

Sept. 29, 1953

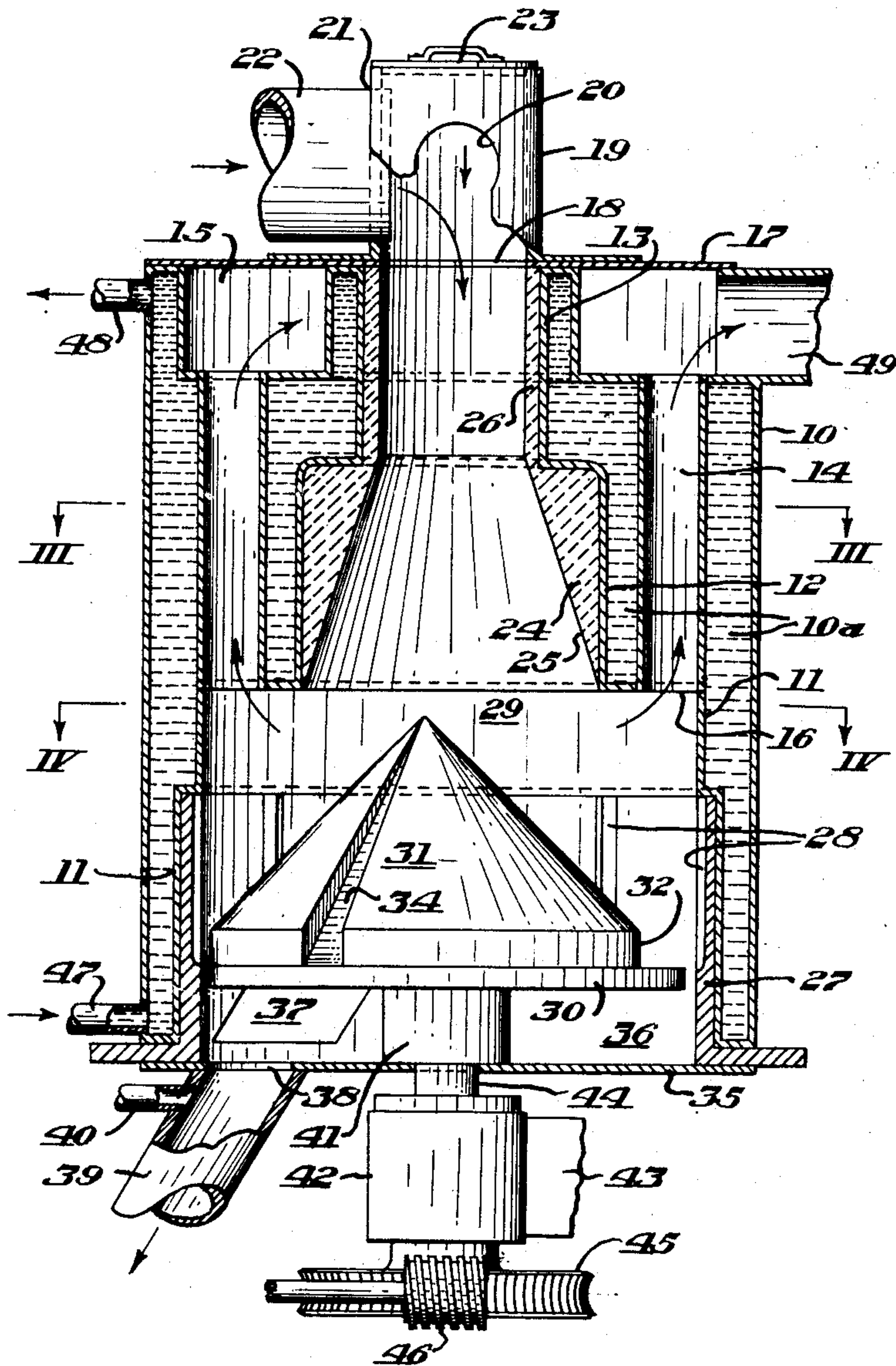
W. J. HATTON ET AL
APPARATUS AND METHOD FOR CONTROLLING COMBUSTION
FURNACES FOR SOLID ORGANIC FUELS

2,653,554

Filed June 11, 1949

2 Sheets-Sheet 1

Fig. 1.



