April 11, 1944. R. S. WALKER ET AL 2,346,526

WATER-COOLED TUBE COOLER

Filed May 27, 1942 3 Sheets-Sheet 1

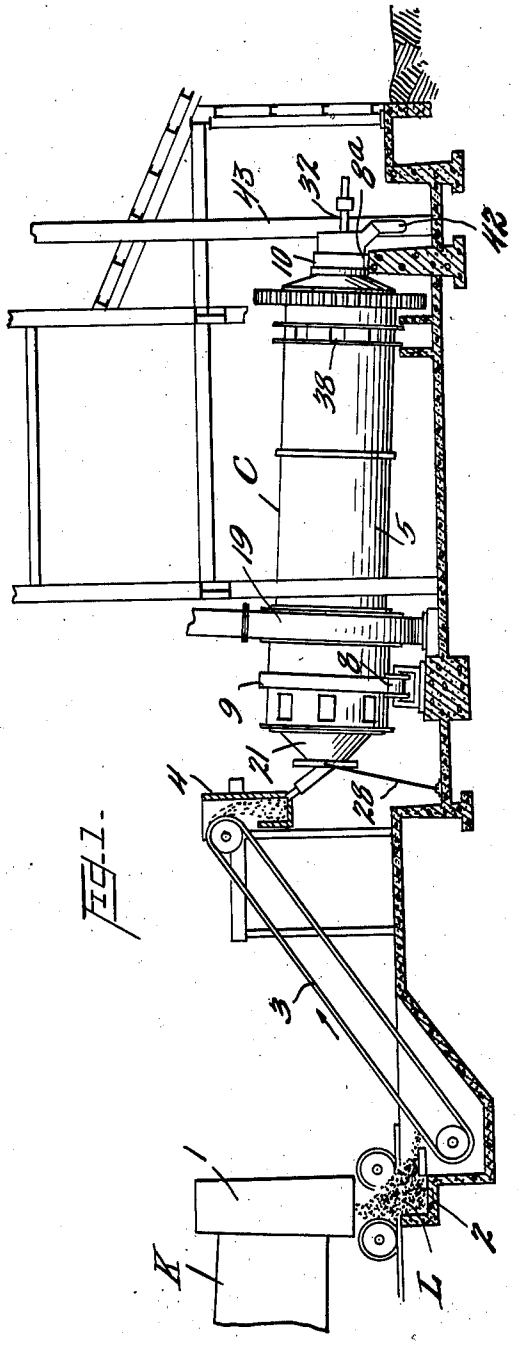


FIG. 1.

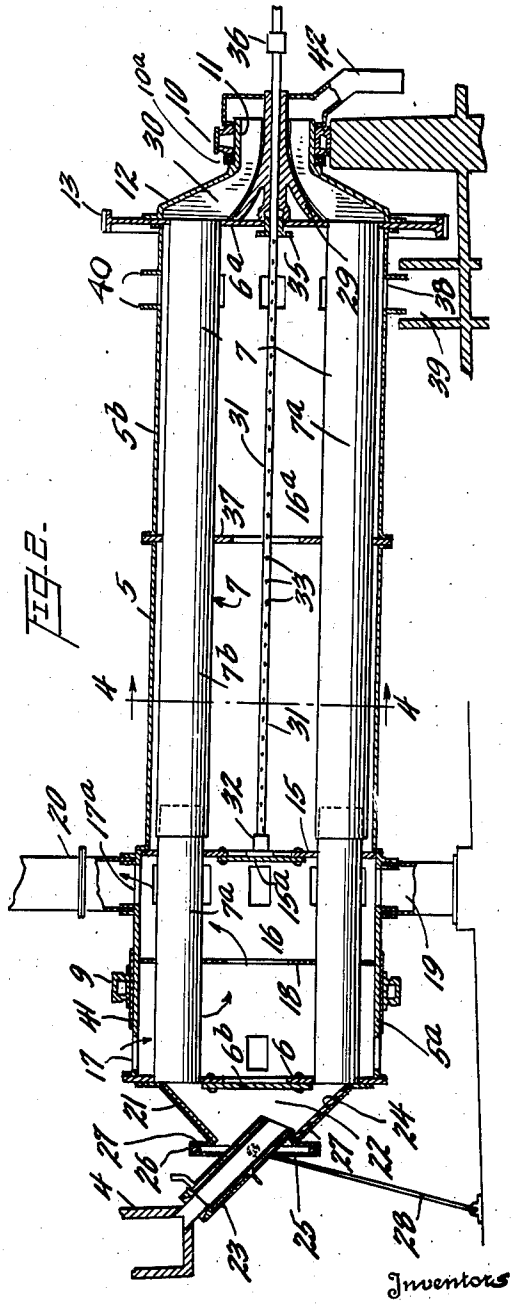


FIG. 2.

