Sept. 26, 1933. A. D. BULLERJAHN 1,928,004

DRYING AND COOLING APPARATUS

Filed Dec. 16, 1929 9 Sheets-Sheet 1

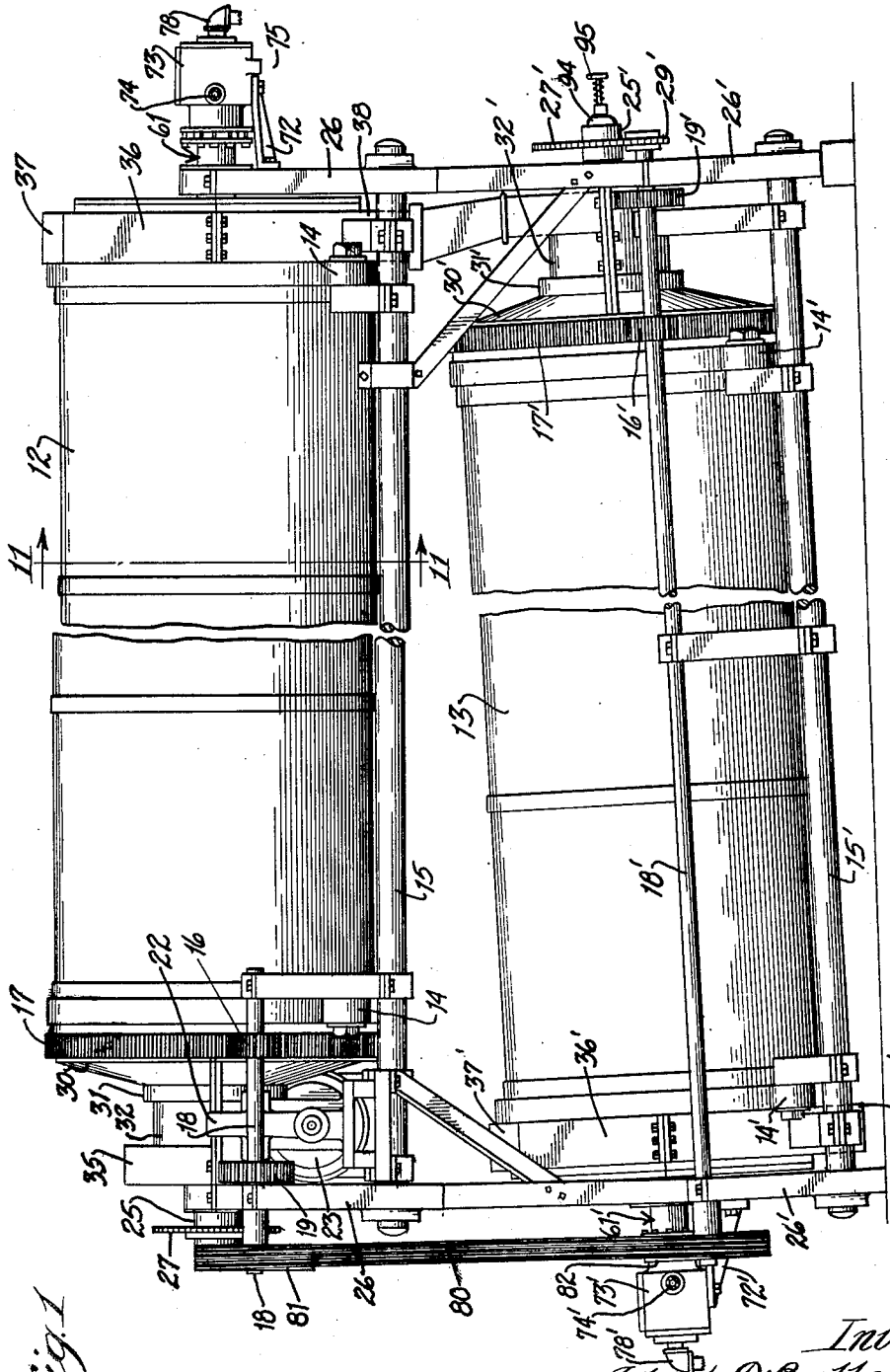

Fig. 1

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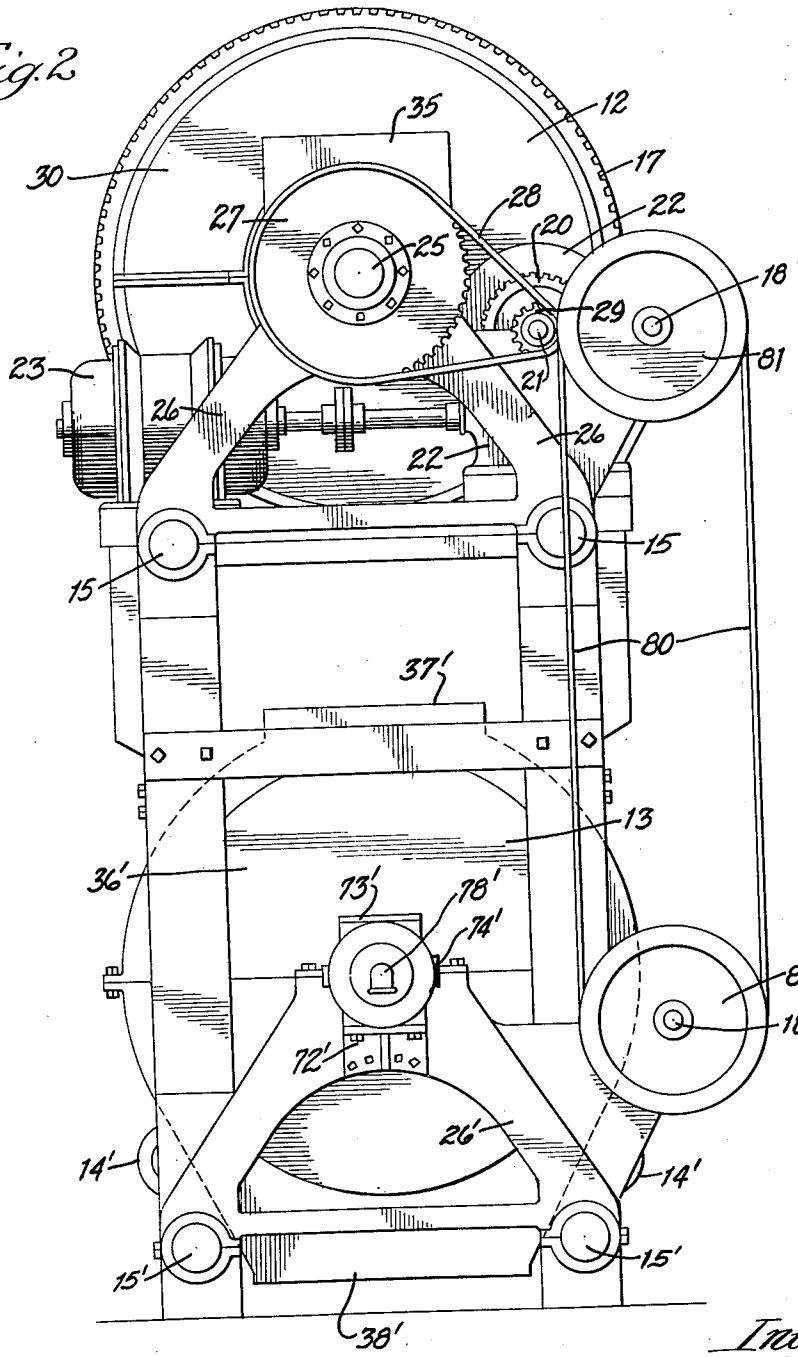
Fig. 2