INVENTORS
WILLARD J. HATTON &
HENNING M. CARLSON

*by Hooper, Leonard & Glenn
their attorneys*

Sept. 29, 1953

W. J. HATTON ET AL
APPARATUS AND METHOD FOR CONTROLLING COMBUSTION
FURNACES FOR SOLID ORGANIC FUELS

2,653,554

Filed June 11, 1949

2 Sheets-Sheet 2

Fig. 2.

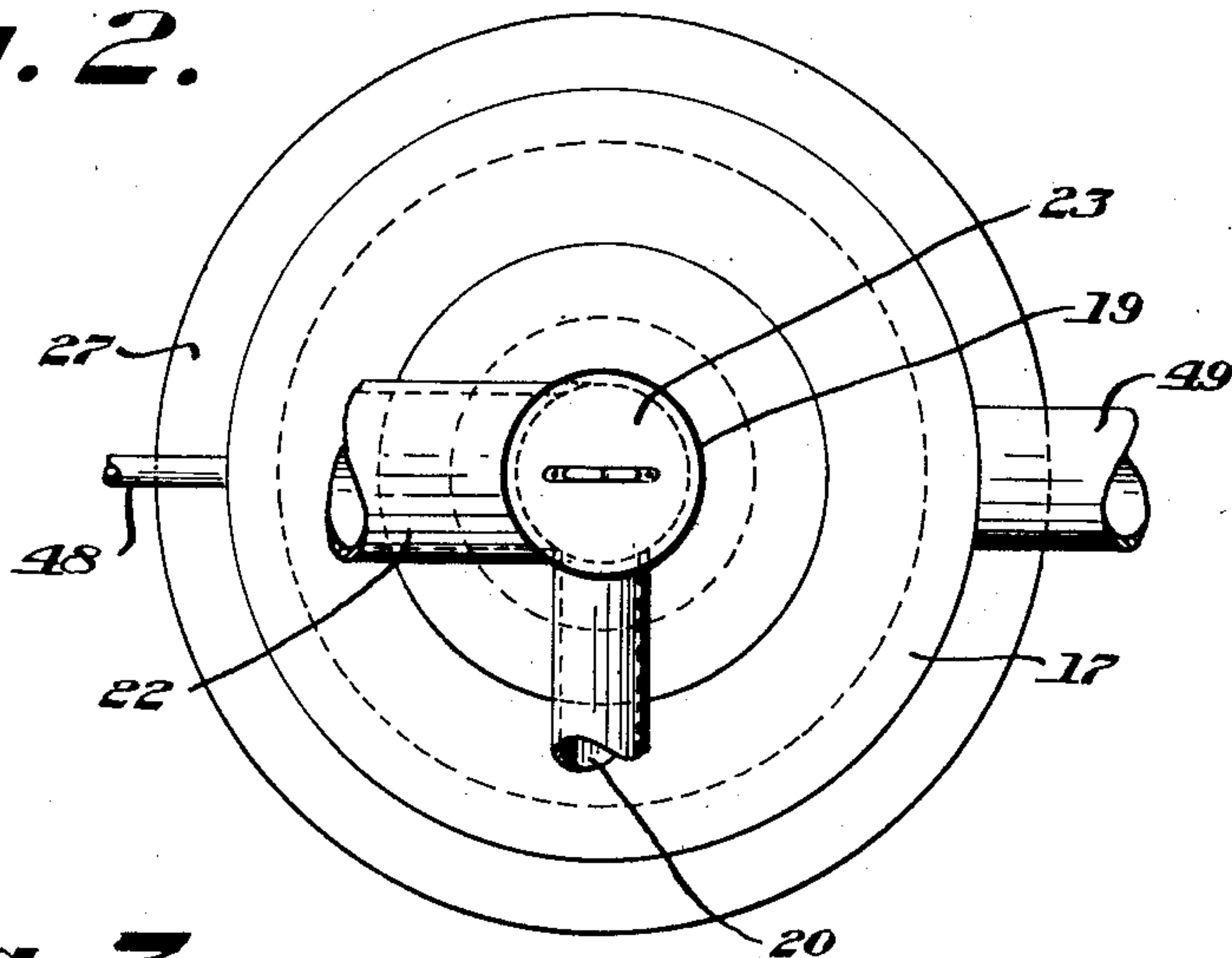


Fig. 3.

