

- [54] METHOD OF FILLING CONTAINERS
ENCLOSING SOLID MATTER WITH AN
ACCURATE AMOUNT OF LIQUID

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 & Samuel

- [30]
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141/51; 141/61; 141/115; 141/275

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- [58] **Field of Search** 53/86, 88; 136/159, 162;
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115, 116, 119, 275, 277, 67, 68, 148, 149,
150, 172, 194, 269, 276, 278, 281, 282; 222/363

- [56]
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- [57]
- ABSTRACT**

Method and device for filling containers enclosing solid matter with an accurate amount of liquid. The containers are evacuated and a pre-metered amount of the liquid is fed into said container under overpressure. Particularly, a subpressure can act upon liquid supplied in excess and not received by said container in order to avoid contamination etc.

9 Claims, 2 Drawing Figures

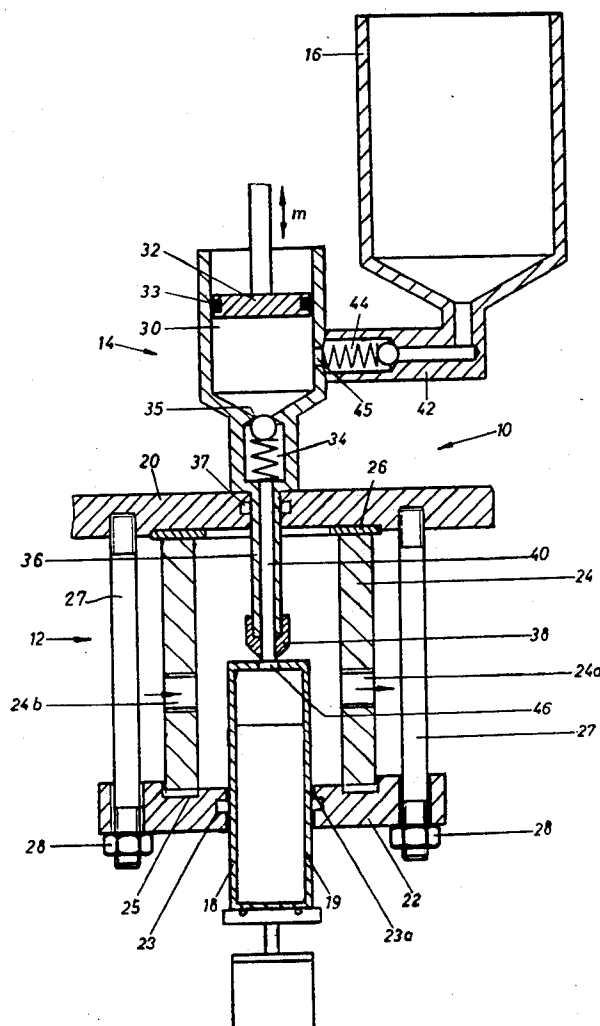


FIG. 1

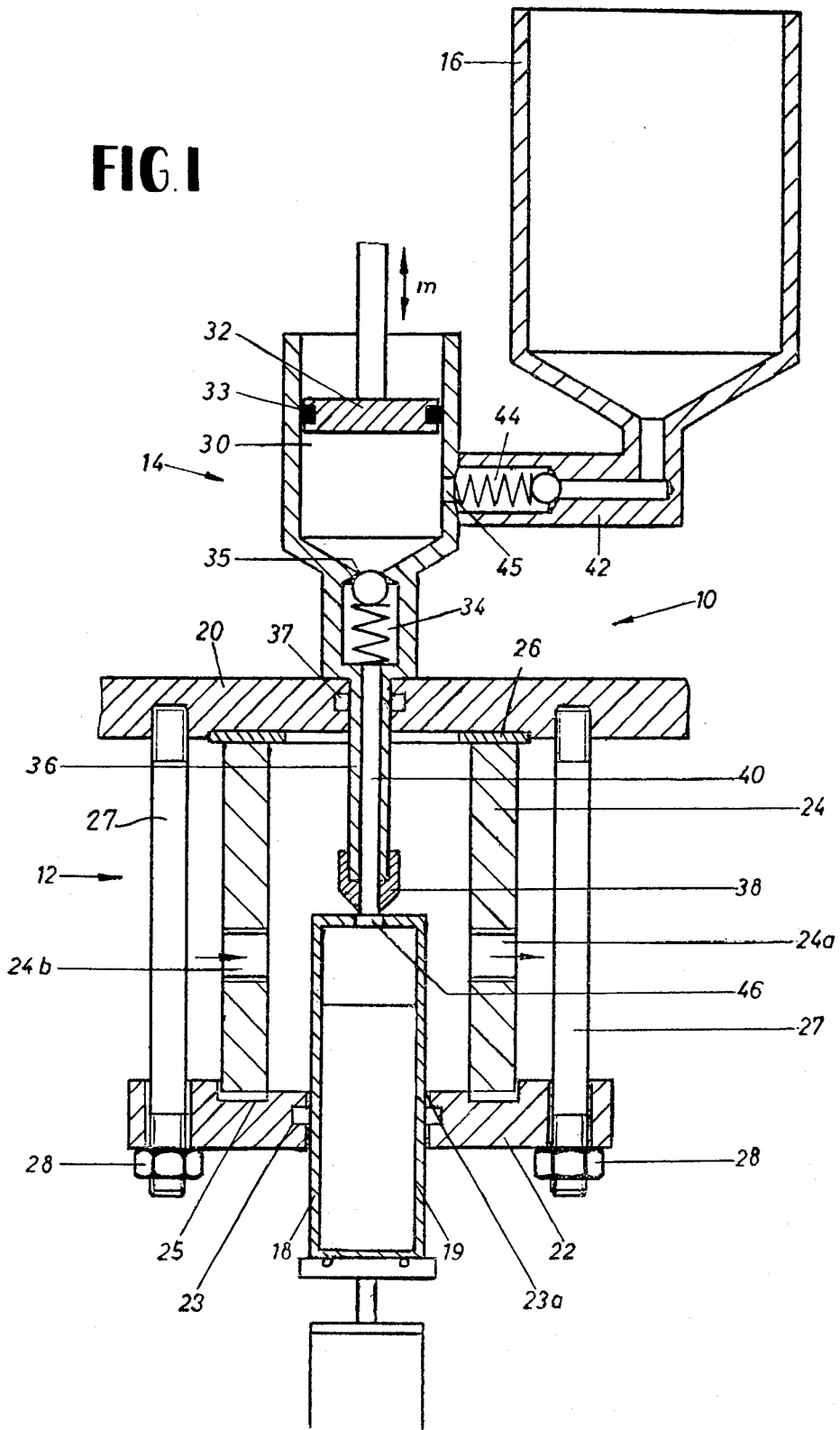
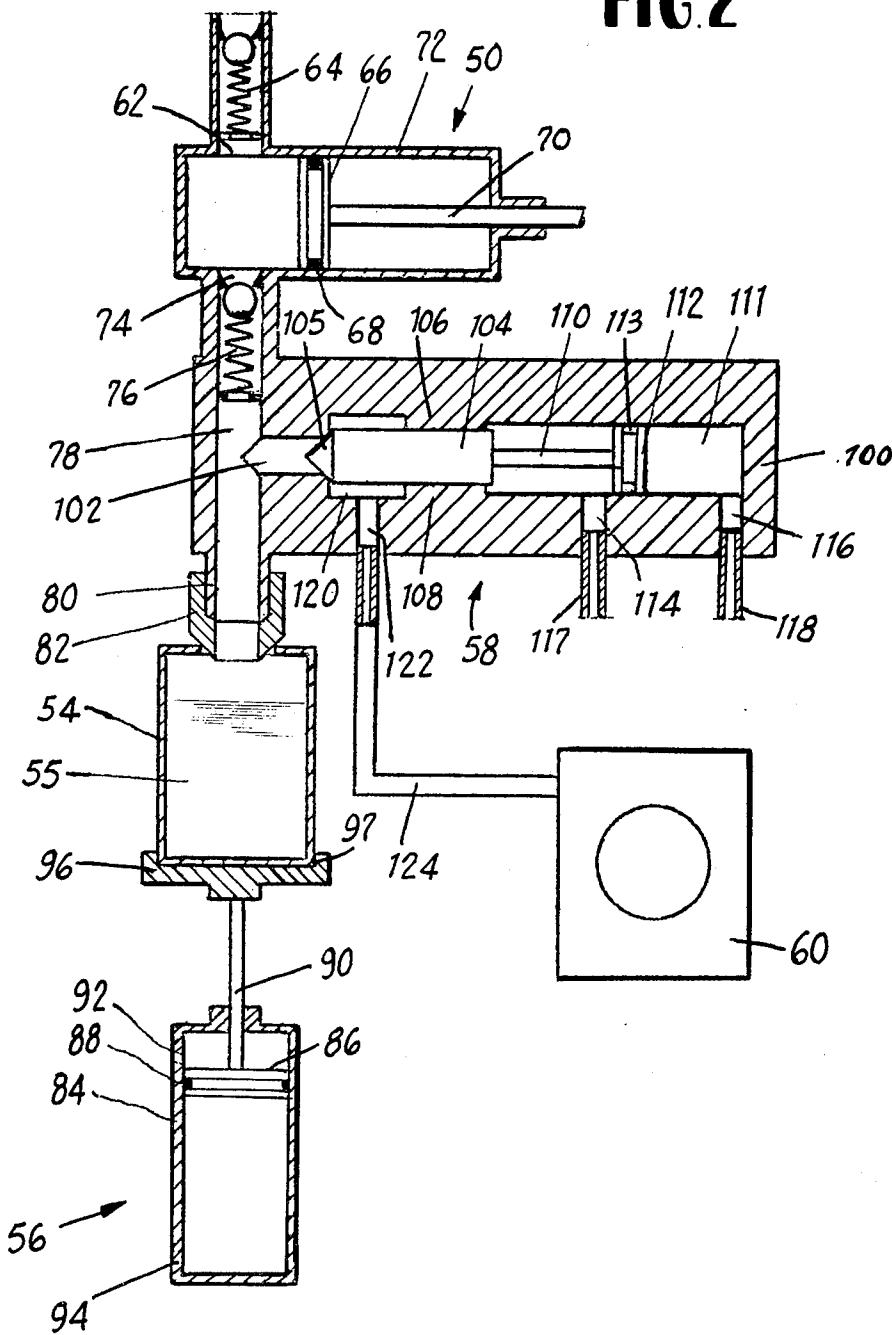