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DRYING AND COOLING APPARATUS

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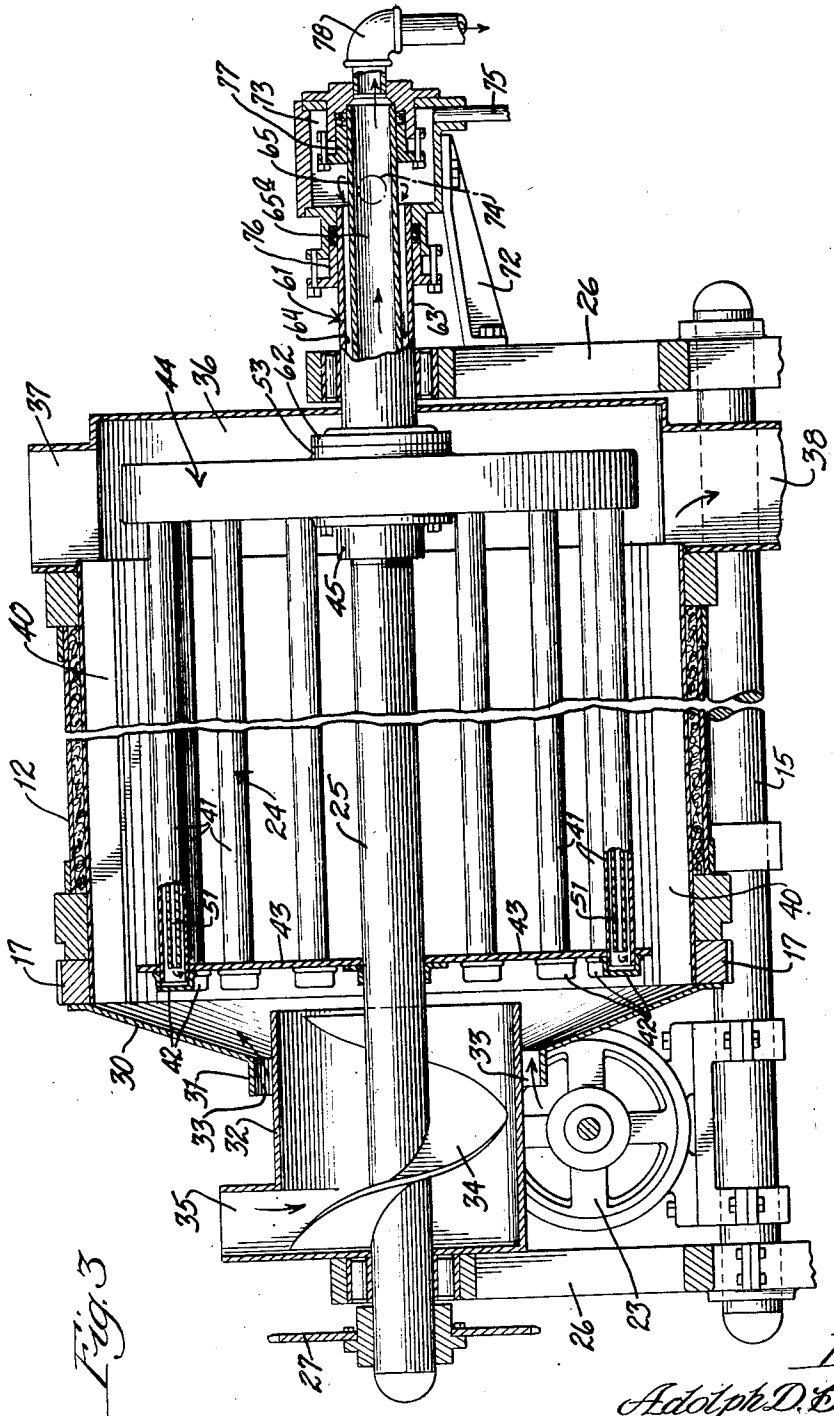

Fig. 3

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DRYING AND COOLING APPARATUS

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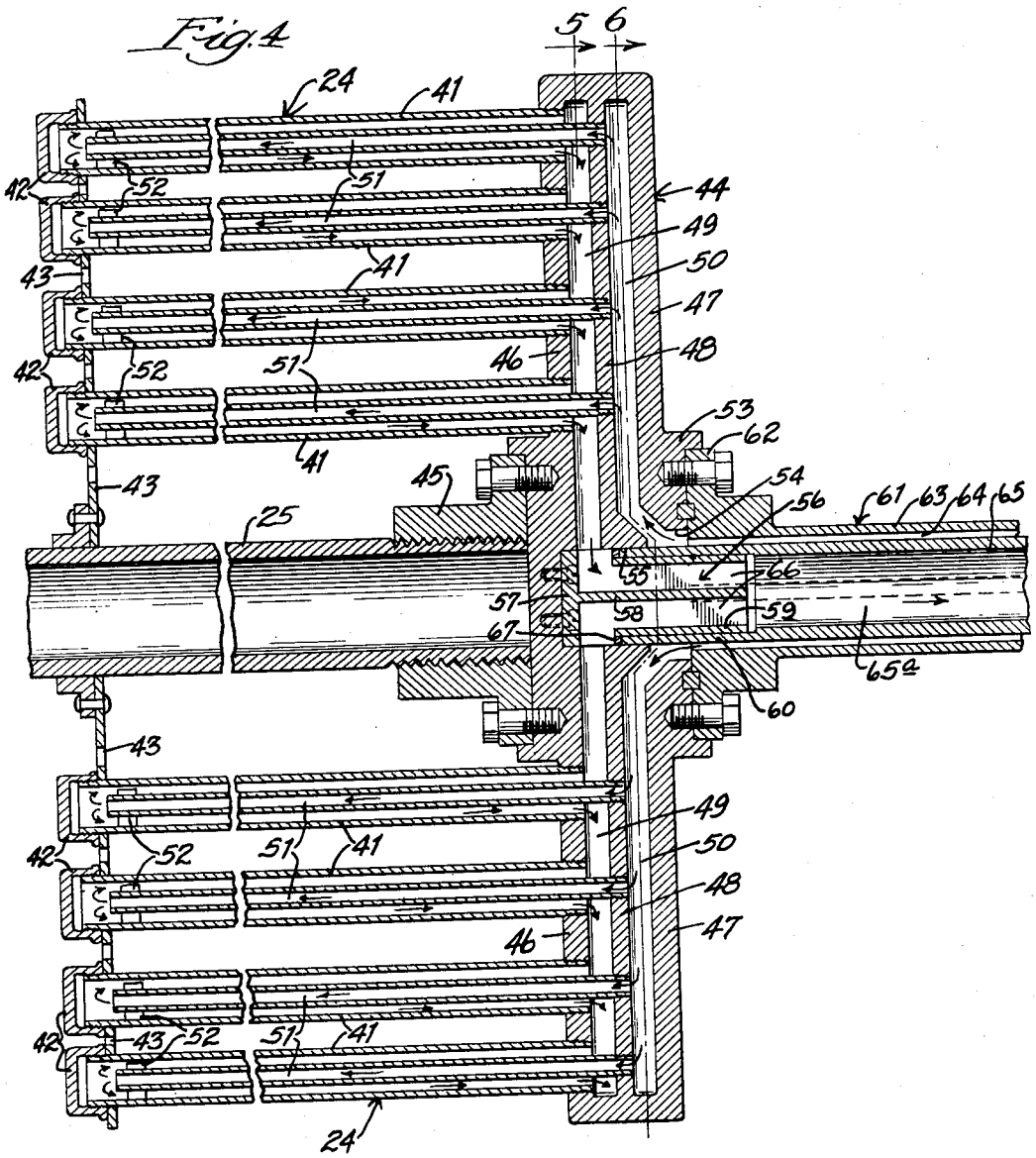
Fig. 4



