March 25, 1952 C. E. SHAFFER ET AL 2,590,133

STOKING APPARATUS FUEL STORAGE BIN AND CONVEYER

Filed Aug. 1, 1945 3 Sheets-Sheet 1

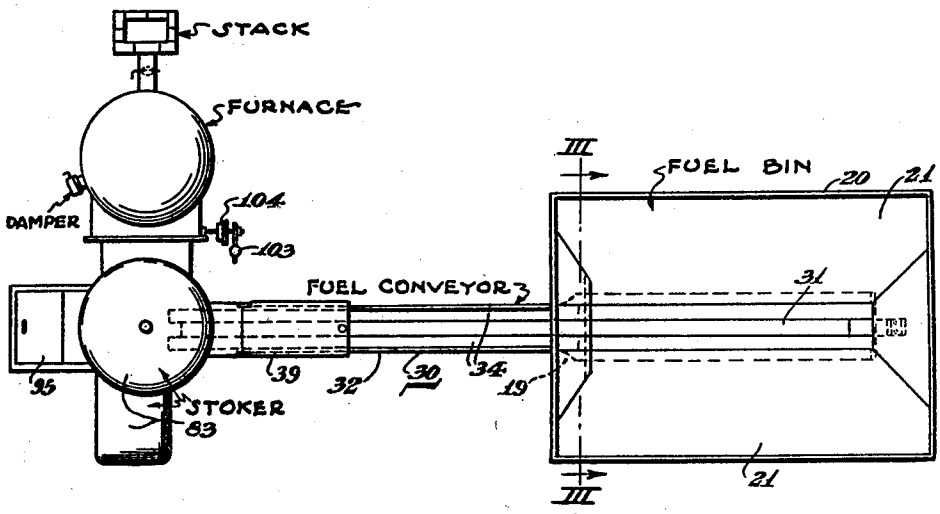


Fig. 1

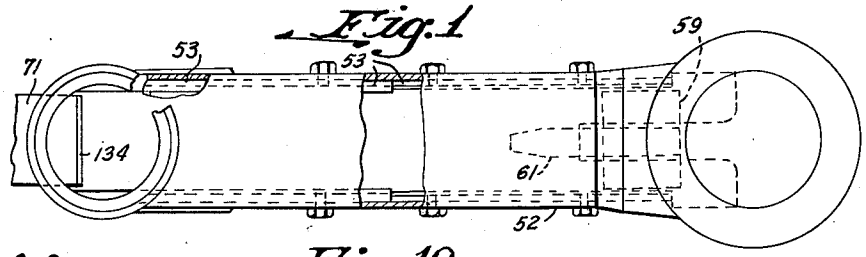


Fig. 10

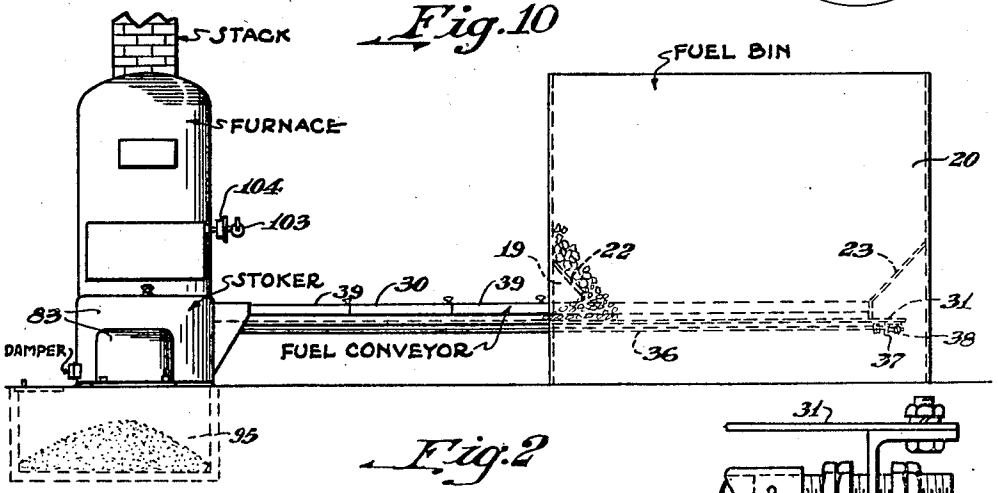


Fig. 2

Fig. 2a

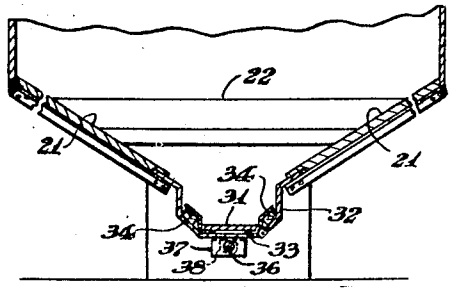


Fig. 3

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STOKING APPARATUS FUEL STORAGE BIN AND CONVEYER

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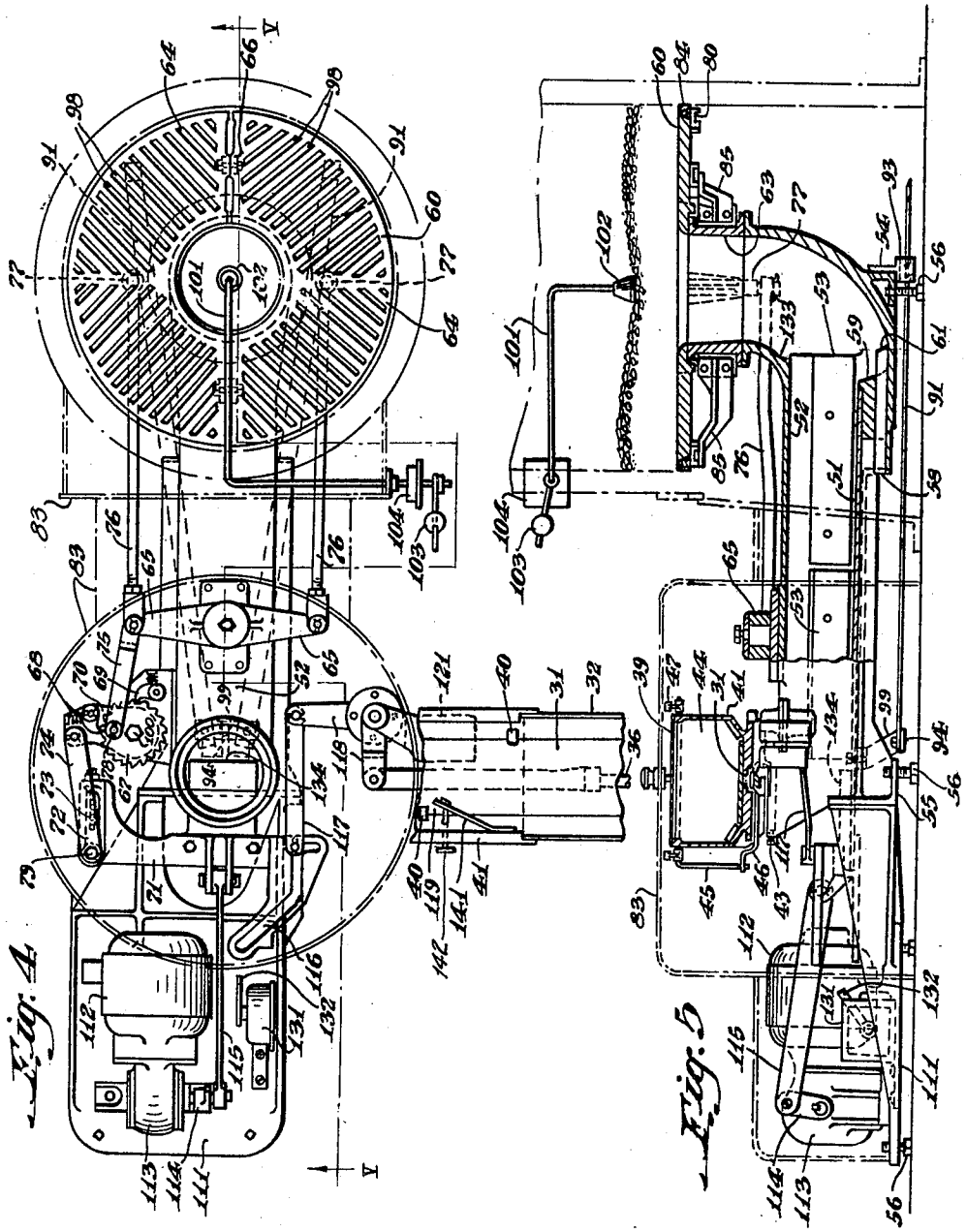


