United States Patent [19]

Böhnke et al.

[11] **3,764,012**

[45] **Oct. 9, 1973**

[54] **AUTOMATICALLY OPERABLE TWO-STAGE BIOLOGICAL COMPACT CLEARING INSTALLATION**

[75] Inventors: **Botho Böhnke**, Aachen; **Paul Diers**, Eilendorf, both of Germany

[73] Assignee: **said Böhnke, by said Diers**, Aachen, Germany

[22] Filed: **July 24, 1972**

[21] Appl. No.: **274,630**

[52] **U.S. Cl.** **210/195**, 210/197, 210/256, 210/525

[51] **Int. Cl.** **B01d 21/02**, C02c 1/02

[58] **Field of Search** 210/195, 197, 199, 210/200, 202, 206, 220, 256, 521

[56] **References Cited**

UNITED STATES PATENTS

3,505,212	4/1970	Huber	210/256 X
3,534,857	10/1970	Berk	210/256 X

FOREIGN PATENTS OR APPLICATIONS

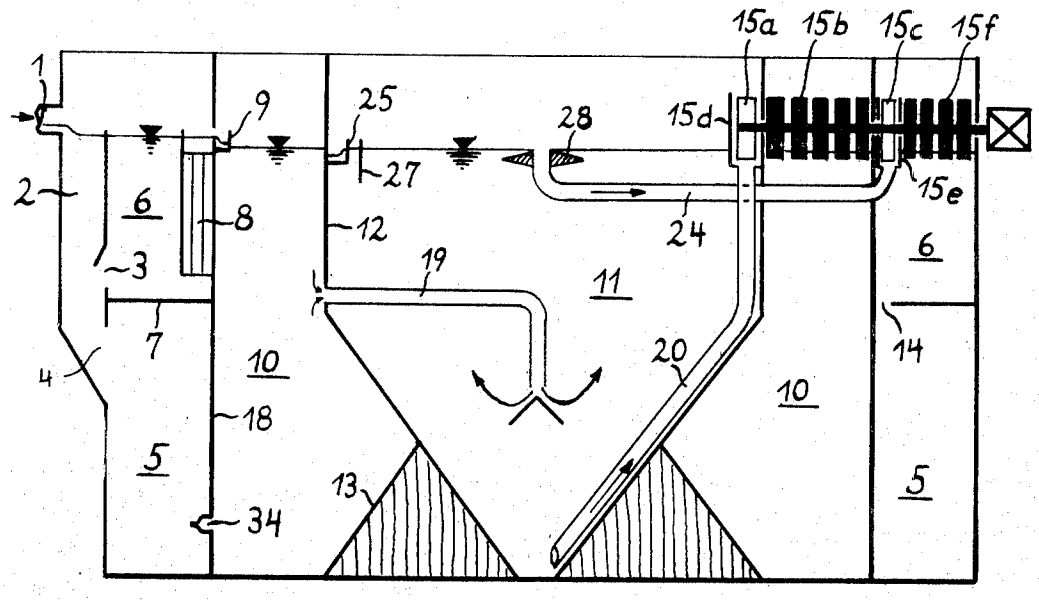
1,324,936	3/1963	France	210/195

Primary Examiner—Samih N. Zaharna
Assistant Examiner—Robert H. Spitzer
Attorney—Walter Becker

[57] **ABSTRACT**

An automatically working two stage aerobic biological compact clearing installation, in which a single container is subdivided into a plurality of coaxial compartments one within the other, in which the outermost compartment comprises an upper section forming a pre-agitating chamber and a lower section forming a digesting chamber, while the compartment within the outermost compartment forms an activating compartment and the compartment within said last mentioned compartment forms a post-clearing chamber, the three mentioned compartments hydrostatically communicating with each other so as to permit a trouble-free unimpeded flow of waste water through all of the compartments.

