United States Patent

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[15] **3,636,638**

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[54] AUTOMATIC GRAIN DRYER

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[52] **U.S. Cl.** **34/45**, 34/48, 34/56, 34/174

[51] **Int. Cl.** **F26b 13/10**

[58] **Field of Search** 34/45, 48, 56

[56] **References Cited**

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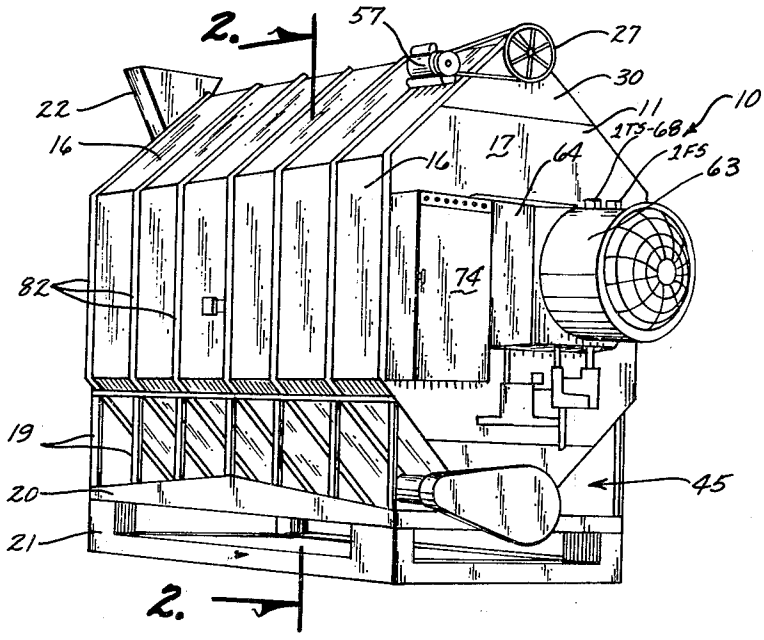
[57] **ABSTRACT**

This invention comprises a grain dryer wherein the entire operation of drying the grain from a wet condition to one of a predetermined lower moisture content is completely automated, with an improved control circuitry including a bilevel photoelectric unit mounted within the dryer for refilling the drying column based purely upon moisture removal rate or shrinkage rate of the grain, the circuitry including further a temperature-controlled unit for sensing the temperature of the air as it passes through the grain column based on a predetermined temperature setting, and wherein the circuitry includes a second temperature-controlled unit for alternately turning the burner on and off during the heating cycle such that the grain is dried by a heat-pulsing action.

