APPELLATUS FOR FEEDING POWDERED FUELS

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This invention relates to apparatus for feeding powdered, pulverized, fuels and air to furnaces.

The principal object of this invention is to obtain complete and thorough aeration of the fuel particles as they are fed to the furnace.

Another object is to provide fuel feeding apparatus which is highly efficient as a unit, which handles the fuel from the point of supply to the point of discharge with the least possible expenditure of driving power, and which at the same time keeps the fuel thoroughly mixed with air throughout its entire travel from source to burner.

Another object is the provision of improved apparatus for feeding fuel from a storage bin into the conduit through which it is conveyed to the burner.

A further object is the provision of improved means for mixing the powered fuel as it leaves the storage bin with induced currents of air.

Another object is the provision of improved means for supplying pre-heated air with the fuel.

Another object is the provision of improved means for regulating the fuel and air feed, the one with respect to the other, and both with respect to the requirements of the furnace being supplied.

A further object is the provision of an improved type of fuel burner and one which will be particularly efficient in association with the other apparatus forming a part of this invention.

Other objects and various features of novelty residing in the apparatus devised will be apparent from the description and the showing of the drawings forming a part of this specification.

Figure 1 is a side elevation partly in section of one embodiment of the invention;

Figure 2 is a horizontal section taken on the line 2—2 of Figure 1;

Figure 3 is a central vertical section on the line 3—3 of Figure 2;

Figure 4 is a detail view of an agitator shown in Figure 1;

Figure 5 is a detail view of a burner shown in Figure 1;

Figure 6 is a side elevation of a modification, parts being shown in section;

Figure 7 is a section on the line 7—7 of Figure 6;

Figure 8 is a detail view of a member shown in Figure 6;

Figure 9 is an enlarged detail view of a portion of an aerating plate shown in Figure 6;

Figure 10 is a view similar to Figure 1 showing another modified form of the invention;

Figure 11 is a horizontal section on the line 11—11 of Figure 10;

Figure 12 is a plan view of a burner shown in elevation in Figure 11; and

Figure 13 is a perspective view of a modified form of burner.

Various difficulties have been encountered in the past in the feeding of powdered fuels. Arching of fuel in the feed bin or hopper has presented one difficulty of considerable moment. Powdered fuels subjected to even a slight amount of moisture readily arch above the usual agitator provided in the supply bin, thereby temporarily stopping the feed to the fuel burner. During the time the fuel feed is discontinued, the fire at the burner may die out. When the arch breaks, the feed line and burner are overloaded, and moreover, the fuel is likely to be wasted unless the furnace walls are sufficiently hot to reignite the fuel as it emerges from the burner. According to this invention, arching of the fuel with consequent breaking and flooding are effectively prevented by providing improved agitating devices. In one case cutting fingers are provided on a novel type of agitator, while in another case a supplementary forked member is provided auxiliary to the agitator, for continuously undermining the fuel arch at its base. This provides a smooth continuous feed with consequent improvement in combustion and elimination of smoke.

Another difficulty has been the sticking, caking and clogging of the fuel in the supply conduit prior to reaching a blower such as
is usually employed in powdered fuel feeding devices. When these cakes or balls of fuel are struck by the fan blades, they are not thoroughly disintegrated and hence are fed to the burner in a very objectionable manner. Besides, the fan is injured when called upon to handle fuel in this condition. It is desirable to feed the fuel to the blower in a finely divided condition. According to the present invention, the fuel is intimately mingles with a preliminary charge of air, preferably preheated air, as soon as it comes from the fuel bin into the fuel conduit, the air inlets being located as near the fuel bin outlet as it is possible to arrange them. To insure a draft through these inlets, all other inlets to the fuel blower are eliminated. Also the inlets are so disposed with respect to the fuel conduit that the fuel as it falls from the bin will drop upon a stream of air issuing from the inlets and flowing along the bottom surface of an inclined section of the conduit. The fuel is first floated thereon and then suspended therein as finely divided dust particles, and is received in this condition by the blades of the blower. A device is also provided for breaking up and whirling the fuel preparatory to its descent upon the stream of air. A further difficulty has been the improper functioning of burners heretofore devised or provided. The immediate causes of this difficulty are many and varied and need not be discussed in detail. The burner herein disclosed is designed to remedy the difficulty. By the provision of an expanding fish-tail nozzle for the preliminary mixture of fuel and air and a circumscribing supplementary air nozzle terminating near the end of the fuel nozzle, a highly efficient burner is produced.

