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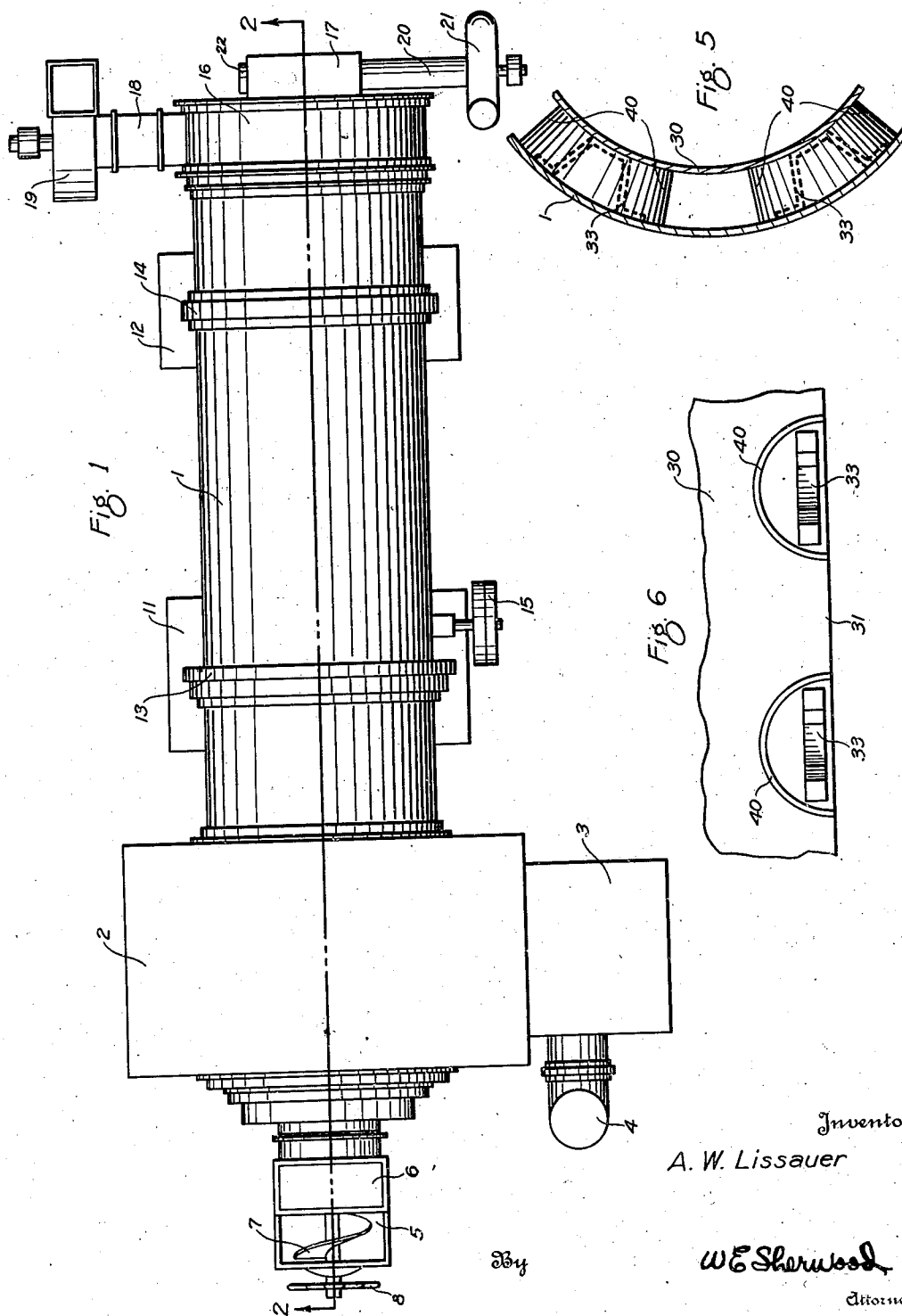
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# APPARATUS FOR DRYING MATERIALS

Filed July 10, 1936

3 Sheets-Sheet 1



Oct. 19, 1937.

