PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in Filters

We, FILTRATION AND WATER SOFTENING PROPRIETARY LIMITED, a company organised and existing under the laws of the State of Victoria, Commonwealth of Australia, of 395, Collins Street, Melbourne, Victoria, Commonwealth of Australia, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to improvements in and connected with filters of the kind having a filter bed of sand or like granular material and is applicable both to filters of the gravity and pressure types.

In the filtration of water by means of graded beds of sand and gravel or other suitable comminuted material, it is customary to first coagulate the impurities by treatment with a suitable coagulant and then to cause the water to pass downwards through the filter bed.

The impurities removed from the water form a film of "floc" at the upper surface of the filter bed and on the grains of material forming the upper zone of said bed, and, though this film plays an important part in the filtering operation, it gradually increases the resistance to the flow of water therethrough and consequently must be removed at intervals.

This removal of accumulated impurities is usually effected by a reverse flow of prefiltered wash water and, as it is desired to agitate the filter bed in order to obtain an effective dislodgment and removal of the impurities, the reverse flow of wash water is sometimes accompanied by agitation with air or by means of rakes.

Of recent years, however, it has become a common practice to agitate the bed by employing a high velocity reverse flow of wash water, thus obviating the necessity of employing agitation by air or mechanical means.

With this last mentioned method of cleaning the filter bed, the velocity of the wash water is sufficient to cause at least a partial hydraulic suspension of the granular particles forming the bed which accordingly assumes an expanded condition during the washing or scouring operation. For this purpose the upward velocity of wash water is usually from about 24″ to 32″ vertical rise per minute. The expression "vertical rise per minute" designates the velocity the wash water would have if the filter bed were not present, the actual velocity between the particles being, of course, much higher.

The wash water—in the case of a gravity or open filter—is usually discharged from the upper end of the filter chamber by means of one or more discharge troughs disposed horizontally about 18″ to 24″ above the filter bed or by means of one or more discharge openings disposed at the requisite height at one or more sides of the filter chamber.

From this description, it will be understood that, in the case of a gravity filter, the wash water usually flows laterally to a greater or lesser extent above the filter bed when passing to the discharge means.

In the case of filters of the enclosed or pressure type, the collection and discharge of the wash water is usually effected by means of a perforated plate or pipe, but, as far as we are aware, no means have been provided in either this or the gravity type of filter for obtaining a uniform upward flow through the surface of and above the filter bed, though considerable attention has been paid to the problem of obtaining a uniform distribution of wash water below the filter bed.

Now, it has been found that the impurities deposited on the surface of the filter bed—and which it is desired to discharge during the washing operation—consist in part of relatively compact flaky particles the density of which is not much less than that of the sand grains.

We have ascertained that, during the washing of the filter bed by the high velocity method, these flaky particles and certain other foreign materials remain suspended just above the surface of the expanded filter bed and settle on the surface of the bed when the washing operation is completed.

In this connection, it should be noted that, in the case of a filter chamber of

uniform or substantially uniform cross-sectional area, the velocity of flow during washing decreases towards the top of the expanded bed where the particles are more widely separated and that a substantial drop in velocity occurs above the expanded bed. This relatively lower velocity above the filter bed is detrimental to the removal of the aforementioned flaky particles of floc and the like.

It is now considered good practice for the wash water to flow at such a high velocity that the individual particles of the filter bed will be effectively scrubbed and with such velocities (about 28″ to 32″ vertical rise per minute) the volume of the expanded bed is usually about 40% to 50% greater than the volume of the bed during the filtering operation.

It is found that this large expansion of the bed sometimes allows the heavier particles of suspended floc to fall into the bed during the washing operation, thus further serving to prevent their removal.

This disadvantage cannot be satisfactorily overcome by employing a still higher wash water velocity which would serve to carry off and discharge the heavier floc particles because such higher velocity would result in a greater expansion of the filter bed and it has been found that, if the expanded volume is more than about 50% of the compacted volume, the scouring action is less efficient owing to the greater separation of the individual sand particles. In addition, the increased consumption of wash water is a disadvantage.

Now, the object of the present invention is, inter alia, to provide a method of and means whereby the abovementioned disadvantages will be overcome or minimised and the efficiency of the washing operation will be enhanced.

It has previously been proposed in specification No. 28197/1897 to use a filter provided above the filter bed with a sand trap which forms between its outer surface and the wall of the filter an upwardly converging expansion zone through which the velocity of the wash water progressively increases until it enters the upper part of the said trap. The trap is provided at its lower end with a valve by means of which the heavy or comparatively heavy particles of the granular filtering material deposited in the still or comparatively still waters of the trap are returned to the filter bed.

