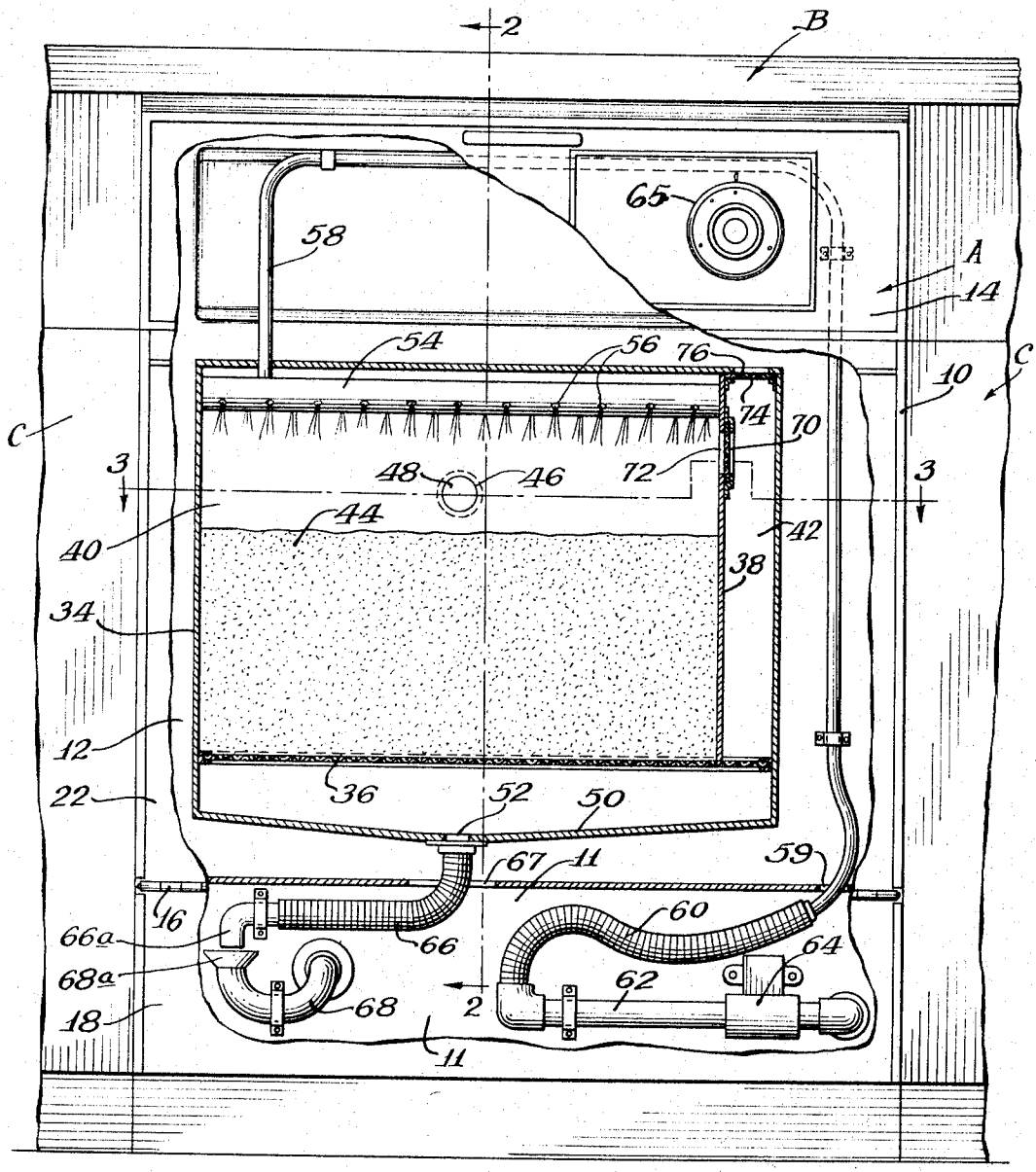
Jan. 16, 1968 H. M. RUMBAUGH ET AL 3,363,637

WATER SOFTENING APPARATUS FOR ARTICLE WASHING MACHINES

Original Filed Nov. 16, 1964 2 Sheets-Sheet 1

FIG. 1.



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FIG. 2.

