

May 1, 1923.

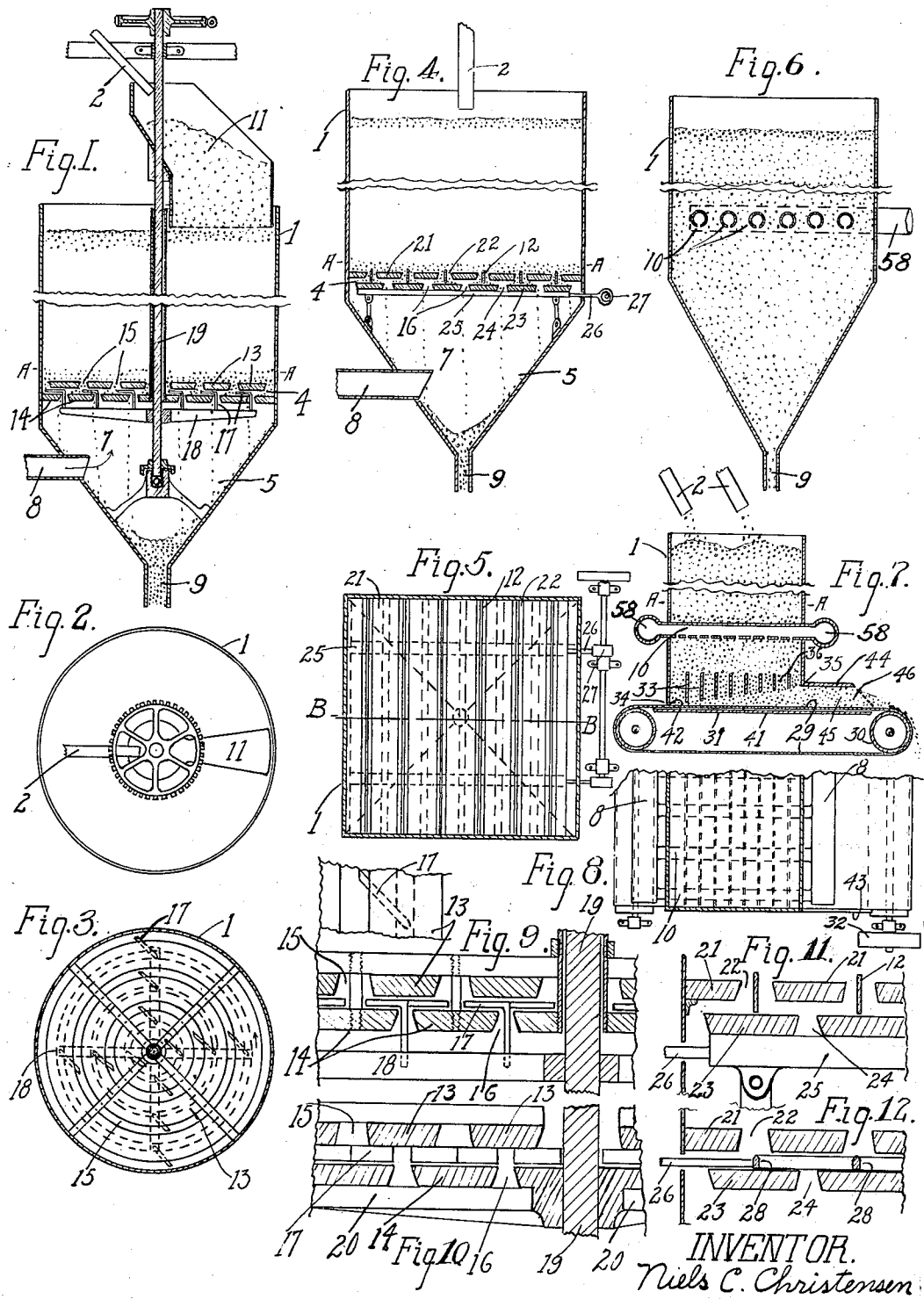
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N. C. CHRISTENSEN

