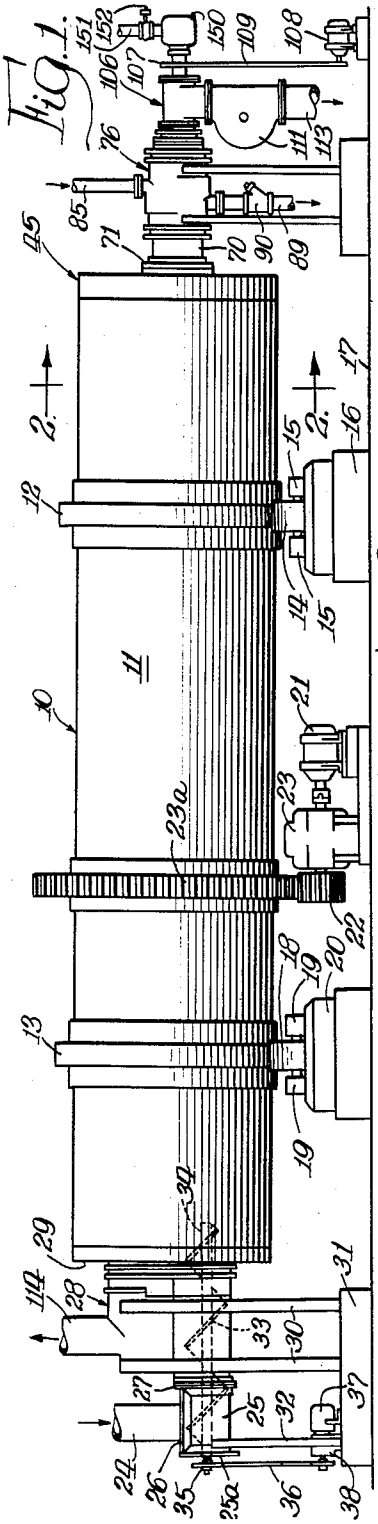
Aug. 19, 1958 C. E. BILL 2,848,198

FLUID JOINT AND PROCESSED MATERIAL DISCHARGE ASSEMBLY FOR ROTARY PROCESSING VESSELS

Filed Jan. 28, 1957 4 Sheets-Sheet 1

Fig. 1.



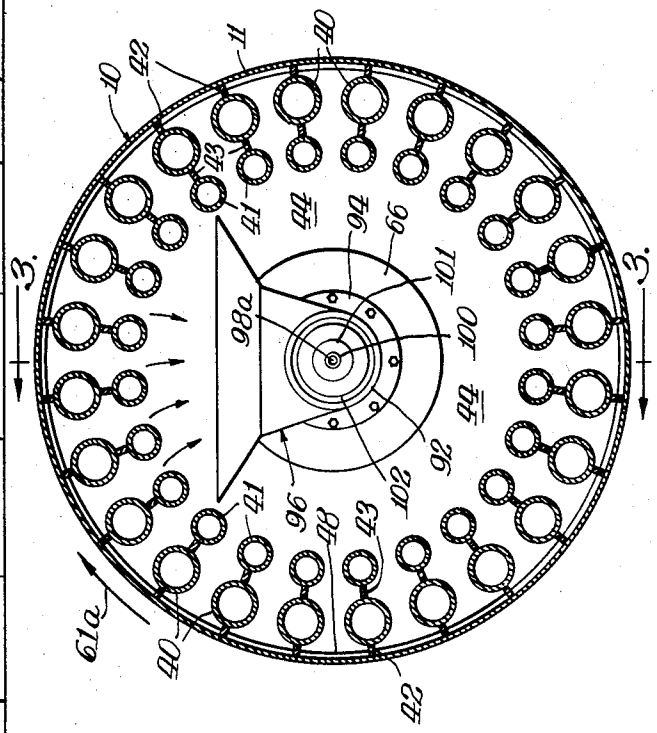


Fig. 2.

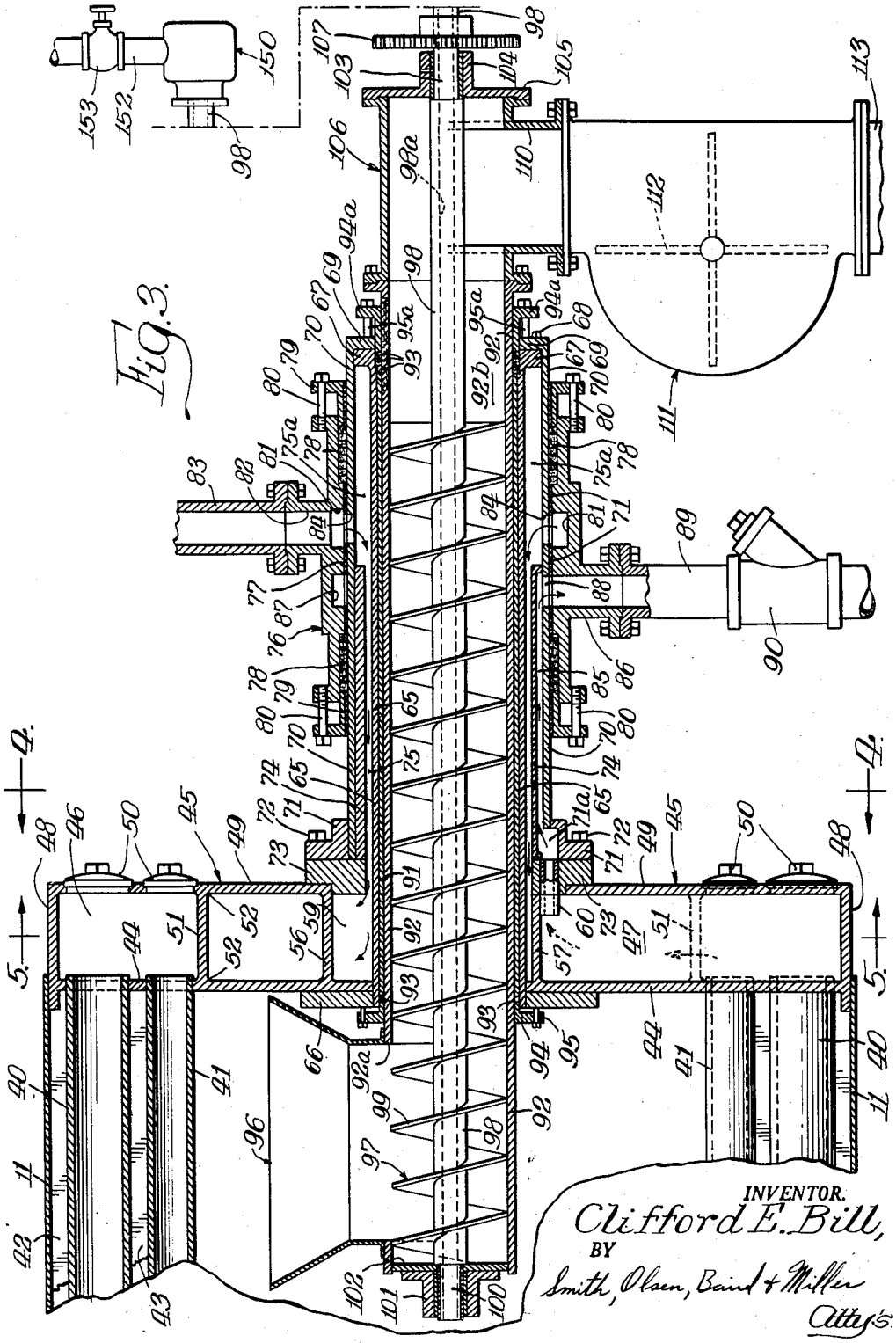
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FLUID JOINT AND PROCESSED MATERIAL DISCHARGE ASSEMBLY FOR ROTARY PROCESSING VESSELS

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Fig. 3.



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FLUID JOINT AND PROCESSED MATERIAL DISCHARGE ASSEMBLY FOR ROTARY PROCESSING VESSELS

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Fig. 5.

