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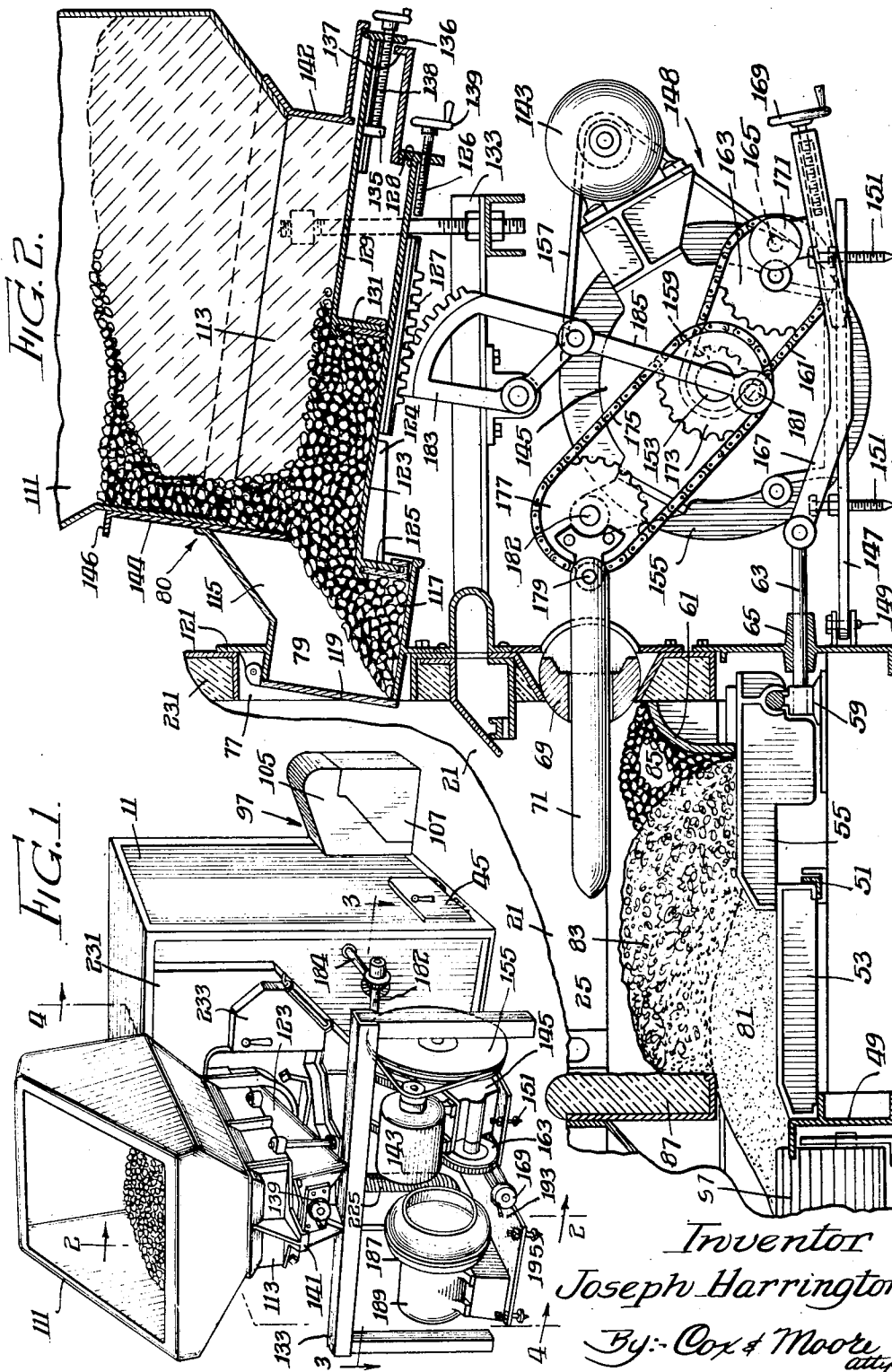
J. HARRINGTON

2,331,907

FURNACE AND ASSOCIATED FEEDING DEVICE

Filed July 27, 1938

6 Sheets-Sheet 1



Oct. 19, 1943.

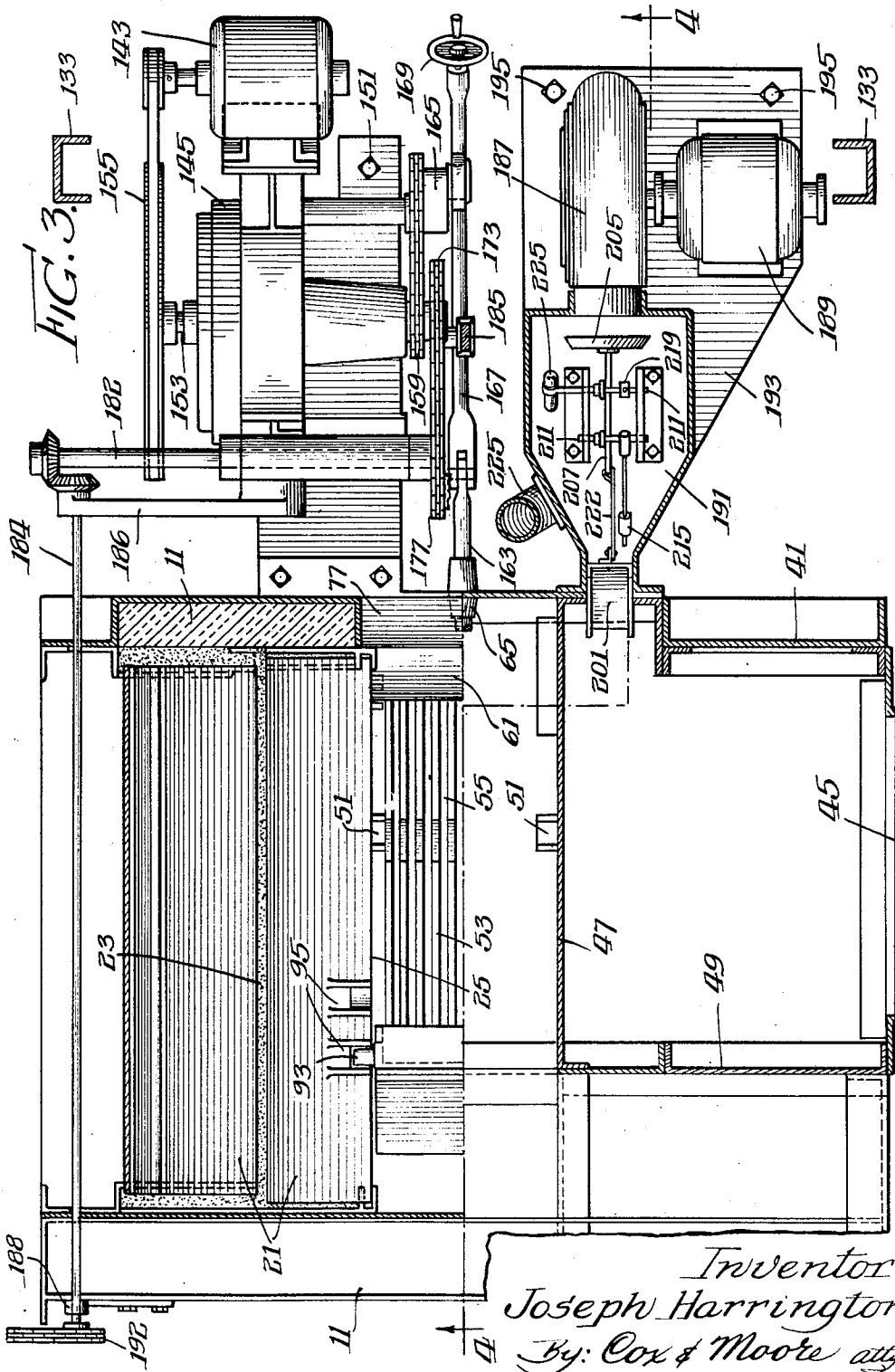
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2,331,907

FURNACE AND ASSOCIATED FEEDING DEVICE

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6 Sheets-Sheet 2



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2,331,907

FURNACE AND ASSOCIATED FEEDING DEVICE

Filed July 27, 1938

6 Sheets-Sheet 3

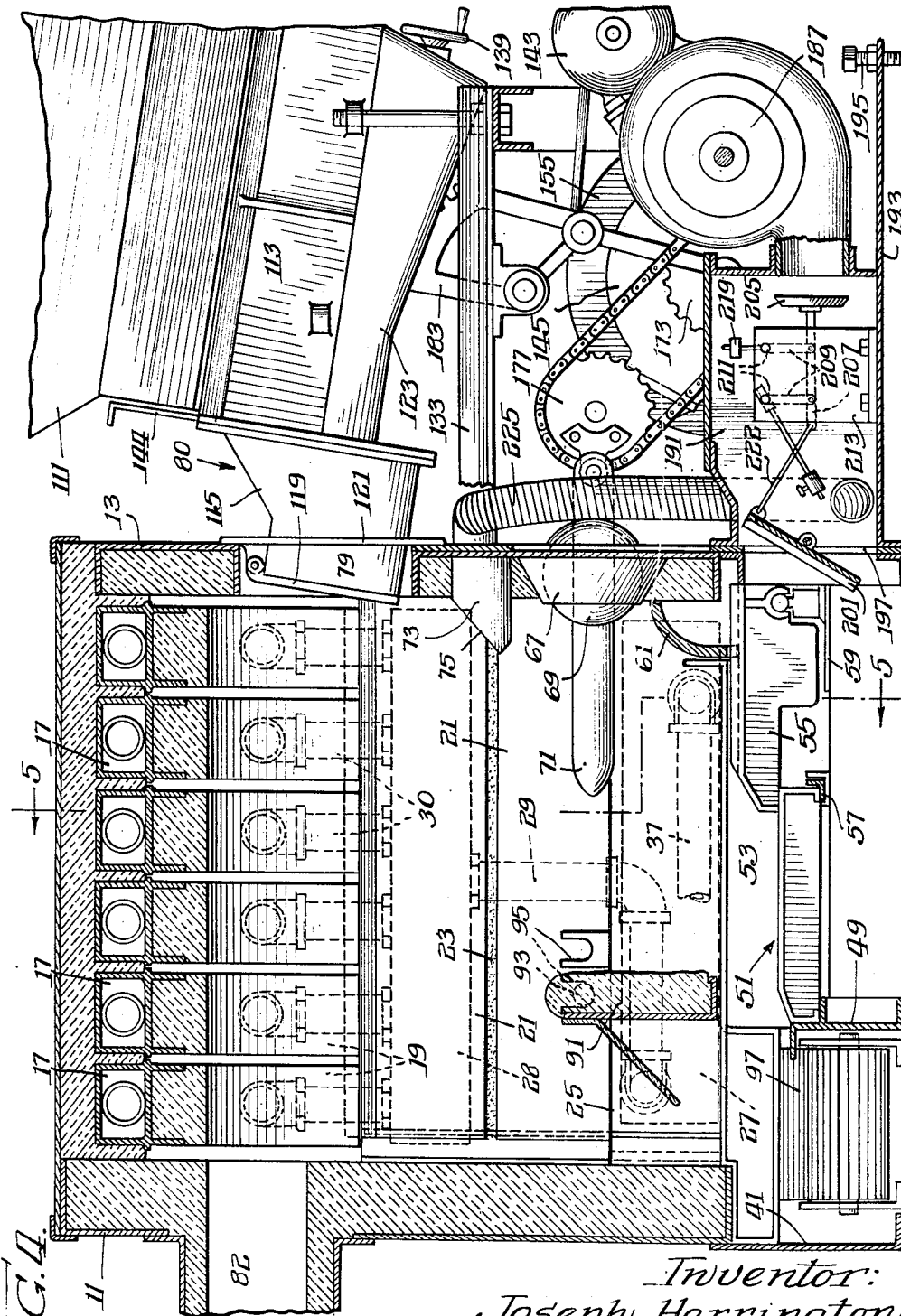


FIG. 4.