The present invention provides a method of washing a filter bed by an upward current of water at a rate sufficient to cause an expansion of the filter bed, comprising increasing the velocity of the wash water in a zone which is disposed above the normal surface of the bed, and in such relation thereto as to cause a secondary expansion of said bed due to the increased velocity characterised in that the said zone is of such depth and form that the upper surface of the finally expanded bed is disposed within the zone and at a section thereof in which the velocity is substantially uniform.

The expansion of the bed may be controlled manually, though it is preferably carried out automatically by any known device, such as a float responsive to the expanded-sand level, a thermostat responsive to the temperature of the water, and/or means for maintaining a uniform velocity of the wash water.

The filter according to the invention comprises a filter bed, and one or more substantially vertical passages forming a zone of increased velocity for wash water, said passage or passages being of appreciable height and having their lower ends above the normal level of the upper surface of the filter bed and being so constructed and arranged that, when the filter bed is initially expanded by an upward flow of wash water, the increased velocity in said zone will cause a secondary expansion of the filter bed, so that the upper surface of said expanded bed will be disposed within said zone and at a section thereof in which the velocity is substantially uniform.

In the case of filter chambers of substantial cross-sectional area, we provide a plurality of vertical passages arranged in parallel at regular intervals so as to ensure that the draw-off of water above the filter bed shall be substantially vertical and uniform.

The lower portions of the vertical passage or passages abovementioned are preferably of substantially uniform area for an appreciable length whilst the upper portions of said passages are restricted in area to cause the requisite high velocity for the removal of the flaky particles and the like. With this arrangement the wash water velocity is such as to cause an initial expansion of the sand whereby its upper surface enters the zone of increased velocity due to the lower portions of the passages.

This increased velocity results in an increased or secondary expansion of the sand to a position below the restricted areas at the upper ends of the passages, thus enabling the flaky particles and the like to be drawn off owing to the further increase in velocity, whilst, at the same time, preventing loss or any material loss of sand.

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This increased sand expansion is advantageous in that it facilitates the removal of the flaky particles and other matter and enables a given degree of expansion to be obtained with a lower velocity of wash water through the filter chamber so that a more effective scouring action is obtained for a given consumption of wash water. The improved scouring action is not confined to the sand grains initially close to the upper surface of the filter bed as it has been found that there is a substantial vertical migration of the sand particles whilst the bed is in suspension and thus sand particles are continually moving into the lower portions of the passages from the filter chamber and vice versa.

Other features of the invention reside in the construction and arrangement of the parts and are set forth in the following detailed description.

Whilst the invention is especially applicable to filters which are cleansed by a high velocity flow of wash water, as above described, it should be recognised that some of the advantages of the invention are applicable to relatively low velocity flows of wash water.

Having set forth the object and nature of the invention, reference will be made to the accompanying drawings which illustrate several preferred forms thereof and in which:—

Figure 1 is a diagrammatic view in vertical section of a filter chamber provided at its upper end with a fixed passage for effecting a secondary expansion of the sand bed during washing.

Figure 2 is a view similar to Figure 1 and shows a vertically adjustable passage.

Figure 3 is a diagrammatic view in vertical section of portion of a filter chamber and shows a further form of adjustable passage.

Figure 4 is a view similar to Figure 2 and shows a still further adjustment device.

Figure 5 is a diagrammatic view of an enclosed filter having a plurality of vertical draw off passages.

Figure 6 is a view similar to Figure 5 but in which the passages are vertically adjustable.

Figure 7 is a view in vertical section through a filter chamber showing a further form of the invention.

Figure 8 is a view in plan of the filter shown in Figure 7.

Figure 9 is a diagrammatic view in vertical section of an enclosed filter chamber having means disposed below the level of the expanded filter bed for causing an enhanced scouring action during washing.

In the various figures of the drawings the reference numeral 10 designates a filter chamber provided at its upper end with an inflow passage 11 and at its lower end with an effluent passage 12. The chamber 10 contains a graded bed of suitable comminuted material usually consisting of sand 13 and gravel 14.

During the normal filtering operation, water enters the upper end of the chamber through the passage 11, passes downwards through the filter bed and is discharged through the effluent passage 12.

When the filter bed is being washed, prefiltered wash water enters the lower end of the chamber through the passage 12, passes upwardly through the filter bed at a relatively high velocity so as to cause an expansion thereof and is discharged through the passage 11. Though the passages 11 and 12 are described as serving both for normal filtration and for reverse upward flow during washing, it will be clear that separate pipes may be provided for these purposes. In such cases the passages 11 shown at the upper ends of the filter chambers should be regarded as wash water discharge passages as the present invention is concerned primarily with improvements in connection with the washing of filter beds.

