1983
DESIGN INSTITUTE
Shell Design Award

WATERMASTER®

Detailed Watering Mechanism

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The Watermaster® Cap is at the heart of the Watering System™. The Watermaster® battery venting and watering cap comprises a simple float actuated valve housed in a small protective compartment or bowl above the battery cell, and a **Level Sensing Tube (LST)** which protrudes into the battery cell. **(Fig. 1)** The Watermaster® cap uses **simple natural forces without any complicating mechanical linkages to achieve the highest possible reliability.** No other watering system has less components to control the flow from source to cell.

Watermaster® is the easiest single-point cap to install and to use.

It utilizes low pressure gravity feed ensuring the lowest possible risk of water leakage at all times.

Fifteen years of experience backed by continuous development and the sale of millions of caps world-wide provide authentic and fundamental assurance of reliability and dependability.

The float and the valve do not perform essential functions in the Watermaster® cap - they're important, of course, but not essential.

The shape of the device and the dimensions of the bowl, tube and hole actually determine the flow of liquid and the final level of the electrolyte upon filling.

The principle of operation of the Watermaster® cap is easier to understand without the float and valve in the picture. These two components are therefore left out until later in the explanation. And, as will be seen, Watermaster® will still work without these components, albeit with restricted performance. **(Fig. 2)**

Thus, in its basic form, Watermaster® comprises a bowl with a hole in the bottom, and a tube attached to the bottom of the bowl concentric with the hole. Two breather pipes allow gas to escape from the cell and provide essential pressure equalization between the interior of the cell and the exterior ambient pressure.

Water is poured into the bowl to the level shown. **(Fig. 3.)** Since there is a hole in the bottom, the water runs out. Water is added to keep the level in the bowl constant. The cell fills until the level of the electrolyte rises to cover the opening at the bottom of the LST.

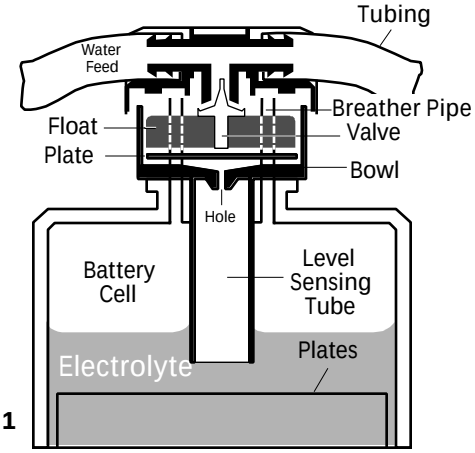


Fig. 1

Simplified Representation of Watermaster® Cap

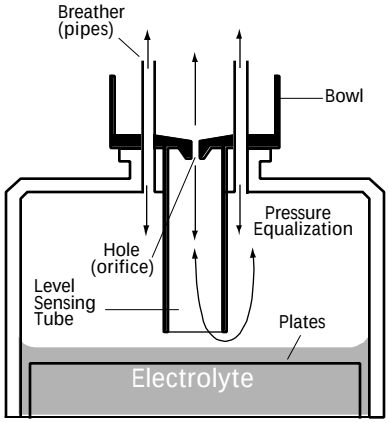


Fig. 2

Elementary Representation of Watermaster® Cap with Float and Valve Removed

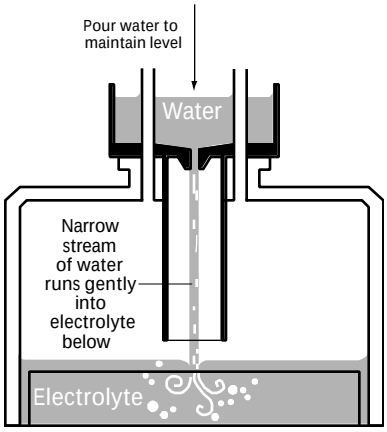


Fig. 3

Watermaster® Cap Operation: Basic Principles.