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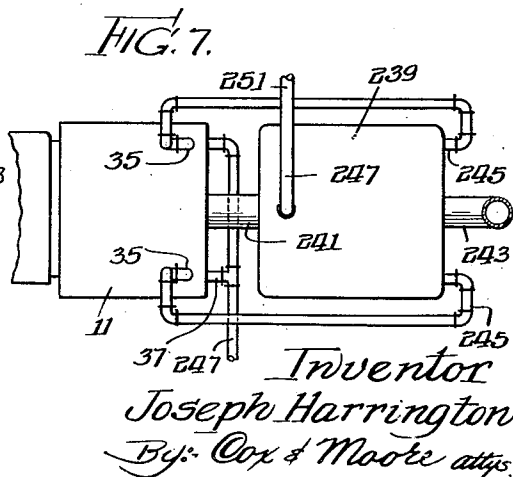
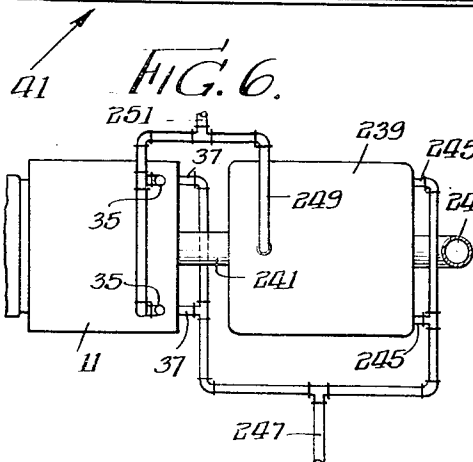
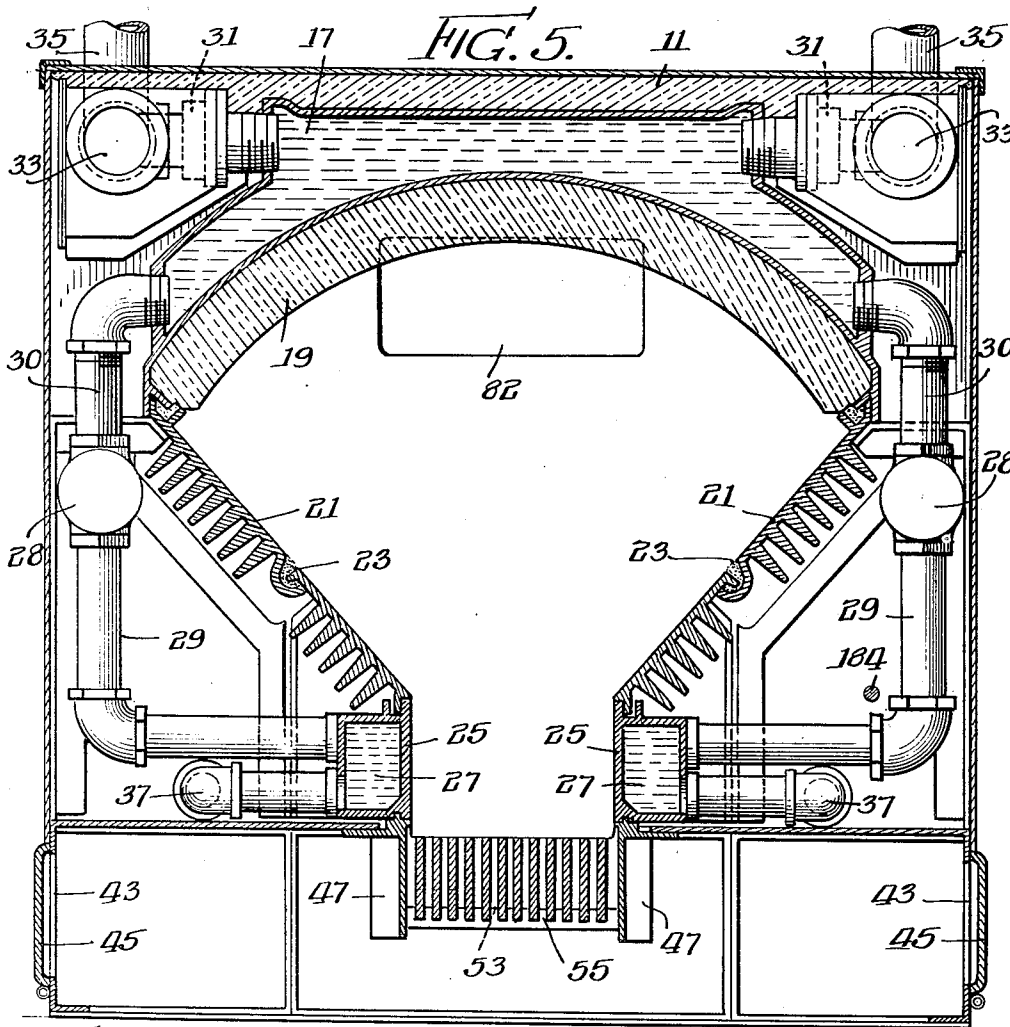
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2,331,907

FURNACE AND ASSOCIATED FEEDING DEVICE

Filed July 27, 1938

6 Sheets-Sheet 4



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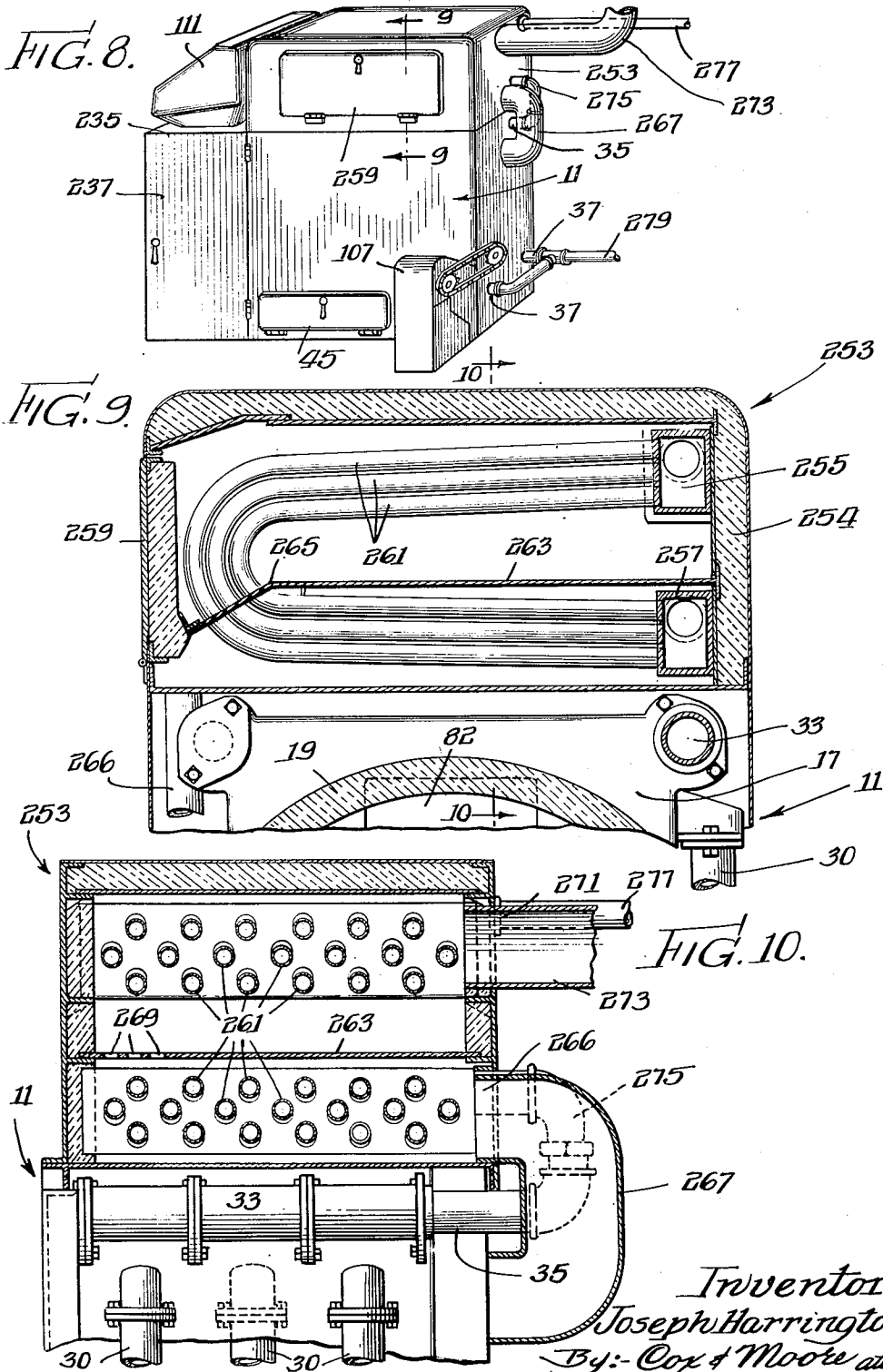
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2,331,907

FURNACE AND ASSOCIATED FEEDING DEVICE

Filed July 27, 1938

6 Sheets-Sheet 5



Oct. 19, 1943.

