Aug. 20, 1946. W. M. SCHWEICKART ET AL 2,405,982

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Original Filed Aug. 28, 1937 5 Sheets-Sheet 1

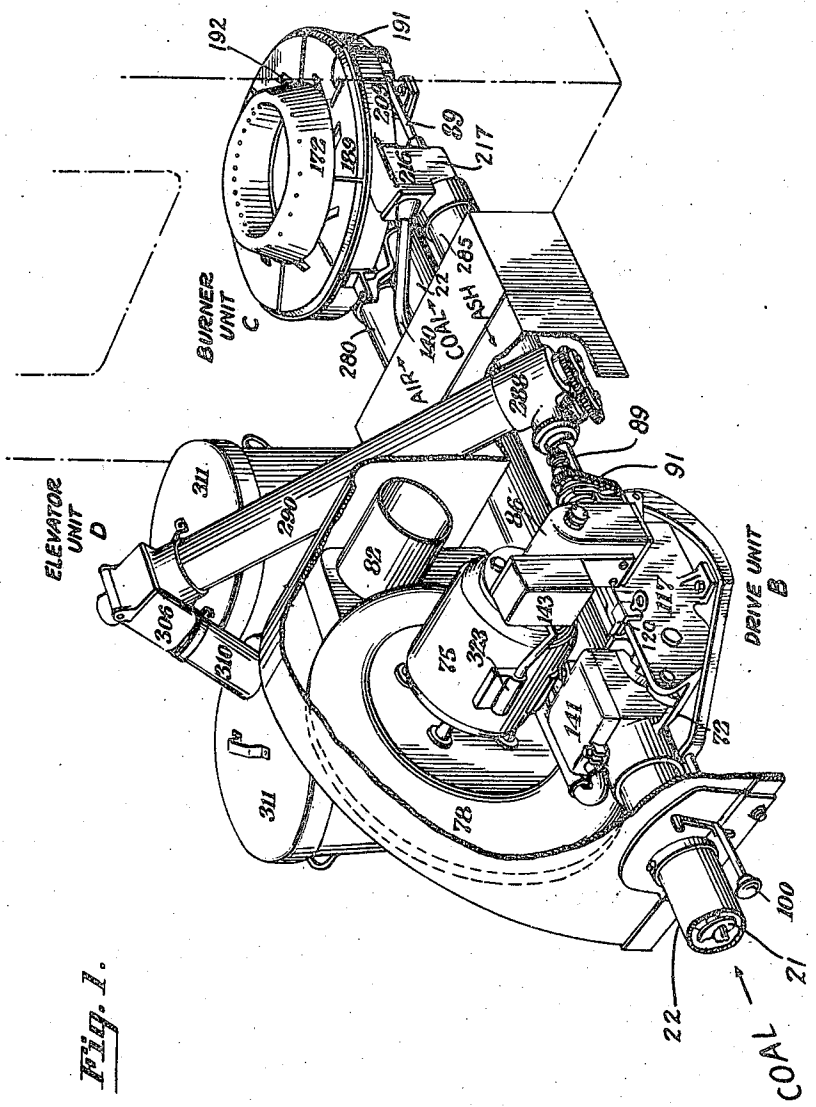


Fig. 1.

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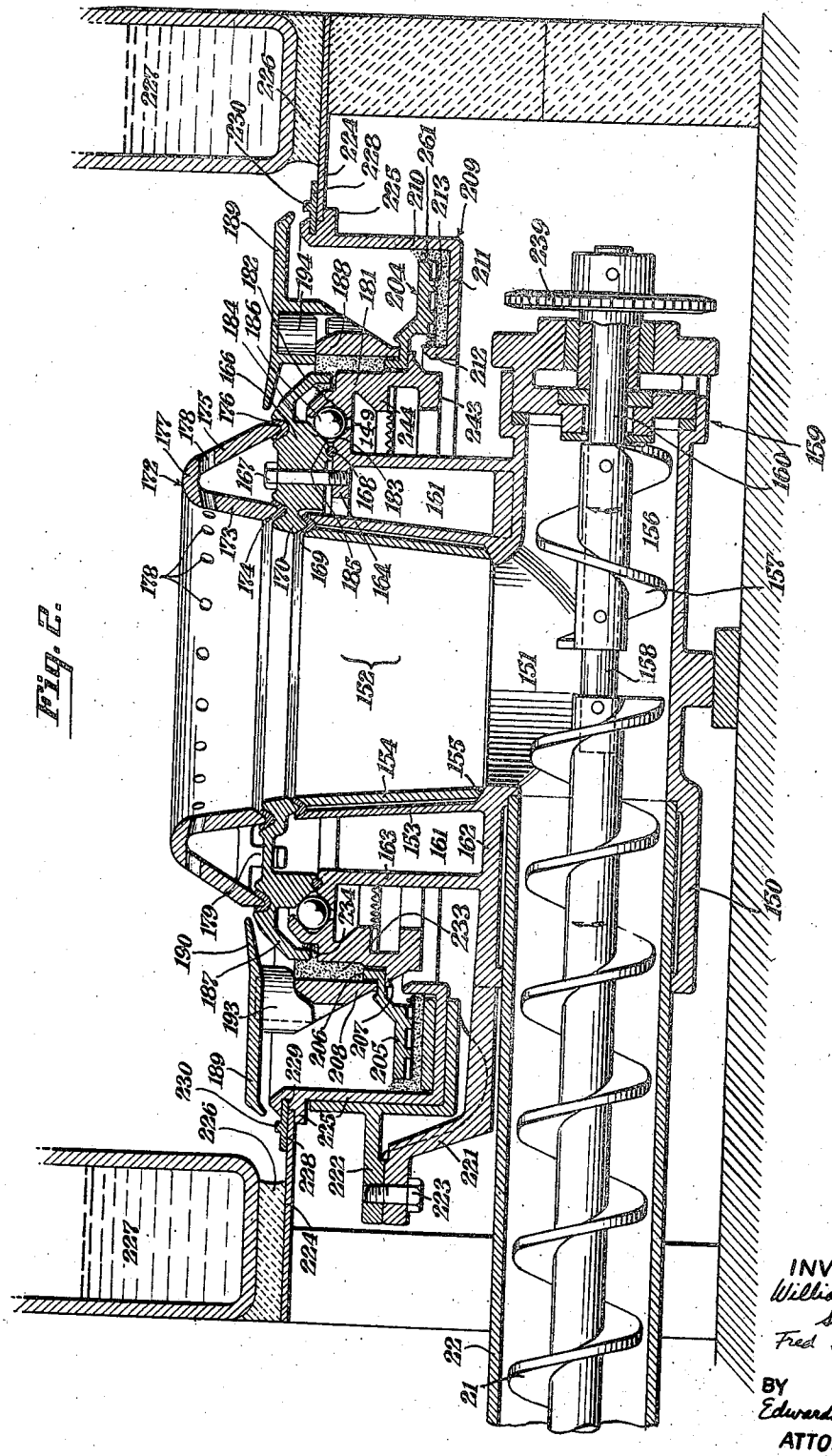


Fig. 2.