Referring now to the drawings and particularly to Figures 1 to 5, there is shown a bin 10 having supports or pedestals 11. The top of the bin is provided with a filling opening 12 normally closed by a cap 13 adapted to fit in the opening to prevent the admittance of excess air during operation. The lower end of the bin is provided with a hopper 14 of frusto-conical shape having a flange 15 at its bottom end. A lower continuation 16 of the hopper also carries a complementary flange 17 which for the purposes of convenient assembly and ready demountability may be secured to the upper flange 15 by rivets or by bolts 18 and nuts 19.

A conduit 20 is connected to the bottom end of the lower hopper 16 and extends into the side of a blower casing 21 and as near the center thereof as the fan shaft 22 of the blower will permit. The conduit 20 has an elbow 23 which connects a vertical section 24 of the conduit with an inclined section 25 in order to lead it away from the agitator shaft 26 which extends concentrically within the vertical section 24. The inclination of the section below the elbow also serves a useful purpose in the aeration of the fuel as will be explained hereafter.

The agitator shaft 26 is rigidly and detachably secured at its upper end and if desired at other points to a double-conical common-base agitator or stirrer 27 for the purpose of imparting rotation thereto. The upper conical surface of the agitator is provided with spiral ribs 28 which extend free of the surface at their upper ends to provide stirring fingers 29. The rotation imparted by the shaft is in the direction to cause the spiral ribs to feed the fuel downward after the fashion of a spiral conveyor worm.

The lower conical surface of the agitator 27, as clearly shown in Figure 1, has a steeper slope than the hopper 16 so that the base lies nearer the surface of the hopper than does the apex of the cone. This provides practically a line cut off at the base 31 of the cone between the hopper and agitator when the latter drops down. Ribs 30 are provided on the lower conical surface and have slightly spiral disposition in the same direction as the ribs 28 to continue the movement of fuel. The outer surface of the ribs 30 is practically parallel to the sides of the hopper 16. The ribs then are of decreasing thickness from bottom to top and at the base of the lower conical surface have almost no thickness at all, insuring a good cut-off of fuel at that line. Cutting fingers 32 are secured to the upper conical portion of the agitator in any suitable manner. Conveniently, the lower ends of the fingers are made of round stock and threaded into the wall of the agitator. These fingers are flat and have their front edges sharpened to aid them in moving through the fuel.

In order to vary the feed, the agitator, together with its carrying shaft 26 is mounted to have vertical movement. A sleeve 33 is secured and sealed to the lower inclined surface of the elbow 28 around the shaft 26 and extends well within the lower end of the agitator 27. The agitator has a bearing 34 surrounding the sleeve and the bearing is free to slide longitudinally of the sleeve. This construction provides a sturdy and dust-proof bearing for the shaft through the conduit.

The agitator for convenient assembly is preferably made in two abutting conical portions. The lower portion is provided with a web 27b across its base having a sleeve 27c for the shaft. A pin 27d passed through the pin and shaft holds the parts in proper relative position. The base skirt of the upper conical portion fits closely over the base of the lower portion, the latter being chamfered slightly to permit of this. As thus arranged the parts are securely held in their proper positions.
The supports 11 carry a horizontal plate 35 and below this a smaller plate 36 secured to the supports by rods 37, each attached to one corner of the small plate and to one of the supports 11. A sleeve 38 is bolted to the plate 35 concentric with an aperture therein for the shaft 36 which extends into the sleeve. The plate 36 has an opening vertically below the axis of the shaft and a pindle rod 39 extends freely through this opening at its lower end. A castellated nut 39a resting upon the plate 36 and threaded upon pindle rod 39 supports the same in a position to have its upper end project into the lower end of sleeve 35. The lower end of the shaft 36 rests with its full weight upon a ball bearing 40 which in turn rests on the upper end of the pindle rod 39. By adjusting the vertical position of the rod 39 the shaft 26 and the agitator 27 are both adjusted longitudinally through a corresponding distance. An adjusting lever 41 has an elongated slot 42, the sides of which operate in an annular groove in a collar 43 threaded into the center of the castellated nut. The lever 41 has a detent 44 projecting downwardly and toward the center of the slot and when the handle is pushed toward the nut this detent engages one of the teeth in the castellated top thereof to turn the motor.

