United States Patent [19]

Eimer

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[54] **HYDRODYNAMIC SORTING APPARATUS**

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[52] **U.S. Cl.** **165/95,** 209/250

[51] **Int. Cl.** **F28g 13/00**

[58] **Field of Search** ..... 165/95; 15/104.06 A, 3.51; 209/250, 255, 258, 155

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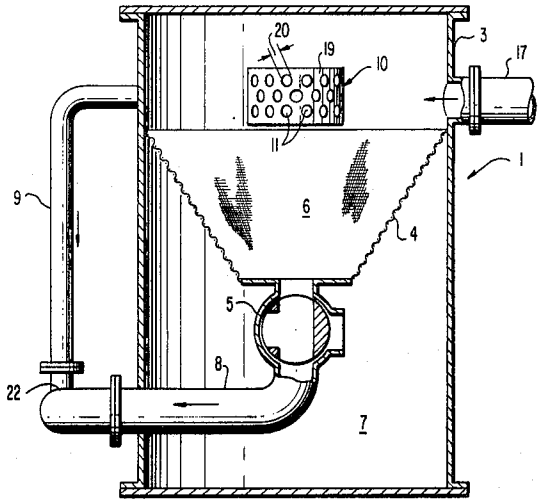
[57] **ABSTRACT**

A hydrodynamic sorting apparatus for continuously sorting out condenser element cleaning balls that have been worn to a reduced diameter during circulation through a condenser system. Each of the preferred embodiments includes a sorting conduit having a sorting basket interposed in the flow of cooling fluid and cleaning balls through the condenser system. The sorting conduit is arranged in bypassing relationship to the normal cooling fluid circulation so as to accept a partial stream of cooling fluid therethrough. The sorting basket includes an apertured plate having openings which permit passage of balls below a reduced diameter while preventing passage of the remaining balls and the sorting conduit includes a sorting gate for trapping the balls passing through the basket and for accommodating removal of these worn balls.

