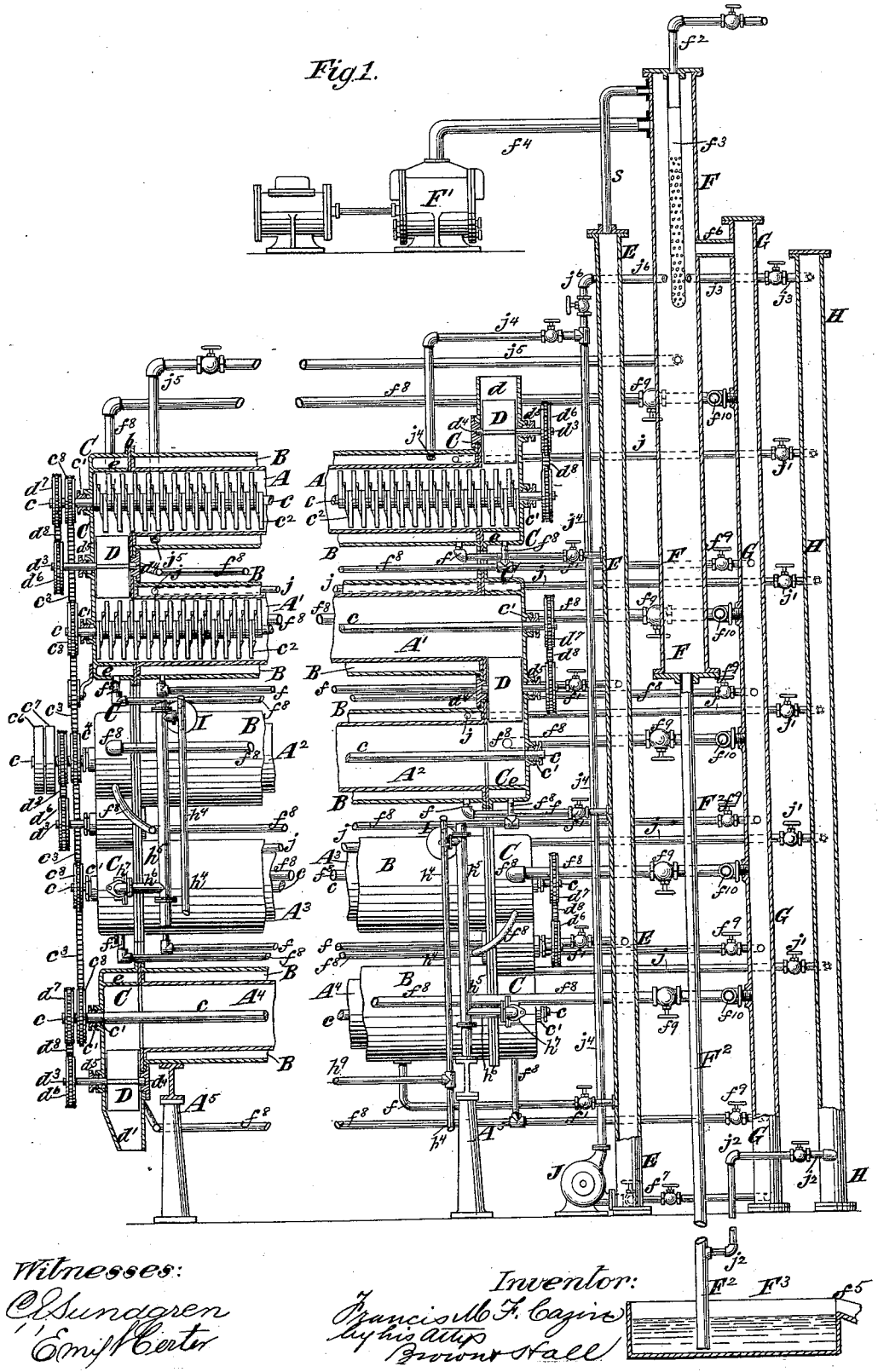
(No Model.) 4 Sheets—Sheet 1.

# F. M. F. CAZIN.

## APPARATUS FOR DRYING STARCH REFUSE, BREWERS' GRAINS, &c.

No. 408,824. Patented Aug. 13, 1889.

Fig. 1.



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(No Model.) 4 Sheets—Sheet 2.

# F. M. F. CAZIN.

## APPARATUS FOR DRYING STARCH REFUSE, BREWERS' GRAINS, &c.

No. 408,824. Patented Aug. 13, 1889.

