Nov. 1, 1932. H. EDHOLM 1,885,998

TREATMENT OF GRAINY MATERIALS

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Fig. 1.

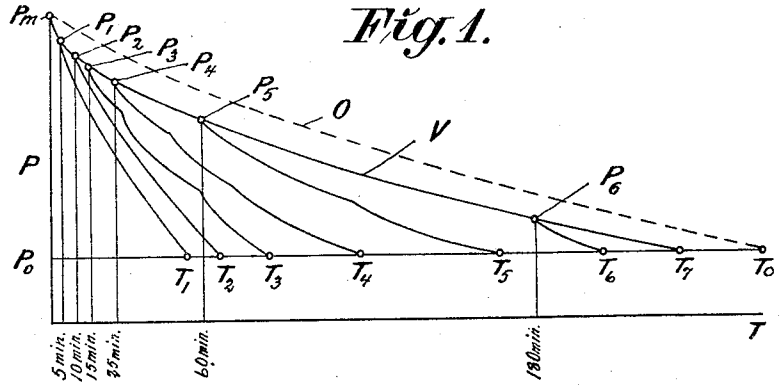


Fig. 2.

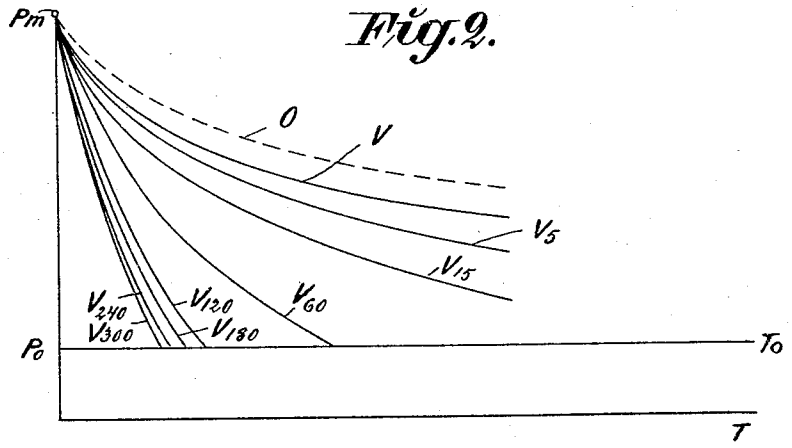
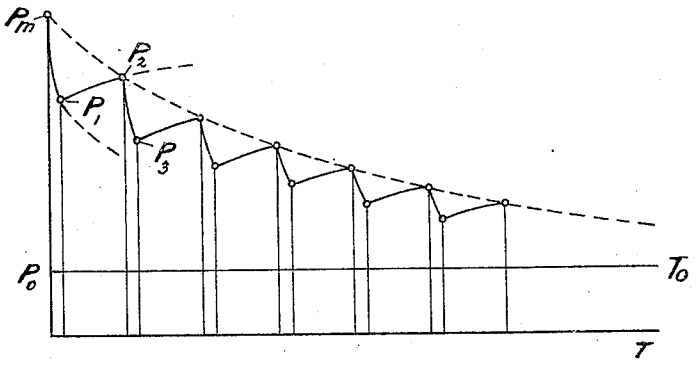


Fig. 3.



