No. 673,434. Patented May 7, 1901.

J. W. HORNSEY, W. E. ELLENBERGER & S. M. DUTY

HOT AIR FURNACE.

(Application filed Nov. 8, 1899. Renewed Oct. 5, 1900.)

(No Model.) 9 Sheets—Sheet 1.

Fig. 1.

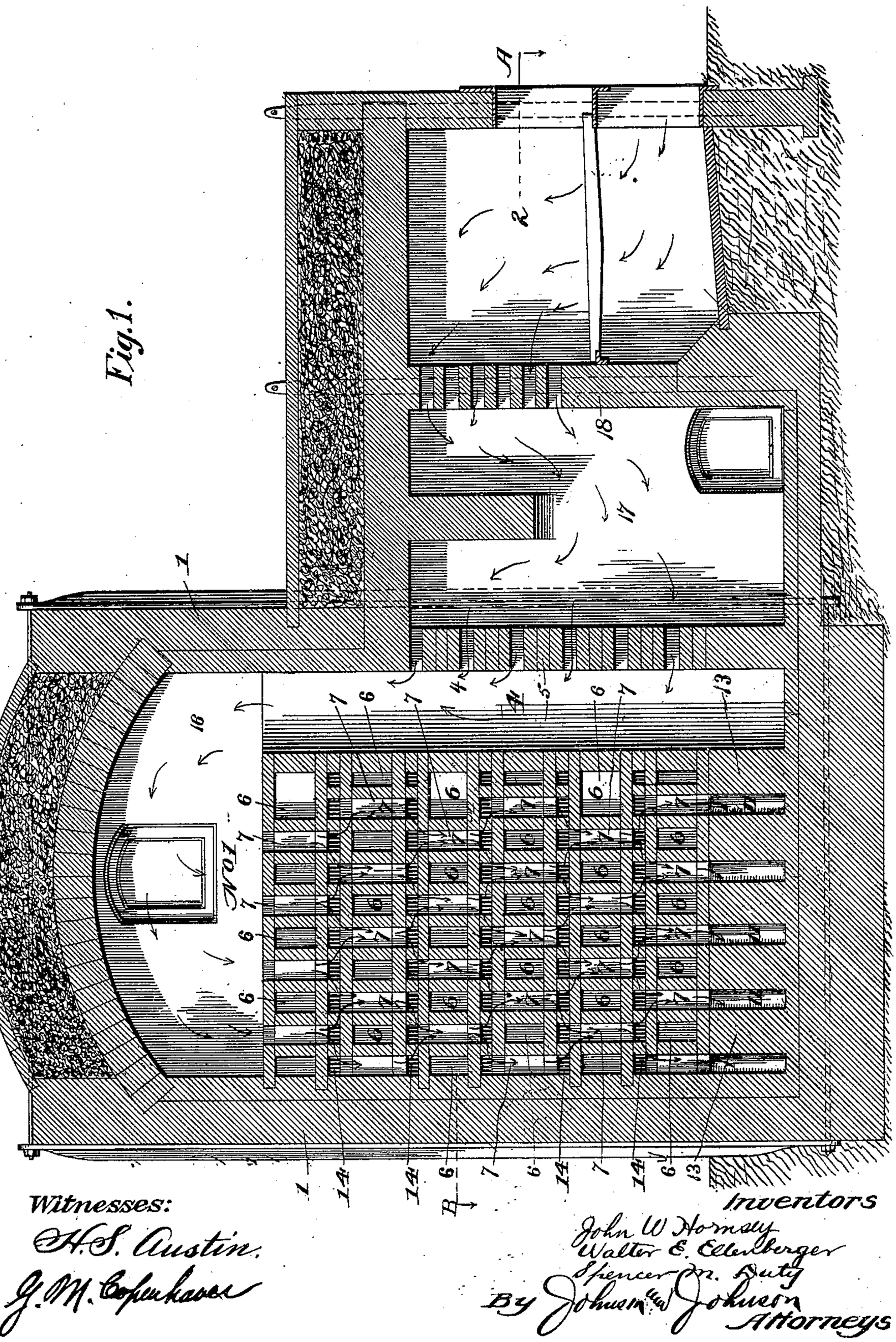

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Fig. 12.

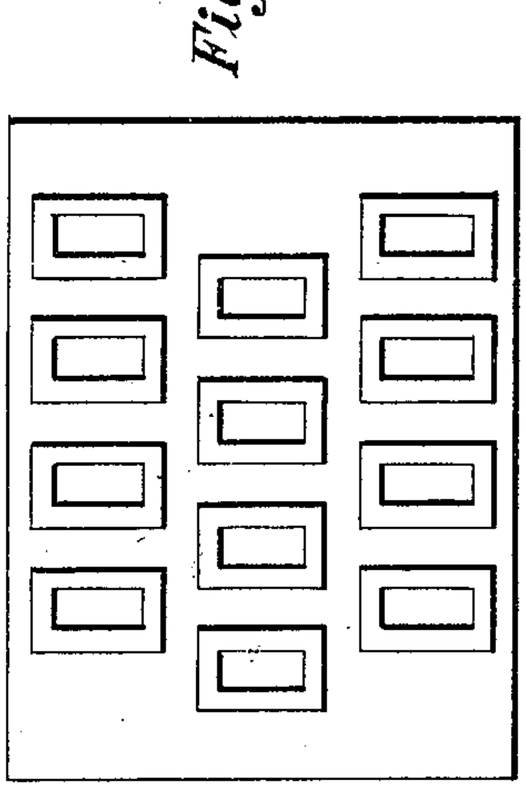

Fig. 13.

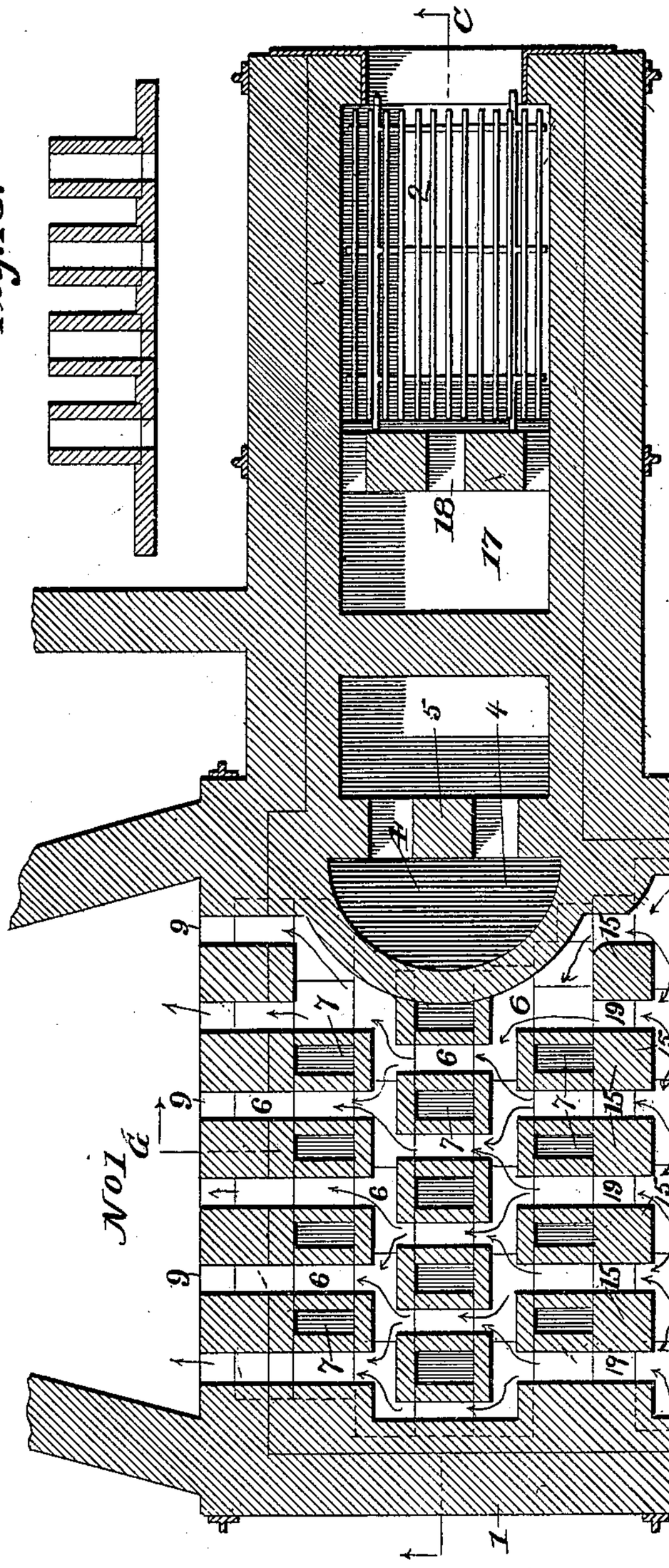

Fig. 2.