Fig. 4

Fig. 5

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Filed Aug. 1, 1945 3 Sheets-Sheet 3

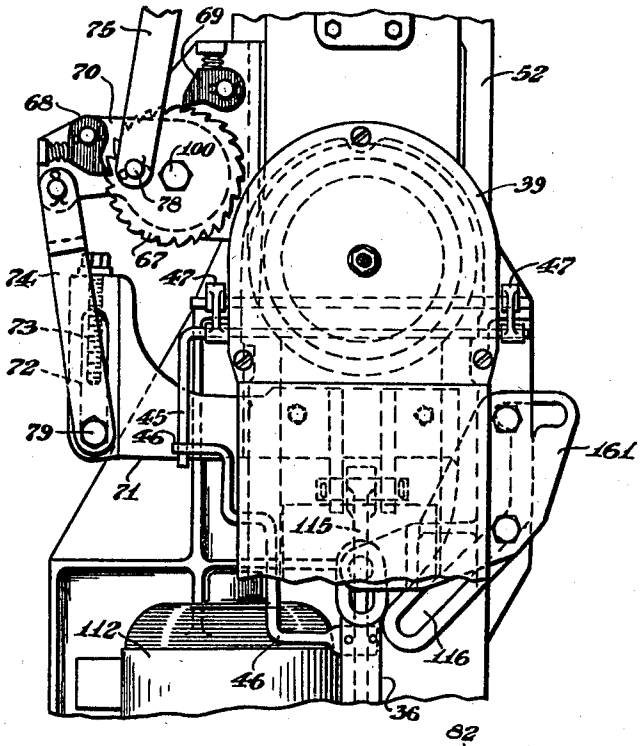


Fig. 6

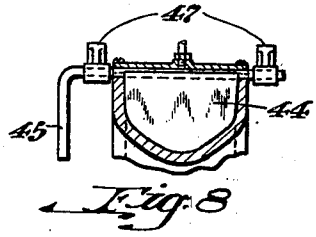


Fig. 8

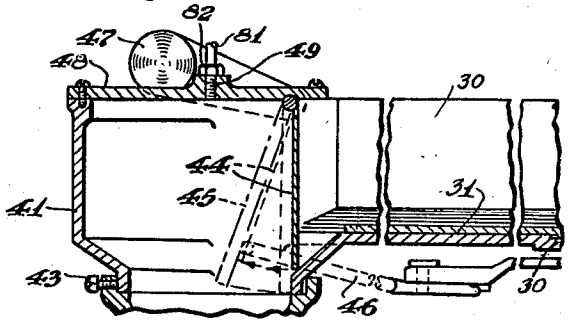


Fig. 7

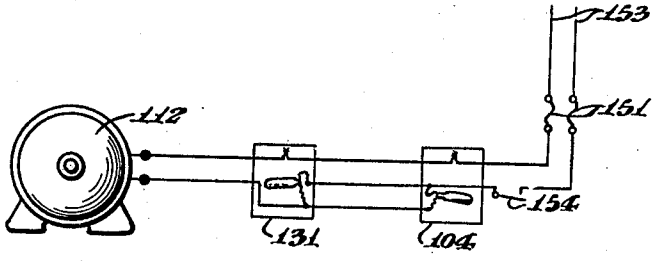


Fig. 9

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UNITED STATES PATENT OFFICE

2,590,133

STOKING APPARATUS FUEL STORAGE BIN AND CONVEYER

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Application August 1, 1945, Serial No. 608,234

6 Claims. (Cl. 198—53)

1

The present invention relates to the domestic-heating art and pertains more especially to novel improvements in apparatus and their auxiliary equipment for employing solid fuels, and more particularly coke derived from coal, in the automatic supplying of heat to furnaces forming a part of the heating installations of dwellings, smaller buildings, and the like.

More particularly the present invention relates to the fuel conveyor, and storage bin and fuel conveyor therefor, suitable for conveying solid fuel, such as coke or coal, disclosed in our Patent No. 2,388,294 issued November 6, 1945, of which the present application is a division.

The primary object of the present invention is to provide an apparatus by which fuel may be fed in controlled quantities from a storage bin to a stoker mechanism.

Another object of the invention is to provide an apparatus for feeding fuel from a storage bin to a stoker wherein the bin may be located at different positions relatively to the stoker.

A further object of the invention is to provide a feeding mechanism for feeding fuel from a storage bin to a stoker wherein the amount of fuel passing to the stoker may be effectively regulated.

The invention has for further objects such other improvements and such other operative advantages or results as may be found to obtain in the apparatus hereinafter described and claimed.

In the accompanying drawings forming a part of this specification and showing for purposes of exemplification a preferred apparatus in which the invention may be embodied and practised but without limiting the claimed invention specifically to such illustrative instance or instances;

Fig. 1 is a general schematic view in plan of heating apparatus embodying features of the unitary system in which the present improvements for employing solid fuels in domestic furnaces is incorporated;

Fig. 2 is a view in elevation of the apparatus shown in Fig. 1;

Fig. 2*a* shows an enlarged fragment of Fig. 2;

Fig. 3 is a sectional view taken along the line III—III of Fig. 1 and shownig details of construction of the fuel-conveyor and storage bin of the instant improvement in the unitary system;

Fig. 4 is a partial plan view, parts being broken away, of the furnace-grate, the stoker, the conveyor means for operating the present improved system for employing solid fuels in domestic furnaces;

Fig. 5 is a side elevational view with parts shown in section taken on the line V—V of Fig.

