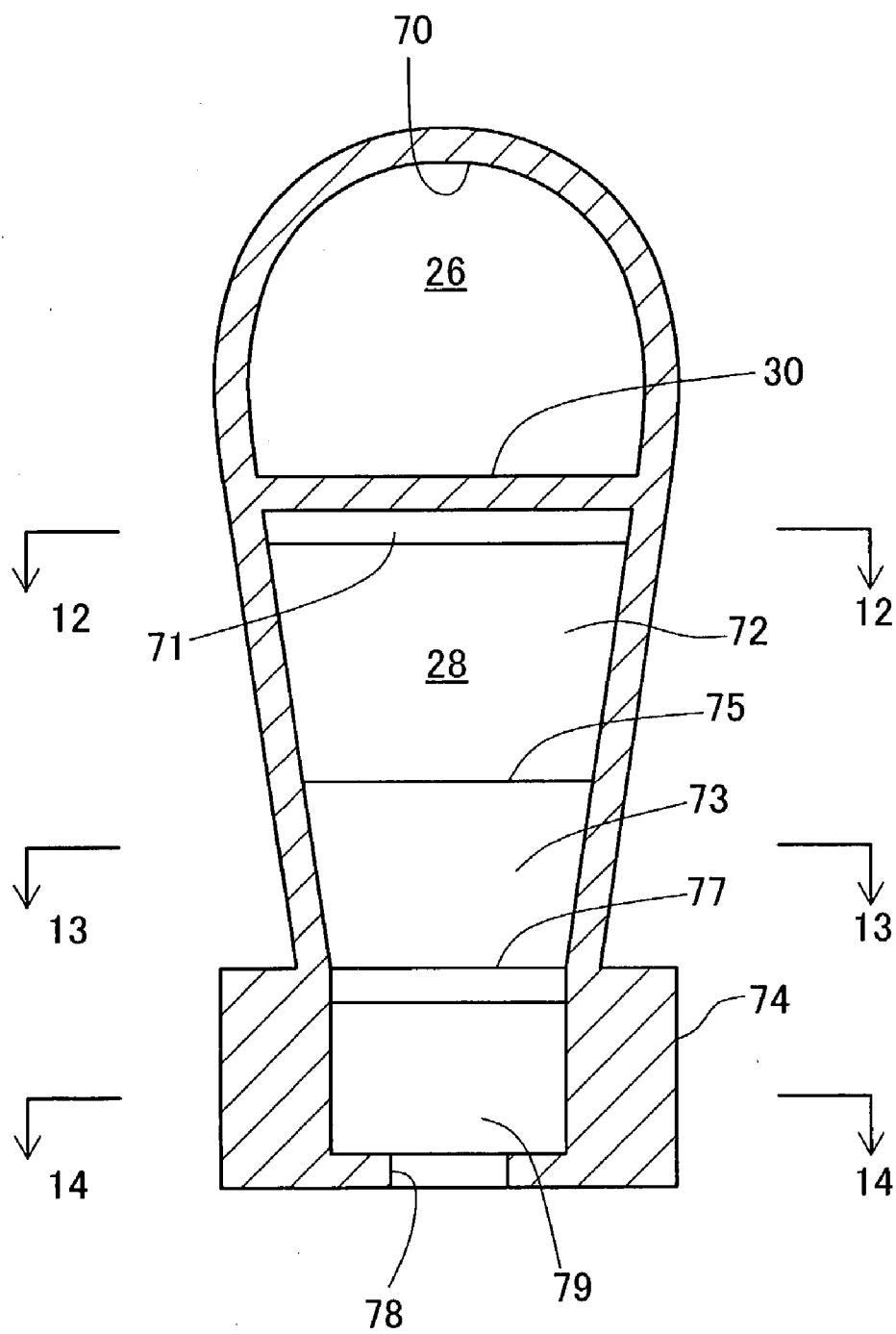
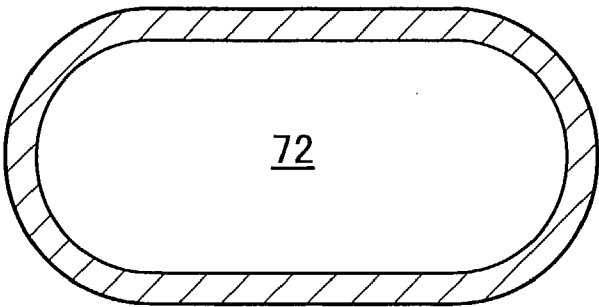
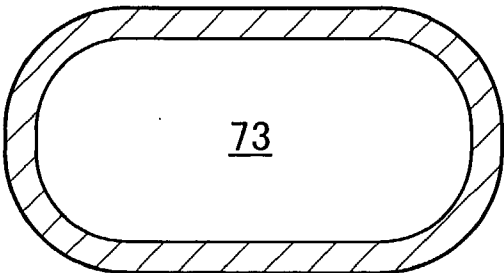


Fig. 12



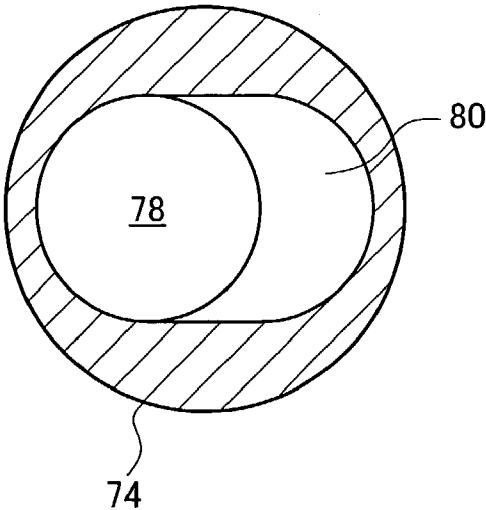
TOILET BOWL  
PORTION SIDE

Fig. 13



TOILET BOWL  
PORTION SIDE

Fig. 14



TOILET BOWL  
PORTION SIDE



Fig. 16

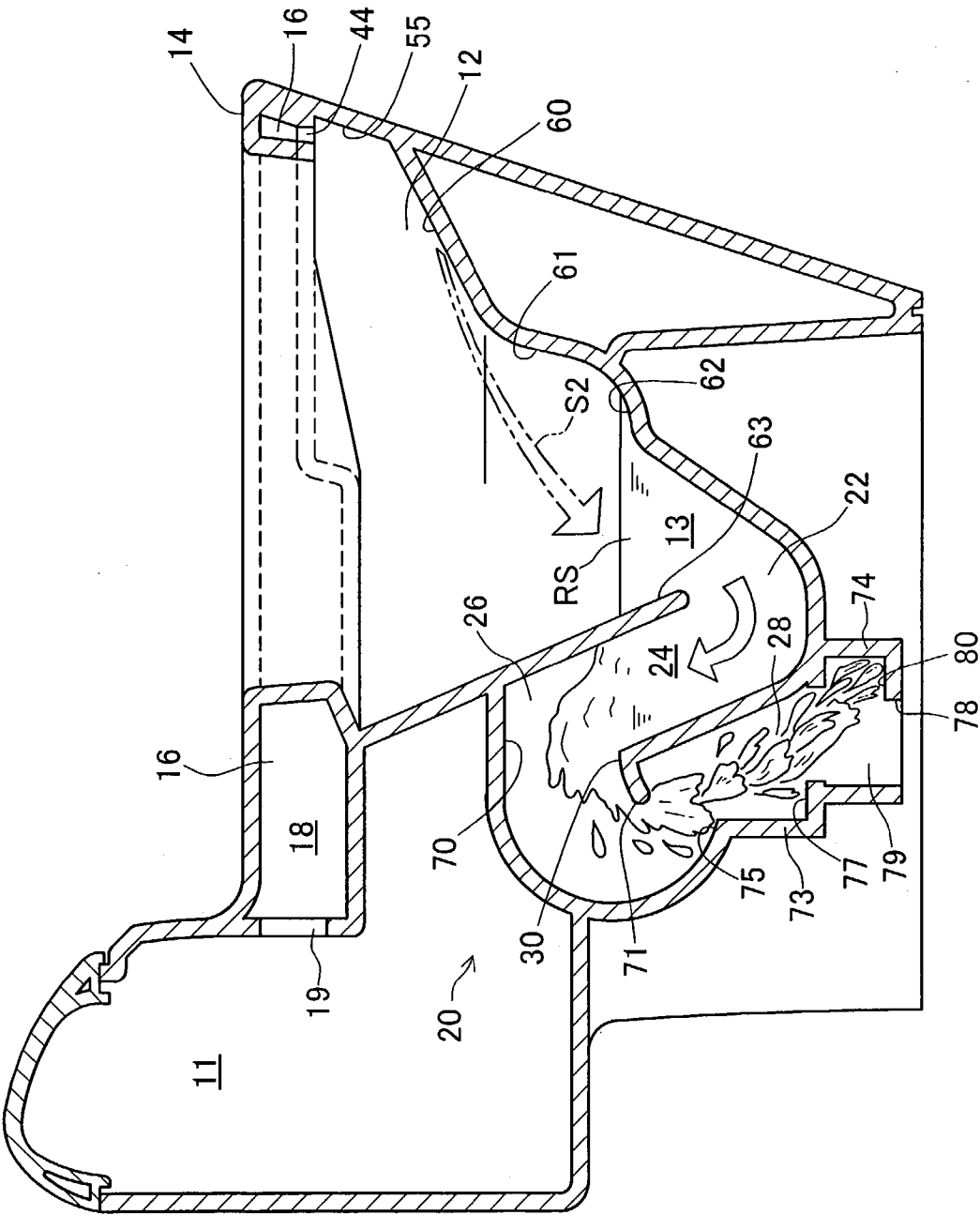


Fig. 17

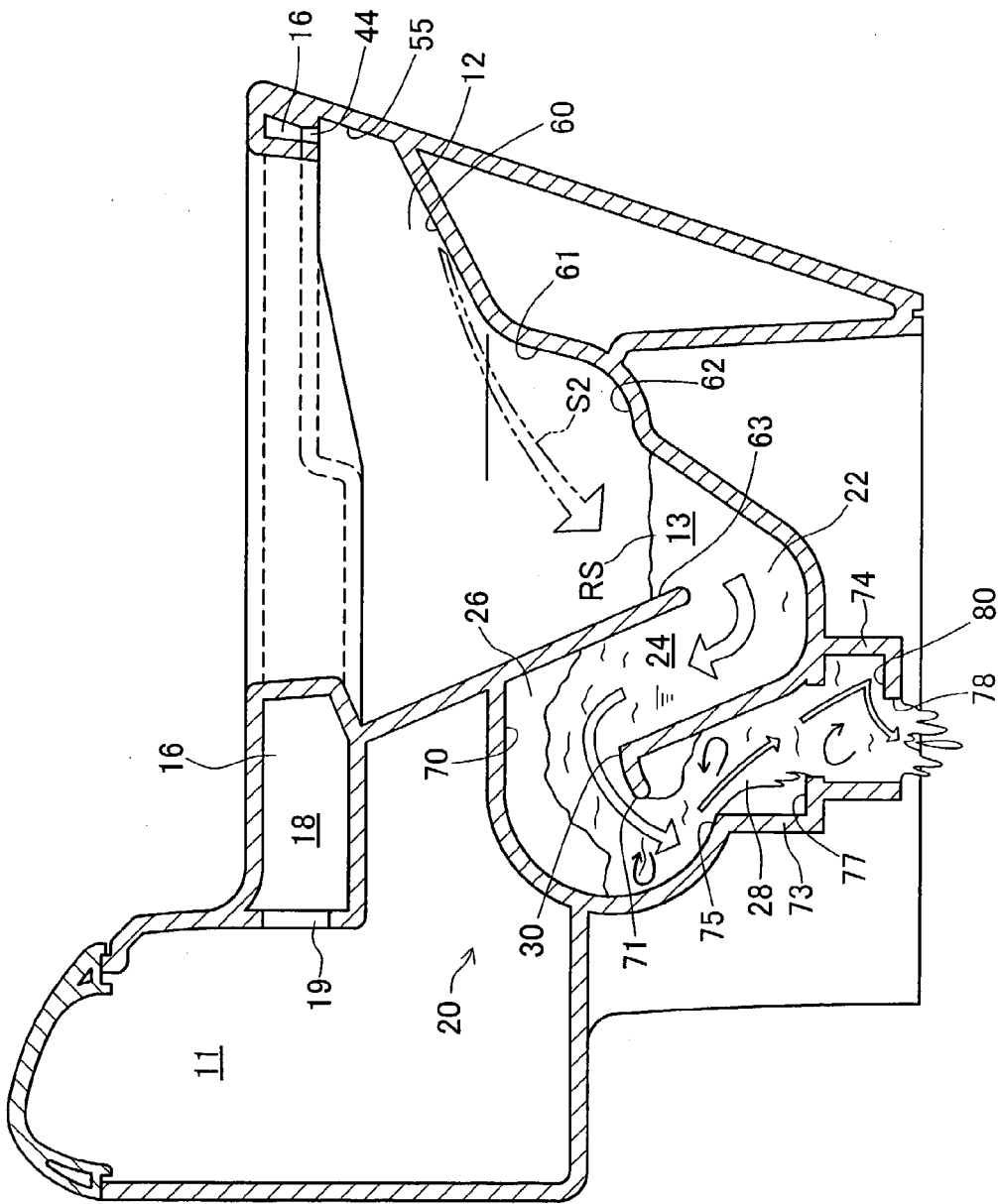
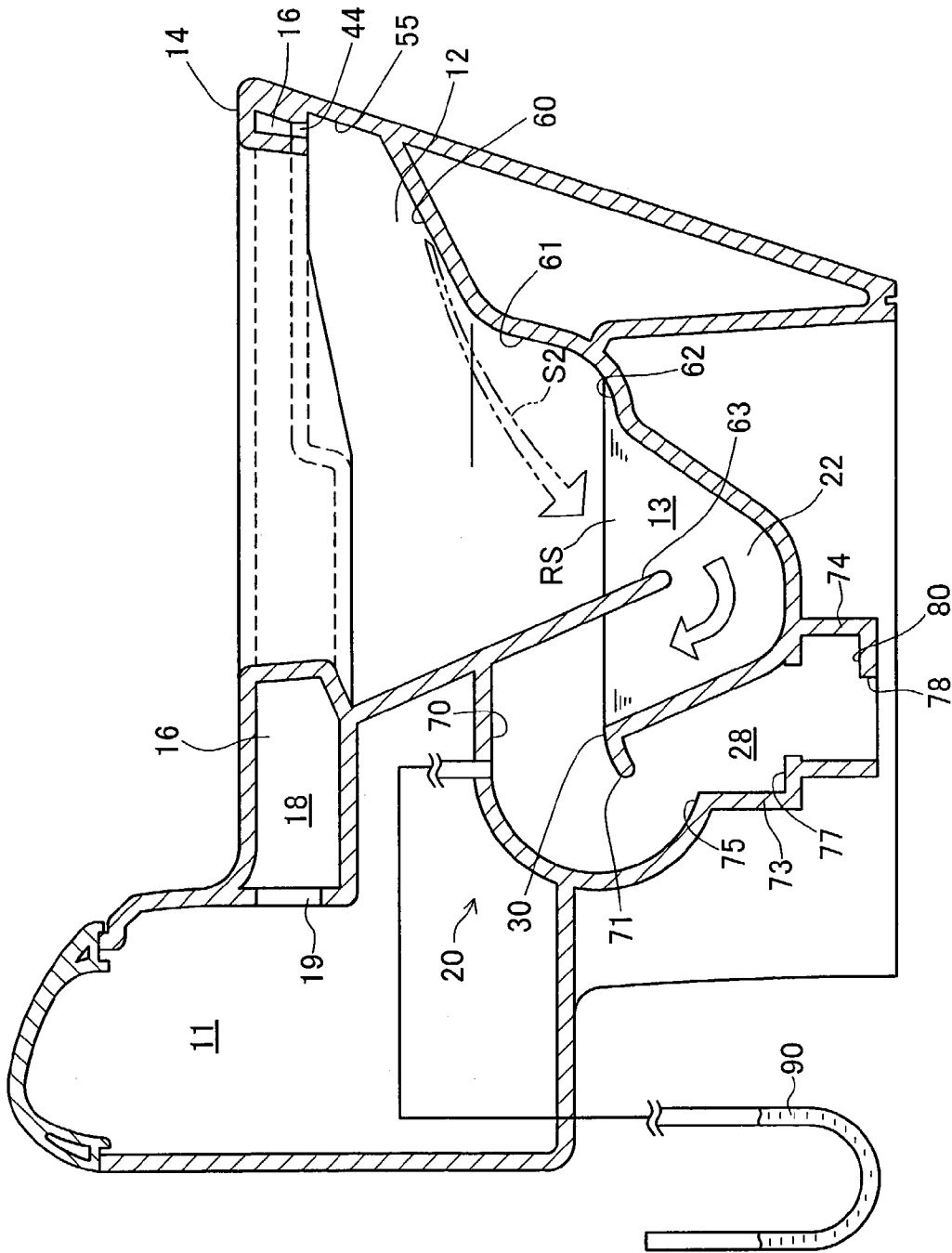


