Oct. 29, 1940. L. C. HAMLINK 2,219,894

FURNACE

Filed March 10, 1938 5 Sheets-Sheet 1

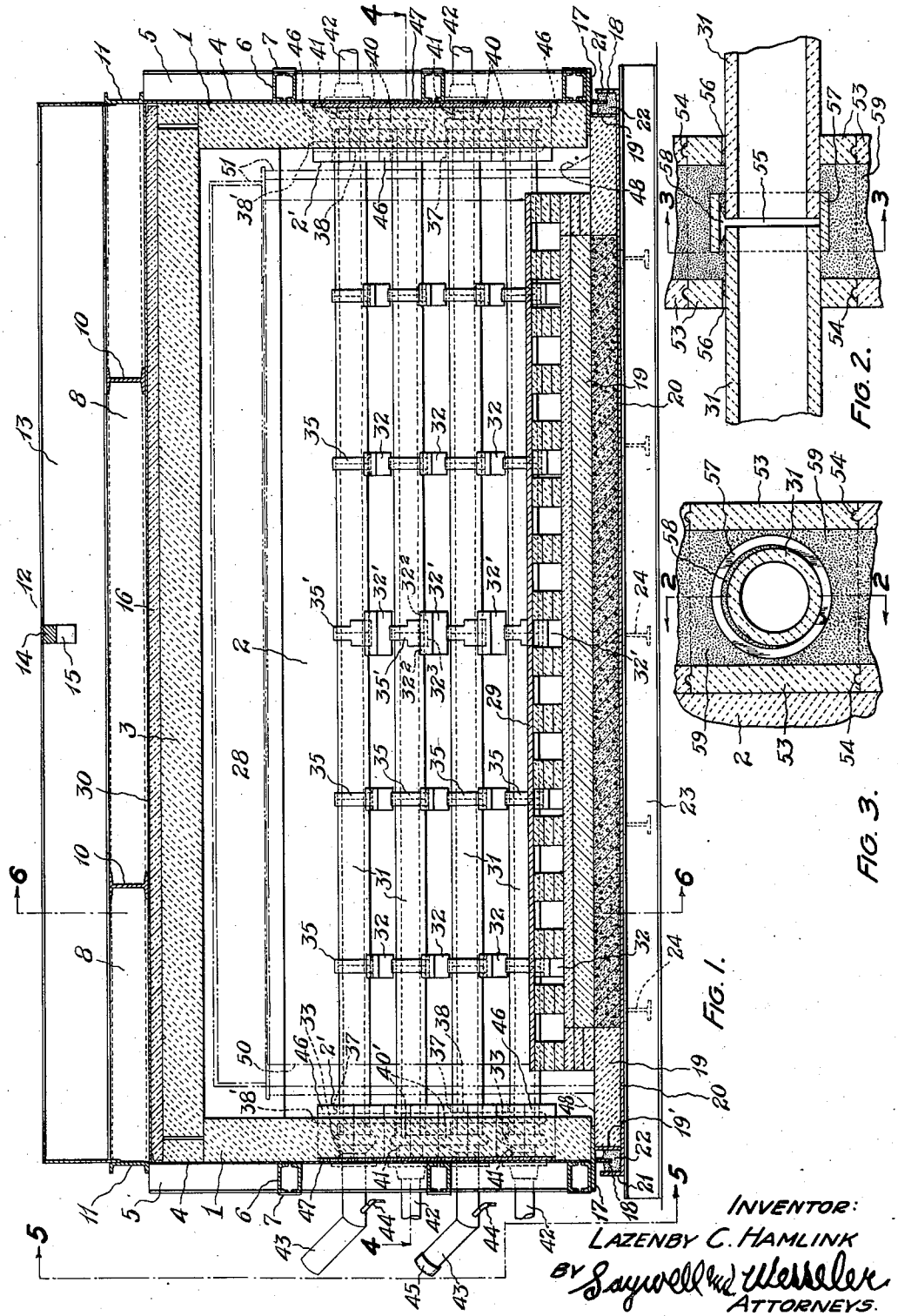


FIG. 1.

FIG. 2.

FIG. 3.

INVENTOR:
LAZENBY C. HAMLINK
BY Sayrell and Wesseler
ATTORNEYS.