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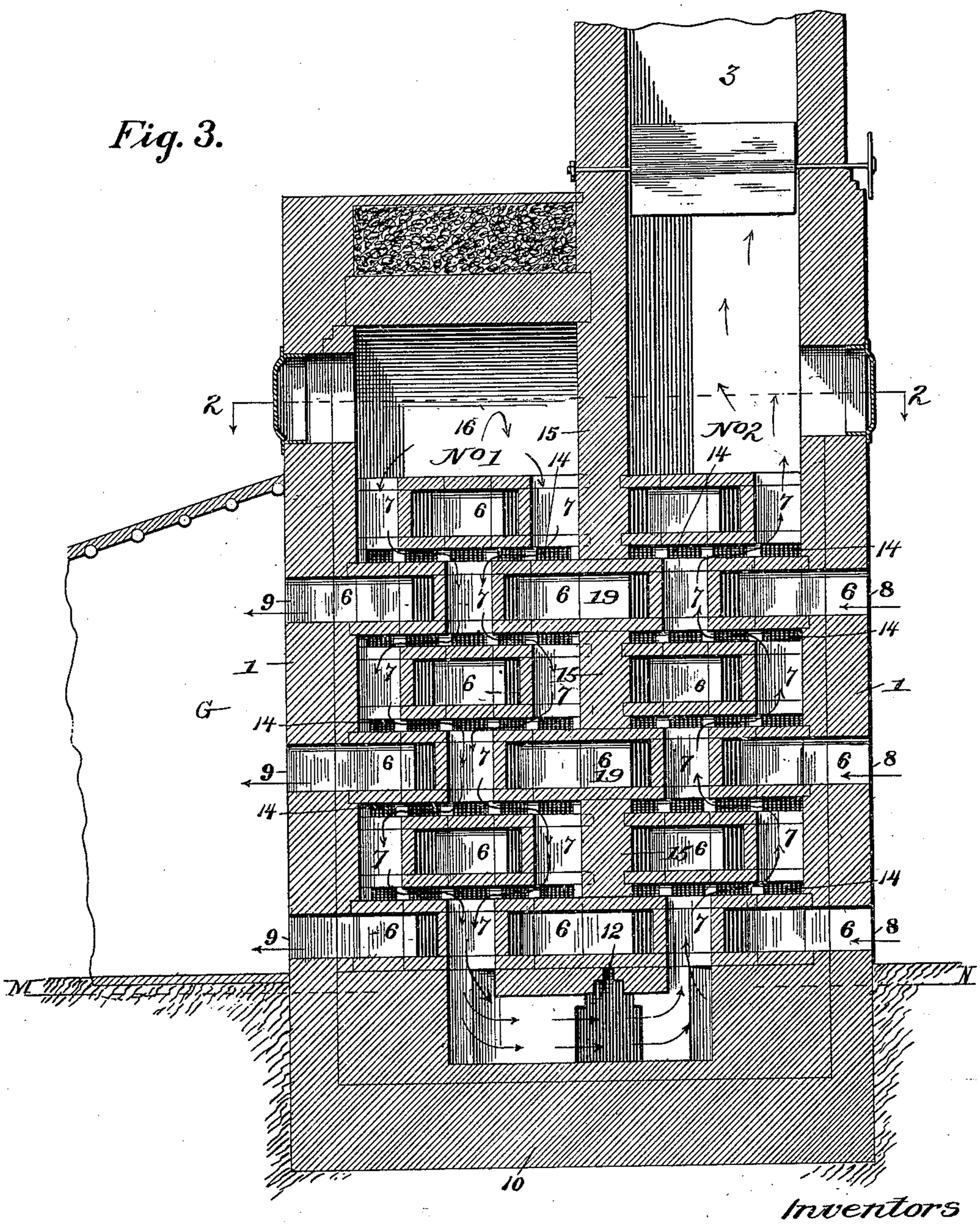
Fig. 3.



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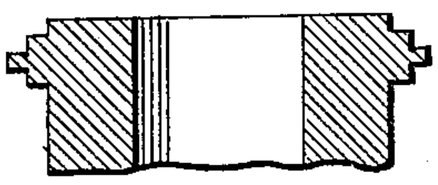

Fig. 4.

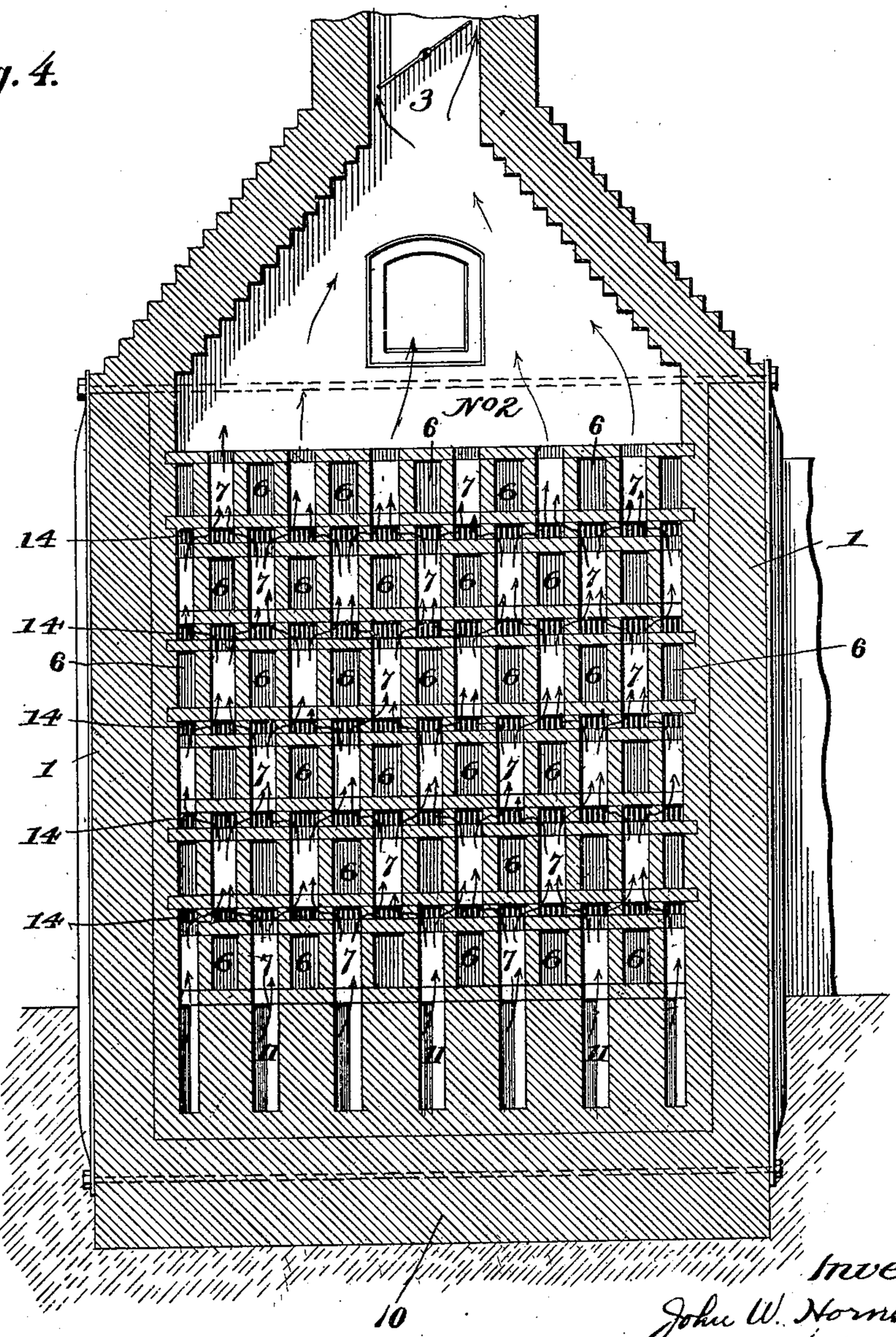

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Fig. 5.