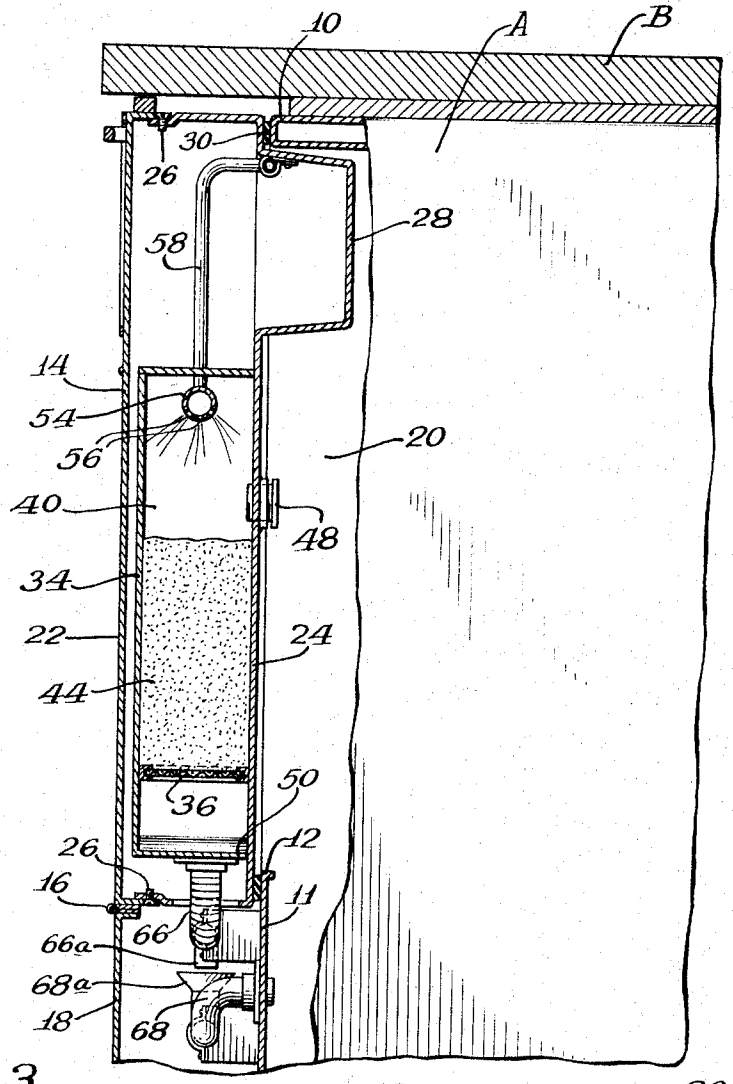
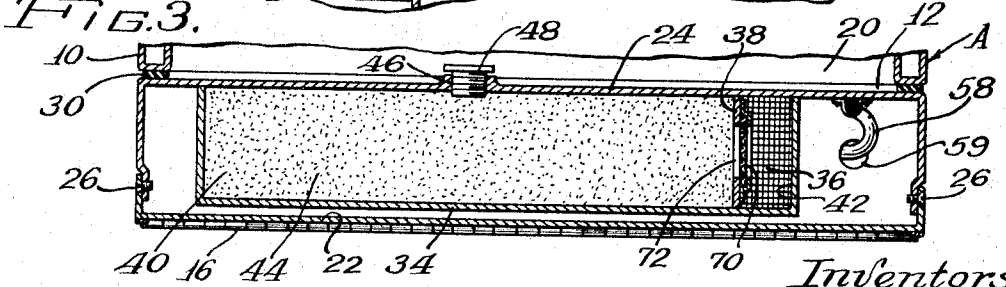


FIG. 3.



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WATER SOFTENING APPARATUS FOR ARTICLE WASHING MACHINES

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Continuation of application Ser. No. 411,341, Nov. 16, 1964. This application June 9, 1966, Ser. No. 556,527
14 Claims. (Cl. 134—109)

ABSTRACT OF THE DISCLOSURE

A water-softening unit is provided on the door of a dishwasher or clotheswasher, so that each time the door is opened and/or closed the particles of the ion-exchange material used for softening the water is agitated. Alternatively the unit may be otherwise movably attached to the machine. The water used in the washer flows by gravity through the unit. The unit is provided with an air vent which prevents pressure build up in the unit, and an air gap is provided in the discharge from this equipment into the chamber in which the washing takes place to prevent the water from this chamber siphoning back into the water-softening unit.

Specification

This application is a continuation of applicants' copending application Ser. No. 411,341, filed Nov. 16, 1964, now abandoned.

This invention relates to novel apparatus for aiding in washing of articles such as dishes, tableware and the like in a dishwashing machine and such as fabric articles in a clothes washing machine. More specifically, our invention relates to water softening apparatus for incorporation in either dishwashing machines or clothes washing machines. For convenience, reference will now be directed specifically to the application of our invention to dishwashing machines, and it will be apparent that corresponding advantages are obtainable when embodied in clothes washing machines.

