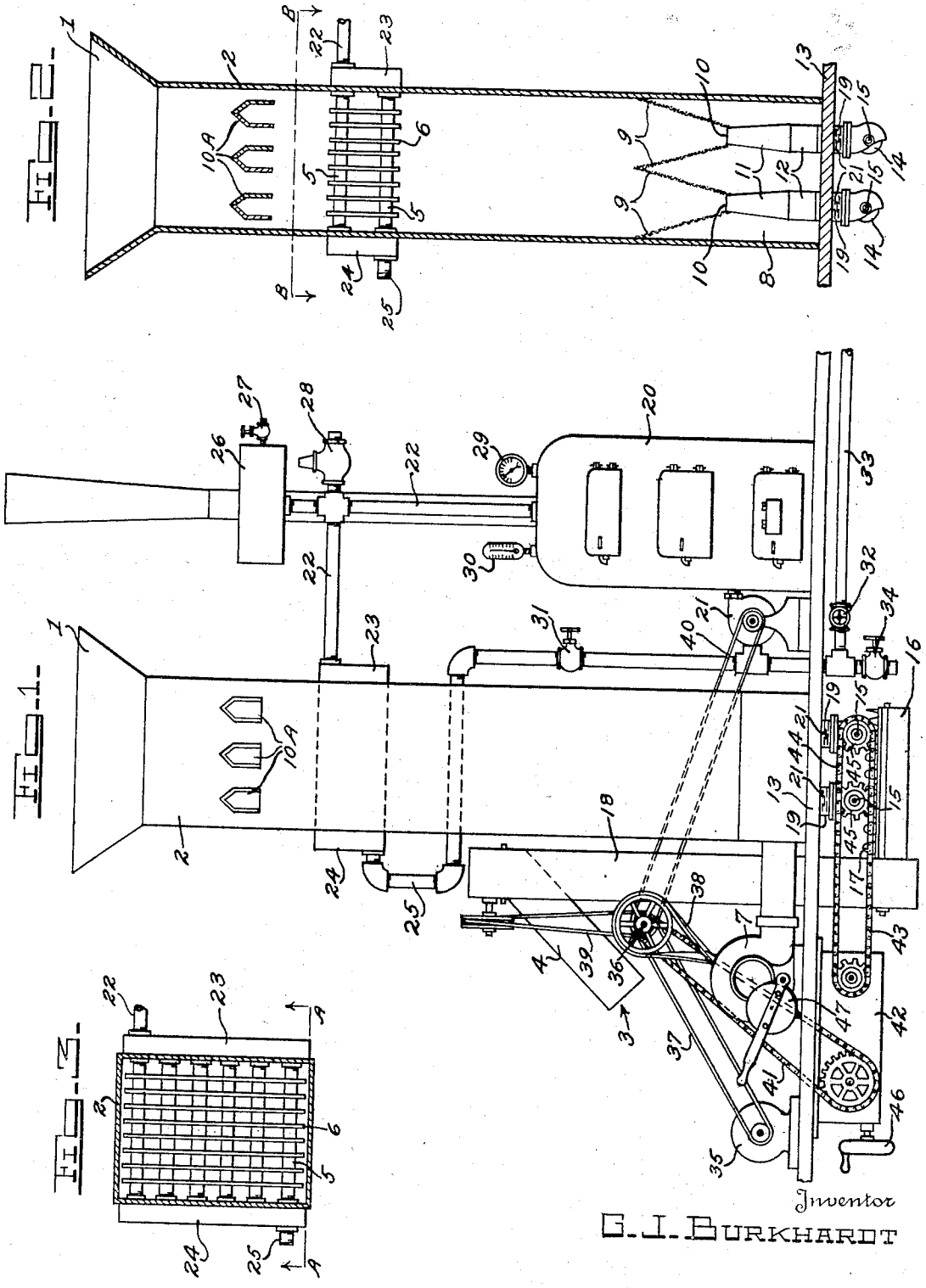
Nov. 2, 1943. G. J. BURKHARDT 2,333,089

GRAIN DRIER

Filed Feb. 12, 1941 2 Sheets-Sheet 1



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FIG. 4.

