(No Model.) 3 Sheets—Sheet 1.

R. B. CARSLEY & J. H. BETTS.

FURNACE FOR STEAM GENERATORS, &c.

No. 540,718. Patented June 11, 1895.

FIG: 1.

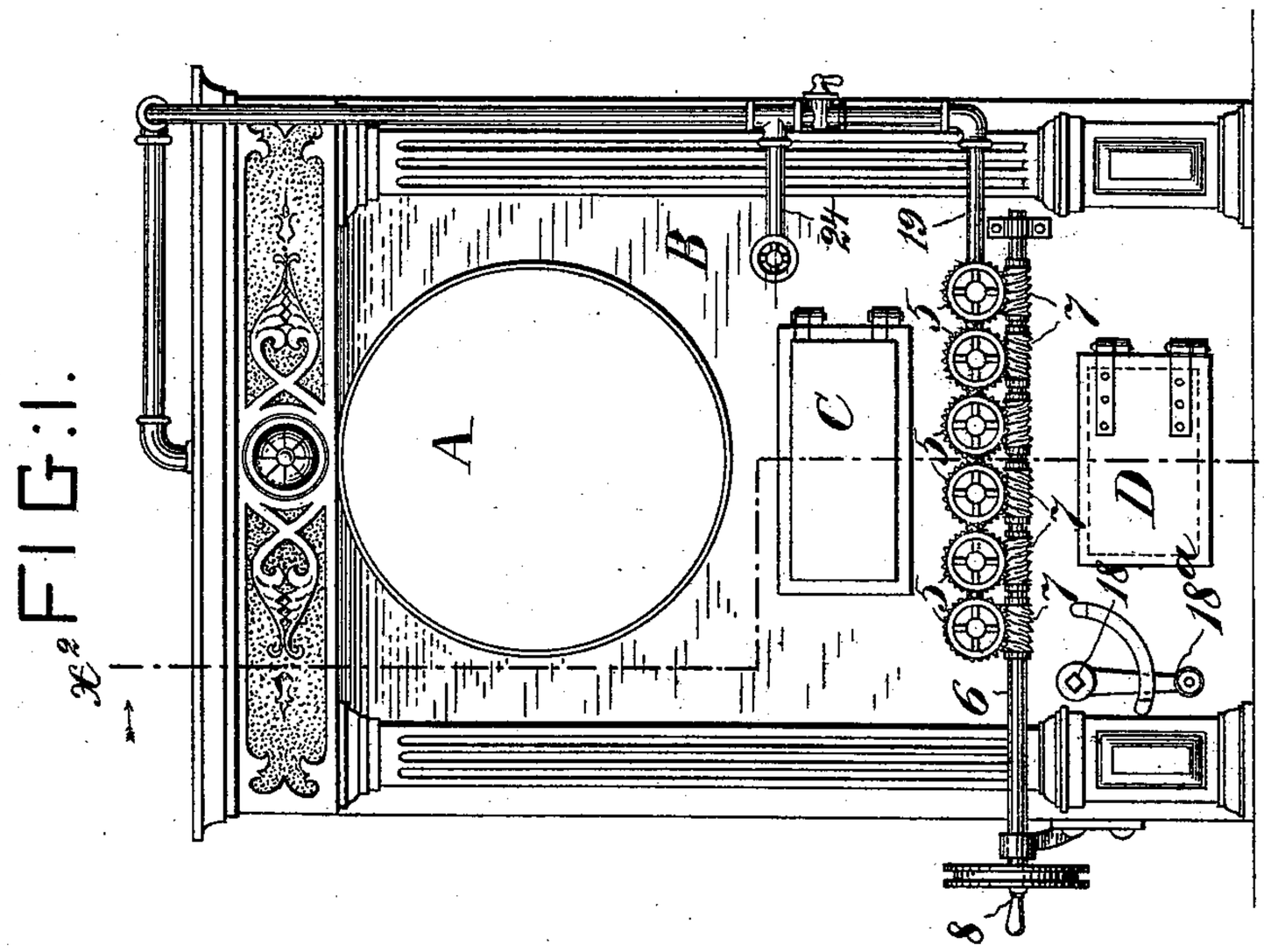

FIG: 2.