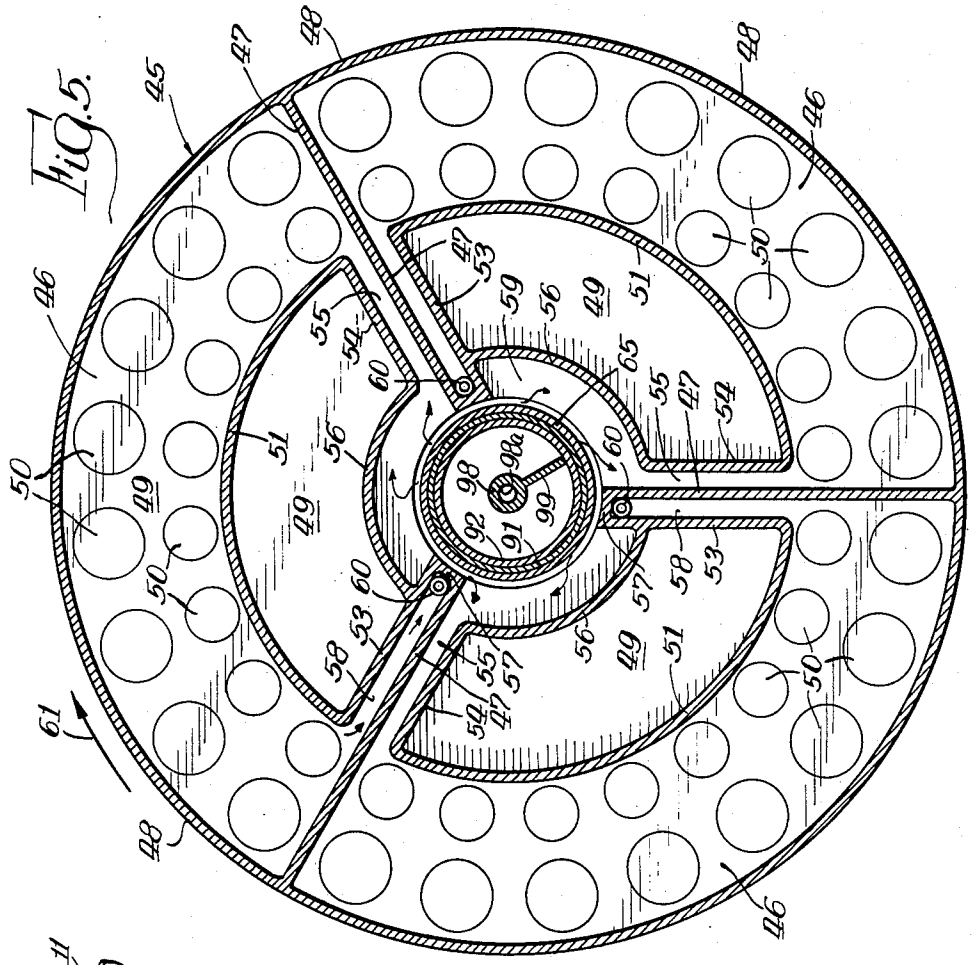
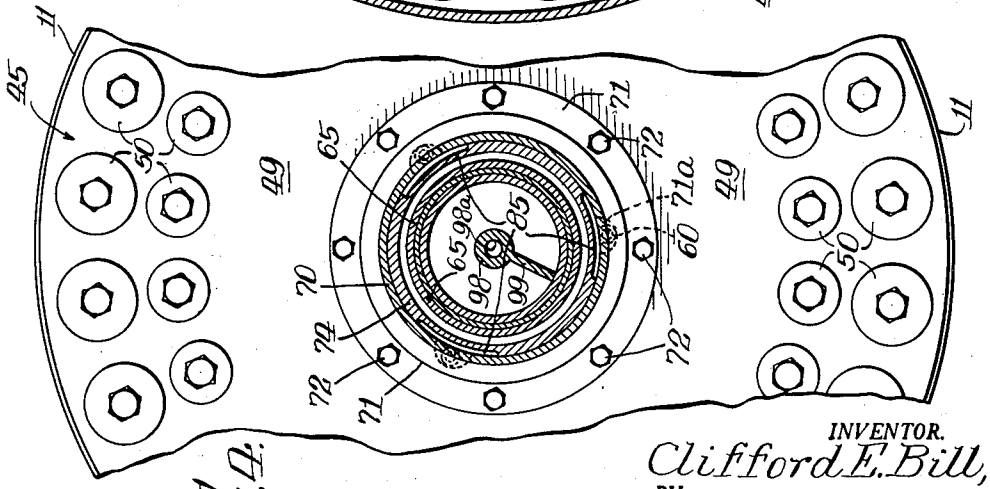


Fig. 4.



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Filed Jan. 28, 1957 4 Sheets-Sheet 4

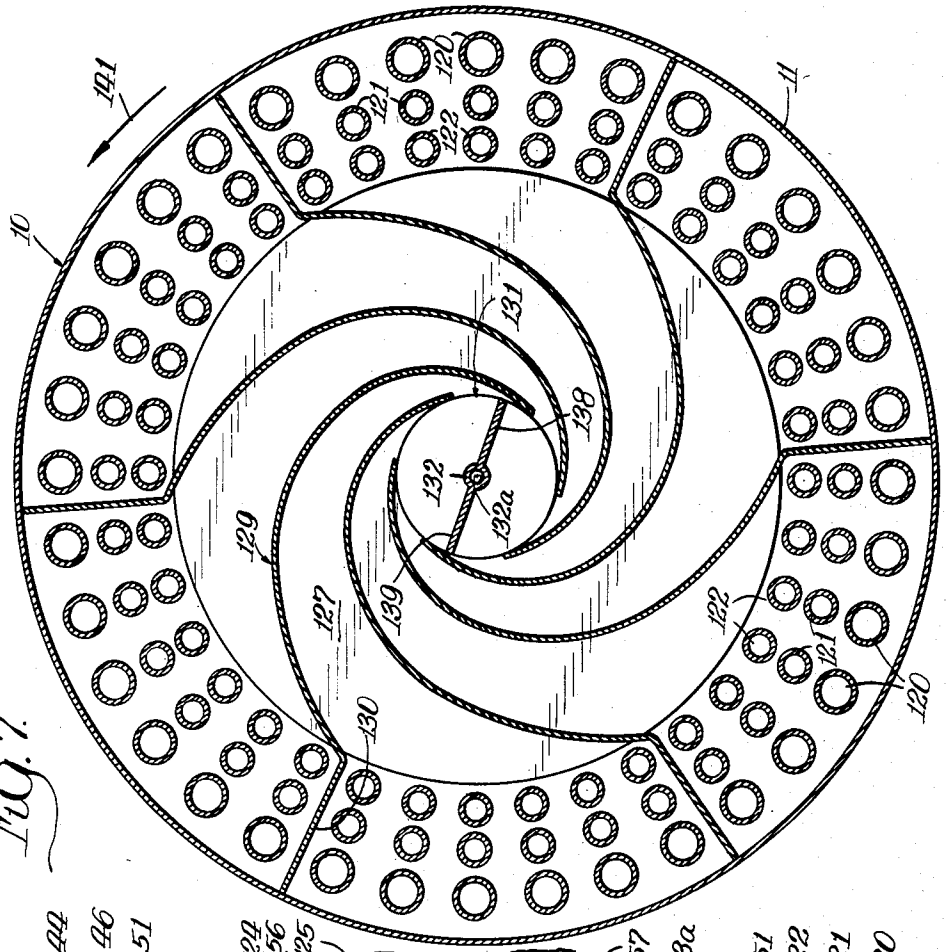


FIG. 7.

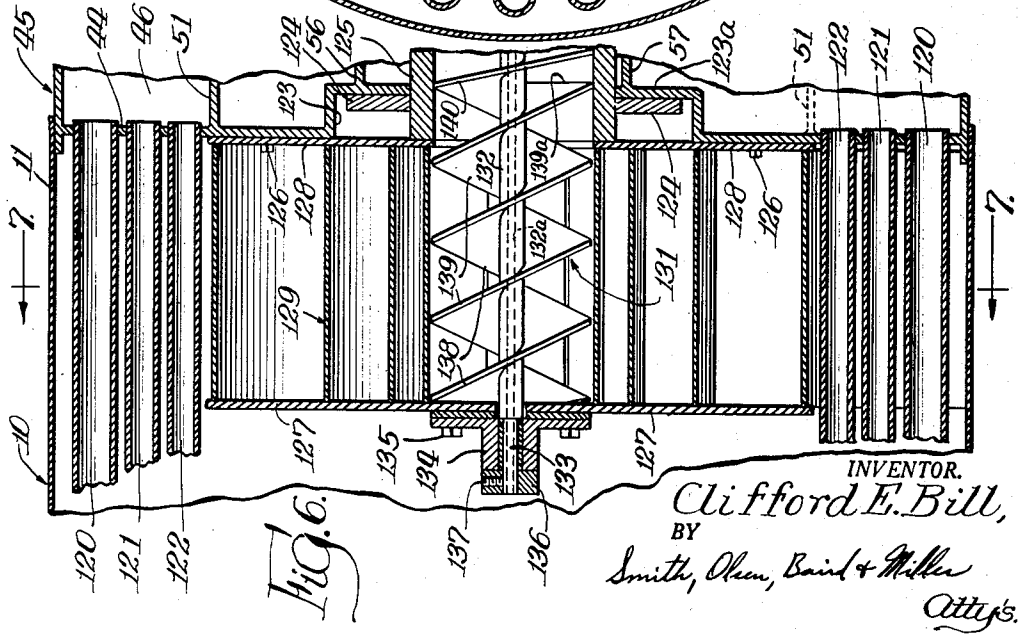


FIG. 6.

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2,848,198

FLUID JOINT AND PROCESSED MATERIAL DISCHARGE ASSEMBLY FOR ROTARY PROCESSING VESSELS

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Application January 28, 1957, Serial No. 636,610

27 Claims. (Cl. 257—92)

This invention relates to improvements in rotary processing vessels of a type for heating or cooling or otherwise processing materials that are fed into the vessel and, more particularly, the present invention pertains to an improved apparatus for supplying heating or cooling fluids and/or special atmospheres to said vessels, and for constantly removing processed materials therefrom, all while the vessel is being rotated.

Processing vessels of the type just referred to may be rotary driers, rotary calciners, or rotary reaction vessels of various kinds in which materials to be processed are more or less continuously introduced at one end of the vessel and are removed from the other end thereof after having undergone the particular treatment or reaction desired within the vessel. The reaction or treatment contemplated by the present invention may be plain drying, in which case the interior of the vessel will be provided with steam coils or the like over which the material to be dried is passed, or the treatment may comprise cooling of the material, or chemically reacting the same within the vessel as the result of the heating or cooling and/or as the result of subjecting the material to a special atmosphere within the vessel.

