Jan. 5, 1960 R. A. BAYARD 2,919,905

APPARATUS FOR COOLING FLUIDIZED SOLIDS

Filed May 26, 1952 2 Sheets-Sheet 1

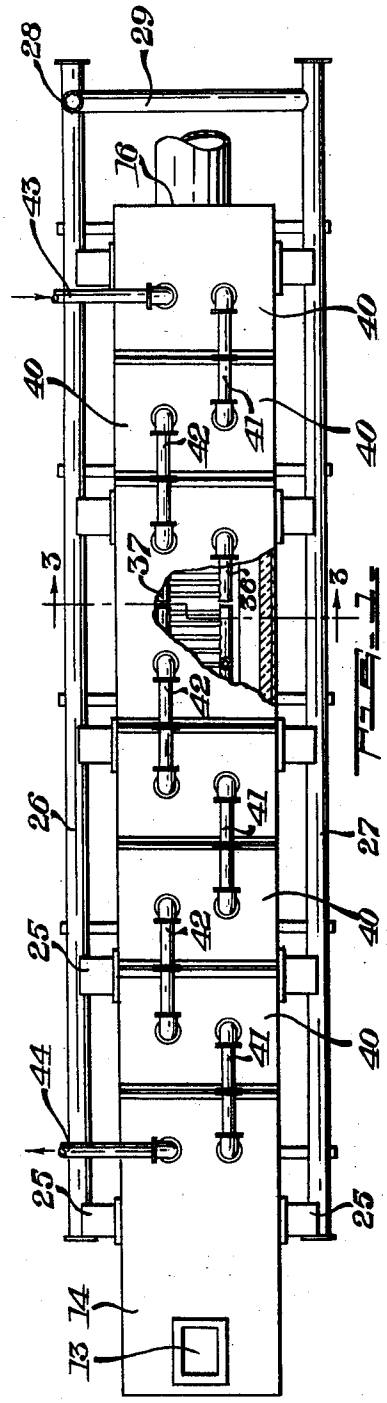


FIG. 1

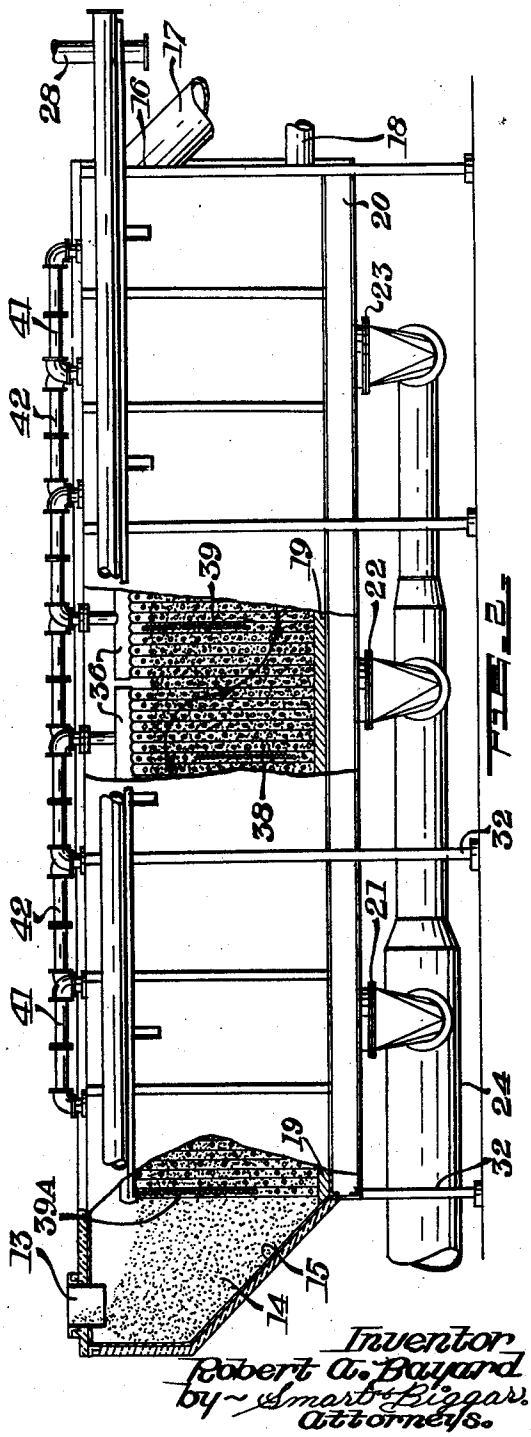


FIG. 2

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FIG. 4

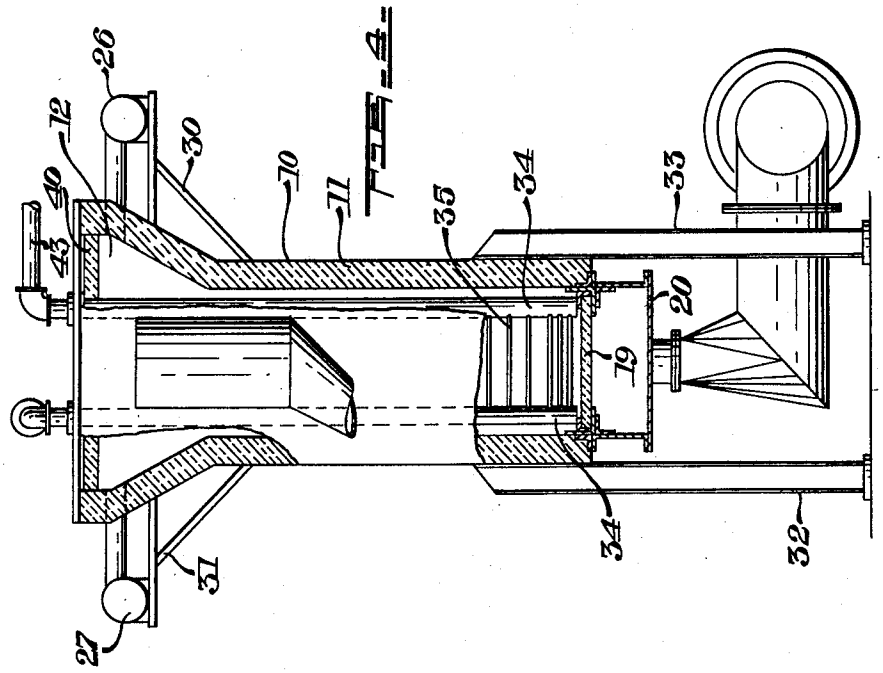
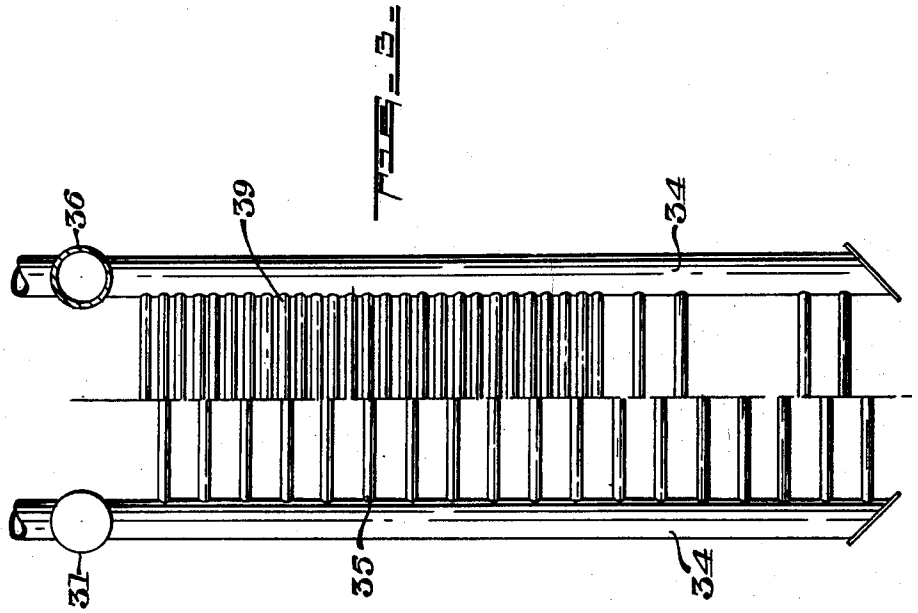


FIG. 3



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APPARATUS FOR COOLING FLUIDIZED SOLIDS

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4 Claims. (Cl. 257—235)

This invention relates to a cooler for finely divided hot fluidizable solid materials, and more particularly it relates to an improved apparatus for carrying out the cooling of such materials while in fluidized condition.