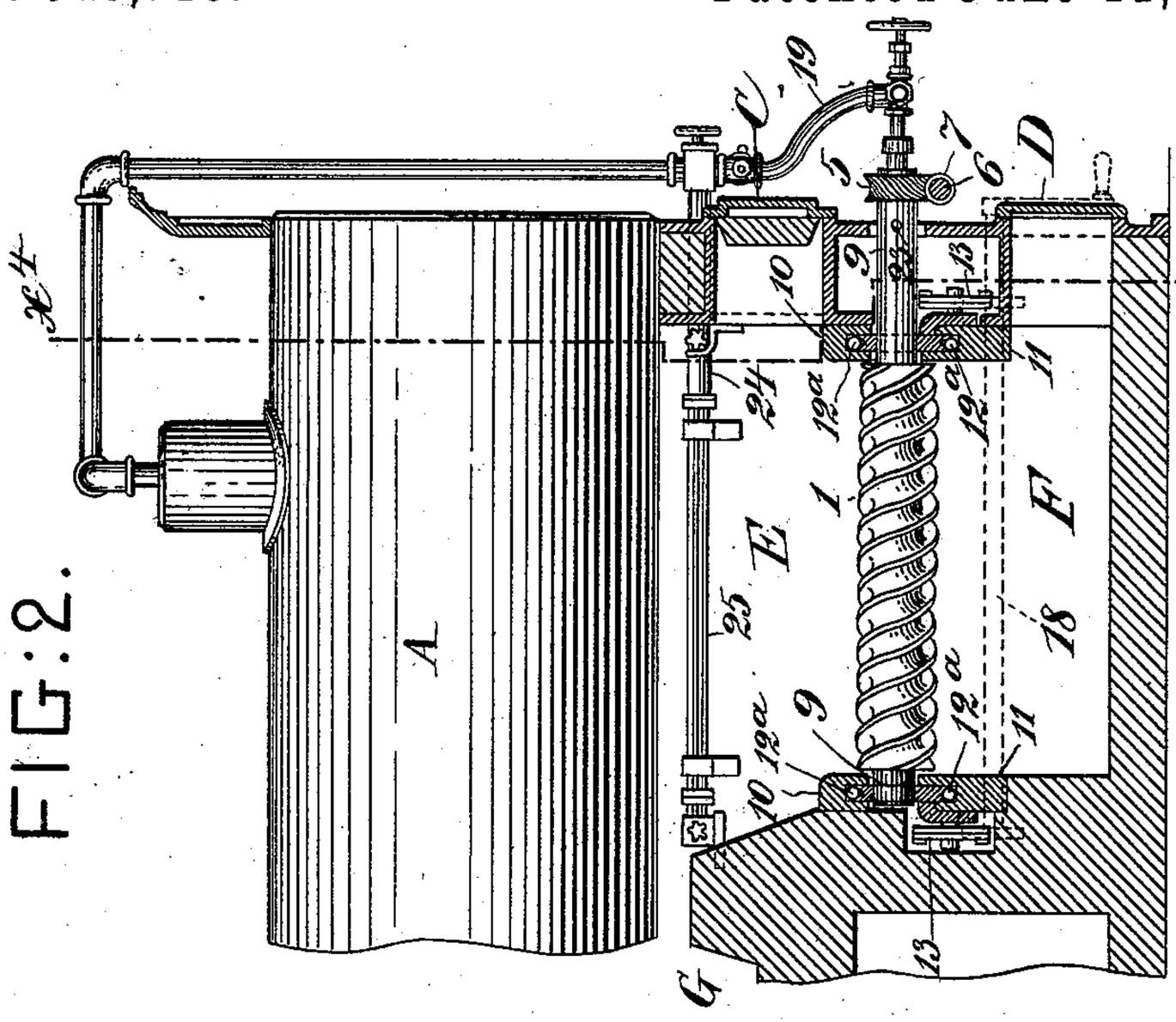

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FIG: 4.