Rotary processing vessels of the general type first above referred to are well known and have found wide use in treating or drying various materials while maintaining the interiors of the vessels at about atmospheric pressure. Such vessels, for the most part, have been generally cylindrical in form and have been rotated about axes that are slightly tilted from the horizontal, so that materials to be treated introduced at one end of a vessel of this type will be moved slowly toward the other end while being tumbled over and over in contact with heat transfer coils or the like inside the vessel as the vessel is rotated. By the time the material being treated has reached the lower end of the cylindrical vessel, it will be dry or otherwise treated and will be ready to be discharged. Heretofore, the treated material has been discharged from the lower end portion of these slightly tilted cylindrical vessels through a plurality of openings provided in the side wall of the vessel adjacent the lower end wall, the treated material being caught in a hopper or the like disposed below these openings, and then transported away from the vicinity of the vessel in any suitable desired manner.

While treating vessels of the kind just described have been suitable for many uses, it has been found to be extremely difficult to operate such vessels under special conditions requiring the treatment to take place under substantial pressure, or in a vacuum, or in special atmospheres of hydrogen, carbon dioxide or the like, as so often required by commercial chemical processes. Due to the fact that severe gas leakage around the peripheral discharge openings for the treated material has seemingly been unavoidable, commercial vessels of this general type have heretofore found little use in special treating or reacting processes such as those just mentioned, or in special processes where a high percentage

of recovery of solvents or gaseous reaction products or other volatile materials is required.

One of the principal objects of the present invention is to provide a highly improved combination fluid joint and processed material discharge apparatus for a hermetically sealed rotatable treating vessel, operative for continuously supplying hot or cold fluids to heat transfer coils in the vessel and for continuously removing processed material from the vessel while the vessel is being rotated and while being operated under either internal pressure or internal vacuum or while containing a gaseous reaction atmosphere or gaseous reaction products. Another object of the invention is to provide a combination fluid joint and processed material discharge apparatus of the character just stated, whereby the processed material may be removed from the rotating vessel at substantially any reasonable rate desired without the escape of substantial amounts of gas from the interior of the vessel or leakage of air into the vessel. This characteristic of the present apparatus, it will be understood, renders a properly constructed vessel with which the apparatus is used, to be employed in a great variety of heating and drying and reaction processes where the maintenance of a given positive or negative pressure within the vessel is important, and where the recovery of gaseous products or the maintenance of a gaseous reaction atmosphere is desired.

An example of one such heating and reaction process, for which the apparatus of the present invention is ideally suited, is encountered in one of the steps of the so-called Solvay process by which a large portion of the very important chemical compound, sodium carbonate (Na_2CO_3), often called "soda ash," is manufactured in this country for use in the glass, soap, textile, paper and many other industries. After sodium bicarbonate has been precipitated in an earlier step, it is dried and heated, preferably under moderate pressure and temperature, to cause the following reaction to take place:

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O\uparrow + CO_2\uparrow$$

thereby providing the desired end product. It is necessary, however, for commercial reasons, that this process be carried on in a continuous operation—that is, that the sodium carbonate be discharged from the sealed vessel without loss of moderate pressure, so that the gaseous carbon dioxide reaction product may be recovered from the operation and be fed back for re-use in an earlier step in the overall Solvay process. That the present apparatus is ideally adapted for carrying out a process of this kind, as well as a great variety of similar processes, will be readily apparent to those skilled in the art.

Other objects of the present invention include the provision of means by which the processed material may be removed from the vessel along a path coincident with the axis of rotation of the vessel, while at the same time supplying heating or cooling fluid to heat transfer coils in the continuously rotating vessel and, when steam is used as the heating fluid, draining condensate from the steam heating coils. Yet another object of the invention is to provide screw type conveyor means for removing the processed material from the rotating vessel, and the provision of means in conjunction with the screw for preventing the leakage of gases past the screw during operation. Still another object of the invention is the provision of the conveyor screw as an integral part of the fluid joint assembly. Yet another object is the provision of novel means for introducing the treated material within the vessel to the screw for transportation to the exterior of the vessel. Still another object of the invention is to provide in the screw and fluid joint assembly means by which a reaction fluid may continuously be introduced into the interior of the vessel or by which

gaseous reaction products or volatile solvents stripped from the material undergoing treatment may be withdrawn from the vessel.

These and other objects and advantages of the invention will be apparent from the following description of a preferred embodiment, as well as a modification, of the invention, taken with the accompanying drawings in which:

Fig. 1 is an elevational view of a cylindrical, rotary drier or calciner incorporating one form of the fluid joint and processed material discharge apparatus of the present invention;

Fig. 2 is an enlarged vertical cross-sectional view taken through the drier vessel substantially along the line 2—2 in Fig. 1, showing the interior of the drier at its dried material discharge end, and showing a hopper within the drier into which the dried material is tumbled as the vessel is rotated and from which the material is fed to a conveyor screw for movement in an axial direction out of the drier;

Fig. 3 is a further enlarged vertical axial cross-section taken substantially along the line 3—3 in Fig. 2, showing the dried material discharge end of the drier and showing the details of construction of the combination fluid joint and processed material discharge assembly;

Fig. 4 is a fragmentary cross-section taken substantially along the line 4—4 in Fig. 3 at right angles to the axis of rotation of the drier and looking toward the dried material discharge end of the drier vessel;

Fig. 5 is a view similar to Fig. 4, but taken substantially along the line 5—5 in Fig. 3 and looking in the opposite direction;

Fig. 6 is a fragmentary axial cross-section taken through that portion of the drier vessel immediately adjacent its dried material discharge end, showing a modification of the sleeve structure and arrangement within which the conveyor screw rotates, and showing a modified means for introducing the dried or processed material to the conveyor screw; and

Fig. 7 is a cross-sectional view taken substantially along the line 7—7 in Fig. 6 in order to bring out the spiral shape of scoop elements for directing dried material to the conveyor screw.

The fluid joint and processed material discharge assembly of the present invention is shown in the drawings and described below as being incorporated, by way of example, in a rotary drier or calciner. The details of the construction of the drier vessel, however, may be varied greatly, depending upon the nature of the treatment to be given to the material to be processed therein. During the course of the description, again by way of example, the vessel will be referred to as a drier vessel, but it will be appreciated by those skilled in the art that the vessel and the apparatus of the present invention are not limited to use in a simple drying operation. Instead, it will be apparent, as the description proceeds, that the vessel may be a reaction vessel in which a chemical reaction is caused to take place in the presence of heat, or the reaction may be one of an exothermic character, in which case heat will be carried away from the vessel, as explained hereinafter. Furthermore, it will be apparent that the treatment of the material within the vessel may take place in an atmosphere of air or other gas, and also at atmospheric pressure or at positive or negative pressures, as the case may be. It will also be seen that, as the treatment of the material in the vessel takes place, gas may be constantly supplied to the interior of the vessel if the gaseous atmosphere therein requires replenishment, or gases of the reaction may be constantly recovered from the vessel—again as the necessities of the treating process may require.

Referring to the drawings, and first to Fig. 1, the rotary dryer there shown comprises a long, axially extending, hermetically sealed, cylindrical vessel **10** having a cylindrical side wall **11** with annular steel tires **12** and **13** mounted thereon. The tires **12** and **13** are utilized for rotatably supporting the vessel in a generally horizontal attitude, but with the axis of the vessel tilted slightly with respect to the horizontal, as illustrated in Fig. 1. The tire **12** rides upon a pair of trunnion rollers **14** mounted in suitable bearing blocks **15** supported on a foundation block **16** resting upon a floor **17** or other supporting structure. Similarly, the tire **13** rotatably rides upon a pair of spaced trunnion rollers **18** that are respectively rotatably mounted in bearing blocks **19** that rest on a foundation block **20**. Rotation of the cylindrical drying vessel upon the tires **12** and **13**, and upon the rollers **14** and **18**, is accomplished by means of an electric motor **21** that drives a pinion gear **22** through a speed reducing unit **23**, the pinion gear meshing with a large ring or girth gear **23** fixedly mounted upon and encompassing the cylindrical wall **11** of the vessel.

In the presently illustrated arrangement, wet materials to be dried in the cylindrical dryer are fed downwardly through a pipe **24** and into a casing **25**, the upper portion of which is hermetically sealed to the pipe **24** at a joint **26**. The forward end of the casing **25**, in turn, is hermetically joined at **27** to an intermediate casing **28** of generally cylindrical form, the forward end of which is rotatably and hermetically joined in any suitable well known manner to an end wall **29** of the drying vessel about a large axial opening therein. The intermediate casing **28** is supported independently of the dryer vessel upon upwardly extending struts **30** mounted upon a supporting block **31**, and the rear casing **25** may be similarly supported by a plurality of struts **32**. A helical feed screw **33** is provided in the casing **25** and extends forwardly therefrom through the hermetic joint **27** and through the lower portion of the casing **28**, into the interior of the dryer vessel through the previously mentioned axial opening provided in the wall **29** thereof. The feed screw **33** includes an axial shaft **34** having a pulley or sprocket **35** fixed upon an external end thereof that extends from a hermetic seal in the end wall **25***a* of the casing **25**, a belt or chain **36** being arranged to drive the pulley or sprocket **35**, and thus the screw **33**, by means of an electric motor **37** and a gear reducing unit **38**. Wet materials moving or dropping downwardly through the pipe **24** fall into the casing **25** where they are picked up by the feed screw **33** and carried forwardly through the lower portion of the intermediate casing **28** and into the interior of the drying vessel **10**.

The interior of the vessel **10** is lined with a plurality of longitudinally extending steam pipes **40** and **41**, as shown in Fig. 2, the larger of these pipes **40** being located next adjacent the shell **11** of the vessel. The longitudinal central portions of the pairs of steam pipes may be joined by longitudinally extending webs **42** and **43**, and the ends of the pipes adjacent the feed screw **33** are supported in any suitable fashion upon the inner side of the end wall **29** of the drying vessel, or upon the closure structure of which the wall **29** is a part. Preferably, the supporting relationship between the ends of the steam pipes and the wall **29** is such that the ends of the pipes may move or slide in an axial direction upon their supports with respect to the wall so as to accommodate any slight increase or decrease that may occur in the lengths of the pipes due to temperature changes therein.