In copending application Serial No. 237,032, filed July 16, 1951, Arthur C. Turney et al., now Patent No. 2,824,-723, dated February 25, 1958, there is described an apparatus of the above character wherein hot pulverulent material is fed to an elongated trough into which a controlled flow of air is admitted through a diaphragm running along the bottom thereof to fluidize the material in the trough so that a fluidized bed of material is maintained therewithin, which bed is continuously flowing from the inlet towards the outlet end of the trough. As it flows horizontally in the said apparatus, the material in the bed flows around and about a plurality of cooling elements disposed within the bed whereby the heat in the material is transferred to a coolant within the cooling elements, permitting it to be utilized, for instance in the form of process steam.

While the apparatus described and claimed in said copending application operates satisfactorily, its cooling capacity per unit of length is not all that might be desired, and a considerable amount of difficulty has been encountered in its use due to the tendency of the side walls of the trough to buckle under the influence of the variation in temperature from the inlet to the outlet end thereof.

The present invention affords an improved construction for such apparatus according to which the capacity of a cooling trough of given length is greatly increased, while at the same time the difficulties previously encountered with buckling of the side walls are completely eliminated.

A further feature of the apparatus according to the invention is that a more uniform cooling effect upon the material undergoing treatment is obtained with consequent advantages in heat economy and in control of opereration. Other features and advantages of the invention will become apparent as the specification proceeds.

According to the present invention, the cooling elements are disposed horizontally extending from side to side of the cooling trough between vertical headers. These vertical headers are arranged side by side throughout the length of the trough to form a continuous wall, the corresponding headers on each side of the trough having a series of uniformly spaced horizontal cooling elements running between them so that individually each such pair of headers and the associated cooling elements has the appearance of a "ladder." The disposition of the cooling elements in consecutive ladders is preferably such as to produce a staggered relationship so that the cooling elements associated with each ladder will be at a different elevation than the cooling elements in the ladders immediately next to it on either side. Using this construction, the cooling elements may be very densely spaced so as to extract a maximum amount of heat from

the material within the minimum amount of space, without seriously affecting the proper fluidization of the material.

In order that the material may be cooled uniformly, a series of underflow and overflow baffles are spaced consecutively at intervals throughout the length of the trough. These baffles are formed between pairs of opposed headers simply by increasing the number of cooling elements passing between the two headers to the point where very little or no material is capable of flowing between them.

Preferably, according to the invention, the ladders are arranged in groups, the top end of all the headers on either side of each such group being connected to a horizontal manifold, each manifold having a connection from its central portion communicating with the manifold either preceding it or following it on the same side of the tunnel as the case may be so that the cooler arrangement, when in operation, will provide for flow of the cooling liquid originally into one or other of the manifolds at the discharge end of the tunnel, down through the associated headers, across the cooling elements, up the headers on the opposite side of the tunnel into the associated manifold, into the manifold associated with the group of ladders immediately preceding, down the headers associated with that manifold, across the cooling elements, and so forth until the heated cooling medium is finally withdrawn from a manifold associated with the group of ladders adjacent the inlet end of the apparatus. Generally speaking, each group of ladders will contain either an underflow or an overflow baffle constructed in the manner already described.

The apparatus of the invention and its construction will be more fully understood from the following detailed specification taken in conjunction with the accompanying drawings wherein is described and illustrated a preferred embodiment thereof which is particularly adapted for the cooling of hot calcined alumina.

In the drawings:

Figure 1 is a top plan view of an apparatus according to the invention partly broken away to illustrate the interior construction thereof;

Figure 2 is a side view of the apparatus illustrated in Figure 1 also partly broken away to illustrate the interior construction;

Figure 3 is a front elevation showing the manner in which a baffle may be formed from the cooling elements and also showing the preferred method of forming cooling ladders from tubular members as seen when viewed on the line 3—3 looking in the direction of the arrows, and

Figure 4 is an enlarged elevation of the discharge end of the apparatus illustrated in Figures 1 and 2 again partly broken away to illustrate the interior construction.