2

4 and showing the adapter-member whereby fuel moved from the storage bin by the conveyor is introduced into the underfeed stoker;

Fig. 6 shows an enlarged fragment of Fig. 4 with the fuel-conveyor, however, disposed substantially at right angles to its relative position illustrated in the latter said figure;

Fig. 7 is an enlarged view of the adapter-member of Fig. 5 that serves communicably to connect for purposes of fuel-flow the stoker and the fuel-conveyor of the system and also shows the damper arrangement for elimination draft through the stoker and into the fuel bed during such times as the system is idle;

Fig. 8 is a front view of the damper arrangement of Fig. 7;

Fig. 9 shows in diagram electrical circuits employable in actuating the instant system for feeding solid fuels to domestic furnaces according to the present improvement.

Figure 10 is a partial plan view of the stoker feed tube with parts broken away to show the arrangement of the tube by which reverse movement of the fuel in the tube is prevented.

As the present invention is of general application, for example, it may be used with various other types of stoking apparatus, as well as being of especial utility with the type of apparatus of our aforesaid patent, which is hereby expressly made a part hereof by cross-reference thereto, a brief description herein of only so much of the general features thereof as is essential to an understanding of the present invention will suffice for an understanding of the same.

The same reference characters used in said Patent No. 2,388,294 will be used herein to designate the same parts in each of the several views. Figs. 1 to 9 are identical copies of Figs. 1, 2, 2*a*, 3, 4, 5, 7, 8, 9, and 12, respectively, of said application.

Referring now to the drawings: the unitary system in which the present improvement is embodied for using such solid fuels as anthracite, bituminous coal, pitch coke, and the like, and more particularly coke derived from coal, in the automatic supplying of heat to domestic heating installations essentially comprises: an improved arrangement of bin for storing and supplying a quantity of fuel; an improved conveyor for transporting fuel therefrom in a horizontal path to a stoker; an underfeed stoker; an improved grate to support the fuel-bed above the furnace hearth; means for automatic removal of ash from the furnace-hearth; a fuel-bed-level control; suitable regulable connections between the above-mentioned features of apparatus and an electric motor whereby said apparatus can be all co-operatively actuated by the motor to provide for

the combustion of that amount of solid fuel which is necessary to deliver uninterruptedly and automatically the quantity of heat required to maintain a given space at a predetermined temperature.

In accordance with the present invention, the fuel bin 20 is of a capacity to provide adequate storage of fuel for a preferred period and, as clearly shown in Figs. 1, 2, is formed with a hopper-like bottom comprising the pair of inclined surfaces 21, 21, that are disposed along its lengthwise dimension, and also the inclined surfaces 22, 23, that the arranged transversely of the former respectively adjacent the outlet and its opposite end of the bin. The said surfaces 21, 21, do not meet on the bin's median but rather stop short thereof, as shown in Fig. 3, at the vertically-extending walls of a trough-like member 32 that forms the lowest part of the space of the bin, and all of the said inclined surfaces function as directing baffles to deliver fuel from all sections of the bin into the trough-like portion thereof. That inclined surface 22, which is located above the bin-outlet should have its lower edge located at about 6 to 9 inches above the bottom of the bin-trough, such distance being regulated according to the sizes of solid fuel employed, and at about 5 inches inwardly from its adjacent vertical wall, thus forming a sort of pocket 19 whereinto a portion of the bin-contents can freely flow along the bin-trough and assume its angle of repose unobstructed by the weight of the column of fuel thereabove. In order to effect, by means of the conveying device provided for the purpose by the present improvement, a uniform rate of removal of the entire contents of the bin, it has been found advantageous to incline the surfaces 22, 23, at not less than 45 degrees and the surfaces 21, 21, at not less than 32 degrees to the horizontal, depending on the nature of the material used in their construction. Tempered, pressed-wood, such as the material "Masonite," has been found in practice a satisfactory material for facing said surfaces 21, 22, 23.

The conveyor means 30 of the invention for transporting fuel in a horizontal plane between the bin the stoker members of the unitary system comprises plate 31 that is reciprocally mounted in a sheet metal housing 32 that forms the side walls and the bottom of the bin trough, as clearly shown in Fig. 3. In order to facilitate the reciprocatory movement of plate 31, it is slidably supported above the bottom of its housing 32 on metal strips 33 that serve as tracks. The said conveyor-housing 32 extends from substantially the lower edge of directing baffle 23 the entire length of the storage-bin and to a receiver 41 for a stoker feeder. In that section thereof where the housing forms the bin-trough, its side walls are bent outwardly to such angle that they in effect form extensions of inclined surfaces 21, 21, thereby promoting the flow of fuel onto the upper surface of reciprocating plate 31. From the bin outlet, at pocket 19, to the stoker receiver, these side-walls are substantially vertical. Metal-covered wooden strips 34 are affixed to the walls of conveyor-housing 32 and extend substantially the entire length thereof sufficiently adjacent the vertical surfaces of plate 31 to prevent wedging of fuel particles between said housing and reciprocatory plate, but are also sufficiently removed therefrom to allow free movement of the latter. In effect, the wooden strips 34 form a sort of recess in which the reciprocating conveyor-plate is actuated, and have the

effect of directing all fuel that flows into the bin-trough only onto said plate's upper surface. By obviating any possibility of cake jamming at its edges, they are an important feature in the successful operation of a conveyor of this type.

Beneath the reciprocatory plate 31 of the conveyor and affixed thereto at its outer end is connecting-rod 36 whereby it is actuated by the electric motor that is adapted to operate the unitary system, said connecting-rod being attached to the conveyor-plate by angle-iron 37 that is itself bolted to the latter and through which the reduced and threaded outer-end of rod 36 extends, as shown in the enlarged view of Fig. 2*a*. Lock-nuts 38 support and retain the connecting-rod in the angle-iron. Increasing or decreasing the distance between the pairs of said lock-nuts respectively serves to increase or decrease the amount of movement made by driven connecting-rod independently of the conveyor-plate, so that they are employable correspondingly to decrease or increase the amount of movement imparted to the conveyor-plate during each stroke of the connecting-rod and, consequently, serve as means of regulating the quantity of fuel carried from the bin during each cycle of movement of the conveyor-plate.

Solid fuels have been successfully transported on conveyor-plates, of the above described type, that were 25 feet long; the practical limit therefore of their length is considerably above that dimension. A conveyor-plate that is 5 inches wide is capable of carrying 200 pounds of solid fuel per hour.