APPARATUS FOR DRYING GRANULAR PRODUCTS

Filed March 8, 1921

2 Sheets-Sheet 1



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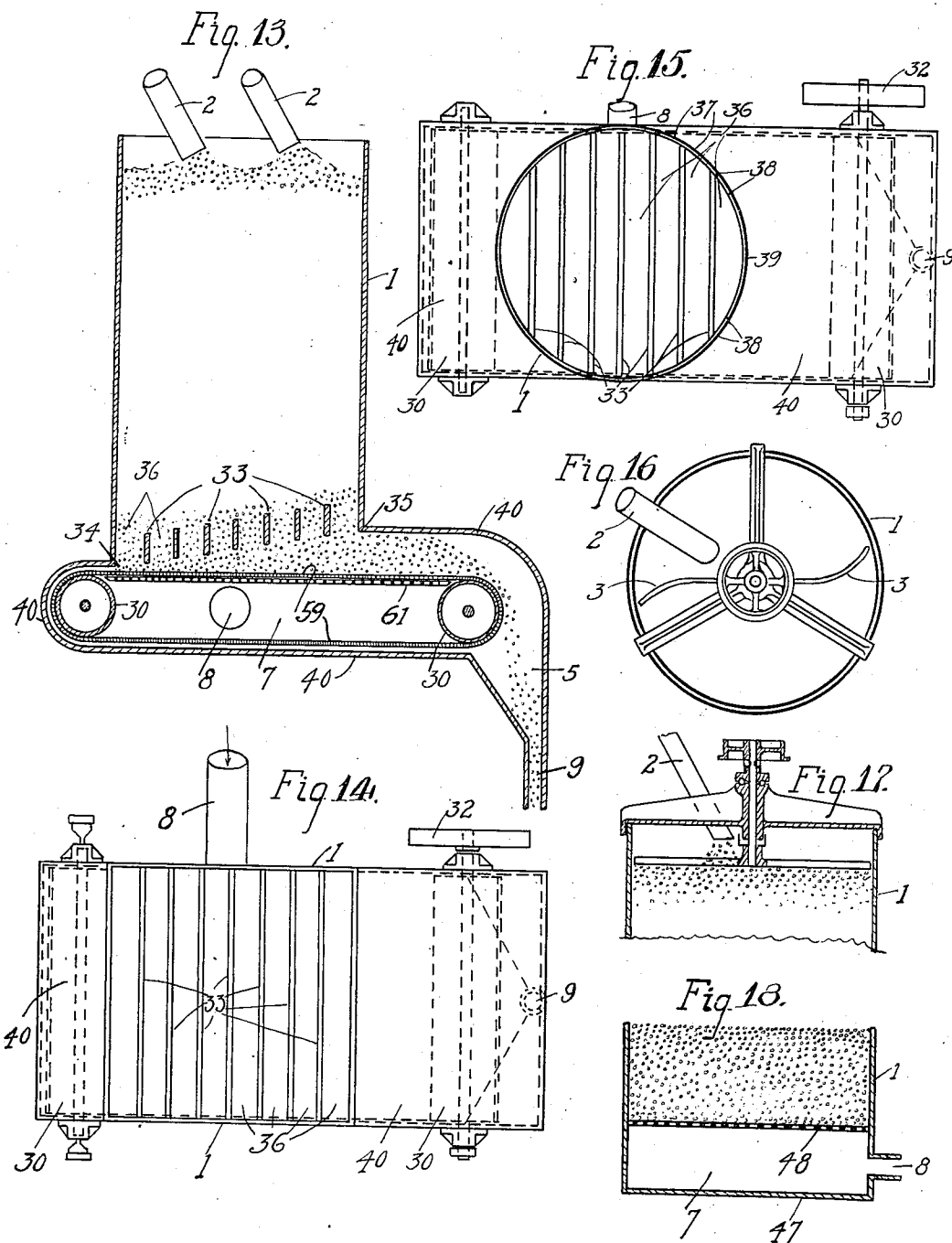
N. C. CHRISTENSEN

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APPARATUS FOR DRYING GRANULAR PRODUCTS

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE.

