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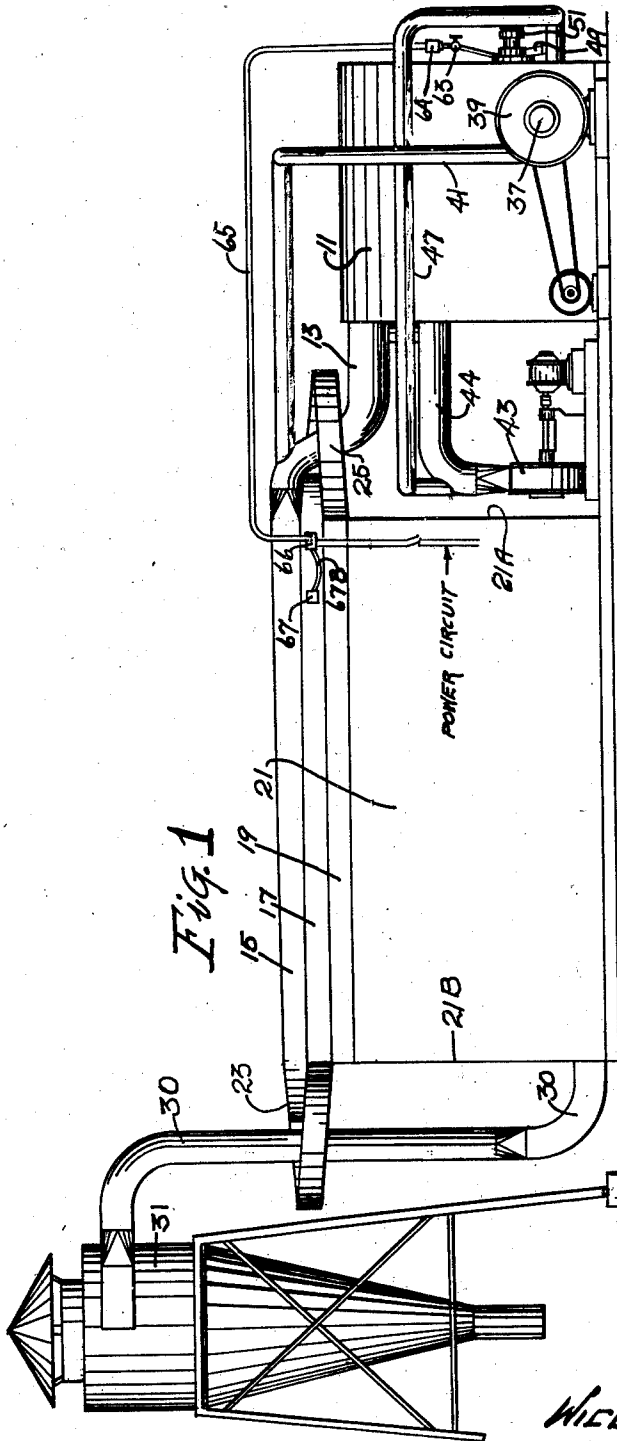
W. W. O'NEAL ET AL