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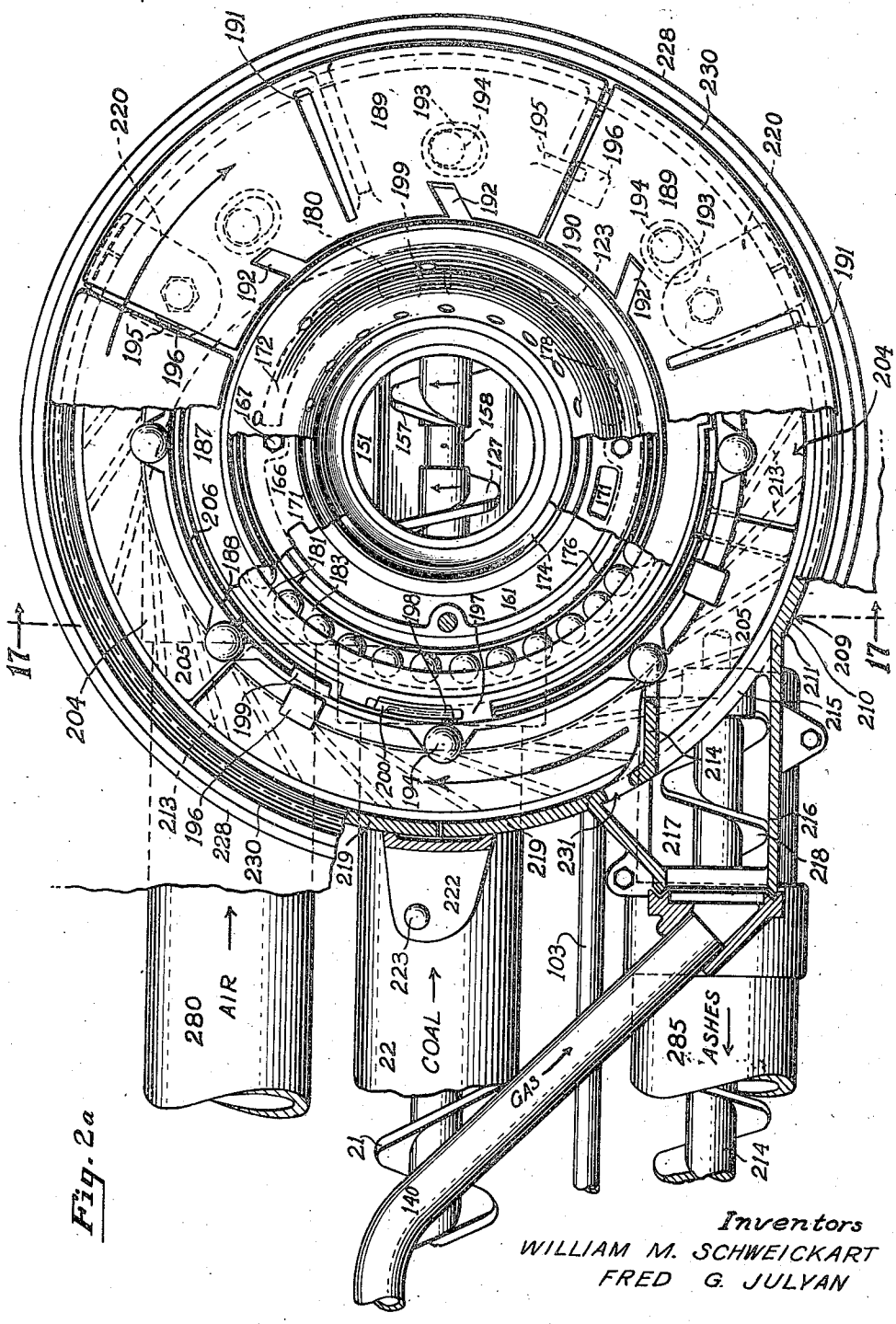


Fig. 2a

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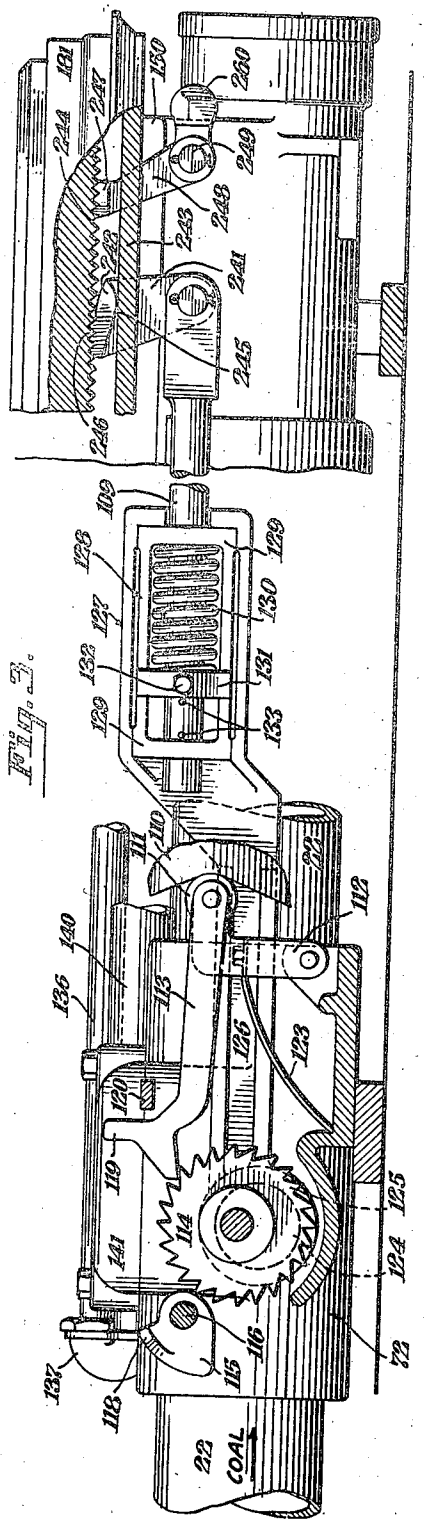


Fig. 3.

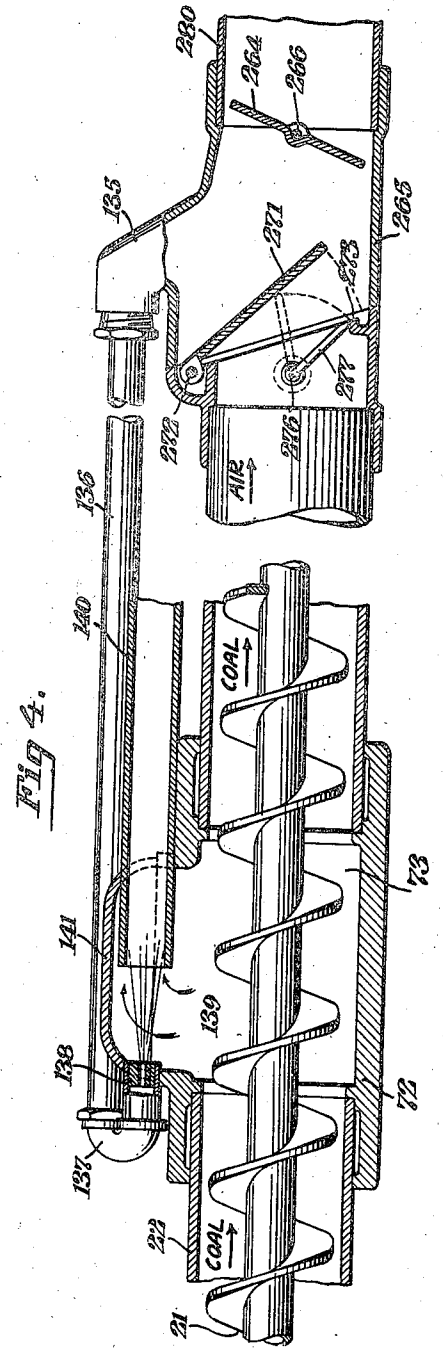


Fig. 4.

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Original Filed Aug. 28, 1937 5 Sheets-Sheet 5

Fig. 7.