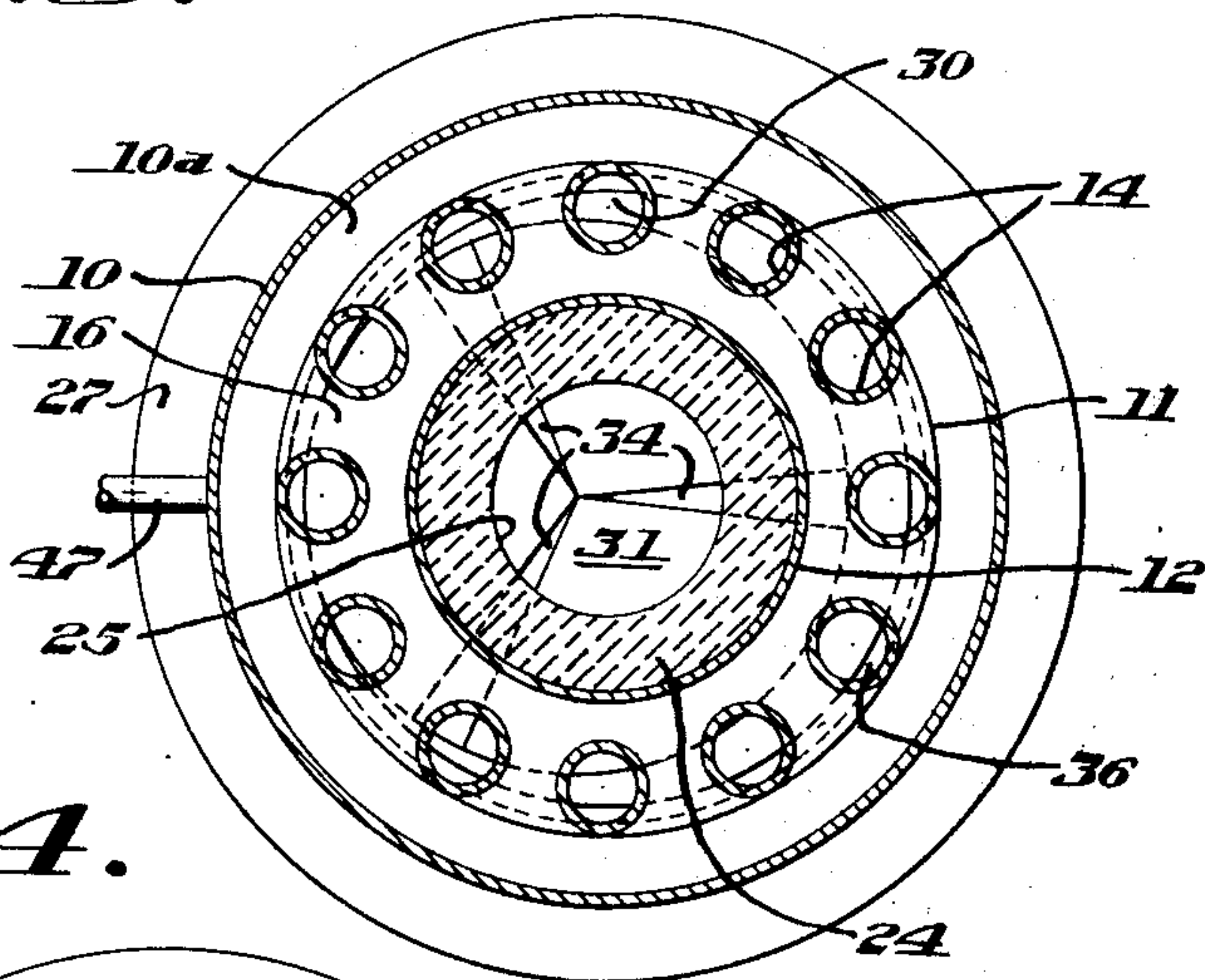