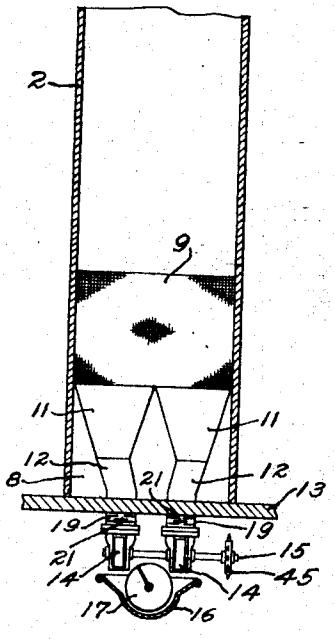
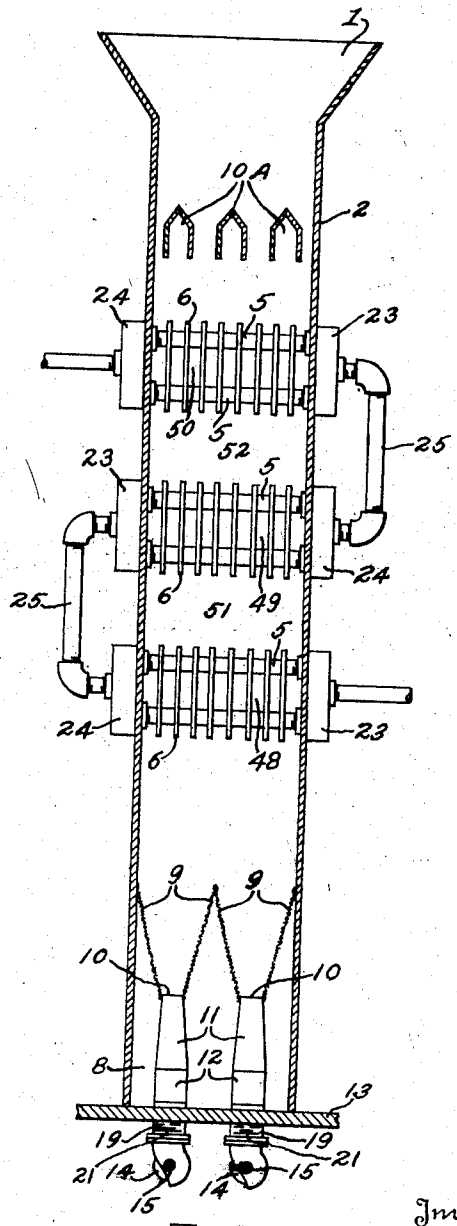


FIG. 5.



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GRAIN DRIER

George J. Burkhardt, Riverdale, Md.

Application February 12, 1941, Serial No. 378,508

1 Claim. (Cl. 34—65)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

This application is made under the act of March 3, 1883, as amended by the act of April 30, 1928, and the invention herein described and claimed, if patented, may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment to me of any royalty thereon.

My invention relates to apparatus for drying grain. It is well known that grains of various kinds vary considerably with regard to the amount of moisture contained at the time of harvesting, the actual percentage of moisture varying with the kind of grain and, more particularly, according to weather conditions obtained during and immediately preceding the period of harvesting. It is well understood by grain handlers generally, that grain having too high a moisture content cannot be safely held in bulk storage for any length of time owing to the tendency of such grain to become self-heating when so stored. Heating of stored grain may occur through either the rapid germination of mould spores which are carried along with the grain and become active under appropriate conditions of moisture and temperature, or may occur through metabolic processes taking place within the grain kernels themselves, which processes are materially accelerated by the presence of excessive moisture in the grain. The temperature rise of the grain, resulting from either of these processes, or both in combination, is at first gradual, but becomes more pronounced as the grain temperature increases, the process being self-accelerating, and sooner or later results in a rapid increase of the temperature to values at which rancidity and mustiness quickly develop, together with more or less complete loss of germinating power, all of which markedly depreciate the value of the grain.