Fig. 18



*Fig. 19*

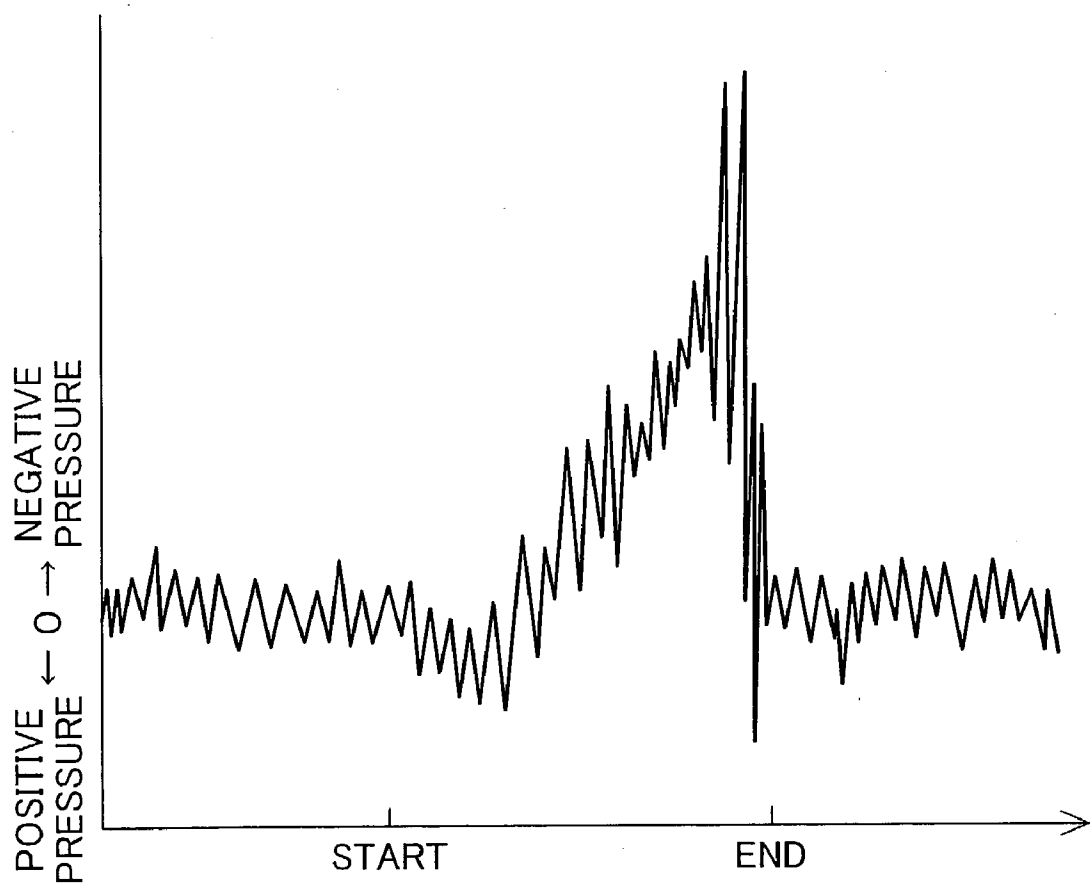


Fig. 20

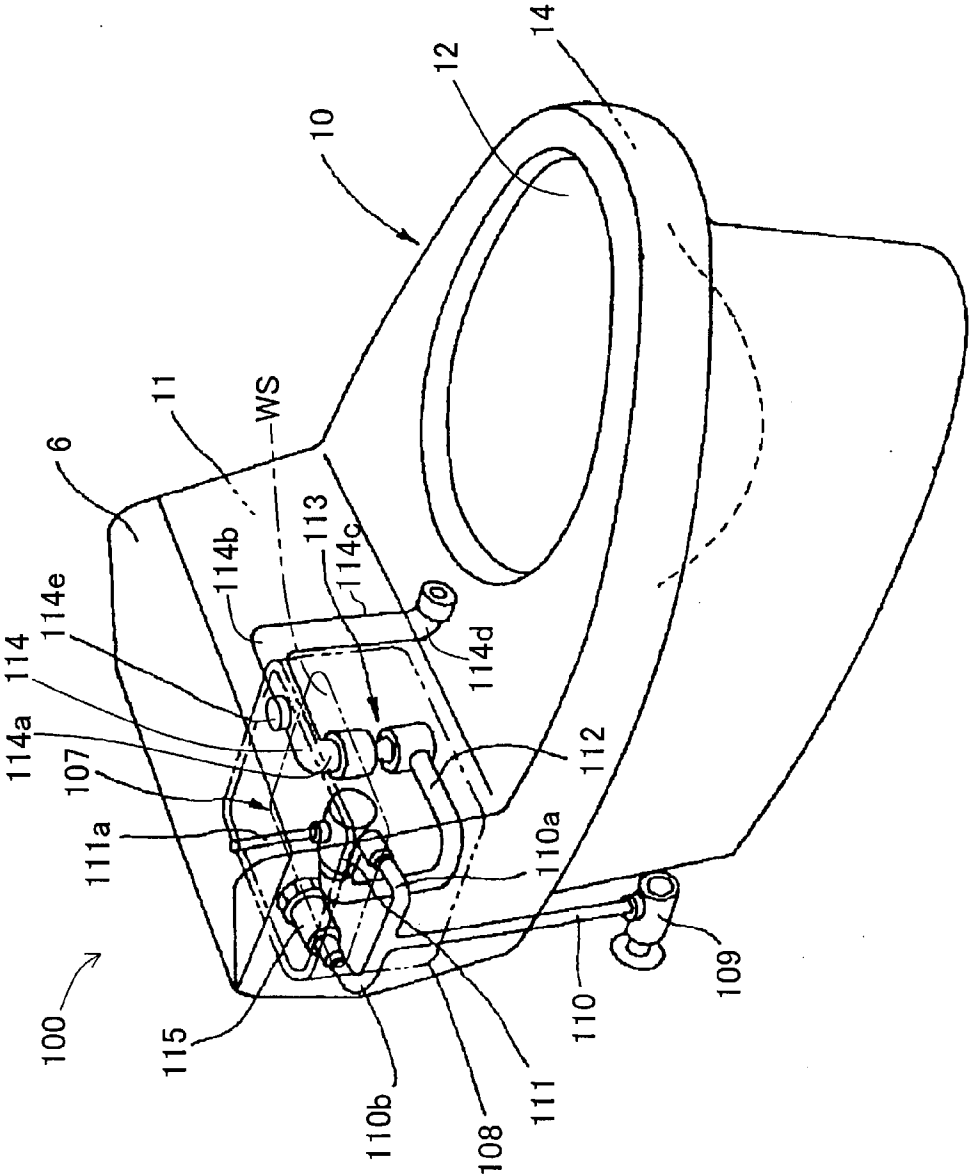


Fig. 21

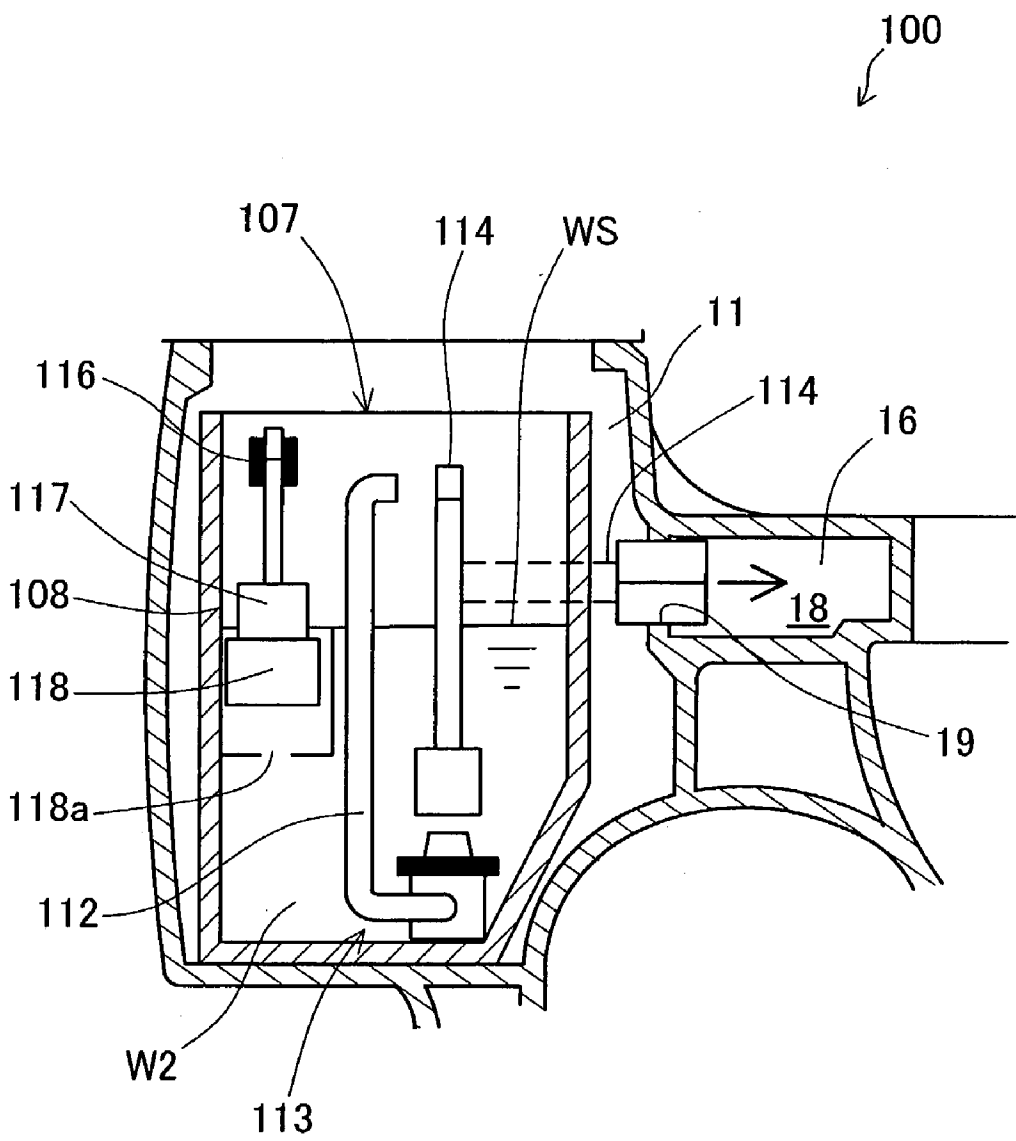


Fig. 22

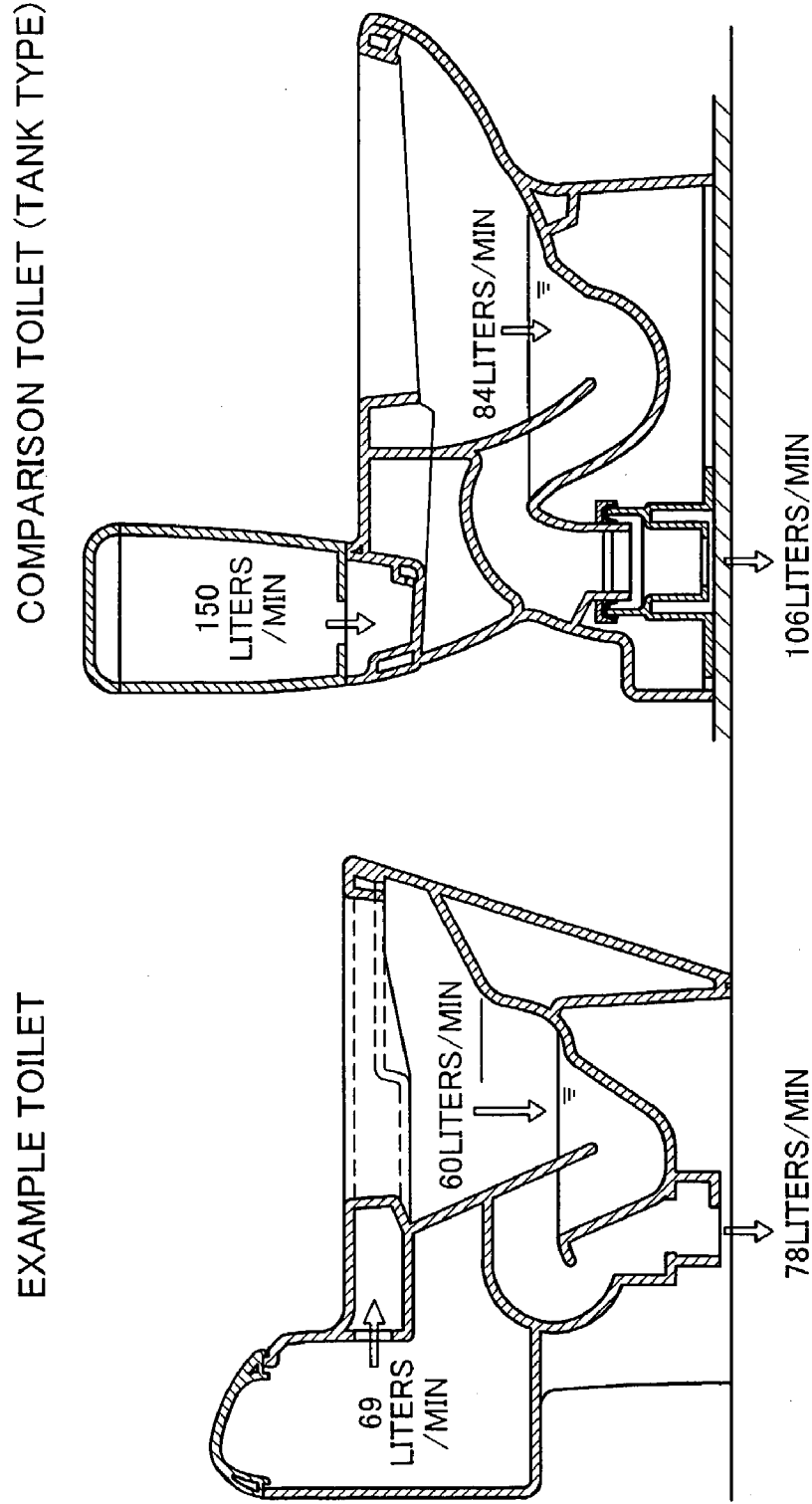


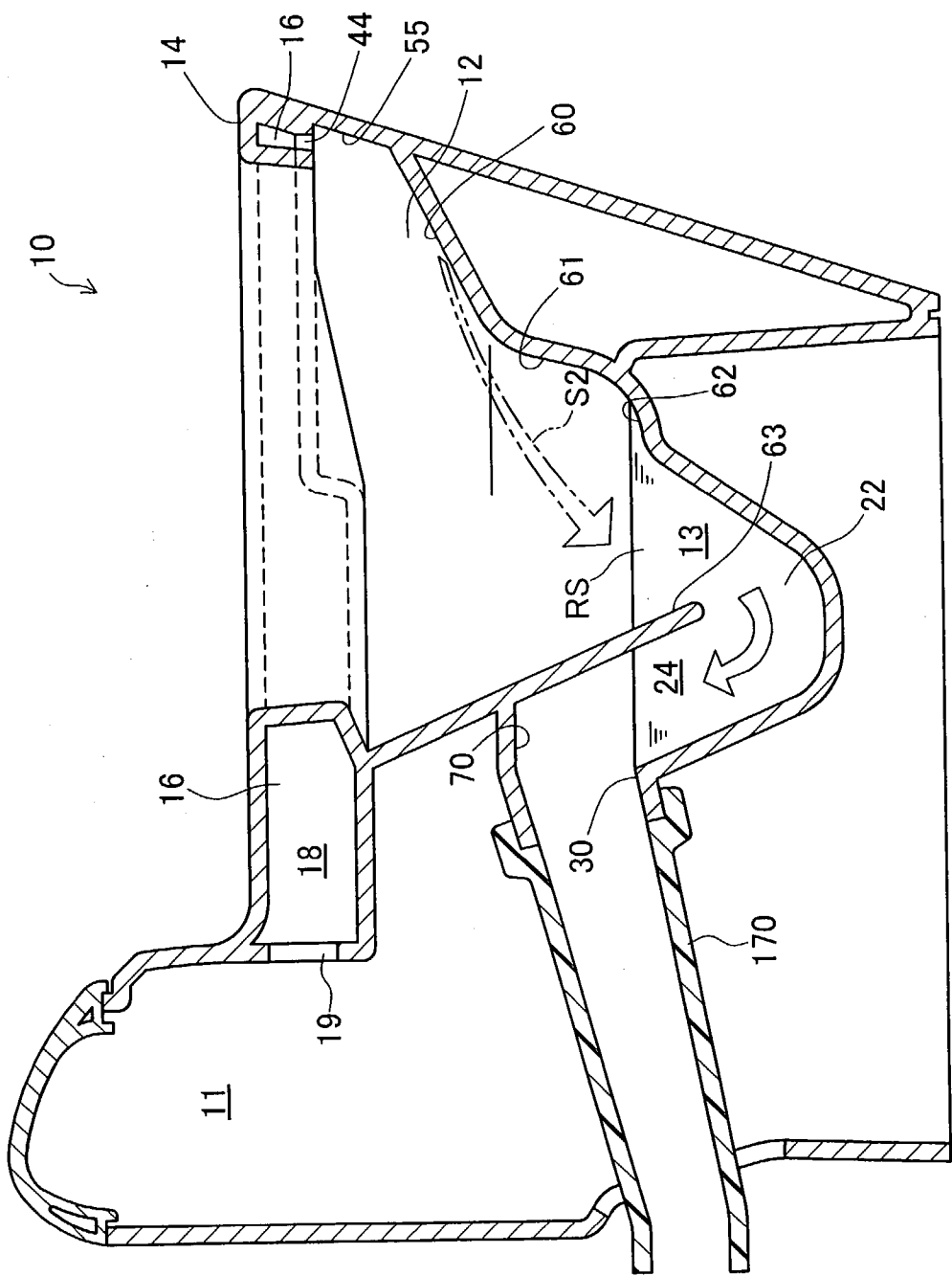
Fig. 23

|              |                             | EXAMPLE TOILET | COMPARISON TOILET |
|--------------|-----------------------------|----------------|-------------------|
| 6 LITER GOAL | PE GRANULE RESIDUAL TEST    | 5 pieces       | 22 pieces         |
|              | WATER CONSUMPTION           | 5.03 LITERS    | 5 LITERS          |
| 5 LITER GOAL | PE GRANULE RESIDUAL TEST    | 22 pieces      | 78 pieces         |
|              | WATER CONSUMPTION           | 3.87 LITERS    | 4 LITERS          |
|              | PP BALL RESIDUAL COUNT TEST | 18 pieces      | 28 pieces         |
|              | BOWL PORTION                | 7 pieces       | 12 pieces         |
|              | TRAP                        | 11 pieces      | 16 pieces         |
|              | WATER CONSUMPTION           | 4.05 LITERS    | 4 LITERS          |

Fig. 25

|              |                             | EXAMPLE TOILET | COMPARISON TOILET |
|--------------|-----------------------------|----------------|-------------------|
| 6 LITER GOAL | PP BALL RESIDUAL COUNT TEST | 9 pieces       | 39 pieces         |
|              | BOWL PORTION                | 8 pieces       | 36 pieces         |
|              | TRAP                        | 1 pieces       | 3 pieces          |
|              | WATER CONSUMPTION           | 5.85 LITERS    | 5 LITERS          |

Fig. 24



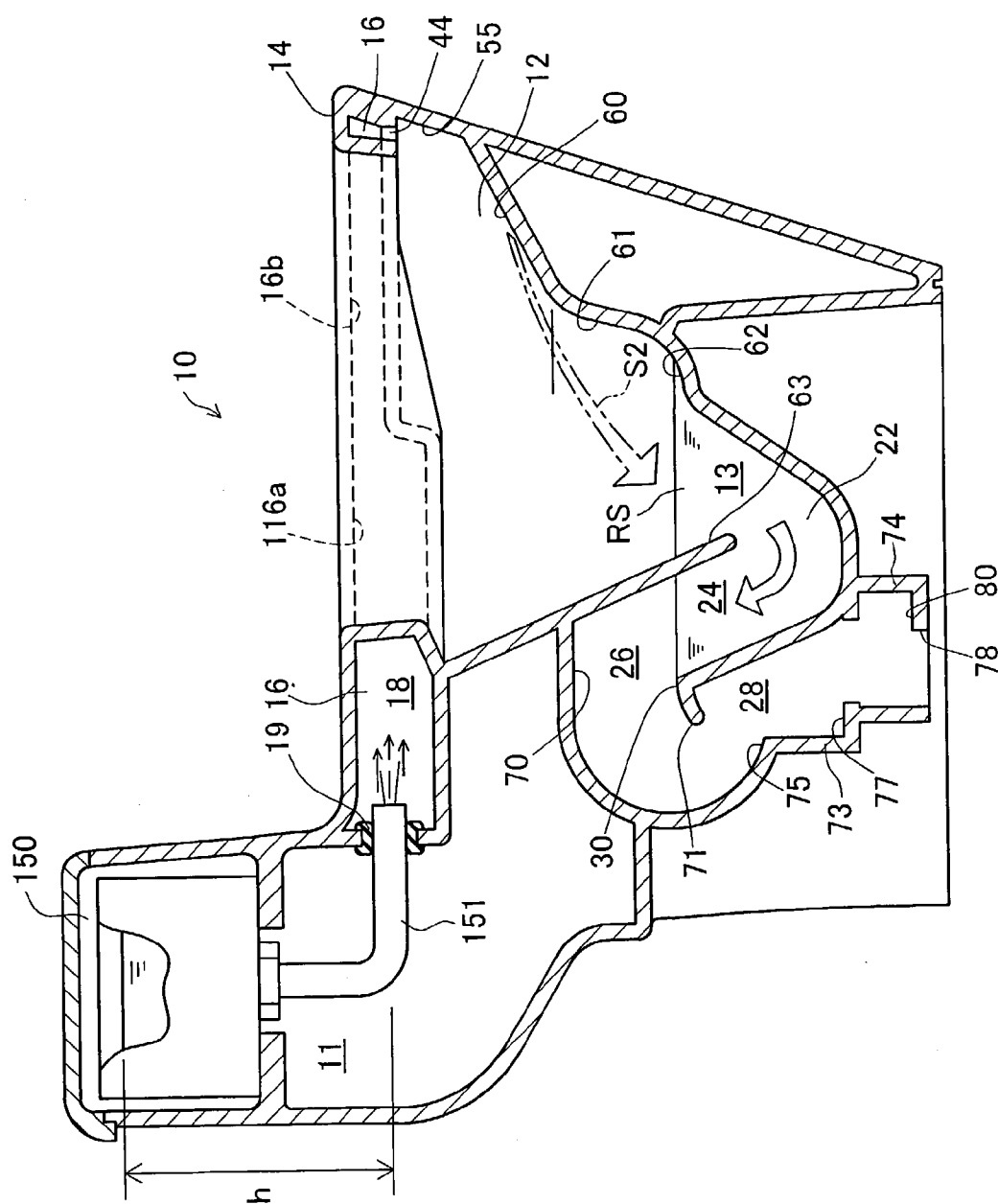


Fig. 26



Fig. 28(a)

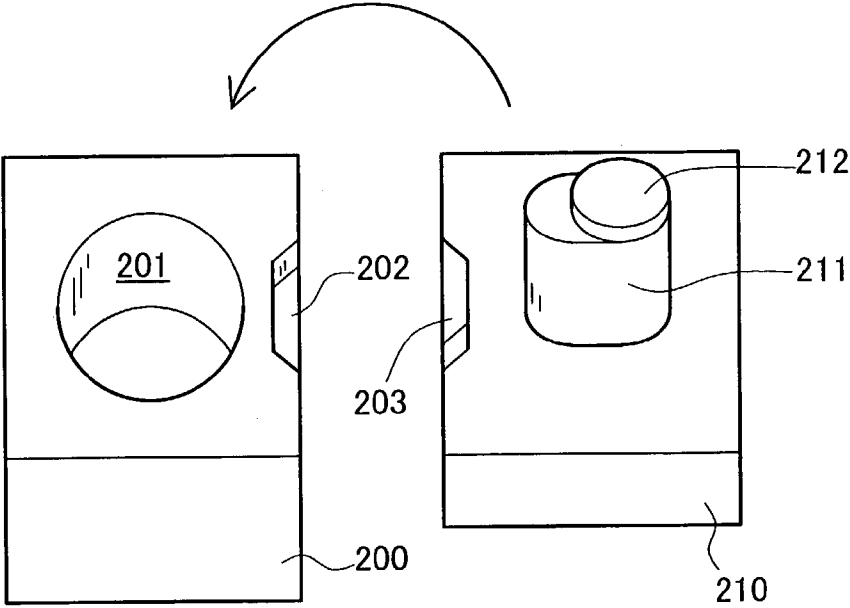


Fig. 28(b)

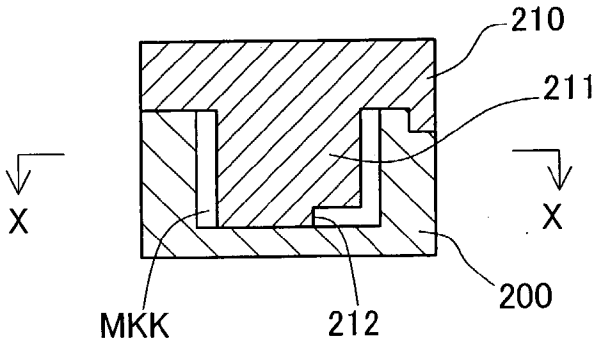
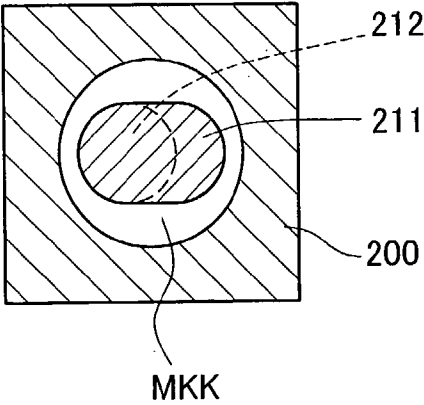
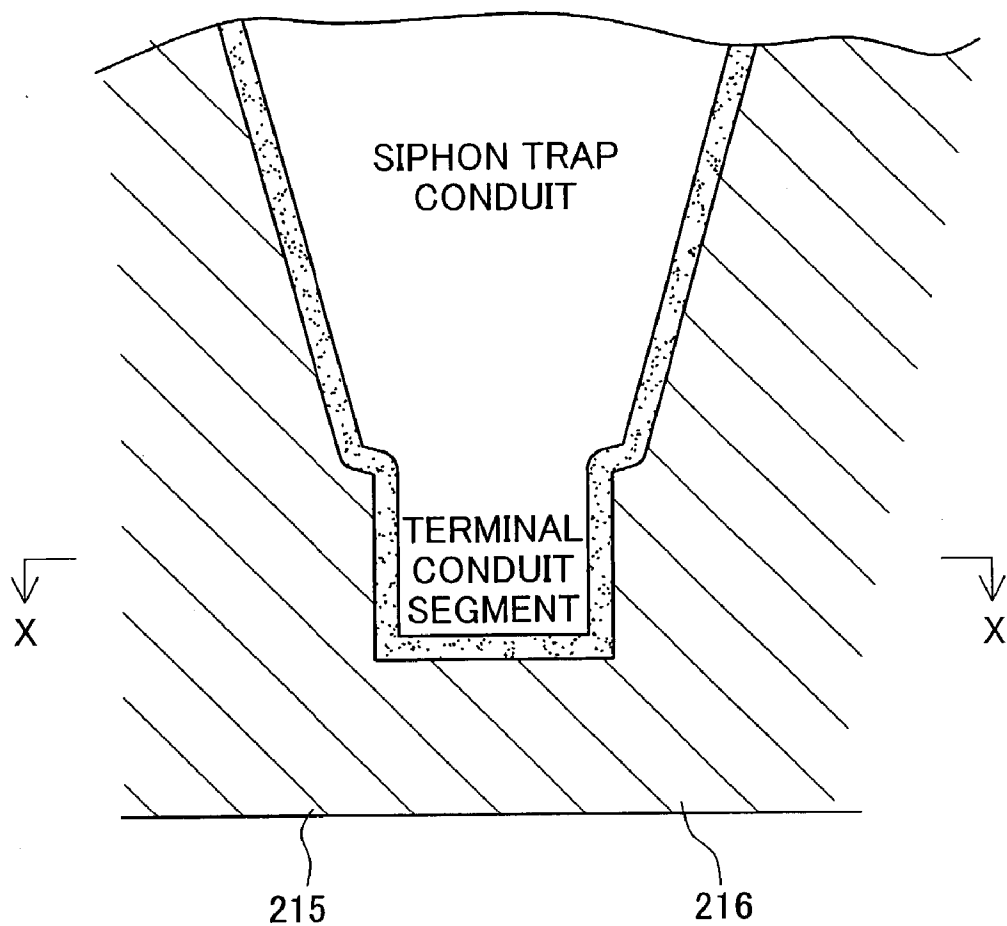


Fig. 28(c)