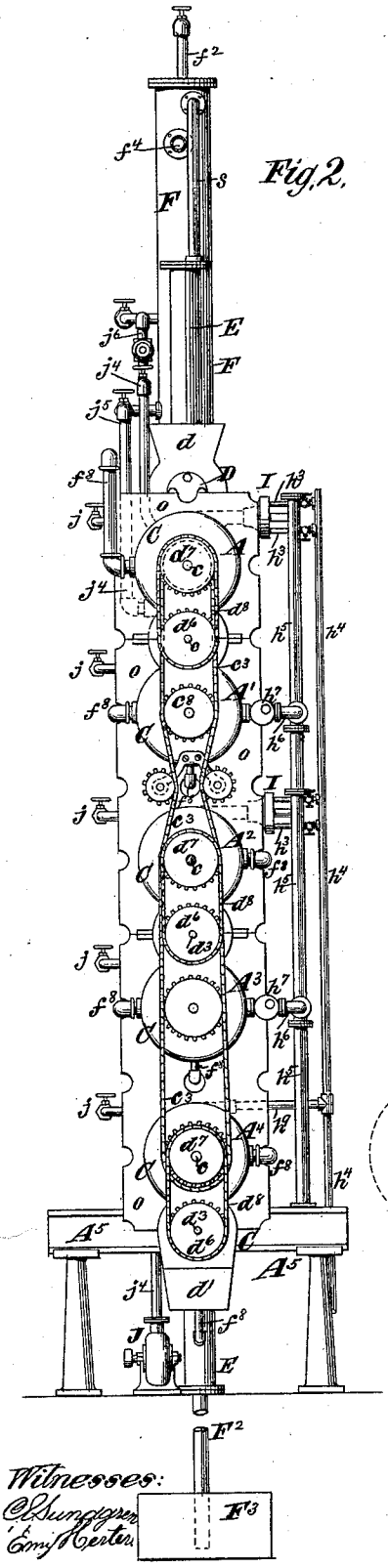

Fig. 2.

Fig. 7.

Fig. 8.

Fig. 9

Fig. 10.

Fig. 11

Fig. 12.

Fig. 13.

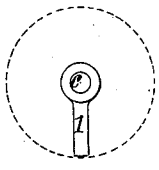

Fig. 14.

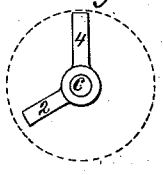

Fig. 15.

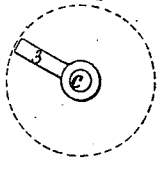

Fig. 16.

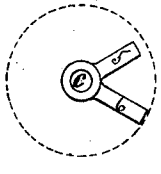

Fig. 17.

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(No Model.)

4 Sheets—Sheet 3.

# F. M. F. CAZIN.

## APPARATUS FOR DRYING STARCH REFUSE, BREWERS' GRAINS, &c.

No. 408,824. Patented Aug. 13, 1889.

Fig. 5.

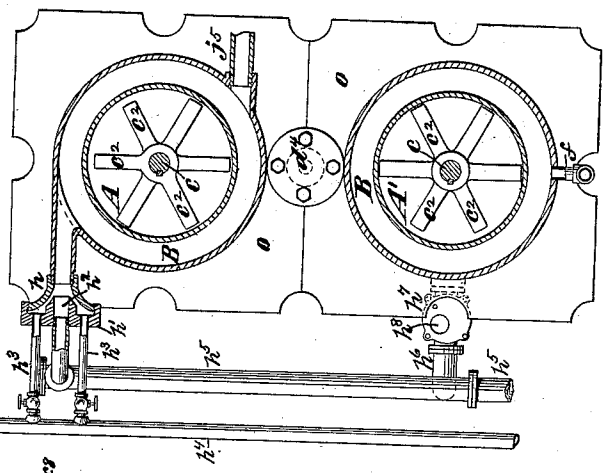


Fig. 4.

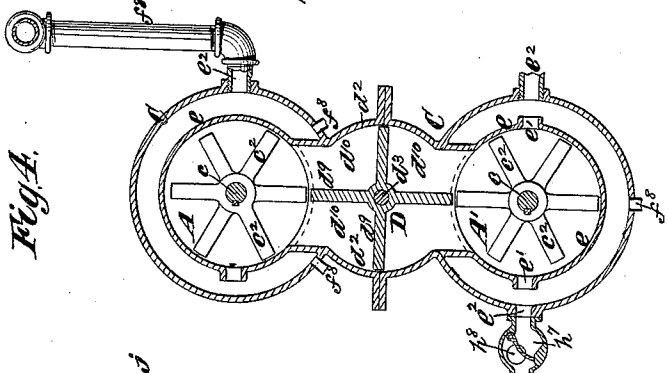
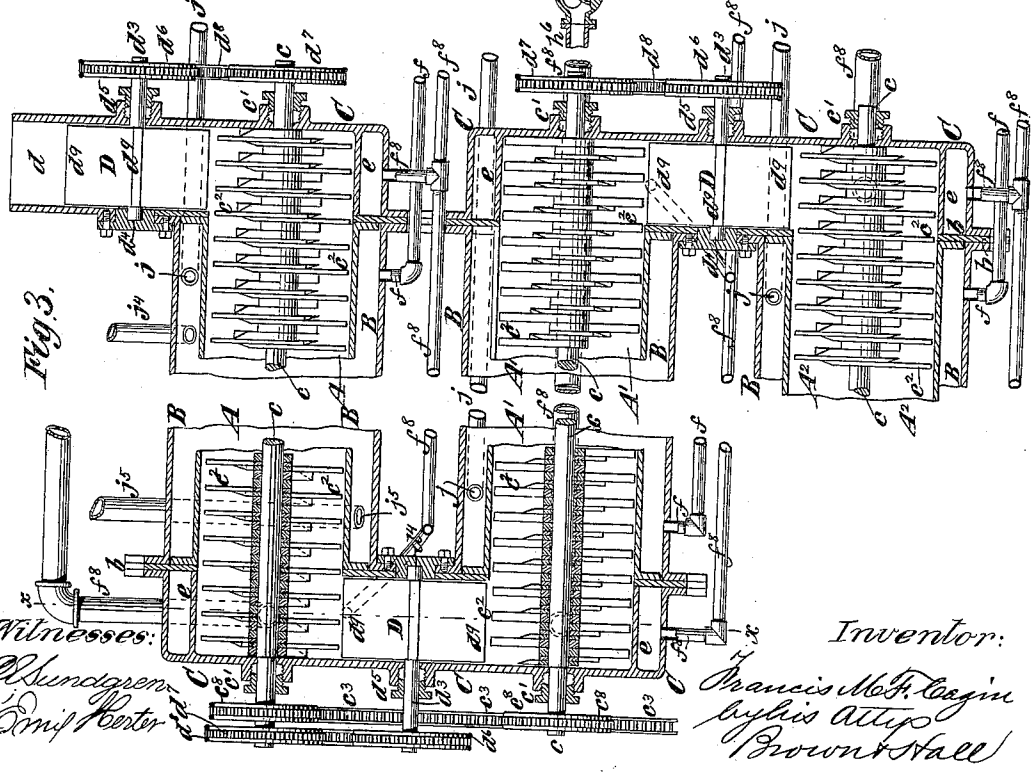