The only practicable means so far found of keeping such grain in sound condition is the reduction, by drying, of the moisture content of the grain to a value at which it will be stable in bulk storage. Various means and methods of drying grain have been used but drying apparatus hitherto employed have been unsuited to farm use, by reason of being too cumbersome and costly, or, if constructed of small size, were either of inadequate grain handling capacity or incapable of removing moisture at a sufficiently rapid rate. My invention provides a grain drying apparatus of simple and compact type and of moderate cost and relatively high grain drying capacity in proportion to its size and weight, capable of effecting a pronounced reduction in moisture content with a single pass of the grain through the apparatus, drying being effected at a high thermal efficiency, under controlled temperatures without danger to grain from overheating.

I obtain the aforementioned important advantages by means of the apparatus herein described and shown in the accompanying drawings, in which

Fig. 1 is a side elevation of a complete drying apparatus;

Fig. 2 is a vertical section of the drying chamber of the apparatus shown in Fig. 1 along the line A—A in Fig. 3;

Fig. 3 is a horizontal section of the drying chamber along the line B—B in Fig. 2;

Fig. 4 is a vertical section through the lower portion of the drying chamber and the plenum chamber;

Fig. 5 is a vertical section through the drying chamber of a modified form of my invention.

Similar figures of references refer to similar parts in the several views.

Moist grain to be dried is received in a hopper 1 at the top of a vertically extending drying chamber 2, at such a rate as to keep the chamber constantly filled with the grain. The grain moves downward by gravity through said chamber and is removed from the bottom thereof at a constant controlled rate and elevated by means hereinafter described, and is discharged at 3 by grain discharge spout 4. As the grain moves downwardly in chamber 2, it contacts and passes between horizontal heating pipes 5 adapted to receive and convey a heating fluid, such as hot water or steam, said heating pipes extending transversely of said chamber in parallel spaced arrangement, the grain also contacting and passing between vertical heating plates or fins 6 also extending transversely of chamber 2 in parallel spaced arrangement and transversely of pipes 5 and secured to said pipes by welding, brazing or shrinking, etc., whereby the surfaces of said plates become virtually, for heat conducting purposes, extensions of the outer surfaces of said pipes, thereby providing within a limited space, a relatively large area for heat conduction to the grain descending between said pipes and said plates or fins, and making possible a high total rate of heat transfer from the heating fluid in said pipes to said grain, with a relatively small difference between the temperatures of said fluid and said grain.

The downwardly moving grain in drying chamber 2 is constantly subjected to the action of an upwardly moving current of air drawn from the

atmosphere by a fan 7 and forced into a plenum chamber 8 immediately below drying chamber 2. The bottom of drying chamber 2 is formed of wire netting surfaces 9 of such mesh as to retain the grain in the drying chamber but permit air to pass freely from plenum chamber 8 into the grain over nearly the entire bottom of drying chamber 2. Instead of wire netting, surfaces 9 may be of any other material; as for example, perforated sheet metal, adapted to retain the grain in chamber 2 while allowing air to pass freely into the same from the plenum chamber 8. The air passes upwardly through the grain, passing between heating pipes 5, and heating plates or fins 6, and being heated by contact therewith, and emerges from the grain into outlet flues 10A adapted to extend transversely of the drying chamber, the bottoms of outlet flues 10A being open to the grain, and returns to the atmosphere through the open ends of said outlet flues.