*Fig. 29(a)*



*Fig. 29(b)*

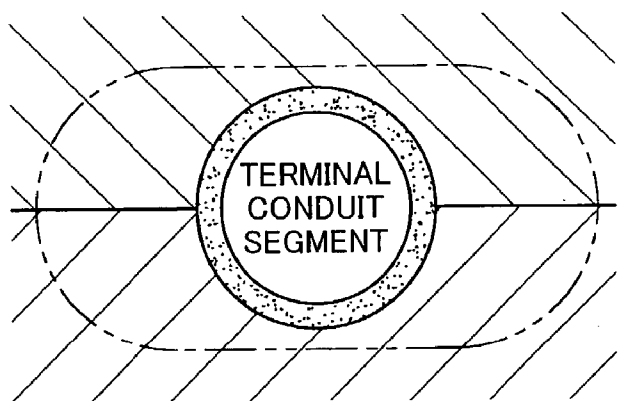


Fig. 30

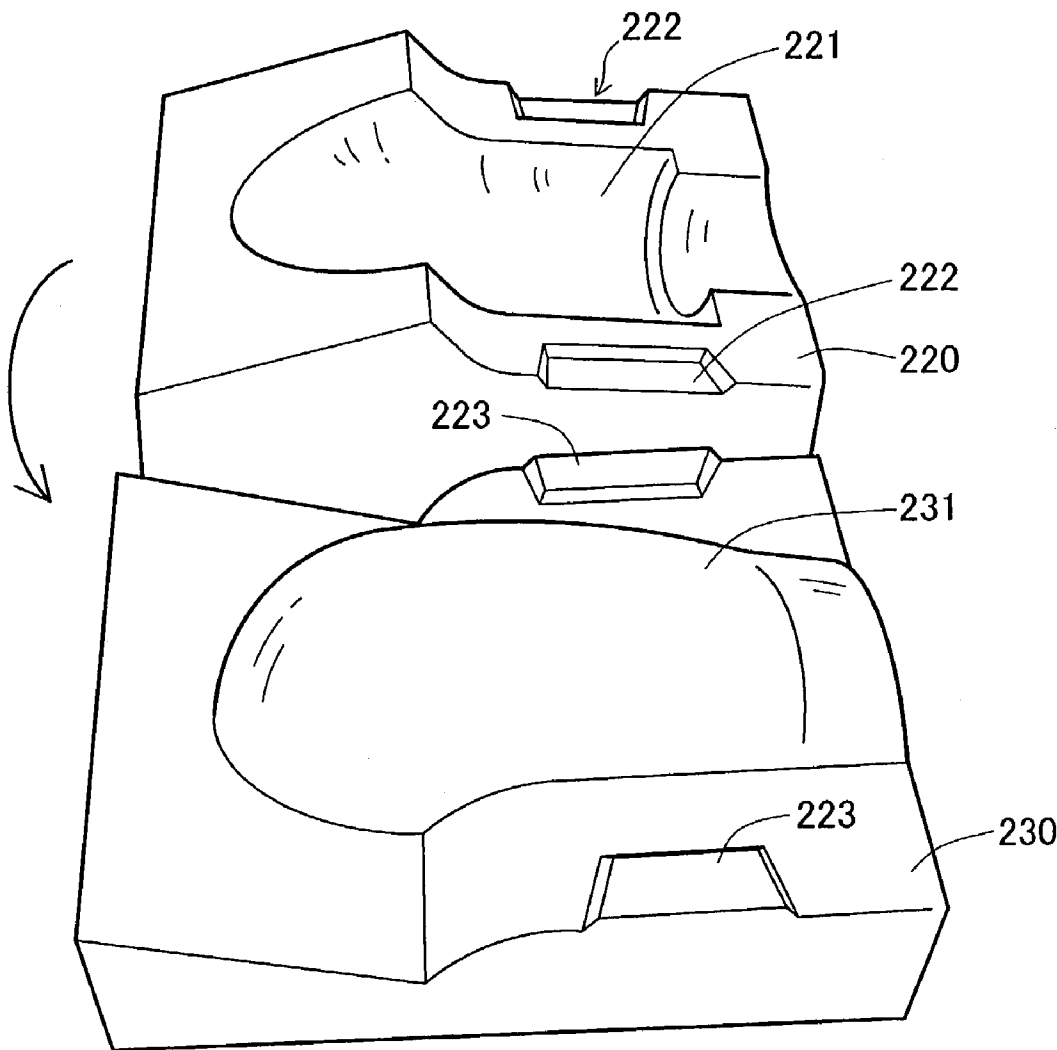


Fig. 31

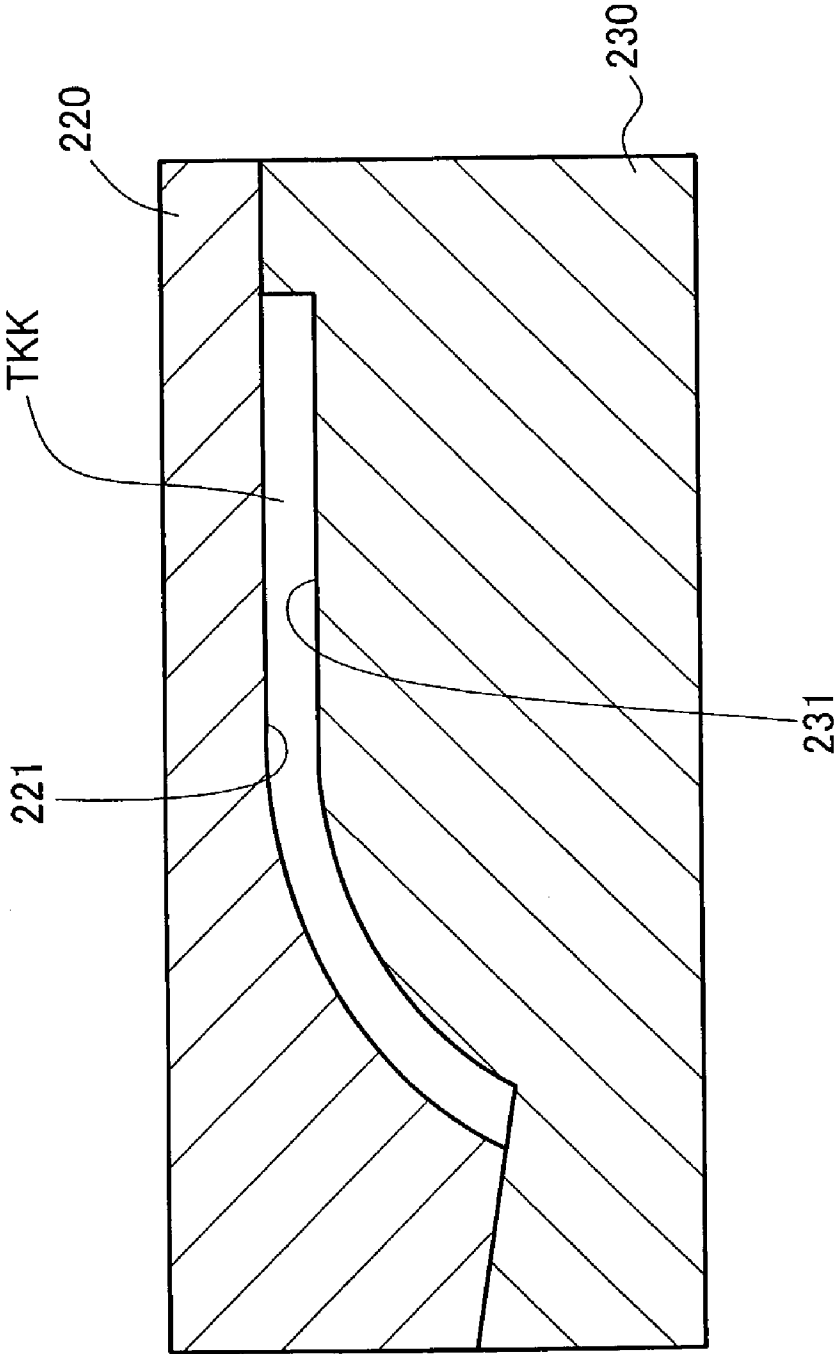


Fig. 32

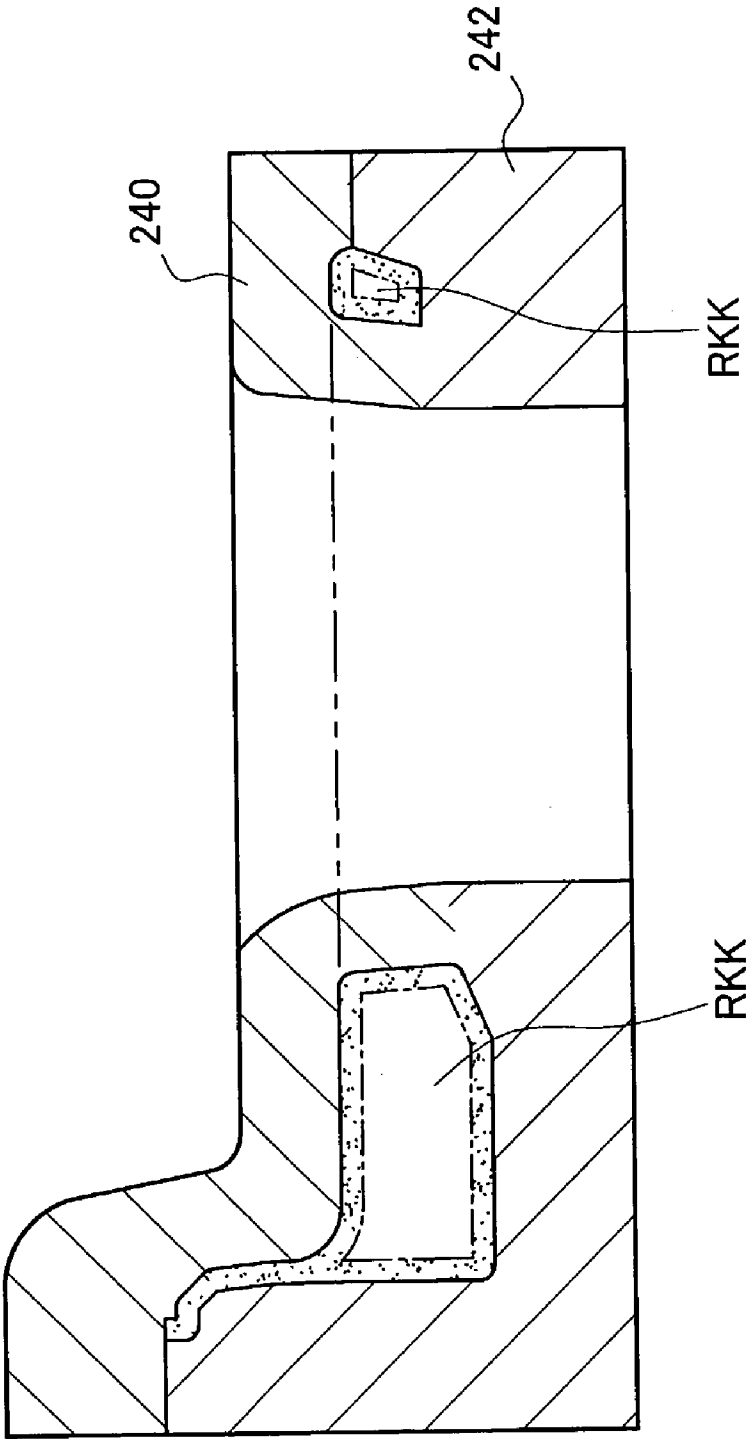


Fig. 33

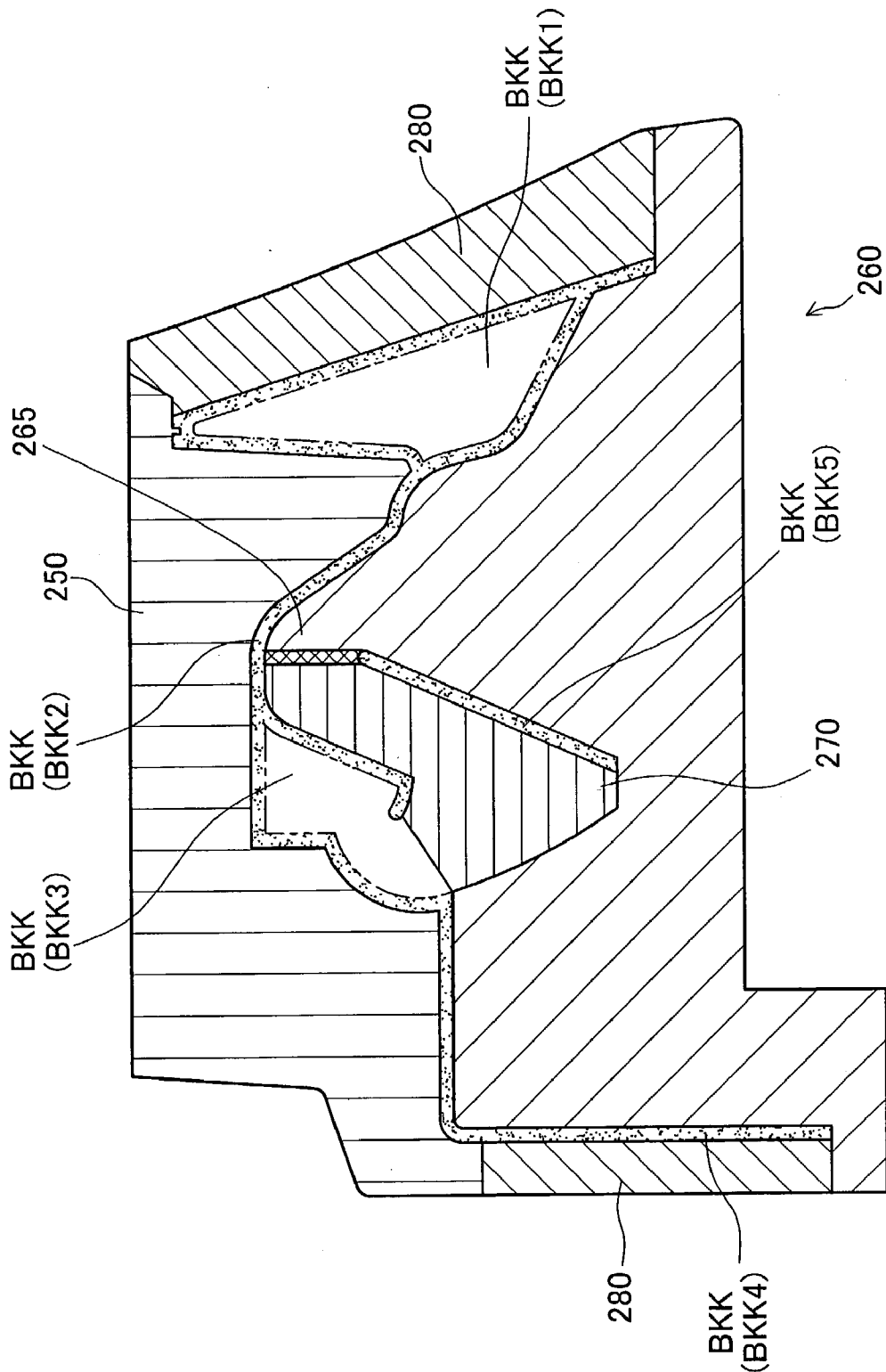


Fig. 34

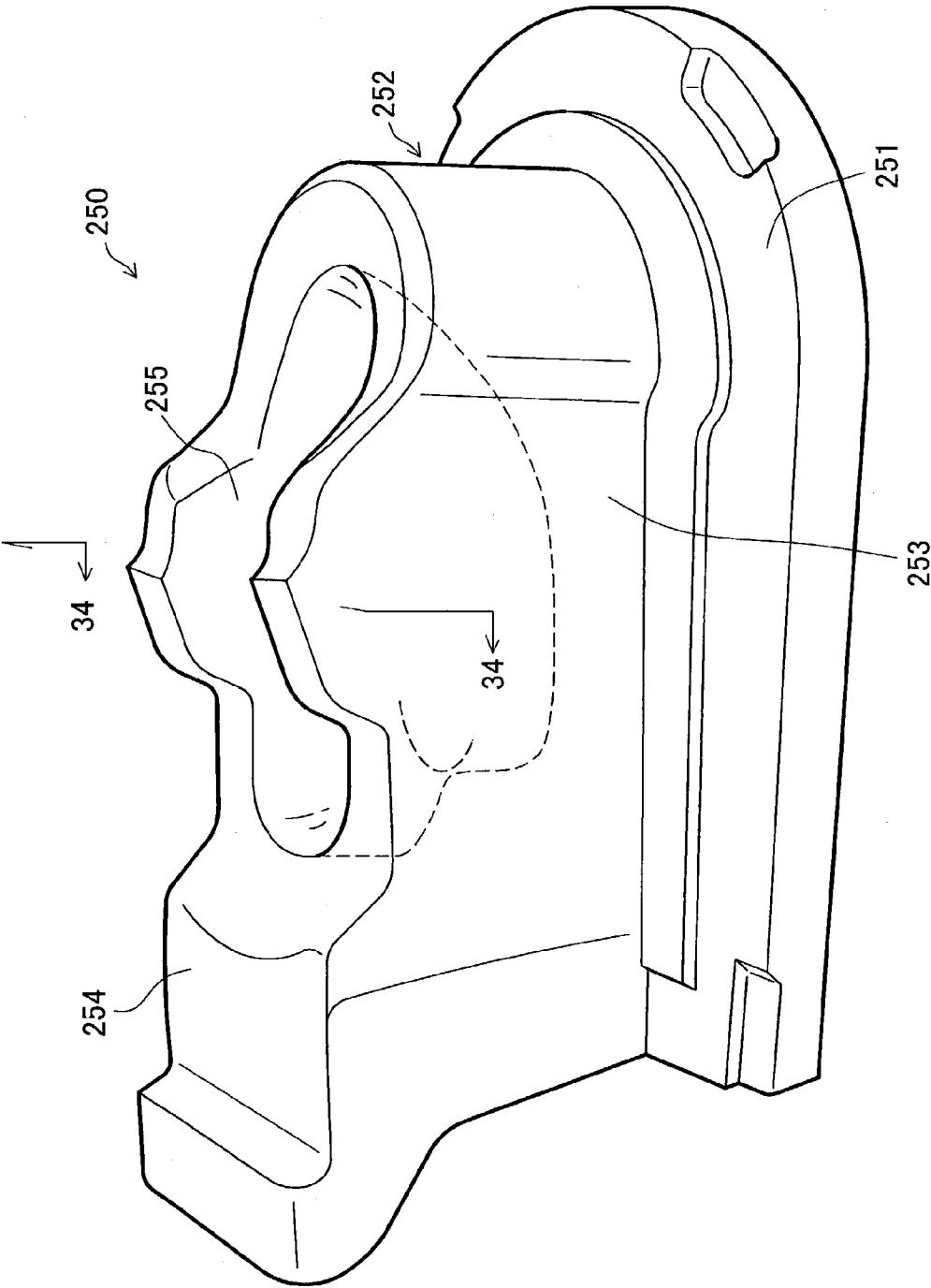


Fig. 35

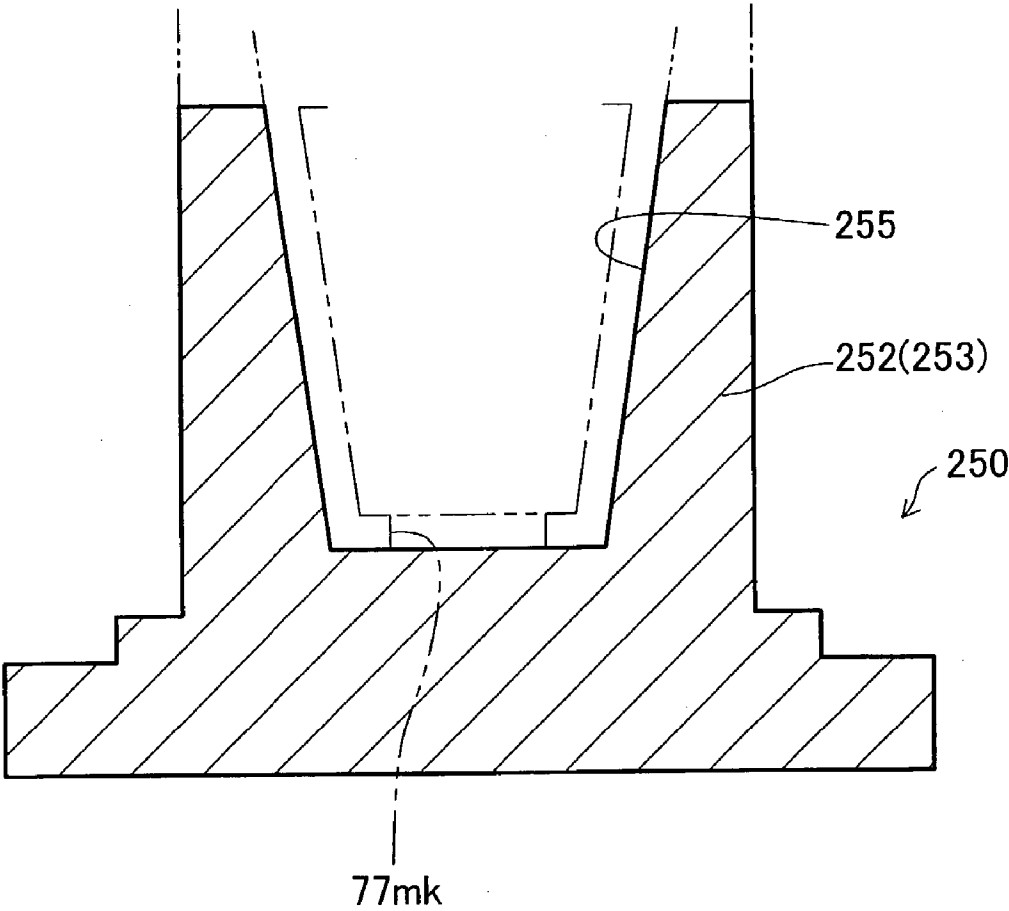


Fig. 36

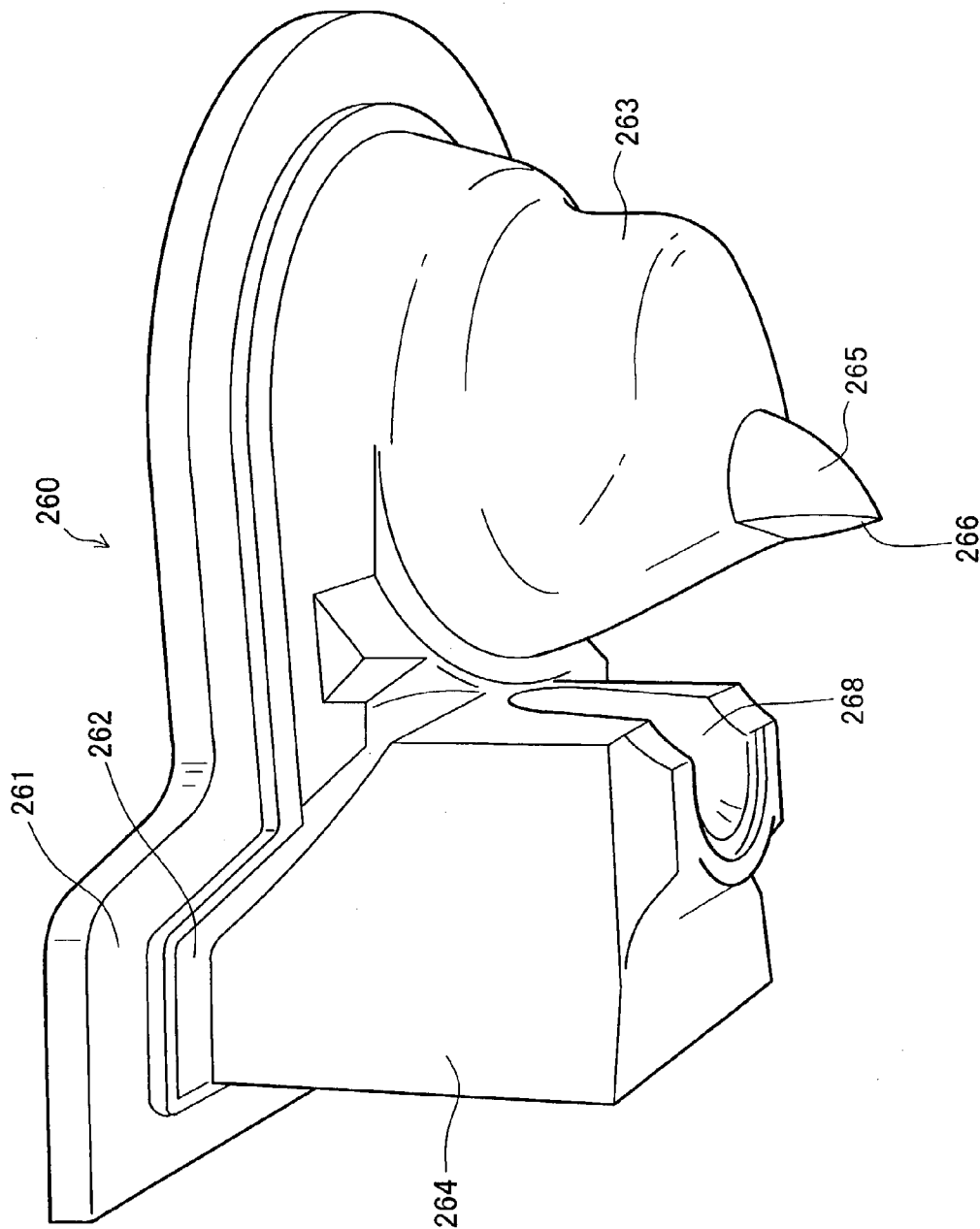


Fig. 37

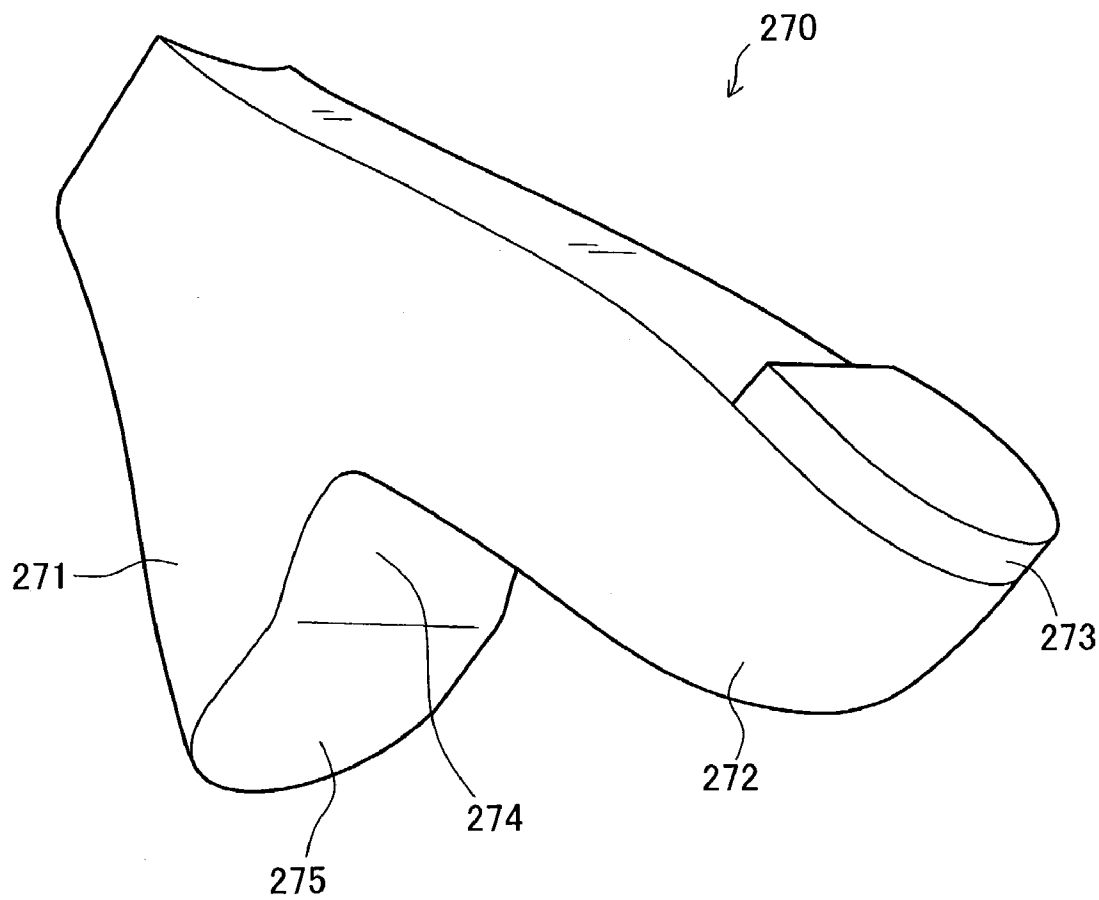


Fig. 38

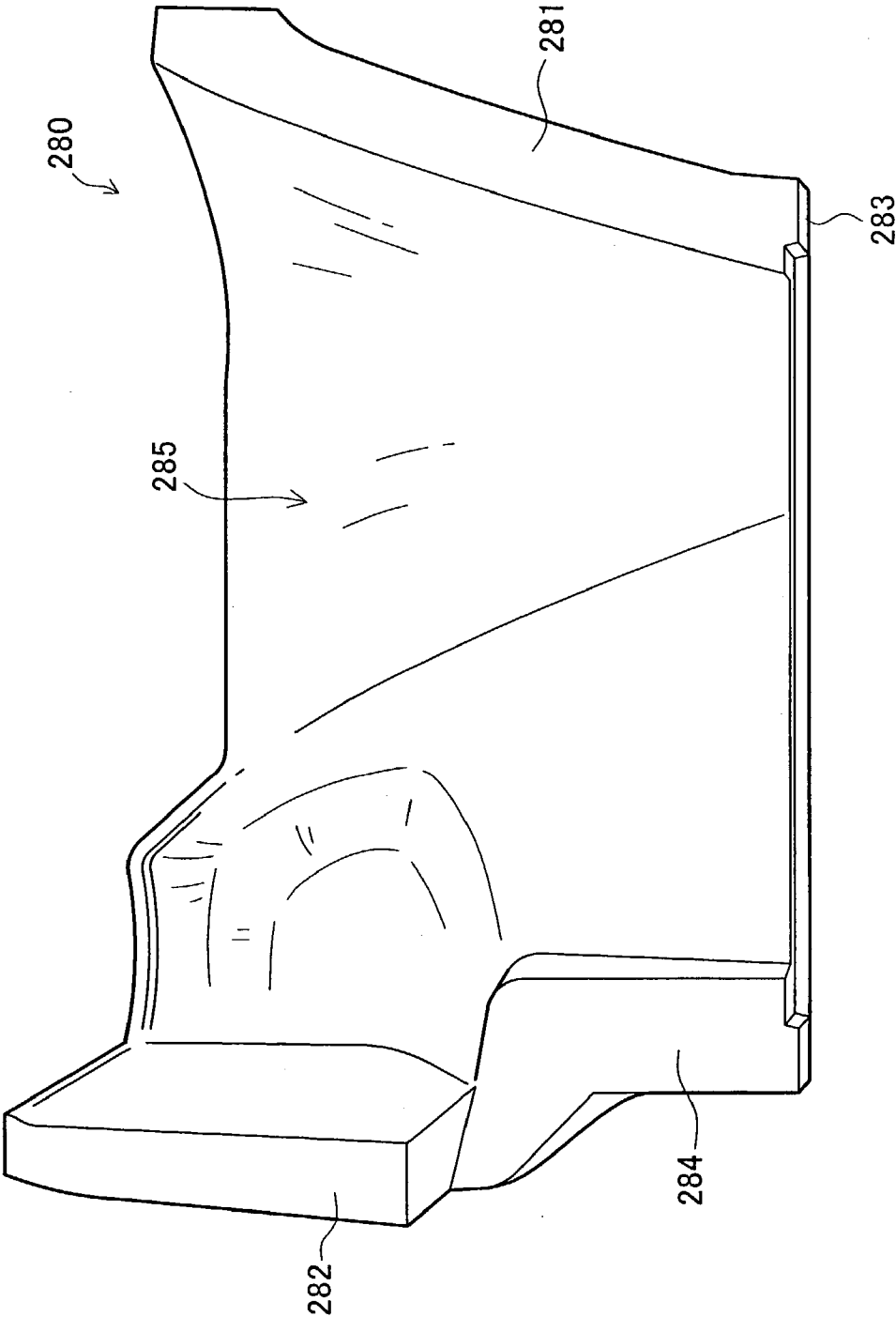


Fig. 39

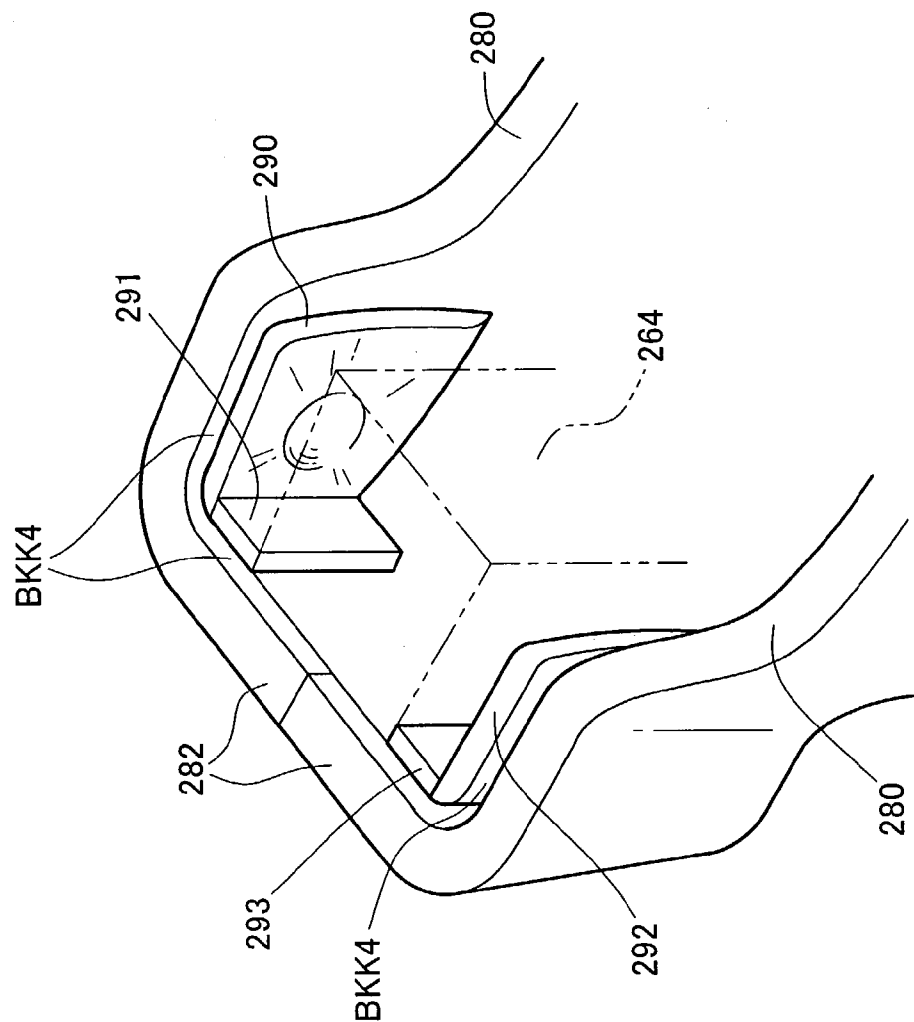
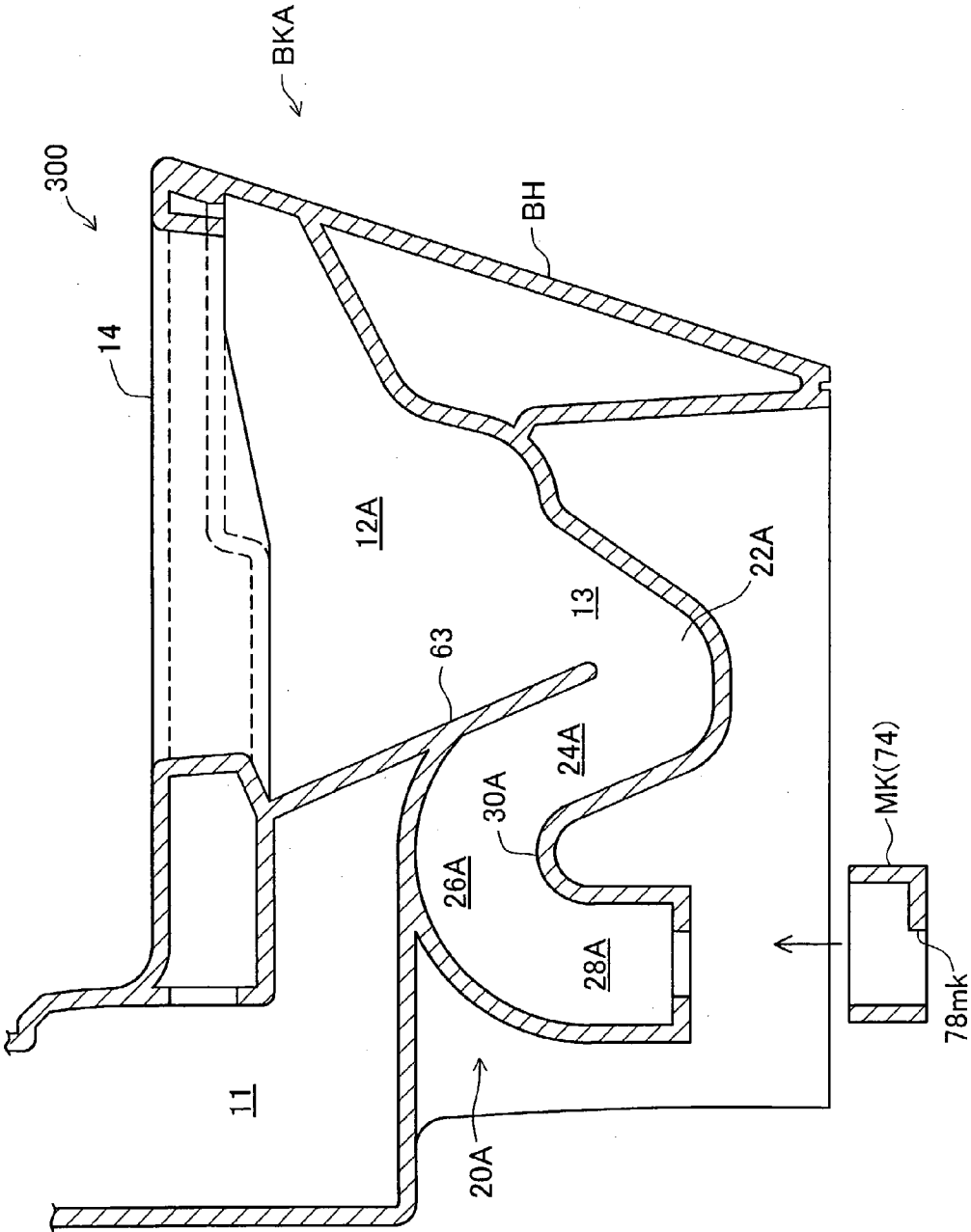
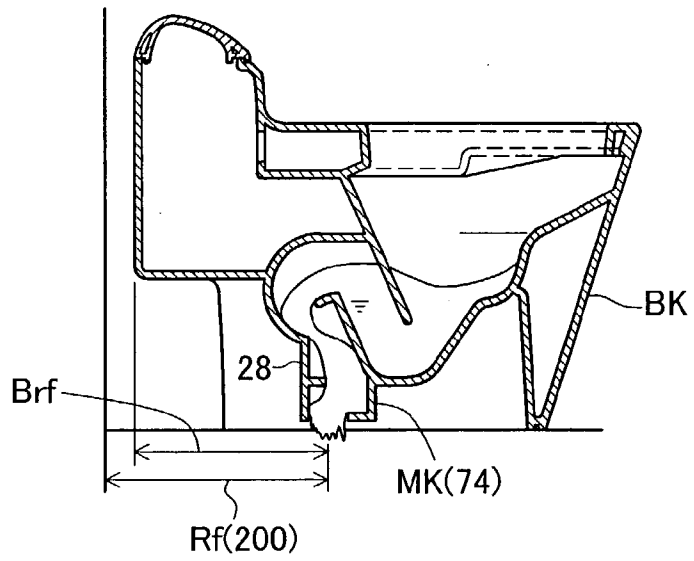


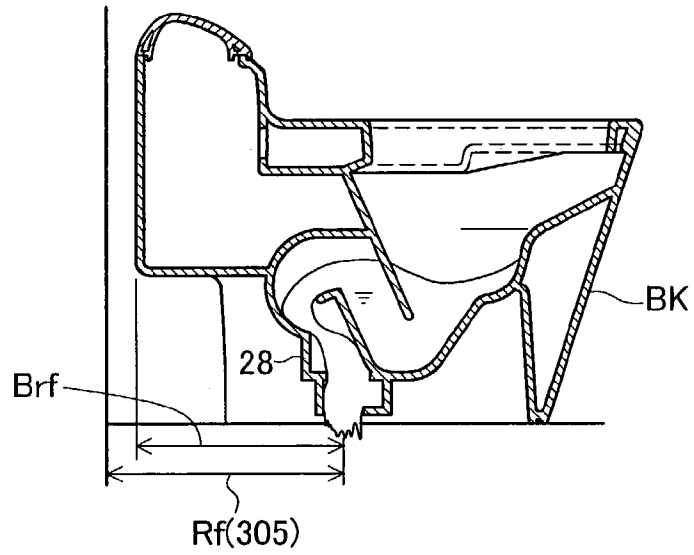
Fig. 40



*Fig. 41(a)*



*Fig. 41(b)*



*Fig. 41(c)*

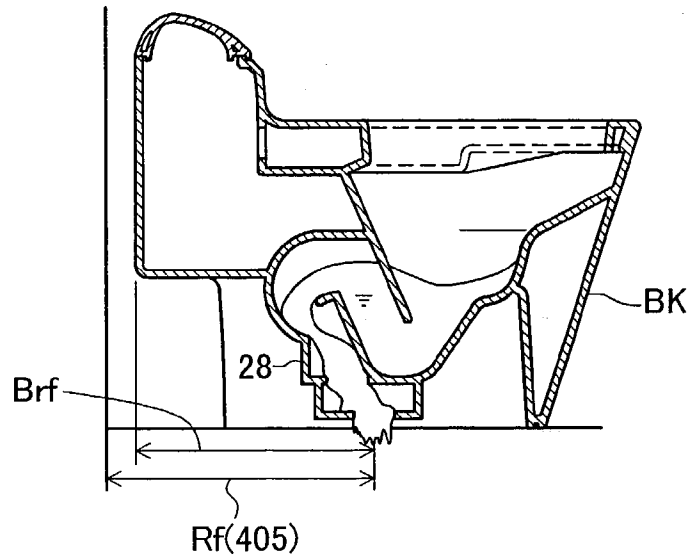


Fig. 42(a)

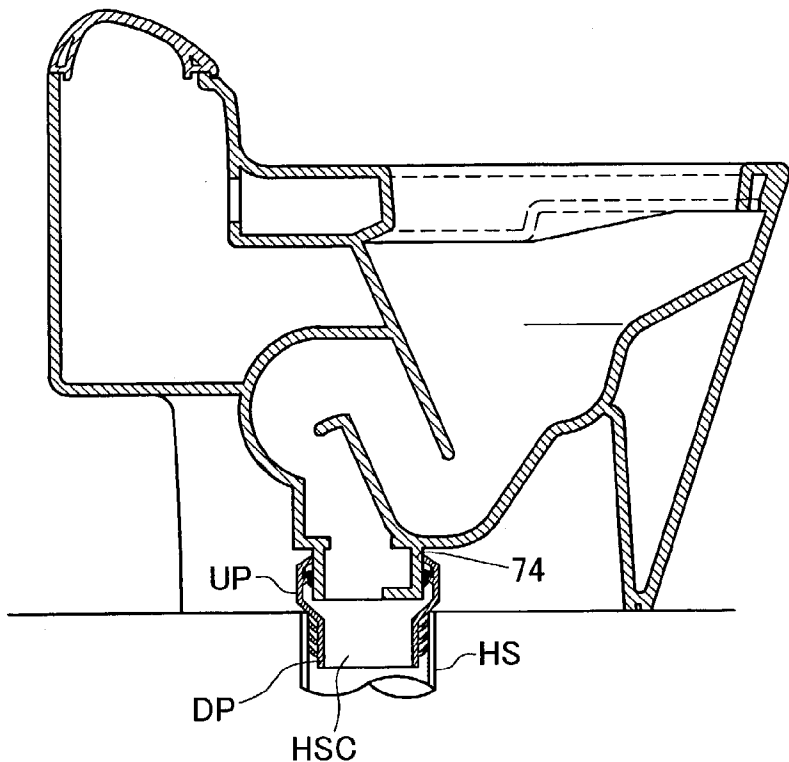


Fig. 42(b)