Referring more particularly to the drawings, a cooler according to the invention comprises an elongated, trough-shaped shell **10** formed from sheet metal and insulated as indicated at **11**. The upper portion of the shell is expanded outwardly forming the somewhat enlarged space **12** at the top of the apparatus. Material is fed to the apparatus through the feed chute **13** which empties into the feed bin **14** having a sloping bottom **15**, while material is withdrawn from the apparatus by overflowing the discharge gate **16** flowing down the discharge chute **17**. A small additional amount of material leaves the apparatus through the auxiliary discharge duct **18** situated just above the bottom of the discharge end of the tunnel. The floor **19** of the trough **10** consists of a porous membrane **19** capable of passing an upward flow of fluidized medium therethrough. The membrane **19** may be a screen or a punched plate, but preferably it consists of two layers of screen or punched plate with a layer of asbestos cloth sandwiched between them. It

has been found that fluidizing conditions within the trough are maintained more uniformly if the membrane 19 has substantial resistance to flow air therethrough.

Beneath the membrane 19 is situated the air chamber 20, which is supplied with air or other fluidizing medium through the three ducts 21, 22 and 23 which are in turn fed from a fluidizing medium manifold 24. Fluidizing medium is withdrawn from the sides of the top of the apparatus through the ducts 25 which empty into the manifolds 26 and 27 running longitudinally of the trough on opposite sides thereof, and is finally withdrawn through the conduit 28, the flow of spent fluidizing medium from the manifold 27 being joined to that from the conduit 28 by means of the connecting conduit 29. The manifolds 26 and 27 are supported on either side of the apparatus by the brackets 30 and 31 respectively. The whole apparatus is suitably supported above the floor to provide clearance for the manifold 24 by a series of supports 32 and 33. Situated side by side so as to form a continuous water wall running the length of the fluidizing chamber on either side of the apparatus within the shell 10 are two series of cooling element headers 34. These two series of cooling element headers form the walls of a fluidizing trough within which material being treated is confined during passage through the apparatus. Opposing pairs of headers 34 are joined together by a plurality of uniformly spaced horizontal cooling elements 35 to form a ladder-like structure. In each succeeding "ladder" the cooling elements 35 are situated at a different height than in the preceding ladder so that the height of the cooling elements is staggered throughout the length of the trough formed between the headers 34. These ladders are arranged in groups connecting at their top ends to cooling medium manifolds 36 and 37 for each group. Within each group of ladders so connected, there is provided either an overflow baffle 38 or an underflow baffle 39 formed by increasing the density of the cooling elements in one of the ladders over a portion of the height thereof to an extent where there is no room for flow of material between adjacent cooling elements. Each such group of ladders connected to a given pair of mainfolds 36 and 37 may be removed from the apparatus independently for purposes of which a series of hatches 40 are provided in the top of the tunnel. The cooling medium manifolds 36 are connected in pairs by the connecting conduits 41, while the manifolds 37 are connected from their central portions by the connecting conduits 42, the connections between manifolds being such that cooling medium leaving the top of one group of ladders will flow through a conduit 41 into the next manifold 36 down through the headers 34 of that group of ladders, across through the cooling elements 35 to the associated headers 33, up into the associated manifold 37, through the associated connecting conduit 42, down into the next manifold 37 and so forth throughout the length of the trough working from the discharge end where the cooling medium enters the apparatus through the pipe 43 to the feed end of the apparatus where the cooling medium leaves through the discharge pipe 44.

In operation, the material which enters the feed bin 14 through the feed chute 13 flows by gravity under the underflow baffle 39A at the feed end of the trough out into the space in the interior of the trough between the headers 34 above the diaphragm 19. The material is then fluidized by the gases rising through the diaphragm 19 and fills up the interior of the trough until it begins to overflow the discharge gate 16, at which time the level of material in the trough will remain substantially constant and the material will continue to overflow into the discharge chute 17 at the rate of which it is being fed into the feed bin 14 through the feed chute 13. In flowing the length of the trough, the material will be forced by the underflow baffles 39 and the overflow baffles 38 to follow a tortuous path indicated roughly by the arrows of Figure 2, thus insuring that each particle is exposed to the maximum cooling effect in its passage through the tunnel and insuring uniformity of cooling upon each particle passing through the apparatus.