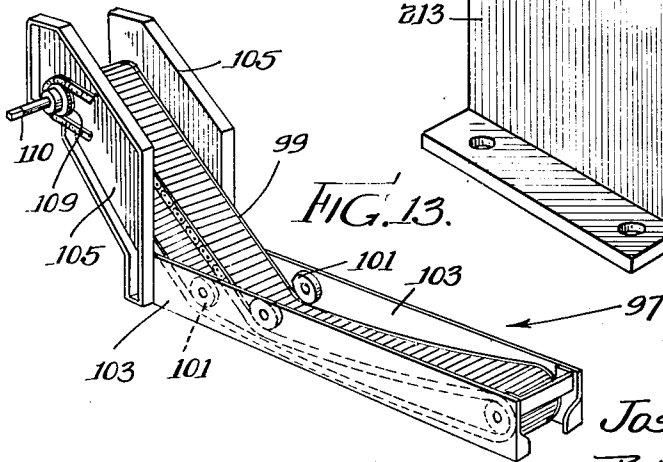
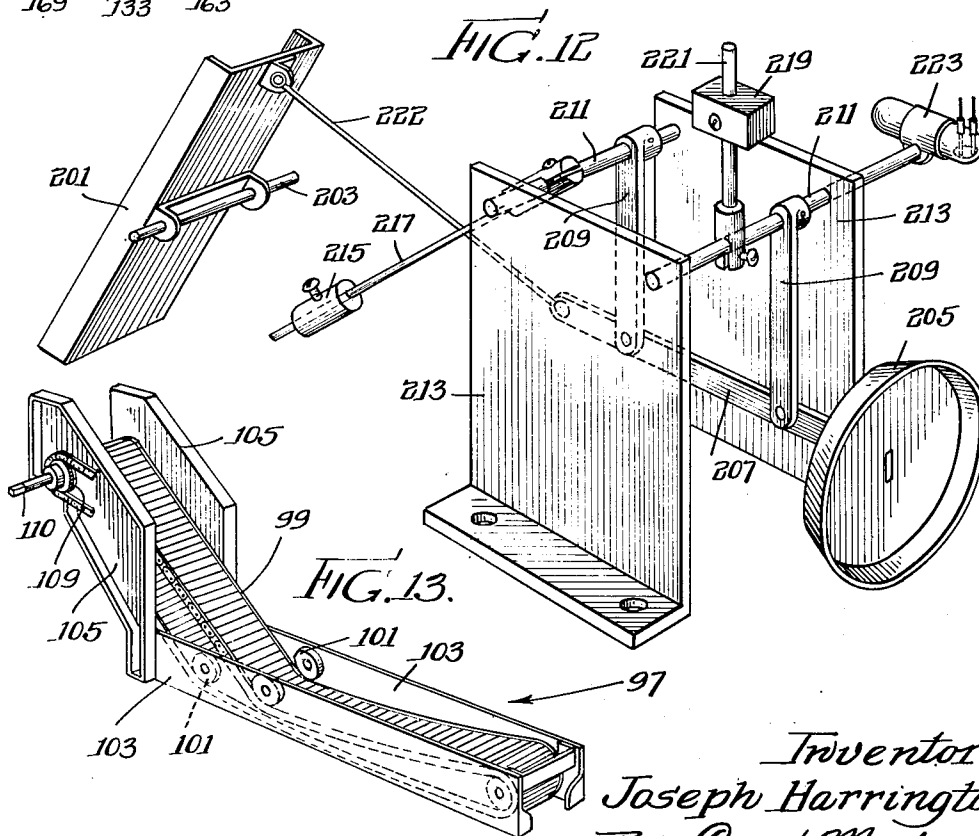
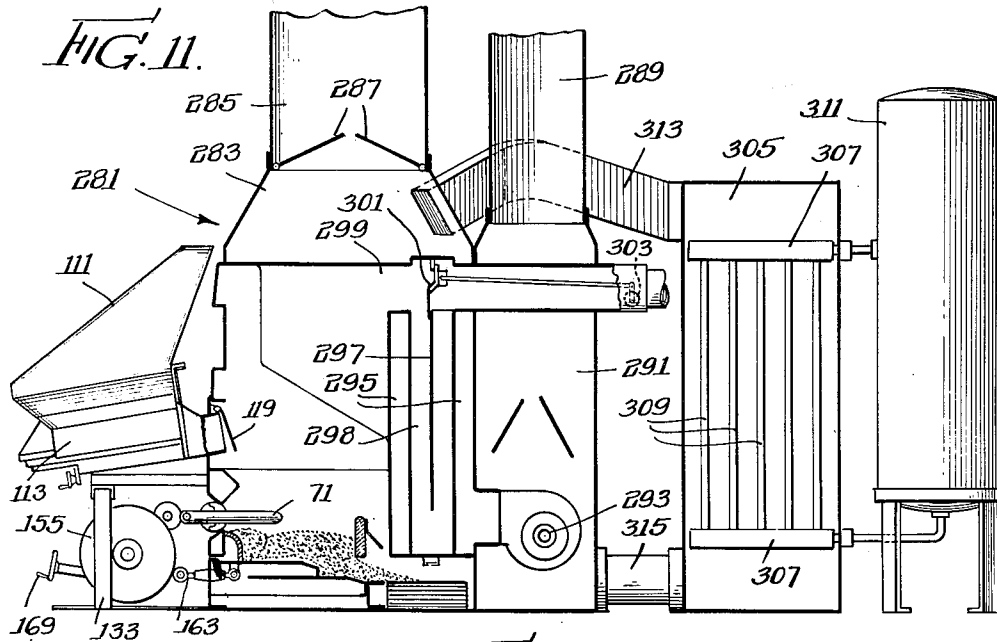
J. HARRINGTON

2,331,907

FURNACE AND ASSOCIATED FEEDING DEVICE

Filed July 27, 1938

6 Sheets-Sheet 6



UNITED STATES PATENT OFFICE

2,331,907

FURNACE AND ASSOCIATED FEEDING
DEVICE

Joseph Harrington, Riverside, Ill.

Application July 27, 1938, Serial No. 221,622

15 Claims. (Cl. 122—371)

My present invention relates in general to combustion and has more particular reference to the provision of means for a method of delivering and burning fuel under controlled conditions in a furnace, the invention relating specifically to a mechanical stoker particularly well adapted for feeding and burning coal and other solid fuels, although certain features of the invention are not necessarily limited to coal combustion.

An important object of the invention is to provide for delivering fuel in successive measured charges at one end of a grate surface, and causing the same to be conveyed across the grate surface by the reciprocation of a grate section beneath a stationary thrust wall forming a back stop.

Another important object is to control the rate at which the fuel is delivered across the grate area by regulating the rate of reciprocation of a grate section, as well as the frequency at which successive measured charges are deposited; a further object being to control the rate of fuel delivery across the grate area by regulating the quantity of fuel contained in the successive charges.

Another important object is to provide means for feeding successive charges of fuel at predetermined intervals to a combustion zone and providing for controlling the frequency or rate at which the charges are successively delivered, and also to regulate the amount of fuel comprising a charge.

Another important object is to provide for the delivery of a combustion supporting fluid, such as air, to the combustion zone, and providing for the continuous regulation of the air supply so that at all times substantially the exact quantity of combustion fluid required for ideal combustion will be supplied in the combustion zone.

It is well established that complete combustion of any unit quantity of fuel requires a definite volume of air, the ratio varying with the character of the fuel being burned but being constant for any given fuel. The problem is to furnish an adequate supply of the combustion fluid—in the present case, air—as combustion takes place. When coal is burned as a bed in a furnace, even when the coal is more or less continuously delivered to and across the grate area, the exigencies of combustion, including the variant character and quality of the fuel, which may vary as to size and quality from time to time, the optimum rate of delivery of the combustion fluid required to provide combustion under ideal conditions also varies.

Due to size or grade variation in the fuel, the bed may at times become relatively thinner and

less resistant to the flow of the combustion fluid than at other times. Consequently, where the combustion fluid is delivered at constant pressure beneath the grate area for passage through the fuel bed, it is obvious that when the bed becomes less resistant to the passage of the fluid, a relatively larger quantity of the fluid will be delivered through the bed than at times when the bed has greater resistance to the flow of the fluid.

Increase in the quantity of the combustion fluid under such conditions in turn promotes a more vigorous combustion in the portions of the bed having low resistance, thereby burning the fuel rapidly at such portions and making them still less resistant so that the effect is cumulative and the bed may reach a condition where substantially all of the combustion fluid passes through a localized bed area of low resistance, the remaining thicker areas of relatively higher resistance obtaining little of the combustion fluid and thus becoming starved.

Furthermore, where combustion fluid, such as air, is supplied in quantities greatly in excess of the requirement for ideal combustion, much of the heat value of the fuel is lost by heating up the excess quantities of combustion fluid. This is an undesirable loss and, in order to overcome the foregoing conditions promoting the same, I provide novel and improved means for controlling the fluid supply so that, as the fuel bed becomes less resistant to the flow of the combustion fluid therethrough, a proportionately smaller volume of the fluid is delivered and vice versa, to the end that at all times substantially the exact requirements in combustion fluid for ideal combustion are supplied.

An important object of the present invention, therefore, is to provide pneumatic control for regulating the flow of a fluid so that the quantity of fluid delivered is in inverse proportion to the resistance to fluid flow of the passage or passages through which the fluid is delivered, and this feature of the invention is not necessarily restricted to the delivery of air or other fluid to a combustion zone, but may have application wherever a fluid is required to be delivered along a path having variant resistance to fluid flow. This method of pneumatic control and the means for accomplishing it, however, is of particular value when used in combination in a combustion device, particularly a coal furnace, and is especially valuable in conjunction with a furnace to which fuel is delivered continuously as by means of an automatic stoker.

Another important object is to provide a pneumatic control of the character mentioned, including throttling means which may conveniently comprise a shutter disposed in a delivery conduit, and means for throttling the throat substantially inversely in response to the rate of speed at which the fluid is delivered to and through the conduit; a further object being to form the shutter-actuating element as a target disposed in the path of flow of the fluid being regulated to operate in effect as a pneumatic speed-responsive mechanical relay; a still further object being to provide for adjusting the shutter-operating effect of the target as by means of adjustable counterweights to regulate the throttling orifice with respect to the speed of fluid flow therethrough.

Another important object is to provide a combustion device for supplying fuel, as well as a combustion fluid, such as air, in a combustion zone, including means for regulating the rate of supply of the combustion fluid as well as of the fuel, so that at all times the fluid is supplied in substantially the exact quantities required for ideal combustion of the fuel in the combustion zone; a further object being to supply the fluid in response to varying heat requirements, such, for example, as the temperature to be maintained in a boiler heated by the combustion of the fuel, or the temperature in a room where the fuel is burned for house heating purposes, while the supply of fuel is regulated solely in response to the fuel requirement in the combustion zone, as indicated by the speed at which the combustion fluid is able to penetrate the fuel bed existing in the combustion zone.