The forward ends of the steam pipes **40** and **41** are open and are supportably mounted in an inner wall **44** of a circular steam manifold **45** that is welded or otherwise fixed in the forward end of the drier vessel to close the dried material exit end thereof. This manifold **45**, as perhaps best shown in Figs. 3 and 5, may be provided internally with three peripheral steam chambers **46** and a corresponding number of radial spokes **47**, as shown. Each of the spokes constitutes a radially extended web having its rear edge welded or otherwise joined to the rear wall **44** of the manifold **45** and its outermost edge similarly joined to the inner surface of the peripheral wall

48 of the manifold. The forward edge of each of the spokes 47 is welded to the inner surface of a drum-like forward wall 49 of the manifold 45 that is provided with a plurality of plugs 50 located opposite the ends of the steam pipes 40 and 41, as best shown in Fig. 3. The interior of the steam pipes, and the pipes themselves, are thus accessible through the three peripheral manifold chambers 46 upon removal of the plugs 50. The inner wall, radially speaking, of each of the chambers 46 of the steam manifold 45 comprises an arcuate shaped member 51, the forward and rear edges of which are respectively welded or otherwise joined at 52 (Fig. 3) to the forward and rear walls of the manifold. The opposite ends of each of the arcuate members 51 are respectively joined with radially extending walls 53 and 54 which are similarly welded to the forward and rearward walls of the manifold. Each wall 54, as best seen in Fig. 5, extends radially inwardly parallel to an adjacent spoke 47 but spaced therefrom to provide a steam passage 55 therebetween, the radial inner end of the wall 54 being joined to one end of an arcuate shaped wall 56. The opposite end of each wall 56 is joined to one of the walls 53, the latter of each of which extends radially inwardly beyond the arc of the wall 56, where it is joined by an element 57 to the innermost end of one of the spokes 47. As best seen in Fig. 5, each wall 53 is spaced from the adjacent spoke 47 so as to provide a condensate drain passage 58 therebetween. It will also be observed from Fig. 5 that the inner arcuate walls 56 are symmetrically located about the axis of the drying vessel 10 so that they define an inner steam chamber 59 that is joined to each of the three peripheral chambers 46 by the respective steam passages 55.

Steam is introduced into the inner steam chamber 59 of the manifold 45, and thus is supplied to the peripheral chambers 46 and to the steam pipes 40 and 41, by means of the novel steam neck and dried material discharge assembly about to be described. Furthermore, the condensate from the steam pipes and from the peripheral chambers 46 is drained through the condensate passages 58 to forwardly extending pipes 60 as the vessel is rotated in the direction shown by the arrow 61 in Fig. 5, the condensate being led through the pipes 60 and thence through the steam neck assembly and to the exterior thereof in a manner to be hereinafter described.

The inner wall 44 of the manifold 45 has an axial opening therein in which there is located an axially arranged, forwardly extending cylindrical sleeve 65 having an annular flange 66 formed or welded upon its inner end, this flange in turn being welded or otherwise hermetically secured to the inner surface of the manifold wall 44 about the opening. The sleeve 65, which rotates with the drying vessel, extends well forwardly of the steam manifold 45 and has an outwardly extending annular flange 67 welded or otherwise formed upon its forward end (see Fig. 3). This flange, in turn, has secured thereto, as by bolts 68, an overlapping annular flange 69 welded or formed upon an outer axially disposed sleeve 70 which extends rearwardly therefrom. An annular, built-up collar 71 is welded or otherwise formed about the rear or inner end of the outer sleeve 70 and this latter collar is secured, as by a plurality of bolts 72, to another collar 73 that is welded, or secured by extensions of the bolts 72, about an axial opening in the forward wall 49 of the steam manifold 45 at the forward end of the drying vessel. A further sleeve 74 is tightly fitted within the outer sleeve 70 adjacent its rear portion, with the rear end of the sleeve 74 abutting the forward face of the collar 73 and with the inner peripheral surface of the sleeve 74 being spaced from the outer peripheral surface of the previously mentioned sleeve 65 so as to provide a longitudinally extending, cylindrically shaped, steam passage 75 therebetween. The forward end of the sleeve 74 terminates well short of the forward ends of the sleeves 65 and 70 so as to provide a steam receiving area 75*a* therebetween that is connected to the steam passage 75, the inner end of the steam passage 75 being in open communication with the inner chamber 59 of the manifold 45 of the drier vessel, as best shown in Fig. 3.

A stationary cylindrical steam manifold, designated generally by the numeral 76 rotatably encompasses and rides upon the outer sleeve 70, with cylindrical bushings 77 therebetween, it being understood that the cylindrical sleeve assembly, comprising the sleeves 65, 70 and 74, rotates within the stationary manifold when the drier is rotated. Annular packing spaces are provided at opposite ends of the stationary manifold 76 for retaining packing elements or rings 78 held in place by packing glands 79 adjustably secured to the ends of the manifold as by bolts 80. The cylindrical interior surface of the manifold 76 is provided with an annular groove 81 which is in open communication with a steam neck 82 formed upon the upper side of the manifold 76 and joined to a steam pipe 83 that is connected to a suitable source of steam. The groove 81 is in constant communication with the steam receiving area 75*a* within the outer sleeve 70 by means of a plurality of circumferentially spaced openings 84 provided in the sleeve 70 opposite the groove 81. As the drying vessel and its steam manifold 45 are rotated, it will be observed that the two sleeves 65 and 70 of the steam neck assembly likewise rotate as a unit, the manifold 76 riding in a stationary manner upon the bushings 77 encompassing the sleeve 70. Thus, it will be understood that during the rotation of the drier vessel, steam is constantly admitted to the steam pipes 40 and 41 thereof through the steam neck 82 of the manifold 76 and into the annular groove 81 therein, and thence through the openings 84 in the sleeve 70 into the steam receiving area 75*a*, and from that area through the cylindrical steam passage 75 into the inner steam chamber 59 of the manifold 45 and thence through the steam passages 55 to the three peripheral steam chambers 46 of the manifold 45.

The condensate that forms in the steam pipes 40 and 41 constantly drains toward the peripheral steam chambers 46 in the manifold 45 due to the slope of the axis of the drying vessel. This condensate collects in the peripheral chambers and, as previously indicated, it is drained therefrom into the condensate passages 58 as the drying vessel is rotated. From the passages 58 the condensate enters the pipes 60 that extend through the collar 73 secured to the forward wall 49 of the manifold 45, which pipes are respectively connected, by interior passages 71*a* formed in the collar 71, to three longitudinally extending grooves 85 provided in the outer surface of the sleeve 74. As shown in Fig. 3, the underside of the stationary steam manifold 76 is provided with a condensate discharge neck 86 that communicates with an annular groove 87 formed in the inner cylindrical surface of the stationary manifold. This latter circular groove is in constant communication with the condensate passages 85 in the sleeve 74 through a plurality of circumferentially arranged openings 88 provided in the outer sleeve 70 opposite the outer ends of the passages 85. Thus, as the steam manifold 45 is rotated with the drying vessel, the condensate collected in each of the peripheral steam chambers 46 is drained downwardly through the respective condensate passages 58 as each passage is carried toward a vertical position. The condensate then passes through the pipes 60 into the condensate passage grooves 85 in the sleeve 74, in the direction shown by the arrows in Fig. 3, and thence through the openings 88 in the outer sleeve 70 into the annular groove 87 in the stationary steam manifold 76, and then through the drain neck 86 downwardly into a drain pipe 89 containing an ordinary steam trap 90 for preventing the steam pressure within the system from blowing out through the pipe 89.

A long, cylindrical bushing 91, of bronze or the like, is fitted within the sleeve 65, as shown in Fig. 3, and a stationary, fixed inner sleeve 92 is provided within the

bushing **91** so that the bushing, together with the sleeve **65** and its related parts, will rotate about the inner sleeve **92** when the drier vessel is rotated. The bushing **91** provides a hermetic seal between the inner sleeve **92** and the sleeve **65**, packing **93** being provided at the innermost and outermost ends of the bushing, if desired, with an adjustable packing gland **94** adjustably secured to the flange **66** by means of bolts **95** at the inner end of the bushing, and a similar packing gland **94***a* provided at the outer end of the bushing and adjustably secured to the annular flange **69** by means of bolts **95***a*.

The innermost end of the stationary inner sleeve **92** extends well into the interior of the drier vessel, a large opening **92***a* being provided in the upper wall of the inwardly projecting portion of the sleeve **92**. A hopper **96** is mounted upon the casing **92** about this opening and is adapted to receive dried materials that have reached the dried state during their progressive axial movement through the drying vessel. The tumbling of the material within the drying vessel greatly increases the speed with which the material is dried, so that when the material reaches the exit end of the vessel it is ready to be removed. This removal is accomplished, in the embodiment of the invention shown in Figs. 2 to 5, by tumbling the dried material into the hopper **96**, the material being carried upwardly into the hopper by the steam pipes **40** and **41** and the webs **42** and **43** located about the peripheral interior of the vessel, as shown in Fig. 2. With the vessel rotating, for example, in the direction shown in Fig. 2 by the arrow **61***a*, it will readily be understood that the dried material will be carried upwardly by the steam pipes and by the webs **42** and **43** at the left side of the view, dropping the material into the hopper as they reach their uppermost positions.