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APPARATUS FOR DRYING GRANULAR PRODUCTS.

Application filed March 8, 1921. Serial No. 450,679.

To all whom it may concern:

Be it known that I, NIELS C. CHRISTENSEN, a citizen of the United States, residing at Salt Lake City, in the county of Salt Lake and State of Utah, have invented certain new and useful Improvements in Apparatus for Drying Granular Products, of which the following is a specification.

This invention relates to improvements in methods and apparatus for drying granular products such as wheat and other grains or granular mineral products. It is particularly adaptable to the drying of sized products, i. e., products in which the grains or particles are of approximately the same size, but is useful for the treatment of all products which are granular in their nature. It is not applicable to the treatment of fine material or to the treatment of a mixture of coarse and fine in which the fine is in such proportion as to fill the voids between the coarser or granular products.

The method of drying now most commonly used consists in dropping the material to be dried through a current of air which is either cold as in some wheat driers now used or hot as is used in different forms of ore and coal driers, etc. The dropping of the material to be dried, through the air current is accomplished in two general ways, either by dropping the material down a shaft supplied with baffles or deflectors against an upward current of air as exemplified in some wheat driers, or by passing the material through a revolving substantially horizontal cylinder supplied with lifting devices which lift the material as the drum revolves and drops it through the current of hot air or furnace gases. In some forms of driers the drying gases are merely passed over the surface of the mass of material which is stirred to bring different portions of the mass into contact with the gases.

In all these forms of apparatus the material to be dried occupies a relatively small part of the space in the machines and is in intimate contact or mixture with the drying gases but a small part of the time and these machines therefore have a relatively small capacity in relation to their size. This is particularly true when relatively cold drying gases must be used, as in drying wheat or other grains in tower driers in which case a very large and very high apparatus and an extremely large volume of air at ordinary temperatures must be used to secure any con-

siderable drying effect. In the case of grains such as wheat the drying thus secured is only superficial and is subject to the changes in moisture content of the air used in drying which may have practically no drying effect at all during rainstorms or periods of high humidity. In all these forms of apparatus the material is subjected to considerable abrasion and bruising which is detrimental to many products and also results in the formation of fines which are blown away in the drying gases.

This invention aims to overcome all these objections and disadvantages by the use of a new method of drying by which the capacity of the apparatus per unit volume is very greatly increased, greater efficiency of drying by the gases is secured and practically all bruising and abrasion of the material prevented and the temperature of drying may be easily regulated and controlled.

This new method consists in passing a current of drying gas through a bed of the granular material i. e., forcing the drying gas under sufficient pressure through the voids between the particles and thus bringing the gas into intimate contact with the individual grains. This may be done in a simple apparatus consisting of a vertical shaft with a closed bottom with a perforated grating a short distance above the bottom upon which the grain is supported, the drying gas being supplied under pressure to the space beneath the grating and forced up through the bed of granular material.

To secure the greatest efficiency in the use of the drying gases and to secure continuous operation rather than intermittent, this method of drying should preferably be carried out in counter-current fashion.

My preferred manner of utilizing this new method consists therefore in passing the granular product to be dried downward as a mass through a vertical shaft and at the same time forcing the drying gases up through the mass in the voids between the granular products. In this way practically the entire drying apparatus is filled with material to be dried and this material is in the most intimate contact with the drying gases during the entire time of passage through the apparatus. The apparatus has therefore a very large capacity per unit of volume. Due to the intimate mixture of the gases and solids and their counter-current flow the drying efficiency of the gases is

very high and a relatively smaller amount of drying gas may be used. Due to these factors gases at a much lower temperature than in other methods may be used to secure a desired drying effect. Due to the compactness of the apparatus the material may also be kept longer in the drying operation than would be practical with the older forms of driers. Due to this factor and the very high drying efficiency of the gases it is commercially practicable to dry many products to a much lower moisture content than would be practical with the methods of drying now in common use, due to the low capacity of the apparatus using these methods.