As will be noted in the lower right hand corner of Fig. 2, the driven end of the conveyor-plate 31 extends beyond the end of the bin-trough into the free space under inclined plate 23 so that in its reciprocatory motion fuel cannot be jammed between the outer edge of said plate and the walls of the trough.

That section of the conveyor housing located between the storage-bin and the stoker is provided, for purposes of cleanliness, with cover-plate 39.

Adjacent the discharge end or inner-end of conveyor 30, the reciprocatory plate and the recess-forming members 34 therefore are both supported on the horizontal surface of the inlet to feeder receiver 41, that is held atop the stoker apparatus, and which serves to direct conveyed fuel downwardly onto the actual stoking device of said stoker. Cleats 40 affixed to the walls of the adapter-member allow free movement of the conveyor-plate and assist in supporting it in a substantially horizontal plane.

Flexible finger 141 attached to the walls of feeder receiver 41, as shown in Fig. 4, can be moved by its associated thumb-screw 142 to restrict or increase the free-way for fuel flowing along the conveyor-plate and thus, in addition to the described device at the outer end of said connecting-rod for limiting the motion of the conveyor-plate, serves as means for obtaining fine regulation of the quantity of fuel delivered from storage to the stoker during any period. The flexible finger 141 is a flexible plate or gate in the form of sheet metal, the upper edge of which is shown in Figure 4.

Feeder-receiver 41, for directing conveyed fuel into the stoker apparatus, is supported in the circular inlet to the latter by means of screws 43 as shown in Figs. 5 and 7; in consequence of this arrangement, the receiver and its associated conveyor are pivotable around the stoker-inlet

and can be thus arranged at a diversity of angles to the stoker and the furnace, a feature making it possible to employ the present improved improvement in places where the existing fuel-storage space is variously disposed in respect of the furnace openings.

As also shown in Figs. 5, 6, 7, and 8, a damper-valve 44 is installed at the inlet side of said receiver 41 for disestablishing communication between the conveyor and the stoker during such times as fuel is not being introduced into the latter, thereby to prevent combustion-air being drawn into the furnace through a conduit comprising the conveyor-housing and the horizontal section of the stoker casting when they are only partially filled with solid fuel at any interval. As shown in said Figs. 7, 8, gate 44 is supported at its top by a hinged arrangement to the walls of receiver 41 adjacent its inlet. Finger 45 depending from one end of the hinge-pin serves to open and close said gate, said finger being automatically actuated by arm 46, that is attached to and moves correspondingly with connecting-rod 36, as is evident in Figs. 5, 6, and 7, in such manner that during the forward stroke of the latter, when coke is being delivered to the receiver 41, the damper is opened and conversely is closed on the return stroke of said connecting-rod. Inasmuch, as will be hereinafter set forth, connecting-rod 36 is always at the end of its back stroke when the unitary system is at rest, gate 44 is in open position only at such times as fuel is being delivered to the stoker. Counter-weights 47 are employed to close and insure a close sealing of the gate.

Removable plate 48, which is attached to and forms the top of the receiver, supports, in the threaded hole 49, the bolt 81 which has a lock-nut 82 and carries the principal metallic covering 83 for the working parts of the assembly.

Referring now to Figs. 4, 5, and 6, the stoker apparatus with which is incorporated the present invention is of the underfeed type and comprises a casting 52 having a relatively extended, horizontal section that, beneath the furnace-grate terminates in substantially a right-angle bend on the upper surface of which there is supported a removable extension-ring 63, the vertical section of the stoker-tube and said extension ring being flared slightly outwards, thereby to facilitate flow of fuel through the tube and impede backward movement of such thereof as has been elevated above its horizontal section.

Casting 52 is essentially a hollow, cylinder-like body whose top and side walls are of continuous metal construction. In the bottom of the casting, there is a large rectangularly-shaped opening that extends from directly beneath its fuel inlet up to a point somewhat short of its upward sweep. The member 52 is lined with replaceable liner-plates 53 that cover most of the lower part of the side walls of the tube and are conveniently formed of cast iron, hard-surfaced steel, or other appropriate material. These plates 53 are of greater thickness adjacent the fuel inlet of the stoker-tube than they are further thereabout, their vertical edges thus forming a sequence of ridges or offsets that have the effect of preventing the solid fuel as it traverses the casing from being moved backward toward the receiver 41 upon the return stroke of the stroker plate 51. Also the stoker tube has an increasing cross-sectional area which facilitates the stoking operation and tends to restrict any backward movement of the stoked fuel during the backward stroke of the reciprocatory stoker-plate 51.

Reciprocally mounted within tube-casting 52, and forming a substantial portion of its lower wall, is the stoker-plate 51 which, adjacent the inlet-end of said tube-casting, is mounted on cross-head 71 of the driving mechanism for the unitary system and extends through a provided slit in the adjacent end-wall of said casting. At its opposite end, said stoker-plate is rigidly affixed to the upper surface of ramhead 59, the said cross-head, plate, and ram-head being all arranged for reciprocatory movement as a unit. The shelf-like ridges on the inner walls of the tube-casting form a track for the stoker-plate during its reciprocatory movements.

Removably mounted in the lower wall of the stoker-tube adjacent its upward bend, is the finger-bar 61 which is retained in position by means of its attached lug that slidably fits into a corresponding opening in the walls of the stoker-tube. As shown in Fig. 5, ram-head 59 is formed with a median groove which permits it to move freely backwards and forwards over the said stationary finger-bar 61 which serves the function of aiding in the support of the vertical column of fuel above it during the backward stroke of the ram-head.

Lugs 54, 55, formed integrally with the stoker-tube casting have threaded holes containing bolts 56 whose heads serve as feet for said casting and whereby the stoker can be levelled. Rib 133 that is cast integrally with the stoker-tube walls and which, in combination with the hereinabove described finger-bar 61, and also the adjacent offsets formed at the termini of liner-plates 53, assists in supporting, above the normally only partially filled horizontal section of the stoker-tube, that vertical column of fuel which is about to be elevated into the fuel-bed by the movements of the reciprocatory ram head 59.

The upper edge of extension-ring 63 is flanged and presents a smooth surface whereon there is rotatably supported, by means of a co-acting groove, the grate 60 of the unitary system. For simplicity of fabrication, the grate can be formed of sections having integrally-cast lugs 66 whereby said sections can be bolted together to form a single rotatable unit. The smooth upper surface of said grate lies in substantially a horizontal plane and its slotted perforations 98, that extend through the body thereof for the removal of ashes from and for the admission of combustion air to the fuel bed, are arranged in groups according to a barred pattern wherein each has at least one slot substantially radially disposed whereas the remainder are in parallelism therewith.