19 Claims, 6 Drawing Figures



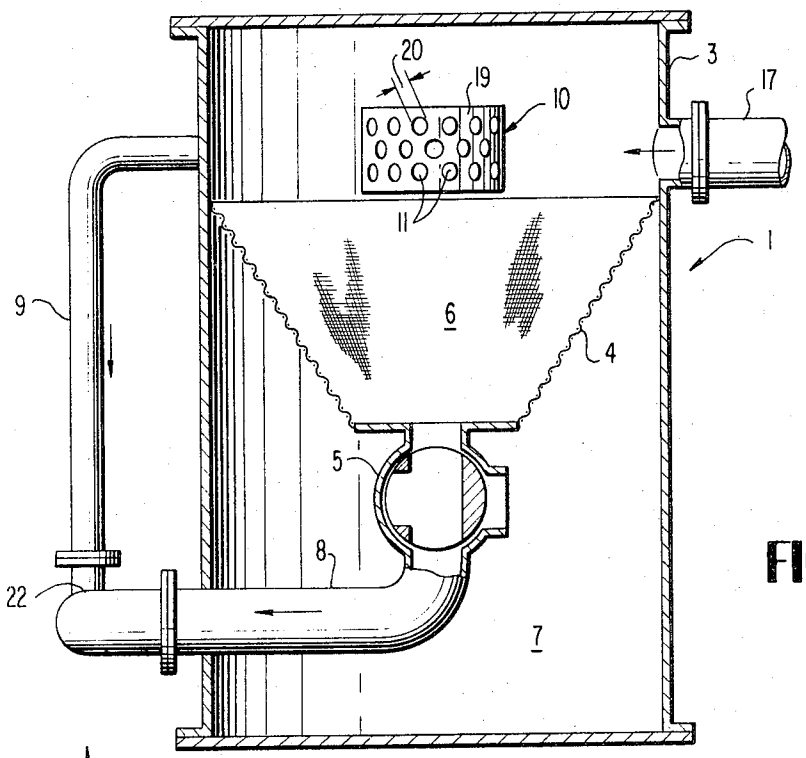


FIG 1

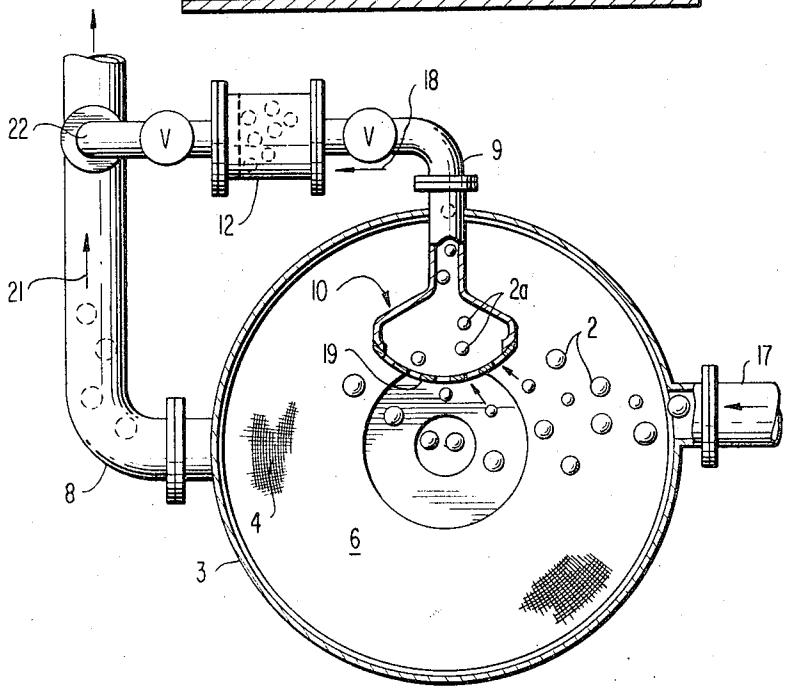


FIG. 2

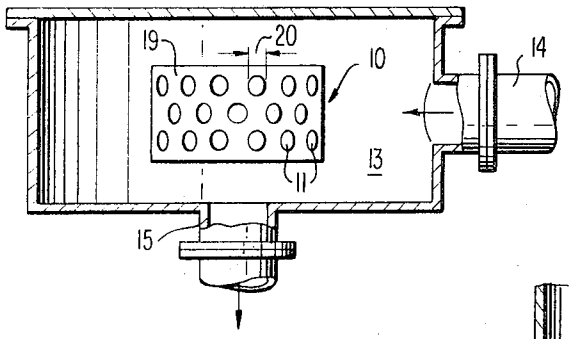


FIG. 3

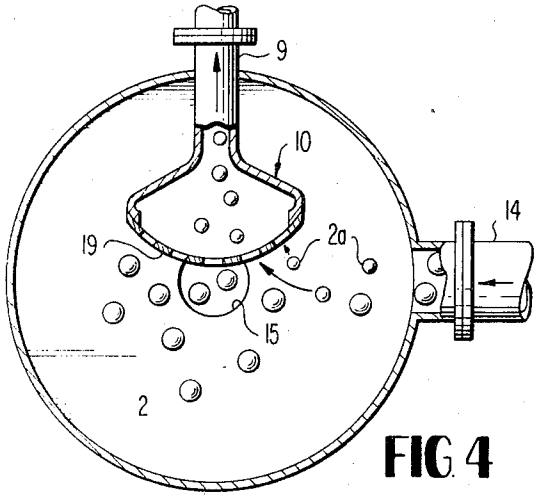
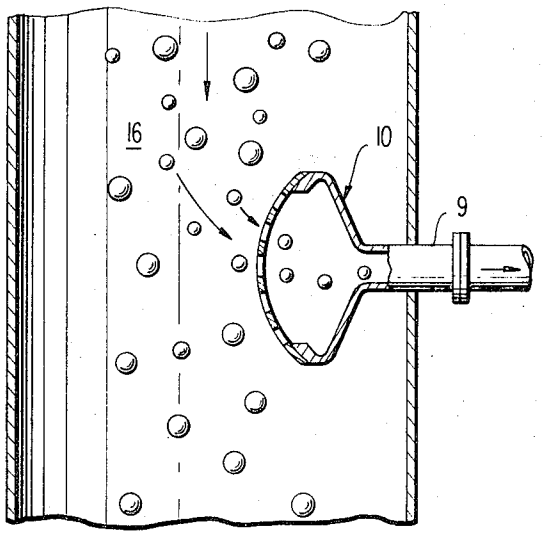