A motor M is mounted on the plate 36 and drives the shaft 22 already referred to as the shaft which turns the blades of the blower. Intermediate its length, the shaft 22 carries a worm 45 which drives a ring gear 46 upon shaft 47 carried in bearings in brackets 48 secured to plate 36 and a bevel pinion 49 splined to shaft 47 drives a bevel gear wheel 50 splined to shaft 26. The bevel wheel 50 has a series of concentric bevel gears which mesh with the bevel pinion 49 to provide a change-speed drive for the agitator 27. Both the pinion and gear wheel have hubs with annular grooves whereby they may be moved and locked in position by detent handles 51 and 52 respectively. The usual segments 53 and 54 are provided upon the plate 35 for cooperation with the detents of the handles 51, 52. By sliding gear wheel 50 up, the bevel pinion 49 may be moved to another of the annular gears thereon, and latched in position by the detent handle 51, whereupon the bevel wheel is dropped back into mesh with the pinion and latched in this position by detent lever 52.

A plurality of ducts 55 open into the elbow 23 near the lower sloping surface thereof. These ducts have flaring outer ends 56 in order to provide for the entrance of air thereinto from the least possible amount of frictional resistance. The amount of air entering the conduit by these ducts may be regulated by adjusting the position of the slotted plugs 57 in the ends of the ducts or by completely removing one or more of the plugs from the ducts. As shown in Figure 3 the plugs are hollow and have slots 57a in their sides. The ends of the plugs are somewhat flexible and will serve to hold the plugs in any adjusted position but if desired the plugs and the interior of the ducts may be provided with screw threads for this purpose. The ducts 55 constitute, in effect, the sole source of air intake to the blower with the exception of the air which enters with the fuel from the bin, and this is negligible since the bin, as stated, is closed at the top by a tight-fitting cap 13. The fuel dropping down the vertical section 24 of the conduit falls toward the inclined bottom surface of the conduit, and since a stream of air from the ducts 55 is induced to flow along this bottom surface, the fuel will be carried thereon and intimately mixed therewith as it flows down the inclined section 25 of the conduit to the interior of the blower. By the time the fuel reaches the blower it will have been intimately mixed with the air so that it is suspended therein as a dust cloud free from all large cakes or lumps. This dust cloud of fuel is caught by the blades of the blower and driven through an outlet pipe 58 into a fuel nozzle 59. The outlet pipe 58 from the blower converges in diameter toward the nozzle for the purpose of concentrating the mixed charge of fuel and air, and the nozzle flares gradually so that the charge will be relieved of pressure to a certain extent as it emerges therefrom. A plurality of supplementary air ducts 60, regulated by dampers 61, feed into an air nozzle surrounding or circumscribing the fuel nozzle 59 and terminating approximately in the plane of the end of the fuel nozzle.

For the complete and rapid mixing of fuel and air it has been found that a fish-tail nozzle gives best results. This form of burner also has peculiar advantages in connection with the localization of the flame. For cupolas the axis of the flat burner may stand vertically to direct the flame against the side walls of the cupola while for heating furnaces the axis of the flat burner may stand horizontally to spread the flame beneath the tubes to be heated. A shape which has been found efficient for general purposes is one of cruciform, winged or double fish-tail cross-section. The shape of this nozzle is clearly shown in Figure 5. The dampers 61 turn upon journals 65 protruding through the sides of the air ducts. One end of these journal rods is formed into a crank 66, and a rod 66 pivotally engages these cranks for simultaneous regulation of the dampers. The outer ends of the supplementary air ducts have flared inlets for the purpose already explained in connection with the ducts 55.

The fuel feeder devised is adapted in all parts to provide efficient and economical feeding and combustion of fuel. While it is possible to regulate the device so that it will blow

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the fuel and air from the nozzle with considerable velocity as is necessary in burning coarse powdered fuel where an amount of air in excess of that required for the combustion of the fuel is required as a vehicle to suspend the particles, it is peculiarly adapted to float highly pulverized fuel into the furnace with just sufficient air for proper combustion as a slow moving dust cloud. This has peculiarly beneficial results. With high velocity feeding the excess air takes useful heat out of the stack as waste and besides a long fire box is required. With the present method of feeding, there is a minimum waste of heat and the fire box may be quite short. Indeed, this burner may be used very successfully in the fire boxes of ordinary house heating furnaces where high velocity feeding has been found entirely unsatisfactory.