FIG. 2



METHOD OF FILLING CONTAINERS ENCLOSING SOLID MATTER WITH AN ACCURATE AMOUNT OF LIQUID

BACKGROUND OF THE INVENTION

This invention generally relates to filling containers that are entirely closed except for a filling opening and which enclose solid matter, with an accurate amount of liquid, in particular containers of comparatively small volume such as battery cells.

Filling of containers enclosing solid matter with predetermined amounts of liquid through a filling opening — as for example impregnating of battery elements (monocells) with potassium hydroxide solution — heretofore is carried out in such a manner that a plurality of such containers is entirely submerged into said filling liquid. The container is kept submerged in said filling liquid for a period of time during which, according to experience, the container or the solid matter enclosed therein are supposed to have received the desired amount of filling liquid. However, considerable amounts of residual liquid adhere to the outer surface of the containers so treated when these have been removed from the bath of filling liquid so that a particular cleaning process is required. Further, there is an unnecessary loss of filling liquid. Even more important is the fact that the known technique of submerging the containers does not assure exact results because by keeping a predetermined time of treatment the actually received amount of liquid may be controlled only in a comparatively vague manner. Beyond that, the known technique is particularly time-consuming in situations when the solid matter is absorbent and the containers must remain submerged in the filling liquid for a period of time presumably sufficient for allowing the absorbent solid material to receive the required amount of liquid. Principally, the necessary displacement of air by filling liquid entails inaccuracies, and comparatively much time is required in order to complete the filling process.

Under certain circumstances additional problems may arise insofar as when the entire predetermined amount of liquid has been fed into the container, due to capillary action, adhesion or the like, residual amounts of the filling liquid may remain in the path between a reservoir containing the liquid and the filling opening of the container so that at least in connection with filling containers with very small amounts of liquid metering inaccuracies may occur. Possibly, the residual quantities of filling liquid may tend to drip so that again contamination may take place. This is particularly undesirable if the liquid is aggressive such as potassium hydroxide solution.