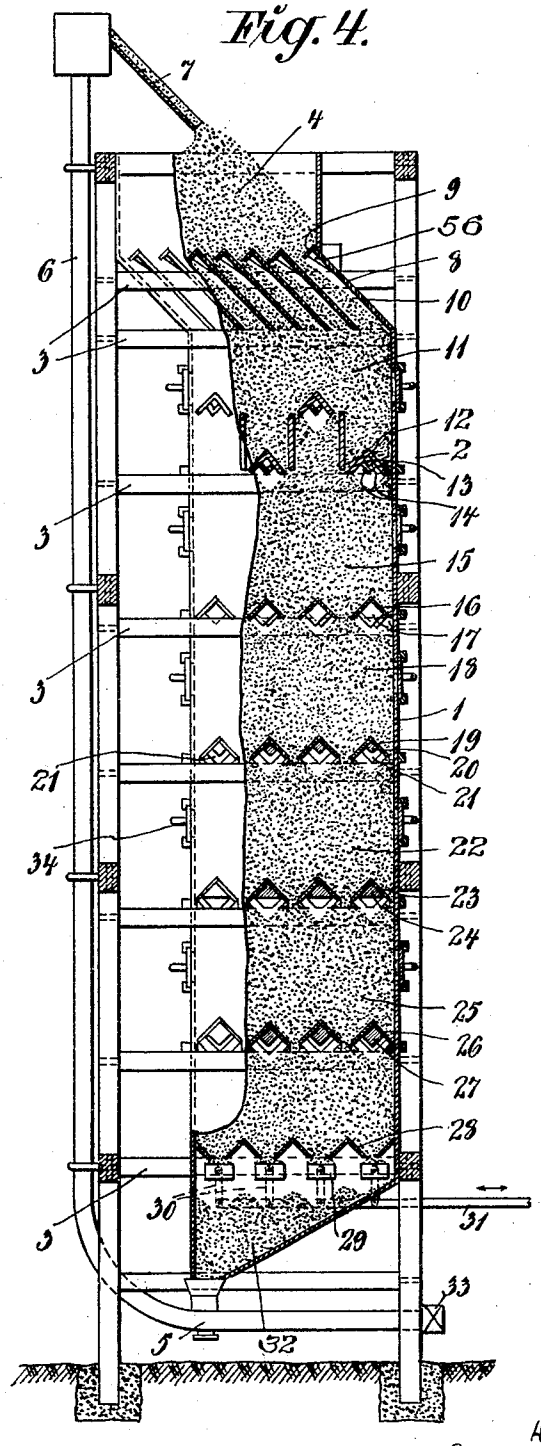
Inventor;
Harald Edholm
By Pennie Davis Marvin & Edmonds
attorneys

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Fig. 4.