Oct. 29, 1940. L. C. HAMLINK 2,219,894

FURNACE

Filed March 10, 1938 5 Sheets-Sheet 2

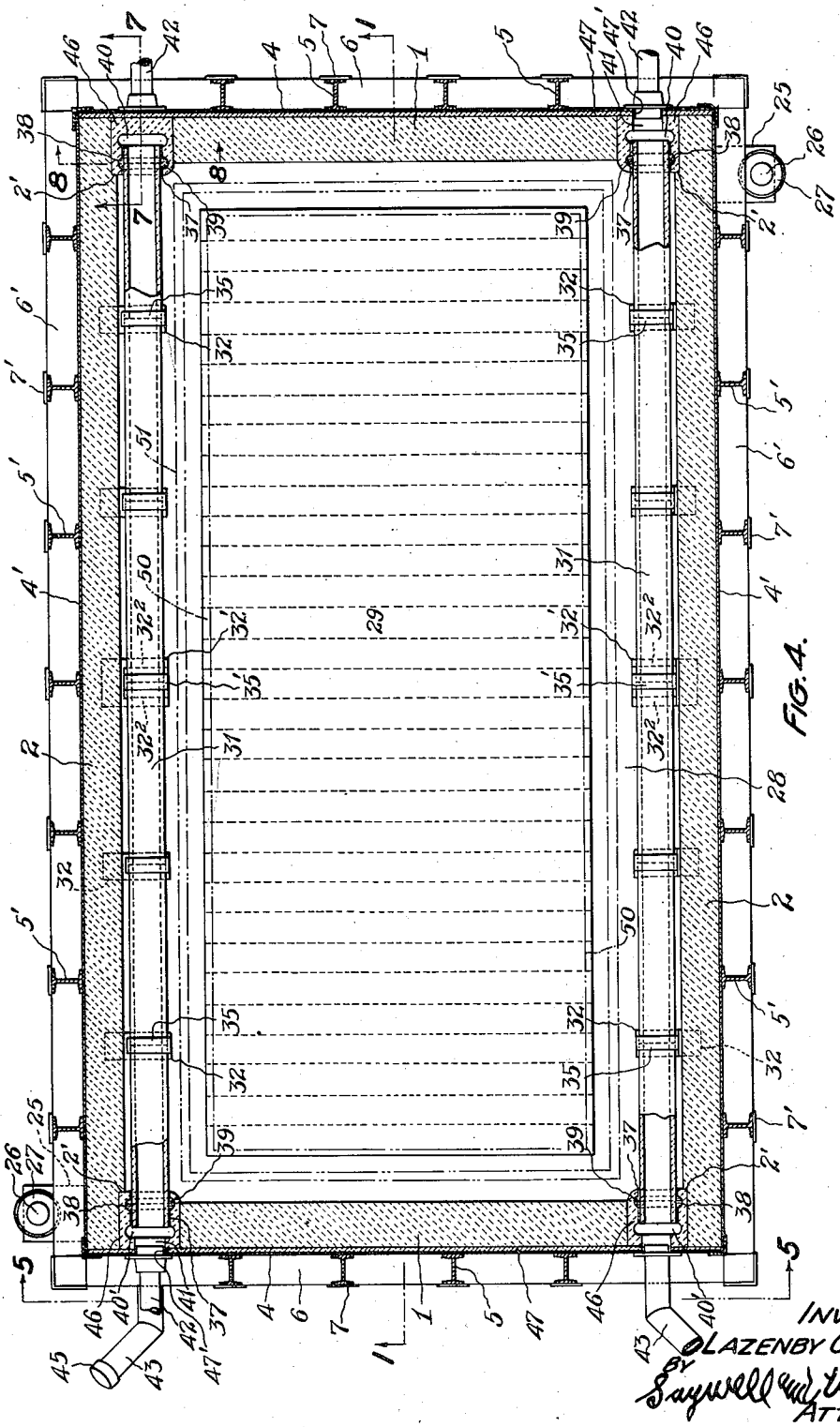


FIG. 4.

INVENTOR:
LAZENBY C. HAMLINK
BY
Sayrell and Wesselex
ATTORNEYS.

Oct. 29, 1940. L. C. HAMLINK 2,219,894

FURNACE

Filed March 10, 1938 5 Sheets-Sheet 3

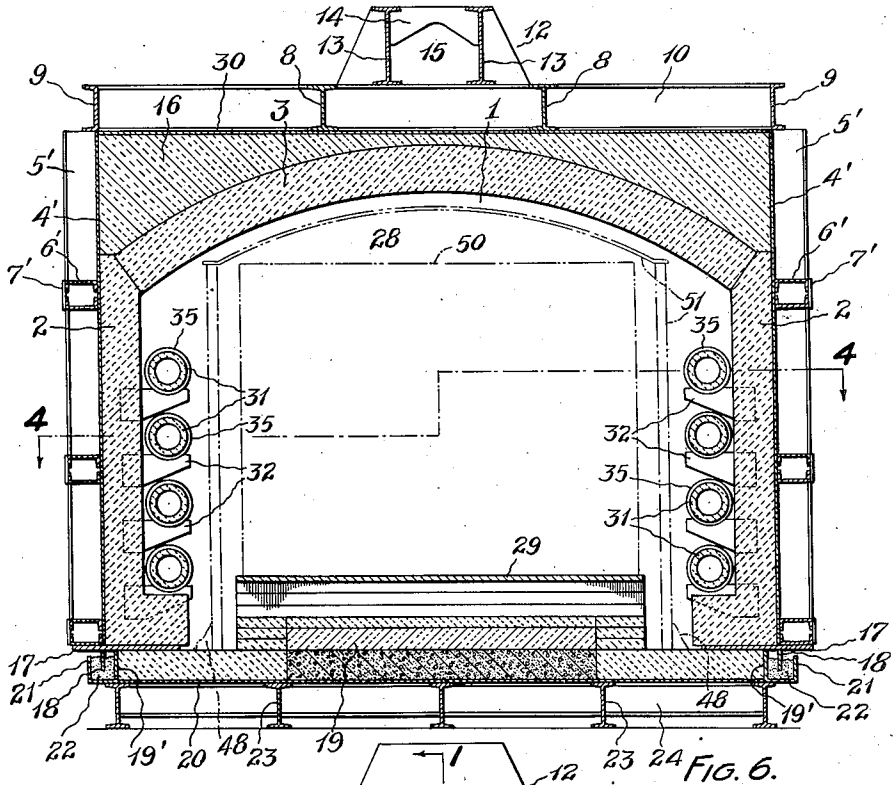


FIG. 6.