9 Claims, 8 Drawing Figures



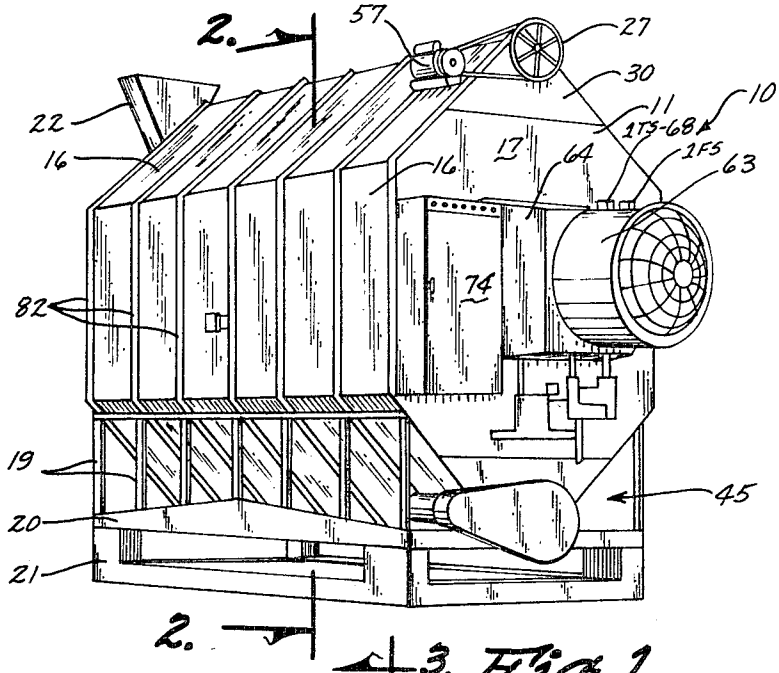


Fig. 1

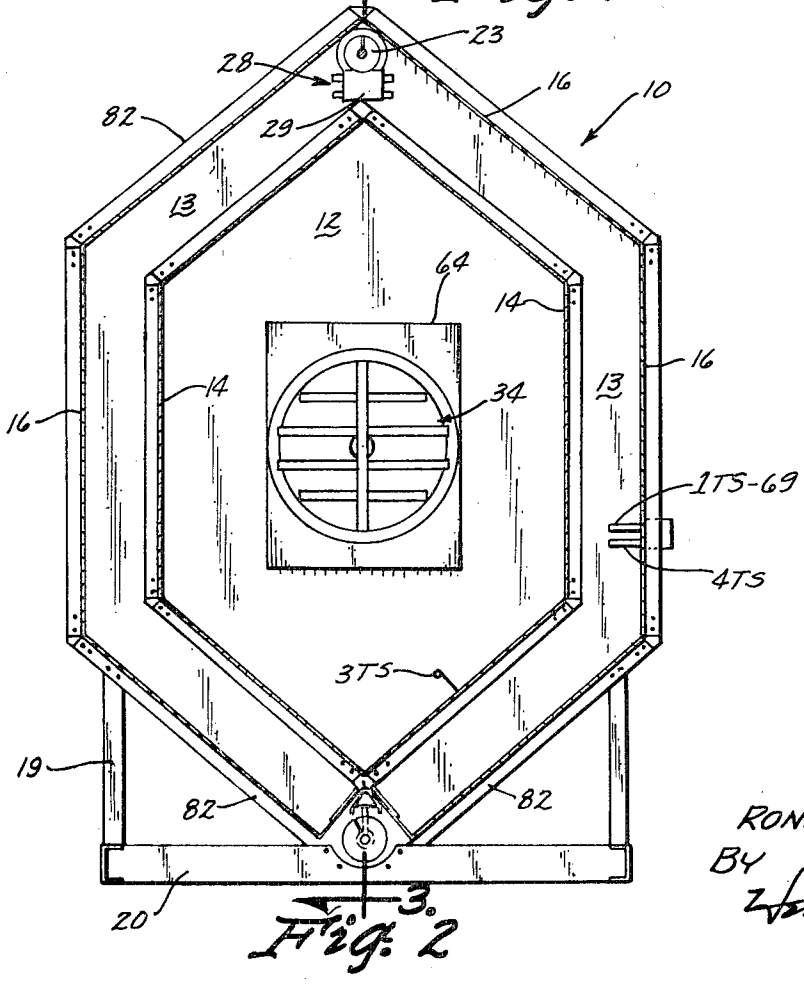


Fig. 2

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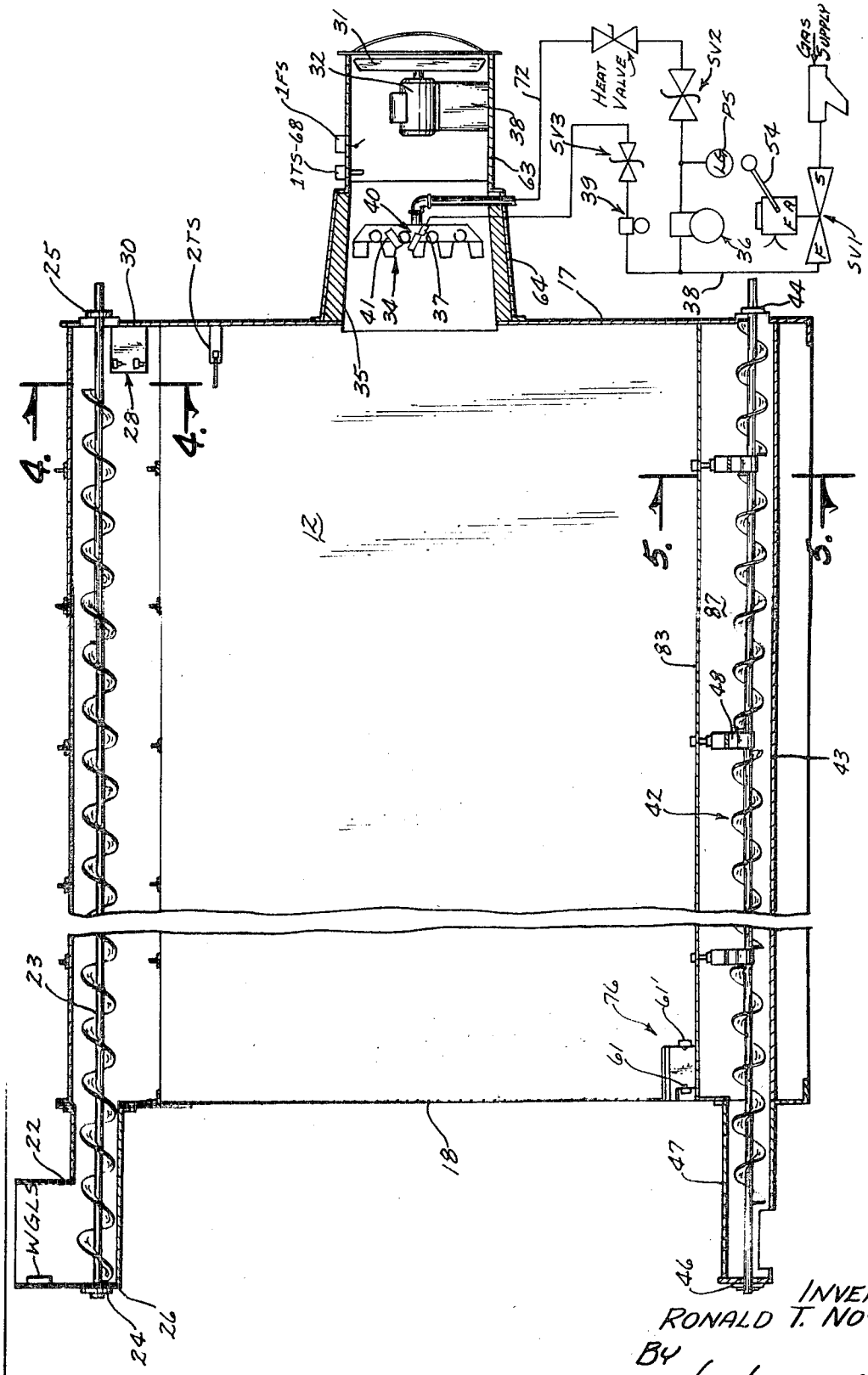

Fig. 3

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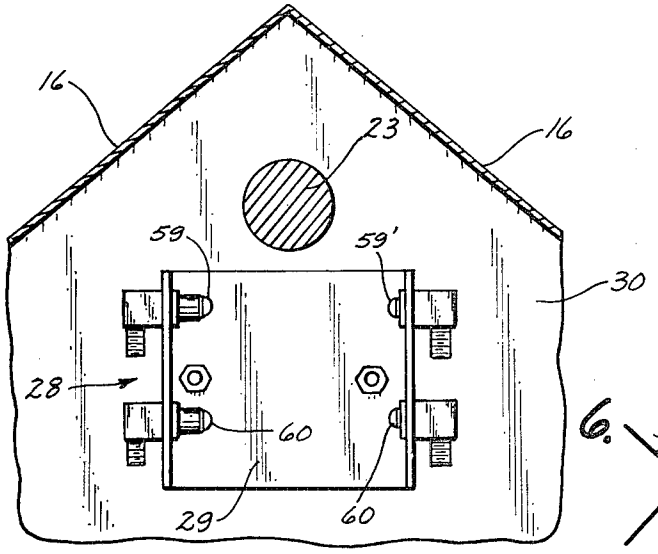

