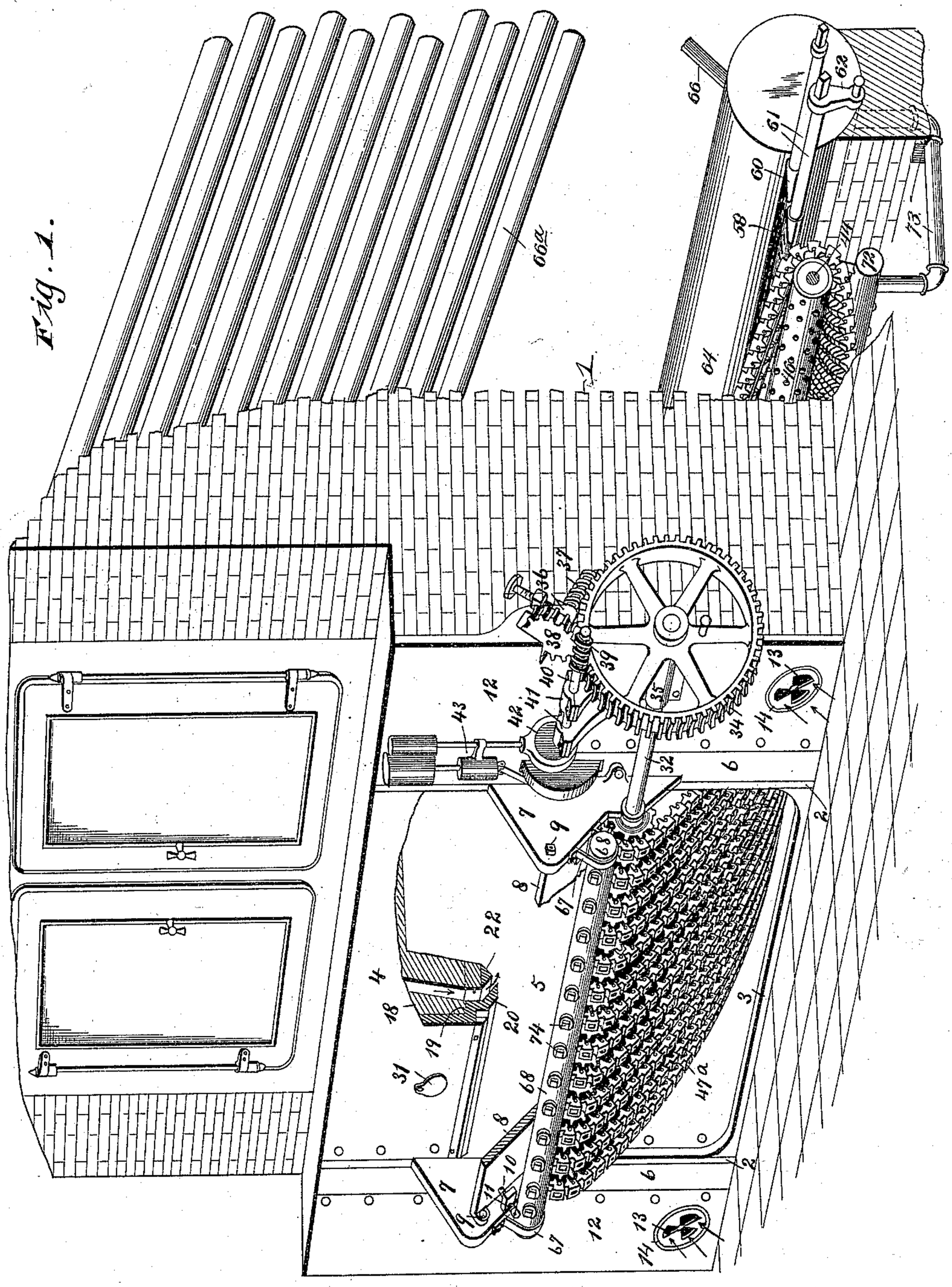
(No Model.) 2 Sheets—Sheet 1.

P. L. CROWE.

FURNACE.

No. 547,244. Patented Oct. 1, 1895.

Fig. 1.



Witnesses:

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C. H. Thorpe.

Inventor:

Paul L. Crowe

By Higdon & Higdon.
Attys.

(No Model.) 2 Sheets—Sheet 2.

P. L. CROWE.

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Fig. 8.

