

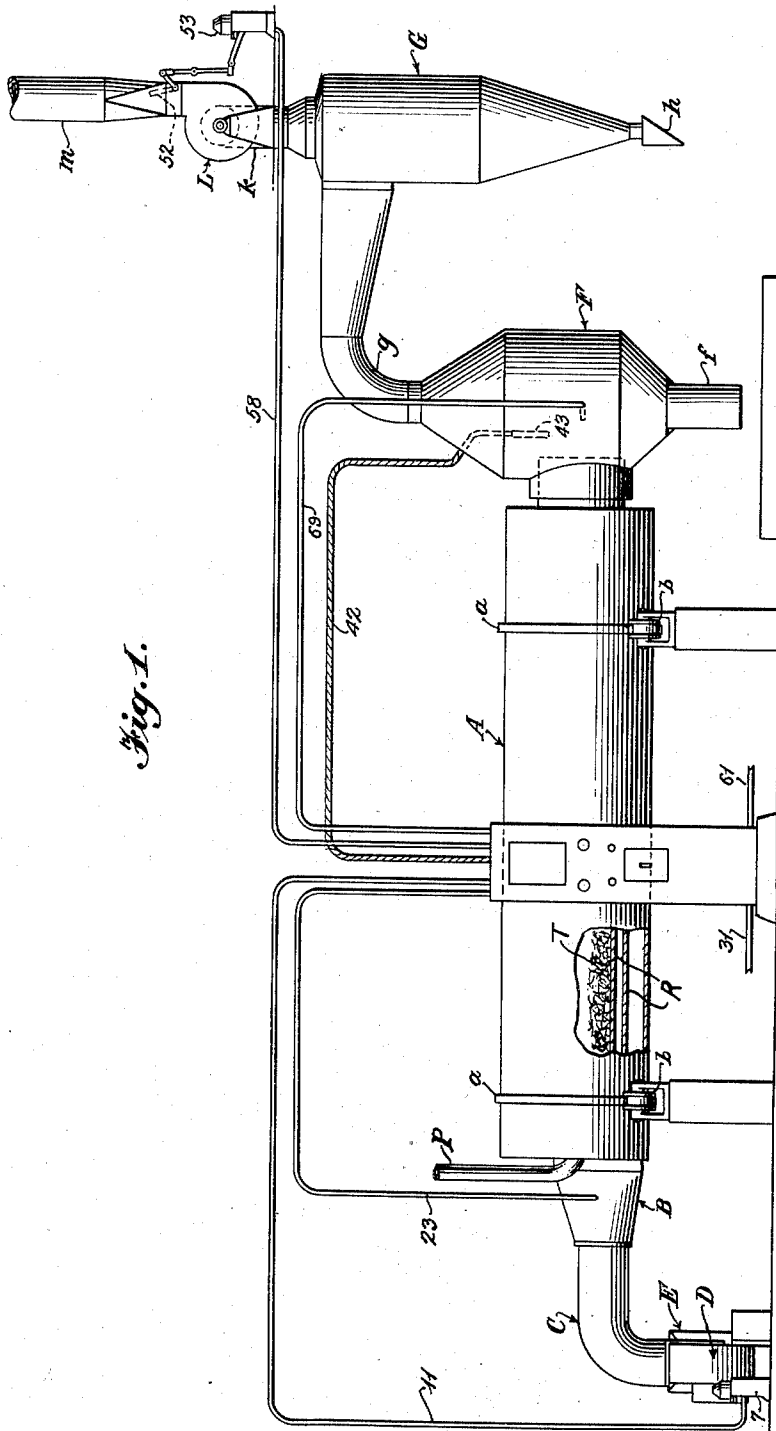
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2 Sheets-Sheet 1