Fig. 4

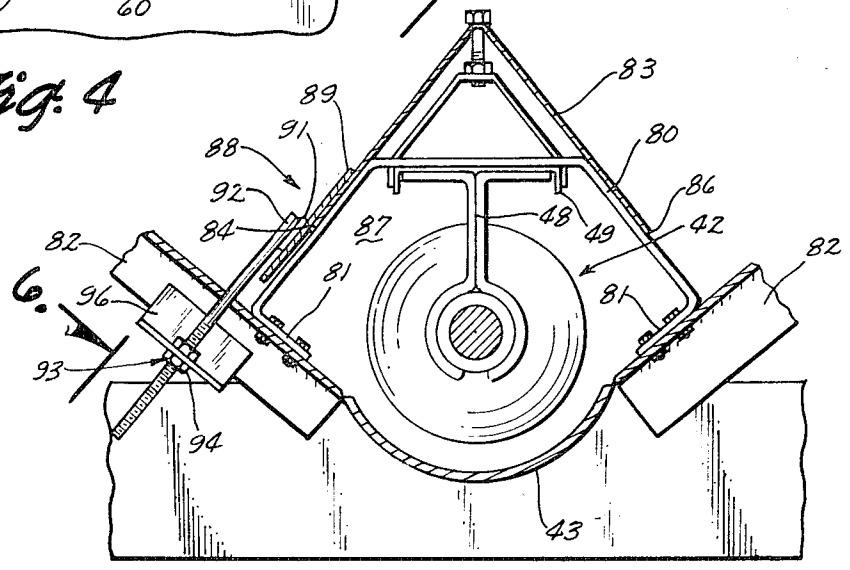

Fig. 5

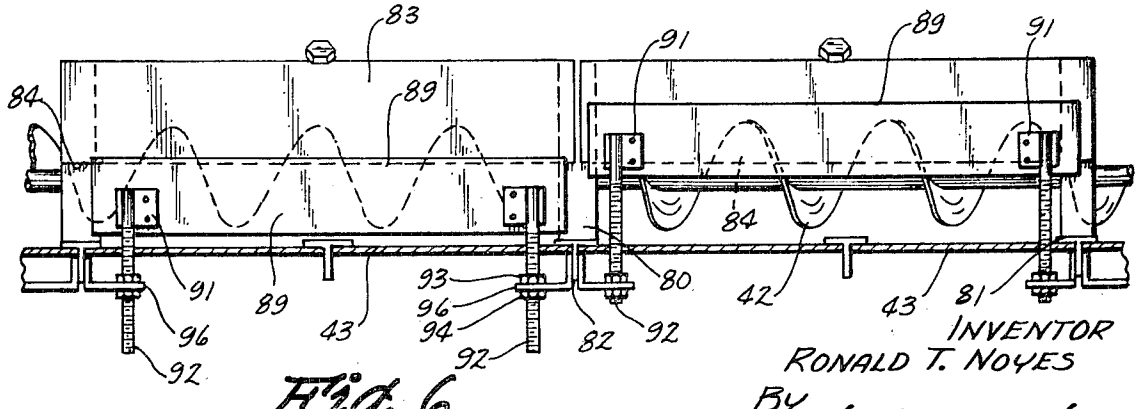

Fig. 6

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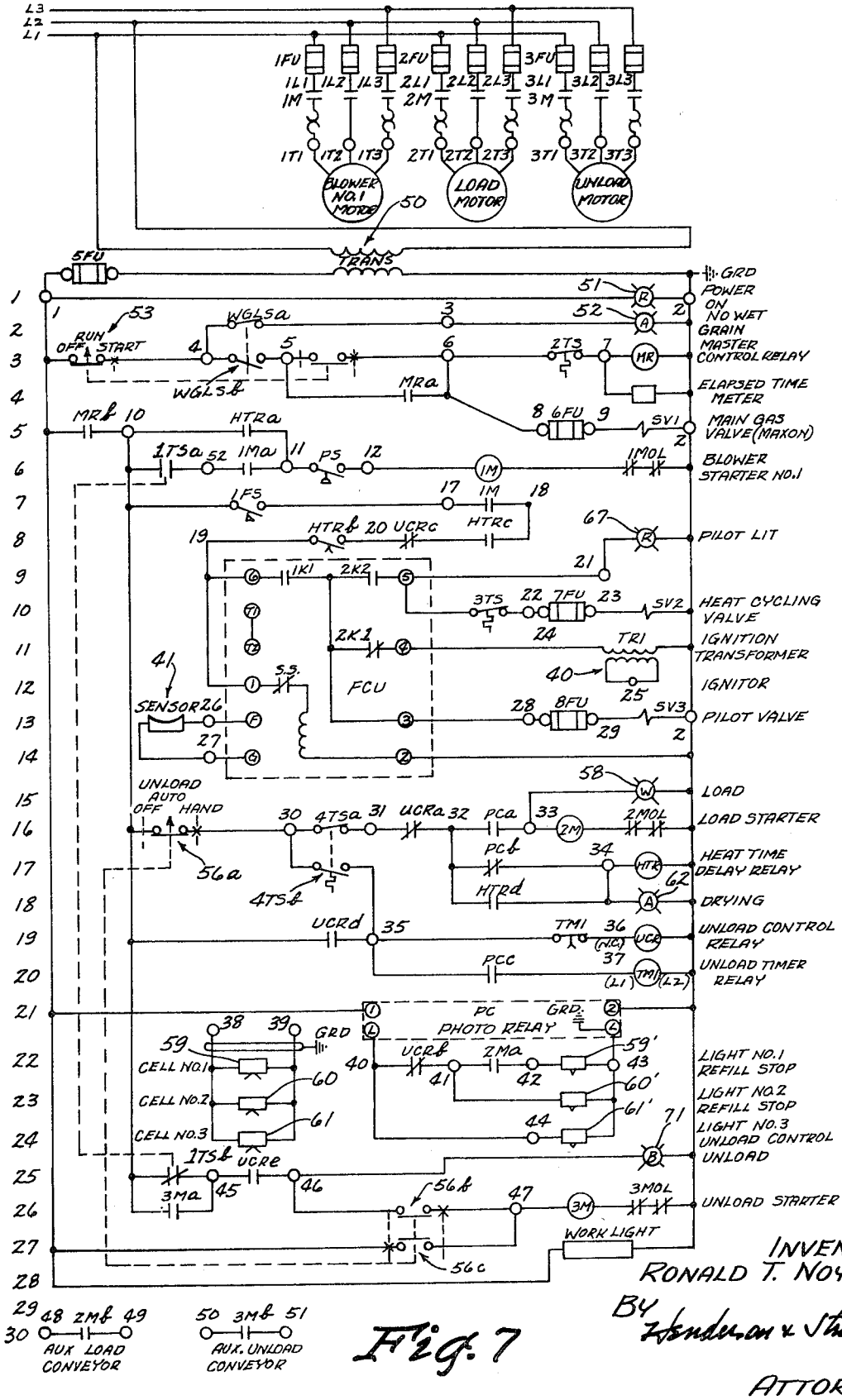