Referring now to the modification shown in Figures 8 to 9, it will be seen that there is a bin 10' supported on pedestals 11' carrying near their lower ends a plate 33' This bin 10' is rectangular in horizontal section instead of round as in the case of the modification just described, and is provided with an opening 12' at the top, closed by a cap 13'. The hopper 14', also of rectangular cross-section, extends from the lower end of the bin 10' and this hopper is provided with a flange 15', to which a continuation hopper 16' is secured by bolts 18' passing through a flange 17' thereon and the flange 19'. The bolts 18' are secured by nuts 19'.

A conduit 20' leads from the lower end of hopper 16' to the blower casing 21'. This conduit comprises a vertical section 24', which in effect is a continuation of the hopper 16', and an inclined portion 25'.

An agitator or feed roll 70 operates within the hopper 16' and is of cylindrical shape so that it will fit between the longer parallel sides 16a of the hopper 16'. The agitator 70 has journals 71 at either end operating in bearings 72 provided on the ends 16b of the hopper 16'. The journal 71 at one end of the fuel feeder is provided with a cam 73 which oscillates within the sides of a slot 74 formed in a lateral arm 74a of a member 75 having cutting fingers 75a which extend along the sides of the hopper 16'. A bearing 76 is provided in one end of the hopper for the shaft of the cutting member. If desired, the fingers may be joined at their outer ends to form a journal and bearings may be provided for this journal in the other end of the hopper. The end 16b of the hopper 16' away from cam 73, has an arc shaped slot 77, and a regulator 78 formed as part of a cylinder fits within this slot above the cylindrical feed roll. By moving this regulator 78 longitudinally fuel is allowed to fall upon the roll 70 for a regulated distance along its length.

The feed roll 70 has longitudinal ribs 79 along its periphery. These ribs consist of radial sides 79a and tangential sides 79b of diminishing depth from one end of the cylinder to the other. It will thus be seen that as a greater length of the cylinder 70 is uncovered by the regulator 78, the feeding capacity will be increased due to the greater length of the cylinder to which fuel is admitted, and also to the increasing depth of the grooves formed by the ribs 79. Thus the feed regulation corresponds in a manner to the double means for regulating the feed provided in the first modification consisting of the speed gear and the mechanism for varying the distance between the agitator 27 and the hopper 16.

The agitator or feed roll 70 has a bevel gear 71c thereon which is driven by a bevel pinion 80' fast upon a shaft 80 carried in bearings of brackets 81 and 82 secured to the plate 35'. The shaft 80 in turn is driven through the bevel pinion 83 thereon in mesh with a similar bevel pinion 84 carried by a motor and blower shaft 29'.

An aerating plate 85 extends across the upper end of the conduit 20' beneath the feed roll 70. This plate has a number of apertures 86 throughout its entire area in the conduit and the metal strips or blades 87 which are punched out of the plate on three of their sides to form the apertures 86 are pushed below the plate and twisted at their outer ends to give the fuel a swirling movement as it falls from the apertures 86 upon them. A plurality of air ducts 55' having flaring funnel shaped outer ends 56' open into the conduit below the plate 85 and immediately above the lower surface of the inclined portion 25' of the conduit. Plugs 57' may be employed in the ducts 55' to regulate the amount of air passing into the conduit and blower. The blower has no appreciable air intake other than by these ducts 55' and hence all of the air taken in by the blower will be effective for floating the fuel to the blower. As the fuel falls from the blades 87 it drops upon the stream of air from the ducts 55' to be floated thereon and intimately mixed therewith as it proceeds to the blower. An outlet pipe 58' is provided for the blower as before, and this outlet leads to a fuel burner such as that already described in connection with Figures 1 to 5.

The fuel feeding devices described above take air directly from the atmosphere but it is quite desirable at times to supply preheated air with the fuel. This is particularly true if the air is to be supplied at the burner to be slightly moist. Figures 10 to 12 illustrate a fuel feeding device quite similar to that shown in Figs. 1 to 5 but which includes means for supplying preheated air. The air supplied may be heated in any desired manner but preferably in such manner as to utilize heat from the furnace which would otherwise be lost.
example a preheater may be positioned in the line leading to the smoke stack. In these figures 10' designates a bin resting on pedestals 11'. The bin has a top charging opening 12' covered by a cap 13' and a bottom hopper 14' provided with an extension hopper 16' connected thereto by bolts 18' passing through flanges 15' and 17' and clamped by nuts 19'. An inclined conduit 20' having an elbow 28', vertical section 24' and inclined section 25' leads from the hopper to a blower casing 21' adjacent the blower shaft 22'.