FIG. 4

FIG. 5



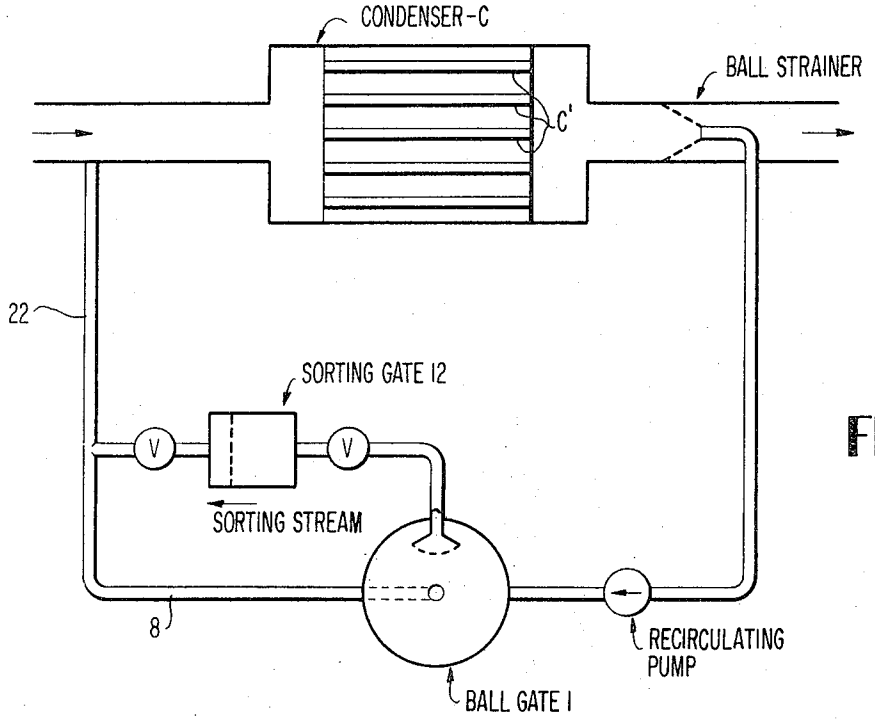


FIG. 6

HYDRODYNAMIC SORTING APPARATUS

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to a condenser system for steam turbines and the like with a cooling water cycle extended through the condenser and with elastically deformable cleaning balls of rubber, a synthetic resin, or the like, entrained by the cooling water circulation. (See U.S. Pat. No. 3,021,117, dated Feb. 13, 1962 of Joseph Taprogge for conventional condenser system of this type.)

In conventional condenser units of the above-described type, the cleaning balls are subject to abrasion during the course of time and in a statistically fluctuating manner. Once the abrasion has reached a certain extent, the thus-worn cleaning balls no longer fulfill their cleaning function. These worn cleaning balls must then be removed and replaced by new ones. For removing and replacing worn balls, it has been contemplated to provide a so-called ball gate or sluice in the cooling water cycle, consisting of a more or less cylindrical container with a screen basket inserted therein. A discharge conduit is connected via a valve to the screen basket, on the one hand, and to the space underneath the screen basket, on the other hand, so that it is possible to selectively withdraw either the cooling water with the cleaning balls entrained therein from the space upstream of the screen basket, or only the cooling water without the cleaning balls (cleaning balls being retained in the screen basket). This arrangement affords the prerequisite for retaining all cleaning balls in the screen basket. Thus, the cleaning balls, if necessary, are captured in this ball gate and withdrawn therefrom. The used-up or worn balls, after removal of the entire number of balls, are sorted out manually or by means of a perforated screen plate and replaced by new ones. All of this removal and replacement of worn balls is a complicated, time consuming, uneconomic procedure.