Fig. 7

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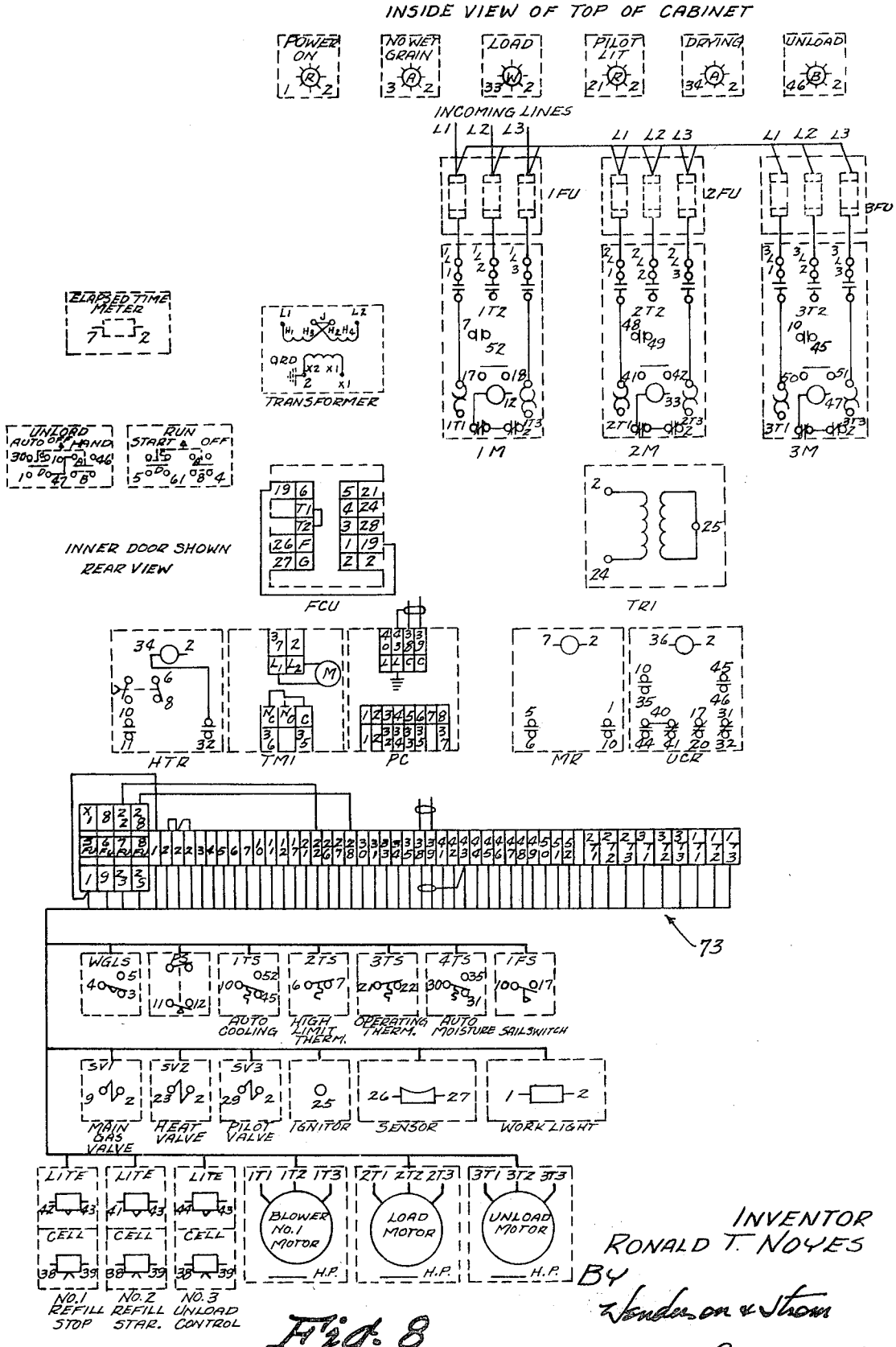

Fig. 8

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AUTOMATIC GRAIN DRYER

BACKGROUND OF THE INVENTION

The provision of grain dryers, both portable and stationary, is not new, nor is the provision of rendering the drying process at least semiautomatic. However, known dryers are lacking in the provision of a pulsing on-off application of heat to the grain so as to enable the withdrawal of moisture from the grain slowly and evenly, and at a lower temperature than those usually had, the latter high heat arrangements causing a casehardening type of heat damage which creates cracks in the grain and lowers its quality and value.

Furthermore, known dryers apply heating and cooling over given periods of time which are preset manually, as compared to a much more advantageous process of applying the heating and the cooling air over periods of time determined solely by the nature of the grain itself as it dries.

SUMMARY OF THE INVENTION

The invention relates to a grain dryer for automatically drying primarily batches of grain, the dryer being portable but susceptible of being made permanent or stationary for long periods of time.

The invention pertains particularly to five areas, first during the loading of wet grain and so as to utilize the capacity of the dryer to the utmost, a bilevel vertical arrangement of photoelectric cell units are arranged to keep refilling the dryer according to the shrink rate of the grain as the moisture is removed. Secondly the heat of the grain is controlled by a temperature-sensitive unit which provides a continuous on-off cycling of the burner providing heat to the grain such that a continuous, alternating application and nonapplication of heat occurs.

Thirdly, the heating cycle of the grain is determined by sensing a predetermined set temperature of the air passing through the grain column, based primarily on the moisture condition of the grain. Fourthly, the cooling cycle of the dryer is based purely on the differential between the ambient temperature and the exhaust air temperatures, respectively, utilizing thermostatic devices. The fifth area relates to the capability of matching the rate and volume of dried grain being discharged from the dryer to that of the equipment into which it is being discharged which matching can be accomplished during operation of the dryer.

It is an object of this invention to provide a novel grain dryer which is capable of automatically operating auxiliary equipment for loading wet grain into itself and moving dried grain discharged from itself, and which is capable of drying the wet grain to a predetermined moisture content and cooling the dried grain to a temperature differential, all based upon the rate of moisture removal from the grain and the nature of the grain itself.

These objects and other features and advantages will become readily apparent upon reference to the following description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a grain dryer embodying the features of this invention, and shown placed in a stationary position;

FIG. 2 is a vertical sectional view as taken along the line 2—2 in FIG. 1;

FIG. 3 is a vertical sectional view as taken along the line 3—3 in FIG. 2;

FIG. 4 is a further enlarged fragmentary view of the bilevel photoelectric unit as taken along the line 4—4 in FIG. 3;

FIG. 5 is a fragmentary view of the discharge auger and volume control device as taken along the line 5—5 in FIG. 3;

FIG. 6 is a view taken along the line 6—6 in FIG. 5;

FIG. 7 is a diagrammatic representation of the electric control circuitry for the dryer; and

FIG. 8 is a composite view of the inside of the control cabinet door showing the actual placement of certain of the electric components for the control circuitry.