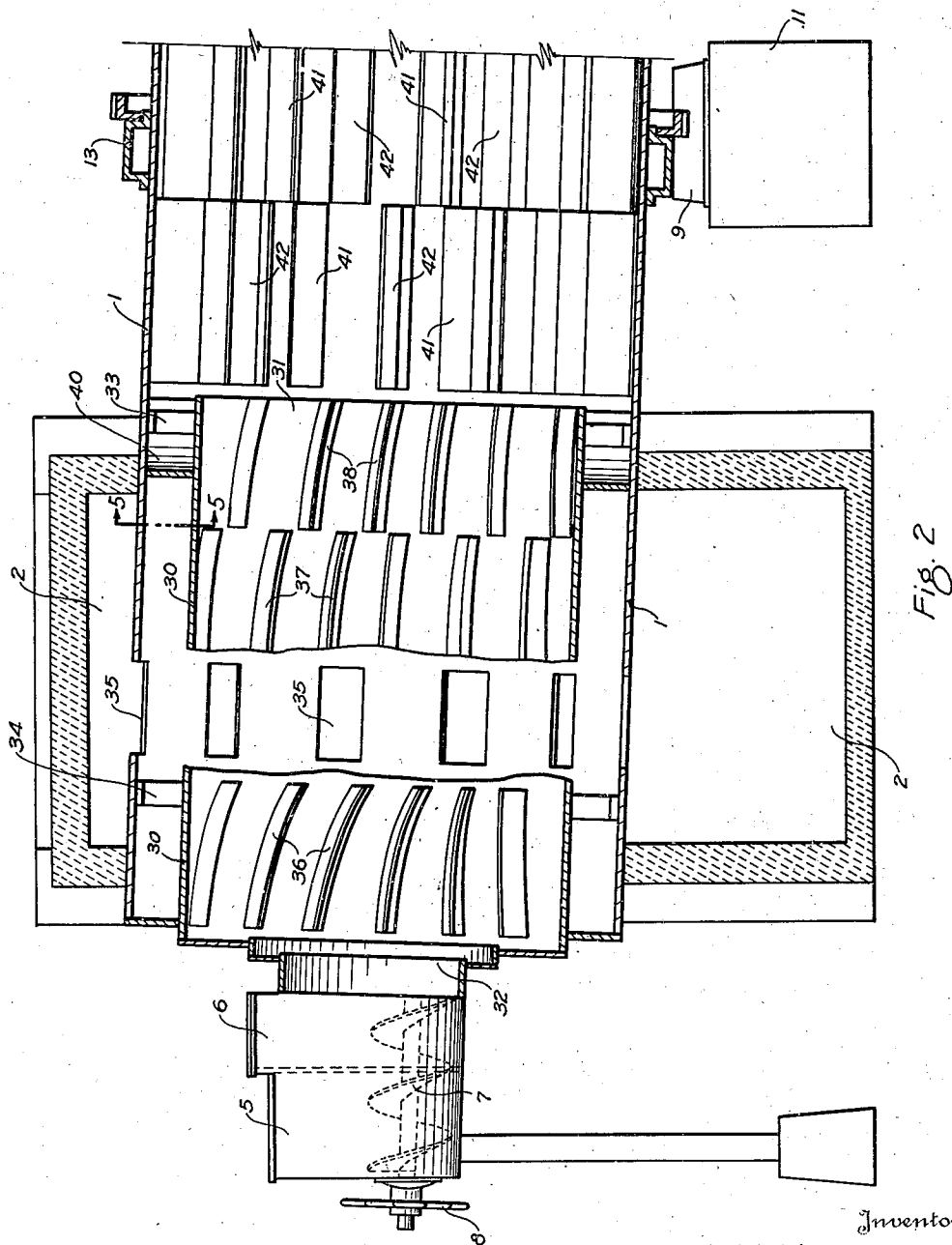
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APPARATUS FOR DRYING MATERIALS

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APPARATUS FOR DRYING MATERIALS