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Filed May 27, 1942 3 Sheets-Sheet 2

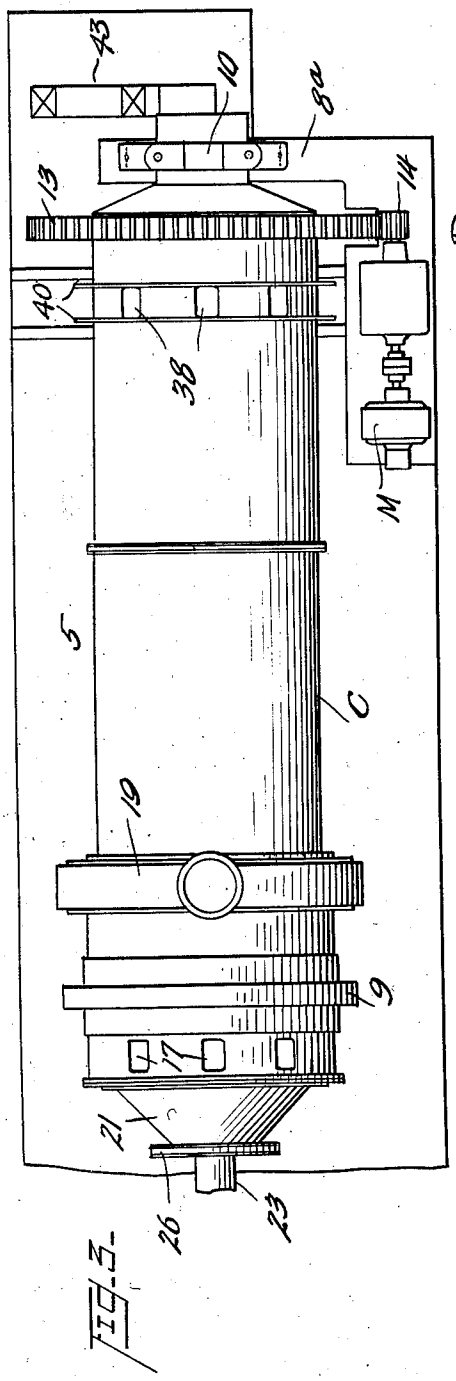


FIG. 3.

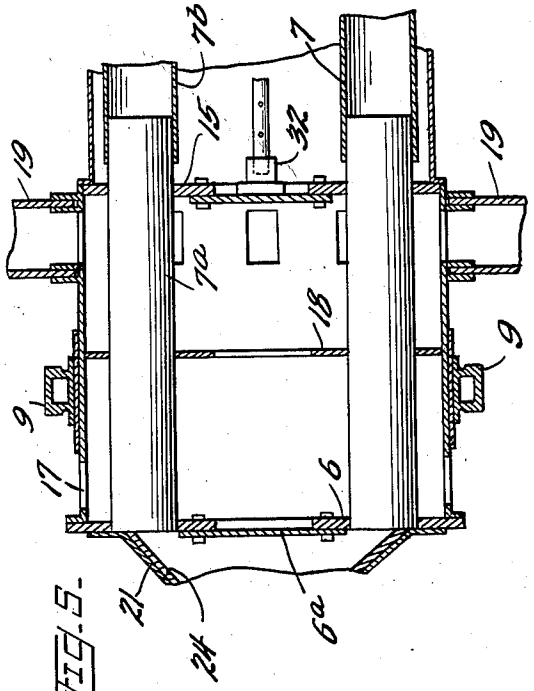


FIG. 5.

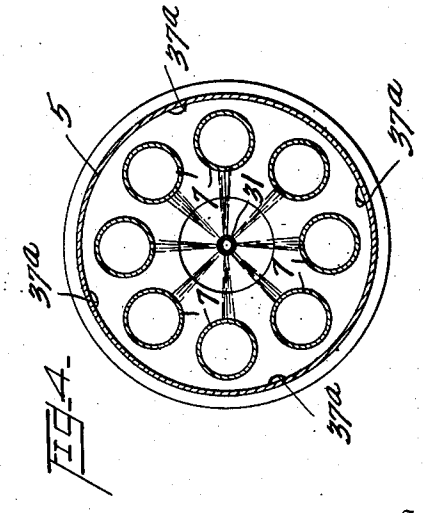


FIG. 4.