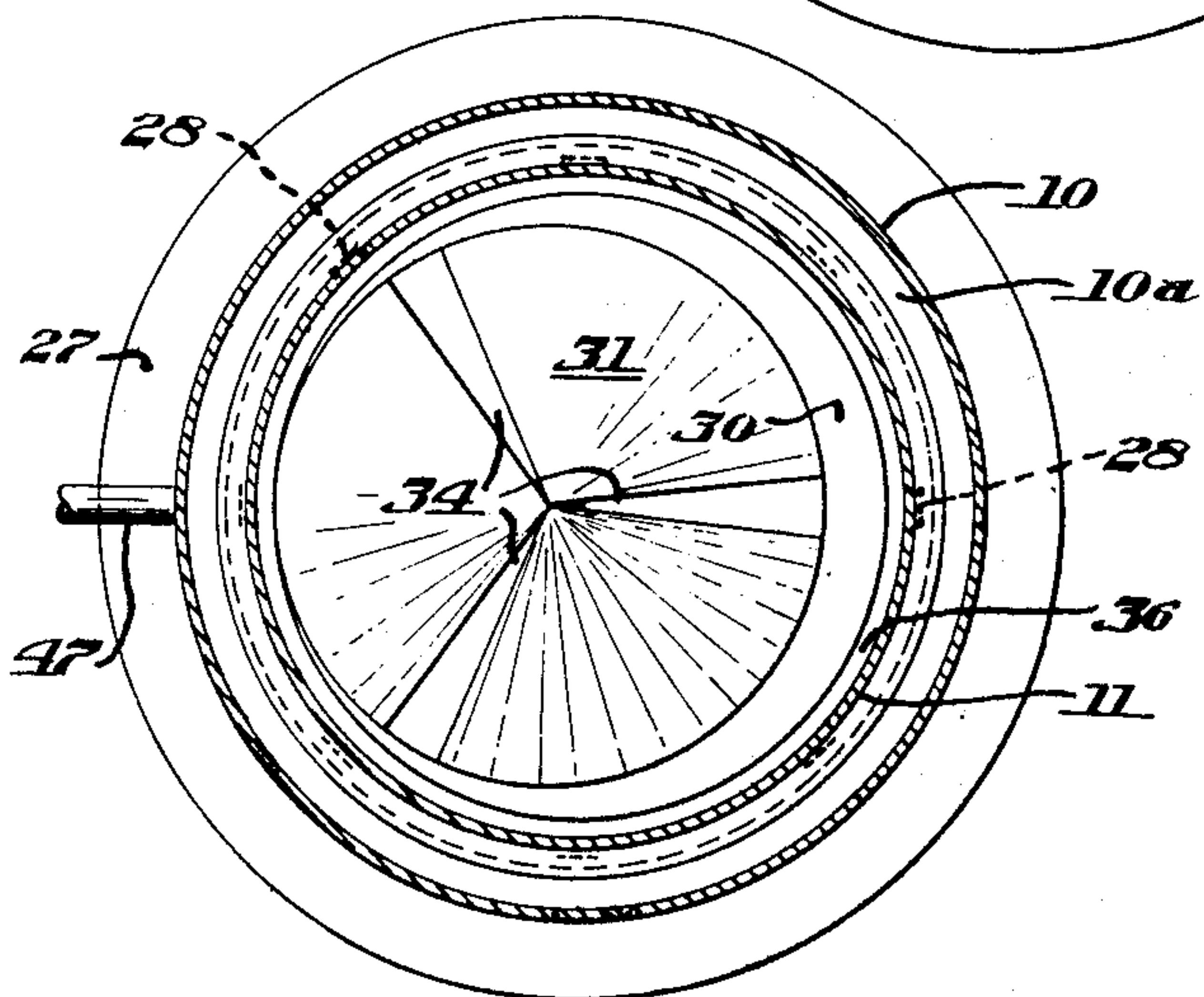