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3 Sheets-Sheet 3

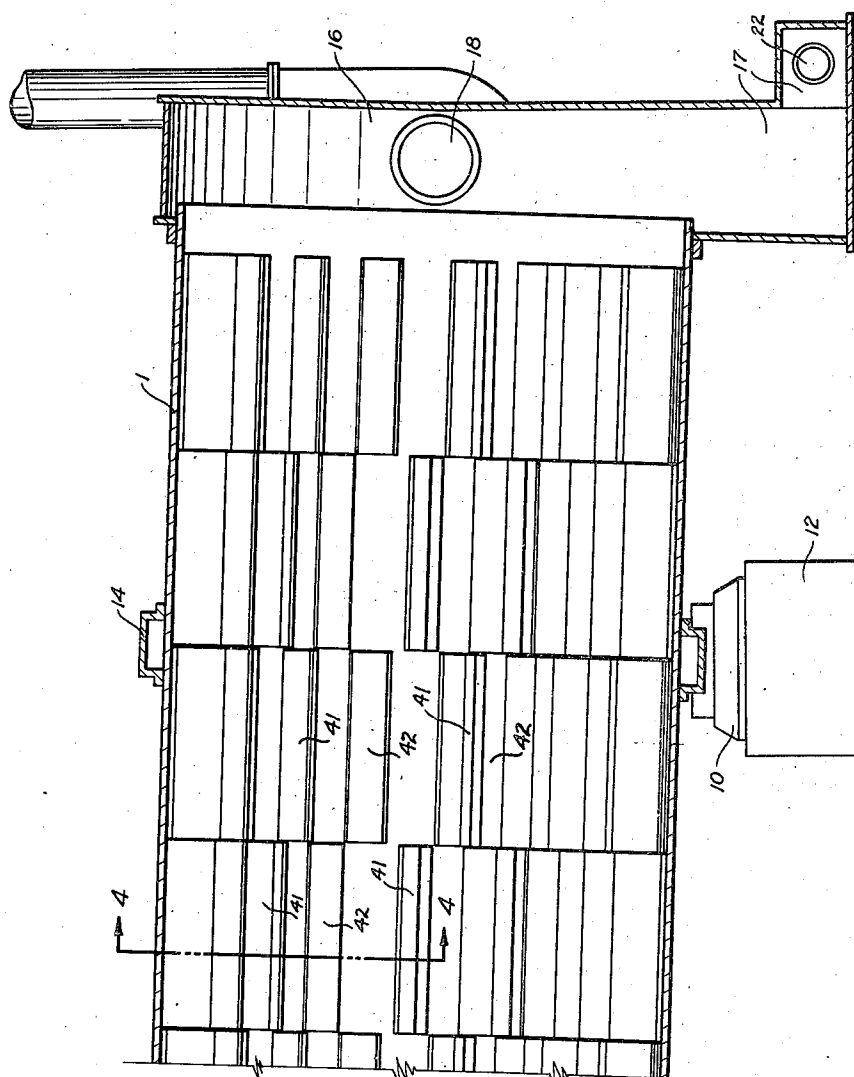


Fig. 3

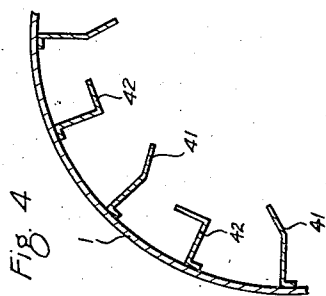


Fig. 4

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## UNITED STATES PATENT OFFICE

2,096,049

## APPARATUS FOR DRYING MATERIALS

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6 Claims. (Cl. 34—6)

This invention relates to an improved method of and apparatus for drying materials which have characteristics rendering the use of known drying processes unsatisfactory for the purpose. In order to disclose the invention, the drying of a material such as alfalfa is taken as an example. However, it is to be expressly understood that the invention is not limited in any way to usage with that particular material, but on the contrary may be used in the drying of numerous and widely diversified materials merely by varying the component parts of the invention in accordance with the characteristics of the material being treated.

Heretofore, in the drying of a material such as alfalfa certain difficulties have been encountered due primarily to the inherent characteristics of the substance. This material initially has a moisture-content of from 65 to 80% and is composed of light leaf portions which dry readily and heavier stem portions which dry more slowly. The moisture contained in the outer cell portions of the material can be easily removed by heat while the moisture contained in the inner cell portions is more difficult to remove. It has been found, therefore, that if heat is improperly applied during the drying stages, the outer surfaces of the material will dry rapidly and form a hard surface encasing the wet inner cells of the material. This result which is termed "case hardening" produces an inferior product and has been difficult to avoid when drying the material with any degree of rapidity. An additional danger has arisen in the conventional drying processes due to the fact that the light portions of the alfalfa are often burned and charred when brought into contact with a heating source having a temperature sufficient to dry the heavy stem portions of the same material. Moreover, it is found that the introduction of the undried alfalfa directly into a zone of high temperature results in a bleaching of the substance and a consequent reduction in the market value of the same.

The present invention, therefore, is directed toward the solution of these and similar disadvantages in the drying of various materials and has as a chief object the provision of a method for drying material in a rapid and efficient manner.