The invention contemplates further developing a condenser system of the aforedescribed type so that the worn-down cleaning balls can be automatically eliminated.

Prefered embodiments of the invention relate to a condenser system for steam turbines and the like with a cooling water cycle passing through the condenser and with elastically deformable cleaning balls of rubber, a synthetic resin, or the like, entrained by the cooling water circulation. The invention contemplates providing the cooling water cycle with a device for the hydrodynamic sorting of the cleaning balls. A device for hydrodynamic sorting within the scope of the present invention is intended to mean any apparatus which, by hydrodynamic forces and screens, sort out worn cleaning balls from the cooling water cycle. This can be done in various ways.

A preferred embodiment of the invention is characterized in that the device for the hydrodynamic sorting of the cleaning balls consists of a sorting conduit constructed as a bypass or branch line of the cooling water cycle, which conduit is designed for a partial stream of the cooling water. The sorting conduit has, at the inlet, a sorting basket with passage openings, which basket allows these cleaning balls to pass which are to be sorted out and which are reduced in diameter by wear and tear. A sorting gate is provided in the sorting conduit which retains these cleaning balls and which can be opened for the removal of thus-retained cleaning balls. For this purpose, the cooling water cycle can be provided with special structural components. The sorting process is accomplished in a maximally short period of time in a preferred arrangement of the condenser system where the cooling water cycle is equipped with a turbulence chamber with radial or tangential extrance for the cooling water and with an axial outlet for the cooling water. The sorting conduit extends radially into the turbulence chamber with the screening or sorting basket being arranged inside this chamber. This sorting basket is preferably arranged in the zone of the center of the turbulence chamber eccentrically close to the outer wall so as to be in a zone of maximum turbulence.

In further preferred embodiments, the turbulence chamber can additionally be designed as a ball gate and can be provided for this purpose in a manner similar to that described above for previously contemplated systems without a hydrodynamic sorter. In this embodiment, the sorting conduit and sorting basket extend into the space of said ball gate upstream of the screen basket and the other downstream end of the sorting conduit connects with the discharge conduit of the ball gate at a position downstream of the screen basket and valve of the ball gate.

In a still further preferred embodiment the sorting conduit and sorting basket extend radially into a straight turbulence path of the cooling water cycle.

The present invention is advantageous in that worn-down cleaning balls can be sorted out automatically in a very simple operation continuously or periodically, which balls can then be replaced in any desired manner by new cleaning balls. In this connection, the device for the hydrodynamic sorting process can be installed either separately from or in combination with a customary ball gate according to the above and below described preferred embodiments.

These and further objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawings which show, for purposes of illustration only, several embodiments in accordance with the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an axial part-sectional schematic view through a ball gate of a condenser system device for the hydrodynamic sorting of the cleaning balls in accordance with a preferred embodiment of the present invention;

FIG. 2 is a top part-sectional schematic view of the arrangement of FIG. 1;

FIG. 3 is an axial part-sectional schematic view of another embodiment of a device for the hydrodynamic sorting of cleaning balls in a condenser system according to this invention;

FIG. 4 is a top part-sectional schematic view of the arrangement of FIG. 3;

FIG. 5 is an axial part-sectional schematic view of a pipe conduit of a condenser system with a further embodiment of the device for the hydrodynamic sorting of the cleaning balls according to this invention; and

FIG. 6 is a schematic view depicting the apparatus of the present invention in conjunction with a condenser system.

DETAILED DESCRIPTION OF THE DRAWINGS

The ball gate 1 illustrated in FIGS. 1, 2 and 6 pertains to a condenser system for steam turbines and the like with a cooling water cycle extended through the condenser elements C' of the condenser C and with cleaning balls 2 of rubber, a synthetic resin, or the like, entrained by the cooling water. The ball gate 1 consists of a cylindrical container 3 with a screen basket 4 installed therein. A three-way valve 5 for selectively connecting discharge line 8 with the space 6 of the cylindrical container 3 disposed upstream of the screen basket 4 in the flow direction and with the cylindrical space 7 disposed downstream of the screen basket 4. If the space 6 upstream of the screen basket 4 is connected to the discharge line 8, all cleaning balls 2 are conducted through this ball gate 1 without being retained (other than those balls sorted out by the hydrodynamic sorting device which is described below). If the space 7 disposed downstream of the screen basket 4 is connected to the discharge line 8 (with valve 5 closing off passage of balls through the central outlet of basket 4) then all cleaning balls are retained since the openings in screen 4 are much smaller than the balls 2.

