March 23, 1948. J. A. KREUSER 2,438,407

HEATING PLANT AND FURNACE

Filed April 13, 1944 2 Sheets-Sheet 1

Fig. 1.

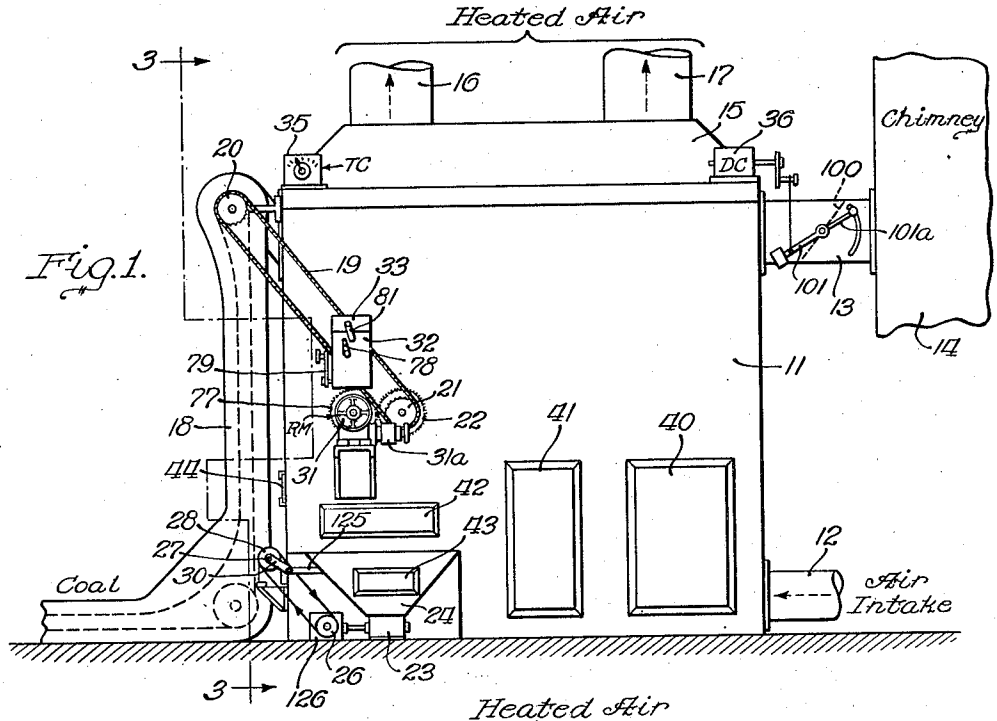
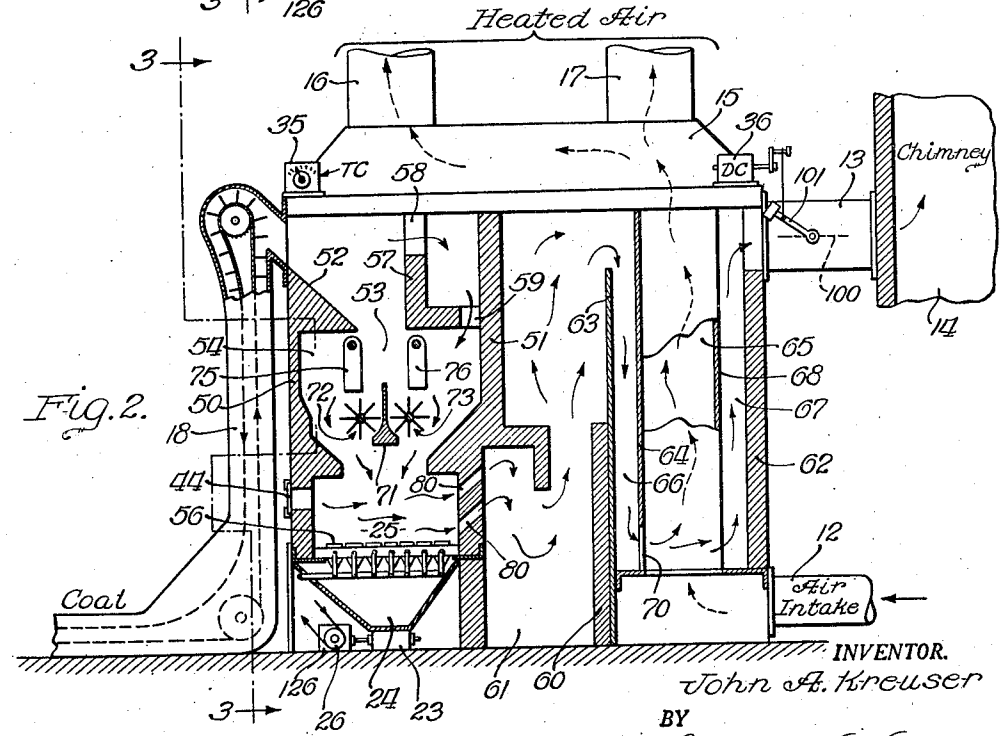


Fig. 2.



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Fig. 3.

