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Castanoli

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[54] **MULTIPLE PASS DRYING APPARATUS**

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[52] **U.S. Cl.** **34/166;** 34/180; 34/183; 34/206

[51] **Int. Cl.²** **F26B 17/12**

[58] **Field of Search** 34/180, 179, 181–183, 34/166–168, 171, 175, 176, 173, 206, 216, 217; 432/121, 139, 112, 113, 118

[56] **References Cited**

UNITED STATES PATENTS

644,682	3/1900	Pratt	34/180
713,859	11/1902	Criswell	34/182
1,795,302	3/1931	Forrest	34/182
2,509,543	5/1950	Truax	34/180
3,827,158	8/1974	Bradshaw et al.	34/182

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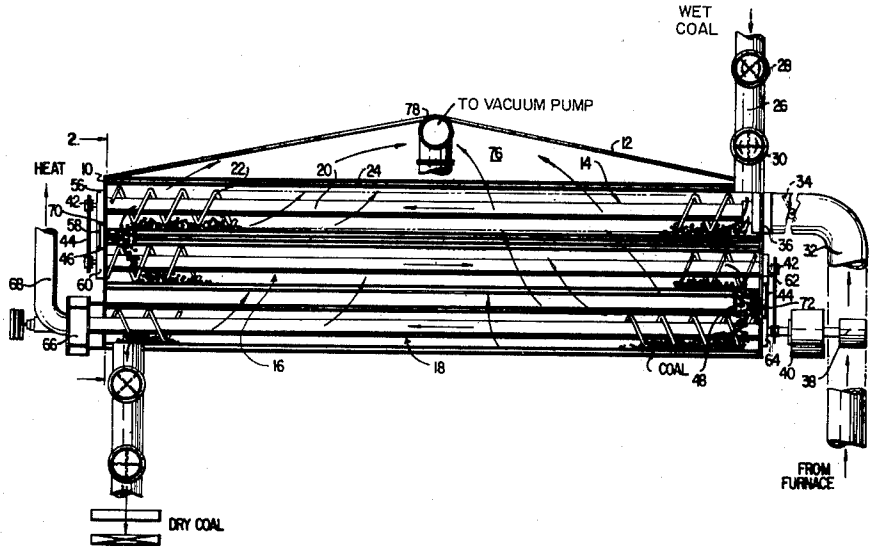
[57] **ABSTRACT**

Apparatus for treating a material by indirect heat exchange comprising a plurality of conveyor passes arranged in series, each pass having a centrally disposed hollow conveyor screw, means for passing a heating medium through the conveyor screw and through a hollow screw flight of the conveyor screw, a heating jacket disposed around the conveyor screw and the material to be treated, means for exhausting vapor emanating from the material under a vacuum, and the material passing in series from one pass to another. Preferably the conveyor screws are driven in unison and the heat exchange medium from one pass flows to the next concurrently with the material. Breaker means are provided adjacent the inlet to the apparatus to prevent caking of the wet material. The breaker means are disposed around the conveyor shaft and are actuated by a planetary gear arrangement connected to the drive for the conveyor shaft. The apparatus has particular utility for the drying of wet coal since the coal is maintained out of direct contact with the heating fluid and thus coal dust does not exhaust to the atmosphere.