DESCRIPTION OF THE PREFERRED CIRCUITRY

Referring now to the drawings and particularly to FIG. 1, one example of a batch-type grain dryer embodying this invention is indicated generally at 10, and comprises a metal housing 11 of a generally six-sided shape in front elevation having an interior chamber 12 (FIG. 2) about which is formed a column 13 by a pair of parallel inner and outer perforated sidewalls 14 and 16, and with the chamber 12 enclosed at the ends by a front end wall 17 and a rear end wall 18 (FIG. 3). The housing 11 is mounted by upright braces 19 on a platform 20 in turn supported on a concrete base 21.

For receiving wet grain, for example, at the upper rear of the dryer 10 a grain fill hopper 22 (FIG. 3) is provided, which hopper 22 is secured to the end wall 18 and into which a loading auger 23 is extended, being mounted in bearing blocks 24 and 25 on the rear 26 of the hopper 22 and the front triangular plate 30 on the front wall 17, respectively. The auger 23 extends along the top apex of the housing 11. The loading auger 23 is rotated by a loading motor 57 (FIG. 1) operating through a belt-driven pulley 27.

Associated with the loading auger is a wet grain load switch WGLS (FIG. 3) which is a pressure-sensitive switch that senses the presence, or absence, of wet grain at the mouth of the fill hopper 22. The switch WGLS can as well be used at a remote position not directly associated with the dryer. At the other end of the loading auger 23 is a bilevel photoelectric unit 28 (FIGS. 3 and 4). A pair of vertically spaced receiving cells 59 and 60 are mounted on a bracket 29 directly opposite a pair of vertically spaced lights 59′ and 60′; each pair of opposite cell 59 and light 59′; and cell 60 and light 60′ being capable of completing a circuit when energized as hereinafter described, which circuit is broken when grain is deposited between a respective cell-light combination. The utilization of the bilevel photoelectric unit 28 is described in detail hereinafter. The bracket 29 is secured to the inner surface of a triangular plate 30 (FIG. 1) which is removable, and which forms the upper part of the housing front wall 17.

To move air from external the dryer housing 11 into the chamber 12, from whence it passes outwardly in all directions through the inner sidewall 14, then the column 13 interior, then the outer sidewall 16 to the atmosphere, a fan 31 (FIG. 3) is provided which is mounted within a circular shroud 63 secured in axial alignment to a burner housing 64 connected to the outside of the front wall 17. The fan 31 is driven by a motor 32 which is supported by a mounting 33 concentrically within the shroud 63.

Also mounted within the fan shroud 63 for use in combination with the fan 31 is a sail switch 1FS and the sensing bulb 1TS–68 of an automatic cooling relay 1TS. The operation of these components of the electric control system will be described hereinafter.

To heat the air being blown into the chamber 12, a burner 34 (FIG. 3) is provided within a conical transition liner 35 extended through the front wall 17 and into the chamber 12. Low pressure gas is supplied the burner 34 through a main gas safety valve SV1, operable manually by a handle 54, and then through a main regulator 36 and a main heat valve SV2 to the burner via a conduit 72.

Gas for a pilot 37 at the burner 34 is tapped off the main line 38 through a regulator 39 and pilot valve SV3. An ignitor 40, indicated at 25 in FIG. 7, is provided for electrically igniting the pilot 37, and also at the burner 34 is a sensor 41 for sensing the pilot flame at the burner. Operation of the heating arrangement is described hereinafter.

To unload the grain after it has been dried and cooled, an unloading auger 42 (FIGS. 3, 5 and 6) is provided along the bottom apex 43 of the housing, the front end mounted in a bearing block 44 (FIG. 3) and belt driven from an unloading

motor illustrated generally at **45** in FIG. **1**, with the rear end mounted in a bearing block **46** secured to the rear of a discharge tube **47**. Referring to FIG. **5**, the auger **42** is supported at spaced intervals by a T-hanger **48** secured via a U-shaped channel plate **49** to a bracket **80** the flanges **81** of which are secured to the sidewall **16** at a sloped rib **82**.

To provide for matching the discharged flow of grain from the column **13** to auxiliary unloading conveyors so as to prevent overloading the auxiliary conveyors, an inverted V-shaped cover **83** (FIGS. **5** and **6**) is secured as illustrated over the unloading auger **42** throughout the length of the housing column **13**. The cover **83** is secured to the brackets **80**, and has lower edges **84** and **86** (FIG. **5**) which are spaced upwardly from the sidewall **16** to provide spaces through which the grain may flow from the column into the auger chamber **87**.

The amount of each space on one, or both sides of the cover **83**, is adjustable as by the provision of a plurality of shield units **88**. As each shield unit **88** is identical only one will be described. It comprises a flat plate **89** of a length and width sufficient to substantially cover a space defined horizontally between a pair of brackets **80**, and vertically between the lower edge **84** or **86** of a cover **83**, and the adjacent sidewall. Secured to each end of a plate **89**, as by a bracket **91**, is a long, threaded rod **92**, threaded through a pair of nuts **93**, **94** on either side of an angle piece **96**, the latter connected to a rib **82**.

As the rods **92** and nuts **93**, **94** are exposed to the outside of the dryer housing wall **16**, one can manipulate them to adjust the location of a plate **89** relative to its space, thereby letting more or less grain into the unloading auger chamber **87**, during operation of the dryer **10**. FIG. **6** shows the left plate **89**, as viewed, substantially covering its space while the right plate **89** is up as far as it can go, thus leaving the space open the maximum amount.

In using FIGS. **7** and **8** to describe and understand the electric circuitry, numerals **1–30** inclusive are placed in a vertical column on the left side of FIG. **7** to indicate horizontal lines, respectively, of the diagrammatic of FIG. **7**, and the right-hand side of a line is indicated by the numeral **2**, indicating the neutral wire of a 120 v. circuit. Thus, if a designation **3** in parentheses, such as (**3**) is given following, for example, the element MR, one would quickly go to line **3**, and moving left to right, the element MR would be found.