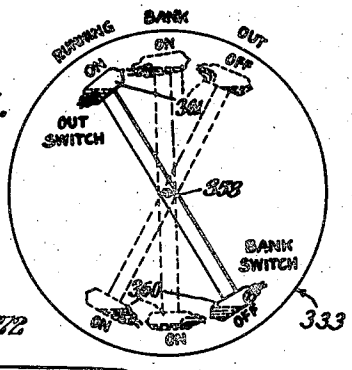


Fig. 5

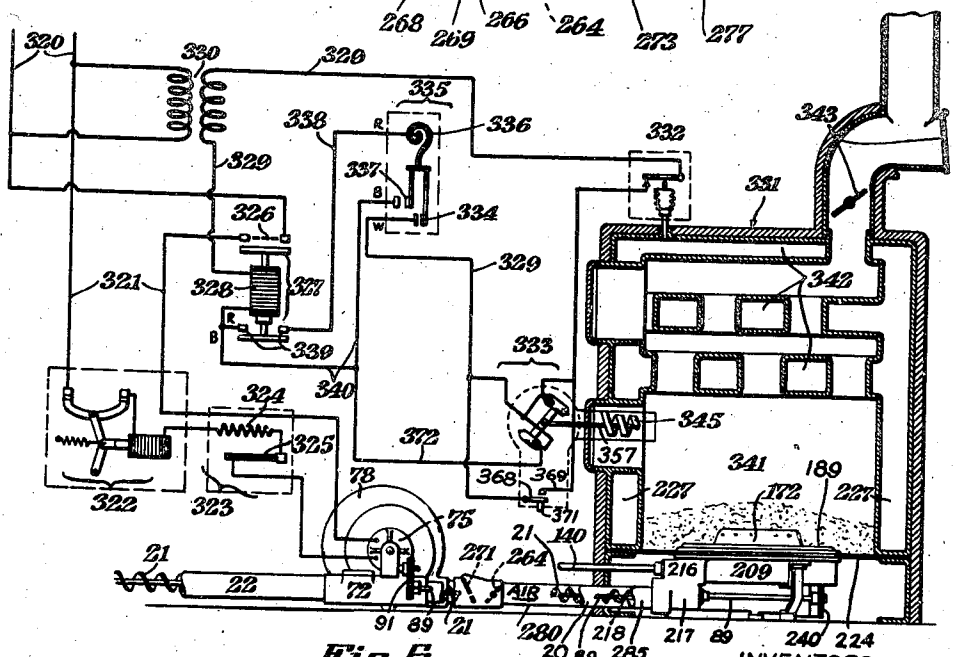


Fig. 6.

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Patented Aug. 20, 1946

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UNITED STATES PATENT OFFICE

2,405,982

STOKER

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Original application August 28, 1937, Serial No. 161,494, now Patent No. 2,306,189, dated December 22, 1942. Divided and this application August 8, 1941, Serial No. 405,894

6 Claims. (Cl. 110—45)

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This invention relates to improvements in automatic coal burners.

A primary feature of this invention is the provision of a burner that will burn different types of coking coal efficiently and economically, in small domestic installations as well as in larger furnaces, and which is adapted to utilize various sizes of coal down to slack.

The burner is arranged to provide a novel combustion zone properly related to the feed so as to assure efficient coking, ignition and combustion of the solid and gaseous components without danger of back coking or clinker formation at points that would interfere with the coal feed and efficient combustion, arranged moreover to avoid the back flow of gas under appropriate operating conditions.

Another object is to provide a burner that will have high combustion efficiency, particularly when burning bituminous coal. The burner is arranged to produce a relatively thin bed of burning fuel, and to eliminate difficulties with clinker formation and ash accumulation which would tend to interfere with proper combustion. The ash removal mechanism removes the ashes and small clinkers rapidly and uniformly without interference with the fire bed, conveying them continuously to an ash discharge.

Another purpose is to improve the efficiency and control of the air supply to the fire. The forced draught is introduced in a zone at the top of the retort and outward over the grate, and is provided with an adjustment to meet the conditions of each installation as well as the varying fusion points and other characteristics of combustion of different types of coal. Under banking conditions provision is made for independent regulation of the air drawn by natural draught, permitting the efficient and certain maintenance of a suitable fuel bed.

An efficient electrical control system has been provided, which may be incorporated in combination with standard proven electrical devices. In general, the drive unit is controlled from the room thermostat and is protected by safety devices. An important feature of the invention is the provision of an efficient, sensitive and reliable banking control cooperating with the burner construction and the banking air control to assure the maintenance of a minimum fire by automatically providing fuel and forced draught accurately as needed.

An important object is to provide apparatus embodying features set forth herein which is simple, compact, strong, suitable for installation under widely varying conditions and economical in operation.

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Other objects and advantages of the invention will appear from the following description considered in connection with the accompanying drawings in which,

Fig. 1 is a perspective view of the assembly;

Fig. 2 is a longitudinal vertical section through the burner;

Fig. 2a is a plan view of the burner with parts broken away;

Fig. 3 is a detailed side elevation of the grate drive;

Fig. 4 is a fragmentary view of the coal and air feed tubes and air control;

Fig. 5 is a fragmentary side elevation of the blower and air control viewed from the side of the assembly which is to the rear as shown in Figs. 1 and 4;

Fig. 6 is a diagram of an electrical control arrangement schematically applied to the burner assembly installed in a domestic furnace; and

Fig. 7 is a diagram illustrating the operation of the banking control switch shown in Fig. 6.

In the specific embodiment shown (Fig. 1) the apparatus comprises a drive unit B, a burner unit C, and an ash discharge unit D.

A coal collector unit, not shown, is positioned in the coal bin and supplies coal to the coal feed tube 22 in which is positioned the coal screw 21, with the collector unit driven from the coal feed screw 21. A suitable collector unit is shown and described in our Patent No. 2,233,085 granted February 25, 1941.

Where the conveyor tube 22 requires a bend, this is preferably made as an angle, for instance, a right angle, through a feed knuckle (not shown) provided for conveying the coal around the angle.

The drive unit B includes the motor with its controls, the blower and air supply, the drive for the coal feed and ash discharge screws, the grate rotor drive and gas withdrawal construction.

The drive assembly is mounted on a base 72 provided with a longitudinal cylindrical passage for the coal to which sections of the coal feed tube 22 are connected and through which the last section of the coal feed screw 21 passes. Supported upon the base 72 is the motor 75 having the rotor 77 of the blower 78 secured to one end of its shaft. A housing 80 surrounds the blower air inlet, and air is admitted to the housing by the air inlet tube 82. The other end of the shaft of motor 75 is connected to the ash removal shaft 89 through reduction gearing contained within the casing 86 and through a sprocket and chain drive including

the chain 91 which engages a sprocket mounted upon the ash removal shaft 89. These connections may include a clutch operable from the handle 100 extending outside of the drive unit cover.

The burner unit C hereinafter described includes a rotating grate structure which is intermittently operated by reciprocating shaker rod 109. A suitable mechanism is provided for imparting such reciprocating movement at the proper rate. In the form shown best in Fig. 1, the sprocket engaged by chain 91 and mounted on ash removal shaft 89 is provided with a suitable cylindrical face cam 110 engaging cam roller 111 rotatably mounted on the upper end of rocker arm 112 pivoted at its lower end to base 72. Pawl 113 is pivoted at one end on rocker arm 112 with its other end engaging ratchet 114 which is rotatably mounted on base 72 and is prevented from backlash by a silent detent cam 115 having an offset pivotal mounting 116 on vertical web 117 of the base 72 arranged so that the unbalanced weight of cam 115 will maintain its cam surface in locking engagement with the teeth of ratchet 114 to prevent backlash, lug 118 on cam 115 being positioned to engage the upper face of web 117 when cam 115 is rotated out of engagement with ratchet 114, preventing cam 115 from being accidentally jarred or otherwise shifted into inoperative position.