4 Claims, 5 Drawing Figures



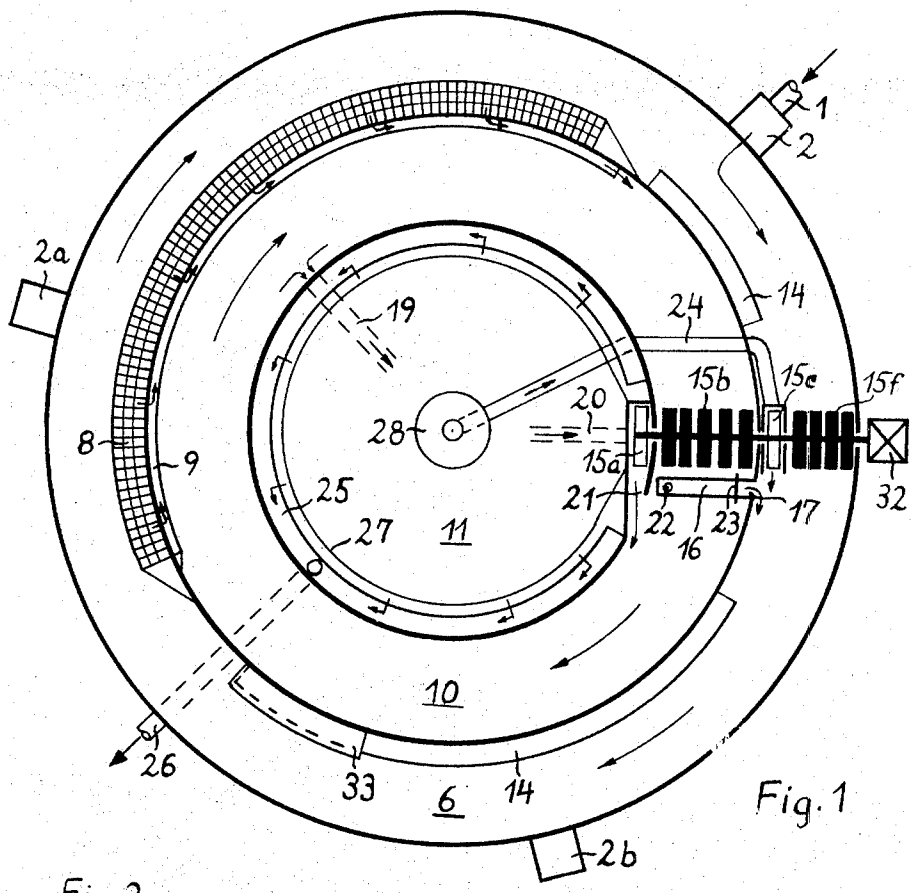

1
2
2a
2b
8
9
14
19
24
15b
15c
15f
20
28
15a
21
22
16
23
17
32
25
27
11
10
26
33
6
14

Fig. 1

Fig. 2

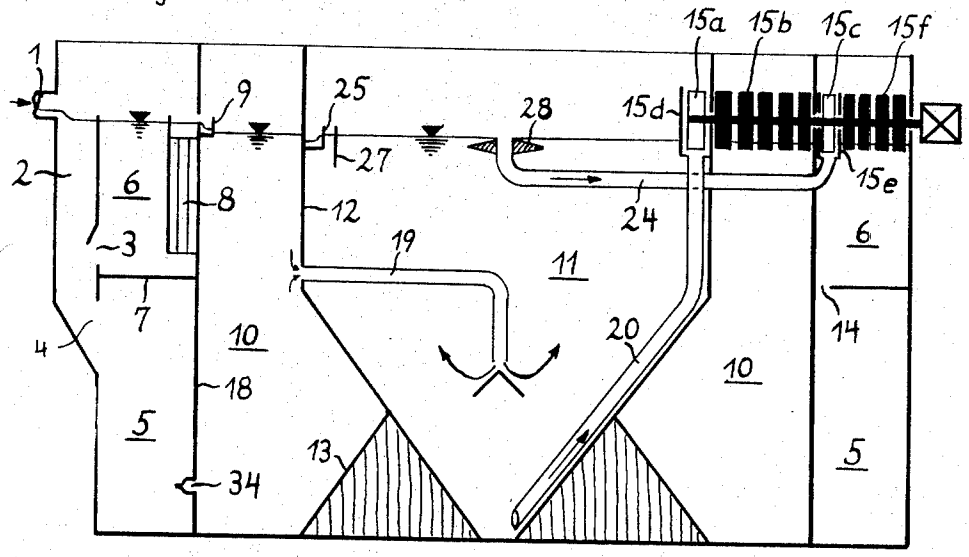

15a
15b
15c
15f
1
9
25
28
15d
2
27
6
8
12
24
15e
3
19
11
6
7
10
20
14
4
18
10
5
13
5
34

