J. H. & C. H. CAMPBELL.

DESICCATING APPARATUS.

APPLICATION FILED DEC. 18, 1900.

956,038. **Patented Apr. 26, 1910.**

3 SHEETS—SHEET 1.

FIG. 1.

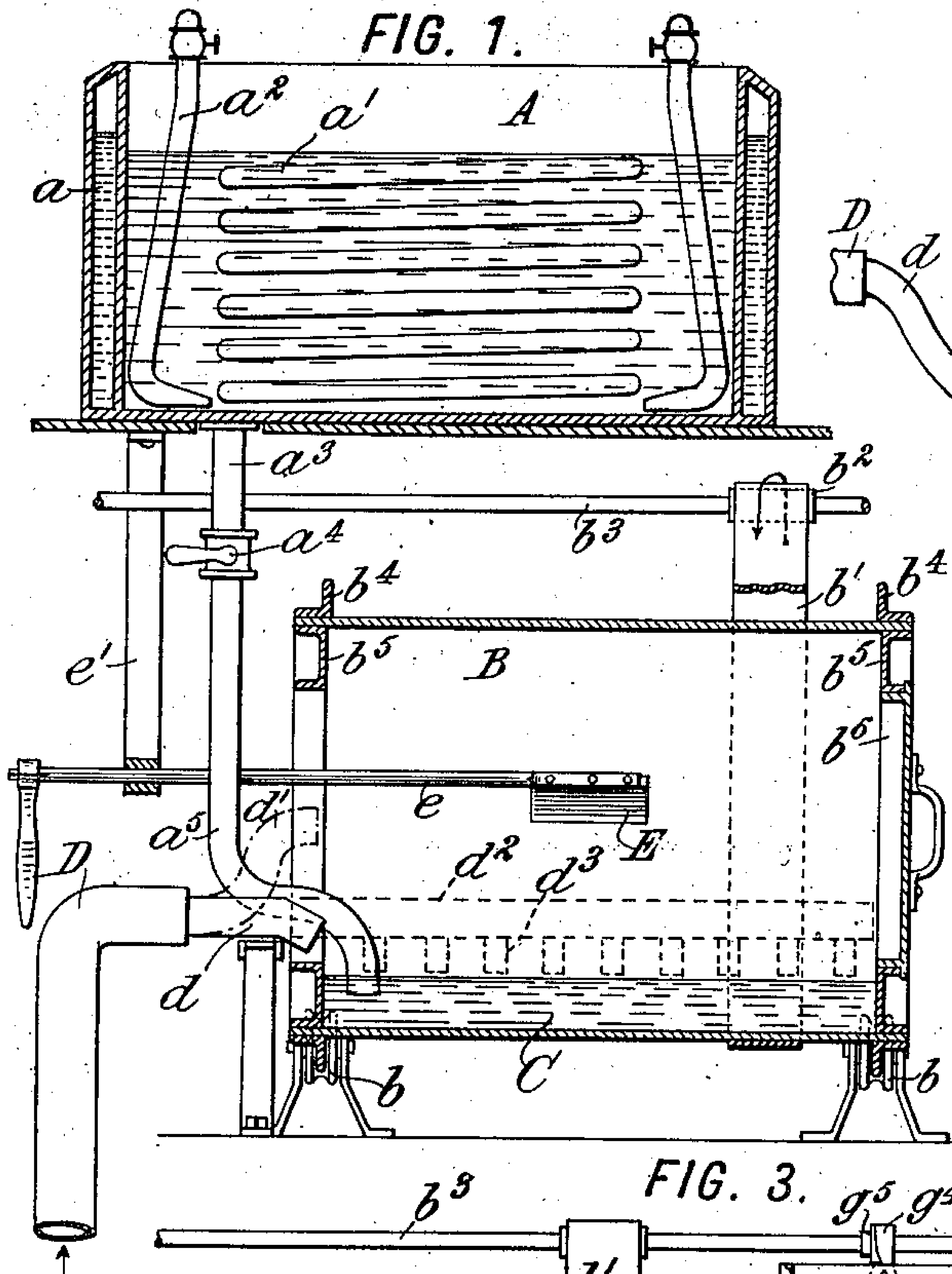


FIG. 2.

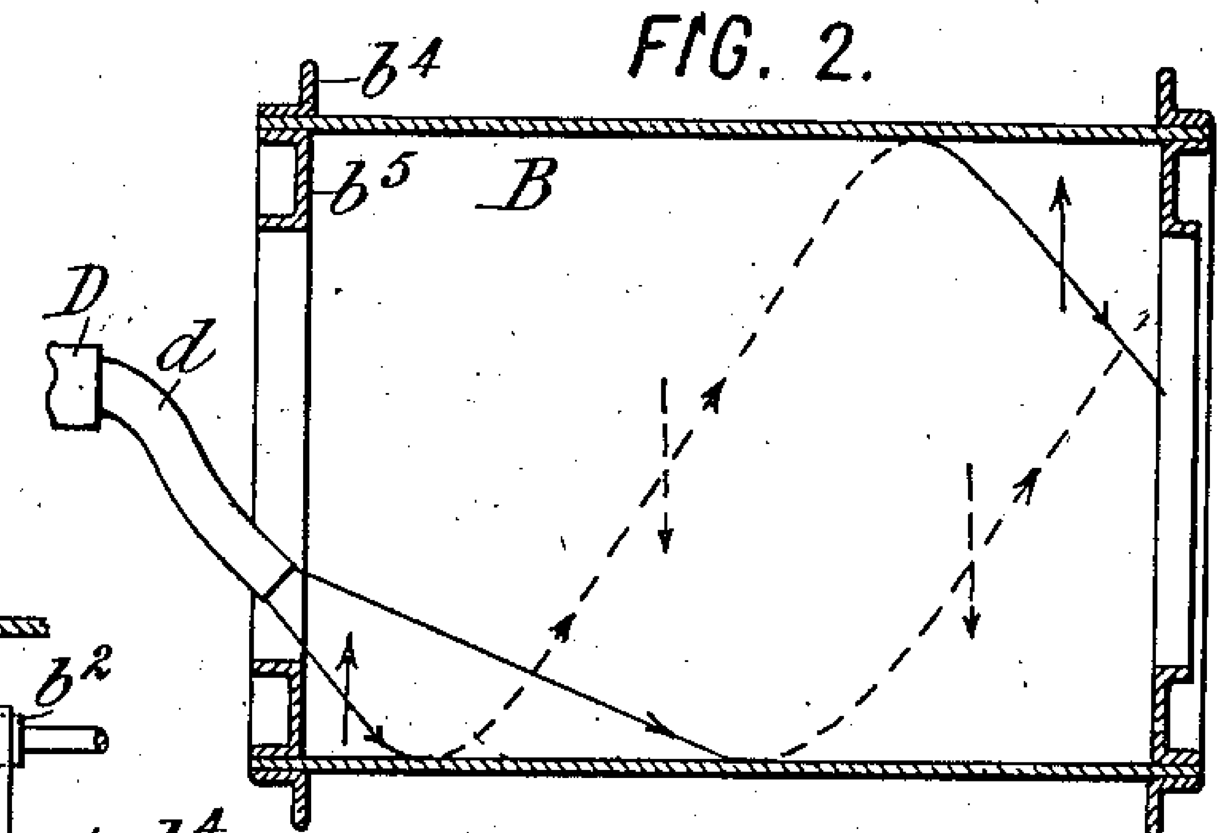


FIG. 4.

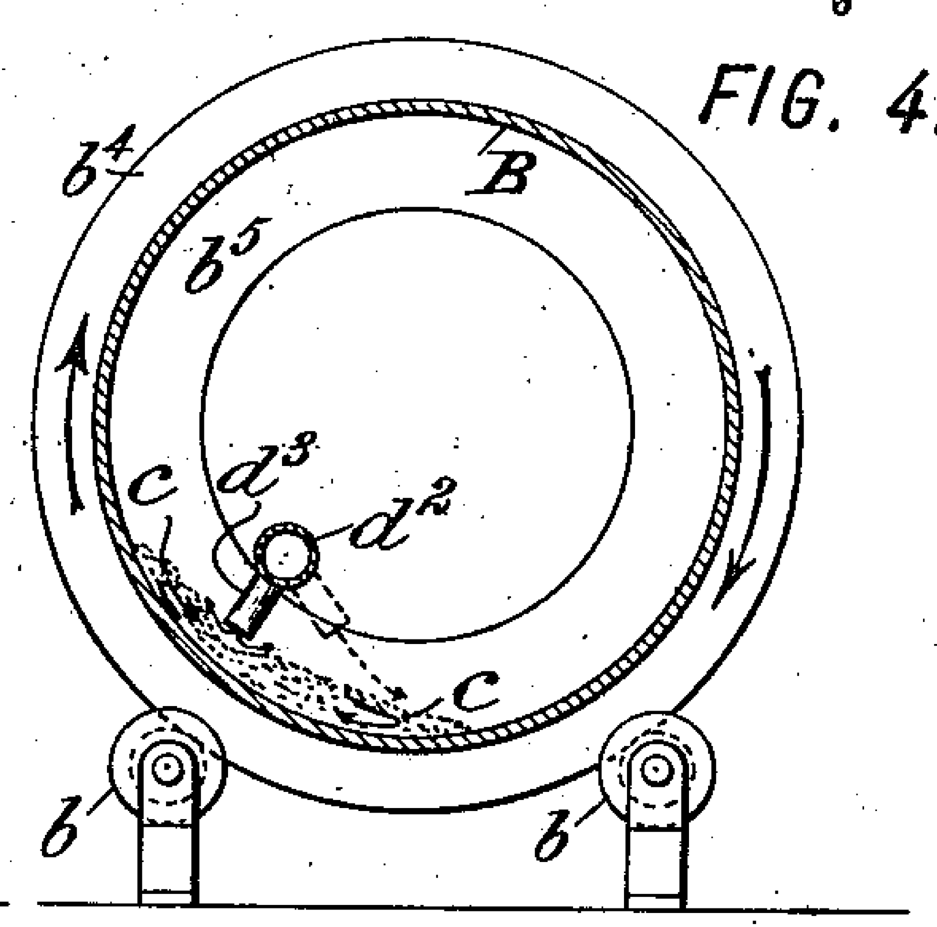


FIG. 3.

