No. 717,306. Patented Dec. 30, 1902.

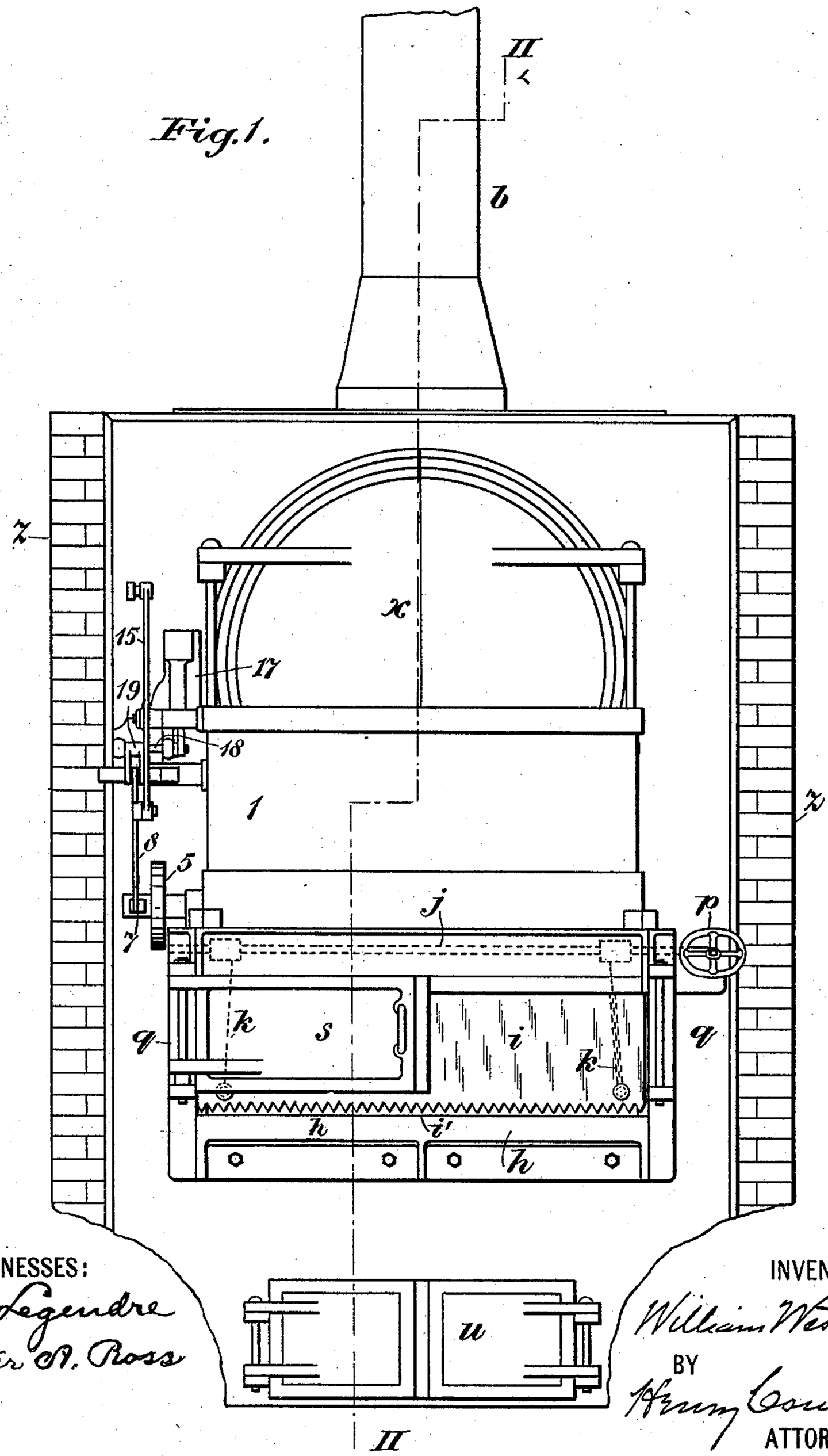
W. WESTLAKE.

FURNACE FOR BURNING POWDERED FUEL.

(Application filed Sept. 27, 1900.)

(No Model.) 7 Sheets—Sheet 1.

Fig. 1.



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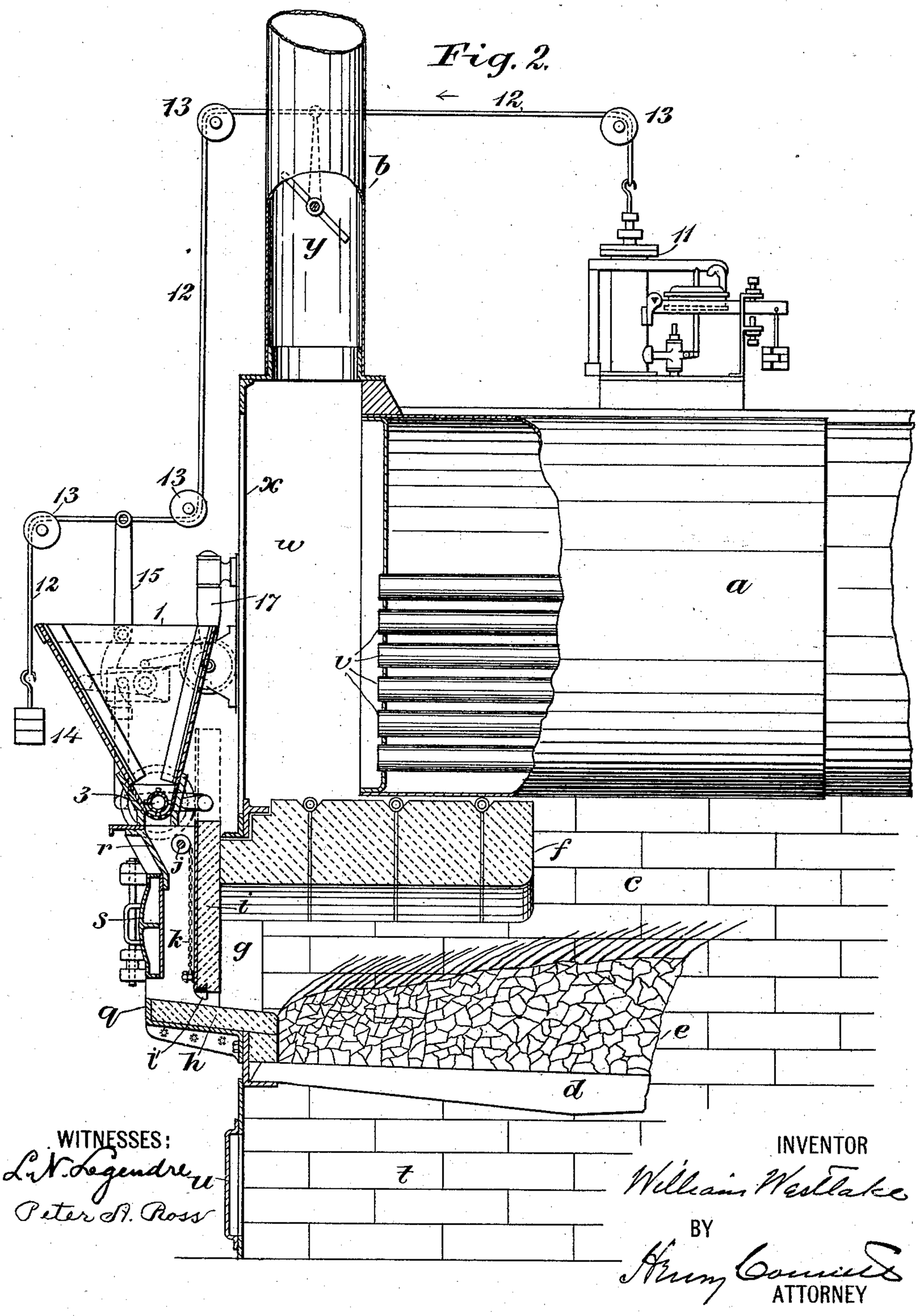
(No Model.) 7 Sheets—Sheet 2.