Fig. 5

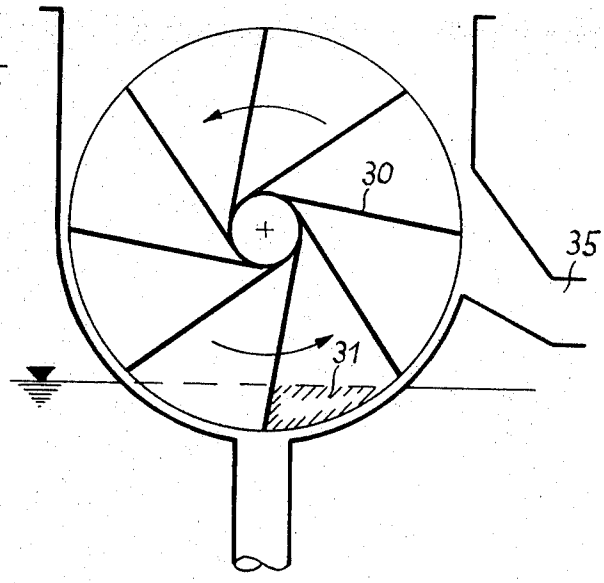


Fig. 4

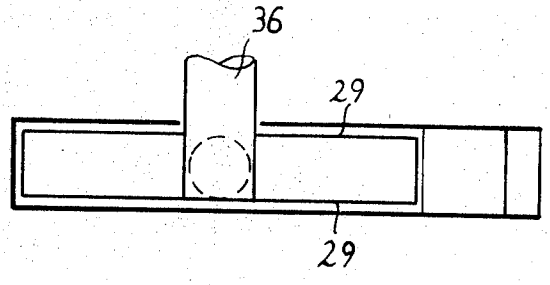
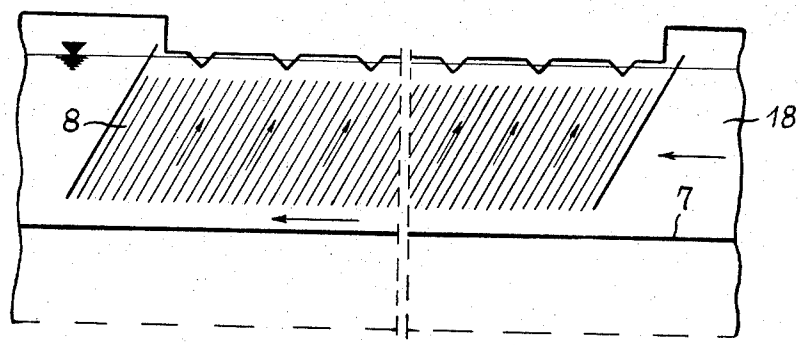


Fig. 3



AUTOMATICALLY OPERABLE TWO-STAGE BIOLOGICAL COMPACT CLEARING INSTALLATION

Already at the present time, the requirement as to hygienically proper drinking water and water fit for domestic and industrial use can no longer be met from ground water alone. Therefore, a recourse to surface water is generally necessary. On the other hand, the ecological condition of surface water is well-known as to pollution. It is furthermore to be anticipated that in the course of the further industrial development, the water requirement will increase considerably and that this additional requirement can be met only by further resorting to surface water.

Therefore, the purification and maintenance of our water in pure condition becomes more and more acute. To solve this problem, not only industry and communities will have to do their part, but it will also be necessary to eliminate the enormously great number of small sources of pollution, which as shown in the pertinent literature have a considerably greater influence than assumed upon the pollution of the surface waters.

While the essential problems of waste water purification may with medium and large units be considered as having been technically solved, so that in this field, questions of investment costs and economy are the foremost questions rather than the purification output expected and the safe function thereof, the technical problems proper with small clearing installations below one thousand inhabitants connected to small clearing installations have not been solved satisfactorily. The real reason for the present lag of the technical development behind the practical necessities is seen primarily in that the fundamental difference between large installations requiring a continuous servicing and adapted to afford the costs for a permanent servicing personnel, and small clearing installations which cannot economically afford an equivalent servicing personnel has not been analyzed structurally to the necessary extent. Only in this way can it be explained that during the last years numerous types of small clearing installations have been developed and marketed which essentially are merely installations which on the basis of large installations of a conventional type have been reduced as to their scale. This is evident already from the fact that they consist of a plurality of units and in part require mechanical units in order to convey the wast water from one unit to another unit.