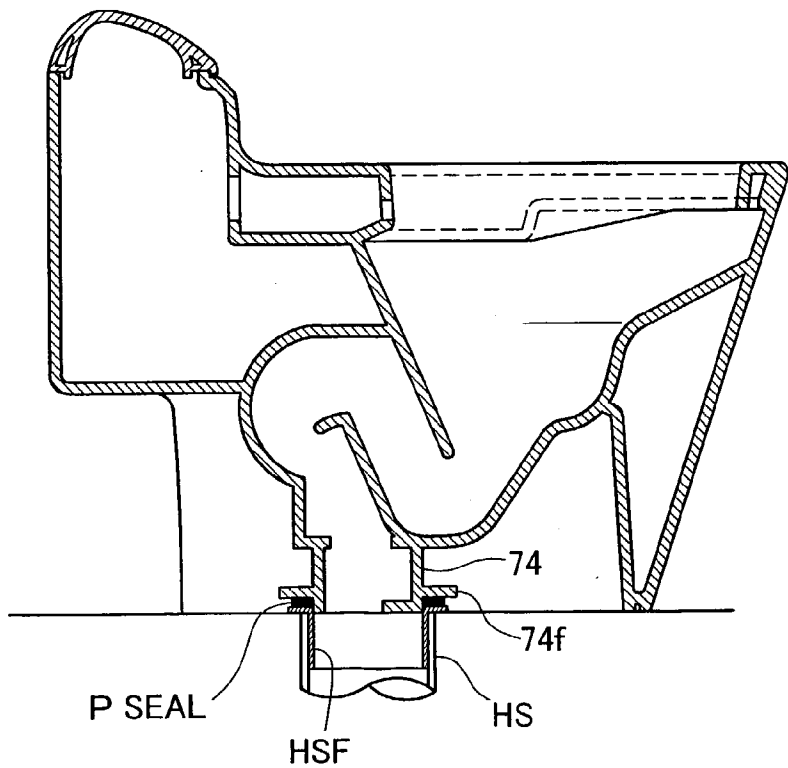


Fig. 43

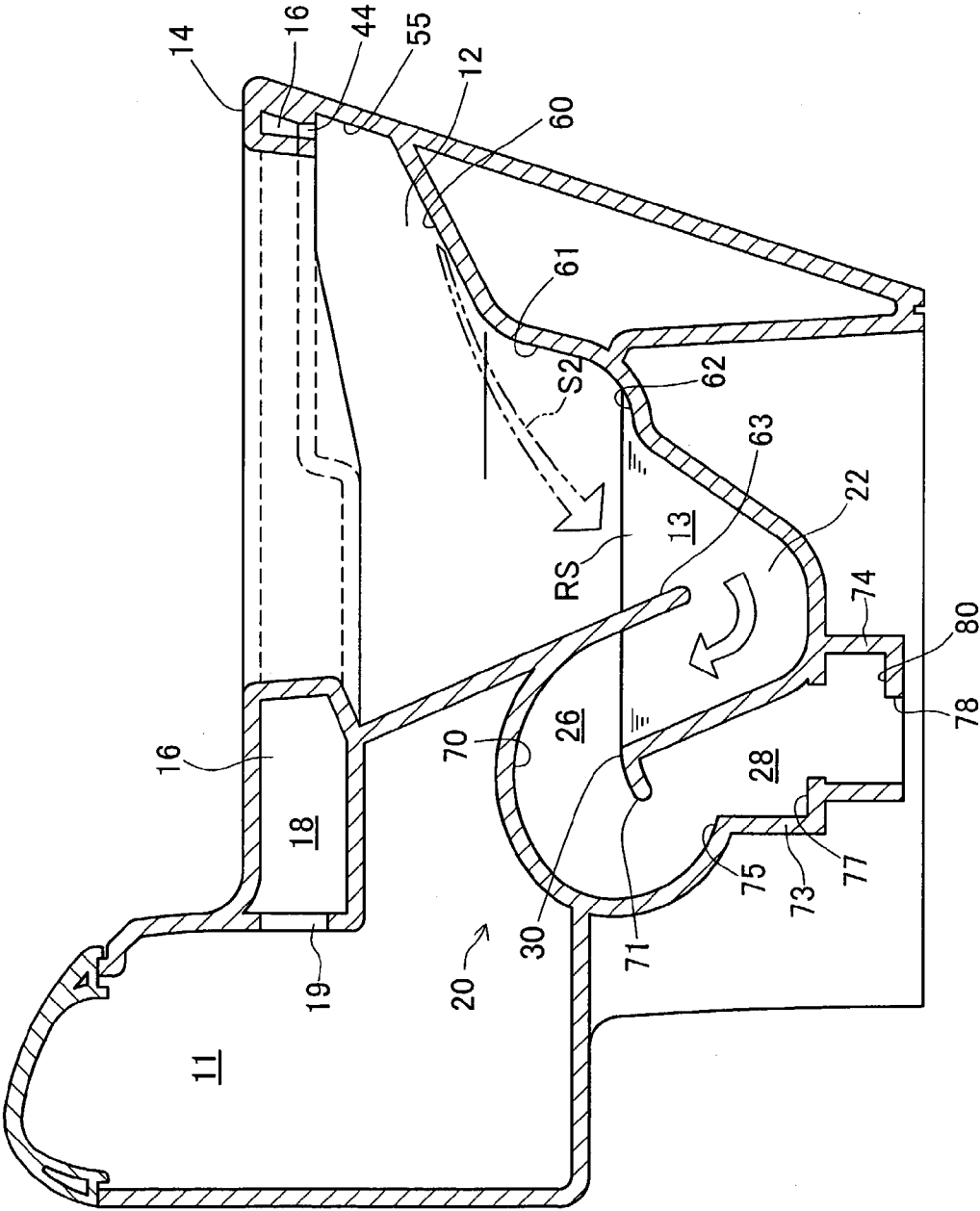
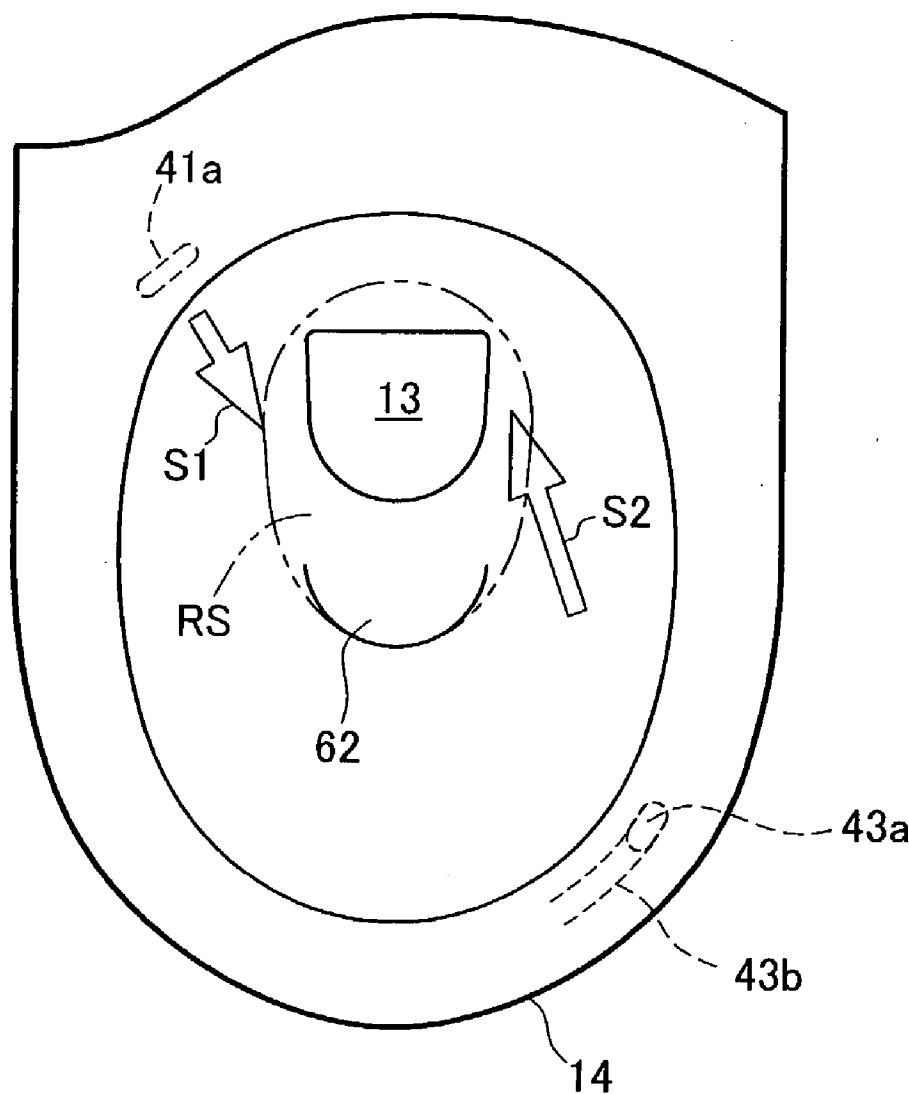


Fig. 44



## TOILET AND METHOD FOR MANUFACTURE OF THE SAME

### TECHNICAL FIELD

[0001] The present invention relates to a toilet designed to supply flush water to the toilet bowl to effect flushing thereof; and a method for manufacture of a toilet having a siphon trap conduit.

### BACKGROUND ART

[0002] In toilets of this kind, there exists a need to efficiently flush away waste using a combination of water in the toilet bowl and flush water discharged therein, so as to reduce the total amount of water needed per flush. To date a number of methods have been proposed to meet this need, and these can be broadly classified as follows. The first method involves directing flush water into the bowl water so as to create circular flow, this circular flow forcing waste into the trap. The second method involves sucking away waste, together with the bowl water and flush water, by means of a siphoning action.

[0003] Where this method is employed, the rim of the toilet bowl is typically provided with a rim perforate passage, and flush water is discharged into the bowl water from nozzle holes provided to the perforate passage, to create circular flow in the bowl water. Siphoning action is produced by forcing bowl water into the trap by means of this circular flow, and by pushing the bowl water by means of downward flow of clean flush water from the plurality of nozzle holes in the rim perforate passage.

[0004] However, methods employed in toilets to date are not entirely satisfactory, and a number of drawbacks, such as the following, have been pointed out.

[0005] In recent years there has been an increasing need to reduce the total amount of water per flush needed to flush away waste (total amount of flush water in the tank), and lower amounts of water per flush—typically about 6 liters—are becoming commonplace. In order to generate the above circular/siphoning action with less water per flush, attention has been directed to delivering flush water at high pressure, i.e. at a high rate of flow, with flow rates of flush water into the bowl often ranging from about 100 to 150 liters/min.

[0006] In toilets in which flush water is dispensed from a flush water tank, the need to create a high pressure flow of water has in turn led to the need to raise the water level of the flush water in the tank in order to ensure high pressure flow of water, by ensuring adequate head pressure. However, this entails making the flush water tank taller, and for integrated tank/stool configurations, certain design limitations apply, making it difficult to design a toilet with a low profile.

[0007] In toilets of which flushing water is supplied directly from a water line, such as a municipal water line (service) etc., it is necessary for water pressure in the water line to be high enough to produce water flow strong enough to flow into the bowl water. On the other hand, where a circular flow is created by a powerful flow of flush water converging with the bowl water, while high water pressure is useful in terms of creating circular flow, the converging flush water flow retains its force, creating unwanted turbulence in the circular flow. This energy (force) of the flush

water is useless in terms of sustaining circular flow, and poses the risk of lowering the efficiency with which flush water is forced into the trap by means of circular flow. Further, in locales where water supply pressure is low, the force of the flush water will be low as well, lowering the efficiency of pushing by the circular flow. Accordingly, circular flow type toilets have not gained widespread use in regions or countries where water pressure is low.

[0008] With regard to toilets that utilize a siphoning action, generation and sustaining of siphoning action are crucial. Thus, it is important that as supplied flush water flows into the bowl water, all of the air present in the siphon trap conduit be expelled from the trap during the initial inflow, so that the conduit fills with water. Regardless of whether flush water is discharged into the toilet bowl in the circular flow configuration described above, or in a straight descent configuration, if the flush water flows with high force into the bowl water, expulsion of air in the conduit to fill it with water can be accomplished rapidly with a smaller amount of flush water. On the other hand, as it is thought that where flush water inflow has low energy, flush water must be supplied over a relatively long time interval in order to expel air and fill the conduit with water, which in turn necessitates a large quantity of flush water, there has to date been substantially no research regarding adoption of a low pressure flush water inflow system. In light of this background, in terms of ensuring adequate head pressure, even toilets employing siphon traps are subject to design limitations in terms of flush water tank height and to restrictions of minimum plumbing system pressure (water supply pressure).

[0009] Existing siphon trap type toilets, on the other hand, are provided with various means for creating rapid siphoning action, and methods for quickly filling the siphon trap conduit with water are widely used. Specifically, where flush water is delivered to the toilet bowl at high force, i.e. about 90-100 liters/min and in some cases about 150 liters/min, the air within the siphon trap conduit will be forced from the conduit under the force of the water, and the conduit will rapidly fill completely with flush water.

[0010] The design of existing siphon trap type toilets of this kind is predicated on the conduit becoming filled with water by means of a high rate of flow of flush water, and thus a number of configurations for routing the siphon trap—going from a rising conduit through an elbow conduit and thence to a descending conduit—have been proposed with the aim of accommodating inflow/passage of flush water at high flow rates. With such techniques no particular consideration has been expended towards improving the precision of forming of the siphon trap conduit during the manufacturing process, or to conduit configuration in individual areas thereof. However, given the increasing demand to reduce the total amount of water per flush (total amount of flush water in the tank) of recent years, measures for improving the precision of forming of the siphon trap, and consideration of configuration in individual sections of the conduit, while necessary, are not currently adequate.

[0011] A more detailed description follows.

[0012] As noted, since flush water flows into the toilet bowl at a high rate of flow, it is not difficult to produce a siphon action provided that the siphon trap conduit is composed of a rising conduit, a top elbow conduit whose

apical dam determines the bowl water level, and a descending conduit. Thus in toilet production, slip is built up on a mold having convex shape suitable for the inside rim of the toilet bowl, with the mold-contacting end of the resultant form serving as the inside wall of the toilet bowl and the opposing end of the form serving as the inside wall of the rising conduit. As this other end of the form is shaped without contacting the mold surface, it is sometimes bumpy. The same is true of the apical elbow segment. In particular, as the apical dam in the apical elbow segment is situated within the conduit, the apical segment must inevitably have convex configuration within the conduit by bending the conduit, with no significant modification to this configuration being possible. That is, as existing toilet design is predicated on a high rate of flow of flush water, even if the conduit inside wall is bumpy the bumps will not hinder the passage of flush water through the conduit, and thus this was not seen as a problem. Further, in existing toilets, as air in the conduit is driven out all at once by a high flow of flush water, the apical dam may be of convex configuration produced by bending of the conduit, and this configuration was not seen as a problem either. From these standpoints, consideration of forming precision and conduit individual configuration was absent.

**[0013]** When installing a siphon trap toilet of this kind, it is necessary to hook up the siphon trap conduit to a drain opening outside the toilet. Waste pipe specifications are not uniform, being subject to local and national codes or those of other organizations, and for this reason a separate part termed a socket, of a different material from the porcelain toilet, is used to hook up the siphon trap conduit to the drain opening outside the toilet.

**[0014]** For example, rough-in specifications—meaning the distance from the toilet wall to the center of the drain opening—differ by country or region. Different rough-ins entail different distances from the back end of the toilet to the drain opening. In contrast siphon trap routing in toilets is substantially standardized, and thus during toilet installation it is necessary to select an appropriate socket, e.g. an elbow socket, depending on the particular rough-in, making for a complicated installation procedure. This problem may be addressed by modifying the siphon trap terminus location in porcelain toilets to match the rough-in, but this will require a larger number of molds for toilet stool fabrication (stool molds) on hand at the factory, and will require mold selection, contributing to higher production costs and mold control costs. For this reason, proper socket selection is currently the only viable approach.

**[0015]** In view of the problems discussed above, it is an object of the present invention to enable a lower toilet profile and to provide a more universal toilet installation process.

**[0016]** It is a further object to provide more diverse siphon trap conduit configurations in siphon trap type toilets, and to enhance the compatibility of porcelain toilets per se with the various waste pipe specifications.

#### DISCLOSURE OF THE INVENTION

**[0017]** To provide at least a partial solution to this problem, the first toilet herein is a toilet for discharging a supplied flush water from the top of the toilet bowl to create circular flow in the bowl water held in the toilet bowl so as to effect flushing of the toilet, the toilet comprising a

perforate passage for guiding the flush water around the top of the toilet bowl, a discharger disposed in the perforate passage and for creating confluence of the flush water with the bowl water in a flow arrangement composed of two principal flows, the discharger discharging the flush water in a bowl water confluence arrangement wherein the two principal flush water flows are converged with the bowl water as streams substantially parallel to either side of the bowl water, as viewed in the horizontal plane of the toilet, and are converged with the bowl water in such a way as to create circular flow in the bowl water in the same circling direction.

**[0018]** According to the first toilet herein having the arrangement described above the two principal flush water flows are converged with the bowl water in such a way that confluence of the principal flows takes place substantially parallel to either side of the bowl water, as viewed in the horizontal plane of the toilet, so as to create circular flow in the bowl water in the same circling direction. By directing each principal flow into confluence with the bowl water in this bowl water confluence arrangement, the principal flows do not disturb generation of circular flow. Thus circular flow can be produced in the bowl water in a reliable manner. As regards the circular flow created by the principal flows, as confluence is substantially parallel and occurs in the same circling direction, circular flow is impelled without disturbing the direction of circular flow, so that the energy of the flush water discharge (water pressure) is used efficiently to create circular flow. This enables the bowl water to be more efficiently pushed along by the circular flow. Additionally, as this condition can be brought about with smaller flow rates of the two principal flows, less flush water can be used to generate the two principal flows of flush water while still maintaining vigorous pushing action by the circular flow. Flush water can therefore be discharged at low flow rates so as to reduce the total amount of flush water.

**[0019]** The ability to both discharge flush water at lower flow rates and reduce the total amount of flush water in turn allows for lower head pressure where the flush water for generating the principal flows is supplied from a flush water tank, and the height of the flush water tank can be made lower to a corresponding degree. This allows for improved design of the toilet overall, including the flush water tank, and allows the toilet to have a lower profile.

**[0020]** Where the flush water for generating the principal flows consists of a flush water supplied directly from a water pipe, the circular flow required for flushing can be generated with flush water discharge at low flow rates and can therefore be adapted to areas where plumbing systems have low water pressure. Thus, the toilet herein can be installed in areas where plumbing system pressure is low due to municipal water supply conditions etc. This ability for more universal installation promotes greater adoption of circular flow type toilets like that herein in regions and countries where toilet water supply pressure is low. In countries and regions where codes etc. require high water pressure, it is a simple matter to install the toilet herein by using a pressure reducing valve or the like.

**[0021]** Further, as a high flow is not required to generate forceful flush water discharge, less sound is produced by the flush water discharge and by confluence of the flush water with bowl water, thereby providing a quieter flush operation.

Unwanted splashing due to forceful discharge and confluence of flush water is also reduced.

[0022] Convergence of the two principal flush water flows with the bowl water to either side of the bowl water can be created at each long side of the edge of the bowl water surface. By so doing it is a simple matter to aim in the direction of flow when the principal flows converge with the bowl water.

[0023] The first toilet herein having the arrangement described hereinabove may take a variety of embodiments, described hereinbelow.

[0024] [In one embodiment] the perforate passage discharger comprises a first discharger for directing flush water in the perforate passage towards the toilet front end on the diagonal with respect to the bowl water to create a first principal flush water flow which is the first of the two principal flush water flows;

[0025] a second discharger for discharging flush water in the perforate passage from the same side as the first discharger with respect to a center axis dividing the toilet into left and right halves, to create on the toilet bowl surface above the surface of the bowl water a flow of flush water circling along the surface of the bowl; and

[0026] a third discharger converging with the flow of flush water from the second discharger so as to correct the flow of flush water from the second discharger, the corrected second discharger flush water flow constituting a second principal flush water flow which is the second of the two principal flush water flows.

[0027] By so doing the second principal flush water flow can converge with the flush water flow (stream), be endowed with high force in the correct direction by means of the convergence with the stream. Accordingly the course of the second principal flush water flow can be stabilized, allowing the principal flows to be guided substantially parallel to each other and in the same circling direction. Thus, when the first and second principal flush water flows are generated by discharging flush water, reliability with a smaller total amount of flush water discharged at a lower flow rate is enhanced.

[0028] The first discharger discharges flush water in the perforate passage from a plurality of nozzle holes formed in the perforate passage, the flush water streams from each nozzle hole converging to create the first principal flush water flow.

[0029] By so doing the course of flow of the first principal flush water flow can be stabilized and strong flow created in the confluence portion, thereby stabilizing the course of the second principal flush water flow consequently reliability with low flow rate flush water discharge and smaller total amounts of water per flush can be enhanced.

[0030] The third discharger comprises

[0031] a fourth discharger for discharging flush water in the perforate passage towards the bowl water at the front end of the toilet bowl so as to converge with the flow of flush water from the second discharger

and correct the direction of flow of flush water from the second discharger towards the surface of the bowl water; and

[0032] a fifth discharger for discharging flush water in the perforate passage from the side opposite the first discharger with respect to a center axis dividing the toilet into left and right halves so as to converge with the flush water flow from the second discharger corrected by flush water from the fourth discharger, to further correct the flow direction thereof at the bowl water surface side, and for converging the corrected flow of flush water from the second discharger constituting the second principal flush water flow to bring about convergence thereof with the bowl water and with the first principal flush water flow according to the above-mentioned confluence arrangement.

[0033] With this arrangement, the fifth discharger discharges flush water in opposition of the flow of flush water from the second discharger so that the discharged flush water converges with flush water flow from the second discharger, so that the flow of flush water from the second discharger is converged with the bowl water parallel to the first principal flush water flow and in the same circling direction therewith.

[0034] By so doing correction of the second principal flush water flow may be accomplished at diagonally opposite side of the first principal flush water flow and the front of the toilet, thereby further stabilizing the course of the corrected second principal flush water flow, to improve the reliability with which the two principal flows converge substantially parallel and in the same circling direction, providing more reliable reductions in the amount of water per flush.

[0035] The perforate passage further comprises an auxiliary discharger, separate from the first to fifth dischargers, for discharging along the surface of the toilet bowl flush water guided through the perforate passage, the flush water, including the flush water discharged from the auxiliary discharger, flowing over substantially the entire surface of the toilet bowl.

[0036] By so doing, flush water can be made to flow over substantially the entire surface of the toilet bowl. Thus, paper or waste adhering to the bowl surface can be reliably washed away into the bowl water so as to keep the surface of the bowl clean.

[0037] The toilet bowl comprises a first bowl peripheral wall for receiving the first principal flush water flow and guiding same into circular motion, and for regulating the circular flow of flush water after the first principal flush water flow has converged with the bowl water; and

[0038] a second bowl peripheral wall for receiving the second principal flush water flow and guiding same into circular motion, and for regulating the circular flow of flush water after the second principal flush water flow has converged with the bowl water.

[0039] By so doing, the course of flow of the first and second principal flush water flows may be stabilized, improving the reliability with which the two principal flows converge substantially parallel and in the same circling direction, and providing more reliable reductions in the amount of water per flush.

[0040] The first and second bowl peripheral walls create a differential in the condition of circular flow of flush water subsequent to convergence with the bowl water, with one of the bowl peripheral walls producing a large circular lead in the depthwise direction of the bowl water, and the other bowl peripheral wall producing a small circular lead in the depthwise direction of the bowl water. The second bowl peripheral wall may produce a large circular lead of the second principal flush water flow, and the first bowl peripheral wall may produce a small circular lead of first principal flush water flow.

[0041] By so doing, the pushing ability of the bowl water through circulation thereof due to the large lead circular flow can be enhanced, while the small lead circular flow collects waste and carries it into the large lead circular flow so that the waste can be flushed away. Thus, pushing ability can be sustained even if the principal flush water flows are generated at low flow rates. In other words, pushing ability can be sustained even where the amount of water per flush is reduced while discharging flush water at a low rate of flow, so as to ensure the ability to flush away waste by this pushing action (toilet flushing ability).

[0042] The toilet bowl has a base portion of mortar shape, so the diameter of the circular flow gradually decreases going towards the trap opening in the base of the bowl, and increasing the force of the circular flow. This has the effect of further improving the pushing ability of the circular flow described earlier.

[0043] Where bowl peripheral walls that create a differential in the leads are provided,

[0044] the first bowl peripheral wall may comprise a guide shelf formed enclosing the bowl water on the side opposite the trap opening into the base of the toilet bowl, for receiving the first principal flush water flow, the guide shelf being situated at substantially equal or a little low height with the surface of the bowl water, and producing in the first principal flush water flow the small circular lead circular flow condition.

[0045] The second bowl peripheral wall may comprise a peripheral wall portion having a steeper slope than the guide shelf across the vertical direction of the bowl water, for receiving the second principal flush water flow and producing in the second principal flush water flow the large circular lead circular flow condition, at the location where the second principal flush water flow converge with the bowl water.

[0046] By so doing, the first principal flush water flow is received by the guide shelf and guided into substantially lateral circular flow in proximity to the bowl water surface, so that a circular flow with a small circular lead may be created in a reliable manner. The second principal flush water flow is received by the steeply sloping peripheral wall portion, a circular flow with a large circular lead being reliably created by the slope thereof. As a result, pushing action from the circular flow created reliably, and waste can be reliably collected by the circular flow with the small lead.

[0047] The second bowl peripheral wall can be such that the percentage of expansion in area of the bowl water surface occurring with a rise in bowl water level due to inflow of flush water into the bowl water is within about 40% of the original area.

[0048] By so doing, the second principal flush water flow guided by the second bowl peripheral wall more reliably creates in the bowl water circular flow with a large lead, further enhancing the pushing ability of the circular flow.

[0049] Taking a vertical cross section of the peripheral wall portion of this second bowl peripheral wall, where the angle defined by the vertical plane of the bowl water surface and the peripheral wall surface in cross section of the peripheral wall portion has a steep slope of approximately 5 to 25°, this is desirable in terms of generating circular flow with a large lead to the second principal flush water flow guided by the peripheral wall of the peripheral wall portion.

[0050] To provide at least a partial solution to the above problem, the second toilet herein is a toilet for discharging the supplied flush water from the top of the toilet bowl to create circular flow in the bowl water held in the toilet bowl to effect flushing of the toilet, comprising:

[0051] a perforate passage for guiding the flush water around the top of the toilet bowl,

[0052] the perforate passage having two dischargers for discharging flush water from diametrically opposite locations about the center of the bowl water as viewed in the horizontal plane of the toilet, each the discharger directing the flush water into convergence with the bowl water so as to create circular flow in the same direction in the bowl water.

[0053] With this arrangement as well, the flows of flush water discharged from the dischargers converge with the bowl water in parallel to either side of the bowl water as viewed in the horizontal plane of the toilet, and produce in the bowl water circular flow in the same circular direction. Thus, as with the first toilet described previously, this toilet reliably induces circular flow in the bowl water, and accordingly offers the same advantages as the first toilet.

[0054] Like the first toilet, this second toilet may take a variety of embodiments.

[0055] To provide at least a partial solution to the above problem, the third toilet herein is a toilet for flowing the supplied flush water into the bowl water held in a toilet bowl and draining it away together with the bowl water from a siphon trap, wherein

[0056] the siphon trap comprises:

[0057] an ascending conduit segment having a trap opening that opens into the lower wall of the toilet bowl, and defining a conduit that extends diagonally upward from the trap opening;

[0058] an apical conduit segment of elbow configuration connecting to the top end of the ascending conduit segment, having an apical dam for regulating the level of the bowl water; and

[0059] a descending conduit segment connecting to the apical conduit segment and descending therefrom, the descending conduit segment comprising a conduit shelf for receiving and deflecting flush water flowing into the ascending conduit segment, over the apical dam of the apical conduit segment, and down into the descending conduit segment due to inflow of the discharged flush water into the bowl water; a downstream conduit

segment for guiding flush water deflected by the conduit shelf towards the downstream end; and a constrictor having a constricted conduit area situated at the terminus of the downstream conduit segment, for guiding flush water to a drain opening outside the toilet;

**[0060]** the descending conduit segment having a descending conduit configuration, as flush water conveyed from the ascending conduit segment drains to the drain opening, to reception by the conduit shelf of flush water flowing down over the apical dam, to diversion of the flow direction of the flush water downflow towards the constrictor, and to accumulation of the flush water downflow in the constrictor, whereby a seal is produced in the constrictor by means of flush water from the upstream conduit, and such that even with air trapped in the conduit segment extending from the apical conduit segment to the conduit shelf, flush water accumulating in the constrictor forms a water column extending to the apical dam, and once the water column has formed, even with the trapped air sealed in the apical conduit segment, siphoning action is generated to suck down the flush water in the toilet bowl and the siphoning action may be sustained.

**[0061]** According to the third toilet herein having the arrangement described above, when an inflow of flush water into the bowl water is initiated to commence flushing, flush water flowing from the ascending conduit segment over the apical dam of the apical conduit segment is down into the descending conduit segment and received and deflected by the conduit shelf of the descending conduit segment. The flow direction of the deflected flush water is diverted towards the constrictor and flows further downstream, at which time is produced a flush water down-flow accompanied by entraining of air present in the descending conduit segment, and a reduction in the flow velocity of the flush water accompanying the diversion of flow direction, until reaching the constrictor of the downstream conduit segment terminus. While flush water reaching the constrictor with air still entrained therein passes through the constrictor and flows out through the drain opening, it nevertheless accumulates in the constrictor due to the constricted conduit area. Some of the accumulated flush water passes through the constrictor and flows out through the drain opening. As flow velocity is reduced during accumulation of the flush water, the flow rate of flush water flowing over the apical dam and down into the descending conduit segment is greater than the flow rate of flush water through the constrictor and out through the drain opening, so during the initial period of flushing flush water may accumulate in the constrictor in tandem with outflow to the drain opening. The amount of flush water accumulating in the constrictor increases as flush water continues to flow down into the descending conduit segment, so in the downstream conduit segment, the upstream conduit is sealed by the accumulated flush water in the constrictor. Once this seal has formed, subsequent continued downflow of flush water forms a water column extending from the constrictor to the apical dam, and entry of air from outside the drain opening is prevented by this column of flush water.