It is therefore an object of the instant invention to provide a method and a device for filling containers enclosing solid material with predetermined amounts of liquid with less contamination, faster, substantially more accurate and finally with less loss of material than this heretofore had been feasible.

It is another object of this invention to provide a method for filling containers enclosing solid matter in which dripping of filling liquid upon completion of the filling process is definitely avoided.

SUMMARY OF THE INVENTION

In accordance with the present invention, a method

of filling containers with an accurate amount of liquid, which containers are entirely closed, except for a filling opening, and which enclose solid matter, comprises the steps of first evacuating the interior of the container, then accurately metering the amount of liquid required for filling the container and finally feeding said metered amount of liquid through said filling opening into said container under the influence of an overpressure.

Thus, it is possible in a surprisingly simple manner to accomplish filling of small containers enclosing solid matter, such as battery cells, with an accurate amount of liquid within a minimum of time without any contamination of the outer surface of the container, without any loss of liquid, yet maintaining as accuracy within very narrow limits of tolerance.

Preferably, during the period of completion of a first filling process until beginning of a new one, a subpressure is continuously exerted upon liquid that may have been supplied in excess and was not received by the container, in order to continuously remove such excessively supplied liquid.

A device for carrying out the basic method of the present invention comprises a metering pump having an outlet opening, a reservoir for the filling liquid which communicates with the pump, a filling stud connected at its one end to the outlet opening and terminating at its other end in a filler head adapted to tightly engage the filling opening, so that upon evacuation of the container, the liquid premeasured by said metering pump can be forced into the interior of the container with the filler head being pressed against the filling opening. The filling stud may be enclosed by a hermetically sealed filling chamber having a first opening for generating a subpressure and a second opening for generating an overpressure as well as a third opening for sealingly introducing the container into the filling chamber. Thus, the container may be inserted into the filling chamber through said third opening and a subpressure may act through said first opening thus evacuating the interior of the container. Thereafter, the container is moved against the filling head, liquid is supplied into the container, and finally, the overpressure may act through the second opening thus aiding in removing the filled container from the filling chamber.

According to a preferred embodiment of the invention, a device particularly designed for filling small containers enclosing solid matter with an accurate amount of liquid and simultaneously ensuring removal of excessive liquid, comprises a metering pump normally tightly closed by means of a check valve and having an inlet opening for filling in liquid and an outlet opening to which said check valve is associated, a filling stud communicating at its one end with said outlet opening and terminating at its other end in a filler head for tightly engaging the filling opening of the container, a channel connecting the outlet opening and the filling head with each other, means for continuously generating the subpressure, and means for connecting said means for continuously generating the subpressure to said channel when said check valve is closed and said container is disengaged from said filling head, and for disconnecting said means for continuously generating said subpressure from said channel when the check valve is open and said container is in engagement with said filling stud. The means for continuously generating a subpressure may thus act upon the channel immediately when upon completion of a filling process a filled con-

tainer is separated from the filler head so that excessive liquid possibly still remaining in the channel is sucked off by the subpressure, thereby preventing possible dripping of the filling liquid onto the outer surfaces of containers, loss of liquid or affecting the precise metering of the filling liquid due to residual amounts of filling liquid that otherwise still might remain in the channel and further areas communicating therewith when a subsequent filling process is started.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference may be made to the preferred embodiments, exemplary of the invention, shown in the accompanying drawings, in which:

FIG. 1 shows schematically a vertical cross-section through an apparatus used to carry out the basic method of this invention; and

FIG. 2 shows schematically and substantially a vertical cross-section through another embodiment of an apparatus for carrying out the modified filling method of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1 of the drawings, a filling device generally designated with 10 comprises a filling chamber generally designated 12, at the top of which a metering pump generally designated 14 is provided, this metering pump 14 communicating with a reservoir 16. At the lower end of filling chamber 12, there is located a container 18, such as a battery cell, the interior of which accommodates solid matter as schematically indicated by absorbent material 19 to be impregnated with a liquid such as potassium hydroxide solution.