Fig. 3.



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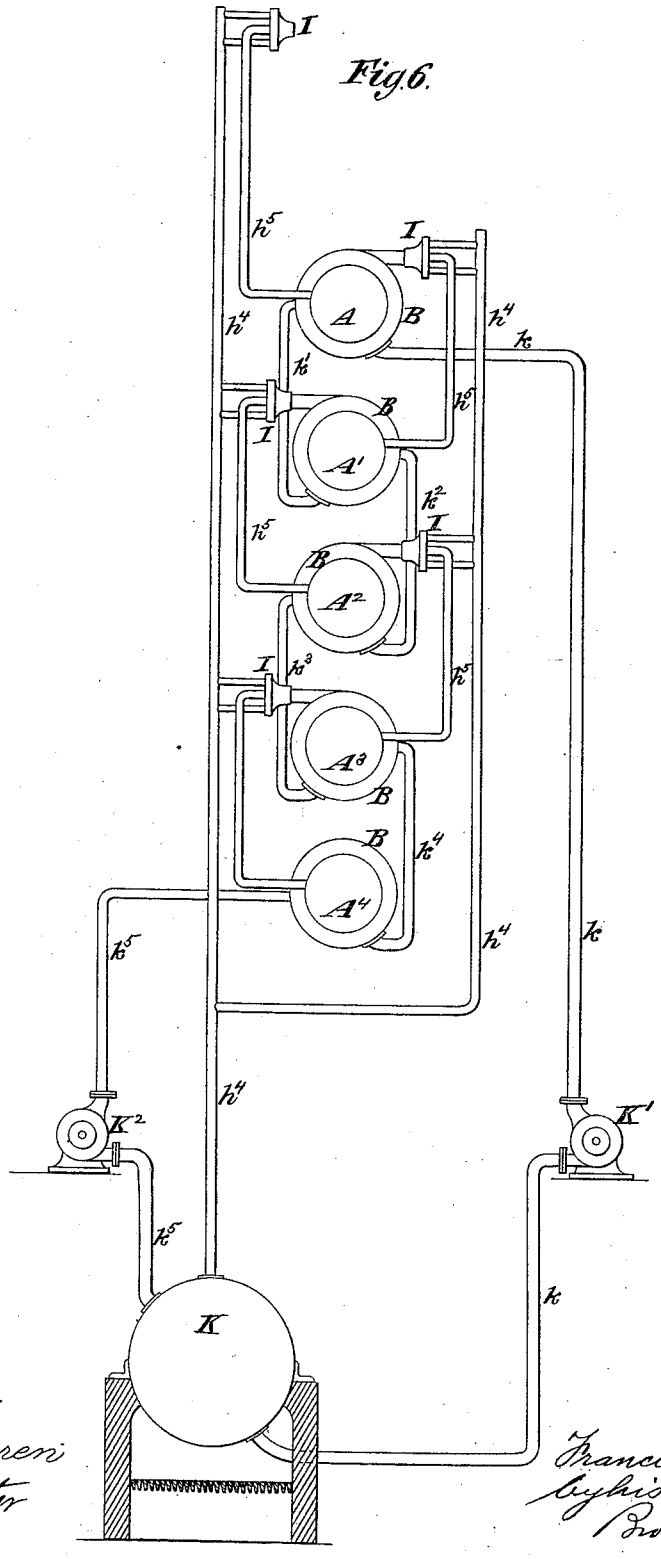
4 Sheets—Sheet 4.

# F. M. F. CAZIN.

## APPARATUS FOR DRYING STARCH REFUSE, BREWERS' GRAINS, &c.

No. 408,824. Patented Aug. 13, 1889.

Fig. 6.

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# UNITED STATES PATENT OFFICE.

FRANCIS M. F. CAZIN, OF NEW YORK, N. Y.