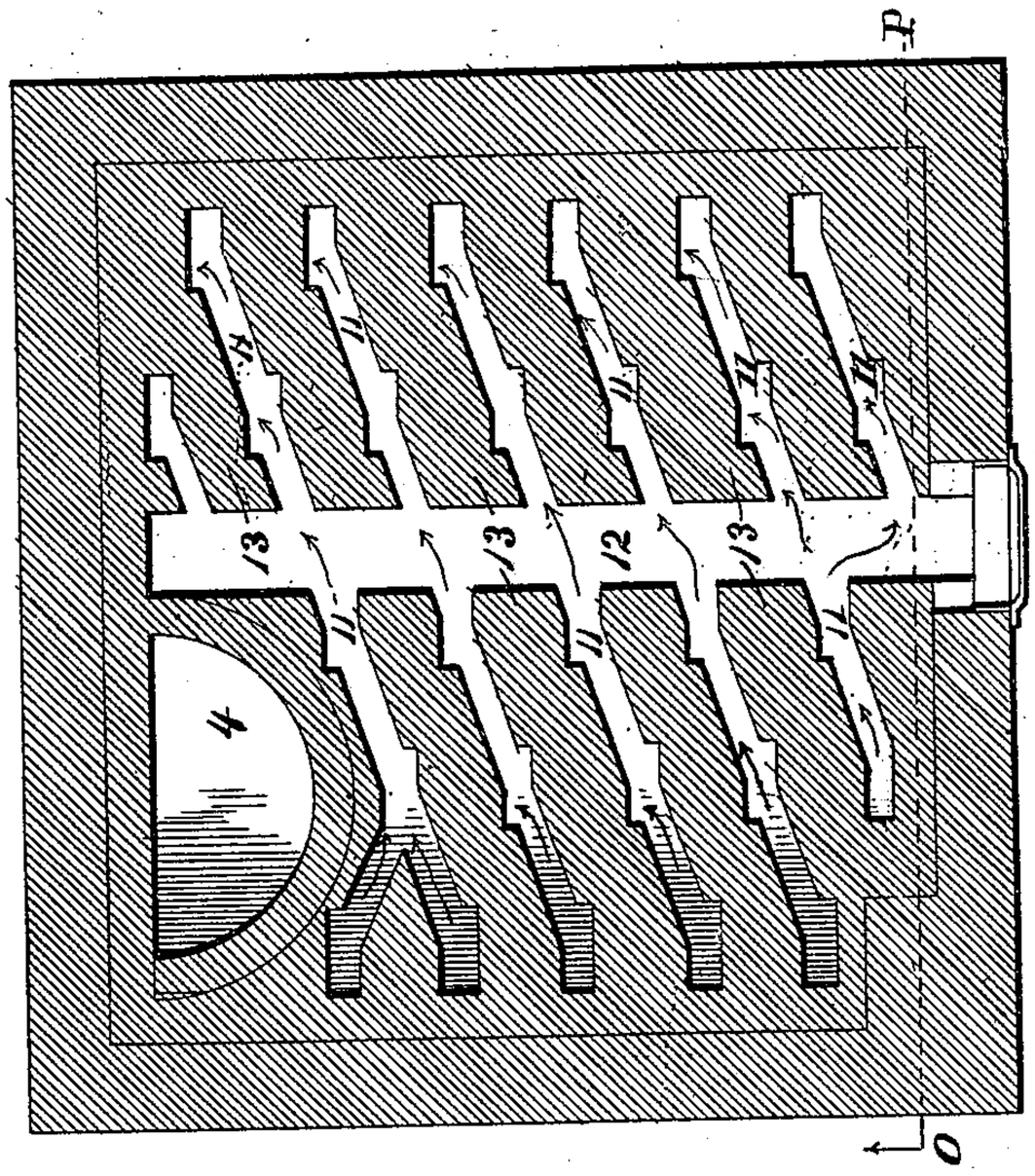

Fig. 6.

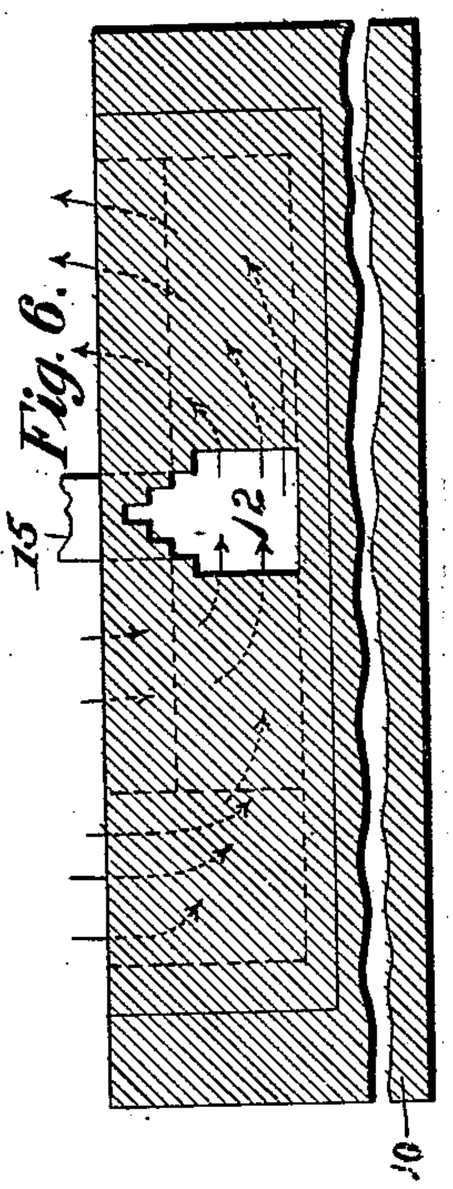

Fig. 7.

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(No Model.) 9 Sheets—Sheet 6

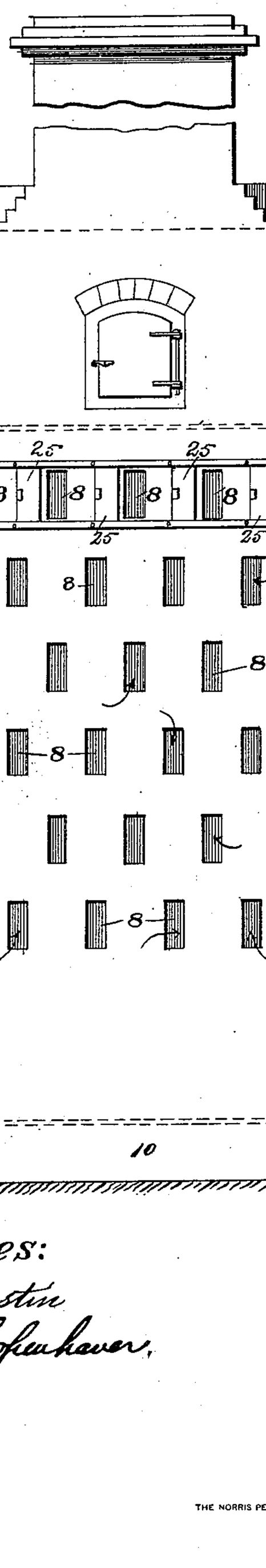

Fig. 8.