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DRYING AND COOLING APPARATUS

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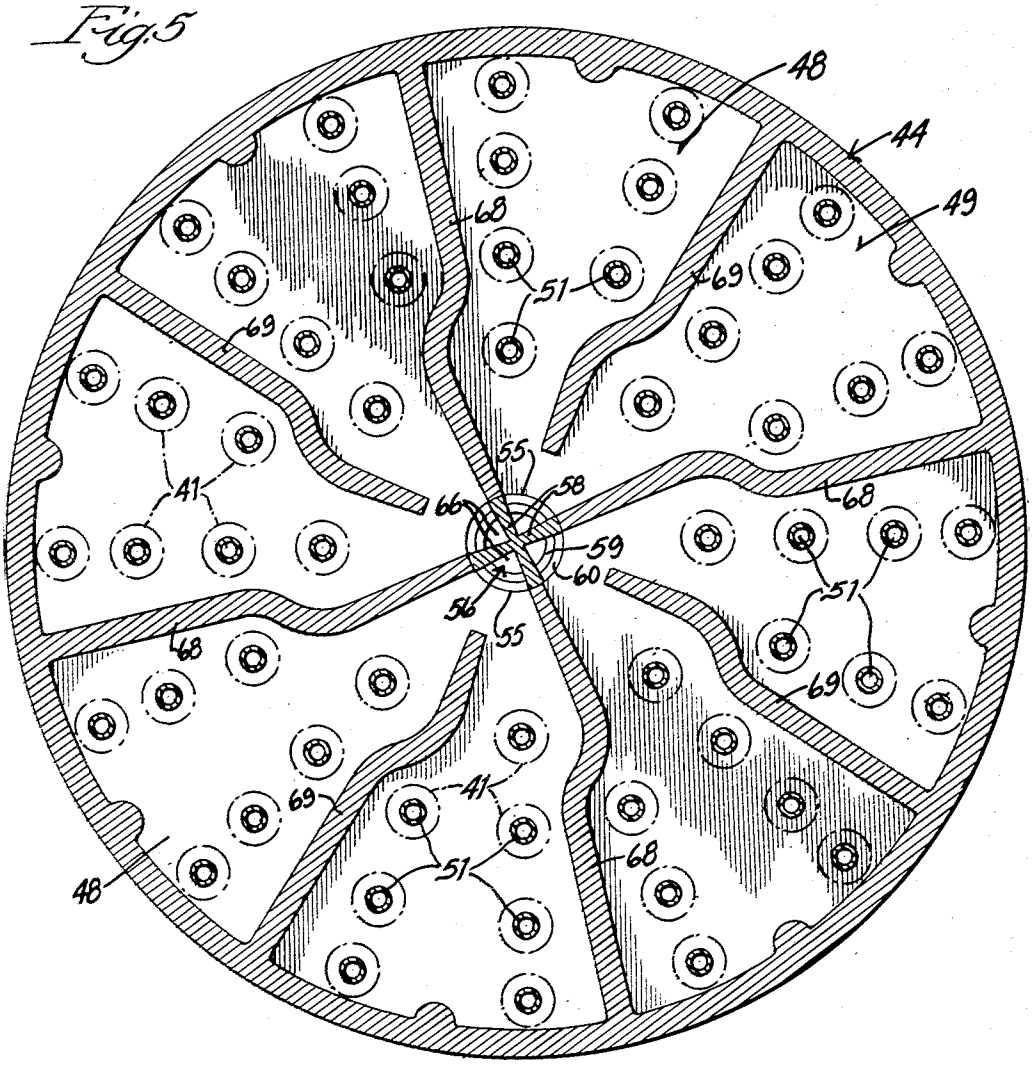
Fig. 5



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DRYING AND COOLING APPARATUS

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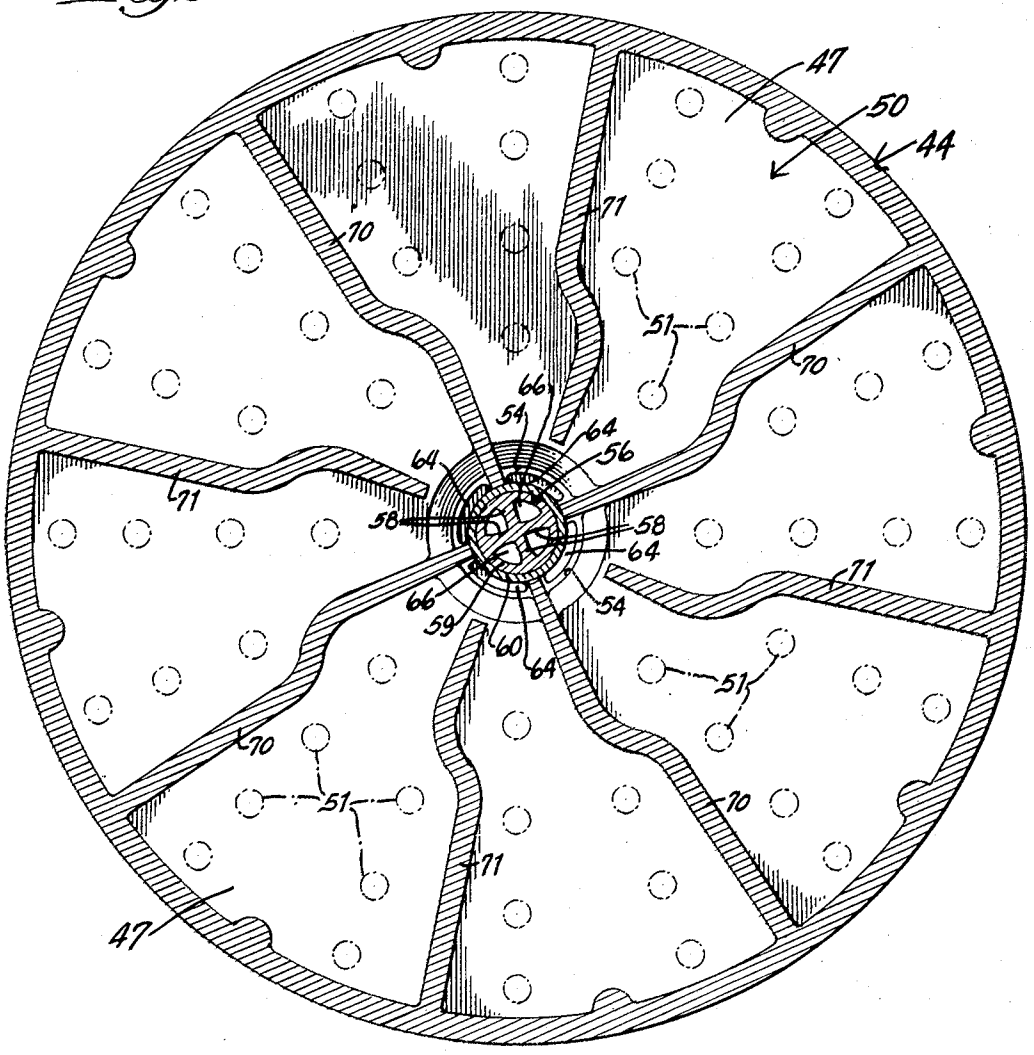
Fig. 6