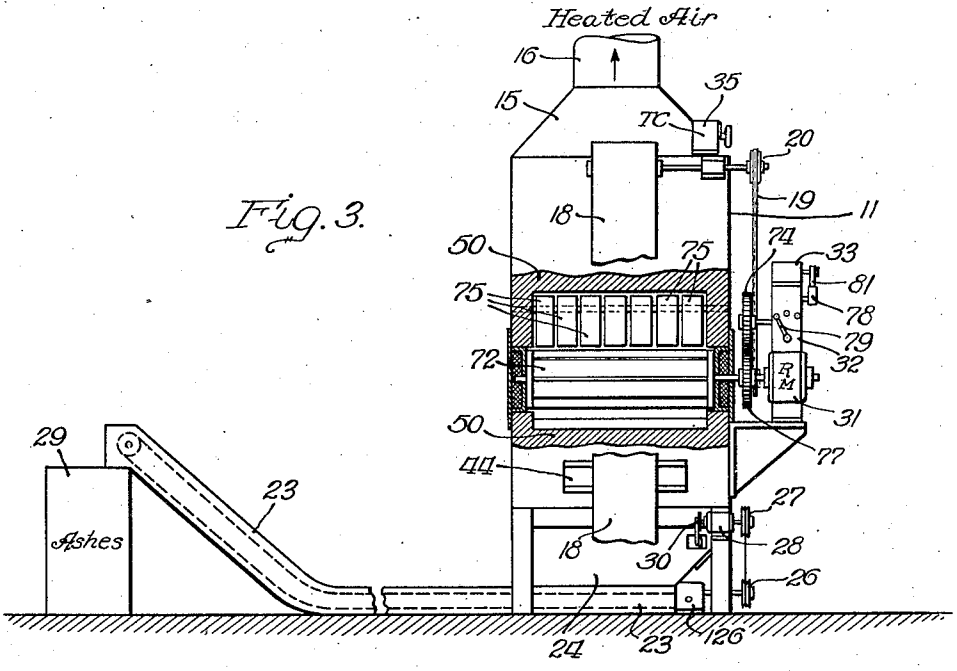
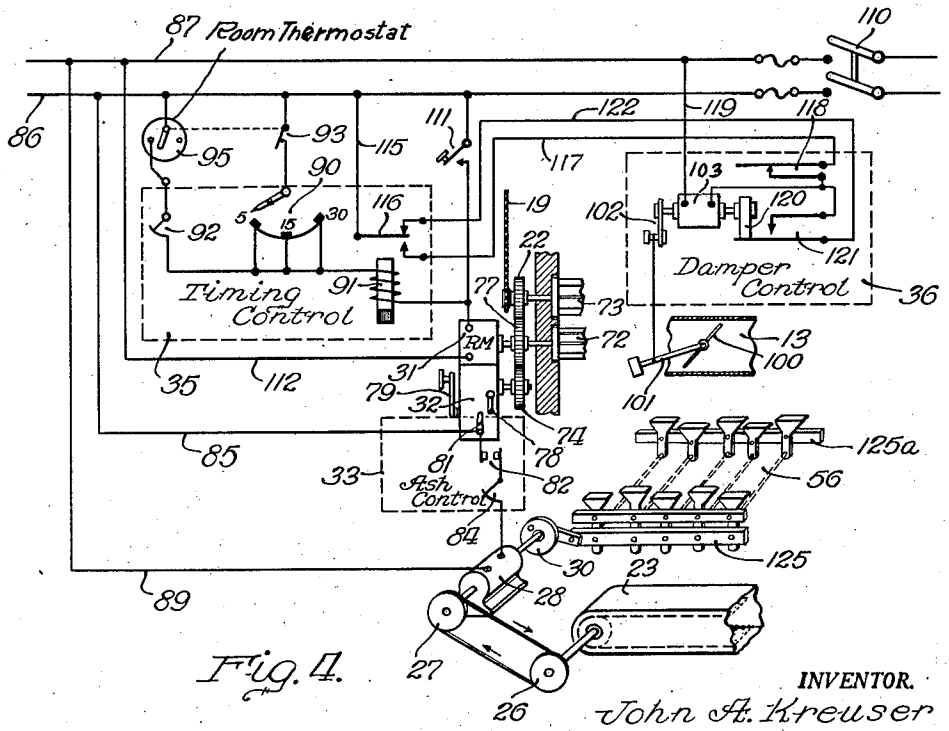


Fig. 4.



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Patented Mar. 23, 1948 2,438,407

UNITED STATES PATENT OFFICE

2,438,407

HEATING PLANT AND FURNACE

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Application April 13, 1944, Serial No. 530,901

22 Claims. (Cl. 110—32)

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This invention relates to heating plants and furnaces, and is particularly concerned with an automatically operated smokeless furnace using a solid fuel.

The principal object of the invention resides in the provision of a furnace having features adapted for any desired plant conditions, but particularly for domestic heating systems including hot air, hot water or steam furnaces, and further adapted to burn solid fuel, such as finely divided coal, substantially without formation of smoke, regardless of the volatile contents of the coal, and substantially without formation of clinkers, regardless of the caking qualities of the coal.

This object is in part realized by the provision of means, in combination with a firebox and a grate, forming a gas producer or generator, including a mechanically operated heat-controlled retort for successively converting amounts of coal into coke and thereupon successively completing the combustion of the resulting amounts of coke on the grate.

The combustible gases originating in the generator or producer incident to the coking of the coal and resulting from the burning of the coke on the grate are conducted through the medium of a mixing device which operates somewhat in the nature of a torch, into a separate combustion chamber forming the principal heat-producing unit of the furnace. The combustion of the volatile contents of the coal is completed in this combustion chamber, thereby substantially avoiding the production of smoke. A plurality of serially related communicating combustion chambers may be provided if desired, each receiving combustible gases through the medium of a mixing device as indicated.

The above intimated arrangement makes it possible to operate the generator, including the retort, and the firebox, at a temperature below the fusion temperature of the ash, thereby preventing the formation of clinkers.

Further objects and features relates to the provision of means for automatically feeding coal to the furnace and removing the ashes from the ash pit thereof.

Additional objects are concerned with the provision of means for timing the coal feed and ash control as well as ash removal operations so as to satisfy variable needs in accordance with the requirements that may result from seasonal changes or from other contingencies that may arise in the effective production of heat.

Means are provided in accordance with certain other objects of the invention for automatically

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controlling the air feed into the firebox, and through the furnace, in timed relation with the operations resulting from the feeding of the coal and combustion thereof, and means for coordinating the coal feed, the ash control and ash removal, including shaking of the grate, and the air feed, so as to obtain entirely automatic and efficient operation of the whole furnace as may be desired or required by operating conditions of any one plant produced in accordance with the invention.

Further objects relate to the provision of a structure forming a unit for heating a desired medium, e. g., air, which operates in the nature of an economizer, whereby the hot gases are conducted around the heating unit in a labyrinth path including the entire heating surface of the unit.

These and other objects and features will be described below in detail with reference to the embodiment of a furnace adapted for domestic air heating purposes as illustrated in the accompanying drawings. In these drawings,

Fig. 1 is a plan frontal view of an example of a furnace made in accordance with the invention;

Fig. 2 represents the furnace Fig. 1 with the front wall removed and some parts broken away so as to show details;

Fig. 3 shows an end view of the furnace with some parts in section, taken approximately along lines 3—3 of Fig. 2; and

Fig. 4 is a schematic operation and wiring diagram showing essential parts of the furnace and means for obtaining the automatic control of individual functions and the coordination thereof for the purpose of forming an automatically harmoniously operating unit.

Like parts are designated by like reference numerals throughout the drawings. Elements and details which may be presumed to be well known will be discussed only to the extent required for conveying an understanding of what is believed to be new.