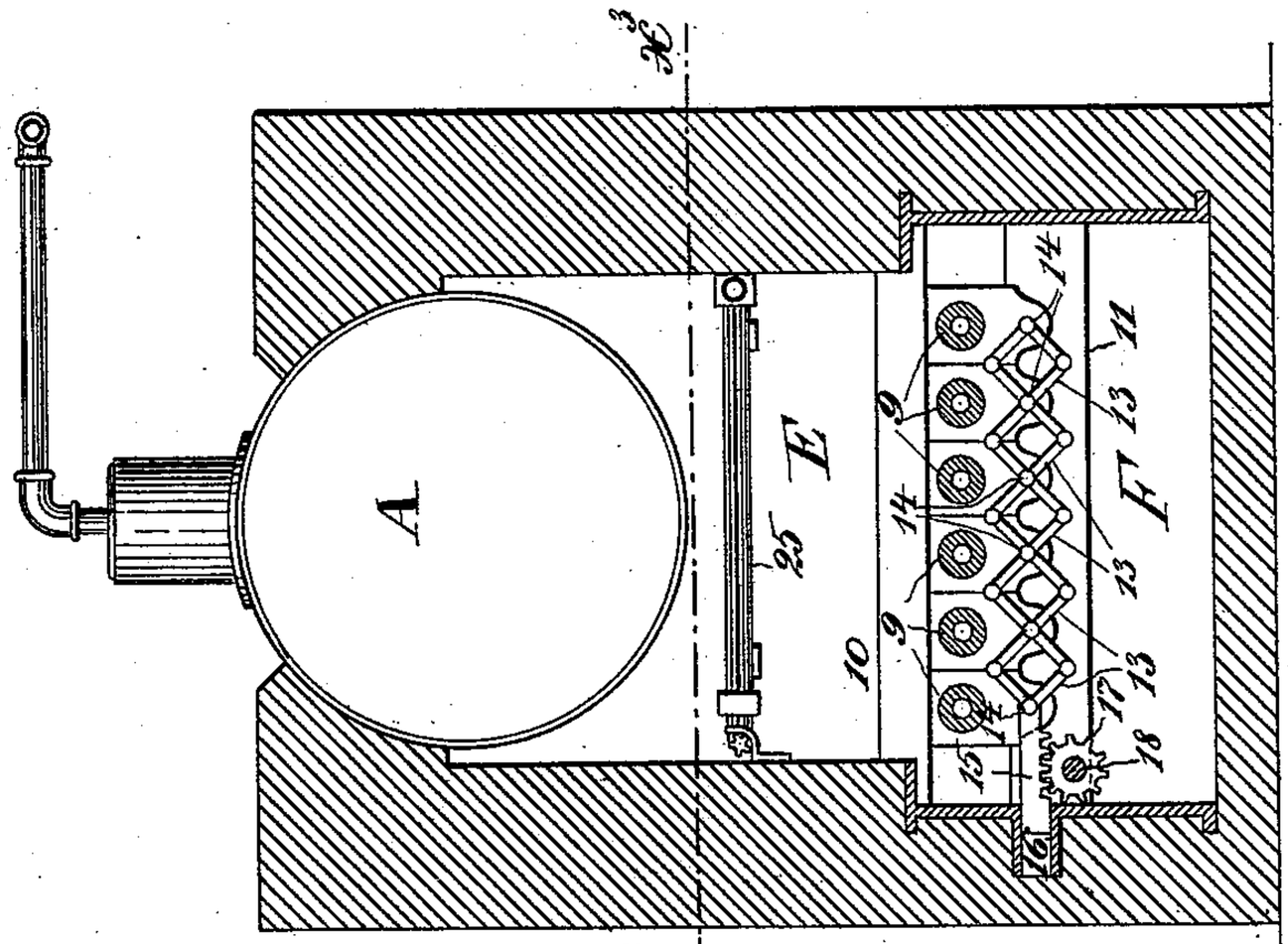
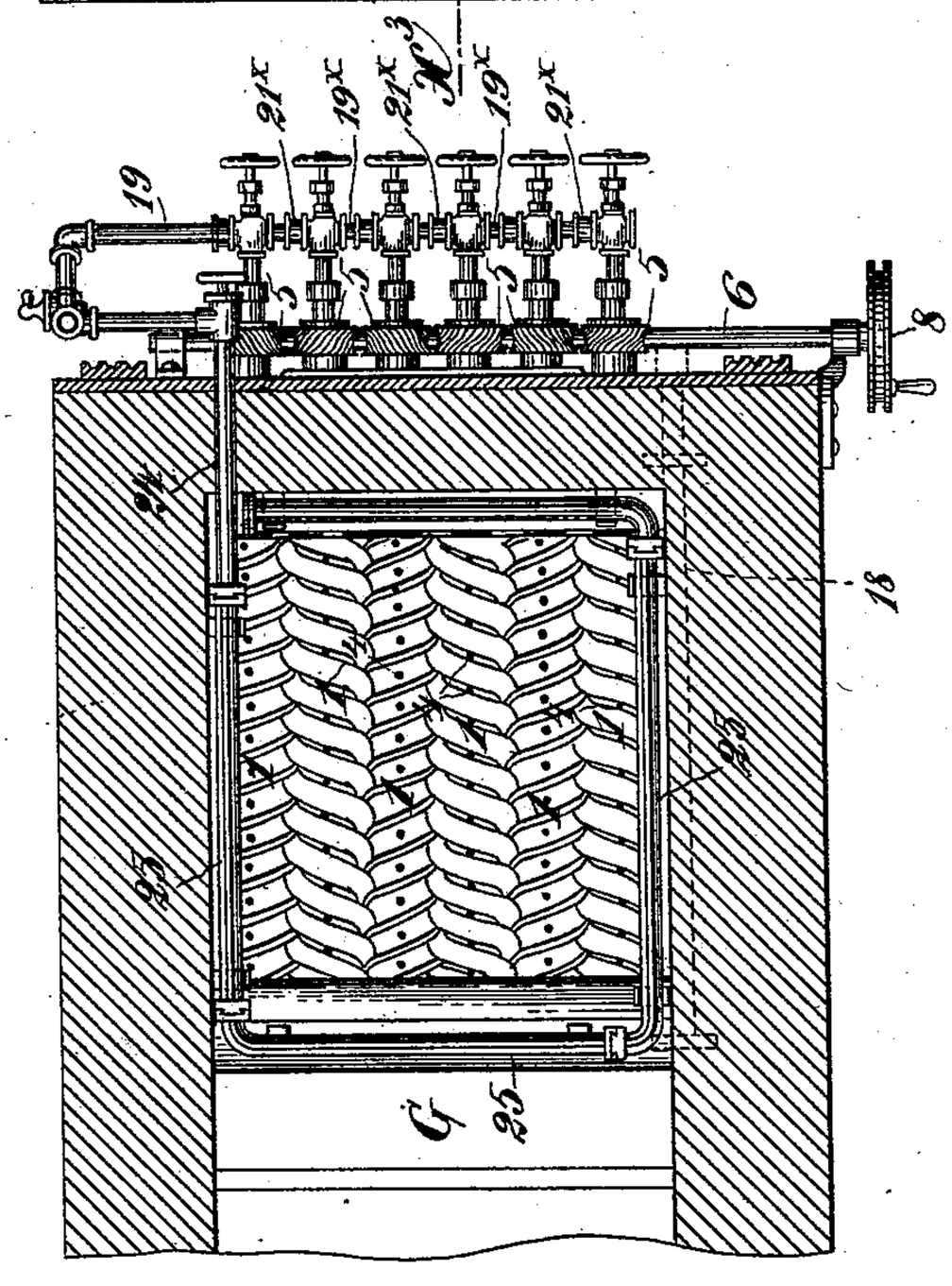