The numerals **1–51** inclusive are also used internally of FIGS. **7** and **8** to indicate connections on either the actual element, such as for example the master relay MR, or on the terminal strip **73** (FIG. **8**). A connection on an element is indicated by a solid dot, while one on the strip **73** is indicated by a small circle. FIG. **8** shows the physical placement of the elements illustrated therein on the inner side of the door of a control panel **74** (FIG. **1**), and all like numerals are electrically connected. Looking at the master relay MR, it is seen that its coil is connected from a terminal connection **7** to the common neutral **2**; and that it has relay contacts connected between terminals **5** and **6**, and **1** and **10**. Referring to FIG. **7**, one quickly finds the relay MR on line **3** between the numeral **7** and the right-hand side of the line at **2**; and finds normally open contacts MR*a* and MR*b* between terminals **5–6** and **1–10**, respectively. Not only, therefore, are the numerals **1–51** of FIGS. **7** and **8** used as a guide for describing the sequence of operation as described hereinafter, but they also are the blueprint for making the electric connection of all elements.

Referring particularly to the electrical circuit schematic and layout wiring diagrams of FIGS. **7** and **8**, the closed-loop "-stage-controlled" cycle process of the instant grain dryer **10** is as follows. Upon the closing of a main power disconnect so as to provide power to the lines L1, L2 and L3, control transformer **50** reduces the voltage to 120 v. in the three phase units; a "power on" light **51** illuminates; a photocell relay coil PC(**21**) is energized, switching the photocell contacts PC*a* (**16**), PC*b* (**17**), and PC*c* (**20**) from the positions shown; and an automatic cooling control relay 1TS (FIG. **2**) is energized, switching its contacts 1TS*a* (**6**) to the normal condition shown. The numerals in parenthesis indicate certain of the numbered lines of the schematic of FIG. **7** and are merely and only for ease of following the explanation of the sequence of operation of the grain dryer electrical system as described hereinbefore.

A pressure switch WGLS (**2**), see also FIG. **3**, is provided at the grain fill hopper **22** for sensing the presence or absence of wet grain. This switch WGLS may be located at an alternate location; for example, in the discharge hopper of a wet grain holding tank (not shown) used in conjunction with an auxiliary wet grain loading device. If no wet grain is available, the switch closes at WGLS*a* (**2**), opening at WGLS*b* (**3**), a "no wet grain" light **52** turns on, and the dryer will not start. If wet grain is available at the grain fill hopper **22**, the switch WGLS closes at WGLS*b*, opening at WGLS*a*, and the dryer **10** is ready to start and to operate continuously. If the supply of wet grain runs out, the wet grain switch contacts *a* and *b* will reverse to their normal condition shown, breaking the master relay circuit beyond the switch WGLS, thus stopping the dryer.

Next rotate the "off-run-start" selector switch **53** (**3**) to the spring-loaded "start" position, providing thereby power to the master control relay coil MR (**3**) through a high limit switch 2TS (**3**). At this time, the normally open contacts MR*a* (**4**) and MR*b* (**5**) close.

The main gas valve coil SV1 (*f*), see also FIG. **3**, is energized at this time, with the closing of the MR*a* contacts. The operator of the dryer **10** cocks the valve SV1 open manually by a lever **54** (FIG. **3**), and upon being energized the valve is held open by a solenoid latch (not shown). This pressurizes the low gas pressure switch PS (**6**), and the reset tab on this normally open switch is then manually depressed, closing the switch.

Power is supplied through MR*b* (**5**) to the "unload" selector switch **56***a* (**16**), which includes switch contacts **56***b* (**26**) and **56***c* (**27**). For semiautomatic drying wherein the dryer starts and continues through but one heating-cooling cycle, the switch **56** is placed in the "off" position. For continuous dryer operation, the unload switch **56** is placed in the "auto" position. Power then runs through normally closed contacts 4TS*a* (**16**) of the automatic moisture control thermostat 4TS, the sensing element shown in FIG. **2**, the normally closed contacts UCR*a* of the unloaded control relay UCR (**19**), and the switched (now closed) contacts PC*a*, thereby energizing the starter 2M for the load motor **57** (FIG. **1**). The energized starter 2M (**16**) switches normally open contacts 2M*a* (**22**) and 2M*b* (**30**) closed, causes "load" light **58** to illuminate, thus starting the load cycle.

If an auxiliary loading arrangement is being used, energization of the auxiliary starter 2M*b* causes grain to flow through the inlet hopper **22** to the loading auger **23**, otherwise the dryer **10** will now load itself within the column **13** until the photoelectric bilevel eye unit **28** is actuated, thereby automatically shutting off the loading auger and initiating the drying cycle.

Photocells **59**, **60**, and **61** (**22**, **23** and **24** respectively) are connected in parallel for continuous monitoring of their respective lights **59'**, **60'**, and **61'**. The bilevel unit **28** holding cells and lights **59**, **59'** and **60**, **60'** is mounted at the front end of the loading auger **23**, at the upper apex portion of the column **13** such that it is at the area of the column last to be loaded with untreated wet grain, prior to the start of the drying cycle. The cell **61** and its light **61'** are part of the unloaded control system, and are located as a unit **76** at the lower portion of the column **13** near the discharge end of the unloading auger **42** (FIG. **3**). The PC (**21**) relay energizes light **59'** (**22**) through normally closed unloaded control relay contacts UCR*b* (**22**) and now closed 2M*a* contacts; light **60'** (**23**) is energized through the contacts UCR*b* (**22**); and light **61'** (**24**) is always energized.

The dryer will load itself by means of the loading auger **42** until the grain fills the column **13** and breaks both the lower

beam of light 60' and then the higher beam of light 59' (FIGS. 3 and 4). This, combined with the beam of the third light 61' being broken, deenergizes the PC-relay (21), switching the contacts of PC*a* (16), PC*b* (17), and PC*c* (20) back to their illustrated conditions thus opening the load motor circuit at 2M*a* (22). With the contacts 2M*a* open, the load motor 57 stops and the load light 58 goes off.

As explained hereinafter, the initial deenergization of the PC-relay initiates the drying cycle, whereupon removal of moisture from the grain shrinks it and thus fills less space within the column 13. As the grain shrinks past and below the lower bilevel light 60', such that the beam strikes cell 60, relay PC (21) is again energized, switching the PC-contacts *a* (16), *b* (17), and *c* (20) back to their nonillustrated condition, loading motor 2M, 57 (FIG. 1), and closing the 2M*a* (22) contacts which energizes light 59', to rotate the loading auger 23 and refill the column 13 until the beam of light 50' is again broken. The steps of deenergizing the PC-relay and initiating the drying cycle are again performed.

