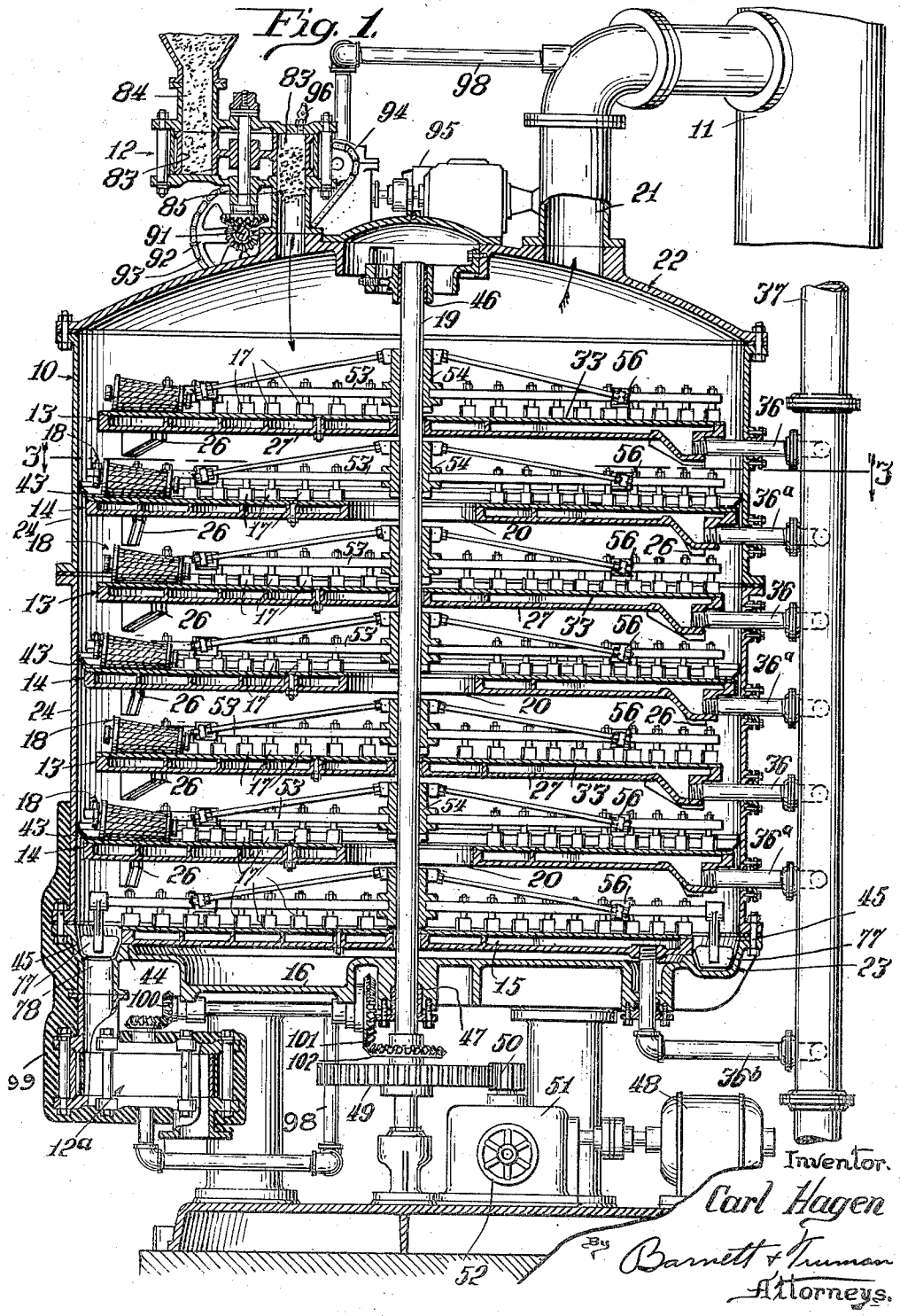
July 18, 1939. C. HAGEN 2,166,351

VACUUM DRIER

Filed Feb. 6, 1936 5 Sheets-Sheet 1

Fig. 1.



July 18, 1939. C. HAGEN 2,166,351

VACUUM DRIER

Filed Feb. 6, 1936 5 Sheets-Sheet 2

Fig. 2.

