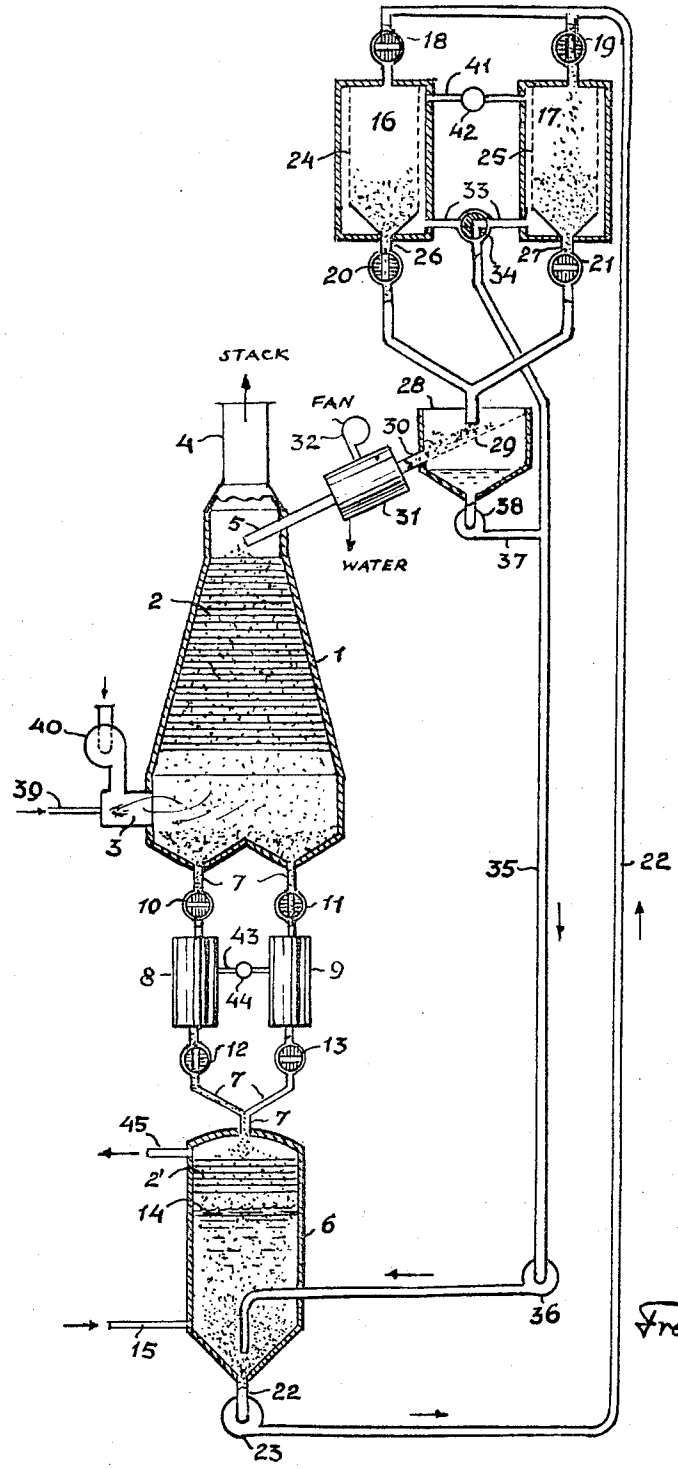
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PROCESS AND APPARATUS FOR MOVING SOLID PELLETS IN A CLOSED CIRCUIT

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PROCESS AND APPARATUS FOR MOVING SOLID PELLETS IN A CLOSED CIRCUIT

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This invention deals with plants in which comminuted or granular solids are used for heating or cooling fluids and/or gases which may be at pressures substantially above the atmospheric, with the solid circulating in substantially closed flow circuits. The problem arises how to introduce the solids into the spaces under pressure and/or how to withdraw them to spaces of lower pressure.

Transportation of such solids, which for the purposes of this specification shall be called "pellets," across pressure differences is generally achieved either by power-driven rotary feeders such as screws or cell-wheels, or by the known sluicing system.

Rotary feeders have not been found suitable for large pressure differences for which only sequentially operated sluice chambers shall be considered for the purposes of my invention.

In order to maintain pellet flow in a closed circuit, lifting of the pellet stream in part of the circuit is nearly always necessary. This is achieved either by conventional elevator devices, such as for example bucket elevators, air jets working mostly near atmospheric pressures. These devices tend to damage the pellets by impact by the buckets or abrasion in the pipes guiding the pellets. Besides, the power requirements of these devices are very considerable.

This invention specifically refers to plans in which the pellets are submerged in a lower chamber containing a fluid under pressure from which they must be lifted and led into another chamber at higher elevation, working at near-atmospheric pressure.