Fig. 4.



INVENTORS
WILLARD J. HATTON &
HENNING M. CARLSON
by Hooper, Leonard & Glenn
their attorneys

UNITED STATES PATENT OFFICE

2,653,554

APPARATUS AND METHOD FOR CONTROLLING COMBUSTION FURNACES FOR SOLID ORGANIC FUELS

Willard J. Hatton and Henning M. Carlson, Columbus, Ohio, assignors, by mesne assignments, to Bituminous Coal Research, Inc., Washington, D. C., a corporation of Delaware

Application June 11, 1949, Serial No. 98,484

2 Claims. (Cl. 110—29)

1

This invention relates to new means for automatically controlling the depth of a live fuel bed in a stoker-fed coal furnace for residences and the like. More particularly, it relates to a system for maintaining the plane of ignition of such a fuel bed at a relatively constant level in the furnace despite variations in the composition and size of the fuel. This invention is of especial value when used in connection with the downflow stoker-fed furnace system for bituminous coals which is more fully disclosed in United States patent application Serial No. 93,562, filed May 16, 1949, in the name of Willard J. Hatton and Ralph A. Sherman, having the same assignees.

By means of the furnace system of said application Serial No. 93,562, the substantially fully automatic heating of average size residences and small buildings with bituminous coals and the like was made feasible using conventional control circuits.

In that system, a small furnace is provided to which bituminous coal and air in correlative amounts are periodically or continuously fed as demand requires to the top of a live fuel bed, the upper part of which is confined and remains in a restricted zone within the furnace. A zone of discontinuity, in the sense of maintaining a space between fresh coal other than a thin layer fed from time to time and the top of the fuel bed, is provided substantially at the plane of ignition so that the coal remains relatively cool until it is actually subjected to kindling conditions at the time it is so fed. Under the high rate of burning (relative to the rates of burning in conventional furnaces) that ensues at least during the "on" periods of heat demand and hold-fire, all volatile and tarry matter released passes through the fuel bed whence the heat release potentiality thereof is recovered and smoke emission which might otherwise be caused thereby is prevented. The agglomerating properties of such volatile and tarry matter are suppressed or destroyed during such active burning and remaining agglomerating tendency, if any, is nullified by ignition suppression obtained by predetermining the setting of the control circuit. The particles in the fuel bed gravitate downwardly into the unconfined lower portion of the combustion chamber where gaseous combustion products escape through the upper surface of said bed around the restricted zone. Ash also gravitates downwardly through the fuel bed and out of the combustion chamber before any material clinkering thereof can take place.

The aforesaid system makes it possible to burn

2

strongly agglomerating coals in equilibrium which may be defined as that condition in which the fuel bed, for a constant rate of primary air, maintains the same character of combustion and thickness. In other words, the rate of burning and the rate of ignition remain substantially equal and free burning results with the plane of ignition staying in the restricted zone during heat demand and hold-fire periods. The restricted zone is the upper confined portion of the combustion chamber which opens unrestrictedly into the lower unrestricted portion of the combustion chamber. The fuel bed, which is substantially entirely a live fuel bed, extends upwardly into and fills at least the lowermost end of the restricted zone. It is inherent in furnace systems employing a variation of the underfeed principle that some thinning of the fuel bed occurs when the air rate is increased. Such a change will shift the plane of ignition to some extent within the restricted zone which is generally not sufficient, however, to disturb the bed's equilibrium.

However, there are variation factors which would materially tend to change the level of the plane of ignition in a given furnace if such tendency were not counteracted. Important factors of this character arise from the differing agglomeration properties of bituminous coals from different beds, from the different reactivities of the respective sizes of coal fed to the furnace system, and from fluctuations in heat demand. On the subject of size, bituminous coal supplied for domestic stokers, for example, may vary between the approximate size limits from about 1 1/4" maximum to 1/8" minimum, a wide size consist in terms of the combustion reactivity of the size gradations in that consist. Since the furnace in the system disclosed in application Serial No. 93,562 is relatively small, any tendency towards its becoming "upset" by disturbing its equilibrium must be counteracted that much more quickly. Any tendency to lose equilibrium is particularly present during hold-fire operation, as distinguished from heat demand operation. Although the aforesaid system achieves equilibrium burning at all times, when the upper portion of the combustion chamber thereof has vertical walls throughout the entire lowermost portion thereof, there may be somewhat less latitude possible in the presetting of the circuit controls and relatively greater quantities of combustion air required particularly for hold-fire operation.