In accordance with the state of the art, the thus-retained cleaning balls 2 may all be withdrawn from the cycle (removed from screen basket 4), for the purpose of replacing worn cleaning balls 2. The balls 2 may then be sorted and reintroduced into the cooling water cycle after the used cleaning balls have been replaced by new ones.

In accordance with the present invention, a device for the automatic hydrodynamic sorting of the cleaning balls 2 is now provided which avoids the necessity of retaining all of the balls at one time. All illustrated preferred embodiments of the device for the hydrodynamic sorting of the cleaning balls 2 in accordance with the present invention include a sorting conduit 9 designed as a bypass or branch line of the cooling water cycle, which conduit 9 is constructed for accepting a partial stream of the cooling water. This sorting conduit 9 has, at the inlet, a sorting basket 10 with passage openings 11, which allows the cleaning balls 2*a*, which have been reduced in diameter by wear and tear and are to be sorted out, to pass through, whereas the other balls are prevented from passing through. The sorting conduit 9 furthermore comprises a sorting gate or second gate (in the embodiment of FIGS. 1 and 2 with the ball gate 1) 12. The sorting gate 12 retains these cleaning balls 2*a* and is openable in order to remove the thus-retained cleaning balls 2*a*.

The ball gate 1 (FIGS. 1 and 2) still operates as usual as a ball gate, i.e. the gate 1 is switchable to the ball retaining position if, for some reason, all cleaning balls 2 are to be removed. Additionally, an automatic sorting out of the worn cleaning balls 2*a* is accomplished via the above-described arrangement of the bypass line or sorting conduit 9. In this connection, the ball gate 1 in total already acts as a turbulence chamber due to the flow of cooling water therethrough as described below. Because of the turbulene flow in the ball gate 1, the worn down balls 2*a* are quickly passed through openings 11, and into conduit 9 and the second gate 12.

Other preferred embodiments (FIGS. 3–5) include a turbulence chamber in place of or in addition to a ball gate. The FIGS. 3 and 4 embodiments include a turbulence chamber 3 with a radial or tangential cooling water inlet 14 and an axial cooling water outlet 15, wherein the sorting conduit 9 extends radially into the turbulence chamber 13, and the sorting basket 10 is disposed in the zone of the center of the turbulence chamber 13. In the embodiment of FIG. 5, in contrast thereto, the cooling water cycle is provided with a straight turbulence path or zone 16, the sprting conduit 9 extending radially into the turbulence path 16 and the sorting basket 10 being arranged in the zone of the center of the turbulence path.

The operation of the hydrodynamic sorting devices of the present invention will be explained in greater detail with reference to the embodiment of FIGS. 1 and 2. The main stream of the cooling water cycle conducts the balls 2, via a preferably eccentric inlet 17 (eccentric with respect to centerline of cylindrical container 3 so as to enhance turbulence), into the ball gate 1 which is in the "passing" position (position freely connecting line 8 with space 6 so that balls can cycle through system). In the ball gate 1, a small stream of water, namely the so-called sorting stream 18, enters the sorting conduit 9 through the free cross-sectional areas 20 of the openings 11 of the screen or perforated plate 19 of the sorting basket 10. Worn cleaning balls 2*a*, the diameter of which is smaller than 20, likewise enter the sorting basket 10. The sorting stream 18 is recombined with the main stream 21, namely at 22. The sorting stream 18 preferably comprises quantitatively about 10–30 percent of the main stream 21, depending on the size of the main stream 21.