2,409,787

DEHYDRATOR

Filed Jan. 17, 1942

3 Sheets-Sheet 1



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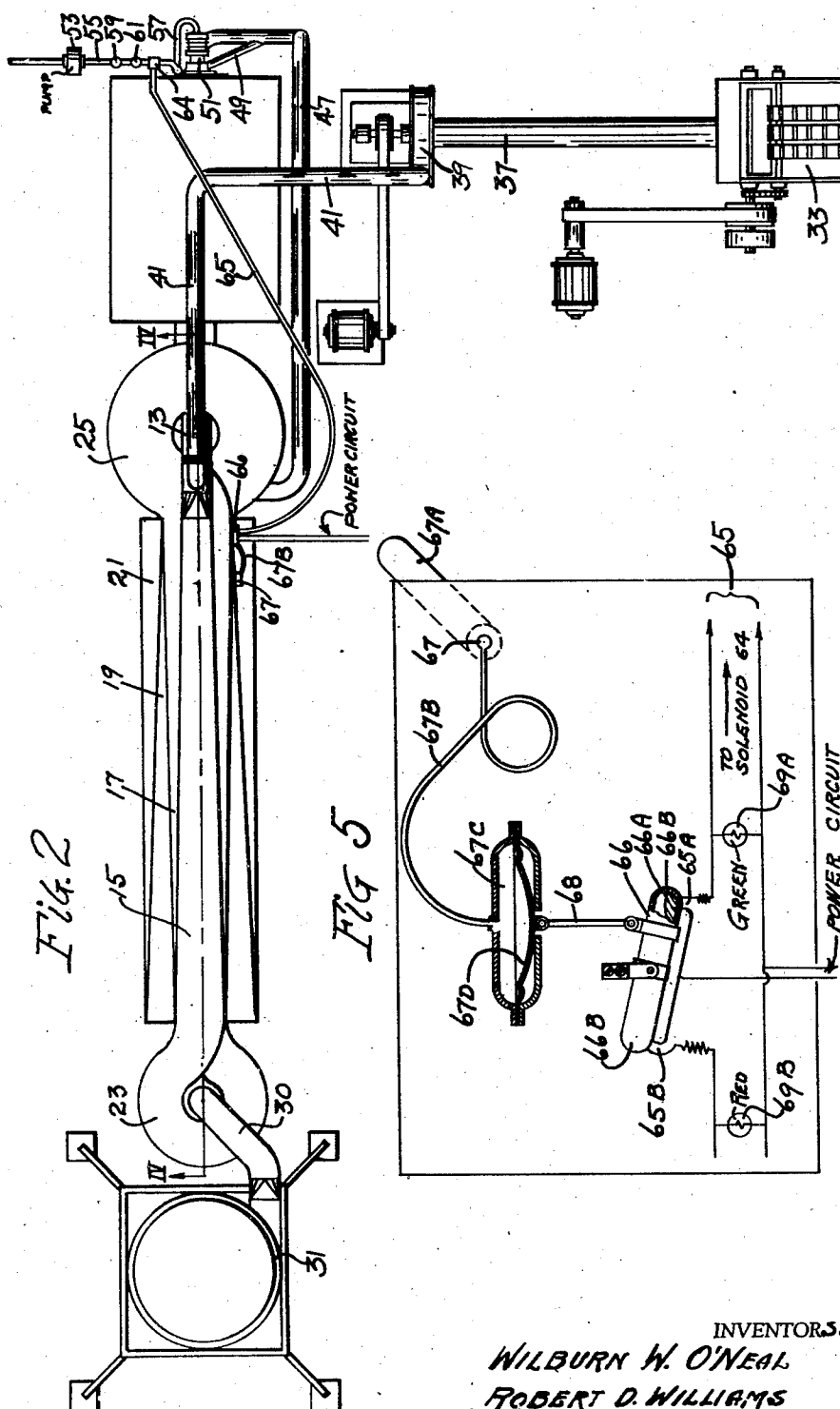
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3 Sheets-Sheet 2