A helical feed screw, designated generally by the numeral **97**, is rotatably mounted within the inner sleeve **92** for receiving the dried material from the hopper **96** and propelling it forwardly through the inner sleeve **92** to the exterior of the drying vessel. This helical screw is provided with a hollow shaft **98** and with helical flights **99** having a diameter only slightly less than the inner diameter of the sleeve **92**, the inner end **100** of the shaft being rotatably supported in a bearing **101** mounted upon a rear wall **102** that closes the innermost end of the sleeve **92**. The forward end **103** of the shaft **98** extends forwardly well beyond the outermost end of the stationary sleeve **92** and is rotatably supported in a hermetically sealed bearing **104** formed on a wall **105** of an elbow **106** which may be bolted or otherwise secured to the forward extremity of the stationary sleeve **92**. This outer end of the shaft **98** has a sprocket **107** fixed thereto which may be driven by an electric motor **108** (Fig. 1) and by means of a chain **109** in order to turn the shaft independently of the rotation of the drying vessel. Rotation of the shaft **98** of the helical screw **97** causes the dried material introduced into the hopper **96** to be carried forwardly through the inner sleeve **92** and into the elbow **106**. During this forward propulsion of the dried material, the dried material itself completely fills, or tends completely to fill, the spaces between the flights **99** of the screw **97**, thus tending to seal the sleeve **92** against the passage of gas therethrough. More importantly, however, it will be observed that the sleeve **92** extends well forwardly of the outer end of the screw **97** so as to provide a longitudinally extending hollow space **92***b* therein which joins the hollow interior of the elbow **106**. This hollow space **92***b* and the interior of the elbow forms an intermediate receptacle for the dried material discharged by the screw into which the dried material is packed by the screw against the wall **105** of the elbow, thereby forming a plug of the material. This plug of material definitely seals the sleeve **92** against passage of gas out of the vessel when the pressure therein is greater than atmospheric pressure, and against passage of gas into the vessel when the pressure therein is less than atmospheric pressure.

As the dried material is pushed forwardly by the screw **97** into the elbow **106**, portions of the plug of material pass downwardly through a downwardly directed arm **110** of the elbow into the chamber of a large star valve **111** that is hermetically secured to the underside of the elbow **106** in the manner shown in Fig. 3, the star valve having a rotatable valve member therein that is shown schematically at **112**. Star valves of this type are well known and the details thereof need not be given here, it being sufficient to say that the rotatable valve member **112** of the valve prevents the passage of gases therethrough. Intermittent or continuous slow rotation of the valve member is made in the present instance at regular intervals in order to dump the dried material that has collected in the star valve and in the lower leg **110** in the elbow **106**, the dried material being dumped from the valve into a conduit **113**, the interior of which may be at atmospheric pressure. This conduit, or its equivalent, transports the dried material away from the vicinity of the drier vessel.

Use of the star valve **111** in the manner described above is not necessarily required in those instances where the dried material is of a fine nature such that it packs easily and completely fills the spaces between the flights **99** of the helical discharge screw **97** within the stationary inner sleeve **92** or forms a tight plug of material in the space **92***b* at the outer end of the sleeve **92** and in the elbow **106**. The presence of material of this character within the screw and that forming the plug will adequately seal the drying vessel and prevent the passage of gases into or out of the same through the sleeve **92**, particularly when the pressure to be maintained within the drying vessel does not differ greatly positively or negatively from atmospheric pressure. However, when the dried material is of a more granular character, or of a character that does not pack closely between the flights **99** of the screw **97** or does not tend to form a tight plug, and particularly when the differential between atmospheric pressure and the pressure to be maintained within the vessel is great, the star valve **111** may be employed in the manner shown in Fig. 3 and described above, so as to help insure against the passage of gases into or out of the drying vessel through the inner sleeve **92**.

As previously stated, the shaft **98** of the helical screw **97** is hollow. The hollow interior of the shaft forms a passage **98***a* which extends throughout the length of the shaft and provides a conduit through which gases may be introduced into the dryer vessel through the open inner end of the shaft when the drying operation is to take place in a special atmosphere or when the material in the vessel is to be reacted with a special atmosphere. Similarly gases from within the vessel may be removed therefrom through the hollow shaft, if desired. The outer end of the shaft extends beyond the sprocket **107** and has a fluid joint **150** rotatably and hermetically secured thereon in any suitable fashion such that the shaft rotates within the joint and gases may be introduced from the joint through the inner passage **98***a* in the shaft and into the interior of the vessel, or gases may be withdrawn from the vessel through the passage **98***a* and the joint without leakage at the outer end of the shaft. The joint **150** may be in communication with a pipe **151** having a valve **152** therein to control the flow of gas through the passage **98***a* in the shaft **98**.

From the foregoing description it will be appreciated that the combination fluid joint and processed material discharge assembly of the present invention provides a means not only for continuously introducing steam into the steam pipes or heat exchange coils of the rotating processing vessel and for continuously draining condensate therefrom, but it also provides means for hermetically sealing the discharge end of the vessel and for

removing processed material therefrom in an axial forwardly directed path. This characteristic of the present invention renders the vessel ideally suitable for use in substantially any commercial drying or reacting operation, including those first mentioned above, wherein the interior of the vessel must be maintained at a substantially constant pressure that is either greater or less than atmospheric pressure. The mechanism, as suggested in the early part of this specification, also renders the vessel useful in processes that require drying or heating to take place in special atmospheres, such as in atmospheres of carbon dioxide or hydrogen, and it also renders the vessel readily useable in processes in which gaseous products must be recovered. For example, it has previously been mentioned that it is of commercial importance in the Solvay process to recover the carbon dioxide that is produced during the formation of the dried "soda ash," the latter of which, in the present instance, is removed from the drying vessel by the helical screw **97**. The carbon dioxide, in turn, may be recovered and removed from the drying vessel through the passage **98***a* in the screw shaft **98** or through the intermediate casing **28** and through a conduit **114** joined thereto, the interior of the drying vessel at all times being maintained in a pressurized condition when the wet products are introduced to the vessel through the pipe **24** under pressure and when the gases to be recovered are similarly removed under pressure through the pipe **114**.

Again, while the vessel **10** has been hereinbefore referred to as a drying vessel, it will be appreciated that it may be used in many applications other than drying. It may be employed as a reaction vessel in which various types of reactions may be commercially carried out, the above mentioned reaction of the Solvay process being only one of these reactions. The reactions may be either endothermic, in which case steam or other hot fluids may be introduced into the heat exchange pipes **40** and **41** through the stationary steam manifold **76**, as described above, or they may be exothermic, in which case cold water may be introduced into the system of pipes **40** and **41** through the steam neck **83** of the stationary manifold **76**. In the latter case, the condensate drain pipe **89** will be closed by a suitable valve and the warm water from the pipes **40** and **41** will be discharged therefrom at their rear ends through suitable passages through the end wall **29** of the vessel and into a trough or any suitable device for catching the water, it being understood, of course, that the water discharge passages through the wall **29** must not interfere with the hermetic nature of the closure for the vessel provided by that wall or the closure of which it is a part. Furthermore, the reactions carried out in the vessel may be made under pressure or under a vacuum or in special gaseous atmospheres which may be replenished as required through the fluid joint **150** and through the passage **98***a* in the hollow shaft **98**.

A modification of a portion of the structure of Figs. 1 to 5 is shown in Figs. 6 and 7 where, among other things, the vessel **10** is provided with a plurality of heat exchange pipes **120**, **121** and **122** arranged in groups of three, rather than in groups of two as previously described. The forward ends of these pipes, like those discussed earlier, pass through the rear wall **44** of the manifold **45** that is hermetically secured to the forward end of the cylindrical wall **11** of the vessel, and those pipes are adapted to receive steam or other heat exchange fluid from the chambers **46** of the manifold in the same manner as in the embodiment described hereinbefore. The central portion of the inner wall **44** of the manifold **45**, however, is recessed in the modification, as at **123**, to receive an annular flange **124** that is welded or otherwise fixed about the periphery of a sleeve **125** that corresponds in every respect to the sleeve **65** of the previously described structure except that the wall of the sleeve **125**, in the present instance, is shown to be thicker than the corresponding sleeve **65**, and the flange **66** is secured to the sleeve **65** at the extreme inner end thereof, whereas the innermost end of the sleeve **125** extends inwardly from the corresponding flange **124** in the modification and terminates in the plane of the inner surface of the inner wall **44** of the manifold **45**. The flange **124**, similarly to the corresponding flange **66** in Fig. 3, is welded or otherwise secured to the recessed portion **123***a* of the wall **44** about an axial opening provided therein for the sleeve **125**. The wall **44** of the manifold **45**, in the modification, has a spiral cage structure secured thereto, as by bolts **126**, so that the cage structure will rotate with the drying vessel **10**. This cage structure comprises an inner circular head or drum **127** and a corresponding outer drum or head **128**, the latter of which lies flush against the inner surface of the wall **44** of the steam manifold **45** and is secured thereto by the previously mentioned bolts **126**. The diameter of the heads **127** and **128** is somewhat less than the diametric distance between the oppositely disposed steam pipes **122**, as shown in Fig. 6. The head **127** is supported by and joined to the head **128** by a plurality of involuted sheet metal scoops **129**, each of which has an outermost portion **130** (Fig. 7) which may be welded or otherwise secured to the interior of the cylindrical wall **111** of the vessel and which extends radially inwardly therefrom to a position inside the innermost pipes of the adjacent clusters of pipes **120**, **121** and **122**. From this point, each of the scoops involutes about the axis of rotation of the vessel and radially inwardly along a progressively sharper curved path, the innermost ends of each of the scoops **129** terminating immediately adjacent the periphery of the flights of the inner end portion of a helical feed screw **131** having an axis of rotation coincident with the axis of rotation of the vessel and coincident with the center of curvature of the scoops **129**. As shown in Fig. 6, this feed screw comprises a hollow shaft **132** having a rear end portion **133** that is rotatably supported in a bearing **134** fixed by bolts **135** upon the rear face of the rear drum **127**, the innermost end of the shaft **132** being provided with a collar **136** that is secured thereto by a set screw **137** so as to prevent axial, longitudinal movement of the shaft **132** in a forward direction. The shaft **132** of the helical screw extends completely through the sleeve **125** (which in this instance rotates with the drier vessel) and may be suitably journalled forwardly of the forward end of the sleeve **125** in, for example, an elbow like the elbow **106** shown in Fig. 3 which may be joined to the forward end of the sleeve **125** in any suitable manner permitting rotation of the sleeve with the drying vessel and with respect to the elbow. The shaft **132** also is provided with a drive sprocket, similar to the previously mentioned sprocket **107**, by means of which the shaft **132** may be rotated independently of the rotation of the drying vessel, and the shaft has a passage **132***a* therethrough that opens at its inner end into the interior of the vessel **10** and communicates at its forward end with the fluid joint **150** in the same manner as that described above with respect to the inner passage **98***a* of the shaft **98**. The inner end portion of the shaft **132** is provided with a double set of helical flights **138** and **139** within the area defined by the innermost ends of the scoops **129**. The flight **139**, however, terminates at **139***a* just inside the inner end portion of the sleeve **126**. The flight **138**, on the other hand, merges with a single flight **140** that extends in a helical fashion forwardly through the sleeve **125**, the flights **140** having a lesser pitch than the flights **138** and **139**.