The illustrated furnace has a housing comprising a front wall 11, an air intake 12 which may be provided with or may connect with a suitable air intake control fan, a damper or exhaust duct 13 leading to a chimney 14, and a distributor hood 15 provided with ducts 16, 17 for distributing the heated air as may be desired. Coal from a suitable bin is fed to the furnace by means of a conveyor contained in a casing 18. The conveyor is operated by a chain 19 engaging a driven sprocket 20 and a drive sprocket 21 on a shaft which also carries a gear wheel 22.

An ash removal conveyor 23 is provided underneath the ash pit 24 of the firebox 25. This conveyor is operated by means of a drive including a driven pulley 26 and a drive pulley 27 actuated by the motor 28, and deposits the ashes in a suitable receptacle 29. The motor 28 also operates a crank 30 for shaking the grate in the firebox. A gear box 126 may be provided between the pulley 26 and the conveyor 23, as shown in Figs. 1–3.

On the front wall of the furnace are mounted certain control means including the retort motor RM, also indicated by numeral 31, the gear box 32, and the control device 33. The motor 31 may be provided with a gear reducer indicated in Fig. 1 at 31*a*. These devices control the coal feed, the retort which will be presently described, and the operation of the motor 28 which in turn governs the grate-shaking crank 30 and the ash removal conveyor 33. On top of the structure, as seen from the front in Fig. 1, is provided the timing control device TC, also indicated by numeral 35, and a damper control device DC, also numbered 36. The timing control is adapted for setting or adjusting the frequency of operation of the coal feed coordinated with the frequency of operation of the retort motor, and the damper control governs the automatic actuation of the air supply in coordination with the needs of the furnace as determined by the coal feed and by the actuation of the retort motor. A lever 101*a* is provided for manual control of the damper as shown in Fig. 1.

Numerals 40, 41 in Fig. 1 indicate cleaning doors through which access may be gained to certain interior sections of the furnace. Numeral 42 denotes the fire door; 43 the ash pit door; and 44 the air intake for the firebox. The air intake may be provided with manually adjustable slots or openings.

The furnace, as particularly shown in Fig. 2, is provided with a transverse end wall 50 forming with the transverse intermediate wall 51 the frontal section comprising the inclined coal feed 52, the retort 53, the generator or producer section 54, and the firebox 25 which is equipped with a suitable grate 56 disposed above the ash pit 24. Predetermined periodically supplied amounts of coal are successively converted into coke in the retort 53, and these amounts of coke are periodically fed to the firebox for complete combustion of the combusible solid constituents of the fuel.

An angular transverse wall partition 57 forms ducts 58 and 59, for conducting downwardly traces of gases which enter the feed and the generator retort section to mix with gases produced in the firebox above the grate 56 for passage through the openings 80. The lower section of the transverse wall 51 forms with the partition 60 a combustion chamber 61 which receives for complete combustion, of the volatile contents of the coal, the gases produced in the coking of the coal in the retort section 53, and in the burning of the coke on the grate 56. The gases are conducted into the combustion chamber 61 through the openings 80 in the lower portion of the wall 51. These openings operate in the manner of torches, ejecting the hot gases for complete combustion into the combustion chamber 61. The duct 59 permits the traces of gases which enter the upper region of the feed and retort section to mix with the gases from the retort and from the grate to find their way to the passages 80 because these are the only passages under suction

from the chimney. A single combustion chamber is shown. It is understood, however, as previously mentioned, that a plurality of combustion chambers may be provided, each receiving gases through a mixing device including gas inlets or jet openings such as indicated at 80.

An end wall 62 closes the structure at the right, as seen in Fig. 2. The walls 50—51, 60—62 and the partition 57 may be made of heat-resisting material of the type usually employed in furnace structures.

A shield 63 projects from the partition wall 60 and forms with one wall 64 of the air duct 65 a transverse space 66 for receiving the hot gases coming from the combustion chamber 61 in the direction indicated by the full-line arrows. The wall 64 extends transversely through the furnace structure. The hot gases are thus conducted downwardly through the space 66, washing the surface of the wall 64 of the air duct. They are then directed through openings 70, provided on opposite sides in the wall 64 at the bottom thereof, into the space 67 formed by the wall 68 of the air duct and by the end wall 62 of the furnace, and into like spaces formed by front and rear walls of the air duct 65. The gases escape through the damper or exhaust duct 13 into the chimney 14.

The arrangement including the air duct 65 and the walls 60, 63 and 62 operates in the nature of an economizer. The air duct 65 forms a centrally positioned chimney-like structure within the space formed by the front and rear walls, and by the walls 60, 63, 62, and the hot gases wash the outer surface of this air duct on all sides moving first downwardly along one side wall (64) and then upwardly around the remaining three side walls, for escape through the exhaust or damper duct 13. Air entering through the intake 12 and moving through the air duct 65 in the direction of the dotted arrows is thus effectively heated.

It is deemed desirable to mention at this point that the furnace is shown as an air-heating unit only for the purpose of convenience and to give an example of how the invention may be used in practice. The structure may be adapted for water-heating, steam-producing, and like purposes.

Inside of the generator or producer chamber 54, disposed between the walls 50 and 51, is a transverse partition 71. On each side of this partition is a rotatable shaft having vanes in the manner of a star wheel and forming on each shaft eight pockets, each pocket occupying a sector of 45°. These two retort rotor members are indicated by numerals 72 and 73. They constitute movable supporting means for receiving amounts of coal for coking or de-gasing.

The star wheels or rotors 72, 73 are mounted in the furnace walls, as particularly indicated in Fig. 3. One of the rotors, namely, the one indicated in Fig. 2 at 72, is directly rotatable by the motor 31 (RM), the shaft also carrying a gear wheel 77 indicated in Figs. 1 and 3. The latter gear wheel meshes with the gear wheel 22, thereby rotating the shaft of the other rotor 73. The direction of rotation is indicated in Fig. 2 by arrows. The operation, as will be presently described, is such that the rotors 72, 73 are always rotated through an arc sufficient to allow emptying of one pocket of each wheel downwardly into the firebox. Two of the buckets of each rotor, that is, two of its segment-shaped sections, are filled with coal from the conveyor contained in

the housing 18 over the coal feed inclined hopper surface 52. Rotation of the rotors 72, 73 also causes rotation of the drive sprocket 21 and consequently of sprocket 20 connected therewith by the chain 19, for the purpose of feeding to the furnace an amount of coal to compensate for the amount of coked coal permitted to drop into the firebox.