In the present invention, means are provided which effect an immediate inherent and auto-

3

matic corrective condition to oppose any change in the depth of the fuel bed and hence in the position of the plane of ignition irrespective of a change in heat demand or in fuel characteristics. In form this invention provides a tubular combustion chamber in which the upper or restricted portion is frusto-conical throughout at least the lower end thereof. The frusto-conical part of the combustion chamber may be lined with refractory or other insulation of greater thickness at the top thereof, such thickness gradually decreasing towards the bottom thereof, or, in other words, generally varying inversely to the cross sectional area of that end of the upper portion of the combustion chamber. Hence, if the fuel bed tends to deepen, the somewhat irregular substantially plane surface or zone at the top of the fuel bed, called the plane of ignition, tends to diminish in area. It appears that the rate of burning thereby tends to increase counteracting any tendency to agglomeration. If the fuel bed should tend to thin, the plane of ignition tends to increase in area and appears to tend to lower the rate of burning and thus correct the thinning condition.

The insulation of at least the frusto-conical part of the combustion chamber of this invention, particularly if that insulation varies in thickness, generally inversely with the cross sectional area of the flared part, seems to augment the control obtained by means of the frusto-conical part, possibly because of the general correspondence in the variation of the heat-retaining capacity thereof and in the variation in the rate of burning at different levels therein. Thereby, the corrective increase tendency in the rate of burning as the plane of ignition tends to rise would be correspondingly enhanced by the progressive increase in the temperature of the insulation. The insulation is effective also in maintaining combustion temperatures at least during "off" feed periods in hold-fire operation. The downwardly flared part of the combustion chamber facilitates the downward progression of burning fuel and ash particles in the fuel bed to the lower portion of the combustion chamber and eliminates any tendency to bridging which sometimes occurs across relatively vertical surfaces.

Other objects and advantages of this invention will be apparent from the following description and from the drawings, which are illustrative only in which

Figure 1 is a view in vertical cross section of a residential downflow stoker-fed furnace embodying this invention;

Figure 2 is a plan view of the entire furnace shown in cross section in Figure 1;

Figure 3 is a horizontal cross sectional view taken substantially along line III—III of Figure 1; and

Figure 4 is a horizontal cross sectional view taken substantially along line IV—IV of Figure 1.

Referring to the drawings, the furnace illustrated has a casing 10 forming the outer wall of a jacket or boiler 10a. Jacket 10a contains a heat absorbing fluid such as water and has an inner wall consisting principally of a lower tubular inner wall section 11, an offset intermediate inner wall section 12 and an upper inner wall section 13. A plurality of vertical flue pipes 14 are concentrically positioned around inner wall sections 12 and 13, and extend from offset wall portion 16 to an annular flue collar 15 thus connecting the latter to the lower portion of a

4

combustion chamber 29. Flue pipes 14 are sealed around their respective edges to keep boiler 10a fluid tight.

A cover plate 17 rests on the top of casing 10 and closes flue collar 15 to which respective portions of the furnace it is bolted or otherwise affixed. A central opening 18 is provided in cover plate 17 which opening is in registry with the opening at the top of tubular wall section 13. A turret head 19 closes opening 18 and has a port 20 therein for the admission of combustion air. A further port 21 in head 19 is connected to the delivery end of a conveyor conduit 22 within which a feed screw (not illustrated) operates to feed bituminous coal or other fuel in predetermined amounts dependent upon the heat demand and control conditions operative at the time being. A cover 23 tightly closes a corresponding opening in the top of head 19. This cover may be removed to insert and ignite kindling at the commencement of operations if automatic ignition apparatus should not be provided.

Wall section 12 is lined with a refractory material 24 so disposed that the innermost surface 25 thereof is substantially in the form of a frusto-conical part substantially forming an upper restricted portion of combustion chamber 29. This refractory 24 thereby increases in lateral thickness in an upward direction and generally inversely to the reduction in internal horizontal cross sectional area of the frusto-conical part defined by surface 25. Uppermost inner wall section 13 may be lined with a substantially vertical layer of refractory 26 which, at its lowermost edge, meets the uppermost edge of refractory layer 24. The interior space within refractory lining 26 may be regarded as the very top of combustion chamber 29 although the plane of ignition is adapted to remain within surface 25 which confines the upper part of the live fuel bed.

