

June 12, 1962

W. O. DOW ETAL

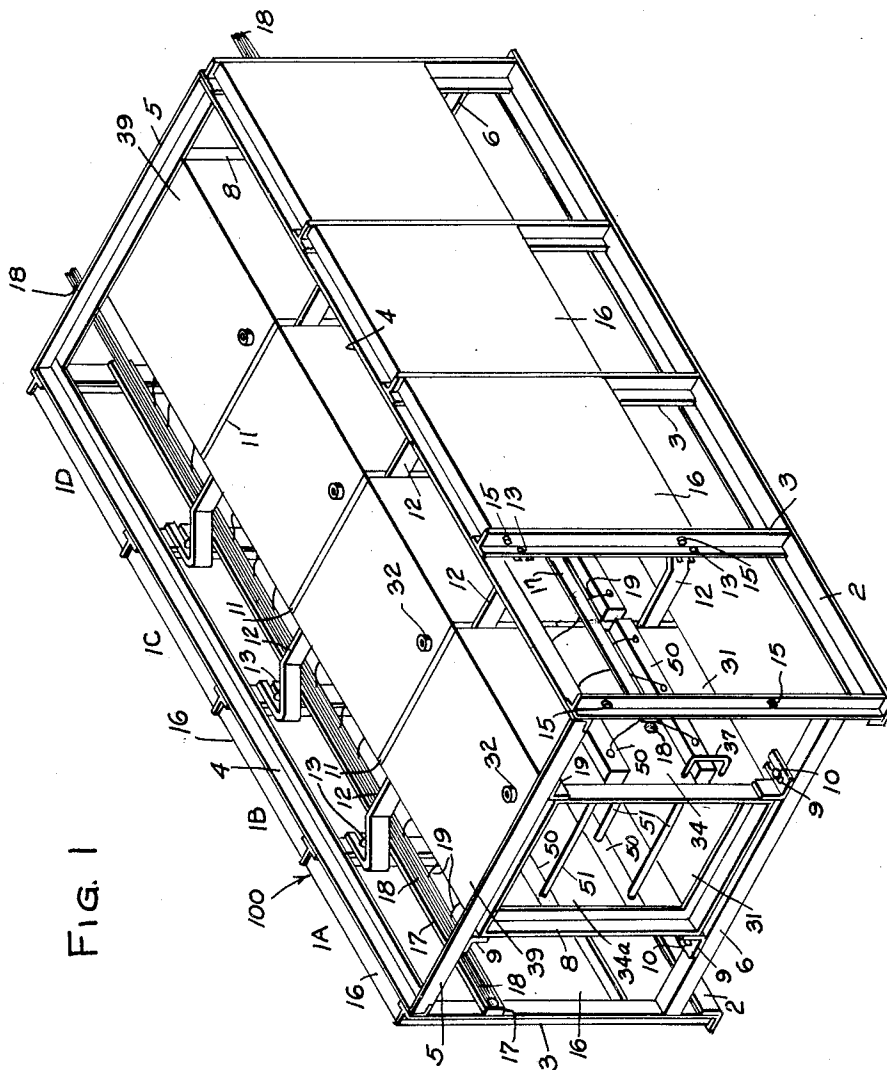
3,038,987

WATER-COOLED RADIANT-HEAT FURNACE

Filed Sept. 14, 1959

7 Sheets-Sheet 1

FIG. 1



INVENTORS:
WALTER O. DOW
ALBERT R. COLLINS
BY

Kegan, Bellamy & Kegan