FIG: 3.



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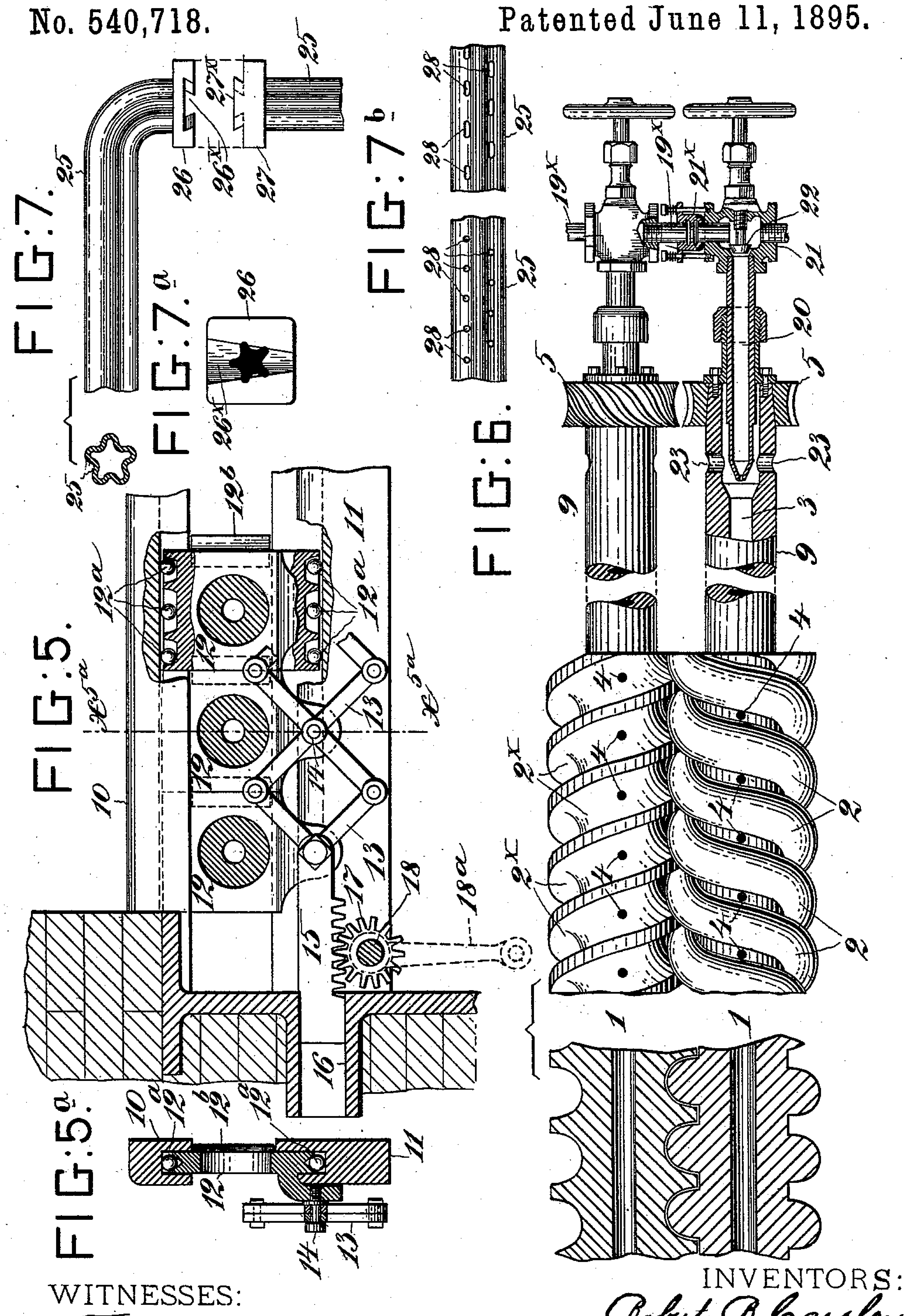

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UNITED STATES PATENT OFFICE.