Means for regulating the throw of pawl 113 and thereby varying the actuation of the rotary grate structure includes an upward extension 119 on pawl 113 positioned to engage stop lug 120 adjustably mounted as by a slot and a locking screw on web 117 to control the length of the return throw of pawl 113. The lug 120 acts to swing the pawl 113 downward into engaging position with the ratchet 114. Cam roller 111 is suitably maintained in engagement with cam 110, as by leaf spring 123 bearing against base 72 and rocker arm 112.

The intermittent movement of ratchet 114, which in the form shown is actuated twice during each revolution of sprocket engaged by chain 91, is suitably transmitted to the ash grate, as by eccentric 124 mounted on ratchet 114 and carrying eccentric strap 125 on connecting rod 126 which may be connected to shaker rod 109 by a suitable shock absorbing arrangement. For this purpose rod 126 may terminate in frame 127 in which the spring cage 128 is mounted, including end flanges 129 in which shaker rod 109 is slidably mounted, between which flanges shock absorber spring 130 is set under initial compression and maintained in compressed condition by compression collar 131 held in suitable position on rod 109 by stop pins 133 projecting from shaker rod 109 in position to engage the adjacent flange 129 and collar 131 under pressure of spring 130. Collar 131 is held against rotation by engagement with cage 128, and operates through clamp screw 132 to hold rod 109 in adjusted position. Cage 128 is preferably mounted removably on frame 127. This shaker rod spring construction will allow the stoker to run even though the grates are jammed, the rest of the mechanism continuing to function normally and the placing of the absorber spring 130 under initial compression is important to quiet operation.

This rotary grate structure surrounds an inner retort of the burner unit C of the type in which the coal is forced upwardly through the bottom of the burner retort or pot structure, burning in the upper portion thereof and traveling over the edge onto the grate structure through which the ashes pass. In the arrangement disclosed the section of the coal feed tube 22 extending from the drive unit base 72 is clamped in the burner body 150 and supplies coal to the throat 151 at the bottom of the fire pot 152, which preferably is tapered outwardly from throat 151.

The lower portion of pot 152 may consist of a pot wall 153 integral with burner body 150, and a frusto-conical pot liner 154 having a smooth, preferably enameled inner surface, fitting within wall 153 and resting on a suitable ledge 155 to provide a smooth continuation of the surface of throat 151.

A pocket 156 extending beyond throat 151 concentric with the axis of coal feed screw 21 has mounted therein a reverse screw 157. One end of this reverse screw is connected to the adjacent section of feed screw 21 by a connecting shaft 158 and the other end is connected to a terminal shaft 160 which extends through the bearing 159 at the end of pocket 156, the projecting end of shaft 160 having a sprocket 239 mounted thereon by means of which the terminal shaft 160, reverse screw 157, connecting shaft 158, coal feed screw 21 and the mechanisms of the coal collector unit (not shown) are driven.

To provide for supply of air to the burning fuel, inlet air chamber 161 surrounds the pot wall 153, formed by bottom wall 162 and outer wall 163 and generally open at the top.

A suitable upper margin for the pot 152 is provided preferably in separable form and is generally referred to as a retort. While the retort may be formed and mounted in various ways, it is advantageous to provide a retort base ring 166 which may perform a number of functions. In the form illustrated ring 166 is held in position by bolts 167 threaded into lugs 164 on outer wall 163 of air chamber 161, and may have a sealed engagement therewith by employing an asbestos gasket 168. Base ring 166 may likewise form a closure for the junction between pot wall 153 and pot liner 154, the form shown having an annular ridge 170 engaging a seal ring 169 of asbestos or the like located on the suitably beveled edges of wall 153 in liner 154. The ring 166 is provided with openings 171 (Fig. 2a) to permit the air from air chamber 161 to pass upwardly to the retort.

The retort 172 is removably mounted on the base ring 166 and forms a continuation of the pot 152, being provided with air outlets or tuyères for furnishing air in the most advantageous zone for efficient operation. In the form shown the retort 172 is provided with an inner wall 173 forming a continuation of pot 152 and the inner face of base ring 166, and resting on an asbestos gasket 174 in a suitable depression in base ring 166. The outer wall 175 slopes outwardly and downwardly to the grate structure, and rests on an asbestos gasket 176 in a suitable depression in base ring 166. The retort crown 177 provides an integral smooth curve between walls 173 and 175, and is preferably relatively narrow to prevent retention of material thereon.

Suitable tuyère openings 178 extend through the retort 172 at appropriate points. It has been determined that the most advantageous construction comprises provision of a series of tuyère openings 178 in the upper part of the inner retort wall 173, preferably sloping slightly downward, and a smaller number of tuyère openings 178 extending through the upper part of the outer retort wall 175 at about the same level. The

retort 172 is held in place by means which preferably permits its ready removal and replacement, such as hooks 179 which may be cast integral with the retort walls 173 and 175, and which engage the lower face of the retort base ring 166 through suitable retort lock openings.

The rotary grate structure located around the retort 172 is adapted to receive the burning coal and ashes which flow outwardly over the retort, sifting the ashes into a suitable annular receiver in which they are carried around the burner to a point of discharge. The various parts are carried by a rotor ring 181 which is rotatably mounted on the pot 152. The mounting of rotor ring 181 on ball bearings is such that the parts may be readily assembled, the bearing will be easily accessible and the structure will function smoothly under the substantial variations in temperature and consequent expansion and contraction of the parts encountered under these conditions, the ball race being formed by cast surfaces. The arrangement comprises a ball race groove 182 in the inner face of the upper part of rotor ring 181. An upwardly beveled flange 183 on wall 163 and a downwardly beveled flange 184 on base ring 166 are arranged to provide a ball race groove 185 cooperating with groove 182 to retain the balls 186. By the removal of retort base ring 166, the balls 186 will be readily accessible; and as the faces of grooves 182 and 185 are substantially at 90° to each other, their spacing permits smooth unobstructed travel of the balls under various conditions of expansion due to changes in temperature.

The outer margin of the retort base ring 166 is provided with an apron 187 extending outwardly and downwardly over the upper edge of the rotor ring 181, apron 187 providing a smooth path of flow for ashes around the ball bearing structure and beyond the outer face of rotor ring 181, the adjacent faces of apron 187 and rotor ring 181 being suitably shaped to provide a relatively slight clearance and prevent substantial amounts of ashes from reaching the balls 186, the opening 149 below said balls permitting any ashes or the like to fall out of the raceway. The annular pocket 233 below apron 187 accumulates ashes and an inner seal of ashes 234 is formed at the lower edge of the apron, restricting the passage of air to the space above the grate.

In the embodiment shown a grate ring 188 is utilized, removably mounted on rotor ring 181 and adapted to receive removable grate segments 189. These segments are preferably flat integral castings provided with an inner flange 190 extending into close relationship to retort base ring apron 187. Suitable slots permitting ashes to pass the segments 189 include the radial slots 191, restricted marginal slots 192 in flange 190, preferably angled inwardly in the direction of rotation, and the spaces left between the periphery of each segment 189 and the adjacent parts.

Segments 189 are mounted on the grate ring 188 in suitable manner securely held in operation but permitting ready removal and preferably adapted to construction by casting. In the form shown each grate segment 189 is provided with two downwardly extending slightly elongated annular sockets 193 adapted to receive supporting studs 194 on the upper margin of grate ring 188. An integral locking tongue on the advance end of each segment 189 extends beneath a locking lug formed on the upper edge of grate ring 188. Grate ring 188 may extend to a point higher than the lower edge of apron 187, the intervening space normally filling with ashes which form the air seal across the narrow slot between the apron margin and ring 181.