Though, the drawings illustrate filters of the pressure or enclosed gravity type, it will be understood that the invention is equally applicable to filters of the open gravity type.

Figure 1 diagrammatically illustrates a form of the invention in which the upper end of the filter chamber is provided centrally with a vertical passage 31 the upper end of which converges into a passage as 15.

The area of the passage 31 is substantially smaller than that of the filter chamber and is substantially greater than that of the passage 15.

During normal downward filtration when the filter bed is compacted the upper surface of the sand bed is in the position designated by the reference numeral 16.

When however the filter bed is expanded by a high velocity upward wash, the upper surface thereof is initially brought into the zone of increased velocity due to the passage 31. As a result of this increased velocity, a secondary expansion of the sand is produced whereby the upper level thereof is disposed (as shown) at 17 just below the zone of still further increased velocity due to the passage 15. It will be clear, therefore, that the length of the passage 31 is sufficient to permit of the secondary ex-

pansion of the sand without allowing same to enter the zone of the passage 15.

It has been found desirable, though not essential, for the area of the passage 31 to be approximately half the area of the filter chamber and though it is preferred that the said passage 31 be of uniform area from end to end, it will be understood that this is not essential. It is important however that the section of the passage 31 at which the upper surface of the expanded bed is positioned should be substantially parallel sided so that the said surface is disposed in a zone of substantially uniform velocity.

The flaky particles and other foreign materials which are carried upwards just above the upper surface of the expanded sand bed enter the high velocity zone of passage 15 and are thereby removed.

The removal of these foreign particles is facilitated by the passage 31 because, owing to the decrease in area from that of the filter chamber, these particles are more concentrated and form a layer of greater depth in the passage 31 than in the filter chamber.

As the degree of expansion of the said bed during washing is dependent on such factors as the size and specific gravity of the sand particles and the temperature and upward velocity of the wash water, it is usually necessary to provide suitable means for regulating the velocity of the water to ensure that the level of the upper surface of the expanded bed will be disposed in an appropriate position with respect to the zone of increased velocity.

Accordingly, a suitable control valve 18 may be fitted to the passage 12 as shown (or to the wash water discharge passage 11). This valve 18 may be controlled manually for which purpose a suitable inspection window (not shown) may be fitted to an upper portion of the filter chamber, but preferably it is controlled automatically by any known means responsive to variations in the level of the sand bed, for example as shown in Figure 1, a float 19 may be arranged to respond to the level of the expanded sand and cause the valve 18 to open or close to a greater or lesser extent as required to maintain a constant predetermined level.

Figure 2 shows a construction in which a diaphragm 25 provided with the passages 15 and 31 is arranged movably within the filter chamber whereby it may be adjusted to correspond to variations in the expanded-sand level.

Means may be provided to cause the control valve in the outlet passage and/or the level of the diaphragm to be automatically adjusted in response to the level of the expanded sand bed. Such control means do not form an essential part of the present invention, and will not be described in detail as many different arrangements may be employed for the purpose.

However in explanation of the diagram in Figure 2 it may be stated that 20 and 21 designate line conductors of an electric circuit, the former being connected to a contact 22 on the float rod of the float 19 and the latter being connected to a pair of motor reversing relays 23 and 24 arranged in parallel and connected at their opposite ends to contacts disposed at each side of the contact 22.

Relays 23 and 24 serve to control the energisation in opposite directions of an electric motor (not shown) for actuating the valve.

As one alternative, a photo-electric cell apparatus responsive to the comparative opacity of the upper portion of the expanded filter bed may be employed to control the regulating valve.

The level of the diaphragm may be automatically regulated by means of the screwed shaft 26 which extends through a gland in the top of the filter chamber and supports the diaphragm 25. This screwed shaft is fitted with a nut in the form of a worm wheel 27 which is restrained against vertical movement by a bracket 28. The worm wheel 27 is in mesh with a worm (not shown) on a spindle rotated by the motor 48 controlled by the relays 23 and 24. The contacts 49 and 50 are carried by a rod 51 mounted on the diaphragm 25.

Figure 3 shows a modification in which the diaphragm 25 is in the form of a float which, similarly to the float 19 in Figures 1 and 2, is responsive to the level of the expanded filter bed.

If desired, portion of the weight of the float may be balanced in any suitable way and stops 32 may be provided to limit the downward movement of said float during downward filtration.