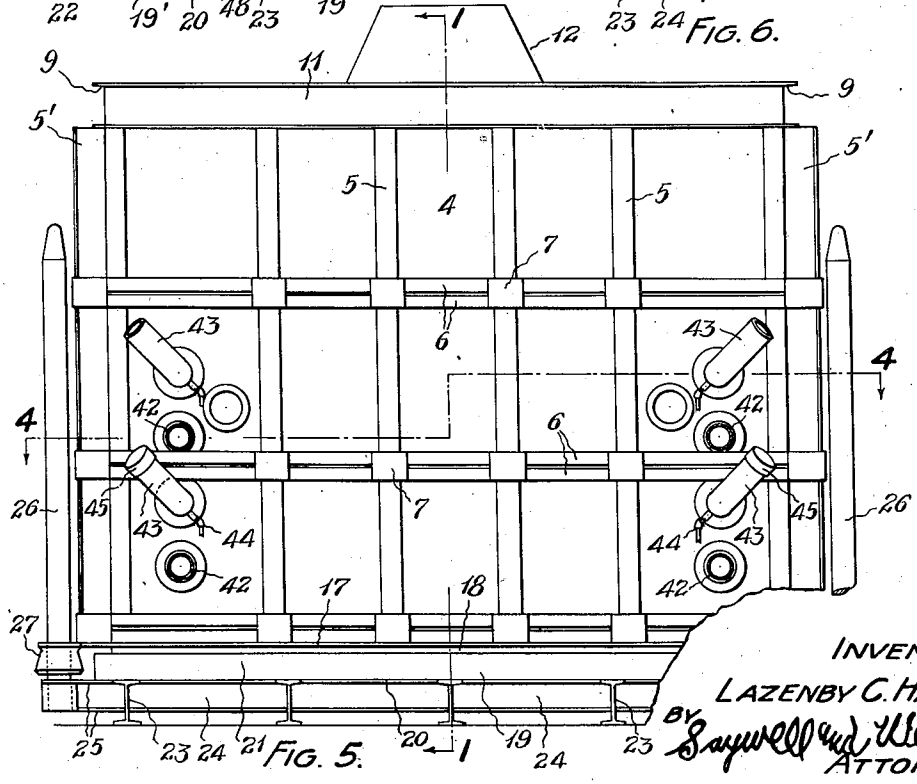


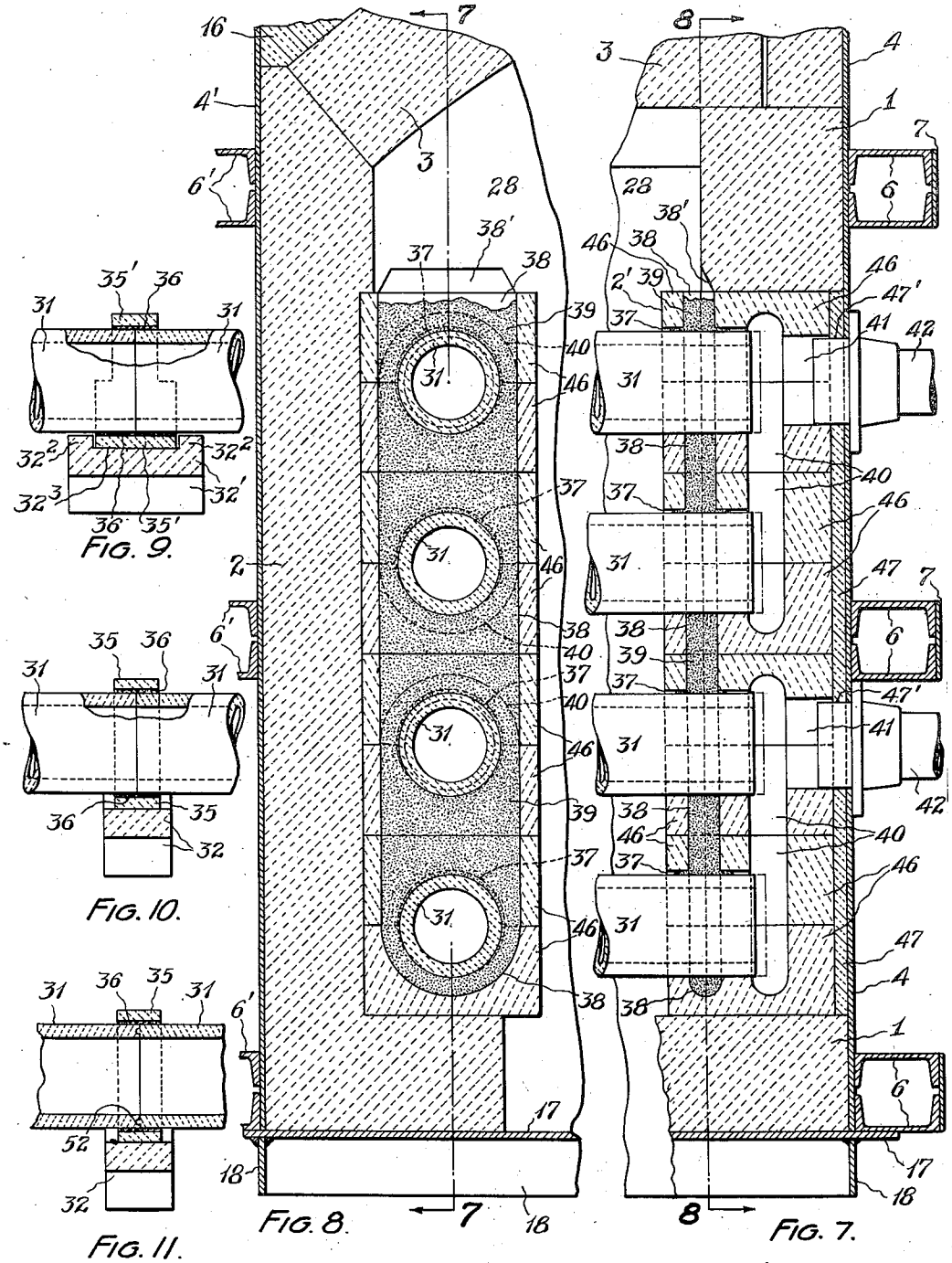
FIG. 5.

INVENTOR:
LAZENBY C. HAMLINK
BY Sayrell and Wesseler
ATTORNEYS.

Oct. 29, 1940. L. C. HAMLINK 2,219,894

FURNACE

Filed March 10, 1938 5 Sheets-Sheet 4



INVENTOR:
LAZENBY C. HAMLINK
BY Sayrell and Wessler
ATTORNEYS.