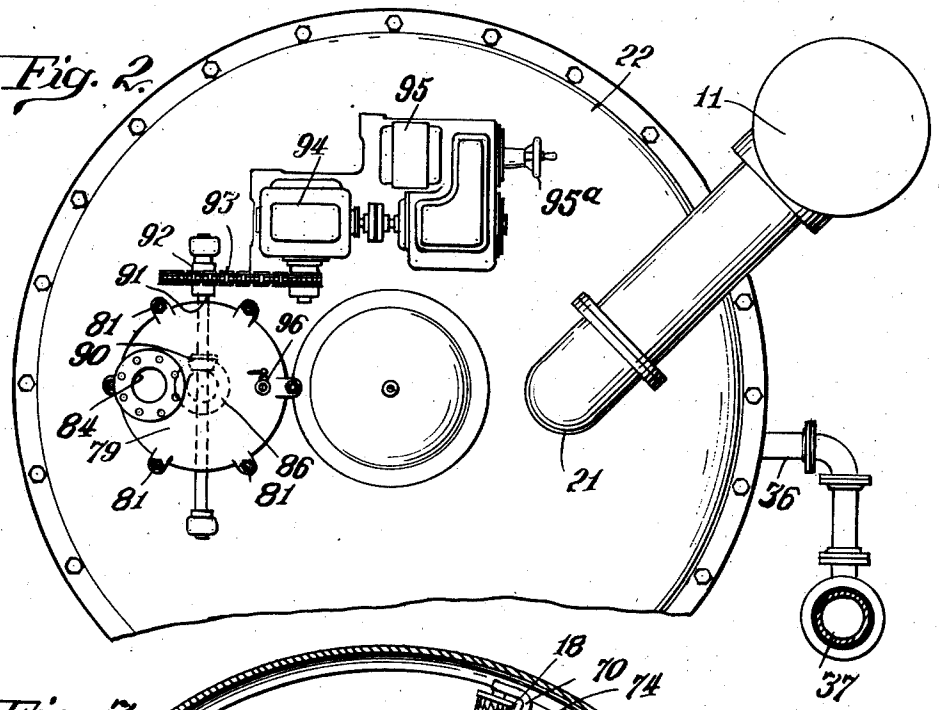
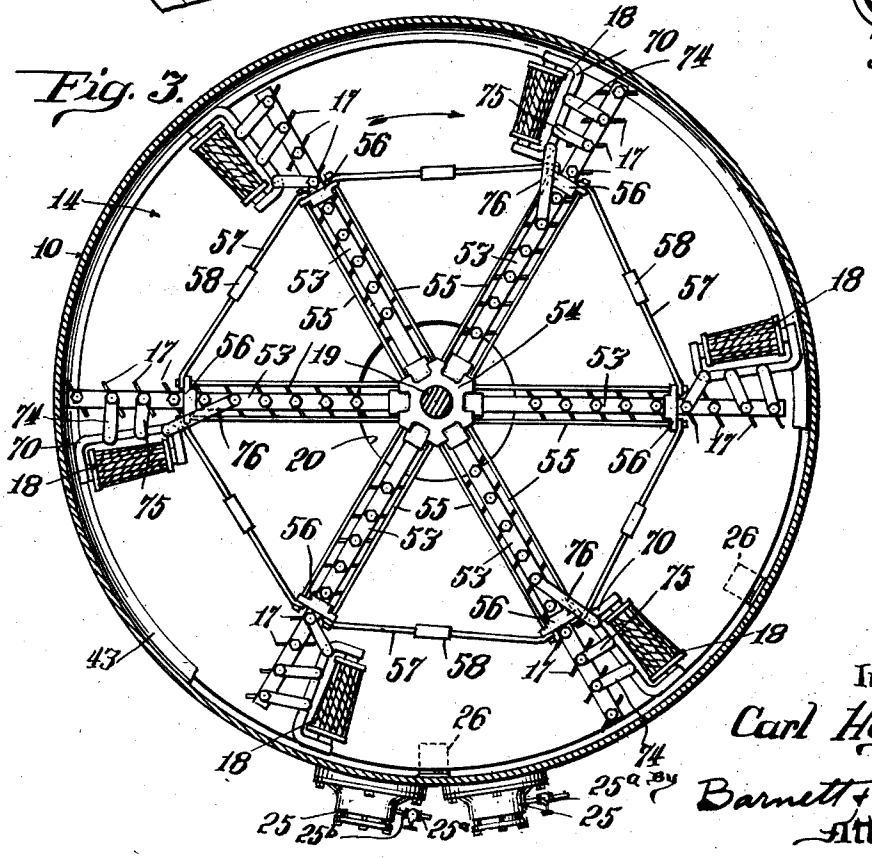


Fig. 3.



Inventor
Carl Hagen
By Barnett & Krumen
Attorneys.

July 18, 1939. C. HAGEN 2,166,351

VACUUM DRIER

Filed Feb. 6, 1936 5 Sheets-Sheet 3

Fig. 4.

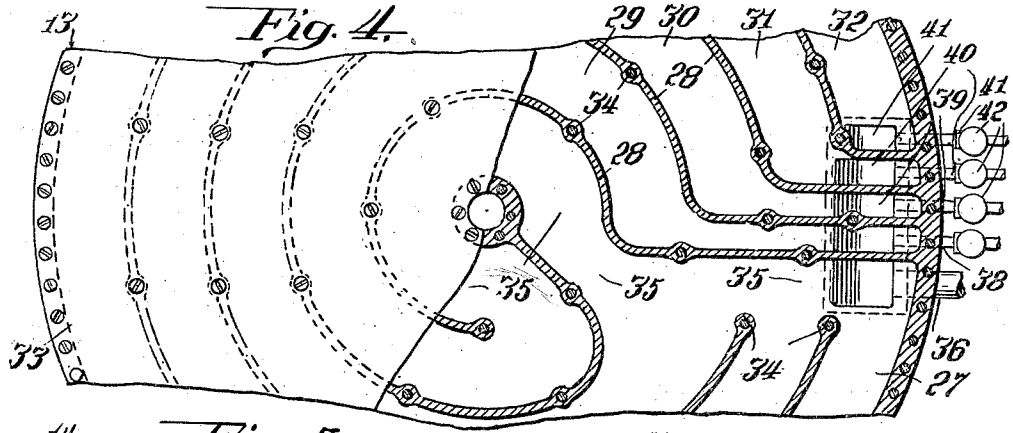


Fig. 5.