This causes the air pressure inside the LST to begin rising as the liquid level inside the LST attempts to rise and remain equal with the liquid level exterior to the LST. **(Fig. 4)**

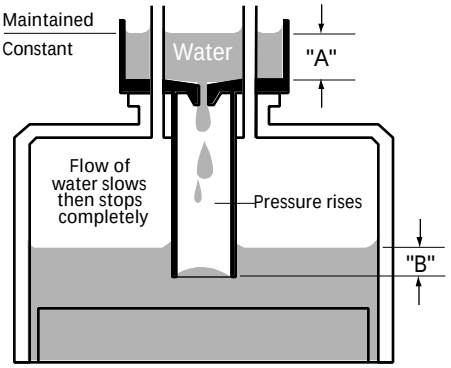


Fig. 4

Surface tension of the water in the orifice prevents air from escaping from the level sensing tube.

As the pressure rises inside the LST, the water flow out of the bowl via the hole will be progressively impeded, until finally it will stop.

The two breather pipes will maintain the pressure inside the cell itself at ambient throughout the entire filling phase. It is irrelevant whether the cell is of sealed construction or not.

When the flow of water finally stops, "A" will be approximately equal to "B" - since the pressure inside the LST pushing upwards through the hole will equal the pressure exerted by the depression of electrolyte at the bottom. Column "A" will approximate column "B," though "B" will be slightly shorter due to the higher SG of the electrolyte - the difference being of no practical significance.

The size of the hole as well as the liquid level inside the bowl determines the flow rate into the cell. The length of the LST determines the final filling level of the electrolyte. The float and valve have very little influence on these two factors.

Surface tension of the water in the hole provides a membrane-like barrier between the air inside the LST and the liquid in the bowl above. There's no likelihood of any air escaping during filling.

The hole provides one-way valve action without the use of any mechanical moving parts. If the water in the hole is lost, all it takes to renew the valve is a little more water.

The size of the hole is not critical to proper operation. If too small, the flow will be too slow. If too large, however, the valve-like action will be lost because the surface tension of the water will not be able to sustain the integrity of the water seal. The practical working size of the hole provides ample flow and an excellent safety margin in both directions.

By restricting the flow of water into the bowl deliberately, the water barrier across the hole will not be lost. The barrier will remain in place for days after the flow of water into the bowl is cut off. On most batteries the barrier will never disappear because there will be continuous replenishment from the acid mist or spray given off by normal cell activity. The point being made here is that the seal is NOT a fragile contrivance or artifice. It will not vanish suddenly. Neither is it affected by changes in temperature or surfactants - substances which radically change the surface tension of water. By way of example, the continuous presence of traces of battery acid within the hole greatly enhances wetting, yet neither the flow rate nor the final filling level are affected. The tiny spout which projects from the bottom of the hole is responsible for this. It makes sure that when flow ceases, there will always be a substantial "plug" of water remaining in the hole, with a well formed, and therefore **very strong**, drop at the bottom.

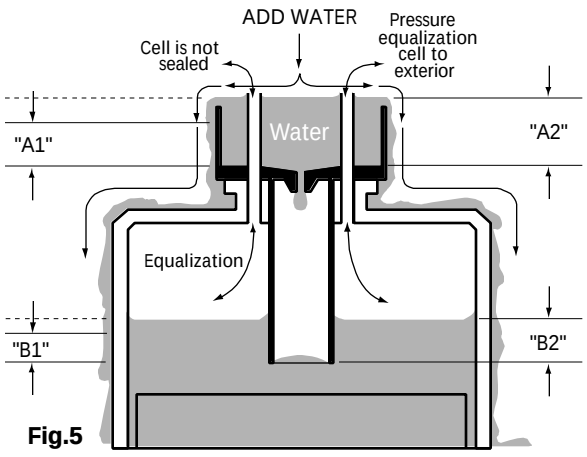


Fig.5

The liquid that overflows is plain water, not battery acid.

Note, that on this scale, a drop of water is very tough indeed.

Adding too much water to the bowl **(Fig. 5)** won't lead to any overflowing of the cell. The very principle upon which Watermaster® is based guards against that. There's absolutely no mechanism involved. And since there's no mechanism involved, the overflow guard is very reliable.

Adding too much water raises the level in the bowl, and the bowl simply overflows. The more water that is added, the greater will be the overflow rate.