ROBERT B. CARSLEY AND JOHN H. BETTS, OF KEYPORT, NEW JERSEY.

FURNACE FOR STEAM-GENERATORS, &c.

SPECIFICATION forming part of Letters Patent No. 540,718, dated June 11, 1895.

Application filed February 9, 1895. Serial No. 537,732. (No model.)

To all whom it may concern:

Be it known that we, ROBERT B. CARSLEY and JOHN H. BETTS, citizens of the United States, and residents of Keyport, Monmouth county, New Jersey, have invented certain new and useful Improvements in Furnaces for Steam-Generators and other Purposes, of which the following is a specification.

Our invention relates broadly to furnaces, but particularly to boiler-furnaces, and we have illustrated it herein as embodied in a boiler-furnace.

The object of the invention is to promote perfect combustion in the fire-box of the furnace and thereby effect an important economy in fuel as well as, incidentally, to prevent the generation of free carbon in the form of smoke. These results we attain partly by an accelerated forced draft, partly by the introduction into the furnace at the proper points, of steam in the form of a permanent gas at a relatively high temperature, whereby an incandescent heat is obtained through the combustion of hydrogen gas, and partly by a peculiar construction of the fire-bed, all as will be hereinafter described.

In the accompanying drawings, which illustrate an embodiment of our invention, Figure 1 is a front elevation of the furnace as applied to heating a steam-generator. Fig. 2 is a vertical longitudinal section of the same, taken in the plane indicated by line $x^2\,x^2$ in Fig. 1. Fig. 3 is a horizontal section taken in the plane indicated by line $x^3\,x^3$ in Fig. 4. Fig. 4 is a vertical transverse section on line $x^4\,x^4$ in Fig. 2. Fig. 5 is an enlarged detail view illustrating the mechanism for shifting the rotating grate-bars laterally, and Fig. 5^a is a cross-section of same on line $x^{5a}\,x^{5a}$ in Fig. 5. Fig. 6 is an enlarged detail plan view of two of the grate-bars and their appurtenances. Figs. 7, 7^a, and 7^b are views illustrating in detail the construction of the appliances for supplying the combustion-chamber with superheated steam in the form of a permanent gas.

We will designate in the drawings the steam-generator and the ordinary parts of the furnace connected therewith by reference-letters and the parts of the furnace which embody our invention by reference-numerals.

A is an ordinary steam-boiler; B, the furnace-front, provided with a charging door or doors, C, and ash-door, D. E is the combustion chamber above the fire-bed. F is the ash-box below the fire-bed, and G is the bridge-wall at the back or rear of the fire-bed. All of the above parts are, or may be those common to boilers and boiler-furnaces.

Our purpose is, in general, to produce a furnace having a fire-bed made up wholly of rotary, interlocking, hollow bars, adapted to receive steam and air and to deliver it in jets to the fuel resting on the bars, thereby producing what we call a cyclone draft. These bars are mounted at their ends in sliding blocks, and these blocks are mounted in cross-bearers or tracks and coupled by levers arranged as "lazy-tongs" so that, by the rotation or rocking of a shaft geared to said tongs the bars may be shifted laterally so as to set them closely together or separate them more or less. Above the level of the fire-bed, and within the combustion chamber of the furnace, we arrange a steam-superheating device consisting of a pipe which enters the combustion chamber and passes around the same near the walls, one cross-branch thereof being parallel and adjacent to the bridge-wall, and another across the front above the charging door C. This latter branch has jet-apertures from which the gaseous steam is thrown out over the fuel in the fire-bed. In such a furnace we may and do burn slack or culm from bituminous coal without the generation of smoke, and we produce with it, as well as with other carbonaceous fuels, incandescent, gaseous ignition throughout the combustion chamber, with full and complete gaseous combustion. This combustion we conceive to be due to the decomposition of the gaseous steam introduced in part through the grate-bars and up through the bed of incandescent carbonaceous matter thereon, in part to the peculiar gyratory forced draft which brings the gases forming the draft into contact with all parts of the bed of incandescent fuel, and in part to the decomposition of the gaseous steam introduced above the fire-bed, the elements of which combine above the carbonaceous fuel to produce an incandescent heat due, as we believe, principally to the large volume of hydrogen developed from the steam.

The fire-bed or grate is made up wholly of rotatively mounted grate-bars, 1, arranged

side-by-side and extending from front to rear. Fig. 3 shows the set of bars on a rather small scale but in Fig. 6, two adjacent bars are shown on a larger scale, and this view is referred to for details.

Each bar 1 has somewhat the appearance, externally, of a four-threaded screw; that is, it has four spirally arranged flanges, which are separated by grooves. The spirals of adjacent bars are oppositely inclined, one being like a right-hand screw and the other like a left-hand screw; and there is another difference. The spiral flanges, 2, of one bar are rounded or convex as seen in cross-section, while the adjacent bar has concave interspaces, $2^{\times}$, between its thinner flanges. In other respects than this the bars are alike.