It will be observed that the construction of the modified form of the present invention, shown in Figs. 6 and 7 and just described, is such that as the drying vessel **10** is rotated in the direction shown by the arrow **141** in Fig. 7, the radially extending portions **130** and the outer portions of the curved parts of the scoops **129** will progressively pick up the dried material so as to carry it upwardly along the right hand side of the interior of the vessel, as viewed in Fig. 7. As the scoops

129 are raised, the dried material collected therein slides downwardly along the surfaces of the involuted portions of the scoops and into the spaces between the double flights 138 and 139 of the helical screw 131, this radial inward movement of the dried material on the scoops being assisted by the fact that the curvature of the scoops is in a direction opposite the direction of rotation of the vessel and of the scoops themselves. The double flights of the screw pick up the material thus deposited therebetween and propel it forwardly into the sleeve 125 where the material is packed as it is received by the flight 140 of the lesser pitch. The flight 140 of the helical screw thereupon carries the dried material forwardly through the sleeve 125 to discharge the material into the forward end of the sleeve, which may have an open space therein like the space 92*b* in the sleeve 92, and into the elbow 106 or its equivalent where the material packs to form a plug and progressively drops to the star valve 111, as previously described. Due to the fact that the double flights 138 and 139 pack the dried material into the flights 140 of the feed screw 131, this material along with the plug formed at the forward end of the sleeve 125 and in the elbow 106, serves to seal the interior of the sleeve 125 against passage of gas into or out of the drying vessel through the sleeve. Thus, the modified form of the present invention, like the form thereof first described above, permits the interior of the vessel to be maintained at any pressure desired commensurate with the needs of the particular drying operation or reaction process being carried out. At the same time, the modified form of the invention, like the form shown in Figs. 2 to 5, provides for continuous axial discharge of the dried or treated material while permitting heating or cooling fluid to be introduced into the heat exchange pipes as the vessel is being rotated.

While the modification of the invention shown in Figs. 6 and 7 appears, at first glance, to be greatly different from that shown in Figs. 2 and 3, it must be remembered that the modification involves only changes in certain parts of the mechanism of Fig. 3. These changes reside primarily in the employment of the novel scoop cage mechanism for introducing the processed material to the discharge screw, rather than the use of the hopper 96 for that purpose; the use of double flights on the inner end of the screw, one of which is interrupted within the sleeve 125 and the other of which merges with a single flight 140 of lesser pitch than the double flights; and the elimination of the stationary inner sleeve 92 and the bushing 91 of Fig. 3, so that the discharge screw rotates directly within, and is in close fitting contact with, the sleeve 125, which is merely a modified form of the sleeve 65 of Figs. 3, 4 and 5. It will thus be understood that all of the several sleeves and parts that encompass the sleeve 65 in Figs. 3 to 5, likewise encompass the sleeve 125 exteriorly of the drier vessel, that particular portion of the structure being the same in both forms of the invention. Thus, in the embodiment of the invention shown in Figs. 3 to 5 the several sleeves 65, 70, 74 and 92 comprise a compound sleeve unit hermetically sealed in the end of the drier vessel containing a helical discharge screw, whereas in the embodiment shown in Figs. 6 and 7 the sleeves 125, 70 and 74 comprise a corresponding compound sleeve unit. Furthermore, viewed in a slightly different way, it will be observed that in the form of the invention illustrated in Figs. 2 to 5, the sleeves 65, 70 and 74 comprise a compound sleeve unit that rotates with the drier vessel around the stationary inner sleeve 92 that contains the helical discharge screw.

The foregoing description of both forms of the invention have been given for clearness of understanding only, and no unnecessary limitations are intended thereby, for it will be apparent to those skilled in the art that numerous variations may be made in the invention without departing from the spirit and scope of the appended claims.

I claim:

1. In combination with an elongated hermetically sealed vessel for processing material and having a processed material discharge end provided with an end wall, said vessel being mounted for rotation about the longitudinal axis thereof and having a heat exchange conduit therein adapted to be contacted by material being processed therein; a fluid joint and processed material discharge assembly comprising a cylindrical longitudinally extending sleeve unit mounted in an opening in said end wall and with the axis of said sleeve unit coinciding with the axis of rotation of said vessel, said sleeve unit including a rotatable part hermetically sealed to said end wall and a cooperating stationary part hermetically sealed to said rotatable part, a helical conveyor screw extending axially in said sleeve unit and mounted for rotation therein, the diameter of the flights of said screw being only slightly less than the inner diameter of said sleeve unit so as to provide a relatively close fit therebetween, the length of said screw being such that its inner end is exposed to the interior of said vessel and its outer end is located exteriorly thereof, a manifold encompassing and riding upon a portion of said sleeve unit exteriorly of said vessel, said manifold and said sleeve unit having interconnected passages therein communicating with said heat exchange conduit in said vessel for conducting heat exchange fluid to said conduit, means within the interior of said vessel for feeding the processed material to the inner end of said screw during rotation of said vessel, and means for rotating said screw independently of the rotation of said vessel to carry the processed material in an axial discharging direction through said sleeve unit and to the exterior of said vessel during the rotation of said vessel.

2. In combination with an elongated hermetically sealed vessel for processing material and having a processed material discharge end provided with an end wall, said vessel being mounted for rotation about the longitudinal axis thereof and having heat exchange coils therein adapted to be contacted by material being processed therein; a fluid joint and processed material discharge assembly comprising a cylindrical longitudinally extending sleeve unit mounted in an opening in said end wall and with the axis of said sleeve unit coinciding with the axis of rotation of said vessel, said sleeve unit including a rotatable part hermetically sealed to said end wall and a cooperating stationary part hermetically sealed to said rotatable part, a helical conveyor screw extending axially in said sleeve unit and mounted for rotation therein, said screw and said sleeve unit being constructed and arranged in a manner such that the inner end of said screw is exposed to the interior of said vessel and the outer end of said screw terminates within said sleeve unit short of the outer end thereof, thereby providing a longitudinally extending space within said sleeve unit in the outer end portion thereof unoccupied by said screw, a fluid manifold encompassing and riding upon the exterior of said sleeve unit exteriorly of said vessel, said manifold and said sleeve unit having internal interconnected passages therein in communication with said heat exchange coils of said vessel for conducting heat exchange fluid thereto during the rotation of said vessel, means within the interior of said vessel for feeding the processed material to the inner end of said screw during said rotation of said vessel, means for rotating said screw independently of the rotation of said vessel progressively to carry processed material forwardly in said sleeve unit and into said space in the outer end portion of said sleeve unit, means cooperating with said screw for constantly maintaining said outer end portion of said sleeve unit completely filled with the processed material to plug said sleeve unit and prevent the passage of gases therethrough

into or out of said vessel, said sleeve unit having an opening in said outer end portion thereof through which plugging processed material is progressively discharged.

3. The combination set forth in claim 2, wherein said means cooperating with said screw for constantly maintaining said outer end portion of said sleeve unit completely filled with processed material includes a wall for retarding the movement of processed material in an axial direction in said outer end portion of said sleeve unit.

4. In combination with an elongated hermetically sealed vessel for processing material and having a processed material discharge end provided with an end wall, said vessel being mounted for rotation about the longitudinal axis thereof and having heat exchange coils therein adapted to be contacted by material being processed therein; a fluid joint and processed material discharge assembly comprising a cylindrical longitudinally extending sleeve unit mounted in an opening in said end wall and with the axis of said sleeve unit coinciding with the axis of rotation of said vessel, said sleeve unit including a rotatable part hermetically sealed to said end wall and a cooperating stationary part hermetically sealed to said rotatable part, a helical conveyor screw extending axially in said sleeve unit and mounted for rotation therein, said screw and said sleeve unit being constructed and arranged in a manner such that the inner end of said screw is exposed to the interior of said vessel and the outer end of said screw terminates within said sleeve unit short of the outer end thereof, thereby providing a longgitudinally extending space within said sleeve unit in the outer end portion thereof unoccupied by said screw, a fluid manifold encompassing and riding upon the exterior of said sleeve unit exteriorly of said vessel, said manifold and said sleeve unit having internal interconnected passages therein in communication with said heat exchange coils of said vessel for conducting heat exchange fluid thereto during the rotation of said vessel, means within the interior of said vessel for feeding processed material to the inner end of said screw during rotation of said vessel, means for rotating said screw independently of the rotation of said vessel progressively to carry processed material forwardly in said sleeve unit and into said space in the outer end portion of said sleeve unit, said outer end portion of said sleeve unit having an opening through which processed material is progressively discharged therefrom, and means for constantly maintaining said outer end portion of said sleeve unit completely filled with processed material to plug said sleeve unit and thereby prevent the passage of gases therethrough into and out of said vessel.