An agitator shaft 26' passes through a sleeve 53' in the vertical pass of the conduit 20' and is connected at its upper end to an agitator 27' disposed in the hopper 16'. The agitator is the same as that shown in Figs. 1-5 and need not be described particularly here.

A plate 35' attached to pedestals 11' supports the blower 21' and a second somewhat smaller blower 121 the blades of which are driven by the same shaft 29' from motor M'. Preferably the blower 121 is secured to the side of the blower 21' by bolts 122 through lugs 123, the side of blower 21' constituting one of the side walls of the blower 121. The second blower 121 takes preheated air from the blower 21' and forces it through conduits 124 and 126 into ducts 65' and supplementary ducts 60' respectively. The branches 126 of conduit 125 are removably fitted in the ducts 55' in place of plugs 57'. A damper 128 in conduit 125 regulates the flow of preheated air to all of the ducts 55'. Plate 36' carries a sleeve 130 which supports an oil tight housing 131 within which a ring gear 132 and a worm 45' mesh therewith operate. The worm is fast on the motor shaft 22' and drives the ring gear 132 fast on the agitator shaft 26'. A sleeve 134 secures the housing 131 by a flange 135 extends into the hub of the ring gear 132 above the normal level of the oil in the housing whereby the gears may be immersed in oil without leakage along the shaft. Obviously the change speed gearing previously described may be substituted if desired.

A small plate 36' is supported by rods 37' attached to plate 35'. On plate 36' is supported a pin 138 having a sleeve portion 38' attached to plate 35' by bolts through its flange. A cam 137 pivoted upon a pin 138 carried in the support 136 supports the shaft 26' through a pinle rod 50' and a ball bearing 40'. Integral with the cam 137 is a gear segment 140 meshing with a similar pivoted segment 141 provided with a regulating lever 142. A connector 143 attached to the rod may be actuated by any desired regulating device, preferably a thermostat controlled regulating device indicated generally at 144. A nut 145 threaded on rod 142 serves as an adjusting member. Movement of the cam about its pivot will cause vertical movement of shaft 26' and agitator 27' to regulate the distance between the base of lower conical portion and the hopper 16' to regulate the feed of fuel.

The outlet conduit 126 leads to an air nozzle 62' surrounding a fuel nozzle 59' and is provided with a regulating damper 146 to control the flow of preheated air there-through.

In Figure 13 a fuel nozzle 59' is formed as a single flat fish-tail member. An enclosing air nozzle 62' is of similar shape and both nozzles are journaled to the ends of their supply conduits 55' and 126' at 147 and 148 respectively so that the flat flame produced may be turned at any angle to obtain the most efficient distribution of heat for any one of numerous purposes.

The operation of the device will be apparent from the foregoing description. Referring to the first modification, powdered, pulverized or atomized fuel is placed within the bin 10 and the top of the bin is closed by the cap 13. The motor M is then started to operate the blower and agitator. The correct gear ratio between the shaft 47 driven from the motor shaft and the shaft 26 operating the agitator is established by putting the bevel pinion 49 into engagement with the desired ring gear upon the bevel gear wheel 50. This is done as described, by moving the detent handle 52 to carry the bevel wheel up the splined shaft 36 away from the bevel pinion 49 whereupon the other detent handle 51 is moved to slide the bevel pinion 49 to the desired place along its shaft, after which the detent handle 52 is again moved to drop the bevel wheel 50 down upon the pinion 49. Both the bevel pinion 49 and the bevel wheel 50 are held in adjusted positions along their shafts, and in mesh with each other by locking the detent pins of the detent handles 51 and 52 in the teeth of the segments 53 and 54 respectively. The vertical position of the agitator 27 with respect to the hopper 16' is adjusted by raising or lowering the pintle rod 39 by means of the castellated nut 39a, which is turned by the adjusting lever 41. The pintle rod 39 may be splined or keyed to plate 36 or sleeve 33 to prevent it from turning when the nut 39a is turned. After the blower and agitator have been set into operation and the feeding adjustments made, the fuel will be fed down by the stirring fingers 29 and the ribs 28. In case an arch of fuel is formed in the hopper, the cutting fingers 39 will immediately undermine the base thereof so that the feed is kept uniform. The fuel drops down on the stream of air entering from the ducts 55 and the air and fuel are intimately mixed as they travel to the blower. The amount of air fed to the blower is regulated by inserting or removing one or more of the plugs 57 in the ends of...
the air ducts 55, or by changing the positions of the plugs in the ducts. The fuel from the blower is fed through the outlet pipe 55 and fuel nozzle 59. The regulated amount of air is fed to the air nozzle 62 surrounding the fuel nozzle 59 by changing the position of the dampers 61 in the supplementary air ducts 60.