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DRYING AND COOLING APPARATUS

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Fig. 7

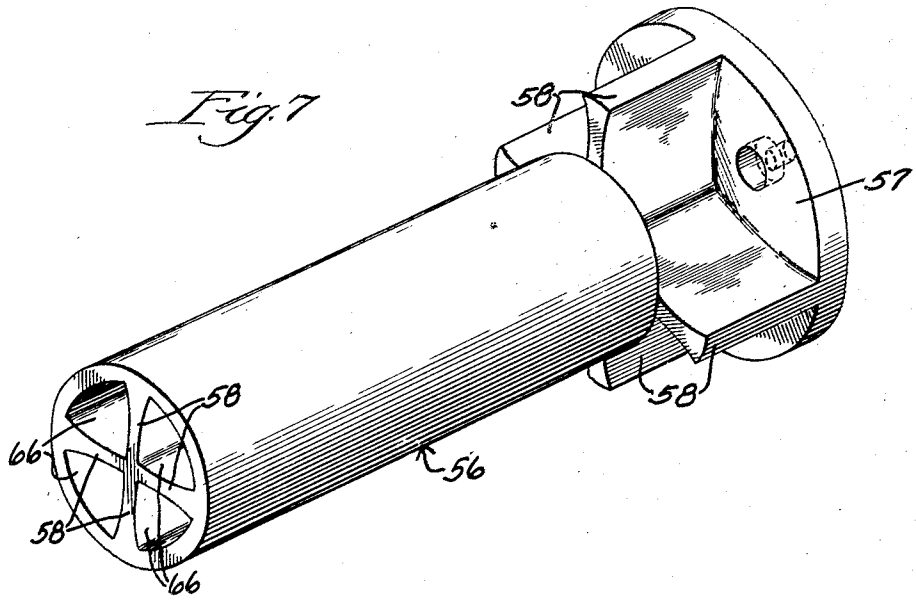


Fig. 9

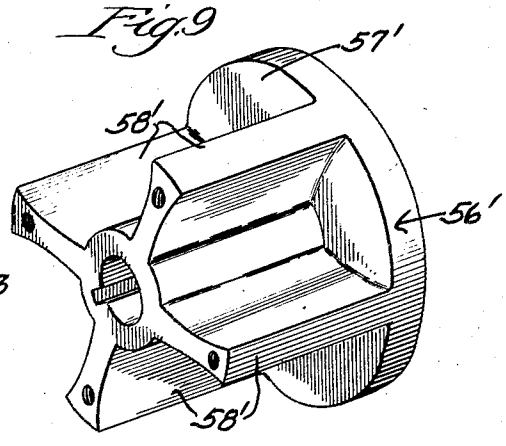
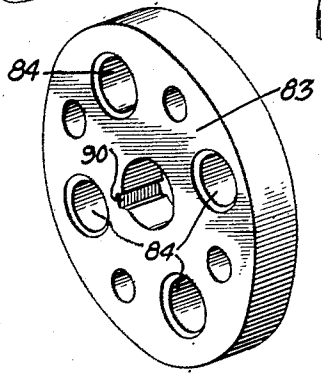


Fig. 10



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DRYING AND COOLING APPARATUS

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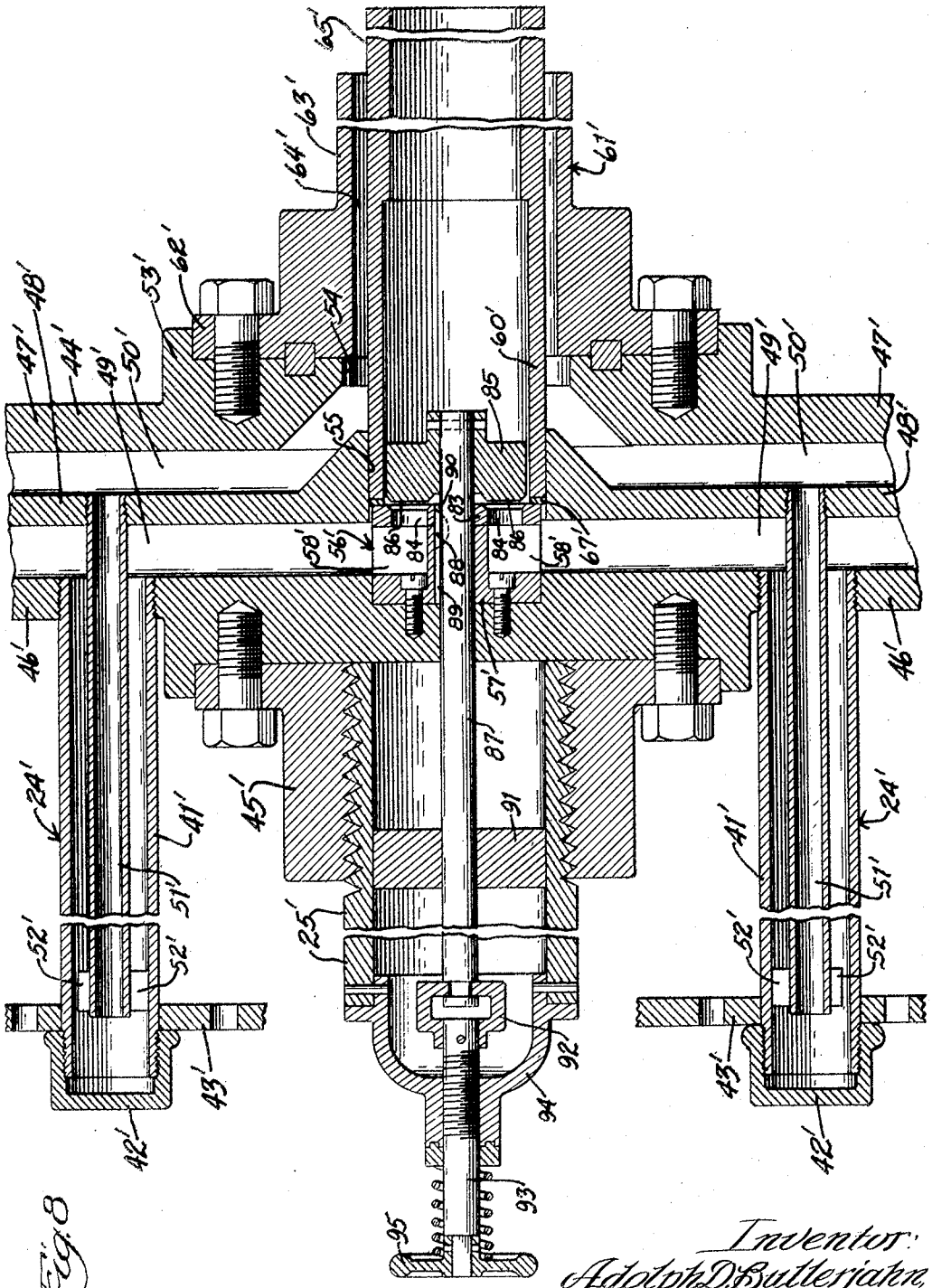

