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APPARATUS FOR PROCESSING AIR, GAS OR VAPORS

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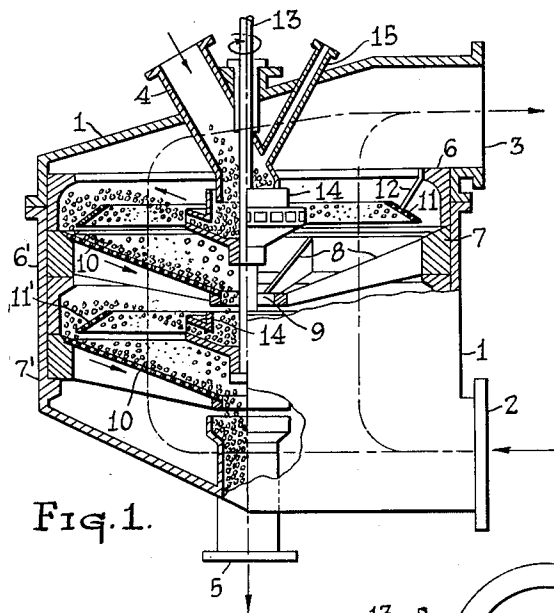


FIG. 1.

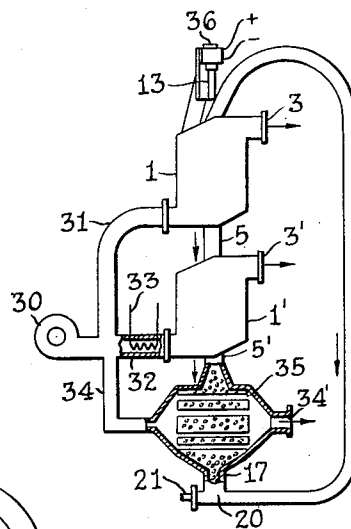
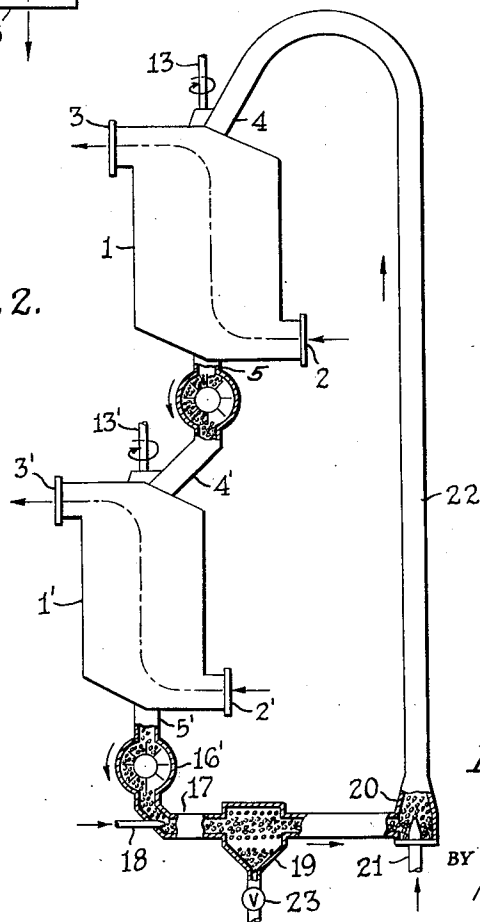


FIG. 3.

FIG. 2.



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APPARATUS FOR PROCESSING AIR, GAS OR VAPORS

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This invention deals with apparatus for processing air, gas or vapors, involving the use of granulated material as heat carrier, drying, cleaning, chemical or catalytic agent.

The granulated material may be of any chemical composition including, for example, metals, ceramics, sand, and may or may not enter into chemical reaction with the medium processed.

It is known to use granulated material, which for the purposes of this specification shall hereafter be referred to as "sand," for heating or cooling of gaseous media. The best known of these use sand in fluidized bed form through which the gas passes. Fluidization involves, however, substantial pressure losses of the gas which makes it unsuitable for some purposes. In other known coolers or heaters the sand moves by gravity only, which involves difficulties in maintaining regular sand distribution and flow, and leads to large physical dimensions of the apparatus. Similar disadvantages are met with in drying and cleaning apparatus.

This invention avoids these defects by providing mechanical means to move the sand across the stream of the medium to be processed at substantial velocity, thereby increasing the heat transfer from the sand to said medium or vice versa at substantially reduced space requirement and high effectiveness.

In the accompanying drawing are shown by way of non-limiting examples in diagrammatic form several embodiments of my invention:

Fig. 1 represents a simple form of an air-gas or vapor cooler or heater.

Fig. 2 shows a combination of a gas cooler and an air heater forming together a heat exchanger between said gas and air.

Fig. 3 indicates an air dryer arrangement using moisture absorbent sand, for example silica-gel or activated alumina and a regenerating device for the latter.