To secure the greatest efficiency in using my method it is necessary that the flow of material downward through the drying shaft and the flow of drying gases upward through the mass of material be practically continuous and uniform over the entire horizontal cross section of the mass of material in the shaft. To secure these conditions the material to be dried should be fed practically continuously onto the upper part of the charge and should be discharged from the lower part of the charge at the same rate, and the discharge from the bottom of the charge should be substantially uniform over the whole bottom and the depth of the charge should be substantially the same in all parts. The finer the granular particles, the more exactly must these conditions be met to secure good results. With coarser material the depth of the charge need not be so exactly the same in all parts.

To secure these conditions in my method of drying, I use the type of apparatus shown in the drawings which consists in general of a vertical shaft, to contain the material to be dried, with means for feeding the material substantially continuously and at a uniform rate, into the top of the shaft and distributing it over the whole area of the shaft, and means for substantially continuously discharging the material at a uniform rate at the bottom and uniformly over the entire bottom of the charge, and means for forcing drying gases up through the charge from the bottom to the top. Extraneous means for heating the gases to the desired temperature will be used in most cases as the volume of drying gas is so very much less when it is warm as compared with cold gases that the cost of warming the gases is much less than the cost of forcing the much larger volume of colder gases through the charge.

It will be apparent that many variations in the form and details of construction will be possible in an apparatus of this type. The drawings show some of the forms of my apparatus which may be used for this purpose.

Fig. 1 is a vertical section on a diameter

of a circular form of the apparatus, Fig. 2 a plan view of the same and Fig. 3 a horizontal section of the same just above the discharge device. Fig. 4 is a vertical section of a square type of my apparatus on the line B—B of Fig. 5 which is a horizontal section just above the discharge device of Fig. 4 on the line A—A. Fig. 6 is a vertical section on a center line of a square or round type using no mechanical discharge device. Fig. 7 shows a vertical section of a type of the apparatus of which Fig. 8 is a partial plan view. Figs. 9 and 10 are enlarged sections of the discharge device or feeder which may be used in the form of apparatus shown in Figs. 1 and 3, and Figs. 11 and 12 enlarged sections of the discharge device or feeder which may be used in the form of apparatus shown in Figs. 4 and 5. Fig. 13 is a vertical section on line A—A of the plan views shown in Figs. 14 and 15 of my preferred form of apparatus. Figs. 16 and 17 show a form of distributing device which may be used with the form shown in Fig. 15, Fig. 16 being a plan view and Fig. 17 a vertical section on a diameter of Fig. 16. Fig. 18 is a vertical section of the simple apparatus for intermittent drying.

As previously stated the preferred apparatus consists in general of a vertical shaft (1) which may be square or rectangular or circular in cross-section. The length of the shaft will depend on the depth of the charge used which will in turn depend on the time of drying and the nature of the charge. The longer the time required, the longer the shaft, and the coarser the grains, the longer the shaft may be without having to use an excessively high pressure to force the gases through the charge. At the top of the shaft is a suitable feed spout (2) and a suitable distributing device or rake (3) or feed hopper (11) to keep the top of the charge level. At the bottom of the charge is a discharge device or discharge feeder (4) which may be constructed in a number of different ways. The function of this feeder is to substantially continuously discharge the dried material uniformly over the whole bottom of the charge. The means used to cause the current of drying gas to flow up through the charge may also be of different forms. In my preferred form the bottom of the shaft beneath the discharge feeder (4) is closed by a suitable hopper (5) or plate or housing (40) and hopper (5) as shown in Figs. 1, 4, 13 and 15 and the gases are introduced into this hopper (5) or closed space (7) under pressure through a pressure pipe (8) and pass up through the discharge feeder (4) and up through the charge. The discharge hopper (5) has a suitable discharge spout (9) at its lower point through which the dried product is discharged. This spout should be kept filled

in a portion of its length in order to prevent escape of the drying gases through it. Another method of passing the gases up through the charge consists in the use of stationary perforated pipes (10) in the lower part of the shaft as shown in Figs. 6 and 7. These pipes are connected with the main pressure pipe (58) outside of the shaft and are so arranged that the dried product may flow downward around them and be discharged at sufficient distance beneath the pipes to secure a uniform flow and discharge.