Fig. 8

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DRYING AND COOLING APPARATUS

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Fig. 11

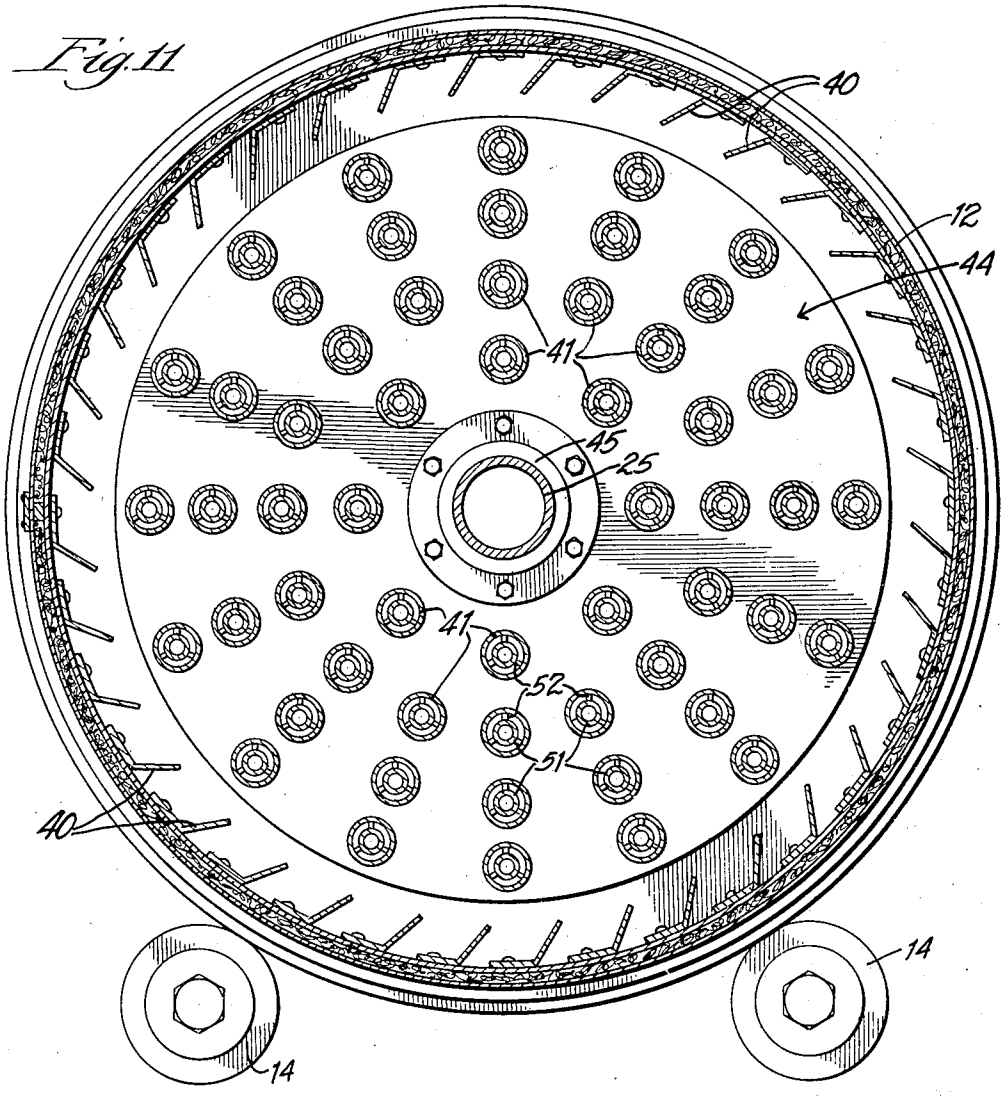
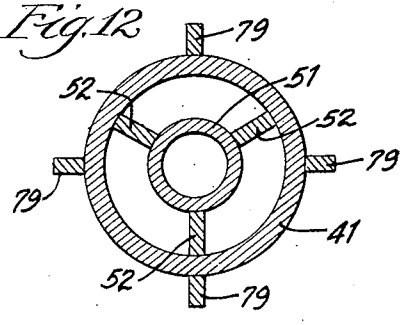


Fig. 12



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Patented Sept. 26, 1933 1,928,004

UNITED STATES PATENT OFFICE

1,928,004

DRYING AND COOLING APPARATUS

Adolph D. Bullerjahn, Minneapolis, Minn.

Application December 16, 1929
Serial No. 414,292

15 Claims. (Cl. 257—79)

This invention relates to drying apparatus and cooling apparatus and, in general, to apparatus suitable for supplying heat to, or abstracting heat from solid material in subdivided or powdered condition.

The invention relates particularly to heat exchange apparatus comprising a rotating drum through which the material to be dried or cooled passes continuously, a coil being provided within the drum through which heating or heat absorbing medium, as the case may be, is adapted to be passed.

One of the objects of the invention is to provide an apparatus of this type in which said coil is adapted to be rotated independently of the drum and preferably in either direction and at variable speed so as to adapt the machine for use with various materials.

Another object of the invention is to provide simple and effective means whereby the heat exchange medium, after passing through the coil, is effectively and automatically removed from the apparatus.

Other objects, advantages and capabilities will later more fully appear.

The invention also resides in the combination, construction and arrangements of parts illustrated in the accompanying drawings, and while I have shown herein a preferred embodiment, I wish the same to be understood as illustrative only and not limiting the scope of my invention.