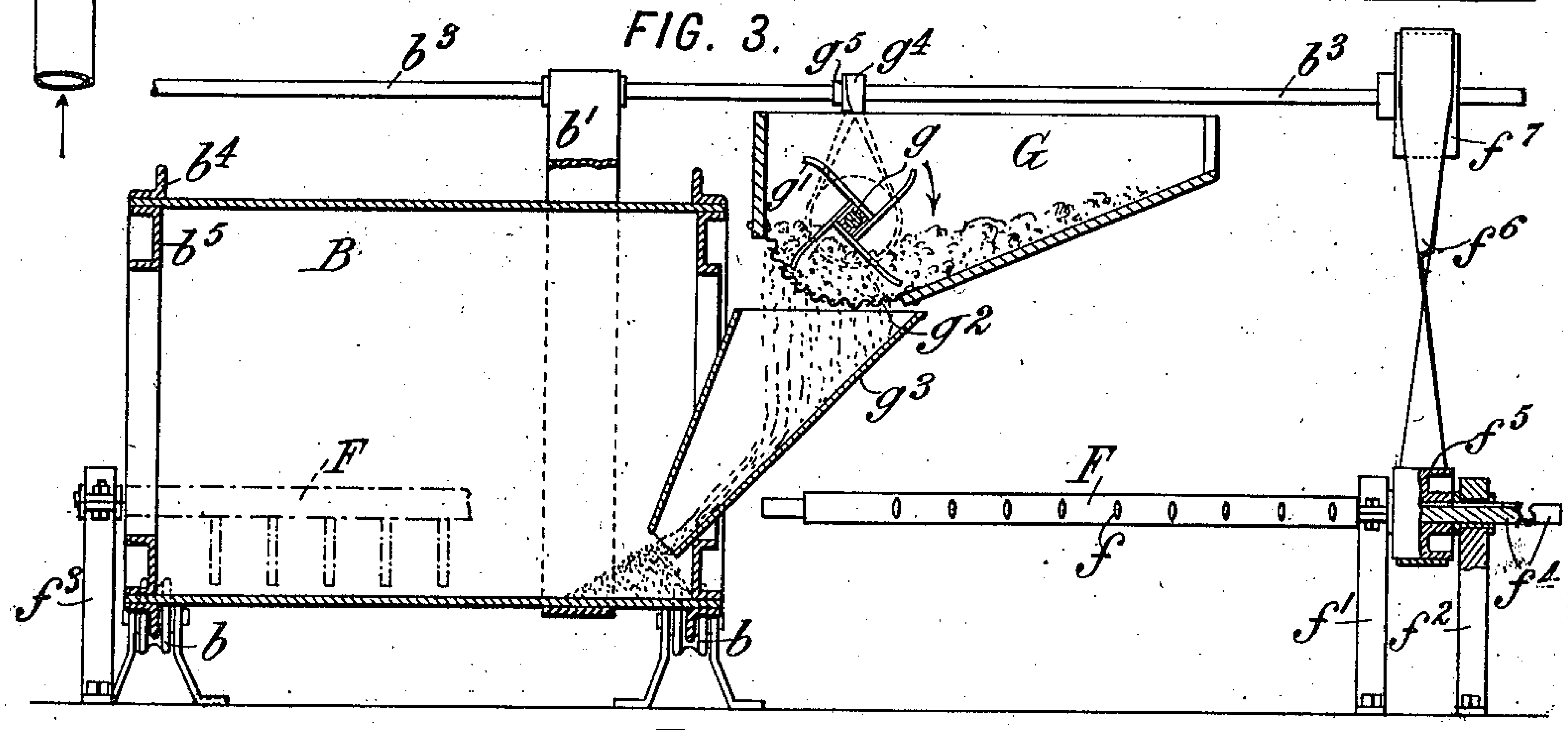
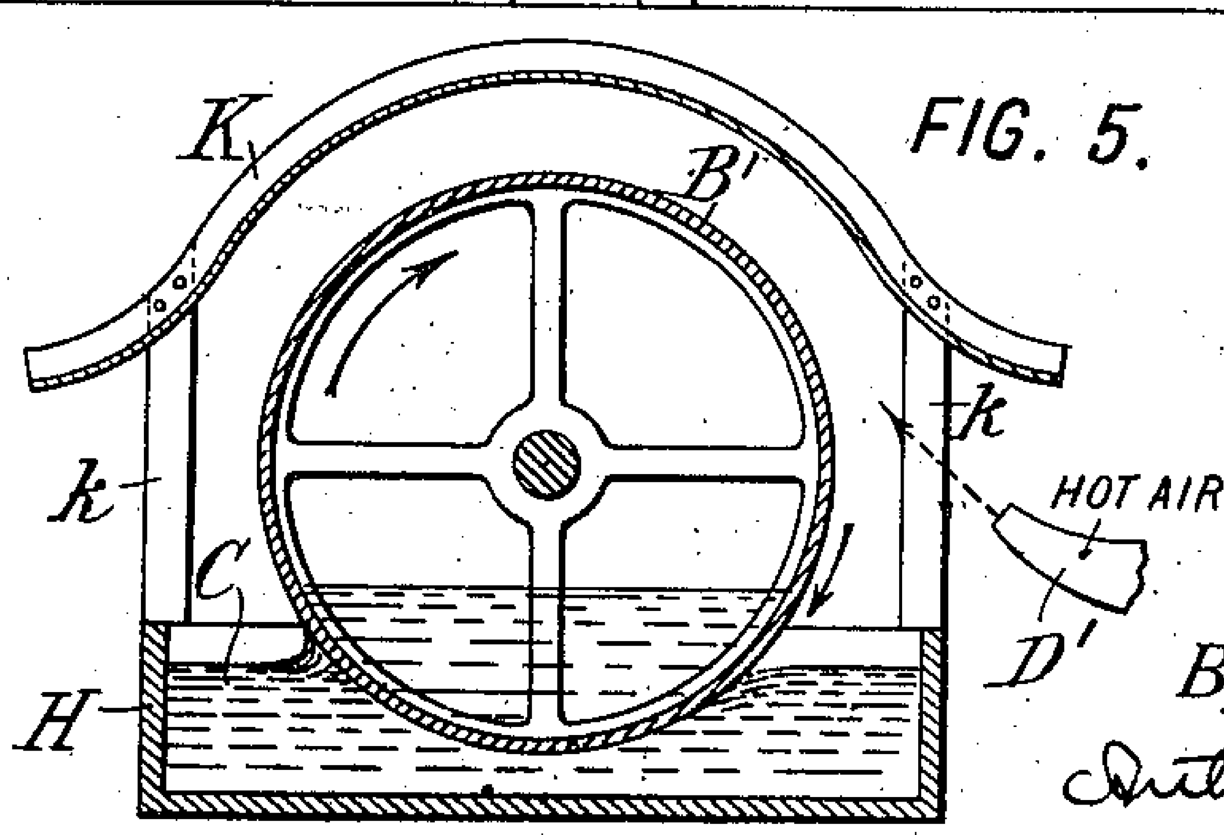


FIG. 5.



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3 SHEETS—SHEET 2.

FIG. 7.