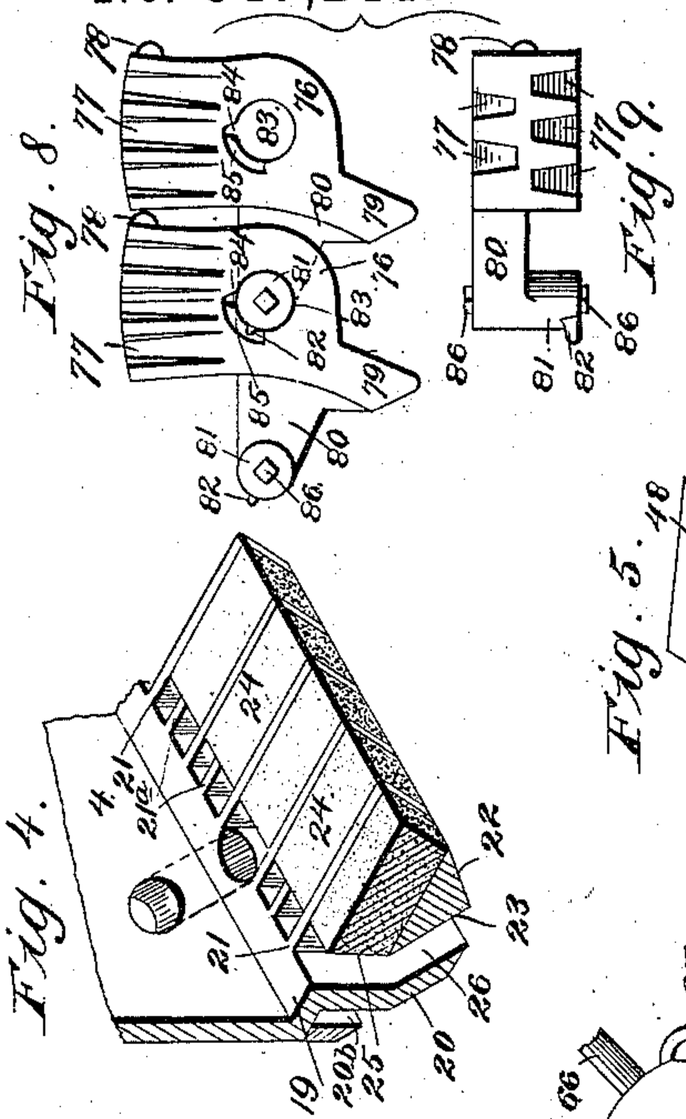


Fig. 11.

Fig. 4.

Fig. 5.

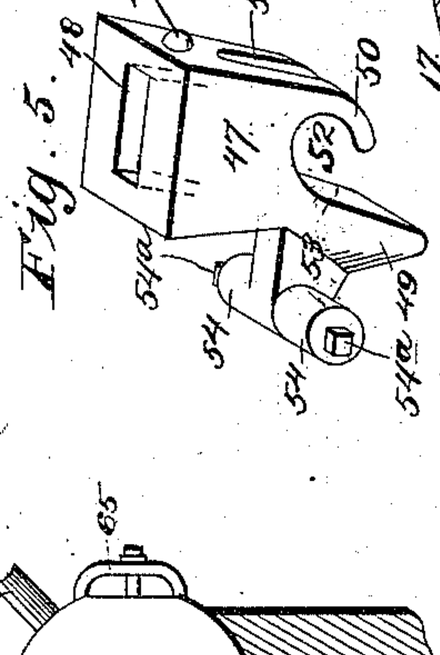


Fig. 6.

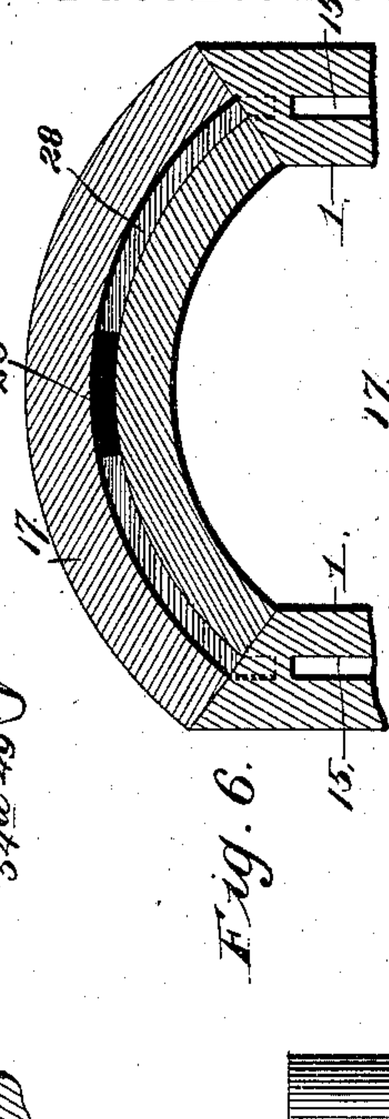


Fig. 7.

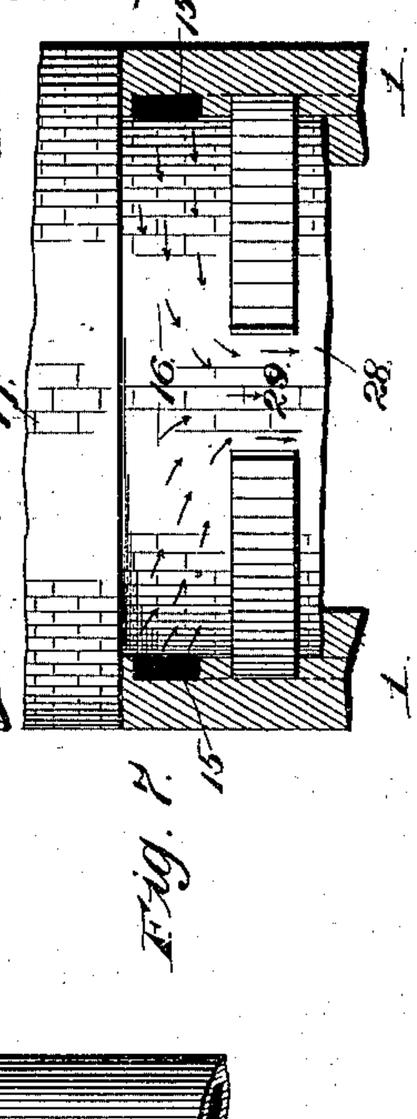


Fig. 2.