Oct. 29, 1940. L. C. HAMLINK 2,219,894

FURNACE

Filed March 10, 1938 5 Sheets-Sheet 5

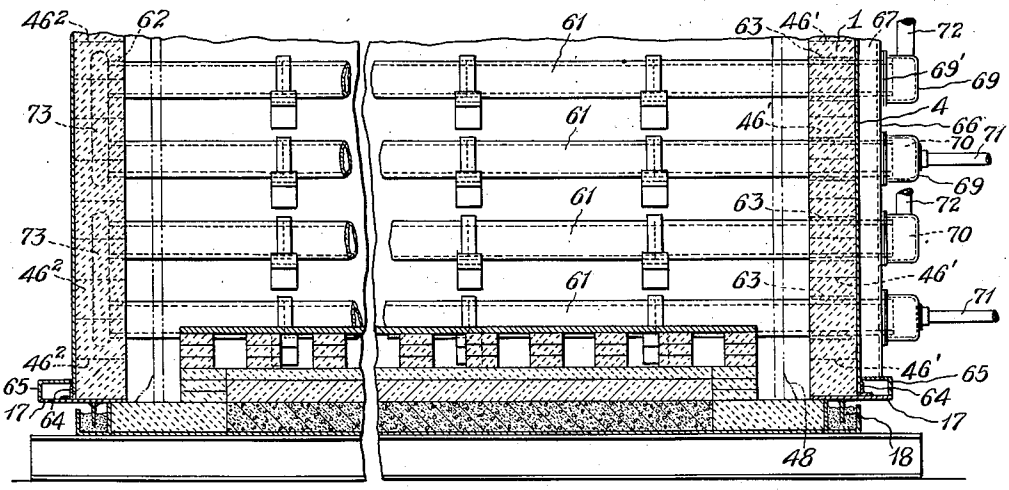


FIG. 12.

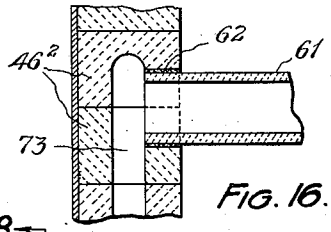


FIG. 16.

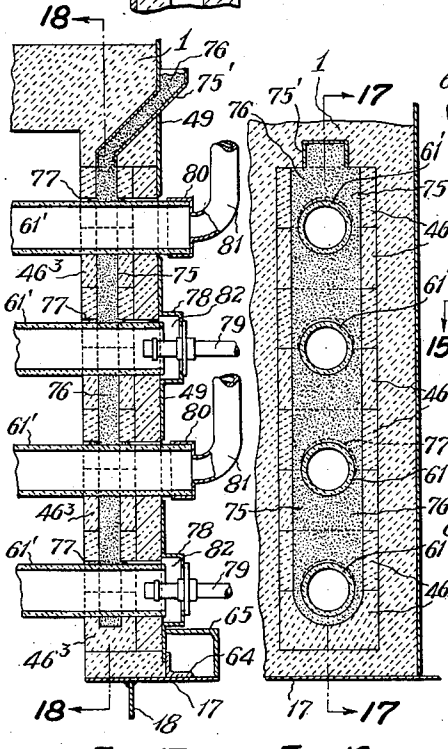


FIG. 17.

FIG. 18.

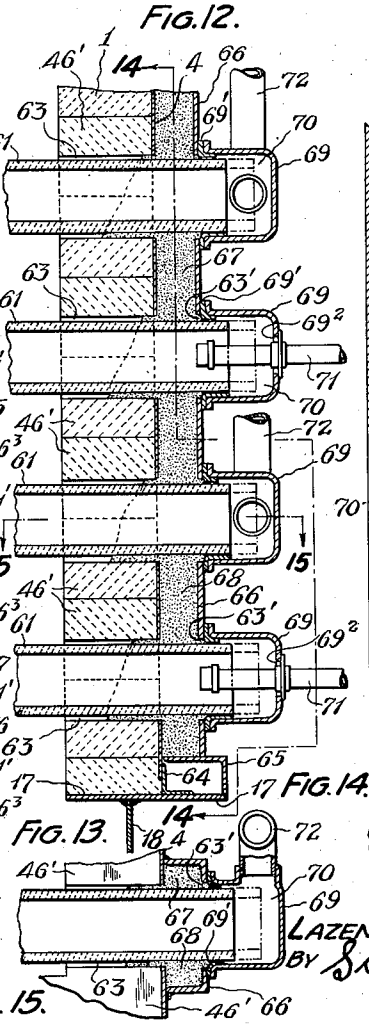


FIG. 15.

FIG. 13.

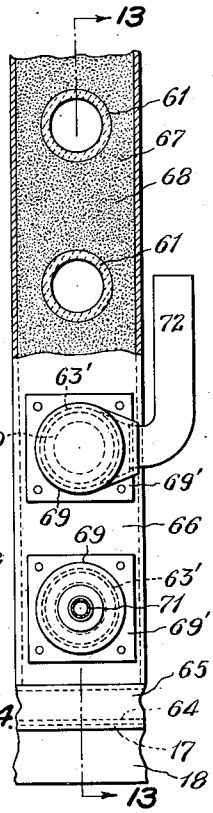


FIG. 14.

INVENTOR:
LAZENBY C. HAMLINK
BY Lawrence Wheeler
ATTORNEYS

Patented Oct. 29, 1940 2,219,894

UNITED STATES PATENT OFFICE

2,219,894

FURNACE

Lazenby C. Hamlink, Cleveland Heights, Ohio, assignor to The Gas Machinery Company, Cleveland, Ohio, a corporation of Ohio

Application March 10, 1938, Serial No. 195,075

10 Claims. (Cl. 266—5)

My invention relates to furnaces and particularly to annealing and other heat-treating furnaces. The objects of the invention are to provide apparatus of this character which can be economically made and assembled, which is efficient in operation, and the heating elements of which will be extremely resistant to deterioration during operation. A primary object of the invention is to provide new and improved heating tubes for annealing and other heat-treating furnaces, and new and improved assemblies of such tubes and the other necessary elements of such furnaces.

The annexed drawings and the following description set forth in detail certain means illustrating my improved furnace structures, such means constituting only a few of the various forms in which the principles of the improved furnaces may be embodied.