Each bar is hollow, or has in it a bore or passage, 3, which extends nearly through it, and from this bore jet-passages, 4, extend out through the shell of the bar, opening in the grooves or interspaces between the spiral flanges, at the upper sides of the bars.

On the outer end of each bar is fixed a worm-wheel, 5, and on a cross-shaft, 6, (Figs. 1, 2 and 3) exterior to the furnace at the front, are worms or screws, 7, which gear with the respective worm-wheel 5, whereby, when the shaft 6 is rotated the bars 1 will be rotated. It is not contemplated that, under ordinary circumstances, the bars will be actually rotated, or turned round and round in one direction, but they may be, if such rotation is required. Ordinarily they will be rocked to and fro through a part of a revolution, and left, when at rest, with the jet-apertures 4 uppermost. The shaft 6 will be provided with a crank or pulley, 8, for turning it.

Each grate-bar has a journal, 9, at each end, and these journals are mounted in bearing-blocks mounted in tracks or ways, as will be described with especial reference to Figs. 4, 5 and 5^{a}. As the construction is the same at both ends of the bars we will describe only that at the front end, which is fully illustrated.

Extending across the furnace are two grooved tracks, 10 and 11, the former above the latter (Fig. 5^{a},) and in the grooves in these tracks are mounted like bearing-blocks, 12, one for each grate-bar. The journals on the bars find bearings in the blocks 12, which are connected together by "lazy-tongs" levers, 13. At their crossing points, 14, the levers are pivotally attached to pendent lips on the respective blocks, as seen in Figs. 5 and 5^{a}, and in order to move the grate-bars laterally, a rack-bar, 15, is coupled to the end of the lazy-tongs and mounted in a guide, 16, in the furnace-wall. A pinion, 17, on a shaft, 18, gears with the rack-bar, and on the outer end of this shaft is a handle or crank, 18^{a}, by which the shaft and pinion may be turned. By means of this device the grate-bars may be moved apart to a limited extent, and spaced as desired, for the purpose of clearing the grate of ashes and clinkers and for adapting it to different kinds or grades of fuel.

As before stated, the grate-bars are furnished with the same appliances at their rear or inner ends as at their front or outer ends, and the shaft 18 extends back to the rear ends of the bars and has a pinion at that end like the pinion 17. This shaft 18 is indicated in dotted lines in Figs. 2 and 3.

In order to lessen the friction which tends to resist the movements of the bearing-blocks 12, in the grooves in the tracks 10 and 11, we prefer to provide balls, 12^{a}, interposed between the blocks and tracks, as seen in Figs. 5 and 5^{a}, the blocks and tracks being broken away in Fig. 5 to disclose the construction. The balls are arranged in pockets in the upper and lower ends of the block in order to prevent them from bunching.

To prevent openings being produced between adjacent blocks when they are moved apart, each bearing-block 12 is provided at one side with a lapping piece, 12^{b}, which takes over the adjacent block and enables the blocks to separate to a sufficient extent without producing an opening.

The devices for admitting steam and air to the grate-bars and furnishing a forced draft, is best illustrated in Fig. 6. A steam-pipe, 19, (Fig. 1) supplies steam to the grate-bars from any source. In the outer end of each grate-bar 1, is inserted a steam-jet nozzle, 20, about which the bar turns or rocks. This nozzle is fixed at its outer end in a valve-casing, 21, provided with a valve, 22, furnished with a screw-stem and hand-wheel to enable the steam to be admitted separately to each grate-bar. The valve-casings 21 are coupled together by steam-pipes, $19^{\times}$, which form continuations of the steam-pipe 19, as clearly shown in Fig. 3. The pipe 19 supplies steam to the first valve-casing of the series, and the steam flows successively through the pipes $19^{\times}$ to all of the other casings. In order to allow the grate-bars to be moved laterally by means of the lazy-tongs 13, as already explained, without interference from the steam pipe connections, the connecting steam-pipes, $19^{\times}$, are each screwed or otherwise fixed in one valve-casing (see Fig. 6) and plays through a gland or stuffing-box, $21^{\times}$, on the adjacent valve-casing. The steam-pipe 19 has a like sliding connection with the valve-casing to which it is coupled.

When steam is admitted to the grate-bar through the jet-nozzle 20, it acts as an injector to take in air through an inlet or inlets, 23, in the journal 9 of the bar, and this air, mingled with the steam from the jet, serves to keep the bars cool, or below an injurious temperature, to supply an abundance of combustible gas to the furnace, and to provide a forced draft.

We will now describe the means for introducing steam in a gaseous condition to the combustion chamber above the fire-bed, referring especially to Figs. 2, 3, 4, 7, 7^{a} and 7^{b} for illustration.