**[0062]** In the stage of flushing subsequent to creation of a seal by the flush water and formation of a water column, the head pressure created as column of water which has formed in the downstream conduit segment descends to the drain opening causes flush water to pass through, creating a pressure drop in the trap. Inflow of flush water flowing through the ascending conduit segment, over the apical dam and down into the descending conduit segment continues even during this pressure drop, so air is not drawn in from the ascending conduit segment side. Thus, by means of a difference in the level of the bowl water in the toilet bowl and the height of the constrictor, there is generated a so-called siphoning action which sucks down the flush water in the toilet bowl, this siphoning action continuing until the siphon is broken by means of air being sucked in from the trap opening into the toilet bowl. Thus, waste present in the toilet bowl is forcibly sucked into the siphon trap together with the bowl water and flush water, and drained away.

**[0063]** As noted, under initial flush conditions giving rise to formation of a column of flush water, flush water is deflected by the conduit shelf of the descending conduit segment, giving rise to entrainment of air by the deflected flush water and to conduit downflow, so that air is expelled to below the conduit shelf. Since the sealed water column has already formed, any air that has not been expelled to below the conduit shelf rises up through the water column and accumulates in the conduit segment extending from the apical conduit segment to the conduit shelf. Or, rising air accumulates at an underside of the guide piece projecting from the apical dam.

**[0064]** Such residual air is considerable where the toilet is flushed with a relatively small amount of flush water, and in conventional toilets has been avoided by flushing the toilet with a large amount of flush water in order to expel all air present in the trap conduit. According to the present invention, however, the descending conduit configuration has been designed such that even with residual air present in the conduit segment extending from the apical conduit segment to the conduit shelf, this residual air is trapped so as to enable formation of the water column, so that siphoning action may be generated and sustained. Thus, siphoning action may be generated and sustained using a relatively small supply of flush water. As the siphoning action is generated, residual air trapped in the apical conduit segment is entrained in the sucked flush water, but as a water column extending to the apical dam has already formed, it does not readily pass through the water column and expelled out from the drain opening. Thus, the water column resists being broken by expulsion of residual air, which is favorable in terms of sustaining siphoning action.

**[0065]** The ability to generate and sustain siphoning action despite the presence of residual air in a conduit segment of the siphon trap during initial flushing offers the following advantages.

**[0066]** As noted, in a toilet having a conventional siphon trap, it was considered important to expel all air present within the siphon trap conduit from the siphon trap when the supplied flush water flows into the bowl water at initial flushing. For this reason it was thought necessary to have a sustained large inflow of flush water into the toilet bowl from the outset of the flushing.

**[0067]** According to the toilet herein, it is not necessary to expel air from the siphon trap during initial flushing, and

thus it is sufficient to have a sustained small inflow of flush water into the toilet bowl from the outset of the flushing. Accordingly, where [the toilet] employs a flush water tank to supply the flush water, the head pressure in the tank can be lower, and the height of the flush water tank can be reduced to a corresponding degree. As a result it is possible to design the toilet with a low profile, and thus improve its design.

[0068] In a toilet of which flushing water is supplied directly from a water line, such as a municipal water line (service) etc., small inflow of flush water into the toilet bowl can be sustained from the outset of the flushing despite low pressure of the water supply. Thus, the toilet herein may be used even in areas where water pressure is low due to municipal water supply conditions or precipitation conditions, or to climatic or regional characteristics, enhancing the universality thereof. In countries or regions where codes mandate high water pressure, the toilet herein may be readily installed by providing a pressure reducing valve or the like.

[0069] Additionally, in [a toilet] designed to create circular flow in the bowl water in order to push flush water into the trap, discharging a low flow of flush water converging with the bowl water is sufficient to create circular flow. That is, there is no need to discharge flush water with high force created by a high rate of flow, it being sufficient to discharge a low flow of flush water with relatively low force to converge with the bowl water. Accordingly, on the occasion of generating circular flow through of flush water streams with the bowl water, discharge of the flush water at low force (low flow rate) avoids unwanted disturbance of circulation of the circular flow. As a result, the energy (force) of the discharged flush water can be fully utilized in producing circular flow, affording stable formation of circular flow and increased efficiency of pushing of flush water into the trap by the circular flow.

[0070] Additionally, as there is no need to discharge flush water with high force by means of a high rate of flow, the noise associated with flush water discharge and with convergence of the flush water with the bowl water is reduced, enhancing quietness during flushing of the toilet. Unwanted splashing due to discharge of flush water with high force and due to convergence of the flush water with the bowl water in large flow rate is also avoided.

[0071] To provide at least a partial solution to the above problem, the fourth toilet herein is a toilet for flowing the supplied flush water into the bowl water held in a toilet bowl and draining it away together with the bowl water from a siphon trap, wherein

[0072] the siphon trap comprises:

[0073] an ascending conduit segment having a trap opening that opens into the underside wall of the toilet bowl, and defining a conduit that extends diagonally upward from the trap opening;

[0074] an apical conduit segment of elbow configuration connecting to the top end of the ascending conduit segment, having an apical dam for regulating the level of the bowl water; and

[0075] a descending conduit segment connecting to the apical conduit segment and descending therefrom, the descending conduit segment comprising a conduit shelf for receiving and deflecting

flush water flowing into the ascending conduit segment, over the apical dam of the apical conduit segment, and down into the descending conduit segment due to inflow of the supplied flush water into the bowl water; a downstream conduit segment for guiding flush water deflected by the conduit shelf towards the downstream end; and a constrictor having a constricted conduit area situated at the terminus of the downstream conduit segment, for guiding flush water to a drain opening outside the toilet;

[0076] the descending conduit segment having a descending conduit configuration giving rise, as flush water conveyed from the ascending conduit segment drains to the drain opening, to reception by the conduit shelf of flush water flowing down over the apical dam, to diversion of the flow direction of the flush water downflow towards the constrictor, and to accumulation of the flush water downflow in the constrictor, whereby a seal is produced in the constrictor by means of flush water from the upstream conduit, and such that when air present in the apical conduit segment is pushed by flush water rising up the ascending conduit segment and flows into the conduit downstream from the apical conduit segment, the inflowing air is trapped at a location downstream from the apical conduit segment and prevented thereby from returning to the apical conduit segment, whereby flush water accumulated in the constrictor forms a water column extending up to the apical dam, so that siphoning action is generated to suck down the flush water in the toilet bowl and the siphoning action may be sustained.

[0077] The fourth toilet herein differs from the third toilet herein in that it is presumed that when flush water flows from the ascending conduit segment over the apical dam and down into the descending conduit segment, air present in the apical conduit segment is pushed by the flush water and flows into the conduit downstream from the apical conduit segment. Specifically, since, due to the relationship of ascending conduit area and apical conduit area, etc., air present in the apical conduit segment can be pushed into the conduit downstream from the apical conduit segment even where flush water is supply at a low flow rate, the following countermeasures are taken.

[0078] Some of the air pushed along the flush water is entrained in the flush water reaching the constrictor and flows out into the drain opening from the constrictor, as in the third toilet described previously, but air that has not been expelled rises up the conduit. Air rising up to the apical conduit segment can break the water column, i.e. disrupt the siphoning action. According to the present invention, however, this air is trapped downstream from the apical conduit segment, preventing it from returning to the apical conduit segment. Accordingly the fourth toilet herein affords the same advantages as the third toilet described previously.

[0079] The third and fourth toilets herein having the arrangements described hereinabove may take a variety of embodiments, described hereinbelow.

[0080] Specifically, the descending conduit segment has a descending conduit configuration whereby the siphoning

action may be generated and sustained with inflow of the flush water supplied to the bowl water at a flow rate of about 50-100 liters/min.

[0081] By so doing, forcible sucking down of waste/bowl water/flush water by the siphoning action can be achieved not only with flow rates close to conventional flow rates, but also with lower flow rates.

[0082] The apical conduit segment has a conduit configuration such that the flow of flush water flowing over the apical dam and descending into the descending conduit segment partitions the part of the conduit segment connecting with the descending conduit segment as a residual air area.

[0083] By so doing, a residual air area may be produced in a regular conduit segment, allowing air to be efficiently entrained in the flow of flush water descending into the descending conduit segment and subsequently expelled, providing advantages in terms of sealing and water column formation, generation of a siphon thereby, and effective sucking and draining away of waste and bowl water in the toilet bowl.

[0084] The apical conduit segment connects the ascending conduit segment to the descending conduit segment by a sectional area larger than the conduit sectional area of the ascending conduit segment.

[0085] By so doing, an area for trapping residual air can be assured, so that air can be effectively entrained and expelled by the flow of flush water down into the descending conduit segment, thus providing the aforementioned advantages in terms of sealing and water column formation, generation of a siphon thereby, and effective sucking and draining away of waste and bowl water in the toilet bowl. While it is desirable for the apical conduit segment to have a sectional area larger than the conduit sectional area of the ascending conduit segment, depending on factors such as the constriction in area provided by the constrictor and the flow rate of flush water flowing into the bowl water, the apical conduit segment may have a sectional area about equal to or smaller than the conduit sectional area of the ascending conduit segment. By so doing, flush water can be efficiently accumulated in the descending conduit segment.

[0086] The descending conduit segment has a descending conduit configuration wherein the area of the conduit cross section gradually constricts going from the conduit shelf to the constrictor, until the area thereof is at least about equal to the conduit cross sectional area of the ascending conduit segment.

[0087] Where this kind of gradual change in area is intended, the conduit cross section of the descending conduit segment may have a cross sectional shape constricting towards the center axis of the conduit in the lateral direction of the toilet.

[0088] By so doing, flush water flowing over the apical dam and deflected by the conduit shelf of the descending conduit segment quickly seals a portion of the descending conduit segment, and assures that [water] accumulates in the constrictor, increasing the reliability with which siphoning action is generated and sustained by means of the air trapping/expulsion and water column formation described

above. That is, waste etc. is forcibly sucked away in a reliable manner by the siphoning action, increasing the ability to drain away waste.

[0089] Where, in addition to gradually constricting the conduit cross section of the descending conduit segment towards the center axis of the conduit in the lateral direction of the toilet, the following is done, the following advantages result.

[0090] In addition to this cross sectional shape,

[0091] the descending conduit segment is arranged such that the descending conduit segment guides downflowing flush water flowing over the apical dam to be deflected towards the toilet bowl and into the constrictor,

[0092] the constrictor comprising a shelf portion for receiving the guided flush water on the toilet bowl side, and after the flush water is received by the shelf portion the flush water being guided into the drain opening.

[0093] Rod-shaped articles such as cotton swabs and matches are often used around toilets, and such rod-shaped articles sometimes accidentally fall into the toilet and are carried into the trap together with the flush water. Such rod-shaped articles reach the descending conduit segment together with the flush water, are deflected towards the toilet bowl together with the flush water flowing down over the apical dam, flow down into the constrictor, and subsequently are received by the shelf portion of the constrictor and reach the drain opening.

[0094] Since the conduit cross section of the descending conduit segment constricts towards the center axis of the conduit in the lateral direction of the toilet, a rod-shaped article has the attitude of its passage adjusted by this conduit cross section while being carried through the descending conduit segment. That is, a rod-shaped article can only flow through the conduit in one of two attitudes: with the lengthwise axis of the rod-shaped article substantially aligned with the lengthwise axis of the conduit cross section (the front-to-back direction of the toilet) or with the lengthwise axis of the rod-shaped article intersecting the lengthwise axis of the conduit cross section (the front-to-back direction of the toilet) from the direction of flow of the flush water (descent direction). Thus, a rod-shaped article flowing down in this attitude, when deflected towards the toilet bowl, moves toward the shelf portion of the constrictor with the lengthwise axis of the rod substantially aligned with the direction of flow of flush water towards the shelf portion of the constrictor. As the rod-shaped article is deflected at this shelf portion as well, past the shelf portion the rod-shaped article proceeds with the lengthwise axis of the rod substantially aligned with the direction of flow of flush water towards the drain opening. The rod-shaped article will then enter the drain opening with a lengthwise end thereof facing the drain opening. Thus, the problem of the constrictor becoming clogged by a rod-shaped article can be avoided.

[0095] First and second principal flush water flows may be generated in the manner described earlier to direct flows of supplied flush water into the bowl water held in the toilet bowl to create circular flow in the bowl water, and there may be provided a toilet bowl having a peripheral wall shape effective in inducing such circular flow.

[0096] By so doing the efficiency of pushing by the circular flow may be improved, and in addition to the attendant advantages, a further advantage is that siphoning action may be generated and sustained in the presence of residual air.

[0097] To provide at least a partial solution to the above problem, the fifth toilet herein is a toilet comprising: a toilet bowl for holding bowl water; a toilet stool for supporting the toilet bowl; and a siphon trap conduit for generating a siphoning action when flushing away waste, wherein the siphon trap conduit comprises an ascending conduit segment extending diagonally upward from a trap opening that opens into the underside wall of the base portion of the toilet bowl; an apical conduit segment forming an elbow conduit connecting to the top end of the ascending conduit segment and having an apical dam for regulating the level of the bowl water; and a descending conduit segment connecting to the apical conduit segment and descending therefrom,

[0098] wherein a portion of the wall of the elbow conduit of the apical conduit segment, the wall portion constituting the conduit wall opposite the apical dam, and extending from the coupling portion with the ascending conduit segment to the coupling portion with the descending conduit segment, is composed of a discrete element in the casting stage prior to firing of the toilet, [the element] being separate from the toilet stool, the toilet bowl, and the remainder of the siphon trap conduit exclusive of the wall portion,

[0099] the wall portion casting being joined to the remainder of the siphon trap conduit to close off the siphon trap conduit, and fired.

[0100] According to the fifth toilet herein having the arrangement described above, in the casting state prior to firing, a portion of the wall of the elbow conduit of the siphon trap conduit segment—this portion constituting the conduit wall opposite the apical dam—is absent over an area extending from the coupling portion with the ascending conduit segment to the coupling portion with the descending conduit segment. With the area corresponding to this portion of the wall absent, a separate mold for forming the inside wall of the ascending conduit segment and the apical dam can be set in the mold. Since casting surfaces deposited in intimate contact with the mold surface serve as the inside wall of the ascending conduit segment and the apical dam, inside walls free from bumpiness can be produced in these areas, and an apical dam having a portion projecting into the conduit can be formed. The wall portion casting is then joined to the siphon trap conduit casting to close off the conduit, giving a connected siphon trap conduit, and the product is then fired. While the mold used to form the above-mentioned apical dam etc. is subject to certain limitations in terms of being set in the other mold, there is a greater degree of freedom in terms of mold configuration, allowing for a variety of siphon trap conduit configurations.

[0101] To provide at least a partial solution to the above problem, the manufacturing method herein is a method for manufacturing a toilet comprising a toilet bowl for holding bowl water; a toilet stool for supporting the toilet bowl; and a siphon trap conduit for generating a siphoning action when flushing away waste, wherein the siphon trap conduit comprises an ascending conduit segment extending diagonally

upward from a trap opening that opens into the lower wall of the base portion of the toilet bowl; an apical conduit segment forming an elbow conduit connecting to the top end of the ascending conduit segment and having an apical dam for regulating the level of the bowl water; and a descending conduit segment connecting to the apical conduit segment and descending therefrom,

[0102] the method comprising the steps of:

[0103] (1) molding a casting for a wall portion constituting the conduit wall opposite the apical dam, and extending from the coupling portion with the ascending conduit segment to the coupling portion with the descending conduit segment;

[0104] (2) molding a casting for a toilet integrally composed of the toilet stool, the toilet bowl and the siphon trap conduit apart from the wall portion; and joining the wall portion casting to the toilet casting to close off the siphon trap conduit, and with the ascending conduit segment, apical conduit segment and descending conduit segment connected to form the siphon trap conduit, subjecting the same to firing;

[0105] wherein the step (2) comprises the steps of:

[0106] preparing a bottom mold having a concave shape conforming to the bottom wall contours of the toilet bowl, the bottom wall contours of the toilet stool, and the exterior contours of the descending conduit segment of the siphon trap conduit, excepting the wall portion;

[0107] side molds having concave shape conforming to the side wall contours of the toilet stool;

[0108] a bowl insert mold having a convex shape conforming to the inside peripheral wall contours of the toilet bowl; and

[0109] a split mold having exterior contours conforming to the conduit inside wall contours of the ascending conduit segment of the siphon trap conduit and to the apical dam contours of the apical conduit portion, and capable of being assembled with the bowl insert mold, the split mold, when assembled with the bowl insert mold, joining therewith in portion conforming to the bottom inside wall of the toilet bowl of the convex shape of the bowl insert mold, the joining location serving as the opening location for the trap opening;

[0110] assembling the prepared molds to form, by means of the concave contours and convex contours of the molds, a cavity for molding the toilet casting, [the casting] integrally composed of the toilet stool, the toilet bowl and the siphon trap conduit apart from the wall portion; and

[0111] flowing slip into the cavity to deposit a slip layer on the molds, draining, drying, and parting the molds to produce the toilet casting.

[0112] According to this toilet manufacturing method, a wall portion situated in the elbow segment of the apical conduit segment and constituting the conduit wall opposite

the apical dam is composed, in the casting stage, of an element separate from the other toilet portions. Thus, during molding of the toilet casting, since this wall portion is absent a split mold for forming the inside wall of the ascending conduit segment and the apical dam can be assembled in the bowl insert mold, so that the casting surfaces deposited in intimate contact with the split mold surface serve as the inside wall of the ascending conduit segment and the wall of the apical dam. Thus, as noted, there is a greater degree of freedom in terms of split mold configuration, so that siphon trap conduits having a variety of configurations can be manufactured easily. As the joining location of the split mold and the bowl insert mold serves as the opening location for the trap opening, the trap opening can be formed with high dimensional accuracy.

**[0113]** The toilet and manufacturing method for the same herein may take a variety of embodiments, described hereinbelow.

**[0114]** The terminal conduit segment situated at the terminus of the siphon trap conduit and connecting with a drain opening outside the toilet constitutes, in the casting stage, a separate element from the toilet, the casting for this terminal conduit segment being joined to the terminus of the siphon trap conduit in the casting stage, and fired. During formation of the casting, a plurality of terminal conduit segments suitable for different distances between the drain opening and the back end of the toilet may be prepared, selecting one suitable for the particular distance, and joining this casting to the toilet stool at the proper location for this distance. By so doing, it is sufficient to have a stock of molds for fabricating the terminal conduit segment while using standardized molds for producing the toilet stool with a siphon trap, thus reducing the costs associated with mold production and management. Further, the toilet produced by joining a terminal conduit segment casting and subsequently firing the product enables the porcelain toilet per se to be adapted to these different distances—i.e. the rough-in from the toilet wall to the drain opening center—one of the specifications for a drain opening.

**[0115]** The perimeter of the drain opening may be sealed by arranging the terminal conduit segment facing the drain opening and forcing an annular sealing element around the drain opening, so as to allow flush water to drain into the drain opening without leakage. By so doing leakage of waste water during draining of the waste water into the drain opening can be avoided by means of the terminal conduit segment per se, by means of a simpler arrangement that does not require an elbow or other socket.

**[0116]** The terminal conduit segment may also be arranged facing the drain opening and connected to the drain opening via a drain connector situated between the drain opening and the terminal conduit segment. By so doing leakage of waste water during draining of the waste water into the drain opening can be avoided by means of the drain connector. As the drain socket simply connects the drain opening and the terminal conduit segment which are situated in opposition, it can be a simple straight pipe, this simple shape making it easy to handle.

**[0117]** Alternatively the terminal conduit segment may be inserted into the drain opening. By so doing, the toilet can be installed with the terminal conduit segment thereof inserted into the drain opening, notwithstanding the fact that

the toilet, including the terminal conduit segment, consists entirely of porcelain. This provides a cost advantage since there is no need to preinstall sockets, etc., or for the process/production equipment management entailed in socket production. As the terminal conduit segment inserts in the drain opening for hookup, the siphon trap furnished with this terminal conduit segment can be adapted to drain opening specifications despite being composed entirely of porcelain.

**[0118]** As noted, since the terminal conduit segment can be formed independently, the casting therefor can be molded by means of a convex mold and a concave mold to define the outside diametral contour thereof by means of the concave mold and the inside diametral contour thereof by means of the convex mold. This allows the terminal conduit segment to be given different inside/outside wall contours, for example a cylindrical exterior wall contour and an oval interior wall.

**[0119]** The sixth toilet herein comprises a toilet bowl for holding bowl water; a toilet stool for supporting the toilet bowl; and a siphon trap conduit for generating a siphoning action when flushing away waste, the toilet further comprising:

**[0120]** a terminal conduit segment situated at the terminus of the siphon trap conduit and connecting with a drain opening outside the toilet, the terminal conduit segment connecting the descending conduit segment to the drain opening via the terminal conduit segment,

**[0121]** wherein the terminal conduit segment constitutes, in the casting stage prior to firing of the toilet, a separate element from the casing composed of the siphon trap conduit, the toilet bowl and the toilet stool,

**[0122]** the casting for the terminal conduit segment being joined to the terminus of the siphon trap conduit in the casting stage, and fired.

**[0123]** By so doing, the terminal conduit segment can be fabricated as a separate element during the casting stage, even for a toilet not requiring any special configuration for the inside wall of the ascending conduit segment or the apical dam, so that the aforementioned advantage of compatibility with the drain opening is achieved with a porcelain toilet per se.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0124]** **FIG. 1** is an illustrative diagram depicting an exemplary toilet **10** in top sectional view;

**[0125]** **FIG. 2** is an illustrative diagram depicting the left half of the toilet **10** of **FIG. 1** in sectional view taken along a centerline extending from front to back;

**[0126]** **FIG. 3** is an illustrative diagram depicting the right half thereof;

**[0127]** **FIG. 4** is an illustrative diagram showing a cut-away view of the area of the left central nozzle hole **43** of the rim in **FIG. 2**;

**[0128]** **FIG. 5** is an illustrative diagram depicting flow behavior of flush water discharged from the basal first nozzle hole **41** and the basal second nozzle hole **42**;

[0129] FIG. 6 is an illustrative diagram depicting flow behavior of flush water from the left center nozzle hole 43, first correcting nozzle holes 45, rim front nozzle hole 44 and second correcting nozzle holes 48, FIG. 6(a) being an illustrative diagram depicting flush water flow behavior on the assumption that flush water is discharged independently from each nozzle hole, and FIG. 6(b) being an illustrative diagram depicting flush water flow behavior occurring with flush water discharge from each hole;

[0130] FIG. 7 is an illustrative diagram modeling flush water flow behavior occurring with flush water discharge from all holes;

[0131] FIG. 8 is an illustrative diagram modeling a hypothetical condition in which the principal flows S1, S2 giving rise to the flush water flow behavior separately converge with bowl water RS;

[0132] FIG. 9 is an illustrative diagram modeling circular flow behavior in the bowl water when the two principal flows S1, S2 simultaneously converge with the bowl water RS;

[0133] FIG. 10 is an illustrative diagram showing a sectional view of toilet 10 taken along line 10-10 in FIG. 1, in the vicinity of the location of convergence of the principal flow S2 with the bowl water;

[0134] FIG. 11 is an illustrative diagram showing a section of the conduit taken along line 11-11 in FIG. 3, for the purpose of illustrating the siphon trap 20 conduit arrangement;

[0135] FIG. 12 is an illustrative diagram showing a section of the descending conduit segment 28 taken along line 12-12 in FIGS. 3 and 11;

[0136] FIG. 13 is an illustrative diagram showing a section of the descending conduit segment 28 taken along line 13-13 in FIGS. 3 and 11;

[0137] FIG. 14 is an illustrative diagram showing a section of the descending conduit segment 28 taken along line 14-14 in FIGS. 3 and 11;

[0138] FIG. 15 is an illustrative diagram illustrating flow behavior of flush water during initial flushing;

[0139] FIG. 16 is an illustrative diagram illustrating accumulation of flush water in the terminal conduit segment 74;

[0140] FIG. 17 is an illustrative diagram illustrating generation of the siphoning action;

[0141] FIG. 18 is an illustrative diagram depicting installation of a "U" shaped tube in order to verify that siphoning action is generated and sustained in the presence of residual air;

[0142] FIG. 19 is a graph charting the change in water level in the "U" shaped tube;

[0143] FIG. 20 is a partly see-through perspective view of a toilet 10 having a flush water supply unit 100 installed therein;

[0144] FIG. 21 is an illustrative diagram showing in sectional view the area around the flush water supply unit 100;

[0145] FIG. 22 is an illustrative diagram giving comparisons of flow rates for the water supply to the toilet bowl, inflow into the bowl, and flush water drainage from the trap for the toilet 10 of this example and a comparison toilet;

[0146] FIG. 23 is an illustrative diagram giving results of evaluation tests conducted with the toilet 10 of this example and a comparison toilet;

[0147] FIG. 24 is an illustrative diagram showing the toilet of the example without a siphon trap;

[0148] FIG. 25 is an illustrative diagram showing a comparison of results of the tests for efficiency of pushing by the circular flow for the toilet of the example and a comparison toilet;

[0149] FIG. 26 is an illustrative diagram illustrating a toilet 10 according to a modification that incorporates a flush water reservoir tank;

[0150] FIG. 27 is an illustrative diagram illustrating a casting arrangement for producing a toilet 10;

[0151] FIG. 28 is an illustrative diagram illustrating molding of the terminal conduit casting MK, FIG. 28(a) being an illustrative diagram illustrating the female mold 200 and male mold 210 prior to mating, FIG. 28(b) being an illustrative diagram illustrating the cavity MKK formed when the two molds are mated, and FIG. 28(c) being an illustrative diagram illustrating the cavity MMK viewed in cross section along line x-x in FIG. 28(b);

[0152] FIG. 29 is an illustrative diagram illustrating, for purposes of comparison, the forming process when the terminal conduit segment is formed together with a toilet casting that includes a siphon trap conduit, FIG. 29(a) being an illustrative diagram illustrating the slip layer of the casting of the terminal conduit segment and the siphon trap conduit, and FIG. 29(b) being an illustrative diagram illustrating the slip layer of the casting of the terminal conduit segment viewed in cross section along line x-x in FIG. 29(a);

[0153] FIG. 30 is an illustrative diagram illustrating a mold used for molding the apical conduit segment casting TK;

[0154] FIG. 31 is an illustrative diagram illustrating molding of the apical conduit segment casting TK;

[0155] FIG. 32 is an illustrative diagram illustrating molding of the rim casting RK;

[0156] FIG. 33 is an illustrative diagram illustrating molding of the toilet stool casting BK;

[0157] FIG. 34 is a simplified perspective view of the floor mold 250 used in molding the toilet stool casting BK;

[0158] FIG. 35 is an illustrative diagram showing a sectional view taken along line 34-34 in FIG. 34;

[0159] FIG. 36 is a simplified perspective view of the bowl insert mold 260 used in molding the toilet stool casting BK;

[0160] FIG. 37 is a simplified perspective view of the split mold 270 used in molding the toilet stool casting BK;

[0161] FIG. 38 is a simplified perspective view of one side mold 280 used in molding the toilet stool casting BK;

[0162] FIG. 39 is an illustrative diagram illustrating molding of the toilet stool casting BK in the vicinity of the mechanism housing portion 11 of the toilet 10, and the inside split molds used for this purpose;

[0163] FIG. 40 is an illustrative diagram illustrating a toilet 300 pertaining to another embodiment;

[0164] FIG. 41 is an illustrative diagram illustrating arrangements for various rough-ins, FIG. 41(a) depicting an arrangement for accommodating a rough-in to 200 mm, FIG. 41(b) depicting an arrangement for accommodating a rough-in to 305 mm, and FIG. 41(c) depicting an arrangement for accommodating a rough-in to 405 mm;

[0165] FIG. 42 is an illustrative diagram illustrating connections of terminal conduit segment 74 to drainpipe, FIG. 42(a) depicting a method using a drain connector HSC, and FIG. 42(b) depicting a method using a drain flange HSF;

[0166] FIG. 43 is an illustrative diagram showing a toilet wherein the apical conduit segment 26 has a conduit area approximately equal to that of the ascending conduit segment 24 so that air present in the apical conduit segment 30 flows into the downstream conduit; and

[0167] FIG. 44 is an illustrative diagram showing a toilet wherein the flush water of the first principal flow S1 and second principal flow S2 is discharged from locations diagonally opposite side of the center of the bowl water as viewed in the horizontal plane of the toilet, to create circular flow.

#### BEST MODE FOR CARRYING OUT THE INVENTION

[0168] The embodiments of the toilet herein are now described on the basis of examples. FIG. 1 is an illustrative diagram depicting an exemplary toilet 10 in top sectional view; FIG. 2 is an illustrative diagram depicting the left half of the toilet 10 of FIG. 1 in sectional view taken along a centerline extending from front to back; FIG. 3 is an illustrative diagram depicting the right half thereof; and FIG. 4 is an illustrative diagram showing the central portion of the rim in FIG. 2 in partial cutaway. The toilet of Example 1 features particular conduit configurations at individual locations on the siphon trap conduit and is designed to create and sustain siphoning action with a low flow rate of flush water. The overall arrangement of the toilet is discussed first.

[0169] As will be apparent from the drawings, toilet 10 comprises a toilet bowl 12, the upper edge of which is a rim 14. The rim 14 surrounds the toilet bowl 12 and has a rim perforate passage 16 formed in the interior thereof. The rim perforate passage 16 connects to a flush water supply path 18 at the back of the toilet.

[0170] The back side of the toilet bowl 12 is a mechanism housing portion 11 for housing a flush water supply unit, described later; the flush water supply path 18 is supplied with flush water, via a communicating opening 19, from a flush water supply unit housed in the mechanism housing portion 11. Flush water supplied via the flush water supply path 18 enters the rim perforate passage 16 from the left and right and is directed around the top edge of the toilet bowl 12 as shown in FIG. 1.

[0171] The toilet bowl 12 communicates at the bowl base portion 13 thereof with a siphon trap 20. The siphon trap 20 comprises a trap inlet 22 that opens into the bowl base

portion 13; an ascending conduit segment 24 that forms a conduit extending diagonally upward from the trap inlet 22 towards the back of toilet; an apical conduit segment 26 coupled to the top end of the ascending conduit segment 24 and bending downward; and a descending conduit segment 28 coupled to the apical conduit segment 26 and descending therefrom. The apical conduit segment 26 comprises, in the portion thereof coupled with the ascending conduit segment 24, an apical dam 30 that deflects downward towards the descending conduit segment 28; the level of the bowl water RS held in the bowl is determined by this apical dam 30. The siphon trap 20 conduit configuration will be discussed later.