ATTORNEYS

June 12, 1962

W. O. DOW ET AL

3,038,987

WATER-COOLED RADIANT-HEAT FURNACE

Filed Sept. 14, 1959

7 Sheets-Sheet 2

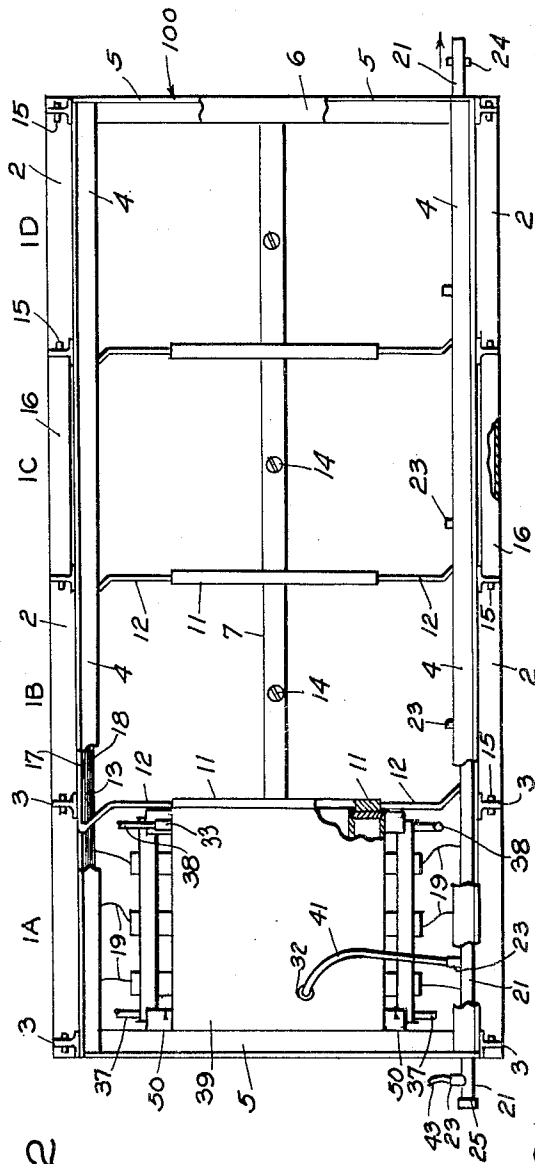


FIG. 2

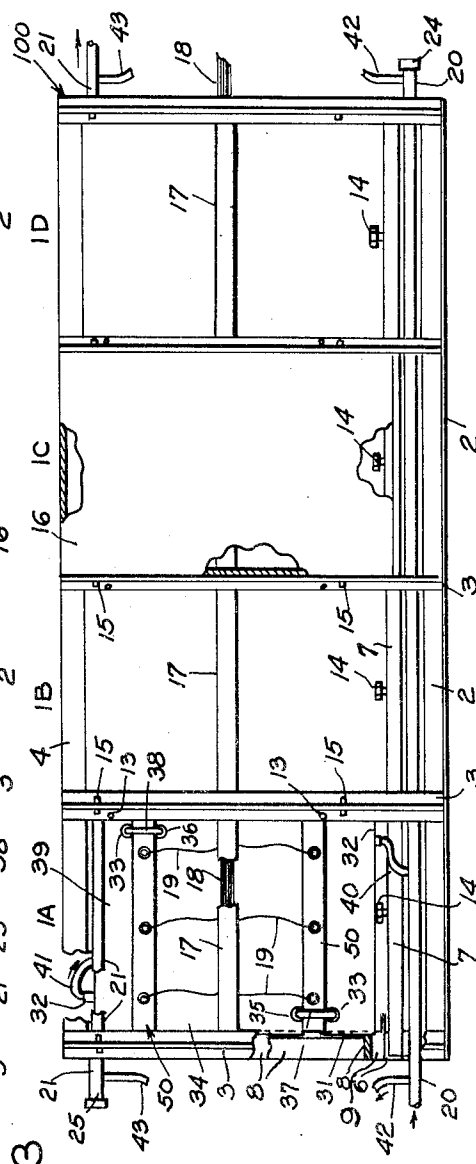


FIG. 3