Cleaning balls 2*a* having a diameter smaller than the adjustable perforation diameter 20 of the sorting basket 10, can, as mentioned above, enter the sorting basket 10 and are collected in the sorting gate 12, where they can be withdrawn and replaced by new cleaning balls 2, without having to stop the cooling water cycle conducted via the ball gate 1 and without having to remove all of the balls 2, 2*a*. For this purpose, the sorting conduit 9 is preferably equipped on both sides of the sorting gate with shutoff valves V and V'. Balls 2 having a diameter larger than the diameter 20 cannot enter the sorting basket 10.

Due to the relatively small pressure difference at the screen or perforated plate 19 of the sorting basket 10, as well as due to the high turbulence of the main stream 21, the disadvantages are avoided that balls 2 having a diameter larger than the perforation diameter 20 clog the sorting basket 10 at the screen or perforated plate 19 of this basket 10, or creep through gradually. This last-mentioned phenomenon actually was to be expected, but surprisingly does not occur.

The above-described device for the hydrodynamic sorting of the cleaning balls 2, 2*a* has a suprisingly accurate sorting effect with a very small range fluctuating about the theoretical sorting limit. During experiments, it was found that a collective number of cleaning balls circulated in the system of 18 – 22 mm. diameter can be divided into classes or graduations of 0.5 mm., wherein, of course, the sorting basket 10 is equipped with an appropriate screen or perforated plate 19. The device for the hydrodynamic sorting of the cleaning balls 2, 2*a* can thus differentiate very accurately. This result is surprising, considering that a cleaning ball 2

which is just above the stage where it is to be sorted out, requires due to its elastic deformability, merely a force of 0.1 Newton in order to be pressed into the sorting basket **10** before its size is sufficiently reduced below the predetermined size governed by the size of openings **16**.

It will be understood that the worn-down balls **2***a* are not all sorted out during the first circulation. For statistical reasons, several cycles are required to effect a complete sorting. If the device for hydrodynamic sorting is inserted for continuous operation, then the sorting process will be continuous. However, since the sorting speed is very high as compared to the wearing speed of the cleaning balls **2**, it is also possible to operate in a periodic type of process.

It will also be understood that the complete condenser fluid circulation circuit for the embodiments of FIGS. **3** to **5** will also include a condenser C and shutoff valve V, V' as in the FIG. **1** and **2** embodiment.

Plates **19** are preferably interchangeably mounted to accommodate changing to different size hole patterns for different use conditions.

The invention contemplates both continued and intermittent operation of the sorting apparatus. In the case of intermittent operation, all balls are collected in the ball gate (with valve **5** connecting space **7** to line **8**) for the sorting operation as described above. After the sorting operation, space **6** is connected to line **8** for normal ball recirculation. Particularly preferred operations in conducted tests include extending the intermittent operation to only a fiew minutes per week of condenser system operation.

While I have shown and described several embodiments in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of numerous changes and modifications as known to those skilled in the art and I therefore do not wish to be limited to the details shown and described herein but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

I claim:

1. A condenser system for steam turbines and the like comprising:

condenser elements,

cooling fluid circulation means extending through said condenser elements,

a plurality of cleaning balls positioned in said circulation means and entrainable by cooling fluid passing through said circulation means so as to effect a cleaning action on the condenser elements during circulation of cooling fluid through said circulation means,

and hydrodynamic sorting apparatus interposed in the circulation means for separating those of said cleaning balls which have been worn to below a predetermined reduced size from the remainder of said cleaning balls.

2. A system according to claim **1**, wherein said hydrodynamic sorting apparatus includes ball retention means for preventing those balls of reduced size from being circulated through said condenser elements.

3. A system according to claim **1**, wherein said hydrodynamic sorting apparatus includes means for preventing those balls of reduced size from being circulated through said condenser elements while permitting uninterrupted continuous circulation of the remaining balls and the cooling fluid through said circulation means.