In the drawings;

Figure 1 is a side elevation of a combined drying and cooling apparatus arranged in series, both being of the same general type and embodying my invention,

Fig. 2 is an end elevation of same,

Fig. 3 is a longitudinal section through the drying apparatus,

Fig. 4 is a longitudinal section through the coil and associated parts,

Fig. 5 is a section through the drain chest on the line 5 of Fig. 4,

Fig. 6 is a section through the steam chest on the line 6 of Fig. 4,

Fig. 7 is a perspective view of an element which controls the escape of water from the drain chest,

Fig. 8 is a sectional view showing a modified form of coil which is particularly suitable for use in a cooler,

Fig. 9 is a perspective detail of a modified control element embodied in the structure shown in Fig. 8,

Fig. 10 is a perspective detail of a valve seat plate associated therewith,

Fig. 11 is a sectional view on the line 11—11 of Fig. 1, and

Fig. 12 is a sectional detail showing a modified form of coil pipe.

Referring to the drawings, the numeral 12 designates a drying drum, while the numeral 13 designates a cooling drum arranged in series relation to the drying drum 12. The drying drum 12 and the parts associated therewith will be first described in detail.

The drum 12 is rotatably mounted on rolls 14 carried by longitudinal frame members 15. Suitable thrust rolls (not shown) are provided, in known manner, to prevent longitudinal movement of the drum. The drum 12 is rotated by means of a pinion 16 which co-operates with a ring gear 17 mounted on said drum. The pinion 16 is mounted on the shaft 18 which carries a pinion 19 which co-operates with a pinion 20. The pinion 20 is mounted on a shaft 21 which is driven through the gear reduction 22, which, in turn, is actuated by the electric motor 23.

The heating coil, generally designated 24, is located within the drum 12 and is mounted, as will hereinafter be described, upon a shaft 25, which is rotatably mounted in end frames 26, which are suitably united with the longitudinal frame members 15. The shaft 25 carries a sprocket wheel 27 which is connected by the chain 28, to a sprocket wheel 29, which may, for example, be mounted upon the shaft 21. It will be readily understood that the direction of rotation of the coil 24 relative to the direction of rotation of the drum 12 may be reversed by mounting the sprocket wheel 29 on the shaft 18 or otherwise and the relative speeds of rotation of the coil 24 and drum 12 may be varied by varying the relative sizes of the pinions 19 and 20 or of the sprocket wheels 27 and 29 as desired.

The forward or feed end of the drum 12 is provided with an end plate 30, preferably of frustro-conical shape. Said end plate is provided at its outer end with a concentric collar 31 into which extends freely a stationary feed box 32 leaving an annular opening 33 therebetween for the admission of a current of air into the drum 12. The shaft 25 extends through said feed box 32 and is provided with a helical vane 34 which feeds the material to be dried from the inlet 35 of the feed box 32 into the drum 12.

The drum 12 is tilted downwardly from the feed to the outlet end which extends into a stationary casing 36. From the top of said casing

extends an air conduit 37 which communicates with the suction side of a suitable pump or blower (not shown). The bottom of the casing 36 communicates by means of a conduit 38 with the feed box 32' associated with the cooling drum 13 so that material dried in the drum 12 is continuously supplied to the drum 13 to be cooled therein.

The interior surface of the drum 12 is provided with a plurality, and preferably a substantial number of vanes or flights 40 which serve to elevate the divided solid material and allow same to fall towards the lowermost part of the drum and co-operate with the coil 24 which will now be described in detail.

The coil 24 comprises a large number of tubes 41, which extend longitudinally of the drum 12. The ends of said tubes which are directed towards the feed end of the drum are closed by caps 42 and said ends are supported by a perforated plate 43 rigidly mounted on the shaft 25. The other ends of the tubes 41 are supported by the head 44 which is rigidly connected to the shaft 25. For example, the shaft 25 may be threaded into the internally threaded collar 45 which may be bolted to a central boss on an outer face of said head.

The head 44 is suitably of somewhat smaller diameter than drum 12 and may be located at or near the discharge end thereof. The head is provided with outer walls 46 and 47 and an intermediate wall 48 which divides the interior of the head into a drain chest 49 and a steam chest 50. The tubes 41 are threaded into the wall 46 so as to communicate with the drain chest 49. Smaller tubes 51 extend through the tubes 41 substantially to the capped ends thereof. The free ends of said tubes 51 are supported by spiders 52 and their other ends are threaded into the intermediate wall 48 so that they communicate with the steam chest 50.

The wall 47 of the head 44 is provided with a central exterior boss 53 which is provided with a central opening 54. The intermediate wall 48 is provided with a smaller central opening 55 in alignment therewith.

The distributing device 56 is mounted upon the inner face of the wall 46 and at the center thereof so as to project outwardly through the openings 55 and 54 of the intermediate wall 48 and the wall 47 respectively. The distributing device 56 comprises a circular end wall 57, suitably of the same diameter as the opening 55. Said end wall 57 is received in a recess in the wall 46 and is rigidly attached thereto, for example, by means of bolts. The device 56 comprises a plurality of longitudinal partitions 58 which extend radially from the axis thereof. As shown in the drawings, four such partitions may be provided, although a lesser or greater number may be employed, depending upon the structure of the drain chest 49 which will be hereinafter fully described. The portions of the partitions 58, adjacent the end wall 57, have a sliding fit in the opening 55 and in mounted position, said portions partially extend thereinto. Outwardly of said portions, the partitions 58 are of reduced size and are connected to an outer wall 59 of cylindrical form, and of such size that an annular space is left between it and the opening 55, in which is received a tight fitting projecting sleeve 60 of a fitting 61 which will now be described.

The fitting 61, which may suitably be a casting, is provided with a flange 62 whereby it may be bolted to the boss 53 of the wall 47. The flange 62 integral with a cylindrical body portion 63 which is provided with longitudinal steam ducts 64. Inside of the steam ducts 64, and extending beyond the flange 62 is the sleeve 60 referred to above. The other end of the cylindrical body portion is provided, inside of said steam ducts 64 with an outward extension 65. It will be understood from Fig. 4 that the ducts 64 communicate with the steam chest 50, while the central conduit 65^a communicates through the passages 66 of the distributing device 56 into the drain chest 49. Suitable washers 67 are provided to prevent leakage.

As shown in Fig. 5, the drain chest 49 is divided into a plurality of pockets by means of substantially radial partitions 68 and 69. The partitions 68 correspond in number to the partitions 58 of the device 56 and register therewith so as to complete a pocket from which the only outlet is one of the passages 66. The partitions 69 stop short of the central opening 55 in the wall 48 so that a plurality of pockets discharge into one passage 66. The partitions 69 may be omitted, or a greater or lesser number may be employed, if desired. As shown in Fig. 5, the partitions 68 and 69 may be curved somewhat so as to clear the pipes 41 and 51.

As shown in Fig. 6, it is preferred to provide the steam chest 50 with similar partitions 70 and 71 which cause any condensate, in said chest, to return to the steam ducts 64 in the fitting 61 and escape thereby. Said partitions also serve to strengthen the head 44, particularly when same is cast as a unit, as is preferred.

The fitting 61 and the end of the shaft 25 remote therefrom, are mounted in bearings carried by the end frames 26.

