

Dec. 21, 1937.

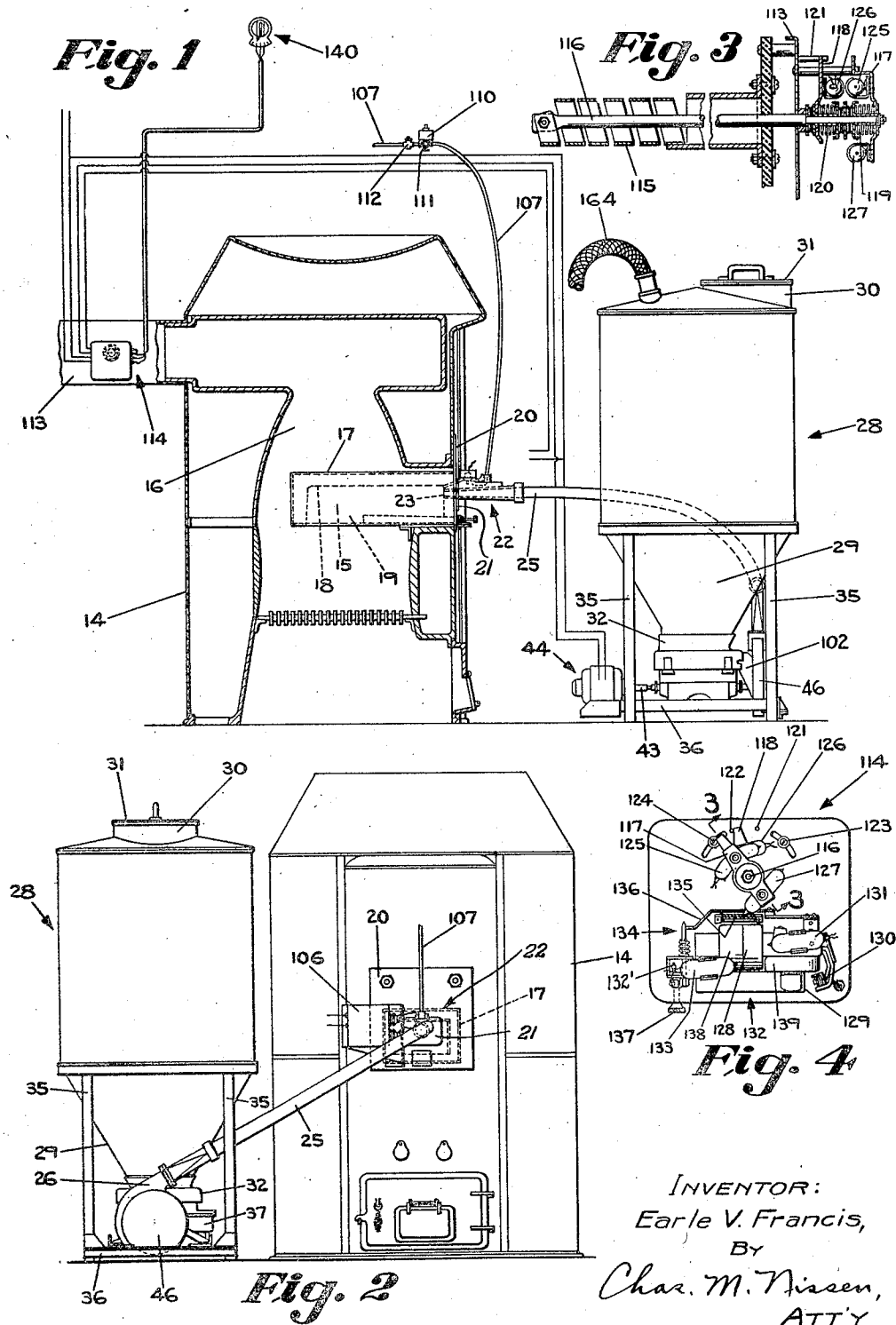
E. V. FRANCIS

2,102,691

AUTOMATIC SYSTEM FOR SUPPLYING PULVERIZED FUEL TO FURNACES

Filed Jan. 18, 1935

4 Sheets-Sheet 1



INVENTOR:
Earle V. Francis,
By
Char. M. Nissen,
ATT'Y.

Dec. 21, 1937.