Baffles such as 75 and 76 are provided above the star wheels or rotors 72, 73, a row of such baffles on each side, and the baffles in each row are movably mounted on a shaft secured in the side walls of the structure as shown in Fig. 3. The purpose of these baffles is to confine coal feed to the retort, i. e., the structure above the rotors, but in a non-rigid manner to permit equalization required by unavoidable shifting and packing of the coal. The baffles may be made of suitable stone or ceramic material.

The coal is fed into the retort 53 between the baffles 75 and 76, dropping into the buckets formed by the corresponding upper sectors of the rotors 72 and 73. Heat radiating upwardly from the firebox causes coking of the coal in these pockets, and these pockets therefore may be considered part of a retort and a generator or producer. Whenever the rotors 72 and 73 are rotated as described, two pockets, i. e., one pocket or sector of each rotor, will empty the coked coal downwardly into the firebox where the coke is burned on the grate to obtain complete combustion of the combustible solid constituents of the coal. The rotation of the rotors is periodic and the angular displacement thereof always amounts to 45°, or one-eighth of a revolution of each rotor.

The gear wheel 77 operated by the retort motor 31 meshes with a gear wheel 74 (see Figs. 3 and 4) mounted on a shaft extending from the gear box 32 disposed above the retort motor, as shown in Figs. 1 and 3. In Fig. 4, the arrangement of the gear box 32 and its gear wheel 77 is reversed with respect to the retort motor 31. This, however, is done merely for the sake of convenient schematic representation.

The gear box 32 contains known gear means adapted to drive a trip lever 78 in a desired ratio with respect to the speed of the gear wheel 77, which ratio is adjustable by means of a lever 79. It is thus possible to rotate the trip lever 78 once for a given selected number of rotations of the gear wheel 77, i. e., once for a selected number of revolutions of the shaft of the retort motor 31 or, conversely, once for a selected number of operations of the rotors 72, 73 by the retort motor 31. For example, the device may be adjusted so as to obtain one revolution of the trip lever 78 to every thirty-six operations of the rotors 72, 73. It is assumed in such case that the retort motor is adjusted to produce ½ R. P. M. and that it is operated every five minutes to rotate the star wheels 72, 73 by 45° or one-eighth of a turn, which would result in placing the trip lever 78 once in every three hours in operative position with respect to the trip arm 81.

The coaction of trip lever 78 actuated by the gear box device 32 with the trip arm 81 governs the frequency of operation of the ash control, that is, the shaking of the grate 56 as well as the actuation of the ash removal conveyor 23. When the arm 81 is operated it closes the contact 82 shown in Fig. 4 and thereby completes a circuit for the motor 28 over a timing switch 84, the circuit including the conductor 85 from one pole 86 of a current source and back to the other pole 87 by way of the conductor 89. The timing switch 84 permits operation of the motor 28 for a definite adjustable time interval, for example, for the same time interval of fifteen seconds for which the retort motor is operated to rotate the retort rotors 72, 73. The manner in which the ash control functions is apparent from Fig. 4 and will be presently described more in detail.

The timing control device 35, as shown in Fig. 4, includes the adjustable time switch 90, a relay 91, and the contact switch and timing provisions 92 and 93. The time switch may be set to actuate the retort motor once at definite intervals, for example, once in five minutes, once in fifteen minutes, or once in thirty minutes, and in each case for definite duration, e. g., fifteen seconds. The retort motor which may be set at ½ R. P. M. will make upon each actuation one-eighth of a turn and will empty the two buckets or sectors of coke into the firebox. Operation once in every five minutes may be adjusted for very cold weather; once every fifteen minutes may be sufficient for medium cold weather; and once every thirty minutes may be satisfactory in mild weather. These data are not intended to indicate absolute values; they are noted for explanatory purposes.

The operation of the retort motor 31 may also be initiated independently of the timing control device 35 by a thermostat 95. The timing device 90 will be disconnected, in a manner to be presently explained, whenever the thermostat takes over the control.

The damper in the exhaust duct 13 comprises a simple valve indicated by numeral 100. This valve may be manually set by means of the hand lever 101*a*; it is normally held in nearly closed position, as shown in Figs. 1 and 4, by means of a weighted lever 101. This lever may be raised for placing the valve in open position, as shown in Fig. 2, by means of a crank operable by a motor 103 which is operated whenever the retort motor 31 is actuated, and automatically opens the valve 100.

It will thus be seen that air is supplied to the firebox in throttled manner during the burning of coke on the grate, but that air supply is increased for a time interval subsequent to the operation of the retort motor 31. The damper motor 103 stops when the crank 102 has made a 180° turn and starts again, after the stopping of the retort motor, to close the valve 100 slowly, whereupon it is disconnected after the valve is put again into the normal partially throttled position shown in Figs. 1 and 4. This damper control admits a greater amount of air to the combustion chambers during the period of intense gas-producing, that is, during and shortly after the time when coke is fed from the retort into the firebox for burning on the grate therein.

The operation will now be described with particular reference to Figs. 2 and 4.

It will be assumed first that the furnace is to be started, as would be the case upon completing installation thereof. The fire in the firebox 25 is prepared in the usual way by piling up fuel on the grate and igniting it. This is done through the door 42 (Fig. 1) of the firebox. The ash pit door 43 is open. The damper valve 100 in the exhaust or damper duct 13 is manually placed in open position by operating and suitably locking the lever 101*a*. For the time being the airport door 44 remains in closed position. The draft resulting upwardly through the grate and thence through the mixer ports 80, combustion chamber 61, and through the channels of the economizer

heater unit and the damper duct into the chimney, is self-explanatory.

After the fire has been started, the switch 110 of the main circuit shown in Fig. 4 may be closed to prepare for the automatic operation of the furnace. Coal must now be supplied to the retort 53, that is to say, to the buckets formed by the upwardly and inwardly directed sectors of the retort rotors 72 and 73. For this purpose the switch 111 is manually closed so as to start the retort motor 31 from the pole 86 of the main line by way of switch 111, retort motor 31, and conductor 112, back to the pole 87 of the main line.