8 Claims, 3 Drawing Figures



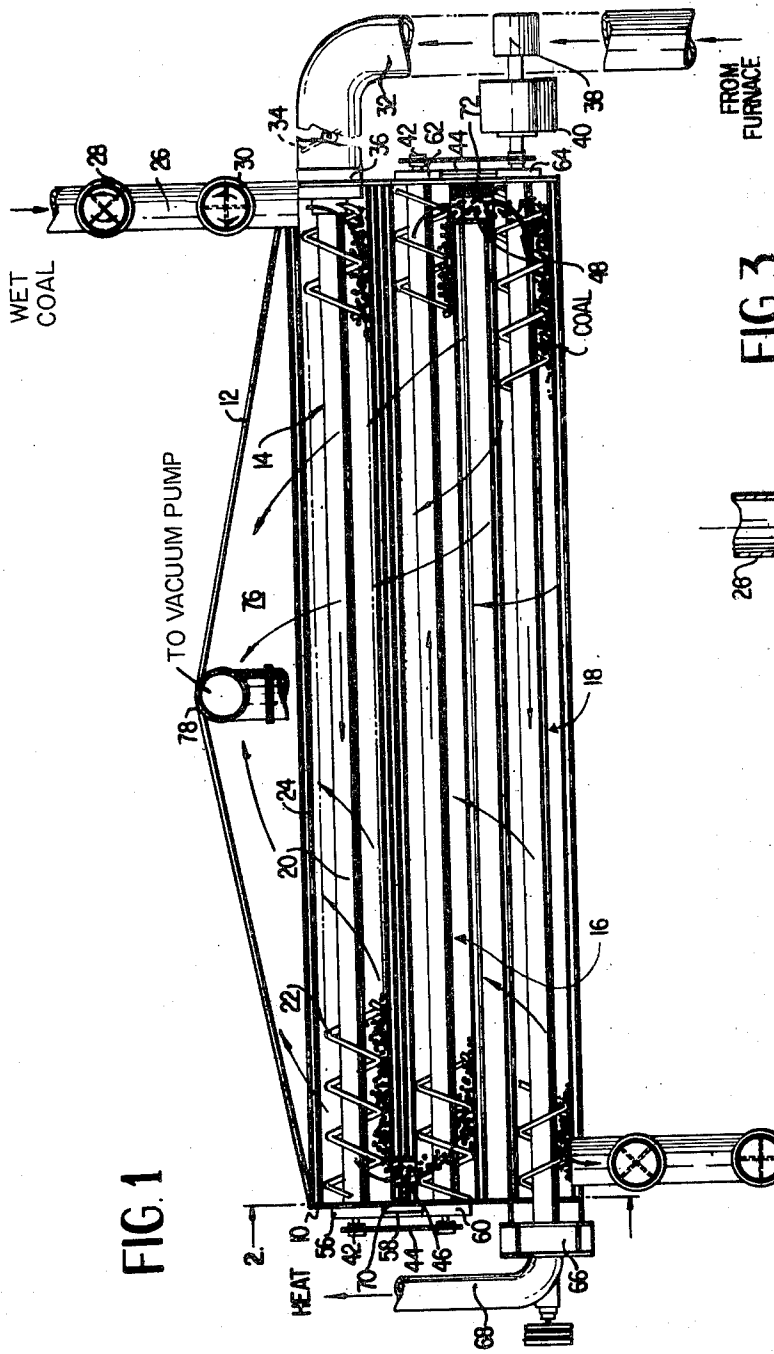


FIG. 1

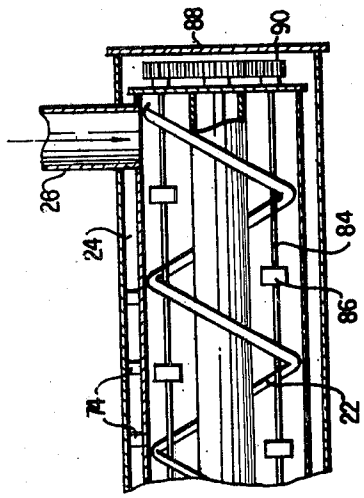


FIG. 3

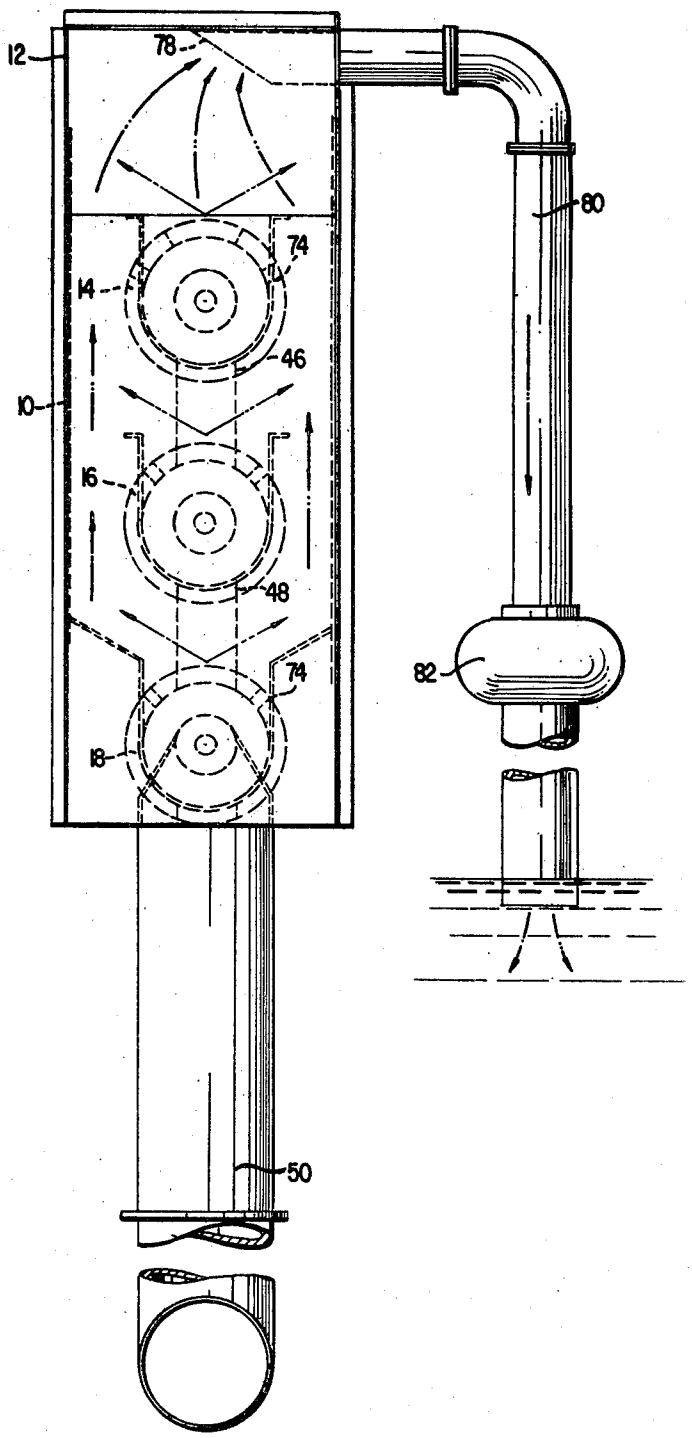


FIG. 2

MULTIPLE PASS DRYING APPARATUS

The present invention relates to material treating apparatus and more particularly to a multiple pass drying apparatus wherein the material to be dried passes in series from one pass to another. Each pass comprises a hollow conveyor screw and an outer jacket, with heat exchange fluid being passed both through the hollow conveyor screw and the heating jacket for indirect heat exchange with the material being conveyed in the annulus between the conveyor screw and the jacket. The apparatus is maintained under vacuum so that when the material is being dried the drying may be carried out at lower temperatures.

While the apparatus of the invention has many applications, for example, in food processing, desalination of water to obtain pure water, and/or salt or bittern of any gravity for further treatment to produce magnesium chloride etc., and for drying of various particulate materials; the apparatus finds particular utility in the drying of wet coal. For illustration purposes, coal will in general be referred to as the material being dried throughout this description although it will be understood that this is merely for purpose of illustration.

As is well known, it is frequently necessary to dry wet coal. Heretofore, prior art apparatus for this purpose have usually employed direct contact of the wet coal with a heating medium such as furnace gases or heated air. While this provides for intimate heat exchange, it is subject to the drawback that coal dust may be taken up by the heating gas and discharged to the atmosphere, even in installations in which dust collectors are employed. The dust laden steam and air emission may travel for miles and is a serious source of pollution.

When employing the apparatus of the subject invention, the coal or other material to be dried is not in direct contact with the gaseous heating medium. Therefore, atmospheric pollution is eliminated as is the need for dust collectors and the like. In addition, there is no contamination of the material being dried by the heat exchange fluid, which is essential in many applications. Since the drying is carried out under vacuum, the rate of moisture evaporation is far greater than at atmospheric pressure and in addition the chance of fire or scorching of the material being dried is minimized. In accordance with the invention, drying takes place at temperatures considerably below the customarily 1000°F. of prior art processes.

It will of course be appreciated that the apparatus is equally useful in cooling a material rather than heating the material.

It is primary object of the present invention to provide improved apparatus for effecting heat exchange between a material and a heat exchange fluid by indirect heat exchange.

Another object of the present invention is to provide an improved particulate material treating apparatus comprising a plurality of serially arranged passes in which the particulate material is subjected to indirect heat exchange under vacuum.

A further object of this invention is to provide improved means for preventing caking of wet material being transported by a conveyor screw.

Still another object of the present invention is to provide an improved procedure for drying wet coal which substantially eliminates atmospheric pollution by coal dust and which substantially prevents fires and explosions while drying the coal dust.

The above and other objects, features and advantages of this invention will become more apparent as this description proceeds.