Heretofore the most common method utilized for obtaining soft water for use in dishwashing machines was by the provision of a conventional water softening unit, generally located a substantial distance from the dishwashing machine. Such remotely located water softeners usually supply many other demands for soft water in the household by virtue of which there results a substantial fluctuation in the hardness and softness of the water delivered by the water softening unit. Such water softening units are usually regenerated at a time when there is least demand upon them, such as after midnight. In some installations, depending upon the requirements for soft water, regeneration of the water softening apparatus is accomplished after an interval of two or more days. By reason of such use of conventional water softeners it will be apparent that there is a great fluctuation of the hardness or softness of the water that is utilized at some particular time in a dishwashing machine. Generally, such conventional water softening units, when regeneration is to be accomplished, requires back flushing or washing of the bed of ion exchange material, usually under substantial line pressure wherein the water is caused to move through the bed in an upward direction. Such action tends to remove the clodiness or turbidity which has accumulated on top of the bed during use of the apparatus. The primary purpose of back washing or back flushing is to loosen or fluff the bed of softening material so that the salt solution or brine subsequently introduced into the system will come in contact with the

surfaces of all particles. After the back flushing operation, the salt solution or brine is caused to pass through the bed of ion exchange material and by virtue of this, sodium is put back into the softening material, simultaneously driving off calcium and magnesium which have accumulated on the particles of the ion exchange material and the calcium and magnesium deposits are washed to waste by a water rinse along with the excess salt solution or brine. By such treatment, the water softening material has now been recharged and the softener is again ready to remove hardness from the water.

The primary reason for the use of a water softener supplying a dishwashing machine is to remove calcium and magnesium salts usually present in raw water and results in spotting, streaking, and cloudy appearance of the articles washed in the dishwasher.

Another method of obtaining softening of water for use in dishwashing machines results from the use of suitable detergents which are currently available and which include chemicals for effecting a softening of the water or which render inactive the calcium and magnesium salts in the water. It is recognized that the use of such detergents is rather costly even when used in connection with water of relatively low-grain hardness. More importantly, the use of detergents including such water softening chemicals results in no advantage. Such chemically treated detergents are only utilized in the dishwashing machine during the main wash cycles of operation of the machine. It will therefore be apparent that in subsequent rinse cycles of the machine raw water is utilized, not containing chemically treated detergents. Therefore, the use of water softening chemicals in detergents, during the wash cycle, is of no effect because the raw water used during the subsequent rinsing cycles contains calcium and magnesium salts and other salts, causing hardness of the water, will result in spotting, streaking and clouding up of the washed articles. Frequently it can be observed that such washed articles contain a deposit in the form of a white film thereon. Moreover, in the use of such commercially available detergents containing water softening chemicals the power or effectiveness of the water softening agents contained therein is materially decreased under certain conditions involving—(1) inadequate water temperature; (2) excessive grease on the articles to be washed; (3) the character of soil on the articles to be washed, i.e. certain foods absorb detergents; (4) age of the detergent, i.e. decreases its softening power; (5) excessive sudsing caused by certain foods which reduces efficiency of detergents; (6) failure of some detergents to go into solution due to temperature of water or short period of cycle of machine, causing unacceptable, inefficient and unsatisfactory washing.

In the use of such detergents containing water softening chemicals, it is a continuous problem to endeavor to determine the quantity of detergent to be used to effect a proper softening of the water to be utilized in the machine. As above pointed out, even if one were able to make a reasonably accurate guess as to the quantity of chemically treated material to be utilized in the machine, it must be remembered that it will not result in providing washed articles of a desired appearance because the subsequent use of raw water in the rinse cycles after the washing operation, and there usually are several rinse cycles, which results in depositions upon the articles of calcium and magnesium present in the hard water. These materials cause spotting, streaking, clouding, etc., of the washed articles.

The present invention contemplates a controlled system for assuring delivery of treated water, softened to a proper degree, for use in a dishwashing machine for all washing and rinsing cycles of the machine, and by virtue

of which relatively less expensive types of detergents may be used in the machine provided with our novel controlled system. The use of water softening chemicals may be totally eliminated and the highly desirable biodegradeable soft detergents now available may be more accurately formulated and used as a dishwashing detergent. By our novel controlled system of assuring delivery of soft water to the dishwashing machine, the foregoing deficiencies above enumerated are overcome.

One of the primary objects of our invention is to provide a relatively simple, practical, inexpensive, and efficient arrangement for embodiment in a dishwashing machine for insuring that the water used in the machine, for all cycles of operation, is adequately softened.

Another object is to provide a water softening assembly, carried on and movable with the door or closure of the dishwashing machine so that the normal operation of opening or closing of the door or closure, incident to loading or unloading the machine, continuously causes loosening, breaking up and agitation of the bed of ion-exchange material, resulting in continuously exposing new surfaces of the particles of material for efficiently performing a water softening operation.

A further object of this invention is to provide a novel form and arrangement of water softening apparatus in association with a dishwashing machine which greatly increases the efficiency in the performance of both washing and rinsing operations on the articles being washed, with the result that the tableware and glassware sparkle and are obviously clean.