The densely packed cooling elements 35 provide for maximum extraction of heat from the material in the shortest possible space, while the fact that the walls of the fluidizing trough are formed by the headers 34 prevents any tendency for the side walls to distort due to temperature differentials within the trough, while at the same time providing for additional cooling effect. The arrangement of the cooling elements in groups connected to pairs of manifolds enables individual sections of the cooling system to be withdrawn and replaced in the apparatus for maintenance and repair. Very little of the heat in the material is lost in the fluidizing medium because of the relatively small amount of medium required to maintain fluidized conditions and substantially all of the remaining heat removed from the material during its passage through the apparatus is recovered in the cooling medium and may be utilized either in the form of process steam or in the form of hot boiler feed water.

What I claim as my invention is:

1. A cooler for finely divided hot fluidizible solid materials, said cooler comprising; means for passing a controlled flow of fluidizing medium upwardly through said cooler; a plurality of pairs of opposed vertical cooling medium headers; and a plurality of horizontal cooling elements connected between each said pair of headers to form a series of ladders composed of a pair of headers and the associated cooling elements; said ladders being arranged in abutting relationship whereby the inner faces of abutting headers form the side walls of a fluidizing trough; an insulated shell surrounding the fluidizing trough so formed and arranged to provide a space thereabove for spent fluidizing medium; means for withdrawing spent fluidizing medium from said space, means for supplying hot material to one end of said fluidizing trough, means for withdrawing cool material from the other end of said fluidizing trough and means for circulating a coolant medium through said headers and associated cooling elements.

2. A cooler as defined in claim 1 in which the cooling elements in each of said "ladders" are at a different elevation than those in the preceding and succeeding "ladder" whereby said cooling elements in said trough present a vertically staggered formation.

3. A cooler of the type in which finely-divided, hot, fluidizable, solid materials are caused, while in fluidized condition, to flow horizontally through a fluidizing trough containing cooling elements, comprising a plurality of pairs of opposed vertical cooling medium headers, and a plurality of horizontal cooling elements connected between each said pair of headers to form a series of ladders composed of a pair of headers and the associated cooling elements, said ladders being arranged in abutting relationship whereby the inner faces of abutting headers form the side walls of said fluidizing trough, said cooler comprising at least one vertical baffle within said trough for controlling the flow of material therethrough, and formed from a plurality of horizontal cooling elements in one of said ladders, said elements in said baffle being so closely spaced that substantially no flow of fluidized material can pass between them.

4. A cooler of the type in which finely-divided, hot, fluidizable, solid materials are caused, while in fluidized condition, to flow horizontally through a fluidizing trough containing cooling elements comprising a plurality of pairs of opposed vertical cooling medium headers, and a plurality of horizontal cooling elements connected between each said pair of headers to form a series of ladders composed of a pair of headers and the associated cooling elements, said ladders being arranged in abutting relationship whereby the inner faces of abutting headers form the side walls of said fluidizing trough, said ladders

being arranged in groups, and comprising a plurality of opposed pairs of horizontal cooling medium manifolds, the manifolds of each pair being connected to the upper ends of the vertical headers on either side of a group of ladders, means for conducting cooling medium between adjacent manifolds, said means being arranged to provide progressive flow of cooling medium out of one manifold and into an adjacent manifold on the same side of the trough, through the group of ladders associated with said adjacent manifold, out through the manifold associated with the headers of said group on the opposite side of the trough, and into the adjacent manifold on that side of the trough, and so forth throughout the length of the cooler, means for supplying cooling medium to a manifold associated with a group of ladders at one end of said trough, and means for withdrawing cooling medium from a manifold associated with a group of ladders at the other end of said trough, said cooler further comprising a plurality of baffles within said

trough for controlling the flow of material there-through, each baffle being formed from a plurality of horizontal cooling elements in one of said ladders, said elements in said baffles being so closely spaced that substantially no flow of fluidized material can pass between them, each of said groups of ladders containing one of said baffles, the baffles being consecutively underflow baffles and overflow baffles so that a tortuous path of flow through said trough is provided for the material undergoing treatment.

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