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WATER-COOLED TUBE COOLER

Filed May 27, 1942 3 Sheets-Sheet 3

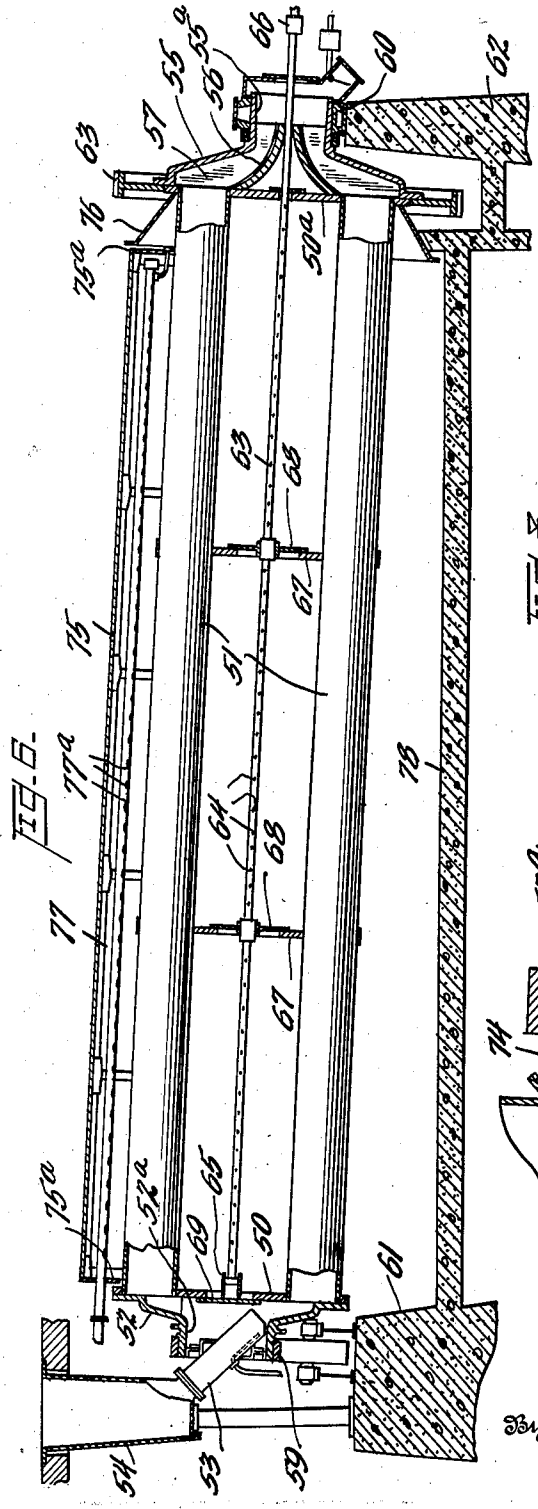


FIG. 6.

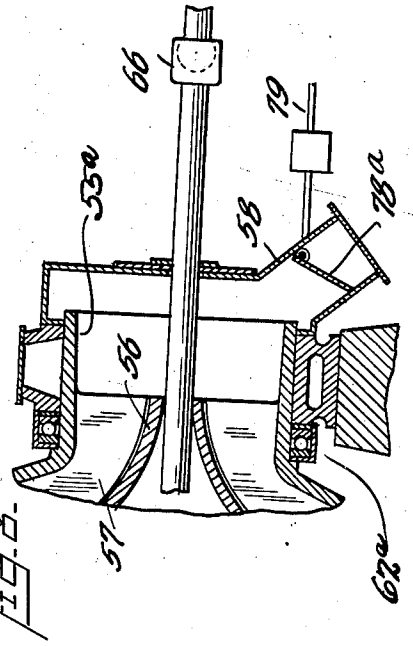


FIG. 8.

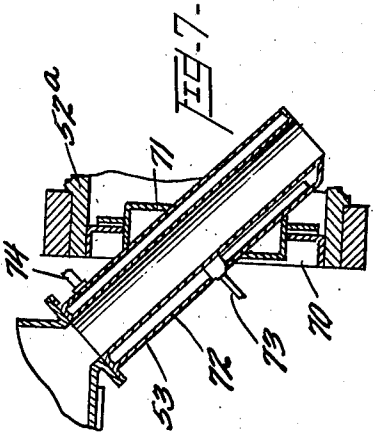


FIG. 7.