In said annexed drawings:

Figure 1 is a vertical longitudinal section of an annealing furnace embodying one form of my invention, the section being taken in the plane indicated by the line 1—1, Figures 4 and 5, the showing being that of a rectangular furnace in which a removable outer cover is utilized and in which heating gases are fired at different vertically-aligned levels, two series of improved refractory heating tubes being incorporated in the furnace adjacently interior of opposed side walls, said tubes being secured at the center, the assembly being such that the tubes can expand at both ends;

Figure 2 is a fragmentary vertical longitudinal section of a form of joint between the adjacent ends of contiguous sections of a heating tube, different than the form of such joint included in Figure 1 in that the tube shown in Figure 2 can expand at the joint, a modified form of tube-supporting structure also being shown in this figure, the section being taken in the plane indicated by the line 2—2, Figure 3;

Figure 3 is a fragmentary vertical transverse section, taken in the plane indicated by the line 3—3, Figure 2;

Figure 4 is a plan section of the form of furnace shown in Figure 1, the section being taken in the planes indicated by the line 4—4, Figures 1, 5, and 6;

Figure 5 is a broken end elevation, taken from the planes indicated by the line 5—5, Figures 1 and 4;

Figure 6 is a vertical transverse section, taken in the plane indicated by the line 6—6, Figure 1;

Figure 7 is a fragmentary enlarged vertical longitudinal section of the furnace assembly as shown at the right hand end of Figure 1, the section being taken in the plane indicated by the line 7—7, Figures 4 and 8;

Figure 8 is a fragmentary enlarged vertical transverse section, taken in the plane indicated by the line 8—8, Figures 4 and 7;

Figure 9 is a fragmentary enlarged vertical longitudinal section showing the nature of the central joint between adjacent ends of contiguous sections of my new and improved heating tube shown in Figures 1, and 4–8;

Figure 10 is a view similar to Figure 9, but showing a joint between contiguous sections of the heating tube, other than the central joint;

Figure 11 is a view similar to Figure 10, but showing a modification of the joint between the adjacent ends of contiguous sections of the heating tube;

Figure 12 is a broken and fragmentary vertical longitudinal section of an annealing furnace embodying a modified form of my invention in that the cooperative arrangement of the heating tube assembly with the furnace walls is different from that shown in Figure 1, the figure also illustrating a form of structure in which the expansion of the heating tubes is provided for entirely at one end of the tubes;

Figure 13 is a fragmentary vertical longitudinal section, upon an enlarged scale, of the structure shown in Figure 12, the section being taken in the plane indicated by the line 13—13, Figure 14;

Figure 14 is a fragmentary vertical transverse section, taken in the planes indicated by the line 14—14, Figure 13;

Figure 15 is a fragmentary horizontal longitudinal section, taken in the plane indicated by the line 15—15, Figure 13;

Figure 16 is a fragmentary vertical longitudinal section through that end of the furnace shown in Figures 12 and 13 opposite the end thereof which is shown in Figure 13;

Figure 17 is a fragmentary vertical longitudinal section, similar to Figure 13, but on a smaller scale, of a further modified form of annealing furnace in which expansion of my improved heating tubes is provided for entirely at one end of the furnace, the section being taken in the plane indicated by the line 17—17, Figure 18; and

Figure 18 is a fragmentary vertical transverse section, taken in the plane indicated by the line 18—18, Figure 17.

Referring to the annexed drawings in which the same parts are indicated by the same respec-

tive numbers in the several views, and first particularly referring to Figures 1, 4, 5, 6, 7, 8, 9, and 10, a form of my improved furnace construction is exemplified in a rectangular annealing furnace having a removable outer cover or hood with refractory end walls 1, side walls 2, and an arched brick roof portion 3 topped by refractory insulating material 16. To the end walls 1 are secured exterior plates 4 to whose exterior faces are secured spaced vertical I-beams 5. Intermediate adjacent I-beams 5 are pairs of opposed horizontal channel sections forming box girders 6, the outer flanges of the channel sections being secured together by plates 7 which are welded to said flanges and the outer flanges of the I-beams 5. The remainder of the reinforcing exterior side structure comprises longitudinal plates 4' secured to the exterior faces of the side walls 2, to the exterior faces of which plates 4' vertical I-beams 5' are secured; also intermediate horizontal pairs of opposed channels whose outer flanges are welded together by plates 7' to form box girders 6'. Exterior longitudinal channels 9 and transverse channels 11 are secured to the top ends of the vertical end I-beams 5 and the vertical side I-beams 5'. Secured to the top of the end I-beams 5 and upon a plate 30 mounted upon the top of the insulating material 16 are intermediate longitudinal I-beams 8 braced by cross I-beams 10, these I-beams 8 and 10 being extended across the roof of the furnace. To provide lifting means 12 whereby the aforedescribed hood may be positioned on or removed from the furnace base, there are secured to the top of the roof I-beams 10 a pair of spaced longitudinal and upwardly-extended I-beams 13 which are secured together by a bar 14 whose bottom edge is somewhat spaced from the I-beams 10 whereby to provide a hook or grab slot 15. To the base of the hood structure is secured a peripheral plate 17 forming a supporting and wear member for the seating of the hood upon the furnace base, this plate 17 having a depending flange 18 which dips into a base seal, hereinafter described, for the purpose of sealing the inner furnace chamber 28 from the outside atmosphere.

The base of the furnace upon which the described hood is mounted for the heating operation comprises a composite member 19 of spaced tile and other refractory insulating material to the bottom face of which and extended slightly outwardly from which is secured a plate 20 having an upwardly-extended peripheral flange 21 which, in conjunction with an inner spaced plate 19' secured to the edge of the base 19, forms a reservoir for the sealing material, such as sand 22, into which sand the aforementioned depending flange 18 of the hood dips. Secured to the lower face of the base plate 20 are longitudinal I-beams 23 and transverse I-beams 24. I provide means for properly positioning the hood upon the furnace base 19, the same consisting of two pairs of relatively vertically disposed plates 25, Figures 4 and 5, extended from one side of each of the outside I-beams 23 and formed with a socket to hold guide posts 26, which guide posts are adapted to register with spool-shaped members 27 secured to the base plate 17, when the hood is moving downwardly in proper registering position.