As noted the feeding device may consist of spouts (2) alone or a spout and rotary feeder hopper (11) or a spout (2) and suitable leveling devices (3). The spouts alone may be used with coarse granular material and the feeding (2) and leveling devices (3) with finer material. The exact form of this part of the apparatus will depend on the nature of the product and the shape of the shaft. With the circular forms as shown in Figs. 1, 6 and 15 a rotating feed hopper (11) or spouts (2) and a rotating rake or levelling device (3) may be used. If desired the necessary levelling may be done by hand at suitable intervals. The form of the discharge device may vary with the shape of the shaft. In the circular forms as shown in Figs. 1, 2, 3 and 9 it may consist of two sets of concentric circular plates, one set slightly above the other, both the upper set (13) and the lower set (14) being stationary and staggered so that the dried product cannot pass down through the annular openings (15) and (16) into the hopper. As shown the lower rings of the feeder (14) are beneath the annular opening (15) between the upper rings so that the dried product may flow through the upper openings (15) onto the lower rings (14). The material on these lower rings (14) is continuously removed by the plows (17) which project up through the annular rings (16). The plows are attached to the radial arms (18) which are attached to the rotating shaft (19) to which the feed hopper (11) is also attached. Fig. 10 shows a rotary feeder which is similar to the foregoing except that the plows (7) are attached to the upper rings (13) and the lower rings rotate being supported by a suitable spider (20) which is attached to the central shaft (19). In the square form of any apparatus a reciprocating discharge feeder of the type shown in Figs. 4, 5, and 11 may be used. This consists of an upper set of stationary parallel plates (21) separated by openings (22). Beneath the upper set is a similar set of parallel plates (23) with openings (24) so arranged that the plates (23) are beneath the openings (22) so that no dried product can flow into the hopper (5) beneath. In the middle of each opening (22) is a stationary vertical plate extending down so as to almost

touch the plates (23). The plates (23) are supported by the beams (25) and moved backward and forward by the rod (26) and eccentric (27) (or other reciprocating device) so that the material on the plates (23) is pushed off through the openings (24). The discharge feeder shown in Fig. 12 is similar to the above except that both sets of plates are stationary and the dried material is pushed off the lower plates (23) by the rods (28) which are moved back and forth on the lower plates by the reciprocating device (26 and 27). As will be readily seen by the use of these feeders a substantially uniform discharge from the whole area of the bottom of the charge is secured and that the rate of downward flow of the charge may be accurately regulated by the speed of the feeder mechanism.

If it is necessary or desirable to secure a very uniform feed into the top of the shaft (1) over the whole area of the shaft this may be secured by feeding the material into the top of the shaft through a feeder similar to those described and shown in the foregoing and shown in Figs. 1, 3, 4 and 5, instead of by means of leveling devices as previously described.

Another type of discharge feeder, which is my preferred type for many purposes, is shown in Figs. 7, 8 and 13, 14 and 15. This type of feeder consists of an endless belt which is held in place on the two pulleys (30) and supported by the plate (31) beneath the charge. The part of the belt on which the charge rests, which is supported by the plate (31), is pulled forward toward the discharge side or hopper (5) by turning one (or both) of the pulleys, preferably the one near the discharge, by applying power to the pulley (or gear or sheave) (32). In order to secure a uniform discharge over the whole bottom the transverse vertical distributing plates (33) are used. These extend across the charge above the belt and are arranged preferably at equal distances apart and the lower edges in a sloping plane extending from the rear edge (34) of the shaft at the level of the belt to the edge (35) of the discharge opening in the front of the shaft. In this way a layer of equal thickness is removed from each of the spaces (36) between the vertical plates (33), thus securing a similar discharge from the entire bottom of the charge. As shown in Fig. 15 this type of discharge feeder may be used with a shaft of circular cross section. In this case the lower edges of the portions (37) of the side of the shaft between two adjacent plates should slope upward from lower edge of the rear plate to the lower edge of the forward plate, and the lower edge of the portions (38) should slope up to the level of the lower edge (39) (between the two side portions 38) at the discharge opening, and the por-

tions (38) of the rear distributing plates (33) which extend beyond the next plates to the rear, should be at the same level as the next plate to the rear, in order to secure a uniform downward flow over the entire cross-section of the charge.