Grain passing downward through drying chamber 2 and passing between and around air outlet ducts 10A, into the space below said ducts, encounters and is somewhat heated by the air passing upwardly through said chamber, which air at that portion of its travel through the chamber has been heated, partly by heat absorbed by the air from heated grain and partly by heat received directly from portions of heating pipes 5 and heating plates or fins 6. The heating surface of the heating element comprised by pipes 5 and plates or fins 6, is so generally distributed over the cross section of drying chamber 2, as may be noted in Fig. 3, that a large proportion of the kernels in the grain make contact with some portion of said heating surface and are forced into intimate contact with the same by the pressure due to the weight of the grain in the chamber above said heating element, thereby providing conditions favorable for rapid conduction of heat from said heating element to the grain. Each kernel of grain so heated makes contact with the heating surface on only a relatively small proportion of its total perimeter. Much of the remainder of said perimeter is, at the same time, subjected to the action of the current of air rising through the grain, and is therefore giving up both heat and moisture to said air current. The thermal conditions provided by this arrangement are, therefore, favorable to a rapid transfer of both heat and moisture from the grain to the air. The continuous removal of heat from the grain while it is receiving heat from the heating element, tends to prevent the accumulation of heat within the grain and thereby avoids overheating of the grain.

The portion of drying chamber 2 extending between said heating element and plenum chamber 8 constitutes a heat exchanger in which the heated grain and cool air from the atmosphere move in countercurrent, the grain moving downwardly and the air upwardly. The downwardly moving heated grain gives up heat, in both sensible and latent form, to the upwardly moving air current, the sensible and latent heat content of the air being correspondingly increased. The temperature of the grain and the vapor pressure of its moisture content, both tend to approach the corresponding values for the incoming air, the grain being both dried and cooled as it moves downward through the said space.

The wire netting surfaces 9 which form the bottom of drying chamber 2 and separate said drying chamber from the plenum chamber 8, are steeply inclined to right and to left in alternation, forming a plurality of V-shaped troughs, extending in parallel contiguous arrangement. The lower edges of the surfaces 9 which form each such trough do not meet but are somewhat separated leaving a narrow slot-like grain discharge opening 10 at the bottom of the trough into which the dried grain descending in chamber 2 is guided by the inclined surfaces 9 and through which the dried grain exits from said chamber. Each discharge opening 10 is connected to a plurality of grain discharge hoppers 11 which receive the dried grain issuing from drying chamber 2 through openings 10 and guide said grain into closed grain spouts 12 which extend through the bottom 13 of plenum chamber 8. The lower end of each spout 12 is provided with a grain discharge wheel 14 of conventional type adapted to discharge grain at a controlled rate determined by the rate at which said wheel is rotated. Wheels 14 are carried upon and rotated by shafts 15 which are driven at a controlled speed by means hereinafter described. Wheels 14 discharge the dried grain into trough 16. Spiral conveyor 17, operating in trough 16 conveys the dried grain to the foot of dried grain elevator 18 which elevates the grain and delivers it into grain discharge spout 4, the dried grain being discharged at 3.

Air vent openings 19 are provided in the walls of spouts 12 below the bottom 13 of plenum chamber 8, said openings being adapted to permit the free escape to the atmosphere of such air as may be forced through the grain in hoppers 11 and spouts 12 by the pressure of air in plenum chamber 8, thereby preventing the building up in spouts 12 of air pressure which might affect the delivery of grain by wheels 14.

The drying apparatus shown in Fig. 1 is arranged for utilizing water as the heating fluid circulated through the heating pipes in the drying chamber. As shown in that figure, the water is heated in boiler 20, of a conventional type, and is circulated by circulating pump 21 through said boiler 20, flow pipe 22, flow header 23, heating pipes 5, return header 24 and return pipe 25, back to pump 21. The heating system being of the closed type is conventionally equipped with an expansion tank 26, air cock 27, relief valve 28, pressure gauge 29, and thermometer 30. The rate of flow of the hot water through heating pipes 5 in drying chamber 2 may be regulated by valve 31 in return pipe 25, and the temperature of the hot water observed by thermometer 30, and regulated as required by manipulation of conventional draft controls of boiler 20. Water is supplied to the heating system when required through water supply valve 32 and water supply pipe 33, extending from a suitable source, not shown. Drain valve 34 permits the heating system to be drained, when required.