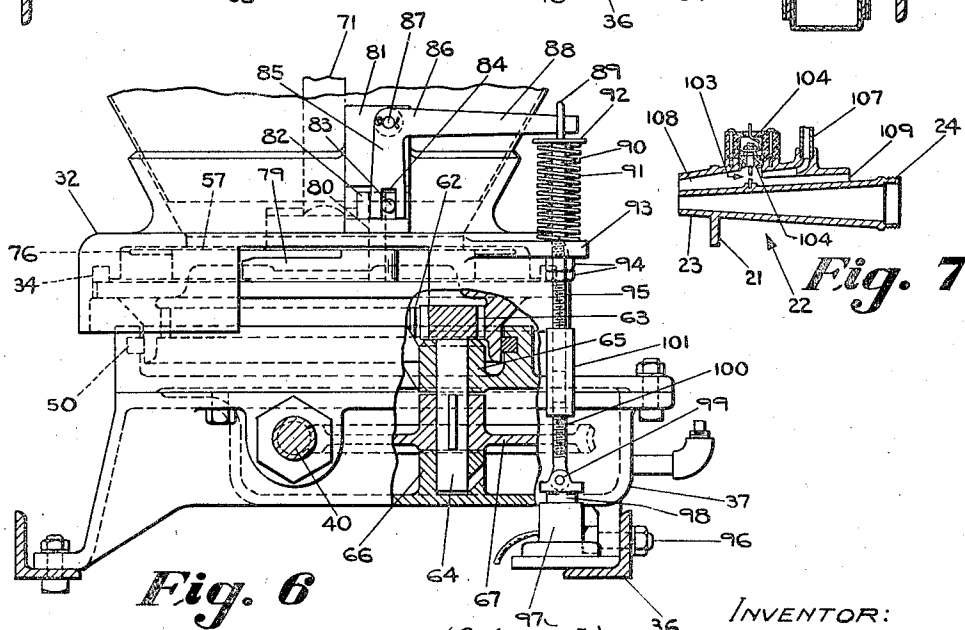
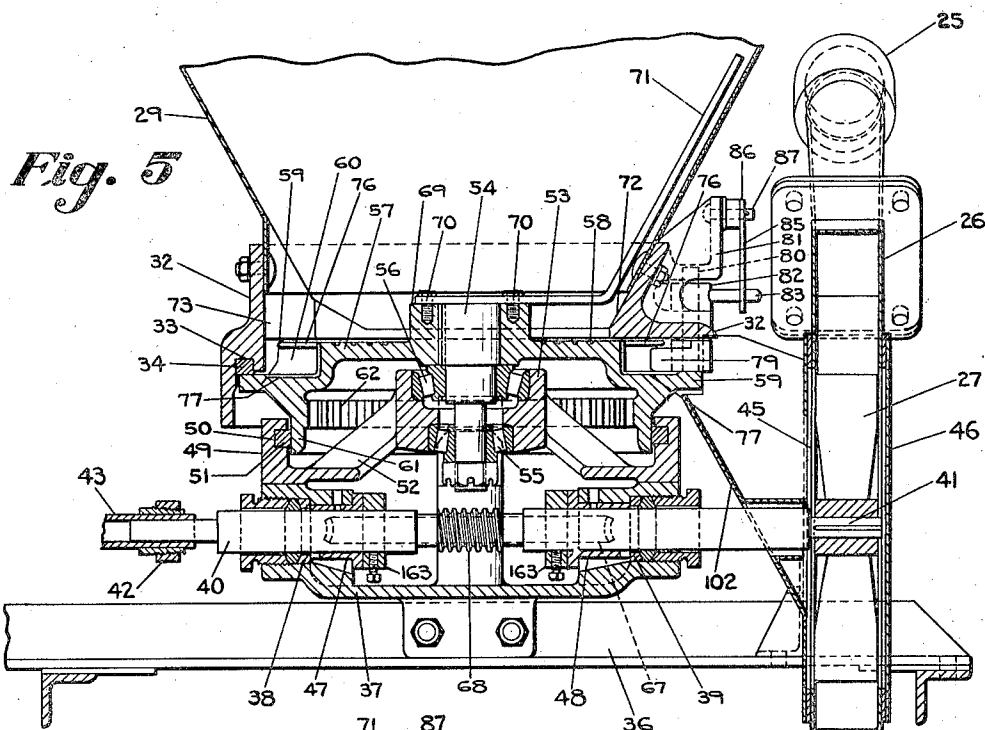
E. V. FRANCIS

2,102,691

AUTOMATIC SYSTEM FOR SUPPLYING PULVERIZED FUEL TO FURNACES

Filed Jan. 18, 1933

4 Sheets-Sheet 2



INVENTOR:
Earle V. Francis,
By
Chas. M. Nissen,
ATTY.

Dec. 21, 1937.

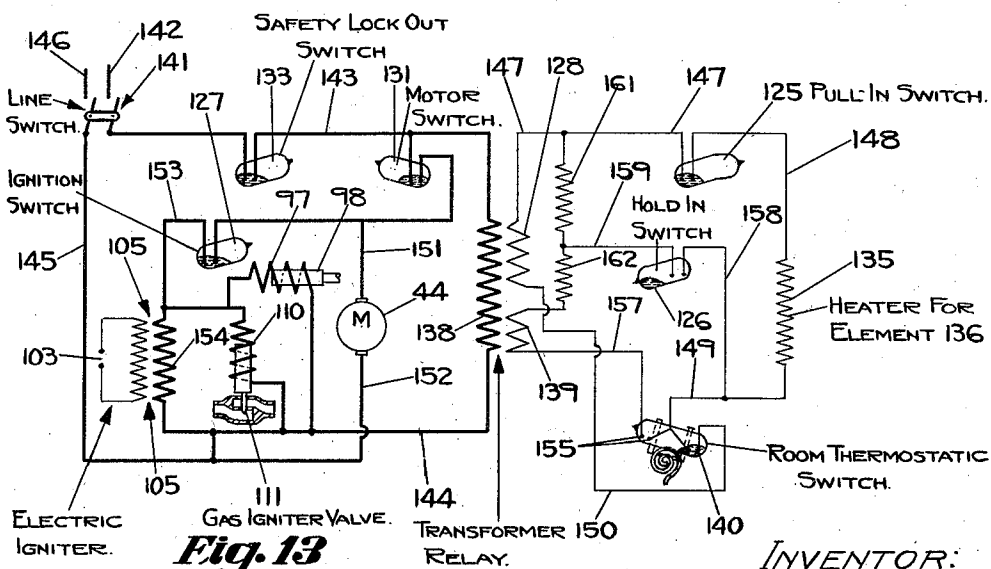
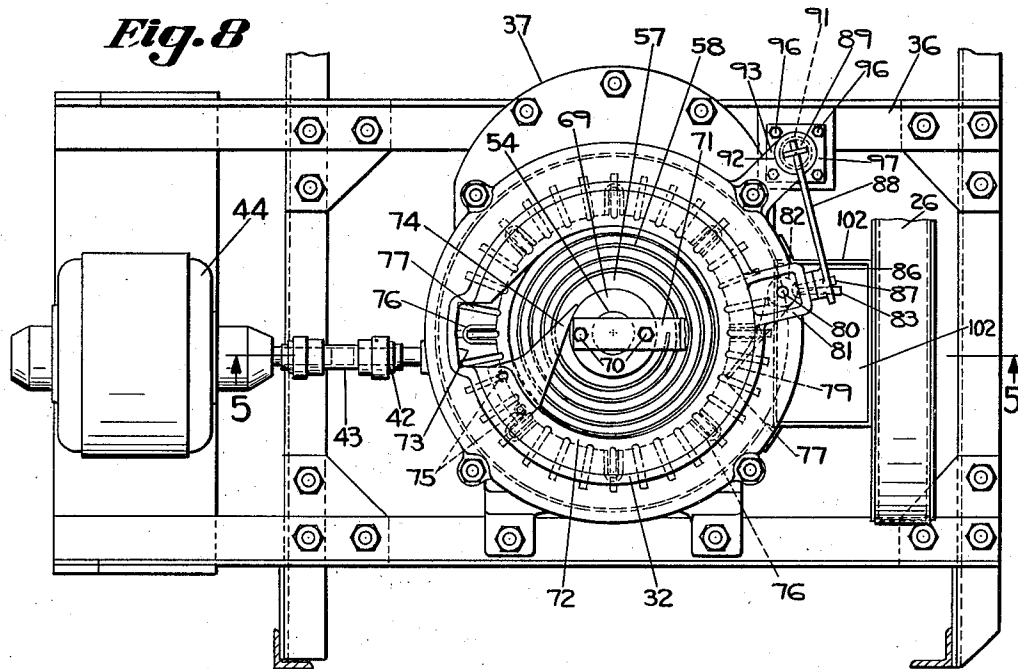
E. V. FRANCIS