5. The combination set forth in claim 4, wherein said last mentioned means includes means for limiting the free movement of processed material through said outer end portion of said sleeve unit.

6. In combination with an elongated hermetically sealed vessel for processing material and having a processed material discharge end provided with an end wall, said vessel being mounted for rotation about the longitudinal axis thereof and having heat exchange coils therein adapted to be contacted by material being processed therein; a fluid joint and processed material discharge assembly comprising a cylindrical longitudinally extending sleeve unit mounted in an opening in said end wall and with the axis of said sleeve unit coinciding with the axis of rotation of said vessel, said sleeve unit including a rotatable part hermetically sealed to said end wall and a cooperating stationary part hermetically sealed to said rotatable part, a helical conveyor screw extending axially in said sleeve unit and mounted for rotation therein, said screw and said sleeve unit being so constructed and arranged that the inner end of said screw is exposed to the interior of said vessel, a fluid manifold encompassing and riding upon the exterior of said sleeve unit exteriorly of said vessel, said manifold and said sleeve unit having internal interconnected passages therein in communication with said heat exchange coils of said vessel for conducting heat exchange fluid thereto during the rotation of said vessel, means within the interior of said vessel for feeding processed material to the inner end of said screw during said rotation of said vessel, means for rotating said screw independently of the rotation of said vessel progressively to carry processed material forwardly in said sleeve unit in a discharge direction, and means cooperating with said screw for constantly maintaining a plug of processed material in said sleeve unit to prevent the passage of gases through said sleeve unit and past the flights of said screw into or out of said vessel.

7. The combination set forth in claim 6, wherein said screw includes a shaft having a passage therethrough, and valve means at the outer end of said shaft for selectively opening and closing said passage.

8. In combination with an elongated hermetically sealed vessel for processing material and having a processed material discharge end provided with an end wall, said vessel being mounted for rotation about the longitudinal axis thereof and having heat exchange coils therein adapted to be contacted by material being processed therein; a fluid joint and processed material discharge assembly comprising a cylindrical longitudinally extending sleeve unit mounted in an opening in said end wall and with the axis of said sleeve unit coinciding with the axis of rotation of said vessel, said sleeve unit including a rotatatable part hermetically sealed to said end wall and a cooperating stationary part hermetically sealed to said rotatable part, a helical conveyor screw extending axially in said sleeve unit and mounted for rotation therein, said screw of said sleeve unit being so constructed and arranged that the inner end of said screw is exposed to the interior of said vessel, a fluid manifold encompassing and riding upon the exterior of said sleeve unit exteriorly of said vessel, said manifold and said sleeve unit having internal interconnected passages therein in communication with said heat exchange coils of said vessel for conducting heat exchange fluid thereto during the rotation of said vessel, means within the interior of said vessel for feeding processed material to the inner end of said screw during said rotation of said vessel, a processed material receiving conduit in gas-tight communication with the outer end of said sleeve unit, means for rotating said screw independently of the rotation of said vessel progressively to carry processed material forwardly in said sleeve unit and into said conduit, and substantially gas-tight valve means in said conduit for progressively expelling processed material therefrom and for preventing the flow of gases into and out of said vessel through said sleeve unit and said conduit.

9. In combination with an elongated hermetically sealed vessel for processing material and having a processed material discharge end provided with an end wall, said vessel being mounted for rotation about the longitudinal axis thereof and having a heat exchange conduit therein adapted to be contacted by material being processed therein; a fluid joint and processed material discharge assembly comprising a cylindrical longitudinally extending sleeve unit mounted in an opening in said end wall and with the axis of said sleeve unit coinciding with the axis of rotation of said vessel, said sleeve unit including a rotatable part hermetically sealed to said end wall and a cooperating stationary part hermetically sealed to said rotatable part, a helical conveyor screw extending axially through said sleeve unit and mounted for rotation therein, the diameter of the flights of said screw being only slightly less than the inner diameter of said sleeve unit so as to provide a relatively close fit therebetween, the length of said screw being such that its inner end is exposed to the interior of said vessel and its outer end is located exteriorly thereof, a manifold encompassing and riding upon a portion of said sleeve unit exteriorly of said vessel, said manifold having steam and condensate

passages therethrough connected with said heat exchange conduit in said vessel for directing steam into said conduit and for draining condensate therefrom, means within the interior of said vessel for feeding processed material to the inner end of said screw during rotation of said vessel, and means for rotating said screw independently of the rotation of said vessel to carry processed materials in an axial direction through said sleeve unit and to the exterior of said vessel during rotation of the vessel, the presence of processed material between the flights of said conveyor screw in said sleeve unit tending to prevent the flow of gases into or out of said vessel through said sleeve unit.

10. In a rotatable cylindrical processing vessel of the continuous type having heat exchange coils therein and having means for continuously introducing into one end of said vessel material that is to be progressively treated therein and progressively removed from the other end of said vessel, an assembly for introducing heat exchange fluid to said coils and for continuously removing treated material from said vessel comprising a cylindrical axially extending sleeve unit mounted in an opening in the end wall of said vessel at the treated material discharge end thereof and with the axis of said sleeve unit coinciding with the axis of rotation of said vessel, said sleeve unit including a rotatable part hermetically sealed to the adjacent end wall of said vessel and a cooperating stationary part hermetically sealed to said rotatable part, a helical conveyor screw extending axially through said sleeve unit and mounted for rotation therein, the diameter of the flights of said screw being only slightly less than the inner diameter of said sleeve unit so as to provide a relatively close fit therebetween, the length of said screw being such that its inner end is exposed to the interior of said vessel and its outer end is located exteriorly thereof, a manifold encompassing and riding upon a portion of said sleeve unit exteriorly of said vessel, said manifold and said sleeve unit having interconnected passages therein in communication with said heat exchange coils for circulating heat exchange fluid through said coils, means within the interior of said vessel for progressively feeding treated material into direct contact with the inner end of said screw during rotation of said vessel, and means for rotating said screw independently of the rotation of said vessel to carry treated material in an axial discharging direction through said sleeve unit and to the exterior of said vessel during the rotation of said vessel.

11. In a rotatable cylindrical processing vessel of the continuous type having heat exchange coils therein and having means for continuously introducing into one end of said vessel material that is to be progressively treated therein and progressively removed from the other end of said vessel, an assembly for introducing heat exchange fluid to said coils and for continuously removing the treated material from said vessel during the rotation thereof comprising a cylindrical sleeve unit mounted in an opening in the end wall of said vessel at its discharge end and with the axis of said sleeve unit coinciding with the axis of rotation of said vessel, said sleeve unit including a rotatable part hermetically sealed to the adjacent end wall of said vessel and a cooperating stationary part hermetically sealed to said rotatable part, a conveyor screw extending axially through said sleeve unit and mounted for rotation therein, the length of said screw being such that its inner end is exposed to the interior of said vessel and its outer end is located exteriorly of said vessel, a manifold encompassing and riding upon a portion of said sleeve unit exteriorly of said vessel, said manifold having passages therethrough connected to said heat exchange coils for circulating heat exchange fluid through said coils, means within the interior of said vessel for progressively feeding treated material into direct contact with the inner end of said screw during rotation of said vessel, and means for rotating said screw independently of the rotation of said vessel to carry treated material in an axial discharging direction through said sleeve unit and to the exterior of said vessel during the rotation of said vessel.

12. The combination set forth in claim 11, wherein said means for feeding treated material into contact with the inner end of said screw includes a hopper disposed within said vessel and supported upon the inner end of said sleeve unit.

13. In combination with an elongated hermetically sealed vessel for processing material and having a processed material discharge end provided with an end wall, said vessel being mounted for rotation about the longitudinal axis thereof and having a heat exchange conduit therein adapted to be contacted by material being processed therein; a fluid joint and processed material discharge assembly comprising a cylindrical longitudinally extending sleeve unit mounted in an opening in said end wall and with the axis of said sleeve unit coinciding with the axis of rotation of said vessel, said sleeve unit including a rotatable part hermetically sealed to said end wall and a cooperating stationary part hermetically sealed to said rotatable part, a helical conveyor screw extending axially through said sleeve unit and mounted for rotation therein, the diameter of said screw being only slightly less than the inner diameter of said sleeve unit so as to provide a relatively close fit therebetween, the length of said screw being such that its inner end portion extends well into the interior of said vessel and its outer end is located exteriorly thereof, the flights on the inner end portion of said screw having a greater pitch than the flights on the remainder of said screw, a manifold encompassing and riding upon a portion of said sleeve unit exteriorly of said vessel, said manifold having fluid passages therethrough connected with said heat exchange conduit in said vessel for directing heat exchange fluid into said conduit and for draining the same therefrom, means within the interior of said vessel for feeding processed material to the inner end portion of said screw, and means for rotating said screw independently of the rotation of said vessel to carry processed material in an axial direction through said sleeve unit and to the exterior of said vessel during rotation of said vessel, the flights on the inner end portion of said screw tending to cause processed material to be packed between the flights on the remaining portion of said screw so as to prevent the flow of gases into or out of said vessel through said sleeve unit.