The retort motor, having been set for ½ R. P. M., operates, rotates the rotors 72 and 73, and also operates the coal conveyer in the housing 18 by way of the chain 19. An amount of coal is thus supplied to the retort 53. The switch 111 is then opened and the retort motor stops.

The timing control device 35 is now set to the desired operation, which will depend on weather conditions. It is assumed, for the purpose of explanation, that the furnace is to be set for very cold weather in which fuel is to be supplied for combustion at intervals of five minutes. The timing control 35 is set for five-minute operation, in which position it will supply current to the retort motor 31 for fifteen seconds every five minutes, to rotate the retort rotors in each period of operation by 45°, or one-eighth of a turn in the direction of the arrows shown in Fig. 2. Accordingly, during such periodic operation the retort rotors 72 and 73 will empty the fuel disposed in one bucket or sector of each rotor downwardly into the firebox 25.

It is further assumed that for this operation it will be necessary to remove the ashes every two hours by shaking the grate 56 and simultaneously operating the ash removal conveyor 23. The gear device 32 is for this purpose adjusted by means of the lever 79 for a gear ratio of 3 to 1; that is to say, whenever the retort motor 31 makes one revolution; the trip lever 78 will make one-third of a revolution. The trip lever 78 will therefore engage and trip the trip contact lever 81 of the ash control device 33 once every two hours. The duration of operation of the motor 28 which controls the grate-shaking and the operation of the ash removal conveyor 23 may be set by means of a switch 84 indicated in Fig. 4.

The damper valve 100 is put in normal position in which it is shown in Figs. 1 and 4, by releasing the manual control 101*a*, which was actuated upon starting the fire. The ash pit door 43 is closed and the fire door 42 is likewise closed. The door 44 controlling the airports in front of the firebox is now opened. The size of the opening may be manually adjustable in the usual manner. The draft through the furnace diminishes and is now entirely through the firebox above the fire on the grate 56. The furnace is now set for automatic operation and this condition will continue throughout such operation.

Two upwardly and inwardly directed sectors or buckets of the retort rotors 72 and 73 are filled with coal. The hot gases developing in the firebox 25 and radiating upwardly into the producer or generator chamber cause a coking of the coal in the buckets or sectors of the retort rotors.

The temperature in the firebox is kept below the fusion point of the ashes, due to the cold air current from the airports controlled by the door 44 sweeping through the firebox above the fuel on the grate in the direction of the full-line arrows.

The combustible gases developing in the retort incident to the coking of the coal and the gases developing in the firebox incident to burning of the coke, are collected, mixed, and escape through the mixer ports 80 into the combustion chamber 61 where they are subjected to complete combustion. The highest temperature in the furnace therefore develops in the combustion chamber 61.

During the automatic operation, a circuit will be closed every five minutes, for fifteen seconds duration, for the retort motor 31 (which is set for ½ R. P. M.), from the pole 86 of the main circuit over contact 93, timing device 90, slow-release relay 91, retort motor 31, and conductor 112, back to pole 87 of the main circuit. The retort motor operates as already described and rotates the retort rotors 72, 73 for fifteen seconds so as to obtain a 45° rotation or angular displacement of the fuel-supporting device, which is equivalent to one-eighth of a turn of each retort rotor. During this operation the coked coal in two buckets of the retort rotors drops down into the firebox.

During and slightly after completion of this phase of operation it is desirable to increase the draft of air through the furnace for the purpose of promoting the combustion of the amount of coke supplied to the grate. This is done automatically as follows:

Whenever the slow-release relay 91 is energized (upon starting the fifteen-second periodic operation of the retort motor 31), it closes a circuit for the damper control motor 103, from the pole 86 of the main circuit by way of conductor 115, contact 116 of the relay 91 in operated position, conductor 117, closed contacts 118 of the damper control device, motor 103, and conductor 119, back to the other pole 87 of the main circuit. The damper control motor 103 operates slowly, turning its crank 102 and thereby lifting the weighted lever 101 to displace the damper valve 100 gradually into its open position, as illustrated in Fig. 2. This operation may consume a longer period than the fifteen-second period of operation of the retort motor 31. For this purpose the relay 91 is slow-releasing, as indicated, and maintains the circuit over contact 116 after the retort motor 31 has stopped at the end of the fifteen-second operating period.

The damper control motor 103 is also equipped with a cam 120 which, in the position shown, maintains open the contact 121. The contact 121 is closed shortly after starting operation of the motor 103 to rotate the crank 102. No result is obtained at this time by the closing of contact 121 because the circuit extending from this contact by way of conductor 122 is open at the normally closed contact 116 of the slow-release relay 91 which is now in operated position due to energization of relay 91 in series with the motor 31. The operation of the damper control motor 103 therefore continues. Upon displacing the crank 102 by 180° the damper control motor 103 stops because its circuit is interrupted at contact 118 by the cam 120 which also has been displaced by 180°. The maximum amount of air is now supplied to the firebox through the airports in the door 44 for burning the amount of coke dropped onto the grate by the operation of the retort rotors 72 and 73.

The slow-release relay 91 deenergizes after a while and places contact 116 into the normal position shown in Fig. 4. A circuit is thereby closed for the damper control motor 103 which

extends from the pole 86 of the main line by way of conductor 115, contact 116 in normal position, conductor 122, now closed contact 121, motor 103, back to the pole 87 of the main line by way of conductor 119. The damper control motor therefore rotates again and slowly places the damper valve 100 into the nearly closed position in which it is shown. When the cam 120 reaches its normal position incident to rotation of the damper control motor 103, it interrupts the operating circuit of the motor by opening contact 121. The damper valve is again in its nearly closed position. The air draft through the firebox is again throttled to a predetermined low which is sufficient for further combustion of the coke, as explained before.

The above described operation is repeated every five minutes for a predetermined adjustable period which may be, for example, two hours. At that time the gear device 32 has advanced trip lever 78 into engagement with the trip control lever 81 of the ash control device 33. When the trip control lever 81 is actuated, it operates the contacts 82 and thereby closes a circuit for the motor 28 which extends from the pole 86 of the main line by way of conductor 85, contacts 82, and the timing device 84 through the motor and back to the other pole 87 of the main line by way of conductor 89. The device 84 is a timing means which may be set to maintain the circuit for a desired period, for example, fifteen seconds, in accordance with the setting of the operation of the retort rotors 72, 73. Accordingly, motor 28 will operate for fifteen seconds and rotate its crank 30, thereby rocking the rocker bar 125 provided with rods which are in pivotal engagement with the individual grate members to rock these members so as to remove the ashes from the grate and drop the ashes down into the ash pit 24.