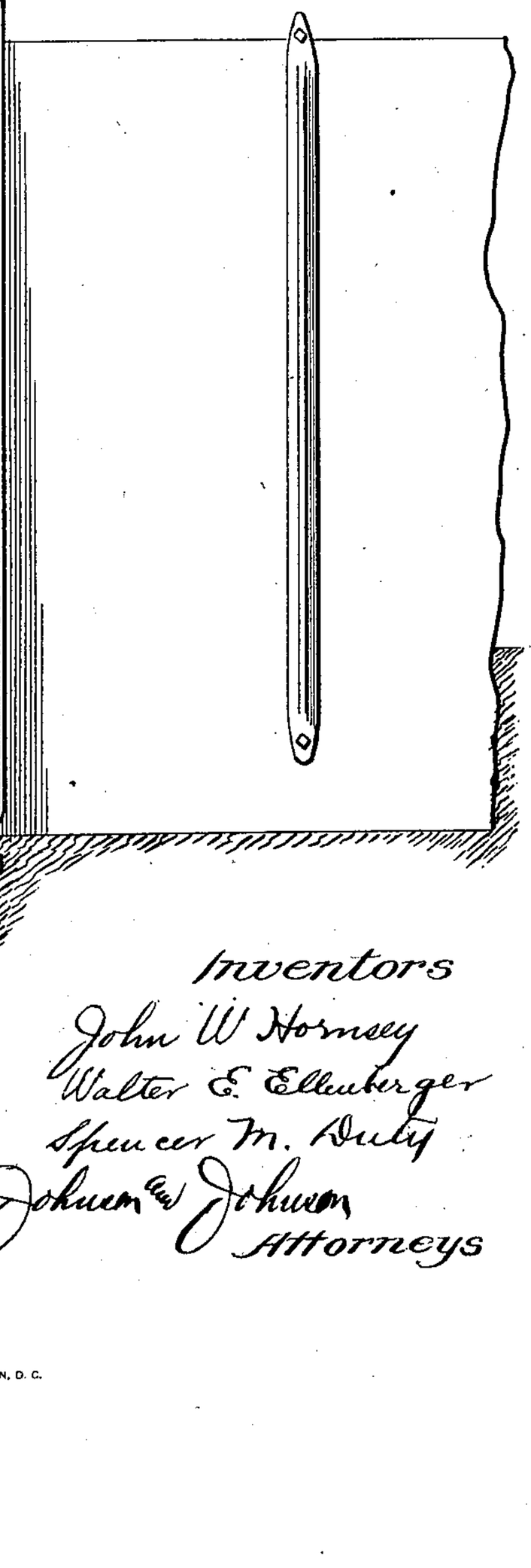

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Fig. 9.

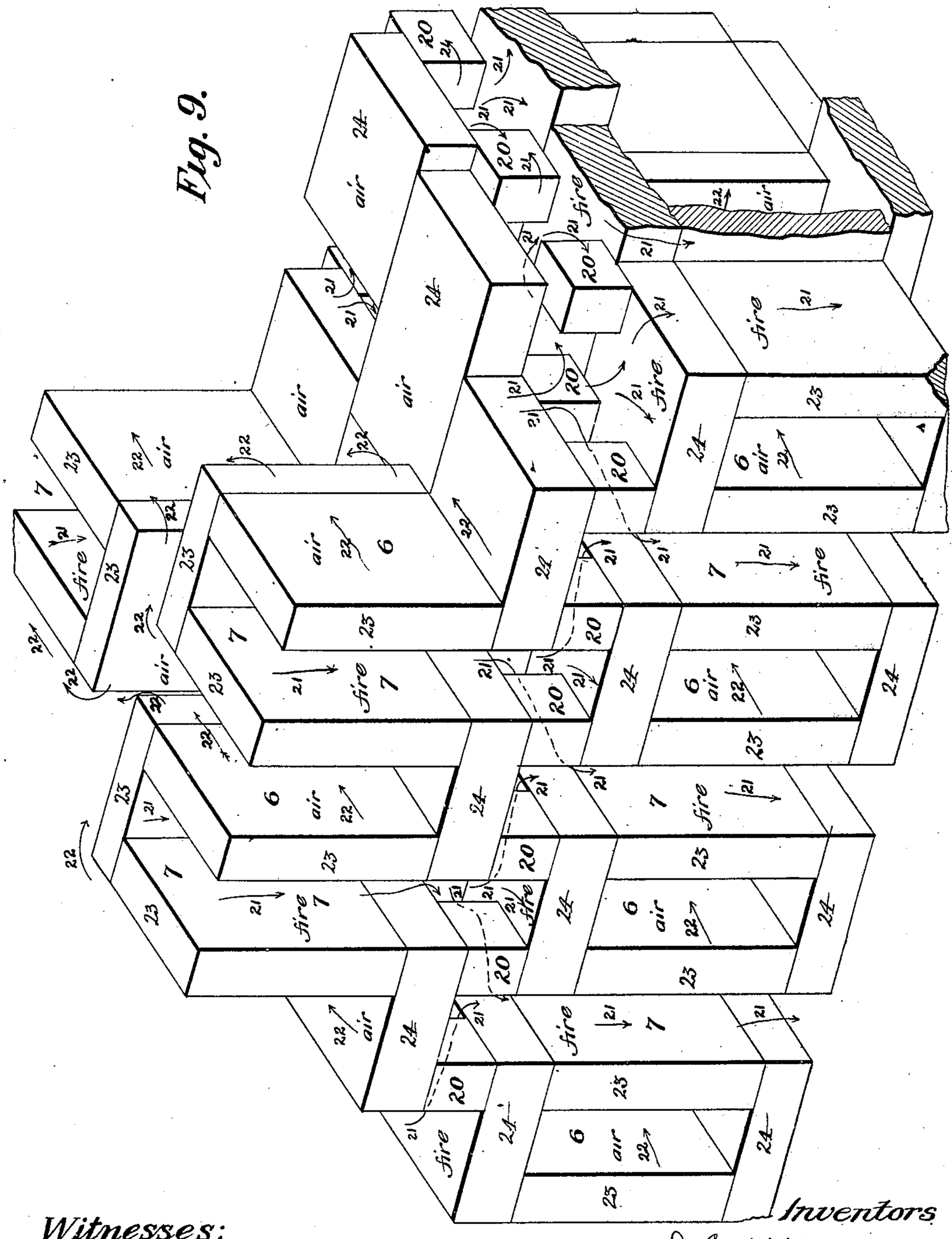

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Fig. 10.