INVENTORS:
WALTER O. DOW
ALBERT R. COLLINS

BY

Kegan, Bellamy & Kegan
ATTORNEYS

June 12, 1962

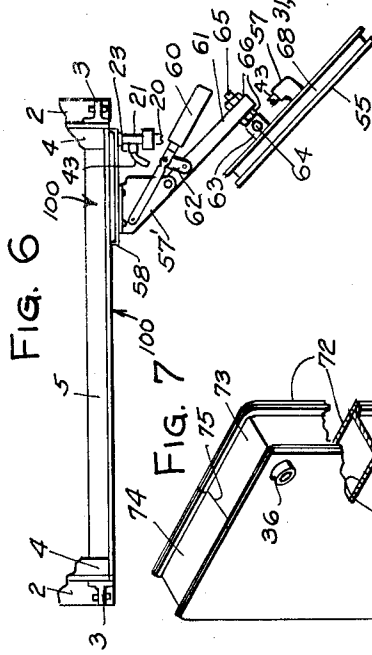
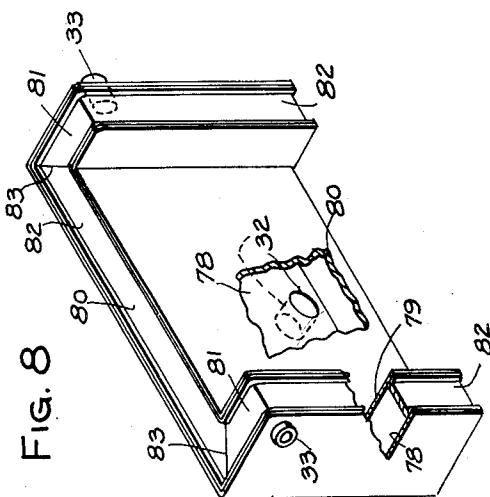
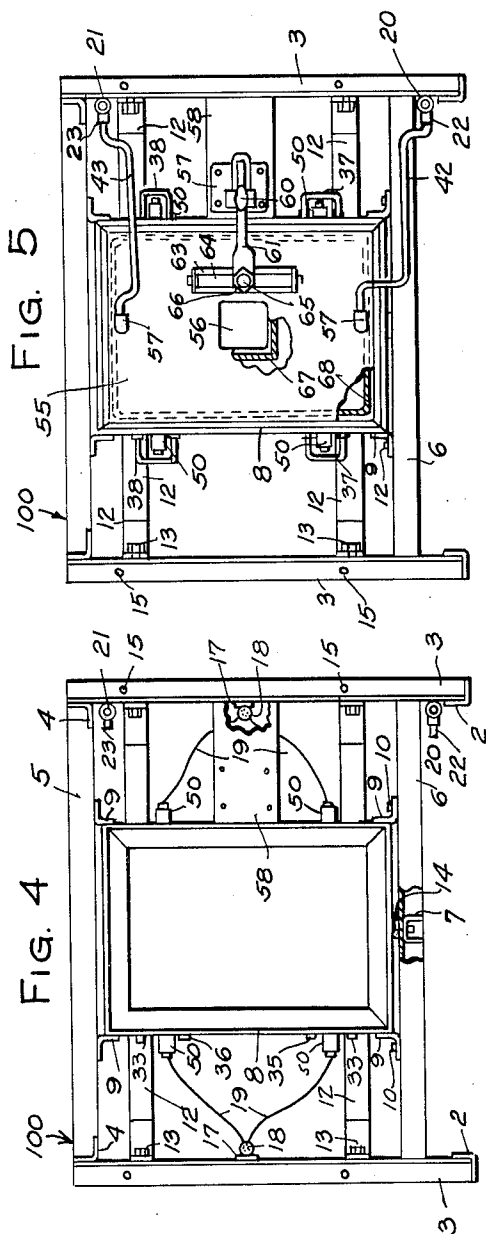
W. O. DOW ET AL