At the same time, the drive pulley 27 is operated by the motor 28, thereby rotating the driven pulley 26 to advance the ash removal conveyor 23, which removes the accumulated ashes from the ash pit.

In Figs. 1, 2 and 3, the pulley 26 is shown connected to a gear device 126 which in turn operates the conveyer 23. This gear device is shown in these figures only for the sake of convenient representation, the motor 28 being shown mounted at the foot of the end wall 50. The motor may be mounted alongside the furnace housing, e. g., at the foot of the front wall 11, and in that case the gear 126 is not required. The operation is direct, as shown in Fig. 4.

The correct ratio between the number of ash-removing periods and the number of retort turns will always be determined by the type of coal delivered to the coal bin, that is to say, by the amount of ashes that will remain after combustion of any one type of coal. The setting of the gear ratio in the gear device 32 therefore will have to be determined usually once in a heating season in accordance with experience data which may be furnished by the manufacturer of the furnace. The ash-removing frequency may be set, as above described, once for two hours, or different periods once in three, four or five hours, or portions thereof, as may be necessary. The duration of operation in each period may be determined by the switch 84.

In addition to the automatic control provided by the timing control device 35, I have provided a thermostatic control 95 which is dependent on a mean temperature desired at a designated place which may be, e. g., remote from the furnace. Whenever the thermostatic control is made operative, which may be done by a manually controlled switch (not shown), and the temperature changes at the designated point from a desired mean, the control is taken over by the thermostatic device 95. Upon operation either to high or to low position, the thermostatic device 95 first opens the contact 93 and thus disconnects the normally operative timing device 90.

This operation takes place, e. g., when the thermostatic device responds to an increase of temperature beyond the desired mean. In this case the movable contact of the thermostatic device 95, as shown in the drawing, would be displaced in counter-clockwise direction. The operation has no effect except that further periodic feeding of coal to the furnace and further coincident periodic feeding of coke from the retort to the firebox is discontinued, due to the opening of contact 93. As soon as the temperature drops to the desired mean, the thermostatic device again closes contact 93 and the periodic automatic operation continues as described before.

If the thermostatic device 95 is affected by a drop in temperature, this will indicate that feeding of larger amounts of fuel to the furnace is desired, e. g., by increasing the frequency of operation of the retort motor 31. In such case the thermostatic device 95 again disconnects the normal timing control 90, at contact 93, and closes an alternate circuit over the timing device 92, which may be adjusted for a desired increased rate of periodic feed control. The circuit for the retort motor will now be periodically closed at a more rapid predetermined rate by the timing device 92. All other operations will proceed as previously described except, of course, that the initial control circuit over relay 91 is controlled from the timing device 92 instead of from the timing device 90.

The device 92 may be set to increase the frequency of operation of the furnace, for example, from one fifteen-second operation every five minutes to one such operation every three or four minutes, or it may be adjusted to increase the duration of each period, e. g., from fifteen to thirty seconds. In the latter case, twice the amount of fuel would be supplied for combustion to compensate quickly for the drop in temperature.

As soon as the desired mean temperature is restored, the thermostatic control 95 restores the normal operation by opening the circuit over the timing device 92, and also restores the control over the normally operative timing device 90 by again closing the contact 93.

Changes may be made within the scope and spirit of the appended claims in which I have defined what I believe to be new and desire to have protected by Letters Patent of the United States.

I claim:

1. A furnace of the class described having a housing comprising front and rear walls, an end wall extending transversely of said front and rear walls at one end thereof, an intermediate wall extending transversely between said front and rear walls in spaced relation to said end wall generally in parallel therewith and forming with said end wall a generally vertically extending principal passage; projections extending inwardly of said passage from opposite sides of said end wall and said intermediate wall, respectively, and defining in said passage (a) a bottom cham-

ber forming a firebox, (b) a retort chamber above said firebox, and (c) a feed chamber above said retort chamber; a rotatable member in said retort chamber having vanes forming pockets for receiving from said feed chamber a solid fuel which is substantially converted into coke by the heat radiating upwardly into said retort chamber from said firebox; a motor for actuating said rotatable member so as to feed said coke downwardly from said retort chamber into said firebox for burning on a grate therein; partition means disposed transversely of said front and rear walls and extending upwardly from the top projection on said intermediate wall forming with such projection and with the inside of said intermediate wall a space within said principal passage above said retort chamber for receiving combustible gases moving upwardly therefrom; said gases moving from said space through an opening formed in said top projection on said intermediate wall downwardly within said principal passage generally along the intermediate wall for intermixture with and for escape together with combustible gases developed in said firebox through ducts formed in said intermediate wall substantially at the horizontal level of said firebox; and a third transverse wall extending between said front and rear walls in spaced relation to said intermediate wall forming a combustion chamber for receiving the mixture of combustible gases for complete combustion therein.

2. The structure defined in claim 1, together with means for periodically actuating said motor for the purpose of rotating said rotatable member to release from the pockets formed by the vanes thereon the coke contained in such pockets for burning on the grate in said firebox.

3. The structure defined in claim 1, together with feed means for supplying to said feed chamber solid fuel for deposit in and for coking in the pockets formed by the vanes on said rotatable member in said retort chamber, means for periodically actuating said motor for the purpose of rotating said member to release from said pockets the coke contained therein for burning on the grate in said firebox, and means governed by said motor upon each periodic actuation thereof for operating said feed means to supply an amount of solid fuel for deposit in and for coking in the pockets of said rotatable member which amount corresponds substantially to the amount of coked fuel released therefrom into said firebox.

4. The structure defined in claim 1, together with variably adjustable timing means for actuating said motor periodically for the purpose of rotating said rotatable member to release from the pockets formed by the vanes thereon the coke contained in such pockets for burning on the grate in said firebox, an ash pit for receiving the ashes from said firebox, a conveyor for removing the ashes from the ash pit, a motor for operating said conveyor, and means governed by the first-named motor, which actuates said rotatable member, in variably adjustable timed relation therewith, for periodically operating said conveyor-operating motor.