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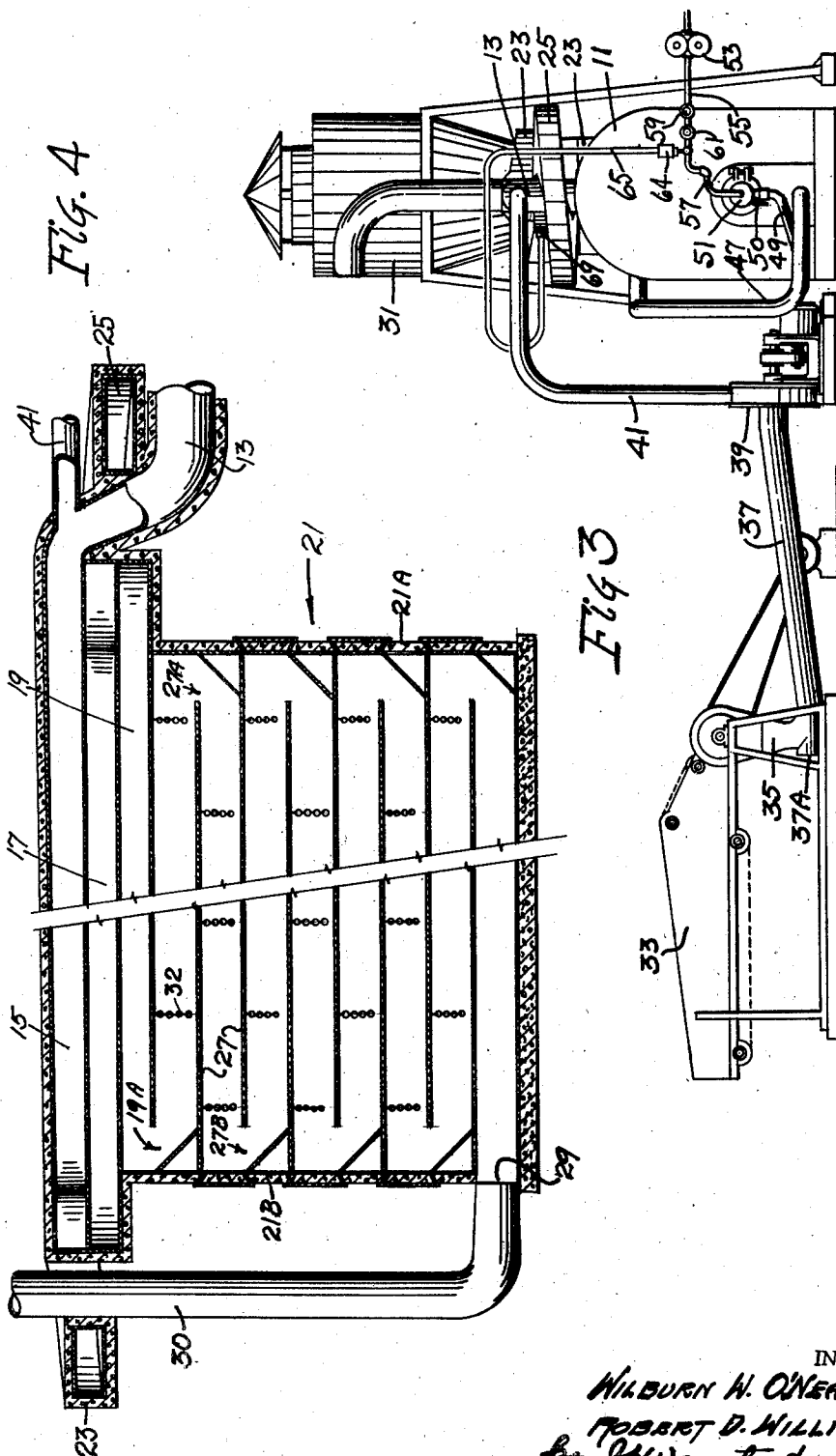
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DEHYDRATOR

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3 Sheets-Sheet 3



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DEHYDRATOR

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Application January 17, 1942, Serial No. 427,103

8 Claims. (Cl. 263—43)

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This invention relates to improvements in apparatus for dehydrating forage crops or other materials requiring either surface drying or removal of contained moisture and is a continuation in part of our application for patent for Dehydrators, now Patent No. 2,334,949.

Forage crops as they come from the fields contain a large amount of moisture which must be removed in order that they may be safely stored and the same is also true of numerous other things, such as sea weed, grains and the like. Additionally certain field crops, and perhaps other products, are now being dried to an extent that they may be immediately ground into a product approximating meal, the present invention being directed to such drying, but being concerned only with the drying proposition and not with the subsequent treatments.

Many attempts have been made to remove the moisture by passing highly heated air through such materials, but these materials vary so largely from time to time in moisture content that extreme difficulty is had in satisfactorily regulating the temperatures and other conditions in the drying chamber and the progression of the materials therethrough, in order that they may not be overdried to the point of burning or so underdried that they cannot be properly ground, and also in order that portions of the materials having differing moisture content may automatically progress at differing rates of speed whereby the lighter, more readily dried portions of the material will advance and be discharged more rapidly than the heavier portions requiring a greater drying period.