With regard to such developments which do not do justice to the problem involved, it is to be emphasized that clearing installations for the above mentioned number of consumers involved will make sense only when such installations meet the following requirements:

1. They will work automatically, i.e., without continuous daily servicing;

2. They will be able to absorb safely and purify the unavoidable peak loads as they invariably occur with small installations;

3. They will operate without preceding comb and sand trap, inasmuch as such devices automatically require a regular servicing within short time intervals;

4. They will get by with a minimum of mechanical devices;

5. They will be so designed that they will be able to store for a longer period of time all deposits and excess sludge;

6. They will have sufficiently dimensioned overflows (inlets and outlets) so that no clogging up can occur;

7. They will be equipped with a ventilating system that will prevent any accumulation of floating substances or an accumulation and compacting of textile residues;

8. They will have such large reserves that foreign water, and with rainy weather also a certain proportion of mixed water on-flow, can be handled without washing out the activated sludge; and

9. They will not spread odors.

Clearing installations which do not meet these requirements represent for the water ecology a danger rather than a help because they are too often liable to disorders and require servicing so that sooner or later they will perform their intended functions only to a reduced extent.

At present, the number of installed small clearing installations with mechanical venting devices amounts only to fourteen hundred in the Federal Republic of Germany, but this number would have to be multiplied several hundred times within a few years if the requirements are to be met. In the interest of water ecology and also from a public and economical standpoint only such small clearing installations should be installed which meet the above outlined requirements.

While small clearing installations are known for from ten to fifty connected households which will substantially meet the above mentioned requirements, corresponding installations for from 100 to 1500 households are still lacking. However, this last mentioned range is of particular importance for restoring the polluted waters because it comprises the majority of small communities and settlements which at present have none or only insufficient clearing installations.

It is, therefore, an object of the present invention to provide an automatically operating two-stage aerobic compact clearing installation for biologically fully purifying domestic waste waters which will close the gap existing below the present communal clearing installations.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings, in which:

FIG. 1 is a top view of a clearing installation according to the invention.

FIG. 2 is a vertical central section through the clearing installation of FIG. 1.

FIG. 3 shows a side view of a detail of the installation according to the invention.

FIG. 4 shows a top view of another detail of a clearing installation according to the invention.

FIG. 5 shows a vertical section through the detail of FIG. 4.

The problem underlying the present invention has been solved primarily by the fact that the compact clearing installation consists of a single upwardly opening container with a substantially cylindrical inner cross section while the inner chamber of said container is subdivided into concentric rings of different radial width. The outermost annular chamber is at its upper range provided with a pre-clearing or pre-activating chamber and shunted thereto has a sludge digestion

chamber. The next inwardly located annular chamber has an activating chamber, and the innermost chamber forms a post-clearing chamber. The chambers communicate hydrostatically with each other through openings which have been dimensioned so large as to be sufficient for a trouble-free and unimpeded through flow of the waste water. The clearing installation is at the container top side provided with a venting and conveying device driven by a common drive shaft while the venting part of this venting and conveying device will be able separately in the pre-clearing or pre-activating chamber and in the activating chamber to convey air to the water surface and to produce a uniformly directed water flow in the circumferential direction of the container. The conveying part of said clearing installation is adapted automatically and separately to convey return sludge from the lower region of the post-clearing chamber into the activating chamber and furthermore to convey in controllable quantities excess sludge from the activating chamber into the pre-clearing or pre-activating chamber, and also to convex floating sludge from the upper region of the post-clearing chamber into the pre-clearing or pre-activating chamber. This compact clearing installation has the advantage that among other reasons, in view of the two-stage aerobic method, the above mentioned requirements and conditions have been met to a high and satisfactory extent as numerous practical tests have proved.

Referring now to the drawings in detail, the illustrated clearing installation or plant has a single cylindrical container whiqh is open toward the top and the inner chamber of which in the form of concentric rings contains the following chambers when progressing from the outside toward the inside: The outermost ring divided by a horizontal partition **7** contains a lower digestion tank **5** and an upper pre-clearing or pre-activating chamber **6**, henceforth called pre-activating chamber, the intermediate ring comprises an activating chamber **10**, and the innermost ring comprises a post-clearing chamber **11**.