5. The structure defined in claim 1, together with a variably adjustable timing device for actuating said motor periodically for the purpose of rotating said rotatable member to release periodically from the pockets formed by the vanes thereon predetermined amounts of coke contained in such pockets for burning on the grate in said firebox, one of the walls of the furnace housing having air ports formed therein on a horizontal level which extends above the grate in said firebox for admitting air thereinto, means forming a duct for withdrawing from said furnace exhaust gases, a valve in said duct, means for normally maintaining said valve in relatively throttled position, whereby a relatively small amount of air is normally drawn from said air ports through said firebox above the fuel burning on the grate therein, means for operating said valve, and means governed by said timing device for periodically actuating said valve-operating means for the purpose of opening said valve to permit increased amounts of air to be drawn through said firebox during periods of operative actuation of said motor and consequent release of amounts of coke into said firebox.

6. The structure defined in claim 1, together with a variably adjustable timing device for actuating said motor periodically for the purpose of rotating said rotatable member to release periodically from the pockets formed by the vanes thereon predetermined amounts of coke contained in such pockets for burning on the grate in said firebox, one of the walls of the furnace housing having air ports formed therein on a horizontal level extending above the grate in such firebox for admitting air thereinto, means forming a duct for withdrawing from said furnace exhaust gases, a valve in said duct, means for normally maintaining said valve in relatively throttled position, whereby a relatively small amount of air is normally drawn from the said air ports through said firebox above the fuel burning on the grate therein, means for operating said valve, means governed by said timing device for periodically actuating said valve-operating means for the purpose of opening said valve to permit increased amounts of air to be drawn through said firebox during periods of operative actuation of said motor and consequent release of amounts of coke into said firebox, and means controlled by said valve-operating means for returning said valve to normal position subsequent to stopping of said motor.

7. The structure defined in claim 1, together with a variably adjustable timing device for operating said motor periodically in predetermined successive intervals of set duration for the purpose of rotating said rotatable member to release periodically from the pockets formed by the vanes thereon predetermined amounts of coke into said firebox, additional timing means for controlling said motor to operate in accordance with successive intervals of different duration, a thermostat for governing said additional timing means, and switching means governed by said thermostat for disconnecting said first-named timing device upon effecting the operation of said additional timing means.

8. The structure defined in claim 1, together with a variably adjustable timing device for operating said motor periodically in predetermined successive intervals of set duration for the purpose of rotating said rotatable member to release periodically from the pockets formed by the vanes thereon predetermined amounts of coke into said firebox, an ash pit underneath said grate, means for shaking said grate to release ashes therefrom into said ash pit, a conveyor for removing ashes accumulated in said ash pit, means for operating said conveyor, and means governed by said motor in variably adjustable timed relation therewith for periodically oper-

ating said grate-shaking and conveyor-operating means.

9. The structure defined in claim 1, together with variably adjustable timing means for operating said motor periodically in predetermined successive intervals of set duration for the purpose of rotating said rotatable member to release periodically from the pockets formed by the vanes thereon predetermined amounts of coke into said firebox for burning on the grate therein, an ash pit underneath said grate, means for shaking said grate to release ashes therefrom into the ash pit, a conveyor for removing the ashes from said ash pit, means for operating said conveyor, means governed by said motor in variably adjustable timed relation therewith for periodically operating said grate-shaking and conveyor-operating means, and means for variably adjusting the duration of operation of said grate-shaking and conveyor-operating means.

10. In a furnace of the class described, wall means defining a coking chamber, a rotatable feed member disposed in said coking chamber, said feed member having radial vanes forming pockets for receiving coal, a conveyor for supplying coal for deposit in the pockets of said feed member, wall means defining a chamber forming a firebox provided with a grate disposed underneath said coking chamber, the heat radiating upwardly from said firebox being utilized for the conversion of the coal in the pockets of the rotatable member to form coke, a motor for controlling the operation of said rotatable member, variably adjustable timing means for periodically operating said motor for successive intervals of set duration, whereby said rotatable member is rotated by predetermined angular amounts to dispose said pockets angularly so as to release amounts of coke successively into said firebox for burning on the grate therein, and means governed by said motor for actuating the coal supply conveyor for like intervals of operation, whereby amounts of coal are supplied to the pockets of said rotatable member for coking therein which correspond substantially to the amounts of coke removed therefrom for burning on the grate in said firebox.

11. The structure and operation defined in claim 10, together with wall means forming with the wall means defining said firebox a combustion chamber disposed adjacent to but separated from said firebox, partition means in said coking chamber forming with a wall of the means forming such coking chamber a passage for conducting downwardly gases which move upwardly from the coking chamber, one of the wall means of said firebox having ducts formed therein for receiving the combustible gases formed in the coking of the coal in said coking chamber and conducted through said passage and the combustible gases produced in the burning of the coke on said grate for conducting the intermixed gases into said combustion chamber for combustion therein at a temperature exceeding that which obtains in said coking chamber and in said firebox.

12. In a furnace of the class described, wall means forming a coking chamber, a rotatable feed member in said coking chamber having radial vanes forming pockets for receiving coal, a conveyor for supplying coal to said pockets, wall means forming a firebox provided with a grate disposed underneath said coking chamber, the heat radiating upwardly from said firebox being utilized for the conversion of the coal in the pockets of the rotatable member to form coke to be burned on the grate in said firebox, a motor for controlling the operation of said rotatable member, variably adjustable timing means for periodically operating said motor for successive intervals of set duration, whereby said rotatable member is rotated by predetermined angular amounts to cause release of predetermined amounts of coke successively from the pockets thereof into the firebox, means governed by said motor for actuating said coal supply conveyor for like intervals of operation, whereby amounts of coal are supplied to the pockets of said rotatable member for coking therein, which amounts correspond substantially to the amounts of coke removed therefrom for burning on the grate in said firebox, a device for regulating the air supply to said firebox, said device comprising a valve disposed in a gas exhaust duct, control means for normally maintaining said valve in a position wherein the air supply is relatively throttled, and means governed by said timing means for operating said control means to increase the air supply to said firebox during and slightly after the periods of operation of said motor.