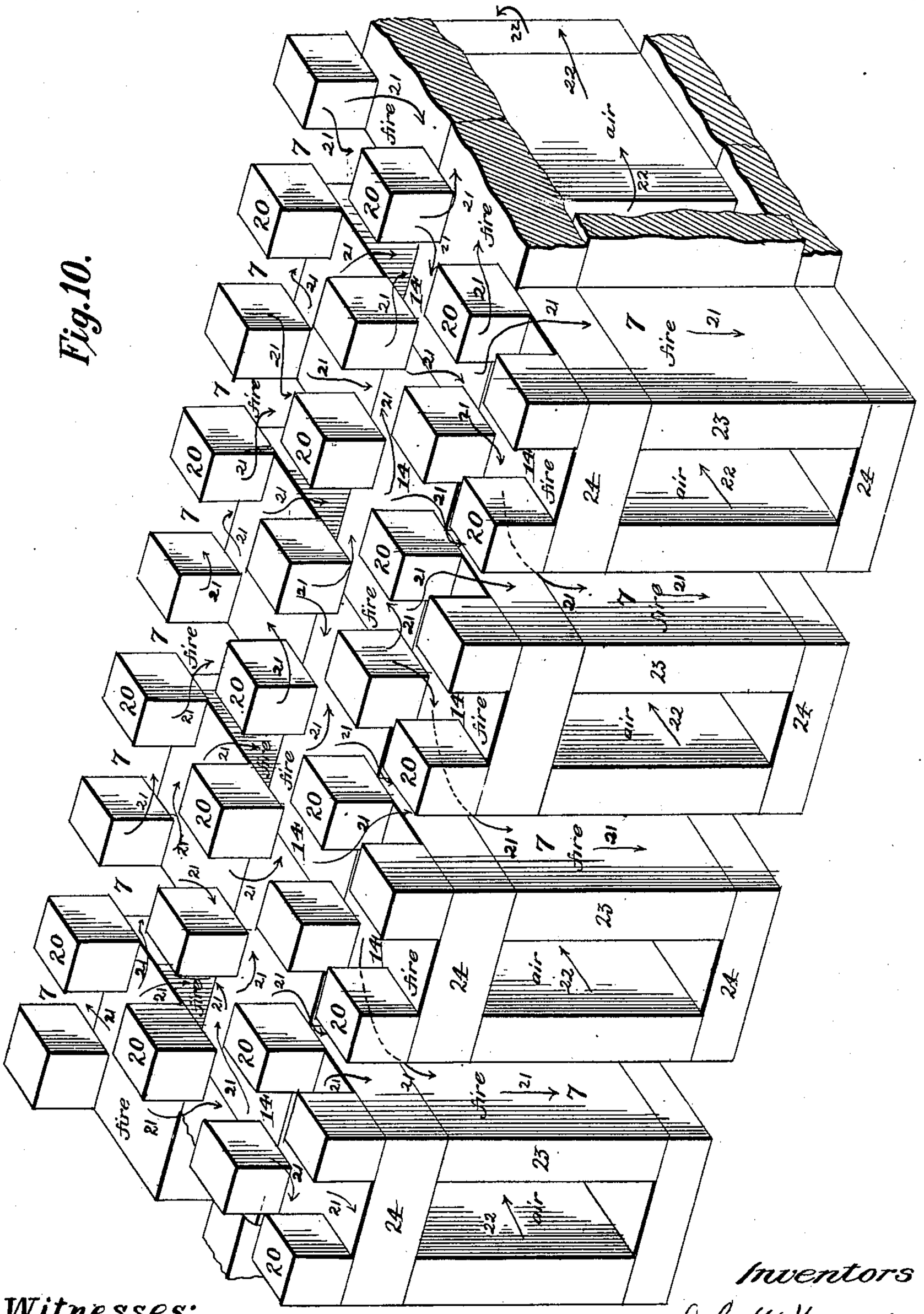

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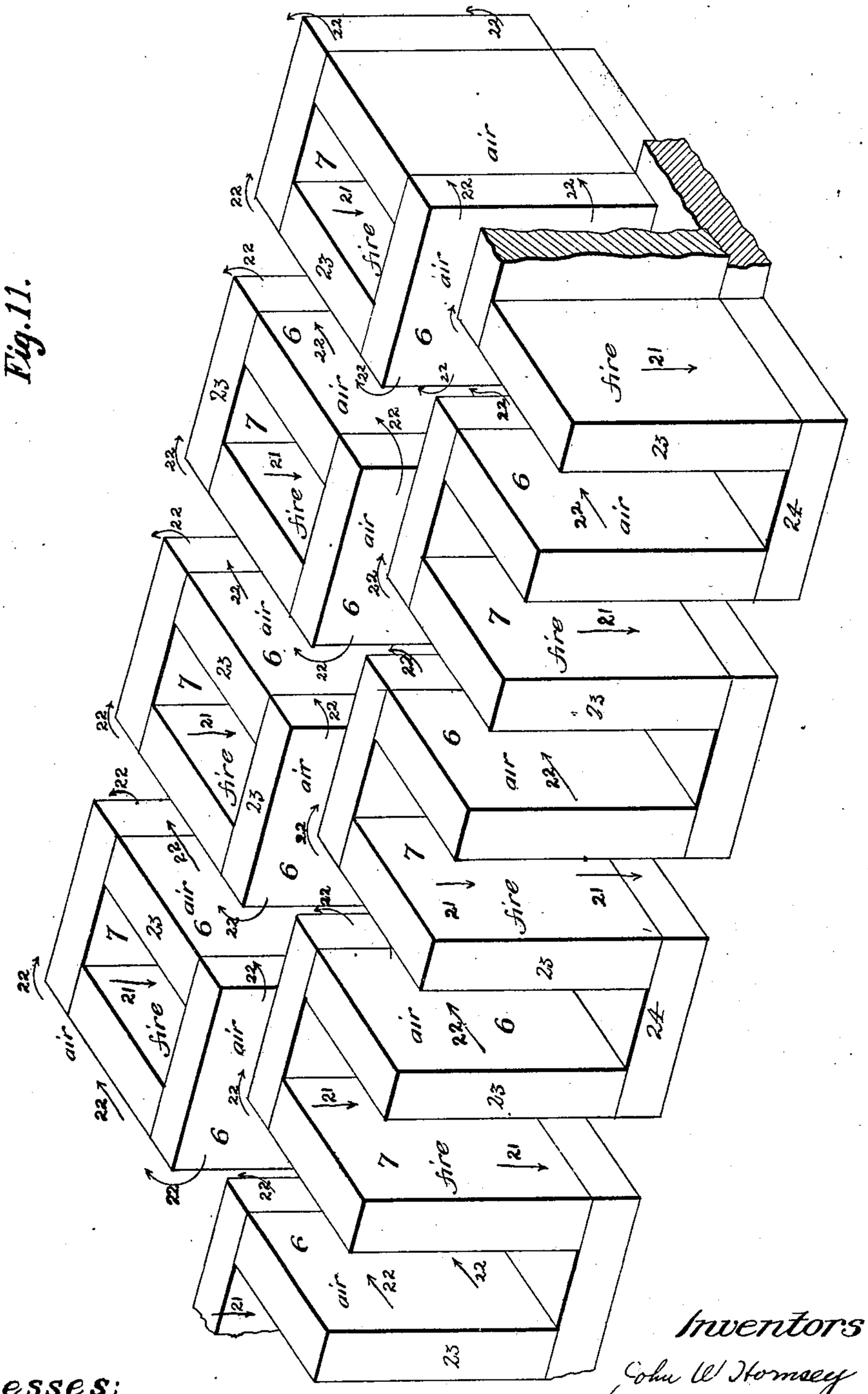
Fig. 11.



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UNITED STATES PATENT OFFICE.

JOHN W. HORNSEY, WALTER E. ELLENBERGER, AND SPENCER M. DUTY, OF CLEVELAND, OHIO, ASSIGNORS, BY MESNE ASSIGNMENTS, TO THE CROWN DRYER COMPANY, OF SAME PLACE.

HOT-AIR FURNACE.

SPECIFICATION forming part of Letters Patent No. 673,434, dated May 7, 1901.

Application filed November 8, 1899. Renewed October 5, 1900. Serial No. 32,187. (No model.)

To all whom it may concern:

Be it known that we, JOHN W. HORNSEY, WALTER E. ELLENBERGER, and SPENCER M. DUTY, citizens of the United States, residing at Cleveland, in the county of Cuyahoga, and State of Ohio, have invented certain new and useful Improvements in Hot-Air Furnaces, of which the following is a specification.

For heating air for drying brick and other materials and for heating buildings and for other purposes we have produced a structure whereby the air is heated in one or more comparatively thin volumes within flues surrounded by fire products and at a higher temperature than can be effected by the ordinary system of radiation and by which practically all the heat units of the fuel are rendered effective on air flowing in extended separate and distinct thin layers in contact with the fire-flue walls. For certain purposes it is highly important to produce pure air heated to a very high degree, and for this purpose the structure should be of material which will withstand without injury the intense heat and to secure the best results from the combustion of the fuel, which can only be secured under very high temperatures.