## APPARATUS FOR DRYING STARCH-REFUSE, BREWERS' GRAINS, &c.

SPECIFICATION forming part of Letters Patent No. 408,824, dated August 13, 1889.

Application filed June 22, 1886. Serial No. 205,861. (No model.)

*To all whom it may concern:*

Be it known that I, FRANCIS M. F. CAZIN, a citizen of the United States, residing at New York, in the county and State of New York, have invented a new and useful Improvement in Apparatus for Drying Starch-Refuse, Brewers' Grains, and other Solid Matters, of which the following is a specification.

My invention may be embodied in apparatus for the economical and thorough drying of solid matters, such as the coarse refuse resulting from the manufacture of starch or glucose and from the distillation of spirits and brewing of ale or beer.

My improved apparatus is intended for carrying out a method of drying, in which the matter to be dried, while being conveyed through tubes or chambers, is subjected to heat transmitted through metal contact-walls, the air being excluded, and the vapors emanating from the drying matter being exhausted from the tubes or chambers during the drying operation, so that drying is performed under a pressure less than that of the atmosphere or, as it is termed, in a "vacuum." In drying by such a method economy of operation may be secured by employing the hot vapors emanating from the contents of one tube or chamber for heating, through metal contact-walls, the contents of another tube or chamber.

In my pending application, Serial No. 205,759, filed June 21, 1886, I have shown an apparatus for carrying out the above-referred-to method upon solid matters, which will be caused to disintegrate or separate into particles by the drying operation. This apparatus in itself, and independent of the method upon which it operates, forms the subject of my present invention.

The apparatus in its complete form, and as illustrated in the drawings, comprises a series of closed drying-tubes, which are arranged one above another, and which are provided at the ends with hoods, through which they communicate alternately at opposite ends, and in which hoods are valves for controlling and permitting the passage of the solid drying matter from one tube to another of the series, without permitting the passage of vapors emanating from the drying matter from one to another of said tubes. Each drying-tube has arranged within it a series of conveyer blades or arms, which are secured spirally upon a concentric shaft, and which serve to gradually move the material from end to end of the tubes.

The valves which I prefer to employ in the hoods connecting the tubes are of rotary form, and are so constructed as to form hopper-like cavities, which, when presented upward, receive material from an upper tube, and when presented downward by the continuous rotary motion of the valves deposit such portion of material into the next lower tube.

The several drying-tubes are surrounded by heating jackets or spaces, which are supplied with the heat-producing or heat-giving fluid employed, and through the metal walls of the drying-tubes transmit heat to the solid matter within the tubes. I also prefer to construct the hoods which connect the drying-tubes with inner circular walls, forming jackets within the hoods concentric with the tubes and communicating through openings in such inner walls with the interior of the drying-tubes.

Steam may be introduced to the heating-jacket of the lower or one tube of the series, and the remaining tubes may have their heating-jackets supplied by a steam-jet exhauster, which serves by the inductive action of a jet of live or exhaust steam to withdraw from the interior of a lower tube the vapors emanating from its contents and to discharge such vapors, together with the steam employed in the exhauster, into the jacket of the next tube above, thereby utilizing the heat present in the vapors emanating from one body of drying material for the purpose of heating another body of drying material.

The employment of the steam-exhausters, as described, will serve to maintain the pressure within the several drying-tubes considerably below the atmospheric pressure, or to produce a vacuum in such drying-tubes.

To further aid in exhausting vapors from the drying-tubes, and to be employed in connection with the steam-jet exhausters as the experience of the operator may determine, I employ a condenser, which may deliver its water through a Torricellian column or baro-

metric leg and an air-pump connected with the condenser; and the interior of the several drying-tubes, either through the hoods at the ends thereof or in any other suitable way, are in free and constant communication by pipes leading from them to a vapor-collector consisting of a stand-pipe or hollow column which communicates with the condenser.

To equalize the pressure, and, also, in a measure, the temperature within the jackets of the several drying-tubes, I connect all the jackets by a series of pipes and valves with a surplus-steam column or stand-pipe.

The water of condensation may be withdrawn through suitable pipes from the jackets of each drying-tube and collected in a hot-water stand-pipe or column; and in order to utilize the heat retained in this hot water I may supply such hot water by a pump to the jacket of the upper drying-tube, which is the first tube into which the solid matter enters, and after performing its work in such jacket the water may be delivered to the condenser.

According to the method which forms the subject of my aforesaid application, I may use steam and vapor, or steam alone, or hot water, in part or in total, in the jackets of the drying-tubes for drying solid matters; or I may partly fill said jackets with a concentrated solution of caustic soda or analogous salt, which, by the condensation of steam and vapor within the jackets, will be diluted and free heat thereby produced, exerting its effect, through the metal contact-walls, on the solid matters within the drying-tubes.

My present invention in apparatus for carrying out my said method also comprises a boiler for the salt solution and pumps and pipes whereby the concentrated solution may be delivered to the jacket of an upper drying-tube, and other pipes connecting the jackets of the several tubes in such manner that the solution will overflow from each to the jacket of the next tube below, and will finally be returned in a diluted state to the boiler. The steam which is generated by the concentration of the salt solution within the boiler may be employed for operating the several steam-jet exhausters, whereby the vapors emanating from the drying contents of each drying-tube are delivered into the heating-jacket of another drying-tube.