2,102,691

AUTOMATIC SYSTEM FOR SUPPLYING PULVERIZED FUEL TO FURNACES

Filed Jan. 18, 1935

4 Sheets-Sheet 3



INVENTOR:
EARLE V. FRANCIS,
BY
Chas. M. Nissen,
ATTY.

Dec. 21, 1937.

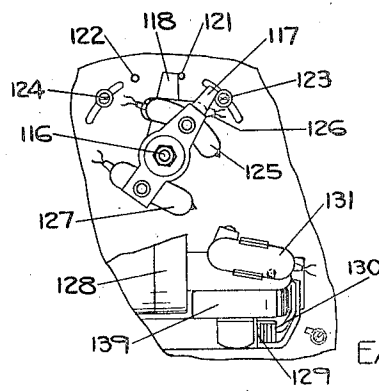
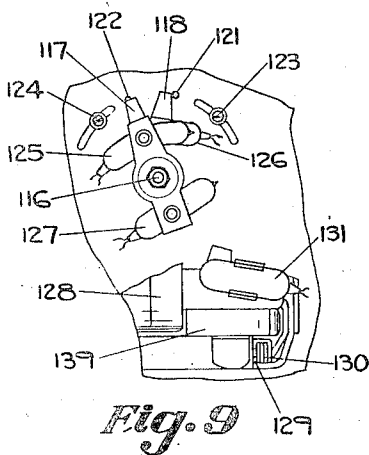
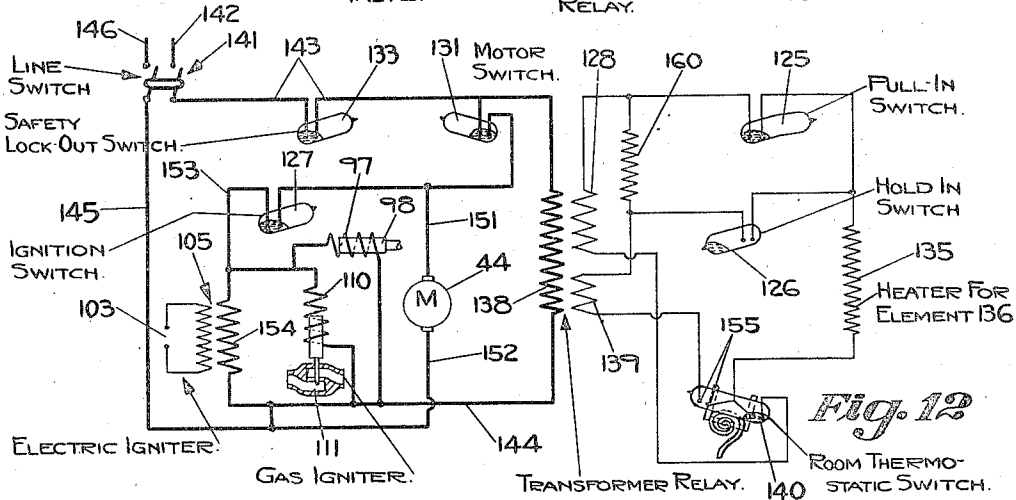
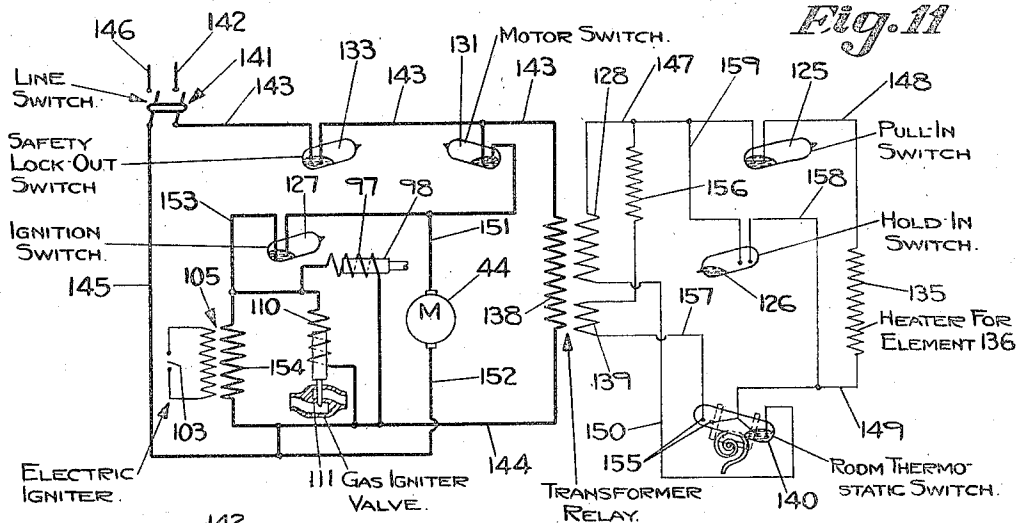
E. V. FRANCIS