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2,346,526

UNITED STATES PATENT OFFICE

2,346,526

WATER-COOLED TUBE COOLER

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Application May 27, 1942, Serial No. 444,736

3 Claims. (Cl. 257—94)

This invention relates to the class of coolers known as tube coolers in which the hot material discharged from a heating kiln passes through a series of relatively thin-walled metal muffle tubes mounted for rotation about a generally horizontal axis and exposed to a cooling medium, the cooling medium serving to carry off the heat transmitted through the walls of the tubes and thereby hastening the cooling of the material.

Heretofore it has been the usual practice to cool the tubes by passing a current of air through a housing surrounding the tubes, the heated air, after flowing in contact with the tubes, being withdrawn from the housing and used in part as the combustion air for the burner of the kiln and, where pulverized coal is used for firing the kiln, for pre-drying the coal delivered to the burner. Such coolers, because they maintain the material out of contact with the air are especially suitable for the cooling of materials like lime, for example, which when highly heated is extremely active in drawing moisture from the air, which causes "air-slaking" with consequent impairment of the quality of the lime.

The factors primarily affecting the cooling efficiency of such class of coolers are the volume of the air flow through the cooler and the area of cooling surface presented by the muffle tubes; and the cooler must be so designed with due regard to these factors as to effect a cooling of the material from approximately kiln temperature down to a temperature at which it may be safely placed in paper or fabric sacks without danger of charring or burning the sacks. For this reason, a fan of high operating capacity, usually on the order of 50 horsepower, is required to deliver the large volume of air through the cooler and even under the most favorable conditions the cooler must be made quite extended in length in order to present a large area of tube surface to the air stream. Coolers of this type, therefore, are subject to the disadvantage that they are relatively expensive to operate, because of their large consumption of power for driving the fan and for rotating the long heavy cooler; and such coolers are subject to the further disadvantage that they take up a considerable amount of floor space which in many plants cannot conveniently be spared.

It is an important aim of our invention to provide a rotary tube cooler which overcomes the above objections by utilizing water, or both air and water together, as the cooling medium or mediums, the water desirably being sprayed upon the muffle tubes for rapidly reducing the temperature of the material contained within the tubes. This object is preferably accomplished by locating the water spray within the circle of travel of the series of muffle tubes and causing the spray to discharge in different directions to drench the tubes with cooling water throughout the entire or major part of their period of rotation. The water spray may be advantageously provided by extending a spray pipe longitudinally of the housing which encloses the tubes (which housing may be either rotary or stationary) and externally connecting this pipe with a source of water supply. As a consequence of such a cooler construction, the material is quickly and efficiently cooled without requiring a heavy duty fan for moving air through the cooler, and the apparatus therefore may be made shorter in length and lighter in weight so as to conserve floor space and to economize on power consumption.

Another object of our invention is to provide in a tube cooler of the above character means for utilizing both air and water as the cooling mediums throughout different longitudinal zones of the cooler. By virtue of this construction, heated air is made available for use in apparatus correlated to the cooler, such as for supplying the air of combustion to the burner of the kiln or for drying and heating the fuel prior to its introduction into the burner. According to the preferred form of our cooler, the housing enclosing the muffle tubes is partitioned off intermediate its length so as to divide it into two chambers, namely a chamber adjacent the forward or inlet end of the cooler through which air is flowed in contact with the muffle tubes, and a longer spray chamber adjacent the rear or outlet end of the cooler for water-cooling the tubes. Besides providing means for recovering heat from the cooler (which otherwise would be lost) for useful application elsewhere in the plant, the forward air-cooled compartment additionally serves to gradually reduce the temperature of the highly heated material as it enters the cooler from the kiln and thereby avoids the possibility of damage to the thin-walled metal tubes by cracking or buckling, such as might occur by quenching from too high a temperature.

Our invention has a further object to provide in a tube cooler of the above character, an improved form of muffle tube composed of two longitudinal, metal tube sections having their adjacent ends telescopically interfitted so as to allow for longitudinal expansion and contraction of the tubes without transmitting dangerously high stresses to other parts of the apparatus.

Still another object of our invention is to provide an improved form of water-cooled feed spout for introducing material into the cooler, this spout having a surrounding jacket adapted to be connected to a source of water supply for circulating cooling water therethrough and protecting the spout against overheating.