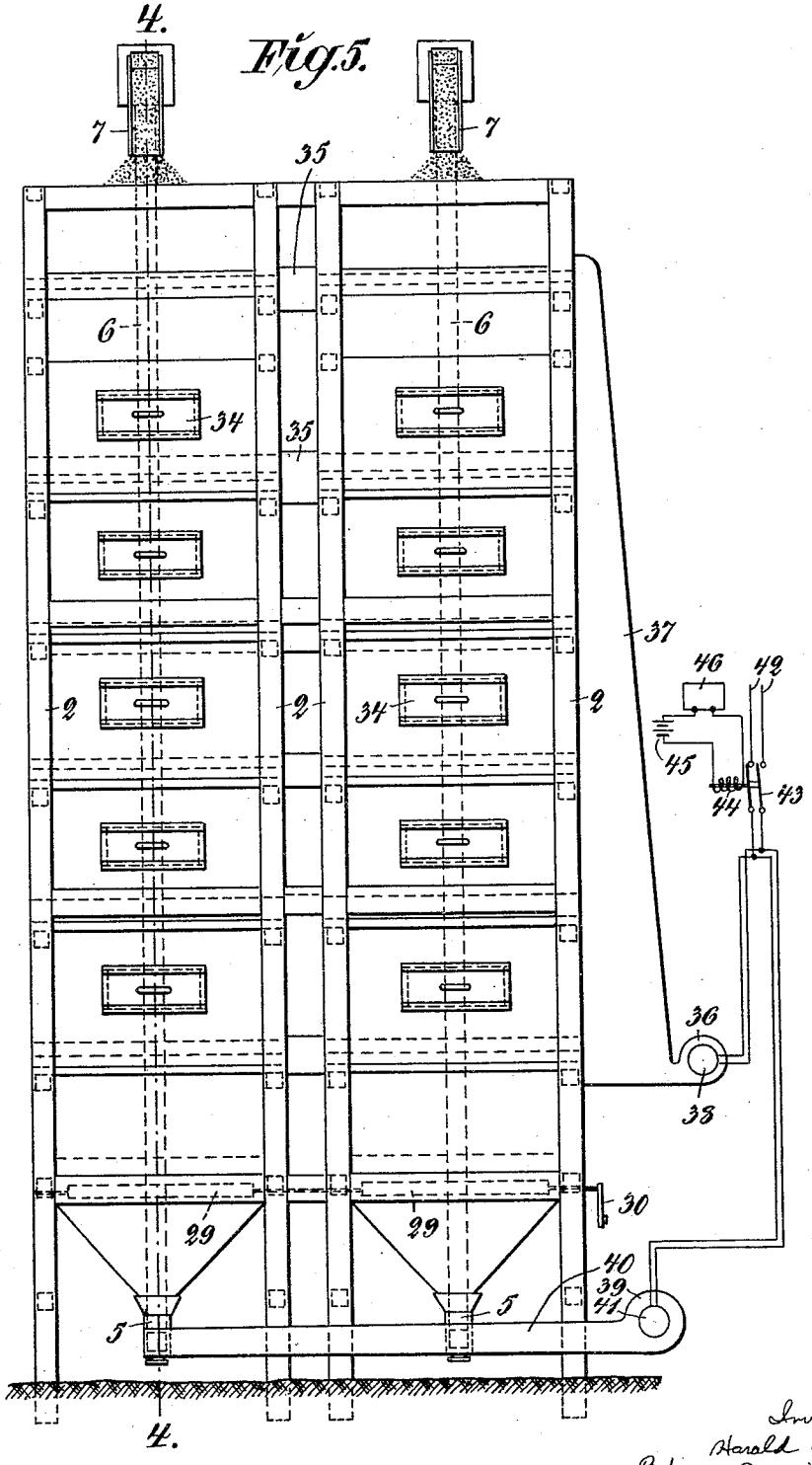
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TREATMENT OF GRAINY MATERIALS

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Fig. 5.



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Fig. 6.

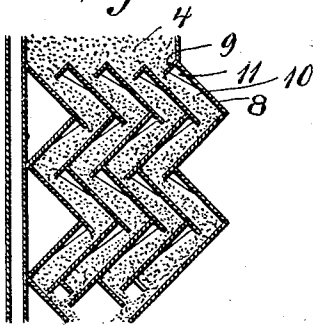


Fig. 7.

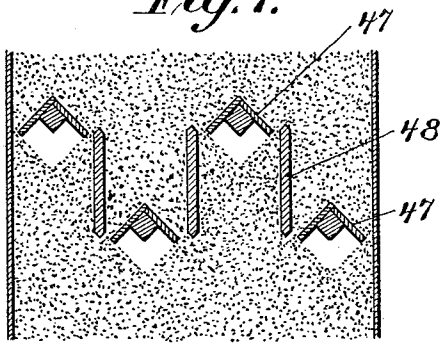


Fig. 8.

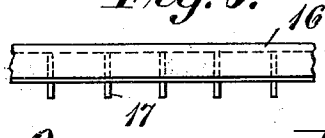


Fig. 9.

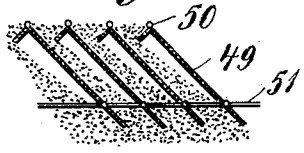


Fig. 10.

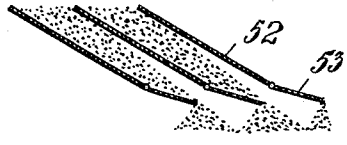
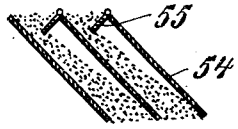


Fig. 11.