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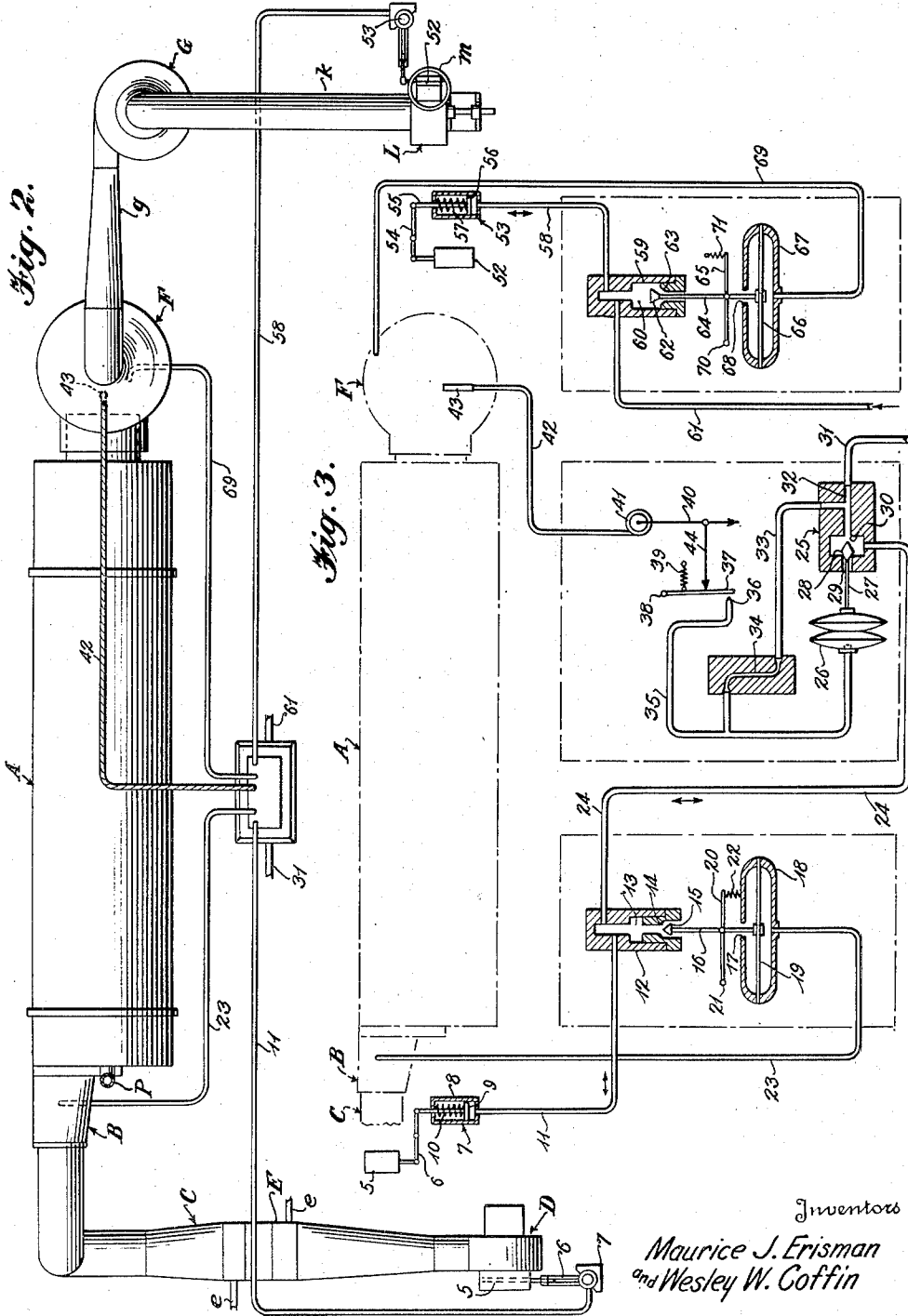
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CONTROL SYSTEM FOR DRIERS

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This invention relates to new and useful improvements in control systems for dryers of the type which handle flowable solids in bulk and which pass the drying medium through a bed of such solids.

There is one type or class of dryer now in common commercial use which progressively advances a bed of flowable solids through a treatment chamber, usually a rotary kiln or drum, and which effects forced circulation of the drying medium upwardly through the bed of solids. The patent to Gustav Bojner et al., No. 1,709,456, issued April 16, 1929, is illustrative of this type of dryer.

It, of course, is necessary, with this type of dryer, to control the temperature of the drying medium that is circulated through the treatment chamber in accordance with the amount of drying that is necessary for each particular material being treated. It, also, is necessary to control the amount or volume of drying medium that is circulated through the material at the desired, constant temperature.

It is the primary object of this invention to provide a control system for dryers in which the amount of drying medium delivered to the treatment chamber, for passage through the bed of material, is determined by, or regulated in accordance with, variations in the resistance offered by the bed of material to the flow of the drying medium therethrough and variations in the temperature of the medium exhausted from the treatment chamber.

A more specific object of the invention is to provide a control system for dryers in which a drying medium flow regulating inlet damper is moved through a predetermined throttling range by a suitable motor, the operation of which is controlled by variations in the inlet air static pressure and the exhaust air temperature.

A further object of the invention is the provision of a control system for dryers of the type in which the drying medium is circulated through a bed of material in a treatment chamber by means of two circulating fans which are connected respectively to the inlet and the exhaust ducts of said chamber, said control system operating to automatically maintain the desired drying effect at all times by varying the amount of drying medium forcibly delivered to the treatment chamber in accordance with variations in the resistance offered by the bed of material to the flow of the drying medium therethrough and the temperature of the medium exhausted from the treatment chamber, and by

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continuously maintaining a proper state of pressure balance inside the chamber as a result of varying the amount of drying medium forcibly exhausted from the treatment chamber in accordance with variations in the static negative pressure, or vacuum, prevailing in the discharge hood for the treatment chamber.

Other objects and advantages of the invention will be apparent during the course of the following description.

In the accompanying drawings forming a part of this specification and in which like numerals are employed to designate like parts throughout the same:

Figure 1 is a side elevational view, partly broken away, of a dryer with the form of control system embodying this invention operatively associated therewith,

Figure 2 is a plan view of the dryer and the control system illustrated in Fig. 1, and

Figure 3 is a diagrammatic view illustrating a portion of the dryer and all of the instrumentalities embodying said control system.