2,102,691

AUTOMATIC SYSTEM FOR SUPPLYING PULVERIZED FUEL TO FURNACES

Filed Jan. 18, 1935

4 Sheets-Sheet 4



INVENTOR:
EARLE V. FRANCIS,
BY
Char. M. Nissen,
ATTY

UNITED STATES PATENT OFFICE

2,102,691

AUTOMATIC SYSTEM FOR SUPPLYING PULVERIZED FUEL TO FURNACES

Earle V. Francis, Columbus, Ohio, assignor to
The Jeffrey Manufacturing Company, a corporation of Ohio

Application January 18, 1933, Serial No. 652,347

1 Claim. (Cl. 110—28)

My invention relates to automatic systems for controlling the supply of pulverized coal to furnaces and one of the objects of the invention is the provision of improved and efficient thermostatically controlled apparatus for starting and stopping the operation of a furnace and feeding a mixture of powdered coal and air thereto in accordance with requirements.

Another object of the invention is the provision of improved mechanism and a control therefor for feeding from storage pulverulent material and mixing the same with air for delivery to a furnace for combustion of the material therein.

A further object of the invention is the provision of an improved and efficient system of electrical control of the delivery of fuel to a furnace and rendering safe the operation of the furnace.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claim.

Referring to the accompanying drawings, Fig. 1 is an elevational view with the furnace shown in section, of my improved automatic system for burning pulverized coal;

Fig. 2 is a front elevation of the installation shown in Fig. 1;

Fig. 3 is a sectional elevation of the stack switch mechanism, taken on the line 3—3 of Fig. 4 looking in the direction of the arrows;

Fig. 4 is an elevational view of the stack switch mechanism with the front cover removed;

Fig. 5 is a sectional elevation of the feeding and mixing mechanism shown at the lower right hand portion of Fig. 1, the section being taken along the line 5—5 of Fig. 8 looking in the direction of the arrows;

Fig. 6 is an elevational view partly in section of that portion of Fig. 5 to the left of the fan shaft therein;

Fig. 7 is an enlarged sectional elevation of the burner nozzle for the furnace with the electric ignitor attached thereto;

Fig. 8 is a plan view of the feeding and mixing mechanism shown in Figs. 5 and 6 but with the storage bin removed;

Figs. 9 and 10 are broken away portions of Fig. 4 showing positions of the parts during the starting and running periods respectively;

Fig. 11 shows a wiring diagram of the circuits and connections for the automatic system;

Fig. 12 is a modified wiring diagram embodying an additional safety feature; and

Fig. 13 is another modified wiring diagram embodying another safety feature.

In Fig. 1, 14 designates a furnace of the vertical type and may be either in a hot air heating system, vapor heating system or steam heating system. While my improvements are particularly adapted to be installed in connection with a furnace already in operation for the burning of

coal in the ordinary manner, it should be understood that my system may be permanently or detachably connected to a furnace when initially installed. Upon removal of the ordinary fire door of a previously installed furnace an ignition or preliminary combustion chamber 15 may be placed in the furnace chamber 16 by inserting through the fire door of the furnace a casing 17 which is lined with refractory or fire resisting material 18 and which is provided with an opening at 19 in its bottom to communicate with the furnace chamber 16. The casing 17 is secured to a plate 20 which in turn is secured to the front of the furnace to close the fire door opening therein.

Secured to the front face of the plate 20 by means of the radial flange or plate 21 is a burner nozzle 22 which has its inner end 23 projecting into the auxiliary or preliminary combustion chamber 15. The nozzle 22 is preferably conical as shown in Fig. 7 with its rear end screw threaded at 24 for connection to the pipe 25 which leads to the pipe 26 and casing 46 in which is mounted a blower or fan 27 as shown in Fig. 5.

The powdered fuel such as pulverized coal is adapted to be stored in the large bin or casing 28 the lower end of which is conical or hopper-shaped as shown at 29 in Fig. 1. The upper end of the casing 28 is provided with a filling opening at 30 through which the pulverized coal may be placed in the bin 28 after removal of the cover 31. In order to prevent coal dust from flying about in the furnace room and to protect the persons performing the filling operations a vacuum cleaner may be connected through the suction pipe 164 to the interior of the bin 28 as shown in Fig. 1.

To the lower end of the hopper-shaped portion 29 of the pulverized coal bin 28 is secured a casing 32 which is provided with an annular groove 33 to receive a felt packing 34 shown in Fig. 5, the latter serving to prevent leakage of pulverized coal from the annular portion 59 of plate 57.

The pulverized coal bin 28 may be mounted on spaced vertical standards 35 as shown in Fig. 1 and to the lower end of these standards is secured a base frame 36 on which is mounted the worm gear housing 37 as shown in Fig. 5. Mounted in the bearings 41, 48 is a shaft 40 which is connected at one end 41 to the fan wheel 27. The other end of the shaft 40 is coupled at 42 to the shaft 43 and the latter is connected to the armature of the electric motor 44. Upon rotation of the motor 44 in the proper direction the fan 27 will operate to take a mixture of powdered coal and air through the intake opening 45 of the fan housing 46 and blow such mixture through the pipe 26 into the pipe 25 and thence into and through the nozzle 22 into the preliminary combustion chamber 15. Thrust bearings for the shaft 40 are provided at 47, 48 as shown

in Fig. 5 and associated with such thrust bearings are suitable lubricating openings.