Directly beneath the grate for which it can function as means to prevent tipping of the former in the event of unequal loading, or the like, but operatively independent thereof, is the ash-ring 80 which is supported by the radial brackets 85 that are themselves supported at their inner ends on the outer walls of extension-ring 63. Ash-ring 80 is formed of arc-like sections bolted together, the ends of such sections having slot-like openings that permit adjustment of its overall diameter, so that its periphery can be made substantially equal to that of the grate or be increased somewhat thereover. This feature of extensibility of said ash-ring permits the employment of a grate of some standardized dimension in an existing furnace having a fire-box of which the internal diameter is so much greater than

that of the grate that otherwise excessive leakage of ash and of fuel would take place in the peripheral space therebetween. The closing of this peripheral space by the ash-ring is susceptable of further refinement by supporting thereon, during the installation of the apparatus, a seal 84 formed from an asbestos cement, or the like.

After ashy combustion-residues have passed through the slots 98 of the grate, they are removed from the furnace floor or hearth by means of a pair of reciprocatory bars 91 which are pivotally secured to that cross-head 94 depending from the post 99 that is itself affixed to the under side of the reciprocatory feeder-plate 51 and with which it moves backwards and forwards in unison. Adjacent their opposite ends, said bars 91 are slidably held in guides 93 therefor which are spaced apart a distance greater than that obtaining between the said bar's pivots on their cross-head. During their reciprocatory movement the ash-removal bars are thus provided with some lateral as well as a lengthwise movement, the former said movement serving to clear a path through the ash-heap which is wider than the bars, so that any of the ashes falling onto their upper surfaces can be moved therealong and out of the furnace-hearth without being brushed off by adjacent material of the ash-pile.

The opening to the furnace hearth is surrounded with a tightly-fitted metal plate 83 thereby to prevent uncontrolled inflow of air through said opening to the grate. Ashes extracted from the furnace-hearth, by the movement of the ash-removal bars, drop from their surfaces into ash-pit 95 and into a therefrom removable container, if preferred.

In its embodiment shown in the drawings, the present improvement, as well as the unitary system in which it is incorporated, for employing solid fuels in the automatic supplying of heat to domestic heating installations, is arranged for actuation in response to fuel requirements of the fuel-bed to keep the same at a constant level. Means for accordingly actuating the improvement as a unitary part of the unitary system are provided by an improved fuel-bed-level control which comprises geniculate rod 101 to which is affixed at its lower end a truncated metal body 102, preferably formed from such resistant alloy as "Ni-Resist," or the like, that is in constant contact with the upper surface of the fuel-bed, said rod being pivotally mounted on a bracket for movement in a vertical plane, so that the member 102 can easily follow small changes in the level of the upper surface of the fuel-bed. Counterweight 103 is adjustably mounted on the outer end of rod 101 thereby increasing its ease of movement and sensitivity to changes in the fuel-bed level and also functioning to prevent the said rod's own weight causing its sinking below the surface of the bed. Adjustably affixed to the said geniculate rod where is extends through switchbox 104, there is an electrical switch, preferably of the Mercoid type, that is included in the circuit for driving electrical motor 112 whereby the unitary system formed with the present improvement is actuated. The said switch is disposable to open or close said circuit when the upper surface of the fuel-bed has respectively been for any reason raised or lowered beyond a predetermined level, the opening of said electrical switch however does not necessarily stop motor 112 immediately, unless the driving-rod 115 for the assembly is at the end of a full stroke.

The above-described features of the system are all interconnected for simultaneous movement by means of electrical motor 112 operative through speed-reducer 113, crank-arm 114, and the single driving-rod or lever 115, all of said members being mounted on the basal casting 111. Pivotally attached to lever 115 and adapted to be reciprocally moved thereby is cross-head 71 to which is bolted the one end of stoker-plate 51 that reciprocates inside stoker-tube 52.

All of the driven features of apparatus, that is, conveyor member 31, stoker-plate 51, ash-bars 91 and grate 60, are arranged to communicate directly or indirectly with the said driven cross-head 71. Viewing Fig. 4 from that end thereof adjacent the actuating motor, there is observed at the right-hand side of the cross-head 71 a thereto affixed arm containing an extended obtuse-angled slot 116 which terminates at its upper end in a short transverse slot. By means of the illustrated bolt that can be slid along said slot 116 and secured at any preferred position therein, link 117 is pivotally secured to said cross-head and serves as a connecting arm whereby reciprocatory motion of the cross-head is utilized to reciprocate the two cranks 118, disposed at right angles to each other, about their own pivot, which is supported in the bracket 121 attached to the lower side of the adapter-member 41. Two cranks 118 shown at right angles to each other in Figure 4 are adjustable to any angle about their own pivot, so that when the angle of approach of the conveyor to the stoker receiver is changed the angle between the crank arms 118 will be changed. Through this lever system, reciprocatory movement of the cross-head is resolved into similar movement of connecting-rod 36 which actuates the fuel conveyor-plate 31. The particular shape of obtuse-angled slot 116 and the adjustable angle between cranks 118 makes it possible to dispose conveyor-plate 31 at a wide range of angles-of-approach to the stoker inlet and yet to employ the motion of member 71 for operating the conveyor-plate to feed the stoker.

Operatively connected with the opposite end of crosshead 71 is the train of co-operative devices whereby the furnace-grate 60 is, made adjustably rotatable about its vertical axis accordingly as there is required in the co-ordinable system a greater or lesser removal of ashy residues, and the like, from the fuel-bed during any period of combustion. Within linear slot 72 of the cross-head, the effective length of said slot, as is clearly visible in Fig. 6, being simply regulable by means of a screw bolt 73 that is adapted for movement longitudinally thereof, the pin 79 is adapted to slide freely and independently of the cross-head a distance determined by and regulable according to the accorded space between the end of said bolt 73 and its adjacent slot-end and the both of which surfaces are adapted to engage said pin at some point during respectively the backward or forward movement of the reciprocatory cross-head, and in doing so, to move in the same direction the link 74 which is pivotally moveable at both its ends. Movement of said link 74 by pressure of the cross-head thereagainst effects corresponding movement of link 70 that is supported on a bracket, projecting from the walls of the underfeed-tube, by the bolt 100 which also serves to support for movement independently of said link 70 the ratchet 67 which is rotatable around said bolt.

Spring-actuated click 68 and pawl 69, of which the former is mounted on a pin for independent movement on lever 70 whereas the latter is simi-

larly mounted on the above-mentioned bracket affixed to the walls of the stoker-tube, are so disposed in respect of the teeth of ratchet **67** that pawl **69** engages a tooth thereof during the forward stroke of the cross-head, thereby allowing lever **70** similarly to move about pin **100** independently of the ratchet and the click **68** to advance in the direction of pawl **69** a number of teeth that is regulable by the effective length of slot **72**, and during the backward stroke of the cross-head, click **68** under the influence of its actuating spring is arranged to engage the adjacent ratchet-tooth so that both ratchet and the lever **70** are simultaneously moved in a counter clockwise direction. During backward movement of the cross-head, pawl **69** slides over the moving ratchet-teeth.