[0172] The rim 14 comprises, in the rim perforate passage 16 thereof on the left half of the toilet depicted in FIG. 1, a basal first nozzle hole 41, a basal second nozzle hole 42, and a left central nozzle hole 43, as well as a plurality of first correcting nozzle holes 45 situated between the left center nozzle hole 43 and a rim front nozzle hole 44, and a plurality of auxiliary nozzle holes 46 situated between the left center nozzle hole 43 and the basal second nozzle hole 42. On the right half of the toilet the rim 14 comprises a right center nozzle hole 47, with a plurality of second correcting nozzle holes 48 and third correcting nozzle holes 49 situated between this right center nozzle hole 47 and the rim front nozzle hole 44, and a plurality of fourth correcting nozzle holes 50 and auxiliary nozzle holes 51 situated between the right center nozzle hole 47 and the coupling with the flush water supply path 18.

[0173] The basal first nozzle hole 41 and basal second nozzle hole 42 are formed on the bottom of the rim perforate passage 16, and are of rectangular slot configuration (in this example, W×L is 12×43 mm for the basal first nozzle hole 41 and 13×35 mm for the basal second nozzle hole 42) as shown in the drawing. The auxiliary nozzle holes 46, first correcting nozzle holes 45, rim front nozzle hole 44, second correcting nozzle holes 48, third correcting nozzle holes 49, right center nozzle hole 47, fourth correcting nozzle holes 50 and auxiliary nozzle holes 51 are each holes of substantially circular shape formed in the bottom of the rim perforate passage 16. Nozzle hole diameter in this example is approximately 4 mm for the auxiliary nozzle holes 46 and auxiliary nozzle holes 51; approximately 13 mm for the first correcting nozzle holes 45; approximately 10 mm for the rim front nozzle hole 44 and second correcting nozzle holes 48; approximately 5 mm for the third correcting nozzle holes 49 and fourth correcting nozzle holes 50; and approximately 16 mm for the right center nozzle hole 47.

[0174] Flush water flowing into the rim perforate passage 16 flows along the perforate passage route of the rim perforate passage 16 at a speed (flow rate) which is dependent upon the flow rate provided by the flush water supply unit, and by the time the flush water reaches the nozzle holes it is led with directionality in accordance with the locations of the nozzle holes in the interior of the rim perforate passage. As depicted in model form in FIG. 1, the nozzles discharge flush water along the surface of the toilet bowl 12 towards the bowl base portion 13 while reflecting the directionality of the flush water.

[0175] In the central portion of the rim perforate passage 16 on the left and right halves of the toilet, a left downward projecting portion 51 and a right downward projecting portion 52 that project downward from the bottom of the

perforate passage are formed. These two downward projecting portions divide the rim perforate passage **16** into a wide perforate passage **16a** of wider perforate passage cross section at the upstream end of the direction of flush water flow, and a narrow perforate passage **16b** of smaller cross section at the downstream end. Accordingly, the amount of flush water flowing through is greater in the wide perforate passage **16a**, while flush water whose flow has been regulated by the left and right downward projecting portions flows through the narrow perforate passage **16b**.

[0176] As flush water is discharged from the basal first nozzle hole **41** and the other nozzle holes, the basal first nozzle hole **41** and basal second nozzle hole **42**, owing to their rectangular opening configuration, to being situated on the wide perforate passage **16a**, and to being situated in proximity to the flush water supply path **18**, discharge flush water in greater amounts than do the other nozzle holes. Due to flow regulation by the narrow perforate passage **16b** the first correcting nozzle holes **45**, right center nozzle hole **47**, rim front nozzle hole **44** and second correcting nozzle holes **48** discharge flush water with the directionality of the discharged flush water stabilized, the discharged amount being dependent upon the hole diameter.

[0177] Referring now to **FIG. 4**, the left center nozzle hole **43** is a hole approximately 16 mm in diameter formed in the right downward projecting portion **52**, the direction of the opening thereof being coincident with the direction of flush water passage through the wide perforate passage **16a**. Accordingly, flush water discharged through the left center nozzle hole **43** flows directly forward from the left center nozzle hole **43** and is guided along the upper peripheral wall **55** of the toilet bowl **12** below the rim **14**, the course of the discharged flow being indicated by flow course TS in **FIGS. 2 and 3**. The narrow perforate passage **16b** has a pendent plate portion **56** extending towards the toilet front from the left downward projecting portion **52** inside of thereunder, so that the area in front of the left center nozzle hole **43** is enclosed by the pendent plate portion **56**, the bottom portion **57** of the narrow perforate passage **16b**, and the upper peripheral wall **55**. Accordingly the left center nozzle hole **43** discharges a highly directional and focused flow of flush water along flow course TS.

[0178] The action of flush water discharged from the basal first nozzle hole **41** etc. is now described. **FIG. 5** is an illustrative diagram depicting flow behavior of flush water discharged from the basal first nozzle hole **41** and the basal second nozzle hole **42**; **FIG. 6** is an illustrative diagram depicting flow behavior of flush water from the left center nozzle hole **43**, first correcting nozzle holes **45**, rim front nozzle hole **44** and second correcting nozzle holes **48**, **FIG. 6(a)** being an illustrative diagram depicting flush water flow behavior on the assumption that flush water is discharged independently from each nozzle hole, and **FIG. 6(b)** being an illustrative diagram depicting flush water flow behavior occurring with flush water discharge from each hole. **FIG. 7** is an illustrative diagram modeling flush water flow behavior occurring with flush water discharge from all holes; **FIG. 8** is an illustrative diagram modeling a hypothetical condition in which the principal flows giving rise to the flush water flow behavior separately converge with bowl water RS; and **FIG. 9** is an illustrative diagram modeling

circular flow behavior in the bowl water when the two principal flows simultaneously converge with the bowl water RS.

[0179] As shown in **FIG. 1** and **FIG. 5**, the basal first nozzle hole **41** and basal second nozzle hole **42** are formed at locations opening out from the bottom of the wide perforate passage **16a** located towards the rear of the toilet. Accordingly, these two nozzle holes discharge flush water diagonally above the bowl water RS, and directed towards the front of the toilet. Since the two nozzle holes are each of rectangular configuration the flush water is discharged in a wide stream spreading out from rectangular shaped holes. As the two nozzle holes are situated in proximity to each other, the flush water flows after being discharged, and this convergent flow produces a strong principal flow (first principal flow S1) having the correct directionality, this first principal flow S1 ultimately converging with the bowl water RS. Due to the locations of the nozzle holes and direction of flush water discharge this first principal flow S1 converges with the bowl water RS diagonally rightward and forward from the left rear edge of the toilet [bowl], as seen in the plan view illustrated in the drawings. As the first principal flow S1 is produced by confluence of flush water streams from the two nozzle holes, it takes a stable course to converge with the bowl water RS. Flush water discharged from other nozzle holes and thus not contributing to the creation of the first principal flow S1 converges with the bowl water RS in the form of flows to either side of the first principal flow S1, thereby rinsing off the surface of the toilet bowl **12** in the areas thereof not reached by the first principal flow S1. Flush water discharged by the auxiliary nozzle holes **46** performs a similar function.

[0180] The left center nozzle hole **43** discharges the flush water guided through the rim perforate passage **16** on the same side as do the basal first nozzle hole **41** and the basal second nozzle hole **42** (i.e., the left side of the toilet). As shown in **6(a)** the discharged flush water circles around the upper peripheral wall **55** (see **FIG. 4**) flowing along the flow course TS described previously. While flush water is being discharged from the left center nozzle hole **43**, flush water is also discharged from the first correcting nozzle holes **45**, rim front nozzle hole **44**, second correcting nozzle holes **48**, and right center nozzle hole **47**. The flush water streams discharged from these nozzle holes intersect the flow course TS of the flush water discharged from the left center nozzle hole **43**. Accordingly, the flow of flush water along flow course TS sequentially merges, at the front of the toilet, with the flush water streams discharged from the first correcting nozzle holes **45**, the rim front nozzle hole **44**, the second correcting nozzle holes **48**, and the third correcting nozzle holes **49**. On the side opposite the left center nozzle hole **43**—i.e. the right side of the toilet—the flush water stream discharged from the right center nozzle hole **47** and the flush water streams discharged from the fourth correcting nozzle holes **50** merge with the flow of flush water along flow course TS.

[0181] The converging flow of flush water has the effect of correcting the merged flow of flush water along flow course TS, and producing a principal flow (second principal flow S2) with the proper directionality and high force from the flow of flush water on flow course TS by means of convergence of these streams, this second principal flow S2 then converging with the bowl water RS. This second principal

flow S2 is composed of a flow of flush water along flow course TS around the upper peripheral wall 55, corrected at the front and right side of the toilet by the converging flow of flush water described above, and as such converges with the bowl water RS diagonally rearward from the right front of the toilet, as depicted in the plan view in 6(b). As this second principal flow S2 has been merged/corrected with streams of flush water discharged from a plurality of nozzle holes—i.e., the first correcting nozzle holes 45 etc.—it follows a stable course to converge with the bowl water RS in to the right side of the bowl water, and, as depicted in FIG. 6(b) and FIG. 7, converges with the bowl water RS substantially parallel to the first principal flow S1, as viewed in the horizontal plane of the toilet, with the two principal flows convergence with the bowl water RS in such a way as to create circular flow in the same circling direction. The auxiliary nozzle holes 51 and fourth correcting nozzle holes 50 rinse the surface of the toilet bowl 12 not reached by the second principal flow S2 (i.e. the surface at the back of the toilet).

[0182] As the first principal flow S1 and second principal flow S2 are substantially parallel to either side of the bowl water RS as viewed in the horizontal plane of the toilet in such a way as to create circular flow in the bowl water RS the same circling direction, in the toilet 10 according to this example, when these principal flows create circular flow in the bowl water R, the principal flows do so without disturbing the circular flow in the circling direction. Thus, circular flow is energized without creating any disturbance of the circular flow, so that the energy (force) of the discharged flush water can be fully utilized, whereby the efficiency of pushing of the bowl water by the circular flow is increased. This effect is described later.

[0183] The structure of the inside wall of the bowl portion for inducing the convergence of the principal flows in this manner is now described. FIG. 10 is an illustrative diagram showing a sectional view of toilet 10 taken along line 10-10 in FIG. 1, in the vicinity of the location of convergence of the principal flow S2 with the bowl water. As shown in FIG. 10 and FIGS. 1 to 3, in the toilet 10 according to this example, the inside wall of toilet bowl 12 at the front end of the toilet comprises an upper peripheral wall 55 descending from the rim 14, a gently sloped portion 60 continuous therewith, a sharply sloped portion 61, and a bottom shelf portion 62 of reduced slope, this bottom shelf portion 62 being situated at a location in proximity to the surface of the bowl water RS. This bottom shelf portion 62 directs the first principal flow S1 onto a circular path, and as shown in FIG. 8 circulation of the flush water created by convergence of principal flow S1 with the bowl water RS is such that the circular flow has a small lead S1L in the depthwise direction of the bowl water RS.

[0184] The inside wall of the toilet bowl 12 at the back of the toilet is composed of a rear sloped portion 63 having a substantially uniform sharp slope descending from the rim 14. This rear sloped portion 63 extends to the trap inlet 22 of the bowl base portion 13 below the level of the bowl water RS surface. The inside wall of the toilet bowl 12 at the sides of the toilet comprises an upper peripheral wall 55 descending from the rim 14, a gently sloped left or right portion 64R, 64L continuous therewith, and a sharply sloped left or right portion 65R, 65L, as shown in FIG. 10. Sloped portions 64R, 64L are continuous with the sloped portion 60 at the

toilet front so as to form a receiving face for flush water during flow correction of the second principal flow S2, described earlier, and are continuous also with the rear sloped portion 63 at the back of the toilet. While the sloped portion 64 does guide the first principal flow S1 into proximity with the bowl water RS, since the first principal flow S1 travels forward diagonally from the rear, confluence of the first principal flow S1 with the bowl water and subsequent direction thereof to generate circular flow is performed by the bottom shelf portion 62, as described later.

[0185] Sloped portions 65R, 65L are continuous with the sloped portion 61 at the front of the toilet, and with the rear sloped portion 63 at the back of the toilet. The sloped portion 65R and the rear sloped portion 63 continuous therewith direct the corrected second principal flow S2 into convergence with the bowl water RS in the manner described previously, and also regulate circulation of the flush water created by confluence of the merged second principal flow S2 with the bowl water RS. The sloped portion 65R and the rear sloped portion 63 each have a sharp slope, with the slope thereof being such that when the rise in the bowl water level  $\Delta H$  in FIG. 10 occurring with inflow of flush water into the bowl water RS is compared with the expansion in bowl water surface area  $\Delta S$ , the expansion in bowl water surface area  $\Delta S$  is approximately  $\frac{1}{5}$  to  $\frac{2}{5}$  to the rise in bowl water level  $\Delta H$ , with the ratio of expansion in bowl water surface area occurring with the rise in water level being no more than about 40% of the original area. That is, even after the second principal flow S2 has converged with the bowl water RS, the same is directed into a circular flow by these sloped portions. Thus, the circular flow of flush water created by convergence of the second principal flow S2 with the bowl water RS has a large lead S2L in the depthwise direction of the bowl water RS, as shown in FIG. 8. For the sloped portion 65R, rear sloped portion 63 and sloped portion 65L are composing the curving faces the degree of slope thereof has been described above in terms of a comparison of the rise in the bowl water level  $\Delta H$  with the expansion in bowl water surface area  $\Delta S$ ; however the slope of the curving surfaces defined by the angle between the vertical plane of the bowl water surface and the peripheral wall surfaces—viewed in vertical cross section thereof—can be sharp angles, about 5 to 25°. By so doing the second principal flow S2 guided by the sloped portion can be made to produce a circular flow with a large lead S2L.

[0186] The circular flow produced subsequently to the convergence of the principal flows does not occur independently, but rather is generated in the bowl water as simultaneous progression. Accordingly, it is presumed to have the following flow behavior.

[0187] The circular flow induced in the bowl water RS by the second principal flow S2 so as to create a large circular flow lead directs into the side of the bowl base portion 13, i.e. into the trap inlet 22. As depicted in FIG. 9, this pushing force also affects the small-lead circular flow created by the first principal flow S1, so that circulating waste carried on the circular flow of the first principal flow S1, as well as the circulating flush water per se, are pushed towards the trap inlet 22 by this pushing force. This enhances the action of pushing the bowl water RS and waste. Notwithstanding, this pushing action does not create disturbance of the circular flow in the direction of circulation.

[0188] Additionally, as the toilet bowl 12 has a bowl base portion 13 shaped like a mortar, the diameter of the circular path of the two circular flows gradually constricts towards the trap inlet 22, with the circular flow increasing in force. This further enhances the pushing action of the circular flow. Resultant advantages will be described later.

[0189] When circular flow of the bowl water is generated by the first principal flow S1 and second principal flow S2 in the above manner, flush water and waste present in the toilet bowl 12 is transported (pushed) through the trap inlet 22 to the siphon trap 20, and is expelled from the siphon trap 20 in the following manner. Prior to describing expulsion of waste, we turn first to a detailed description of the siphon trap 20 arrangement. FIG. 11 is an illustrative diagram showing a section of the conduit taken along line 11-11 in FIG. 3, for the purpose of illustrating the siphon trap 20 conduit arrangement; FIG. 12 is an illustrative diagram showing a section of the descending conduit segment 28 taken along line 12-12 in FIGS. 3 and 11; FIG. 13 is an illustrative diagram showing a section of the descending conduit segment 28 taken along line 13-13 in FIGS. 3 and 11; and FIG. 14 is an illustrative diagram showing a section of the descending conduit segment 28 taken along line 14-14 in FIGS. 3 and 11.

[0190] The apical conduit segment 26 is coupled to the ascending conduit segment 24 and extends towards the rear of the toilet, and flush water from the apical dam 30 flows down the descending conduit segment 28. In this example, the apical conduit segment 26 has a sectional area larger than that of the ascending conduit segment 24, so as to provide an air seal in the topmost portion 70 of the apical conduit segment 26, as described later.

[0191] In addition to the apical dam 30 the apical conduit segment 26 also comprises a tongue portion 71 projecting diagonally downward from the apical dam 30 towards the descending conduit segment 28. Whereas the apical dam 30 is situated at the inflection point on the conduit going from the ascending conduit segment 24 to the descending conduit segment 28, and, as noted, determines the level of the bowl water, this tongue portion 71 features a configuration projecting diagonally downward into the conduit, thereby guiding the flow of flush water passing the apical dam 30 into the descending conduit segment 28. Thus, flush water reaching the apical dam 30 is guided by the tongue portion 71 to flow down the descending conduit segment 28, so as to reliably reach an upper conduit shelf portion 75 and lower conduit shelf portion 77 (described later) provided to the descending conduit segment 28, where it flows downward as its descent is deflected by these shelf portions. As the tongue portion 71 curves to project diagonally downward, the lower area thereof serves as an air reservoir during flush water expulsion.

[0192] Descending conduit segment 28 comprises in order, following the apical conduit segment 26 end thereof, an elbow conduit segment 72, a medial conduit segment 73, and a terminal conduit segment 74. As shown in FIGS. 11 to 14, the descending conduit segment 28 is provided with an elbow conduit segment 72 and medial conduit segment 73 of gradually constricting sectional area going towards the terminal conduit segment 74. That is, the elbow conduit segment 72 and medial conduit segment 73 are designed with a gradually constricting sectional area along the path of

the flush water flowing through the conduit, and as shown in FIG. 12 and FIG. 13, this constriction takes the form of constriction towards the center axis of the conduit, in the lateral direction of the toilet.

[0193] The elbow conduit segment 72 comprises an upper conduit shelf portion 75 situated at the coupling with the medial conduit segment 73. This upper conduit shelf portion 75 deflects the flow of flush water flowing down from the apical dam 30 and guided by the tongue portion 71, to direct the downward flow of flush water down into the medial conduit segment 73.

[0194] The medial conduit segment 73 comprises a lower conduit shelf portion 77 situated at the coupling with the terminal conduit segment 74. This lower conduit shelf portion 77 deflects the flow of flush water flowing down from the tongue portion 71, as well as flush water descending from the upper conduit shelf portion 75 along the outside peripheral wall portion 76 of the medial conduit segment 73, so as to direct the downward flow of flush water down into the terminal conduit segment 74.

[0195] The terminal conduit segment 74, depicted in FIG. 14, has an outer wall of round cylindrical configuration, with the interior thereof constituting a conduit segment 79 of elliptical cross section. This terminal conduit segment 74 is "slipped in" to a drain opening (not shown) via a drain connector (not shown), to connect the descending conduit segment 28 to the drain opening. The terminal conduit segment 74 is provided at the bottom end of the conduit segment 79 with a through-hole 78 around whose opening is left a portion of a bottommost shelf portion 80; this through-hole 78 functioning to constrict the size of the opening. The bottommost shelf portion 80 receives flush water deflected towards the toilet bowl 12 by the upper conduit shelf portion 75 and lower conduit shelf portion 77, and deflects the flush water so as to direct the flush water from the through-hole 78 into the drain opening.

[0196] As will be apparent from the preceding description, the descending conduit segment 28 is provided with an upper conduit shelf portion 75 and lower conduit shelf portion 77, and thus when there is a low flow of flush water descending over the apical dam 30 and down the descending conduit segment 28, flush water is deflected by the lower conduit shelf portion 77, whereas in the case of a larger downward flow flush water is deflected by both the upper conduit shelf portion 75 and the lower conduit shelf portion 77. Thus, regardless of the magnitude of the flow rate of the descending flush water, the flush water will be deflected by the bottommost shelf portion 80 of the terminal conduit segment 74 and then expelled into the drain opening. The spatial relationship of the outer peripheral wall portion 76 of the medial conduit segment 73 and the tongue portion 71 of the apical dam 30 is such that even if the flow (discharge) supplied from the flush water supply unit is the minimum contemplated in this example (about 40 liters/min), the flush water descending from the apical dam 30 can be reliably deflected by the lower conduit shelf portion 77. The conduit area of the medial conduit segment 73 and the opening area of 78 of the terminal conduit segment 74 are such that even where the flow of water from the flush water supply unit is at the above-mentioned minimum level, flush water accumulation can occur, as described later.

[0197] Expulsion of waste by means of the descending conduit segment 28 having the arrangement described above

is now discussed in terms of the flow behavior of flush water in the descending conduit segment 28. FIG. 15 is an illustrative diagram illustrating flow behavior of flush water during initial flushing; FIG. 16 is an illustrative diagram illustrating accumulation of flush water in the terminal conduit segment 74; and FIG. 17 is an illustrative diagram illustrating generation of the siphoning action.

[0198] When a flush button or flush lever (not shown) is operated to initiate a flush operation, flush water flows from the flush water supply unit into the rim perforate passage 16, and the flush water then flows into the bowl water RS in the first principal flow S1 and second principal flow S2 described previously. As depicted in FIG. 15 the flush water in the ascending conduit segment 24 is pushed along by the flush water inflowing into the bowl water RS, so that the water level in the ascending conduit segment 24 rises. This pushing action by the flush water for the bowl water to be directed towards the trap inlet 22 occurs as a result of a circular flow created by means of parallel confluence in the same circling direction of the first principal flow S1 and second principal flow S2 into the bowl water RS.

[0199] Flush water pushed in this way flows from the ascending conduit segment 24 over the apical dam 30 of the apical conduit segment 26, and flows down into the descending conduit segment 28. As shown in FIG. 16, this flush water is deflected by the upper conduit shelf portion 75 and lower conduit shelf portion 77 of the descending conduit segment 28. The deflected flush water continues to flow downward, with the direction of flow thereof diverted thereby towards the downstream terminal conduit segment 74, reaching the downstream terminal conduit segment 74 while producing the flush water down-flow accompanied by entraining of air present in the descending conduit segment, as well as reducing the flow velocity of the flush water due to the diversion of flow direction. By means of this flow behavior, sealing of the downstream conduit by means of the flush water commences downstream from the upper conduit shelf portion 75.

[0200] As the terminal conduit segment 74 is provided with a bottommost shelf portion 80, flush water is again deflected by the bottommost shelf portion 80 and then drains through the through-hole 78. As shown in FIG. 14 the opening area of the through-hole 78 is constricted, and thus while some of the flush water in the terminal conduit segment 74 drains through the through-hole 78, flush water also accumulates in the conduit segment 79.

[0201] In this example, even if water is supplied at the minimum flow rate mentioned previously, since the velocity of flow is reduced by means of deflection by the shelf portions as described above during accumulation of flush water, the flow of flush water crossing the apical dam 30 and descending through the descending conduit segment 28 will exceed the flow of flush water draining into the drain opening through the terminal conduit segment 74. Accordingly, during the initial period of a flush, accumulation of flush water in the terminal conduit segment 74 and draining into the drain opening can occur in parallel. The amount of flush water accumulating in the terminal conduit segment 74 increases as flush water continues to flow down into the descending conduit segment 28. During the time interval that flush water continues to flow down, the flow of flush water flowing over the apical dam 30 and down into the

descending conduit segment 28 functions as a water curtain extending from the tongue portion 71 of the apical dam down to the upper conduit shelf portion 75 or to the lower conduit shelf portion 77, as shown in FIG. 16.

[0202] During the initial period of a flush operation in which flush water both accumulates in and drains from terminal conduit segment 74, air trapped downstream from the upper conduit shelf portion 75 becomes entrained in the flush water deflected by the aforementioned shelf portions and is expelled from terminal conduit segment 74. Flush water subsequently continues to accumulate in the terminal conduit segment 74, whereby the medial conduit segment 73 and terminal conduit segment 74 become filled with water and sealed, as depicted in FIG. 17. As flush water subsequently continues to flow down, a column of water forms extending from the terminal conduit segment 74 to the apical dam 30, and entry of air from outside the through-hole 78 is prevented by the column of flush water. Once this column of water has formed, flush water continues to flow down into descending conduit segment 28 from apical dam 30 so as to increase the amount of flush water accumulated in the terminal conduit segment 74, so when the column of water formed in the descending conduit segment 28 descends to through-hole 78, the flush water composing the column of water is forced to flow through due to its head pressure, thereby reducing the pressure in the trap. The flow of flush water moving past the ascending conduit segment 24, over the apical dam 30 and down into the descending conduit segment 28 continues during this pressure drop, and thus no air is sucked in from the trap inlet 22 through the ascending conduit segment 24 side. Thus, by means of a difference in the level of the bowl water in the toilet bowl 12 and the height of the ascending conduit segment 24 accumulating the flush water into the water column, there is generated a so-called siphoning action which sucks down the flush water in the toilet bowl 12, this siphoning action continuing until the siphon is broken by means of air being sucked into the siphon trap 20. Thus, waste present in the toilet bowl 12 is forcibly sucked into the siphon trap 20 together with the bowl water and flush water, and drained away.

[0203] Air remaining in the topmost portion 70 of the apical conduit segment 26 from the beginning of the flushing remains trapped in the topmost portion 70, and since a water column has already formed in the descending conduit segment 28, air not expelled from the descending conduit segment 28 by being entrained with the flush water rises up through the water column and is trapped in the topmost portion 70. A pocket of air may also form at the area under the tongue portion 71. However, as accumulation and draining of flush water occur in the terminal conduit segment 74, providing sealing, air does not intrude into the siphon trap 20 through the through-hole 78. Nor is air sucked in from the toilet bowl 12 side, so the water column is not interrupted by trapped air or intruding air, allowing the siphoning action generated in the manner described above to continue. Thus, waste present in the toilet bowl 12 is forcibly sucked into the siphon trap 20 together with bowl water RS due to this siphoning action, and is flushed away. That is, a feature of this toilet 10 is that even under a condition different from that of existing toilets—which are designed so that air is expelled all and once and the conduit is filled with water by means of a large flow of flush water—specifically, a condition in which air remains in the topmost portion 70 of the apical conduit segment 26 and/or an air pocket is present at

the area under the tongue portion **71**, siphoning action can nevertheless be generated and sustained even with a low flow of flush water. The special configurations for the ascending conduit segment **24**, apical conduit segment **26**, descending conduit segment **28** and terminal conduit segment **74** of the siphon trap **20** described above are employed in order to generate and sustain this siphoning action.

[**0204**] When siphoning action is generated and sustained in this manner, residual air trapped in the topmost portion **70** of the apical conduit segment **26** can be expected to become entrained in the flush water being sucked in, and to be continuously expelled together with the flush water.

[**0205**] In this example, the area of the descending conduit segment **28** constricts as it descends, as depicted in FIGS. **11** to **14**. Thus, flush water spilling over the apical dam **30** down into the descending conduit segment **28** and continues to accumulate in the terminal conduit segment **74**, assuring that flush water accumulates. This enhances the reliability with which siphoning action is generated and sustained by means of expulsion/trapping of air as described above. In other words, as waste etc. is forcibly sucked down in a reliable manner, flushing performance is enhanced.

[**0206**] In this example, circular flow is generated by a first principal flow **S1** and second principal flow **S2** having different circular leads, and therefore the effectiveness of pushing by the circular flow is higher, as will be apparent also from the comparison of effects described hereinbelow. Thus, a condition in which siphoning action is generated and sustained in the presence of residual air in the manner described previously can be verified by connecting a “U” saped tube to a suitable location in the siphon trap **20**, for example, the topmost portion **70**, and observing the change in water level in the “U” saped tube starting at the outset of the toilet flush. FIG. **18** is an illustrative diagram depicting installation of a “U” saped tube in order to verify that siphoning action is generated and sustained in the presence of residual air; and FIG. **19** is a graph charting the change in water level in the “U” saped tube.

[**0207**] As shown in the figure the water level in the “U” saped tube **90** moves to positive pressure when the siphon is initially generated, and subsequently goes to negative pressure. This can be explained as follows. In this example, a portion of the descending conduit segment is sealed by a small amount of flush water during initial flushing, and thus when flush water is pushed into the siphon trap by means of the circular flow produced during initial flushing, residual air is compressed so that pressure rises within the conduit. The negative pressure observed subsequent to this initial generation of positive pressure can be explained as occurring due to forcible suctioning of flush water in the conduit due to the formation of a siphon. Accordingly, a toilet producing this sort of change in water level in a the “U” saped tube can be considered to generate and sustain siphoning action following an initial strong push of flush water in the presence of residual air.

[**0208**] Where the water consumption of the toilet is about 6 liters as a highly water saving model, a conventional toilet—which simply creates circular flow of bowl water—will not show the positive pressure/negative pressure cycle described above, but rather negative pressure throughout beginning at the initial flush.

[**0209**] The effect of flushing away waste in this example is now described. The description first turns to the flush

water supply unit. The invention is not subject to structural limitations as to flush water supply, and thus while the following description relates to a water supply unit that utilizes a jet pump, any unit designed to supply water under the head pressure of flush water held in a flush water tank could of course be used. FIG. **20** is a partly see-through perspective view of a toilet **10** having a flush water supply unit **100** installed therein; and FIG. **21** is an illustrative diagram showing in sectional view the area around the flush water supply unit **100**.

[**0210**] The flush water supply unit **100** is housed within a unit housing portion **11** situated at the back of the toilet, and supplies water to the rim perforate passage **16** of the rim **14**. As illustrated in detail in FIG. **21**, the flush water supply unit **100** has a flush water tank **108** for holding flush water. The flush water supply unit **100** also comprises a supply pipe **11** connected to a water supply via a water shutoff valve **109**, this pipe is forking into a pair of branch pipes **110a**, **110b** that lead into the flush water tank **108** through the tank side wall. The flush water tank **108** is open at its top end to facilitate installation and maintenance of a ball cock **115**, jet pump **113** and other elements in the tank, described later.

[**0211**] Branch pipe **110a** comprises a flush valve **111** on the segment thereof within the tank, and serves as a flush water (operating water) supply pipe to the jet pump **113**. The flush valve **111** comprises a handle **11a** operated in order to flush the toilet; operation of this handle opens the flush valve **111** so that flush water flows downstream therein.

[**0212**] The flush water pipe downstream from the flush valve **111** is composed of a jet pump **113** situated between pipes **112** and **114**. Pipe **112** takes a route from the flush valve **111** descending in proximity to the floor of the flush water tank **108** and then bending sideways along the tank floor at the descending end, connecting at its terminus to the jet pump **113**. The pipe **114** downstream from the jet pump **113** guides the flush water jetted from the jet pump **113** into the rim perforate passage **16** via a flush water supply channel **18**.