The above mentioned chambers are hydrostatically connected to each other by openings which are sufficiently large to assure a disturbance-free and unimpeded through flow of the waste waters so that special pumping devices for feeding the water from one chamber to the next chamber will be superfluous.

The above mentioned sequence of the chambers from the outside toward the inside brings about the advantage that the digesting tank in the ring which may be given the greatest volume is located between the container wall and the first vertical partition **18** and therefore is able to digest and store for a longer period of time fresh sludge and the excessive sludge which forms automatically with each digesting operation. Consequently, depending on the supply of solids, it is necessary only every three to six months to empty the digesting tank by withdrawing the sludge deposits. Expediently, to this end discharging shafts **2*a*** and **2*b*** are provided through which a suction hose can be introduced into the digesting tank **5.** In order to assure that during the emptying of the digesting chamber, the individual walls of the digesting tank will not be overloaded in view of the occurring static pressure differences, the first vertical partition **18** is expediently provided with a pressure valve **34.**

The horizontal division of the outermost ring into the lower digesting tank and the upper pre-activating chamber **6** in which the waste water is during a first aerobic stage pre-treated by devices to be described further below and is prepared for the second aerobic treatment in the activating chamber **10,** yields the advantage that the digesting tank **5** is covered by the pre-activating chamber **6** and inconveniences as to odor spread will be avoided by the clearing installation.

The activating chamber **10** and post-clearing chamber **11** are separated from each other by a second vertical partition **12** which conically tapers toward the lower end so that a funnel-shaped deepest area of the post-clearing chamber **11** is created in which the activated sludge collects in a concentrated form and from which this sludge can be satisfactorily removed. This funnel-shaped tip may, if necessary, also be located below the bottom of the container so that the activating chamber **10** up to its bottom forms a cylinder of circular cross section. When arranging the funnel-shaped tip within the container, advantageously, a conically flaring wall **13** is arranged adjacent to the conically tapering portion of the partition **12.** This conically flaring wall **13** on one hand serves as support for the partition **12** and on the other hand has the advantage that dead acute angle corners are avoided in which activated sludge could get stuck and could foul or digest; in view of the decreasing cross section of the activating chamber **10,** increased flow velocities of the water in circumferential direction will again be able to occur at the bottom of said chamber **10** whereby also within the region of the bottom of the activating chamber **10,** the activated sludge is effectively in the waste water held in floating condition. The generation of the above mentioned water flow will be described further below.

The raw water flows through an inlet **1** into a somewhat protruding inlet shaft **2.** From here the raw water itself which during each hydrostatic method will take the shortest route passes to a major extent into the pre-activating chamber **6** through an opening **3** which is arranged in the partition between the pre-activating chamber **6** and the inlet shaft **2.** The heavy depositable components of the inflowing raw water sink through a slot into the digesting chamber **5** which so-to-speak is located in shunt with regard to the pre-activating chamber **6** so that the provision of a preceding comb or retaining device which requires servicing is not necessary in front of the clearing installation. Floating particles will, in view of the continuous washing with inflowing waste water in the inlet shaft **2** gradually become so heavy that they, too, will, after a certain time sink through slot **4** to the bottom of the digesting chamber **5.** The opening **3** is at its upper edge provided with an orifice which protrudes into the inlet shaft **2** and is inclined relative to the vertical by an angle of approximately 30°. This orifice deflects the depositable components which sink in the inlet shaft **2,** away from the opening **3,** and prevents this sinking coarse depositable material from passing with the general flow of waste water into the pre-activating chamber **6.**