By means of the above-described train of apparatus, the reciprocatory movement of cross-head **71** is translated into an intermittent moving of the ratchet always in a counter clockwise direction. During its rotation around pin **100**, the ratchet carries with it link **75** mounted thereon by pin **78** and about which said link is rotatable. At its opposite end, the link **75** is rotatably attached to one end of the centrally-pivoted lever **65** on either end of which an adjustable lever-rod **76** is pivotally mounted, the opposite ends of said rod **76** being also pivotally mounted on shoulders **77** that are cast integrally with grate **60** on its lower surface where they are disposed along a diameter and whereby said grate is provided alternately with a clockwise and counter clockwise movement in a horizontal plane.

Rotation of ratchet **67** moves link **75** in alternation forward and backward thus respectively pushing and pulling that portion of member **65** to which it is attached and thereby causing said member to oscillate on its pivotal mounting and move the grate member alternately in opposite directions in a horizontal plane.

The total movement of the grate in any one direction is accomplished in sequences of stepwise movements whose lengths are variously adjustable, thereby enabling the householder to increase or diminish the amount of agitation, incidentally imparted to the fuel-bed, in accordance with the combustion results he wishes to effect with an individual fuel. This feature of adjustability of grate-movement is of importance and advantage for promoting the automatic delivery of heat over protracted periods because it permits either a regulable removal of combustion-residues from the grate and, in consequence, the maintenance of a constant rate of consumption of combustible notwithstanding changes in the ash content of the employed fuels, or, in the case of any particular fuel, a removal of ash from the fuel-bed that can be either increased or decreased to respectively enhance or diminish accessibility of combustion air to the burning fuel and correspondingly alter the rate of consumption of its combustibles. This is all simply and easily effected by suitable adjustment of screw-bolt **73** to regulate the effective length of slot **72** of cross-head **71**, which in turn controls the number of teeth of the ratchet over which click **68** passes before becoming engaged for the backward stroke of the cross-head.

As hereinabove mentioned, perforate slots **98** of grate **60** are arranged in a particular barred pattern wherein some are disposed substantially on or parallel with a diameter of the grate and the remainder in substantial parallelism with them. During the grate's rotational movement

about the axis of its supporting extension-ring **63**, successive contacts of the wall-edges of said slots **98** with the fuel or ash particles lying adjacently thereabove tends, in consequence of their changing angle of incidence in respect of surface irregularities of such materials, to provide said particles with rotational movement around their own axes in addition to that motion which is contributed by the grate itself. Such rotational movement is of course most pronounced near the grate periphery where the ash content of the fuel-bed tends to be highest and therefore the greatest agitation of the fuel-bed is needed to remove the ash sufficiently rapidly therefrom to prevent its fusion into large size clinker. To the lower surface of any such clinker as does form on the top of the grate, the said changing angle of incidence with which a succession of slots comes into contact therewith tends, assisted by the weight of the fuel-bed thereabove, to shear or break the clinker into fragments capable of passing through the grate-slots and being discharged from the installation by means of ash-bars **91**. The facility with which the apparatus is operative to maintain a clean fuel-bed, i. e., one that is relatively free of ashy residues and clinker, and from which such residues are continuously and automatically removable for extended periods, is, it is felt, in large part the result of this particular configuration of the grate-slots and the resultant special movement contributed by it to the fuel-bed, in combination with the regulability of the length of the steps with which the grate is moved between its limits of travel.

As hereinbefore mentioned the unitary system is adapted for actuation by means for maintaining the fuel-bed at a predeterminable level, said means being arranged to close or to open an electrical circuit that includes motor **112** respectively at such times as the upper surface of said fuel-bed has sunk below or been stoked to reach a preferred level. The electrical circuit, wherein said driving motor is included, comprises a novel arrangement of mercury switches whereby the motor, subsequent to a period of operation, comes to rest only at such times as connecting-rod **115** is at the end of its backward stroke, so that said motor will always be started when it is under the least load and gate **44** is always in closed position when the motor is at rest, as will be now described by reference to the drawings and, in particular, to Fig. 9.

Mounted on basal casting **111** of the stoker apparatus is switch box **131** that contains a Mercoid switch which is itself supported on rotatable finger **132**, said finger being under the influence of a spring member that always returns it, when moved therefrom, to a pre-arranged position and carries with it the Mercoid switch which, in the pre-arranged position of the finger, is supported in such manner as to close the electrical circuit. Finger **132** is also so disposed that, during each backward stroke of cross-head **71**, the outer end of that extension therefrom containing slot **116** moves said finger about its supporting shaft in the same direction, thereby tipping the attached Mercoid switch into a position to break flow of current therethrough. On the forward stroke of said cross-head, finger **132** and its associated switch are returned to the reverse position by the spring attached thereto. Connected in parallel with the Mercoid switch in box **131** is a similar switch that is contained in switch-box **104** and is arranged for movement, by the upward and downward movement of fuel-bed-level

control 101, between positions adapted to open or close the electrical circuit to motor 112 respectively as the fuel-bed is stoked to reach a preferred level or sinks therebelow.

The connection in parallel of the two Mercoid switches of members 104, 131, thus provides for delivery of power to the driving motor at all times save when both switches are simultaneously in a position to open said circuit, and by its means power continues to be delivered to the motor, even after that switch of the fuel-bed-level control has opened the circuit in its included branch line, until driving-rod 115 is at the end of its backward stroke when both switches and the motor-circuit will be in open position until member 102 again sinks with the fuel-bed level and moves the therewith communicating switch of 104 to close the circuit to the motor.

This feature whereby the driving-rod 115 can come to rest only at the end of its backward stroke assures, upon its restarting, that motor 112 is always under the least possible load, thereby, at that instant, insuring against heavy current flow and damage to the motor of which the size required depends upon its starting-load.

Members 151, 153 and 154 of Fig. 9 represent respectively circuit fuses, the lines that serve as a source of power, and a power-line switch.

The working parts of the assembly are all encased in a sheet-metal covering to enhance its appearance and protect its working parts. Above adapter-member 41, a portion of said covering is formed as a removable cover-plate 83 that provides ease of access to the several mechanical features.

The co-operation in the unitary system of the present invention and the importance and merit of the adjustable co-ordinable features provided therein for adapting it to solid fuels of varying characteristics and to divers requirements of heat can be best appreciated by a description of its operation while tracing the path of fuel from its storage bin onto the furnace-grate. In the following description the term "forward" will be employed to designate motion of the various parts toward the furnace and conversely the term "return" will be used to indicate motion in the opposite direction.