Secured rigidly to the top of the worm gear housing 37 in stationary position is a circular support or ring 49 which is provided with an inner annular groove 50 to receive a felt packing 51. The inner lower portion of the ring 49 carries a spider frame 52 comprising a plurality of arms inclined upwardly and secured at their upper ends to the thrust bearing support 53.

A vertical shaft 54 coaxial with the ring 49 is provided with stepped thrust roller bearings at its lower and intermediate portions. The lower thrust bearing 55 resists movement of the shaft 54 upwardly and the upper thrust bearing 56 resists downward movement of the shaft 54 relative to the bearing support 53 and the parts secured thereto.

Secured to the enlarged upper end of the shaft 54 is a feed plate 57 the upper surface of which is provided with a spiral groove 58 as shown in Figs. 5 and 8. The inner end of the spiral groove is the leading end relative to the direction of rotation of the feed plate 57 and the end of the groove at the periphery of the feed plate 57 is the trailing end so that when the feed plate rotates in an anti-clockwise direction as viewed in Fig. 8 the spiral groove 58 will produce friction between the plate 57 and the powdered coal in the hopper 29 tending to prevent the plate from sliding under a stationary mass of powdered coal. Furthermore, due to the spiral groove, any such sliding will assist in conveying the central portions of the powdered coal on the feed plate 57 to the periphery thereof.

The feed plate 57 has connected to the lower peripheral edge thereof an annular portion 59 the upper peripheral surface of which engages the bottom of the felt packing 34 so as to effectually confine the powdered fuel in the annular passage-way 60 which is below the horizontal plane of the upper surface of the annular portion 59 of said feed plate 57.

Also secured to the feed plate 57 is a depending annular flange 61 the outer surface of which engages the felt packing 51 so that lubricating oil thrown onto the thrust bearings 55, 56 and the annular gear 62 by rotation of the collars 163, 163, will not leak out from the ring 49.

On the interior of the depending annular flange 61 is an annular gear 62 with which meshes a pinion 63 at the upper end of the vertical shaft 64 as shown in Fig. 6. The shaft 64 is mounted to rotate in the bearings 65, 66 and between these bearings the shaft 64 is keyed to a worm gear 67 with which meshes a worm 68 on the shaft 40. It will thus be seen that when the motor 44 shown in Fig. 1 is rotated, power will be transmitted through the worm gearing 68, 67 and the spur gearing 63, 62 to effect rotation of the feed plate 57. Such rotation should be in an anticlockwise direction as viewed in Fig. 8 so that the inner end of the spiral groove 58 will lead and the outer end will trail so as to effectually transfer the powdered fuel without caking to the annular passage-way 60.

The upper central portion of the feed plate 57 is provided with a hub 69 to which is secured at 70, 70 an agitator 71 which has an arm inclined upwardly for travel along a conical path parallel to the inner surface of the conical hopper 29 and adjacent thereto. The agitator 71 co-operates with the grooved feed plate to secure transfer of the powdered fuel from all portions of the bot-

tom of the hopper 29 to the annular passage-way 60.

By referring to Figs. 5 and 8 it will be seen that the inner surface of the casting 32 is conical at 72 in conformance with the inner surface of the hopper 29 except that an opening is provided at 73 for the passage of the pulverized fuel into the annular passage-way 60. The inner lower edge of the surface 72 overlaps the peripheral edge of the feed plate 57 and is located closely adjacent thereto. Also closely adjacent to the upper surface of the feed plate 57 is a pointed triangular deflector 74 secured at 75, 75 to the casting 32 so as to occupy a stationary position and so as to be adapted to deflect pulverized coal from the plate 57 over an area extending from the hub 69 to the opening 73.

In order to assure the pulverulent condition of the material as it passes into the annular passage-way 60 and to break up any lumps thereof, I have provided radial spaced apart loops of wire attached to feed plate 57, as shown at 76, 76 in Figs. 5 and 8. I prefer to locate these wire loops so as to travel closely adjacent to the top of the passage-way 60 formed by the flat annular surface below the conical surface 72 of the casting 32 so that the material will not tend to adhere to such flat annular surface.

As a further assurance that the pulverized coal will not form in lumps or become caked I have provided radial grooves 77, 77 in the upper surface of the feed plate 57.

On that side of the hopper bottom casting 32 diametrically opposite the opening 73 is an adjustable plow 79 mounted in position for the annular flange 59 to slide under the same as shown in Figs. 5 and 8. The plow 79 is secured to a vertical rock shaft 80 mounted in bearings in a bracket 81 on the casting 32. A collar 82 secured to the vertical shaft 80 is provided with an outwardly projecting or radial pin 83 which is adapted to fit into a slot 84 at the lower end of the arm 85 of a bell-crank lever 86 which is pivoted at 87 to the upper end of the bracket 81.

The horizontal arm 88 of the bell-crank lever 86 extends through a loop 89 secured to the upper end of the vertical rod 90. A spring 91 surrounds the rod 90 between the plate 92 which is secured to the upper end of the rod 90, and the shelf 93 which extends laterally from the casting 32. The spring 91 presses upwardly against the plate 92 tending to hold the rod 90 in its uppermost position. The upper limit of the rod 90 may be adjusted by the nuts 94 which are screw threaded on rod 95 secured to the lower end of the rod 90.

On the base frame 36 is mounted by means of the bolts 96 the solenoid 97. A plunger 98 extends downwardly into the solenoid 97 and at 99 to the upper end of the plunger 98 is pivoted a screw threaded rod 100. A connector 101 provided with right handed screw threads is mounted on the screw threaded rods 95, 100. By removing the pivot pin at 99 and turning the screw 100 and reconnecting the pivot pin the position of the plunger 98 may be adjusted relative to the solenoid 97. The screw threaded connections will then serve to lock the plunger 98 at adjusted elevation.

