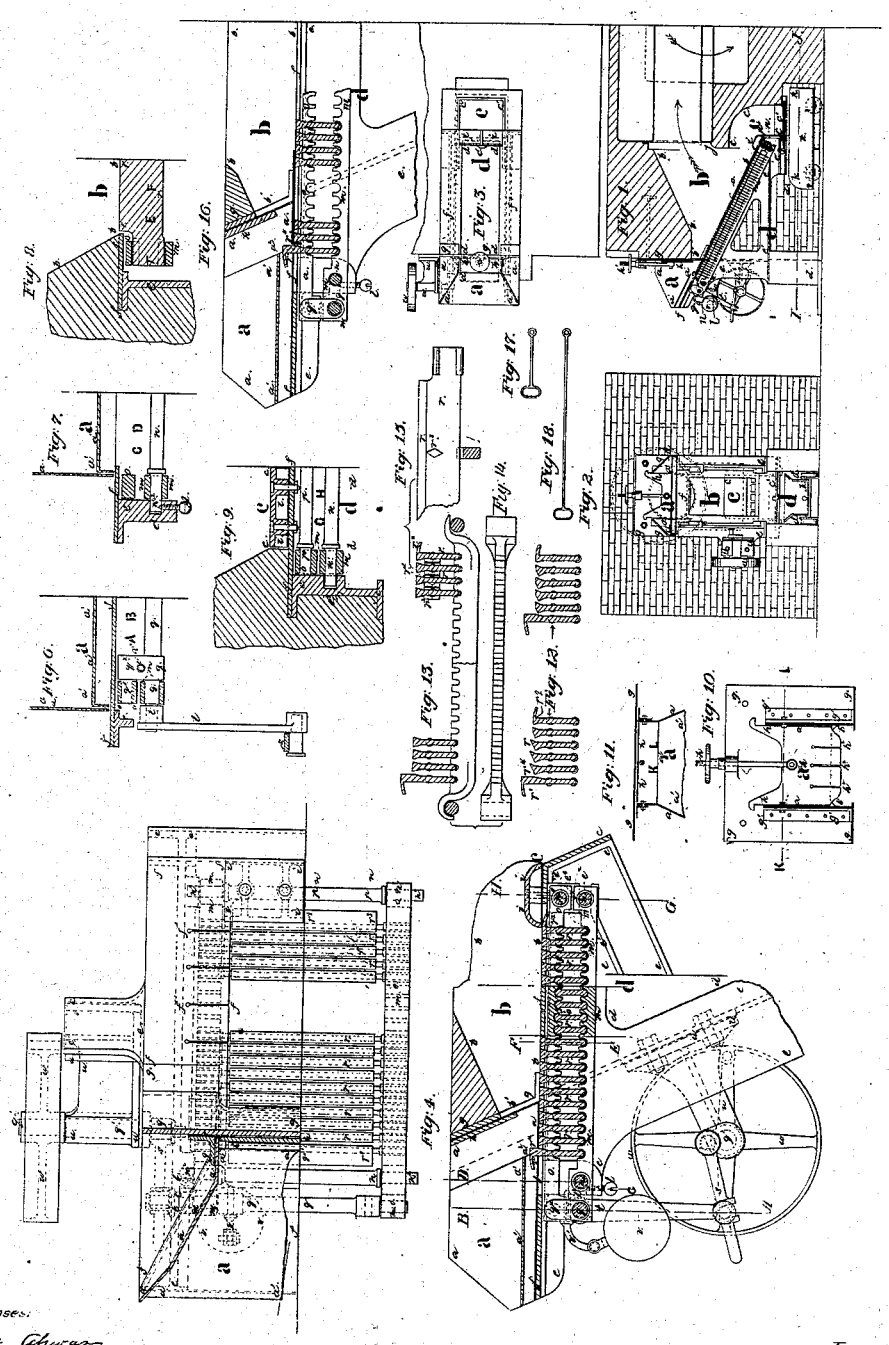
6 Sheets—Sheet 1

J. ZEH.

GRATE FOR STEAM BOILER FURNACES.

No. 48,247. Patented June 13, 1865.



Witnesses:

Chas. de Schwarz

Geo. Gaertner

Inventor:

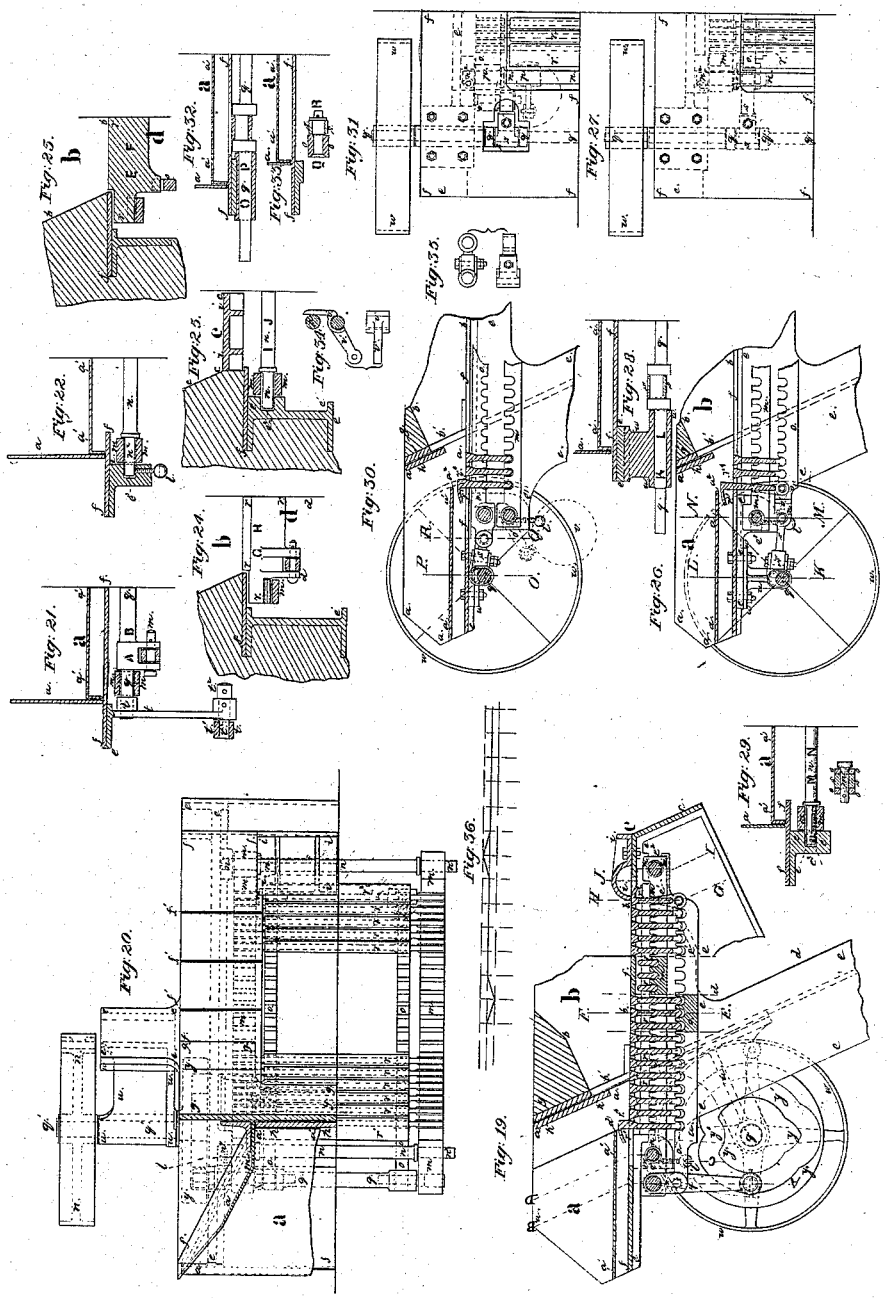
Jacob Zeh

6 Sheets—Sheet 2.

J. ZEH.

GRATE FOR STEAM BOILER FURNACES.