A second object is the teaching of an improved process for drying a material by means of hot air or similar heating medium.

A third object is the teaching of an improved process for bringing a material and a heating

medium into efficient heat transfer relation, without harm to such material.

Another object is the provision of an improved hot air drier.

A further object is the provision of means for effecting a uniform distribution of material in the drier and a uniform application of heat to the material.

Other objects and advantages of the invention will become more apparent as the description proceeds when considered in connection with the accompanying drawings in which,

Figure 1 is a plan view illustrating one manner in which the apparatus may be arranged;

Figure 2 is a partial sectional view of the feed end of the apparatus taken on line 2—2 of Figure 1 and drawn to a larger scale,

Figure 3 is a continuation of Figure 2 showing the outlet end of the apparatus,

Figure 4 is a partial sectional view taken on line 4—4 of Figure 3,

Figure 5 is a view taken on line 5—5 of Figure 2 while

Figure 6 is a partial development of the structure shown in Figure 5 with the outer shell portion removed.

Referring now to Figure 1, one arrangement of the invention is shown comprising a rotary drier having an outer shell 1 the inlet end of which extends into a jacket 2 connected to furnace 3 and forming a plenum chamber for the heating medium. Any suitable exhaust stack 4 cooperating with controlled air and fuel intakes (not shown) for purposes of regulating combustion in furnace 3 and generation of hot gases of suitable nature and volume may be used. An inlet hopper 5 for introducing material into the drier and a suitably regulated air inlet 6 for introducing air into the drier in conjunction with such material are provided at the inlet end of the structure. Passing through the hopper 5 is a conveyor 7 best shown in Figure 2, driven by an actuating means 8 from any convenient source of regulated power and functioning to introduce the material into the drier.

The drier 1 is preferably inclined from the inlet to outlet ends and as explained more completely hereinafter, the material progresses there-through under the combined action of gravity, air movement and certain mechanical means disposed interiorly of the drier shell. As shown, one means for mounting and rotating the drier 1 may comprise the use of suitable supports 9 and 10 mounted upon foundations 11 and 12 and carrying rollers (not shown) upon which the drier

shell may be rotated by any suitable actuating means 15 in cooperation with the rings 13 and 14. At the outlet end of the drier a manifold 16 is provided and at the lower extremity of the manifold a space 17 forms a receptacle for the dried material. For purposes of removing the heating medium and evaporated moisture an outlet pipe 18 leads from manifold 16 to a suitable exhaust fan 19 driven by any convenient means and preferably connected to a cyclone separator (not shown) for recapturing small particles of material drawn out in the exhaust.

The dried material may be withdrawn from space 17 through a second conduit 20 by means of a second fan 21 which entrains the material with air drawn in from an intake port 22. Fan 21 may discharge the air and dried material into a separator (not shown) from which the material may be taken for storage. Air seals of any suitable nature may be provided adjacent the inlet and outlet ends of the rotary drier and adjacent the junctions of drier shell 1 with stationary chamber 2 in order to prevent loss of heat or inefficient control of the drying process.

As shown in Figure 2, the outer shell 1 of the drier is securely journaled in a stationary chamber 2 filled with a heating medium of requisite temperature and volume and providing a constant reservoir of heat under a pressure sufficient to insure an efficient drying process at all loads. Interiorly disposed in the outer shell 1 within the chamber 2 is an imperforate inner shell 30 having an open end 31 which opens into the drying spaces of the outer shell and a second open end 32 communicating with the housing of conveyor 7. Inner shell 30 is secured to the closed outer end of the drier shell at one end by any suitable construction, such as welding, and at the other end is concentrically mounted within the outer shell 1 by suitable support members 33, best shown in Figures 5 and 6. Other supports 34 may be interposed between shells 1 and 30 adjacent the inlet end of the drier to provide additional support when the use of the same is desired.

At a convenient point intermediate the sides of chamber 2 a series of equally spaced inlet ports 35 are arranged in the outer shell 1. As a result of this construction, the hot heating medium fills the space between the outer and inner shells and results in a transmission of heat to the material on the inner shell primarily by radiation from the surface of the inner shell and secondarily by conduction through the shell to material temporarily resting upon the same.

Material entering the inner shell from conveyor 7 at once becomes under the influence of a series of curved flights 36 which shower the material across the drier cross-section as the drier revolves and assist in the movement of the material longitudinally of inner shell 30. In one construction three series of flights 36, 37, and 38 have been employed with success although it will be apparent that the number or exact location or construction of such flights may be widely varied without departing from the scope of the invention.