As hereinafter explained more fully, when the furnace is started in operation the solenoid 97 is energized to pull down the plunger 98 which will cause the loop 89 to swing downwardly the arm 88 and consequently the shaft 80 will be rotated to swing the plow 79 in a clockwise di-

rection as viewed in Fig. 8, and thereby cause said plow to effect an initial maximum scooping of the powdered coal from the annular trough 60 into the chute 102 as shown in Figs. 5 and 8.

After the furnace is in running condition the solenoid 97 is de-energized automatically and the spring 91 will move the plow 79 away from the center of the feed plate 57 to a running position. It can readily be seen that by means of the nuts 94 the running position of the plow 79 may be adjusted so as to scoop pre-determined quantities of powdered coal from the trough 60 during each rotation of the feed plate 57.

On top of the nozzle 22 as shown in Fig. 7 is mounted an electric spark gap igniter 103 comprising a lower terminal connected to the metal of the nozzle 22 and an upper terminal mounted in insulating material 104. The terminals of the spark gap igniter 103 are electrically connected to a transformer 105 (Fig. 11) in the ignition box 106 (Fig. 2).

An illuminating gas supply pipe 107 is connected as shown in Fig. 7 to the gas burner nozzle 108 which is preferably in alignment with the air intake port 109. An electromagnet 110 as shown in Fig. 11 is adapted to open and close a valve 111 in the gas pipe 107. A manually operated regulating valve 112 may also be located in the gas supply pipe 107. At the same time that the spark gap igniter 103 is operated the electro-magnet 110 acts to open the valve 111 and therefore during the flow of gas through the nozzle 108 the igniter is operating and air is drawn into the intake port 109.

Extending into the outlet flue 113 of the furnace 14 is an electric stack switch device 114 which is shown in Fig. 4 with its cover removed. This stack switch device comprises a thermostatic element 115 which is in position to receive the heat from the flue gases and thereby rock the shaft 116 to the outer end of which are freely pivoted two mercury switch carrying plates 117, 118. Clutch means including springs 119, 120 are relied on to effect rotating of the carriers 117, 118 with the shaft 116 until the carriers are stopped by means of abutments. The rear carrier 118 is limited in its arcuate movement by striking against the abutments 121, 122 shown in Fig. 4, while the front carrier 117 has a larger arcuate movement and is limited by the adjustable abutments 123, 124.

The rear carrier 118 carries the hold-in mercury switch 126 while the front carrier 117 carries the pull-in mercury switch 125 and the ignition mercury switch 127.

Below the outer end of the rock shaft 116 is mounted an electro-magnet 132 having a winding 128 and adjacent the pole 129 of this electro-magnet is a pivoted armature 130. This armature has mounted thereon a motor mercury switch 131 controlling the motor circuit so that when the armature 130 is attracted to the pole 129 the circuit of the electric motor 44 will be closed.

Pivotally mounted at 132' on the frame of the electro-magnet 132 is a lockout mercury switch 133 held normally in closed position by the tripping device 134. Wound on insulating material is a resistor or electric heater 135 under an expansion element 136 as shown in Fig. 4. When this resistor receives a certain amount of current for a sufficient length of time the tripping device 134 will be operated to release the switch 133 and the latter will be tilted in a clockwise direction as viewed in Fig. 4 to open the supply

circuit. The supply circuit cannot again be energized until the tripping device has been reset manually at 137.

The electro-magnet 132 also comprises two transformers comprising one primary winding 138 and two secondary windings 128 and 139.

The operation of the system will be understood by referring to Figs. 3, 4, and 11. When the furnace is not operating the stack switch device 114 will have its parts located as shown in Fig. 4 with the lockout switch 133 closed, the motor switch 131 open, the pull-in switch 125 closed, the hold-in switch 126 open, and the ignition switch 127 closed. When the room thermostat mercury switch 140 moves to closed position as shown in Fig. 11 current flows through the primary 138 of the transformer of the electro-magnet 132 provided the main line switch 141 is closed. The circuit will be from the main 142, through the switch 141, conductor 143, switch 133, primary 138, conductors 144, 145 to the other supply main 146. The closure of this circuit will furnish sufficient voltage to the secondary 128 to cause sufficient current to flow through the conductor 147, switch 125, conductor 148, resistor 135, conductor 149, thermostat switch 140, and conductor 150, to energize the electro-magnet 132 to cause its armature 130 to tilt the mercury switch 131 to closed position as shown in Fig. 11. It should be particularly noted that in order to enable the electro-magnet to attract the armature 130 and close the switch 131 the pull-in switch 125 must be closed.

Immediately upon the closure of the switch 131 current will be supplied to the motor 44 through the conductors 151, 152 to effect rotation of the feed plate 57 in an anti-clockwise direction as viewed in Fig. 8.

Simultaneously with the starting of the motor 44 the electro-magnet 97 is energized to move the plow 79 toward the center of the feed plate 57 to enable such plow to scoop from the annular passage-way 60 a maximum amount of powdered coal during each rotation of the feed plate 57 and deliver such coal to the chute 102 for delivery to the fan 27 which rotates immediately upon the starting of the motor 44.

Also simultaneously with the starting of the motor 44 the electro-magnet 110 is energized to effect the opening of the valve 111 to effect a flow of gas through the pipe 107 into the nozzle 108 shown in Fig. 7.