Other objects and advantages will be apparent from the following detailed description of a preferred embodiment of the invention, reference being had to the annexed drawings in which:

Figure 1 is a side view of a rotary tube cooler utilizing both air and water as the cooling mediums, the cooler being shown associated with the discharge end of a rotary kiln;

Figure 2 is a slightly enlarged view in longitudinal vertical cross-section through the cooler of Fig. 1;

Figure 3 is a plan view of the cooler;

Figure 4 is a transverse cross-sectional view through the cooler on the line 4—4 of Fig. 2;

Figure 5 is an enlarged fragmentary cross-sectional view of the forward end of the cooler;

Figure 6 is a longitudinal cross-sectional view of a modified form of water-cooled rotary tube cooler;

Figure 7 is a longitudinal cross-sectional view through the water-cooled spout for feeding material into the forward end of the cooler; and

Figure 8 is an enlarged cross-sectional view through the outlet end of the cooler of Fig. 6.

Referring now to the drawings, in Fig. 1 is shown the outlet end of a horizontal rotary kiln K of a well-known type such, for example, as is used for the calcining of limestone in the manufacture of lime. The outlet end of the kiln is enclosed within a hood 1 and the hot burned lime (indicated at L) issuing from the kiln drops through the open bottom of the hood into a sump 2, from which it slides down onto an inclined pan conveyor schematically indicated at 3. The conveyor carries the material upwardly and finally delivers it into a hopper 4 supported above and adjacent the forward end of a rotary cooler C.

The cooler C is of the rotary tube type and, as more clearly shown in Figs. 2 and 3, comprises generally a cylindrical housing in the form of a drum 5, front and rear header plates 6 and 6a, respectively, closing opposite ends of the drum, and a series of spaced-apart, circularly arranged muffle tubes 7 extending longitudinally of the drum and opening through the header plates. The muffle tubes are preferably made of comparatively thin gage heat-resistant steel possessing good heat-conducting properties, and while illustrated as of circular, cross-section, they may be of oval, sector or any other desired cross-sectional shape. The forward end of the drum rests upon rollers 8 located upon opposite sides of the drum and engaging a riding ring 9, and the rear end of the drum is supported in a saddle bearing 10 encircling a hollow trunnion 11 extending axially outward from a dome-shaped closure member 12 at the rear or outlet end of the drum. The forward and rear supports for the drum are so arranged that the drum rotates about an axis inclining slightly upwardly and forwardly out of a true horizontal position. For taking up the endwise thrust of the sloping drum, an anti-friction thrust bearing 10a encircles the hollow trunnion 11 and bears against one side of the saddle bearing 10. A ring gear 13 is circumferentially secured to the closure member, and this ring gear is engaged by a pinion 14 driven by a motor M, through a suitable speed reduction mechanism, for imparting rotation to the cooler upon its supports 8 and 10.

The drum 5 is divided into two chambers 16 and 16a by a transverse partition plate 15 located inside the drum and about one-third of its length from its forward end. The forward chamber 16 is designed for the circulation of air about the inlet ends of the muffle tubes, and for this purpose a series of air-inlet ports 17 are circumferentially provided in the wall of the drum at the forward end of the chamber 16, while similarly a series of air-outlet ports 17a are circumferentially provided in the drum adjacent the rear end of this chamber. A transverse baffle ring 18 is supported within the chamber 16 about midway of its length, and this baffle ring deflects the cooling air entering through the inlet ports 17 across the tubes in its travel toward the outlet ports 17a. A stationary casing 19 surrounds the drum so as to include the outlet ports 17a, this casing serving as a collector for the heated air issuing from these ports. The casing may be connected through a pipe 20 with a suction fan (not shown) for inducing a rapid flow of air through the chamber 16 and for delivering the heated air either to the burner of the kiln or to a coal pulverizing mill for pre-drying the fuel used in the burner; or if desired the heated air may be allowed to escape up the chimney into the outside atmosphere.

At the forward end of the cooler a frusto-conical shaped closure member 21 is secured to the front header plate 6 and this member projects outwardly from the header plate so as to form therewith a material-receiving compartment 22. An inclined feed spout 23 directs the hot material to be cooled from the hopper 4 downwardly through a centrally located opening in the front closure member 21 and into the compartment 22. The closure member is provided with a refractory lining 24, and the incoming material discharging onto the sloping interior surface of the closure member slides down into the open ends of the muffle tubes 7. A stationary cover plate 25 supported on stanchions 26 for bodily swinging movement toward and away from the closure member, abuts a sealing ring 26 supported on a bearing flange 27 surrounding the opening in the front closure member.