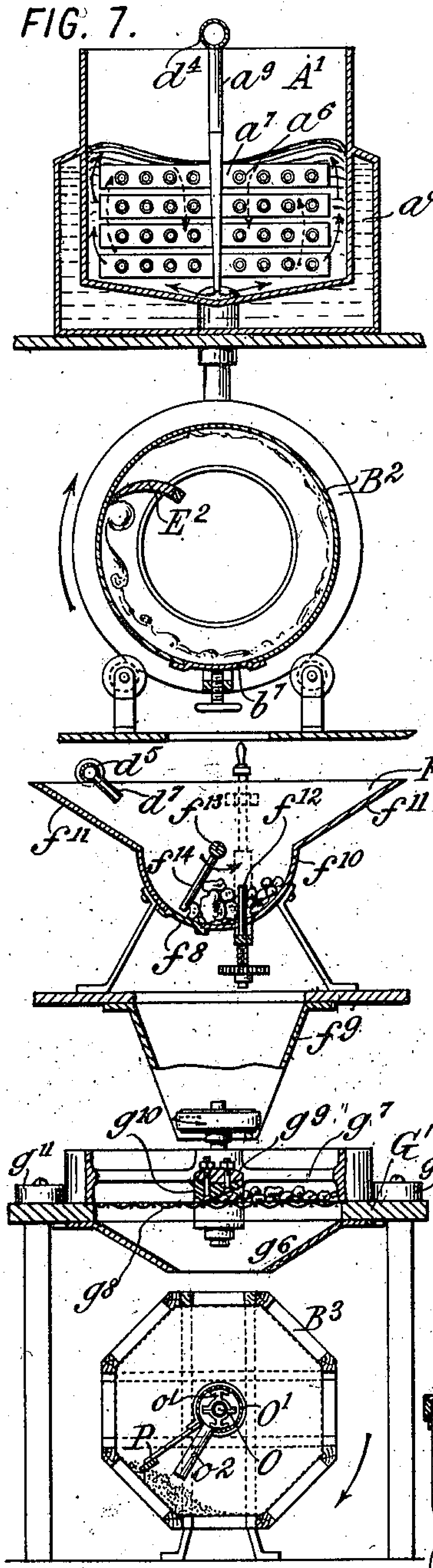
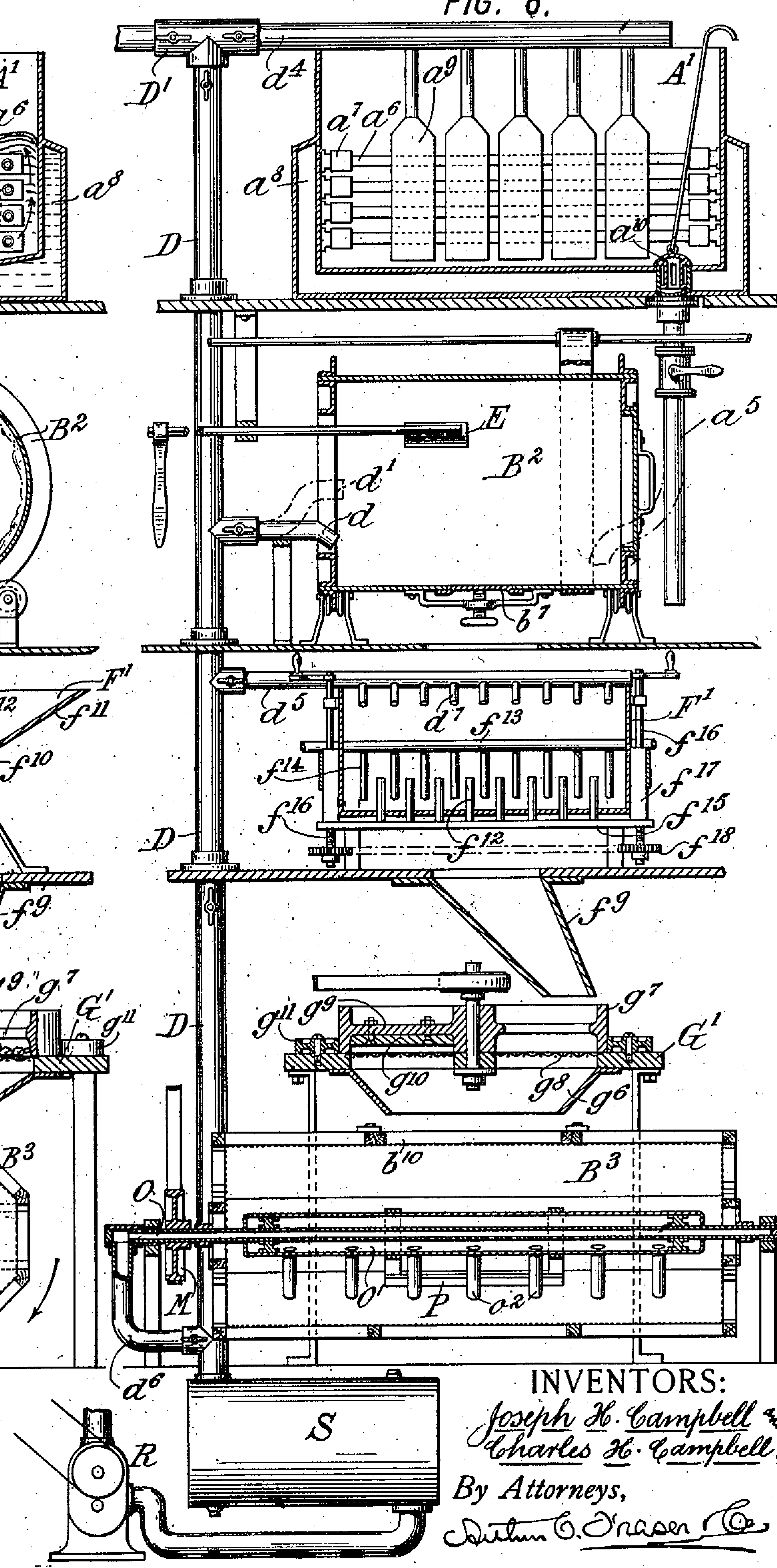


FIG. 6.



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3 SHEETS—SHEET 3.

FIG. 8.