The invention consists in novel combinations of parts and details of construction, which are hereinafter described, and pointed out in the claims.

In the accompanying drawings, which represent a battery of five drying-tubes arranged one above another, Figure 1 is a partly sectional elevation of the apparatus in a plane lengthwise of the drying-tubes. Fig. 2 is an end elevation of the apparatus. Fig. 3 is a longitudinal section, upon a larger scale, of portions of the three upper drying-tubes, with their appurtenances, the middle portion of the tubes being broken away to reduce the length of the figure. Fig. 4 is a transverse section upon the plane of the dotted line $x\,x$, Fig. 3—that is, through one of the hoods which connect the tubes. Fig. 5 is a transverse section through the drying-tubes and jackets, between their ends. Fig. 6 is a diagram illustrating an end elevation of the apparatus adapted for the employment of caustic soda or other salt solution in the jackets, the tubes and jackets in this figure being represented by concentric circles only. Fig. 7 is a diagram illustrating the positions of the conveyer-blades as they follow each other in the rotary motion of the shaft. Figs. 8 to 13, inclusive, are diagrams illustrating, by straight lines, the interior surface of a drying-tube, and illustrating the positions to which material is moved and in which it is left by each of the several blades; and Figs. 14 to 17, inclusive, are views illustrating by dotted lines the interior circle of a drying-tube and the several blades which constitute one circular series.

Similar letters of reference designate corresponding parts in all the figures.

A A′ $A^2$ $A^3$ $A^4$ designate the several drying-tubes, which are respectively surrounded by metal jackets B. This battery may be supported at the bottom on a frame-work or columns $A^5$, and the exterior of the jackets may be clothed with non-conducting material to prevent loss of heat by radiation. The drying-tubes are connected alternately at opposite ends by hoods C, which provide for the passage of drying material or solid matter from one to another of them, and which are furthermore provided with rotary valves D, which prevent the vapors emanating from the contents of one drying-tube from passing into the interior of another drying-tube. The several drying-tubes and also their jackets B may be flanged at the ends, as best shown in Fig. 3, and said tubes and jackets, as well as the hoods C, may be connected with and by metal expansion-plates *b*, of copper or other metal, and which will permit the unequal expansion of the drying-tubes and their surrounding jackets without straining the joints of the apparatus.

The drying-tubes and their jackets being both connected with the expansion-plates *b*, any unequal expansion will simply deflect or bend the expansion-plates, which are usually of copper, in a well-known manner, and prevent leakages by undue straining caused by the unequal expansion. The flanges *o* of the several hoods and jackets and the expansion-plates *b* may be of rectangular form, as shown best in Fig. 5, so as to mutually support each other.

The solid matter to be dried, whether it be the refuse of starch or glucose manufacture, or the result of distilling or brewing spirits or ale or beer, or of any other such character as to disintegrate, is delivered by a feeding-hopper or mouth *d*, under control of the valve D, to the upper drying-tube A of the series at the end thereof, and by a series of con-

veyer-blades $c^2$, arranged spirally upon the central shaft $c$, the solid matter is conveyed from the entrance end of the tube A to the opposite end thereof, and is distributed over the lower portion of the interior surface of the tube in the form of a thin layer, in which condition it remains while being traversed or moved through the tube.

As the material reaches the opposite end of the tube A from where it entered, which is the left-hand of Fig. 1, it falls through the hood C into the tube A′, next below, and by the conveying-blades $c^2$ therein is moved toward the right of Fig. 1, and in such manner the solid matter undergoing the drying operation passes through all the drying-tubes of the series in succession and finally escapes under control of the rotary valve D from the lower tube $A^4$ of the series and through an outlet-mouth or delivery-opening $d'$.

I find it advantageous to employ conveyer blades or arms $c^2$, arranged spirally on the rotary shaft, as distinguished from a screw or conveyer having a continuous spiral blade, because such separate blades or arms perform successfully the work of moving the drying matter through the tube and do not close the transverse area of the tube, as would a continuous spiral blade.

I will now describe the particular construction and arrangement of these conveyer-blades with reference to Figs. 7 to 17, inclusive, and although in the main views of my apparatus I have designated the blades by the letters $c^2$, I prefer in these diagrams to refer to them by numerals in order to more clearly describe their operation. I therefore number the blades in Fig. 7, 1, 2, 3, 4, 5, and 6, beginning at the top. The blades 2 and 4, which are only half the thickness of others of the blades, may be formed in the same plane, as shown in Fig. 15, and the blades 5 and 6, which are of like thickness, may also be formed in the same plane and piece, as shown in Fig. 17. The blades 2 and 5 need not extend clear to the interior surface of the cylinder, but fall slightly short thereof, and these blades therefore distribute portions of the layer of material as it is moved forward in bulk by the action of the blades 1 3 4 6. The blade 1, which projects to the inner surface of the tube, first moves all the material in its path forward to a slight distance—say one inch. The blade 2, which is a distributing-blade, then follows and moves forward about one-half an inch the solid matter which lies upon the tube-surface in excess of the layer desired. The blade 3 then follows and cuts the matter moved by 1 in half, and moves one half still farther forward for half the former distance. The blade 4 then follows and moves forward the other half for also half the former distance, or equal to its thickness—say about one-half inch. The blade 5 then follows and, being short, spreads the matter, and the blade 6, which is of half-thickness, next follows and moves the layer which is remaining of proper thickness on the tube-surface forward. Thus the matter is alternately divided at the center of a furrow and moved alternately in thick and narrow furrows and again spread and moved forward, so as to afford the largest possible surface, and to do so in the most complete manner.