The horizontal partition **7** between the pre-activating chamber **6** and the digesting chamber **5** is provided with passages **14,** the cross section of which, is variable by displaceably arranged orifices **33.** Due to these passages **14,** excessive activating sludge which will be conveyed into the pre-activating chamber will be able from the pre-activating chamber **6** to pass into the digesting chamber **5.** Furthermore, the digesting tank water displaced by new inflow of depositable solid materials is

able through the passages **14** to rise into the pre-activating chamber **6** for purposes of being treated together with the raw water which flows through the opening **3** into the pre-activating chamber **6.** In view of the change in cross section of the passages **14** by means of the orifices **33,** the sludge discharge from the top in downward direction can be adjusted in conformity with the respective requirements in such a way that either much sludge sinks and the chamber **6** has more the character of a pre-clearing, or sufficient sludge is retained in chamber **6** so that the latter will then have more the character of a pre-activating tank. Furthermore, a small portion of the kinetic energy of the water flowing in circumferencial direction, said energy being generated in the pre-activating chamber, can through the passages **14** be conveyed to the upper zone of the digesting chamber **5** in order to bring about that the particles depositing in the digesting chamber will distribute themselves relatively uniformly over the circumference of the chamber **5** so that the formation of undesired resting hills at the bottom of the digesting chamber **5** will be avoided.

The pre-activating chamber **6** has first the function to prepare the raw water for the activating process proper, which raw water flows in through the opening **3** and the passages **14.** This preparation is effected in cooperation with excessive sludge which has been conveyed from the successive actuating chamber **10** into the chamber **6.** This preparation is adapted to be controlled to a certain and desired extent by means of the above mentioned passages **14.** As a result of this preparation, already a portion of the organic load is disintegrated or flocculated. A further important function of the pre-activating chamber **6** consists in catching organic load shocks as they are unavoidable particularly in small installations so that they cannot, via the shortest route, spread to the post-clearing chamber **11.** The pre-activating chamber **6** is so designed that the waste water is therein treated for approximately five hours before it passes through openings at the upper edge of the vertical partition **18** into a catching trough **9** arranged within the chamber **10** from which it overlows into the activating chamber **10** proper. The trough **9** is preceded by an intermediate clearing device **8** arranged in the chamber **6.** This intermediate clearing device **8** comprises a plurality of vertically arranged small tubes which are inclined in the direction of the water flowing in chamber **6** in circumferential direction. This inclination relative to the horizontal amounts to an angle of approximately 60° (FIG. **3**). This intermediate clearing device **8** separates depositable materials from the water which continues flowing to the activating chamber **10.** The inclined position of the pipes aids in causing the depositable materials to circulate by the lower end of the tubes so that the last mentioned materials will not be pushed into the tubes by the water flowing by.

The activating chamber **10** is so designed that the pre-treated and pre-cleared waste water is here, on an average, treated aerobically for approximately 5 hours. The treated water which contains floating activated sludge passes through a conduit **19** into the post-clearing chamber **11** which is designed in conformity with the principle of the Dortmund well (Brunnen). This post-clearing chamber **11** is passed through in vertical direction. The activated sludge deposits at the funnel tip thereabove will form a plate filter which is retained also when the installation at certain times of the day or regularly during the night hours is not charged with waste water. After a staying time of an average of four hours, the post-cleared biologically treated waste water flows through a discharge trough **25** and through an outlet **26** which is connected to the outlet trough **25.** The discharge trough **25** is preceded by an immersion board **27** (Tauchbrett) which holds back the floating sludge. Inasmuch as a fully biological purification is assured by the compact clearing installation according to the invention, the waste water being discharged can be introduced into the next draining device (Vorfluter).