It has been attempted to meet these conditions in numerous ways, temperature control being variously effected prior to the entrance of the drying gases to the dryer or after it has passed entirely therethrough, such control in the one case taking no account of the condition of the material to be dried and in the other case effecting the regulation after the undesired conditions have been set up. Concurrently also, responsive to entrance or discharge temperatures, feed-in of the material has also been automatically controlled, thus concurrently stepping up temperatures and decreasing material feed, emphasizing fluctuation from over-heating and burning to under-heating and under-drying.

The primary object of the present device is to provide means and methods for effecting temperature control in accordance with the condition of the materials to be dried and the volume of such materials introduced.

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A further object of the invention is to provide means for traversing the materials at varying rates of transfer through the drying apparatus to initially minimize the period of injection of the materials to the extremely high introduction temperatures of the drying gases and to subsequently slow down progress of the materials during the intermediate and final stages of the drying; and

A still further object is to so introduce the materials that all parts thereof will be immediately and uniformly subject to the action of the current of drying gases and the materials also will be introduced with greater uniformity into such drying current.

In accomplishing these and other objects the present invention contemplates highly heating air under pressure and mingling that air with the products of furnace combustion under similarly high pressure to complete the combustion of such furnace products and reduce the oxygen content of the air, introducing into such gas current under similar pressure air carried materials to be dried, discharging such currents and materials carried thereby into a drying chamber through an elongated passageway of continuously increasing cross sectional area forming part of such drier; controlling the temperatures of such furnace through the temperature of the gases in such elongated passageway after introduction of the materials into such current and prior to the subsequent drying passage of said air and materials through the body of said drying chamber.

The manner in which this is effected and the objects of the invention accomplished, will readily be understood from the following specification on reference to the accompanying drawings, in which:

Fig. 1 is a side elevation of the preferred form of our apparatus.

Fig. 2 is a corresponding plan view of the apparatus; and

Fig. 3 is a corresponding end elevation.

Fig. 4 is a sectional elevation of the drying chamber on a somewhat enlarged scale, taken on the line IV—IV of Fig. 2; and

Fig. 5 is a diagrammatic view of a signal panel and switch and thermostatic control therefor.

Referring now to the drawings in which the various parts are indicated by numerals:

11 is a furnace of pressure type having a sealed enclosing shell 12, from which furnace highly heated gases are delivered under pressure through a connecting flue 13 into a drying chamber having tubular passageways 15, 17 and 19, preferably respectively of increasing area from

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end to end, and a main body portion 21, the passageways 15 and 17 being connected by a spiral return bend 23 and the passageways 17 and 19 by a similar spiral return bend 25, the passageway 19 at its discharge end having an opening 13—A discharging on the upper of a number of shelves 27 extending from side wall to side wall and which are horizontally disposed in the body of drying chamber and alternately terminate short of the intake and discharge ends 21—A, 21—B of the chamber, leaving openings 27—A, 27—B through which material traversed along the shelves may drop from each respectively to the next lower shelf, the shelf structure setting up a continuation of the passageway 19, which continuation extends to an outlet 29. From the outlet 29 the dried materials are discharged through an outlet flue 30 and delivered thereby to suitable separating and cooling apparatus 31, not herein further referred to. Preferably the drying chamber is also provided with baffles, here indicated as short lengths of chain 32, hung from the undersides of the shelves and depending into adjacency with the respective underlying shelves.

The material if of stalky or viny type as alfalfa is chopped into short lengths by a silage cutter of well known type purchasable in the open market and here indicated by the numeral 33. From this cutter the chopped material drops into a hopper 35 from which it is withdrawn through a suction pipe 37, having its end 37—A open for the entrance of air, to a pressure blower 39 and discharged by the blower through a flue 41 into the flue 13 adjacent its juncture with the passageway 15, substantially in alinement with the longitudinal axis of the passageway, the blower 39 being adapted to build up a pressure through flue 41 at least equal to that in the flue 13.