3,038,987

WATER-COOLED RADIANT-HEAT FURNACE

Filed Sept. 14, 1959

7 Sheets-Sheet 3



INVENTORS:
WALTER O. DOW
ALBERT R. COLLINS

BY
Kegan, Bellamy & Kegan
ATTORNEYS

June 12, 1962

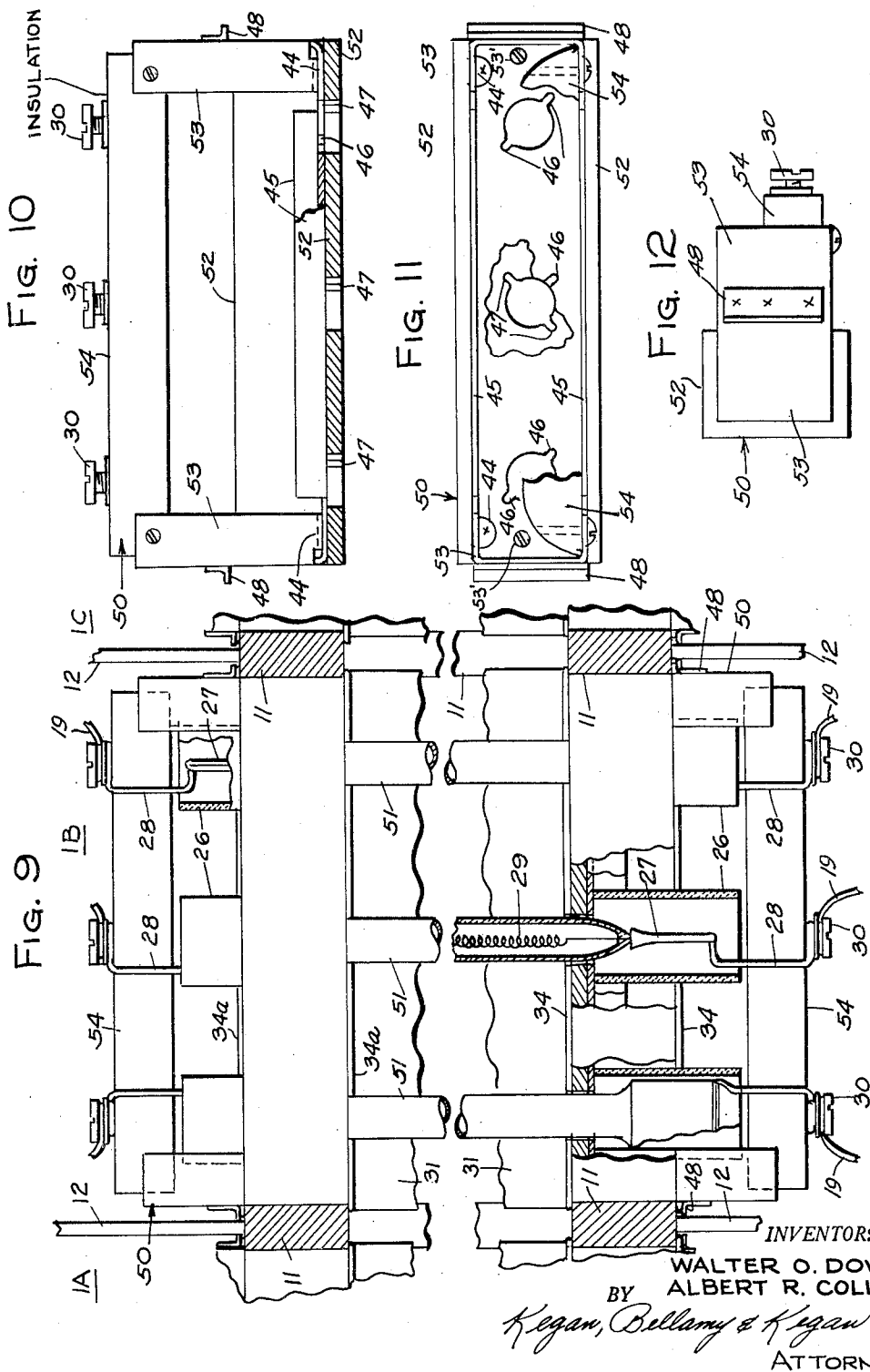
W. O. DOW ETAL

3,038,987

WATER-COOLED RADIANT-HEAT FURNACE

Filed Sept. 14, 1959