Fig. 2.



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(No Modal.) 7 Sheets—Sheet 3.

Fig. 3.

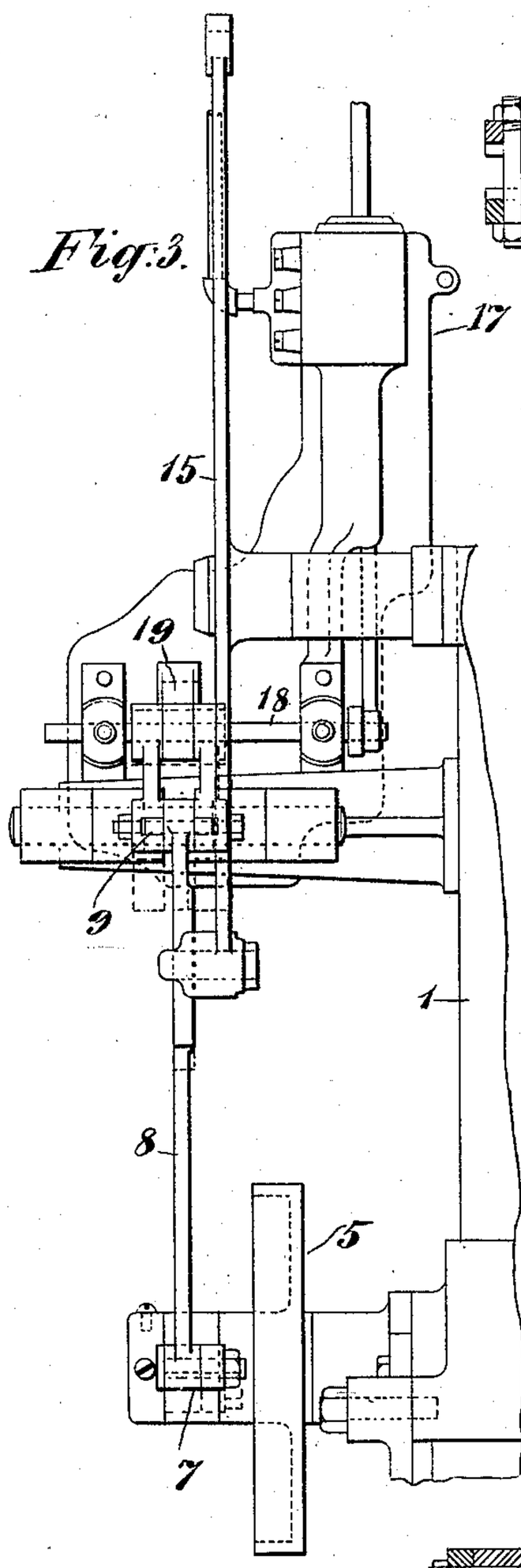


Fig. 5.

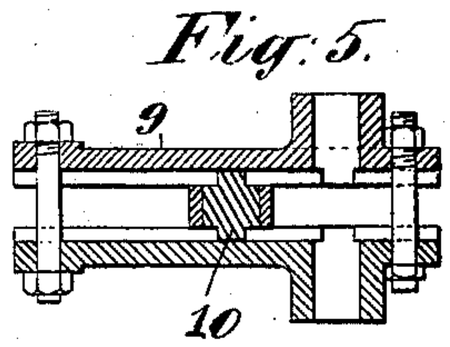
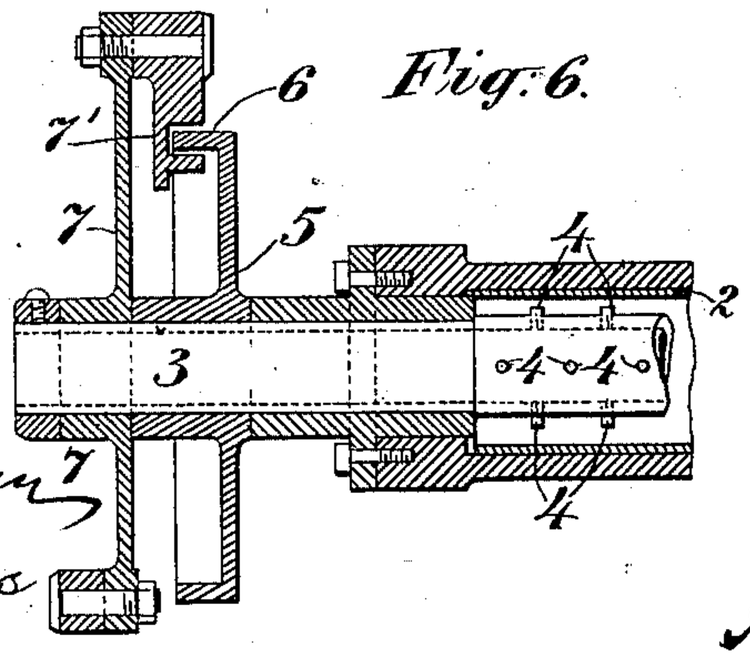


Fig. 4.