While I do not desire to limit my invention to such an arrangement of conveyer-blades as is shown, I find it very desirable to employ this construction and arrangement.

The several conveyer-shafts $c$ extend through stuffing-boxes $c'$ in the heads and may be driven by any suitable mechanism. I have here shown an endless chain $c^3$, which receives motion from a wheel $c^4$, placed upon one of the conveyer-shafts $c$, to which motion is imparted by a belt (not shown) driving upon fast and loose pulleys $c^6$ $c^7$. The remaining conveyer-shafts $c$ are provided with wheels $c^8$, onto which the chain $c^3$ drives.

The shafts $d^3$ of the rotary valves D, which are supported in bearings $d^4$ at the inner side of the hood C and in stuffing-boxes $d^5$ at the outer side of the hoods, may each be driven from an adjacent conveyer-shaft $c$ by chain-wheels $d^6$ $d^7$ and a chain $d^8$, or in any other suitable way.

The construction of the valves D will be best understood from Figs. 3 and 4. Each hood C is formed between the two tubes which it connects with segmental or curved walls $d^2$, and the valve has radial blades or wings $d^9$, which fit snugly against these walls as the valve rotates, and forms between them hopper-like cavities $d^{10}$. These valves are so constructed that the cavity $d^{10}$ will never be in communication with the upper and lower tubes, which the hood connects at the same time, but will, by the rotary motion of the valve, be cut off from communication with one tube before coming into communication with the other tube. When any cavity $d^{10}$ is presented upward, material is delivered into it from the tube above, and when such cavity is brought opposite the tube below or presented downward such material will fall into the bottom of the hood and will by the conveyer be carried forward through the tube. Each hood C is formed with an inner circular wall $e$, as shown in Figs. 3 and 4, thereby forming an outer jacket or space within the hood and the interior of the tube, which is concentric with the inner wall $e$ of the hood and is in communication with the outer space or jacket of the hood through openings $e'$, formed in the wall $e$.

All the vapors which emanate from the drying contents of each tube are exhausted through the hood and through the openings $e'$, as I shall soon describe; and it is advantageous to have the hood constructed with the walls $e$, because the steam or vapor condensing upon these walls and within the jacket-space of the hood serves to impart additional heat to the drying material. It is to be noted, however, that the heat-jackets B of

the several tubes are isolated from the tubes and from each other and are not in communication save through pipes $j$, which serve to equalize the pressure within them, as I shall soon describe.

E F G H designate, respectively, a hot-water collector or stand-pipe, a condenser, a vapor-collector or stand-pipe, and a surplus-steam column or stand-pipe. From each of the heat-jackets B drain-pipes $f$, which are provided with valves $f'$, lead to the hot-water collector E, and deliver thereinto all water of condensation from the jackets and hoods.

The condenser F may be supplied with condensing water through a pipe $f^2$ from any suitable source, and a distributer $f^3$, arranged within it, and the condenser is freed from water by a Torricellian column or barometric leg $F^2$, which is sealed at the bottom within a trough or box $F^3$, provided with an overflow weir $f^5$.

F′ designates an air-pump, which is connected with the condenser by a pipe $f^4$, and serves to withdraw from the condenser air which may be freed from the solid matters during the drying operation.

The vapor-collector or stand-pipe G is shown as connected with the condenser by a pipe $f^6$ for the passage of vapor from it into the condenser, and at the bottom it is connected by a pipe $f^7$ with the hot-water column or stand-pipe E.

The hoods C are provided at the sides and bottom with openings $e^2$, (shown in Fig. 4,) and from one or more of these openings in each hood a pipe $f^8$ extends to the vapor-collector G, and is provided with a valve $f^9$ for controlling the exhaustion of vapor through said pipe from the interior of the drying-tube. It will therefore be seen that through the openings $e'$ in the inner walls of the hoods and the openings $e^2$ and pipes $f^8$, the interior of each drying-tube A, &c., is in open communication with the vapor-collector G. Similar pipes $f^8$, having valves $f^9$, lead from the drainage-openings of the jackets in the hoods C to the collector G. The several jackets B of the drying-tubes A, &c., are connected by pipes $j$ and valves $j'$ with the surplus-steam collector or stand-pipe H, and thereby the pressure within the several jackets is equalized. This surplus-steam collector H may be connected by a pipe $j^2$ with the barometric leg $F^2$, and its upper end may be connected by a small pipe $j^3$ with the condenser F.