Incorporated in the described hood structure are refractory tubes 31 for heating the work 50 in the furnace chamber 28, this work 50 being piled upon a suitable hearth plate 29 secured to the top of the refractory furnace base 19, the work 50 preferably being covered by an inner cover 51 during the heating and subsequent cooling operations. The heating tubes 31 are disposed in two longitudinal series extended along the side walls 2 of the hood and adjacently interiorly of said side walls, each series comprising a plurality of vertically-aligned tubes 31, and each tube comprising a plurality of sections whose adjacent ends are jointed by means hereinafter described. These refractory heating tubes 31 are slidably mounted upon the top surfaces of spaced horizontal brackets 32 whose outer ends are incorporated with and mounted in the hood side walls 2 and whose inner ends project inwardly of said side walls into the furnace chamber 28, as clearly shown in Figure 6. Referring particularly to Figure 10, it will be noted that the joint between the adjacent ends of each two contiguous tube sections 31 is covered by a collar 35 mounted on a bracket 32 and having an opening slightly greater in diameter than the outside diameter of the tube 31, the inner surface of the collar being securely fastened to the adjacent ends of the abutting heating tube sections by cement 36. Such joints between the heating tube sections, as are illustrated by Figure 10, prevent longitudinal sliding of the sections of the tubes 31 relatively to each other, but do not prevent the sections sliding relatively to the supporting brackets 32, so that any expansion of the heating tube 31 during the heating operation can be accommodated at the end hood walls 1 as as will be hereinafter fully described. However, I fasten the heating tubes 31 at the center joint and for this purpose I provide a special center bracket or support 32', Figure 9, which has upwardly-extended end flanges 32^2 serving to restrain the tube sections at this central joint against longitudinal movement, since the central joint collar 35', which is of elongated formation at its lower end, is confined in the recess 32^3 formed between the two end flanges 32^2 of the central support 32'.

Except at the top and bottom, the hood end walls 1, adjacent the ends of the heating tubes 31, do not extend entirely across the ends of the hood completely to fill the spaces between the ends of the side walls 2 but terminate short of the ends of said side walls 2. Refractory supporting blocks 46, Figures 4 and 7, for the ends of the heating tubes 31 are mounted between the adjacent vertical surfaces of the end walls 1 and the side walls 2 and the adjacent horizontal surfaces of the respective top and bottom portions of the end walls 1. The blocks 46 at their outer ends abut insulating plates 47 which are disposed adjacent to the inner faces of the hood end plates 4, the inner ends of the blocks 46 abutting shoulder members 2' formed upon the hood side walls 2. These refractory blocks 46 are formed with recesses 37 to accommodate the ends of the refractory tubes 31, these recesses 37 being somewhat larger in diameter than the diameter of the heating tubes 31. The blocks 46 are also formed with vertically aligned openings 38, the upper opening 38 having an open top and the bottom opening having a closed end, the openings 38 intersecting the recesses 37, so that sand 39 can be poured into the open top of the upper opening 38 to fill all the openings 38, which sand also fills in between the walls of the recesses 37 and the exterior surfaces of the heating tubes 31, all as shown in Figures 7 and 8. For facilitating the application of the sand 39, an adjacent corner of the top portion of the end wall 1 is cut off, as indicated by the number 38', Figure 7.

The blocks 46, at one end of the removable hood

(right hand end, Figures 1 and 7), are formed with vertically-aligned recesses, which recesses of each pair of blocks 46 are communicating and form a closed chamber 40. These chambers 40 form risers for the heating gases, as hereinafter explained. The extreme right hand ends of the refractory tubes 31, Figures 1 and 7, extend through the recesses 37 into these gas risers 40 so that thereby there is provided accommodation for expansion of the tubes 31 in the gas risers 40, as shown in Figure 7. A gas riser 40' is also provided at the left hand end of the heating tube structure, which riser 40' vertically connects adjacent tubes of two pairs of heating tubes 31. In other words, each right hand riser 40 connects the open ends of the two tubes of each pair of tubes, and the left hand riser 40' connects the open ends of one of each of two pairs of tubes. These two adjacent tubes can expand in the gas riser 40'. In the accompanying drawings, I show four vertically-aligned heating tubes 31, for purposes of illustration. The other two heating tubes 31 expand at their left-hand ends in vertical chambers 33 formed in two of the left hand blocks 46 and vertically-aligned with the gas riser 40'. Intersecting the risers 40 on the right hand side are openings 41 in the upper of each pair of blocks 46, and intersecting the top of the riser 40' on the left hand and also the lower chamber 33 on the left hand are similar openings 41, aligned communicating openings 47' being formed in the insulating plates 47 and the end plates 4, whereby heating gases can be fired into the refractory tubes 31 from burners 42. In the form of apparatus described, the burners 42 at the left hand end of the apparatus, Figure 1, fire into the lower tubes of the two pairs of heating tubes 31 and the burners 42 at the right hand end of the furnace are booster burners which fire into the upper tubes of the two pairs of refractory tubes 31, the lower tube having no outlet, but communicating with the upper tube of its pair through a riser 40. The upper tube of the lower pair of tubes 31 has an outlet flue 43 passed through one of the left hand end blocks 46, this flue 43 being provided with an ejector 44. The upper tube of the upper pair of tubes 31 also has an outlet flue 43 passed through a left hand block 46. If it is desired that the same heating gases pass through the entire vertical series of tubes 31, the lower flue 43 is covered by a cap 45 and the partially spent gases pass at the left hand end of the furnace from the upper of the lower pair of heating tubes 31 to the lower of the upper pair of heating tubes by means of the left hand riser 40', so that in that case the upper burner 42 on the left hand end of Figure 1 acts as a booster burner as well as the burners 42 at the right hand end of Figure 1 and the outlet for all the products of combustion is the upper flue 43 also passed through one of the left hand blocks 46.

To insure non-leakage of outside atmosphere into the heating compartment within the inner cover 51, sand 48, Figure 6, is piled upon the refractory base 19 exteriorly of the bottom edge of the cover 51.

Referring to Figure 11, a modified form of face joint between the ends of contiguous tube sections is utilized, consisting of an interlocking tongue and groove 52 in addition to the mere abutting of such end faces, such as is shown in Figure 10.