Lifting is effected by withdrawing from the lower chamber a slurry of pellets in the liquid in such a way that the pressure in said lower chamber provides most of power for the lifting. While this method, due to the fact that the slurry can move at comparatively low speed through the conduit, drastically reduces the possibility of mechanical damage to the pellets, another problem arises from the necessity to separate the pellets from the fluid and from the necessary de-pressurizing of the pellets before they can be fed into the chamber at higher elevation working at near-atmospheric pressure.

It is the principal object of this invention to provide ways and means to avoid or reduce the disadvantages of the known methods and apparatus, and to simplify operation. This and other objects of my invention will be apparent from the following specification, when taken together with the accompanying drawing, which shows by way of non-limiting example an embodiment of my invention:

The single figure of the drawing shows schematically a plant consisting of an upper chamber **1** for the heating of pellets and a lower chamber **6** for steam generation through heat transferred from said pellets, with associated equipment for the transportation of the pellets.

The present invention will be described for a steam boiler plant where a stream of pellets, acting as heat transfer agent, moves in a substantially closed circuit through a plurality of chambers located at different vertical elevations and approximately in vertical alignment, the lowest chamber being partly filled with water and partly with steam under pressure and pellets being led from the lowest chamber to at least two elevated closed sluice chambers into which a slurry formed of pellets and water from the lowest chamber is fed sequentially.

The basic object of my invention is achieved by lifting the said slurry from said lowest chamber to the level of two elevated sluice chambers, with a mojor part of the lifting force supplied by the fluid pressure in the lowest chamber, and by using said sluice chambers for screening the pellets in the slurry from most of the water before discharging them at near-atmospheric pressure into another chamber at an elevation higher than the lowest chamber.

The sundry means used include a first upflow (riser) pipe connecting the bottom of said lowest chamber with the sluice chambers arranged in parallel. Each sluice chamber is equipped with a screen for separating the pellets from the bulk of the liquid under pressure. First valves interposed in said first pipe near the entrance to the sluice chambers control the slurry flow through said pipe.

A second pipe (downcomer) connects the sluice chambers with the lowest chamber for returning the separated liquid under pressure into the lowest chamber.

Third pipe means connect the sluice chambers with the higher chamber for discharging into it depressurized pellets from which the bulk of the liquid has been separated by the screens. Second valve means, interposed in said second pipe, control the liquid flow therethrough. Furthermore, third valves interposed in said third pipe, control the pellet flow through the latter.

A fourth pipe connects the two sluice chambers. Interposed in the fourth pipe is a throttle device for limiting the liquid flow between the sluice chambers and for ensuring that both chambers are always filled with liquid. The throttle device is preferably adjustable.

The pressure in the sluice chamber receiving pellet-liquid slurry will in most cases be equal to that prevailing in the lowest chamber minus the static head between said chamber and the sluice chambers and the friction loss caused in the riser pipe.

A pump is interposed in the second (downcomer) pipe to maintain slurry and water flow, respectively, through the system.

Only in exceptional cases the pressure in the sluice chambers may be higher than that in the lowest chamber. In these cases a slurry pump is provided in the first (riser) pipe.

The valves in the first, second and third pipes are according to this invention sequentially operated as will be described in more detail as this specification proceeds.

Modifications in specific applications depend primarily on the required lifting height of the slurry and the available pressure in the lowest chamber. Where this height times the specific gravity of the pellet-water slurry exceeds the available fluid pressure (above atmospheric), the difference in lifting work must be supplied by a slurry pump interposed in said first pipe. In this case the static height of the fluid column in the second pipe will usually suffice to return the water from the sluice chambers via the second pipe into the lowest chamber, so that no pump is required in said second pipe. If the static pressure in the second pipe is insufficient, a pump has to be provided in said second pipe, as mentioned before.

Where, on the other hand, the fluid pressure is substantially greater than the required lifting height times the specific gravity of the pellet-water slurry, the sluice chambers will operate under superatmospheric pressure. In such case the differential between the fluid pressure and the slurry pressure in the elevated sluice chambers is sufficient to do all the lifting work and one pump only in the second pipe will ensure return of the separated water into the lowest chamber.

A slurry pump in the first (riser) pipe may nevertheless be used for starting purposes while the fluid pressure in the lowest chamber may be insufficient; such pumps

need be kept in operation only until the fluid pressure in the lowest chamber has risen sufficiently.

Reverting now in detail to the single figure of the drawing, the reference numeral **1** denotes an upright heat exchange chamber (pellet heater) with internal transverse baffles **2** for delaying the fall of the pellets. Hot gases enter the chamber **1** through an inlet **3** adjacent to the bottom of the chamber and leave in a cooled state through a stack **4** adjacent the top of the chamber. The upper part of chamber **1** also includes an elevated inlet conduit **5** for admission of cool pellets. Below the upper chamber **1** another chamber **6** (steam generator) is located, the same being connected to Chamber **1** through a vertical forked pellet conduit **7**. Interposed in **7** are two pellet sluice chambers **8** and **9**. Each of these sluice chambers has pellet valves at its inlet, marked **10** and **11**, as well as at the outlet, marked **12** and **13**. By proper sequential operation of these valves, known per se, pellets can flow by gravity from chamber **1** into chamber **6** against the pressure prevailing in the latter.