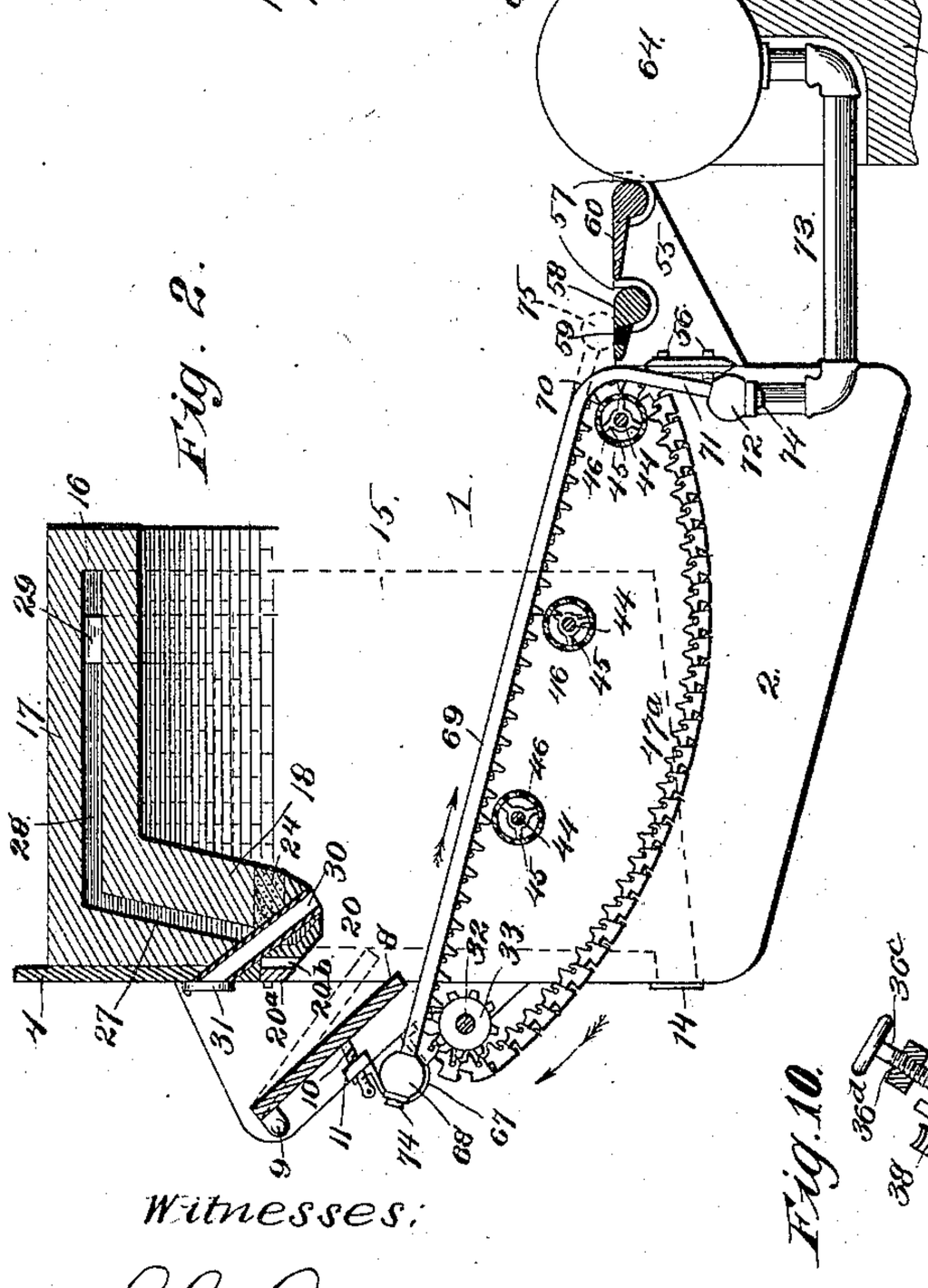


Fig. 3.

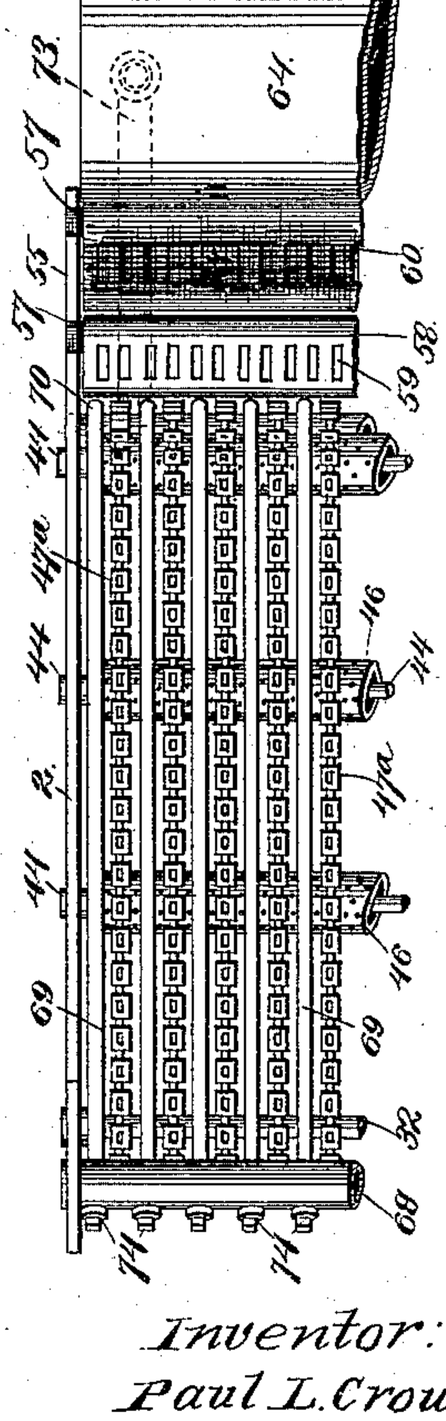
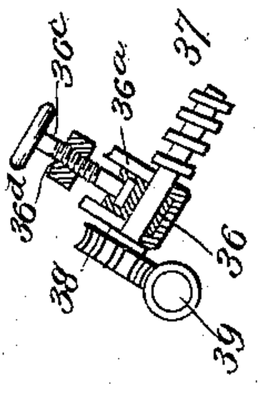


Fig. 10.