A tiny initial additional amount of water will enter the cell, raising the level from "B1" to "B2," since "A1" has risen to "A2." As soon as the bowl begins to overflow, the level "A2" is stabilized, hence "B2" will automatically be stabilized as well. It's as simple as that.

Taking matters to the extreme, imagine the ultimate fault: A defective reservoir stop-valve which allows water to run unimpeded to the battery, as well as total failure of all the floats in the caps. All that will happen is that after each cell has accepted just over the normal amount of water, the contents of the reservoir will be meticulously diverted by each and every cap - the water will end up on the floor, and not inside the cells. The electrolyte in the cell rises only slightly and in fact no electrolyte is spilled. Watermaster® has this exclusive **Fail to Safe** feature, no other watering system can match it.

By rigorously eliminating every single moving part, every bit of mechanical control, and by deliberately feeding water into the battery under such a desperate situation, the individual cells of the battery will be topped, indeed will still be filled to virtually the exact required level, plus a tiny additional amount only. Shouldn't every battery watering system be able to do that? Clearly they should - but none other has been able to even come close.

If the cap, as shown, **(Fig. 6)** is permitted to dry out - for whatever reason, and assuming an already correct electrolyte level in the cell, the pressure inside the LST will be at ambient, thus water will enter the cell.

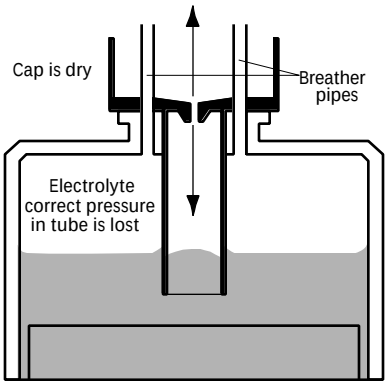


Fig. 6

Quandary: What to do if the cap should dry out?

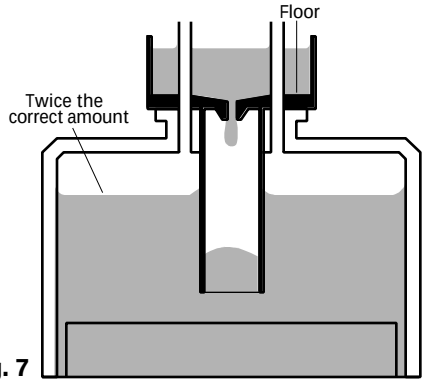


Fig. 7

Solution to the potential for a high level of electrolyte.

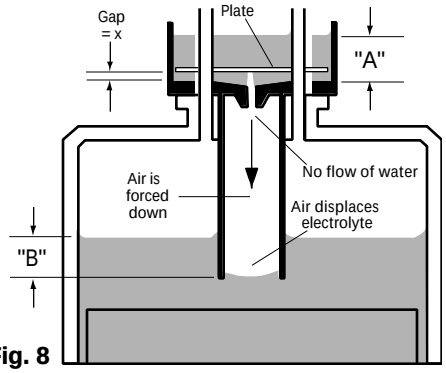


Fig. 8

The Plate - a Watermaster® first

The cell would be filled to a higher level which corresponds to twice the regular dimension above the lower end of the LST.

If filling is repeated a sufficient number of times in succession in this way, progressive overfilling would be the result. **(Fig. 7)**

This is totally unacceptable. Fortunately there is a simple solution to this progressive overfilling complication which involves nothing other than a simple baffle plate positioned immediately above the hole in the floor of the bowl. **(Fig. 8)** This principle

is patented world-wide.

Watermaster® has a baffle plate above the base or "floor" of the bowl, which is positioned quite close to the hole. The floor of the bowl is contoured to increase the spacing between the plate and the floor progressively towards the center. **(Fig. 8)**

Water flowing under the plate initially meets resistance as it begins to flow under the perimeter of the plate, which falls off as the water nears the center, and the hole.

However, since the plate possesses a comparatively large perimeter, the total area available under the perimeter to the flow of water is much larger than the cross sectional area of the hole. The flow of water is therefore only impeded during the initial start-up phase of filling, when the bowl has not yet been filled.

The effect of the restriction is to encourage the first few drops of water entering the bowl to fully encircle the outer perimeter of the plate. This seals off the volume of air under the plate against escape upwards.