Initial deenergization of the PC-relay closes PC*a* (16) which energizes the heat time delay relay HTR (17), closing the normally open contacts HTR*a* (5). A timing sequence of normally open timed-closed HTR*b* (8) switch begins, with normally open HTR*c* (8) and HTR*d* (18) contacts closing. The latter contacts HTR*d* (18) are wired in parallel with PC*b* (17) contacts to form a holding circuit. "Drying" light 62 (18) turns on and remains on while the heat time delay relay HTR (17) is energized.

The closing of HTR*a* (5) energizes the starter 1M (7) for the blower fan motor 32 (FIG. 3), whereby an airflow is established from external the dryer 10 through the fan shroud 63 and burner housing 64 to the interior chamber 12 of the dryer which is surrounded by the column 13. In so doing, a sail switch 1FS (7) mounted within the fan shroud 63 (FIG. 3) is closed, whereupon with the time-delayed closing of switch HTR*b* (8), provided for purging the dryer 10 prior to turning on the burner 34, the flame safeguard relay FCU, shown in dotted line enclosure between lines 8–15 (FIG. 7), is energized.

When energized, relay 1K in FCU closes contact 1K1 which provides power simultaneously to the pilot valve SV3 (13), see FIG. 3, and through normally closed 2K1 (11) contact to an ignition transformer TR1 (11). Thus, ignition spark is supplied at the instant pilot gas is released. As soon as a flame at the pilot 37 (FIG. 3) is established by the ignitor TR1, the sensor (13) transmits a continuous signal to relay 2K of FCU, switching the contacts of 2K1 and 2K2 to the positions not illustrated.

Normally closed 2K1 (11), now open, switches TR1 off, while normally open 2K2, now closed, energizes "pilot lit" 67 (8) and the main heat valve SV2 (10) (FIG. 3) through normally closed 3TS (10), starting operation of the burner 34 (FIG. 3). Thermostat 3TS (10), with sensing bulb mounted within the heat chamber 12 (FIG. 2), controls the on-off cycling of the burner 34. When the temperature of the air within the chamber 12 builds up to the setting of 3TS, it opens, shutting off the main heat valve SV2, but with the fan 31 (FIG. 3) continuing to force cool air into the dryer chamber 12. When the cool air drops the chamber temperature below the differential setting of 3TS (10), it closes again energizing the heat valve SV2 and again beginning the heating.

Under these conditions, the operating thermostat 3TS may have the heat on for approximately 12–15 seconds, with it off approximately 3–4 seconds. Heat valve (FIG. 3) is a manually set valve as regards the volume of gas inflow through pipe 72 to the burner 34, and is used to control the rate of rise of the air temperature at 3TS (FIG. 2). The rate of cycling, wherein the grain is alternately heated and cooled, over and over again, can be fine tuned by adjusting the differential setting of the operating thermostat 3TS (10), which varies the "off" time of SV2 for a given heat valve setting.

The automatic cooling control relay 1TS has a pair of sensing bulbs, 1TS–68 (FIG. 3) inserted in the fan shroud 63 to sense the ambient air temperature and 1TS–69 (FIG. 2) inserted in the column to sense the temperature of the air exhausting from the chamber 12 through the column 13 to external the dryer 10.

The relay 1TS has a set point of operation depending upon the bulbs attaining a predetermined differential temperature range above ambient, 10° F. for example, such that as the exhausting air temperature rises past the set point during the heat cycle, the relay 1TS switches the normally open relay contacts 1TS*a* (6) and normally closed 1TS*b* (25) from the positions shown. 1TS*a* (6) provides a holding circuit to close magnetic starter 1M (6) to keep the latter energized when closed HTR*a* (5) opens at the end of the heat cycle. Open 1TS*b* (25) is now set to close at the end of the cooling cycle, automatically starting the unload cycle.

During the drying cycle, which includes both the heating and cooling cycles, the grain in the column is continually being added to by new, additional grain, due to operation of the bilevel photoelectric eye unit 28 (FIG. 4). As the grain shrinks during drying, the lower cell-light 60—60' senses the absences of grain, and the circuit operates to start the top-loading auger 23 to refill the dryer. Then when the dryer is again full, the upper cell-light 59—59' detects the grain, shutting off the loading auger 23. This two-level interlocked electric eye circuit provides an optimum refill condition as the refill time delay is therefore based purely on the moisture shrink rate of the grain being dried at any time during the heat cycle; thus, frequent refills are obtained early in the cycle while refills are less frequent later in the cycle.

When the temperature of the air exhausting through the column 13 rises to the set point of the automatic moisture control 4TS (16), operation of that relay switches normally closed 4TS*a* (16) and normally open 4TS*b* (17) from their illustrated positions. Opening 4TS*a* ends the heating cycle by deenergizing the heat time delay relay HTR (17), breaking the "drying" light 62 (18) circuit, and eliminating the refill for shrink operation by breaking the circuit to the starter 2M (16) for the loading motor 57.

The closing of normally open 4TS*b* (17) results in energizing the relay UCR (19) through the normally closed timed-open unload time delay relay TM1 (19), and closed UCR*c* (8) opens, deenergizing the flame safeguard relay FCU, shutting off the burner 34 and pilot 37 (FIG. 3), and starting the cooling cycle. The grain in the column 12 has now been dried to the desired moisture content by alternate cycles of heated and tempered air passing through the column 12 and the burner 34 has been shut off.

Normally closed UCR*a* (16) opens, breaking the 2M (16) and HTR (17) circuits, and normally open UCR*d* (19) closes, maintaining a holding circuit for the unload control relay UCR (19) as the automatic moisture control thermostat 4TS (FIG. 2) cools and resets. Normally closed UCR*b* (22) opens, isolating lights 59' and 60' (22 and 23), while normally open UCR*e* (25) closes establishing the unloading circuit.

When the temperature differential between the 1TS sensing bulbs 68 and 69 (FIGS. 3 and 2, respectively) reaches the set point, the relay 1TS switches, opening 1TS*a* (6), deenergizing the magnetic starter 1M (6) for the blower (fan) motor 32 (FIG. 3), which opens 1M*a* (6), eliminating the 1M (6) restart for the blower motor. Open 1TS*b* (25) closes, energizing the "unload" light 71 (25) and unload starter 3M (26) for the unloading motor 45 (FIG. 1), starting the unloading cycle. This presumes the unload selector switch 56 (16) is in the "auto" position. If it is in the "off" position, the dryer 10 is now left in a standby condition. A restart can be effected manually by turning the switch 56 to "hand," then to "auto." By this provision, the unload of the dryer can be controlled by the operator.