13. In a furnace of the class described, means forming a coking chamber, a rotatable feed member disposed in said coking chamber having radial vanes forming pockets for receiving coal, a conveyor for supplying coal to said pockets, means forming a firebox provided with a grate disposed underneath said coking chamber, the heat radiating upwardly from said firebox being utilized for the conversion of the coal in the pockets of the rotatable member to form coke to be burned on the grate in said firebox, a motor for controlling the operation of said rotatable member, a normally operative variably adjustable timing means for periodically operating said motor for successive intervals of set duration, whereby said rotatable member is rotated by predetermined angular amounts to cause release of predetermined amounts of coke successively from the pockets thereof into said firebox, means governed by said motor for operating said coal supply conveyor for like intervals of operation, whereby amounts of coal are supplied to the pockets of said rotatable member for coking therein which correspond substantially to the amounts of coke removed therefrom for burning on the grate in said firebox, a control device for governing the operation of said motor in accordance with heat conditions produced by said furnace, said control device comprising switching means for disconnecting said normally operative timing means, and additional timing means coacting with said control device for thereafter governing the periodic operation of said motor in accordance with intervals of different duration.

14. In a furnace of the class described, means forming a coking chamber, a rotatable feed member disposed in said coking chamber and having radial vanes forming pockets for receiving solid fuel, a conveyor for supplying coal to said pockets, means forming a firebox provided with a grate disposed underneath said coking chamber, the heat radiating upwardly from said firebox being utilized for the conversion of the coal in the pockets of the rotatable member to form coke to be burned on the grate in said firebox, a motor for controlling the operation of said rotatable member, variably adjustable timing means for periodically operating said motor for successive

intervals of set duration, whereby said rotatable member is rotated by predetermined angular amounts to cause release of predetermined amounts of coke successively from the pockets thereof into the firebox, means governed by said motor for actuating said coal supply conveyor for like intervals of operation, whereby amounts of coal are supplied to the pockets of said rotatable member for coking therein which correspond substantially to the amounts of coke removed therefrom for burning on the grate in said firebox, a device for controlling the disposal of ashes from the furnace, variably adjustable timing means governed by said motor for periodically operating said device in timed relation with the operation of said motor, and means for variably adjusting the duration of operation of said ash disposal device.

15. In a furnace of the class described, wall means forming a coking chamber, a supply device in said coking chamber, said supply device comprising a pair of rotatable members disposed in parallel and extending transversely across said coking chamber each member carrying a plurality of radial vanes forming sector-like pockets thereon, means for periodically downwardly feeding to said supply device a predetermined amount of coal for deposit in the pockets of said rotatable members which are at the time of such feeding upwardly directed, wall means forming a firebox provided with a grate disposed underneath said coking chamber, the heat radiating upwardly from said firebox being utilized for substantially converting the coal in said pockets into coke, and means for periodically rotating said rotatable members to rotate said coke-containing pockets angularly to release the coke therein for deposit on said grate in said firebox for burning therein.

16. The structure and combination defined in claim 15, together with means forming a gas combustion chamber adjacent said firebox, the wall means forming said firebox having ports formed therein for conducting combustion gases from said coking chamber and from said firebox into said combustion chamber for substantially complete combustion therein.

17. In a furnace having a firebox provided with a grate for burning solid fuel, apparatus for governing the operation of said furnace, said apparatus comprising a timing device, means governed by said timing device for automatically periodically supplying predetermined amounts of fuel to said grate, damper means for regulating the draft through said firebox, control means governed by said timing device for automatically operating said damper means, said control means comprising a motor for rotating a cam and for simultaneously actuating said damper means, and means governed by said cam for governing the operation of said motor to cause opening of said damper means to furnish an increased draft through said firebox for and slightly after the duration of periods of feeding the fuel to the grate and for thereafter returning said damper to normal so as to furnish a decreased draft through the furnace for periods when no fuel is fed to the grate.

18. In a furnace of the class described having wall means defining a chamber forming a firebox provided with a grate for burning solid fuel, a device for feeding fuel to said grate, said device comprising a pair of rotatable members positioned side by side and extending in parallel relation transversely across the chamber above the grate in said firebox, each rotatable member having a plurality of radially extending vanes forming thereon sector-like pockets, delivery means for periodically supplying amounts of fuel downwardly into said chamber for deposit in the pockets of said rotatable members which are upwardly positioned, and means for rotating said members to rotate the pockets thereon which are filled with fuel angularly downwardly so as to release the amounts of fuel therein for deposit on said grate, thereby rotating other pockets angularly upwardly to position them for receiving fuel supplied by said delivery means.

19. The structure and combination defined in claim 18, together with a row of pivotally mounted downwardly depending movable shields disposed above each rotatable member, said rows of shields forming a laterally yieldable downwardly directed passage for directing the periodically supplied amounts of fuel downwardly from deposit in the pockets of said members.

20. In a furnace having a firebox for burning solid fuel and equipped with supply means for supplying fuel to said firebox, apparatus for governing the operation of said supply means, said apparatus comprising a normally operative variably adjustable principal timing device for causing the operation of said supply means periodically in predetermined time intervals of set duration for the purpose of periodically feeding predetermined amounts of fuel to said firebox, an auxiliary timing device for operating said supply means periodically in accordance with time intervals of different duration, a thermostat for actuating said auxiliary timing device, and switching means governed by said thermostat for disconnecting said principal timing device when the auxiliary timing device becomes effective.

21. In a furnace having a firebox containing a grate for burning solid fuel and supply means for feeding such fuel to said grate for burning therein and provided with damper means disposed in a gas exhaust duct for regulating the draft through the firebox, apparatus for operatively correlating the actuation of said supply means with the actuation of said damper means, said apparatus comprising a motor for actuating said supply means, a motor for actuating said damper means, and a variably adjustable timing device for actuating said motors periodically for predetermined time intervals of set duration for periodically supplying predetermined amounts of fuel to said firebox for burning therein and for simultaneously adjusting said damper means.

22. In a furnace having a firebox containing a grate for burning solid fuel disposed above an ash pit equipped with grate-shaking means and ash-removal means and provided with supply means for feeding fuel to said grate for burning thereon, apparatus for operatively correlating the actuation of said supply means with the actuation of said grate-shaking and said ash-removal means, said apparatus comprising a motor for actuating said supply means, a motor for actuating said grate-shaking and said ash-removal means, a variably adjustable timing device for actuating the motor of said supply means periodically for time intervals of set duration for the purpose of periodically feeding predetermined amounts of fuel to said grate for burning thereon, auxiliary time-controlled means for governing the operation of the motor of said grate-shaking and ash-removal means, and means governed by the motor of said supply means for operating said auxiliary time-controlled means to actuate said grate-shak-

ing and said ash-removal motor for a time period of set duration once for a predetermined plurality of periodic operations of said supply means.

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