As more and more water enters the bowl, the air trapped underneath the plate is injected into the LST, and this volume of air will displace sufficient electrolyte down the LST to prevent the progressive overfilling complication entirely. This Air Injection Guard™ against overfilling of the cell is a Watermaster® exclusive.

Column "A" and column "B" will remain essentially the same with the baffle in. The gap may be reduced significantly, until the effective area under the perimeter of the plate provides more impediment to the flow than the hole, column "B" will be reduced in height, and is now shown as "C," while column "A" remains unchanged. **(Fig. 9)**

While a reduction in the height of column "B" to "C" is an advantage, the flow rate decreases at the same time, and this may be unacceptable.

A further solution is easily at hand. **(Fig. 10, 11)** Column "C" can be maintained, as well as the original flow rate, by "corrugating" concentric circles on the floor of the bowl, and bringing the "crests" of the "corrugations" very close to the bottom of the plate, while at the same time keeping the "troughs" well away from the base plate. By narrowing the "crests" as much as possible, and by widening the "troughs," a very good flow rate is maintained, while significantly improving the "dry starting" capability of the cap.

Watermaster® caps may therefore be operated with confidence on batteries under conditions of light as well as heavy water usage.

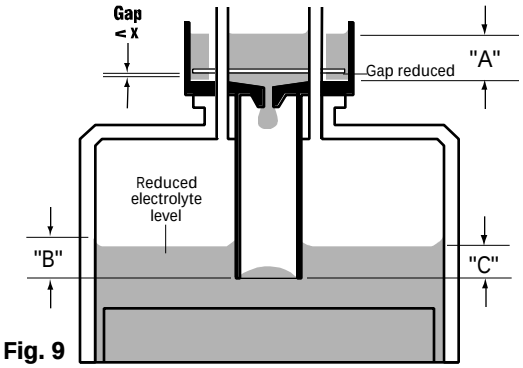


Fig. 9

Characteristics of the Plate.

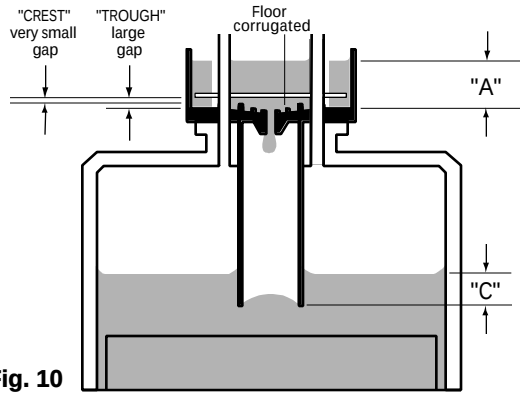


Fig. 10

Optimizing the Plate.
Corrugated Floor.

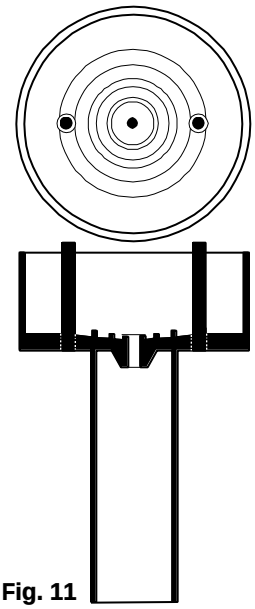


Fig. 11

Top & Cross section view of Watermaster® Cap

The corrugations in the floor of the bowl provide steps of resistance against the radial flow of water, from the perimeter directly to the hole in the center. At the same time, the corrugations promote circular flow. Concentric water barriers of high integrity are created in this way one after the other with decreasing radii, providing higher pressure and forcing more air into the LST at the beginning of every filling.

At this point, a float with a small valve and an appropriate cover, as well as a suitable water tubing connector are introduced. **(Fig. 12)**

The float is extremely simple - because simplicity is the easiest way to maximize reliability. The valve is a simple cone, which slides smoothly into the valve seat closing off the water flow into the bowl when the electrolyte reaches the required level inside the cell below.