The grate ring 188 is suitably mounted on rotor ring 181 to permit ready removal without affecting the rigidity and reliability of the mounting under service conditions. A suitable arrangement is indicated best in Fig. 2a, and includes beveled wedge lugs 197 on rotor ring 181 engaging beveled wedge lugs 198 on grate ring 188 to force the grate ring downwardly into proper position by rotating it relative to rotor ring 181; stop lugs 199 on rotor ring 181 and removable locking slugs 200 fitting between stop lugs 199 and wedges 198 when the grate ring 188 has been turned into proper position.

The grate rotor structure is preferably provided with an ash table 204, receiving ashes which pass the grate segments 189 and conveying such ashes to a point of discharge. A plurality of ash table segments 205 forms a continuous annular platform around rotor ring 181 adapted to receive the ashes. Each table segment 205 is provided with an inner flange 206 extending inwardly and upwardly, resting on an annular shoulder 207 on rotor ring 181, the abutting edges of the table segments 205 being preferably in overlapping relationship to provide continuity and accurate registration. The lower rim 208 of grate ring 188 bears against flanges 206 and securely locks the table segments 205 in firm fixed position when the rotor ring and grate ring wedge lugs are interlocked as above described. Table segments 205 may be accurately located by positioning lugs on rotor ring 181 engaging corresponding positioning recesses in segments 205.

An ash trough extends around and below the ash table segments 205, for the direct discharge of ashes from the ash table. The ash trough 209 has an outer wall 210, a bottom 211 extending beneath and slightly spaced from the table segments 205, and an inner flange 212 extending upwardly substantially beyond the lower face of table segments 205. Segments 205 are preferably provided with diagonally tangential ribs 213 which serve to plow outwardly toward wall 210 ashes which fall between ash table 204 and wall 210, preventing the ashes from escaping over flange 212 while avoiding any engagement between the rotating and fixed parts. The ashes brushed outward by the ribs 213 accumulate at the outer edge of the bottom plate 211 and form an outer ash seal 261 at the periphery of the table 204 so as to restrict the flow of air to the space above.

The ashes carried around by ash table 204 are continuously discharged by a scraper 214 including an ash plow or vertical plate on the outer wall 210 of the ash trough extending into juxtaposition to the ash table 204 and grate ring 188 and deflecting ashes outwardly through a discharge opening 215 in wall 210 into the ash discharge pocket 216 formed in said wall (Figs. 1 and 6). An ash discharge chamber 217 forms a downward continuation of pocket 216 and houses the receiving end of the ash removal screw 218 mounted on ash removal shaft 89 (Fig. 6).

A suitable arrangement is provided for supporting ash trough 209 and for connecting it to the furnace body. For convenience, trough 209 may be constructed in three segments, supported at the right of the burner (Figs. 1 and 2) by two bracket legs 220 overlying the two junctions of the segments and removably mounted on the burner body 150 to permit convenient mounting

and disassembly of the ash trough 209. The remaining junction between segments 219 overlying the coal feed tube 22 is supported by a bracket 221 on the burner body 150, provided with a detachable clamp 222 overlying the junction and which may be detachably fastened to the bracket 221.

The upper margin of the ash trough 209 is connected to the furnace body to close the space between the body and the burner unit. This may be accomplished by providing a closure plate 224 resting on shoulder 225 formed at the upper margin of outer wall 210 of the ash trough, and extending outwardly to the furnace walls. A suitable filling or lagging 226, such as furnace cement or the like, may be employed to fill the spaces between plate 224 and the furnace walls, which are shown as comprising the usual water leg 227 of a domestic furnace. Plate 224 may be locked on shoulder 225 by segmental locking plates 228 fitting into an annular recess 229 in the upper margin of the outer wall 210 of the ash trough and provided with a longitudinal rib 230.

The mechanism for rotating the grate unit employs an intermittent drive, imparting a periodic impact to the rotating structure, as such an arrangement serves to break up the fuel mass and to facilitate the sifting of the ashes and small clinkers through the grate. In the construction shown the shaker rod 109 extends beneath the ash trough 209 and is pivotally connected at its end to the lower end of a feed dog arm 241 extending upwardly between the air chamber 161 and the grate rotor ring 181 and having at its upper end a feed dog 242 projecting laterally between the support flange 243 on the inner face of rotor ring 181, and rack 244 on said ring overlying flange 243. The feed dog 242 is provided with a rocking face 245 riding on flange 243, and suitable teeth 246 at its forward end adapted to engage rack 244. The arrangement is such that when the shaker rod 109 is shifted to the left of Fig. 3 the dog 242 will be rocked on face 245 until teeth 246 engage rack 244, further movement of the shaker rod 109 serving to rotate ring 181 and the grate parts mounted thereon, while ring 181 will be free from dog 242 at the end of such stroke and during the return stroke of shaker rod 109 owing to the disengagement of teeth 246 when the dog 242 is rocked in the reverse direction by continued travel of the grate rotor ring 181 under its own momentum or by the return travel of shaker rod 109.

To prevent reverse rotation of the grate ring 181 and associated parts a detent dog 247 is provided on detent arm 248 pivotally mounted on stud 249 on the burner body 150 at any convenient circumferential point and held yieldably in operative position as by counterweight 260.

Figs. 4, 5 and 6 show the air supply and control system between the blower 78 and the burner unit C. The volume of air from blower 78 is suitably regulated, as by butterfly damper 264 mounted in air control housing 265 on spindle 266 preferably provided with suitable locking means, the form illustrated having a locking disc 267 mounted on the end of spindle 266 at the rear of housing 265 (Fig. 5) and held in adjusted position by locking knob 268 threaded on screw stud 269 extending through concentric slot 270 and mounted on housing 265.

Means are provided for indicating the flow of air from blower 78, for preventing backflow into the blower system from the burner unit C, and for permitting a regulable flow of air to the burner unit when the blower is not in operation. These functions may all be performed by a single mechanism comprising a valve flap 271 fixed to pivot spindle 272 located in the upper part of a section of the air control housing 265 in advance of damper 264 and engaging valve seat 273, which is preferably inclined in the direction of air flow from the blower. The end of spindle 272 may be bent downwardly outside of housing 265 to form a pointer 274 serving in conjunction with suitable marks 275 or the like on the outer face of housing 265 to indicate the position of flap 271.

To arrest valve flap 271 at a predetermined preferably variable distance from seat 273 we provide a natural draft regulator spindle 276 threaded in housing 265, provided with a laterally extending stop arm 277 within housing 265 positioned for engagement with the face of flap 271 and serving as a variable stop for arresting the downward movement of flap 271 at any point between the valve seat 273 and the maximum desired opening of flap 271 by rotation of spindle 276 by means of knob 278, spindle 276 being frictionally held in adjusted position as by spring washer 279.

The air control housing 265 is connected to a suitable air duct 280 running to air inlet chamber 261 (Fig. 5) in the burner body 150, and merging, around the casing for the coal feed passage, with the air inlet chamber 161 to provide a generally tangential air feed adapted to distribute the air evenly throughout the air chamber 161 and thence to tuyère openings 178.

A suitable arrangement is provided for automatically removing the ashes from the burner unit C and discharging them at an appropriate point, the construction shown including an ash removal conveyor and an elevator for transferring the ashes from the conveyor to a suitable discharge point. In the form illustrated the ashes are removed from the ash discharge chamber 217 by ash removal tube 285 mounted in the burner body 150 and forming a continuation of chamber 217. Tube 285 extends to an appropriate point and is shown as terminating adjacent drive unit B (Fig. 1). At this point a suitable elevator unit D is positioned to receive the ashes. A convenient construction is disclosed, employing an arrangement in which the ash removal tube 285 terminates in an elevator pocket formed in elevator base 288. Ash removal screw 218 terminates at the pocket while the shaft 89 on which the screw is mounted extends through the pocket and a suitable bearing at the opposite side of the elevator base 288, and thence to the drive mechanism as already set forth.