The upper portion of combustion chamber 29 opens unrestrictedly into its lower portion, substantially forming the top of an inverted L. This lower portion broadens out around a conical grate 31. Grate 31 is supported in fixed, eccentric position on a rotating base 30. Ash passes between base 30 and the lower section of jacket 10a into an ash pit 36 where it is removed. The lower section of jacket 10a behind wall section 11 absorbs heat directly from the lower portion of the fuel bed, thereby aiding in the maintenance of temperatures at least in the lower portion of the fuel bed which discourage any material formation of clinker by the melting or fusion of ash. Additional cooling in the lower portion of combustion chamber 29 may be obtained if desired by the provision of some supplemental combustion air through a line 40 and ash pit 36. Such supplemental combustion air will also mix up and burn combustible which might otherwise tend to be present in the ash and in the gaseous combustion products. Normally, such supplemental combustion air would not be in excess of one-quarter by weight of the downflow primary combustion air supplied to the furnace through port 20.

A metal liner 27 surrounds the lower portion of combustion chamber 29 in contact with lower wall section 11. The inside of liner 27 is in vertical registry with wall 11 above it so that fly ash may have substantially no non-vertical surface or "land" on which to deposit in the fur-

5

nace. A series of vertical grooves 28 are disposed around the inside of liner 27 and cooperate with a plurality of grooves 34 in grate 31 and with its lower vertical edge 32 to break up such small clinker particles as may form. Sufficient clearance is left between the edge of base plate 30 and the interior of liner 27 so that only readily removable ash falls into ash pit 36. A sweep 37 is adjustably affixed to the underside of base 30 and pushes ash out of ash pit 36 through an opening 38 leading into an ash removal duct 39. A bottom plate 35 closes the bottom of ash pit 36 and casing 10. Suitable lagging may be provided for all exposed portions of the furnace.

Base 35 is rigidly mounted on a hollow rotatable shaft 44 having passages therein (not shown) through which cooling water may be circulated if, under the particular circumstances of a given furnace, the temperature in the lower portion of the fuel bed tends to be too high. A hub block 41 is supported by closure 35 and supports a live fuel bed extending from the upper surface of plate 30 to the plane of ignition within refractory surface 25. A bushing 42 is provided at the end of a fixed bracket 43 to assist in the journaling of shaft 44 which is keyed at its upper end to base plate 30 and at its lower end to a worm wheel 45. A worm gear 46 is driven either continuously or stepwise by appropriate control and driving mechanism (not shown) during the operation of the furnace system. Heat-absorbing fluid is supplied to jacket 10a through a pipe 47 and after circulation therethrough passes out through an outlet pipe 48. Gaseous combustion products including entrained material after passing through the fuel bed filling the lower end of the upper portion of combustion chamber 29 make an abrupt turn and pass laterally and then upwardly through the bed and into the proximate vertical flue pipes 14. Thence, they pass into flue chamber 15 and out through a duct 49 to a stack. The vertical surfaces of flue pipe 14 and the absence of horizontal ledges around the walls of combustion chamber 29 minimize any possibility of deposition of fly ash or soot.

In operation, relatively cool fuel and combustion air are fed downwardly into the top of combustion chamber 29 at predetermined rates controlled by the control system (not shown) which is employed. This combustion air, normally in some excess of that required for theoretical perfect combustion for the weight of fuel fed, is supplied through port 20 at ambient temperature or preheated. If preheated, as is well understood, the reactivity of the operation is increased and the presetting of the control circuit will make due allowance therefor. The fuel becomes relatively rapidly ignited within the frusto-conical part surrounded by refractory 24 and burns at a high rate in relation to any previously known furnace systems for such use. Such high rate burning continues at least until all troublesome caking tendencies are suppressed. Thereafter, as in the case of an "off" period during hold-fire operation, the chimney effect induced by the draft through the stack will normally provide sufficient air for the maintenance of combustion. Some additional combustion air, if desired, may be supplied during such "off" periods. All volatiles and tarry material in the fuel must pass through the fuel bed where it is burned.