Rigidly mounted near the fitting 61, for example, on a bracket 72 carried by the adjacent frame 26, is a steam box 73 provided with an inlet port 74 and a drain pipe 75 which is connected to a suitable steam trap, (not shown). The inwardly directed wall of the box 73 is provided with an opening to receive the enlarged cylindrical portion 63 of the fitting 61 and is provided with a stuffing box 76 to prevent leakage. As will be readily seen in Fig. 3, the ducts 64 communicate freely with the interior of the box 73 and are supplied with steam therefrom. The opposite wall of the box 73 is provided with a stuffing box 77 which engages the outward extension 65 of the fitting 61. A stationary drain pipe 78 leads from said wall to a suitable steam trap (not shown) so as to remove the condensed water removed from the drain chest through the central conduit 65^a.

As shown in Fig. 11 the tubes 41 are dispersed within the drum 12 so that every part of the surface of each tube is exposed to the solid material elevated by the flights 40 and dropped therefrom at a high elevation, or material which has accumulated on other tubes and is precipitated therefrom, owing to the continued rotation of the coil. One important feature of this arrangement is that the poorly conducting gas film which tends to adhere to the surface of the heated tubes and thereby substantially reduce their efficiency, is continuously being broken up. Furthermore, when material is released from the flights 40, it tends to build up on the tubes 41, in small piles. Owing to the continued rotation of the coil, said piles topple over and are, to some extent, received on the other tubes. In the ordinary course of events, the top of a pile, which portion has not been exposed to direct contact

with the tube, will fall first so that the least dried portion tends to come into contact with the next heating tube and protect the more thoroughly dried portions from direct contact, at least immediately after it is removed from one tube. As shown in Fig. 12, projecting ribs 79 may be welded or otherwise attached to the outer surface of the tubes 41, in order to increase their ability to support a substantial amount of the solid material being dried.

The cooler 13 and associated parts are of preferably substantially the same construction as the drum 12 and corresponding parts. Accordingly, similar elements are identified by the same reference numerals with the addition of primes thereto. The constructional features which differentiate the cooling apparatus will now be described.

The drum 13 and the coil therein is driven from the motor 23 by means of a belt 80 which engages pulleys 81 and 82 carried by the shafts 18 and 18' respectively. The shaft 18', which carries the pinions 16' and 19', extends the whole length of the drum 13. The arrangement of the drive is otherwise similar to that of the drum 12.

The drum 13 is directed downwardly slightly towards its discharge end in the usual manner. It is preferred to pass the air through the cooler in the opposite direction to the travel of the material being cooled. Accordingly it is preferred to connect the air conduit 37' of the casing 36', to a blower (not shown) instead of a suction pump.

Since water is preferably employed as the cooling medium, it is preferred to modify, somewhat, the parts associated with the cooling coil. Thus, as shown in Figs. 8 and 9, the distributing device 56' comprises a base disk 57' which is integral with a plurality of vanes 58' which extend to the circumference of base 57' in the radial direction and are relatively shallow in the axial direction. To the outer faces of the vanes 58' is attached, for example, by means of screws, a valve seat disk 83. The disk 83 is provided with a plurality of openings 84 each of which communicates with one of the pockets formed by adjacent vanes 58'. A valve member 85 is located within the extension 60' of the fitting 61' and is provided with projections 86 which are adapted to cooperate with the openings 84 and regulate the passage of fluid therethrough. The valve member 85 is non-rotatably mounted upon a valve rod 87 which extends through openings in the disk 83, the distributing device 56' and the wall 46' and through the hollow shaft 25' to the feed end of the cooler. The rod 87 is prevented from rotating relative to the coil 24' by means of a key 88 which cooperates with the registering key ways 89 and 90 in the distributing device 56' and the disk 83. The rod 87 may suitably be guided within the hollow shaft 25' by means of wooden blocks 91. Its outer end is connected through a swivel connection 92 to a stem 93, which is threadedly mounted in a fitting 94 which is rigidly attached to the outer end of the hollow shaft 25'. The outer end of the steam 93 is provided with a hand wheel 95 whereby the relation between the valve member 85 and the openings 84 may be adjusted at will.

In the operation of the machine, the relative speeds of the drum 12 and coil 24, and of the drum 13 and coil 24', and also the direction of rotation of the said coils are adjusted in the manner described above. It will be understood that the helical vanes 34 and 34' are adapted to feed the material into the drums 12 and 13 and are necessarily replaced by vanes of opposite direction when the direction of rotation of the coils is reversed. The direction of rotation of the coil relative to the direction of rotation of the drum and the relative speeds of rotation thereof are of great practical importance. Thus, when treating granular, flake or other material of frangible nature, of which it is desired to maintain the structure substantially unchanged, the coil and drum may be suitably rotated in the same direction and with little, if any, speed differential. When treating less delicate material the speed differential may be substantially greater and the coil and drum may be rotated in opposite directions. In some cases it is desired to subject the material to the very violent agitation within the drums, and for this purpose the coil may suitably be given a very high speed in the direction opposite to that of the drum.

During the operation the material to be dried is supplied to the feed box 32 and passes progressively through the drum 12, being repeatedly brought into contact with the heated tubes 41, and is discharged into the conduit 38 by means of which it is supplied to the drum 13. Said material passes through the drum 13 in the same manner, is thoroughly cooled by contact with the tubes 41' therein and is finally discharged through the conduit 38'.

Steam is supplied to the steam box 73 by the inlet port 74 and makes its way by the steam ducts 64 into the steam chest 50. The steam passes outwardly through the tubes 51 to the capped ends of the tubes 41 and returns through the latter towards the drain chest 49. Condensate formed in the tubes 41 drains into the drain chest 49 and collects in the lowest parts of the pockets formed therein by the partitions 68 and 69. When said pockets become elevated during each revolution of the coil the condensate flows therefrom downwardly into the pocket formed by adjacent partitions 58 of the distributing device 56 and flows through one of the passages 66 thereof into the central conduit 65^a of the fitting 61, from which it escapes through the drain pipe 78.

Any condensate which forms or collects in the steam chest 50 and is not carried by the steam into the tubes 51, is directed by the partitions 71 through the steam ducts 64 into the steam box 73, from which it escapes by the drain pipe 75.

The current of air drawn through the drum 12, in the manner already described, effectively removes the moisture evaporated during the drying operation. Since said air passes through the material while it is falling from the flights 40 and while it is beng buffeted from one heated tube 41 to another, it operates under highly advantageous conditions.

Cooling medium, suitably water, chilled brine or the like, is supplied under pressure through the inlet port 74' into the box 73' from which it passes by the ducts 64' into the cold medium chest 50'. From said chest the cold medium passes outwardly through the tubes 51' to the capped ends of the tubes 41'. The cooling medium passes inwardly through said tubes 41' and becomes heated therein owing to heat exchange with the material being cooled. The heated medium enters the spent cooling medium chest 49' and escapes therefrom through the openings 84 under the pressure which is maintained upon the medium throughout the cooling

coil 24'. The valve member 85 is adjusted by means of the hand wheel 95 to control the rate of flow of the cooling medium through the coil 24' and to ensure the substantial release of pressure when said medium issues through the openings 84. Air or other gas which separates from the cooling medium during its use collects in the chest 49' and when each pocket occupies its lowest position said air ascends into the corresponding pocket in the distributing device 56' and is carried by the cooling medium in the form of a spray through the corresponding opening 84 into the central conduit 65a'. The cooling medium together with said air is passed out by the drain pipe 78'.