This type of discharge feeder may be enclosed in a housing (40) as shown in Figs. 13 and 14 into which the drying gases are forced through the inlet pressure pipe (8). In this case a perforated supporting plate (61) is used and the endless belt (59) is also perforated so that the drying gases may pass up through the supporting plate (61) and belt (59) and upward through the charge. The belt may be made of any suitable chain or link or screen construction with small enough openings so that the dried material will not run through or blind the openings.

This type of discharge feeder may also be used without the enclosing housing as shown in Fig. 7. In this case the belt (33) is supported on the bottom (41) of the shaft and enters beneath the charge through a slot (42) at the rear of the bottom of the shaft. The sides (43) and top (44) of the discharge passage (45) are extended so as to prevent excessive leakage of the drying gases through the discharge opening (46). The drying gases are introduced into the charge through the perforated pipes (10) connected with the pressure pipes (8) as previously described.

Fig. 6 shows a vertical section of a form of my apparatus in which no discharge feeder is used the discharge being regulated at the end of the discharge spout (9). This form is not my preferred type as a uniform downward flow of the charge cannot be secured except in small machines. The drying gases in this form are introduced through the perforated pipes (10) from the pressure pipe (8). This form may be either circular or square in cross-section.

For intermittent drying the simple apparatus shown in Fig. 18 may be used. This consists of a vertical shaft or box (1) of any desired shape in cross-section with a closed bottom (47) and a grating (48) above the bottom, and a pressure (or vacuum) pipe (8) connected with the open space (5) beneath the grating. The charge is filled into the upper part of the shaft and levelled and air is then forced through the charge from the pressure pipe (5). (Or may be drawn down through the charge by application of suction to the pipe (8).) When the charge has been dried it is removed from the grating by any suitable means, such as dropping the grating, and a new charge supplied.

From the foregoing description the operation of my apparatus will be apparent so that an extended description will not be necessary. To secure the best results a substantially continuous feed should be supplied to

the top of the charge which should preferably be maintained at approximately the same level at all times and a substantially continuous discharge at a uniform rate should be maintained. The drying gases should also preferably be supplied at a uniform rate and pressure. Good results may also be secured by intermittent continuous operation, i. e., by feeding and discharging at short intervals with no movement of the charge between providing the intervals are not too long. The depth of bed and amount of drying gases and the required pressure and temperature of these will vary with each material to be dried according to the nature of the material, the size of the grains, the moisture content, the difficulty of drying, and the desired drying effect. As previously noted, the invention is especially applicable to the drying of material which are dried with difficulty and which must be dried with relatively low temperature drying air or gas, such as wheat and other grains.

Having described my invention, what I claim and desire to patent is:

1. The apparatus for drying grains and granular products which consists of a vertical shaft for containing a bed of such above said material, a discharging device arranged to support a such said bed and arranged to discharge such above said material from the bottom of a such above said bed in such a manner as to secure a substantially uniform downward movement of the material in all parts of said bed, means for forcing a current of a gaseous medium upward through such above said bed in said shaft.

2. The apparatus for drying grains and granular products which consists of a vertical shaft for containing a bed of such above said material, means for feeding such above said material onto the top of such above said bed in said shaft and means for maintaining the top of a such said bed substantially level; a discharging device arranged to support a such said bed and arranged to discharge such above said material from the bottom of a such above said bed in such a manner as to secure a substantially uniform downward movement of the material in all parts of said bed, means for forcing a current of a gaseous medium upward through such above said bed in said shaft.