The filling device 10 has a basic plate 20 formed for example by the support table or frame of a machine or the like (not shown). A bottom plate 22 extends at a certain distance from basic plate 20 and substantially parallel therewith, having an opening 23 corresponding with the cross-section of the container 18. An O-seal 23a extends along the periphery of opening 23 within a circumferential groove provided in bottom plate 22.

A prismatic or cylindrical hollow member 24 is tightly engaged between basic plate 20 and bottom plate 22. Annular seals 25 and 26 arranged at the opposite ends of hollow member 24 provide for the necessary hermetic connection of the hollow member 24 with basic plate 20 and bottom plate 22. Bolts 27 are provided for tightening basic plate 20 and bottom plate 22 relative to each other, in connection with nuts 28. The hollow member 24 may be made of transparent material so that the interior of the hollow member 24 may always be observed. A first port 24a for generating a subpressure and a second port 24b for generating an overpressure are provided in the wall as illustrated in FIG. 1. The hollow member 24 is clamped between basic plate 20 and bottom plate 22 in such a manner that the hollow member 24 is in sealed engagement with respect to basic plate 20 and bottom plate 22, so that a subpressure or an overpressure may be maintained through port 24a or port 24b, respectively.

The metering pump 14 has a cylindrical hollow space, wherein a plunger 32 is reciprocal in direction of the double-headed arrow *m*. Plunger 32 sealingly, by means of a seal 33, engages the interior surface of hollow space 30. At its lower end hollow space 30 termi-

nates in an outlet opening 35 normally closed by means of a ball pertaining to a biased check valve 34. When check valve 34 opens, outlet opening 35 communicates with a filler channel 40 extending centrally through a filler stud 36, and in axial direction thereof. The filler stud 36 attached to the lower end of cylindrical hollow space 30 sealingly extends through the basic plate 20 and projects into hollow space 30. An O-seal 37 provides for the tight fit of filler stud 36 relative to basic plate 20. At its lower end filler stud 36 terminates in a filler head 38 which preferably is of tapered configuration and capable of engaging a filling opening 46 provided at the upper end of container 18 in a pressure-tight manner.

The metering pump 14 communicates with reservoir 16 through a passage 45 provided in its lateral wall, a check valve 44 and a transverse connection 42.

Filling of the container 18 or impregnation of the absorbent material 19, respectively, takes place as follows:

Filling liquid contained in reservoir 16 enters into hollow space 30 through transverse connection 42 and passage 45 when check valve 44 is opened. Check valve 34 prevents liquid from undesiredly leaving hollow space 30. Container 18 is introduced into filling chamber 12 through opening 23 provided in the bottom plate 22 until its filling opening 46 sealingly engages filler head 38 provided at the lower end of filler stud 36. Hereupon plunger 32 is moved downwardly by a predetermined distance so that—with the connection between hollow space 30 and reservoir 16 being blocked by means of check valve 44—a precisely metered amount of liquid passes check valve 34 under an overpressure, reaching the hollow space of container 18 and the absorbent material provided therein. This filling process can take place very rapidly inasmuch as the liquid can be accommodated in the hollow space of the container 18 so that the liquid may enter the absorbent material 19 independently of further supply of liquid. The outer surface of container 18 is kept entirely free from filling liquid.

When the precisely metered amount of liquid has been fed into the container 18, container 18 is moved in downward direction thereby separating from filler head 38 and leaving filling chamber 12, so that a fresh filling cycle may be started.

In order to ensure a fast and efficient introduction of filling liquid into container 18, this container 18 is evacuated prior to connecting filler head 38 and filling opening 46 with each other. To achieve this, a subpressure is generated via the first port 24a thus evacuating the interior of hollow member 24. When container 28 is inserted into opening 23, this subpressure simultaneously acts upon a first portion of container 18 adjacent filling opening 46, the remaining second portion of the container 18 being subjected to the ambient air, so that a pressure difference is formed causing container 18 to travel toward filler head 38 without requiring the assistance of further mechanical driving means. Preferably, O-seal 23a exerts a static frictional force upon container 18 so that a subpressure may first be built up in the interior of hollow member 24 capable of ensuring the desired evacuation of container 18, filling opening 46 still staying disengaged from filler head 38. Only when the subpressure required for evacuation has been exceeded will the pressure difference be sufficient to overcome the static frictional force exerted by O-

seal 23a and to alter the static frictional force to a dynamic frictional force allowing for the desired transfer of container 18 toward the filler head 38.