4. A system according to claim **1**, wherein said hydrodynamic sorting apparatus includes:

a sorting conduit fluidly connecting first and second portions of said circulation means in bypassing relationship to the normal flow of cooling fluid from the first portion to the second point, said sorting conduit being positioned for continuously conducting a portion of the cooling liquid therethrough in a direction from said first portion to said second portion,

a sorting basket at the first portion of said circulation means which has passage openings for permitting passage therethrough of cleaning balls of a size smaller than said predetermined reduced size while preventing passage therethrough of cleaning balls of a size greater than said predetermined reduced size,

and a sorting gate in said sorting conduit downstream of said sorting basket for retaining balls from said sorting basket while permitting flow of said portion of the cooling fluid to said second portion.

5. A system according to claim **4**, further comprising sorting gate access means for accommodating access to and removal of the balls retained therein.

6. A system according to claim **5**, wherein said sorting gate access means includes stop valves positioned at either side of said sorting gate for stopping the flow of cooling fluid to and from said sorting gage and openable cover means which provide access to said balls in said sorting gate.

7. A system according to claim **4**, wherein said circulation means includes a turbulence chamber with an axially directed cooling fluid outlet and a cooling fluid inlet extending transverse to said cooling fluid outlet, and wherein said sorting conduit extends into said turbulence chamber in a direction transverse to said cooling fluid outlet with said sorting basket disposed in the turbulence chamber.

8. A system according to claim **7**, wherein said cooling fluid inlet extends radially of said turbulence chamber.

9. A system according to claim **7**, wherein said cooling fluid inlet extends tangentially into said turbulence chamber.

10. A system according to claim **7**, wherein said turbulence chamber is constructed as a ball gate in the form of a cylindrical container with a screen basket disposed therein, and wherein valve means are provided for selectively communicating the flow of fluid from said screen basket to downstream portions of said circulation means by one of said cooling fluid outlet and screen mesh portions of said screen basket which bypass said cooling fluid outlet, whereby all of said balls can be retained in said ball gate by moving said valve means so as to communicate said flow of fluid to said downstream portion of said circulation means only by way of said screen mesh portions.

11. A system according to claim **10**, wherein said cooling fluid outlet is dimensioned to accommodate passage of all of said balls therethrough and said screen mesh portions are dimensioned to prevent passage of any of said balls therethrough.

12. A system according to claim **4**, wherein said circulation means includes a straight turbulence section through which all cooling fluid and balls pass, and

wherein said sorting conduit extends radially into said straight section with the sorting basket in the turbulence flow path through said straight section.

13. A system according to claim **1**, wherein said balls are elastically deformable substantially spherically shaped balls of rubber, synthetic resin and the like.

14. A system according to claim **1**, wherein said cooling fluid is water.

15. A hydrodynamic sorting apparatus for automatically separating cleaning balls of a size below a predetermined reduced size from the remainder of the cleaning balls in a condenser system where cleaning balls are circulated with cooling fluid in a cooling fluid circulation means to clean condenser elements, wherein said hydrodynamic sorting apparatus includes:

a sorting conduit fluidly connecting first and second portions of said circulation means in bypassing relationship to the normal flow of cooling fluid from the first portion to the second portion, said sorting conduit being positioned for continuously conducting a portion of the cooling liquid therethrough in a direction from said first portion to said second portion,

a sorting basket at the first portion of said circulation means which has passage openings for permitting passage therethrough of cleaning balls of a size smaller than said predetermined reduced size while preventing passage therethrough of cleaning balls of a size greater than said predetermined reduced size,

and a sorting gate in said sorting conduit downstream of said sorting basket for retaining balls passed through said sorting basket while permitting flow of said portion of the cooling fluid to said second portion.

16. Apparatus according to claim **15**, wherein means are provided for effecting a continuous operation of said separating of said cleaning balls during operation of the condenser system.

17. Apparatus according to claim **15**, wherein means are provided for effecting an intermittent operation of said separating of said cleaning balls during operation of the condenser system.

18. A system according to claim **1**, wherein means are provided for effecting a continuous operation of said separating of said cleaning balls during operation of the condenser system.

19. A system according to claim **1**, wherein means are provided for effecting an intermittent operation of said separating of said cleaning balls during operation of the condenser system.

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