Another important object is to provide a device of the character mentioned, including an air blower for supplying a combustion fluid to a furnace in position to pass through a fuel bed therein, and including differential throttling means to reduce the volume of air supplied to the fuel bed as the resistance of said bed to fluid flow there-through increases, the equipment including a stoker operable to supply fuel continuously to and across the combustion zone as long as the fuel bed has less than a predetermined resistance to the flow of the combustion fluid; a further object of the invention being to control the operation of the fuel-feeding means by a switch influenced by the fluid flow responsive element forming a part of the fluid throttling regulator.

Another important object is to provide a solid fuel combustion device having means for supporting a bed of fuel during combustion, and means operable continuously to stir the fuel bed to break up clinker formation to aid in maintaining uniform combustion conditions in said bed and to form a depression in the fuel bed to receive a portion of the new charge of fuel therein; a further object being to utilize a reciprocating and tilting plunger as a bed-stirring and bed forming element; a still further object being to utilize a plunger of the character mentioned in conjunction with a reciprocating grate section for advancing the fuel bed progressively through the combustion zone, the plunger and grate section being movable in timed relationship.

Another important object is to provide domestic heating equipment embodying fuel-feeding means of the character mentioned and including ash discharge means for continuously receiving ashes from the grate section and ejecting the same to a remote ash receptacle.

Another important object is to provide a do-

mestic heating equipment comprising an oven fitted with fuel feeding and combustion means and adapted for fabrication as a unit; a further object being to provide a unit of the character mentioned adapted for assembly with an existing boiler by connecting the unit to discharge products of combustion therefrom through such existing boiler, the oven of the unit having water pipes connectible with the water heating system of the existing boiler, whereby to provide an exceedingly efficient arrangement for the conversion of the heat contents of the fuel and apply the same in heating the liquid circulating in the oven, as well as in the existing boiler.

Another important object is to provide a unit, including a stoker containing oven, adapted for use as a conversion unit with an existing boiler and also adapted for assembly with an auxiliary boiler attachment so that the oven unit and attachment may form complete boiler equipment for initial installation, as in a domestic heating system.

Another important object is to provide an improved hot air furnace; a further object being to incorporate the stoker of my present invention in such hot air furnace; a still further object being to provide for the forced circulation of air through the furnace and the delivery thereof for heating purposes, including novel means for regulating the delivery of heated air through said furnace in response to the prevailing temperature in a zone to which the air is delivered for the purpose of maintaining a desired temperature condition; a further object being to provide an improved arrangement for utilizing the products of combustion as the same are exhausted from the furnace in preheating the air circulated to the furnace.

Another important object is to provide means for utilizing a hot air furnace for maintaining a constant supply of hot water for domestic use, to the end that the furnace may be operated continuously in warm, as well as in cold, weather, only sufficient fuel being burned to maintain an adequate hot water supply when there is no demand for hot air heat.

Another object is to provide automatic stoking equipment having features of novelty rendering it especially well adapted to control the more or less continuous consumption of fuel in relatively small quantities at varying or intermittent rates, as required in house heating as distinguished from commercial heating where relatively large quantities of fuel are consumed continuously under the close inspection and control of a furnace tender. The invention, however, is not, of course, necessarily limited to stokers of small capacity.

Among the other objects of the invention are to provide a practical domestic coal stoker adapted for house heating and to provide new methods and means for controlling the operation of the stoker and the supply of combustion fluid for promoting combustion of the fuel under variant conditions which prevail in a stoker required to operate at the intermittent rates required by the exigencies of house heating.

The foregoing and numerous other objects, advantages and inherent functions of the invention will become apparent as the same is more fully understood from the following description, which taken in connection with the accompanying drawings, discloses a preferred embodiment of the invention.

Referring to the drawings,

Figure 1 is a perspective view of an oven and

associated fuel-feeding equipment embodying my present invention;

Figures 2, 3 and 4 are sectional views taken substantially along the lines 2—2, 3—3 and 4—4, respectively, in Figure 1;

Figure 5 is a sectional view taken substantially along the line 5—5 in Figure 4;

Figures 6 and 7 illustrate, in schematic manner, modes of interconnecting the oven and stoker in a conventional hot water heating system;

Figure 8 is a perspective view illustrating the oven and stoker of my present invention, together with a boiler attachment, to provide a complete heating unit for house heating purposes;

Figures 9 and 10, respectively, are enlarged sectional views taken substantially along the lines 9—9 in Figure 8 and 10—10 in Figure 9.

Figure 11 is a sectional view taken through a hot air furnace and associated water heating equipment and fitted with a stoker, both stoker and furnace separately and in combination embodying features of patentable novelty;

Figure 12 is a perspective view of means for controlling fluid flow, more particularly the supply of air, to a fuel combustion space, the mechanism embodying features of novelty forming a part of my present invention; and

Figure 13 is a perspective view of conveyor means for removing ash from the furnace.

To illustrate my invention, I have shown on the drawings a mechanical stoker mechanism for delivering fuel for consumption in a furnace or other combustion space.

As shown in Figures 1—5, the furnace comprises an oven 11 of any suitable, preferably insulated construction, the device illustrated including suitable, preferably metallic support and sheathing members 13 and a refractory lining arranged to form a housing, in the upper portions of which, as shown more particularly in Figures 4 and 5, is or may be arranged a plurality of hollow arch member 17 forming chambers for the circulation of a fluid, such as water, to be heated by the combustion of fuel in the furnace.

I prefer, also, to provide a refractory furnace lining 19 at the under surface of the members 17 in order to protect the same from the deleterious effects of direct contact with the products of combustion burned immediately therebeneath. Beneath the chambered elements 17 I prefer to provide oppositely and inwardly inclined walls 21 extending downwardly from the opposite ends of the members 17, said walls preferably comprising metallic plates interfitted and cemented together at their abutting edges, as at 23.

The lower ends of the inclined walls 21 bear upon and are in part supported by the upper edges of a fire-pot, preferably comprising the spaced metallic plates 25 which define the opposed side walls of the fire-pot and which are preferably formed as hollow blocks providing chambers 27 along the opposite sides of the fire-pot. These chambers may be interconnected with the chambered elements 17, as by means of the conduits 29 connected with the chambers 27 and with headers 28, which headers in turn are connected by means of the coupling conduits 30 with each of the chambered elements 17, so that a liquid, such as water, may be circulated in the vicinity of the fire-pot to absorb heat from the walls 25 and maintain the same against the deleterious effect of undue heating, and also to assist in heating the fluid in the oven.

The chambered elements 17 also are preferably each interconnected, as by the conduit means 31,

with one or more bus-pipes 33 extending as at 35 outwardly of the casing 13. The chambers 27 are also provided with communicating conduits 37 extending outwardly of the casing 13 to permit the circulation of fluid to and from the chambered elements 17 and 25.

The oven 11 is erected upon a suitable supporting base indicated generally at 41, having openings 43 normally closed by doors 45 which may be opened, if necessary, to afford a natural draft to the under side of the fire-pot. The base 41 forms a chamber beneath the fire-pot and includes a pair of members 47 comprising downward extensions of the spaced walls 25 defining the sides of the fire-pot. The base also provides support elements 49, 51 and 53 which extend at the lower edges of the members 47 to afford support for grate-forming means. In the illustrated embodiment the grate-forming means comprises a preferably stationary grate section 53 comprising spaced grate bars and supported at opposite ends by the support members 49 and 51.

The grate also includes a reciprocating section 55 comprising grate bars, the forward ends of which are slidably supported upon the rearward end of the stationary section 53. The opposite end of the movable section 55 is supported on a slide 57 which in turn is movable in the ways 59 formed on the base 41. Above the sliding grate section 55, I arrange a back-stop 61 comprising a preferably curved plate extending entirely across the movable grate section and anchored at its opposite ends in suitable slots formed in the side plates 25 forming the walls of the fire-pot. The upper edge of the plate forming the back-stop rests against the inner surface of the front wall of the furnace. The movable grate section, however, is free to reciprocate beneath the back-stop and is actuated in any suitable fashion, as by means of a shaft 63, which is connected at one end to the slide 57, extending thence outwardly through a support journal 65 which may conveniently be formed in the furnace base 41. The grate 51 thus comprises movable and stationary grate sections arranged in stepped relationship, with the movable section arranged for reciprocation beneath the back-stop.

Above the back-stop 61 is preferably formed an opening in which I may assemble a frame 67 for the reception of a spherical journal 69 having a guide channel therethrough in which may be arranged a stirring device, preferably in the form of a shaft-like poker 71. One end of the poker extends within the oven substantially at the top and forward portions of the fire-pot, the opposite end of the poker extending outwardly of the oven in position for connection with means for rocking and reciprocating the stirring device for the purpose of breaking up the fuel bed in the fire-pot, and preventing the formation of coke masses. Operation of the poker also may serve to aid in advancing the fuel bed from the forward toward the rearward portions of the fire-pot and tends also to maintain uniform fuel bed conditions. In addition, the poker or poking means is arranged to oscillate above the fire pot first pointing downwardly into the bed, then lifting either to force the bed in the vicinity of the poker toward the back wall 87 or to spread the fire laterally; in any event this poker forms a substantially cup-shaped depression in the bed which receives a portion of the new fuel charge dumped through the feed inlet 119 hereinafter referred to. Above the poker, in the forward wall of the

oven, I also prefer to arrange a shell or casing 73 comprising a tuyère block or fitting through which air may be supplied to the interior of the oven above the fire-pot. The inwardly extending portions of the casing 73 preferably have downwardly-inclined upper surfaces 75 which, as will hereinafter appear, aid in the delivery of fuel into the fire-pot.

Above the tuyère block, the wall of the oven is formed with an opening 77 through which fuel may be delivered, preferably in measured charges, through the delivery outlet 79 of a fuel feeding device 80 extending in the opening 77. The delivery outlet 79 is in position with respect to the grate so that fuel delivered through said outlet may fall into the fire-pot and upon the reciprocating grate immediately in front of the back-stop 61, the inclined surface 75 of the tuyère block serving to deflect the fuel and cause it to drop immediately in front of the back-stop plate 61.

The end wall of the oven opposite the fuel inlet opening 77 is preferably formed with a fuel outlet 82 to permit products of combustion to escape from the oven.