No. 48,247. Patented June 13, 1865.



Witnesses:
Thos. de Schwarz
Gwyapp

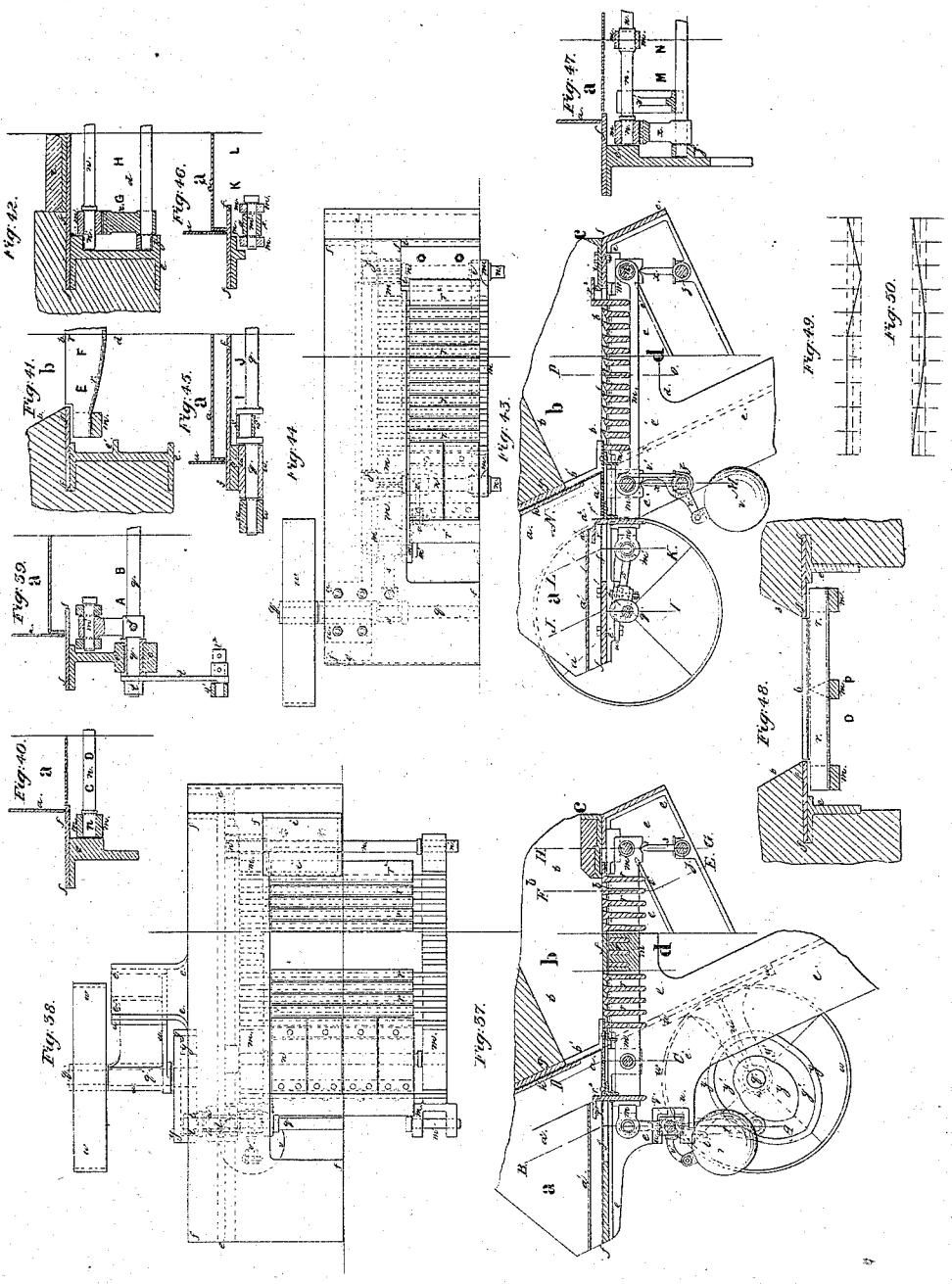
Inventor:
Beh. Zeh

6 Sheets—Sheet 3.

J. ZEH.

GRATE FOR STEAM BOILER FURNACES.

No. 48,247. Patented June 13, 1865.



Witnesses:
Chas. de Schwarz
J. W. Zeh

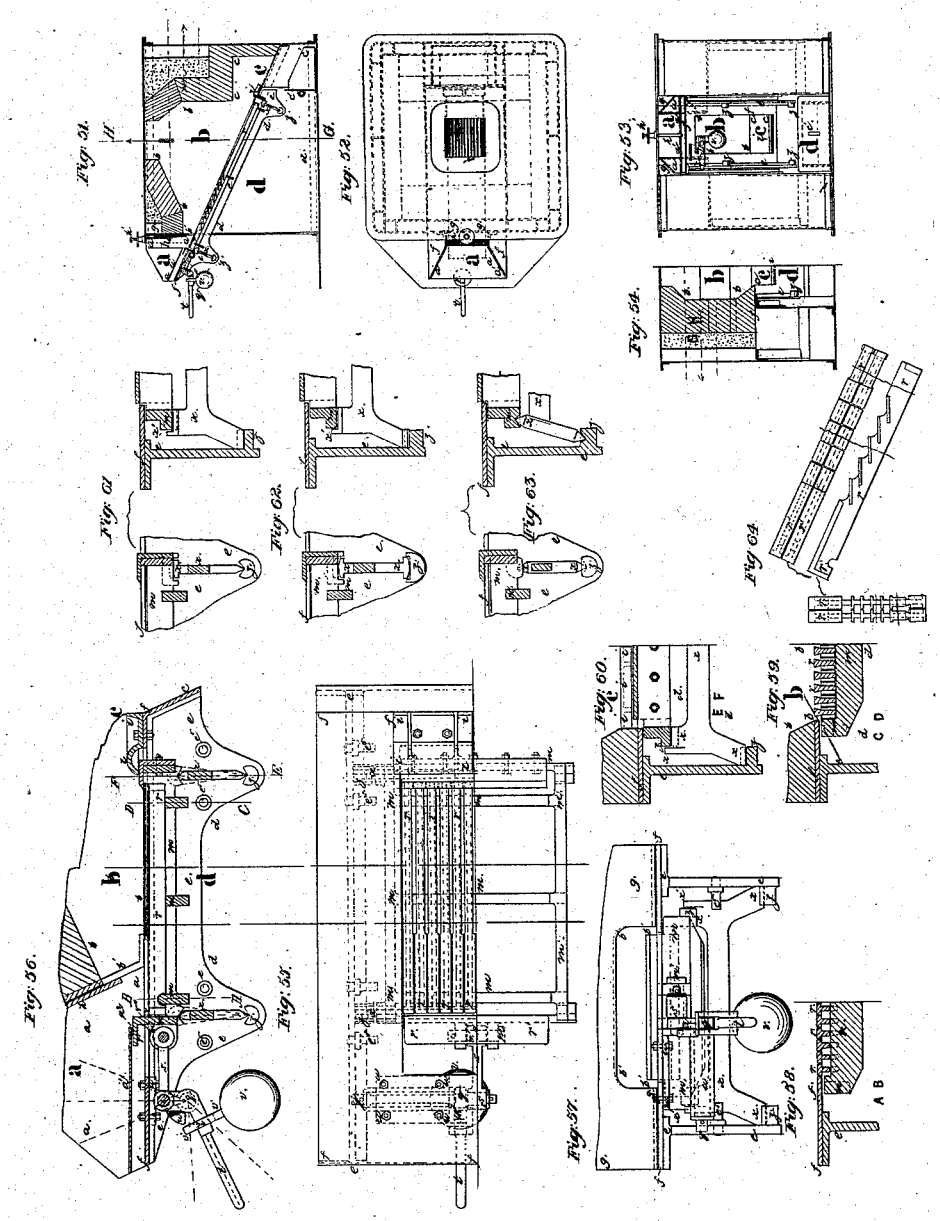
Inventor:
Jos. Zeh

6 Sheets—Sheet 4.

J. ZEH.

GRATE FOR STEAM BOILER FURNACES.