By referring to Fig. 11 it will be seen that the ignition switch 127 is located in the conductor 153 and that between the conductor 153 and the conductor 145 is located the primary 154 of the transformer 105 to which the terminals 103 of the spark gap igniter are connected. The closure of the switch 131 by movement of the armature 130 to the pole 129 starts the motor 44, the fan 27 and the feed plate 57, while at the same time the plow 79 is moved toward the center of the feed plate 57, the valve 111 is opened and the electric ignition is operated. Consequently as soon as the mixture of air and powdered fuel is projected from the nozzle 22 it is ignited by the burning gas at the nozzle 108 and the mixture of air and powdered coal starts its combustion in the combustion chamber 15 and completes its combustion in the furnace chamber 16. The intense heat due to the primary combustion is resisted by the lining of the casing 17 and the flame is projected downwardly for wide distribution over the interior walls of the furnace chamber 16.

When the gases flowing through the flue 113 become sufficiently heated the shaft 116 will be rocked to move the inner carrier 118 from the position shown in Fig. 4 to the position shown in Fig. 9, whereupon the hold-in switch 126 will be closed and the motor switch 131, the pull-in switch 125, and the ignition switch 127 remain closed. Fig. 9 represents the positions of the switches 125, 126, 127, and 131 for the starting period. If the stack switch element 115 does not become sufficiently heated within a predetermined period of time to close the hold-in switch 126, say within a minute and a half, the heat generated by the resistor 135 will be sufficient to warp the flexible element 136 and enable the trip device 134 to open the switch 133, whereupon the main supply current through the conductor 143 will be opened thereby cutting off current from the motor 44, the solenoid 110 and the ignition transformer 105. Thereupon the feeding of the fuel will be stopped and the flow of the gas through the nozzle 108 will be cut off. Before the furnace can be restarted the trip device 134 must be manually reset by actuation of the knob 137.

Under normal conditions, however, the hold-in switch 126 will be closed thereby short-circuiting the resistor 135 and preventing further heating thereof. Continued heating of the stack element 115 will rock the shaft 116 to a greater angle to move the carrier 117 to its position shown in Fig. 10 which represents the running positions of the switches 125, 126 and 127 or their positions when the feeder is running after the transient or starting period. When the switches 125 and 127 are moved from their positions shown in Fig. 9 to their positions shown in Fig. 10 they are both opened and consequently the ignition switch 127 will cut off the current from the electro-magnets 97 and 110 and from the primary 154 of the ignition transformer 105. The plow 79 will then be moved by the spring 91 back to its adjusted position where it will operate to scoop the predetermined quantity of powdered coal from the annular passage-way 60 during each rotation of the feed plate 57. The spark gap igniter 103 will be discontinued but the motor 44 will continue to operate the fan 27 and the mixture of air and powdered coal will continue to be delivered for combustion, into the combustion chambers 15 and 16. So long as the thermostatic switch 140 remains in the position shown in Fig. 11 the secondary 128 will continue to act to hold the armature 130 against the pole 129 and therefore hold the motor switch 131 closed.

When the room temperature reaches a predetermined point the thermostatic switch 140 will be tilted to the opposite position from that shown in Fig. 11 to effect closure of the contacts 155. Thereupon the circuit of the secondary winding 128 will be opened and consequently the armature 130 will be released and the switch 131 will be opened which will result in opening the motor circuit and stopping the rotation of the feed plate 57 and the fan 27 automatically.

When the contacts 155 are closed a circuit is completed through the secondary winding 139. The voltage of this secondary winding is relatively low and insufficient to energize the electro-magnet to move the armature 130. The winding 139 therefore acts merely as a transformer secondary and the switch 131 remains open. As soon as the operation of the furnace is discontinued the stack element 115 tends to cool sufficiently to open the hold-in switch 126 and close the pull-in switch 125 and the ignition switch 127.

If, however, due to some abnormal conditions the operation of the thermostatic switch 140 does not stop the operation of the motor and the fan the hold-in switch 126 will remain closed. Consequently upon the closure of the contacts 155 the auxiliary heating resistance 156 will effect tripping of the lockout switch 133. The resistance 156 may be such as to take a longer period of time than is taken by the resistance 135 to effect the opening of the switch 133. The circuit of this safety feature may be traced from the secondary 139 through the conductor 157, contacts 155, conductor 158, hold-in switch 126, conductor 159, and resistance 156 to the other terminal of the secondary 139. If desired the voltage of the secondary 139 may be approximately 20 and that of the secondary 128 approximately 40 and the time for the resistance 135 to act may be 1½ minutes and that for the resistance 156 to act may be 3 minutes.

Under normal conditions of operation the motor 44 will be stopped when the thermostatic switch 140 closes the contacts 155 and the stack element 115 will act to move the parts back to the normal position shown in Fig. 4, whereupon the pull-in switch 125 will be closed, the ignition switch 127 will be closed, and the hold-in switch 126 will be opened. The resistances 156 and 135 will then be in series with each other through the switch 125 and the current through the resistances 135 and 156 will then be insufficient to effect opening of the lock-out switch 133.

In the modification shown in Fig. 12 the same resistance 135 is employed as a safety device for both the starting period and the end of the desired running period. The resistance 160 is an added resistance placed in circuit with the resistance 135 to prevent heating of the latter if the conditions are normal. During normal starting the thermostat closes the circuit from the primary 128 directly through the resistance 135 and if the pull-in switch 125 does not open within a pre-determined period of time, say 1½ minutes, the tripping device 134 will operate to open the lock-out switch 133 thereby requiring manual resetting. If at the end of the intended running period the contacts 155 close and the hold-in switch 126 does not open within a period of about 3 minutes the current from the secondary 139 will heat the resistance 135 sufficiently to effect opening of the lock-out switch 133. If, however, the hold-in switch 126 opens as it should the resistance 160 will be thrown in series with the resistance 135 so as to prevent the latter from becoming sufficiently heated to open the switch 133.