In the steam generator chamber **6** constant water level marked **14** is maintained by regulating by conventional means, not shown, the feedwater flow through the pipe **15** into **6**. Within **6**, located above the water level, baffles **2'** are arranged which serve to superheat the steam rising from the water surface before said steam leaves through the pipe **45** for use elsewhere.

Further, two other chambers **16** and **17** are arranged above the chamber **1** for handling the pellet-water slurry which collects at the bottom of the steam generator chamber **6**. These slurry sluice chambers are provided with inlets near the top and outlets near the bottom controlled by the slurry valves **18**, **19** and **20**, **21**, respectively. At the bottom of **6** a slurry outlet pipe **22** is connected with the valves **18** and **19**. Through this pipe, with interposed pump **23**, the slurry can be lifted into the chambers **16** and **17**. As mentioned before, the lifting work for the slurry is effected either partly or fully by the pressure prevailing in **6**.

Inside the chambers **16** and **17** screens **24** and **25** are provided into which slurry is discharged via the valves **18** and **19**. Outlet pipes **26** and **27** at the bottoms of said screens, in which the valves **20** and **21** are interposed, lead concentrated slurry into the open hopper **28**. Another screen **29** in said hopper allows the water filling the interstices between the individual pellets to drip off. The still surface-wetted pellets flow via the conduit **30** into the dryer **31** where a fast air flow, produced by the blower **32**, removes residual moisture from the pellets which proceed by gravity via the conduit **5** into the upper chamber **1** through which they cascade downwards over the baffles **2** being heated by the hot gases in counterflow heat exchange with the latter which leave cold through the stack **4**.

Each of the chambers **16** and **17** is connected near its bottom via the water pipe **33** with interposed three-way valve **34** to the downcomer water pipe **35**, which leads water back into the steam generator chamber **6** as shown. A water pump **36** may be interposed in pipe **35**.

Drip water, accumulating at the bottom of hopper **28**, is pumped back into the pipe **35** via the pipe **37** with pump **38**.

The hot gasses entering the pellet heater **1** through the inlet **3** may come from any source, including, for example, hot gases from chemical, metallurgical or other processes. In the plant as per the single figure of the drawing the gases are produced by combustion of fuel of any kind, supplied through the pipe **39**, in air supplied by the forced draft air blower **40**.

The sluice chambers **16** and **17** are further connected preferably near their tops via the water pipe **41**, with adjustable valve **42**, the purpose of which will be explained later.

The plant operates as follows:

The sluice chambers **8** and **9** are sequentially filled with pellets from the bottom of the chamber **1** and then discharged into **6**. In the position shown (valve **11** open and valve **13** closed) pellets can fall by gravity into chamber **9** and fill it. In the meantime the chamber **8**, with valve **10** closed and valve **12** open and assumed filled with hot pellets, has been pressurized by steam from **6** so that the pellets can flow by gravity into **6**.

While the chamber **8** is being emptied, chamber **9** is being filled and when this is completed, valves **11** and **12** are closed, followed by opening of valves **10** and **13**. Obviously, the role of the chambers **8** and **9** is now reversed, chamber **8** being filled from **1** and chamber **9** discharging into **6**. In order to save some of the steam under pressure remaining in the emptied chamber, a cross connecting pipe **43** between said chambers with interposed valve **44** is provided. The valve **44** is only momentarily opened.

The specific feature of this invention concerns the design and operation of the slurry sluicing and pellet separating chambers **16** and **17**. These preferably cylindrical chambers and the valves controlling their operation are basically of similar design as the chambers **8** and **9**. The main differences lie in the provision of the screens **24** and **25**, the valved water discharge pipe **33**, and the water cross-connection pipe **41** with adjustable throttle orifice **42**.

These chambers operate as follows:

Assuming slurry under pressure is supplied through the riser pipe **22**, with valves **19** and **20** open, valves **18** and **21** closed and the valve **34** in the position as shown connecting the chamber **17** to the downcomer pipe **35**, slurry will enter the chamber.

The water which carried the pellets, passes through the screen **25** and the valve **34** into the downcomer pipe **35** in a steady stream while the pellets accumulate in the space within the screen **25**, filling this space gradually.

Assuming also that such filling with pellets has previously taken place in the chamber **16**, pellet concentrate from **16** can simultaneously flow via the pipe **26** and valve **20** into the hopper **28**. For smooth discharge it is necessary to prevent formation of a vacuum in **16**. For this purpose water is introduced from **17** via the cross connection **41** as long as pellets are discharged from **16**.