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UNITED STATES PATENT OFFICE

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TREATMENT OF GRAINY MATERIALS

Application filed December 27, 1929, Serial No. 416,790, and in Sweden January 2, 1929.

The present invention relates to methods for drying, storing and ventilating grainy materials. The invention relates more especially to the treatment of humid cereal grains in a silo or other similar apparatus through which the material is slowly sinking in a substantially vertical direction.

As is well known, damp weather often occurs when the grain crop has to be harvested in which case the grain must be stored in granaries or the like in humid condition. Said granaries are generally of such construction that the air has access only to the uppermost layer of the grain mass. If no special measures are taken the grain will after a short time begin moulding and even decaying which appears as a bad smell and a temperature rise in the grain mass. It is a known fact that immense losses in this manner are incurred annually by the farmers.

In agriculture efforts have been made since long ago to prevent the deterioration of the grain by subjecting it to a thorough shoveling whereby the grain is so shifted that new parts of the grain mass will lie in the uppermost layer and be subjected to the drying influence of the surrounding air. This method is, however, very circumstantial and time wasting besides which it represents a waste of expensive labour.

To reach a more economical result one has devised so-called silos, especially used in large mills and granaries, said silos comprising a vertical trunk of considerable height in which the grain is stored. In the bottom part of the silo there is usually provided an outlet through which the grain runs down by its own weight. The grain is thereupon transported to the top of the silo by means of a pressure air injector or bucket elevator. Each time the grain is transported to the top of the silo it will thus be brought into contact with the air. Such an arrangement will, however, be comparatively expensive because the price of the power required for the transport of each unit weight of the grain will be considerable in comparison with the drying result obtained for which reason said arrangement has not reached any general application amongst the smaller farmers which, of course, cannot afford any great expenditures.

It has also been proposed to reduce the transport energy consumption by the provision in the silo of horizontal air channels disposed closely above each other through which drying air is brought to pass either on account of the natural draft caused by pre-heating the air or by the action of a power driven fan. Also this arrangement has, however, not reached any general application, because the energy required to force the drying air through the numerous channels becomes too expensive besides which the large number of air channels requires high costs of erection. There will also be the disadvantage that the air channels disposed closely above each other encroach upon the useful space in the silo it being thus possible to treat simultaneously only a small quantity of grain.

The present invention has for its object to eliminate said inconveniences by reducing the total costs of erection and operation to a minimum. In order to set forth more clearly the idea of the invention, it is necessary first to examine the course of the drying process.

When, by way of example, a moist grain particle is exposed to air, the superficial layer of the particle will evidently first deliver its humidity which takes place comparatively rapidly. Thereupon the drying process proceeds at a much slower rate because the humidity remaining in the interior of the particle must first penetrate to the surface before it may be absorbed by the drying air.

Figure 1 is a diagram indicating the relation between the humidity P in percent of the weight of the material and the efficient time T required for the drying;

Fig. 2 is a diagram showing the influence of the length of the inoperative period at a constant drying period;

Fig. 3 is a diagram illustrating the variations of the humidity in the superficial layer of the material particles when the material is treated according to the invention;

Fig. 4 is a side elevation and partly a sec-

tion of a silo plant according to the invention;

Fig. 5 shows the same as Fig. 4 in front view;

Fig. 6 shows a detail of the silo where the beams are disposed in zig-zag;

Fig. 7 shows a modified arrangement of the beams in the silo;

Fig. 8 shows the arrangement of the flanges on the underside of the V-shaped beams;

Fig. 9 shows another modification of the beams in the silo whereby the flow of material may be regulated;

Fig. 10 shows another modification of the beams in the silo with flow regulating elements at the lower end of the beams; and

Fig. 11 shows another modification of the beams in the silo with the flow regulating elements at the upper end of the beams.