In the modification shown in Fig. 13 the switch 126 is shown in position to deflect current from the heating resistance 135 through the resistance 161. The circuit will then be from the secondary 128 through the conductor 150, switch 140, conductors 149, 158, switch 126, conductor 159, resistance 161 and conductor 147 to the other terminal of the secondary 128. So long as the pull-in switch 125 remains closed the resistance 161 will be in parallel with the resistance 135 and there will be sufficient current by-passed around the resistance 135 to prevent the latter from heating sufficiently to open the lock-out switch 133. When the pull-in switch 125 opens, the circuit from the secondary 128 will be through the resistance 161 alone and such resistance will cut down the current so that the switches 140 and 126 will not be overheated.

When the room thermostat tilts to close the contacts 155 a circuit will be closed from the

low voltage secondary 139 through the conductor 157, contacts 155, conductors 149, 158, switch 126, conductor 159 and resistance 162 to the other terminal of the low voltage secondary 139. The resistance 162 will cut down the current in the circuit secondary to prevent overheating of the contacts 155 and 126. In the same manner the resistance 156 in Fig. 11 may be used to cut down the current in the circuit of the secondary 139 and not be used as an auxiliary heater. However, if desired the resistance 162 in Fig. 13 may be used as an auxiliary heater to effect the opening of the lock-out switch 133 if such abnormal conditions should occur as to unduly prolong the heating of the stack element 115 in the flue 113. Such abnormal condition will unduly prolong the closure of the switch 126 and consequently the heating resistance 162 connected to the low voltage secondary 139 will effect the opening of the lock-out switch 133 after a pre-determined length of time. That is to say, both in the form shown in Fig. 11 and in the modification shown in Fig. 13 auxiliary heating resistances may be employed as safety features so as to operate after a longer interval than taken by the resistance 135 to automatically open the lock-out switch 133 when abnormal conditions of heating unduly prolong the heating of the stack element 115.

It should also be noted that various hook-ups may be employed for the electrical circuit and connections shown in Figs. 11, 12, and 13 without altering the positions of the switches shown in Fig. 4. Various results may be obtained by re-wiring and by use of the auxiliary heating resistances either to effect the opening of the lock-out switch 133 or by serving to protect the switches 126, 155.

While in some furnaces a pulverized fuel burner may be provided without having connected thereto the ignition or preliminary combustion chamber 15, such burner would require continued burning of gas at the gas burner nozzle 108 during the burning of the pulverized fuel so as to assure the continued burning of the latter. That is to say in a thermostatically controlled heating system, certain furnaces may at certain times become so cooled that when started in operation the cooling effect on the flame of burning pulverized coal may be sufficient to cause the same to be extinguished if the gas flame from the nozzle 108 is not maintained. When the preliminary combustion chamber 15 is omitted I therefore prefer to so arrange the electro-magnetic valve structure 110 as to be dependent on the switch 131 alone. This may be done by placing the electro-magnet of this valve structure in the motor circuit direct in the conductor 151, 152 or 145 shown in Fig. 11. Then the gas will continue to burn at the nozzle 108 whenever the pulverized fuel burns at the nozzle 22 and the fuel flame will not be extinguished but will be maintained so long as the motor 44 operates the feeding mechanism and the blower.

However, it is highly desirable to reduce the consumption of the gas and I therefore prefer to include the preliminary combustion chamber 15 so that the gas may be cut off during the running period of the furnace. The refractory lining 18 of the preliminary combustion chamber becomes sufficiently heated during the starting period to act continuously during the running period to maintain the pulverized fuel flame. For instance, such refractory lining may reach a temperature during the running period of approximately

2400° F. so that irrespective of the temperature of the walls of the main furnace chamber 16 the burning of the fuel will be maintained. Furthermore, the preliminary chamber 15 confines the mixture of the pulverized coal and air for ignition to a limited space without preventing gradual expansion from the opening 19 for further and complete combustion in the chamber 16. This arrangement also affords a more uniform distribution of the heat over the walls of the main furnace chamber 16 and eliminates any warping of the furnace walls.

It should also be noted that while the fan 27 is directly connected to the motor 44 the speed of rotation of the feed plate 57 is greatly reduced by reason of the speed reduction gearing 68, 67 and 63, 62. Since the intense heat of the fuel flame maintains the refractory lining 18 heated to a high temperature the pulverized coal may be burned with maximum efficiency and therefore the consumption of the fuel may be reduced to a minimum. For instance, I have found by actual test of a practical heating system such as that disclosed herein, that the feed of the pulverized coal to the fan need be no greater than one cubic foot in a period of twelve hours while burning of the pulverized coal in the furnace is being continuously sustained without the burning of any gas from the pipe 107 and burner nozzle 108 during the running period.

Obviously those skilled in the art may make various changes in the details and arrangement of parts without departing from the spirit and scope of the invention as defined by the claim hereto appended, and I wish, therefore, not to be restricted to the precise construction herein disclosed.

Having thus described and shown an embodiment of my invention, what I desire to secure by Letters Patent of the United States is:

In a furnace system, the combination with a furnace constructed and adapted for domestic operation and having a main combustion chamber, of an ignition chamber within said furnace and within said main combustion chamber, feeding means for supplying pulverized fuel mixed with air to said ignition chamber for initial combustion, said feeding means including a rotating plate, an adjustable non-rotating plow positioned to remove material from said plate, a fan, means directing material removed from said plate to said fan, and means fed by said fan and directing pulverized coal mixed with air to said ignition chamber as aforesaid; electro-magnetic means for adjusting said plow to increase the feeding rate of said feeding means during a flame starting period whereby the ignition chamber becomes sufficiently heated during the flame starting to act continuously during a following running period to maintain combustion of the mixture of pulverized fuel and air, ignition means for igniting said mixture, and automatic thermostatically controlled means constructed and arranged to effect operation of said ignition means, said feeding means and said plow to initiate combustion with the mixture of pulverized coal and air fed at an increased rate during the starting period as aforesaid after which said ignition means and electro-magnetic plow adjusting means are de-energized, and for stopping the operation of said feeding means after a longer period of operation.

EARLE V. FRANCIS.