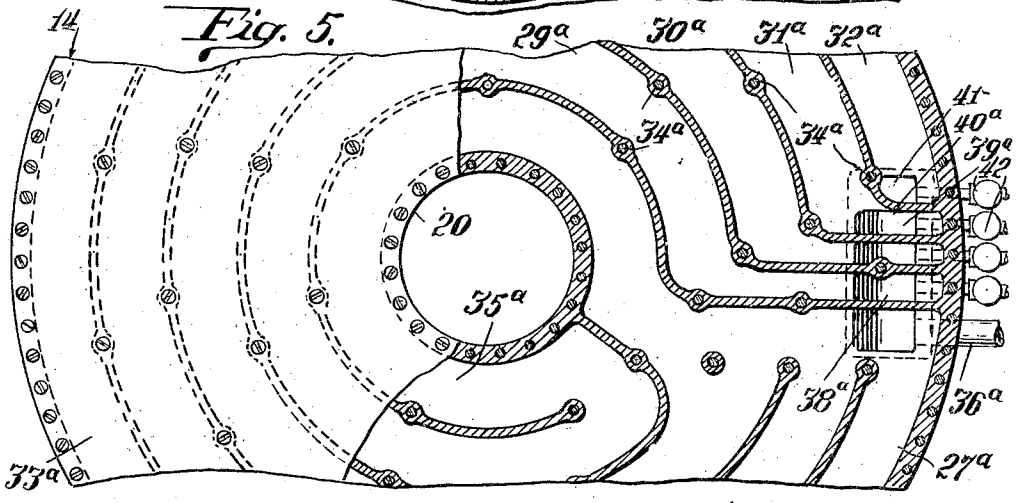
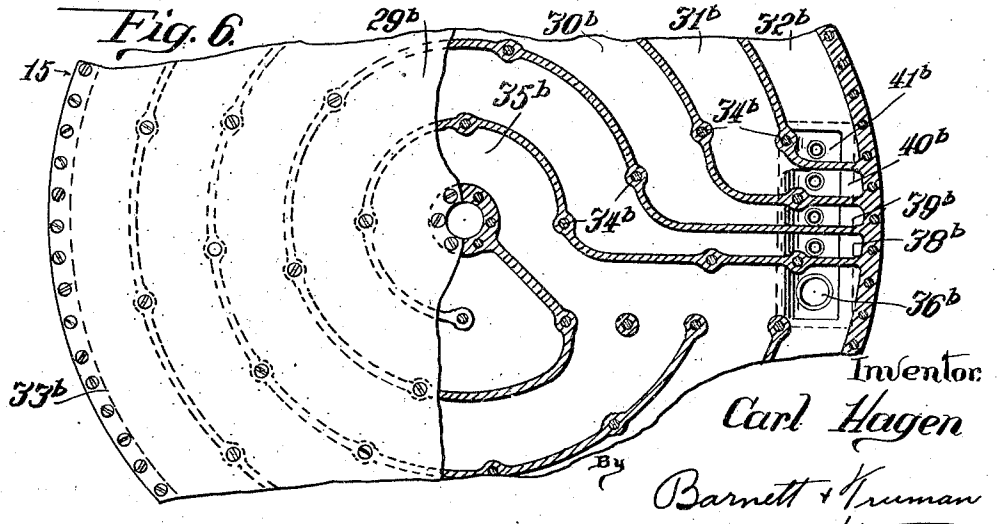


Fig. 6.



Inventor
Carl Hagen
By
Barnett & Truman
Attorneys

July 18, 1939. C. HAGEN 2,166,351

VACUUM DRIER

Filed Feb. 6, 1936 5 Sheets-Sheet 4

Fig. 7.

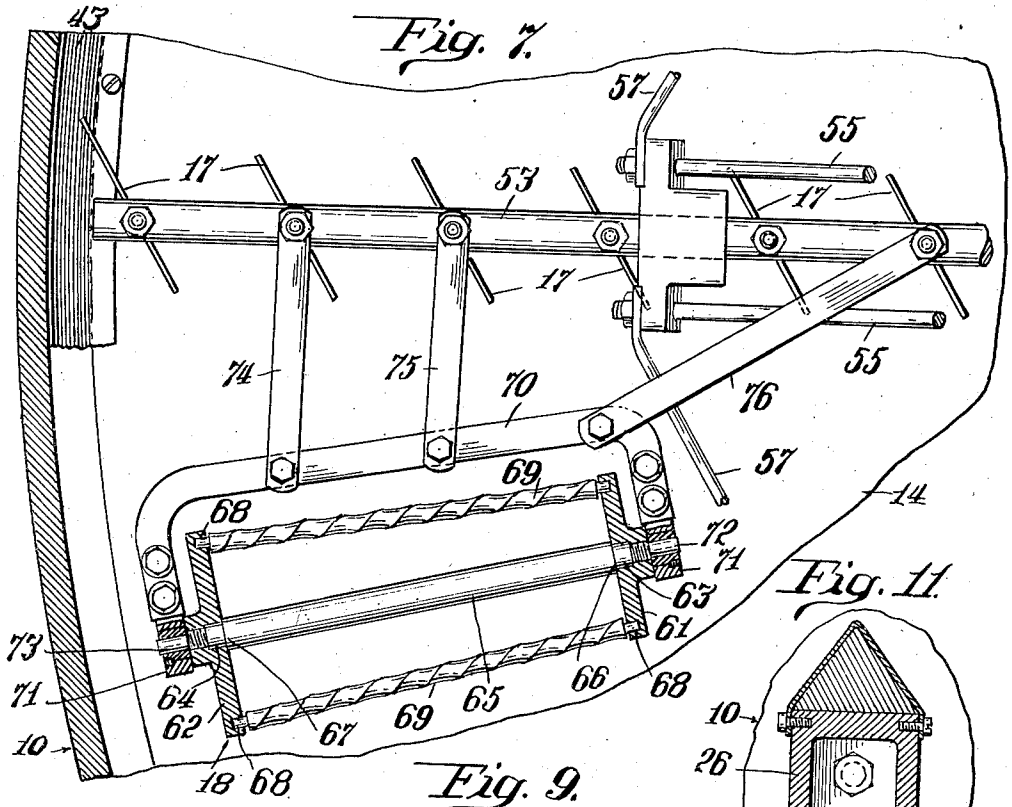


Fig. 11.

Fig. 9.

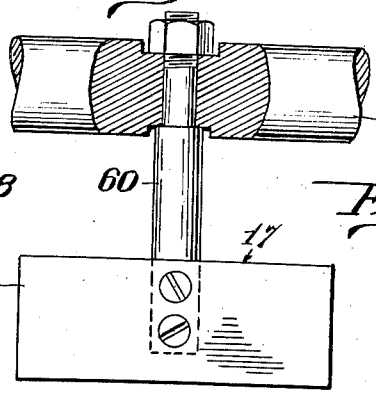


Fig. 8.