Upon completion of the filling process the subpressure produced through the first port 24a may be interrupted, and an overpressure may be generated through the second port 24b. This overpressure now acts upon the first portion of the container 18 adjacent filling opening 46 and causes a pressure difference forcing container 18 out of opening 33.

FIG. 2 shows a preferred embodiment of this invention for removing filling liquid possibly supplied in excess or not having been received by the container in spite of having been determined therefor. A metering pump here generally designated 50 is in communication with a container 54 (corresponding to container 18 of the embodiment as described before) accommodating in its interior solid matter or absorbent material to be impregnated with a certain quantity of liquid. Container 54 is supported by a lifting mechanism generally designated 56 capable of bringing container 54 in engagement with metering pump 50 or disengaging it therefrom, respectively.

A channel 78 constituting a path connecting metering pump 50 with container 54 is coupled to shut-off valve designated generally 58 connected to a vacuum pump 60 acting upon channel 78 or remaining without effect on channel 78, depending on the condition of shut-off-valve 58.

Metering pump 50 is provided with an inlet opening 62 and a first check valve 64 located before inlet opening 62. Filling liquid for container 54 may enter the interior of a housing 72 of metering pump 50 through inlet opening 62. Check valve 64 (or inlet opening 62, respectively) preferably is in communication with a reservoir (not shown). A plunger 66 is guided reciprocally in housing 72 in a manner known per se, sealingly engaging the interior surface of housing 72 by means of a plunger seal 68. A plunger rod 70 sealingly extending through housing 72 serves for transmitting the required reciprocal motion to plunger 66.

Housing 72 has an outlet opening 74, and a second check valve 76 is positioned upstream of outlet opening 74. Via this outlet opening 74 the interior of housing 72 is in communication with channel 78 which at its lower end terminates in a filler stud 80 closed by a filler head 82 corresponding to filler head 38 of FIG. 1. A metered amount of liquid supplied by metering pump 50 may reach container 54 through the path formed by channel 78 connecting outlet opening 74 and filler head 82 with each other.

Lifting mechanism 56 comprises a housing 84 with a plunger 86 reciprocally mounted within the interior of that housing. An annular seal 88 extending along the periphery of plunger 86 keeps plunger 86 in sealing engagement to the interior surface of housing 84. A plunger rod 90 sealingly extends through housing 84 and rigidly connects plunger 86 to a platform 96 of the lifting mechanism 56 which at its upper side may accommodate a container 54. Along the circumference of platform 96 there may be a flange-like rim 97 having an inner diameter selected so that container 54 may be engaged in a clamping manner.

At its upper and its lower end housing 84 has an upper port 92 and a lower port 94, respectively, through which a fluid such as air or oil may be fed to

one side of the plunger and may be withdrawn correspondingly from the opposite plunger side.

Shut-off-valve 58 has a valve housing 100 with a transverse bore 102 communicating with channel 78. The end of transverse bore 102 remote from channel 78 constitutes a valve seat for a plunger-like valve member 104 which at its end facing the transverse bore 102 terminates in a cone 105 cooperating with the valve seat formed by the adjacent end of transverse bore 102.

At its end remote from transverse bore 102 the plunger-like valve member 104 by means of a plunger rod 110 is connected to a piston 112 reciprocally mounted in a chamber 111 formed in valve housing 100. An annular piston seal 113 seals piston 112 relative to the interior surface of chamber 111. Valve member 104 sealingly extends through an O-seal 106 annularly surrounding valve member 104 and being arranged in a recess 108 provided in valve housing 100 so that chamber 111 reliably remains sealingly closed off with respect to transverse bore 102 despite of disengagement of valve member 104 or cone 105, respectively, from the valve seat formed by transverse bore 102.