[**0213**] This pipe **114** takes the route depicted in FIG. **20**, and comprises an ascending pipe segment **114a** that extends upward from the jet pump **113** to a location in proximity to the top edge of the tank; a horizontal pipe segment **114b** that bends sideways and extends out from the flush water tank **108** from the tank side wall; a descending pipe segment **114c** that bends downward and descends along the outside of the tank wall; and a communicating pipe segment **114d** whose downstream end communicates with the flush water supply channel **18**. The horizontal pipe segment **114b** has at a medial location thereof a vacuum breaker **114e** that is situated above the full water level **WS** when the flush water tank **108** is filled with flush water **W2** prior to flushing the toilet. Thus, if for some reason there should be a backflow of flush water from the toilet **10**, the air opening provided to the pipe by the vacuum breaker **114e** will easily and reliably prevent backflow of flush water into the flush water tank **108**. The communicating pipe segment **114d** at the terminal end of the pipe **114** is connected water tightly to a connector opening **19** provided to the flush water supply channel **18** at a location above the full water level **WS**.

[**0214**] Branch pipe **110b** is connected to a ball cock **115** inside the tank, and refills the flush water tank **108** with flush water in response to opening and closing of the ball cock

**115.** The ball cock **115** is connected to a first end of a float ball support shaft **116**, and the second end of the support shaft is connected to a float ball **117**. The float ball **117** is situated within a small tank **118** attached to the top of the flush water tank **108**. The small tank **118** is open at its top end. A small-diameter through hole **118a** is formed in the bottom wall of the small tank **118**. Thus, the float ball **117** rises and falls with the amount of flush water (water level) in the small tank **118**, the ball cock **115** opening and closing in association with rise and fall of the float ball **117**, so that a predetermined full water level **WS** is maintained in the flush water tank **108** by this opening and closing action.

**[0215]** The jet pump **113** jets flush water (tap water) supplied from pipe **112** into the pipe **114** situated in opposition. This jet of flush water enters the throat at the bottom end of pipe **114**, at which time the tank flush water in the flush water tank **108** is drawn into the throat. In this way an accelerated jet of water is supplied to the rim perforate passage **16** via the flush water supply channel **18**. The flush water is subsequently discharged from the nozzle holes in the rim perforate passage **16** in the manner described previously.

**[0216]** The water supply pressure (upstream pressure) for supplying flush water is determined with reference to the total amount of flush water used to flush the toilet (about 4.5 to 6 liters) and the flow rate of the flush water supplied by the jet pump (about 18 to 25 liters/min); relatively low upstream pressure on the order of about 0.09 MPa (about 1 kgf/cm<sup>2</sup>) is sufficient.

**[0217]** Water supply is halted as follows. About the time that the bowl water **RS** in the toilet bowl **12** is sucked down so that the toilet bowl **12** becomes empty, halting the siphoning action, the water level of the flush water **W2** in the flush water tank **108** falls to below the level of the jet pump **113** so that the flow rate increasing action of the jet pump **113** stops due to intake of air. The tap water jetted from the jet nozzle **131** subsequently reaches the rim **14** via the pipe **114**, and is supplied to the toilet bowl **12**. As a result, tap water flows into the empty toilet bowl until the level of the bowl water **RS** reaches the water level determined by the apical dam **30**.

**[0218]** The flush valve **111** closes automatically once a predetermined amount of tap water has flowed through. This halts the supply of tap water to the jet pump **113** so that jet pump **113** operation halts. The timing for halting of the flush valve **111**—i.e., the timing for shutoff of the tap water supply—is adjusted to coincide with the bowl water **RS** in the toilet bowl reaching the level mentioned previously. This timing is adjusted with reference to the amount of bowl water, the increase in flow rate produced by the jet pump **113**, the total amount of flush water needed to flush the toilet, etc., and the flush valve **111** is designed and fabricated to halt under a timing based on these factors.

**[0219]** Flush water **W2** is discharged from the flush water tank **108** by means of operation of the jet pump **113**, whereupon the level of the flush water **W2** in the flush water tank **108** drops. This drop in the level of the flush water **W2** in the flush water tank **108** is accompanied by a drop in the level of the flush water **W2** in the small tank **118**. At this time the flush water **W2** in the small tank **118** gradually flows into the flush water tank **108** through the small-diameter through-hole **118a** made in the bottom wall, so the rate of drop of the

flush water **W2** in the small tank **118** is slower than the rate of drop of the flush water **W2** in the flush water tank **108**. Accordingly, the float ball **117** descends at a lower rate of speed, so that the ball cock **15** supplies the flush water subsequently to the water supply to the jet pump **113** with some delay. As the rate of descent of the float ball **117** is dependent on the speed of passage of flush water through the through-hole **118a**, i.e., on the diameter of the through-hole, the timing for shutoff of the ball cock **15** can be adjusted by manipulating the diameter of the through-hole. In the present example, this is done in the following way. The diameter of the through-hole **118a** is such that the float ball **117** descends to a predetermined level at about the time that operation of the jet pump **113** has been halted through closure of the ball cock **15** to complete flushing of the toilet **10**. Thus, the ball cock **15** closes substantially simultaneously with completion of toilet flushing, the flush water tank **108** is refilled with flush water, and subsequently flush water **W2** fills the flush water tank **108** until reaching the full level **WS**.

**[0220]** The working effects of a toilet **10** equipped with the above flush water supply unit **100** are now described. The comparison toilet is a conventional tank type siphon trap toilet, having a siphon trap of substantially uniform conduit area, wherein circular flow is created in the bowl water by discharging flush water into the toilet bowl. As a comparison test for demonstrating ability to flush away waste, an ordinary PE granule removable test was conducted, as was a removable test using PP (polypropylene) balls. The PE granule removable test was carried out by floating approximately 2500 PE granules (particle size approximately 4.5 mm) in the bowl water, and then flushing the toilet. In this test, waste flushing ability is deemed satisfactory if the number of residual particles in the toilet bowl does not exceed 125. The PP ball removable test was carried out by floating approximately 100 fine particles (size approximately 9 mm) in the bowl water, and then flushing the toilet. In this test, waste flushing ability is deemed satisfactory if the number of residual balls in the bowl and trap does not exceed 25 in total. The above tests were conducted with the toilet **10** of this example and the above-described comparison toilet, while varying the total flush water amount (target value). **FIG. 22** is an illustrative diagram giving comparisons of flow rates for the water supply to the toilet bowl, inflow into the bowl, and flush water drainage from the trap for the toilet **10** of this example and the comparison toilet; and **FIG. 23** is an illustrative diagram giving results of evaluation tests conducted with the toilet **10** of this example and the above-described comparison toilet.

**[0221]** As will be apparent from **FIGS. 22 and 23**, the toilet **10** of this example had markedly better results in evaluation tests, despite a lower rate of flow of water supply to the toilet bowl, rate of flow of inflow into the bowl, and rate of flow of flush water drainage from the trap than the comparison toilet. That is, with the toilet **10** of this example appreciably better flushing action was achieved with a current total flush water amount considered to effectively conserve water (about 6 liters). This is due to reliable creation of the siphoning action described above with the present example, which creates strong waste/bowl water suctioning force, as well as efficient pushing by the circular flow created by convergence of the first principal flow **S1** and second principal flow **S2** substantially parallel and in the same circling direction. Accordingly the toilet of this

example exhibits good waste flushing ability. While the comparison toilet was observed to produce a siphoning action, different results in the PE granule removable test indicated that the suctioning force of the siphoning action and the efficiency of pushing by the circular flow was not superior to that achieved with the toilet of this example. In light of the finding that waste flushing ability was not good, the PP ball removable test was not conducted.

[0222] When the PE granule removable test and PP ball removable test were subsequently conducted using less water (about 5 liters) than the current total flush water amount, the toilet **10** of this example exhibited in both tests better flushing ability than did the comparison toilet. These results also indicate that with the present example there is achieved reliable creation of the siphoning action described above, resulting in strong waste/bowl water suctioning force, as well as efficient pushing by the circular flow created by convergence of the first principal flow **S1** and second principal flow **S2** substantially parallel and in the same circling direction. In particular the number of PP balls remaining in the bowl water was successfully reduced, despite the smaller amount—namely 5 liters—of flush water supplied (in actual practice about 4 liters). This demonstrates efficient pushing by the circular flow created by convergence of the first principal flow **S1** and second principal flow **S2** substantially parallel and in the same circling direction.

[0223] Efficiency of pushing by the circular flow was then compared. The toilet of the example and the comparison toilet, without the siphon trap but with the toilet bowl and flush water supply to the bowl water composed, were compared for efficiency of pushing by the circular flow. In place of the siphon trap the socket for the wall drain arrangement was connected to the top end of the ascending conduit segment **24**. **FIG. 24** is an illustrative diagram showing the toilet of the example without a siphon trap, and **FIG. 25** is an illustrative diagram showing a comparison of results of the tests for efficiency of pushing by the circular flow for the toilet of the example and the comparison toilet.

[0224] As shown in **FIG. 24**, the toilet used to verify the efficiency of circular flow pushing is a toilet **10** according to the example described above, from which conduit downstream from the apical dam **30** has been removed, and a drain socket **170** for wall draining has been water tightly installed in place of the siphon trap **20**. Where this is done no siphoning action is produced, and thus the ability of the illustrated toilet **10** to carry away waste is determined exclusively by the pushing efficiency of the circular flow.

[0225] As shown in **FIG. 25**, with the toilet **10** of this example flushing capacity (PP ball removable efficiency) is higher than with the comparison toilet. This result may be attributed to the high pushing efficiency of the circular flow created by the parallel, unidirectional convergence of the first principal flow **S1** and second principal flow **S2** in the present example.

[0226] This means that in a toilet **10** producing the circular flow described previously, the pushing efficiency of the circular flow is high, so that high flushing capacity is achieved through implementation of the circular flow of this example, even in a toilet having a construction that does not utilize siphoning action, as the wall draining toilet equipped with a drain socket depicted in **FIG. 24**. The wall draining arrangement depicted in **FIG. 24** is not limiting, it being

possible to achieve high flushing capacity through implementation of the circular flow of this example also where connected to a floor drain pipe with a bent drain socket.

[0227] In this example, the high flushing capacity described above is achieved with low flow of flush water. The amount of flush water supplied to the toilet was checked and found to be approximately 70 liters/min for the toilet **10** of this example, versus approximately 150 liters/min for the comparison toilet. With existing toilets this approach of reducing flow, using a low flow that will not drive out trapped air in the siphon trap during initial flushing, has not been employed to date. The present invention, however, is based upon the novel concept of not completely expelling trapped air during initial flushing, so as to achieve high performance with lower water flow.

[0228] With an existing toilet (the comparison toilet), complete expulsion of trapped air during initial flushing is accomplished by means of strong force of water into the bowl water, i.e., by supplying flush water at a high flow rate. Thus, the noise associated with flush water supply and the noise associated with expulsion of trapped air is considerable. In the present example, however, as flush water is supplied at a lower flow rate, noise is reduced to a corresponding degree, assuring greater quietness. Results obtained with a sound collecting/measuring instrument shown that noise is reduced by approximately 5-10% with the toilet **10** of this example. Where the total amount of flush water is approximately 4 liters, the comparison produces approximately 66 db, whereas the present example produces only about 58 db. Where total amount of flush water is approximately 5 liters, the present example gives a reduction from about 67 db to about 63 db.

[0229] By way of an embodiment of the invention, flush water may be supplied by under head pressure, rather than by the flush water supply unit **100** described above. **FIG. 26** is an illustrative diagram illustrating a toilet **10** according to a modification that incorporates a flush water reservoir tank.

[0230] In the illustrated toilet **10**, a flush water reservoir tank unit **150** is housed within the mechanism housing portion **11**, and flush water in the tank is supplied to flush water supply path **18** via a water supply line **151** leading out from the tank bottom. As described previously, flush water supplied to flush water supply path **18** flows into the rim perforate passage **16** and is discharged into the toilet bowl **12** through the basal first nozzle hole **41** and other nozzle holes. Subsequently, the flush water is pushed by means of circular flow created by parallel, unidirectional convergence of first principal flow **S1** and second principal flow **S2**, and siphoning action is produced by the siphon trap **20**. Thus, advantages such as a lower total amount of water per flush can be achieved with a toilet **10** employing a reservoir tank unit **150** as well.

[0231] With this toilet the amount of flush water flowing into the bowl water **RS** is determined by head pressure **h** created by the full water level of tank flush water held in the reservoir tank unit **150**. With this toilet **10** as well, as there is no need to completely expel air in the trap during initial flushing, flush water can be supplied at a lower flow rate. Accordingly, it is sufficient for the reservoir tank unit **150** to ensure a head pressure **h** sufficient to give a low flow supply of water on the order of the approximately 70 liters/min mentioned previously. Thus the height of the reservoir tank

unit **150** can be approximately  $\frac{1}{2}$ - $\frac{2}{3}$  that of existing flush tank type low-flow toilets (approximately 6 liters per flush), affording a flush water tank type toilet that nevertheless has a low profile, improved appearance, and a greater degree of freedom in design.

[0232] A process for manufacturing a toilet **10** capable of generating and sustaining siphoning action with a low flow of flush water, even with air trapped in the topmost portion **70** of the apical conduit segment **26** and air trapped below the tongue portion **71**. **FIG. 27** is an illustrative diagram illustrating a casting arrangement for producing a toilet **10**.

[0233] As shown, the toilet **10** castings prior to firing comprise a toilet stool casting **BK** that includes a toilet bowl **12**, a bowl base portion **13**, a toilet stool **BH** supporting these, and a mechanism housing portion **11**; an apical conduit segment casting **TK** constituting the upper half of the apical conduit segment **26**; a rim casting **RK** that includes a rim **14** and a front side wall portion of the mechanism housing portion **11** continuous therewith; and a terminal conduit casting **MK** constituting the terminal conduit segment **74**. The apical conduit segment casting **TK** constitutes the conduit wall at a location in the elbow conduit segment of the apical conduit segment **26** situated opposite the apical dam and forming the connecting portion with the ascending conduit segment **24**, i.e., the wall in a predetermined segment extending from the joining location thereof with the rear sloping portion **63**—which partitions the ascending conduit segment **24** from the toilet bowl **12**—to the connecting portion with the descending conduit segment **28**. These castings are precast, and then connected together and fired in the manner described later, to produce the toilet **10**.

[0234] **FIG. 28** is an illustrative diagram illustrating molding of the terminal conduit casting **MK**; and **FIG. 29** is an illustrative diagram illustrating, for purposes of comparison, the forming process when the terminal conduit segment is formed together with toilet castings that include a siphon trap conduit.

[0235] As shown in **FIG. 28**, a female mold **200** and a male mold **210** are employed. These two molds are absorbent, being fabricated from porous material, so that the fluid slip becomes deposited on each mold face. The female mold **200** has a bottomed cylindrical recess **201** in its center, and has at the top edge thereof an irregular shape recess **202** for mating. The male mold **210** has a projecting portion **211** projecting up from the top face in an substantially oval configuration, and a distal end portion **212** projecting upward from a first end of the projecting portion in a round configuration. At the top edge there is an irregular shape projecting portion **213** that mates with the irregular shape recess **202** of the female mold **200**.

[0236] When these two molds are mated with the distal end portion **212** inserted into the bottomed recess **201**, a cavity **MKK** is defined between the mold faces of the bottomed recess **201** and projecting portion **211**, as depicted in **FIG. 28(b)** and the sectional view thereof taken along line x-x shown in **FIG. 28(c)**.

[0237] The fluid slip is then cast into the cavity **MKK** through an inlet (not shown), and through absorption by the molds a slip layer becomes deposited on the surface of each mold. During this process the cavity **MKK** becomes filled

with slip layer having a thickness of approximately 10 mm in the portions contacting the surface of each mold, with fluid slip remaining in the remaining portion. The fluid slip remaining is drained from the mold through a slip drain (not shown), and the slip in the cavity is then dried to remove water. This completes the “half drying” process, and the molds are then parted, to give a terminal conduit casting **MK** of cylindrical cup shape corresponding to the unfired terminal conduit segment **74**. As the distal end face of the distal end portion **212** joins to the bottom face of the bottomed recess **201**, the terminal conduit casting **MK** has at the bottom face thereof a circular through-hole **74mk** of a shape conforming to the contour of the distal end portion **212**. The outside wall configuration of the terminal conduit casting **MK** is circular conforming to the contour of the inside wall of the bottomed recess **201**, and the inside wall configuration is oval conforming to the contour of the outside wall of the projecting portion **211**. That is, the inside and outside contours differ from each other. With firing, the through-hole **74mk** in the terminal conduit casting **MK** becomes through-hole **78**, and the bottom portion other than through-hole **78mk** becomes the bottommost shelf portion **80**.

[0238] Where the terminal conduit segment is molded together with toilet castings that include a siphon trap conduit, left and right side molds **215**, **216**, depicted in **FIG. 29(a)**, are used for molding a toilet casting. In that portion of the casting that corresponds to the terminal conduit segment, the deposited slip layer is “single layer” so the inside wall contour (circular contour) in this portion of the casting must reflect the outside contour thereof, to reflect the shape of the mold, so it is not possible to produce differing inside and outside contours, as above.

[0239] **FIG. 30** is an illustrative diagram illustrating a mold used for molding the apical conduit segment casting **TK**; and **FIG. 31** is an illustrative diagram illustrating molding of the apical conduit segment casting **TK**.

[0240] As depicted in **FIG. 30**, an upper mold **220** and a lower mold **230** are used for molding the apical conduit segment casting **TK**. The upper and lower molds are both absorbent, being fabricated from porous material, so that a slip layer becomes deposited on each mold face. The upper mold **220** has a sunken recessed portion **221** defining the contour of the outside wall of the apical conduit segment casting **TK** corresponding to the location of the aforementioned wall of the apical conduit segment **16**; and irregular shape recesses **222** situated at the left and right edges for mating. The lower mold **230** has a projecting portion **231** that projects out in a configuration defining the contour of the inside wall of the apical conduit segment casting **TK**; and irregular shape projections **223** situated at the left and right edges for mating with the irregular shape recesses **222** of the upper mold **220**.

[0241] When the two molds are mated with the recessed portion **221** and projecting portion **231** facing each other, a cavity **TKK** is formed between the mold faces of the recessed portion **221** and projecting portion **231**, as depicted in **FIG. 31**.

[0242] The fluid slip is then cast into the cavity **TKK** through an inlet (not shown), and through absorption by the molds a slip layer becomes deposited on the mold surfaces; [the fluid] slip is drained and [the casting] is then dried. The drying process completes the “half drying” process, where-

upon the two molds are parted. The apical conduit segment casting TK formed in this manner has inside and outside wall contours defined by the mold wall contours of the recessed portion 221 and projecting portion 231 of the upper and lower molds, thus allowing multitude different of inside and outside wall contours and increasing the degree of freedom in design selection. As the inside and outside wall surfaces of the apical conduit segment casting TK are the surfaces of the casting that are in intimate contact with the mold surfaces as [the slip layer] is deposited, they are free of unwanted bumpiness.

[0243] FIG. 32 is an illustrative diagram illustrating molding of the rim casting RK.

[0244] As shown in the drawing, molding of the rim casting RK is performed using an upper mold 240 and a lower mold 242. The upper and lower molds are both absorbent, being fabricated from porous material, so that a slip layer becomes deposited on each mold face. The upper mold 240 has a mold wall of a configuration that defines the contour of the outside wall of the upper half of the rim 14, the front sidewall of the mechanism housing portion 11 that continues up from the rim 14, and the portion that includes the inside edge of the rim opening. The lower mold 242 has a mold wall of a configuration that defines the contour of the outside wall of the lower half of the rim 14, the aforementioned front sidewall, and the portion that includes the peripheral wall along the bottom face of the rim opening. The fluid slip is then cast into the cavity RKK through an inlet (not shown), and through absorption by the molds a slip layer becomes deposited on the mold surfaces; [the fluid] slip is drained and [the casting] is then dried. In cavity RKK the slip is deposited in a single layer on the upper and lower mold surfaces, and drying in this state completes the "half drying" process in the cavity. The molds are then parted, and the unmolded casting is then drilled to produce the basal first nozzle hole 41, left central nozzle hole 43, and other nozzle holes, and the communicating opening 19. This completes forming of the rim casting RK that corresponds to the rim 14 prior to firing.

[0245] FIG. 33 is an illustrative diagram illustrating molding of the toilet stool casting BK; FIG. 34 is a simplified perspective view of the floor mold 250 used in molding the toilet stool casting BK; FIG. 35 is an illustrative diagram showing a sectional view taken along line 34-34 in FIG. 34; FIG. 36 is a simplified perspective view of the bowl insert mold 260 used in molding the toilet stool casting BK; FIG. 37 is a simplified perspective view of the split mold 270 used in molding the toilet stool casting BK; FIG. 38 is a simplified perspective view of one side mold 280 used in molding the toilet stool casting BK; and FIG. 39 is an illustrative diagram illustrating molding of the toilet stool casting BK in the vicinity of the mechanism housing portion 11 of the toilet 10, and the inside split molds used for this purpose.

[0246] As shown in FIG. 33, when molding the toilet stool casting BK the bowl insert mold 260 is first arranged on a molding stage (not shown) with the convex bowl portion 263 thereof facing upward. The left and right toilet side molds 280 are then arranged enclosing the bowl insert mold 260. The split mold 270 is assembled with the bowl insert mold 260 in the manner described later. The bottom mold 250 is then mated with the top edges of the side molds 280. In this way an inverted cavity BKK, depicted in FIG. 33, is

defined by the mold surfaces. The molds are absorbent, being fabricated from porous material, so that slip becomes intimately deposited on each mold face, producing a layer of slip. The molds have irregular shape recesses and projections for mating.

[0247] This cavity BKK is used to cast a toilet casting BK that includes the bowl water 12, bowl base portion 3, bowl body BH supporting these, and that includes the siphon trap 20 except for the apical conduit casting TK, and is therefore divided as follows. As illustrated, the cavity BKK is divided, to the front and left and right sides of the toilet, into a cavity section BKK2 defined by the bowl insert mold 260 and the bottom mold 250; a cavity section BKK3 defined by the split mold 270 and the bottom mold 250; a cavity section BKK4 defined by the bottom mold 250, the side molds 280, and the bowl insert mold 260; and a cavity section BKK5 defined by the bowl insert mold 260 and the split mold 270. The cavity section BKK5 extends in the front-to-back direction in the plane of the paper in FIG. 33, and communicates with cavity section BKK2. The cavity section BKK4 also extends in the front-to-back direction in the plane of the paper, and communicates with cavity section BKK2.

[0248] As depicted in FIGS. 34 and 35, the bottom mold 250 for forming cavity BKK has a bottom face portion 251 serving as the mating portion, and, on the top face thereof, a projecting portion 252. This projecting portion 252 has projecting area 253 for forming the conduit outside wall of the siphon trap 20 and a projecting area 254 for forming the bottom wall of the mechanism housing portion 11; the projecting area 253 has a trap recess 255. The trap recess 255 conforms to the exterior contours of the descending conduit segment 28 of the siphon trap 20, and is also recessed in conformance with the exterior contours of the bottom face of the bowl base portion 13 of the toilet bowl 12, the exterior contours of the bottom face of the bottom portion of the toilet bowl 12, the base portion end and bottom face of the bottom leg portion BHK of the toilet stool BH (see FIG. 27), so as to define the contours thereof. As shown in FIG. 11, the descending conduit segment 28 has a downwardly constricting taper, so the portion of the trap recess 255 corresponding to the descending conduit segment 28 is tapered as well, as depicted in FIG. 35.

[0249] The projecting area 254 has a shape at its top face conforming to the exterior contours of the bottom face of the of the bottom wall of the mechanism housing portion 11 so as to form a portion of the cavity section BKK4 described previously. The casting for the bottom and lower wall of the mechanism housing portion 11 is formed over the entire extension thereof by means of the projecting area 254, the side molds 280 described later, and the bowl insert mold 260.

[0250] As shown in FIG. 36 the bowl insert mold 260 comprises at the top end thereof an top upper edge portion 261 serving as the mating portion with the top edges of the left and right side molds 280 described later; and a bottom upper edge portion 262 for forming the portion continuous with the rim casting RK, described previously. The bowl insert mold 260 also has on the low face of the bottom upper edge portion a bowl convex portion 263 and a rear projecting portion 264.

[0251] The bowl convex portion 263 has at the lower end thereof a lower end projecting portion 265 formed with a

convex shape for defining the contour of the inside peripheral wall of the bowl base portion 13. This lower end projecting portion 265 has an end cutaway portion 266 conforming to the shape of the opening of the trap inlet 22 (see FIGS. 2 and 3) of the ascending conduit segment 24.

[0252] The convex shape of the bowl convex portion 263—apart from this lower end projecting portion 265—defines the contour of the entire inside peripheral wall of the toilet bowl 12, more specifically, the contours of the entire inside peripheral walls of the upper peripheral wall 55, sloped portion 60, sloped portion 61, bottom shelf portion 62 and rear sloped portion 63.

[0253] The rear projecting portion 264 has, on the side thereof facing the bowl convex portion 263, an insert recess 268 for insertion of the split mold 270, described later. The bottom end face and rear face (the left end in the drawing) of the rear projecting portion 264 conform to the exterior contour of the inside of the bottom and the rear wall of the mechanism housing portion 11, so as to form a portion of the cavity section BKK4 described previously.

[0254] As shown in FIG. 37, the split mold 270 is bifurcated into an insert portion 271 that inserts into the insert recess 268 of the bowl insert mold 260; and convex portion 272 for molding the conduit. The relationship of the insert portion 271 and the insert recess 268 is as follows. With the insert portion 271 inserted into the insert recess 268 and the inverted split mold 270 assembled together with the bowl insert mold 260, a cavity is defined without chattering of the split mold 270; and the dimensions and shape of the insert portion 271 and the insert recess 268 have been adjusted such that during the mold parting operation, described later, the bowl insert mold 260 and the split mold 270 can be parted independently.

[0255] An ancillary mold 273 for molding the trap opening is attached to the split mold 270, and by means of magnets (not shown) embedded in the two molds the ancillary mold 273 may be magnetically attached to the bottom side face of the convex portion 272 for forming the conduit. In the completely assembled state, the ancillary mold 273 magnetically attached to the split mold 270 fits, without any clearance, into the end cutaway portion 266 at the lower end projecting portion 265 of the bowl insert mold 260. In this state the split mold 270 leaves a crack present between the convex portion 272 for forming the conduit, and the bowl convex portion 263 facing thereto, this crack constituting the cavity section BKK5 described earlier.

[0256] The convex portion 272 for forming the conduit is shaped to conform to the contour of the inside conduit wall of the ascending conduit segment 24 of the siphon trap 20, so as to define the inside wall contour thereof. The forked connecting portion 274 of the conduit forming convex portion 272 and the insert portion 271 is shaped to conform to the contour of the conduit side wall of the tongue portion 71 and the apical dam 30 of the apical conduit segment 26, so as to define the contours thereof. The lower end face portion 275 of the insert portion 271 is covered with resin or the like to prevent slip from becoming deposited in this area. If the lower end face portion 275 is not covered with resin, slurry deposited in this area should be cut away after parting the mold.

[0257] As shown in FIG. 38, the side mold 280 comprises a toilet front side edge portion 281—serving as the mating

face for the left and right side molds—a toilet rear side edge portion 282; a bottom edge portion 283 serving as the mating face with the bottom mold 250; and a bottom end side edge portion 284 serving as the mating face with the projecting area 254 of the bottom mold 250. The side mold 280 has an outside peripheral recessed portion 285 at a location thereof surrounding by these edge portions. This outside peripheral recessed portion 285 has a shape conforming to the exterior contour of the toilet stool BH, including the mechanism housing portion 11, so as to define the shape thereof.

[0258] When the bottom mold 250 and side molds 280 are assembled as shown in FIG. 33, the cavity BKK described previously is formed by the mold faces. In the toilet rear portion for forming the mechanism housing portion 11, inside split molds 290-293 are assembled between the side molds 280 and the bowl insert mold 260 in order to produce a cavity portion BKK4 appropriate for the shape of the peripheral wall of the mechanism housing portion 11, as depicted in FIG. 39.

[0259] Once the cavity BKK for molding the toilet stool casting BK has been formed by assembling the molds together, the fluid slip is injected into the cavity BKK from an inlet (not shown), and through absorption by the molds a slip layer becomes deposited on the mold surfaces; [the fluid] slip is drained and [the casting] is then dried. In cavity portion BKK1 and cavity portion BKK3 of cavity BKK the slip is deposited in a single layer on each mold face, and in the other cavity portions is deposited in two layers, i.e. with the gap between opposing mold faces filled with slip. Subsequent drying completes the “half drying” process in the cavity, completing the toilet stool casting BK in the cavity BKK.

[0260] Correspondence of cavity portions with castings is now described.

[0261] In cavity portion BKK1 there is formed a casting constituting the following portions of the inside peripheral wall of the toilet bowl 12: the entire extension of the upper peripheral wall 55 and sloping portion 60 at the top edge of the toilet bowl 12, and substantially all of the sloping portion 61; as well as a casting constituting the bottom end leg portion BHK and areas extending along the left and right walls from the toilet stool of the toilet stool BH. In cavity portion BKK2 there is formed a casting constituting the connecting portion of the sloping portion 61 with the bottom shelf portion 62, and the entire area of the bottom shelf portion 62 and the bowl base portion 13. In cavity portion BKK3 there is formed a casting including the bottom end conduit wall of the ascending conduit segment 24 of the siphon trap 20 (i.e. the wall dividing it from the descending conduit segment 28) and the apical dam 30 and tongue portion 71 connected thereto, as well as the elbow conduit segment 72 and the medial conduit segment 73 of the descending conduit segment 28, the upper conduit shelf portion 75 and lower conduit shelf portion 77 in this conduit, and the outside wall portion 76. In cavity portion BKK4 there is formed a casting that extends along the toilet wall surrounding the mechanism housing portion 11; and in cavity portion BKK5 there is formed a casting constituting the entire rear sloping portion 63 that divides the toilet bowl 12 and the ascending conduit segment 24, and the area connecting it to the interior wall of the toilet bowl described earlier.

[0262] After drying to complete the half-drying process, the molds are parted. First, the bottom mold 250 set on top is lifted off and removed, and after removing the mold a through-hole 77mk is made in the casting at the bottom end of the descending conduit segment 28 as shown in FIG. 35. The bottom end wall portion around the through-hole 77mk constitutes the lower conduit shelf portion 77 shown inter alia in FIG. 2. In this stage, the terminal conduit casting MK can be attached to the toilet stool casting BK as described later. Next, the bottom mold 250 is replaced with a support panel for supporting the unmolded section of the casting, and the entire casting is turned over so that the toilet stool casting BK is normally oriented. The bowl insert mold 260, which after turning over is now situated on top, is lifted off. During this process, since the split mold 270 is subjected to a modicum of constricting force in the upward direction by the half dry casting in cavity portion BKK5, the bowl insert mold 260 can be lifted off independently due to the relationship (i.e. dimension/shape adjustments) of the insert portion 271 and the insert recess 268 described previously.