Our improvement involves a diffusion of hot air and fire products in separate and distinct contiguous courses at right angles to each other, whereby air in a multiple of extended layers is caused to flow in contact with intensely-heated walls passing through the flues which confine the air-layers.

The following description, read in connection with the accompanying drawings, will enable any one skilled in the art to which our improvement relates to understand its nature and to practice it in the form which we prefer to employ it. These drawings illustrate an air-heating structure adapted for carrying into effect our method of diffusing the heat products from a furnace and utilizing them to heat air in a multiple of thin extended bodies, as we will now proceed to describe.

Figure 1 shows in vertical section the structure wherein the heat is extracted in its relation to the furnace and intermediate provisions whereby the fire products are commingled, diffused, and directed, the section being taken on the line C D of Fig. 2 and showing the fire products entering and passing downward through one section of the heat-extractor flue. Fig. 2 shows in horizontal section, taken on the line A B of Fig. 1, the relations of the two divisions or sections of the flue heat-extractor and the connection of the furnace therewith and particularly illustrating the disposition of the walls separating the air-passages from the fire, at which point the heated air is delivered for use for heating or drying. Fig. 3 is a vertical transverse section, taken on the line G H of Fig. 2, illustrating the relation and connection of the two flue-divisions of the heat-extractor and the course of the fire products from the point of greatest heat to the point where they leave with the heat extracted. Fig. 4 shows in vertical section, taken on the line E F of Fig. 2, the flue structure wherein the heat is extracted and particularly illustrating that portion of such structure through which the fire products ascend to the stack. Fig. 5 is a horizontal section taken on the line M N of Fig. 3, particularly showing the foundation and base-flues connecting the two flue-divisions of the heat-extractor. Fig. 6 shows a vertical section on the line O P of Fig. 5, illustrating the arching of the mediate diffusion base-flue connecting the two divisions of the heat-extractor. Fig. 7 is a horizontal section on the line 2 2 of Fig. 3, illustrating in top view the two flue heat-extracting sections and their dividing-wall, the top heat-diffusion chamber, and the vertical flue connecting it with the furnace, the oblique base-flues being seen in dotted lines. Fig. 8 shows in elevation the wall having the openings for the admission of the air into the flue heat-extracting structure. Fig. 9 shows in perspective a group of the slabs forming the air-passages and fire-flues of two tiers and an intervening flue-space for the heat to illustrate more particularly the method of delivering the fire and the air and the direction at right angles they take through their respective flues and passages. Fig. 10 shows a like view of the horizontal

fire-flue space and the blocks at the corners of the descending fire-flues, the direction of the fire and air being indicated by the arrows, especially the fire products in the flue-space. Fig. 11 shows a tier of horizontal air-passages and fire-flues uncovered and the direction of the fire and air by the arrows. Fig. 12 shows in plan view a slab in which the vertical fire-flue openings are made; and Fig. 13 is a vertical section of a slab, showing the recess and shouldered seating with the vertical fire-flues in place.

The course of the fire products is indicated by the arrows 21, and the course of the air is indicated by the arrows 22.

The structure has the character of a kiln, such as is used for the burning of brick and similar materials, and is constructed within suitable closure-forming walls 1 in communication with a suitable furnace 2 and stack 3 or fan for the production of the required draft.

In the design shown the products of combustion from the furnace enter the flue structure at the top by a suitable vertical fire-flue 4, which communicates with the furnace through a mixing-wall 5 at one of the vertical sides of the structure; but our invention comprehends any other arrangement of flues or direction of products from the furnace.

In the construction shown the heat-extracting structure is of two distinct and separate flue sections or bodies side by side and organized for a continuous draft for the products of combustion passing through the flues of one into and through the flues of the other, preferably as shown at the top of the initial flue-section into the bottom of the connecting flue-section, while the air in large volumes enters and passes through horizontal passages 6, surrounding the walls 23 24 of the heat connecting-flues 7 in a way to bring the air in contact with the largest heat-radiating surface. Preferably, as shown, the course of the air in being heated is substantially at right angles to the course of the products of combustion. While the air in its course accumulates heat in a large volume within the horizontal passages 6 of the structure, it is introduced therein through apertures 8 in that vertical wall of the structure which is opposite to the exits 9 of said passages 6 in such manner that the walls of the air-passages are surrounded by the fire-flues 7, provided for the products of combustion, the said passages and flues being formed by the vertical and horizontal slabs, which in separate tiers are supported by the corner-blocks 20.

Upon a suitable foundation 10 the separate flue-sections of the structure are reared and have at their base separate flues 11 in communication with the furnace and with each other through the arched heat-diffusion flue 12. For distinguishing the flue-sections of this structure we will call the initial section "No. 1" and the connecting-section "No. 2," and while only two flue-sections are shown it is obvious that the number may be increased, each having substantially the same system of heat and air flues, or a simple section may be used. Section No. 1 has in its bed vertical fire-flues 11, which open into a base draft-flue 12 beneath the mediate wall, and upon the walls 13, which form these flues and which separate the latter, are built up other walls by bricks or slabs 23 24 and corner-blocks 20, forming and separating fire and air flues from the bed to the top. (See Fig. 5.) These walls are built in horizontal tiers or layers supported so as to form intervening spaces 14, Figs. 4 and 10, connecting the fire-flues of the respective tiers and at the same time separating the air-flues. In this construction the fire-flues are vertical, open at the top of flue-section No. 1 in communication with the furnace and at the bottom through the base-flues 11 with section No. 2 through the mediate base-flue 12, while the air-flues are horizontal and passing through both sections open through the outer wall, as in Figs. 2 and 3. The mediate wall forms the inside wall of a top diffusion-chamber 16, and the inside wall of the chamber above section No. 2 leading into the smokestack, as in Fig. 3. In this figure is also seen an important feature of novelty in the mediate wall in its relation to the two sections and the tiers of flues thereof, wherein is disclosed the manner in which the base communication is made between the two sections and also the manner in which the air-flues are built up with said wall so as to project from each side of the wall into the respective ascending and descending flue-sections, and which will be more particularly presently described in connection with section No. 2. Within the space between the mediate and the air-exit walls of section No. 1 is built the vertical flue 4, preferably of semicylindrical form, joining the furnace-connecting walls forming the inlet fire-flue from the furnace and opening at its top into the arched diffusion-chamber 16, which incloses and directs the fire into the upper openings of all the fire-flues of section No. 1.

The arched heat-diffusion chamber opening into a series of down fire-flues and the vertical flue 4 opening into the combustion-chamber 17 of the furnace 2 by means of a checkered wall 5 gives the advantage of delivering the products of combustion in a perfectly-commingled condition into section No. 1, and it is by this diffusion in the arched chamber 16 that the maximum heat is produced.

An important advantage due to the concentration of the maximum degree of heat at a point over the section No. 1 is that such location practically isolates the heat-diffusion chamber and carries it away from any point of the furnace where cold air is admitted. This advantage is also enhanced by the interposition of the vertical flue 4, the commingling-walls 5 and 18, and combustion-chamber 17 between the grate-bars and diffusion-chamber, and it is this isolation which main-

tains the intensity of the heat at the very point where it is most needed. In thus concentrating and maintaining the maximum heat at the point where the gases of combustion and air are most completely mixed insures the most thorough combustion with the resultant economy. The provision of this diffusion-chamber in effecting the results stated becomes an essential factor in the accomplishment of the most complete combustion of the heat-producing elements in immediate proximity to the entrance of the fire-flues of section No. 1, and it is at this point we obtain the full effect of the most intense heat upon the radiating-surfaces, and it is from this side of the structure that the air after having passed through the entire structure makes its exit for heating or drying purposes.