At both ends of the distance through which piston 112 may travel in carrying out its reciprocal motion connections 114 and 116 are provided into which conduits 117 or 118, respectively, terminate. Through these conduits 117 and 118 a fluid may be supplied or withdrawn, respectively, so that piston 112 in a manner known per se may be shifted in one or the other direction.

At its end facing the valve seat formed by transverse bore 102 valve member 104 is surrounded by an annular hollow space 120 connecting transverse bore 102 upon disengagement of valve member 104 from the valve seat through a bore 122 and a conduit 124 terminating in bore 122 to vacuum pump 60.

The operation of the device according to this invention is as follows:

Liquid for filling container 54 is fed into the interior of housing 72 through inlet opening 62, thereby opening the first check valve 64. Preferably, this is accomplished by retracting plunger 66 so that within the interior of housing 72 a subpressure is generated capable of overcoming the inherent closing force of the first check valve 64. By returning plunger 66 toward the left end of housing 72 the precisely metered amount of liquid as sucked into housing 72 during the retracted motion of plunger 66 is forced through outlet opening 74 in a precisely metered manner, thereby opening the second check valve 76. Due to the so generated overpressure the liquid is forced through channel 78 into container 54 which before that step has been evacuated and then sealingly engages filler head 82 with its filling opening. The shut-off-valve 58 is then in its closed condition.

As soon as the entire predetermined amount of liquid has been fed under overpressure into container 54 due to respective displacement of plunger 66, the second check valve 76 will close again thus disconnecting the path between metering pump 50 and filler head 82. By introducing a suitable fluid through upper port 92 rod 90 is lowered so that container 54 which so long had been in tight engagement with filler head 82, is separated from filler head 82 due to its being clamped to platform 96. At least until this point of time shut-off-

valve 58 remains closed so that the subpressure generated by vacuum pump 60 may not withdraw liquid from container 54 which would of course be undesired. However, as soon as container 54 is separated from filler head 82, residual quantities of liquid possibly still adhering to the inner surface of channel 78 may begin to drip under the influence of the force of gravity. Therefore, shut-off-valve 58 which is coupled to lifting mechanism 56 is transferred into its opened condition so that vacuum pump 60 may act upon transverse bore 102 and channel 78, respectively, via conduit 124, bore 122 and hollow space 120, in order to suck off residual quantities of liquid that may have been left in that area.

In the lower end position of platform 96 container 54 is substituted by a further container to be filled, the subpressure generated by vacuum pump 60 still continuing to act upon channel 78. When the new container 54 engages filler head 82 with its filling opening, the subpressure produced by vacuum pump 60 may also act upon the interior of this new container 54 and thus evacuate same in the necessary manner. As will be understood, evacuation is so controlled that no liquid may enter the interior of the new container 54 during this interval. Only when the new filling process will begin and the second check valve 76 will open again, will valve member 104 return into its closing condition so that the subpressure of the vacuum pump will terminate affecting the actual filling process. Closure of shut-off-valve 58 at the time of opening the second check valve 76 is again controlled by means of the coupling provided between check valve 76 or metering pump 50, respectively, and shut-off-valve 58. Shut-off-valve 58, as indicated earlier, is actuated by supplying fluid through conduit 117 or 118, respectively.

Precise adjustment of the point of time at which the subpressure of vacuum pump 60 will begin or terminate, respectively, to act upon channel 78 may take place depending on the circumstances. It is significant, however, that shut-off-valve 58 is kept in its closed condition as long as the filling process is carried out and until container 54 is withdrawn from filler head 82. The subpressure may then become effective immediately upon separation of the container 54 from filler head 82 or rather at the time when a fresh container 54 has been brought in engagement with filler head 82. Preference, however, is to be given to an adjustment at which shut-off-valve 58 will open immediately upon separation of the container 54 from filler head 82, provided it has been assured that the subpressure generated by vacuum pump 60 will not be capable any more of withdrawing any liquid from container 54.