Witnesses:

F. G. Fischer

W. H. Thorpe.

Inventor:

Paul L. Crowe

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Attys.

UNITED STATES PATENT OFFICE.

PAUL L. CROWE, OF KANSAS CITY, MISSOURI.

FURNACE.

SPECIFICATION forming part of Letters Patent No. 547,244, dated October 1, 1895.

Application filed November 17, 1894. Serial No. 529,099. (No model.)

To all whom it may concern:

Be it known that I, PAUL L. CROWE, of Kansas City, Jackson county, Missouri, have invented certain new and useful Improvements in Furnaces, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming a part hereof.

My invention relates to furnaces, and my objects are to provide, first, a grate having the greatest possible air-space consistent with strength and durability, whereby the fuel is conveyed from the point of supply to the point of discharge and feed-water for the boiler of the furnace is heated; secondly, to provide a drum upon and forming a part of the bridge-wall, so that all heating-space possible shall be utilized in heating the water and connecting said drum to the water-grate and the boiler; thirdly, to provide a construction whereby hot air is directed upon the burning fuel to assist in producing a quick and perfect combustion thereof and thereby generate heat to the utmost capacity of the fuel and to confine the hot air within the furnace, so that the fuel in the feed-hopper shall not be unduly heated; fourthly, to provide a construction whereby the quantity of fuel automatically fed upon the grate may be regulated, and, fifthly, to provide means for operating the traveling portion of the grate.

Other objects of the invention appear in the following description and are pointed out in the appended claims.

In the accompanying drawings, which illustrate the invention, Figure 1 is a perspective view of a furnace embodying my invention and showing the same broken away to disclose the interior construction more clearly. Fig. 2 is a vertical sectional view of the lower portion of the furnace. Fig. 3 is plan view of the traveling and water-grate construction of the feed-water drum and of the dumping-plates. Fig. 4 is a detail perspective view, enlarged, of a portion of the arch-supporting casting. Fig. 5 is a detail perspective view, enlarged, of one of the links which form the traveling portion of the grate. Figs. 6 and 7 are vertical and horizontal sectional views, respectively, to show more clearly the hot-air passages. Fig. 8 is a side elevation of a link of a modified form of the traveling grate, and Fig. 9 is a top plan view of one of said links. Fig. 10 is a sectional view to illustrate clearly the sliding box, which is raised or lowered to throw the engine out of or into engagement with the traveling grate.

Similar numerals refer to corresponding parts in all the figures, in which—

1 designates the side walls of a furnace, and 2 designates a pair of vertical and longitudinally-extending supporting-plates, which are arranged against the side walls and internally of the furnace, and in conjunction with the transverse tie-bar 3 and the arch-plate 4 form the opening 5 at the front end of the furnace. Bolted or otherwise rigidly secured outward of said supporting-plates and at the front end of the furnace are the plates 6, which at a suitable point are provided with the forwardly-projecting arms 7. These arms, in conjunction with the plate 8, extending transversely of the furnace and pivoted at its upper corners at 9 to said arm 7, form the feed-hopper into which the fuel for the furnace is placed. This plate 8, hereinafter termed the "feed-regulator," is adjustable, so as to enlarge or diminish the size of the opening between the same and the lower margin of the arch-plate 4, by means of the screws 10, which engage openings in the lugs 11, projecting inwardly from said arms 7.

Secured to the front end of the furnace and outward of the plates 6 are the plates 12, which are provided with openings 13 near their lower ends, controlled by the rotatable register-plates 14 of the construction shown or of any other suitable or preferred construction, whereby more or less air may be allowed to pass through said openings 13, or the draft may be entirely cut off. These openings 13 communicate with the lower ends of extended air spaces or passages 15, which are formed between the side walls proper of the furnace and the fire-brick lining thereof, and said passages 15 communicate at their upper ends with the transverse arched passage 16, which is formed in the arch 17, extending from the arch-plate 4 rearwardly a suitable distance. The front end of said arch 17 extends pendently downward, as shown at 18, and the front portion of said arch rests upon the horizontally and inwardly projecting shoulder 19 of the arch-plate 4. Said arch-plate below said

shoulder is formed its entire width with the depending arm 20, which extends vertically for a short distance and then inclines rearwardly, as shown most clearly in Fig. 4. Said arch-plate is also formed with a number of rearwardly-projecting arms 21. Some of these arms 21 terminate a short distance rearward of the shoulder 19, while the remaining arms, which are alternately arranged with said short arms, extend rearwardly some distance and are united by the transverse bar 22, the upper surface of which bar lies in a plane below the upper surface of the said arms 21, and the front side 23 of the same extends parallel with the inclined portion of the arm 20, and secured upon said bar and fitting snugly between the said long arms 21 and against the ends of the short arms 21 are the fire-bricks 24, which thus protect the inner pendent portion of the arch, which rests upon said bricks and upon the long arms 21 of the plate 4. The inner ends of said fire-bricks terminate at the front end of the bar 22 and form, in conjunction with said bar and with the opposing depending arm 20, the air-passage 26, which is divided into narrow passages by the arms 21, as shown clearly in Fig. 4, and said narrow passages communicate with the lower end of the passage 27 of the depending portion of the arch, which passage 27 communicates with the main passage 28, which in turn communicates at its rear end and midway its width through the passage 29 with the arched passage 16, as shown in Figs. 2, 6, and 7.