The operation of the fuel-feeding device and of the movable grate section 55 is preferably controlled in coordinated timed relationship so that the fuel charge is deposited upon the grate section 55 in front of the back-stop 61 when the grate section is substantially at the limit of its forward movement under the back-stop. After the charge of fuel is thus delivered the grate section 55 may be retracted beneath the back-stop and the fuel, because of the relative movement between the shiftable grate section and the back-stop, is advanced upon the grate section. During the next succeeding forward movement of the grate section under the back-stop, the fuel charge will be advanced in the fire-pot, leaving a depression between the rear of the fuel bed and the back-stop, so that the succeeding charge of fuel may be deposited into and fill the void so created. Eventually, the fire-pot becomes charged with burning fuel which assumes the relative position indicated in Figure 2 of the drawings, wherein the burned ash is shown at 81, burning fuel at 83, and a freshly-deposited charge of fuel at 85.

At the discharge end of the grate I provide means forming an adjustable ash discharge throat. For this purpose I preferably provide an adjustable shutter 87 comprising a metallic frame 89 carrying a heat-resisting material, such as fire-brick 91, in position facing into the fire-pot. This shutter 87 extends between the side walls of the fire-pot and may be pivoted in any convenient fashion as by means of the stub shafts 93 formed at the opposite ends of the shutter in position for reciprocation in brackets 95 formed on or at the upper edges of the plates 25. The shutter has a lower edge spaced above the discharge end of the stationary grate section 53. By adjusting the tilted position of the shutter, the distance between its lower end and the stationary grate may be varied to provide a variable ash discharge throat.

The partially burned fuel 83 rides upon the top of the ash bed 81 which in turn is carried on the stationary grate section. The shutter 87 may be adjusted to retain the unburned fuel 83 in the fire-pot, while permitting ashes to escape beneath the shutter. Suitable adjusting means operable from outside of the furnace may be provided for setting and locking the shutter in a desired adjusted position.

It will be noted that I provide more than one set of brackets 95 whereby the shutter or gate 87 may be mounted at a desired distance from the back stop 61 so as to permit regulation in the size of the grate area, thereby providing for conditioning the equipment for operation under a variety of conditions and improving the operating flexibility of the apparatus. For example, in relatively warm weather, when the demand for heat is low or when the equipment is maintained in operation during summer months, as for domestic water heating, a minimum grate area is desirable to allow consumption at maximum efficiency only of enough fuel to meet the relatively light heat demand. When the heat demand is greater, as in winter house heating, the grate area may be increased to correspondingly increase the rate of fuel consumption and consequent heat production. Furthermore, the ability to regulate grate area permits a standardized equipment to be installed for service in heating buildings of exceedingly diversified size, and then easily adjusted in accordance with heat requirements for operation at optimum efficiency. It will be noted, also, that the forward end of the shiftable grate section extends substantially opposite the ash discharge throat so that reciprocation of the movable section 55 not only serves to advance unburned fuel, but also serves to push a substantially equal volume of ash across the stationary grate section and discharge the same beneath the shutter 87.

Suitable conveying means 97 is provided, extending at the ash discharge end of the stationary grate for receiving the ash and conveying the same outwardly of the furnace.

In the illustrated embodiment, the conveying means 97 is shown in Figure 13 of the drawings and comprises an endless, flexible belt 99 conveniently fabricated of steel slats mounted between spaced chains. This belt is mounted on and guided by rollers 101 arranged in a frame comprising a pair of spaced members 103. Portions of this frame and the belt are adapted to extend into the base 41 through an opening in the walls thereof, the conveyor extending at and opposite the rear end of the stationary grate section in position to receive ashes discharged therefrom.

The frame has portions 105 extending outwardly of the casing, the parts being arranged to support the outwardly extending portions of the conveyor at an inclination, so that the ashes may be elevated and discharged over the outer end of the conveyor into a container 107.

The outer end of the conveyor is carried preferably on sprockets forming a driving connection therewith, said sprockets being supported on a shaft extending through the frame elements 105. This shaft may carry a driving sprocket 109 for the purpose of driving the conveyor from a suitable power source. The sprocket shaft may be extended beyond the driving sprocket 109 and formed, as at 110, to receive a manually-operable handle so that the conveyor may be actuated by hand, if desired.

The outwardly extending portions 105 of the conveyor support frame may be and preferably are enclosed to suppress and retain any dust that may arise from the ashes as the same are dumped into the container 107.

The fuel delivery means comprises sheet-metal means forming a hopper 111, the bottom of which is formed as a preferably rectangular trough 113 which opens at one end to a delivery chamber

115, the lower end of which forms a trough 117. The chamber 115 forms the fuel-feeding outlet 79 which is preferably provided with a flap cover 119. Chamber 115 also is preferably formed with a peripheral flange 121 at the delivery outlet 79, which flange is adapted to overlie and form a cover for the opening 77.

In the trough 113 I prefer to arrange pushing mechanism preferably in the form of a compound slide, comprising a slide member 123 having a portion extending in the bottom of the trough 113, and a forward end formed with a pusher 125 which extends in the delivery chamber 115. The slide member 123 is reciprocable in the trough 113 and in the trough 117 by means of a rack 127. The rack 127 is relatively slidable to a limited extent on the member 123, the sliding movement being limited in one direction by the stop 124 against which the end of the rack may engage and in the other direction by an adjustable stop comprising the end of a threaded rod 126 which is carried in a bracket 128 on the slide 123, the stop being adjustable by means of a handwheel 139 on the rod. The compound slide also comprises a slide member 129 having a pusher portion 131 extending in the trough 113 and adapted to ride upon the portions of the member 123 within the trough 113, the member 129 being suitably guided on the trough-forming portions 113.

The hopper 111 may conveniently comprise a sheet-metal structure. The portions forming the trough 113 and the delivery chamber 115, however, are preferably formed of cast metallic members, and are supported in any suitable or convenient manner as on the frame 133. The slide member 129 is caused to reciprocate in the trough 113 by a preferably adjustable lost motion connection with the member 123, said connection comprising preferably a finger 137 carried by the slide 123 and a pair of fingers 135 and 136 on the member 129, the finger 135 being slidably adjustable on the member 129 by means of the stem and hand wheel 138.

The trough-forming means 113 also is provided with a stop 141 to limit and determine the retractive movement of both slides 123 and 129. As the slide members 123 and 129 are reciprocated, it will be seen that the pushing portion 125 will be advanced in the chamber 115 and push a charge of fuel contained in said chamber through the opening 79, the flap cover 119 being raised to permit discharge of the fuel through the opening. After the slide 123 has thus moved a predetermined distance, the finger 137, in conjunction with the stop 135, will cause the slide member 129 to move with the member 123 and carry a quantity of fuel from the trough 113 into the chamber 115. As the slide 123 is retracted, it will first slide a predetermined distance with respect to the slide 129 until the finger 137 engages the stop 136. During this interval the fuel in the chamber 115 will be pushed over the forward end of the slide 123 and will fall into the trough 117, ready, upon the succeeding feeding stroke of the member 123, to be pushed into the oven. When the finger 137 engages the finger 136, the slide 129 will thereafter be retracted with the slide 123, and the fuel in the hopper will settle onto the slide 123 in front of the pusher portion 131 of the slide 129, the trough 113 at its rearward end having a shoulder 142 to aid in the fuel settling movement in the trough.

Opposite the shoulder 142 the trough, of

course, opens into the chamber 115, and I prefer to provide a manually adjustable shutter plate 144, the lower portions of which extend in the upper portions of the opening. The plate 144 has a handle 146 by means of which the elevation of the plate in the opening may be adjusted in order to determine the size of the opening through which the fuel is delivered from the trough 113 and the hopper into the delivery chamber 115. By means of the shutter 144, the quantity of fuel delivered into the chamber 115 during the operating cycle of the feeding device may be regulated.

The fuel-feeding mechanism, the stirring device 71 and the shiftable grate section 55, may be actuated from any convenient power source or sources. I prefer, however, to operate the same from a common, preferably electric, motor 143 by suitable driving mechanism 148.

The motor 143, as shown clearly in Figure 2 of the drawings, may be conveniently mounted on a frame 145 carried on a base plate 147 which I prefer to secure, as at 149, to the wall structure of the oven 11. The base plate 147 is preferably provided with adjustable feet 151 comprising screw members extending through the base 147 and operable to level the frame 145 on the floor or other sub-support upon which the mechanism is based. These screws are adapted to accommodate unevenness in the underlying support.

The frame 145 forms a journal for a shaft 153 which is drivingly connected with the motor 143 in any suitable fashion as by means of a flywheel 155 on the shaft and connected as by means of the belt 157 with the motor 143. The shaft 153 may be drivingly connected, in any suitable or preferred fashion, to actuate the feeding mechanism, the stirring device, and the movable grate section 55. In the illustrated embodiment this is accomplished by providing on the shaft a sprocket 159 having a chain 161 for driving a gear 163 which is journaled in the frame 145 and which is provided with an eccentric pin 165. This pin is drivingly connected with the grate reciprocating shaft 63 by means of the connecting rod 167. The connecting rod 167 is adjustably connected by means of a screw manually adjustable as by a hand wheel 169, with a journal fitting 171 carried by the pin 165. By adjusting the hand-wheel 169, the effective travel of the reciprocating grate beneath the back-stop 161 may be varied to alter the rate at which the fuel is delivered through the combustion chamber.

The shaft 153 may also carry a pinion 173 connected, as by the chain 175, with a gear 177. This gear 177 is rotatably supported on the frame 145 and carries an eccentric pin 179 pivoted in the outwardly extending end portions of the poker 71 so that, upon rotation of the gear 177, the poker is reciprocated and oscillated in a manner to perform its function upon the fuel bed in the fire-pot.

The pinion 173 may also carry an eccentric pin 181 for the actuation of the fuel feeding mechanism. In the illustrated embodiment this is accomplished by means of a gear quadrant 183 meshing with rack 127, the quadrant 183 being rockingly mounted on the support frame 133 and drivingly connected with the pin 181 by a connecting rod 185.

I prefer also to provide means for driving the ash discharge conveyor 97 from the motor 143. This, as shown more particularly in Figure 3 of the drawings, is accomplished by fastening

the poker-actuating gear 177 on a shaft 182 which is journaled in the frame 145 and extends outwardly thereof in position for gear connection with a shaft 184 which, as shown in Figure 5 of the drawings, may extend through the casing of the oven. This shaft 184 may be journaled at its end adjacent the shaft 182 in an extension 186 of the frame 145. The opposite end of the shaft 184 may be journaled as at 188 in a bracket mounted on the shell of the oven. The shaft 184 may carry a sprocket 192 providing for chain drive connection with the sprocket 189 which is drivably connected with the conveyor 97. I may also provide for actuating the conveyor 97 by hand by extending the shaft of the sprocket 189 and forming the shaft as at 110.