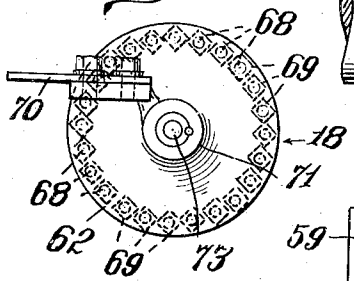


Fig. 10.

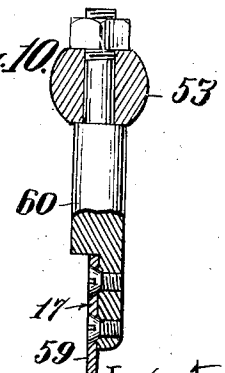
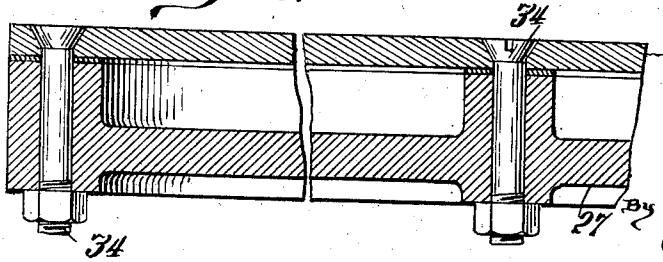


Fig. 12.



Inventor

Carl Hagen

By Barnett & Truman

Attorneys

July 18, 1939. C. HAGEN 2,166,351

VACUUM DRIER

Filed Feb. 6, 1936 5 Sheets-Sheet 5

Fig. 13.

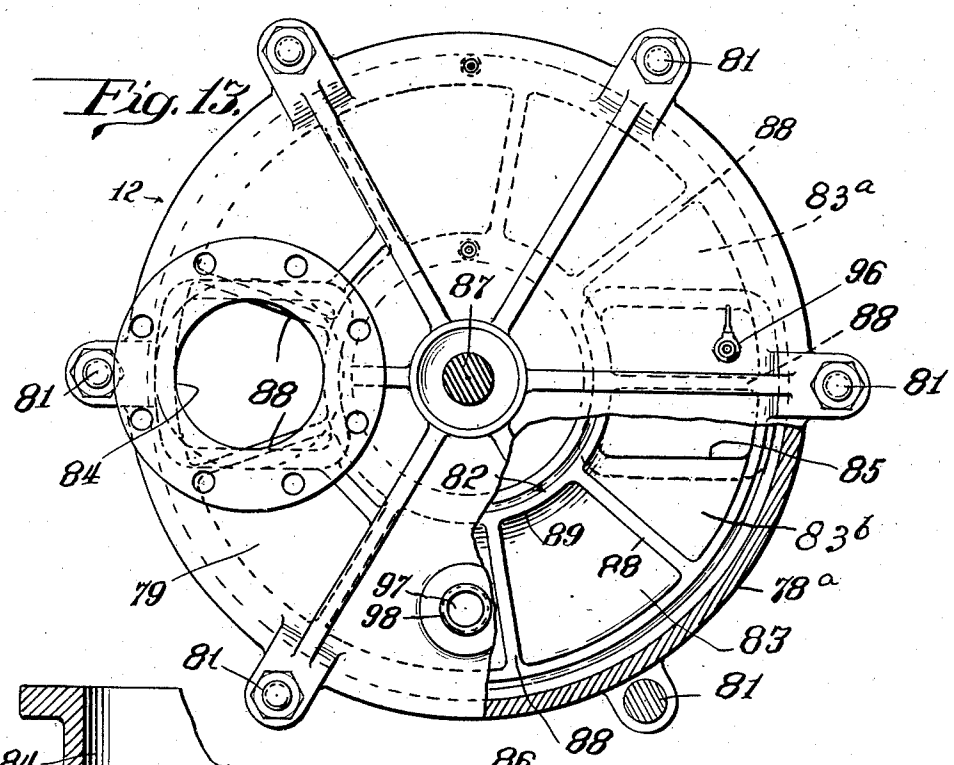


Fig. 14.

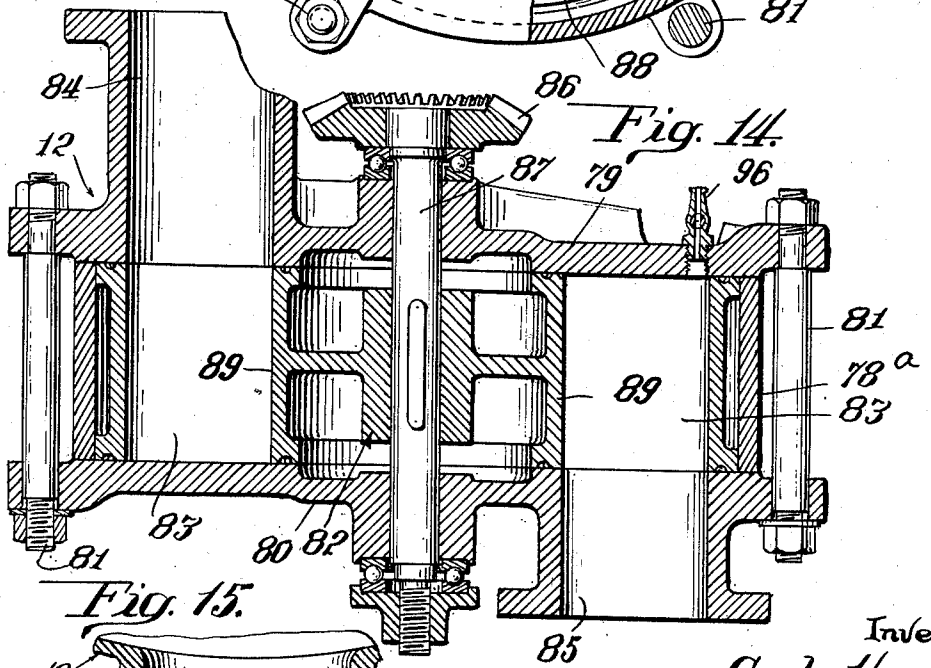
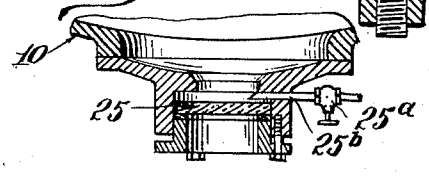


Fig. 15.