No. 48,247. Patented June 13, 1865.



Witnesses:
Chas. de Schwarz
Geo. Gaylord

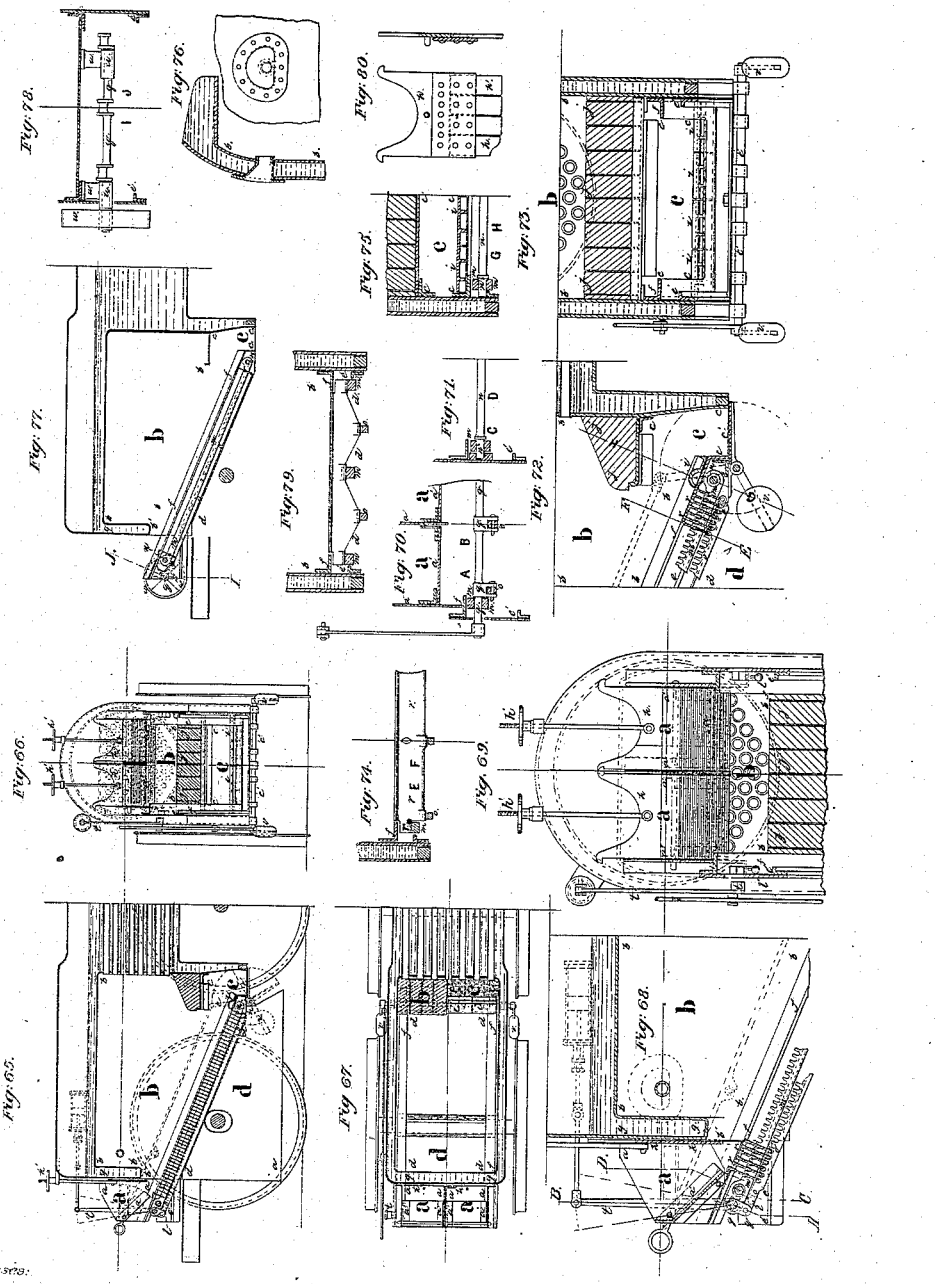
Inventor
Joh. Zeh

6 Sheets—Sheet 5.

J. ZEH.

GRATE FOR STEAM BOILER FURNACES.

No. 48,247. Patented June 13, 1865.