Referring to Figures 2 and 3, I illustrate a form of support for the heating tubes 31 and joint means for adjacent ends of contiguous sections of the tubes which provides for expansion between each two contiguous sections of the heating tubes. In this form of structure, the tubes are supported by tile 53 forming a chambered structure, the tile having abutting end faces formed with interlocked tongues and grooves 54, the adjacent ends of contiguous tube sections being spaced within the tile 53 so as to provide an expansion space 55. Recesses 56 in the tile 53 through which the tube section ends extend are somewhat larger than the diameter of the tube and the collar 57 which covers the adjacent ends of contiguous tube sections is also somewhat larger in diameter, as illustrated by the recess 58, than the diameter of the tube section. The chamber within the tile structure is filled with sand 59 and this sand sifts into the recesses 56 and 58 whereby leakage of gas is substantially entirely eliminated while permitting necessary expansion between adjacent sections of the heating tube structure.

The assembly of elements forming the annealing furnace which has been described lends itself with particularly satisfactory results to the use of heating tubes made of refractory material. The nature of the incorporation of the heating tubes in the removable hood, and the relation of the heating tubes to the heating chamber and the work positioned therein under the inner cover, render efficiently available the emissivity and thermo-conductive factors of the refractory heating tubes, as well as rendering available the mechanical strength thereof, at the same time effecting highly satisfactory and economical heating of the work by radiation from the heating tubes. The assembly allows for the necessary expansion of the refractory heating tubes without the subjecting of the latter to undue strains, and the arrangement of the tubes in vertically-aligned series, combined with the method of firing into, and venting from, the same, provide uniform heating temperatures throughout the work chamber. Leakage of heating gases from the heating tubes, and disturbance of the desired atmospheric conditions within the inner cover 51, are effectually prevented. These conditions under the cover 51 are variable for different purposes, all as well understood in the art, and the obtaining of which, whether neutral, oxidizing or de-oxidizing, are standard practices also well understood in the art, and a showing of which has not been included in the instant specification or accompanying drawings.

The operation of the described furnace is the one usually incident to that of an annealing furnace having a removable hood. Briefly, it consists in assembling the work 50 on the hearth plate 20, Figure 6, and then placing the inner cover 51 over the work, after which sand 48 is shovelled around the lower edge of the cover 51, and then the removable hood lowered onto the refractory base 19 with the flange 18 depending into the sand seal 22. Proper atmospheric conditions having been effected under the inner cover 51, the burners 42 are turned on and the heating continued so long as is suitable, the venting of products of combustion being through the two flues 43, Figure 1, or, if desired, the lower flue 43 is covered by the cap 45 and the entire venting of products of combustion takes place through the upper flue 43.

Referring to the type of furnace shown in Figures 12–16, refractory heating tubes 61 are permitted to expand at one end only. As shown in these figures, for the purpose of illustration, the expansion takes place at the right hand end

of the tube. The left hand end is secured in blocks 46^2 of a furnace end wall by cement 62, Figure 16. Blocks 46' at the right hand end wall 1 are formed with holes 63 therethrough somewhat larger in diameter than the diameter of the tube 61 and the end of the tube is passed through this hole 63 and extends outwardly from the blocks 46', Figure 13. An angle 64 is secured to the exterior face of the lower part of the wall plate 4 and secured to an extended end portion of the base plate 17 is a reversed angle 65 which forms with the angle 64 a box girder upon which is mounted a vertical metal plate 66 through enlarged holes 63' of which also extend the tubes 61, the plate 66 being positioned at such a distance exteriorly of the wall plate 4 as to form an intervening vertical space 67 which is open at the top and is filled with sand 68. This sand also sifts into the annular recesses between the exterior of the refractory tube 61 and the adjacent surfaces of the blocks 46' and plate 66. Secured to collars 69' which in turn are secured to the outer face of the vertical plate 66, and around the several holes 63' of said plate 66, are outwardly-extended hoods 69 into which the ends of the refractory heating tubes 61 extend and within which are provided expansion spaces 70 for the respective tubes 61, as indicated by dot-and-dash lines, Figure 13, alternate hoods 69 having openings 69^2 intersected by burners 71 which fire into vertically alternate refractory tubes 61. As shown in Figures 12 and 13, the burners 71 fire into the bottom tube 61 and the third from the bottom, the second and fourth tubes from the bottom discharging into flues 72 supported on vertically alternate hoods 69 and communicating with the chambers thereof. The heating medium passes at the left hand end of the furnace from the bottom tube 61 to the next higher tube, or from the tube which is the third from the bottom to the next higher tube, by means of risers 73 formed in the left hand blocks 46^2. In the form of furnace shown in Figures 12–16, each pair of heating tubes 61 is fired at one end only, the firing, and the venting of products of combustion, all being effected at one end of the furnace.

A modification of the form of furnace shown in Figures 12–16 is illustrated in Figures 17 and 18 in that the furnace end wall 1 and the blocks 46^3 thereof are formed with a vertical opening 75 which has an outwardly-bent upper section in which is mounted a metal funnel 75' which intersects and extends outwardly of the furnace wall plate 49 and thus serves as means for the feeding of sand 76 into the opening 75, which sand also sifts into the annular sections of enlarged tube-accommodating holes 77 formed in the blocks 46^3 of the furnace wall 1. In this form of furnace the ends of the refractory tubes 61' also project outwardly from the furnace end wall 1 and in the case of the lower tube and the tube third from the bottom receive heating gases from burners 79, and in the case of the alternate tubes discharge into flues 81, the burners 79 being mounted in outwardly-extended angular portions 78 of a wall plate 49 and the flues 81 having end collars 80 which are mounted upon the outwardly-extended tube ends. In the construction shown in Figures 17 and 18, the lowermost heating tube 61' of each pair of tubes expands at the right hand end in the space 82 afforded by the angular wall portion 78, and, in the case of the uppermost tube of each pair of tubes, which discharges into the flue 81, the expansion is accommodated exteriorly of the furnace, the flue 81 moving with the expanding tube.