In order to protect the fuel in the hopper to a great extent from the heat generated by the combustion of the fuel, I secure by the bolts, as shown, or in any other suitable manner, to the arch-plate 4, and opposite the depending arm 20 thereof, the depending plate 20^a, so as to form between said depending plate 20^a and said arm 20 the vertical air-space 20^b, which extends transversely the entire width of the hopper.

The furnace is provided with a pair of peep-holes, one only of which is shown, and each of said holes is formed by casting in the arched plate the inclined tube 30, as shown clearly in Fig. 2 and as indicated by dotted lines in Fig. 4. The outer end of each of said tubes is closed by a pivoted lid 31. Extending transversely and horizontally of the front end of the furnace is the power-shaft 32, and this shaft is journaled in bearings formed in the supporting-plates 2, and mounted rigidly upon said shaft at regular intervals are a number of sprocket-wheels 33. The end of the shaft 32, which projects some distance beyond the adjacent supporting-plate, carries a worm-wheel 34, and said shaft is provided with an additional bearing 35, which is bolted or otherwise rigidly secured to the adjacent plate 12. Said plate is also provided with an inclined notch to form the depending bearing-arm 36. This arm is slotted, as shown at 36^a, and mounted in said slot is the sliding box 36^b, and said box is raised and lowered, for a purpose which hereinafter appears, by means of the screw 36^c, which finds a bearing in the internally-screw-threaded arm or projection 36^d of the plate 12. Rotatably journaled in said sliding box is a shaft provided with worm-threads 37, meshing with said worm-wheel and with the small worm-wheel 38, engaging the said notch and meshing with the worm-thread 39 upon a transversely-extending and horizontal shaft 40. Said shaft 40 is journaled in the boxes 41, projecting forwardly from said plate 12, and is eccentrically connected at 42 to a small steam-engine 43, which is secured to said plate 12 in any suitable manner. It will now be apparent that the object of the sliding box 36^b and the means for operating the same is to throw the engine in and out of gear with the worm-wheel 34.

Journaled at its opposite ends in the supporting-plates 2, near the upper rear corners and parallel with the power-shaft 32 and in a plane lower than said shaft, is the shaft 44. Two or any suitable number of similar shafts 44 are arranged between the shaft 32 and the first-mentioned shaft 44 and in the inclined plane occupied by said shaft 32 and the said shaft 44. These last-mentioned shafts 44 are also journaled in their opposite ends in the side supports 2. Projecting radially from said shafts 44 are the arms 45 and mounted rigidly upon said arms are the perforated rollers 46. These rollers are open at their ends and are perforated to permit free access of air through them to the grate, or, in other words, so as not to retard the draft. The rollers in construction have enough holes drilled in them to take out about forty or fifty per cent. of the metal. These rollers, in conjunction with the sprocket-wheels 33, form the support for the sprocket-chain portion 47^a of the grate, and these sprocket-chains are each composed of a number of links constructed as follows: 47 designates the body portion of the link, which is provided with a suitable aperture or air-passage 48, and is provided at one corner with the tooth or projection 49, which engages the sprocket-wheel when in operative position, as will be understood by reference to Fig. 2. Opposing said tooth or projection 49 is the curved or hook portion 50, which is bifurcated, as shown at 51, and forms, in conjunction with the body portion 47 and the projection or tooth 49, a segmental opening 52. Projecting approximately at right angles from the opposite side of said projection or tooth at its upper end or junction with the body portion 47 is the arm 53, which lies in the same vertical plane as the bifurcation 51, and is slightly narrower than said bifurcation in width, and projecting from each side of said arm 53 are the cylindrical shoulders or bosses 54, from the ends of which project the lugs 54^a. A chain is formed by causing the cylindrical shoulders or bosses 54 of one link to engage the cylindrical opening 52 of the preceding link and

then pivotally operating the same until the arm 53 engages the bifurcation 51 of said preceding link. Each link is also provided with a boss or projection 47ª above the bifurcation 51, so that it will be impossible for the front or rear margins of the body portion of one link to come in contact with the adjacent or opposing margin of the body portion of the preceding or succeeding link, as shown clearly in Fig. 2. By use of these bosses or projections it will be apparent that the air has free passage to the fuel at all times between the opposing margins of the links. It will be apparent that this sprocket-chain or traveling grate, while being heavy and therefore strong and durable and able to stand the work of expansion and contraction, has ample air-space, the air-spaces being small enough to permit the use of slack coal of any kind or quality, and said grate, consisting of a number of parallel sprocket-chains, performs the function of an ordinary rigid grate-bar, as their upper portions are supported in practically a single inclined plane at various points throughout the length of the side supports 2 by the perforated rollers 46. A pair of supporting plates or castings 55 are flanged and bolted, as shown at 56, to similar flanges projecting from the rear ends of the side supports 2 and occupy approximately the same vertical plane as said side supports, and said supporting-plates 55 are provided with bearing-recesses 57. A dump-plate 58 is journaled in the front bearings 57, as shown in Fig. 2, and is provided with a series of apertures or perforations 59. A bearing-plate 60 is journaled in the rear bearings 57. This plate it is not necessary to perforate. Projecting laterally and axially from said dump-plates and through the adjacent side wall of the furnace are the extensions or rods 61, and these dump-plates are adapted to be operated so as to permit the ashes or refuse to drop down into the ash-pan below by means of a crank-handle 62, which detachably fits upon the squared end of either of said rods.