A still further object is to provide a novel form of water softening apparatus in association with a dishwashing machine, constructed in a manner by virtue of which the regeneration median may be quickly and easily introduced in direct association with the bed of ion-exchange material for effecting a quick and complete regeneration of the ion-exchange material.

It is also an object of this invention to provide a novel and simple form of water softening apparatus, in direct association with a dishwashing machine by virtue of which the cost of providing adequately softened water for the machine is greatly reduced.

It is still another object of this invention to provide a novel water softening apparatus, in association with and as a direct part of a dishwashing machine, constructed and arranged so as to utilize the components of the dishwashing machine to assist in performing the operation of regenerating the bed of ion-exchange material.

Still another object is to provide a novel form of water softening apparatus, in association with a dishwashing machine, having means for distributing raw water over and through the bed of ion-exchange material so as to enable the water to pass, by the action of gravity, following the lines of least resistance, through the bed of ion-exchange material.

This invention further contemplates the provision of means in a water softening apparatus, formed as a direct part of a dishwashing machine, by virtue of which air lock is precluded, and insures that filtered, treated, water collected below the ion exchange bed of material, is supplied directly to the washing chamber of the machine.

It is also an object of this invention to provide a novel form of water softening apparatus as a part of a dishwashing machine, constructed and arranged to provide for air venting with respect to the bed of ion exchange material so as to preclude any build up of pressure in the unit.

A still further object is to provide a novel form and arrangement of water softening apparatus, in direct association with a dishwashing machine, having a novel by-pass arrangement to insure supplying of water to the washing chamber of the dishwashing machine in the event of restriction of flow of water through the bed of ion-exchange material.

A still further object of our invention is to provide a novel form of water softening apparatus, in direct association with a dishwashing machine, having an air gap or vacuum breaker provided in the conduit system of the water softening apparatus.

Other objects and advantages of this invention will be apparent from the following description, taken in connection with the accompanying drawings in which:

FIGURE 1 is a front elevational view of a dishwashing machine provided with water softening apparatus embodying the present invention, having portions of the door and the lower front panel of the machine broken away to show details of construction.

FIGURE 2 is a vertical sectional view, taken at line 2—2 on FIGURE 1, showing our novel form of water softening apparatus embodied within the door of the dishwashing machine.

FIGURE 3 is a horizontal sectional view through the door of the dishwashing machine, taken as indicated at line 3—3 on FIGURE 1.

As may be seen in the drawings, the present invention is illustrated in connection with a conventional form of dishwashing machine, indicated generally at A, which is of the built in type, that is, it is mounted in place beneath a counter top B, with other cabinet structures C, located at opposite sides thereof. The dishwashing machine includes a conventional, generally rectangular cabinet **10**, having a front wall **11**, provided with a relatively large, generally rectangular opening **12**, which is normally sealed by a door or closure member **14**, hingedly connected at its lower end at **16**, to the skirt or front wall portion **18** of the cabinet of the machine. The cabinet of the machine is formed to provide a washing chamber **20** in which there is usually mounted a plurality of retractable racks (not shown) for supporting dishes, tableware and the like which are to be washed. Also positioned within the chamber is a suitable form of water impeller (not shown) which serves to discharge water removed from the bottom portion or sump of the chamber and directing the water over, around and against the articles to be cleansed. Such machines include a conventional drive mechanism and control apparatus including timing devices, by virtue of which the machine is caused to perform a series of washing and rinsing cycles for cleansing of the articles therein. As is well known, some of such machines require manual introduction of detergent into the machine and in other types of such machine, the detergent is introduced into the machine automatically from a storage supply of detergent associated directly with the machine.

As shown in the drawings, the water softening apparatus is substantially, totally, confined within the door or closure **14** of the machine. The door or closure of the machine includes a pair of spaced apart front and rear walls **22** and **24**, formed as sheet metal stampings, with their marginal edges flanged and interconnected by fasteners **26**. The rear wall **24** is formed with an inwardly offset portion **28** (FIGURE 2), for accommodating the usual electrical controls and timer for the machine. The marginal edges of the rear wall **24** of the door or closure is provided with a suitable water sealing gasket **30**, for engaging cooperating surfaces of the cabinet of the washing machine, in surrounding relation to the main opening **12** for sealing the chamber **20**. Mounted within the door, between the walls **22** and **24**, is a relatively flat, generally rectangular container **34**, with a portion of the rear wall **24** of the door constituting the rear wall of the container. Mounted within the lower portion of the container and extending transversely thereof is a relatively fine mesh screen **36**. The container is also provided with an upright partition wall **38**, extending to the top wall of the container, and its lower end being positioned in contact with the screen **36**, so as to provide a main compartment **40**, and an air vent and water overflow chamber **42**. Disposed within the main compartment **40** of the container and supported upon the screen **36** is a bed of suitable ion exchange material or resin **44**,

Desirably the container **34** is so dimensioned that the main compartment **40** may contain approximately four quarts of said ion exchange material, occupying normally, slightly more than one-half of the vertical height of the main compartment **40**. Preferably, the depth of the bed should be substantial, and we have found that by proper dimensioning of the container said four quarts of material will provide a bed depth of approximately eight inches. The bed of ion-exchange material or resin may be of any suitable material, preferably of small particulate form, such as for example, 8% divinylbenzene crosslinked resin of a 30–60 mesh size produced by Dow Chemical Company.