In accordance with a presently preferred embodiment of the invention, wet coal is fed into the opening at one end of an outer heat exchange jacket in which there is disposed conveyor screw having a hollow shaft and hollow screw flights. As the wet coal is transported by the conveyor screw, it is heated by furnace gases or other heat exchange medium which is introduced into the outer heating jacket as well as into the hollow conveyor shaft and screw flights at the same end of the apparatus. The wet coal and the heat exchange medium move through the apparatus in concurrent fashion. At the end of the first pass, the coal passes to the inlet to a second pass and so on throughout the apparatus. Similarly, the heat exchange medium from the first pass flows to the second pass and so on. Openings made with sections of small diameter tubes are provided in the jackets to enable moisture evaporated from the wet coal to pass out of the coal to a source of vacuum. The dried coal discharges from the discharge end of the last pass, and the now cooled heat exchange medium is separately removed from the apparatus and may be vented to the atmosphere after additional heat recovery treating if desired. In the drawings:

FIG. **1** is a view of a presently preferred embodiment of the present invention taken primarily in longitudinal, vertical cross-section.

FIG. **2** is a vertical cross-sectional view taken on the line **2—2** of FIG. **1.**

FIG. **3** is a vertical cross-sectional view on an enlarged scale of a portion of the first pass of the FIG. **1** embodiment showing planetary breaker means for preventing caking of material in the apparatus.

Referring now to the drawings and more particularly to FIG. **1,** there is shown a presently preferred material treating apparatus of the present invention which includes an air tight casing **10** having a pitched roof **12.** For purpose of illustration, the apparatus is shown as containing three serially arranged conveyor passes **14,** 16 and **18.** Each pass includes a conveyor having a hollow shaft **20** and a hollow helical screw thread **22.** The conveyor is disposed within an annular heat exchange jacket **24.** Wet coal is fed to the inlet to the upper pass **14** through an inlet conduit **26** in which there are positioned a pair of rotary valves **28** and **30** in order to assist in maintaining a vacuum in the apparatus. The wet coal is deposited in the annulus between the conveyor shaft **20** and the jacket **24.**

Furnace gas or another suitable heat exchange medium flows through inlet duct **32** in which there is mounted a thermostatically controlled damper **34** to a header **36.** From header **36** the heat exchange medium is introduced into the shaft **20** and into the housing **24** of the first pass.

The conveyor shafts are driven in any suitable manner. In the illustrated embodiment, the drive mechanism is a variable speed motor **38** connected to the shaft **20** of the lower pass **18** via a transmission **40** to impart rotation to the lowermost shaft **20.** The three shafts **20** are driven in unison by means of pulleys **42** and V-belts **44** or chain drives or the like which interconnect the lowermost shaft **20** and the intermediate shaft **20** at the right hand of the apparatus as seen in

FIG. 1 and which similarly interconnect the other end of the middle shaft **20** with the upper shaft **20** at the left hand end of the apparatus.

After the coal traverses the upper pass **14**, it is discharged through a conduit **46** which extends through the heating jackets **24** of the two upper passes into the middle pass **16**. In pass **16**, the coal from passage **46** is conveyed in the opposite direction to its path of movement in pass **14**.

At the other end of pass **16**, coal is discharged through a passage **48** into the lower pass **18**. After being conveyed along by the conveyor of the lower pass, the now dried coal flows out of the apparatus through discharge conduit **50** in which there are provided rotary valves **52** and **54**.

The heat exchange medium which flows through the shaft **20** of the upper pass **14** is discharged into a header **56** which is appropriately sealed about the end of the shaft **20**. Header **56** is connected to a similar header **60** disposed about the end of the shaft **20** of the middle pass **16** by a conduit **58** so that the heat exchange fluid from the first pass shaft enters shaft **20** of the second pass. After flowing through the shaft **20** and the hollow screw flight **22** of the second pass, the heat exchange medium enters a header **60** at the other end of the shaft **20**. From header **60**, the heat exchange medium flows to a header **62** disposed around the shaft of the lower pass **18** through a conduit **66**. At the discharge end of the pass **18**, the expended heat exchange fluid from shaft **20** enters a collecting header **66** from which it is passed to discharge through heat exchange discharge conduit **68**.

The heat exchange medium which traverses the jacket **24** of the upper pass **14** flows through a conduit **70** into the jacket **24** of the second pass **16**. The heat exchange medium then flows to the other end of the jacket of pass **16** and discharges through conduit **72** into the adjacent end of the jacket **24** of the lower pass **18**. After traversing the jacket of the lower pass the expended heat exchange medium enters the header **66** and is combined with the heat exchange medium from the conveyor shaft and exits with it through discharge conduit **68**. From the foregoing description, it will be appreciated that the heat exchange medium in both the jackets and in the conveyor screws flows concurrently with the path of movement of the material being dried. However, if desired countercurrent flow could readily be accomplished.