It will be seen from the foregoing that the motor 143 drives the fuel-feeding mechanism, the poker 71, and the reciprocating grate section 55, and these operations may all be caused to occur in a coordinated time relationship.

I prefer to arrange the driving mechanism so that the slide member 123 reaches the forward limit of its fuel-feeding movement approximately at or very slightly after the movable grate 55 reaches the limit of its forward movement beneath the back-stop 61, and I prefer to arrange the poker actuating mechanism so that it will be substantially retracted in the journal 69 at the instant when the fuel charge is deposited in front of the back-stop. Thereafter the poker is projected from retracted position in a downward and inward direction through the support 69, and digs into the fresh charge of fuel 85 and then into the ignited portions of the fuel bed 83, thus stirring the fuel bed and serving, to a limited extent, to spread and mingle the material of the charge 85 with the previously-ignited fuel forming the portion 83.

The action of the poker and associated parts is as follows: Starting from the position of complete withdrawal from the fire box, the poker point moves rearwardly and downwardly through the surface and into the upper portion of the fuel bed. The point or inner end of the poker pushes the coke masses backwardly or sideways to other portions of the fire, and, by so doing, produces a hollow or depression in the fuel bed at the forward end thereof. The poker then retracts until the point is substantially flush with the inner face of the front wall of the furnace. As the poker recedes, the ram in the coal hopper moves ahead and pushes a predetermined quantity of fresh fuel out of the hopper. This fuel falls directly onto the fire at the forward end, into the depression formed by the inward movement of the poker, as above described. The heat of the fire then immediately heats the fresh fuel, driving off some of the volatile constituents and cokes, the remainder to form a fairly solid cake or mass. As this action takes place in the depression previously produced by the poker, it is in a position to be similarly pushed back or sideways by the succeeding movement of the poker. The coal ram and poker are thus synchronized and complete a cycle in about two minutes.

It will be noted that the gear 173 in the illustrated embodiment, is two times the size of the gear 159, so that the stirring device may be projected and retracted through two complete cycles while the reciprocating grate and the fuel-feeding mechanism pass through but one complete cycle. Each fresh charge 85 is thus sub-

jected to a plurality of stirring operations before the succeeding charge of fuel is deposited.

In order to provide for the combustion of fuel in the fire-pot under ideal conditions, it is necessary to supply a definite amount of combustion supporting fluid, such as air, in the vicinity of the fuel bed. If less than the required amount of air is supplied, combustion is incomplete and excessive amounts of the fuel escape from the combustion chamber in unburned condition in the form of solid particles, such as soot, and as unburned gases. If more than the required air is supplied, waste of heat energy occurs in heating the excess air which then escapes through the flue, and the excess cold air reduces the temperature at which the fuel is burned, thereby impairing the combustion.

In order to promote combustion under ideal conditions in the furnace of my present invention, I have provided means for supplying air beneath the fire-pot in position to pass upwardly through the fuel bed at all times in quantities substantially equal to the requirements for ideal combustion.

The problem of supplying substantially the exact air requirement at all times is complicated by several variant factors which conspire to create constantly varying fuel bed conditions which require constant variation in the air supply. These variant factors, including quality and size of the fuel, result in variations in the porosity of the fuel bed itself from time to time during the combustion thereof, and this, of course, in turn results in variation in the resistance of the fuel bed to the passage of air there-through. Where air is supplied at constant or substantially constant pressure beneath the fuel bed, it is obvious that as the resistance of the bed to flow decreases, a relatively larger volume of air will flow through the bed per unit of time than will flow during intervals when the resistance to air flow is relatively higher. The resistance to flow of the fuel bed usually occurs due to the formation of openings or voids in the bed, as by the rapid combustion of the fuel. Formation of such a void permits an excess amount of air to flow therethrough, thus starving the relatively denser portions of the fuel bed. Excess air thus passing through a zone of low resistance, increases combustion in the vicinity of such zone and tends, if anything, to further increase porosity and reduce resistance to air flow, with the result that ever-increasing volumes of aid tend to penetrate the fuel bed through such a zone. The effect is cumulative and quite undesirable for the reasons mentioned.

To overcome these problems and to promote, as far as possible, substantially ideal conditions under which combustion may take place, I have provided air flow control means of exceedingly simple and inexpensive construction, and which operates to reduce the volume of air delivered at substantially constant pressure as the resistance to air flow increases and vice versa. This phase of the invention is not, of course, restricted to the control of air delivered to furnaces but in fact may be utilized wherever it is desired to accomplish the control of a fluid in the manner mentioned.

As shown in the illustrated embodiment, more particularly in Figure 4 of the drawings, the combustion fluid, namely, air, is delivered to a chamber 191 as by means of a suitable fan or pump 187 driven preferably by an electric motor 189. The chamber 191 comprises a casing which, with

the blower 187 and the motor 189, is mounted on a base 193. This base may be formed with adjustable feet 195 similar to the feet 151 which support the frame on which the stoker driving mechanism is mounted.

The chamber 191 is formed with an opening 197 which communicates with the interior of the oven base 41 through a suitable opening formed in the side wall thereof, so that air delivered in the chamber 191 may pass thence to the under side of the grate sections 53 and 55. Within the chamber 191 I prefer to arrange the air flow control mechanism embodying my present invention, the same being illustrated in enlarged detail in Figure 12 of the drawings. This flow control mechanism comprises a shutter 201 movably mounted in the opening 197 to control the passage of air therethrough. The shutter is preferably tiltably mounted in the opening on a pin 203 so that the shutter may swing about its horizontal, medial axis. The shutter thus is substantially balanced and requires little force to swing it between open and closed positions in the opening 197.

The control mechanism also comprises a target 205 disposed substantially in line with the air discharge opening of the fan or blower 187. The target is thus in direct line with the air blast delivered by the fan and is supported freely to swing under the influence of the air blast. Means is provided to substantially uniformly and yieldingly resist the tendency of the target to move under the impact of the air blast so that the target in effect comprises an air velocity meter, the target moving toward the blower discharge as velocity decreases, and moving away therefrom in response to increased air velocity impinging thereon. By connecting the target to operate the control shutter 201, and by adjusting the control mechanism, I am able to provide for the flow of a substantially constant volume of air per unit of time through the opening 197, regardless of changes in the velocity of air delivered into the chamber 191 as a result of the operation of the fan 187.

The target and the shutter may be formed and arranged, interconnected and supported in any suitable or preferred manner. However, I prefer to arrange the target 205 as a circular, dished plate, preferably of sheet-metal, which is carried on a stem or arm 207 which is fastened to the target substantially at its center and extends in a direction normal to the plane of the plate forming the target.

The stem 207 is pivotally suspended in any suitable fashion, preferably on a pair of spaced, parallel arms 209 pivoted at spaced points on the stem 207 and tiltably supported preferably on the shafts 211. I prefer to make the arms 209 fast on the support shafts 211 and to journal the shafts 211 in a pair of spaced-apart, upright support plates 213 which may be anchored in the chamber 191 in any suitable fashion and between which support plates the stem 207 and the arms 209 are free to swing.

Any suitable means may be employed for urging the target toward the blower outlet, that is to say, in a direction countering the air blast, but I prefer to utilize a counterweight 215 adjustable on a stem 217 which in turn is fastened on and extends from one of the support shafts 211. By adjusting the counterweight 215 on the stem 217, I may vary the counter air flow urge applied to the target 205. One of the arms

211 may be provided with an additional adjustable counterweight 219 on a stem 221.

The weight 219 on stem 221 is designed to statically counterbalance the movable parts on the opposite side of the pivots, so that there will be no force countering the velocity head acting against the target 205 other than the counterweight 215. By thus balancing the force of gravity acting on the suspended parts of the mechanism, accurate control of the volume of fluid passing through the opening 197 may be had by the simple placement of weight 215.

The target 205 may be connected with the shutter 201 in any suitable fashion, as by means of the connecting rod 222, the opposite ends of which are pivoted, respectively, to the shutter, preferably at one end thereof, and to the target carrying stem 207.

The movement of the target 205 may also be utilized to accomplish a control function as, for example, the operation of an electric switch 223 mounted for operation by the movement of the shaft 211.

Blower 187 is of a type such that when the volume of air moved is reduced by restricting the discharge, the static pressure is increased, that is to say, the blower has a "rising characteristic." This produces an increased pressure in the plenum chamber below the fuel bed whenever, due to increasing fuel bed resistance caused by a thicker fire or finer sized fuel, the volume of air is reduced.

This "rising characteristic" effect in blowers when used generally with mechanical stokers, overcomes slight increases in fuel bed resistance and thereby maintains constant the weight (or volume) of combustion air.

The extent of increase in static pressure is limited, however, and becomes ineffective in maintaining a constant combustion rate, if or when the resistance passes a certain point, viz., the upper limit of pressure possible in the particular pan used. When such a condition occurs, the practical procedure is to stop the supply of fuel and allow the natural processes of combustion to reduce the quantity and consequent thickness of the fuel on the grate, until the resistance thereof is lowered to a degree permitting the normal rate of flow of combustion air.

In my design for effectuating this procedure mechanically and automatically, I attach an electric switch 223 to one of the pivotal shafts 211 in such a manner that angular movement of the shaft will cause the mercury switch to close or open, according to which way the shaft is rotated.

In practice, this switch 223 is so adjusted that the circuit is opened when the counterweight 215, due to lowered velocity head, is able to overcome such lowered velocity and rotate the suspended parts in a counterclockwise direction. At a predetermined point in this rotation, the switch 223 is tilted enough to cause the mercury to move and break the circuit. Inasmuch as the current operating the fuel feed motor passes through this switch, the breaking of the circuit stops the motor and coal feed stops.

Conversely, as soon as the fuel bed burns down a certain amount, its resistance to the flow of air will decrease, volume and velocity will be reestablished and the target 205 will move back, tilting the switch to the closed position when the coal feed motor will again operate.

It is possible to compute the necessary volume of air required for ideal combustion of the fuel

contents of the fire-pot. These contents, of course, are substantially constant during the operation of the furnace, and therefore the flow control mechanism may be adjusted to deliver the required volume of air beneath the grate sections for ideal combustion. If, for any reason, the resistance of the fuel bed to the flow of air decreases, as by the formation of a thin spot or by rapid combustion of fuel in a localized zone in the bed, the volume of air delivered by the blower will, of course, tend to increase. An increased volume of air passing through the blower discharge into the chamber 191 necessarily travels through the discharge opening at proportionately increased velocity. This circumstance immediately affects the target 205 which moves away from the fan discharge outlet and causes the shutter 201 to move toward closed position in the opening 197, thus reducing the area of said opening available for the passage of air therethrough, and reduces the amount of air delivered at such increased velocity, that is to say, maintains substantially constant the total volume of air delivered through the opening 197. Thus, although the velocity of air through the available opening may be increased or decreased, the total volume of air delivered to the fire-pot per unit of time remains constant to thereby at all times supply only the substantially exact quantity required for combustion under ideal conditions.