I designates steam-jet exhausters which are each employed to exhaust the vapor from one drying-tube and discharge it, together with the steam required to work the exhauster, into the jacket of another drying-tube, thereby utilizing the heat which may be in the vapors emanating from the drying matter, for the purpose of heating through the metal contact-walls of another drying-tube the matter contained therein. As best shown in Fig. 5, each exhauster consists of a body $h$, closed by a cap or head $h'$, in which is a concentric nozzle for vapors $h^2$. The steam for operating the exhauster may be supplied through branch pipes $h^3$ from a steam-supply pipe $h^4$, and through a suction-pipe $h^5$, having a branch $h^6$, leading to an outlet-opening $e^2$ of the jacket-space in a hood, as shown in Fig. 4. The vapors emanating from the contents of one drying-tube may be exhausted therefrom and discharged, together with live steam, into the jacket B of a second drying-tube.

By adjusting the cap or head $h'$ of the exhauster relatively to the body $h$, the annular space between the nozzle for vapors $h^2$ and the body $h$ may be reduced or increased in area, so as to control the flow of steam supplied by the branches $h^3$ to operate the exhauster.

In each branch suction-pipe $h^6$ is a check-valve $h^7$, opening outwardly from the hood C, and having at the side peep-holes $h^8$, closed by glass, and through which the operation of the valve may be seen, and the operation of the steam-jet exhauster thereby determined.

It will be seen by reference to Fig. 1 that the suction-pipes $h^5$ $h^6$ of the steam-jet exhausters I communicate with the hoods C at those ends of the tubes which first receive the solid matters from the tubes above them, while the exhaust-pipes $f^8$ communicate with one side of the hood C at one end of the drying-tube and with the opposite side of the hood C at the other end thereof. I do not, however, limit myself to any particular arrangement of the several pipes described or to any particular manner of connecting them with the jackets and hoods, except as may be necessary to the carrying out of my invention.

Steam may be supplied to the jacket B of the lower and last drying-tube of the series through a pipe $h^9$, (best shown in Fig. 2,) and which leads from one of the steam-pipes $h^4$, and the heating-jackets of the other drying-tubes may each be supplied with hot vapor taken from the interior of the tube below and the live steam employed to operate the exhauster I, whereby the flow of such hot vapor is introduced.

I have shown as a means of exhausting vapors emanating from the contents of the several drying-tubes both the steam-jet exhausters I and the pipes $f^8$, communicating with the condenser F, and the air-pump F′. These devices may be used conjointly for the purpose intended, as the experience of the operator shall determine, or, if desired, either of them may be used singly. The employment of the condenser and air-pump alone as a means of exhausting vapor from the several drying-tubes would, however, necessitate the employment of live or exhaust steam from an outside source in the jackets B of all the drying-tubes, except, possibly, the upper one, for a reason soon to be described.

In order to utilize the heat which remains in the hot water of condensation within the collector or column E, and thereby to promote the economy of operation, I may take

such hot water, by a pump J, from the bottom of the column E and deliver it through a pipe $j^4$ into the jacket B of the upper drying-tube A, and after giving up its heat to the solid matter contained in this tube through the metal walls thereof the cooler water may pass from the jacket through a pipe $j^5$ to the condenser F. The pipe $j^4$ may also have a branch $j^6$, through which any surplus hot water will be delivered by the pump J direct to the condenser. The upper end of the hot-water column may be connected by a pipe *s* with the upper part of the condenser.

I will now describe the construction of apparatus and arrangement of connections which I employ when a concentrated solution of caustic soda or other salt is used in the jackets B of the several drying-tubes, such an arrangement being represented by the diagram, Fig. 6. In that figure I have represented the several tubes and their jackets by concentric circles only, and it will be understood that such tubes and jackets are to be connected with the condenser F, the vapor-collector or stand-pipe G, and the surplus-steam collector H in the manner before described.

K designates a boiler, which should be capable of resisting strong internal pressure, and which may be heated by a furnace for the concentration of a solution of caustic soda or other salt. Through a pipe *k*, leading from the bottom of this boiler, the concentrated solution is taken by a pump K′ and is delivered into the jacket B of the upper drying-tube near the bottom. From about the middle of the height of this jacket the soda solution overflows through a pipe *k′* to the bottom of the jacket B of the next lower tube A′, and in like manner the soda solution overflows from each jacket through pipes $k^2$ $k^3$ $k^4$ to the jacket next below, and finally is taken through a pipe $k^5$, and in its diluted form is returned by a pump $K^2$ to the boiler K.

It will be understood that the condensation of steam and vapor, either or both, within the jackets of the several drying-tubes serves to dilute the concentrated salt solution, and thereby sets free or produces heat, which is transmitted through the metal contact-walls to the solid matter undergoing the drying operation within the tubes. The steam which is generated in the boiler K during the concentration of the salt solution may be conducted through pipes $h^4$ and employed to supply the steam-jets necessary for operating the steam-jet exhausters, which are used to withdraw the vapors emanating from the contents of the several drying-tubes and to discharge such vapors, together with the high-pressure steam which operates the exhausters, into the heating-jackets of the tubes next above.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The combination, with a plurality of closed drying-tubes severally provided with heating-jackets and with inlets and outlets for solid matter at opposite ends, of conveyers for moving solid matter through the tubes, a pipe for introducing heating-fluid from an outside source to the jacket of one tube, and a connection through which the hot vapors emanating from the contents of that tube are delivered to the jacket of the next tube in the series to serve as a heating agent therefor, substantially as herein described.