The rear closure member 12 projecting outwardly away from the header plate 6a provides a compartment for receiving the material spilling from the muffle tubes 7. Secured to the rear header plate 6a and directed axially outward through this material-receiving compartment and the hollow trunnion 11 is a bell-shaped deflecting member 29. The position and arrangement of the deflecting member is such as to guide the material out through the hollow trunnion 11, this action being assisted by a plurality of radial lifting blades 30 supported upon the interior of the closure member 12. The deflecting member affords support for one end of a spray pipe 31 extending axially into the drum through the hollow trunnion and having its forward end closed and resting in a socket 32 on the partition plate 15. The spray pipe is circumferentially provided with a multitude of orifices 33 located in different positions upon its circumference so that the pipe will discharge in different radial directions toward the tubes 7. The clearance around the opening through which the spray pipe extends through the bell-shaped deflector 29 is sealed by a packing gland 35, and the end

of the spray pipe projecting exteriorly of the drum is adapted to be connected to a source of water pressure through a swivel coupling 36.

The muffle tubes 7 are each composed of two longitudinal sections 7a and 7b of different diameters. The sections 7a, which extend entirely through and rearwardly beyond the front chamber 16, are of smaller diameter than the tubes 7b which extend through substantially the length of the rear chamber 16a. The smaller size tube sections 7a at their forward ends are welded to the front header plate 6, while the larger size tube sections 7b are welded to the rear header plate 6a. The tube sections 7a may be also welded to the partition plate 15 if not too long, or they may have a sliding fit with the partition plate in those cases where changes in length of the sections under expansion or contraction must be reckoned with. The rear and forward ends of companion tube sections are telescoped to provide a sliding fit (as shown in Fig. 5 and also indicated in dotted lines in Fig. 2) at a location adjacent but to the rear of the partition plate 15, this construction permitting sliding movement of the tubes, one within the other, under the influence of expansion and contraction. A centrally apertured disk 37 is provided upon the inside of the drum midway of the length of chamber 16a for supporting the tube sections 7b, the aperture of this disk allowing free passage for the spray pipe 31. Cut-outs 37a located adjacent the edge of the disk (Fig. 4) allow the passage of spray water longitudinally of the drum. A series of circumferentially-spaced drain slots 38 open through the wall of the drum, and below the drum in line with these slots is a basis 39 for receiving the water draining out of the drum through these slots. Shields 40 encircle the drum upon opposite sides of the drain slots.

The drum 5 may be composed of two longitudinal sections, namely a forward section 5a defining the forward air-cooled chamber 16, and a rear section 5b defining the water-cooled chamber 16a. The forward section, because it must support the weight of the front end of the cooler, is composed of comparatively thick metal plate, reinforced by a circumferential strap 41 which distributes the pressure transmitted through the riding ring 9 over a wide circumferential area of the drum section. The rear section 5b is made of relatively light metal plate to reduce the weight of the cooler since this drum section is not called upon to withstand heavy stresses and serves principally as a housing for the water spray.

For affording convenient access to the interior of the cooler, the front header plate 6 is provided with a centrally formed manhole adapted to be closed when the cooler is in operation by a cover 6b detachably bolted to the header plate. Similarly, the partition plate 15 is centrally provided with a manhole normally closed by a cover 15a.

The material leaving the cooler through the hollow trunnion 11 escapes through a chute 42 into the lower end of a vertical bucket conveyor 43, indicated schematically in Fig. 1, feeding to a sacking station where the material may be directly placed in bags, or the elevator may deliver the material to a hopper from which it is subsequently withdrawn for sacking.

In the operation of the cooler just described, the hot material coming from the rotary kiln K is fed through the spout 23 into the material-receiving compartment 22 at the forward end of the drum. From the compartment 22 the material during rotation of the cooler flows down the inclined surface of the front closure member 21 into the inlet ends of the muffle tubes 7. Under the combined influence of gravity and the agitation produced by rotation of the cooler, the material passes slowly through the muffle tubes, finally issuing from the ends of the tubes and spilling down the inclined surface of the deflecting member 29 and assisted by the lifting blades 30, out through the hollow trunnion 11.

During the period of travel of the material through the forward chamber 16 of the cooling drum, the heat transmitted through the walls of the muffle tubes is carried off by the air which, by means of a fan of small capacity connected to pipe 20 leading off from the casing 19, is drawn into the chamber through inlet ports 17 and deflected across the tubes by the baffle ring 18. The highly heated material thus initially undergoes a gradual cooling and the air entering the casing 19 is heated to a high temperature by reason of its passage into contact with the muffle tubes so that this air desirably may be used in the burner of the kiln for supplying the air of combustion or may be piped to the coal pulverizing mill, such as is frequently provided in conjunction with coal-fired kilns, for drying and preheating the fuel in advance of its delivery to the burner.