[0263] After removing the bowl insert mold 260, with [the toilet] turned upside down from the orientation depicted in FIG. 33, the split mold 270 is withdrawn diagonally upward and backward, and removed. During this procedure the ancillary mold 273 which is magnetically attached to the split mold 270 is subjected to a modicum of constricting force in the diagonal upward direction by the half dry casting in cavity portion BKK5, and therefore the split mold 270 pulls out in opposition to the magnetic force, leaving the ancillary mold 273 behind. Subsequent removal of the ancillary mold 273 gives accurate forming of the trap opening. During the process of subsequently removing the inside split molds 290-293, as the toilet stool casting BK (which corresponds to the toilet stool BH prior to firing) is completed, all of the pre-cast castings needed to manufacture a toilet 10, i.e., the apical conduit segment casting TK, the rim casting RK, the terminal conduit casting MK, and the toilet stool casting BK, are unified as follows.

[0264] First, the apical conduit segment casting TK and the terminal conduit casting MK are joined to the toilet stool casting BK. The apical conduit segment casting TK is joined to the ascending conduit segment 24 and descending conduit segment 28 of the toilet stool casting BK are connected so as to close off the siphon trap 20 conduit, as shown in FIG. 27. When the terminal conduit casting MK is joined to the descending conduit segment 28, it is positioned corresponding to the drain opening configuration and rough-in of which the toilet 10 is installed. For example, it may be arranged such that the terminal conduit segment 74 of the fired product inserts into the drain opening during toilet installation. Joining of the terminal conduit casting MK is discussed later. Next, the rim casting RK is joined to the top edge of the toilet stool casting BK, and the left and right side molds 280 supporting the toilet stool casting BK are then removed. The resultant toilet 10 casting, after passing through a drying process, is fired under predetermined firing conditions to complete the toilet 10. After firing the flush water supply unit 100 is attached. In the tank model depicted in FIG. 26, a water supply line 151 and reservoir tank unit 150 will be attached.

[0265] As noted, in the process of manufacturing a toilet 10 that features siphoning action generated and sustained with a lower flow of flush water than possible previously,

before the casting is fired, the apical conduit segment casting TK in the wall section serving as the conduit wall face opposite the apical dam 30 in the elbow conduit segment of the apical conduit segment 26 of the siphon trap 20 is absent over an area extending from the ascending conduit segment 24 connecting portion to the descending conduit segment 28 connection portion. It is accordingly possible to form the toilet stool casting BK by inserting into the bowl insert mold 260 the split mold 270 for forming the inside wall of the ascending conduit segment 24, the apical dam 30 and the tongue portion 71. As the inside wall face of the ascending conduit segment 24 and the faces of the apical dam 30 and the tongue portion 71 constitute surfaces produced by intimate contact [of the slip layer] with the surfaces of the split mold 270, the inside wall will be free of bumpiness in these areas, and the apical dam 30 may be given a configuration not possible with conventional molding techniques, namely a portion projecting into the conduit (i.e. the tongue portion 71).

[0266] The split mold 270 for forming the ascending conduit segment 24 and apical dam 30, while subject to certain limitations imposed by the need to insert into the insert recess 268 of the bowl insert mold 260, nevertheless permits a higher degree of freedom as to mold configuration, thus allowing for a greater variety of siphon trap conduit configurations. Accordingly, it is relatively easy to produce toilets having a variety of siphon trap conduit configurations by means of the manufacturing process of this example. Further, the ancillary mold 273 of the split mold 270 joins with to the lower end projecting portion 265 of the bowl insert mold 260, this location serving as the location of the opening for the trap inlet 22, thereby allowing the trap inlet 22 to be formed with a high degree of dimensional accuracy.

[0267] Since the contours of the apical dam 30 and the trap inlet 22 are determined by the split mold 270 and the ancillary mold 273, the height of the bowl water seal in the bowl portion (equivalent to the height difference between the apical dam 30 and the top end of the trap inlet 22), which is dependent on these contours, can be precisely set.

[0268] Water seal height determines trap performance in terms of preventing backflow of small animals and waste from the drain line, and as such must be at least a certain height. If the water seal height is too high, however, waste floating in the bowl water must travel a considerable distance to reach the trap inlet, lowering the ability to flush away waste. Thus the water seal height must be set within an appropriate range so as to assure that these functions will be performed satisfactorily. The toilet and manufacturing method herein offer advantages not found elsewhere in terms of the precision with which water seal height can be set.

[0269] Further, as the terminal conduit segment 74 for insertion into a drain opening is constituted of a separate casting, while the toilet after firing, including the terminal conduit segment 74, consists entirely of porcelain, the terminal conduit segment 74 can be inserted into the drain opening during installation of the toilet 10. This provides a cost advantage since there is no need to pre-install sockets, etc., or for the process/production equipment management entailed in socket production. As the terminal conduit segment 74 inserts in the drain opening for hookup, the siphon trap 20 furnished with this terminal conduit segment 74 can

be adapted to drain opening specifications despite being composed entirely of porcelain. Further, the terminal conduit segment **74**, being molded by means of a female mold **200** and a male mold **210**, can be given cylindrical exterior-wall contours suitable for insertion into a drain opening, while the interior wall contours thereof can be made oval, a configuration that as noted is suitable for accumulating the flush water needed to generate siphoning action and flushing away swabs, etc. The added value of the toilet **10** per se is increased as a result.

[**0270**] The description now turns to another embodiment. In this embodiment siphoning action is generated by means of a high flow of flush water, and siphon trap conduit configuration is substantially identical to existing models. **FIG. 40** is an illustrative diagram illustrating a toilet **300** pertaining to another embodiment.

[**0271**] As shown, this toilet **300** is equipped with a simple elbow siphon trap **20A**, the ascending conduit segment **24A** thereof opening into the toilet bowl **12A** via a trap inlet **22A**. The rim **14** is substantially identical in configuration to that of the toilet **10** described previously, but the flow of flush water from the rim is assumed to be rather high, on the order of approximately 100-150 liters/min.

[**0272**] The siphon trap **20A** of this toilet **300**, like that of toilet **10**, comprises an ascending conduit segment **24A** that forms a conduit leading from a trap inlet **22A** diagonally upward towards the back of toilet; an apical conduit segment **26A** coupled to the top end of the ascending conduit segment **24A** and bending downward; and a descending conduit segment **28A** coupled to the apical conduit segment **26A** and descending therefrom. However, given the assumption that flush water will be supplied at a high rate of flow, the apical conduit segment **26A** simply has a bent convex apical dam **30A** for regulating the level of the bowl water in the toilet bowl **12A**, with the conduit sections described above having substantially identical cross section. With this toilet **300** as well, in the casting stage the terminal portion of the descending conduit segment **28A** is composed of a terminal conduit casting MK separate from the toilet stool casting BKA that includes the rim **14**, toilet stool BH and siphon trap **20A**. As with the toilet **10**, this terminal conduit casting MK is joined to the descending conduit segment **28A** of the toilet stool casting BKA prior to firing. The toilet stool casting BKA has the siphon trap **20A** integrally cast therein by means of a bottom mold, left and right side molds, and bowl insert mold, with the rim casting RK for the rim **14** being a separate element from the toilet stool casting BK.

[**0273**] In this embodiment as well the terminal conduit segment **74** for insertion into the drain opening is a separate casting, thereby providing the same advantages as the terminal conduit segment **74** described earlier.

[**0274**] The description now turns to joining of the terminal conduit casting MK. In the preceding embodiment, the terminal conduit segment **74** is cast as a separate element, and in the fired product the terminal conduit segment **74** is insertable into the drain opening. Where the bottom end of the terminal conduit segment **74** is recessed below the bottom face of the toilet, the drain opening should be extended up from the bathroom floor. By providing a suitable sealing element (packing etc.) between the drain opening extending up from the bathroom floor and the terminal conduit segment **74** inserted therein, wastewater leakage can

be prevented in a reliable manner. Other arrangements are possible as well. **FIG. 41** is an illustrative diagram illustrating arrangements for various rough-ins; and **FIG. 42** is an illustrative diagram illustrating connections of terminal conduit segment **74** to drainpipe.

[**0275**] Rough-in varies by country and region: in Japan, the most common rough-in is approximately 200 mm, in the US approximately 305 mm, in China approximately 305 mm or 405 mm; and in Taiwan approximately 405 mm. In the preceding embodiment the Japanese rough-in of approximately 200 mm is assumed, but in order to accommodate alternate rough-ins the following arrangements are used. **FIG. 41(a)** depicts an arrangement for accommodating a rough-in to 200 mm; **FIG. 41(b)** depicts an arrangement for accommodating a rough-in to 305 mm; and **FIG. 41(c)** depicts an arrangement for accommodating a rough-in to 405 mm. As these show, different rough-ins Rf mean different distances Brf from the back end of the toilet to the terminal conduit segment **74** (specifically, to the center of the water passage hole thereof), this distance Brf being determined by the rough-in Rf.

[**0276**] As shown in **FIG. 41**, for a shorter rough-in Rf the terminal conduit casting MK will be joined to the toilet at a location closer to the back end thereof, and fired together with the toilet stool casting BK. For a longer rough-in Rf the terminal conduit casting MK will be joined a location closer to the toilet bowl end, and fired together with the toilet stool casting BK. That is, the location for joining the terminal conduit casting MK is adjusted with reference to the rough-in Rf. This adjustment is made with reference to the aforementioned distance Brf determined by the rough-in Rf. Where there is considerable offset towards the toilet bowl end, as in the case of rough-in **405**, the terminal conduit casting MK (terminal conduit segment **74**) may have a correspondingly large shape so as to cover the water passage hole at the bottom end of the descending conduit segment **28**. Specifically, a stock of terminal conduit castings MK (terminal conduit segments **74**) having different shapes corresponding to different rough-ins Rf may be prepared, and the location for joining of the terminal conduit casting MK [determined] during the toilet production stage, with reference to the actual rough-in for the region in which the toilet will be installed. By so doing the toilet stool casting BK which molds are rather large and thus difficult to fabricate, store and otherwise maintain, can be standardized. As it is sufficient to have a stock of molds for fabricating the terminal conduit castings MK (see **FIG. 28**)—which are relatively small castings—the costs associated with mold production and management can be reduced. Further, the toilet produced by joining a terminal conduit casting MK and subsequently firing the product enables the porcelain toilet per se to be adapted to different rough-ins—one of the specifications for a drain opening.

[**0277**] As shown in **FIG. 41(c)**, where the terminal conduit casting MK (terminal conduit segment **74**) is larger the conduit segment thereof may not be able to insert into the drain opening, in which case the following measure should be taken. The perimeter of the drain opening is sealed by forcing an annular sealing element around the drain opening at the bottom face of the terminal conduit segment **74**, which will allow flush water to drain into the drain opening without leakage.

[0278] The description now turns to an arrangement for connecting the terminal conduit segment 74 to a drain opening that extends substantially to floor level, rather than inserting the terminal conduit segment 74 into a drain opening extending above floor level. As shown in FIG. 42(a), a first method is to arrange a drain connector HSC on the drain opening HS extending up to the floor. This drain connector HSC is a straight pipe, the top half of which clamps around the terminal conduit segment 74 by means of a clamping portion UP to seal it. The lower half of the drain connector HSC is an insert portion DP that inserts into the drain opening HS to provide a drain seal. By so doing the terminal conduit segment 74 facing to the drain opening HS can be connected to the drain opening HS via a drain connector HSC to provide a reliable drain seal. Since the drain socket HSC is simply a straight pipe composed of a clamping portion UP and an insert portion DP and its shape is integrated, the component cannot be installed incorrectly, and is easy to handle.

[0279] A second method, depicted in FIG. 42(b), is to provide the terminal conduit segment 74 with a disk-shaped flange 74f extending around the peripheral wall in proximity to the bottom end of the terminal conduit segment 74. The terminal conduit segment 74 of this configuration may be manufactured by allowing the female mold 200 depicted in FIG. 28 to split into upper and lower sections, and forming a cavity for molding the flange 74f on the parting faces. Prior to installation of the toilet a drain flange HSF having a flange at its top end is inserted into the drain opening HS, and an annular sealing element (a so-called "P seal") is arranged between the flange 74f of the terminal conduit segment 74 and the flange portion of the drain flange HSF. The flange 74f of the terminal conduit segment 74 forces the P seal around the drain opening HS to provide sealing, thus preventing leakage of wastewater. By so doing, connection to the drain opening HS and prevention of leakage of wastewater can be accomplished with terminal conduit segment 74 per se, obviating the need for an elbow socket etc. so as to provide simpler installation.

[0280] While the present invention has been described hereinabove with reference to certain preferred embodiments, these are merely illustrative and not limiting of the invention, with various modifications and improvements being possible without departing from the scope and spirit of the invention.

[0281] For example, whereas in the preceding embodiments the first principal flow S1 is generated by convergence of flush water discharged from the basal first nozzle hole 41 and flush water discharged from the basal second nozzle hole 42, the first principal flow S1 may consist solely of flush water discharged from a single nozzle of slot configuration.

[0282] In the toilet 10 depicted in FIGS. 2, 26 etc., the apical conduit segment 26 may be given a conduit area approximately equal to that of the ascending conduit segment 24 as shown in FIG. 43, so that air present in the apical conduit segment 30 is pushed out by flush water rising up the ascending conduit segment 24, and flows into the conduit downstream from the apical conduit segment. With this arrangement as well, the conduit arrangement of the descending conduit segment 28 ensures that the water column will not be broken by rising air via the air seal below the tongue portion 71, and accordingly that siphoning action

will not be lost. Advantages analogous to those of the preceding embodiments are provided thereby.

[0283] Alternatively, as shown in FIG. 44 the rim 14 may be provided with a first nozzle hole 41a situated at the rear left side of the toilet and a second nozzle hole 43a situated at the front right side of the toilet, these two nozzle holes being situated at diagonally opposite side of the center of the bowl water RS as viewed in the horizontal plane of the toilet. The first principal flow S1 and second principal flow S2 generated by discharge of flush water from these two nozzle holes converge with the bowl water RS substantially parallel to either side of the bowl water RS, and the convergence of the two principal flows creates a circular flow moving in one direction in the bowl water RS. This modification accordingly offers the same advantages as does toilet 10 described previously. Flush water may be directed into the second nozzle hole 43a by the rim perforate passage 16, or by means of a hose 43b. The second principal flow S2 from the second nozzle 43a may be stabilized by installing a nozzle head in the nozzle hole.

#### INDUSTRIAL APPLICABILITY

[0284] The invention is applicable in manufacture of a toilet designed to flush by discharging flush water into the toilet bowl, and a toilet of this kind having a siphon trap.

1. A toilet for discharging the supplied flush water from the top of the toilet bowl to create circular flow in the bowl water held in the toilet bowl to effect flushing of the toilet, comprising:

- a perforate passage for guiding the flush water the top of the toilet bowl,
- a discharger disposed in the perforate passage and for creating confluence of the flush water with the bowl water in a flow arrangement composed of two principal flows, and

the discharger discharging the flush water in a bowl water confluence arrangement wherein the two principal flush water flows are converged with the bowl water as streams substantially parallel to either side of the bowl water, as viewed in the horizontal plane of the toilet, and are converged with the bowl water in such a way as to create circular flow in the bowl water in the same circling direction.

2. The toilet according to claim 1 wherein the perforate passage discharger comprises:

- a first discharger for directing flush water in the perforate passage towards the toilet front end on the diagonal with respect to the bowl water to create a first principal flush water flow which is the first of the two principal flush water flows;
- a second discharger for discharging flush water in the perforate passage from the same side as the first discharger with respect to a center axis dividing the toilet into left and right halves, to create on the toilet bowl surface above the surface of the bowl water a flow of flush water circling along the surface of the bowl; and
- a third discharger converging with the flow of flush water from the second discharger so as to correct the flow of flush water from the second discharger, the corrected second discharger flush water flow constituting a sec-

ond principal flush water flow which is the second of the two principal flush water flows.

3. The toilet according to claim 2 wherein the first discharger discharges flush water in the perforate passage from a plurality of nozzle holes formed in the perforate passage, the flush water streams from each nozzle hole converging to create the first principal flush water flow.

4. The toilet according to claim 2 or 3 wherein the third discharger comprises:

a fourth discharger for discharging flush water in the perforate passage towards the bowl water at the front end of the toilet bowl so as to converge with the flow of flush water from the second discharger and correct the direction of flow of flush water from the second discharger towards the surface of the bowl water; and

a fifth discharger for discharging flush water in the perforate passage from the side opposite to the first discharger with respect to a center axis dividing the toilet into left and right halves so as to converge with the flush water flow from the second discharger corrected by flush water from the fourth discharger, to further correct the flow direction thereof at the bowl water surface side, and for converging the corrected flow of flush water from the second discharger constituting the second principal flush water flow to bring about convergence thereof with the bowl water with the first principal flush water flow according to the bowl water confluence arrangement mentioned above.

5. The toilet according to claim 4 wherein the perforate passage further comprises an auxiliary discharger, separate from the first to fifth dischargers, for discharging along the surface of the toilet bowl flush water guided through the perforate passage, the flush water, including the flush water discharged from the auxiliary discharger, flowing over substantially the entire surface of the toilet bowl.

6. The toilet according to one of claims 1 to 5 wherein the toilet bowl comprises:

a first bowl peripheral wall for receiving the first principal flush water flow and guiding the same into circular motion, and for regulating the circular flow of flush water after the first principal flush water flow has converged with the bowl water; and

a second bowl peripheral wall for receiving the second principal flush water flow and guiding the same into circular motion, and for regulating the circular flow of flush water after the second principal flush water flow has converged with the bowl water.

7. The toilet according to claim 6 wherein the first and second bowl peripheral walls create a differential in the condition of circular flow of flush water subsequent to convergence with the bowl water, with one of the bowl peripheral walls producing a large circular lead in the depthwise direction of the bowl water, and the other bowl peripheral wall producing a small circular lead in the depthwise direction of the bowl water.

8. The toilet according to claim 7 wherein the second bowl peripheral wall produces a large circular lead of the second principal flush water flow, and the first bowl peripheral wall produces a small circular lead of first principal flush water flow.

9. The toilet according to claim 8 wherein the first bowl peripheral wall comprises a guide shelf formed enclosing the

bowl water on the side opposite the trap opening into the base of the toilet bowl, for receiving the first principal flush water flow, the guide shelf being situated at substantially equal height with the surface of the bowl water, and producing in the first principal flush water flow the small circular lead circular flow condition; and

the second bowl peripheral wall comprises a peripheral wall portion having a steeper slope than the guide shelf across the vertical direction of the bowl water, for receiving the second principal flush water flow and producing in the second principal flush water flow the large circular lead circular flow condition, at the location where the second principal flush water flow converges with the bowl water.

10. The toilet according to claim 9 wherein the peripheral wall portion of the second bowl peripheral wall is such that the percentage of expansion in area of the bowl water surface occurring with a rise in bowl water level due to inflow of flush water into the bowl water is within about 40% of the original area.

11. A toilet for discharging a supplied flush water from the top of the toilet bowl to create circular flow in the bowl water held in the toilet bowl to effect flushing of the toilet, comprising:

a perforate passage for guiding the flush water around the top of the toilet bowl,

the perforate passage having two dischargers for discharging flush water from diametrically opposite locations about the center of the bowl water as viewed in the horizontal plane of the toilet, each the discharger directing the flush water into convergence with the bowl water so as to create circular flow in the same direction in the bowl water.

12. A toilet for flowing the supplied flush water into bowl water held in a toilet bowl and draining it away together with the bowl water from a siphon trap, wherein

the siphon trap comprises:

an ascending conduit segment having a trap opening that opens into the underside wall of the toilet bowl, and defining a conduit that extends diagonally upward from the trap opening;

an apical conduit segment of elbow configuration connecting to the top end of the ascending conduit segment, having an apical dam for regulating the level of the bowl water; and

a descending conduit segment connecting to the apical conduit segment and descending therefrom, the descending conduit segment comprising a conduit shelf for receiving and deflecting flush water flowing into the ascending conduit segment, over the apical dam of the apical conduit segment, and down into the descending conduit segment due to inflow of the discharged flush water into the bowl water; a downstream conduit segment for guiding flush water deflected by the conduit shelf towards the downstream end; and a constrictor having a constricted conduit area situated at the terminus of the downstream conduit segment, for guiding flush water to a drain opening outside the toilet;

the descending conduit segment having a descending conduit configuration, as flush water conveyed from the ascending conduit segment drains to the drain opening, to reception by the conduit shelf of flush

water flowing down over the apical dam, to diversion of the flow direction of the flush water downflow towards the constrictor, and to accumulation of the flush water downflow in the constrictor, whereby a seal is produced in the constrictor by means of flush water from the upstream conduit, and such that even with air trapped in the conduit segment extending from the apical conduit segment to the conduit shelf, flush water accumulating in the constrictor forms a water column extending up to the apical dam, and once the water column has formed, with the trapped air sealed in the apical conduit segment, siphoning action is generated to suck down the flush water in the toilet bowl and the siphoning action may be sustained.

**13.** A toilet for flowing the supplied flush water into bowl water held in a toilet bowl and draining it away together with the bowl water from a siphon trap, wherein

the siphon trap comprises:

an ascending conduit segment having a trap opening that opens into the underside wall of the toilet bowl, and defining a conduit that extends diagonally upward from the trap opening;

an apical conduit segment of elbow configuration connecting to the top end of the ascending conduit segment, having an apical dam for regulating the level of the bowl water; and

a descending conduit segment connecting to the apical conduit segment and descending therefrom, the descending conduit segment comprising a conduit shelf for receiving and deflecting flush water flowing into the ascending conduit segment, over the apical dam of the apical conduit segment, and down into the descending conduit segment due to inflow of the discharged flush water into the bowl water; a downstream conduit segment for guiding flush water deflected by the conduit shelf towards the downstream end; and a constrictor having a constricted conduit area situated at the terminus of the downstream conduit segment, for guiding flush water to a drain opening outside the toilet;

the descending conduit segment having a descending conduit configuration, as flush water conveyed from the ascending conduit segment drains to the drain opening, to reception by the conduit shelf of flush water flowing down over the apical dam, to diversion of the flow direction of the downflowing flush water towards the constrictor, and to accumulation of the downflowing flush water in the constrictor, whereby a seal is produced in the constrictor by means of flush water from the upstream conduit, and such that when air present in the apical conduit segment is pushed by flush water rising up the ascending conduit segment and flows into the conduit downstream from the apical conduit segment, the inflowing air is trapped at a location downstream from the apical conduit segment and prevented thereby from returning to the apical conduit segment, whereby flush water accumulated in the constrictor forms a water column extending to the apical dam, so that siphoning action is generated to suck down the flush water in the toilet bowl and the siphoning action may be sustained.

**14.** The toilet according to claim 12 or 13 wherein the apical dam comprises a guide piece for guiding flush water such that flush water descends in toward the conduit shelf, the guide piece projecting out such that underside of the

guide piece constitutes an air reservoir for air rising from the conduit segment below the conduit shelf.

**15.** The toilet according to one of claims 12 to 14 wherein the descending conduit segment has a descending conduit configuration whereby the siphoning action may be generated and sustained with inflow of the flush water supplied to the bowl water at a flow rate of about 50-100 liters/min.

**16.** The toilet according to one of claims 12 to 15 wherein the apical conduit segment has a conduit configuration such that the flow of flush water flowing over the apical dam and descending into the descending conduit segment partitions the part of the conduit segment connecting with the descending conduit segment as a residual air area.

**17.** The toilet according to claim 16 wherein the apical conduit segment connects the ascending conduit segment to the descending conduit segment by a sectional area larger than the conduit sectional area of the ascending conduit segment.

**18.** The toilet according to claim 17 wherein the descending conduit segment has a descending conduit configuration wherein the area of the conduit cross section gradually constricts going from the conduit shelf to the constrictor, until the area thereof is at least about equal to the conduit cross sectional area of the ascending conduit segment.

**19.** The toilet according to claim 18 wherein the conduit cross section of the descending conduit segment may have a cross sectional shape constricting towards the center axis of the conduit in the lateral direction of the toilet.

**20.** The toilet according to claim 19 wherein the descending conduit segment is arranged such that the descending conduit segment guides downflowing flush water flowing over the apical dam to be deflected towards the toilet bowl and into the constrictor,

the constrictor comprising a shelf portion for receiving the guided flush water on the toilet bowl side, and after the flush water is received by the shelf portion the flush water being guided into the drain opening.

**21.** The toilet according to one of claims 12 to 20 comprising the perforate passage according to one of claims 1 to 5 for directing a flow of supplied flush water into the bowl water held in the toilet bowl; and

a toilet bowl having a peripheral wall shape in compliance with one of claims 6 to 9 effective in inducing such circular flow.

**22.** A toilet comprising: a toilet bowl for holding bowl water; a toilet stool for supporting the toilet bowl; and a siphon trap conduit for generating a siphoning action when flushing away waste, wherein the siphon trap conduit comprises an ascending conduit segment extends diagonally upward from a trap opening that opens into the underside wall of the base portion of the toilet bowl; an apical conduit segment forming an elbow conduit connecting to the top end of the ascending conduit segment and having an apical dam for regulating the level of the bowl water; and

a descending conduit segment connecting to the apical conduit segment and descending therefrom,

wherein a portion of the wall of the elbow conduit of the apical conduit segment, the wall portion constituting the conduit wall opposite the apical dam, and extending from the coupling portion with the ascending conduit segment to the coupling portion with the descending conduit segment, is composed of a discrete element in

the casting stage prior to firing of the toilet, [the element] being separate from the toilet stool, the toilet bowl, and the remainder of the siphon trap conduit exclusive of the wall portion,

the wall portion casting being joined to the remainder of the siphon trap conduit to close off the siphon trap conduit, and fired.

**23.** The toilet according to claim 22 comprising a terminal conduit segment situated at the terminus of the siphon trap conduit and connecting with a drain opening outside the toilet, the descending conduit segment being to the drain opening via the terminal conduit segment,

the terminal conduit segment constituting, in the casting stage prior to firing of the toilet, a separate element from the siphon trap conduit, the toilet bowl and the toilet stool,

the terminal conduit segment casting being joined to the terminus of the siphon trap conduit in the casting stage, and fired.

**24.** A toilet comprising a toilet bowl for holding bowl water; a toilet stool for supporting the toilet bowl; and a siphon trap conduit for generating a siphoning action when flushing away waste, the toilet further comprising:

a terminal conduit segment situated at the terminus of the siphon trap conduit and connecting with a drain opening outside the toilet, the terminal conduit segment connecting the descending conduit segment to the drain opening via the terminal conduit segment,

wherein the terminal conduit segment constitutes, in the casting stage prior to firing of the toilet, a separate element from the casing composed of the siphon trap conduit, the toilet bowl and the toilet stool,

the casting for the terminal conduit segment being joined to the terminus of the siphon trap conduit in the casting stage, and fired.

**25.** The toilet according to claim 23 or 24 wherein the terminal conduit segment is selected from a plurality of shapes thereof prepared with reference to difference distances between the drain opening and the toilet back, the joining location thereof in the casting stage being adjusted with reference to the distance.

**26.** The toilet according to claim 25 wherein the terminal conduit segment is arranged facing the drain opening and an annular sealing element is forced around the drain opening to effect sealing of the drain opening, for waste water to drain into the drain opening.

**27.** The toilet according to claim 25 wherein the terminal conduit segment is arranged facing the drain opening and connected to the drain opening via a drain connector situated between the drain opening and the terminal conduit segment, for waste water to drain into the drain opening.

**28.** The toilet according to claim 25 wherein the terminal conduit segment is inserted into the drain opening.

**29.** A method for manufacturing a toilet comprising a toilet bowl for holding bowl water; a toilet stool for supporting the toilet bowl; and a siphon trap conduit for generating a siphoning action when flushing away waste, wherein the siphon trap conduit comprises an ascending conduit segment extending diagonally upward from a trap opening that opens into the underside wall of the base portion of the toilet bowl; an apical conduit segment forming an elbow conduit connecting to the top end of the ascending conduit segment and having an apical dam for regulating the

level of the bowl water; and a descending conduit segment connecting to the apical conduit segment and descending therefrom,

the method comprising the steps of:

- (1) molding a casting for a wall portion constituting the conduit wall opposite the apical dam, and extending from the coupling portion with the ascending conduit segment to the coupling portion with the descending conduit segment;
- (2) molding a casting for a toilet integrally composed of the toilet stool, the toilet bowl and the siphon trap conduit apart from the wall portion; and
- (3) joining the wall portion casting to the toilet casting to close off the siphon trap conduit, and with the ascending conduit segment, apical conduit segment and descending conduit segment connected to form the siphon trap conduit, subjecting the same to firing;

wherein the step (2) comprises the steps of:

preparing a bottom mold having a concave shape conforming to the bottom wall contours of the toilet bowl, the bottom wall contours of the toilet stool, and the exterior contours of the descending conduit segment of the siphon trap conduit, excepting the wall portion;

side molds having concave shape conforming to the side wall contours of the toilet stool;

a bowl insert mold having a convex shape conforming to the inside peripheral wall contours of the toilet bowl; and

a split mold having exterior contours conforming to the conduit inside wall contours of the ascending conduit segment of the siphon trap conduit and to the apical dam contours of the apical conduit portion, and capable of being assembled with the bowl insert mold, the split mold, when assembled with the bowl insert mold, joining therewith in portion conforming to the bottom inside wall of the toilet bowl of the convex shape of the bowl insert mold, the joining location serving as the opening location for the trap opening;

assembling the prepared molds to form, by means of the concave contours and convex contours of the molds, a cavity for molding the toilet casting, [the casting] integrally composed of the toilet stool, the toilet bowl and the siphon trap conduit apart from the wall portion; and

flowing slip into the cavity to deposit a slip layer on the molds, draining, drying, and parting the molds to produce the toilet casting.

**30.** The method for manufacturing a toilet according to claim 29 further comprising the steps of:

forming a casting for a terminal conduit segment, the terminal conduit segment being situated at the terminus of the siphon trap conduit and connecting with a drain opening outside the toilet with the terminal conduit segment connecting the descending conduit segment to the drain opening; and

prior to the step (3), attaching the terminal conduit segment casting to the terminus of the siphon trap conduit in the casting state.

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