Mounted upon the upper end of the bridge-wall 63 and adjacent to the rear dump-plate 60, as shown, or in any other suitable manner, is the drum 64, and said drum is provided with hand-hole openings, which are closed by hand-plates braced in position by clamping-nuts bearing against the arms or brackets 65, of the ordinary or any preferred construction. (The hand-plates closing said holes are not shown in the drawings, as they are of the ordinary construction employed in connection with all boilers and do not form a part of my invention.) Said drum is also connected by one or more pipes 66 with a boiler 66ª, of the construction shown or of any other preferred construction. Secured transversely of the furnace and extending parallel with and a slight distance forward and in the plane of the upper portion of the traveling grate and supported in clips 67, bolted to the under portion 7 of the hopper, is the receptacle 68, and communicating at their front ends with said receptacle and occupying the same inclined plane as and interposed between the upper portion of the chains forming the traveling grate are the water-grate tubes 69, and said tubes curve downward, as at 70, to the horizontal plane occupied by and concentric to the axis of said roller, and therefore in the same plane as the correspondingly-curved portion of the traveling grate, and from said point extend approximately vertically downward, as at 71, and communicate at their lower ends with the upper side of a receptacle 72, which extends parallel with the similar receptacle 68, and said receptacle 72 is connected near each end by a system of pipes 73 with the drum 64.

It may sometimes be found inconvenient to employ a water-drum upon the bridge-wall, and in such cases the water-drum will be dispensed with and the pipes 73 connected directly to the boiler, as will be understood.

In the sides of the receptacles 68 and 72, opposite the ends of the pipe 69, are openings through which an instrument is inserted to expand the ends of the tube therein in the ordinary manner, and said openings also serve to give access to the interior of said receptacles and said pipes for cleaning purposes. Said openings are capped in the ordinary manner, as shown at 74.

The chains forming the traveling grate and the tubes forming the water-grate are arranged alternately and a sufficient distance apart to permit air to pass up freely to the fuel upon the grate, and the inclination of the whole grate is such as to facilitate the descent of the fuel.

While I have shown the tubes extending downward below and between the rearmost supporting-roller and the dump-plates, it is to be understood that equally good service may be had by supporting the receptacle 72 in the position shown in dotted lines at 75 and connecting the same in a direct line with the receptacle 68 by employing straight pipes in lieu of the pipes 69, having bent portions 70, as also shown in dotted lines, but in this case it would be necessary to dispense with one of the dump-plates or else dispose them in positions slightly different from those illustrated in the drawings. When it is desired for any purpose to remove said dump-plates, the supporting-plates 55 can be detached from the side supports 2.

After the fire has been started upon the grate the hopper is filled with fuel, and in order to regulate the quantity which by gravity automatically passes from said hopper onto the grate the screws 10 are turned, so as to force the feed-regulator plate 8 inward, as shown in dotted lines, and therefore contract the passage affording communication between the hopper and the interior of the furnace, or to permit said plate to swing in the opposite direction and therefore enlarge said passage to permit the fuel to pass more freely and in

larger quantities onto the grate. Immediately after the fire is started the sliding box is moved downward to cause the engagement of the worm 37 with the wheel 34 and the wheel 38 with the worm 39, if these parts were not previously engaged, and the engine 43 is started in the ordinary manner and causes the rotation of the shaft 40 and of the power-shaft 32, through the medium of the intermediate mechanism described. The rotation of the power-shaft in the proper direction causes the chain-grate to move slowly in the direction indicated by the arrows, Fig. 2, so as to convey the fuel thereupon to the rear. This speed of movement is so proportioned to the length of the grate and to the time necessary for the proper consumption of the fuel that when the best results have been obtained from the fuel upon the grate it will be dumped automatically upon the dump-plate 58, which retains the same thereon until, by reason of the air-passages or apertures 59, the consumption of the fuel is completed and the resultant ashes or refuse is forced by the oncoming fuel in quantity back upon the dump-plate 60, from which, and also from the dump-plate 58, it is removed at intervals by the pivoted operation of said plates by the attendant through the medium of the crank-handle 62.

To ascertain at any time whether or not a perfect combustion of the fuel is in progress the attendant raises one of the pivoted lids 31 to observe through the peep-hole pipe 30 the burning fuel.

In order to insure a quick and perfect combustion of the fuel upon the grate, the registers 14 are open more or less, and the air passing through said registers into the passages 15 is distributed over a wide area of heated surface and passes upward as extremely hot air from opposite sides through the arch-passage 16 and forwardly through the passage 29 into the passage 28. From said passage it is forced by the natural draft down through the passage 27 and the subdivided passage 26, which distributes said highly-heated air in a thin sheet or stream directly upon the burning fuel upon the grate, so that a perfect and quick combustion may be had, that consequently the best results from the fuel may be derived. The water, which is converted into steam in the tubes 69 in a very short time, passes through the system of pipes 73 into the drum 64, from whence it flows by means of the pipe or pipes 66 to the boiler. It will therefore be apparent that a constant and continuous circulation of steam from the water-grate to the boiler and of hot water from the boiler to the water-grate is maintained. By the position of the water-drum upon the bridge it will also be apparent that it receives the intense heat which usually impinges upon the upper portion of the bridge-wall, so that nearly the entire heating-surface of the interior of the furnace is utilized in converting the water into steam, that steam may be generated in the shortest possible time.