The invention has been based upon extensive experimental researches on the drying process, especially in cereal grain. Some of the results then obtained are diagrammatically shown in Figures 1 to 3 on the accompanying drawings. Figure 1 is a diagram indicating the relation between the humidity P in percent of the weight of the material and the efficient time T required for the drying. It is then assumed that a series of samples containing grain of the same humidity P_m is subjected to different drying processes whereby the humidity in all samples finally is brought down to the humidity P_o. The uppermost curve O in dashed lines shows the drying process in a quantity of grain being in contact with air provided the air is practically at rest. A total drying time of T_o minutes is then required. The curve V drawn in full lines shows the course of the drying when the air with a certain velocity/say by way of example four meters per second/ sweeps over the grain. The drying time becomes then T_7 minutes. As is readily understood by this curve a saving in the total drying time is obtained by the draft of air which saving, however, will be most pronounced during the first minutes. Assume now that the drying is interrupted when it has lasted, by way of example, during five minutes, the humidity then being reduced to the point designated P_1. Then the grain is allowed to remain in inoperative condition, by way of example, during four hours, whereupon drying is again started during five minutes, which is then again followed by a resting time of four hours etc. The efficient drying time will then be considerably shorter and the final result is obtained already after the efficient drying time designated T_1. If in another sample the drying instead lasts, by way of example, ten minutes the humidity designated P_2 is reached. If the grain, as before, is allowed to rest in four hours whereupon it is again subjected to drying in ten minutes etc. the final result is obtained after the time designated T_2. Apparently the efficient drying time will be somewhat longer. If the drying now instead is lasting fifteen minutes the humidity designated P_3 is reached. If the grain then is allowed to remain in inoperative condition during four hours and is then again subjected to drying during fifteen minutes etc. the final result is obtained after the time designated T_3. In the same manner the humidities designated P_4, P_5 and P_6 respectively are obtained if using drying periods of, by way of example, 25 minutes, 60 minutes and 180 minutes respectively, whereupon the final result is obtained after the time designated T_4, T_5 and T_6 respectively after an intermittent drying process in the manner above described.

The diagram shown in Figure 2 has for its object to explain the influence of the length of the inoperative period at a constant drying period of, by way of example, five minutes. It is then assumed that one as before starts from a series of samples which each contain humidity of P_m per cent and which slowly have to be dried until the humidity P_o is finally reached. The dashed curve O indicates as before the conditions when the air is practically at rest. The curve V drawn in full lines indicates the conditions when the wind with a cetrain velocity, by way of example four meters per second, sweeps over the grain provided the drying proceeds continuously i. e. without intermediate resting periods. If the grain after five minutes is allowed to rest in five minutes and then again is subjected to drying in five minutes etc. the curve designated V_5 is obtained. Apparently the gain in efficient drying time is comparatively insignificant. If the grain instead after having been dried in five minutes is allowed to rest in, by way of example, fifteen minutes and then again is dried in five minutes etc. the curve designated V_{15} is obtained. The efficient drying time will thus also in this case be further reduced. If the grain instead, while using drying periods of five minutes, is allowed to rest between the drying periods during one hour each time the curve designated V_{60} is obtained. Apparently the profit in applying the intermittent drying method is considerable in this case. If in similar manner drying periods of five minutes but resting periods of two hours are used, the curve designated V_{120} is obtained which brings a further saving of time. If the resting period is allowed to extend over three, four or five hours respectively the curves designated V_{180}, V_{240} or V_{300} respectively are obtained. The further gain becomes comparatively insignificant in the last curves besides which the drying process as a whole is unnecessarily delayed by the long resting periods.

As is clearly understood from said curves, the problem is to adjust the length of the

drying period in relation to the intermediate inoperative period in such a manner that the sum of the costs for driving the drying air and the costs connected with the length of the resting periods becomes a minimum. A too long resting period involves namely that the grain during the inoperative period must be accumulated in large store chambers whereby both the costs of erection and the transport work for each drying are increased. On the other hand, it is readily understood that too short drying periods unnecessarily complicate the required plants and thereby increase the costs of erection.