Fig. 6.



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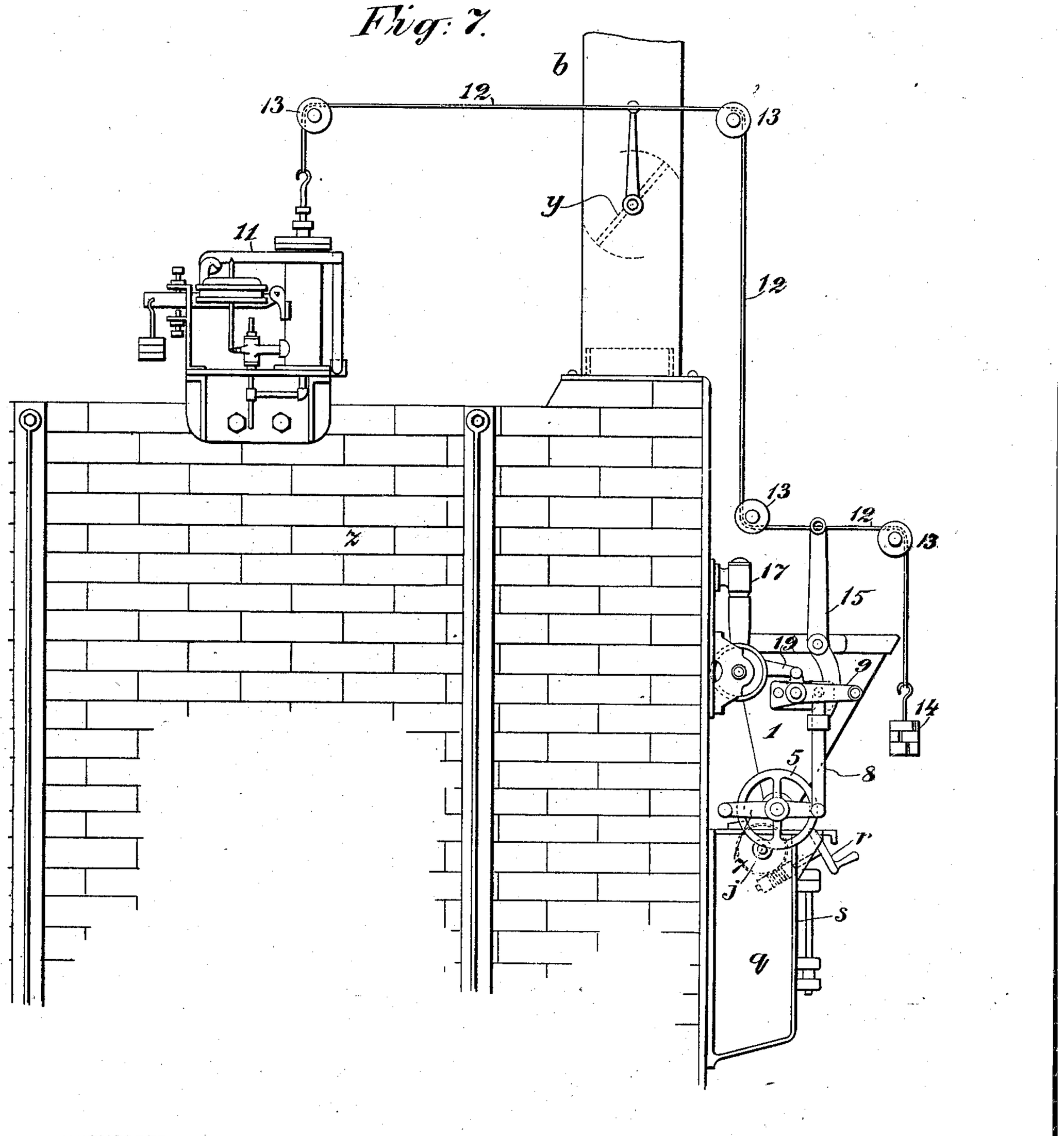
(No Model.) 7 Sheets—Sheet 4.

Fig: 7.



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(No Model.) 7 Sheets—Sheet 5.

Fig. 8.