In the drawings, wherein for the purpose of illustration is shown the preferred embodiment of this invention, the reference character A designates the drying chamber of a conventional form of dryer of the general type illustrated by the above referred to patent to Gustav Bojner et al. This drying chamber consists of a rotatable kiln or drum which is suitably supported by the rings *a* and the rollers *b* in the conventional manner. A suitable drive, not shown, is provided for rotating the drying chamber A.

A feed chute P, or the like, introduces the material to be dried into the central, material receiving compartment at the feed end of the drying chamber A.

As is illustrated by the above identified patent, the interior of the drying chamber A is provided with an annular series of louvres R attached to the inner surface of the kiln or drum shell. These louvres R have their free longitudinal edges overlapping the next adjacent louvres but spaced therefrom. These louvres R provide an equal number of longitudinally extending ducts through which the drying medium, which is usually heated air, passes for delivery to the central, material receiving compartment through the spaces left between the free longitudinal edges of the louvres and the next adjacent louvres R. This annular series of internal louvres functions as a support for a bed T of the material being dried. As the drying chamber A rotates, this bed T of material cascades circumferentially of the cham-

ber and the material is progressively advanced from the feed end to the discharge end of the chamber.

The hot drying air is delivered to the feed end of the drying chamber A by means of the inlet box B. The patent issued to Charles A. Schneider, Number 2,253,098, on August 19, 1941, illustrates in detail the type of air inlet box that is conventionally provided for this type of dryer. This air inlet box functions to deliver the drying air to the adjacent ends of the air ducts that are formed by the louvres R supporting the bed T of material being dried. It will be recognized that as the drying chamber A rotates, the air inlet box B will be progressively placed in communication with the angularly advancing air ducts that are formed by the louvres R. In this way, the air inlet box is connected at all times to only the air delivery ducts that are formed by the louvres supporting the bed T of material.

The air inlet duct C is illustrated as being connected to the inlet box B at one end and to the outlet of the circulating fan D at its opposite end. It is the function of this fan to force the hot drying air through the duct C and the inlet box B in the drying chamber A.

Fig. 2 illustrates a heat exchange unit E through which steam is circulated by means of the pipes e. This steam, by passing in heat exchange relation with the air that is forced through the inlet duct C, will heat the air to the desired temperature. Although no such control is illustrated, it will be understood that the temperature of the air that has passed through the heat exchange unit E may be maintained at a desired, constant temperature by regulating the flow of steam through the unit E. This automatic regulation of the flow of steam conventionally is obtained by a suitable instrument that operates in response to the temperature of the air passing through the inlet box B.

Although the drawings illustrate the use of a steam heat exchange unit for heating the inlet air, it will be understood that dryers of this type also conventionally employ gas, coal, and oil fired furnaces, in place of steam, for heating the inlet air.

The properly dried material, and the exhaust drying air are discharged from the remaining end of the drying chamber A into the discharge or exhaust hood F. The dried material passes out of the hood F through the discharge spout f while the exhaust drying air leaves the hood F by way of the exhaust duct g. This exhaust drying air carries with it the dust or fines which are released from the material while it is being dried in the chamber A.

This dust laden, exhaust air passes from the exhaust duct g into the dust collector G where the dust is separated out for discharge through the lower end h of the collector G. The upper end of the collector is connected by the exhaust duct k to the inlet of the air circulating fan L. The outlet for this exhaust fan L is connected to the stack by means of the duct m.

All of the above detail description refers to the elements of a conventional dryer installation for handling flowable solids. The description that now will be presented refers to the novel control system embodying this invention.

A suitable vane type damper 5 is illustrated in Fig. 2 as being associated with the air inlet for the circulating fan D. It will be understood, however, that a louvre type damper may be used on the downstream side of the fan, is desired. By

adjusting the position of this damper, the amount of air admitted to the fan can be regulated or varied. This damper, therefore, will function to throttle the circulated drying air over a range that has as its limits the closed and opened positions of the damper. It will be noted at this point that dampers of the vane type do not completely shut off or stop the admission of air when they are in their so-called closed position. If a louvre type damper is used, it can be adjusted to only partially close.

This damper 5 is moved through its operating range by means of suitable link and lever mechanism 6 and the differential pressure motor 7. This motor is diagrammatically illustrated in Fig. 3 as consisting of a cylinder 8 with a reciprocating piston 9 mounted therein. This piston is loaded by the spring 10 in the direction the piston must move to arrange the damper 5 in its closed position. The opposite side of the piston 9 is subjected to the action of compressed air that is delivered to the motor cylinder 8 by means of the pipe line 11.

The supply of compressed air delivered to the damper operating motor 7 is regulated or controlled by two instrumentalities which are connected in series in the compressed air supply line leading from a source of supply to the motor 7. Both of these instrumentalities operate on the basic principle of venting or exhausting to the atmosphere variable amounts of the motor operating compressed air. These instrumentalities, therefore, are each capable of venting all of the damper motor operating compressed air; venting any desired fractional portion of such compressed air supply; or completely preventing the venting of any of the compressed air supply. Because the inlet air controlling damper 5 is moved from its closed position toward its fully opened position by the action of the compressed air opposing the action of the spring 10, it will be seen that each one of these control instruments can function independently of the other to cause the damper 5 to move toward its closed position, and that neither one of these control instrumentalities can bring about the movement of the damper 5 toward its fully open position if the second control instrumentality is set or conditioned to vent the entire supply of compressed air.