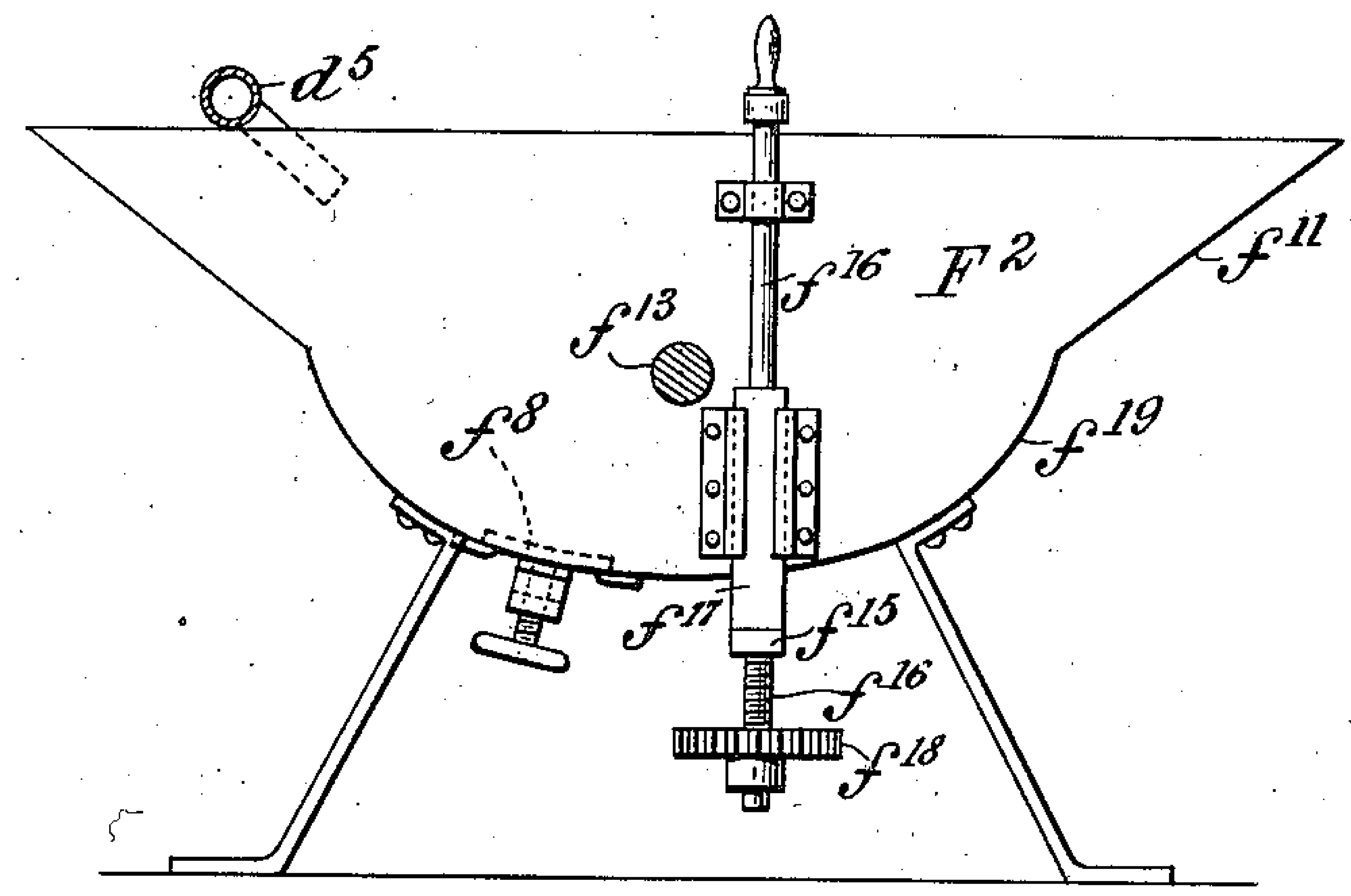


FIG. 9

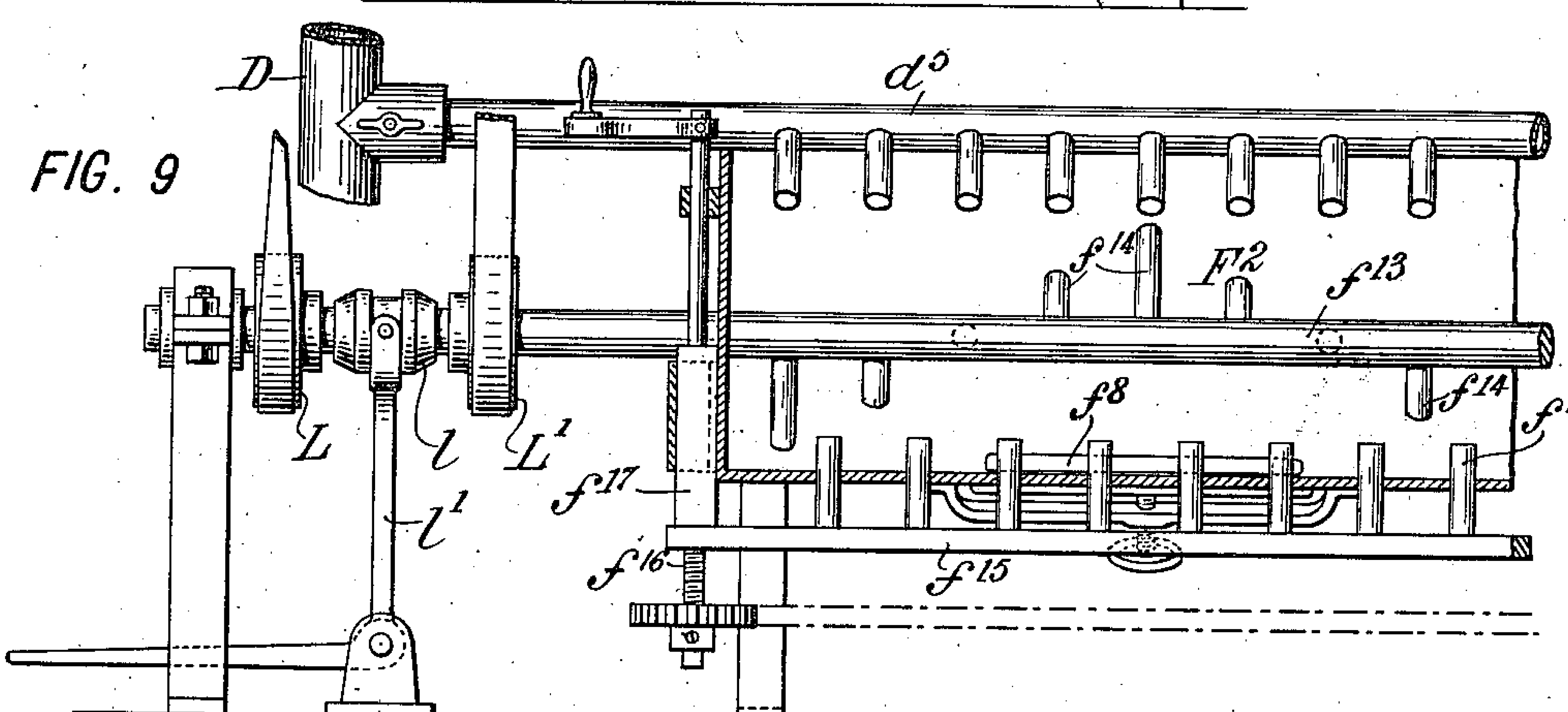


FIG. 11.

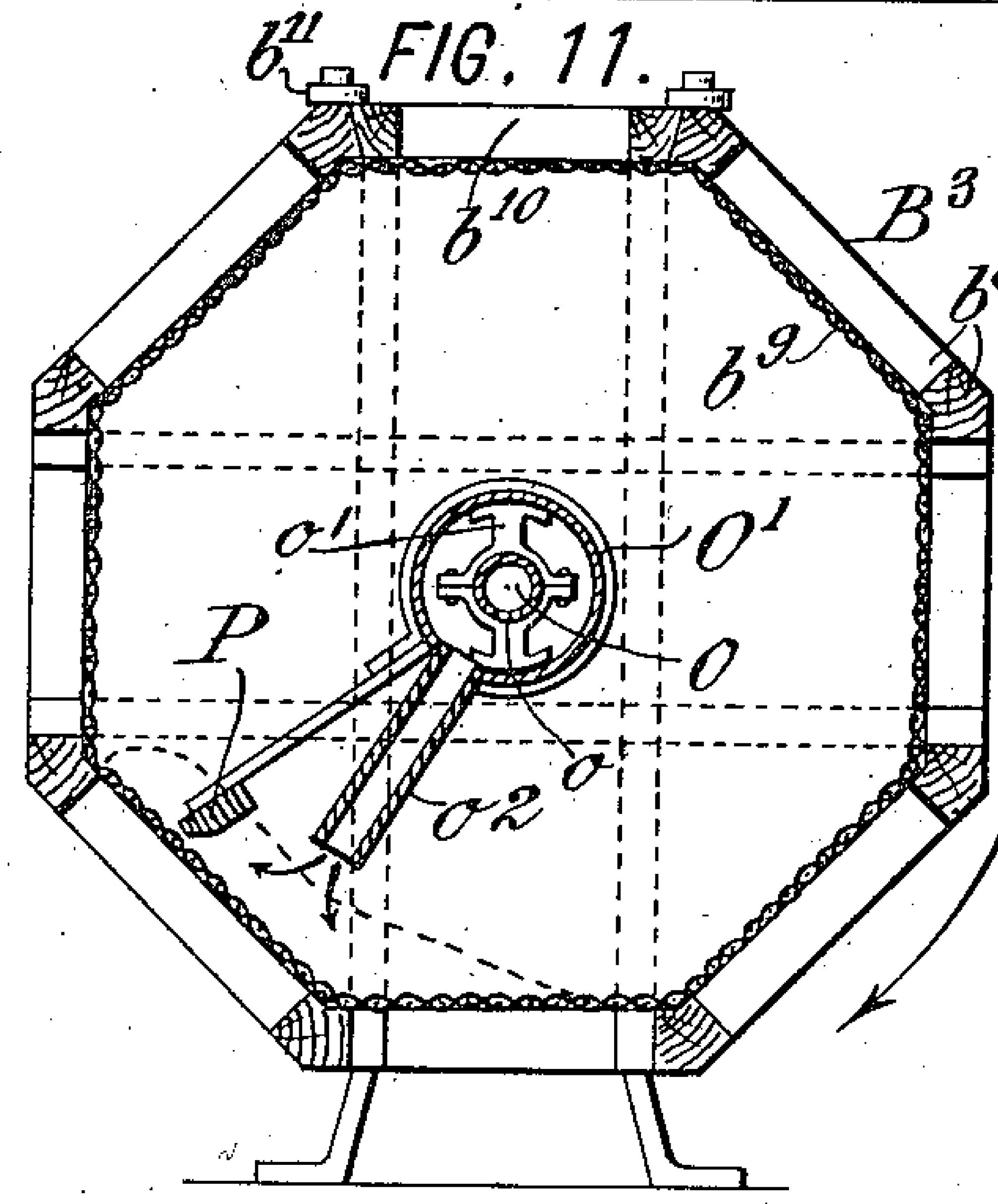
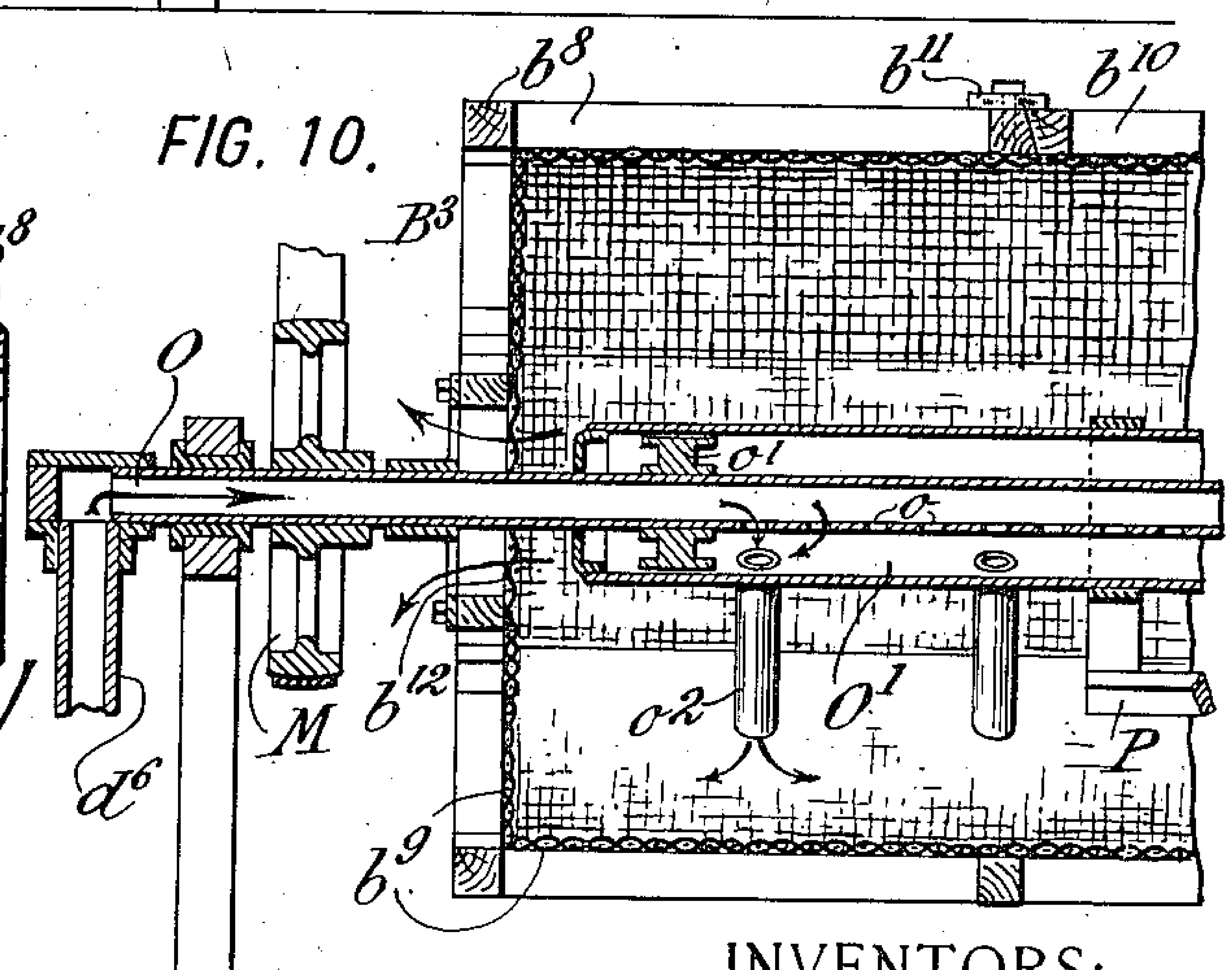