In Figs. 8 and 9 I have shown a modified form of link to be employed in the construction of the traveling grate, if desired, this form being merely a modification of that previously described, and consisting of a body portion 76, provided with a series of vertically-extending grooves 77 in its sides, the base or bottom of said grooves extending from a point a suitable distance above the center of the body portion, and in the plane of the sides thereof, upwardly and inwardly. The base or bottom of the grooves 77, at opposite sides of said link, therefore converge upwardly at an angle that brings them contiguous at the upper surface of the link, as shown clearly in Fig. 9, so as to form air-passages, which are of considerable depth at their upper ends, and run to nothing in the plane of the sides of the link at their lower ends. Each link is also formed near its upper margin with the lug or boss 78, which prevents the contiguous margins coming in contact, as described with relation to and for the same purpose as the bosses or projections 47^a—that is, to provide air-passages between the links. At its opposite end, and diagonally opposite the lug or boss 78, a tooth or lug 79 projects from said body portion, and projecting also from the body portion at its junction with and at right angles to the tooth or lug 79 is an L-shaped arm, which comprises the rectangular portion 80 and the laterally-projecting cylindrical boss or shoulder 81, which is provided with a lug 82, projecting from its periphery. Said body portion, about its center, is provided with a cylindrical opening 83, which is grooved longitudinally, as shown at 84, and at one end is provided with a segmental recess 85. In securing these links in operative relation to each other in the formation of a sprocket-chain the circular boss or shoulder 81 of one link is inserted laterally into the opening 83 of the preceding link, with the lug 82 engaging the groove 84 of said preceding link until said lug comes opposite the segmental recess 85. The links are then pivotally operated properly to cause said lug to move downward into said recess, which thus locks the links together, as they cannot be disengaged without the re-engagement of said lug and said groove, which is impossible when the chain is once secured in position. A chain constructed of the links shown in Fig. 5, or of the links shown in Figs. 8 and 9, can be used to advantage without the water-grate, and sufficient air-space be provided between each pair of chains, if the sprockets are one against the other, by means of the lugs 54^a, projecting from the shoulders or bosses 54, and the lugs 86, projecting from the shoulders or bosses 51, the said shoulders or bosses of the links of one chain coming in contact with the shoulders or bosses of the companion links of the other chain and thereby holding them always

at the required distance apart, so that lateral movement of said chains is impossible and an air-space between them is always provided.

From the foregoing it is manifest that I have produced a furnace wherein the grate and its supports are strong and durable and sufficiently open to permit almost uninterrupted access of air to the fuel upon the grate, wherein an air-space is interposed between the fuel upon the grate and the fuel in the hopper to prevent the latter being prematurely heated, wherein hot air is directed down upon the burning fuel, wherein the quantity of fuel to be automatically fed to the grate may be regulated, and wherein the feed-water for the boiler is heated in the shortest possible time by utilizing all of the available heating-space. It is also manifest that I have produced a traveling grate which is simple, strong, durable, and inexpensive of construction.

It will furthermore be apparent that by directing the highly-heated air down upon the coal the same is quickly coked and the gases consumed, thereby effectually preventing smoke. This furnace, coking the coal and by a perfect combustion, owing to its grate-construction, immediately consuming the gases and thereby preventing smoke entirely, will commend itself to all practical persons or those skilled in the art for its economy, simplicity, and thorough practicability.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In a furnace, the combination with a power shaft, sprocket-wheels mounted thereon, a sprocket-chain grate operatively supported and engaging said sprocket-wheels, and a worm-wheel also mounted upon said power-shaft, of a worm-shaft, a motor operatively connected to one end of the same, a sliding-box, a shaft journaled therein, and carrying a worm-wheel upon one end and formed with worm-threads at its opposite end, and a screw to adjust said sliding-box so as to throw the said worm-wheel and said worm-thread into or out of gear, respectively, with the worm-thread of the motor-shaft and the worm-wheel of the power-shaft, substantially as set forth.

2. In a furnace, the combination with a traveling-grate and means to operate the same, of a hopper formed above the front end of the grate and consisting of outwardly projecting arms, a pivoted feed-regulator plate, and a screw engaging said feed-regulator plate whereby it may be properly adjusted to increase or diminish the quantity of fuel passing to the grate, substantially as set forth.

3. In a furnace, the combination with a grate, of an arch over said grate having a pair of arched passages and having a central passage connecting said arched passages, a front portion depending from said arch and provided with a passage communicating with the foremost or contiguous arched passage, an arch-plate secured to the front of the furnace and supporting the depending portion of the arch, and provided with a passage which communicates with the lower end of the passage of said depending portion of the arch and extends downwardly toward the central portion of the grate, side-walls at the opposite sides of said grate provided with passages which communicate with the opposite ends of the rearmost arch-passage, and registers controlling the entrance of air to said side-wall passages, substantially as and for the purpose set forth.