The container **34** as well as the inner wall **24** of the door and the screen **36** are preferably made of suitable material, such as fiberglass or other materials that will preclude chemical action with the ion-exchange material and which will withstand normal expansion of such material.

The inner wall of the container, that is the inner wall **24** of the door or closure, is provided with a suitable opening **46**, which is normally closed by a suitable plug **48**, to provide convenient access to the interior of the main compartment for the introduction of the ion-exchange material and also for the introduction of regeneration material as hereinafter described. The bottom wall **50** of the container is suitably sloped to facilitate collecting and directing the treated water toward a discharge opening **52**.

Mounted within the upper end of the main compartment **40** is a horizontal disposed header **54**, having a multiplicity of apertures **56**, spaced throughout the length thereof. A raw water supply conduit **58** has its terminal portion extending through the top wall of the container **34**, where it is connected to the header **54** and which constitutes an inlet opening for the supply of raw water to the interior of the container. Preferably, the openings or apertures **56** in the header decrease in size from the right hand end, as seen in FIGURE 1, toward the connection to the water supply conduit **58**, so that the quantity of water discharged from the header onto the bed of ion-exchange material **44** is relatively uniform throughout the length of the bed.

As may be seen in the drawings the water supply conduit, in the main, is within the door and extends through an opening **59** in the bottom wall of the door, where it is connected to a flexible conduit portion **60** which in turn is directly connected to a fixed conduit section **62**, an extension of which connects to main water supply system in the home. Interposed in the conduit portion **62** is a solenoid operated valve **64**. It is to be understood that the solenoid valve is connected into the electrical circuits controlled by the timer **65** utilized in such machines, for controlling the intervals and the quantities of raw water to be introduced into the washing chamber **20** of the machine. The flow rate of raw water introduced is approximately one-half to a gallon per minute, which as above indicated is under control of the usual timer associated with the dishwashing machine, and which quantity of raw water is first discharged into the main compartment **40** of the container of the water softening apparatus, directly onto the bed of ion-exchange material and after softening treatment is discharged into the washing chamber **20**. The temperature of the water introduced for dishwashing purposes is generally recommended to be in the general range of 140° F.

The raw water discharged into the container is permited to flow under influence of gravity through the bed of ion-exchange material, seeking the path of least resistance, as contrasted with most conventional water softening apparatus wherein the raw water is caused to pass through the bed of ion exchange material under the normal pressure of the water system. As the raw water passes through the raw bed of ion-exchange material it becomes softened in the well known manner, resulting

in removing calcium and magnesium salts present in the raw water and attracting and holding them in association with the particles of the ion-exchange material. When such chemicals have collected on the resin particles to an extent that no appreciable ion exchange action continues, then it is necessary to regenerate or recharge the bed of ion-exchange material. The treated or softened water is caused to be discharged through the fine mesh screen **36** and collects in the bottom of the container **34**, and is discharged directly through the outlet **52** into a flexible portion **66** of a discharge conduit system. As seen in FIGURE 1, the flexible portion **66** of the discharge conduit extends through an opening **67**, formed in the bottom flange of the door **14**. The remaining part of the conduit system being indicated at **68**, has its terminal portion extending through the lower portion of the front wall **11** of the dishwasher, as seen in FIGURE 2 for discharging treated water directly into the washing chamber **20**. The end of conduit portion **66** is connected to a down-turned neck portion **66***a*, the end of which is located above and in spaced relation to a funnel-like portion **68***a* of conduit portion **68** to provide an air gap or vacuum breaker in the conduit system to preclude possible back siphonage of the water into the main water supply line. If desired, the air gap or vacuum breaker may be provided in the water supply conduit **58** with the same advantages. The portions **60** and **66** of the conduit systems are flexible so as to readily accommodate free and unrestricted movement of the door or closure **14** to fully open or closed position. Thus the raw water is supplied to the water softening apparatus through conduits **58**, **60** and **62**, under control of the solenoid valve, which in turn is controlled by the timing mechanism of the machine, and by virture of which predetermined quantities of raw water, which heretofore were discharged directly into the washing chamber of the machine, are caused to first pass through the water softening apparatus, to be properly treated and discharged into the washing chamber of the machine.