Witnesses:
Theo. de Schwarz
G. W. Griffith

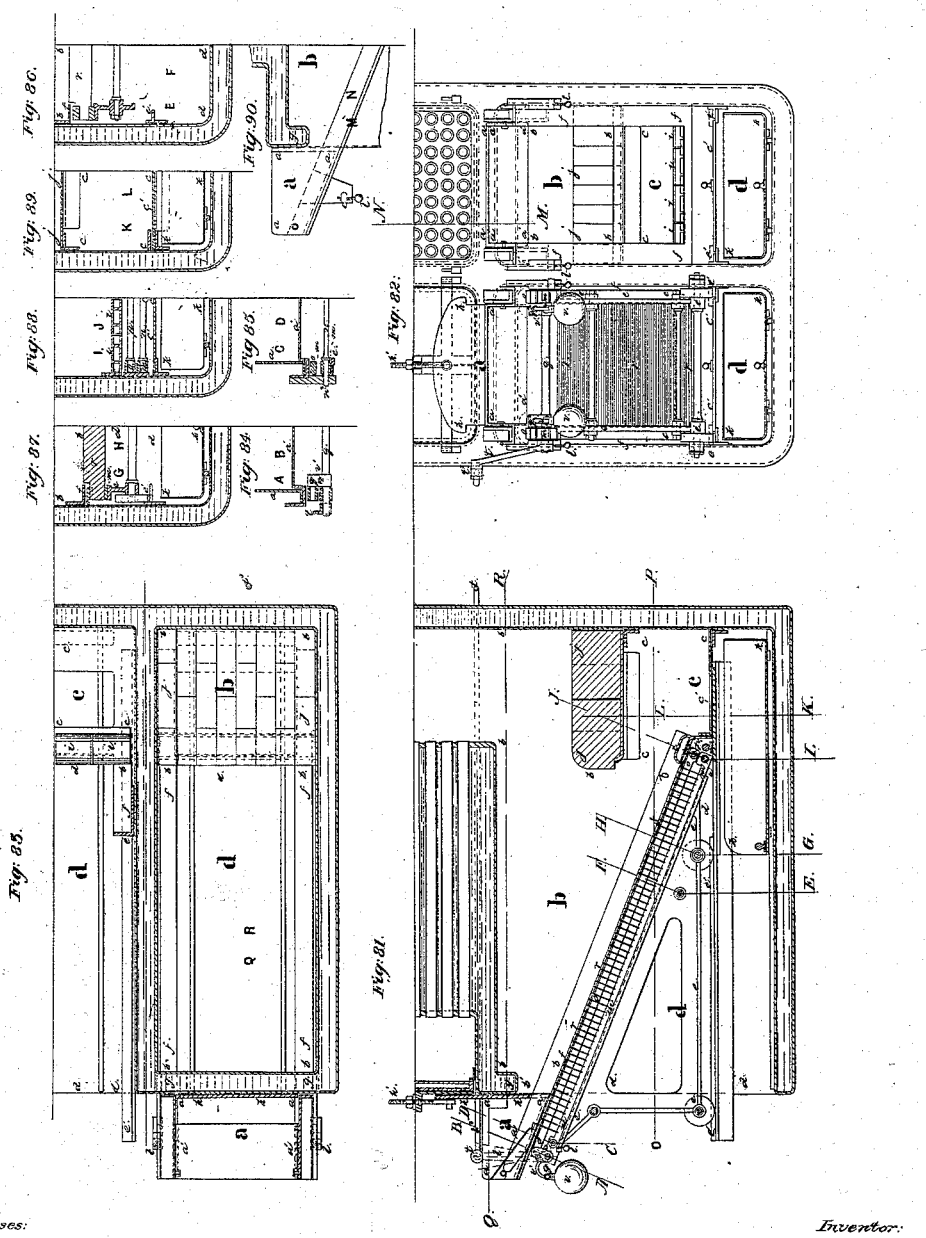
Inventor:
Johs. Zeh

6 Sheets—Sheet 6.

J. ZEH.

GRATE FOR STEAM BOILER FURNACES.

No. 48,247. Patented June 13, 1865.



Witnesses:

Chas. de Schwarz

Geo. Gaupp

Inventor:

Bth. Zeh

UNITED STATES PATENT OFFICE.

JOHANN ZEH, OF VIENNA, AUSTRIA.

IMPROVEMENT IN GRATES FOR STEAM-BOILER FURNACES.

Specification forming part of Letters Patent No. 48,247, dated June 13, 1865.

To all whom it may concern:

Be it known that I, JOHANN (JOHN) ZEH, head engineer of the Western railway of Austria, residing in Vienna, do hereby declare that I have invented certain improvements in moving or mechanical grates or fire-bars for furnaces or other fire-places, and that the following specification, taken in connection with the accompanying drawings, is a full and exact description of the same.

First, that I make use of the inclined position of the fire-grate and of the motion of the same to obtain a regular supply of fuel, to clear the grate of ashes and other incombustible matter, and to produce perfect and regular combustion; second, that none of the fuel can enter between the movable grate and the fixed parts of the fire-place or furnace; third, that the fire bars or grate may be easily removed and replaced; fourth, that my grates are applicable to all kinds of fires and for all kinds of fuel, if not over large, and that they are very simple and durable.

For the sake of distinctness I have divided the description under the eight following heads: first, the inclined position of the grate; second, the movability of the fire-bars; third, the regular supply of fuel; fourth, the clearing of the grate from ashes and other non-combustible matters; fifth, the absence of all danger from choking up with the fuel; sixth, the easy removal and replacement of the fire-bars; seventh, the adaptability of my grates to all kinds of fires and all sorts of fuel; eighth, simplicity and great durability.

No. 1. The inclined position of the grate.—The inclination of the fire-grate in the direction of its length may vary, according to circumstances, from fifteen to thirty-six degrees, the thickness of the layer of coal supplied for combustion and the rate of movement of the grate being augmented in proportion to the diminution of the inclination.

No. 2. The movability of the fire-bars or grate.—The grate may be made to move in two ways: First, the grate-bars, being made movable and of a convenient form, and lying not longitudinally but transversely across the fire-place, may be connected with bars or framing, so as to be capable of an oscillatory motion in the longitudinal direction of the grate; or, second, the whole fire-grate may be arranged in such a manner as to move bodily to and fro in the same direction. These movements may be produced manually, or by means of any kind of power, and may be regular or irregular, periodical or continuous.

No. 3. The regular supply of fuel.—In order that the following may be easily understood, it may be here stated that the bottom of the grate is prolonged toward the front beyond the fire, so as to serve as the bottom or part of the bottom of a coal-box or coal-hopper connected with the fire-place by means of an opening in the front hearth plate or wall, and which can be increased or diminished so as to regulate the thickness of the layer of coal supplied to the fire. When the movement of the bottom of the fire-place is from front to back, and consequently in a downward direction, whatever is placed upon the bars will necessarily follow in the same direction, there being no resistance; but when the movement is in the opposite direction the fuel which is lying on the bars will follow the movement through a part of the distance, which diminishes in proportion to the speed and the inclination of the grate, because, the movement being upward, resistance takes place from the accumulated fuel above. Now, it is clear that if these motions are repeated the fuel will gradually make its way from the coal-hopper to the fire, and in the end to the lowest part of the grate, and that if sufficient fuel be kept in the hopper and at the upper end of the fire-bars the fire will be supplied in a regular manner with fuel, and combustion will be perfect, uniform, and economical. In order that on the movement of the grate backward and downward a portion of the fuel which lies on the front prolongation of the grate, and which might possibly be retained by the weight of the incumbent coal in the hopper or by friction in the opening, may without fail follow the motion of the grate, the front portion of the fire-bars has a slight extra elevation, and by this means it is clear that a portion of the fuel must follow the motion and reach the fire. By the reverse or upward motion of the grate the fuel is retained on the prolongation of the grate by that which lies over it in the hopper. The grate will continue its movement under the fuel and

the space will be stuffed with coal. I declare, however, that the extra elevation described is absolutely necessary, and may be omitted not in many instances.

No. 4. The clearing of the grate from ashes or other incombustible matters.—As all objects lying upon the grate must eventually arrive by its motion at the farthest and lowest part of it, it is clear that the bars are continually freed from ash and other matters, and which would collect at that point were not a receptacle provided for them, from which they are removed at intervals. This space is closed by doors or other arrangements, and also by the accumulated ashes, and it is only when it is opened for the purpose of clearing it that air can possibly pass through it into the fire-place.

No. 5. The absence of all danger of choking up with fuel.—In order to prevent this, which would be a great inconvenience, the ends of the fire-bars or the sides of the whole fire-grate, when movable as a whole, are furnished with prolongations which pass over or under the fixed sides of the fire-place in such manner that only a small uniform distance is maintained between them and no space left to allow the fuel to get in between.

No. 6. The easy removal and replacement of the bars.—In order that any of the fire-bars may be easily taken out and replaced, they are placed on frames or supports independent of the hearth-plates or grate-frames, and secured by means of bolts or pins in any convenient manner; or, in the case of large furnaces, the frames are fixed on a carriage with wheels that run on rails or ledges, and the bars are fixed in like manner. When the grate is movable as a whole the connection with the fire-place is made by means of grate-supports, which are so arranged that the whole of the fire-grate can be moved to and fro. In large furnaces the grate-supports can also be set upon a frame running on wheels, and may be fixed or fastened in any convenient manner to the hearth-plate. It will be clear from the preceding that the grate or bars can at any time be easily removed and replaced, being connected with the fire-place only by means of bolts or pins, or with a movable frame connected with the fire-place or hearth-plate. However, I declare that the movable bars may also be fixed upon supports or frames which are solidly connected with the fire-place or hearth-plate, as their easy removal is only of importance in case of the necessity for repairs, without waiting for the cooling of the furnace.