Arranged at the upper portion of the container is a venting and conveying unit which comprises a common drive shaft and, therefore, can be driven by means to a single electric motor. The venting part of this unit comprises a venting cylinder or roller **15*f*** which rotates at the water surface of the pre-activating chamber **6,** and furthermore comprises a separate venting cylinder or roller **15*b*** which rotates at the water surface of the actuating chamber **10.** These two venting cylinders or rollers bring about a strong ventilation and mixing of the water with air in the chambers **6** and **10** and also impart a sufficiently high flow velocity upon the water in the two chambers and in the same direction. The flow velocity obtainable with this design of the venting part in the form of venting cylinders or rollers is also in the activating chamber of such magnitude that it also acts upon the sole of the activating chamber **10** and prevents undesired sludge deposits at the bottom of the activating chamber **10,** which sludge deposits otherwise would lead to undesired fouling or digesting processes interfering with the purification. The venting cylinder **15b** acting in the activating chamber **10** simultaneously serves as conveying device. To this end, parallel to the venting cylinder **15*b***, and more specifically, on that side ot which the venting cylinder **15*b*** by its rotation draws water upwardly, there is provided a catching trough **16.** The upper edge of said trough **16** is located above the water level when the water is at rest and said trough **16** is located in such spaced arrangement with regard to the venting cylinder **15*b*** that it will catch a considerable portion of the water which is drawn upwardly by the venting cylinder and which contains activated sludge flakes. By means of a valve **23** which is adjustable in the longitudinal direction of the trough **16,** the trough **16** is divided into two sections or compartments, and the relation between the two compartments is variable. One compartment has an outlet **17** to the pre-activating chamber **6,** and the other compartment has a return opening **22** leading back to the activatng chamber **10.** By means of the valve **23** it is thus possible, in conformity with the conditions and requirements of the activating process, to control the quantity of activating sludge which is to be withdrawn from the activating chamber **10** and which exceeds the desired ordinary level. The withdrawn excess sludge will, in the pre-activating chamber **6,** give off the still present activity and thereby will,in the chamber **6,** create an intended pre-stage of a noticeable biological purifying action. After a certain time, the excess sludge drops through the passages **14** into the digesting chamber **5** where it condenses together with the fresh sludge, is digested and stored. That sludge-water mixture which is to be withdrawn in the form of excess sludge flows out of the trough department which comprises the bottom opening **22** and returns to the activating chamber **10.**

The bottom opening **22** prevents activated sludge from depositing and fouling or digesting in the trough **16.**

Mounted on the common drive shaft and forming a further conveyor part is a bucket or scoop wheel **15***a* which rotates in a vat **15***d* immersed into the water surface of the post-clearing chamber **11.** The vat **15***d* communicates through a suction line **20** with the funnel tip of the post-clearing chamber **11** and has an outlet **21** to the activating chamber **10.** By means of this scoop wheel **15***a*, deposited sludge is withdrawn from the funnel tip of the post-clearing chamber **11** and in the form of return sludge is returned to the activating chamber **10.** In this way and in combination with the controllable discharge of excess sludge as brought about by the venting cylinder **15***b* a permanent sludge circuit is created, and a constant activated sludge level is maintained in the activating chamber **10.** This permanent sludge circuit and constant activated sludge level are necessary for maintaining a stabile purification effect and can be adapted to the respective organic load. With the branched-off excess sludge it will then be possible by means of the passages **14** of variable cross section, to adjust the sludge age as well as the content in dry substance in the pre-activating chamber **6.**

Inasmuch as the activating chamber **10** is operated in the only slightly loaded range of from only 0.15 – 0.30 kg BSB_5/kg TS, floating sludge will develop which must not concentrate and form a solid cover on the surface of the post-clearing water. For purposes of eliminating the floating sludge, a second scoop or bucket wheel **15***c* is arranged on the common drive shaft and forms a further conveying part. Wheel **15***c* rotates in synchronism with the wheel **15***a* in a vat **15***e* which is arranged in the chamber **6.** This vat **15***e* has an outlet leading to the chamber **6** and has a suction line **24** which ends in the center of the post-clearing chamber **11** at the water surface and is provided with a dish-shaped mouthpiece **28.** The upper edge of this mouthpiece **28** is located substantially just at the level of the water. By means of this bucket wheel **15***c*, the floating sludge retained by the immersion board **27** is withdrawn continuously and returned to the pre-activating chamber **6.** The above mentioned withdrawal of the floating sludge from the central region of the post-cleearing chamber has the further advantage that in the first place that part of the post-clearing chamber which with regard to the flow through is normally considered dead space, is likewise passed through, ad that secondly the above mentioned vertical flow through of the post-clearing chamber is favorably influenced.

By means of the combined venting and conveying unit, which returns the return sludge from the post-clearing chamber **11** to the activating chamber **10,** and returns excess sludge from the activating chamber **10** to the pre-activating chamber **6,** and also returns floating sludge from the post-clearing chamber **11** to the pre-activating chamber **6,** the automatic operation and the fully biological action of the compact clearing installation is assured which then only at fairly long time intervals will require an emptying of the digesting chamber.