During the course of travel of coal through the apparatus the coal becomes heated and moisture is evaporated from the coal. The resulting vapor passes through short tubes which form openings through the jackets **24**. For purposes of illustration, the openings **74** are shown in greatly enlarged scale in FIGS. **2** and **3**. In actuality, these openings are formed by small diameter tubes so that while they allow vapor to escape none of the coal or other material being treated may pass through the openings into the free space in the casing. The moisture from openings **74** enters the space **76** beneath roof **12** and then is drawn into the inlet opening **78** of an exhaust conduit **80** which is connected to a vacuum pump **82** (see FIG. **2**).

Referring now in particular to FIG. **3**, breaker means are provided to prevent caking of the wet material adjacent the inlet **26**. The breaker means comprise a plurality of paddles **86** on rotating rods **84** which are rotatably disposed in the annulus between the conveyor shaft **20** and the housing **24** and extend through holes provided in the screw flights **22**. The rods **84** have their ends mounted in suitable bearings and are rotated by a planetary gear arrangement. The planetary gear arrangement comprises an annular stationary sun gear **88** which is connected to the end of the casing **10**, and a plurality of planetary gears **90** fixed to the ends of rods **84** and rotated by the stationary sun gear **88**. The sun gear has a central bore through which the conveyor shaft **20** of pass **14** extends. Such breaker means may be provided in connection with each flight but in general they are necessary only at the inlet end of the first flight where the material being treated is wet. Thus, it will be appreciated that for some installations, the breaker means may be provided throughout the entire apparatus.

Although a presently preferred embodiment of the invention has been shown and described with particularity, it will be appreciated that many changes and modifications may readily suggest themselves to those of ordinary skill in the art upon being apprised of the present invention. It is intended to cover all such changes and modifications as fall within the scope and spirit of the appended claims.

What is claimed is:

1. Apparatus for subjecting a material to indirect heat exchange comprising a casing, a plurality of passes arranged in series within said casing, each pass including an annular jacket and a conveyor screw disposed in said heating jacket, said conveyor screw having a hollow shaft and having a hollow screw flight, means for introducing a material to be treated into an annulus provided between the jacket and conveyor screw of a first pass, conduit means for discharging the material from the end of one pass to the beginning of the next pass, means for discharging treated material from said casing, means for introducing a heat exchange medium into the jacket and into the conveyor shaft and screw flight of one of said passes, connecting means for passing the heat exchange medium from one pass to the next, said jackets being provided with aperture means for the passage of vapor which may emanate from the material being treated radially outwardly through said jackets into said casing, said aperture means being defined by a plurality of small passageways spaced along the lengths of said jackets and being of a size to allow moisture passage with substantially no passage of particles of the material being dried, and means for maintaining a vacuum in said casing to exhaust said vapor from said casing.

2. Apparatus according to claim **1**, further comprising breaker means provided adjacent the inlet end of the first pass, said breaker means including a plurality of longitudinally extending rotatable rods disposed in the annulus between the conveyor shaft and the inner periphery of said heating jacket, and planetary gear means for rotating said rods.

3. Apparatus according to claim **2**, further comprising a plurality of paddle members attached to said rods, and said planetary gear means including a stationary sun gear, and a plurality of planetary gears rotating about said sun gear and connected to the ends of said rods.

4. Apparatus according to claim **1**, wherein at least some of said passes are disposed one above the other to enable material to flow from one pass to the next by gravity.

5. Apparatus according to claim 1, further comprising means to drive each of said conveyor screw shafts in unison.

6. Apparatus according to claim 1, wherein the connecting means for passing heat exchange medium from one pass to another including conduit means interconnecting the discharge end of the jacket of one pass with the adjacent end of the jacket of an adjacent pass, headers disposed about adjacent ends of the conveyor shafts of adjacent passes, and conduit means interconnecting adjacent ones of said headers.

7. A process for drying wet coal comprising the steps of introducing wet coal into an annulus between a hollow conveyor screw and a heating jacket forming a first pass of a multi-pass drying apparatus, subjecting the wet coal to indirect heat exchange by introducing a heated heat exchange medium into the hollow screw and into the heating jacket, transporting coal discharged from the first pass to at least one subsequent pass for further indirect heat exchange, flowing heating exchange medium from one pass to the next pass, and removing vapors emanating from the wet coal through small longitudinally spaced transverse passageways extending through said heating jackets under vacuum, said passageways being of a size to allow moisture passage with substantially no passage of coal particles.

8. A process according to claim 7, further comprising rotating the conveyor screws of each pass in unison, and discharging coal from one pass to the next by gravity.

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