Due to the construction of the drier as thus described, material entering the same passes through a retention stage on inner shell 30 before it is dropped from edge 31 of this shell into the outer drier spaces. As explained hereinafter, the conditions under which this retention step takes place exert an important influence on the entire drying process.

In order to complete an efficient drying of the material the hot drying medium is led from the space between shells 30 and 1 into the outer spaces of the rotary drier. As is well known to those skilled in the art, various eddy currents and the like often develop in conventional structures and move the light material backward. If this condition should take place in the drying of alfalfa or the like, the light leaf portions of the same would immediately char in the hot medium between shells 30 and 1. Moreover, when a hot gas serves as the drying medium the hotter portions of the same tend to rise to the top of the drying spaces and an unequal distribution of heat results.

In order to avoid these known disadvantages, the present invention provides means to distribute the hot medium surrounding inner shell 30 into a series of equally spaced velocity jets entering into the outer drying spaces of shell 1. As best shown in the development in Figure 6, arcuate means 40 are equally spaced between outer shell 1 and inner shell 30 surrounding support members 33 and in cooperation with the outer and inner shells direct the heating medium into the drying spaces with a high initial velocity.

In effect, the adjacent arcuate members 40 serve to provide a nozzle which projects the heating medium in a plurality of jets into the outer drying spaces. As described hereinafter, this action results in a uniform dispersion of the heating medium and a uniform mixing of the same with the screen of material.

Material dropping from edge 31 of inner shell 30 comes under the influence of flights 41 and 42 which are disposed in the interior of the outer shell 1, (as shown in Figure 4). It is found that the alternate use of a flight 41 having a large obtuse angle and a flight 42 having a smaller angle will give satisfactory results. As the drier rotates, material held by a flight such as 41 will fall from the flight before reaching a vertical plane of the drier whereas material held by a flight such as 42 will fall from the flight at or after reaching the same vertical plane. In this way a more uniform screen of material may be formed across a transverse cross-section of the drier. A plurality of series of staggered flights may be provided in the outer shell in order to maintain the screen effect of the material and to effect a more intimate contact with the drying medium. Moreover, a uniformly distributed screen of material in cooperation with a uniform distribution of heating medium entering the drier precludes the possibility of a short circuit in the heating stage and results in a uniformly dried material and an efficient drying process.

In actual practice of the invention thus far described it is found that the following drying process results. Alfalfa or similar material being introduced into hopper 5 is moved by conveyor 7 accompanied by a regulated amount of atmospheric air into revolving shell 30. Customarily, the material will be cut into rather fine particles prior to the drying step and may have a moisture-content ranging from 65 to 80%. Upon entering the inner shell which is surrounded with gas of high temperature the material at once begins to heat up with a consequent liberation of moisture. Due, however, to the fact that the volume of the inner shell spaces is relatively limited and that the regulated amount of air accompanying the material is the only moisture absorbing medium present, the moisture remains in contact with the outer surfaces of the material and when

the small amount of air is saturated with moisture further heating in shell 30 merely serves to increase the vapor pressure without additional evaporation from the material. As the material continues to move through inner shell and receive additional heat the moisture from the inner cell structure is driven to the surface of the material and is held thereon without evaporation. The resulting material is then quite hot and humid by the time it moves to the outer edge 31 of shell 30.

As it drops from the edge of the inner shell the material falls upon flights 41 and 42 and is showered across the drier cross-section. At the same time the heating medium issuing in jets from nozzle members 40 strikes the material and effects a rapid evaporation of the moisture therefrom. Due, however, to the preliminary steaming which the material has had in its own moisture this evaporation is insufficient to cause case hardening or burning of the material. As a consequence, the continued contact with the heating medium as the material moves through the drier permits the moisture of the inner cells to be evaporated from the surface of the material and assures a uniformly dried product. Furthermore, since the material has already been heated prior to leaving shell 30, this contact with hot gas fails to result in the usual bleaching which has been prevalent heretofore.

Due to the issuance of the jets of heating medium at equally spaced points on the circumference of the outer shell and the immediate contact with a uniform screen of material, an equally distributed drying effect is produced. This also results in a rapid diminution of the velocity of the jets and the building up of a pressure which precludes eddy currents tending to carry light particles of material back toward the inlet of the drier.