The material after traversing the chamber 16 enters the chamber 16a where the tubes are exposed to a water spray from the axial-extending spray pipe 31. The spray pipe rotates with the drum and directs jets of water in various directions against the muffle tubes, (see Fig. 4) so that the tubes are showered with water throughout their entire period of rotation and the material therein is rapidly cooled. The water falling into the drum flows out through the drain slots 38 into the basin 39 located below the drum, and this heated water may be pumped to other parts of the plant for use in boilers or other appropriate apparatus, or the water may be cooled for recirculation through the cooler.

The water-cooling of the tubes is so efficient that the material is required to travel only a relatively short distance before its temperature is lowered sufficiently to allow it to be sacked without danger of injuring the sacks. Furthermore, in the case of materials, such as lime, which actively interact with oxygen or moisture in the air, the maintenance of the material excluded from the air during its cooling is especially advantageous.

Because of the rapid cooling of the material in the spray chamber 16a the cooler may be substantially shorter than heretofore when the cooling was done entirely by air, thus providing a more compact and lighter structure requiring substantially less power for its operation. Furthermore, by constructing the forward end of the drum for air cooling, sufficient heated air is reclaimed from the cooler to meet the normal needs of the plant. At the same time, the initial air-cooling of the tubes to lower the temperature of the material to a point where water may be safely applied to the tubes without danger of cracking or deforming them, is another advantageous feature of the cooler.

The cooler of our invention may take other forms than that described above. In Figs. 6, 7 and 8 is shown a rotary tube cooler that is wholly water-cooled.

This form of cooler comprises a front header plate 50 and a rear header plate 50a and a series of spaced-apart, circularly-arranged muffle tubes 51 extending between and opening through the header plates. These tubes are welded to both header plates. A dome-shaped closure member 52 having a hollow trunnion 52a extending axially outward therefrom is welded to the front header plate so as to provide a material-receiving compartment at the forward end of the cooler. An inclined spout 53 communicating at its upper end with a hopper 54 extends through the hollow trunnion 52a and delivers material to be cooled into the material-receiving compartment. A closure member 55 is bolted to the rear header plate 50a located at the opposite end of the cooler, and this rear closure member is formed with a hollow trunnion 55a extending axially outward therefrom. A bell-shaped deflecting member 56 secured to the rear header plate serves to direct the material issuing from the ends of the tubes out through the hollow trunnion 55a and into a chute 58 (see Fig. 8) leading to an elevator or other point of discharge. Radial blades 57 upon the interior of the closure member 55 assist in the evacuation of material from the cooler.

The hollow trunnion 52a is circumferentially fitted with a tire which rests upon rollers, one of which is indicated at 59, mounted on foundation 61. The hollow trunnion 55a at the rear of the cooler is supported in a journal bearing 60 suitably mounted on the foundation 62. The cooler is supported at a downward inclination from its forward end toward its rear end and thus produces the gravitational travel of material through the muffle tubes. A thrust-bearing 62a (Fig. 8) encircling the hollow trunnion 55a takes the end thrust of the cooler. A ring gear 63 is secured to the circumference of the rear header plate 50a, and this ring gear is adapted to be connected through suitable gearing (not shown) to a motor or other source of power for rotating the apparatus on its trunnions.

A spray pipe 63 extends axially of the apparatus and is formed with rows of orifices 64 directed in different radial directions for discharging jets of water upon the muffle tubes during rotation of the cooler. The forward end of the spray pipe 63 is closed and rests in a socket 65 secured to the front header plate 50, while the opposite end of the pipe extends axially through the rear header plate 50a and the deflecting member 56 to the exterior of the apparatus where it is connected through a swivel coupling 66 with a source of water supply. The spray pipe by reason of its tight fit within the deflecting member is caused to turn with the cooler.