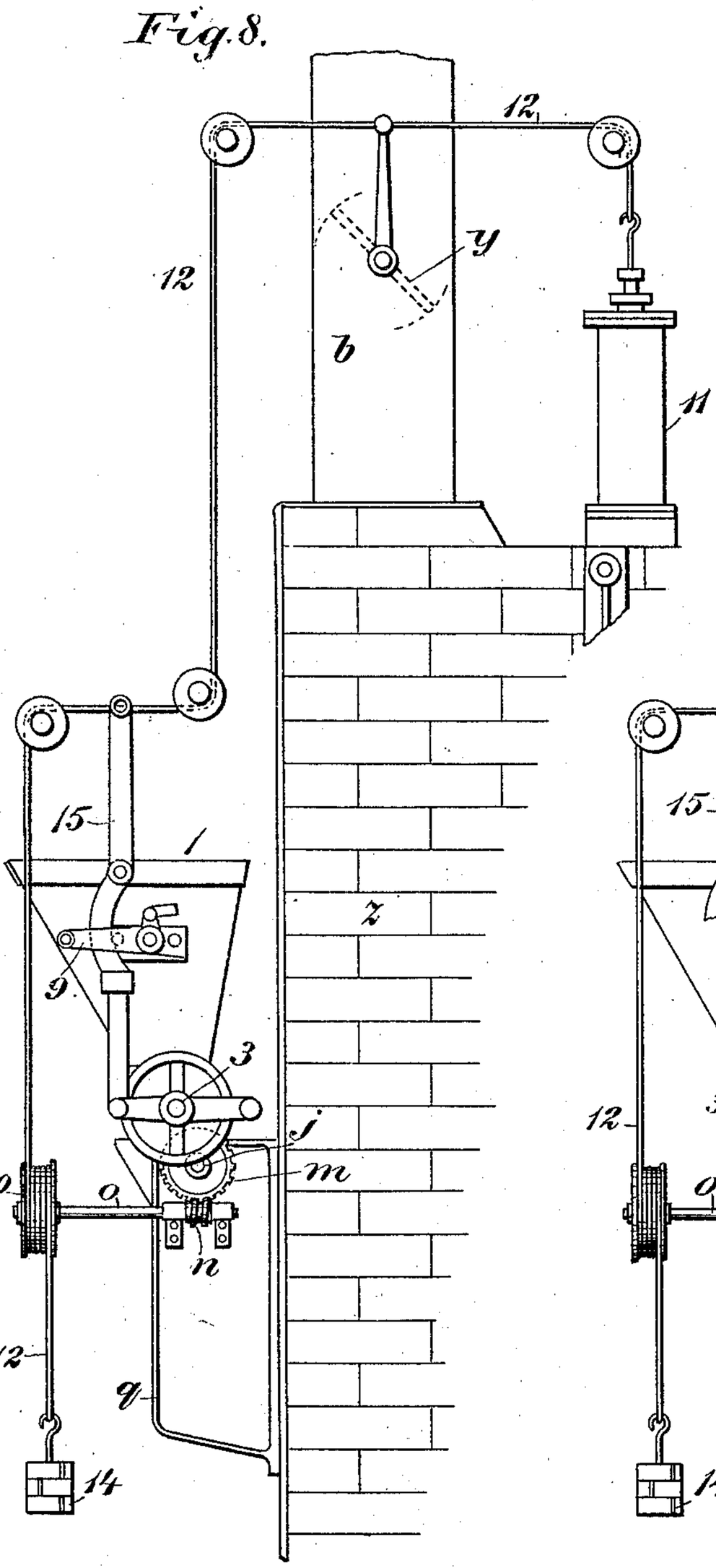
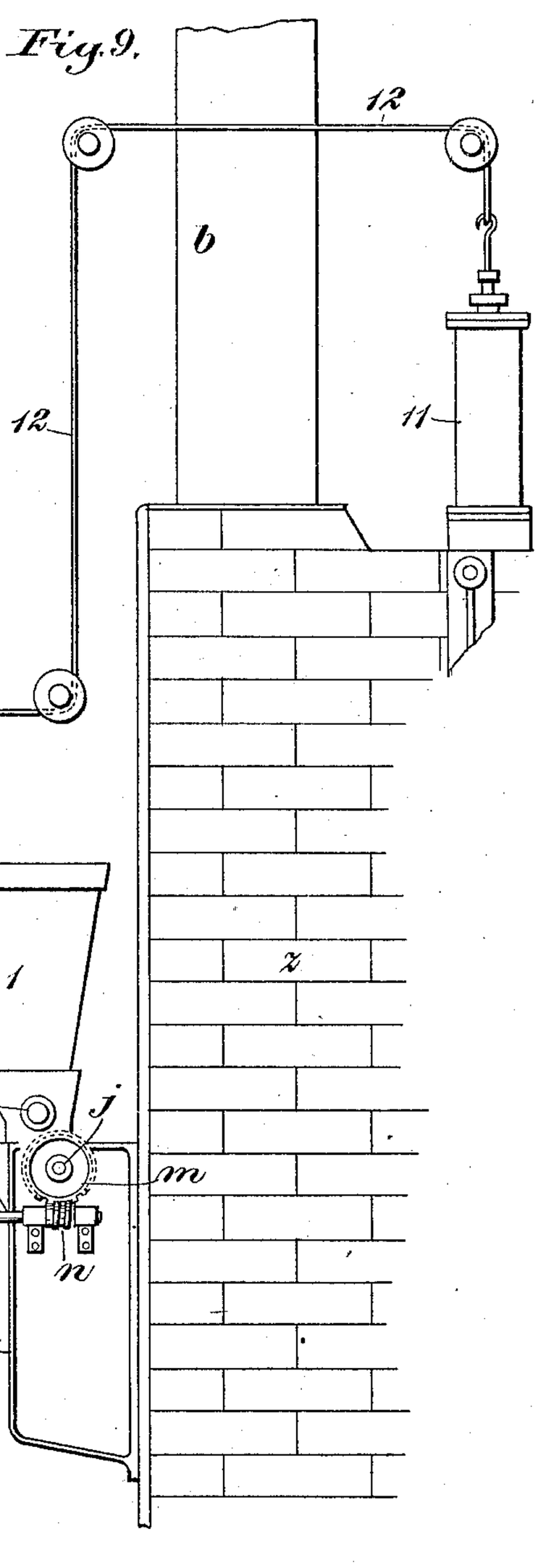


Fig. 9.



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(No Model.) 7 Sheets—Sheet 6.