These two control instrumentalities, as has been noted above, are arranged in series in the compressed air supply line for the damper operating motor 7 and for that reason the action of each one of these instrumentalities, in controlling the delivery of compressed air to the motor 7, is superimposed on the action of the other instrumentality. However, each one of these two instrumentalities obtains its actuating force, or motivating power, independently of the other instrumentality. Expressed in another way, one of these compressed air supply controlling instrumentalities is actuated in response to variations in the inlet air static pressure prevailing in the inlet box B while the second instrumentality is actuated in response to variations in the temperature of the exhaust drying air passing through the discharge or exhaust hood F.

By referring to Fig. 3, it will be seen that the compressed air supply pipe line 11 extends from the damper operating motor 7 to the casing of the pressure venting or regulating valve 12. This valve is only diagrammatically illustrated because pressure venting or regulating valves of this character can be obtained from several different manufacturers. The valve casing 12 is cham-

bered or hollowed out at 13 for communication with the end of the compressed air supply pipe line 11. A suitable valve seat 14 is located in the valve casing 12 and has operatively associated therewith the valve 15. This valve 15 and valve seat 14 are intended to cooperate with each other, by being moved relative to each other, for varying the amount of compressed air that is vented to the atmosphere from the interior or chamber 13 of the valve casing. That is to say, with the valve 15 in its fully opened position, all of the supply of compressed air can be vented to the atmosphere while none of the supply of compressed air will be vented to the atmosphere when the valve 15 is fully seated. In intermediate positions, this valve is intended to vent to the atmosphere different fractional portions of the compressed air supply.

The valve 15 is attached to the stem 16 which extends through an enlarged opening 17 formed in the diaphragm casing 18. The end of this valve stem is connected to the diaphragm 19 that is clamped at its outer margin between the halves of the diaphragm casing 18. A lever 20 is pivotally connected to the valve stem 16, with a lost motion connection to allow for relative transverse movement, and is pivoted on a fixed support at 21. A spring 22 is operatively connected to the free end of the lever 20 and functions to return the valve stem, and its associated valve 15, to the normal positions for these elements, as shown in Fig. 3.

The enlarged opening 17 formed in one side of the diaphragm casing 18 functions to subject one face or side of the diaphragm 19 to atmospheric pressure. The remaining face or side of the diaphragm 19 is intended to be subjected to the inlet air static pressure prevailing in the inlet box B of the dryer chamber A. This is accomplished by the tubing 23 which communicates at one end with the interior of the diaphragm casing 18 and at its other end with the interior of the air inlet box B.

This compressed air supply controlling instrumentality operates in the following manner:

It was noted above that the inlet air controlling damper 5 is never closed so completely as to prevent any air from being delivered to the air inlet box B. Therefore, whenever the air circulating fan D is operating, some air will be supplied to the drying chamber A and there will be a low static pressure within the air inlet box B. This static pressure prevailing in the inlet box B will be applied to the sealed or closed half of the diaphragm casing 18 and will act upon the associated face or side of the diaphragm 19. When the static pressure within the sealed half of the diaphragm casing 18 exceeds the load imposed by the spring 22, the diaphragm 19 will be flexed and the valve 15 will be moved toward its associated seat 14. When the static pressure within the inlet box B reaches a predetermined maximum, the diaphragm 19 will be flexed sufficiently to completely close the venting valve 12, or completely engage the valve 15 with its seat 14. This inward movement of the valve 15, from its illustrated position toward the valve seat 14, will function to reduce the amount of the compressed air supply that is vented by this control instrumentality. When the valve 15 is fully engaged with its seat 14, none of the compressed air supply for the damper operating motor 7 will be vented to the atmosphere by this instrumentality, and the motor will function to open the damper 5 to increase the supply of air to the air inlet box

B. This increase in the supply of air is in response to the increase in resistance to the flow of air through the material in the receiving compartment; the increase of resistance being indicated by the increase in the static pressure within the inlet box B.

The second instrumentality is of a type which is well known in the art and is generally referred to as an air-operated controller. Several different control instrument manufacturing companies produce this type of controller and for that reason the diagrammatic disclosure presented by Fig. 3 of the drawings will be described only generally, and primarily for the purpose of explaining its broad principle of operation.

A compressed air supply line 24 extends from the air pressure regulating valve casing 12 to the valve casing 25 of this instrumentality. The valve casing 25 forms a part of a pilot valve which also includes a bellows 26. This bellows unit 26 is connected by the valve rod 27 to the valve head 28 that partakes of straight line or rectilinear movement. This valve head 28 is adapted to be moved in response to pressure variations that are developed within the interior of the bellows 26. These pressure variations will result in movement of the valve head 28 between the illustrated position, in which it closes the vent opening 29, and a position in which it will close the opening 30 that communicates with the air supply pipe 31 that extends to a suitable source of supply of compressed air, not shown. The source of supply of compressed air operates to provide a suitable compressed air pressure that usually falls within a range of from 15 pounds to 25 pounds.