To supply over-fire air to the tuyère block 73, I may connect the block, outwardly of the oven, with the interior of the chamber 191 by means of a flexible hose 225.

The operation of the stoker and air supply mechanism may be controlled in any suitable or convenient fashion, but I prefer to control the blower motor 189 in response to heat requirements of the medium being heated, and to control the stoker operating motor 143 in turn in response to and as a function of the delivery of air from the blower 187. To this end, the blower motor 189 may be controlled by a thermostat influenced by the temperature of the water or space being heated, or as delivered from the oven through the conduits 35 or by a thermostat influenced by the temperature at a station heated by the fluid delivered through the conduits 35.

When the blower 187 is idle, the target 205, under the influence of the balancing means 215, will ride in position closely adjacent the discharge outlet of the blower 187. When the target is in such idling position, the switch 223 will be open. As soon as the blower is started in operation, as by a demand for heat evidenced by the actuation of the main or controlling thermostat, the target 205 will be immediately moved away from the blower discharge by the resulting air current emitted by the blower. The switch 223 is arranged to close in response to such movement of the target. The switch also may be connected to control the operation of the stoker drive motor 143 so that upon closure of the switch the motor 143 will start in operation to advance fuel on the grate and at intervals to charge fuel through the opening 77 and also to actuate the bed-stirring device 71.

As a result of this manner of controlling the apparatus, the fuel bed may continue under a condition of retarded or slow combustion as long as no heat is demanded by the master control thermostat, sufficient air penetrating to the fuel bed to maintain combustion at a minimum rate while the blower is inactive. The fuel bed thus

may remain in ignited condition over extended periods. As soon as heat is demanded, however, the blower first goes into operation and causes the fuel bed to burn rapidly. At the same time, the stoking equipment goes into operation to deposit a fresh charge of fuel upon the bed. The fresh charge of fuel, however, ordinarily will not be deposited for at least several minutes after the blower commences operation, at which time the fuel bed will have become thoroughly ignited in condition to receive and commence the combustion of the fresh charge of fuel.

It will be noted that the stoking mechanism may not operate when the blower is inactive, and that the blower starts in operation before the fuel feeding mechanism commences delivering fresh fuel and continues in operation until after the stoking mechanism has ceased to function. Thus, delivery of fuel in the absence of an adequate air supply and consequent choking of the furnace with fuel, is prevented.

In the event that excess quantities of fuel are delivered to the furnace to such an extent that the fuel bed becomes unduly thick, the increased resistance to air flow therethrough will result in a reduction in the velocity of air delivered by the blower. This in turn permits the target 205 to move toward the blower, thereby opening the switch 223 and discontinuing the fuel feeding operation until such time as the excess fuel shall have become consumed. The arrangement thus is well adapted to perform complete automatic regulation of the delivery of air, as well as of fuel, in order that combustion may take place under substantially ideal conditions at all times. The equipment is relatively simple and inexpensive to manufacture and is designed to provide continuous trouble-free stoker operation without requiring constant janitor service.

The front wall of the furnace which includes the openings for the fuel-feeding means, the tuyère block, the poker, the grate reciprocating shaft, and the air inlet, may be fabricated as an assembly unit for convenience, and is shown at 231. This wall is preferably provided with doors 233 therein on opposite sides of the fuel-feeding opening 77, in order to provide for inspection of the fire-bed and for the hand stoking of fuel into the fire-pot in emergency, as when the drive motor 143 or other parts of the feeding mechanism should fail. The stoking and blowing mechanism, which is arranged in front of the oven 11, may, if desired, as shown in Figure 8 of the drawings, be enclosed below the hopper 111 as by a preferably sheet-metal enclosure 235 provided with suitable doors 237.

The equipment, including the stoker, blower and oven 11, may be utilized, as shown in Figures 6 and 7, in conjunction with the boiler 239 of an existing heating system by positioning the oven 11 adjacent the existing boiler and connecting the flue outlet 82 of the oven, as by means of a connecting flue 241, with an opening, such as the stoking door of the boiler. The remaining openings of the existing boiler, such as the ash removal opening, should then be sealed so that all of the products of combustion developed in the oven 11 may pass through the flue 241 and into the existing boiler and circulated therein, escaping finally through the existing flue 243 of the boiler 239. In this way, substantially all of the heat remaining in the gases exhausted from the oven 11 may be utilized in heating water in the existing boiler, to the end that the temperature of gases in the flue 243 may be exceedingly

low. The water circulating chambers of the oven and of the existing boiler may be interconnected in any preferred manner.

As shown in Figure 6, the inlet pipes 37 of the oven 11 may be connected in parallel with the inlet pipes 245 of the existing boiler and both connected to the return conduit 247 of a water-circulating system. The hot water delivery pipes 35 of the oven likewise may be connected in parallel with the outlet pipe 249 of the existing boiler and to the hot water conduit 251 of a circulating system. I prefer, however, as shown in Figure 7, to connect the return conduit 247 of the system only to the inlet pipes 37 of the oven, the oven outlet pipes 35 being connected with the inlet pipes 245 of the existing boiler, the outlet pipe 247 of which is in turn connected to the hot water pipe 251 of the circulating system. This method is applicable whenever a circulating pump is used.

The arrangement shown in Figure 7 delivers circulating water at minimum temperature into the chambers 27 where the combustion of the fuel develops a maximum temperature for the rapid heating of the water, the relatively cool water in the chambers 27 serving to maintain the fire-pot plates 25 at a safe temperature. The circulating water receives a maximum amount of heat while in the oven but of course receives additional heat in passing through the water circulating system of the existing boiler.

I may also utilize the oven in conjunction with an attachment 253 in order to provide a complete boiler adapted for initial installation, as distinguished from the conversion arrangements illustrated in Figures 6 and 7. The attachment 253 comprises a casing 254 of a size adapted for mounting upon the top of the oven 11. This casing comprises insulated top and side walls and a bottom wall adapted to rest upon the top of the oven. Within the casing are arranged an upper header 255 and a lower header 257 preferably extending along one side wall of the casing 254. The opposite side wall of the casing is provided with a preferably outwardly opening door 259 extending substantially throughout the entire side of the casing to provide access to the interior thereof.

Between the headers 255 and 257 are arranged a plurality of tubes 261, the opposite ends of which are sealed in and communicate with the interior of the headers 255 and 257. These tubes extend from the lower header 257 toward the door 259 and are reversely bent adjacent the door, extending thence to the upper header 255. A preferably horizontal partition 263 is arranged in the casing between the upper and lower portions of the tubes 261. This partition is sealed on the wall of the casing between the headers and extends thence between the legs of the tubes 261 to the bent portions thereof, forming a baffle dividing the chamber into an upper and a lower compartment.

The partition 263 has an edge portion 265 perforated to receive the tubes 261 therethrough and the door has a preferably ledged portion to engage and seal with the edge of the portion 265 when in closed position. This arrangement permits access to the space above and below the partition, when the door is open, for the purpose of clearing the same.

The casing 254 at one end is provided with an opening 266 communicating with the portions thereof below the partition 263, and a connecting flue 267 is provided for connecting the gas

outlet opening 82 of the oven with the opening 266 in the boiler attachment. The hot gases thus discharged from the oven are delivered into the casing 254 around the lower legs of the tubes 261.

The partition 263 is provided with a series of openings 269 along its edge remote from the opening 266 so that the hot products of combustion entering through the opening 266 are caused to travel around all of the lower legs of the pipes 261. The hot gases then penetrate the openings 269 and pass into the chamber above the partition 263 and circulate around the upper legs of the pipes 261, escaping from the casing 254 through the outlet opening 271 which, of course, may be connected with a suitable flue 273.

The water outlet pipe 35 of the oven may be connected by means of suitable couplings 275 with the lower header 257 so that water from the boiler may be passed through the pipes 261 and into the upper header 255, from whence it may be delivered, as through a conduit 277 forming a part of the hot water circulating system in which the heating equipment is connected. The return pipe 279 of such system may, of course, be connected to the oven inlet pipes 37. In such an arrangement, either one or the other of the pipes 35, whichever is most convenient, may be connected with the header 257, or both of the pipes 35 may be so connected, if desired.

It will be seen from the foregoing that the residual heat in the gases exhausted in the opening 82 from the oven are utilized in additionally heating the water circulated through the oven, to the end that substantially all of the available heat derived from the combustion of the fuel in the fire-pot may be used.

The stoking equipment of my present invention may also be used for other purposes than the heating of water, and in Figure 11 of the drawings I have shown the mechanism as assembled in a hot air furnace. In this embodiment the fuel-feeding mechanism 80, the tuyère block 73, the fuel bed stirrer 71, the stationary and movable grate, and also the ash conveyor and the air delivering and regulating means, including the mechanism for actuating the same, as well as the base 41, the plates 25 defining the fire-pot, the front wall 231, the back stop 61, and the shutter 87, may duplicate the mechanism heretofore described. The hot air furnace, however, comprises a structure 281 providing air conduits and channels for the circulation of air to be heated in heat-exchange relationship with the hot gaseous products of combustion of fuel in the fire-pot, and includes a casing on and over the fire-pot, including a hot air chamber 283 communicating with a delivery conduit 285 under the control of shutters 287 which when closed prevent the delivery of air from the chamber 283 into the conduit 285.

Hot air delivered through the conduit 285 may circulate to a zone or station to be heated, and may be returned thence through a return conduit 289 to an inlet chamber 291 forming a part of the heating system. In the chamber 291 the air may be washed, dried, humidified or otherwise treated, and drawn thence through a blower 293 delivering into the heating chambers of the furnace. I prefer to pass the air from the blower 293 into chambers 295 forming the hollow walls of a casing, the interior of which is provided with a partition 297. This partition 297 defines a tortuous passage in heat-exchange relationship with the chambers 295. The inlet

and outlet ends of the passage are disposed in communication with the outlet passage 299 of the furnace, and I provide a shutter 301 under the control of a thermostatic relay 303 in position in the flue to be influenced by the temperature of gases escaping therethrough. If such gases exceed a predetermined maximum temperature, the thermostat operates the shutter 301 to direct the gases into and through the tortuous passage 298 before delivering the same to the flue in which the thermostat 303 is located. If the gases in said flue are below a predetermined temperature, then the thermostat operates the shutter 301 to permit the gases to be delivered directly from the furnace to the flue, by-passing the tortuous channel 298. In this manner, if flue gases are at an excessive high temperature, indicating that all of the available heat has not been abstracted, the gases are circulated in a manner to preheat the cold air delivered from the intake chamber 291 into the heating chambers of the furnace, thereby promoting maximum heating efficiency.