No. 7. The adaptability of my grates to all kinds of fuel and all sorts of fire-places.—The conditions of complete combustion for all kinds of fuel under all circumstances are invariable—viz., first, the regular supply of such an amount of fuel as is just sufficient to replace the consumption by burning; second, the equal covering of the grate in order that no surplus air may enter the fire-place; third, the securing of sufficient air; fourth, the clearance of the fire-bars from ashes and other like matters; fifth, sufficient heat in the fire-place with sufficient draft. As in my grates all these conditions are present, they are applicable to every mode of firing where sufficient draft can be obtained.

No. 8. Simplicity and great durability.—My grates are really simple, because by the motion and inclination described all the requisites of complete combustion are obtained, and because they are not encumbered by any unnecessary machinery. They are durable, because those movable parts which are exposed to the heat are disposed in such a manner as not to suffer injury, because the machinery necessary for the movement of the grate is placed beyond the reach of the fire and is not exposed to injury, and because the grate is less exposed to wear than in many other furnaces and fire-places, as the grate is always kept clear, and the bars and other parts are thus cooled by the current of air.

Difference between these and other movable grates.—My grates differ from other sloping grates in this, that the inclination can be so arranged that there is no falling of the fuel toward the lower part. Whatever be the nature of the fuel used, it moves onward only according to the motion of the grate itself. The peculiarity in the movement of my grates consists, in part, as follows: In the case of my separately-moving bars the bars themselves move in their places only, and not out of them; the bars are not placed in the inclined position of the plane of the grate longitudinally, but transversely, and the fire-grate is moved to and fro in the longitudinal direction. The other distinctive features of my invention are the prolongation of the grate or fire-bars, as already referred to, the arrangement to prevent choking up of the fuel, and the feeding of the fire, not by hand, but by the motion of the grate itself in its inclined position; that by this motion the fuel advances regularly, and is continually changing its position and presenting new surfaces to the fire, which is necessary for proper combustion; and, lastly, that the fire-bars can easily be taken out and replaced, and that the fire-places are adapted for any kind of fuel.

My mechanical grates may be advantageously applied to ordinary fire-places, in order to keep the fire open and free from dust and ashes, and I claim this application of my invention. In the case of the motion being given to the entire grate as a whole, the motion may be made to take place in a diagonal direction.

Explanation of the drawings.—These are purposely made in full detail in order that any modifications may be made in the grates to meet various cases. The sheets are numbered from I to VI, and the same parts are marked with the same letters in all the drawings.

Sheet I: Figure 1, application of my system to a steam-boiler; Fig. 2, front view of same; Fig. 3, top view of same; Fig. 4, part of Fig. 1,

enlarged four times, the lower portion showing the fire-grate alone; Fig. 5, top view of Fig. 4; Figs. 6, 7, 8, 9, sections on the lines A B, C D, E F, and G H, Fig. 4; Fig. 10, front wall of fire-place and part of hopper *a* in Fig. 2, twice the size; Fig. 11, section on line K L, Fig. 10; Figs. 12, 12, other forms of grate-bars; Figs. 13, 14, 15, middle posts; Fig. 16, part of Fig. 4, several grate-bars connected or supported by a plate; Figs. 17, 18, utensils necessary for the grates.

Sheet II: Fig. 19, part of a grate with different arrangement and united motion of the fire-bars; Fig. 20, top view of Fig. 19, the lower part showing the grate only; Figs. 21, 22, 23, 24, 25, sections on the lines A B, C D, E F, G H, and I J, Fig. 19; Fig. 26, part of a grate with different arrangement and motion of the fire-bars; Fig. 27, top view of Fig. 26; Figs. 28, 29, sections on lines K L and M N, Fig. 26; Fig. 30, part of grate with bearings of fire-bars like Fig. 4, with different motion; Fig. 31, top view of Fig. 30; Figs. 32, 33, sections on the lines O P and Q R, Fig. 30; Fig. 34, arm of counterpoise of Figs. 30 and 31; Fig. 35, guide-rails of Figs. 30 and 31; Fig. 36, diagram of rotation of motion-wheel of Fig. 19.

Sheet III: Fig. 37, part of a grate with united motion of the fire-bars; Fig. 38, top view of Fig. 37, the lower portion showing the grate alone, the coal-hopper and front wall of fire-place being omitted; Figs. 39, 40, 41, 42, sections on the lines A B, C D, E F, and G H, Fig. 37; Fig. 43, part of a grate with united motion of fire-bars, with bars of a different form and grate-bearing, and with other motion as in Fig. 37; Fig. 44, top view of Fig. 43, the coal-hopper and front of fire-place omitted; Figs. 45, 46, 47, 48, sections on the lines I J, K L, M N, and O P, Fig. 43; Fig. 49, diagram of rotation of motion-wheel, Fig. 37; Fig. 50, diagram of rotation of motion-shaft, Fig. 43.

Sheet IV: Fig. 51, application of grate with united motion of fire-bars; Fig. 52, top view of same; Fig. 53, front view of same, fire bars and bearer omitted; Fig. 54, section on the line G H, Fig. 51, fire-bars, bearers, and cinder-chest omitted; Fig. 55, top view of a part of the grate and of the hearth-plate, Fig. 51, increased four times, but with different fire-bars, the lower part representing the grate-frame with bars in place; Fig. 56, section of same; Fig. 57, front view of same, coal-hopper omitted; Figs. 58, 59, 60, sections on the lines A B, C D, E F, Fig. 56; Figs. 61, 62, 63, other forms of grate-bearers; Fig. 64, fire-bars of Fig. 51 magnified four times in width, but not in length.

Sheet V: Fig. 65, grate with cross lying and moving fire-bars for a locomotive or other boiler, with fire-box; Fig. 66, front view of Fig. 65, fire-box omitted; Fig. 67, top view of Fig. 65, boiler and bars omitted; Fig. 68, part of Fig. 65, double size; Fig. 69, front view of Fig. 68, bars omitted; Figs. 70, 71, sections on the lines A B and C D, Fig. 68; Fig. 72, part of Fig. 65, double size; Fig. 73, front view of Fig. 72, fire-bars omitted; Figs. 74, 75, sections on the lines E F and G H, Fig. 72; Fig. 76, section and view of opening into the fire-box, Figs. 65 and 68, for observing the fire; Fig. 77, the grate, Fig. 65, with different motion; Fig. 78, section on the line I J, Fig. 77, double size; Fig. 79, section of a grate in which the fire-bars are supported in the middle, intended to show that they may be supported in one or more places as well as at the ends; Fig. 80, valves or traps for regulating the thickness of the layer of the coal on the bars.

Sheet VI: Fig. 81, grate, with movable cross fire-bars for a marine boiler with two furnaces; Fig. 82, front view of Fig. 81, the grate drawn out on the right side; Fig. 83, top view of Fig. 81, the boiler in section on the lines O P and Q R, fire-bars omitted; Figs. 84 to 90, sections on the lines A B, C D, E F, G H, I J, K L, and M N, Fig. 81.