The present invention consists substantially in a method according to which the material on the way through the silo is subjected to an intermittent drying process in passing a plurality of drying zones disposed above each other and intermediate inoperative zones in which latter the material is not subjected to the influence of the drying air, the inoperative intervals between two consecutive drying processes being several times longer than that time during which the material is subjected to drying in each individual drying zone in such a manner that the humidity remaining in the interior of the material particles is allowed to penetrate to the superficial layers of the particles before the material is again introduced in the next drying zone.

Figure 3 illustrates diagrammatically the variations of the humidity in the superficial layer of the material particles when the material is treated according to the invention. If one is starting from the humidity P_m the humidity of the superficial layer decreases initially very rapidly down to the value P_1 after the lapse of a few minutes. If the drying should be continued the humidity should follow the sharply bent extension of the curve as shown in dashed lines. Evidently it will not be profitable to extend the drying time too far. During the following resting period which may extend over several hours the humidity in the interior of the material particles will penetrate to the surface whereby the humidity of the superficial layer slowly reaches the value P_2 which, however, is located at a considerably lower level than the original humidity P_m. Apparently it will not be profitable to continue the resting period too long because the humidity of the superficial layer will only asymptotically approach the average humidity of the particles. Thereupon a new drying period takes place which reduces the humidity to P_3 etc. At the end of each resting period the humidity has thus been reduced with a certain value and after the repetition of a plurality of such drying processes, the final result P_o is ultimately reached.

It has been proved in practice that a considerable saving is obtained only on the condition that the length of the inoperative period is five to five hundred times larger than the drying period.

If the above rules for the drying are applied it is proved that one may profitably use ordinary cold air from the atmosphere to reduce the humidity of the grain to commercial values provided the humidity of the atmosphere is not too high, by way of example, during a rain fall in which case the drying is preferably discontinued and the power required to drive the fans is used for other purposes. It may, however, occur that it is desirable for the sake of saving time to continue immediately the drying it being then preferred to pre-heat the cold air in order to increase the so-called aqueous capacity of the drying air, i. e., its capability to absorb humidity. It should then, however, be observed that one may obtain a considerable saving in the energy required both for the pre-heating and for the driving of the fans by reducing the current velocity of the drying air in proportion to the increase in the aqueous capacity of the drying air caused by the pre-heating.

In the following there will now be more closely described an apparatus for carrying out the method according to the invention. Reference is then made to the accompanying drawings, Figures 4 to 11 showing different embodiments. Figure 4 is a side elevation and partly a section of a silo plant according to the invention, whereas Figure 5 shows the same in front view. Figures 6 to 11 show different details of the silo.

According to Figure 4 the silo comprises a vertical trunk 1 which is supported by a frame which for each silo comprises four uprights 2. They are interconnected by means of horizontal cross bearers 3. A plurality of substantially horizontal drying zones are disposed in the silo. Said zones comprise each a plurality of horizontal beams between which narrow elongated orifices are formed for the grain 4 running down from the top of the silo. The grain is raised to the top of the silo by means of an elevator known per se, by way of example of the kind using a pressure air injector which brings the grain through a vertical tube 6 up to a supply trough 7. On the way down through the silo the grain meets drying zones of different natures, it being then observed that the grain in the upper portion of the silo should be subjected to a larger quantity of drying air on account of the fact that the grain at the beginning of its treatment naturally contains its highest degree of humidity. The uppermost drying zone comprises a number of beams traversing the silo and being designed in the shape of rectangular slabs 8, the long sides of which are horizontal and the short sides of which are secured to the silo in sloping position parallelly with