FIG. 10.



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UNITED STATES PATENT OFFICE.

JOSEPH H. CAMPBELL, OF NEW YORK, N. Y., AND CHARLES H. CAMPBELL, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNORS TO NATIONAL NUTRIENT COMPANY, OF JERSEY CITY, NEW JERSEY, A CORPORATION OF NEW JERSEY.

DESICCATING APPARATUS.

956,038. Specification of Letters Patent. **Patented Apr. 26, 1910.**

Application filed December 18, 1900. Serial No. 40,282.

To all whom it may concern:

Be it known that we, JOSEPH H. CAMPBELL and CHARLES H. CAMPBELL, both citizens of the United States, and residing in the city, county, and State of New York, and in the city and county of Philadelphia and State of Pennsylvania, respectively, have jointly invented certain new and useful Improvements in Desiccating Apparatus, of which the following is a specification.

Our invention provides an improved desiccating apparatus, and especially an apparatus for the desiccation of materials which possess a certain degree of fluidity such as pure liquids or dry granular materials, or materials which by desiccation may be made to pass from a purely liquid condition to a dry granular condition.

Our apparatus is most efficient on materials which may be spread out or divided to expose an extended area, such, for example, as those which possess in their liquid or viscous condition a certain amount of stickiness which causes them to adhere to a carrier so that they may be drawn out on said carrier into a thin layer or film.

In the accompanying drawings which represent embodiments of our invention, Figure 1 is a vertical section of a concentrator which may be used for reducing the material to a suitable condition for the most efficient operation of our desiccator proper, and of a cylindrical carrier and appurtenances forming the principal elements of one apparatus; Fig. 2 is a horizontal section of said carrier showing the directing of the desiccating blast on the material in a liquid condition; Fig. 3 is a mechanism which may form a continuation, at the right, of Fig. 1, this figure representing a later stage of the operation than that of Fig. 1 and showing a breaker and sizer which may be used in connection with the cylinder of Fig. 1 after certain devices shown in Fig. 1 are removed; Fig. 4 is a cross-section of said carrier showing a means for directing and controlling the blast on the material in a granular condition, this figure representing the final step of the desiccating operation; Fig. 5 is a cross-section of a modified form of said carrier; Figs. 6 and 7 are longitudinal and cross sections respectively of a modified form of the complete apparatus, especially adapted for the rapid handling of large quantities of material; Figs. 8 and 9 are respectively an end view and a section of a modified form of the means for breaking the large lumps shown in Figs. 6 and 7; and Figs. 10 and 11 are enlarged sections similar to those of Figs. 6 and 7, of the means for effecting the final step of the desiccating operation.

The principal elements of the apparatus are a concentrator (preferably including a tank, coils, jacket, air pipes, etc.) in which a mass of liquid is condensed, say, for example, from the consistency of fresh milk to that of condensed milk, and a solidifying means which receives the reduced mass from the concentrator and further condenses it to a solid condition. It will be observed that the word "condensed" is here used as referring to a concentration or reduction of volume. After reduction to a solid condition the material is preferably "desiccated", by which term I mean reduced to an approximately bone-dry condition. In the solid condition the mass is in large lumps which are moist at their center, and these lumps are broken into small particles before the final step of desiccating. The steps of concentrating, solidifying, and desiccating are performed preferably in three different apparatus, which I designate respectively as a concentrator, a solidifying means, and a desiccator. For example, the tank A and jacket, coils, nozzles, etc. as hereinafter described in detail, constitute the concentrator; the cylinder B with the means for rotating it, the scraper, the air nozzle, etc., constitute the solidifying means; and the drum B^3 with the air nozzles constitute the desiccator. Or a drum similar to the drum B used in the solidifying means may also be used in connection with the air nozzles to constitute the desiccator. In the completest form in which I have provided the apparatus it contains not only the concentrator, solidifying means, and desiccator described, but also a breaker and a sizer or sifter; the parts being arranged in the manner indicated diagrammatically in Figs. 6 and 7.

We will first state briefly the conditions through which the material passes and the operation of our apparatus as it acts on the material in different stages of dryness.

Where the material is already in a semi-liquid condition, as, for example, that of condensed milk, it may be introduced directly into a cylindrical carrier B constituting the principal element of the solidifying means, Fig. 1 (or B^2, Figs. 6 and 7). Where the material is quite liquid, however, as in the case of fresh milk, either whole or separated, it is preferably first introduced into the tank A of the concentrator, Fig. 1 (or A′, Figs. 6 and 7) and there reduced to the desired consistency, after which it passes into the cylinder B or B^2. By the revolution of the cylinder the material is extended by being drawn out into a film and by being divided into particles of various sizes which drop from the uppermost side of the cylinder and it is at the same time subjected to a blast of hot air which carries off the greater portion of the moisture, leaving a plastic mass adhering to the inside of the cylinder. The plastic mass is scraped from the sides of the cylinder and, the hot air blast continuing, takes the form of loaves or lumps which are dry enough on their exterior to remain separate. These lumps are then broken either by introducing the breaker F, Fig. 3, into the cylinder containing the lumps or by passing the lumps into a breaker F′, Figs. 6 and 7, continuing the hot blast in either case. The breakers F and F′ may be arranged to reduce the lumps to grains of the uniform size ultimately desired. But we prefer to use an additional "sizer" G or G′ for this purpose. The uniformly granulated, but still somewhat moist, material finally returns to the cylinder B, Fig. 4, or passes to a drum B^3, Figs. 6 and 7, in which the desiccation is completed.

Referring to Figs. 1 to 4 of the drawings, A indicates a tank of the concentrator in which material which is of an extremely fluid nature and possesses very little stickiness may be first reduced to a condensed mass of such a consistency as to exhibit the desired degree of stickiness for further treatment. The specific construction of this tank A forms no part of our present invention. Any other apparatus capable of reducing the material to the proper condition for further treatment in the cylinder B is regarded for the purposes of our invention as the equivalent thereof; or, as explained, in some cases such a tank may be dispensed with entirely. It will therefore be only briefly described. It contains a water jacket a and coils a' through which water at a comparatively high temperature is introduced, and pipes a^2 through which air at a somewhat lower temperature than the water is introduced into the bottom of the tank and passes through the material which is being reduced, taking up a portion of the moisture thereof and maintaining the temperature below that in the water jacket and coils. A detailed description of the operation of this apparatus will be found in the application of Joseph H. Campbell, No. 22,105, filed June 30, 1900. Of course if the material is originally of the desired consistency and stickiness, this apparatus may be dispensed with.

B is a carrier constituting the principal part of the solidifying means shown as a cylinder rotating on a horizontal axis, being supported on guide pulleys b or the like, and rotated by any suitable means, such as a belt b' running around the body of the drum and over a pulley b^2 on a power shaft b^3. External flanges b^4 near the ends of said cylinder form guides which rest in the pulleys b. Internal flanges b^5 at the ends of said cylinder serve as retaining walls to hold the material C in the cylinder as it rotates. A head or cover b^6 is provided for closing the opening inside of the flange b^5 at the end of said cylinder opposite that at which the hot air is admitted. For the purpose of transferring the material from the tank A to the cylinder B, any suitable means may be used, such as a pipe a^3 provided with a cock a^4 and having a flexible lower portion a^5.

The hot air which we preferably use for desiccation is carried through a stationary tube D, which is provided with removable nozzles d d' d^2 for the purpose of projecting the blast in any desired direction.