In order to insure against build up of pressure in the compartment **40** and further to insure against any vacuum action occurring in the container **34**, we provide an air venting arrangement consisting of a screened vent **70**, in registration with an opening **72**, in the partition **38** of the container, above the normal level of ion-exchange material in the compartment **40**. The purpose of the screen is to insure that the particles of ion-exchange material remain within the compartment **40**. The top wall of the container **34** is likewise provided with a screened vent **74**, in registration with an opening **76** at the top of the chamber **42**, and the bottom of said chamber is in registration with a portion of the screen **36**, so that air is free to enter or pass out of all portions of the container **34**. Another and very important function of the screened vent **70** and opening **72** in the partition wall is to permit by-passing of any excess accumulation of water, above the bed of ion-exchange material, which might occur in the event that the ion exchange material becomes clogged with foreign matter, either in the body of the material, or in the nature of a film over the top of the material. In the event of such restriction of flow, water introduced into the system during a cycle of operation of the machine will be caused to flow through the vented opening **70–72** and into the compartment **42** and discharge through the screen **36**, at the bottom of the chamber **42** into the lower portion of the container for discharge through conduit portions **66–68**, into the washing chamber of the machine.

It will be apparent that each time that the door of the machine is moved in the process of placement of articles into the washing chamber or removing them from the chamber, such movement of the door causes a loosening and breaking up and agitation of the body of ion-exchange material, and causes the particles thereof to assume different positions and relationship to each other,

thus exposing surface areas of the particles which, previous to such movement, were not directly exposed to the raw water being fed therethrough. The arrangement thus insures greatly increased efficiency in the softening of the water passing through the ion-exchange material and thus is capable of performing a satisfactory water softening operation for relatively long periods of time.

It will be apparent that by virtue of the present invention the water softening apparatus, when incorporated as a direct part of the dishwashing machine, in no manner or form alters the general operation and timed cycles of the machine and that there is no need to ever back flush the bed of ion-exchange material because it is loosened and agitated at frequent intervals, depending on the extent of opening and closing of the door of the dishwashing machine. By reason of such frequent loosening and agitation of the bed of ion exchange material, the tendency for such material to pack is greatly reduced. Furthermore the tendency of the material to pack is further reduced by reason of the fact that the raw water introduced into the compartment containing the ion-exchange material is dispersed and is not under pressure and the raw water is permitted to filter through the bed of material solely by the action of gravity.

It is to be understood that detergent may be introduced into the machine either manually or by other conventional means such as currently employed in certain types of dishwashing machines which include a storage chamber of detergent and means by virtue of which measured quantities of detergent is automatically injected into the wash chamber at the proper timed portion of a cycle of operation.

While the quantity of ion exchange material used in the container **34** may be varied as desired, we have found that four quarts is sufficient to insure proper water softening of the raw water in the use of the dishwasher for relatively long periods of time before the ion-exchange material requires recharging or regeneration. For example, if the raw water contains ten grains of hardness and the dishwashing machine is used once a day, the life of the bed of ion-exchange material will soften the water satisfactorily for approximately 75 days of normal home use of a dishwasher before regeneration of the material is necessary. When, however, it is determined that the bed of ion-exchange material requires regeneration it should be attended to with all articles removed from the washing chamber of the machine. To regenerate the ion-exchange material the door is opened, preferably to an oblique angle and the plug **48** removed to permit introducing through the opening **46**, a quantity of ordinary salt. It has been found that approximately two to three pounds of salt introduced into the compartment **40**, above the bed of the ion exchange material, is sufficient for effecting through regeneration of the bed of ion exchange material. When the salt is introduced into the chamber **40** and the plug **48** reinserted in opening **46**, the door is then moved to a closed position and the machine is set by the timer into operation for performing a normal operation of washing and rinsing cycles. The salt is mixed with water discharged into chamber **40** to form a brine solution which filters through the entire bed of ion-exchange material for regenerating such material. The brine solution together with the deposits of calcium and magnesium and other hardness material removed from the resin particles is then flushed through the discharge conduit **66** and **68** into the washing chamber **20**. The dishwashing machine water impelling apparatus directs the water within the washing chamber in the same manner as during the usual washing operation throughout the entire fill period cycles of the machine and continues to operate for the usual timed cycles for performing washing operations. The rinse cycle of the machine insures complete flushing out of all effluent matter clinging to the walls of the washing chamber. It is to be understood that after each washing and rinsing cycle the machine continues to function for removing the effluent by the usual pump associated with the machine for discharging it into a drain. Such machines frequently are designed and constructed so as to perform one or more cycles of washing operation and usually a multiplicity of rinsing operations, and after completion of the last rinsing cycle the machine functions for a predetermined period of time for performing a drying operation upon the articles of the machine, after which it shuts off. Upon completion of all of the washing and rinsing cycles of the machine the brine solution will have performed its complete function of regenerating the bed of ion-exchange material to restore it to its full capacity to perform its ion-exchange action between the hard chemicals in the water and the bed of ion-exchange material. The machine is now in condition to again be utilized for performing its normal washing operation upon articles such as dishes, glassware, tableware, and the like, and the raw water introduced into the machine will pass through the water softening apparatus for continuous removal of the hardness elements from the water.