Branching off from the valve casing passage 32 is a pipe line 33 having a restriction 34 located therein. This restriction 34 functions to limit the flow of air from the supply pipe 31 into the branch line 35 that communicates with the bellows 26 at one end and is formed with a nozzle 36 at its other end. This restriction 34 operates to provide a differential air pressure of approximately 1 to 10 between the pipe line 35 and the supply pipe 31 that extends to the interior of the pilot valve casing 25. This differential or ratio of air pressure is desirable because the flow of air to the pipe line 35 is used for control purposes while the flow of air through the pipe line 24 is employed for operating the motor 7 that actuates the control damper 5. If the restriction 34 were not used, the supply of control air to the nozzle 36, for practical purposes, would be considered as unlimited and it would be impossible to cause the pressure within the branch line 35 to be dropped to atmospheric, which is essential and is obtained by controlling the rate of discharge of the air through the nozzle 36.

A flapper 37 is employed for regulating the amount of control air that is discharged through the nozzle 36 as a small jet. To accomplish this function, the flapper 37 is pivotally supported at 38 and is adapted to be moved about 0.002 of an inch relative to the discharge face of the nozzle 36 to effect the desired change in nozzle pressure from the minimum to the maximum.

The flapper 37 is loaded by the spring 39 to cause the flapper to move away from the nozzle 36.

This air-operated controller instrumentality is conventionally provided with either an indicating pointer or a recording pen that is diagrammatically represented at 40. This pointer or pen 40 is illustrated as being actuated by a suitable temperature responsive coil element 41 that

is connected by the tubing 42 to the temperature bulb 43 which is located in the exhaust or discharge hood F. Of course, the pointer or pen 40 just as readily can be actuated by a thermocouple type of instrumentation, if desired. Therefore, the pointer or pen will be operated in response to variations in the temperature of the exhaust drying air passing through the hood F. A suitable link and lever mechanism is diagrammatically illustrated at 44 for operatively connecting the pointer or pen 40 to the flapper 37. It will be appreciated, therefore, that indicating or recording movements of the pointer or pen 40 will bring about corresponding, but greatly reduced, movements of the flapper 37 relative to the face of the nozzle 36.

The operation of this air-operated controller instrument will be presented as follows:

A supply of compressed air at full operating pressure will be delivered to the pilot valve casing 25 by the supply pipe 31. A substantially reduced supply of air will be delivered to the nozzle 36 and to the interior of the bellows 26 by the pipe lines 33 and 35.

The flapper 37 cooperates with the nozzle 36 to vary the back pressure that prevails within the bellows 26 by being moved into contact with or different distances from the discharge face of the nozzle.

It has been pointed out above that the air pressure that is applied to the piston 9 of the motor 7 determines the position of the inlet air control damper 5. This air pressure that is applied to the motor 7 is controlled in part by the instrumentality that has just been described. This instrumentality operates to vary the air pressure applied to the damper operating motor 7 by depending on a balance between the supply of air to this control instrumentality by the supply pipe 31 and the leakage of the air out of this instrumentality by way of the nozzle 36. If the supply of air to the instrumentality is greater than the leakage through the nozzle 36, the pressure applied to the bellows 26 will approach the air supply pressure. If the leakage through the nozzle 36 is greater than the air supply, the pressure within the bellows casing 29 will approach atmospheric.

If we now consider that the flapper 37 is positioned relative to the nozzle 36 in accordance with movements of the pointer or pen 40 and that for every position of this pointer or pen 40 there will be provided a definite control pressure within the bellows 26, it readily will be seen that the valve head 28 will be caused to assume a given position relative to the supply pipe opening 30 and the venting opening 29 for every position of the pointer or needle 40. Consequently, movements of the pointer or needle 40 to the right or left relative to its "control index" will cause the pilot valve 25 to effect increases or decreases respectively in the air pressure supplied to the damper operating motor 7, subject to superimposed control effected by the static pressure regulator instrumentality previously described in detail.

The superimposed operations of the two control instrumentalities to regulate the amount of hot drying air admitted to the drying chamber A in response to variations in inlet air static pressure and exhaust air temperature will be described as follows:

Let it be assumed that the dryer installation has been shut down at the end of a working period and is started up after several hours of

idleness. The drying chamber A will have had an opportunity to cool off during this shut down period. If a bed T of material was left in the drying chamber at the end of the preceding working period, the material of this bed is more than likely completely dried throughout the entire length of the drying chamber as a result of having absorbed heat from the walls of the chamber, the internal, annular series of louvers R, etc. This bed T of material, more than likely, is excessively dried at the discharge end portion of the chamber.

When the dryer installation is first started up, an excessive amount of the heat will be extracted from the drying air in raising the temperature of the drying chamber walls, etc., to the normal working temperature. Consequently, the temperature of the exhaust air will be abnormally low and the position of the flapper 37 relative to the nozzle 36 will be such as to provide a control pressure in the bellows 26 whereby the valve head 28 will assume a position relative to the venting opening 29 which will cause the air-operated controller to call for the delivery of an abnormally high amount of the drying air.