3. The apparatus for continuously drying grains and granular products which consists of a vertical shaft for containing a bed of such above said material, means for continuously feeding such above said material onto the top of such above said bed in said shaft and means for maintaining the top of a such said bed substantially level; a discharging device arranged to support a such said bed and arranged to continuously discharge such above said material from the bottom of a such above said bed in such a manner as to

secure a substantially continuously uniform downward movement of the material in all parts of said bed, means for continuously forcing a current of a gaseous medium upward through such above said bed in said shaft.

4. The apparatus for drying grains and granular products which consists of a vertical shaft, for containing a bed of such above said material, which is closed at the bottom and has a discharging device therein above said bottom arranged to support a such above said bed and arranged to allow the passage of a current of gaseous medium up through said device in such a manner that said current of gaseous medium will be substantially uniformly distributed over the entire horizontal section of said bed and arranged to discharge such above said material from the bottom of such above said bed in such a manner as to secure a substantially uniform downward movement of the material in all parts of said bed, means for introducing a current of gaseous medium under pressure into the closed space beneath said discharge device, and means for removing the such above said material removed from the bottom of such above said bed from the lower part of said apparatus.

5. The apparatus for drying grains and granular material which consists of a vertical shaft for containing a bed of such above said material, said shaft being closed at the bottom, means for feeding such above said material onto such above said bed in said shaft and means for maintaining the top of a such said bed substantially level, a discharging device in said shaft above said closed bottom arranged to support a such above said bed and arranged to allow the passage of a current of gaseous medium up through said device in such a manner that said current of gaseous medium will be substantially uniformly distributed over the entire horizontal section of said bed and arranged to discharge such above said material from the bottom of such above said bed in such a manner as to secure a substantially uniform downward movement of the material in all parts of said bed, means for introducing a current of gaseous medium under pressure into the closed space beneath said discharge device, and means for removing the such above said material removed from the bottom of such above said bed from the lower part of said apparatus.

6. The apparatus for continuously drying grains and granular material which consists of a vertical shaft for containing a bed of such above said material, said shaft being closed at the bottom, means for continuously feeding such above said material

onto such above said bed in said shaft and means for maintaining the top of a such said bed substantially level, a discharging device in said shaft above said closed bottom arranged to support a such above said bed and arranged to allow the passage of a current of gaseous medium up through said device in such a manner that said current of gaseous medium will be substantially uniformly distributed over the entire horizontal section of said bed and arranged to continuously discharge such above said material from the bottom of such above said bed in such a manner as to secure a substantially continuously uniform downward movement of the material in all parts of said bed, means for continuously introducing a current of gaseous medium under pressure into the closed space beneath said discharge device, and means for continuously removing the such above said material removed from the bottom of such above said bed from the lower part of said apparatus.

7. The apparatus for securing a substantially uniform downward movement of the material in all parts of a bed of material in a vertical shaft which consists of an endless belt feeder beneath said shaft, and arranged to support the material in said shaft, with transverse vertical plates above said belt and extending across said shaft and spaced at substantially equal distances apart from the back of said shaft to the discharge opening in the front of said shaft and having their lower edges in a sloping plane extending from the lower edge of the back of the shaft at the belt to the upper edge of the discharge opening in the front of the shaft.

8. The apparatus for securing a substantially uniform downward movement of the material in all parts of a bed of material in a vertical shaft which consists of an endless belt feeder beneath said shaft, and arranged to support the material in said shaft, with transverse vertical plates above said belt and extending across said shaft and spaced at substantially equal distances apart from the back of said shaft to the discharge opening in the front of said shaft and having their lower edges in a sloping plane extending from the lower edge of the back of the shaft at the belt to the upper edge of the discharge opening in the front of the shaft, with means for causing the movement of the upper part of said belt from the back of said shaft to the discharge front of said shaft.

In testimony whereof I have signed my name to this specification.

NIELS C. CHRISTENSEN.