When the electrolyte level rises to cover the lower end of the LST, the flow of water via the hole will begin to slow, resulting in a little surplus water pooling up in the bowl. Consequently, the level in the bowl will rise, partially closing off the valve, and thereby controlling the flow of water into the bowl to exactly match the outflow. The rising electrolyte increases the pressure inside the LST - closing off the water flow from the bowl into the cell, hence will thrust the float upwards until it closes the valve, completely stopping the water flow into the bowl. **(Fig. 13)**

At this point the flow of water into the cell ceases altogether, leaving a small residue of water inside the bowl of the watering cap itself.

During charging, the battery cells produce a significant amount of gas as well as acid mist or spray. The Watermaster® cap is designed to capture a maximum of this mist or spray and to return it to the cell, while allowing gases to escape unimpeded. A charging cell with an electrolyte SG of 1280 will give off a mist or spray with an SG of at least 1100. Condensate of this mist is returned to the cell, rather than allowing it to escape. Its presence inside the Watermaster® cap during charging greatly enhances cleaning of the interior of the cap because the condensate is virtually a "distillate" of battery acid and is remarkably pure. **(Fig. 14)** Since much of the distillate is returned to the cell the battery top remains cleaner and requires less frequent cleaning.

Surprisingly, the interiors of modern industrial lead-acid battery cells aren't particularly clean. A number of substances are given off by the plates, as

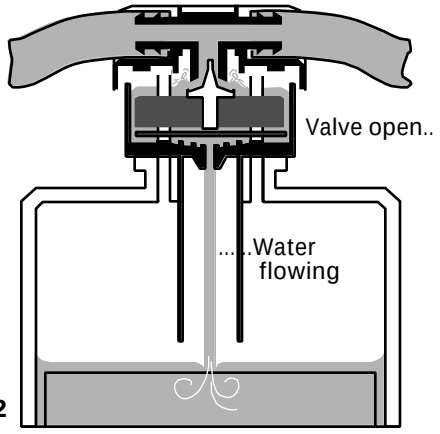


Fig. 12

Finally introducing the Float & Valve, etc.

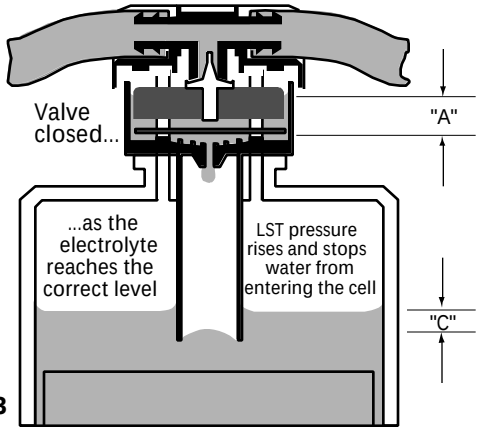
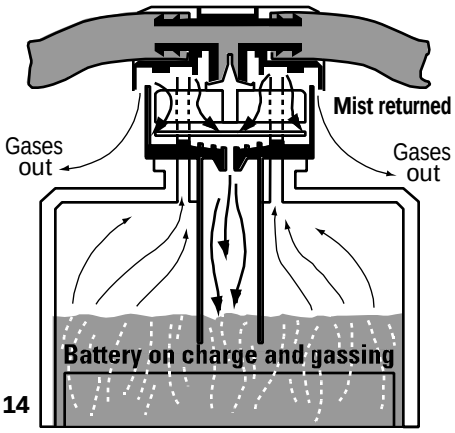


Fig. 13

Rising electrolyte increases the pressure inside the LST- closing off the water flow from the bowl into the cell, hence the float rises thrusting the float upwards until it closes the valve, completely stopping the water flow into the bowl.



Fig, 14

Watermaster® is self cleaning

well as the separators - some settling to the bottom, and some floating to the surface forming an oily black glutinous substance which sticks to everything, especially the parts of permanently fitted single point watering devices protruding into the cells. In time, this substance will work its way into every
available corner. It will enter every duct, and deposit itself on every single component - driven by the almost ceaseless activity of the electrolyte through movement, alternating expansion and contraction and gassing. The oil will slowly leach out of these deposits, leaving an ever-thickening ADHESIVE substance behind which will jam up every single piece of mechanism within reach.