Inventor

Carl Hagen

By

Barnett & Truman

Attorneys

Patented July 18, 1939

2,166,351

UNITED STATES PATENT OFFICE

2,166,351

VACUUM DRIER

Carl Hagen, Park Ridge, Ill., assignor, by mesne assignments, to Corn Products Refining Company, New York, N. Y., a corporation of New Jersey

Application February 6, 1936, Serial No. 62,625

6 Claims. (Cl. 34—23)

This invention relates to improvements in vacuum driers and has for its principal object the provision of a vacuum drier which is so constructed that materials of various character may be passed through the apparatus and dried therein by a continuous operation.

Another object of the invention is to provide an apparatus of the above character in which the material being dried is caused to pass over one or more heat radiating surfaces positioned in a sub-atmospheric zone, whereby the drying operation is effected by the direct contact of the material with the heat radiating surface, thereby effecting substantial saving in fuel cost by reason of the low temperatures required for vaporizing the surplus moisture under sub-atmospheric pressure and by reason of the direct contact of the material with said heat radiating surface.

Another object is to provide, in apparatus of the above character, improved means for distributing the material over the heated surfaces and for keeping it in agitation so as to take advantage of the maximum efficiency of the heat radiating surfaces.

A more specific object is to provide a continuous drier of the above character for quickly and uniformly drying materials which are likely to be altered in character or quality by the use of high temperatures. In this connection the invention includes the provision of an apparatus in which starch, containing approximately 45% of moisture may be quickly and uniformly dried by a continuous operation in a partial vacuum, the apparatus including means whereby the evaporation of moisture and the temperature of the starch can be so controlled as to avoid danger of gelatinizing the starch and at the same time maintain conditions which aid in the production of thicker boiling starch than is obtained with the drying apparatuses now in general use.

While the apparatus of the present invention is not limited in its utility to the drying of starch, it has been designed in view of the various problems encountered in connection with the handling and drying of such material. The apparatus herein shown will be, therefore, described herein in connection with the drying of starch.

The starch drying apparatuses now in general use ordinarily employ heated air as a drying medium, the heated air being circulated through drying tunnels or other chambers so as to come into direct contact with the starch. Such air usually contains dirt and other impurities which become mixed with the starch being dried. If the old type of apparatus is of a construction adapted to keep the starch in agitation during the drying operation, the air becomes impregnated with the dry starch dust so as to form a combustible mixture. If the starch is dried in sizeable quantities, for example, in trays or foraminous containers, the drying operation must be carried on for a relatively long period and at low temperatures in order to avoid gelatinizing the starch. Such apparatuses also require large floor space and the labor and fuel cost required for handling the starch is relatively high as compared with the low operating cost of the present improved apparatus.

The present invention, in addition to overcoming the above mentioned and other objections by effecting economy in operation, eliminating contaminating foreign matter, and otherwise improving the quality of the product, includes various other improvements relating to particular problems encountered in connection with the drying of starch. The rapid evaporation of moisture from the wet starch and also the tendency of the wet starch to adhere to the surfaces over which it is moved are likely to form lump portions in the material which must be broken up in order to insure uniform drying thereof. The present improvement, therefore, includes the provision of improved devices for disintegrating the starch lumps so as to facilitate uniform distribution of the starch over the heating surfaces. The disintegrating means are themselves of novel construction so that they will operate efficiently on the wet and the partially dried starch, as well as on the thoroughly dried starch.

The drying tables over which the starch is caused to pass from the inlet to the outlet of the drying chamber are so arranged as to provide circuitous paths for the starch and the vapors emitted therefrom during the drying operation; the vapors being adapted to contact the bottom surfaces of the drying tables so as to be superheated and thereby avoid condensation of the vapors within the drying chamber. The vapors pass through the starch at the locations where the starch is discharged from one table to another. The dry starch dust suspended in the vapors is therefore collected from the vapors by contact with the damp starch in the upper portion of the drying chamber. The dry starch dust thus collected reduces, to some extent, the tendency which the wet starch has to adhere to the drying tables. When found desirable, a quantity of the dry starch from a suitable source, for example, from the discharge valve of the drier,

may be mixed with the wet starch fed into the machine and thereby reduce the tendency of such starch to adhere to the inlet valve and other parts of the apparatus.

The present embodiment of the invention is illustrated in the accompanying drawings wherein

Fig. 1 is a vertical section through the drying apparatus and shows the arrangements and general constructions of the principal parts of the apparatus.

Fig. 2 is a plan view of the drying chamber, the inlet valve and the means for operating said valve.

Fig. 3 is a sectional plan view taken on line 3—3 of Fig. 1.

Figs. 4, 5 and 6 are fragmentary views illustrating the constructions of three of the drying tables.

Fig. 7 is a fragmentary illustration, on a larger scale, of the elements shown in Fig. 3 for moving the starch over the top surface of the drying table and for disintegrating the lumps present in the starch.

Fig. 8 is an end view of the lump disintegrating rollers shown in Fig. 7.

Figs. 9 and 10 are side and cross sectional views respectively of one of the scraper members for distributing the starch over a drying table and for moving it toward one edge thereof.

Fig. 11 shows one of a plurality of brackets secured to the inner wall of the drying chamber for supporting the drying tables.

Fig. 12 is a fragmentary section of one edge portion of a drying table.