a represents the coal-hopper; a^{I}, the bottom of the same; a^{II}, space between the bottom of the hopper and the top fire-bar; *b*, the furnace or fire-box; b^{I}, opening between *a* and *b* in the front wall of the furnace; *c*, the ash-conduit; c^{I}, slider to same; *d*, ash-pit beneath the fire; *e*, cheeks or furnace-frames; e^{I}, guide-rail for the removal of the entire grate of the furnace; e^{II}, socket for the lower bearing, n^{I}; e^{III}, socket for the upper bearing, n^{II}; e^{IIII}, elevation on *e*, serving as a sidewise guide for the grate-frame; e^{V}, projection on *e* for *x*; *f*, hearth-plate, by which the area of the fire-bars is covered at the sides, in order that the whole grate or any of the bars may be removed; f^{I}, slots in *f* to allow for expansion; *g*, front wall of the fire-place; g^{I}, angle-iron on *g* for the fastening of *a*, and as a guide to *h*; g^{II}, screws for the fastening of *a*; *h*, trap or slide for regulating the thickness of the layer of coal; h^{I}, screw fixed to plate *h*, the portion of the screw beyond the plate indicating the thickness of the layer of coal; h^{II}, slots in *h* for expansion; *i*, bridge for the clinkers and cinders; *j*, fire-bridge; *k*, cinder-box; *l*, screws for fastening the fire-bars to the hearth-plate; *m*, frames for supporting the fire-bars; m^{I}, pins to connect *m* with parts of motion; *n*, connecting-links for *m*; n^{I}, projections on *n* for the support of the fire-bars on the under side; n^{II}, same for the upper side; *o*, motion-rods; *p*, connecting-rods; *q* q^{I}, motion-shafts; *r*, fire-bars; r^{I}, prolongation of the first fire-bar; r^{II}, prolongation of the last fire-bar; r^{III}, projection on fire-bars for keeping them at proper distance from each other; *s*, guides; *t*, levers or rods; t^{I}, cam for moving *t*; t^{II}, pin in *t* for the cam t^{I}, t^{III}, rod for moving *t*; *u*, pillar or support; u^{I}, projection on *u* for limiting the motion; *v*, counterpoise; v^{I}, arm of counterpoise; *w*, pulley; *x*, grate-bearer; x^{I}, projection on *x*, serving as side guide for the fire-bars; *y*, motion-wheel; y^{I}, opening in *y* for the cam t^{I}; *z*, pillar or support for *x* on *e*.

Figs. 1 to 30 illustrate grates with cross fire-

bars having an oscillating or vibratory motion, either continuous or intermittent, and worked by straps and pulleys. Figs. 1, 2, 3 represent a grate applied to a steam-boiler. The flame is supposed to pass, in the first instance, from *b* through the flue to the back of the boiler, then, dividing itself, returns on both sides of the boiler to the front, and, again uniting near the lower part, passes again along the bottom to the chimney. It being understood that if the boiler is of a different form, or if the flame is desired to pass in another manner or to be used for other purposes—such as the superheating of the boiler—the masonry must be otherwise arranged, so that this form of grate is applicable to other furnaces as well as those for steam-boilers.

The grate consists of the following main pieces: first, the fire-bars or grate itself; second, the machinery to give the movement; third, the hearth-frame; fourth, the coal-hopper, and, fifth, the ash-conduit.

First. The grate (or fire-bars) is composed of the parts *r m n o p*, Figs. 4, 5, shown on a large scale. The bars *r r* rest on the fixed pieces *m m*, Figs. 4, 5, 6, 7, 8, 9, and are moved by the rods or levers *o*. The movement of the fire-bars *r r*, Fig. 4, is continuous, and oscillating, as seen by the parts of motion. The fire-grate is shown by itself in Fig. 5, some of the bars being omitted. The projections $n^{I} n^{II}$ of *n*, Figs. 5, 7, 9, serve to connect the grate with *e* or with the hearth, the projections n^{II} lying in the openings e^{3}, Figs. 4, 5, 7, where they are fixed, and the projections n^{2} falling into the grooves e^{2}, which are so made along the whole length of the grate as to permit the expansion and contraction of the fire-bars. To remove the fire-grate the connection with the parts of motion is severed by the loosening of the screws *l l*, and the grate being drawn forward, whereby the projections n^{2} come out of the sockets e^{3} and out of the sockets or slots e^{2} and lie on the guide-rail e^{I}.

Figs. 81, 82 represent an arrangement whereby large and heavy grates are placed on a frame provided with wheels, and which can be drawn along like a carriage. In the figure the arrangement is applied to a marine boiler, but it applies equally to other kinds of furnaces. The wheels run on the guide-rails e^{I}, Fig. 1, and the projections n^{I} are not required. The projections n^{2} may serve to fix the fire-grate and the traversing frame to the hearth-plate or cheeks only. The slots e^{3} for the projections n^{2} must in that case be parallel to the guide-rails e^{I}, so as not to hinder the forward movement of the grate. The fire-bars *r* are in all the figures, where they lie across the fire-place, of the same size and form and placed equidistantly, with the exception of the two bars at the ends. Therefore the air-passages are equal to each other. If it is desired to leave less space between the front bars in order that the fuel may not fall through, and at the same time to leave sufficient room for the ashes to escape and for air to pass in toward the back of the fire-grate, then the heads of the bars *r* may be made unequal, according to the requirements of the case, or the bars may be placed at varying distances apart; and in Figs. 12, 12 is shown an arrangement for very small fuel, in which no space is left between the front bars.

Fig. 16 shows an arrangement for preventing the fuel falling down on the upper part of the grate, a plate being substituted for the front fire-bars. In order to prevent this plate from becoming warped, it may be made in several pieces, with links or straps at the back, (see Figs. 38, 44,) to allow for expansion and contraction, and one or more stays may be applied, as in the case of the fire-bars, Figs. 13, 14, 15. These stays lie on the shafts or connecting-rods *n*, and by means of the slots support the fire-bars at the side, Figs. 13, 14. On the lower shafts the stays are free to allow of their expansion and contraction, and they are held up by the shafts *n*. The distances between the fire-bars may be maintained by means of the projections r^{3}, Figs. 13, 15, and if the back links or straps are used, as before described, they will not hinder the motion of the bars. The first or upper fire-bar rises above the rest and forms the easel-like elevation described. The prolongations r^{I} of the first and r^{3} of the last bar correspond with the distance through which the grate moves, and the connection between the movable and fixed parts remains always the same. Consequently no squeezing in or choking up by the fuel can happen. The prolongation r^{I} passes under the coal-hopper and the prolongation r^{2} under the cinder-conduit *i*, Figs. 4, 5.

Second, the motion and its machinery.—The parts connected with the movement of the fire-grate are marked *q* q^{I} *s t u w*. The shaft *q* is connected with the rods *m*, and communicates motion by means of the lever-piece q^{2} and the studs q^{3}, Figs. 4, 5, 6, to the rods *o*, and through these to the fire-bars. On one side of *q* is fixed the arm or lever *t*, Figs. 4, 5, 6, connected by *s* with q^{I}. The pillar or support *u*, Figs. 4, 5, for q^{I} is fixed on the side or cheek *e*. On the outer end of q^{I}, Figs. 4, 5, is fixed the pulley *w*, to which movement is communicated by a strap. It may, however, be observed that as the movement of the fire-grate and of the shaft q^{I} is but small it would be more advantageous to give the motion by gearing than immediately by strap and pulley, and the turbine would be best suited to the purpose. The movement becomes less when the inclination of the fire-grate is increased or a thicker layer of coal is required; and when the movements are not continuous, but periodical, they are fewer and quicker, as shown in Figs. 19, 36, 37, 49. The movement may be given manually, in which case either the shaft q^{I}, Figs. 1, 4, is used or the arm *t* is so formed and placed as to be convenient to the hand. (See Fig. 51.) The counterpoise *v*, Figs. 1, 4, 5, serves to keep the proper balance of the fire-grate in all positions,

in order that the motions of the latter may not be impeded, and is so arranged that it can be removed with ease. (See Figs. 4, 5, 6.)