After **16** is empty of pellets and **17** is filled with pellet concentrate, the valves **19** and **20** are closed, the valves **18** and **21** are opened, and the chamber **16** connected to the downcomer pipe **35** via the valve **34** while interrupting the water discharge from the chamber **17** via **34**. With the closing of valve **20** the chamber **16** is pressurized through pipe **41**, and with the opening of valve **18** pellets will start accumulating in it within the screen **24**, repeating the process as previously described for the chamber **17**.

Simultaneously with the closing of the valve **19** and opening of the valve **21** pressure in **17** drops to near-atmospheric but water flowing from the now pressurized chamber **16** enters **17** via the pipe **41** keeping it filled with water.

This sequential operation of **16** and **17** can be continued indefinitely assuring a practically continuous flow of pellet concentrate into the hopper **28**. In the latter the remaining water drips off through the screen **29** accumulating at the hopper bottom. From there this water is led back into the downcomer pipe **35** via the pipe **37** with interposed pump **38**.

The now only surface-wet pellets may be led via the pipe **30** into a pellet dryer **31** in which a fast air stream supplied by the fan **32** blows off most of the surface moisture. The thus dried pellets are led into the pellet heater via the conduit **5**. The water separated in **31** may also be recovered by leading it back into the chamber **6**.

The drying of the pellets is optional.

Characteristic for the present invention is the triple use of the chambers **16** and **17**.

(a) for depressurizing the slurry by sluicing,

(b) simultaneous formation of a slurry concentrate in

which water fills only the interstices between the packed pellets,

(c) for returning the bulk of the separated water under pressure into the steam generating chamber 6.

It is immaterial for the present invention whether more than two sequentially operated chambers are used in the slurry circuit, and what material and shape is employed for the pellets or whether a fluid different from water is being evaporated. It is further immaterial from what source the hot gases entering the pellet heater originate, or what fuel is used to produce said hot gases. Also immaterial are the control means by which sequential operation is achieved.

Having now described and illustrated my invention, I wish it to be understood that it is not limited to the special form and arrangement of parts herein described and shown.

What I claim is:

1. In the method of moving pellets, used as heat transfer agent, continuously in a closed circuit, said circuit comprising an upward flow (riser) part in which the pellets are lifted to a highest level, and a downward flow (downcomer) part, in which the pellets descend under the effect of gravity, the upward flow part containing pellets suspended in the form of a slurry in a rising stream of a liquid at substantially superatmospheric pressure, while the first portion of the downward flow part contains pellets falling through a gas of substantially atmospheric pressure,

the steps of passing the slurry stream through two sequentially operated sluice chambers arranged in parallel and disposed at said highest level, said sluice chambers being at all times completely filled with liquid, separating the pellets from the bulk of the liquid by screening the slurry within said chambers and while still under substantially superatmospheric pressure, thereafter decompressing the resulting slurry concentrate within said chambers, removing the remaining liquid from the pellets at substantially atmospheric pressure, and feeding the dried pellets at substantially atmospheric pressure back into the downward flow part.

2. Apparatus for moving a continuous stream of solid pellets in a substantially closed circuit extending between a lowest level and a highest level, wherein the pellets move downwards under the effect of gravity first through an upper space (first space) at near-atmospheric pressure and thereafter through a lower space (second space) containing a liquid at superatmospheric pressure, whereupon the pellets are returned upwards in the form of a pressurized slurry formed by a mixture of said pellets and said liquid, said apparatus comprising two sluice chamber means arranged in parallel with regard to said pellet stream and disposed at its highest level, each chamber containing first screen means for separating the pellets from the bulk of the liquid under pressure, said screen means dividing each sluice chamber into a "pellet chamber" and a "liquid chamber," first pipe means (riser) connecting the bottom of said second space with said pellet chambers for lifting the slurry from said second space into said sluice chambers, second pipe means (downcomer) connecting said liquid chambers with said second space for returning the separated liquid under pressure, third pipe means connecting said pellet chambers with said first space for discharging into it depressurized pellets from which the bulk of the liquid has been separated by said screens, fourth pipe means interconnecting the liquid chambers of said two sluice chambers, first valve means for controlling the slurry flow from said first conduit means into said pellet chambers, second valve means for controlling the liquid flow from said liquid chambers into said second pipe means, third valve means for controlling the pellet discharge from the sluice chambers into said third pipe means, throttle means interposed in said fourth pipe means for limiting the liquid flow from one sluice chamber into the other, hopper means with second screen means interposed in said third pipe means for separating the remaining liquid from the pellets.

3. Apparatus as set forth in claim 2, having pump means interposed in said second conduit means.

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