The nozzle d is shown in plan view in Fig. 2, together with spirals indicating the direction of the extreme elements of the blast which is projected therefrom, and arrows indicating the direction of movement of the film; the dotted lines indicate the portion of the blast or film which is above the plane of section, that is, in the upper half of the cylinder. The arrow in Fig. 1 shows the direction of rotation of the belt b' and of the cylinder to be opposite to the direction of the blast produced by the nozzle d, as shown in Fig. 2.

The body of the material C in its original state or as reduced in the tank A, rests in the lower part of the cylinder B, as shown in Fig. 1. The rotation of said cylinder by reason of the adhesiveness of the material C, draws said material out into a film on the inner side of said cylinder, taking said film around from one side of the body of the material in the bottom of the cylinder, and returning it to the other side of said body. At the same time the blast from the nozzle d is projected against said film in a direction opposite to the movement of the film, so as to retard such movement and continue the exposure of the film to the hot air for as long a period as possible; the hot air meantime carrying off the moisture from the film. The entire body of material is thus drawn out into successive films or one continuous film, and exposed while in this form to the desiccating action, which is therefore very complete and rapid, without any necessity for the use of a high temperature. At the same time the dropping of the material like rain from the upper side of the cylinder exposes an additional extended surface to the hot air and conduces to greater rapidity of operation.

Whether the blast be projected spirally or centrally through the nozzle d', I prefer to close the opposite end of the cylinder by means of the head b^6 (as shown in Fig. 1) while the blast is in operation, and thus to retard the escape of the hot air, compelling it to travel back to the entrance end of the cylinder and to take up additional moisture before allowing it to escape. I thus use the same air twice with a considerable increase of the speed of the operation over that which would be possible with both ends of the cylinder open.

The temperature on the side of the carrier or cylinder opposite to the film is somewhat lower than that within the carrier or on the film-coated side thereof, and the carrier is preferably also made of conducting material, such as tinned sheet metal. It results from this arrangement that the film is kept at a temperature considerably lower than that of the hot blast applied to it, by reason of the rapid evaporation and the rapid conduction of the heat through the material of the carrier to the cooler atmosphere on the uncoated side thereof. This cooler atmosphere may be only such as is common in work rooms, say from 70 degrees to 80 degrees, or it may be an artificially created atmosphere somewhat cooler than this if desired.

For the desiccation of materials of a thickly viscous consistency, or material which has been reduced to such consistency, the cylindrical form of our apparatus is especially adapted. The desiccation of very fluid materials which form a very thin film or coating on the carrier, may be accomplished on carriers of a great variety of shapes, and moving in a great variety of directions, and the cylindrical shape which I have shown for carrying out this stage of the desiccation is but one of the many forms which may be used for this purpose. When the material is viscous, however, it coats the carrier with a much thicker coating, and for the purpose of automatically removing this coating from the carrier, the cylindrical form shown is best adapted.

The material being in the bottom of the cylinder, is carried on the upwardly moving side thereof, gradually increasing in thickness as the successive layers accumulate upon one another and are partially desiccated. By being carried upward and then toward the horizontal on the under side of the carrier as is the case inside of our cylinder, the weight of said coating causes it to separate from the carrier and roll down the ascending side or drop directly into the bottom, thus exposing the various portions thereof again and again to the desiccating atmosphere within said cylinder, until the whole is reduced to such a comparatively dry condition that it is largely in lumps, solid or slightly plastic, and with just sufficient adhesive power on their exposed portions to travel up the ascending side of the carrier. For completely removing material of this consistency from the sides of the cylinder, I provide a knife E adapted to project through an open end of the cylinder by means of a long handle e, preferably supported in a bearing e' beyond the end of the cylinder. This knife being pushed into the cylinder at the desired point of desiccation, and preferably while the hot air blast continues, is turned so that its edge bears against the ascending side of the cylinder and scrapes the nearly solid material from the carrier and rolls it down in lumps as aforesaid into the bottom of the carrier, where it stays by reason of the desiccation of its exposed surface. Material which is in the condition last described, lumps of irregular size desiccated on their exposed surfaces, but still moist on their interiors, or material which has been previously reduced to such a condition, would require a great length of time for its complete desiccation, unless the lumps be broken so as to expose their interiors. For this purpose we provide (see Fig. 3) a breaker F composed of a shaft having arms f and adapted to be extended into the cylinder through one of the open ends thereof as shown in dotted lines, and rotated rapidly therein so as to break up the lumps of said material and expose their moist interiors to a desiccating atmosphere. Said breaker F is provided with bearings f' and f^2 beyond one end of said cylinder, and a bearing f^3 beyond the opposite end. An extension f^4 of said breaker slides through a pulley f^5 to which it is splined, said pulley being rotated in a direction opposite that of the cylinder B by a belt f^6 and a pulley f^7 on the driving shaft b^3. Said pulley f^7 may be provided with any suitable means for connecting it to and disconnecting it from said shaft, or when the breaker is not in operation the belt f^6 may be thrown off its pulley f^7. In use, the rotation of the cylinder and the projection of the blast being continued, the breaker F is shoved into the cylinder, the arms f being held in a horizontal or upwardly-turned position for this purpose; the belt f^6 is then driven and the breaker rotated at a rapid rate, reducing the lumps to a size somewhat smaller than the distance between the arms f. This action breaks the lumps in a free space, so that there is no compression of the material, and no consequent rise in temperature. The newly exposed moist surfaces become dry immediately, so dry at least as to prevent their adhering to other lumps and reforming objectionable large lumps. This action is also assisted by the fact that the material is in particles of various sizes, and the small particles enter the fissures caused by the arms f and prevent their closing again. If the material is still of such a size that the desiccation would require a considerable length of time, the particles may be further reduced in any suitable manner, as by passing them through a sieve G having a rotating shaft g and arm g' for forcing the material through the meshes of the bottom g^2, whence they are conducted by a trough or funnel g^3 to the cylinder, or to any other apparatus for continuing the desiccation. The shaft g of the sieve is driven by a belt g^4 running over a pulley g^5 on the power shaft b^3.

For the desiccation of a granular mass, or of a mass which has been reduced to the granular condition, we may use the same cylinder B, the granular mass being deposited in the lower part thereof, as shown in Fig. 1, and the cylinder being rotated slowly, as shown by the arrows. In this condition, in order to avoid overheating the material and yet to obtain the desiccation in as short a period of time as possible, we provide for the reduction of the temperature applied to the material as it approaches the practically completely desiccated state. This reduction is necessary in material which would be injured by a high temperature, by reason of the fact that as the desiccation proceeds and the evaporation becomes less, the temperature of the material itself, under a constant applied temperature, rises. The means which we prefer for regulating the applied temperature consists of the nozzle d^2 having lateral or branch nozzles d^3 fitting at one end into the main air pipe D, as shown by dotted lines in Fig. 1, and adapted to be oscillated as shown in dotted lines in Fig. 4. In the full line position of Fig. 4 it is evident that the material is subjected to the intensest temperature; by turning the nozzles d^3 to the dotted position the hot blast passes for a greater distance through the surrounding cooler atmosphere, and therefore is more reduced in temperature when it reaches the material, and it also strikes the material at a more oblique angle, whereby the heat applied is distributed over a larger surface and thereby reduced in intensity.

Whether operating on the liquid or semi-liquid mass, or on the granular mass, it is apparent that the apparatus of Figs. 1 to 4 serves always to expose continuously fresh portions of the material to the desiccating action (see for example the arrows c in Fig. 4) either by separating the same into small particles or by drawing the same out into a film from one part of the body of material under treatment and returning said film to another part of said body, or if it be thickly viscous, by drawing it up on an overhanging surface and causing it to separate from said surface and drop or roll over and over again until it returns to the body under treatment, or if it be granular by bringing the successive lower portion of the body continually upward. The arrangement of the direction of the air blast as shown in Figs. 2 and 4, is that which we have found most effective in dealing with liquid or granular materials, but with thickly viscous materials the direction of the blast is not of so much importance, and the nozzle d' may be used to project the hot air centrally against the opposite end of the cylinder, where it is spread out and returned in close contact with the inner surface of the cylinder.

The function of the various elements of our apparatus having been described in detail, we will now describe briefly the operation of the entire apparatus on materials, such, for example, as milk, which by continuous desiccation are gradually changed from the very liquid to a viscous condition of gradually increasing thickness, then to a solid or slightly plastic lumpy condition, and finally to a granular condition hard and practically bone dry. The material being placed in the bottom of the cylinder B, as shown in Fig. 1, the cylinder is rotated in the direction of the arrows shown in Figs. 1 and 4, and the material is drawn out into a thin film, and carried around within the cylinder, small particles dropping like rain directly into the bottom and the film entering the body of the material at the side opposite that at which it was drawn out therefrom. At the same time the nozzle d projects a blast of hot air upward and against the descending portion of said film, retarding the descent of the same, and at the same time extracting moisture therefrom. This condition of affairs continues for a length of time depending upon the original condition of the material and the temperature of the blast, and of the surrounding temperature. The material then becomes so viscous that the film is gradually increased in thickness by continuous additions thereto of portions of the material from the body in the bottom of the cylinder, until it finally becomes so heavy that it separates from the ascending and overhanging portion of the cylinder, and drops therefrom or rolls down the side thereof, the blast being during this stage projected through the nozzles d' so as to strike equally all parts of the material being desiccated. This action continues until the portions which roll down into the body of the material lose most of their stickiness, and become a body of separated lumps. At this point the knife E is used to scrape the portion of the coating which still adheres to the side of the cylinder down into the main body of the mass. The breaker F is then inserted and rotated rapidly so as to reduce the mass to particles of a size comparatively uniform and convenient for further reduction. The mass so reduced is then further reduced to particles so small that the desiccating action may be as rapid as desired by forcing them through the sizer G. From there they return to the cylinder, which is again rotated, the nozzle d^2 being set in the tube D, and the obliquity of the blast through the branch nozzles d^3 being gradually increased as the material approaches practically complete desiccation.