Third, the hearth or furnace-frame.—The parts of the frame are marked with the letters *e f g i*. These are fixed together in any convenient manner. To prevent warping or buckling, the slots *f*, Fig. 5, are provided, or, as in Fig. 20, the plates or frames are of several pieces, so disposed that the spaces marked f^1 remain between them to allow for expansion of *f*. The cinder-bridge *i*, of any convenient form, is fixed on *f*, and is composed of several pieces to allow for expansion. In Figs. 4, 5, 9, 19, 20, and 25, *i* is supposed to consist of two parts, connected by screws with *f*. The bridge *i* connects the fire-grate with the cinder-conduit *c*. By means of the front wall or plate, *g*, Figs. 1, 2, 3, 4, 5, 10, 11, 16, the coal-hopper *a* is united with the fire-place, and the opening b^1 in *g* is for the passage of the coal from *a* to *b*.

Fourth, the coal-hopper.—The hopper consists of the sides *a a*, the bottom a^1, and the sliding plate *h*. The manner of fixing the hopper to the front wall of the combustion-chamber *g* is shown in Figs. 10, 11, and for this purpose two angle-pieces, g^1, are attached to *g*, and serve at the same time as guides for the sliding plate *h*. The two screws g^2, Figs. 10, 11, serve to fix *a*. This may be done in any other convenient manner, provided always that *a* may be easily removed. To prevent the buckling of the slide *h* it is pierced, as already described for other parts, or it may be made in two parts, so that if the lower portion be injured it can be easily removed, as shown in Fig. 80. By means of the plate *h* the thickness of the layer of coal supplied to the furnace is regulated, so that it is made to be easily adjusted to various heights. For this purpose a screw is provided. (See Figs. 1, 2, 3, 10, 51, 52, 53, 65, 66, 81, 82.) The upper portions of this screw *f*, projecting above, shows the thickness of the layer of coal allowed for combustion. The lower end of the slide *h* must never touch the fire-bars, or it would be injured by the movement of the grate. In Figs. 2, 10, 65, 66, 80, 81, 82, *h* is provided with two horns, which, before the lower edge of the slide touches the fire-bars, strike on the top of the angle-pieces between which the slide moves. In Figs. 51, 52, 53 a stud is applied to the other end of the screw for the same purpose. The coal-hopper *a*, the slide *h*, and the opening b^1 in the wall-plate *g* are rather wider than the fire-bars, and the sliding plate is somewhat curved below. (See Fig. 10.) The object of this is that the sides of the grate may be well supplied with fuel. The bottom, a^1, of *a* is so arranged that a narrow opening, a^2, Figs. 4, 16, 19, 26, 30, exists between the bottom and r^1. This shows if the fuel becomes jammed in the hopper, as in that case the fire would shine through a^2. The instrument, Fig. 17, is to loosen the coal in such cases. The hopper and its slide differ from those in ordinary use in being wider than the fire-bars in the curvature of the lower edge of the slide-plate, and also with respect to the opening a^2 in the bottom part of the hopper.

Fifth, the cinder-conduit.—The space *c* for cinders and other non-combustible matter is seen in Figs. 1, 2, 3, and is formed partly of masonry and partly of the framing of the hearth, and can be closed by a slider, c^1. This slider moves in a frame fixed on the hearth-frame or in the masonry. When the slider c^1 is pulled out by means of the hook, Fig. 18, all the contents of the conduit falls into the ash-pit or into a truck, *k*, Fig. 1, which is drawn out by the same hook. It is well to have the cinder-conduit large, so as not to require frequent emptying.

Figs. 19 to 25 represent part of a grate with the fire-bars resting in such a manner on the frames *m* as to be moved by the bars *o* in an oscillating manner. This movement takes place at intervals by means of the wheel *y*, Figs. 19, 20, into which the cam t^1 works, Figs. 19, 20, 21, the motion being communicated by the arm *t*, the shaft *q*, and the rods *o* to the fire-bars. The shaft *q* acts on the frames *m*. No counterpoise is here required. The motion-rods *o*, Figs. 19, 20, 21, 24, are attached to the shaft *q* and the last grate-bar.

Fig. 36 is a diagram of the upper side of the motion-wheel *y*, Fig. 19. The central line shows the middle position of the fire-bars, the length of the line indicates the time for one rotation of *y*, and the black line the movement of the upper part of the fire-bars during that time, by which it is plain that the bars are at rest during two-thirds of the period. In Fig. 26 the fire-bars *r* are like those in Fig. 19. The motion is transmitted from the crank *q* by the rods *s o*, and on to *r*, the rods being attached to the bars. The motion is continuous, as shown in Fig. 50. The pillars or supports *u* are in this case fixed to the hearth-plate *f*. In order to prevent the fire-bars, Figs. 19, 26, warping, they may be supported in one or more places as well as at the ends. In Fig. 70 they are supported in the center.

In Fig. 30 the fire-bars are formed and supported in the same manner as in Fig. 4, and have a continuous motion given to them by the crank *q*. The counterpoises *v* are shown in red; and in Fig. 34 is the bearing v^1 for the counterpoise and its application. The removal of the fire-bars in Figs. 19, 26, 30 is effected in the same manner as is explained under Figs. 4, 5.

Figs. 37 to 64 represent grates with the whole of the fire-bars moved in mass by belts or by hand.

The bars *r* are fixed to the frames *m* and *n* in such manner that they cannot move independently. In Fig. 37 this arrangement is shown with three fire-bars in section, and Fig. 41 is a view of the same. The bars *m* and *n* are joined together and form a frame for the fire-bars, and the whole is supported beneath by the standards *x*, Figs. 37, 38, 42, and above by

the shaft q by means of the pins m^1, Figs. 37, 38, 39. q and x are fixed at the side at z, Figs. 37, 38, 39, 42. The upper portion of the grate in Figs. 37, 38 consists of plates rather than of bars, no interstices being left; but the lower part consists of bars of the usual form, as in the case of grates in which the whole of the grate moves as one piece. The bars may be of any desired form. The motion of the grate, Fig. 27, is produced by w q^1 y q, and is intermittent, as seen in diagram Fig. 49, in which the black line indicates the movement of the grate, and the length of the line the time for a rotation of the wheel y. The grate remains half the time at rest and half in motion. When it is to be removed it is supported at the upper end while the pins m^1, Figs. 37, 38, 39, are taken out, the wheel y being thus thrown out of gear. The point t^2, Figs. 37, 39, and the cam t^1 are then taken out, the screw l, Figs. 37, 38, loosened, the counterpoises removed, and the shaft q, Figs. 37, 38, 39, detached, when the grate can be drawn forward, the projecting pieces n^1 of the shaft n lying on the guide-rail e^1, Figs. 37, 38, 40.

The fire-bars in Figs. 43 to 48 are supported in the middle as at the ends, and here again is seen the arrangements for preventing their warping. The fire-grate in Figs. 42 and 44 is composed in front of bars, or rather of plates, which overlap the interstices. The last of these stands above the rest, its prolonged part r^2 passing beyond the ash-conduit i, thus preventing the fuel or other matters getting in between. The framing for the bars is supported at its upper and lower ends by the bearers x, Figs. 43, 44, 47, and the sides of these supports are fixed in z, but are easily removed. The grate receives its motion from the crank-shaft q by means of the rods s, and this motion is continuous, as shown in diagram Fig. 50. To remove the grate the pins m^1, Figs. 43, 44, 46, are taken out, the counterpoises withdrawn, and the grate drawn forward, when the upper portion will rest on the bar connecting the bearers x and the lower with the projections n^1, Fig. 44, upon the guide-rail e^1. The upper supports or pillars, x, are then removed and the grate drawn out. The replacement of any of the fire-bars themselves is easily understood without explanation. It will be well to apply counterpoises v in the case of grates in which the whole series of bars moves together. In the case of large heavy grates the bearers may be laid on a frame with wheels, when the whole grate may be drawn forward. A drawing of this is unnecessary, as any competent person can make such a grate with the aid of Figs. 81, 82.