Fig. 10

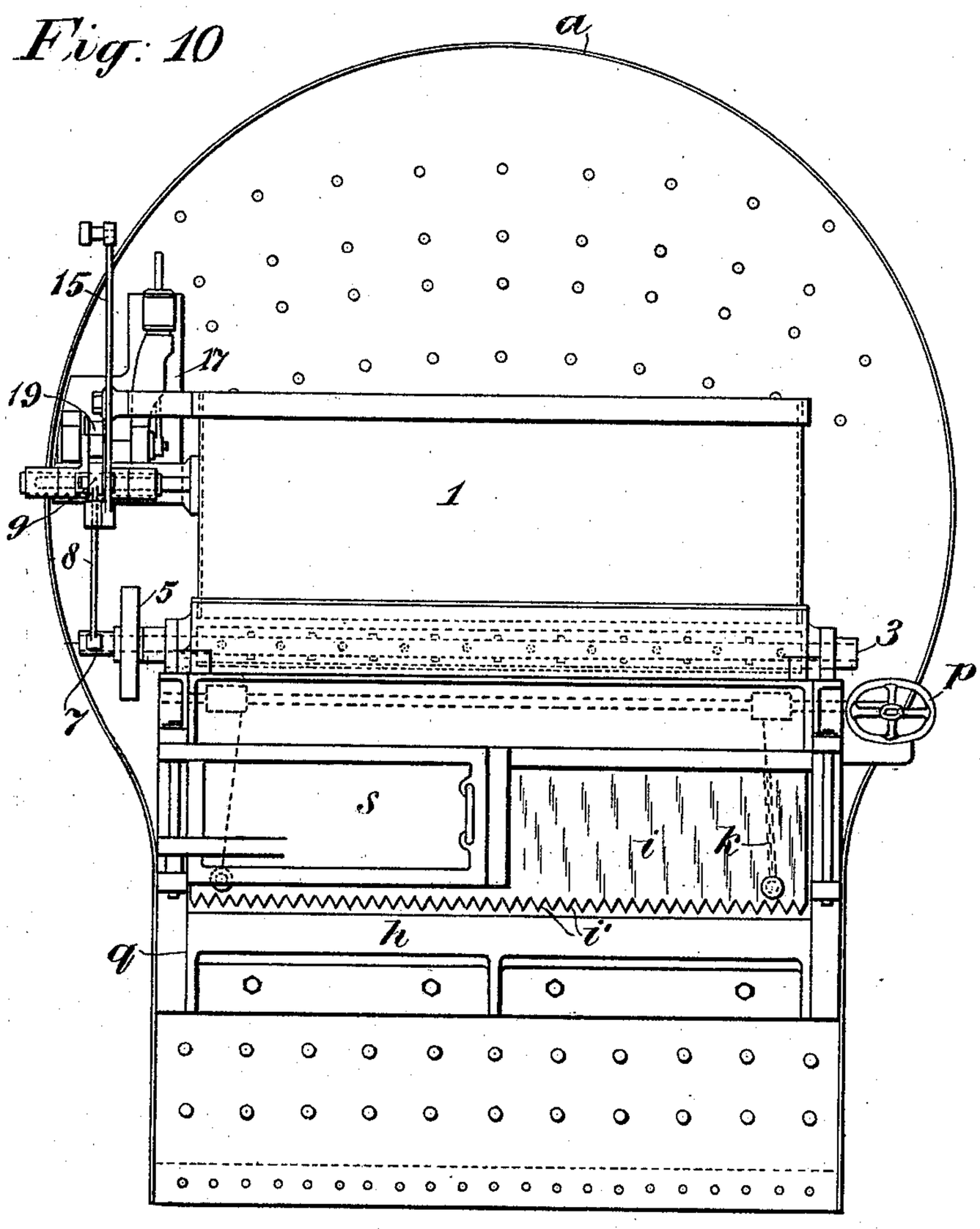

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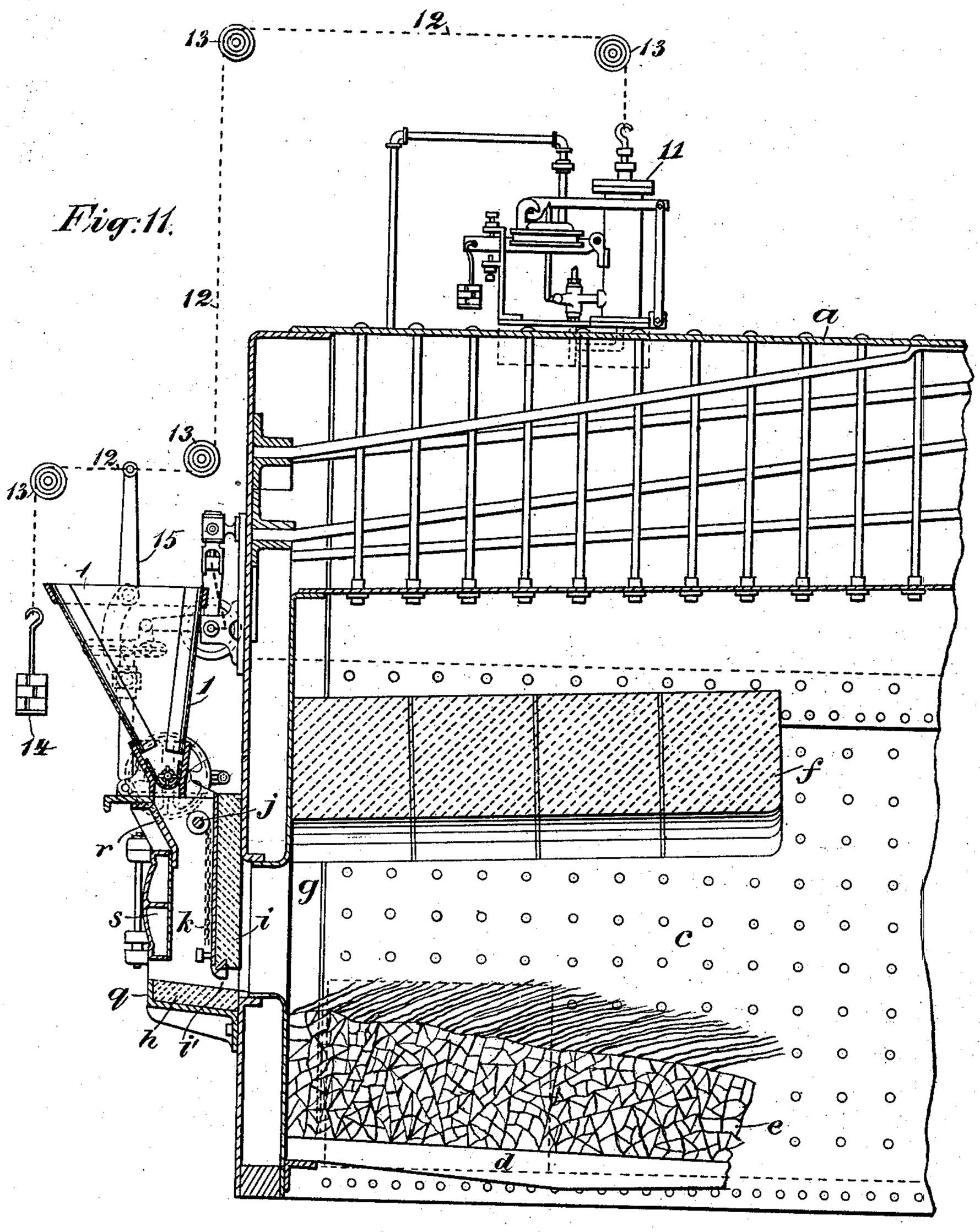
Fig. 11.