An elevator tube 290 is mounted in elevator base 288 extending from the elevator pocket upwardly in any desired direction to permit discharge at any appropriate point dictated by local conditions, the angle of tube 290 being readily adjusted by clamping base 288 in any desired rotated position about ash removal tube 285 through a suitable clamping screw. An elevator screw is positioned in tube 290 to pick up ashes discharged into the elevator pocket and raise them in tube 290 to a discharge at the upper end of the tube.

A suitable discharge arrangement is provided at the upper end of elevator tube 290. This may comprise a discharge head 306 mounted on the upper end of elevator tube 290 and carrying an upper bearing for the elevator shaft. Head 306 is provided with suitable spout discharge means, the illustrated construction employing two discharge spouts, each of which may be provided

with a flexible tube 310 clamped thereto for directing the ashes to any suitable receptacle, such as ash can 311 (Fig. 1).

A suitable arrangement is provided for driving the coal feed screw 21 from shaft 89. In the arrangement indicated shaft 89 extends through a bearing in chamber 217 and a bearing on a bracket on burner body 150, and drives coal feed screw 21 through a sprocket on shaft 89, sprocket chain 240 and sprocket 239 mounted on shaft 160 to which the coal feed screw 21 is connected.

While various proportions and designs may be employed in the different parts of the apparatus disclosed herein, the proportions are of importance in various parts, and particularly in the burner structure, the size and proportions of the pot, retort, grate segments, ash slots in the spacing thereof, having been determined after substantial experiment as adapted to most efficient operation with coking bituminous coal; and the drawings herein are drawn to scale to show the proper dimensional relationships between the various parts.

A suitable electrical control arrangement is illustrated in Fig. 6, and may be of the type in which the motor 75 is operated at full speed at suitable intervals, though the invention is not necessarily restricted to a control of this type.

Motor 75 is connected to the line 320 by motor circuit 321 in which suitable motor protective devices are located, such as the overload cutout 322 and the thermal type cutout 323 which may include a heating coil 324 and a bimetal strip 325 adjacent thereto. The thermal cutout 323 may be mounted directly on the motor so that it may be affected rapidly by all conditions which cause overheating of the motor.

The motor circuit 321 includes the upper contacts 326 of duplex relay 327 whose coil 328 is in line 329 passing through the secondary of the low voltage transformer 330 whose primary is connected across the main line 320. The main secondary lead 329 carries the protective and control devices in the heat generating apparatus, which in the present instance is illustrated by a domestic hot water furnace 331. In the form illustrated the line 329 carries a high point cutout switch 332 operative to break the circuit when the heating medium has reached a predetermined temperature or pressure, and this line 329 also carries the banking control switch unit 333 hereinafter described. Line 329 continues to the lower contact 334 of a room thermostat 335 of the type which includes a bimetal strip 336 operative when the room drops below the desired temperature to close contacts 334 initially and after a further temperature drop to close the connected upper contacts 337, thermostats of this type being well known.

The contacts 334 and 337 are connected through strip 336 and holding circuit line 338 with the lower contacts 339 of relay 327 which connect with the main circuit 329. The upper room thermostat contacts 337 are connected through shunt circuit line 340 with the line 329 at relay 327.

The banking control switch unit 333 is provided with two switches, a bank switch arranged to start motor 75 when additional fuel and air are required during banking periods, stopping motor 75 automatically after a suitable period; and an out switch arranged to stop motor 75 automatically if its operation under control of the bank switch does not result in a suitable pickup of the fire. These switches are operated by a thermal element located suitably for prompt and sensitive reaction to changes in the temperature of the fire. There are extreme differences in such temperature between periods of maximum operation and the low fire bed which it is desirable to maintain under banking conditions when the effort is simply to maintain a minimum heating as in domestic installations in spring and fall.

Electrical control apparatus regulating the operation of motor 75 in connection with the house thermostat system may have appropriate parts thereof mounted as shown in control housing 143 (Fig. 1) carried by a bracket on drive casing 86. It has been found advantageous to locate the thermally responsive element of the banking control apparatus in the combustion chamber 341 at a distance from the fire sufficient to permit the employment of a sensitive thermal device which will operate accurately with slight changes in temperature. For instance, such device may be located upon or at the furnace door mounted in suitable position to be directly affected by both radiation and convection from the fire, without being influenced by various factors affecting temperature at other points in the furnace. Specifically, it has been found that the absorption and radiation of heat by portions of the furnace such as the water legs 227 and 342, the variations in draught due to dampers and stack openings such as those shown at 343, and other variations in draught and temperature conditions seriously affect a sensitive thermal control unit located in the furnace at points other than the combustion chamber 341.

In the form shown the thermal element comprises a bimetal coil 345 arranged to extend through a suitable opening in the furnace door or other part of the furnace into position in the combustion chamber 341 where there will be no obstructions between thermal coil 345 and the fire in retort 172.

The thermal coil 345 is connected at its rear end to rotary switch rod 357. Switch arm 358 is centrally mounted on the end of rod 357 and is provided at its lower end with a clip carrying the mercury type bank switch 360. The mercury type out switch 361 is carried by a clip which is preferably mounted on arm 358 by means permitting the angular adjustment of switch 361 relative to switch 360.

Under certain circumstances, and particularly when burning certain types of coal, gases may be forced back through the coal feed tube 22, and an arrangement is provided for preventing the escape of such gases. Such an arrangement may include a trap in which the gases will collect, and means for conducting the gases from the trap to a suitable discharge. In the preferred arrangement the gases are conveyed to the burner. Owing to the relatively low velocity of such gases it has been found that under certain conditions there is a tendency for fine solid particles to accumulate in the return pipe and eventually to clog the pipe. The preferred form therefore includes means for preventing such accumulation of dust and the like, and for returning the gases to the burner or elsewhere by positive means, such as a suitable supply of air, which may be taken from the blower system.

An arrangement of this type is embodied in the preferred form illustrated herein, and is shown best in Fig. 4. It includes a fresh air connection 135 with the outlet of blower 78 connected by air pipe 136 and return bend 137 with

jet nozzle 138 extending through a wall of the gas pocket 139 formed in the upper face of the coal feed passage 73 in base 72. The fresh air connection 135 thus utilizes a higher pressure from the blower than can be found anywhere beyond the damper control. A gas return pipe 140 extends through the other side of pocket 139 in alinement with nozzle 138 and spaced therefrom by a distance suitable for obtaining an injector effect under the conditions of air pressure and dimensions employed in the arrangement. The gas return pipe 140 is connected to the burner unit C at the ash discharge pocket 216. Gas pocket 139 is sealed by a removable cover 141.

While the apparatus is adapted for use with various types of coal it has been particularly designed to solve certain special problems encountered in the burning of bituminous coal, which has special characteristics affecting its collection, transportation and combustion.

The burner unit C is particularly designed to provide thoroughly efficient combustion both under active operating conditions during coal feed and operation of the blower, and under banking conditions. There is also secured a careful balancing between the rate of coal feed, the rate of air supply and the combustion characteristics of the coal, both as to the time required to burn to ash and the volatilization of combustible gases. The latter problem is especially important in the burning of bituminous coal, and involves likewise the formation of coke, which heretofore has been a source of serious difficulty and obstruction due to the tendency of the coal to coke back into the feed zone, interfering with the operation of the feed mechanism and frequently causing complete stoppage of the machine. The design also contemplates the effect of oil which is frequently used for dust prevention.