Fig. 51 represents the application and use of the hopper a in connection with a series of fire-bars moving all together, with proper combustion-chamber and parts of motion. The flame and heat produced in such a furnace may be applied to various purposes, such as the warming of buildings or for caloric-engines, the flame being conducted from the furnace into a chamber or pipe. For other purposes the flame and heat may be conducted in the direction of either the black or the red arrows in Fig. 51, or in that of the blue arrows in Fig. 54, it being understood that no air be allowed to enter between the furnace and the apparatus or engine to be heated. The ash-conduit c ends in a closed chest or receptacle, and this chest can be emptied from time to time.

Figs. 55 to 60 represent a part of the grate, Fig. 51, but enlarged four times. The fire-bars in these figures have a different form from those in Fig. 51. (Represented in Fig. 64 four times the size.) These form plates at the upper end, steps in the middle, and bars with interstices at the lower end, being arranged thus for burning very small fuel. The fire-bars are so arranged in a frame, m, that they can expand and contract freely, the lower side of the bars r, Fig. 56, being made, as before described, with that object. The frame m consists of one piece, and is supported upon the grate-bearers x, and these again at the lower end are fixed in z. The grate is moved by the crank-shaft q and the rods s. The bearings u for q are fixed on f, and the movement is by manual power and is limited by the projections u^1 on u, Figs. 55, 56, 57. The grate is supported at the sides by the projections x^1 of the grate-supports x. When the grate has to be removed the pin m^1, Figs. 55, 56, 57, must be taken out and the entire grate drawn forward till x lies close to the projections e^5, Figs. 55, 56, 57. The grate is then raised up in front, the front bearer x removed, and the grate lifted off the back grate-bearer x, the projections e^5 preventing the bearers x falling when the grate is removed.

Fig. 61 represents arched grate-bearers standing on their edges, the grate resting on the rounded portion. Fig. 62 represents grate-bearers rounded above and below; Fig. 63, another kind. They may be made of any convenient form, and where the grate is long it may be supported by several bearers.

Figs. 65 to 80 represent the application and working of a grate for a locomotive-boiler. The fire-bars are here supposed to be arranged as in Fig. 19, and are moved by three rods, o, Figs. 73, 74. The arm t of the shaft q, Figs. 65 and 70, is directed upward and is moved by the connecting-rod t^3, which in its turn is moved by the small piston; but it can also be worked in the usual manner. To remove the grate the arm t of t^3 must be disengaged and the screws l, Figs. 65, 68, 69, relaxed, when the grate can be drawn forward and the projections n^1 on n, Fig. 75, will rest upon the guide-rail e^1, and then the grate is drawn upward from below the boiler. The guide-rail e^1 is fixed on the boiler and prolonged, as seen in Figs. 65, 68. The angle-iron f, Figs. 65 to 69 and 70 to 79, is fixed on the boiler and attaches the side walls of the coal-hopper a to the boiler. In the furnace b this angle or frame piece covers

the sides of the fire-grate and prevents it or any of the separate bars being lifted up. In broad furnaces it would be well to have a water-wall along the middle, and thus to have two narrow grates. The coal-hopper *a* has a partition-wall in the middle, which supports the lower part of the hopper, so that when the hopper is full of coals the bottom of it may not rest on the top fire-bar. The sides of the hopper *a* are fixed partly on the boiler, partly on *f*, and the bottom a^1 can be easily removed. The ash-conduit *c* is closed by the valve c^1, and can be easily removed. The fire-bridge *j*, formed of fire-clay, protects the space *c* from the heat and prevents cold air entering the tubes when the space *c* is open.

Figs. 77, 78, represent a fire-grate which is moved like that in Fig. 26. The movement of *w* may be given by the axle of the machine or of the tender, or by means of a small steam-engine.

Fig. 65 exhibits the application of the grate to locomotives or to similar boilers applied to stationary engines; only, if there be no platform to the boiler, the guide-rails may project horizontally instead of upward, and in this case a fire-grate fixed upon a frame with wheels, as in Fig. 81, is applicable. Grates like those represented in Figs. 4, 16, 37, 43, 55 can also be used in such cases.

Figs. 81 to 90 represent a grate for a marine boiler. The fire-bars are supposed to be formed and fixed as in Fig. 4. The rod *t* of the crank-shaft *q*, Figs. 81, 82, is directed upward and moved by the rod t^3, which may be connected with the engine or any other motor. The fire-bars are placed with the bars *m* upon the frame *e*, but only fixed at the upper end, so as to allow for expansion. The wheels of the frame *e* repose upon guide-rails e^1 fixed on the boiler. The projections n^2 of the bar *n* serve to fix the fire-grate to the frame on the boiler. The same fit into the openings e^3, Figs. 81, 82, 85, 90, and are held fast by the screws *l*. To withdraw the frame with the fire-grate, e^1 is prolonged, the screws *l* are relaxed, and the rod t^3, Figs. 81, 82, disengaged from the arm *t*, whereupon the frame can be drawn forward. The angle-iron *f*, Figs. 81, 82, 83, 87, is fixed along the boiler, and its prolongation serves to fix the sides of the coal-hopper *a*. In the furnace *b* the angle-iron covers the ends of the fire-bars and prevents them from lifting up. The sides of the hopper are fixed partly on the boiler and partly on *f*, and the bottom a^1, Figs. 81, 82, 83, is here arranged so as to be removed with ease. The ash-conduit is closed by a slider or valve, c^1. On this slider being opened by means of the hook, Fig. 18, all that is in the conduit *c* falls into the truck *k*, which runs upon ledges and is easily removed. The bridge *j*, of fire-clay, serves to keep the heat from *c*.

Grates and furnaces like those represented in Figs. 19, 37, 43, 55 may also be applied to marine boilers.

The lighting and management of the furnaces.—The grate must be freed from all ash, &c., with the hook 18 before lighting the fire, the refuse being pushed into the ash-conduit *c*, and afterward removed. The fire-bars are then to be completely covered with fuel, either by means of the hook 18 or by moving the grate to and fro manually. The mass is then to be ignited and the motion continued. Whether the movements are too many or too few, and whether the layer of coal is too thick or too thin for such motion, will be easily seen by the light beneath the fire-bars. If the spaces between the lower fire-bars are not lighted up—that is, not covered with incandescent fuel—then the motion is too great or the layer of coal on the upper bars too thick. If the upper bars are not illuminated, then the motions are too few or the layer of coal too thin, or the coal has become jammed in the hopper *a*, which can be ascertained by looking through the aperture a^2. The motion and the thickness of the layer of coal are both then to be so regulated that all parts of the grate from the top bar to the bottom shall be covered with burning fuel.

With respect to the dimensions of the grates it should be mentioned that they should be as long in proportion to their width as circumstances will permit.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The combination, with the transverse grate-bars *r*, of the rods *m* and *o* and their operating devices, for the purpose of imparting to the grate-bars an oscillating movement independent of their side supporting-rods.

2. The combination of the coal-hopper *a*, inclined furnace-grate *b*, cinder-conduit *c*, and ash-pit, constructed and operated as herein described.

3. The combination, with the transverse grate-bars *r*, of the rods *m* and their operating devices, for the puspose of imparting to the entire grate bodily a backward-and-forward motion, as herein specified.

In testimony that the foregoing is a correct description of my said invention I have hereunto subscribed my name in presence of two witnesses.

JOH. ZEH.

Witnesses:

CHEV. DE SCHWARZ,

A. W. JAPP.