Figs. 13 and 14 are plan and vertical sectional views, respectively, illustrating the construction of the valves for controlling the inlet and outlet ports of the drying chamber, and

Fig. 15 is a sectional view taken through one of the windows provided for observing the material being dried and showing improved means for removing any dust which may collect on the inner surface of the window.

The drier illustrated in the drawings may be generally described as comprising a closed drying chamber **10** which is connected at its upper end with an evacuator **11** of any suitable construction for maintaining a suitable vacuum in the chamber. Preferably a vacuum of approximately 27 to 28 inches of mercury is maintained so that the moisture in the starch will vaporize at a relatively low temperature.

The wet starch is introduced into the drying chamber by means of a rotary valve **12** which is constructed, as hereafter described, so that the vacuum in the chamber **10** will assist the discharge of the wet sticky starch from the valve. A plurality of steam heated tables designated **13**, **14** and **15** are arranged in vertically spaced relation in the drying chambers. The starch is spread over the several tables and discharged from one onto another by means of distributing and forwarding mechanism, designated as a whole by the reference numeral **16**. This mechanism includes a plurality of scraper devices **17** and lump disintegrating devices **18**, positioned above each of the several tables and operated by means of a central shaft **19**. The starch is moved over the several tables as follows: It is moved outwardly and discharged over the outer edges of the three tables designated **13** onto the outer marginal portions of the underlying tables **14**. It is moved inwardly on the three tables designated **14** and discharged through a central opening **20** onto the central portions of the underlying tables **13**—**15**. The starch is discharged by means of a rotating valve **12a** which is the same in construction as the inlet valve.

The vapor emitted from the drying starch is discharged from the top of the chamber through the vapor outlet **21**. The said vapor follows the same general course as the starch, but in the opposite direction, and is superheated by contact with the bottom surfaces of the drying tables so as to avoid condensation thereof within the drying chamber. The dry starch suspended in the vapor is removed therefrom by contact with the wet starch in the chamber.

Referring now to the specific arrangement and construction of the various parts: The casing of the drying chamber **10** is preferably cylindrical and comprises a top section **22**, a bottom section **23** and a plurality of intermediate sections **24**. The intermediate sections **24** are preferably formed with a number of windows **25** positioned at different locations around the chamber, so that the operator may observe the operation of the parts enclosed within the chamber. Any dust which may collect on the inner surface of the window, may be removed by opening the valve **25a** momentarily (Fig. 15) so as to permit air to rush through the pipe **25b** and into the vacuum chamber, thereby dislodging any collection of dust on the inner surface of the window.

A plurality of brackets **26**, preferably three for each table, project inwardly from the inner wall of the chamber **10** for loosely supporting the drying tables **13**—**14**.

The drying tables **13** are in the form of disc shaped steam chests, each chest comprising a dished body casting **27** formed with a plurality of concentric upstanding ribs **28**. The said ribs divide the body into a plurality of steam passages **29**, **30**, **31** and **32**, the open sides of which are closed by a removable cover plate **33** which forms the top surface of the drying table. The said cover plate is preferably made of bronze and is clamped in position by means of bronze flat headed bolts **34** which extend through openings in the said ribs **28**. The open ends of the several steam passages communicate with a common inlet passage **35** which is connected by means of branch pipe **36** to a steam supply pipe **37** located outside of the drying chamber. The water of condensation is discharged from the steam passages through separate ports **38**, **39**, **40** and **41** which communicate with suitable steam traps **42** so as to insure a thorough drainage of water of condensation from the several steam passages without the loss of substantial quantities of steam.

The three tables designated **14** in the drawings and the bottom table **15** include the same constructions above described in connection with table **13** and in these respects are identified with corresponding reference numerals with the addition of exponents *a* and *b*, respectively. The tables **14**, however, are each formed with a central opening **20**, previously referred to, and are of larger diameter than the tables **13** so as to receive the starch discharged over the outer edges of the table **13**. The spaces between the peripheries of the tables **14** and the wall of the drying chamber are closed by means of sealing strip members **43** to prevent the passage of starch and vapor around the outer edges of the tables. The bottom table **15** seats on an upstanding rib **44** which forms one side of a channel **45** for receiving the dried starch discharged from the said table. The steam inlet pipe **36b** and the ports

38b, 39b, 40b and 41b for the discharge of water of condensation are formed in the bottom face of the table 15 so as to avoid interference with the starch distributing and forwarding mechanism 16.

The starch distributing and forwarding mechanism for the several tables comprise the shaft 19 which is journaled in upper and lower bearings 46 and 47, respectively. The shaft is operatively connected with a motor 48 by means of a gear 49, a pinion 50 and a variable gear reduction mechanism 51, of well known construction. The variable gear reduction includes a manually operated hand wheel 52 whereby the speed of rotation of the shaft 19 and the members carried thereon may be varied in accordance with the time required for properly drying the starch. A plurality of horizontally disposed arms 53 extend outwardly from the shaft 19 at locations above each of the several drying tables. The said arms are connected to the shaft by means of hub members 54 and are rigidified by truss rods 55 extending from the tops of the hubs to collar fittings 56 secured to intermediate portions of the arms.

The said arms are further rigidified and connected together by means of horizontally disposed tie rods 57 and turn buckles 58 (Fig. 3). A group of scrapers 17 comprising blade portions 59 and shank portions 60 are secured to each of the supporting arms 53. The scraper blades for each table are arranged at suitable angles relative to the path of movement and the blades of one group are disposed in staggered relation to those of another, whereby the starch is agitated by movement thereof from one position to another on the tables. The damp particles of the starch are therefore brought into direct contact with the heated surface of the table. The angular arrangement of the scrapers also serves to distribute the starch over the entire area of the tables and move the starch, by a step by step movement, toward the edge of the table from which it is discharged onto the next underlying table. It will be observed in this connection, that the scrapers for the three tables designated 13, and for the bottom table 15, are positioned to move the starch from the central portion of the tables toward their outer edges and that the scrapers for the three tables designated 14 are positioned to move the starch from the outer edges of the tables toward the central discharge openings 20.