Figure 4 shows a further modification in which the zone of increased velocity at the upper end of the passage 31 is adjustable by means of a displacement member 30.

Figure 5 shows diagrammatically a vertical section through a filter chamber of relatively large area, and having a partition 33 extending horizontally thereacross. The partition or diaphragm is provided with a plurality of vertical passages 15. These are evenly spaced over the area of the filter chamber so as to ensure that the draw off above the filter bed will be as uniform as possible and substantially vertical. The lower ends

of the vertical passages (which may be of any suitable shape in cross section) have parallel portions 31 of larger diameter than the portions 15 to permit of a secondary expansion of the sand bed.

The diaphragm 33 containing these vertical passages may be in the form of a concrete slab extending the full height of such passages as shown at the right of Figure 5, or alternatively the passages may extend above the slab as shown at the left of the Figure. This latter arrangement has the advantage that in normal downward filtration when the raw water is supplied to the chamber above the diaphragm and passes downwardly through the passages at a low velocity, the upper portion of the chamber serves as a settling chamber in that material in suspension may settle on the top of the slab below the upper ends of the vertical passages. Such material is thus prevented from entering the lower portion of the filter chamber and this reduces the work of the filter bed.

Figure 6 shows a construction similar to Figure 5 except that the diaphragm 25 containing the vertical passages is adjustable by any suitable means though it will be understood that a float type of diaphragm as indicated in Figure 3 may be used in lieu thereof.

Figures 7 and 8 show a further form of the invention in which the top of a filter chamber of the enclosed gravity type is formed of a slab 36 as of concrete having a horizontal passage 37 therein communicating with the common raw water inlet and wash water discharge passage 11.

A plurality of members 41 are embedded in the slab 36, said members being shaped in the manner previously described to provide lower passages 31 and upper constricted passages 15.

The constricted portion 15 of each member 41 is provided with a plurality of lateral holes 42 which communicate with the space 37 in the slab.

A manhole 38 having a cover 39 at its upper end provides for access to the chamber and a plurality of downwardly inclined pipes 40 having their upper ends communicating with the constricted upper portion of the manhole have their lower ends in communication with the passage 37 in the slab.

During normal operation water enters the space 37 in the slab through the passage 11 and thence passes through the holes 42 and pipes 40 into the passages 15 and the manhole respectively. As the velocity of the water through the space 37 is slow, said space acts as a settling chamber.

When the filter bed is being washed, the sand is initially expanded until it reaches the lower ends of the members 41 and manhole so that a secondary expansion then takes place.

Flaky floc particles and other like foreign materials are thus brought into the zones of increased velocity caused by the constricted upper portions of the members 41 and manhole and are discharged through the holes 42 or pipes 40 into the space 37. The holes 42 provide sufficient resistance to ensure a uniform draw-off over the area of the filter.

Likewise the upper surface of that portion of the expanded bed located within the manhole, is disposed within the lower part of the parallel sided upper portion of said manhole, immediately below the upper ends of the pipes 40 which form a zone of increased velocity by means of which particles disposed above the sand surface are discharged into the space 37.

It will be understood that in order to minimise lateral movement of the water above the expanded bed, the members 41 should be relatively small in cross-section and as closely spaced as is practicable.

In the arrangement shown in Figure 9 a diaphragm 43 is arranged transversely within the chamber 10 and is disposed above the normal surface 16 of the filter bed and below the surface 17 of the bed when same is expanded by the reverse high velocity wash.

This diaphragm is formed with a series of vertical holes 44 of double conical shape which are evenly spaced over the area of the filter chamber.

When the high velocity wash commences the upper surface of the sand bed rises and when it reaches the diaphragm 43 the increase in the velocity due to the restricted openings therein causes the sand grains during their passage therethrough to be subjected to a more intense scouring action. Above the diaphragm the velocity again decreases. When the wash is ceasing the level of the expanded bed falls and the sand passes downwards through the flared upper ends of the passages 44 to its normal filtering condition.

In order to prevent lodgment of sand above the diaphragm 43 the flared upper ends of the passages 44 therein are preferably of square or polygonal shape whereby they may cover the whole area of the filter chamber.

Vertical draw-off passages of the types previously described, are arranged above the surface 17 of the expanded bed, one such arrangement being indicated by broken lines in the Figure 9.

If desired, the diaphragm 43 may be

vertically adjustable either manually or automatically.

If desired, any or all of the draw-off passages 15 and 31 and the sand scouring passages 44 may be provided with suitable projections preferably in the form of helical vanes, to cause the water passing therethrough to have a rotary movement imparted thereto.