Air to be heated by the furnace 11 and subsequently delivered through the flue 13 is provided by a pressure blower 43 which discharges through a flue 44 into the furnace 11 which is of sealed pressure type. The flues 44 and 13 are preferably connected by a by-pass 45 having a cut-off slide 46 which may be adjusted to establish by-pass of a portion of the air delivered through the flue 44 or to entirely cut off the by-pass. The blower 43 also delivers air under pressure through a branch flue 47, of the flue 44, into the combustion chamber of the furnace 11 and through a branch pipe 49, of the flue 47, to an oil burner 50 through which the furnace is heated, flow of air through the pipe 49 being controlled by a valve 51, and this air flow being regulated in accordance with fuel feed to establish ignition and maintain combustion.

Fuel for the burner is delivered under pressure by a pump 53, preferably of well known rotary type, through pipes 55, 57, the pipe 55 being provided with a cut-off valve 59, needle valve 61 and an auxiliary regulating valve 63 actuated by a solenoid 64, the solenoid being connected through suitable circuit wires 65 with a switch 66 opened and closed by a thermostat 67 disposed and extending into the approach portion of the drier formed by the passageways 15, 17 and 19 and between the junction of the material feed-in flue 41 with the air flue 13 and the point of entrance of the approach portion of the drier to the body portion thereof, the thermostat preferably being located adjacent the discharge end of the passageway 17 in order that the gases entering through the flue 13 may be tempered by the air and materials entering

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through the flue 41 prior to their action on the thermostat. This thermostat and switch control, as diagrammatically shown in Fig. 5, may include a thermostat tube 67—A adapted to contain gas under pressure, from which a tube 67—B leads to a chamber 67—C having a pressure responsive diaphragm 67—D which is connected as by a link 68 to the switch 66. This switch preferably is a centrally pivoted double end mercury switch having at one end the open leads 65—A of the circuit 65, and at its opposite end an auxiliary pair of circuit leads 65—B adapted for respective circuit completion by mercury 66—A on tilting of the end 66—B downward responsive to temperature increase in the passageway 17, or upward by decrease of temperature and pressure. Completion of circuit through leads 65—A and circuit 65 energizes solenoid 64 and reduces or cuts off fuel flow to burner. Mounted across the circuit 65 is a green signal light 69—A and in circuit with the leads 65—B a red signal light 69—B.

Preferably the furnace 11, the flue 13, the passageways 15, 17 and 19, and their return bends 23, and 25, and the body of the drier 21 are insulated to minimize heat loss.

In operation, the furnace 11 is started up and brought to a temperature ordinarily in the neighborhood of two thousand degrees, the blower 43 being concurrently set in motion to build up pressure in the furnace and establish discharge and material transfer flows through the flue 13, the air delivered by the fan 43 being in part delivered through the branch flue 47 into the front of the furnace as supplementary combustion air, and through the branch 49 of the flue 47 as injection air for the burner 51, the pressure of the air delivered to the furnace and to the burner being equalized and balanced.

In starting up and subsequent operation of the burner fuel is delivered by the pump 53 under injection pressure and flow of the fuel to the burner is regulated by the needle valve 61 and of air to the burner by the cut-off valve 51. During this operation and subsequent operation the combustion gases of the furnace are tempered by excess air introduced through the flue 44 and the tempered gases discharged through the flue 13 in the drier. Preliminary operation of the furnace is continued until the drier is thoroughly heated up, during this heating up period the thermostat 67 being usually disconnected, the gases passing through the flue 13, the passageway 15, the return bend 23, the passageway 17, the return bend 25, and the passageway 19 into the body of the drier and escaping through the outlet flue 29.

In subsequent operation the thermostat is connected, and the gases flowing through the passageway 17 impinge directly on the thermostat tube 67—A extending into such passageway and on a selected temperature being reached in the passageway 17 the thermostat acts through the circuit 65 to energize the solenoid 64 and operate the regulating valve 63 which reduces flow of oil to the burner until temperature in the passageway 17 is lowered and thermostatic action again increases flow. Ordinarily the thermostat 67 is set to cut on and off with a range of as little as two degrees.