the other beams in the same drying zone. It is also conceivable that this drying zone is designed as shown in Figure 6 where the beams are disposed in zig-zag. Each beam is at its top provided with a fillet 9 substantially directed downward and, if desired, adjustable in relation to the beam. Said fillet has for its object to control the thickness of the grain layer moving down between the beams. On account of the so called angle of repose or the natural frictional angle, the grain forms a surface 10 according to the figure the angle of slope of the beam being then so adjusted that the surface 10 approaches the beam at its lower edge. Between the surface 10 and the beam 8 there is thus formed an intermediate air space which forms a channel or duct for passing the drying air. The drying air is then introduced through triangular apertures 56 disposed in the end walls of the silo, the lower edge of said apertures being then preferably disposed somewhat above the surface 10 of the grain. Said beams which are subjected to the pressure of the grain lying above are preferably carried by the above mentioned cross bearers 3. After the grain has passed the drying channels it enters an inoperative zone 11 which is adapted to accommodate a grain quantity which is several times larger than the grain quantity simultaneously accommodated in the next above disposed drying zone.

The next drying zone is according to this embodiment carried out in a somewhat different manner. Here the air channels are formed beneath two layers of horizontal beams 12 having a V-shaped section beneath which beams the grain on account of its natural frictional angle takes up the position shown in the figure. The air is preferably supplied through a special duct 13 which is arranged close to the point of the V and communicates with the air channel through narrow apertures or slots 14. Hereby the air current is directed towards the grain layer lying therebeneath. Then the grain enters an inoperative zone 15 and then a new drying zone which comprises a single layer of V-shaped beams 16. They form in the same manner as above air channels on their bottom sides. The beams are below provided with flanges 17 in the manner more closely illustrated in Figure 8. They are disposed in such a manner that the air current is compelled to sweep over the grain layer in zig-zag. Thereupon the grain runs down into an inoperative zone 18 and then into a drying zone formed by horizontal V-shaped beams 19, the section of the air channels being however reduced by lists 20 disposed at the point of the V which lists render the bottom sides of the beams ridge-shaped. The air is introduced in the usual manner through inlets 21 in the silo wall. Thereupon the grain enters an inoperative zone 22 and then a drying zone formed by a layer of horizontal V-shaped beams 23. In said beams the cross section of the air channel is still further restricted by means of a triangular list 24. Thereupon a new inoperative zone 25 and a drying zone formed by a layer of V-shaped beams 26 follow in which latter zone the cross section of the air is very considerably reduced by means of quadrangular lists 27. Thereupon the grain enters a delivery device comprising a number of horizontal V-shaped beams 28, which are arranged quite close to each other. Beneath each delivery slot or orifice formed between each two of the beams there is disposed a quadrangular rotatable roller 29 which is journalled in the two horizontal cross bearers 3 disposed rightly opposite each other the shafts of which outside the silo are provided with levers 30. Said levers are coupled to a common rod 31 which in any suitable manner may be imparted a reciprocating motion. The rollers are so disposed in relation to the corresponding delivery slots that when the rollers are at rest, the grain can not pass the upper edges of the rollers on account of the internal friction in the grain, but upon the motion of the rollers the grain will be delivered alternately on the right and the left sides of the rollers. Thereupon the grain runs down at a rate determined by the delivery device into the funnel-shaped portion 32 wherefrom it is either continually or intermittently supplied to the top of the silo by means of an injector device 5. The pressure air required for this purpose is delivered through the supply conduit 33. To allow inspection of the different drying zones manholes 34 are disposed between the horizontal cross-bearers 3.

Figure 5 shows a suitable disposition of a silo plant comprising two silos. It is then to be observed that the number of silos naturally is not limited to two. It is also conceivable that the different silo arrangements are entirely built together. As is evident from the drawings the air channels in the one silo are series connected to the corresponding channels in the other silo by means of ducts 35 of plate or wood. All the air channels are fed in common from a fan 36 through the intermedium of a duct 37 communicating with all the channels. Said fan may, by way of example, be adapted to be driven by an electric motor 38.