The rotating element 157 provided at the side of the throat opposite to the discharge end of the coal feed tube serves to prevent the coal from forming a packed mass at this point, and thereby increasing notably the facility with which it may be forced upwardly by the horizontal pressure of the feed screw. In one sense it may be said that this auxiliary screw increases the relative fluidity or flowing qualities of coal at this point. In the preferred form the rotating element is in the form of a reverse screw exerting a counterbalancing horizontal pressure on the coal discharged by the feed screw while likewise preventing the formation of a solidly packed mass of coal, the result being that the coal will travel upward as gradually as may be desired without exerting any pressure whatever on the surfaces opposite the coal feed tube discharge. The reverse screw may be arranged to impel coal continuously away from the feed screw bearing, which may therefore be of any desired type. The elimination of the tendency to pack the fuel in throat 151 furthermore permits the maintenance of fuel feed in tube 22 at substantially less than the full capacity of the tube as already indicated, since substantial back pressure on the fuel at the burner owing to the resistance caused by forcing the fuel upward under previous conditions causes the coal to back up along the feed screw; and even if feeding at less than coal tube capacity is attempted, substantial back pressure at the burner and the resultant accumulation of coal in the tube will make it impossible to operate the feed tube 22 partially filled at any point within a substantial distance of the burner. With the construction illustrated however the feed tube is filled for only a short distance from the burner, an arrangement which not only reduces to a minimum the power necessary for feeding at this most exacting point, but which also is desirable since a full feed tube 22 for a short distance from the burner is serviceable in forcing the gases to travel upwardly through the burner and not back through tube 22.

In burner retorts of the prior art difficulties have been encountered because of the tendency of the coal under certain conditions to burn down in the pot toward the feed screw, resulting in the formation of coke and clinkers which obstruct the feed and burning of the coal and may result in breakage or stoppage of the mechanism. The travel of the coal upwardly in the pot may likewise be obstructed by the formation of clinkers and the like which adhere to the pot walls, and by mechanical obstructions provided by the wall surfaces. In the present construction a retort is provided in which the zone of active combustion is restricted to the upper portion, and which extends downwardly for a sufficient distance below the lowest point of air supply so that the fire will not reach the region where formation of clinkers, coke and the like will interfere with the feed mechanism. Any clinker formation developing will be prevented from adhering to the pot by the smooth liner 154 but will be forced upward and broken up by the incoming coal.

Under full draught conditions the relation between the coal feed and the rate of combustion is such that the burning fuel overflows gradually across the retort 172 and over grate segments 189, and may reach the walls of the furnace. The relatively slight projection of the retort 172 above segments 189 facilitates the lateral flow, and is particularly advantageous in bituminous coal combustion in which the incandescent coke is more or less fluent, the arrangement permitting the formation of a relatively wide thin fire which produces maximum efficiency, rather than a high fire above the retort. The rate of combustion will naturally increase with the spreading of the fire until it will equal the rate of coal feed when the fire has reached its maximum area at the walls of the furnace. The inner tuyère openings 178 assure full combustion of gases which pass upwardly from the coking zone and provide an adequate supply of air for full combustion, the outer tuyère openings in wall 175 assisting if necessary in the combustion of the portion of the fire outside of the retort 172. The spreading of the fire is facilitated by the unusual power of the upward thrust of the coal, which likewise serves to scour away any clinkers which may tend to form on and adhere to the surface of the pot structure or retort 172.

When the drive unit is cut off and the fire operates under banking conditions, the portion of the burning coal beyond retort 172 will gradually burn up, and if banking conditions are maintained for a sufficient period, the fire area will gradually contract toward retort 172. Eventually the fire may contract to a zone in the upper part of retort 172 limited in depth by the distance that air will penetrate from tuyère openings 178. This arrangement, limiting the bank tuyère to a zone at the top of the pot substantially spaced from the feed worm 21, eliminates the possibility of coking back under banked conditions, a serious difficulty with prior arrangements. At the same time a small zone of definitely burning fuel is maintained so that when the drive unit is again started and the coal feed is re-

sumed, there will be no difficulty about kindling promptly the green coal that is more or less abruptly forced upwardly in the pot 152.

When operating under banking conditions air is drawn through the tuyère openings 178 by the ordinary stack draught in a manner similar to the operation of hand-fired coal furnaces. This is made possible by the action of stop arm 277 which holds valve flap 217 open to the proper extent, thereby permitting the maintenance of a minimum bed of burning material without risking the extinguishing of such bed by insufficient air, sudden influx of fuel or the burning out of accessible fuel by excessive draught.

The arrangement likewise is adapted to minimize the tendency to form coke in the lower portion of the pot where it might interfere with screw 21 through the depth of the pot, the air-cooled walls and the double-wall construction. If however coke should form in throat 151, it would not wedge between the screw and the end of the feed passage, as in prior arrangements, but would tend to be broken up by the rotary action of the feed screw 21 and reverse screw 157.

The rotary ash collecting unit is arranged to remove accumulations of ashes with a minimum disturbance of the fire bed. This operation is facilitated by the smooth-surfaced grate segments 189 and the intermittent shaking action imparted thereto. The formation of the described type of fire bed likewise facilitates the scouring of fine clinkers from the retort 172 and their discharge on to segments 189, which may be provided with slots sufficiently large to receive the small clinkers as formed and to maintain a clean fire even under conditions which operate the burner at infrequent intervals. The ashes are effectively sealed in the ash receptacle and readily discharged from the burner in a manner already indicated.

Any gas which is formed will normally be generated so high in the pot 152 that it will tend to flow upwardly and to be burned; but in case gas is forced back through coal feed tube 22 it will be positively returned to the ash pocket 216 by the action of jet nozzle 138, and will pass upwardly to combustion past the grate segments 189. This arrangement will also provide a slight air feed outside of the retort 172 which will be operative to some extent when the blower 78 is not running, since the natural flue draught of the furnace will exert a certain suction effect on the gas return pipe 140. This arrangement also prevents any tendency for dust to collect in the gas return line. It may be noted that when the valve flap 271 is allowed to fall upon its seat it provides positive means for preventing gases from the combustion zone from returning through the blower structure, if conditions should arise that demand such an arrangement.

The operation of the arrangement for conveying the ashes to a suitable point of discharge will be apparent from the detailed description. The construction is such that the ashes may be discharged at any desired point, and are kept completely housed in conveniently located conveying tubes.

The drive, operated by a single motor and compactly arranged, is constructed so that the blower may be operated without the coal feed, which may at times permit operation by hand firing in cold weather pending repairs to the coal feed mechanism. The clutch is likewise arranged to permit throwing in the coal feed and ash removal mechanism abruptly after motor 75 is up to speed, exerting a sudden impulse that may be valuable in dislodging a slight obstruction. The apparatus is likewise arranged so that the motor 75 will be stalled before breakage of any of the drive parts, allowing the electrical system to throw out the motor circuit and take care of emergency conditions without damage to any part of the machine.

The blower structure has been carefully arranged to give rapid and accurate control of an adequate supply of air at all times without the usual excessive intake noise.

The general operation of the electrical control system will be understood from the specific description. Assuming that the building is at or above the desired temperature for which the room thermostat 335 is set, the motor 75 will be out of operation, since contacts 334 and 337 of thermostat 335 will be open and relay 327 will consequently be de-energized, opening the motor circuit at the upper contacts 326. When the thermal element 336 contracts due to reduction in room temperature thermostat contacts 334 will first be closed; and continued reduction in temperature will thereafter close contacts 337, completing the circuit between the line 329 and the shunt line 340, closing relay 327 and starting motor 75. At the same time the contact 339 of relay 327 will be closed; and as thermostat contacts 337 open when the room becomes warmer, motor 75 will continue to operate since the secondary circuit through line 329 will be completed by the holding circuit line 338 until the room is warm enough to open thermostat contacts 334, whereupon relay 327 is de-energized and motor 75 will stop. A sudden excessive load on motor 75 will open cutout 322, while heating of motor 75 for any reason will operate thermal cutout 323, affording full protection to the motor. If the temperature of the heating medium should reach a point beyond which it is dangerous to continue, the high point cutout 332 will operate to break the main secondary circuit line 329, open relay 327 and stop motor 75. It is noted that as soon as the heating medium returns below the danger point said circuit will be closed and the motor again started, assuming of course that the room thermostat 335 is in appropriate position with the contacts 334 and 337 closed.