Both the rapid evaporation of the moisture in the starch and the movement of the wet starch over a surface tend to form lumps or balls which do not dry as readily as the more pulverulent starch. Such imperfect drying is due largely to the compact character of the lumps and their tendency to move through the drying apparatus somewhat faster than the pulverulent starch. In order to obviate this difficulty and to insure uniform drying of the starch, the lump disintegrating devices 18 are secured to the scraper supporting arms 53 so as to trail back of each group of scrapers. The lump disintegraters are in the general form of conical rollers or cages and are preferably positioned near the outer edges of the tables. Each of the said disintegraters comprises inner and outer head members 61—62, respectively (Fig. 7). The said head members are keyed or otherwise fixed on reduced end portions 63—64 of an axle 65. Shoulders 66—67 at opposite ends of the axle hold the head members 61—62 in proper spaced relation. The inner faces of the head members are provided with a number of bearing pockets in which are loosely fitted the trunnion end portions 68—68 of a plurality of roller bars 69. Said bars are preferably made by twisting bars, square in cross section, so that the twisted corner portions of the bars form helical edges extending the full length of the bars. A U-shaped frame comprising a flat metal strip 70 and bearings 71 engage the projecting ends 72—73 of the axle. Resilient metal strips 74, 75 and 76 secure the disintegraters 18 to the scraper arms 53 so that resilient force is exerted on the starch as the disintegraters are rolled over it. The helical roller bars 69 are free to turn about their own axes. This independent movement of the bars together with their helical configuration serve to dislodge any accumulation of wet starch on the bars and to break up any lumps which may be pressed into the spaces between the bars. By the time the starch reaches the bottom table of the drier, the starch lumps are thoroughly broken up and dried. Consequently the lump disintegraters 18 may be omitted from the table 15. The starch is discharged from the bottom table into the collecting channel formed in the bottom head 23 of the chamber casing.

Collecting scrapers 77 carried at the ends of the scraper arms for the lower table, move the dried starch to the discharge port 78 from which it is discharged by the rotary valve 12a.

The said inlet and discharge valves 12—12a are of the same construction and comprise a casing made up of a central ring 78a and upper and lower head members 79 and 80, respectively. The ring 78a is clamped between the upper and lower heads by means of a plurality of bolts 81. The rotating valve member 82 is provided with a plurality of pockets 83. When the valve member 82 is in the position indicated in Figs. 13 and 14, one of the pockets 83 communicates with an inlet passage 84 in the top portion of the valve casing and another pocket 83 communicates with a discharge passage 85 formed in the bottom of the casing. Valve member 82 is rotated by a suitable connection with a beveled gear 86 secured to one end of a shaft 87 which in turn is keyed to the rotating valve 82. The inlet passage 84 and the discharge passage 85 of the valve casing are preferably positioned at remote points to each other so that the partitions 88 between the several pockets and the inner walls 89 thereof will serve as sealing members to prevent the passage of atmosphere from the inlet passage to the outlet passage, when the valve is employed as an inlet valve to the drier and to prevent admission of air into the drying chamber when the valve is used as a discharge valve.

The position of the inlet valve, as shown in Fig. 1 of the drawings, is an inverted position with relation to the position of the valve illustrated in Figs. 13 and 14. It is operated by mechanism comprising a bevel pinion 90 which meshes with the bevel gear 86, a shaft 91 on which the bevel pinion is mounted, a large sprocket 92 on the shaft which is connected by means of a chain 93 to a sprocket pinion which forms part of a speed reduction mechanism 94 and an electric motor 95. The speed of rotation of the inlet valve may be varied, by operation of the hand wheel 95a, so as to vary the movement of the valve in accordance with the speed of operation of the distributing and forwarding mechanism 16 within the drying chamber. The means by which the mechanism 94 operates to vary the speed of the shaft

is not illustrated herein, since the mechanism 94 may be any one of the many mechanisms now generally known for accomplishing this result.

When the valve is used as an inlet valve it is provided with an air inlet valve positioned above the discharge passage, the valve being indicated at 96 in Figs. 1, 13 and 14. The said valve normally remains open so that when the pocket charged with wet starch moves into register with the discharge opening, as shown in Fig. 1, the atmospheric pressure enters above the starch to force the wet sticky starch into the drying chamber. Further rotation of the valve, for example, in the direction of the arrow indicated in Fig. 13, moves the pocket 83a into the position now occupied by the pocket designated 83b in Fig. 13, and consequently closes communication between the air valve 96 and the pocket. The said pocket, however, is still in communication with the evacuated drying chamber. Consequently any air remaining in the pocket when it reaches the position indicated at 83b will be withdrawn so that when this pocket moves around to the position beneath the inlet passage of the valve, the vacuum in the pocket will serve to draw the wet starch into the pocket, thereby insuring that each pocket will be completely filled and thereby provide a relatively uniform feed of wet starch into the drying chamber.

When the said valve structure is used as a discharge valve for the dry starch, the air valve 96 is closed and an opening is tapped at the location indicated by the numeral 97 for a suction line 98. The other end of the suction line is tapped into the vapor discharge passage 21 from the drying chamber. The air in the empty pocket is therefore withdrawn before the pocket moves into a position to receive a charge of dry starch from the drying chamber. By withdrawing the air from the empty pocket in the manner thus described, there is no interference to the movement of the dry starch in the discharge passage, nor formation of starch dust clouds, such as would take place by sudden expansion of air if the air were not exhausted from the valve pockets.