Let it be assumed that combustible of the fuel-bed on the furnace-grate has been burned to such point that member 102 of the fuel-bed-level control has sunk below a predetermined level, thereby so moving the Mercoid switch of switch-box 104 as to establish a flow of electrical current from the power lines to the system's driving motor 112. The motor causes driving-rod 115, which is positioned at the end of a return stroke, to move forward carrying with it the cross-head 71. In its forward movement, said cross-head, by means of the hereinabove described trains of apparatus connected therewith, effects similar movement of fuel-conveyor plate 31 and of stoker-plate 51 and also of the link 74 which moves click 68 in a clockwise direction around ratchet 67, the latter being held motionless by pawl 69, a number of teeth determinable by that effective length of linear slot 72 made available by the existing setting of adjustable screw-bolt 73. At the end of its forward stroke, driving-rod 115 is caused to move in the return direction by the crank-arm 114 which in turn causes members 31, 51, to start the return strokes of their reciprocatory motion, and when moving in this direction, click 68 becomes engaged with an adjacent tooth of the ratchet which is thereby moved in counter clockwise direction carrying with it lever-bar 75 which oscillates lever 65 on its pivotal mounting. Grate 60, that is oscillated by movement of the lever 65 operating through the pair of driving-bars 76, is moved in a counter clockwise or clockwise direction depending on whether pin 78 of lever-bar 75 is momentarily respectively on that half of said ratchet which is adjacent or opposite to the click 68. Thus, it is obvious, that the grate member is moved about its axis alternately a definite distance in opposite directions, and that by adjustment of the number of ratchet-teeth moved over by click 68 in the forward stroke of the cross-head, there is established the number of individual steps ascribed to said grate as it is moved between its limits of travel in either direction. The shorter the effective length of said slot 72, the greater will be the number of teeth moved over by said click, and vice versa.

In addition to the above-stated members of the unitary system, the ash-bars 91, that are attached to the lower part of reciprocatory stoker-plate 51 are correspondingly reciprocated with the latter, all of said members being actuated from cross-head 71 and in such manner that those employed for conveying materials all move simultaneously in a forward or return stroke.

Solid fuel, such as coke or coal, contained in storage bin 20, flows beneath inclined surface 22 and into pocket 19 of said bin where it freely lies on the upper surface of said plate at substantially its angle of repose. As cross-head 71 starts its forward stroke thereby effecting similar movement of fuel-conveyor-plate 31, the fuel in said so provided fuel pocket is carried along by said plate and thus advanced toward receiver 41 of the stoker member, the void thus created in said pocket being quickly filled by fuel flowing thereinto from a higher level in the bin. On its return stroke, the conveyor-plate slides beneath the layer of fuel which has been thus advanced therealong and cannot be carried backward because of the resistance of the new quantam of fuel that has flowed into the pocket 19 during the plate's forward travel. After a few cycles of movement of the conveyor-plate, its entire surface is covered with a shallow layer of the fuel and a small portion of which is discharged therefrom, with each forward stroke, past damper-valve 44, whereupon it falls onto the reciprocating stoker-plate 51. The gate 44 is operatively arranged to begin swinging upward to open position as the conveyor-plate 31 starts forward, and vice versa, so that said gate offers no obstruction to flow of fluel into the stoker-tube.

Simultaneously moving forward with the conveyor-plate 31 is the stoker-plate 51, and fuel discharged thereon from the former is moved forward therealong in the direction of the grate assisted by the small vertical offset formed by the thereto attached metallic block 134 which is located adjacent the point where the stoker-plate is secured to cross-head 71, as is clearly visible in Figs. 4 and 5. This offset functions with each forward stroke of said stoker-plate to carry toward the grate a relatively thin layer of the inflowing fuel.

If the solid fuel is discharged from the conveyor into the stoker-tube at a rate in excess of that at which the stoker-plate is adapted facilely to move it forward into the fuel-bed, said stoker-plate will jam. To obviate such circumstance the hereinabove described features for

regulating the rate of discharge from the conveyor are provided. These features comprise adjustable lock-nuts 38, whereby the limits of the reciprocatory movement of conveyor-plate 31 are determinable, as well as the flexible finger 141, which serves to regulate that cross-section of the conveyor-space made available as a free-way for the flow of fuel therealong. By these means it is possible to effect such a fine regulation of the conveyed fuel into the stoker-tube that, when the apparatus of the invention is in operation, a continuous stream of fuel is evenly flowed somewhat as though it were a liquid from the bin, through the stoker-tube and onto the grate without jamming or undue accumulation thereof at any point along its flow-path.

In consequence of the small offsets formed by member 134 and the vertically disposed ridges of liner plates 53, which become progressively thinner as the grate is approached, in combination with the bulk of the inflowing material, fuel that is moved forward on the stoker-plate 51 is prevented from being carried along on the stoker-plate's backward stroke and eventually reaches the lower part of the up-bend of the stoker-tube where it is picked up by the to-and-fro movement of the ram-head 59 and elevated into the vertically-extending section of the former whose cross-section is entirely filled with the solid fuel and the column of which is supported by its slight outward flare combined with removable finger 61, rib 133, and vertical offsets on the sides of tube 52 beneath rib 133.

By the reciprocatory motion of the ram-head 59, new quantities of the employed fuel are elevated into the vertically extending section of the stoker-tube and displace that already there into the fuel-bed atop grate 60, the inflow of such fuel giving more especialy the center of the fuel-bed a measure of agitation and causing a sort of radial flow outward of the fuel particles already therein.

At the same time that the conveyor-plate 31 and stoker-plate 51 are performing their operations, the grate is being moved either clockwise or counter clockwise in steps of regulable distance, thereby revolving and rotating between themselves those particles of unburned fuel and ash closer the periphery of the grate, such movements causing the fine particles of ashy residues to fall through the interstices of the fuel-bed and the grate-slots 98 onto the furnace-hearth therebelow where they are picked up on the upper surfaces of the simultaneously reciprocating ash-bars 91 and moved out of the hearth space toward the front of the furnace whence they fall into ash-pit 95. When sufficient new fuel has been introduced into the fuel-bed to raise member 102 to a predetermined level, the Mercoid switch, in switch-box 104, will be moved to stop current flow therethrough whereupon, during the subsequent backward stroke of driving-rod 115, contact in the Mercoid switch of switch-box 131 will be broken and the system come to rest until the next demand for fuel by the level control.

From this brief description of the operations of the co-operative features of the unitary system and the operative results obtainable therewith, it is evident that by means of said sysem it is possible to flow a solid fuel from an adjacent storage bin onto a furnace-grate and to burn the fuel and to remove the ashy residues from the fuel-bed and the furnace so simply and effectively that heat can be supplied to a heating installation quite automatically.