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UNITED STATES PATENT OFFICE.

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FURNACE FOR BURNING POWDERED FUEL.

SPECIFICATION forming part of Letters Patent No. 717,306, dated December 30, 1902.

Application filed September 27, 1900. Serial No. 31,252. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM WESTLAKE, a citizen of the United States, residing in the borough of Brooklyn, county of Kings, and city and State of New York, have invented certain new and useful Improvements in Furnaces for Burning Powdered Fuel, of which the following is a specification.

This invention relates to that class of furnaces which burn fuel in a finely-powdered condition and wherein the fuel or fuel-dust entering with the air is carried over a bed of burning or incandescent fuel on the grate. In this class of furnaces considerable difficulty has been experienced in feeding or supplying the powdered fuel and the air to support combustion in a practicable manner to the furnace and in such a way as to attain a close approach to perfect combustion and to the best economical results.

The object of the present invention is to supply the fuel-dust in a perfectly uniform and graduated manner automatically to the furnace and to accompany the fuel with a graduated proportion of air, so disposed as to produce combustion of each particle of fuel-dust.

It is also an object of the invention to avoid the caking and agglomeration by heat of the fuel-dust at and about the feeding-point and to provide automatic means for maintaining approximately a predetermined temperature through the regulation of the supply of fuel-dust and of air to support combustion.

The general characteristics of the furnace include a grate to carry a bed of burning fuel—such as coke, for example—in a fire-box having a relatively low arch or surface of fire-brick or tiles. At the front and controlling the charge-opening of the fire-box is a vertically-movable door or closing-slide, which may be of metal lined with tiles of refractory material. This slide regulates the vertical width of the charging-opening, which extends substantially the entire width of the fire-box, the sill of the opening being by preference about at the level of the incandescent fuel on the grate. The fuel, preferably soft coal in the form of fine dust or powder, is fed automatically from a hopper above, the feed-outlet being exterior to the closing-slide and extending also the entire width of the fire-box. The fuel falls in a thin sheet or as a veil down along the outer face of the closing-slide and is drawn into the furnace under the lower edge of said slide by the inflowing induced current of air produced by the draft, the object being to avoid compression by forcing the air in with a blower or fan. No appreciable amount of heat can reach the fuel-dust, either by convection or radiation, until it enters the fire-box, and therefore coking and agglomeration about the feeding-point is wholly avoided. Each particle of fuel-dust enters the fire-box surrounded or embraced by oxygen in sufficient amount to combine with it, and as it is carried back by the air between the bed of fuel below and the white-hot refractory material above it is first reduced to its constituent gases, and these are then combined with the oxygen. The means by which these results are effected will now be described with reference to the accompanying drawings, which illustrate embodiments thereof.

In the drawings, Figure 1 is a front elevation of the furnace as employed in connection with a stationary steam-generator; and Fig. 2 is a vertical longitudinal section of the same, taken substantially in the plane indicated by line II in Fig. 1. Figs. 3, 4, 5, and 6 are detail views, on a larger scale, illustrating the construction of the fuel-feeding and quantity-regulating mechanism. Fig. 7 is a side elevation of the furnace as seen from the left in Fig. 1. Figs. 8 and 9 are views illustrating the application of the draft-regulator to the control of the fuel-feed, the air-supply, and the draft. Figs. 10 and 11 are views corresponding respectively to Figs. 1 and 2, but illustrating the application of the invention to the furnace of a locomotive.

Referring primarily to the first nine figures of the drawings, which illustrate the invention as applied to the furnace of a return-flue stationary boiler, *a* represents the boiler, and *b* the stack. *c* is the fire-box, *d* the grate, and *e* a bed of burning fuel, as coke, on said grate. Over the fire-bed or over the front portion thereof is a relatively low arch *f*, of fire-brick

or tiles, and at the front of the fire-box is a charging-opening *g*, which extends throughout the entire width of the fire-box laterally and from the arch *f* down to the sill *h*, which may be of brick, as indicated in Fig. 2.

The opening *g* is adapted to be closed to a greater or less extent by a suspended closing-slide *i*, which will be, by preference, a cast-iron plate lined with fire-brick or tiles. This slide should fit up closely to the front of the fire-box, and it is adapted to be raised and lowered, so as to contract or enlarge the opening *g* vertically and from above, the width and the lower margin of the opening remaining constant.

The means herein shown for raising and lowering the slide *i* consists of a windlass-shaft *j*, extending transversely, and two chains *k*, connected below to the slide and adapted to wind on the shaft *j*. On the projecting end of the shaft (see Figs. 8 and 9) is secured a worm-wheel *m*, which gears with a worm *n* on a cross-shaft *o*, and this shaft may have a crank or hand-wheel *p*, Fig. 1, for operating it, so as to raise and lower the slide *i*. The shaft *j* may be journaled in a cast-iron frame *q*, secured to the furnace-front and projecting out therefrom beyond the slide *i*, and the sill *h* may extend out to the same extent as said frame. The upper part of the frame *q* is closed in by an inclined plate *r*, and below this plate are doors *s*. The ash-box *t* has doors *u* of the usual kind.

In Fig. 2, *v* designates the tubes in the boiler; *w*, the smoke-box at the front end of the boiler; *x*, doors opening into said box, and *y* a damper in the stack. *z* designates the outer wall of the boiler and furnace.

Seated on the frame *q* above the opening *g* is a hopper or receptacle 1 for the powdered fuel or fuel-dust. This hopper, together with the fuel feeding and regulating devices, will now be described with especial reference to Figs. 3, 4, 5, and 6. Fig. 3 is an elevation of the mechanism as seen from the front. Fig. 4 is a vertical transverse section. Fig. 5 is a sectional view of the adjustable or sliding wrist, and Fig. 6 is a sectional view of the clutch device.