As is shown in FIGS. **4** and **5,** the scoop wheels **15***a* and **15***c* comprise two circular discs **29** which are arranged on the drive shaft **36** driven by the common motor **32** and located between the turbine blade-like radial webs **30.** In axial direction, the circular discs **29** border relatively close to the side walls of the scooping box or vat **15***d*, **15***e*. During the rotation of the drive shaft **36,** each intermediate web **30** lifts the water volume **31** somewhat which lifted water discharges through the discharge **35** of the scoop box or vat. In order to assure that the respective lifted water **31** will be discharged as quickly as possible, and as completely as possible, the intermediate webs **30** are advantageously tangentially arranged on the drive shaft **36.** With the wheel **15***a*, for instance, instead of the discharge **21** from the scoop vat to the activating chamber **10,** a hollow drive shaft may be provided which between the circular discs **29** of the scoop wheel **15***a* has an inlet opening and within the range of the activating chamber **10** has an outlet opening.

The post-clearing chamber **11** of the described compact clearing installation may, in view of the structural design of this installation be selected from the very start of such magnitude that the through flow of three times the intended or produced soiled water quantity will be possible without structural changes. In this way, the inflowing waste water will principally be coped with by separate canalization and even if large rain water quantities are intermixed therewith. If it is necessary to pass through from four to five times the soiled water or waste water quantity for which the device has been designed, this requirement can be met by selecting the next higher type of the clearing installation according to the invention. In view of this possibility, the type series is expediently so selected that starting with a base type, each following type has a **50%** higher volume than the preceding type.

It is, of course, to be understood that the present invention is, by no means, limited to the particular showing in the drawings, but also comprises any modifications within the scope of the appended claims.

What we claim is:

1. An automatically operating two-stage aerobic biological compact clearing installation, which includes: a single container open at the top and having a substantially cylindrical inner cross section, partition means subdividing the interior of said container into a plurality of coaxial compartments arranged one within the other, the outermost one of said compartments representing the first compartment and comprising an upper section forming a pre-activating chamber and also comprising a lower section in shunt arrangement with regard to said upper section and forming a digesting chamber, influent means delivering liquid to be purified to said pre-activating chamber, the compartment within and next to said first compartment representing the second compartment and forming an activating chamber, and a third compartment next to and within said second compartment forming a post-clearing chamber, said first and second and third compartments communicating hydrostatically with each other so as to permit a trouble-free unimpeded flow of waste water through said compartments, venting and conveying means arranged in the upper portion of said container, driving shaft means common to said venting and conveying means for driving the same, said venting means being adapted separately to introduce air at the water surface into said pre-activating chamber and said activating chamber and to generate a uniformly directed water flow in the circumferential direction of said container, and said conveying means being adapted automatically and separately to convey return sludge from

the lower range of said post-clearing chamber into said activating chamber and also to convey excess sludge from said activating chamber into said pre-activating chamber, and furthermore to convey floating sludge from the upper range of said post-clearing chamber into said pre-activating chamber, means for controlling the quantity of excess sludge being conveyed from said activating chamber to said pre-activating chamber, and means for discharging clear effluent from said third compartment.

2. A clearing installation according to claim **1**, which includes two scoop boxes respectively arranged in said post-clearing chamber and said pre-activating chamber, and in which said venting means includes two separate venting drums for partially immersing into the water to be treated and also includes two scoop wheels drivingly connected to the same driving shaft means as said venting drums and respectively rotatable in said scoop boxes, first intake conduit means leading from a lower area of said post-clearing chamber into the scoop box in said post-clearing chamber, first outlet means leading from the scoop box in said post-clearing chamber to said agitating chamber, second intake conduit means leading from the central upper area of said post-clearing chamber into the scoop box in said pre-agitating chamber, and second outlet means leading from the scoop box in said pre-agitating chamber into the latter.

3. A clearing installation according to claim **2**, which includes: catching trough means arranged substantially parallel to the venting drum in said activating chamber and having its upper edge located at a level higher than the water level and spaced from said last mentioned venting drum by such a distance as to permit said trough to catch activated sludge containing water, and valve means adjustable in the longitudinal direction of said trough and dividing the latter into two sections, one of said sections comprising an outlet for communication with said pre-activating chamber, and the other one of said sections comprising an outlet for communication with said activating chamber.

4. A clearing installation according to claim **1**, which includes a substantially horizontal partition separating said pre-activating chamber from said digesting chamber therebelow and ahead of and behind the venting drum in said outermost compartment being provided with passage means, and means associated with said passage means for varying the effective free cross section thereof.

* * * * *