Referring to Figs. 1 and 2, it will be seen that the wall of the vertical flue 4 forms the wall of the adjacent air-flues 6 and which by such construction are enlarged around the wall of this fire-flue. This enlargement of the air-flues gives the advantage of allowing an enlarged volume of air to follow around the wall of this flue, thus absorbing the larger amount of heat radiated by this wall. This flue-wall is built up with and forms part of the section-tiers, while the other wall of this flue is formed by the mixing-wall and the closure-wall above the latter. The structure-section No. 2 is formed on the other side of the mediate wall and between it and the closure-forming wall, and the air-passages of both sections are made continuous by openings 19, Fig. 2, in the mediate wall, while the fire-flues are made continuous and to connect with both sections through the base and mediate flues 11 and 12. The two sections as to their fire and air flues are of identical construction, and it will be understood that the wall, Figs. 2, 3, and 8, at which the air enters forms the outer wall of section No. 2, and the air entering through apertures 8 in this wall, and which correspond to the several tiers of flues, passes through the section No. 2, through the mediate wall, through section No. 1, and finally out at corresponding openings 9 in the exit-wall. In section No. 1 the mediate wall forms the walls of the joining fire-flues, while the outer closure-forming wall forms the wall of the contiguous fire-flues. As seen in Figs. 3 and 10, this section shows the air-flues so arranged as to divert the course of the fire from the outer and the inner flues horizontally into the space 14, formed between the tiers. This space extends on a plane the full area of the section, and into it all the fire-flues open from the next above tier, and through this broad area all the fire-flues opening into it are caused to communicate one with the other and with the flues of the tier below, so that, as seen in these figures, the fire must pass from the diffusion-chamber down in a zigzag course into the base-flue 11 and in so doing must surround the air-flues. It will be noted that the walls of the horizontal flue-tiers are supported one upon the other by small blocks 20 of fire-resisting material, forming intervening horizontal shallow spaces 14, into which the vertical fire-flues open, while upon the bottom of said space the fire products in their downward course strike and are diverted through the spaces into the descending flues of the tiers below. In this diversion of the fire the volume is crowded in a way to retard its passage and to force it out from the space in all directions. This same crowding and diversion of the fire volume is repeated in the space between each tier and produces a continuous commingling of the combustible gases in their downward passage. This same result is effected by an identical construction and arrangement of the flues and spaces in section No. 2, so that there is a continuous zigzag course of the fire products from the top of section No. 1, descending through said section through the base-flues into and ascending through section No. 2.

Referring to Fig. 4, the air and fire flues are those of section No. 2, the arrangement and construction of which is identical with that of section No. 1, (shown in Fig. 1,) in which, however, the course of the fire products is upward to the stack.

Referring to Fig. 2 is seen the zigzag course of the air in its passage in a horizontal direction only through the flues of each and every tier in the sections.

Looking at the flues and their ramifications in the several figures noted, it will be seen that we have accomplished a surrounding of the air-flue walls by fire products at every point of their passage through the heat-extractor, and to the same extent and under the same conditions we have surrounded the walls of the fire-flues by the air to be heated, and it is evident that by so doing we accomplish the vital matter of extracting practically all the heat from the products of combustion, so that while the fire products enter section No. 1 at a very high heat they leave section No. 2 at a comparatively low heat and have parted largely with the combustible matter of the fuel. In the attainment of this important result the air entering section No. 2 at the top wall-openings comes in contact with the coolest part of the heat-extractor, and which is that part at which the heat leaves, it and passing through the mediate wall enters section No. 1 at its highest portion, which is the point at which the fire enters. Taking section No. 2 at its lowest air-flue, the air entering at that point comes in contact with that portion of section No. 2 having the greatest heat, which is the point at which the fire enters said section, and passing through the mediate wall enters section No. 1 at its point of lowest temperature, which is the point at which the fire leaves said section. By this method of heating the air it is delivered from the extractor at a temperature which is uniform at the varying heights of the exit-openings. By this method our invention is capable of produc-

ing pure air heated to a temperature very much higher than can be obtained by steam-heating or metallic radiators, which in any case can rarely exceed two hundred and fifty degrees, whereas by our method air may be heated to two thousand degrees. Looking at the base-flues in Fig. 5, their oblique arrangement is made to render the foundation more solid, and because the vertical flue 4 projects into and shortens section No. 1 and by the connection of these flues 11 with the base draft-flue 12 we secure an equal distribution of the fire products as they enter section No. 2.

At various parts of the furnace and heat-extractor access is had for cleaning and repairs by doors.

In Fig. 2 it is seen that all the air-flues deliver heated air into a chamber common to all, from which it may be conveyed to the point where it is utilized for any desired purpose. In Figs. 9, 10, and 11 is better seen the relative arrangement of the air and fire flues and the horizontal space between each tier and the spreading of the fire products in all directions as they leave the vertical flues and enter this horizontal space, and particularly through the passages between the blocks in directions at right angles.

In the drawings the flues are shown as built up of comparatively small matching brick or parts; but in practice the surfaces forming the top and bottom of the horizontal fire-spaces we prefer to make of slabs the entire area of the sections and having flue-openings. In this construction the flue-openings will be surrounded by a surface recess and the ends of the vertical fire-flues seated into the recesses. The importance of this construction is that it very greatly lessens the number of pieces and necessarily the number of joints in assembling the parts. The vertical fire-flues may also be made with their four walls in one piece.

In Fig. 7 the fire-resisting walls of the heat-extractor are distinguished from the closure-forming walls proper, and this construction gives the advantage of separate surrounding walls for the separate heat-extractors and in this way provides for the varying expansion incident to the difference in the temperature of the two sections and also incident to the difference in the heat of the two walls.

Referring to Fig. 8, it is obvious that a greater or less number of air-flues may be used, and the tiers of fire-flues must correspond. Bricks may be used set in the entrance of these flues to regulate their area, and thereby the volume of air admitted. This regulating provision gives the advantage of cutting out from the heat-extractor one or more flues of each tier or of diminishing the inlet area of one or more of all the air-flues, and this may be done by a separate slide-valve for each opening or by a slide-valve for a tier of openings. The advantage of this regulation is that air admitted in smaller volumes can be heated to a higher temperature, and this gives the attendant absolute control of the temperature of the air at the point of delivery to suit the requirement. In this figure the upper tier of air-inlet openings 8 is seen provided with slides 25, confined between guideways, so that the slides can be set to close or partially close the openings, as may be found necessary for the purpose stated.

In Figs. 1 and 3 a multiple of fire-flues 7 receive the fire products from the diffusion-chamber and deliver them into the base-flues 11 on one side of the mediate wall, and the walls of these fire-flues are seen as forming and inclosing the air-passages 6, each layer of the flue-walls being separated by a horizontal space 14, into which the fire products spread laterally as they descend in a staggered course from one space to another. From the base-flues of the flue-section No. 1 the heat products pass into the base draft-flue 12, and from thence into the base-flues 11 of the flue-section No. 2, into and through the fire-flues 6 of which the fire products pass upward to the draft-stack, and in such course its heat units are given to the air by radiation.

In Fig. 2 the horizontal air-passage of one of the tiers is seen as extending over the full area of the two flue-sections, with inlet and outlet openings corresponding to the number of the passages 6 formed by the flue-walls, and this passage is as deep as the flues 6 (seen in Figs. 1 and 3) and gives free diffusion for the air around the walls, which attain great heat from the fire-flues. The admission of air in a multiple of thin volumes in contact with the walls, which to a greater or less extent are caused to have a red heat, and the delivery of the hot air from the passage in a multiple of volumes aids in obtaining to the fullest advantage the radiated heat from the fire-flues.

Referring to Figs. 9, 10, and 11, it will be seen that the air-passages and the fire-flues are formed by the same walls, the bricks or slabs 23 being vertical and connected at their ends by horizontal bricks or slabs 24, which are separated by the corner-blocks 20.

In the construction and arrangement shown the air-passages are formed by adjacent surfaces and the fire-flues by the adjacent other surfaces of the same walls, and when any one of the air-passages is closed at its inlet-opening such passage becomes a dead space in the flue structure.