By virtue of the present invention it insures total elimination of cloudy, streaked or spotted residue which is normally deposited on the articles by reason of use of raw untreated water. Our novel water softening apparatus, embodied as a part of a unitary washing machine, is extremely simple in construction and efficient in operation and is capable of being economically manufactured. It may be continuously used over long intervals of time at a relatively insignificant cost, for salt to cause regeneration of the ion-exchange material.

Although we have herein shown and described a preferred embodiment of our invention in association with a dishwashing machine, manifestly it is capable of further modification and rearrangement of parts, as well as embodiment in a clothes washing machine without departing from the spirit and scope thereof. We do not, therefore, wish to be understood as limiting this invention to the precise arrangement herein disclosed, except as we may be so limited by the appended claims.

We claim:

1. In combination with an article-washing machine having a chamber for the reception of water and articles to be washed, and a movable closure for a loading and unloading opening in said chamber to permit insertion in and removal of articles from the chamber; the improvement comprising water-softening apparatus including a container carried by and movable with said closure having inlet means for the introduction of ion-exchange material and regeneration material and also water inlet and outlet means, a porous support in the container above the soft-water collection area, a bed of ion-exchange material of particulate form in said container and supported on said support, whereby each movement of the closure tends to rearrange the bed of ion-exchange material, supply means connected to the inlet means and to a source of water supply, and outlet means connected in communication with the chamber for supplying treated water therefrom to said chamber.

2. The combination of claim **1** which includes an air gap in the outlet means for supplying treated water to the chamber.

3. In combination with an article-washing machine having a chamber for the reception of water and articles to be washed, and having a side opening to permit insertion in and removal of articles from the chamber, and a movable closure for said opening; the improvement comprising water-softening apparatus including a container carried on and movable with said closure, a porous support in and extending transversely of the container adjacent the lower end thereof, a bed of ion-exchange material of particulate form in said container and supported on said porous support, whereby each movement of the closure tends rearrange the bed of ion-exchange material, means for introducing ion-exchange material and regeneration material into said container, a water supply and outlet

means for the container, said outlet means being connected in communication with the chamber for supplying treated water to the said chamber.

4. In combination with an article-washing machine having a chamber for the reception of water and articles to be washed and having a side opening to permit insertion in and removal of articles from the chamber, and a movable closure for said opening, hingedly mounted at its lower edge; the improvement comprising water-softening apparatus including a container carried on and movable with the said closure having inlet means for the introduction of ion-exchange mtaerial and regeneration material and also water inlet and outlet means, a porous support mounted in and extending transversely of the container, above the soft-water area, and a bed of ion-exchange material of particulate form in said container and supported on said porous support, whereby each movement of the closure tends to rearrange the bed of ion-exchange material.

5. In combination with an article-washing machine having a chamber for the reception of water and articles to be washed and having a side opening to permit insertion in and removal of articles from the chamber, and a movable closure for said opening hingedly mounted at its lower edge; the improvement comprising water-softening apparatus including a container carried on and movable with the said closure, a porous support mounted in and extending transversely of the container, above the soft-water collection area, a bed of ion-exchange material of particulate form in said container and supported on said porous support whereby each movement of the closure tends to rearrange the bed of ion-exchange material, means for introducing ion-exchange material and regeneration material into said container, supply means connected to a source of water supply and connected to the container for supplying water thereto for flow by gravity through said bed of ion-exchange material, and outlet means connected in communication with the chamber for supplying treated water therefrom to the chamber, and a water-distributing header mounted in the upper end of the container in communication with the water-supply means for distributing water over the bed of ion-exchange material.

6. The apparatus of claim 5 which includes on the inner surface of the closure an opening into the container with a removable closure therefor.

7. In combination with an article-washing machine having a chamber for the reception of water and articles to be washed and having a side opening to permit insertion in and removal of articles from the chamber, and a movable closure for said opening hingedly mounted at its lower edge; the improvement comprising water-softening apparatus including a container carried on and movable with the said closure formed with a soft-water collecting area, a porous support mounted in and extending transversely of the container above the soft-water collecting area, a bed of ion-exchange material of particulate form in said container and supported on said porous support, whereby each movement of the closure tends to rearrange the bed of ion-exchange material, said container having air vents opening above and below the bed of ion-exchange material, means for introducing ion-exchange material and regeneration material into said container, a supply conduit connected at one end to a source of water-supply means and connected to the container for supplying water thereto for flow by gravity through said bed of ion-exchange material, and outlet means for supplying treated water therefrom to the chamber.