The operation of the drying apparatus may be summarized as follows: a vacuum is maintained in the drying chamber by means of the evacuator 11. The rotary inlet valve 12 receives a charge of wet starch from the source of supply and discharges it into the drying chamber; this discharge being effected quickly by reason of the atmospheric pressure which enters through the air valve 96 above the charge of wet starch. Any atmosphere entering the drying chamber with the wet starch is immediately discharged from the drying chamber through the vapor outlet 21 before the said air can come into contact with the partially dried starch. Before the valve pocket is moved out of communication with the interior of the drying chamber, a vacuum is created in the said valve pocket. This condition hastens the recharging of the pocket with wet starch when it moves into communication with wet starch supply.

The wet starch discharged from the inlet valve drops onto the upper table 13 and is spread over the upper surface thereof by means of the angularly disposed scrapers 17 and is at the same time moved outwardly toward the periphery of the table 13 where it is discharged onto the outer portion of the underlying table 14. It is spread over the table 14 in the same manner as previously described and is moved inwardly toward the central discharge opening 20, where it is discharged onto the next underlying table 13. This spreading and movement of the starch is carried out in connection with its movement over each of the tables until it is discharged into the collecting channel 45 in which it is moved by the collecting scraper 77 to the discharge passage 78. By maintaining a vacuum in the chamber 10 the moisture in the starch is vaporized very quickly at a low temperature. Furthermore, the absence of atmospheric air in the drying chamber removes the usual explosion hazard which is present in drying devices when large quantities of starch dust is held in suspension in the air. The vapor emitted from the drying starch is discharged from the top of the drying chamger. In its movement to the discharge passage 21 the vapor passes in contact with the bottom surfaces of the steam heated drying tables and is thereby superheated to a temperature which will prevent condensation. In order to further guard against condensation of the vapor, the walls of the drying chamber and the discharge valve or any part thereof may be covered with insulation, for example, as indicated at 99 in Fig. 1. The rotary discharge valve 12a being operated by gear connections 100, 101 and 102 with the vertical shaft 19 operates at a predetermined speed with relation to the starch distributing and forwarding mechanism. Ordinary commercial starch contains from 10 to 14 per cent of moisture. The moisture content of the starch dried in the present apparatus can be varied at will by varying the amount of vacuum contained in the chamber, by varying the steam supply to the drying tables or by varying the speed of movement of the starch through the drying apparatus. The degree of dryness can be maintained at any fixed point because the starch, as it passes over the tables, is maintained in a pulverulent state by means of the lump disintegrater 18.

While the present invention illustrates as a preferred construction an arrangement and construction of tables together with distributing and forwarding means for moving the starch across the tables transversely of the drying chamber, it will be obvious to persons familiar with the art that the said mechanisms might be constructed to operate so as to give a different movement to the starch than is described herein. It may be understood, however, that the present invention contemplates all modifications in structure coming within the scope of the appended claims.

The improvements of the inlet and discharge valves 12—12a are shown and described herein for the purpose of making a full disclosure of the drying apparatus as a whole. However, I do not claim herein the said valve improvements per se, since these improvements are disclosed and claimed in my copending divisional application Serial No. 186,946, filed January 26, 1938.

I claim:

1. In apparatus for drying pulverulent and adhesive materials, the combination of a drying table positioned to receive a continuous supply of material to be dried, means for moving the material over the table, and means for disintegrating the lump portions of the material so as to insure uniform distribution and movement thereof; said disintegrating means comprising a roller structure, the peripheral portion of which includes a plurality of separately movable roller bars of helical configuration whereby the configuration of the bars disintegrates the lump material without compressing the same and relative movements of the bars effects a self clearing action.

2. In apparatus for drying pulverulent and adhesive materials, the combination of a drying table positioned to receive a continuous supply of material to be dried, means comprising a plurality of angularly disposed scraper elements for agitating and forwarding the material over the table, and means for disintegrating the lump portions of the material so as to insure uniform distribution and movement thereof; said disintegrating means comprising a cage roller structure, the peripheral portion of which includes a plurality of roller bars of helical configuration which are spaced apart and separately movable, whereby the configuration of the bars disintegrates the lump material without compressing the same and the separate movements of the bars effect a self clearing action.

3. In apparatus for drying pulverulent material, the combination of a closed drying chamber having a transparent window closure for facilitating the inspection of the material being dried, means for maintaining a vacuum in the chamber, means utilizing the difference in the internal and external air pressures for removing deposits of dust from the inner surface of said window closure comprising an air nozzle positioned to direct air into contact with the inner surface of said window closure and a hand valve for opening said nozzle to admit inflow of air under atmospheric pressure.

4. A starch drying apparatus comprising, in combination, a drying chamber, a plurality of drying tables positioned in the chamber in vertically spaced relation, and means for spreading the starch over the several tables and discharging it from one table onto another; the said tables being in the form of relatively flat steam chests, each formed with a plurality of concentric passages of substantially equal length for distributing the steam throughout all portions of the chest.

5. A starch drying apparatus comprising, in combination, a drying chamber, a plurality of drying tables positioned in the chamber in vertically spaced relation, and means for spreading the starch over the several tables and discharging it from one table onto another; the said tables being in the form of relatively flat steam chests, each formed with a plurality of concentric steam passages for heating substantially uniform areas of the chest and communicating with a common steam inlet and having separate discharge openings, whereby the steam is distributed throughout the chests in accordance with the requirements of the several passages thereof and the condensate and the non-condensible gases in each passage is discharged therefrom through its discharge opening.

6. In a continuous drier for pulverulent and adhesive material, the combination of a closed chamber, a plurality of circular steam heated drying tables positioned one above the other in the said drying chamber and adapted to receive a continuous supply of material, means for moving the material at uniform speed and in a circuitous course over the several drying tables comprising a series of angularly disposed scraper elements for each table and a plurality of lump disintegrators comprising cone shaped cage rollers for each of the several tables; the peripheral portion of said rollers being composed of a plurality of sepaartely movable self clearing bars.

CARL HAGEN.