The hopper 1 to contain the pulverized fuel or fuel-dust has a concave perforated bottom 2, and extending lengthwise of the hopper or crosswise of the furnace-front is a shaft 3 in the said concave bottom and provided with radial pins or projecting studs 4. This shaft has bearings in the ends of the hopper, and one end of the shaft projects and has rigidly secured on it a clutch-wheel 5 with a crown-flange 6, as clearly shown in Figs. 4 and 6. Mounted loosely on the shaft 3, adjacent to said wheel, is a rocker 7, one arm of which carries a clutch-jaw 7′, adapted when the rocker is turned in one direction to bite on the flange 6 and rotate the shaft 3, but when turned in the other direction to play over said flange and leave the shaft at rest. By rocking the rocker 7 an intermittent rotary movement is imparted to the shaft 3. This clutch device is not new in itself and is not claimed herein nor is this invention limited to this particular form of clutch. A pawl and ratchet will serve. To the other arm of the clutch-rocker 7 is coupled a rod 8, which extends up to an upper rocker 9, Fig. 5, where it is coupled to a wrist 10, adapted to be moved out and in along slotted guides in the rocker. This rocker may be oscillated by any motive power desired, and when oscillated it will impart, through the rod 8 and the clutch-rocker 9, an intermittent but continuous rotary motion to the shaft 3 and cause the fuel-dust to sift down through the perforated bottom of the hopper. It is found that the quantity of the fuel-dust which will fall through the bottom of the hopper in a given time will be proportioned to the extent of rotation of the shaft 3 at each intermittent impulse, and hence a regulator is employed to automatically govern said extent of rotation according to the pressure of steam in the generator. This device comprises a known form of draft-regulator 11. (Sufficiently illustrated in Fig. 2.) This device has a cylinder in which is a piston subject to the pressure of steam in the boiler. To the rod of this piston is coupled a flexible connector 12, in the nature of a cord, wire, or chain, which passes over suitable guide-sheaves 13 and has suspended from its end a weight 14. This connector is coupled to one arm of a shifting lever 15, fulcrumed at 16, the other arm of said lever being coupled to the rod 8, which operates the sliding wrist 10. As the pressure rises in the boiler the wrist 10 is moved inward more nearly to the fulcrum of the rocker 7, thus reducing the amount of fuel-dust fed, and as the pressure falls the wrist 10 is moved outward again, thus increasing the amount of fuel fed.

Figs. 3 and 4 show as a means of operating the feeding mechanism a steam-engine 17, which has no special features of novelty. On the shaft 18, driven by the engine, is an eccentric, the rod 19 of which is coupled to a lateral arm on the rocker 9. Such an engine is within the skill and knowledge of any one familiar with the art, and it need not be more specifically described. Indeed any known kind of steam or other engine may be used.

In Figs. 2 and 7 the draft-regulator is represented as controlling the damper *y* and the feed of the fuel-dust; but it may be made to control the admission of air as well. This is illustrated in Fig. 8, where the connector 12 is passed several times about a sheave 20 on the shaft *o*, which operates the slide *i*. Thus the weight 14 is made in its descent to permit the descent of the slide *i* at the same time that it reduces the feed of fuel-dust and closes the damper in the stack. Fig. 9 is the same as Fig. 8 except that the damper is omitted, the view showing how the draft-regulator may be made to control only the supply of air and fuel.

There may be some known means in the

stack for accelerating the draft, particularly under circumstances where the natural draft from the stack or chimney is not sufficient; but in any case the supply of air entering with the fuel-dust will be induced by some means back of the fire-box. This is important in feeding fuel-dust, as it avoids compression of the gases in the furnace and back-draft or regulation of the fuel and air.

In operating the furnace the fire is first built on the grate. While this is being effected the feed of fuel-dust is arrested, the charging-opening closed, and the doors of the ash-box opened. When a bed of burning fuel is established, the doors *u* are closed tight, the doors *s* are opened, and the feeding-engine 17 started. The fuel-dust falls in a thin laterally-extended sheet down through the relatively cool space between the doors *s* and the slide *i*, and on reaching the lower edge of the latter it enters and mixes with the induced current of air flowing into the fire-box and is carried by the air into the latter over the bed of burning fuel and under the hot refractory material *f* above. As it flows back through the fire-box it is first decomposed, after which its constituent gases are combined with the oxygen from the air. The fuel on the grate will be replenished from time to time, as may be required.

The metal portion of the slide *i* may have formed in its lower edge teeth or serrations *i'*. These serve to prevent the slide from being closed down absolutely, thus cutting off the access of air altogether, and they also serve in some degree to distribute the thin sheet of fuel-dust, so as to equalize it across the furnace-front.

In the construction illustrated in Figs. 10 and 11, where the improvements are applied to a locomotive-furnace, the disposition of the parts is the same as that above described. As the boiler is not of the return-flue class, but belongs to the class where the fire-box is within the rear end of the boiler itself, the arch of refractory material *f* will be above the fire-bed and below the crown-sheet. The same reference characters are employed in these figures as in the principal views, and no specific description will be required.

It will be understood that the word "arch" as referring to the refractory material *f* is not to be limited to meaning a curved or arched surface, as this surface may be flat.

As the ash-box may be closed to the air, so as to shut it off from the grate, and the slide *i* may be raised, so as to open the front of the fire-box above the fire-bed to the free entry of cold air, it will be noted that my furnace provides for banking the fires with facility equal to any furnace, a feature not before attained, so far as I am aware, in furnaces for burning dust-like fuel.

The slide *i*, which may be wholly of refractory material or of metal lined with such material, forms, as will be seen, a part of the fire-box front or furnace-front.

In order to distinguish clearly what is new in this furnace from what is known in the art as formerly practiced or proposed, it will be proper to state that the fuel-dust from soft coal must be supplied in a cloud or with each particle of dust separated from the others as nearly as may be and that when in this condition it is absolutely necessary to screen the dust from heat or it will cake or coke, and thus very soon clog and stop the feed. To prevent this in the present furnace, the parts about the slot or opening where the fuel and air enter is made of refractory non-heat-conducting material, such as fire-brick or tiles, and the fine fuel is fed down practically in the open air, where the temperature is scarcely above the normal. The hearth *h*, which projects out a little from the furnace-front, is comparatively cool at all times, and the fine fuel-dust that may fall thereon will not be caked or coked by heat. The doors *s* are not essential to the working, but they protect the falling dust from gusts of wind and when closed cause air to flow down exterior to the slide *i*, as there is an open space between the bottom of the hopper and the upper edge or part of the slide *i* for the air to enter from above. It is desirable to keep the temperature of the air space or field through which the dust falls down to about the normal temperature and to make the passage through which the dust and air flows from the outside to the inside of the fire-box as short as possible. Hence while the hearth *h* may project the passage under the slide *i* only extends the thickness of the latter. The main idea is the omission of heat-conducting parts or connections between the hopper-outlet and the mouth or heated parts of the furnace, so that the path or field of feed shall be relatively cool or not unduly heated.