7 Sheets-Sheet 4



INVENTORS
WALTER O. DOW
ALBERT R. COLLINS
BY
Kegan, Bellamy & Kegan
ATTORNEYS

June 12, 1962

W. O. DOW ETAL

3,038,987

WATER-COOLED RADIANT-HEAT FURNACE

Filed Sept. 14, 1959

7 Sheets-Sheet 5

FIG. 13

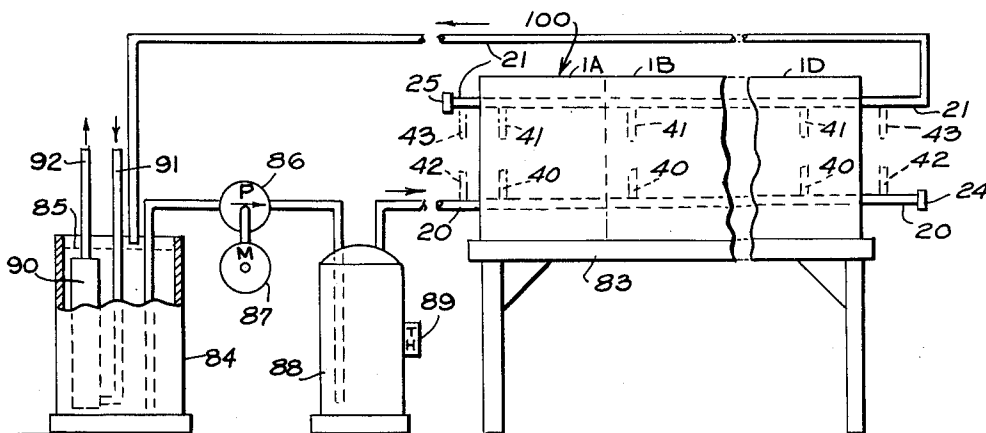
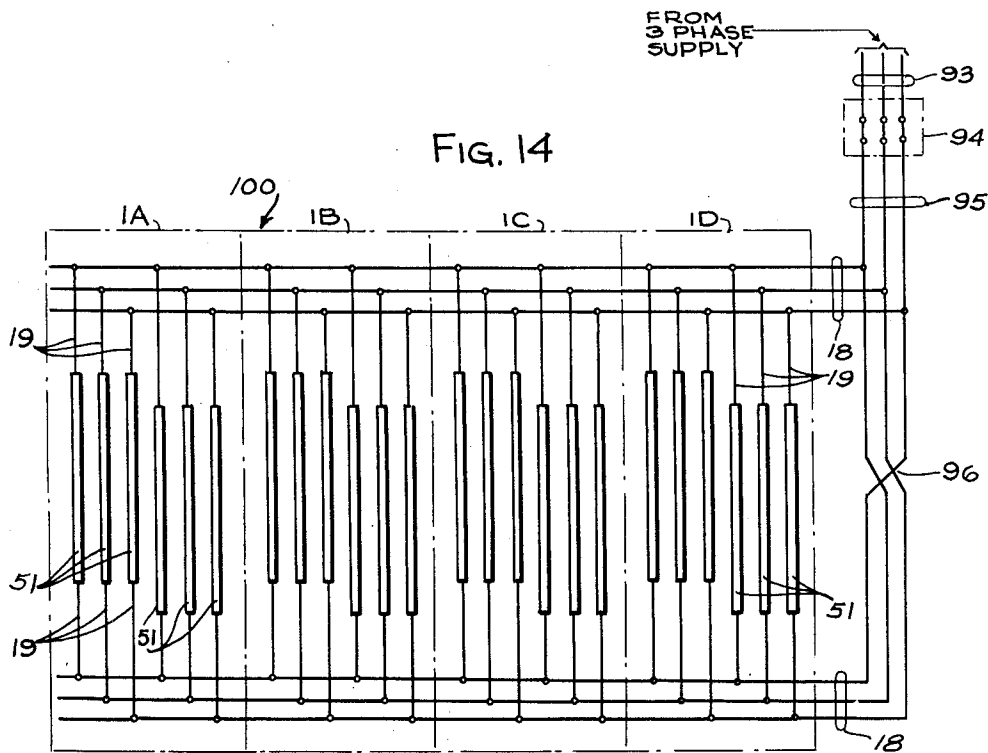