We claim—

1. In combination in a furnace for heating air by radiation including the furnace, a walled closure in communication therewith, a mediate wall dividing said closure vertically, a top heat-diffusion chamber on one side of said mediate wall, a vertical draft-flue connecting the furnace and the diffusion-chamber, of a heat-extracting structure within said closure comprising walls built up of fire-brick forming horizontal passages for separate air volumes, arranged in tiers, each

passage having a multiple of inlet-openings in the outer wall of said closure and a multiple of exit-openings in the opposite closure-wall, the slabs inclosing and forming in separate parallel rows the vertical fire-flues having communication with the vertical draft-flue and with the draft-stack, and the air-passages and the fire-flues staggered as set forth.

2. In combination in a furnace for heating air by radiation including a furnace, a draft-stack and a walled closure of flue structures side by side within said closure, each flue structure constructed of vertical and horizontal walls disposed in tiers to form horizontal passages for separate air volumes, each air-passage having a multiple of inlet-openings in the outer wall of said closure and a multiple of exit-openings in the opposite closure-wall, the walls of each air-passage forming also vertical fire-flues, a mediate wall dividing said flue structures into diving and ascending flue-sections and a vertical draft-flue connecting the diving flue-section with the furnace.

3. In combination in a furnace for heating air by radiation including a furnace, a draft-stack and a walled closure, of a heat-extractor comprising a flue structure within said closure constructed of fire-brick or slabs built up in layers and arranged to form air-passages in separate horizontal tiers and vertical fire-flues arranged in parallel rows transversely of the air-passages, the latter arranged in tiers and having in each tier a multiple of air inlet and exit openings in the opposite closure-walls, each fire-flue opening at the top tier, the walls of the air-passage forming also the walls of the fire-flues, a heat-diffusion chamber above the top tier, a vertical draft-flue connecting said chamber with the furnace and a bottom draft-flue into which the fire-flues terminate and have communication with the draft-stack.

4. In combination in a furnace for heating air by radiation, a walled closure, a mediate wall dividing it, a top heat-diffusion chamber on one side of said mediate wall, and a vertical draft-flue connecting the furnace and said top chamber, a horizontal base draft-flue, a flue structure within the closure between the top diffusion-chamber and the base draft-flue, built up of fire-brick or slabs forming tiers of horizontal air-passages and vertical fire-flues arranged in parallel transverse rows, each fire-flue opening into the top diffusion-chamber and into the bottom draft-flue, the layers of brick which form the horizontal air-passages separated by corner-blocks and the said passages enlarged around in contact with the wall of the vertical draft-flue, and a draft-stack in communication with the fire-flues.

5. In a furnace for heating air by radiation and in combination with the furnace, a draft-stack, a walled closure having a top heat-diffusion chamber in communication with the furnace, and a base draft-flue in communication with the draft-stack, of a flue structure between the top diffusion-chamber and the base-flue constructed of fire-brick or slabs in separate layers upon the walls of the base-flue and forming parallel rows of vertical fire-flues opening into the top diffusion-chamber and into the base-flue, the flues of one row in staggered relation to the flues of the adjacent rows, the layers of slabs forming such fire-flues separated to form horizontal air-passages arranged in tiers, each air-passage surrounding the walls of the fire-flues and having a multiple of inlet and exit air-openings in the opposite closure-walls.

6. In a furnace for heating air by radiation and in combination with the furnace, a draft-stack, a walled closure having a top heat-diffusion chamber in communication with the furnace and a base draft-flue in communication with the draft-stack, of a flue structure between the heat-diffusion chamber and the base-flue, constructed of fire-brick or slabs in layers consisting of vertical and horizontal slabs arranged to form air-passages 6 in tiers, each air-passage extending the entire area of the flue structure and having a multiple of inlet and exit air-openings in the opposite closure-walls, fire-flues 7 formed vertically within said tiers of air-passages, and horizontal fire-spaces 14 between the air-tiers into which the vertical fire-flues open, in the successive tiers from the top heat-diffusion chamber to the base-flue.

7. In a furnace for heating air by radiation and in combination with a furnace, a draft-stack, a walled closure having a top heat-diffusion chamber and a vertical draft-flue in communication with the top chamber and with the furnace, of a flue structure built upon the walls of said closure and of said draft-flue, extending above the furnace forming the bottom of the diffusion-chamber and constructed of fire-brick or slabs arranged in horizontal tiers and vertical parallel rows forming horizontal passages 6 and vertical fire-flues 7 14, the air-passages having inlet and outlet openings for each flue 6 in the opposite closure-walls, the fire-flues opening into the top heat-diffusion chamber and communicating with the draft-stack, a mixing-wall forming one side of the vertical draft-flue and arranged between it and the furnace.

8. In a furnace for heating air by radiation and in combination with the furnace, a draft-stack a walled closure having a top heat-diffusion chamber a vertical draft-flue in communication with said top chamber and with the furnace, a vertical mediate wall dividing said closure, and a draft-flue 12 at the base of said closure, of a flue structure on each side of said wall built upon the closure-walls, extending above the furnace, and constructed of fire-resisting slabs 23 24 separated by corner-blocks 20, forming passages 6 arranged in horizontal tiers passing through the mediate wall and vertical fire-flues 7 14 on each side of said wall, the base-flues 11 on each

side of the base draft-flue 12, both structures having air inlet and outlet openings in the opposite closure-walls, the diving flue structure having direct communicating with the furnace and the ascending flue structure having direct communication with the draft-stack.

9. In combination in a furnace for heating air by radiation and including the furnace, a communicating walled closure a draft-stack, a heat-diffusion chamber at the top of said closure and a vertical draft-flue connecting the top diffusion-chamber and furnace, of a flue structure the top of which forms the bottom of the diffusion-chamber and comprises bricks or slabs built up and arranged to form air-passages 6 in separate horizontal tiers and vertical fire-flues 7 14, in parallel rows, each tier of air-passages provided with a multiple of air-inlet openings and a multiple of outlet-openings, a base draft-flue 12 into which the fire-flues terminate, and means whereby any one or more of the tiers of air-passages may be closed to increase the heat of the flue structure or diminish the volume of air to be heated.

10. In a furnace for heating air by radiation and in combination with the furnace and the draft-stack, of a heat-extractor comprising a walled closure, a flue structure therein constructed of fire-brick or slabs arranged in layers forming air-passages in separated horizontal tiers and vertical fire-flues arranged in parallel rows transversely of the air-passages, each fire-flue passing between the tiers of air-passages, having air supply and exit openings arranged in series for each separate passage, each fire-flue opening at the top tier and terminating at the bottom tier, the air-passages being staggered to deflect the air in the line of the draft and the fire-flues staggered in the line of draft to deflect the fire products as set forth.

11. In a furnace for heating air by radiation and in combination with the furnace, a walled closure in communication with the furnace, a vertical wall mediately dividing said closure, a diffusion-chamber above and on one side of the mediate wall, a vertical draft-flue in communication with the diffusion-chamber, a draft-stack on the other side of said mediate wall and a base draft-flue, of a flue structure comprising a diving section on one side of the mediate wall and an ascending section on the other side of said wall, the said flue-sections constructed in layers forming air-passages in separate horizontal tiers passing through the mediate wall and through both sections, and also forming vertical fire-flues arranged in parallel rows passing between the walls of said tiers, each separate air-passage having a multiple of air inlet and outlet openings in the opposite closure-walls.

12. In a furnace for heating air by radiation and in combination with the furnace, a draft-stack, and walled closure, having a heat-diffusion chamber at the top of the closure, a vertical draft-flue connecting the top chamber and the furnace, with a flue structure within said closure forming the bottom of the top chamber and a wall of the draft-flue and constructed with fire-flues arranged in vertical staggered rows opening into said top chamber and horizontal air-passages arranged in tiers, each passage having a multiple of air inlet and exit openings at opposite sides of the closure, and a base draft-flue in communication with the draft-stack.

In testimony whereof we affix our signatures in presence of two witnesses.

JOHN W. HORNSEY.
WALTER E. ELLENBERGER.
SPENCER M. DUTY.

Witnesses:
J. A. LIGHT,
WILLIAM H. HILL.