A steam-pipe, 24, supplied from any source,

enters the combustion chamber E at the front thereof, and connects with a superheating pipe, 25, which extends along one side of the furnace back to the bridge-wall G, thence across the chamber and along the other side wall thereof to the front wall and thence across the chamber along the front wall to near the point where the pipe 24 enters, where its end is stopped or closed. This pipe 25 being subject to deterioration from heat and oxidizing influences, we prefer to construct it as will be explained with special reference to Figs. 7 and 7ª, which are detail views on a larger scale than the principal views. The pipe will be cast from gun metal, or some like alloy, by preference, as iron or steel will oxidize too readily when subjected to the combined influences of heat and oxygen. The pipe will be, by preference, corrugated longitudinally—as seen in the cross-section at the left in Fig. 7—in order to facilitate lateral expansion and contraction under the influences of pressure and the changes of temperature. In order to facilitate the renewal of the pipe, or of parts thereof, and especially to facilitate such renewal without the necessity of awaiting the complete cooling off of the furnace, the pipe is made in sections, as clearly shown in Fig. 3, with simple interlocking couplings. This coupling is clearly illustrated in Fig. 7, and in Fig. 7ª is seen a face view of the female element of the coupling. The female element, 26, has formed in its face a tapered, dovetail slot, 26×, and the male element, 27, has formed on its face a tapered, dovetail tongue, 27×, adapted to drop into and fit the slot in the other element. This simple coupling will enable a section of the pipe 25 to be quickly removed and replaced.

The steam admitted to the pipe 25 is subjected to intense heat at the bridge-wall and is converted into a highly expanded gas, and this gas is emitted in jets from apertures in the branch of the pipe which crosses the combustion chamber at the front. Fig. 7ᵇ represents parts of this branch of the pipe 25, and illustrates two forms of jet-apertures, 28. The part at the left in the figure shows circular jet-apertures and the part at the right shows laterally enlongated apertures or slits. Either of these forms may be employed or both may be employed together. The purpose is to jet the gaseous steam in regulated quantity and with proper regard to distribution out rearwardly into the combustion chamber over the incandescent bed of fuel, in order that it may mingle and combine with the hot combustible gases arising from the fire-bed and produce gaseous incandescence. This it does and in so doing compels the combination of all the free carbon from the fuel, thus eliminating the element of smoke and reducing the products of combustion substantially to carbon dioxide and nitrogen.

The section or branch of the pipe 25 which crosses the combustion chamber adjacent to the bridge-wall, may be arranged higher or lower, as the circumstances or the character of the furnace may dictate. We have shown it arranged at about the level of the top of the bridge-wall where it will receive the full force or effect of the heat at this point; but it may be best in some cases to protect it somewhat, or place it in a less exposed situation. We do not limit ourselves in this respect.

We are well aware that, broadly speaking, it is not new to employ screw-like, rotating bars in grates, and that it is not new to rotate such bars with screw gearing similar to that herein shown. We are also aware that, broadly speaking, it is not new to admit steam to a furnace through the hollows in the bars of grates. These features we do not broadly claim as our invention.

One of the distinctive features of our invention is the formation of the entire fire-bed or grate surface of right and left spirally flanged bars, with means for rotating adjacent bars simultaneously in opposite directions; and another feature is the admission of steam and air to such bars independently in order to equalize or vary the combustion at different points in the grate-surface. The introduction of steam, or steam and air, into the furnace through jet-apertures arranged in the interspaces between the spiral flanges of the bars, taken in connection with the peculiar contorted passages between the interlocking spiral flanges of adjacent bars through which air is drawn from the ash-box by the forced draft, produces a peculiar and effective draft which we call a cyclone or gyratory draft, and this we find especially important in effecting a thorough combination of the combustible elements.

The employment of the rounded or convex flanges 2, fitting into the concave interspaces 2× on the adjacent bars, enables the bars to be fitted close together so that the finest dust-like fuel may be burned with the forced draft alone, at the first, the bars being afterward gradually separated for the passage of air between them. If the fire burns unevenly, the forced draft may be turned on full at any of the bars and reduced at others. This ability to regulate the draft at any desired point in the width of the fire-bed is provided by the independent admission of steam to the respective bars. Cocks are provided in the pipes 19 and 24, as shown in the drawings, to regulate the supply of steam, which, as herein shown, is supplied by the boiler A.

We are well aware that it is not new, broadly, to introduce steam to a furnace through hollow grate-bars, and that it is not new, broadly, to provide rocking grate-bars with interlocking flanges and with spiral flanges. All of these features are old in themselves and we do not claim them. We are also aware that steam jets have been employed for introducing air into furnaces both above and below the grate and this we do not claim. We util-

ize these features in new combinations whereby we attain what we believe to be new and improved results.

Having thus described our invention, we claim—

1. A furnace-grate or fire-bed having its fuel-supporting surface composed wholly of rotatively mounted grate-bars having right and left-hand intermeshing spiral flanges, those having right-hand spiral flanges alternating in position with those having left-hand spiral flanges, and connecting gearing for simultaneously rotating all of the bars, those with left-hand spiral flanges in one direction and the others in the opposite direction, substantially as set forth.