If this air-operated controller were the only instrumentality that was operating to regulate the air inlet control damper 5, an unusually large amount of drying air would be delivered to the drying chamber A. This delivery of an excessive amount of drying air to the chamber A will cause the bed T of material to blow. The excessively dried condition of the bed T of material left in the chamber during the shut down period will increase the possibility of the bed blowing as a result of this delivery of an excessive amount of the hot drying air.

With the static pressure regulator instrumentality operating in series with the air-operated controller, this blowing of the material bed T will be prevented. That is to say, the excessively dry condition of the starting bed T of material will offer less resistance to the flow of the drying medium therethrough and for that reason a lower inlet air static pressure will prevail in the inlet box B than will exist when the dryer installation is operating normally. Additionally, if the bed T of material in the drying chamber A should start to blow, the inlet air static pressure in the inlet box B will drop accordingly. This low inlet air static pressure in the inlet box B will cause the static pressure regulator instrumentality to effect a control of the inlet air regulator damper 5 which will prevent this damper from being opened in response to the control effected by the air-operated controller.

It will be apparent, therefore, that the two control instrumentalities will operate in combination to prevent the inlet air regulating damper 5 from being opened sufficiently to permit too much air to be admitted to the chamber A until both the static inlet pressure and the exhaust temperature stand at proper values. This dual regulation or control of the damper 5 will continue until the pressure and temperature conditions at the opposite ends of the drying chamber are such that a state of balance will prevail within the drying chamber.

During the continued operation of the dryer, variations in the rate of feed of the material will cause the bed T of material in the chamber A to increase or decrease in thickness and in the amount of resistance the bed offers to the flow of the drying air therethrough. Additionally,

if the moisture content of the material fed to the drying chamber varies, the amount of heat extracted from the drying air, during its passage through the bed of material, will vary. These variations in the condition of the bed T of material will cause the inlet air static pressure in the box B to change correspondingly and will cause the exhaust air temperature to change. The two control instrumentalities will effectively take care of these variations and the most efficient or effective drying condition will be provided in the chamber A.

A very close control over the amount of air admitted to the chamber is necessary when the material being dried is very fine or is of a light, fluffy character. These types of materials will blow very readily.

It has been pointed out above that the drying air is forcibly exhausted from the drying chamber A by the air fan L. This exhaust fan should withdraw the exhaust drying air at a rate which will maintain a slight negative pressure, or vacuum, in the discharge or exhaust hood F. If the exhaust fan L is not operated in unison with the operation of the inlet fan D, unsatisfactory pressure conditions will prevail in the drying chamber A over the bed T of material. If the pressure over the bed T of material is higher than normal, excessive dusting of the material will occur. If too low a vacuum prevails in the chamber space, over the bed T of material, an excessive loss of fine or light materials will occur through the exhaust stack. Additionally, exhausting of the drying air at an improper rate will create false temperature conditions in the discharge or exhaust hood F.

To control the rate at which the drying air is exhausted by the fan L, a control damper 52 is provided in the outlet for the exhaust fan L. This damper is automatically controlled by the differential pressure motor 53 through the medium of a suitable train of mechanical elements 54 that connects the damper with the rod 55 of the motor piston 56. This piston is loaded in one direction by the spring 57 to effect opening of the damper 52. The motor piston 56 is moved in the opposite direction, to effect closing of the damper 52, by compressed air that is delivered to the motor cylinder through the pipe line 58.

This pipe line leads to the valve casing 59 of a static vacuum regulator. This valve casing is chambered or hollowed out at 60 for communication with the pipe line 58. A second pipe line 61 leads from a source of compressed air to the regulator valve 59.

The regulator valve 59, further, includes a valve head 62 that cooperates with a valve seat 63 for controlling and varying the amount of the compressed air supply that is vented to the atmosphere from the regulator valve casing chamber 60. It will be appreciated that the position of the damper operating motor piston 56 can be controlled by the proper venting of the compressed air to the atmosphere.

The valve head 62 is moved into different positions with respect to its seat 63 by the valve rod 64 that is connected to the lever 65 and to the diaphragm 66. This diaphragm is clamped at its margin between the two halves of the diaphragm casing 67. One side of the diaphragm is subjected to atmospheric pressure because of the large opening 68 that allows for the passage of the valve stem 64 into this casing 67. The remaining side of the diaphragm 66 is subjected

to the static negative pressure, or vacuum, that prevails in the discharge or exhaust hood F through the medium of the tube 69. The opposite ends of this tube communicate with the interior of the diaphragm casing 67 and the interior of the hood F. The lever 65 is pivotally mounted at 70 at one end and is loaded at its opposite end by the spring 71.