Though we have described an apparatus embodying our invention with great particularity of detail, we are not to be understood as limiting ourselves to the form shown, as it will be obvious to those skilled in the art that many modifications thereof may be made without departing from our invention. For example the carrier may be in the form of a cylinder B′ (Fig. 5) which rotates with its outer surface in the body of material C carried in the vessel H, drawing said material out into a film from one part of the body C, and returning it to another part thereof, and continuously subjecting said film to the action of a blast of hot air from a nozzle such as D′, said blast being projected in a direction opposite to that of the rotation of the cylinder. This cylinder may of course be of conducting material, and is better adapted for retaining an artificially regulated temperature on the side of the carrier opposite the film than the form shown in Fig. 1. Such regulation is accomplished by introducing water of the desired temperature within the cylinder, as shown. It is not so well adapted, however, to the complete desiccation of a material from its liquid to a solid condition, as is the apparatus illustrated in Fig. 1. The blast of air therein may be confined to the carrier by means of a roof or guide K supported in any suitable manner from the vessel H, as by uprights k.

A further development of our invention, Figs. 6 to 11, consists in the use of a second carrier into which the material passes after being granulated, and is completely desiccated. This carrier takes the place of the cylinder B of Fig. 4 in the last step of the operation, but has certain advantages in the desiccating of a granular mass which are not found in the cylinder B, as hereinafter specified. In connection with this embodiment we have also shown the apparatus arranged so that the several operations of condensing, reducing to pasty lumps, breaking, sizing, and final desiccating, may be carried on simultaneously upon different bodies of the material, whereby a practically continuous operation is obtained instead of the intermittent operation of the form shown in Figs. 1 to 4. We have also shown in these figures an improved form of the condensing tank and improved forms of the breaker and the sizer, whereby a larger quantity of material may be treated and greater rapidity obtained. In this apparatus the condensing tank is shown at A′, the cylindrical tank for reducing the material to a pasty consistency at B^2, the breaker at F′, the sizer at G′, and the desiccating receptacle or drum at B^3. The mass passes from the condensing tank A′ through a flexible tube a^5 as in Fig. 1 into the cylinder B^2. Thence by the removal of a plate b^7 in the side of the cylinder B^2 it falls directly into the breaker F′. From the breaker it passes, by the removal of a similar plate f^8 into a chute f^9 and thence into the sizer G′. After being reduced to size it drops into a chute g^6 and thence into the desiccating drum B^3.

The improved tank A′ has interior coils a^6 arranged in horizontal sets as shown, the pipes of each set being connected by headers a^7, and has a jacket a^8, the coils and jacket extending up to the usual level of the liquid in the tank. Nozzles a^9 are used to inject a blast of hot air into the body of the liquid and to give it a rolling motion as shown by the arrows in Fig. 7, which results in the rapid condensation of the material without the application of a dangerously high temperature. The arrows in full lines show the direction of the air through the body of the material, while the arrows in dotted lines show the rolling movement of the material itself.

a^{10} is a valve of any suitable design in the bottom of the tank, which is opened to admit the condensed liquid through the tube a^5 into the receiver B^2. The construction of the cylinder B^2 is nearly identical with that of the receiver B, Fig. 1, and its operation in reducing the liquid to a pasty mass is identical with that of the cylinder B. The cylinder B^2 has in addition an opening in its side which is normally closed by a plate or cover b^7 in any convenient manner.

The breaker F′ comprises a receptacle having a semicylindrical lower portion f^{10} and a flaring upper portion f^{11}. Projecting upward through the lower portion f^{10} is a row of stationary rods f^{12}. A shaft f^{13} at the center of the lower portion f^{10} carries a series of simliar arms f^{14} set in a straight or a helical line (Figs. 7 or 9) and arranged, when the shaft f^{13} is rotated or oscillated, to pass between the rods f^{12}. The operation of the breaker is shown best in Fig. 7. The shaft f^{13} being rotated in the direction of the arrow, brings the rods f^{14} against the large lumps of the material lying between them and the rods f^{12}. The lumps are thus forced between the rods f^{12} and divided into small particles. As the end of the rod f^{14} passes the upper edge of the portion f^{10} of the receptacle the small particles which have been carried up by it fall again to the bottom and the rods f^{14} by their continued movement engage the additional large lumps which have fallen from the carrier B^2 in the meantime. The rods f^{12} may be omitted, when the operation will be the same as in Fig. 3.

The size to which the lumps are broken may be regulated by raising or lowering the rods f^{12}. This is most conveniently effected by mounting said rods on a bar f^{15} which is adjustable in height by means of the screw-threaded rods f^{16} which pass through upward projections f^{17} on the ends of the bar and which are connected to operate synchronously by means of sprocket-wheels f^{18} connected by a sprocket chain.

Figs. 8 and 9 show in detail the manner of supporting the bar f^{15} on the opposite ends of the receptacle. In these figures also the lower portion of the receptacle f^{19} is made of elliptical shape whereby the particles of material will roll off the ends of the rods f^{14} before reaching the upper edge of the portion f^{19} of the receptacle. For rotating the shaft f^{13} in either direction two pulleys L L′ may be used, which revolve continually in opposite directions and which are normally free to revolve on the shaft f^{13}. A double friction clutch indicated at l is splined on the shaft f^{13} and in a well known way may be operated to connect the shaft f^{13} with either of the pulleys L L′. By a suitable well known mechanical arrangement for oscillating the lever l' of the clutch, a back and forth or oscillating movement of the shaft f^{13} may be obtained. Such a movement would serve to pass the material through the rods f^{12} first in one direction and then in the opposite direction, so as to insure their complete reduction. The sizer which is most conveniently used in the present arrangement consists of a wheel g^7 which rotates above a wire screen g^8 and which carries on one or more of its arms g^9 a block g^{10} having the front portion of its under face inclined, and the rear portion flat and bearing on the screen. Rollers g^{11} serve as guides for the wheel g^7.

It will be understood that instead of the specific breaker or sizer used, we may avail ourselves of any other suitable mechanism for this purpose. By the term "breaker" therefore we include all means for reducing the paste to a granular mass, whether it operate by breaking, screening, or otherwise. The broken material passes through the space between the arms of the wheel g^7 on to the screen g^8, and is forced through such screen by the passage of the block g^{10}. The size of the meshes of the screen of course determines the fineness of the grains.

The final receptacle or drum B^3 constituting the principal part of the desiccator is preferably made of absorbent material, such, for example, as heavy canvas, which serves to take up the moisture driven off from the granulated mass and even to permit the moisture to be driven through it by the pressure of air within, without allowing the loss of any of the granulated material or of the desiccated powder of which a considerable quantity is always present. It may, however, be made more lasting by using metal. Where canvas is used we prefer to employ a framing b^8 of wood of a polygonal or substantially circular section to the inside of which the canvas wall b^9 is attached. b^{10} indicates a portion of the drum which is removable to admit or discharge material, and which is held in place in any suitable way, as by turn-buttons b^{11}. The drum is revolved slowly but continuously, as, for example, by means of a pulley M fixed on a tube which is in turn fixed to the drum. Any other convenient mode of revolving the drum may of course be substituted. This drum operates to expose the desiccated material to the blast of hot air in a way substantially identical with that shown in Fig. 4, that is, by constantly turning the material so as to expose fresh portions thereof to the action of the blast. The arrangement of the hot air nozzle may be the same as that shown in Fig. 4, but as an improvement thereon we have devised another arrangement which we will describe in connection with the entire system of hot air pipes.

The hot air pipes and nozzles are so arranged, as shown in Fig. 6, that the blast may be directed as desired to any portion of the apparatus or to all portions simultaneously. The arrangement shown is chiefly diagrammatical, it being understood that it may be varied at will so long as it is arranged to assist in the mode of operation herein specified.

A main air-pipe D connects by branches with each of the receptacles A′ B^2 F′ and B^3. The connection with the tank A′ is made by a branch d^4; that with the cylinder B^2 by means of nozzles d and d', as in Fig. 1; that with the breaker F′ by means of a branch d^5, and that with the canvas drum by means of a branch d^6. At the entrance to each of these branches is a damper by which it can be cut off from the main pipe. The branch d^5 extends across at one side of the upper part f^{11} of the receptacle of the breaker and has outlets or additional branches d^7 which direct the blast upon the material in the lower part of the receptacle and which are out of the path of the rotating rods f^{14}. Any similar arrangement which will project the blast upon the material without interfering with the operation of the breaker will be equivalent to that shown.