The operation of the modification shown in Figures 6 to 9 is similar to that of the modification just described. The fuel is fed by the agitator or feed roll 70 from the hopper 16' and the amount of fuel fed is controlled by the regulator 78 and the depth of the grooves formed by the ribs 79. The cutting member 75 by its oscillating fingers 75α prevents an arching of fuel within the hopper 16' thus providing a steady uniform flow of fuel to the fuel conduit 20". The fuel from the agitator 70 falls through the openings of the plate 85 upon the stream of inflowing air from ducts 55" and thereafter is drawn into the blower and forced to the fuel burner in the manner already described.

The operation of the modification shown in Figure 10-12 is similar to that of the modification shown in Figures 1 to 5 so need not be described separately here.

It will be seen that the apparatus devised is adapted at all points to handle the fuel in such a way that perfect aeration and uniform feeding will be produced. It is thought that many novel and desirable features will be found in the various forms of the apparatus illustrated and described. However, it is to be understood that the applicant does not wish to limit himself to the particular and specific embodiments shown and described, but contemplates many other modifications falling within the scope of the appended claims.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In a powdered fuel feeder, in combination, a fuel bin, a hopper therefrom, an agitator controlling the feed from said hopper, a fuel conduit opening into the bottom of the hopper, an inclined section forming part of said conduit, air ducts opening directly into the walls of the conduit for supplying air near the lower surface of the inclined section of the conduit, a blower connected to the lower end of the conduit, and fuel discharge means associated with said blower.

2. In a powdered fuel feeder in combination, a source of powdered fuel, a fuel blower, a conduit interposed between the source and blower, a fuel nozzle supplied by said fuel blower, an auxiliary air nozzle enclosing the end of said fuel nozzle, and a blower for supplying preheated air to said supplementary air nozzle and into said conduit near the source, and a rotatable driving shaft on which said air and fuel blowers are mounted.

3. In a powdered fuel feeder in combination, a source of fuel supply, a fuel nozzle, a supply conduit connecting the nozzle to the source, a blower disposed in the conduit intermediate the nozzle and source, a plurality of air ducts opening into the conduit walls near the source, means to regulate the amount of air flowing therethrough, said ducts constituting the sole means of admitting air along said conduit, an air nozzle surrounding said fuel nozzle, said air nozzle having its end adjacent the end of the fuel nozzle, one or more supplementary air ducts opening into said air nozzle, and means to regulate the amount of air flowing through said supplementary air nozzle.

4. In a powdered fuel feeder, in combination, a fuel bin, a conical hopper therefrom, a conical agitator operating in said hopper, a shaft secured to said agitator to rotate it to feed fuel from said hopper, a fuel conduit opening into said hopper about said shaft and having an inclined section leading laterally away from said shaft, a sleeve for said shaft sealed to said conduit, said sleeve extending within the lower end of said agitator, the latter having a bearing surrounding said sleeve, means to slide said shaft and agitator axially along said sleeve to regulate the distance between the lower conical surface of said agitator and the surface of the hopper, a blower with which said fuel conduit communicates, and a fuel nozzle associated with said blower.

5. In a powdered fuel feeder, in combination a fuel bin, a conical hopper therefrom, a common base double conical agitator operating in said hopper, a shaft secured to said agitator to rotate it to feed fuel from said hopper, a fuel conduit opening into said hopper about said shaft and having an inclined section leading laterally away from said shaft, a sleeve for said shaft sealed to said conduit, said sleeve extending within the lower end of said agitator, the latter having a bearing surrounding said sleeve, means to slide said shaft and agitator axially along said sleeve to regulate the distance between the lower conical surface of said agitator and the surface of the hopper, a blower with which said fuel conduit communicates, and a fuel nozzle associated with said blower.

In testimony whereof I hereunto affix my signature.

WILLIAM O. NEASE.