A holding circuit around 1TS*b* (25) is established by normally open contacts 3M*a* (26) closing, and normally open contacts 3M*b* (30) provides control circuit switching for sequencing an auxiliary unload conveyor motor or conveyor motors (not shown), utilized for moving the dried grain being discharged from the discharge tube 47 (FIG. 3).

As the final grain falls away from the energized light **61'** (FIG. 3), cell **61** (**24**) is energized, switching the photocell relay coil PC (**21**) to its "light" condition. Normally open PC*c* (**20**) closes, energizing the unload timer relay TM1 (**20**). When a preset time expires on TM1 (**20**), enabling a complete cleanout of the dryer **10** and any auxiliary unload conveyors, the relay switch TM1 (**19**) opens, deenergizing the unload control relay UCR (**19**) and switching all its contacts UCR*a* (**16**), UCR*b* (**22**), UCR*c* (**8**), UCR*d* (**19**), and UCR*e* (**25**).

Closed UCR*d* (**19**) opens, breaking the UCR holding circuit; open UCR*b* (**22**) closes, energizing light **60'** (**23**). Closed UCR*e* (**25**) opens, deenergizing the magnetic starter 3M (**27**) for the unloading motor **45** (FIG. 1), opening the contacts 3M*b* (**30**) for any auxiliary unload motor(s), and turning off the "unload" light **71** (**25**). Open UCR*a* (**16**) closes, energizing the magnetic starter 2M (**16**) for the loading motor **57** (FIG. 1) and restarting the loading cycle for filling more wet grain into the dryer grain column **13** for the next cycle. The "load" light **58** comes on. UCR*c* (**8**) closes, setting up the circuit to the flame safeguard relay FCU (**9–14**) for pilot ignition. If only a partial load remains, opening of the switch WGLS*b* occurs, shutting down the system, until a manual restart is made when more wet grain is available to close WGLS*b*.

This sequence of events will continue as long as the "off-run-start" selector switch **53** (**3**) remains in "run," and the "unload" selector switch **56** (**16**) is in the "auto" position. When the last cycle is desired, turn the "unload" switch **56** to "off." The dryer **10** will cycle through to the stage of unloading, and then hold for manual unload or automatic mode reset, with the "unload" light **71** (**25**) being lighted indicating the dryer is ready to unload. Turn the switch **53** (**3**) to "off" until ready for the next cycle. The dryer **10** may be manually unloaded at any time, regardless of the stage of drying, by switching the "unload" switch **56** (**16**) to "hand."

By the arrangement of circuitry described herein, the process of "sweat drying" the grain is provided. This process subjects the grain to an alternating cycle of heated and tempered airflow which pulses the grain, causing the moisture within each kernel of grain to flow toward the external surface of the kernel. When the burner **34** is on, heating of the grain builds up an internal vapor pressure in the center of each kernel. When the burner is off, the temperature-diminished air reduces the external vapor pressure on the grain, allowing the moisture to escape from the kernel, or putting it another way, allowing each kernel to "sweat." The intermittent "off" cycling of high heat keeps the kernel pores from closing and sealing over, a condition known as "casehardening."

I claim:

1. In a grain dryer having a housing including inner and outer perforated sidewalls defining a drying column about an interior chamber, loading means in the housing for receiving grain and moving it into the column from the upper rear of the housing, means for moving air from external the housing into the chamber and forcing it outwardly of the housing through the perforated sidewalls, burner means for heating the air as it is moved into the chamber, and unloading means for removing the grain from the bottom of the column for discharge outside of the housing, the improvement of heating the grain and comprising:

an electric circuit for operating the loading means, air moving means, burner means, and unloading means;

first means in said circuit responsive to the grain reaching a predetermined height in the column for ceasing operation of the grain-loading means, and responsive to the grain shrinking to a predetermined lower height in the column for operating the grain-loading means;

second means responsive to the temperature of the air in the chamber for alternately operating and ceasing operation of the burner means;

third means responsive to the moisture content of the grain in the column for ceasing operation of the grain-loading means and for ceasing operation of the burner means;

fourth means responsive to a predetermined differential between the ambient temperature and the temperature in the column for ceasing operation of the air-moving means and for operating the grain-unloading means; and

fifth means responsive to the absence of grain in the column for ceasing operation of the unloading means and initiating a new cycle of operation of the dryer.

2. In a grain dryer as defined in claim **1**, and wherein said first means comprises a photoelectric unit mounted in the top front of the housing and having a vertically spaced pair of opposed light-cell elements in said circuit such that upon grain covering both light-cell pair of elements the loading means operation is stopped, and upon grain uncovering the lower light-cell pair of elements the loading means operation is started.

3. In a grain dryer as defined in claim **1**, and wherein said second means comprises a thermostat bulb mounted inside the chamber and said thermostat bulb having an adjustable setting such that upon the chamber reaching a certain temperature operation of the burner ceases, and upon the temperature falling past the said thermostat differential operation of the burner starts.

4. In a grain dryer as defined in claim **1**, and wherein said third means comprises a thermostat for determining the temperature of air passing through the grain related to moisture content.

5. In a grain dryer as defined in claim **1**, and wherein said fourth means comprises a relay operable by a pair of sensing bulbs one of which is placed near the air-moving means for detecting ambient temperature, and the other of which is placed in the column for detecting the temperature of air passing through the grain therein.

6. In a grain dryer as defined in claim **1**, and wherein said fifth means includes an unload time delay relay which provides a cleanout period of time for unloading the dryer and any auxiliary unload conveyors, the ending of which initiates the new cycle of loading.

7. In a grain dryer as defined in claim **1**, and wherein means is provided for controlling the volume of grain discharged by the unloading means.

8. In a grain dryer as defined in claim **7**, wherein said grain discharge control means comprises an unloading auger extended the length of the housing along the bottom thereof, an inverted V-shaped shield mounted above said auger, the bottom edges of said shield forming one or more spaces with the bottom of the housing through which grain from the column flows, and one or more plates each slidably mounted over one said space so as to adjustably cover said space a predetermined amount.

9. In a grain dryer as defined in claim **8**, and wherein each of said plates is exposed to exterior the housing so as to be adjustable during operation of said dryer.

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