Reverting now in more detail to Fig. 1 which represents an embodiment of my invention which may be used for the purposes indicated above, but which for the purpose of this description shall be considered as air heater.

In Fig. 1 1 denotes a substantially cylindrical shell with an intake opening 2 for the air near the bottom and a discharge opening 3 near the top. Further are provided an intake pipe 4 for the hot sand at the top and a discharge pipe 5 for the cooled sand at the bottom of the shell 1. Inserts are provided to fit the inner circumference of the shell i. e. insert 6 with a curved inner surface, insert 7, disposed below insert 6, to which, as shown at the righthand half of the drawing, radial ribs 8 are connected. These ribs are further connected at the end near the shell center by a ring 9 and support a perforated plate or sieve 10 which covers the space between the insert 7 and the inner ring 9, forming a surface of obtuse conical form, as shown.

Below insert 7 another insert 6' is located which in form is identical with insert 6. Again below insert 6' a further insert 7' is shown which in form is identical with insert 7, also provided with a perforated plate or sieve 10'.

Inside said shell there are further disposed two rings

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of perforated sheet 11 and 11' which are fixed in position by stay-bolts 12, of which one is shown at the righthand side of Fig. 1, connecting the ring of obtuse conical form to the insert 6.

In the center of shell 1 a shaft 13 is provided which, during the operation of the apparatus, is rotated at predetermined speeds by an outside source of power of any known kind (not shown).

Fixed to this shaft are two thrower wheels 14 and 14' which are of a design similar to rotors employed in centrifugal pumps or blowers, with intake for the sand at the top. The upper wheel receives the sand from the pipe 4, while the lower wheel 14' receives it from the opening at the center of the perforated plate 10'.

Another pipe 15 is shown, connecting pipe 4 with the outside, the purpose of which will be explained as this specification proceeds.

The operation of the air heater is as follows:

The air to be heated enters at 2, flows upwards through the perforated plates and out at 3. Hot sand enters through pipe 4, flows, as indicated by the double-crossed arrows, into the inlet opening of the thrower wheel 14. By the rotation of this wheel the sand is accelerated and thrown in the shape of a fountain across the whole section of the shell into the annular space between insert 6 and the ring 11. Thence the sand flows through the gap between said ring and the insert 7 and down by gravity over the perforated plate 10 inwards, being discharged through the ring 9 to the intake of the lower thrower wheel 14', which by its rotation again forms a second fountain of sand, entering the annular space between insert 6' and ring 11'. Thence the sand continues to flow again inwards over the perforated plate 10', discharging via the ring 9' into the discharge pipe 5 and to the space outside the shell 1.

Obviously, the air to be heated and the sand flow in substantial counterflow, making it possible to transfer the heat from the sand to said air in the most effective manner. This effectiveness is enhanced by the uniform distribution of the sand flow across the path of the air. The arrangement specific to my invention further permits a large number of passages of the sand across the air flow within a small shell volume, thus reducing size and cost of the apparatus substantially. Furthermore, the pressure drop of the air flowing through the shell is kept very small which is of vital importance in many applications.

It is immaterial for the purposes of this invention whether one or more thrower wheels are used. For higher effectiveness a greater number of such wheels and perforate plates in series is indicated.

For use of the apparatus as per Fig. 1 as air cleaner, sand of ambient temperature may be taken in by pipe 4 while a wetting agent for the sand, for example water or oil a. s. f. is fed through the pipe 15. The thus wetted sand cleans the air effectively. Impurities are carried by the sand out through the pipe 5 and discharged into a sand washer (not shown) and re-charged by any known transportation means into pipe 4.

Fig. 2 shows an example of an application of my invention to a heat exchanger for transferring heat from a gas of substantially ambient pressure to air which is under a pressure substantially above atmospheric pressure. In this case two shells, each with thrower wheels basically as shown in Fig. 1 are employed. The upper shell 1 is for the hot gas which enters at 2 and leaves at 3. The lower shell 1' is for the compressed air to be heated, entering at 2' and leaving at 3'. The shafts driving the thrower wheels are denoted by 13 and 13'. The sand flows in a closed circuit hot into shell 1 at 4 and out at 4'. Due to the difference in pressure prevailing between shells

1 and 1', the sand has to be forced into shell 1' by a sluice or valve means known per se. Fig. 2 shows for this purpose a cell wheel which is rotated by an outside source of power (not shown) forcing the sand into shell 1' via pipe 4', leaving it via pipe 5' to enter another cell wheel 16' whence it is discharged and depressurized into pipe 17. The motion of the sand through the latter is facilitated by a stream of compressed air or gas entering at 18. The pipe 17 is perforated over the length of the casing 19 surrounding pipe 17 and discharges into another ejector device 20 also operating with compressed air or gas received from pipe 21, forcing the cooled sand back through pipe 22 to the pipe 4 for reentering the shell 1. The casing 19 serves to receive small sand particles which have formed by abrasion during the passage of the sand through the said shells. The small particles collect at the bottom of the casing 19 and are discharged through valve 23.