Having now particularly described and acertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. The method of washing a filter bed by an upward flow of wash water at a rate sufficient to cause an expansion of the filter bed, comprising increasing the velocity of the wash water in a zone which is disposed above the normal surface of the bed and in such relation thereto as to cause a secondary expansion of said bed, due to the increased velocity, the said zone being of such depth and form that the upper surface of the finally expanded bed is disposed within the zone, and at a section thereof at which the velocity is substantially uniform.

2. The method of washing a filter bed according to claim 1 comprising further increasing the velocity of the wash water in a zone disposed immediately above the upper surface of the finally expanded bed in order to facilitate the discharge of impurities entering said last-mentioned zone.

3. The method of washing a filter bed according to claim 2 wherein the expansion of the sand bed is controlled automatically whereby the upper surface thereof is disposed in desired relationship to the zone of increased velocity disposed thereabove.

4. The method of washing a filter bed according to claim 1 or 2 wherein the vertical position of the zone or zones of increased velocity is or are adjustable manually or automatically to correspond with the position of the upper surface of the expanded filter bed.

5. In a filter, a filter bed and one or more substantially vertical passages forming a zone of increased velocity for wash water, said passage or passages being of appreciable height and having its or their lower ends disposed above the normal level of the upper surface of the filter bed, and constructed and arranged so that when the filter bed is initially expanded by an upward flow of wash water, the increased velocity in said zone will cause a secondary expansion of the filter bed so that the upper surface of the finally expanded bed will be disposed within said zone and at a section thereof in which the velocity is substantially uniform.

6. In a filter according to claim 5, a constriction at the upper end of each of said passages to cause a still further increase in the velocity of the wash water.

7. In a filter according to claim 5 or 6, the construction wherein at least the upper portion of each of said passages is of substantially uniform cross section whereby the upper surface of the expanded bed is disposed in a section of the zone in which the velocity is substantially uniform.

8. A diaphragm adapted to be arranged transversely within a filter chamber above the filter bed therein in order to carry out the process set forth in claim 1, said diaphragm having one or more substantially vertical passages therein, said passages being of substantially uniform cross sectional area and of sufficient length to cause a secondary expansion of the filter bed when same is being cleansed by an upward flow of wash water, and a constriction at the upper end of each of said passages.

9. In a filter according to claim 5 or 6 means for automatically controlling the relative positions of said passage or passages and said upper surface of the expanded filter bed.

10. A filter according to claim 6 wherein the said passage or passages is or are provided in a float member which is responsive to the level of the expanded filter bed during the upward flow of wash water.

11. A filter chamber according to claim 6, wherein the vertical passage or passages is or are formed by tubular or like members which extend above the surface of a diaphragm or the like in which they are mounted, and means for introducing the water to be filtered above the diaphragm or the like whereby the space above said diaphragm will serve as a settling chamber.

12. A filter according to claim 6 wherein the upper end or ends of the constricted passage or passages is or are closed and lateral openings are provided for the discharge therefrom of the wash water.

13. In a filter according to claim 5 a cover member arranged above the filter bed and having a horizontal cavity therein, means for supplying raw water to and for discharging wash water from the cavity, a plurality of vertical passages in the cover member and having their lower ends communicating with the filter chamber above the filter bed therein, said passages being substantially parallel-sided for an appreciable length and hav-

ing an aggregate area substantially less than the area of the filter chamber, constricted portions near the upper ends of said vertical passages and lateral passages connecting the upper constricted portions of the vertical passages with the cavity in the cover member.

14. A filter chamber according to claim 13 wherein the lateral passages connecting the upper constricted portions of the vertical passages with the said cavity are disposed near the top of the cavity whereby the latter will serve as a settling chamber.

15. A filter chamber according to claim 5 or 6 wherein the aggregate cross-sectional area of the passage or passages for causing a secondary expansion of the said bed is approximately equal to half the area of the filter chamber below said passage or passages.

16. In a filter according to claim 9, the arrangement wherein a vertically adjustable displacement member is provided to enable the position of the constricted passage or passages to be regulated.

17. In a filter chamber according to claim 6, a member arranged above the normal level of the filter bed and below the level of said bed when same is expanded during washing and one or more substantially vertical passages provided in or formed by said member, to form a zone of increased velocity.

18. Means for facilitating the cleansing of a filter bed constructed and arranged substantially as hereinbefore described and as illustrated in the drawings.

19. The method of washing a filter bed substantially as hereinbefore described.

Dated this 17th day of August, 1934.

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