In Figure 11 I have also shown an arrangement in conjunction with the hot air furnace 281 for maintaining a continuous supply of hot water for domestic or other purposes. To this end I have provided a casing 305 containing a pair of spaced headers 307 with water pipes 309 extending therebetween. These headers are connected through the casing with a hot water supply tank 311. The upper portion of the casing 305 is connected by means of a duct 313 with the hot air chamber 283 of the furnace. The lower portions of the heating chamber 305 are connected with the air inlet chamber 291 by means of the connecting conduit 315. Hot air may thus be circulated directly from the chamber 283 into the chamber 305 and around the water pipes 309, thereby heating the water which circulates by thermo-syphon action between the headers and the storage tank 311. The spent air, after heating the water pipes 309, returns again to the furnace through the chamber 291 and the fan 293. In such an installation, a control thermostat under the influence of the temperature prevailing in the space to be heated by air delivered to the conduit 285, may be connected to actuate the shutters 287, so that upon heat demand the shutters 287 may be opened and hot air delivered to the station to be heated; for example, the room or rooms of a dwelling house. At the same time, the stoker may be controlled to maintain only a desired temperature of air in the chamber 283. This may be accomplished by placing the blower motor 189 under the control of a thermostat influenced by the prevailing air temperature in the chamber 283. Thus, even during the summer months, when there is no demand for the delivery of hot air through the conduit 285, the shutters 287 remaining continuously closed, the stoker may be maintained in operation for the purpose of maintaining a hot water supply. Under such conditions the stoker will operate most efficiently, merely to maintain the fuel bed in ignited condition to heat the minimum quantity of air required to maintain the hot water supply at a desired temperature.

My present application comprises a continuation in part of my copending application for patent on Stoker, Serial No. 733,260, filed June 30, 1934, now issued as Patent No. 2,214,740, dated September 17, 1940, and contains subject-matter

of invention divided from my aforesaid copending application.

It is thought that the invention and numerous of its attendant advantages will be understood from the foregoing description and it is obvious that numerous changes may be made in the form, construction and arrangement of the several parts without departing from the spirit or scope of the invention, or sacrificing any of its attendant advantages, the form herein described being a preferred embodiment for the purpose of illustrating the invention.

The invention is hereby claimed as follows:

1. A furnace comprising a combustion chamber for fuel including means to maintain a substantially horizontal bed of fuel therein and means disposed in spaced relation above the horizontal fuel bed and operable at intervals after the charging of fresh fuel to said bed to stir the bed, including the fresh fuel, to mingle the fresh fuel with the previously ignited fuel in the bed in order to promote ignition and prevent the formation of coke masses.

2. A furnace comprising means forming a back stop wall, a substantially horizontal grate reciprocable with respect to said wall to advance fuel on said grate during the retractive movement thereof beneath said wall and to advance the fuel away from said wall during the projective movement of the grate under the wall whereby fresh fuel deposited on the grate adjacent said wall when the grate is substantially at the forward limit of its projective movement with respect to the wall may be advanced on the grate to form a substantially horizontal progressive fuel bed thereon, and means operable above said bed at intervals to stir the bed, including the fresh fuel, in order to mingle the fresh fuel with the previously ignited fuel of the bed and thereby promote ignition of the fresh fuel and uniform combustion conditions in the bed while minimizing formation of coke masses therein.

3. A furnace comprising means including a casing forming a fire box providing a combustion chamber having a fire-pot, feeding means for delivering fuel and a fluid combustion supporting medium to said fire-pot, said feeding means being mounted on an end wall of said casing, means forming conduits and chambers in said casing comprising a system for the circulation of a liquid heat transfer medium in heat exchange relationship with products of combustion of fuel burned in said fire box, including heat absorbing hollow members forming the roof of said combustion chamber, and a pair of chambered members enclosing all four walls of said fire-pot and interconnected with said heat-absorbing members to form said circulating system.

4. A fuel stoker comprising feeding means to deliver fuel into a furnace, advancing means for carrying the fuel in a horizontal bed through the furnace, bed poking means mounted in the furnace wall above said bed for agitating the fuel during its passage through the furnace, and means to actuate the feeding, advancing and agitating means comprising a frame forming a mounting for an electric motor, a motor on said mounting, a shaft journaled in said frame and carrying a fly-wheel, means to drivingly connect the motor on said shaft, individual driving elements on said frame and drivingly connected with the feeding, the advancing and the bed poking means, and means forming a driving connection between the several driving elements and said shaft, at least one of said connection-form-

ing means providing a driving ratio different from that provided by another of said connection-forming means.

5. In a furnace, the combination of means forming a grate carrying a fuel bed, means for moving the grate to move the fuel bed longitudinally with respect to the grate while undergoing combustion whereby to discharge the ash deposited from said combustion at one end of the bed, bed poking means to create a depression in the surface of the bed at the other end, and means for depositing a fresh quantity of fuel in the depression formed by said bed poking means.

6. A furnace comprising a grate carrying a fuel bed undergoing combustion, means for progressively moving the fuel bed toward one end of the grate, bed poking means overlying the bed and operable to create a depression in the surface of the fuel bed at one end, means to discharge the ash deposited from said combustion at the opposite end of the grate, and means for depositing a predetermined quantity of fuel in the formed depression in the bed.

7. A furnace comprising a fire pot, hollow arched means disposed above said fire pot and forming a water circulating chamber, an arched refractory underlining therefor, oppositely and inwardly inclined wall members extending downwardly from the opposed outer ends of the arched member, the lower portions of such inclined walls connecting with the fire pot, there being chambers along the opposite sides of the fire pot, and means interconnecting said latter chamber with said arched member, and means for circulating water through said latter chamber and connecting means.

8. A furnace comprising a fire pot, a hollow arched member disposed above said fire pot and forming a water circulating chamber having an arched refractory underlining therefor, oppositely and inwardly extending metallic plates extending downwardly from the opposed outer ends of the arched member, the lower portions of such metallic plates bearing upon and being supported by the upper edges of the fire pot, the opposite side walls of the fire pot providing chambers, and means interconnecting said chambers and said arched member, and means for circulating cooling means through said chambers and interconnecting means.

9. In a furnace the combination of a substantially horizontal grate carrying a fuel bed undergoing combustion, means for progressively moving the fuel bed toward one end of the grate, means to deposit ashes discharged from said combustion at said one end of the grate, poker means adapted to form a cup-shaped depression in the top of the fuel bed opposite the end of the bed from which the ash is discharged, and means for discharging a predetermined quantity of fuel onto the bed at the end in which the depression is formed whereby a portion of such fuel is discharged in said depression.

10. In a furnace the combination of means forming a substantially horizontal grate carrying a fuel bed undergoing combustion, means for progressively moving the fuel bed from the forward to the discharge end of the grate, means for discharging the ash deposited from said combustion at the discharge end of the grate, and bed poking means reciprocable through a wall of the furnace at the forward end of the bed and operable to advance the upper portion of the bed at one end thereof toward the ash discharging end of the bed, and means at the forward end

of the bed for depositing a charge of fuel onto the top of the bed.

11. In a furnace in combination with a substantially horizontal grate carrying a fuel bed undergoing combustion, means for progressively moving the fuel bed from the forward end of the grate to the discharge end thereof, means to discharge ash deposited from said combustion at the discharge end of the grate, poker means mounted in the furnace wall at and above the forward end of the bed and adapted to project downwardly into the bed to stir the same, and means disposed in the wall of the furnace at the forward end of the bed and above the bed poking means for depositing a predetermined quantity of fuel onto the bed substantially immediately below the bed poking means.

12. A furnace comprising a grate carrying a fuel bed undergoing combustion, means for progressively moving the fuel bed from the forward end of the grate toward the discharge end of the grate, means at the discharge end of the grate to discharge ash deposited from said combustion, the wall of the furnace at the forward end of the grate having an opening, means in said opening adapted to oscillate with respect to the adjacent walls of the furnace, bed poking means mounted in said oscillatable member and reciprocable with respect to said oscillatable member, and means for oscillating and reciprocating said member and said bed poking means whereby to cause said bed poking means to partially withdraw from the furnace bed, and thence to project downwardly into the bed, and thence move upwardly, and thence again to partially withdraw from the bed, whereby to agitate the bed and form a depression in the bed, and fuel feeding means associated with the furnace wall above said bed poking means and adapted to discharge a charge of fuel onto said bed directly below said bed poking means.

13. A furnace comprising a grate carrying a fuel bed undergoing combustion, means for progressively moving the fuel bed from the forward end of the grate to the discharge end of the grate, means at the discharge end of the grate to discharge the ash deposited from said combustion, bed poking means mounted in the furnace wall above said bed, means for oscillating said poking means in a vertical plane and for reciprocating said poking means relatively to said bed, whereby at times to cause the substantial withdrawal of the poking means from the vicinity overlying the bed, and whereby at other times to cause the depression of said poking means into the bed and the elevation of the poking means to agitate the bed, and means actuated during the withdrawal portion of said poking means relatively to the bed to discharge a quantity of fresh fuel onto the bed at a zone thereof below said bed poking means.

14. A furnace comprising a grate carrying a fuel bed undergoing combustion, means for progressively moving the fuel bed from the forward end of the grate to the discharge end of the grate, means at the discharge end of the grate to discharge the ash deposited from said combustion, means to pass air from the bottom of the grate upwardly through the bed, bed poking means mounted in the wall of the furnace at the forward end of the bed and adapted to reciprocate through the wall of the furnace from a point overlying the bed, there being means likewise to oscillate the poking means in a vertical plane to cause the poking means to project into

the bed and then to move upwardly relatively to the bed to agitate the same, means disposed in the forward portion of the furnace wall above the poking means to create an air blast across the top of the bed, and means disposed in said furnace wall above the air blast for dumping a quantity of fuel onto the bed at the zone of operation of said poking means.

15. In combination, a furnace, a fuel-bed undergoing combustion, means for progressively

moving the fuel-bed from front to rear, means for continuously removing the ash formed by such combustion, a poker above the fuel bed adapted to stir said fuel bed, means for blowing air into the furnace above said poker to promote combustion, and means above said air admission openings for injecting fresh fuel into the furnace and onto the forward part of said fuel bed.

JOSEPH HARRINGTON.