An important feature of the various heating furnace designs shown and described in the instant application, in addition to the practicable incorporation therein of refractory heating tubes, is the extensive and flexible control of the heating whereby to obtain uniform heating or such localized heating as may be desired during the heating operation or certain stages thereof.

What I claim is:

1. A furnace including a casing having a base and a removable cover cooperating therewith to form a heating chamber, vertical series of refractory heating tubes so mounted in and supported by said cover upon opposed sides of the latter as to provide for expansion of the tubes, vertical passages formed in the cover wall respectively with which the several tubes of all the tubes of the several banks of tubes communicate, a bank of tubes comprising at least two tubes, burners firing respectively into at least one of said tubes of each of the several banks of tubes, at least one burner firing into the passage communicating with a bank of tubes, and a flue from each bank of tubes.

2. In a furnace, heating means and means for supporting the heating means so as to permit expansion of the latter, comprising a furnace wall, a heating element movably mounted in said wall and consisting of a plurality of communicating tube units of refractory material, means sealing the joints between adjacent units, means for applying heat interiorly of the heating element, means for exhausting products of combustion from the heating element, and spaced supports for the heating element mounted in the furnace wall and slidably engaging and supporting said joint-sealing means.

3. In a furnace, heating means and means for supporting the heating means so as to permit expansion of the latter, comprising a furnace wall, a heating element consisting of a plurality of communicating tube units of refractory material, including tube units substantially central of the length of the heating element, means sealing the joints between adjacent units, means for applying heat interiorly of the heating element, means for exhausting products of combustion from the heating element, the furnace wall being formed with expansion chambers into which the ends of the heating element extend, a substantially central support for the heating element mounted in the furnace wall and to which said central tube units are fixed, and other spaced supports for the heating element mounted in the furnace wall and slidably engaging and supporting said joint-sealing means.

4. In a furnace, heating means and means for supporting the heating means so as to permit expansion of the latter, comprising a furnace wall, a heating element movably mounted in said wall and consisting of a plurality of communicating tube units of refractory material, collars covering the joints between adjacent units and means for sealing the collars, means for applying heat interiorly of the heating element, means for exhausting products of combustion from the heating element, and spaced supports for the heating element mounted in the furnace wall and slidably engaging and supporting said collars.

5. A furnace including a casing having a base and a removable cover cooperating therewith to form a heating chamber, a vertical series of re-

fractory heating tubes so mounted in and supported by said cover as to provide for expansion of the tubes, vertical passages formed in the cover wall respectively with which all the tubes of the several banks of tubes communicate, a bank of tubes comprising at least two tubes, burners firing respectively into at least one of said tubes of each of the several banks of tubes, and a flue from each bank of tubes.

6. A furnace including a casing having a base and a removable cover cooperating therewith to form a heating chamber, vertical series of refractory heating tubes mounted in and supported by said cover upon opposite sides of the latter, said heating tubes being freely extended at their ends into the cover wall so as to provide for the expansion of the tubes, a vertical passage in said wall for each pair of tubes, the latter communicating at one end with said passage, vertical passages in the cover wall with which the other ends of the tubes communicate to provide communication between adjacent pairs of tubes, burners firing through the cover wall into the ends of the respective tubes, and flues extended outwardly of the cover wall and communicating with an end of the respective pairs of tubes.

7. A furnace including a casing having a base and a removable cover cooperating therewith to form a heating chamber, vertical series of refractory heating tubes mounted in and supported by said cover upon opposite sides of the latter, said heating tubes being freely extended at their ends into opposite sides of the cover wall so as to provide for the expansion of the tubes, vertical passages in one of said wall sides, a passage for each pair of tubes, the latter communicating at one end with said passage, vertical passages in the opposite side of the cover wall, the other ends of one tube of each adjacent pairs of tubes communicating with one of said last-mentioned passages, burners firing through said "opposite" side of the cover wall into the end of one tube of the respective pairs of tubes, burners firing through said "one" wall side into an end of the other tube of the respective pairs of tubes, flues from the respective pairs of tubes communicating each with a vertical passage in said "opposite" side of the cover wall, and means for controlling the passage of products of combustion as between said flues and said last-mentioned vertical passages.

8. A furnace including a casing having a base and a removable cover cooperating therewith to form a heating chamber, a vertical series of refractory heating tubes movably mounted in and supported by said cover, vertical passages formed in the cover wall with which respectively both tubes of the several banks of two tubes communicate, means for sealing and fastening an end of each tube in the cover wall adjacent said passages, burners respectively firing into the opposite end of a tube of the several banks of tubes, supports for the burners secured to the cover wall and having expansion chambers into which the ends of the cooperating tubes extend, flues for the respective banks of tubes, and supports for the flues secured to the cover wall and having expansion chambers into which the ends of their cooperating tubes extend.

9. A furnace including a casing having a base, a wall, and a roof, and forming a heating chamber, a vertical series of refractory heating tubes disposed in said chamber and movably mounted at their ends in said wall, burner housings secured to said wall and forming expansion chambers into which an end of a tube of the several pairs of tubes extends, burners firing into said housings, respectively, flues secured to said wall and having housing portions forming expansion chambers into which an end of the other tube of the several pairs of tubes extends, passages in said wall with which respectively the tubes of each pair of tubes communicate, and a plurality of spaced tube supports extended inwardly from said wall and slidably engaging the tubes.

10. A furnace including a casing having a base, a wall, and a roof, and forming a heating chamber, a vertical series of refractory heating tubes disposed in said chamber and movably mounted at their ends in said wall, plates secured to said wall, spaced from and forming sand chambers exteriorly of the latter, the ends of the tubes being extended through said plates, burner housings forming tube expansion chambers secured to said plates and into which one end of one of each of the respective pairs of tubes extends, burners firing into said end of said tubes through said housings, flues mounted upon an end of the other tube of each pair of tubes, passages in said wall with which the tubes of each pair of tubes communicate, and a plurality of spaced tube supports extended inwardly of said wall and slidably engaging the tubes.

LAZENBY C. HAMLINK.