After the drier is heated up and the thermostat put in operation, the cutter 33 is started, the material to be dried is fed therinto, usually by hand, and the chopped product drops into the hopper 35; concurrently the blower 39 is set in

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operation, the chopped product drawn through the flue 37 into the blower and discharged through the flue 41 into the flue 13, and through the joint action of the furnace gases discharging through the flue 13 is driven at a high rate of speed through the passageways 15, 17 and 19 and their respectively connecting return bends 23 and 25 into the body of the drier 21 and is more slowly thereafter traversed along the shelves 27 of the drier until the discharge end is reached, after which the dried products are discharged through the outlet flue 30 to the collector and cooler 31.

The materials to be treated are usually cut in the fields and loaded directly on wagons, ordinarily without touching the ground, and are hauled to the chopper 33, usually being unloaded manually from the wagons into the chopper feed troughs with hay forks, the chopper feed trough being usually kept full of the materials, and inherently a substantially steady stream of chopped material being delivered into the hopper 35 for delivery to the drier. Feed regulation may be accomplished by varying the speed of the chopper.

It is obvious, and is found in actual practice, that during the early morning the material delivered is dew laden, and therefore carries considerable excess moisture, this excess moisture decreasing and disappearing during the morning, and in many instances during extremely hot weather the material is actually slightly wilted before being cut during the latter part of the day. The chopped material, moisture laden or otherwise, mingles with and is directly acted on by the hot gases from the furnace, these gases immediately evaporating the initial moisture content and a very considerable amount of the material contained moisture, and being correspondingly greatly reduced in temperature before they have passed through the passageways 15 and 17 and reach the thermostat 67. At this point they substantially reflect the conditions set up by the volume and moisture content of the materials which are to be taken care of and dried. Passing the thermostat the materials continue their rapid progress at substantially the same velocity as the traversing gases until the shelves are reached, after which the materials lag behind the gases in their passage along the shelves. During their passage through the passageways 15, 17 and 19 the direction of travel is violently reversed by the return bends 23 and 25, though little checked thereby, and a large portion of the leafy portion of the material is torn from the more bulky stem portions, this action being continued during the passage along the shelves, and drop from shelf to shelf, and by the action of the baffles 32, and automatically as the lighter portions of the material become dried they are picked up and traversed at more nearly the gas speed to discharge, the stalky and heavier portions traversing the shelves more slowly and being subsequently discharged as drying is completed. It is probable that the separation out of the drier portions of the heavier material is largely accomplished in the drop of the materials from one shelf to the next, but great uniformity of dryness is accomplished by the structure.

Obviously each material treated requires a different temperature of air, and in beginning operation and subsequently from time to time, it is usual to test the materials discharged from the collector. If these materials show underdrying

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the thermostat 67 is adjusted to cut on and off at a higher rate of temperature. If the materials are overdried it is adjusted to cut on and off at a lower temperature and in either case adjustment is continued until the material is delivered in a correctly dried condition.

During operation the thermostat 67 is constantly cutting on and off, the change from red to green signal lights indicating to the operator proper functioning of the machine. Should the red light remain steadily on for a considerable period of time the obvious indication is that sufficient heat is not being furnished to maintain the selected operating temperature. In such case the opening of the needle valve 61 is increased and usually additional ignition air is furnished by further opening the valve 51. This regulation is continued until on and off movement of the lights indicate proper operation. Should increase of furnace temperature be ineffective the driving speed of the chopper should be cut down and less material fed in. Obviously should the green light show constantly or excessively long the most desirable step is to speed up material feed, but should this not be possible because of insufficient supply or inadequate chopping action the fuel and ignition air supply are cut down and furnace temperature reduced to a point where the desired signal light fluctuation indicated proper operation.

We claim:

1. In a dehydrating apparatus, the combination of a pressure sealed furnace and a drying chamber having an elongated passageway for air and materials leading therinto and there-through; a fuel burner for said furnace, means for feeding fuel to said burner and for establishing a maximum rate of said feed, means for introducing into said furnace under pressure material-traversing-and-drying air to be heated, and for delivering additional combustion air under like pressure to said burner, an air flue connecting said furnace and said passageway for delivering heated traversing-and-drying air under said pressure from said furnace through said chamber passageway, blower means including a discharge pipe leading into said air flue, for feeding material under traversing air pressure into said air flue, said material having moisture to be removed therefrom, said material and moisture being brought to the boiling point of said moisture by said heated air during traverse of a minor portion of said passageway and control means, in said passageway subsequent to the point of introduction of said material and substantially at the point where the boiling point of said moisture is reached, for regulating said rate of fuel feed below said maximum feed, whereby the conditions which effect drying are set up between the air currents and the materials as they are fed thereinto, and regulation is effected in accordance with the conditions thus set up, substantially at the beginning of the drying cycle.