14. In combination with an elongated hermetically sealed vessel for processing material and having a processed material discharge end provided with an end wall, said vessel being mounted for rotation about the longitudinal axis thereof; a processed material discharge assembly comprising a cylindrical longitudinally extending sleeve unit mounted in an opening in said end wall and with the axis of said sleeve unit coinciding with the axis of rotation of said vessel; said sleeve unit including a rotatable part hermetically sealed to said end wall and a cooperating stationary part hermetically sealed to said rotatable part, a helical conveyor screw extending axially through said sleeve unit and mounted for rotation therein, the diameter of said screw being only slightly less than the inner diameter of said sleeve unit so as to provide a relatively close fit therebetween, the length of said screw being such that its inner end portion extends well into the interior of said vessel and its outer end is located exteriorly thereof, the flights on the inner end portion of said screw having a greater pitch than the flights on the remainder of said screw, means within the interior of said vessel for feeding the processed material to the inner end portion of said screw, and means for rotating said screw independently of the rotation of said vessel to carry processed material in an axial direction through said sleeve unit and to the exterior of said vessel during rotation of said vessel, the flights on the inner end portion of said screw tending to cause processed material

to be packed between the flights on the remaining portion of said screw so as to prevent the flow of gases into or out of said vessel through said sleeve unit.

15. In combination with an elongated hermetically sealed vessel for processing material and having a processed material discharge end provided with an end wall, said vessel being mounted for rotation about the longitudinal axis thereof; a processed material discharge assembly comprising a cylindrical longitudinally extending sleeve unit mounted in an opening in said end wall and with the axis of said sleeve unit coinciding with the axis of rotation of said vessel; said sleeve unit including a rotatable part hermetically sealed to said end wall and a cooperating stationary part hermetically sealed to said rotatable part, a helical conveyor screw extending axially through said sleeve unit and mounted for rotation therein, the diameter of said screw being only slightly less than the inner diameter of said sleeve unit so as to provide a relatively close fit therebetween, the length of said screw being such that its inner end portion extends well into the interior of said vessel and its outer end is located exteriorly thereof, the flights on the inner end portion of said screw having a greater pitch than the flights on the remainder of said screw, a material receiving conduit in gas-tight communication with the outer end of said sleeve unit, means within the interior of said vessel for feeding processed material to the inner end portion of said screw, means for rotating said screw independently of the rotation of said vessel to carry processed material outwardly through said sleeve unit and into said material receiving conduit, the flights on the inner end portion of said screw tending to cause processed material to be packed between the flights on the remaining portion of said screw so as to prevent the flow of gases into or out of said vessel through said sleeve unit, and substantially gas-tight valve means in said material receiving conduit for progressively effecting the discharge of processed material from said material receiving conduit and cooperating with packed processed material in said sleeve unit further to prevent the flow of gases into or out of said vessel through said sleeve unit.

16. In combination with an elongated hermetically sealed vessel for processing material and having a processed material discharge end provided with an end wall, said vessel being mounted for rotation about the longitudinal axis thereof and having a heat exchange conduit therein adapted to be contacted by material being processed therein; a fluid joint and processed material discharge assembly comprising a cylindrical longitudinally extending sleeve unit mounted in an opening in said end wall and with the axis of said sleeve unit coinciding with the axis of rotation of said vessel, said sleeve unit including a rotatable part hermetically sealed to said end wall and a cooperating stationary part hermetically sealed to said rotatable part, in a helical conveyor screw extending axially through said sleeve unit and mounted for rotation therein, the diameter of said screw being only slightly less than the inner diameter of said sleeve unit so as to provide a relatively close fit therebetween, the length of said screw being such that its inner end portion extends well into the interior of said vessel and its outer end is located exteriorly thereof, a manifold encompassing and riding upon a portion of said sleeve unit exteriorly of said vessel, said manifold having fluid passages therethrough connected with said heat exchange conduit in said vessel for directing heat exchange fluid into said conduit, means including a plurality of involuted members fixed to the interior of said vessel radially opposite said inner end portion of said screw for feeding processed material thereto during rotation of said vessel, each of said members terminating at its inner radial end immediately adjacent to the periphery of said inner end portion of said screw, and means for rotating said screw independently of the rotation of said vessel to carry processed material in an axial discharging direction through said sleeve unit and to the exterior of said vessel during the rotation of said vessel.

17. In combination with an elongated hermetically sealed vessel for processing material and having a processed material discharge end provided with an end wall, said vessel being mounted for rotation about the longitudinal axis thereof; a processed material discharge assembly comprising a cylindrical longitudinally extending sleeve unit mounted in an opening in said end wall and with the axis of said sleeve unit coinciding with the axis of rotation of said vessel, said sleeve unit including a rotatable part hermetically sealed to said end wall and a cooperating stationary part hermetically sealed to said rotatable part, a helical conveyor screw extending axially through said sleeve unit and mounted for rotation therein, the length of said screw being such that its inner end portion extends well into the interior of said vessel and its outer end is located exteriorly of the vessel, means including a plurality of involuted members fixed to the interior of said vessel radially opposite said inner end portion of said screw for feeding processed material thereto during rotation of said vessel, each of said members terminating at its inner radial end immediately adjacent to the periphery of said inner end portion of said screw, and means for rotating said screw independently of the rotation of said vessel to carry processed material in an axial discharging direction through said sleeve unit and to the exterior of said vessel during the rotation of said vessel.

18. The combination set forth in claim 17, wherein said members are arranged symmetrically about said inner end portion of said screw and the radius of curvature of each of said members decreases progressively toward its inner radial end.

19. The combination set forth in claim 18, wherein each of said members is involuted about said inner end portion of said screw.

20. The combination set forth in claim 18, wherein each of said members is curved toward its inner radial end in a direction generally opposite the direction of rotation of said vessel.

21. The combination set forth in claim 17, wherein the pitch of the flights on said inner end portion of said screw is greater than the pitch of the flights on the remaining portion of said screw, thereby tending to cause processed material to be packed between the latter of the flights to prevent passage of gases into or out of said vessel through the spaces between the flights.

22. In a substantially hermetically sealed material processing vessel mounted for rotation about a generally horizontal axis and having heat exchange coils therein adapted to be contacted by material being processed therein, which material is adapted to be removed from said vessel in a processed condition through an axial opening in a wall of said vessel at one end thereof, a fluid joint and processed material discharge assembly comprising an outwardly axially extending first sleeve hermetically and fixedly joined at its inner end to said wall about said opening so as to rotate with said vessel, a stationary second sleeve extending axially through said first sleeve and through said opening into the interior of said vessel, means for preventing the escape of gases from said vessel between the inner surface of said rotatable first sleeve and the outer surface of said stationary second sleeve, a helical conveyor screw extending axially in said stationary second sleeve and mounted for rotation therein, the diameter of the flights of said screw being only slightly less than the inner diameter of said second sleeve so as to provide a relatively close fit therebetween, a stationary fluid manifold encompassing and riding upon said first sleeve exteriorly of said vessel, said first sleeve having fluid passages therethrough interconnecting said manifold and said heat exchange coils for directing heat exchange fluid into said coils and for draining the same therefrom, means within the interior of said vessel for

feeding processed material to the inner end of said screw during rotation of said vessel, and means for rotating said screw independently of the rotation of said vessel to carry processed material in an axial direction through said stationary second sleeve and to the exterior of said vessel during rotation of the vessel.

23. The combination set forth in claim 22, wherein said means for feeding processed material to the inner end of said screw includes a hopper disposed within said vessel and supported upon the inner end of said stationary second sleeve.

24. The combination set forth in claim 22, and further including a material receiving conduit in gas-tight communication with the outer end of said stationary second sleeve, and substantially gas-tight valve means in said material receiving conduit for permitting processed material to pass therethrough and for preventing substantial amounts of gas to pass from or pass into said vessel through said conduit and said stationary second sleeve.

25. In a substantially hermetically sealed material processing vessel mounted for rotation about a generally horizontal axis and having heat exchange coils therein adapted to be contacted by material being processed therein, which material is adapted to be removed from said vessel in a processed condition through an axial opening in a wall of said vessel at one end thereof, a fluid joint and processed material discharge assembly comprising an outwardly extending sleeve hermetically and fixedly joined at its inner end to said wall about said opening so as to rotate with said vessel, a helical conveyor screw extending axially through said sleeve and mounted for rotation therein, the diameter of the flights of said screw being only slightly less than the inner diameter of said sleeve so as to provide a relatively close fit therebetween, the length of said screw being such that its inner end

portion extends well into the interior of said vessel, a stationary fluid manifold encompassing and riding upon said sleeve exteriorly of said vessel and hermetically sealed to said sleeve, said sleeve having fluid passages therethrough interconnecting said manifold and said heat exchange coils for directing heat exchange fluid into said coils and for draining the same therefrom, means within the interior of said vessel for feeding processed material to said inner end portion of said screw during rotation of said vessel and said sleeve, and means for rotating said screw independently of the rotation of said vessel and said sleeve to carry processed material in an axial direction through said sleeve and to the exterior of said vessel.

26. The combination set forth in claim 25, wherein the flights of said conveyor screw on said inner end portion thereof are of a greater pitch than the flights on the remainder of said screw, thereby tending to pack processed material between the latter of the flights to prevent the passage of gas into or out of said vessel along said screw.

27. The combination set forth in claim 25, wherein said means for feeding processed material to said inner end portion of said screw includes a plurality of involuted members fixed to the interior of said vessel radially opposite said end portion of said screw, each of said members terminating at its inner radial end immediately adjacent the periphery of said screw.

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