In such a unitary system for employing solid fuels, it is however insufficient to furnish co-operative features of apparatus that are adapted to perform the above-stated operations, because the more common of such fuels vary from one to the other in certain of their characteristics; notably, their ash contents. It is, therefore, highly desirable for the assurance of continued automatic operation over a protracted period, that the component apparatus of such a system be not only co-operatively disposed but also that their individual operations be so regulably co-ordinable within the system that operative results of the one can be made consonant with that of the other. For example, with fuel of a given ash content being consumed on the grate at an established rate and with a corresponding delivery thereof to the fuel-bed by the conveyor and stoker, an established angular movement of the individual steps of the grate in its rotary motion can provide just that amount of agitation to the fuel-bed necessary to give a removal of ashes therefrom and the grate that is adequate to keep apace with their formation, thereby assuring good conditions of combustion and non-formation of clinker that might otherwise accumulate on the grate to prevent combustion air reaching the fuel and thus extinguish the fire. With such co-ordination of these apparatus of the system, excellent combustion conditions can thus be automatically maintained for an indefinite period. Let it now be assumed, however, that the source of solid fuel is changed to one having a higher content of ash but that it is still desirable to burn the combustible of the new at the same rate as in the previous instance. This means that to deliver the same amount of combustible to the grate for a given period, a larger quantity of fuel will necessarily have to be conveyed to the stoker. In the system, this is simply done by increasing the amplitude of movement of conveyor-plate 31 or by retracting finger 141 closer to the walls of the conveyor shell. In consequence of the fact that more ash will accumulate in the fuel-bed with fuel from this new source, it will become necessary, for the obviation of undue accumulations of such material in the fuel-bed, to increase the amount of agitation ascribed thereto by the grate in its stepwise movement.

In the present apparatus, this circumstance is simply provided for by so moving threaded bolt 73 as to decrease the effective length of slot 72, that determines the extent of each angular movement of the ratchet, and which in turn will increase the angularity of each movement of the grate and the resultant agitation of the fuel-bed, thereby increasing the rate of ash withdrawal through the grate onto the hearth. With more rapid accumulation of ashes on the furnace-hearth, ashes will be automatically piled higher on the top of the ash-bars and during each cycle of their reciprocatory movement more ash will be carried to the ash-pit.

If, on the other hand, it is desired to employ more freely-burning solid fuel of sharply reduced ash content which makes it desirable to decrease the rate of ash withdrawal and even to allow a layer thereof to accumulate on the grate in order to reduce the natural draft, the stepwise movement of the grate can be reduced to establish such condition without altering an established setting of the conveyor 31; or, as is now obvious, with any given solid fuel, the extent of movement of

the conveyor-plate 31 can be adjusted to meet the demands of the fuel-bed for any rate of its consumption, and the agitation thereof be arranged properly to remove the ash for such rate by coordinative adjustment of the grate movement to that of the conveyor-plate.

By means of the present improvements in stoker systems it is now possible to assure, for domestic-heating installations, apparatus whereby, for any solid fuel, an appropriate and precise adjustment is always establishable between the rate of fuel delivery, its rate of combustion, and the rate of ash withdrawal from the heating system, so that these factors are always in equilibrium to give optiumum combustion conditions for any of the common solids fuels.

The invention as hereinabove set forth is embodied in particular form and manner and may be variously embodied within the scope of the claims hereinafter made.

We claim:

1. In combination, a stoker feeder, a separate fuel bin adapted to contain a fuel supply, an apparatus arranged to deliver fuel from the bin to the feeder comprising: an elongated trough connecting the bin with the feeder, a smooth flat plate mounted to reciprocate in the bottom of the trough, guides in the trough extending to the edges of the plate to expose only the upper surface of the plate to the fuel to be transported, driving means secured to the bottom of the plate arranged to reciprocate the plate with a continuing controlled stroke, and means to retard the backward movement of the fuel on the plate whereby on the forward stroke of the plate the fuel feeds along the plate and on the return stroke of the plate, the plate slides under the fuel.

2. In combination, a stoker feeder, a separate fuel bin having a bottom hopper adapted to contain a fuel supply and an apparatus arranged to deliver fuel from the bin to the feeder comprising: an elongated trough extending from the feeder to and under the entire length of the hopper under the bin, inclined surfaces in the bin for feeding fuel into the trough, a smooth flat plate movably mounted and extending substantially throughout the length of the trough, guides in the trough extending to the edges of the plate to expose only the upper surface of the plate to the fuel to be transported, driving means secured to the bottom of the plate arranged to reciprocate the plate with a continuing stroke, and means to retard backward movement of the fuel on the plate whereby on the forward stroke of the plate the fuel feeds along the plate and on the return stroke of the plate, the plate slides under the fuel.

3. In combination, a stoker feeder having a fuel receiver, a fuel supply bin adapted to be separated from the receiver, and an apparatus arranged to deliver fuel from the bin to the fuel receiver comprising: an elongated trough connecting the bin to the receiver, a smooth flat plate mounted to reciprocate in the bottom of the trough, guides to confine the fuel being conveyed to the upper face of the plate, means to reciprocate the plate, means to retard backward movement of the fuel on the plate, whereby on the forward movement of the plate the fuel feeds along the plate and on the return stroke of the plate, the plate slides under the fuel, a closure gate for the trough at its discharge end, a connection between the plate driving mechanism and the gate to open the end of the trough on the forward stroke of the plate, and a weighted lever arranged to yieldingly close the gate on the return stroke of the plate.

4. In combination, a stoker feeder having a fuel receiver, a fuel supply bin adapted to be separated from the receiver, and an apparatus arranged to deliver fuel from the bin to the fuel receiver comprising: an elongated trough connecting the bin with the receiver, a smooth flat plate mounted to reciprocate in the bottom of the trough, means to reciprocate the plate, means to retard the backward movement of the fuel on the plate whereby on the forward stroke of the plate fuel feeds along the plate and on the return stroke of the plate, the plate slides under the fuel, and a flexible finger plate mounted in the trough and adjustable transversely across the plate near the discharge end of the trough for controlling the amount of fuel to be carried into the receiver.

5. In combination, a stoker feeder having a fuel receiver, a fuel supply bin adapted to be separated from the receiver, and an apparatus arranged to deliver fuel from the bin to the fuel receiver comprising: an elongated trough connecting the bin with the receiver, a smooth flat plate mounted to reciprocate in the bottom of the trough, a driving rod for reciprocating the plate, a motor driven member mounted adjacent the receiver, an adjustable connection between the driving rod and the driven member arranged to provide for reciprocation of the plate while permitting different angular arrangements of the trough and receiver, and a flexible finger adjustable transversely across the plate to control the amount of fuel being fed to the receiver.

6. In combination, a stoker feeder having a fuel receiver, a fuel supply bin having a bottom hopper adapted to be separated from the receiver and an apparatus arranged to deliver fuel from the bin to the fuel receiver comprising: an elongated trough extending from the receiver to and under the bin hopper, inclined surfaces in the bin for feeding fuel into the trough, a smooth flat plate movably mounted in and extending substantially throughout the length of the trough, guides at the sides of the trough extending to the edges of the plate to expose only the upper surfaces of the plate to the fuel to be transported, means to reciprocate the plate, means to retard the backward movement of fuel on the plate whereby on the forward movement of the plate the fuel feeds along the plate and on the backward movement of the plate, the plate slides under the fuel, a gate mounted in the trough near its discharge end, said gate being adjustable to control the amount of fuel passing off of the plate into the receiver, and a fuel depth means adjustably mounted in the bin to determine the depth of the fuel deposited on the plate.

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