2. In a dehydrating apparatus, the combination of a pressure sealed furnace and a drying chamber having a continuous passageway for air and materials therethrough; a fuel burner for said furnace, means for maintaining fuel flow to said burner for establishing a maximum rate of feed of said fuel, means for introducing into said furnace under pressure, material-traversing-and-drying air to be heated, and additional air under like pressure to said furnace and said burner for combustion; an air flue connecting said furnace

and said drying chamber for delivering heated traversing-and-drying air under said pressure from said furnace through said chamber passageway, blower means including a discharge pipe leading into said air flue, for feeding material under traversing air pressure into said air flue, said material having moisture to be removed therefrom, said material and moisture being brought to the boiling point of said moisture by said heated air during traverse of a minor portion of said passageway and control means in said passageway subsequent to the point of introduction of said material and substantially at the point where the boiling point of said moisture is reached, for regulating said rate of burner fuel feed below said maximum feed, whereby the conditions which effect drying are set up between the air currents and the materials as they are fed therinto, and regulation is effected in accordance with the conditions thus set up, substantially at the beginning of the drying cycle.

3. In a dehydrating apparatus, the combination of a pressure sealed furnace, a drying chamber, and means establishing a continuous passageway for air and materials therethrough; a fuel burner for said furnace, means for feeding fuel to said burner, means for establishing a maximum rate of said fuel feed, means for independently regulating said rate of feed up to said maximum, means for introducing air into said furnace under pressure, a passageway for air, including a substantially horizontal delivery section connecting said furnace and said drying chamber passageway, for delivering heated material-traversing-and-drying air under pressure from said furnace through said chamber, blower means, including a delivery pipe aligned with and discharging into said section, for feeding material under traversing air pressure into said section, said material having moisture to be removed therefrom, said material and moisture being brought to the boiling point of said moisture by said heated air after traverse of a minor portion of said drying passageway, and control means responsive to temperature, in said passageway subsequent to the point of introduction of said materials and substantially at the point where the boiling point of said moisture is reached, said control means being coupled to said fuel feed regulating means for accomplishing said burner regulation, whereby the conditions which effect drying are set up between the air currents and the materials as they are fed therinto, and regulation is effected in accordance with the conditions thus set up, substantially at the beginning of the drying cycle.

4. In a dehydrating apparatus, the combination of a pressure sealed furnace, a drying chamber, and means establishing a continuous passageway for air and materials therethrough; a fuel burner for said furnace, means for feeding fuel to said burner, means for regulating the rate of said fuel feed, means for introducing air into said furnace under pressure, an air passageway connecting said furnace and said drying chamber passageway for delivering heated material-traversing-and-drying air under pressure from said furnace through said chamber, means for feeding material under pressure into said passageway, said material having moisture to be removed therefrom, said material and moisture being brought to the boiling point of said moisture by said heated air after traverse of a minor portion of said passageway, and control means responsive to temperature, in said passageway subsequent

to the point of introduction of materials and substantially at the point where the boiling point of said moisture is reached, said control means being coupled to said fuel feed regulating means for accomplishing said burner regulation, whereby the conditions which effect drying are set up between the air currents and the materials as they are fed therinto, and regulation is effected in accordance with the conditions thus set up, substantially at the beginning of the drying cycle.