Fuel and ash particles move downwardly and outwardly since the fuel bed is substantially in

6

the form of a hollow cone with its apex confined by surface 25 in the upper restricted portion of combustion chamber 29. Ash also rapidly and directly progresses downwardly toward and eventually into ash pit 36. Any particles of clinker which may form are broken up and crushed between grooves 34, edge 32, the outer periphery of plate 30 and the cast or milled vertical grooves 28 in liner 27. Such crushed fragments also pass into ash pit 36 whence they are discharged. Rotation of plate 30 causes grate 31 to agitate the fuel bed and further reduce any opportunity for material formation of clinker. Heat from the combustion chamber and from the gaseous combustion products is rapidly absorbed by the heat-absorbing fluid circulated through jacket 10a.

In general, if despite the high burning rate employed, caking or coking coals tend to have some remaining agglomeration tendencies or an undue proportion of larger size particles of fuel are fed, the fuel bed may tend to deepen. If so, it appears that upon the initiation of any deepening of the bed, the approximate cross sectional area of the plane of ignition tends to be reduced and thus increase the rate of burning to counteract the deepening tendency. Conversely, there may be a tendency in the bed to thin if there is an undue proportion of smaller size fragments in the fuel fed or if the pressure drop through the bed should tend to decrease. If so, the rate of burning, measured in terms of pound weight of fuel burned per square foot of ignition plane area per hour, appears to tend to decrease as the cross sectional area of the plane of ignition tends to increase. This in turn seems to have the effect of counteracting the thinning condition and maintaining equilibrium burning with the plane of ignition in its normal position in the frusto-conical section of combustion chamber 29. In some applications a refractory 24 may not be required or helpful and inner wall section 12 may itself be made in frusto-conical form to achieve the purposes of this invention.

While this invention has particular application to an improved control in the equilibrium burning of bituminous coals and the like, it may also be utilized with other fuels such as anthracite and coke. Moreover, the advantages of this invention are achieved not only under conditions of heat demand but also under hold-fire conditions. Under hold-fire conditions the fuel bed remains substantially constant in depth which keeps the plane of ignition at a relatively constant level within surface 25.

Although we have illustrated and described a practice and embodiment of this invention, it is to be further understood that various changes may be made within the spirit of the invention and the scope of the appended claims.

We claim:

1. In combination, in a furnace system having a combustion furnace for solid organic fuels, apparatus comprising, a substantially tubular generally vertically extending combustion chamber for a live fuel bed, said chamber having a downwardly and outwardly flaring portion, the walls of said flaring portion being progressively more heavily insulated around said portion in a direction proceeding from the lower to the upper part of said flaring portion, a fuel feed conduit connected to said chamber adjacent the upper part of said flaring portion, and an air conduit connected to said chamber adjacent the upper portion of said flaring portion to supply at least

7

primary combustion air generally downwardly into said chamber, whereby any tendency for said bed to change in thickness tends inversely to change the area at and directly to change the insulation around the top of said bed.

2. In a heating furnace system for the combustion of solid organic fuels, the steps comprising, in combination, maintaining a live fuel bed in a combustion zone, laterally confining at least the upper portion of said fuel bed into a generally frusto-conical shape, insulating said confined portion of said fuel bed progressively more heavily in a direction proceeding from the lower wider part of said confined portion to the upper narrower part of said confined portion, generally downwardly feeding fresh fuel to the top of said confined portion of said fuel bed, and feeding primary combustion air downwardly into said top of said fuel bed, whereby any tendency in said bed to change in depth is counteracted by a

8

change in area at and of insulation effect around said top of said fuel bed.

WILLARD J. HATTON.
HENNING M. CARLSON.

5

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
76,010	Watts	Mar. 24, 1868
124,672	Durfee	Mar. 19, 1872
272,692	Hopkins et al.	Feb. 20, 1883
595,339	Rahner	Dec. 14, 1897
1,548,292	Wedge	Aug. 4, 1925
1,848,878	Hagstrum	Mar. 8, 1932
2,180,196	Corbett	Nov. 14, 1939

FOREIGN PATENTS

Number	Country	Date
169,615	Switzerland	June 15, 1934

20