When there is no appreciable pressure difference between the gas and air streams, cell wheels 16 and 16' may be dispensed with, and the sand may flow from shell 1 to shell 1' by gravity. Where the two shells are at considerable distance from each other, any known transporting means for the hot and cooled sand may be employed.

In Fig. 3 an embodiment of my invention is illustrating its use in an air or gas drying plant in which shell 1 receives the air to be dried from fan 30 via conduit 31. The said fan also supplies air to shell 1' via conduit 32, in which an air heating device 33 of any kind, for example an electric heater coil or a steam coil, is disposed. Another conduit 34 furnishes air from said fan to a surface type heat exchanger 35 of the tube or plate type. On top of the shell 1 the shaft 13 is shown which drives the thrower wheel in both shells 1 and 1' by the electric motor 36.

Connections for the sand between the shells and the sand circulating pipe 22 are similar as shown in Fig. 2, by conduits 5, 5' and 17, respectively. An air ejector 20 with intake pipe for the compressed air (preferably dry air) at 21 carries the sand coming from conduit 17 back to the top of shell 1 through pipe 22.

The operation of the plant using granules of silica-gel, for example, as drying medium, is as follows:

Fresh, regenerated sand enters the shell 1 which acts as drying shell at the top and absorbs the moisture in the air flowing upwards through said shell, dry air leaving at 3.

The silica-gel now flows through pipe 5 into the shell 1' which acts as regenerating shell, meeting the hot air stream coming through conduit 32 by which it is regenerated. The regenerated, heated sand now enters the heat exchanger 35 via conduit 5' where it is cooled by the air stream entering the heat exchanger via conduit 34 leaving at 34'. The now regenerated and cooled sand flows through conduit 17 and is transported by the air ejector 20, or any other known means, via pipe 22 back to the top of the shell 1, where the process is repeated.

Many other applications, for example in the chemical and metallurgical industries, are possible according to my invention.

While the time during which the sand is thrown across the stream of the medium to be processed is short, the relative velocity of the sand is high which increases the heat transfer from or to the sand in the case of a heat exchanger as shown in Fig. 2. The length of the path of the sand flow from one thrower wheel to the next lower one below it is increased if according to my invention, the sand particles leave the thrower wheels with a substantial velocity component in the direction of wheel rotation. This causes the path of the individual particles to be of generally spiral shape thus lengthening the path and prolonging the time during which the heat transfer takes place in the individual shells.

It is within the scope of my invention to use for the inserts 6 and 7 material of higher abrasion resistance than

that of the sand proper because it is generally easier and cheaper to replace the sand than to renew the inserts.

It is immaterial for the purposes of my invention what kind of sand is used in the shells, whether it consists of one kind of material or a mixture of different materials, and whether or not it enters into chemical action with the processed medium, or whether it acts as catalyst or radiation carrier. At present I consider sand consisting substantially of aluminum as preferred material for heat exchangers according to my invention, due to its high heat conductivity.

What I claim is:

1. An apparatus for processing a medium such as air, gas or vapors, using granular material for said processing, said apparatus comprising a closed shell arranged with its axis substantially in vertical position, with an inlet opening near the bottom and an outlet opening near the top for the medium, an inlet conduit at the top and an outlet conduit near the bottom of said shell for said granular material, thrower wheel means mounted to rotate about a vertical axis within and centrally of said shell, said means being disposed to receive the granular material from said inlet conduit and arranged to throw said granular material from the center part of said shell in an unobstructed free flight stream to adjacent its circumference, stationary means adjacent the circumference of the shell in a position to be struck by the granular material at the end of its unobstructed free flight path from the center to adjacent the circumference of the shell and so disposed that the granular material impinging on said means immediately leaves the same, the medium flowing crosswise through said free flight stream of granular material in a substantially straight vertical upward path, and a stationary slanted foraminous annular means disposed to receive said granular material from near the shell circumference after striking the stationary means and guide it back toward the center part of said shell below said thrower wheel by gravity, and thence to said outlet conduit, with the flow of said granular material and the medium being essentially in counter-flow.

2. In an apparatus as set forth in claim 1, a multiplicity of thrower wheels and a multiplicity of foraminous means disposed to receive said granulated material successively during its downward flow through the shell before it reaches the outlet conduit near the bottom of said shell.

3. In an apparatus as set forth in claim 1, thrower wheel means with radial blades shaped to impart to the granulated material a velocity with a substantial component in the direction of rotation of said wheel means.

4. In an apparatus as set forth in claim 1, granulated material consisting substantially of aluminum.

5. In an apparatus for processing a medium such as air, gas or vapors as set forth in claim 1, means arranged above the surface of said stationary slanted foraminous annular means disposed to partially obstruct and delay the free flow of the granular material on its way downward over said slanted foraminous means.

6. In an apparatus for processing a medium such as air, gas or vapors as set forth in claim 1, means to delay the free flow of the granular material on its way downward over said slanted foraminous means.

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