2. A furnace-grate or fire-bed having its fuel-supporting surface composed of rotatively mounted grate-bars having right and left-hand interlocking spiral flanges, the spiral flange 2, on one bar being convex or rounded and the interspace $2^{\times}$ on the adjacent bar being concave to receive the flange 2, and having means for simultaneously rotating adjacent bars in opposite directions, substantially as set forth.

3. A furnace-grate or fire-bed having its fuel-supporting surface composed wholly of rotatively mounted hollow grate-bars furnished with right and left-hand interlocking spiral flanges, and jet-apertures in the hollows between said flanges, means for rotating said bars simultaneously, adjacent bars in opposite directions, as described, and means for admitting steam to the fuel through said bars, substantially as set forth.

4. A furnace-grate or fire-bed having its fuel-supporting surface composed of rotatively mounted grate-bars having right and left-handed interlocking spiral flanges, means for simultaneously rotating said bars, those adjacent in opposite directions, and means, substantially as described for simultaneously shifting said bars laterally for varying the spacing between adjacent bars, substantially as set forth.

5. In a furnace, the combination with the bearing-blocks 12, and the transverse supporting tracks in which they are mounted, of the rotary grate-bars, the journals of which have bearings in said blocks, the lazy-tongs 13, connecting said bearing-blocks, and means for operating said lazy-tongs, substantially as set forth.

6. The combination with the transverse tracks, 10 and 11, the bearing-blocks 12, mounted therein, the lazy-tongs 13, connecting said blocks, the rack-bar 15, coupled to said lazy-tongs, the shaft and pinion for operating said rack-bar, and the guide for the latter, of the rotatively mounted, spirally-flanged grate-bars journaled in the respective bearing-blocks, substantially as set forth.

7. The combination with the grooved transverse tracks, 10 and 11, arranged one above the other, the bearing-blocks 12, mounted in said tracks and provided with lapping pieces 12^{b}, and the balls 12^{a}, interposed between the bearing blocks and tracks, of the lazy-tongs 13, connecting together the bearing-blocks, the guided rack-bar 15, coupled to the lazy-tongs, the pinion 17, gearing with said rack-bar, the shaft of said pinion, and the spirally flanged grate-bars, rotatively mounted in the respective bearing-blocks, substantially as set forth.

8. In a furnace, the combination with the rotatively mounted, hollow grate-bars 1, having lateral air-inlets 23, of the steam-jet nozzles 20, mounted in the ends of the respective bars, the valve-casings 21, connected with the outer ends of the respective nozzles 20, the valves 22, in the casings, adapted to control the admission of steam to the nozzle from the casing, a steam supply-pipe connected with one of the valve-casings of the series, and pipes connecting the several casings, whereby the steam may flow through the latter, substantially as set forth.

9. In a furnace, the combination with the spirally flanged hollow, grate-bars, means for rotating or rocking said bars, and means for shifting said bars laterally to vary the interspacing, of the steam-jet nozzles 20, mounted in the outer ends of the respective grate-bars, the valve-casings 21, connected with the respective nozzles 20, and the steam-pipes $19^{\times}$, connecting the adjacent valve-casings, each of said steam-pipes extending through and being adapted to play in a gland in one of said valve-casings in order to accommodate the steam-connections to the lateral shifting of the grate-bars, substantially as set forth.

10. In a furnace, the combination with the fuel-supporting grate, the bridge-wall, and a steam-supply pipe 24, of the sectional superheating pipe, 25, composed of sections provided with interlocking, tapered dovetail couplings, substantially as described, whereby the pipe may be replaced in sections without cooling the furnace, substantially as set forth.

11. In a furnace, the combination with the bridge-wall at the back of the combustion-chamber and the grate for supporting the fuel, a steam generator, and a steam-supply pipe 24, connected therewith, of a sectional pipe 25, extending around the four walls of the furnace, one transverse branch being adjacent to the bridge-wall and the terminal transverse branch, which crosses the combustion-chamber at the front, provided with jet-apertures, the pipe 24 being connected with and adapted to supply steam only to the pipe 25, substantially as set forth.

12. A furnace-grate or fire-bed having its entire fuel-bearing surface composed of rotatively mounted grate-bars having right and left-hand interlocking or intermeshing spiral flanges, and having means for simultaneously rotating or rocking all of said bars, and means for shifting said bars laterally, substantially as set forth.

13. A furnace having its entire fuel-bearing surface composed of rotatively mounted

hollow grate-bars, provided with right and left-hand intermeshing spiral flanges, alternating bars having rounded flanges 2, which engage with concave interspaces $2^{\times}$ between the flanges on the other bars, said furnace having means for introducing steam and air to the fuel through said bars, means for rocking said bars, and means for separating said bars laterally, substantially as set forth.

In witness whereof we have hereunto signed our names in the presence of two subscribing witnesses.

ROBERT B. CARSLEY.
JOHN H. BETTS.

Witnesses:
PETER A. ROSS,
HENRY CONNETT.