The means for projecting the blast upon the granulated material in the drum B^3 may be identical with that shown in Fig. 4. That is, it may consist of a stationary nozzle projecting into the drum, the drum being revolved to bring successive portions of the material into the blast. In the modified form shown in Figs. 6, 7, 10 and 11, the pipe O is attached to the drum B^3 so as to rotate therewith, and is connected at its outer end to the branch d^6. The pipe O has perforations or openings o within the drum through which the hot air escapes from the pipe. If the pipe O were uncovered within the drum, portions of the material would fall on to the openings o as they come uppermost in the course of a rotation and would tend to clog these openings. In order to avoid this difficulty we may use a guard consisting of a pipe O′ which is loosely held in position around the inner pipe O, as by means of arms o' on the inner pipe and upon which the outer pipe is free to rotate. The outer pipe O′ has nozzles o^2 at intervals along its length, the weight of which, being all on one side of the pipe, holds it in the desired position while the pipe O rotates therein. Attached also at one side of the pipe O′ is a bar P which extends nearly to the wall of the drum.

In operation the air enters the pipe O and passes through the openings o into the pipe O′. Thence it escapes by the nozzles o^2 to the granular material. At the same time that the pipe O is rotated, the drum B^3 is also rotated, the direction of rotation being indicated by an arrow in Figs. 4 and 11. The body of granular material is shown in approximately the position which it assumes under the action of the rotating drum. As it is carried from the bottom upward it engages the bar P so as to lift the nozzles o^2 and cause them to act directly upon the material. It will be understood that the relative positions of the bar P and the nozzles o^2 is so arranged that the action of the moving material on the bar P will turn the pipe O′ just sufficiently to bring the nozzle o^2 to bear at the desired point. By omitting the bar P the nozzle o^2 will project the blast toward the lowest point of the drum, which might be found sufficiently efficient in most cases, but we prefer the arrangement shown.

The canvas wall b^9 of the drum is continued over the greater portion of the head of the drum, but in order to permit the escape of the air blown into the drum, and at the same time to retain the very fine particles which are produced by the attrition of the granules as the drum is rotated, a portion of the head, such as the central portion immediately surrounding the pipe O, is composed of material b^{12}, such, for example, as cheese-cloth, the meshes of which are of such size as to permit the passage of air, but which retains the finely pulverized material within the drum.

For supplying hot air to the main pipe D, we have indicated at R an air blower, and at S a heater through which the air passes from the blower to the pipe D.

It is for some reasons desirable to use cold air in the first tank A′ and I prefer to arrange a branch D′ and suitable dampers whereby such tank may be cut off from the hot air main D and connected to a source of cold air.

What we claim therefore and desire to secure by Letters Patent, are the following defined novel elements and combinations, substantially as described.

1. In an apparatus for desiccating liquids, the combination of a concentrator for condensing a mass of the liquid, and having means for applying heat to such liquid, a solidifying means arranged to receive the reduced mass from the concentrator and to further condense it to a solid condition, a breaker arranged to receive the solid mass from the solidifying means and to break it into small particles, and a desiccator for reducing the mass from a moist to a desiccated condition arranged to receive the broken mass and to desiccate it.

2. In an apparatus for desiccating liquids, the combination of a concentrator for condensing a mass of the liquid, said concentrator including a tank, means for heating and blowing air through the liquid in said tank, a solidifying means adapted to expose an extended surface of the condensed liquid and to simultaneously subject the same to a blast of hot air, means for conducting the condensed mass from the concentrator to the solidifying means, a breaker for breaking the solid mass into small particles, means for conducting the solid mass thereto, a desiccator comprising means for turning the moist material to expose fresh portions thereof and for simultaneously subjecting the same to a blast of hot air to desiccate it, and means for conducting the broken mass to the desiccator.

3. In an apparatus for desiccating liquids, the combination of a concentrator for condensing a mass of the liquid, a solidifying means for reducing the condensed mass to a solid condition, means for conducting the condensed mass thereto, a breaker for breaking the solid mass into small particles, means for conducting the solid mass thereto, a desiccator for reducing the broken mass from a moist to a desiccated condition, means for conducting the broken mass thereto, a common air pipe for supplying air to said concentrator, solidifying means, and desiccator, and means for separately controlling the air supplied to each of said devices.

4. In an apparatus for desiccating liquids, the combination of a concentrator for condensing a mass of the liquid, a solidifying means adapted to expose an extended surface of the condensed liquid and to simultaneously subject the same to a blast of hot air until the liquid reaches a more or less hardened state, and means for conducting the condensed mass to said solidifying means.

5. In an apparatus for desiccating liquids, the combination of a concentrator comprising a tank, heating coils therein and means for blowing air therethrough for condensing a mass of the liquid; a horizontal cylinder having internal flanges b^5 for retaining the liquid and adapted to be rotated to expose a film of liquid on its inner surface; a pipe a^5 for conducting the condensed liquid thereto; a pipe *d* and blower R connected thereto for projecting a blast of air against said film of liquid; and a scraper E for scraping the mass from the sides of the cylinder when it has become solid.

6. In an apparatus for desiccating liquids, the combination of a horizontal cylinder B with internal flanges b^5 for retaining the liquid, said cylinder adapted to be rotated to expose a film of the liquid, a pipe *d* and blower R connected thereto for projecting a blast of air into said cylinder at one end, and a head b^6 for closing the opposite end thereof to return the air so that it again acts upon the liquid.

7. In an apparatus for desiccating liquids, the combination of a horizontal cylinder with internal flanges b^5 for retaining the liquid, said cylinder adapted to be rotated to expose a film of the liquid upon its interior, a pipe *d* and blower R connected thereto for projecting a blast of air against said film of liquid, and a scraper E for scraping the mass from the side of the cylinder when it has become solid.

8. In an apparatus for desiccating liquids, the combination of a horizontal cylinder with internal flanges b^5 for retaining the liquid, said cylinder adapted to be rotated to expose a film of the liquid, a pipe *d* and blower R connected thereto for projecting a blast of air into said cylinder at one end thereof, a head b^6 for closing the opposite end thereof to return the air so that it again acts upon the liquid, and a scraper E for scraping the mass from the side of the cylinder when it has become solid.

9. In apparatus for desiccating liquids, the combination of a concentrator for reducing the bulk of the liquid, comprising a tank having means comprising coils for applying heat to a large body of the liquid, and air pipes connected to a blower R for forcing large volumes of air therethrough to evaporate and carry off the vapor therefrom, said tank being open at the top to permit the free escape of large volumes of vapor-laden air, a solidifying means having a carrier for spreading out the liquid in a thin film whereby to evaporate the same and reduce it to a hardened condition, said solidifying means constructed to permit the removal of the hardened mass, and means for conducting the liquid from said concentrator to said solidifying means.

10. In apparatus for desiccating liquids, the combination of a concentrator for reducing the bulk of the liquid, comprising a tank having means comprising coils for applying heat to a large body of the liquid, and air pipes connected to a blower R for forcing large volumes of air therethrough to evaporate and carry off the vapor therefrom, said tank being open at the top to permit the free escape of large volumes of vapor-laden air, a solidifying means having a carrier for spreading out the liquid in a thin film whereby to evaporate the same and reduce it to a hardened moist condition, said solidifying means constructed to permit the removal of the hardened mass, means for desiccating said hard moist mass to dryness, means for conducting the liquid from the concentrator to the solidifying means, and means for conducting the hardened mass to said desiccating means.

11. In apparatus for desiccating liquids, the combination of a concentrator for reducing the bulk of the liquid, comprising a tank having means comprising coils for applying heat to a large body of the liquid, and air pipes connected to a blower R for forcing large volumes of air therethrough to evaporate and carry off the vapor therefrom, said tank being open at the top to permit the free escape of large volumes of vapor-laden air, a solidifying means having a cylinder for spreading out the liquid in a thin film whereby to evaporate the same and reduce it to a hardened condition, said solidifying means constructed to permit the removal of the hardened mass, means for breaking up said hardened moist mass into small particles, means for desiccating said hard moist particles, and means for conducting the material in its several forms from each of said devices to the next in the order named.

12. In an apparatus for desiccating liquids, the combination of a concentrator for condensing a mass of the liquid, including a tank and means for heating and blowing a large quantity of air through the liquid in said tank; a solidifying means including a carrier adapted for exposing an extended surface of the condensed liquid, means for simultaneously subjecting the same to a blast of hot air, and means for moving said carrier; and means for conducting the material to be treated through the apparatus.

13. In an apparatus for desiccating liquids, the combination of a concentrator for condensing a mass of the liquid, including a tank and means for heating and blowing a large quantity of air through the liquid in said tank; a solidifying means including a carrier adapted for exposing an extended surface of the condensed liquid, means for simultaneously subjecting the same to a blast of hot air, and means for moving said carrier; means for breaking the solid mass into small particles; means for desiccating such particles to bring them to a dry condition; and means for conducting the material to be treated through the apparatus.

In witness whereof, we have hereunto signed our names in the presence of two subscribing witnesses.

JOSEPH H. CAMPBELL.
CHARLES H. CAMPBELL.

Witnesses:
DOMINGO A. USINA,
FRED WHITE.