It is to be understood that the form of this invention herewith shown and described is to be taken as a preferred example of the same, and that various changes in the shape, size, and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

Having thus described the invention, we claim:

1. In a control system for dryers, the combination with a chamber through which a bed of material to be dried may be advanced, a discharge hood communicating with one end of the drying chamber, and means for forcing hot drying air through the bed of material in the chamber including an air inlet box communicating with the other end of said chamber, of an adjustable damper for varying the amount of hot air delivered by the aforesaid means, a motor for adjusting the damper toward either its fully opened or its fully closed position, and means for conducting and regulating the flow of a motivating pressure fluid to said motor, said means comprising flow piping for said pressure fluid, two devices connected in series in said flow piping for regulating the flow of the pressure fluid, either of said devices being operable independently of the other to regulate the flow of pressure fluid to effect operation of the motor to move the damper toward its fully closed position, both of said devices being operable jointly but not independently to regulate the flow of pressure fluid to effect operation of the motor to move the damper toward its fully open position, fluid pressure operated means connected to the air inlet box and operable in response to variations in the air static pressure in said box to actuate one of said devices, and temperature operated means connected to the discharge hood and operable in response to variations in the temperature of the exhaust air passing through said hood to actuate the other of said devices.

2. In a control system for dryers, the combination with a chamber through which a bed of material to be dried may be advanced, a discharge hood communicating with one end of the drying chamber, and means for forcing hot drying air through the bed of material in the chamber including an air inlet box communicating with the other end of said chamber, of an adjustable damper for varying the amount of hot air delivered by the aforesaid means, a motor including a piston loaded by a spring for movement in one direction for closing the damper and operated by pressure fluid for movement in the other direction for opening the damper, a pipe line for conducting pressure fluid to the motor, two flow controlling valves connected in series in said pipe line so as to operate independently of each other to reduce the application of pressure fluid to the motor to bring about closing movement of the damper and so as to operate dependently of each other to increase the application of pressure fluid to the motor to effect opening movement of the damper, fluid pressure operated means connected to the air inlet box and operating in response to variations in the air static pressure in said air inlet box for actuating

one of said valves, and temperature operated means connected to the discharge hood and operable in response to variations in the temperature of the exhaust air passing through the discharge hood for actuating the other of said valves.

3. In a control system for dryers, the combination with a chamber through which a bed of material to be dried may be advanced, a discharge hood communicating with one end of the drying chamber, and means for forcing hot drying air through the bed of material in the chamber including an air inlet box communicating with the other end of said chamber, of a damper adjustable in opposite directions for increasing and decreasing the amount of hot drying air delivered by the aforesaid means, spring means for moving the damper in one of said directions, fluid pressure operated means for moving the damper in the other of said directions, a pipe line for supplying constant pressure to said fluid pressure operated means, two instrumentalities operating in series in said pipe line to control the flow of fluid through the latter, means responsive to pressure and operatively connected to the air inlet box for effecting actuation of one of said instrumentalities in response to variations in the air static pressure in said air inlet box, and means responsive to temperature and operatively connected to the discharge hood for effecting actuation of the other of said instrumentalities in response to variations in the temperature of the exhaust air flowing through the discharge hood.

4. In a control system for dryers, the combination with a chamber through which a bed of material to be dried may be advanced, a discharge hood communicating with one end of the drying chamber, an exhaust fan connected to the discharge hood for withdrawing air therefrom, and means for forcing hot drying air through the bed of material in the chamber including an air inlet box communicating with the other end of said chamber, of an adjustable damper for varying the amount of hot air delivered by the aforesaid means, a motor for adjusting the damper toward either its fully opened or its fully closed position, means for conducting and regulating the flow of a motivating pressure fluid to said motor, said means comprising flow piping for said pressure fluid, two devices connected in series in said flow piping for regulating the flow of the pressure fluid, either of said devices being operable independently of the other to regulate the flow of pressure fluid to effect operation of the motor to move the damper toward its fully closed position, both of said devices being operable jointly but not independently to regulate the flow of pressure fluid to effect operation of the motor to move the damper toward its fully open position, fluid pressure operated means connected to the air inlet box and operable in response to variations in the air static pressure in said box to actuate one of said devices, and temperature operated means connected to the discharge hood and operable in response to variations in the temperature of the exhaust air passing through said hood to actuate the other of said devices, and means responsive to pressure and operatively connected to the discharge hood operating in response to variations in the static pressure in the discharge hood for increasing or decreasing the rate of withdrawal of air from the discharge hood so as to maintain a slight negative pressure in said hood.

5. In a control system for dryers, the combina-

tion with a chamber through which a bed of material to be dried may be advanced, a discharge hood communicating with one end of the drying chamber, an exhaust fan connected to the discharge hood for withdrawing air therefrom, and means for forcing hot drying air through the bed of material in the chamber including an air inlet box communicating with the other end of said chamber, of an adjustable damper for varying the amount of hot air delivered by the aforesaid means, spring means for moving the damper toward its fully closed position, fluid pressure operated means for moving the damper toward its fully opened position, a pipe line for supplying constant pressure fluid to said fluid pressure operated means, two instrumentalities operating in series in said pipe line to control the flow of fluid through the latter, means responsive to pressure and operatively connected to the air inlet box for effecting actuation of one of said instrumentalities in response to variations in the air static pressure in said air inlet box, means responsive to temperature and operatively connected to the discharge hood for effecting actuation of the other of said instrumentalities in response to the variations in the temperature of the exhaust air flowing through the discharge hood, and means responsive to pressure and operatively connected to the discharge hood operating in response to variations in the static pressure in the discharge hood for increasing or decreasing the rate of withdrawal of air from the discharge hood so as to maintain a slight negative pressure in said hood.