8. In combination with an article-washing machine having a chamber for the reception of water and articles to be washed, and a movable closure for a loading and unloading opening in said chamber to permit insertion in and removal of articles from the chamber; the improvement comprising water-softening apparatus including a container carried by and movable with said closure formed with a soft-water collection area, a porous support in the container adjacent the soft-water collection area, a bed of ion-exchange material of particulate form in said container and supported on said porous support whereby each movement of the closure tends to rearrange the bed of ion-exchange material, means for introducing ion-exchange material and regeneration material into said container, a water-supply means and water-outlet means for the container, one of said means having means to provide an air gap to serve as a vacuum breaker.

9. In combination with an article-washing machine having a chamber for the reception of water and articles to be washed, and a movable closure for a loading and unloading opening in said chamber to permit insertion in and removal of articles from the chamber; the improvement comprising water-softening apparatus including a container carried by and movable with said closure, a porous support in the container, a bed of ion-exchange material of particulate form in said container and supported on said screen, whereby each movement of the closure tends to rearrange the bed of ion-exchange material, one wall of the container being formed with a normally closed supply opening for the introduction of ion-exchange material and regeneration material into the container, inlet means to supply a source of water to the container, and outlet means in communication with the outlet for suppling treated water therefrom to said chamber.

10. In combination with an article-washing machine having a chamber for the reception of water and articles to be washed and having a side opening to permit insertion in and removal of articles from the chamber, and a movable closure for said opening hingedly mounted at its lower edge; the improvement comprising water-softening apparatus including a container carried on and movable with the said closure formed with a soft-water collecting area and having inlet and outlet openings at the upper and lower ends respectively, a porous support mounted in and extending transversely of the container, above the soft-water collection areas, a bed of ion-exchange material of particulate form in said container and supported on said support, whereby each movement of the closure tends to rearrange the bed of ion-exchange material, means for introducing ion-exchange material and regeneration material into said container, a supply conduit connected to a source of water supply and connected to the inlet opening of the container for supplying water thereto for flow by gravity through said bed of ion-exchange material, and a second conduit connected at one end to the outlet opening of the container with the other end connected in communication with the chamber for supplying treated water to the chamber, said conduits each including a flexible portion for accommodating the movement of the closure.

11. In combination with an article-washing machine having a chamber for the reception of water and articles to be washed and having a side opening to permit insertion in and removal of articles from the chamber, and a closure hingedly mounted at its lower edge and movable into and out of sealing relation to said opening; the improvement comprising water-softening apparatus including a relatively flat, normally upright container carried on and movable with the closure formed with a soft-water collecting area and having an upright partition, a porous screen extending across the interior of the container and positioned above the soft-water collection area to provide a main compartment and an air vent and water overflow chamber, a bed of ion-exchange material of particulate form in the main compartment and supported on said screen, whereby each movement of the closure tends to rearrange the bed of ion-exchange material, said container having means for the introduction of ion-exchange material and regeneration material into said container, a supply means connected to a source of water and connected to said inlet opening for supplying water thereto for flow by gravity through said bed of ion-exchange ma-

terial, and outlet means connected at one end to said outlet opening and at the other end to the chamber of the washing machine for supplying treated water to said chamber, one wall of the container forming the air vent and water over-flow chamber being provided with an opening for venting the latter chamber to the atmosphere, the partition above the bed of ion-exchange material being provided with a screened breather opening to insure against a vacuum action in the main compartment and serving as an overflow bypass to supply water to the chamber of the washing machine in the event of impeded flow of water through said bed of ion-exchange material.

12. In combination with an article-washing machine having a chamber for the reception of water and articles to be washed and a movable closure for a loading and unloading opening in said chamber to permit insertion of articles into and removal of articles from the chamber; the improvement comprising water-softening apparatus including a container carried by and movable with said closure and having inlet means for the introduction of water, ion-exchange material and regeneration material to said container and outlet means, and a bed of ion-exchange material of particulate form in said container, whereby movement of the closure rearranges the bed of ion-exchange material.

13. The combination of claim **12** which includes a timer, a single water-supply conduit connected to said

container with a valve therein for controlling the flow of all water to the container, said valve being connected to and controlled by the timer.

14. In combination with an article-washing machine, a water-softening unit which comprises a porous container for a bed of ion-exchange material in particulate form, which unit is hingedly attached adjacent its bottom to the machine, means for swinging the unit outwardly from the machine to rearrange with each swinging movement the particles of ion-exchange material, means for the introduction of ion-exchange material and regeneration material into the container, means for supplying water to the unit, and means for discharging water from the unit to the interior of the machine.

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