2. The combination, with two or more closed drying-tubes provided with heating-jackets and with inlets and outlets for solid matter at opposite ends, of conveyers for moving the drying-matter through said tubes, a pipe for supplying heating-fluid from an outside source to the jacket of one tube, and steam-jet exhausters, one for each drying-tube and each having a steam-supply pipe, a suction-pipe leading from the interior of one tube, and a delivery-pipe leading to the jacket of another tube, whereby the vapor emanating from the contents of one tube is withdrawn therefrom and delivered, together with the steam employed to work the exhauster, to the heating-jacket of another tube, substantially as herein described.

3. The combination, with a plurality of closed drying-tubes connected at the ends by bonnets or hoods to provide for the passage of solid matter from one to the other of them and severally provided with heating-jackets, of conveyers for moving the matter to be dried through the tubes, steam-jet exhausters, each having a steam-supply pipe, a suction-pipe leading from one drying-tube and a delivery-pipe leading to the jacket of the next tube in the series and each serving to withdraw from one tube the vapors emanating from its contents and to discharge such vapors to the heating-jacket of the next tube, and a condenser and an air-pump also connected with the several tubes for aiding in exhausting air and vapor therefrom, substantially as herein described.

4. The combination, with the jacketed drying-tubes, of bonnets C, connecting said tubes for the passage of solid matter from one to the other of them and constructed with the perforated partitions *e*, forming continuations of the drying-tubes, exhaust-pipes connected with the bonnet-space outside said partitions, conveyers working within said tubes and extending into the bonnets, and rotary valves D, each constructed with wings or bearing portions $d^9$ and interposed pockets $d^{10}$, which are exposed to the two tubes alternately, substantially as herein described.

5. The combination, with the concentric drying-tubes A and jacket-tubes B, of the bonnet C, rotary valves fitting segmental seats in the bonnet and constructed with cavities in their peripheries for delivering solid matter from one to another of the drying-tubes without placing them in direct communication, and the expansion-plates *b*, whereby the bonnet

and tubes are connected and which permits of unequal expansion of the parts without danger of leakage, substantially as herein described.

6. The combination, with a series of closed drying-tubes provided with heating-jackets and conveyers for moving matter to be dried through them in succession, of bonnets connecting the tubes, and rotary valves fitting seats in the bonnets and having peripheral cavities for delivering solid matter from one to another of the tubes, pipes for supplying steam or hot vapor to the jackets of certain of the tubes, and pipes and a pump for receiving and collecting the hot liquid of condensation from such jackets as receive steam or vapor and for supplying the said liquid to the jacket of one of the drying-tubes, substantially as described.

7. The combination, with a series of closed and jacketed drying-tubes connected, as described, by bonnets and valves and provided with conveyers, of pipes for supplying steam or vapor to the jackets of certain of the drying-tubes, exhausting apparatus for maintaining a pressure below the atmosphere in said tubes, the hot-water stand-pipe connected with the jackets, which are supplied with steam or vapor for receiving hot water of condensation from said jackets, and a pump and pipe whereby the hot water of condensation is delivered to the jacket of another of said tubes for heating the same, substantially as herein set forth.

8. The combination, with a series of closed and jacketed drying-tubes connected by bonnets and valves, as described, and provided with conveyers, of a pipe for supplying steam to the jacket of one tube and steam-jet exhausters, each having a steam-supply pipe, a suction-pipe leading from one drying tube and a discharge-pipe leading to the jacket of the next drying-tube in the series, whereby the vapors emanating from the contents of each tube are delivered to the jacket of the next tube in the series, and a condenser and air-pump also connected with the several tubes, substantially as herein set forth.

9. The combination, with a series of closed and jacketed drying-tubes connected by bonnets and valves, as described, and provided with conveyers, of a pipe for supplying steam to the jacket of one tube, steam-jet exhausters, each having a steam-supply pipe, a suction-pipe leading from one drying-tube of the series and a discharge-pipe leading to the jacket of the next drying-tube in the series, whereby the vapors from the contents of each tube are delivered to the jacket of the next tube in the series, and the surplus steam and water stand-pipe connected with the jackets of all the tubes and serving to equalize the pressure within them, substantially as herein described.

10. The combination, with a series of closed drying-tubes connected, as described, by bonnets or hoods and valves to deliver solid matter from one to another of them and provided with heating-jackets and conveyers, of the condenser having the air-pump connection $f^4$, and the vapor-collector G, connected with the condenser and connected by the pipes $f^8$ with the drying-tubes, substantially as herein set forth.

11. The combination, with a series of closed drying-tubes connected, as described, by bonnets or hoods and valves to deliver solid matter from one to another of them and provided with heating-jackets and conveyers, of the condenser F and its air-pump connection $f^4$, the vapor-collector G, connected by pipes $f^8$ with the several drying-tubes and also connected with the condenser, and the surplus-steam collector H, connected by branches with the several heating-jackets and also connected with the condenser, substantially as herein described.

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Witnesses:
C. HALL,
H. MCBRIDE.