Exhaust fan 19 meanwhile is exerting a reduced pressure upon the interior of the exhaust manifold and in combination with the inclination of the drier the material steadily progresses toward the outlet of the drier. By the time the material reaches manifold 16 it has been dried to the requisite degree and will fall into receptacle 17 whence it is withdrawn by fan 21 and moved to any convenient storage point. The heating medium meanwhile has absorbed all free moisture from the material and suffered a concurrent reduction in temperature. Exhaust fan 19 then withdraws the medium at a high relative humidity and forces it through the cyclone separator. By means of the drier construction employed the time of movement of a given portion of the material in the drier is dependent upon the specific gravity of its component particles. Heavier stem portions of the alfalfa will move more slowly and thus receive a longer heat transfer than will the light leaf portions which dry rapidly and move more quickly in the air stream. Consequently, a uniform drying results and the final product comprises stem and leaf portions all dried to substantially the same degree.

Having thus described the invention, it will be apparent that many variations in design and construction of the same may be employed without departing from the essentials thereof. With the intention, therefore, of including such changes in the above disclosure of the invention, I claim:

1. A rotary drier comprising in combination, an outer shell, a concentrically mounted imperforate inner shell adjacent the inlet of said drier, a heat

chamber surrounding the inlet end of said outer shell, spaced apertures in the outer shell communicating with the heat chamber during rotation of the drier, spaced support means forming nozzles for the heat medium and located between the inner end outer shells in order to direct the heat medium into the drying spaces of the outer shell in a plurality of streams, and means to remove the medium and absorbed moisture at the outlet end of said drier.

2. A rotary drier comprising in combination, an outer shell, a concentrically mounted imperforate inner shell adjacent the inlet of said drier, means to introduce a wet material upon the inner shell, means to agitate the material, a heat chamber surrounding the inlet end of said outer shell, spaced apertures in the outer shell communicating with the heat chamber during rotation of the drier, spaced support means forming nozzles for the heat medium and located between the inner and outer shells to direct the heat medium into the drying spaces of the outer shell in a plurality of streams, means to agitate the material and heat medium and means to remove dried material and the medium with absorbed moisture separately at the outlet end of said drier.

3. A rotary drier comprising an outer shell having its head end mounted within a drying medium chamber, an imperforate inner shell spaced from the outer shell and extending through the chamber, apertures through the outer shell in the chamber, means to introduce a damp material into the inner shell, means to remove the drying medium and absorbed moisture from the opposite end of the drier, means to remove the dried material from the opposite end of the drier, and support means forming a nozzle interposed between the inner and outer shells whereby the entire drying medium enters into heat transfer with the material on the inner shell and is partially cooled before entering the remainder of the drier, passes through the nozzle at high velocity in order to carry the material away from the source of heat, mixes with the heated material leaving the inner shell and moves concurrently with the material toward the outlet end of the drier.

4. In a drier, a preliminary heating zone and drying zone, an imperforate shell extending through the heating zone, means to introduce a wet material subject to damage by excessive heat upon said shell, means to introduce a hot medium around said shell, support means surrounding said shell and adapted to direct the heating medium from the heating zone to the drying zone with high velocity in order to carry the material away from the region of excessive heat, means to agitate the heated material falling from the shell into the high velocity medium and means to remove the dried material and the heating medium separately from the opposite end of the drier.

5. In a drier of the character described, an inclined outer shell divided into a preliminary heating section and a drying section, internally of the shell and separated by a transverse support means, an imperforate inner shell spaced from the outer shell within the heating section, support means providing a nozzle construction interposed between the inner and outer shells adjacent the junction of the two sections and adapted to convey a hot medium from the heating section to the drying section, means to introduce a material to be dried into the inner shell and means to introduce a gaseous drying medium into the heating section of the outer shell whereby the medium

may transfer heat to the material on the inner shell and may pass through the support means at high velocity in order to carry material falling from the inner shell away from the injurious heating section.

5 6. A drier having a rotatable outer shell, a source of heating medium adjacent the inlet end thereof, a short imperforate inner shell spaced inside the outer shell adjacent the inlet end,  
10 means to introduce a damp material into the

inner shell, means to introduce the heating medium into the space between the two shells for travel through the drier concurrently with the material and spaced restriction means disposed between the inner and outer shells whereby the heating medium may acquire a high velocity in passing through the restriction means and may mix with the partially dried material as it leaves the inner shell.

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