Having thus described my invention, I claim—

1. A furnace for burning dust-like fuel, having a fire-box, means back of the fire-box for inducing the entry of air at the charging inlet or opening in the front thereof, a hearth of non-heat-conducting material at the lower margin of said opening, a vertically-adjustable slide for covering said opening, said slide being composed in the main of non-heat-conducting material, and means for feeding the dust-like fuel down to said hearth in regulated quantity, substantially as set forth.

2. A furnace for burning dust-like fuel, having a fire-box with a charging-opening in its front and an open, projecting hearth below said opening, said hearth and the front of the fire-box being mainly composed of non-heat-conducting material to avoid the conduction of heat from the fire-box, means back of the fire-box for inducing the entry of air at said charging-opening, and means for feeding the dust-like fuel down, outside of the fire-box to said hearth in regulated quantity, substantially as set forth.

3. A furnace for burning dust-like fuel, having a fire-box with a laterally-elongated charging-opening, a projecting hearth at the lower margin of said opening and extending the width of the same, said hearth being of non-heat-conducting material, a hopper for the fuel above the level of the charging-opening and above said hearth, means for feeding the fuel from said hopper in regulated quantity, and means for inducing the entry of air at said charging-opening, the space or fuel field through which the fuel falls being open to the atmosphere above, substantially as set forth.

4. A furnace for burning dust-like fuel, having a grate, an ash-box, a door to the ash-box, an arch of refractory material over the front portion of said grate, a charging-opening with a projecting hearth of non-heat-conducting material, a slide composed mainly of non-heat-conducting material and adapted to close said opening, and means for feeding the fuel-dust down to said hearth exterior to said slide, substantially as set forth.

5. A furnace for burning dust-like fuel, having a charging-opening in its front, a slide of non-heat-conducting material over said opening, a projecting hearth of non-heat-conducting material at the lower edge of said opening, a feeding device for the fuel above the level of the charging-opening and over said hearth, and separated from the latter by a space open to the atmosphere on all sides, whereby the fuel in its descent falls through an uninclosed space, as set forth.

6. A furnace for burning dust-like fuel, having means for inducing a draft, a grate in the fire-box to support a bed of coarse burning fuel, an opening in the front of the fire-box for supplying to the grate the fuel which forms said bed, for supplying air for combustion, and for the entry of the dust-like fuel, a closing slide or door controlling the area of said opening, and means, independent of said slide or door, for feeding the fuel-dust in front of said opening, whereby said dust is drawn into the furnace by the inflowing air.

7. A furnace for burning dust-like fuel, having means for inducing a draft, a grate in the fire-box to support a bed of coarse burning fuel, an opening in the front of the fire-box for supplying to the grate the fuel which forms said bed, for supplying air for combustion, and for the entry of the dust-like fuel, a closing-slide controlling the area of said opening and having serrations at its lower edge, a hearth at the lower margin of said opening, and means, independent of said slide or door for feeding the fuel-dust in front of said opening, whereby said dust is drawn into the furnace by the inflowing air.

8. A furnace for burning dust-like fuel, having a fire-box with a charging-opening, a non-moving grate therein, and means for feeding the fuel down through the atmosphere in front of and exterior to the furnace-front to said charging-opening, in combination with a vertically-movable slide over said charging-opening, and automatic means for regulating the feed of fuel and the height of said slide in proportion to the heat of the furnace, whereby a substantially uniform heat is maintained.

9. In a furnace for burning dust-like fuel, the combination with a fire-box, and means back of the fire-box for inducing the entry of air into the charging-opening of the same, of means for supplying the fuel to said fire-box, said means comprising a receptacle for the fuel exterior to the front of the furnace above the charging-opening with an outlet at its bottom, a rotatable feeding-shaft in its bottom, a motor, mechanism between said motor and said shaft, whereby the latter is driven by the former, and means for regulating the extent of the fuel-feed independently of the speed of the motor.

10. The combination with a boiler and a draft-regulator 11, connected therewith, of a furnace for burning dust-like fuel for generating steam in said boiler, said furnace having a fire-box, provided with a charging-opening, a suspended, vertically-movable slide *i* over said opening, mechanism for raising and lowering said slide, and means for feeding the fuel down exterior to said slide to the lower edge of same, and an operative connector coupled with said draft-regulator, with the fuel-feed regulator and with the devices for raising and lowering said slide, whereby the draft-regulator controls both the fuel-feed and the air-supply, substantially as set forth.

11. A furnace for burning dust-like fuel, having a fire-box with a charging-opening and grate, a sliding cover for said opening for regulating the same, means for feeding the fuel down exterior to the fire-box and to the lower edge of said slide, means for inducing air through said opening to the fire-box, and outer protecting-doors, between which and said slide the fuel descends, substantially as set forth.

12. A furnace for burning dust-like fuel, having a fire-box, a grate therein to support a bed of burning fuel, an ash-box below the grate, and a charging-opening in the furnace-front, of means for feeding said dust-like fuel down into the atmospheric field in front of the said charging-opening, means for regulating the opening of the fire-box front to any desired extent, and means for closing the ash-box against the entry of air under the grate, whereby a banked fire may be carried.

13. A furnace for burning powdered fuel, having a fire-box, means for feeding the fuel to the charging-opening in the fire-box front, automatic means for regulating the quantity of fuel fed, and automatic means for regulating the escape of the products of combustion at the gas-outlet proportionately to the fuel-supply.

14. A furnace for burning powdered fuel, having a fire-box, means for feeding the fuel

to the charging-aperture in the fire-box front, automatic means for regulating the air-supply to the fire-box, automatic means for regulating the outflow of products of combustion, and automatic means for regulating the supply of fuel proportionately to the supply of air and the outflow of said products.

In witness whereof I have hereunto signed my name, this 24th day of September, 1900, in the presence of two subscribing witnesses.

WILLIAM WESTLAKE.

Witnesses:
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WILLIAM T. DONNELLY.