One of the advantages of my apparatus is the accessibility of the tubes and the ease with which they may be removed and replaced. Thus, by removing the end plate 30, the feed box 32, vane 34 and the casing 36, all of which may be made inseparable parts for such purpose, each tube is rendered accessible from both ends and can readily be removed and replaced.

By dividing the chests 49 and 50 into pockets, any tendency of the medium to by-pass certain tubes or of unequal flow of said medium through the tubes is prevented. Furthermore, the partitions 68 and 70 are preferably formed so that the medium passing from each pocket of the chest 50 drains into two of the pockets of the chest 49 so as to further assure uniformity of the flow of medium through the tubes.

It will be understood that any suitable heating and cooling media may be employed. Thus, in the heating coil 24, I may employ steam under pressure and am able to maintain the temperature of the tubes 41 within a wide range by varying said pressure.

While I have shown and described but a few embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made which do not depart from the spirit and scope of the invention as disclosed in the appended claims.

I claim:

1. A heat exchange apparatus for treating solid material comprising a rotatable drum, a coil adapted for the passage of medium therethrough, and means in said drum adapted to elevate said material and discharge same into heat exchange relation with said coil, said coil being adapted to rotate independently of said drum.

2. A heat exchange apparatus for treating solid material comprising a drum adapted to be rotated, a coil located within said drum, rotatably mounted independently of said drum and adapted for the passage of medium therethrough, means in said drum adapted to elevate said material and discharge same into heat exchange contact with said coil, means for rotating said drum and means for rotating said coil.

3. A heat exchange apparatus for treating solid material comprising a drum adapted to be rotated, a coil located within said drum, rotatably mounted independently of said drum and adapted for the passage of medium therethrough, means in said drum adapted to elevate said material and discharge same into heat exchange contact with said coil, driving means for rotating said drum and driving means for rotating said coil, said driving means being interconnected.

4. In a heat exchanging apparatus, a rotatable coil comprising heat exchange tubes, a chamber communicating therewith, radial partitions in said chamber approaching the center thereof, and a distributing member at the center of said chamber comprising longitudinal partitions co-operating with said radial partitions and extending into a trunnion of the coil so as to provide separate ducts into the pockets formed by said partitions for draining fluid from said pockets.

5. In a heat exchanging apparatus, a rotatable coil comprising a head having a pair of chambers therein, heat exchange tube means communicating into each of said chambers, a trunnion for said coil having a plurality of ducts communicating with one chamber and a central duct communicating with the other chamber, radial partitions in one of said chambers dividing same into a plurality of pockets each of which communicates with one of said ducts, radial partitions in the other chamber dividing same into a plurality of pockets, and a distributing device comprising a plurality of longitudinal partitions co-operating with the last said radial partitions to provide separate outlets from each of the pockets of the last said chamber into the central duct of the trunnion.

6. In a heat exchanging apparatus, a coil comprising a hollow head, a wall therein dividing same into two chambers, a large number of spaced telescoped tubes mounted on said head, the outer tubes communcating with one chamber and the inner tubes with the other chamber, a plurality of substantially radial partitions dividing each chamber into a plurality of radial pockets, a shaft in parallel relation to said tubes mounted on one side of said head, a trunnion member mounted on the other side of said head, said trunnion member being provided with a central duct and a circumferential series of ducts each of which communicates with one of the pockets of one chamber, and a distributing device in the other chamber providing separate ducts from each of the pockets of the other chamber into said central duct.

7. In a heat exchange coil, in combination, a trunnion member comprising an intermediate cylindrical portion provided with a plurality of circumferential ducts and cylindrical extensions of reduced diameter within said ducts, a central duct extending through said intermediate portion and extensions, and a distributing device extending into one end of said central duct and provided with partitions dividing same into a plurality of passages.

8. In a heat exchange coil, in combination, a trunnion member comprising an intermediate cylindrical portion provided with a plurality of circumferential ducts and cylindrical extensions of reduced diameter within said ducts, a central duct extending through said intermediate portion and extensions, and a distributing device comprising an outer cylindrical wall extending into one end of said central duct, and a plurality of longitudinal partitions extending within said cylindrical wall and therebeyond.

9. In a heat exchanging apparatus, a coil comprising a chamber for heat exchange medium, a plurality of radial partitions located in said chamber, a trunnion conduit extending into said chamber, a distributing device in said chamber provided with a plurality of pockets, a disc in said conduit adjacent said device and provided with openings from said pockets into said conduit, a valve member in said conduit adapted to co-operate with said openings and means extending to the exterior of said apparatus for controlling said valve member.

10. In a heat exchanging apparatus, a rotatable coil comprising a pair of chambers for heat exchange medium, a trunnion member comprising an intermediate cylindrical portion, said cylindrical portion being provided with a circumferential series of ducts which communicate with one of said chambers, a cylindrical extension of reduced diameter located within the series of ducts and extending into proximity of the other chamber, a central duct extending through said intermediate portion and extension, a distributing member in last said chamber provided with pockets co-operating with partitions in said chamber to divide same into a plurality of substantially radial pockets, a disc in said central duct provided with perforations which communicate with said pockets, a valve member co-operating with said openings and means extending to the exterior of said apparatus for controlling said valve member.

11. A heat exchange apparatus for treating solid material comprising a rotatable drum, a coil comprising a large number of tubes spaced apart so as to receive falling material around their complete surfaces as the coil is rotated and adapted for the passage of medium therethrough, means in said drum adapted to elevate said material and bring same into heat exchange relation with said tubes, said coil being adapted to rotate independently of said drum.

12. A heat exchange apparatus for treating solid material comprising a drum adapted to be rotated, a coil comprising a large number of tubes adapted for the passage of medium therethrough and spaced apart so as to receive falling material around their complete surfaces as the coil is rotated, said coil being located within said drum and rotatably mounted independently of said drum, means in said drum adapted to elevate said material and discharge same into heat exchange contact with said tubes, driving means for rotating said drum and driving means for rotating said coil, said driving means being interconnected.

13. In a heat exchange apparatus, rotatable coil comprising tubes through which medium is adapted to be passed, said tubes being provided with longitudinal ribs to support material being treated, thereon, and a second tube within the first for supplying a heating medium, said second tube having means for spacing it from the outer tube.

14. In a heat exchange apparatus, a rotatable drum having flights on its inner surface for picking up and pouring through the drum a pulverized material to be dried, a series of steam coils adapted to be rotated within said drum, and means for rotating the drum and coils in the same direction but at different speeds.

15. In a heat exchange apparatus, a rotatable drum having flights on its inner surface for picking up and pouring through the drum a pulverized material to be dried, a series of steam coils adapted to be rotated within said drum, and means for rotating the drum and coils in the same direction, the coils being driven at a higher speed than the drum.

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