While I prefer to employ hot water as the heating fluid circulated through heating pipes 5, it is evident that any other heating fluid, such as, for example, steam, could be similarly employed without departing from the essential principle of my invention.

The moving members of the drying apparatus are operated by electric motor 35, which drives countershaft 36 by means of belt 37. Instead of the electric motor 35, the moving members may be driven by any other suitable means as, for example, an internal combustion engine. From countershaft 36, fan 7 is driven by belt 38, the dried grain elevator 18 by twisted belt 39, and

circulating pump 21 by belt 40. Spiral conveyor 17 is directly connected to the shaft, not shown, carrying the bottom pulley of elevator 18 and receives its motion therefrom.

Grain discharge wheels 14 are driven through chain 41, speed changing transmission 42 and chains 43 and 44 driving sprocket wheels 45 on shafts 15. Transmission 42 is of a conventional type, having speed adjusting means, such as a handwheel 46, by operation of which the speed of wheels 14 may be varied as required.

In operation, in drying grain, the rate of flow of hot water through heating pipes 5 is controlled by adjustment of valve 31, the temperature of the hot water regulated by adjustment of conventional draft controls of boiler 20, the rate of movement of the grain through the drying chamber is controlled by adjusting the speed of the wheels 14 through manipulation of handwheel 46, and the volume of air forced upwardly through the grain in the drying chamber, is controlled by adjustment of shutter 47 on intake of fan 7.

I have found it essential to the proper performance of my drier to employ fins or plates 6 in addition to having two rows of pipes 5. These fins or plates 6 should be properly spaced at substantially 24 per foot.

Under an alternative application of my invention, shown in Fig. 5, I may arrange heating pipes 5 in a plurality of banks, as for example, in three banks, 48, 49, and 50, each of said banks comprising heating pipes 5, heating plates or fins 6, flow header 23 and return header 24, connected and arranged, as hereinbefore described, said banks being positioned, one above another in said drying chamber 2, but separated, one from another, by intervening spaces, 51 and 52 in said chamber. I have found this arrangement to be advantageous where grain of high moisture content is to be dried and its moisture content reduced in relatively large proportion, requiring a correspondingly large amount of heat in relation to the quantity of grain handled. This modification of my invention enables relatively large reductions to be made in the moisture content of grain, with a less total expenditure of heat than is required with heating pipes in a single bank, thereby accomplishing the drying at a higher thermal efficiency with less tendency to overheat the grain.

While I have shown three banks of heating pipes, it is to be understood that I do not limit myself to this particular number of banks, since it is evident that my invention may be practiced with any other number of such banks without departing from the essential principle of my invention.

While grain drying apparatus has been employed having horizontal heating pipes in vertically extending drying chambers in connection with means for forcibly passing currents of air upwardly through the grain in said chambers, I have found that such structure is not adapted for the type of apparatus which has a capacity for high moisture removal; high ratio of heat conducting surface area to the volume of grain to be handled, and a high rate of moisture removal without subjecting the grain to dangerously high temperatures; and, the combination of these features in a compact, portable apparatus as hereinbefore described.

Having thus described by invention, what I claim for Letters Patent is:

A grain drier comprising a vertically elongated chamber adapted to be filled with a column of grain, means for introducing grain into the top of said chamber, a foraminous support for the column of grain at the bottom of the chamber, means for forcing air into the chamber below the foraminous support, whereby the air will pass upward through said support and through the column of grain, controllable positive means for removing grain from said support to the exterior of the chamber, and a radiator in said chamber above said support, said radiator having members spaced to permit the column of grain passing therebetween to be uniformly heated.

GEORGE J. BURKHARDT.