Watering caps with mechanisms protruding into the cells are especially at risk. Watering caps with their mechanisms housed EXTERNAL to the cells are not. Watering caps with their mechanisms protruding into the cells, shrouded or encapsulated for protection, are still at risk. This is because there is invariably a hole or aperture at the bottom, in contact with the electrolyte, through which the water must enter the cell and through which the air inside the cell must enter the filling device to enable the suction or vacuum operated mechanism to determine the level of the electrolyte.

It is now universally acknowledged that single point filling has turned out to be infinitely more difficult in practice than had been anticipated. There are many new devices which regularly appear on the market accompanied by a blaze of advertising claims, only to retreat into oblivion a short time later. A mere handful appear to have addressed the problems correctly, and have grown in strength over the last ten years or so. Without exception, these products were based on designs which were tolerant to abuse and capable of receiving improvements in accordance with application requirements. Significantly, all these successful designs used floats in one way or another, (a historical anomaly which is curiously out of step with the pure “contact-free” philosophy espoused by most modern engineering devotees).

In Watermaster®, the float was taken right out of the cell, and placed inside a small protective compartment above the cell. Placing the float on top of the cell takes it as far away as possible from the oily black deposits, which protects it against mechanical interference, and provides a unique overflow protection mechanism that will vent pure water, rather than battery acid, in case the valve-float assembly fails to close off due to any reasons whatsoever. **(Fig. 15)**

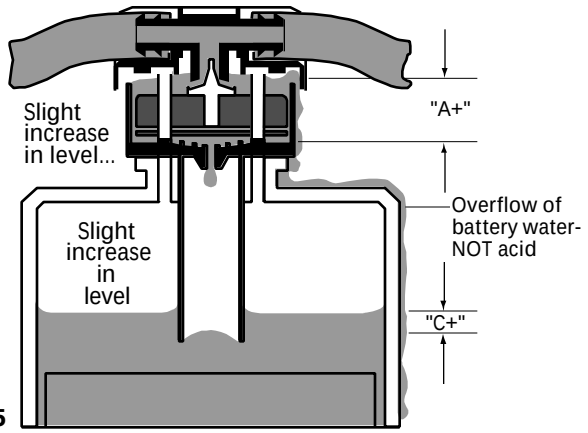


Fig. 15

Worst case problem.
Water vents, not acid

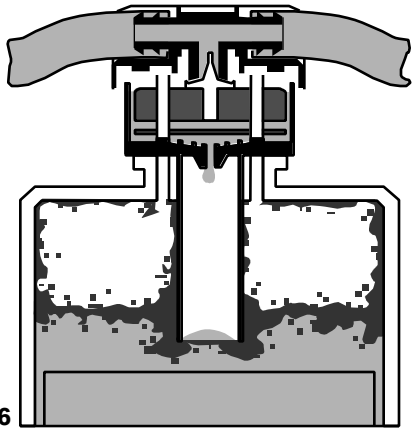


Fig. 16

Covered in dirt, unimpeded in operation.

The interiors of Watermaster® caps which have seen over ten years of use are invariably still clean though slightly browned. No solid deposits form on the float or on the valve, although the LST which projects into the cell may be thickly coated inside, as well as outside, with black deposit. **(Fig. 16)** Even the breathers may be slightly coated

inside - but never the valve-float assembly. Although the valve is small, and is operated directly by the float without any force multiplication whatsoever, over a decade's experience and millions of watering caps have proved only a handful appear ever to have been blocked by water borne substances. That is a problem that is fully resolved with the use of appropriate strainers placed in the incoming water line before the Watermaster® caps.

More likely, the outcome when dirt is carried in by the water is a leaky valve, not a blocked valve. Neither increasing the pressure operating the valve, nor the water pressure itself, can be in any way beneficial because this won't lessen the effect of the dirt! It is remarkable how much dirt, oil, carbon black, etc., can be deposited all over Watermaster® caps without providing the slightest impediment to correct operation. Only when the cap's protective system is forcibly overwhelmed can problems arise. It is a distinctive feature of Watermaster® that it will continue to fill correctly in applications where conventional filling devices are impractical, or will fail.

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