The banking control unit 333 is arranged for operation at times when the room thermostat 335 is open; and such operation may be readily understood from Fig. 6. The thermal coil 345 will naturally expand and contract in accordance with the heat given off by the fire, thereby rotating switch rod 357 and the switch structure mounted thereon. The coil 345 is constructed and arranged so that the bank switch 360 will be appropriately positioned with the mercury out of contact with the terminals when the temperature in the chamber 341 is above a predetermined minimum banking temperature. As the temperature in said chamber approaches such banking temperature rod 357 is rotated by thermostat 345 to turn the arm-carrying switches 360 and 361 and swing switch 360 downwardly until the mercury flows to the contacts of both switches when such banking minimum temperature is reached thereby closing an auxiliary circuit including conductor 126, switch 332, switch contacts 360, 361, conductors 372, 340, coil 328 of relay 327 and conductor 329. The resultant closing of switch 360 completes a circuit through the banking shunt line 372 with the shunt circuit 340

and through the out switch **361** with the main secondary line **329**, energizing relay **327** and starting motor **75**. The resulting increase in heat from the fire will rotate the switch rod **357** in the opposite direction until the bank switch **360** is turned off by the flow of mercury from its terminals at the maximum banking temperature, thereby opening relay **327** and stopping motor **375**. It is noted that this operation is independent of the thermostat **335**, and is effective only when said thermostat is not closed.

The arrangement consequently serves to maintain a minimum banking fire independently of the house temperature control without interfering with the operation of such control and effective when such control is not active. It permits highly accurate and efficient regulation of banking conditions, since it may be constructed for any desired range of banking temperatures, and the temperatures at which it operates may be readily adjusted by shifting arm **358**. Furthermore, it is located at a point where it is affected promptly and directly by very small changes in the banked fire, and is sensitive to slight variations in temperature.

Out switch **361** is arranged and connected to stop motor **75** if the fire temperature should not rise after the motor has been turned on by switch **360**. If the temperature in combustion chamber **341** drops to a predetermined extent below the minimum banking temperature, switch rod **357** will continue to rotate and tilt banking switch **361** until at a predetermined temperature the mercury will flow away from the contacts of switch **361**, breaking the circuit between bank switch **360** and line **329** and opening relay **327**.

This arrangement is utilized to provide manual regulation of the coal feed and forced draught during starting of the fire. This is accomplished by pressing the button **371**, closing contacts **363** and **369**, short-circuiting the out switch **361** and starting motor **75**, which runs as long as button **371** is pressed. If the fire ignites properly the heat will promptly affect thermal element **345**, which may be so sensitive that even very slight heat from the fire will be sufficient to close out switch **361** and permit release of button **371**. In igniting bituminous coal fires this period is extremely short, and may be two minutes or less, since the unit **333** preferably operates at very low temperatures and thereby reduces to an absolute minimum the amount of coal burnt during non-heating bank periods.

The operation of control unit **333** cooperates with the setting of the main air damper **264**, which controls the forced draught, and the setting of valve flap **271**, which controls the natural draught; since it is possible by employing a sensitive control directly responsive to changes in a very low fire, with an air regulating means especially suited for the maintenance of the fire steadily at such low point, combined with a forced draught regulation which appropriately builds up such small fire properly in a brief time, to provide a novel and highly efficient banking arrangement.

The air supply for the fire is intended to come mainly from the tuyère openings of the retort ring **175**, and this supply serves in addition to maintain a proper cooling of the retort. Under running conditions substantially all of the air from the fan passes through the air spaces around the retort tending to cool it and prevent overheating and improper coking and clogging of the rising column of coal. Under banking conditions the natural draft draws air through the partly open valve flap **271** and damper **264** into the spaces around the retort and through tuyère openings **178** together with some slight leakage from the coal tube through pipe **140** and opening **216** into the space below the grate. There may also be some seepage of air through the ash seals for the rotor ring **181** and ash table **204**. In this way the air supplied below the grates is negligible in amount, substantially the entire supply being through the tuyère openings of the retort both under running and banking conditions.

This is a division of our application Serial No. 161,494, filed August 28, 1937, now Patent No. 2,306,189 of December 22, 1942.

We claim:

1. A stoker combustion system comprising in combination with a retort expanding and opening upward, of means forming a combustion chamber above said retort adapted to be subjected to subatmospheric pressure by virtue of the flue draft thereby effecting a natural draft of air into said chamber, means forming the bottom of said chamber and sealing it against entrance of air through the area around said retort including a stationary annular ash member and a grate structure movable around a central axis and comprising an annular upper grate surrounding the upper portion of said retort and a lower ash table overlying said member, said overlying table cooperating with the overlaid part of said member to form an air seal, means for supplying coal to said retort and forcing it upwardly therethrough, and means for supplying air under pressure to the upper portion of the coal column in said retort, said means comprising a blower operable to supply air above atmospheric pressure and an air supply orifice for passing air to said upper portion of said coal column under predetermined conditions of banking air control when said blower is inoperative and the combustion chamber is under pressure below atmospheric.

2. A stoker combustion system as set forth in claim 1 in which the retort and the grate structure have cooperating parts for trapping an accumulation of ashes and thereby forming an inner air seal.

3. A stoker combustion system as set forth in claim 1 in which the stationary ash member is annularly spaced from the outer surface of the retort so as to leave an air space therebetween.

4. Stoker apparatus as set forth in claim 1 having an ash removing conveyor and means cooperating with the air sealing means to form a substantially air tight enclosure beneath the grate for receiving the ashes sifting through the grate and conveying such ashes to and discharging them into the ash removing conveyor and for substantially preventing the passage of air from the furnace room to the furnace combustion zone by way of the furnace ash pit and the grate, thereby providing ash collection and removal while preserving the action of the banking air control when the blower is not in operation.

5. Stoker apparatus as set forth in claim 1 having ash collecting and removing means including an annular ash receiver positioned under the grate and rotatably supported upon the retort, an ash removal conveyor and means for rotating the ash receiver to transfer the ashes thereon to the entrance end of the ash removal conveyor, with the air sealing means of the bank-

ing air control including means forming an inner ash air seal between the ash receiver and the retort, an annular closure means closing the space between the furnace walls and the grate and having an extension projecting downward below the grate, and means forming an outer ash air seal between the closure extension and the ash receiver, both such ash air seals substantially limiting the leakage of air from the furnace room to the furnace combustion zone by way of the clearances around the ash receiver incident to supporting the ash receiver for rotation.

6. A stoker combustion system comprising in combination with a central structure having a retort expanding and opening upward, of means forming a combustion chamber above said retort adapted to be subjected to subatmospheric pressure by virtue of the flue draft thereby effecting a natural draft of air thereinto, means forming the bottom of said chamber comprising an annular grate below the top level of said retort and having an inner edge overlapping said central structure and forming an ash seal therewith against the entrance of air to the combustion space, an ash ring carrying said grate and providing a lower ash seal substantially shutting off the air flow to the space below said grate around said ash ring, means for supply coal to said retort and forcing it upward therethrough, an air conduit for supplying air to the upper portion of the coal column in said retort under said natural draft and a blower adapted to force air through said conduit at pressure above atmosphere.

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