What we claim is:

1. A method of filling containers with an accurate amount of liquid inside an hermetically sealed chamber, said containers being entirely closed except for a filling opening in the upper portion of said container, and enclosing absorbent solid matter, said chamber including a container opening for sealingly engaging said container, said method comprising the steps of (a) placing said upper portion of said container into said chamber opening, then (b) producing an underpressure in said chamber, thereby evacuating the interior of said container, (c) accurately metering the amount of liquid required for filling said container, (d) bringing said filling opening into sealed engagement with the metered supply of liquid, and (e) feeding said metered

amount of liquid through said filling opening into said container under the influence of an over-pressure.

2. A method according to claim 1 including subjecting the upper portion of said container including said filling opening to the influence of a sub-pressure used for evacuating the interior of said container, simultaneously subjecting the remaining portion of the outer surface of said container to the influence of the atmospheric pressure of the ambient air, said container thus being approached by means of the pressure difference between said sub-pressure and said atmospheric pressure toward a filler head for supplying said liquid, and maintaining said sub-pressure until completion of said filling process for filling said container.

3. A method according to claim 2, including subjecting said upper portion of said container, upon its complete filling, to the influence of an over-pressure, and simultaneously subjecting said remaining portion of the outer surface of said container to atmospheric pressure, said filled container thus being removed from said filler head for supplying said liquid under the influence of the pressure difference between said over-pressure and said atmospheric pressure.

4. A method as set forth in claim 1, wherein said steps (a) through (e) are repeated and upon completion of said step (e) until beginning of a subsequent step (a) a sub-pressure is continuously exerted upon liquid excessively supplied and not received by said container, in order to continuously remove said excessively supplied liquid.

5. A method of filling containers with an accurate amount of liquid, said containers being entirely closed except for a filling opening, and enclosing absorbent solid matter, said method comprising the steps of (a) evacuating the interior of said container, (b) accurately metering the amount of liquid required for filling said container, (c) bringing said filling opening into sealed engagement with said metered supply of liquid, (d) feeding said metered amount of liquid through said filling opening into said container under the influence of an over-pressure, and (e) simultaneously removing said container opening from said sealed engagement with said metered supply of liquid and exerting a sub-pressure upon liquid excessively supplied and not received by said container, in order to continuously remove said excessively supplied liquid.

6. A device for filling containers including a filling opening with an accurate amount of liquid comprising a metering pump having an inlet opening for filling said metering pump with liquid and an outlet opening, a filling stud communicating at its one end with said outlet opening and terminating at its other end in a filler head for tightly engaging the filling opening of said container, a check valve for opening and closing said outlet opening, a channel extending through said filling stud connecting said outlet opening to said filling head, a vacuum pump for continuously generating a sub-pressure, a shut-off valve capable of movement between an opened and closed position interconnected between said vacuum pump and said channel, for connecting said vacuum pump to said channel in said open position when said check valve is closed and said container is disengaged from said filling head, and for disconnecting said vacuum pump from said channel in said closed position when said check valve is open and said container is in engagement with said filling stud, and means for preventing said check valve from open-

ing prematurely when said vacuum pump is connected to said channel.

7. A device for filling containers, such as battery cells, with an accurate amount of liquid, said containers being entirely closed except for a filling opening and said containers enclosing absorbent solid matter; said device including:

an hermetically sealed filling chamber having a first, a second and a third opening;

first means including a filler head extending into said filling chamber for sealingly engaging said filling opening and feeding said accurate amount of liquid thereinto;

second means for slidably holding an upper portion of said containers to be filled, including said filling opening, in sealed engagement with said third opening with the remaining portion thereof remaining outside said filling chamber, the upper portion of said container thereby entering said filling chamber;

third means for applying a sub-pressure to said sec-

ond opening for evacuation purposes to evacuate a container disposed in said third opening and to draw the same into engagement with said filler head; and

fourth means for applying an over-pressure to said first opening.

8. A device as defined in claim 7 in which said first means includes: a metering pump having an outlet opening, a reservoir for said liquid communicating with said pump and a filling stud connected at its one end to said outlet opening and terminating at its other end in said filler head.

9. A device according to claim 7, including a seal extending along the periphery of said third opening for engaging the outer surface of a container introduced into said third opening with a frictional force substantially balancing the sucking force produced by the difference between said sub-pressure used for the desired evacuation and the atmospheric pressure of the ambient air.

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