5. In a dehydrating apparatus, the combination of a pressure sealed furnace, and a drying chamber having an elongated, horizontally disposed passageway for air and materials leading therinto; and a plurality of horizontally disposed drying shelves alternately terminating short of opposite ends of said chamber and establishing a continuation of said passageway through said chamber, a fuel burner for said furnace, means for feeding fuel to said burner and for establishing a maximum rate of said feed, means for introducing into said furnace under pressure material-traversing-and-drying air to be heated, and for delivering additional combustion air under like pressure to said burner, an air flue connecting said furnace and said passageway for delivering heated traversing - and - drying air under said pressure from said furnace through said chamber, blower means for feeding material, under traversing air pressure into said air flue, said material having moisture to be removed therefrom, said material and moisture being brought to the boiling point of said moisture by said heated air after traverse of a minor portion of said passageway and control means in said passageway subsequent to the point of introduction of said material and substantially at the point where the boiling point of said moisture is reached, for regulating said rate of fuel feed below said maximum feed, whereby the conditions which effect drying are set up between the air currents and the materials as they are fed therinto, and regulation is effected in accordance with the conditions thus set up, substantially at the beginning of the drying cycle.

6. In a dehydrating apparatus, a drying chamber, including means for establishing a tortuous pathway for materials and air flow therethrough, means for supplying traversing flow of drying air through said chamber, means for feeding material into said chamber and said air flow therethrough, said material having moisture to be removed therefrom, a furnace for heating said air, an air passageway connecting said furnace and said drier, said material and moisture being brought to the boiling point of said moisture by said air-flow after traverse of a minor portion of said pathway, a fuel burner supplying said heat, means for supplying fuel to said burner, means for regulating said fuel supply, and heat responsive control means for said regulating means, operatively coupled to said regulating means, said control means being positioned in said drier in the path of flow of said air therethrough, subsequent to the point of introduction of said material into said air, and substantially at the point where the boiling point of said moisture is reached, whereby to effect said burner regulation responsive to air temperatures modified by the volume and condition of materials as introduced into said air, substantially at the beginning of the drying cycle.

7. In a dehydrating apparatus, the combination of a pressure sealed furnace and a drying chamber, interiorly constructed to establish a

snuttling passageway therethrough, a fuel burner for said furnace, means for establishing fuel feed to said burner, means for regulating the rate of said fuel feed, means for introducing into said furnace under pressure, material-traversing-air to be heated, and combustion air, and for delivering additional combustion air under like pressure to said burner, an air flue connecting said furnace and said drying chamber for delivering heated traversing air under said pressure from said furnace through said chamber, blower means for feeding material under traversing air pressure into said air flue, said material having moisture to be removed therefrom, said material and moisture being brought to the boiling point of said moisture by said heated air after traverse of a minor portion of said drier passageway and heat responsive control means operatively coupled to said regulating means, positioned in said drier passageway, subsequent to the introduction of material and substantially at the point where the boiling point of said moisture is reached for regulating burner fuel feed below said maximum feed, whereby the conditions which effect drying are set up between the air currents and the materials as they are fed thereinto, and regulation is effected in accordance with the conditions thus set up, substantially at the beginning of the drying cycle.

8. In a dehydrating apparatus, the combination of a pressure sealed furnace and a drying chamber, having horizontally disposed shelves alternately terminating short of the opposite ends of said chamber to establish a shuttling passage-

way therethrough, flexible baffling members depending from the under sides of said shelves, each into adjacency with a proximate lower shelf to locally retard movement of material therealong, a fuel burner for said furnace, means for establishing fuel flow to said burner and for establishing a maximum rate of fuel feed, means for introducing into said furnace under pressure material-traversing-air to be heated, and combustion air, and for delivering additional combustion air under like pressure to said burner, an air flue connecting said furnace and said drying chamber for delivering heated traversing and drying air under said pressure from said furnace through said chamber, blower means for feeding material under traversing air pressure into said air flue, said material having moisture to be removed therefrom, said material and moisture being brought to the boiling point of said moisture by said heated air after traverse of a minor portion of said drier passageway and means in said drier passageway, subsequent to the introduction of material and substantially at the point where the boiling point of said moisture is reached, for regulating burner fuel feed below said maximum feed, whereby the conditions which effect drying are set up between the air currents and the materials as they are fed thereinto, and regulation is effected in accordance with the conditions thus set up, substantially at the beginning of the drying cycle.

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