4. In a furnace, the combination with a grate, of the side-walls located at opposite sides of the same, and provided with air passages or chambers, registers controlling the entrance of air to said chambers, an arch over the grate provided with a rear-arch passage, communicating at its opposite ends with the air passages or chambers of the side-walls, and with a front arch-passage which communicates with the rear arch-passage, and with a depending portion provided with a passage which communicates with the front arch-passage, an arch-plate secured to the front end of the furnace and provided with a downwardly and inwardly extending passage which communicates with the passage of the depending portion of the arch, and a peep-hole pipe extending through the arch-plate in line about with the central portion of the grate, and provided with a lid at its front end, substantially as set forth.

5. In a furnace, the combination with a grate, walls at opposite sides of the same, provided with air passages or chambers, registers controlling the entrance of air to said passages or chambers, an arch over the grate provided with a rear arch-passage which communicates with the passages or chambers of the side-walls, and with a front arch-passage which communicates with the said rear arch-passage, and provided also with a depending portion having a passage which communicates with the front arch-passage, of an arch-plate secured to the front end of the furnace above the grate, and comprising a shoulder which supports the front part of the depending portion of the arch, a wall extending downwardly and inwardly from the rear margin of said shoulder, arms projecting rearwardly from said wall, and a transverse portion connecting said arms, and fire-bricks resting upon said transverse portion and between said arms and supporting the inner or rear part of said depending portion of the arch, substantially as set forth.

6. In a furnace, the combination with a rearwardly and downwardly inclined grate, walls at opposite sides of the same, provided with air passages or chambers, registers controlling the entrance of air to said passages or chambers, an arch over said grate provided with a rear arch-passage communicating with said side-wall passages or chambers, and with a front arch-passage which

communicates at its middle with the rear arch-passage, and provided with a depending front portion having a passage communicating with the front arch-passage, of an arch-plate which supports said depending portion of the arch, and is provided with a downwardly and inwardly inclined passage which communicates with the lower end of the passage of said depending portion of the arch, a hopper above the grate and opposite the passage between the same and said arch-plate, comprising outwardly projecting arms which form the ends of the hopper, and a plate secured to the said arch-plate in such manner as to form an air-space which is interposed between the fuel in the hopper and the burning fuel upon the grate, substantially as set forth.

7. In a furnace, the combination with a grate, of walls at opposite sides of the same provided with air passages or chambers, and registers controlling the entrance of air to said passages or chambers, an arch over the grate connecting said walls, and provided with an arched air passage communicating with the air passages or chambers of the walls, and provided also with a depending front portion having a passage connected to the arch-passage, an arch-plate secured to the front of the furnace and supporting the depending portion of the arch and provided with a passage communicating with the passage of said portion, and arms dividing said passage of the arch-plate into a number of smaller passages, substantially as set forth.

8. In a furnace, the combination with side-walls and an arch connecting the same and provided with a depending front portion, a suitable grate, and a feed-hopper for fuel at the front end of the furnace above the grate, of an arch-plate supporting the depending portion of the arch and provided with an inwardly or rearwardly projecting shoulder, and a plate secured to the under side of said shoulder to form an air-space between the burning fuel and the fuel in the hopper, substantially as and for the purpose set forth.

9. A furnace, comprising side supporting-plates, a power-shaft journaled therein, sprocket-wheels mounted upon said power-shaft, a number of shafts journaled in said side-supports, perforated rollers thereon, and a traveling-grate comprising chains which engage said sprocket-wheels and are supported by the same and by said perforated rollers, substantially as set forth.

10. A furnace, comprising side supporting plates, a power-shaft journaled therein, sprocket-wheels mounted upon said shaft, a number of other shafts journaled in said supporting plates, provided with radiating arms, a roller of perforated material mounted upon said arms, and an endless grate, consisting of sprocket-chains engaging said sprocket-wheels and perforated rollers, substantially as set forth.

11. In a furnace, the combination with a hopper and side-supporting plates, of a grate, comprising a traveling portion which consists of a series of parallel sprocket-chains, and a stationary portion which consists of a series of parallel water-tubes which are arranged alternately with and in the same plane as the fuel-supporting portion of said chains, and a perforated dump-plate arranged at the discharge end of the grate, and a non-perforated dump-plate arranged in rear of said perforated dump-plate, substantially as set forth.

12. In a furnace, an improved traveling-grate, comprising a series of links having teeth or projections, cylindrical openings, and forwardly projecting arms provided with cylindrical shoulders, the cylindrical shoulders of said links engaging the cylindrical openings of the preceding links, substantially as set forth.

13. In a furnace, an improved traveling-grate, comprising a series of links having teeth or projections, cylindrical openings, forwardly projecting arms provided with cylindrical shoulders, and bosses or projections to prevent their contiguous margins or edges coming in contact, and laterally projecting lugs to prevent the sides of the links coming in contact; said cylindrical shoulders of said links engaging the cylindrical openings of the preceding links, substantially as set forth.

14. In a furnace, an improved traveling-grate, comprising a series of links provided with depending teeth or projections, and with forwardly projecting arms provided with laterally projecting cylindrical shoulders, and provided also in the rear of said teeth or projections with forwardly projecting bifurcated hook-portions which, in conjunction with said teeth and the body-portion of said links, form cylindrical openings, substantially as set forth.

15. In a furnace, an improved traveling-grate, comprising a series of links provided with teeth or projections, with cylindrical openings, with arms having laterally projecting cylindrical shoulders, and provided with central openings, and with lugs which prevent the contiguous margins of said links coming in contact, substantially as set forth.

In testimony whereof I affix my signature in the presence of two witnesses.

PAUL L. CROWE.

Witnesses:
M. R. REMLEY,
G. Y. THORPE.