A plurality of disks 67 are associated with the muffle tubes at spaced distances throughout their length to rigidify and strengthen the tube assembly, and these disks are centrally provided with manholes normally closed by covers 68 but adapted to be opened by sliding the covers along the spray pipe 63. The front header plate 50 is likewise centrally provided with a manhole closed by a cover 69 detachably bolted to the header plate. As best shown in Fig. 7, the clearance about the feed spout 53 where it extends through the open end of the hollow trunnion 52 is sealed by a ring 70 having snug circumferential bearing with the interior of the trunnion. The ring is provided with a central opening for passing the feed spout 53, and the spout carries a hollow plug 71 adapted to close the clearance around the spout. Because the feed spout is heated to a high temperature by the hot material passing therethrough, we provide a water jacket 72 surrounding the feed passage. Cooling water is caused to circulate through the jacket from an intake pipe 73 leading from a source of water supply and passing through the wall of the jacket. The outlet of pipe 73 is located adjacent the discharge end of the spout, whereby the end of the spout confined within the material-receiving compartment and therefore most liable to overheating is subjected to the maximum cooling effect of the water as it initially enters the jacket. After circulating through the jacket the water is removed through an offtake pipe 74 leading to a suitable point of discharge.

The muffle tubes are enclosed by a stationary arched housing 75, which may be of sheet metal, this housing extending throughout the major length of the tubes. The housing at its ends has inturned terminal flanges 75a lying close to the circular path of rotation of the tubes. A shield 76 attached to the rear header plate so as to turn therewith flares toward the forward end of the cooler and closes the space between the housing and the rear closure member 55.

A stationary water spray pipe 77 extends lengthwise of the housing above the muffle tubes and discharges downwardly through a multitude of orifices 77a upon the tubes. The spray pipe 77 extends between the front and rear flanges 75a of the housing, and one end of this pipe projects externally of the cooler and is suitably connected to a source of water supply. Below the cooler and constituting the bottom of the housing is a shallow basin 78 adapted to receive the water delivered by the spray pipes 63 and 77 upon the tubes. The heated water accumulating in this basin may be drawn off and either used in other parts of the plant or cooled for recirculation through the cooler. A pivoted gravity-closed gate 78a is provided in the chute 58, this gate being adapted to be maintained open by the passage of material through the chute but being held closed by a weighted arm 79 for preventing access of air to the tubes.

The cooler just described corresponds generally to the cooler of Figs. 1 through 5, except that the tubes are entirely water-cooled (instead of being partially air-cooled) and the housing enclosing the tubes, instead of rotating with the tubes as in the case of the drum 5 of the cooler of Figs. 1 through 5, is stationarily mounted. The material coming from the kiln is delivered through the water-jacketed feed spout 53 into the material-receiving compartment formed by the front closure member 52 from which it enters the muffle tubes 51. During rotation of the cooler by means of a suitable source of power operatively connected to the ring gear 63, the material gradually passes through the tubes which are cooled by the water discharged thereon from the spray pipes 63 and 77. The material issuing from the tubes at the lower end of the cooler is directed by the deflecting member 56 and the lifting blades 57 through the follow trunnion 55a and out through the chute 58.

While we have disclosed a water-cooled feed spout only in connection with the embodiment of Figs. 6 and 8, it is to be understood that such a type of water-cooled spout may be used with the cooler of Figs. 1 through 5.

It will be apparent that the invention is capable of being embodied in forms other than those described above without departing from the spirit

of our invention as defined in the following claims.

We claim:

1. A tube cooler comprising a substantially horizontally-disposed housing, a series of heat-conductive muffle tubes extending longitudinally through the housing, means for unitarily rotating said tubes, means for introducing material to be cooled into the tubes at one end of the housing, said tubes being of longitudinal sectional construction, and the sections of said tubes being of different diameters telescopically and slidably interfitted adjacent their opposed ends, and means upon the housing for supporting the tubes adjacent their ends and intermediate their lengths at a point adjacent the telescopically interfitting sections thereof.

2. A cooler comprising a series of circularly arranged muffle tubes supported as a unit about a generally horizontal axis of rotation, means for supplying hot material to the tube series at one end thereof for passage therethrough, a drum portion surrounding a portion of the length of said tubes adjacent said end and including headers provided with openings in which the tubes are received, said drum portion being provided with spaced air inlet and outlet openings, means in connection with the outlet openings for leading heated air to a point of use, and water-cooling means for the tube portions which are outside of said drum portion, the header which is remote from said end forming a closed partition between the air heating zone and the water-cooling zone.

3. A cooler comprising a drum including a peripheral wall and front and rear haders and arranged for rotation about a generally horizontal axis, a series of muffle tubes circularly arranged about said axis and extending between and through said headers, an intermediate header through which said tubes pass and which forms a closed partition separating the drum interior into front and rear compartments, said front compartment being provided with spaced air inlet and outlet openings, means in connection with the outlet openings for leading heated air to a point of use, and water spraying means in said rear compartment for the water cooling of the tube portions which are in said rear compartment, said rear compartment having escape means for the cooling water.

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