The duct 37 may of course just as well be disposed between the two silo arrangements all the drying channels being then mutually connected in parallel. The pressure air required for the transport of the grain is delivered from a fan 39 which by means of a supply conduit 40 communicates with the injectors of the two silo arrangements. The latter fan is preferably driven by an electric motor 41 which motor together with the mo-

tor 38 is fed from the supply mains 42. Said mains are provided with an automatically operated circuit breaker 43 which may be adapted to be controlled by a solenoid 44. The latter may be energized over a local battery 45 and a relay 46. Said relay which is not claimed per se in the present application is in a suitable manner connected to a hygrometer which when the air humidity exceeds a certain predetermined value, actuates the relay which closes the local circuit so as to energize the solenoid 44 whereby the current to the motors is interrupted. When the humidity has again fallen below a certain value the breaker 43 is allowed to close again in corresponding manner.

It is essential in the above described embodiment of the drying zones that each part of the grain mass is compelled to pass the drying channels in a thin layer in order to prevent that any part of the grain escapes from being efficiently subjected to the influence of the air. As soon as this condition is complied with the drying zones may of course be built according to a plurality of different constructions which all are to be considered as different embodiments of the invention. According to Figure 7 the different V-shaped beams 47 may thus be disposed on different levels. In such a case lists 48 may, however, be interposed which compel the grain to pass across the upper air channel and the lower air channel respectively in a thin layer. After the grain has passed such a drying zone, it enters in above described manner an inoperative zone.

The beams 49 shown in Figure 9 may be rotatably journalled at their top 50 and coupled to a horizontal operating rod 51 at their bottom part which rod upon being displaced in the one or the other direction controls the thickness of the grain layer moving downward and thus also the cross section of the air channels. Figure 10 shows in similar manner that the beams 52 may be provided with pivotable lists 53 at their bottom part which lists upon being turned regulate the downward motion of the grain and the cross-section of the air channels. In the embodiment shown in Figure 11 the beams 54 are provided with pivotable lists 55 at their tops.

The invention is, of course, not restricted to the case that the beams are disposed in different manners in the different drying zones. It is also conceivable that the same beam construction may be used all through the entire silo or at least within a certain group of drying zones without going beyond the scope of the invention.

In the shown example it has been assumed that the grain by means of a pressure air injector has been transported to the top of the silo but a bucket elevator or the like may, of course, be used for the same purpose, without receding from the subject matter of the invention.

I claim:

1. A drying zone in a silo or similar apparatus, comprising a plurality of horizontal beams extending across the gravitating grainy mass, and forming an equal number of air channels therebeneath, a corresponding number of lists extending parallel with said beams, said beams being disposed alternately in different horizontal and vertical planes, and said lists being disposed between the lower edges of two adjacent beams and forming, in conjunction with said edges, narrow slots for the gravitating mass.

2. A silo, comprising a plurality of horizontal beams extending across the gravitating grainy mass and forming an equal number of air channels therebeneath, and a number of baffle flanges disposed transversely on the bottom sides of said beams one behind the other and alternately staggered transversely to impart a zigzag motion to the air flow sweeping over the surface of the mass.

3. The method of air-drying granular materials, especially cereal grains, in a container through which the material sinks down in substantially vertical direction, comprising initially subjecting the material, during its descent through the container, to a drying of short duration by conducting it in thin layers through an air drying zone where it is brought into intimate contact with drying air currents; directly thereupon letting the material sink down into an inoperative zone in which it is removed from the influence of drying air or artificial heat; allowing it to remain therein during a period several times longer than the immediately preceding drying period until the humidity remaining in the interior of the material particles is allowed to distribute itself to the superficial layers of said particles; then immediately letting down the material into another air drying zone disposed on a lower level, thereupon directly letting down the material into another inoperative zone and so on until the granular material is dry.

In testimony whereof I affix my signature.

HARALD EDHOLM.