6. In a control system for dryers, the combination with a chamber through which a bed of material to be dried may be advanced, a discharge hood communicating with one end of the drying chamber, and means for forcing hot drying air through the bed of material in the chamber including an air inlet box communicating with the other end of said chamber, of an adjustable damper for varying the amount of hot air delivered by the aforesaid means, spring means for moving the damper toward its fully closed position, air pressure operated means for moving the damper toward its fully opened position, a pipe line for supplying constant pressure air to said air pressure operated means, two instrumentalities operating in series in said pipe line to control the flow of air through the latter, each of said instrumentalities including a valve device for venting to the atmosphere variable amounts of said pressure air, means responsive to pressure and operatively connected to the air inlet box for effecting actuation of one of said instrumentalities in response to variations in the air static pressure in said air inlet box, and means responsive to temperature and operatively connected to the discharge hood for effecting actuation of the other of said instrumentalities in response to variations in the temperature of the exhaust air flowing through the discharge hood.

7. In a control system for dryers, the combination with a chamber through which a bed of material to be dried may be advanced, a discharge hood communicating with one end of the drying chamber, an exhaust fan connected to the discharge hood for withdrawing air therefrom, and means for forcing hot drying air through the bed of material in the chamber including an air inlet box communicating with the other end of said chamber, of an adjustable damper for varying the amount of hot air delivered by the afore-

said means, spring means for moving the damper toward its fully closed position, air pressure operated means for moving the damper toward its fully opened position, a pipe line for supplying constant pressure air to said air pressure operated means, two instrumentalities operating in series in said pipe line to control the flow of pressure air through the latter, each of said instrumentalities including a valve device for venting to the atmosphere variable amounts of said pressure air, means responsive to pressure and operatively connected to the air inlet box for effecting actuation of one of said instrumentalities in response to variations in the air static pressure in said air inlet box, means responsive to temperature and operatively connected to the discharge hood for effecting actuation of the other of said instrumentalities in response to variations in the temperature of the exhaust air flowing through the discharge hood, and means responsive to pressure and operatively connected to the discharge hood operating in response to variations in the static pressure in the discharge hood for increasing or decreasing the rate of withdrawal of air from the discharge hood so as to maintain a slight negative pressure in said hood.

8. A control system for dryers, comprising a chamber through which a bed of material to be dried may be advanced, a discharge hood communicating with one end of the drying chamber, means for forcing hot drying air through the bed of material in the chamber including an air inlet box communicating with the other end of said chamber, a motor operated damper associated with said first mentioned means for varying the amount of drying air delivered by the air forcing means, means for conducting a motivating medium to the damper motor, a first control instrumentality connected in said conducting means and provided with a tube terminating in said inlet box for applying the air static pressure in the inlet box to said first control instrumentality to regulate the flow of the motivating medium to the damper motor, and a second control instrumentality connected in said conducting means on the input side of said first control instrumentality and provided with a temperature responsive element located in heat exchange relation to said discharge hood to regulate the flow of the motivating medium to said first control instrumentality, said control instrumentalities being operable jointly but not independently to regulate the flow of motivating medium to and effect operation of the damper motor to cause more air to be delivered by said air forcing means, said damper motor including means for constantly urging the motor to move the damper in a direction opposite to that in which the damper is moved by the motor when actuated by said motivating medium.

9. A control system for dryers, comprising a chamber through which a bed of material to be dried may be advanced, a discharge hood communicating with one end of the drying chamber, an exhaust fan connected by an exhaust duct to the discharge hood for forcibly withdrawing air therefrom, means for forcing hot drying air

through the bed of material in the chamber including an air inlet box communicating with the other end of said chamber, a first motor operated damper associated with said first mentioned means for varying the amount of drying air delivered by the air forcing means, means for conducting a motivating medium to the motor of said first damper, a first control instrumentality connected in said conducting means and provided with a tube terminating in said inlet box for applying the air static pressure in the inlet box to said first control instrumentality to regulate the flow of the motivating medium to the motor of said first damper, a second control instrumentality connected in said conducting means on the input side of said first control instrumentality and provided with a temperature responsive element located in heat exchange relation to said discharge hood to regulate the flow of the motivating medium to said first control instrumentality, said control instrumentalities being operable jointly but not independently to regulate the flow of motivating medium to and effect operation of the motor of said first damper to cause more air to be delivered by said air forcing means, said first damper motor including means for constantly urging the motor to move the damper in a direction opposite to that in which the damper is moved by the motor when actuated by said motivating medium, a second motor operated damper associated with said exhaust duct for varying the amount of air withdrawn by said exhaust fan, means for conducting a motivating medium to the motor of said second damper, and a third control instrumentality connected in said last mentioned conducting means and provided with a tube terminating in said discharge hood for applying the pressure in said discharge hood to said third control instrumentality to regulate the flow of said motivating medium to the motor of said second damper to increase or decrease the rate of withdrawal of air so as to maintain a slight negative pressure in said hood.

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