FIG. 14



INVENTORS:
WALTER O. DOW
ALBERT R. COLLINS
BY
Kegan, Bellamy & Kegan
ATTORNEYS

June 12, 1962

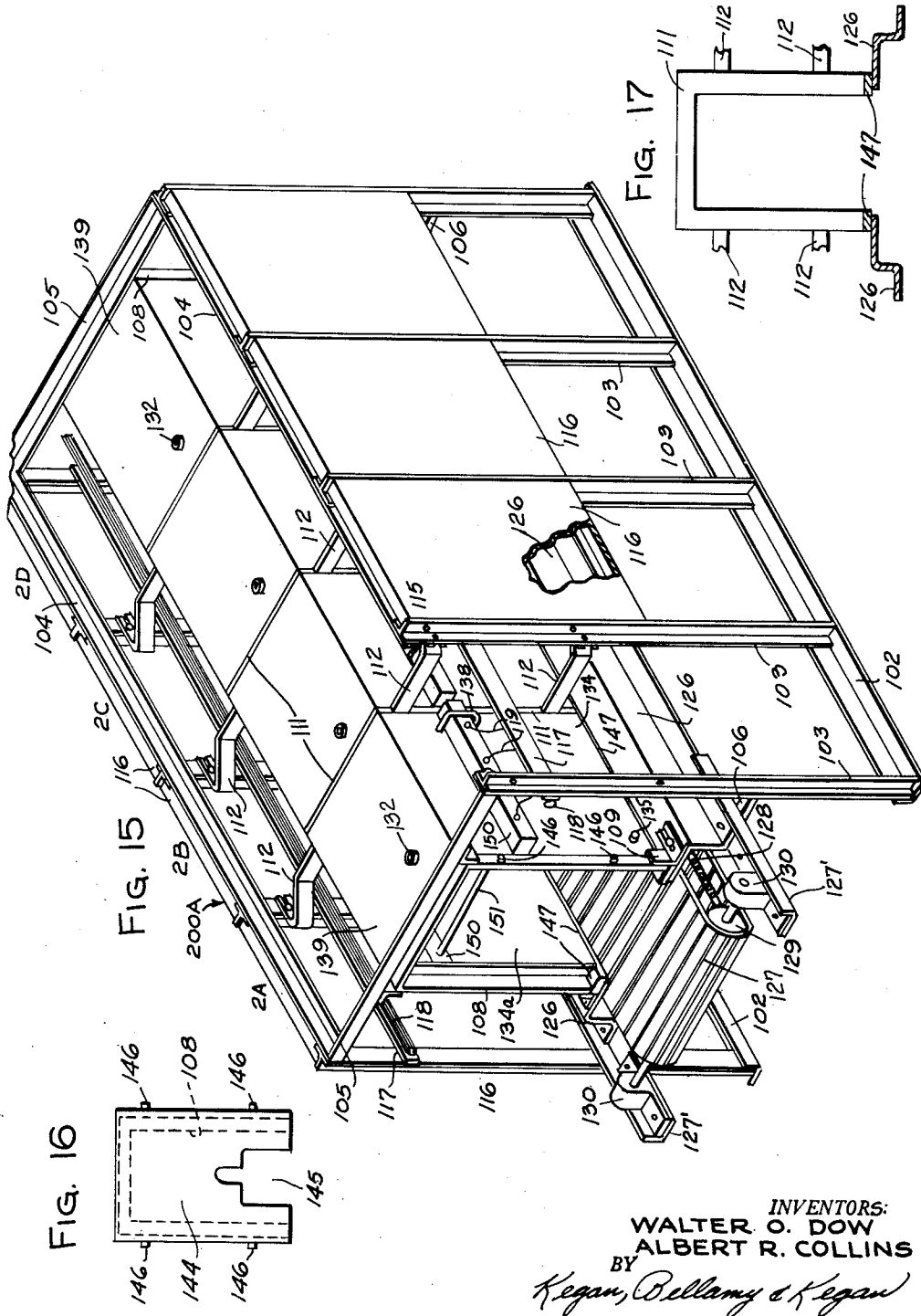
W. O. DOW ETAL

3,038,987

WATER-COOLED RADIANT-HEAT FURNACE

Filed Sept. 14, 1959

7 Sheets-Sheet 6



INVENTORS:
WALTER O. DOW
ALBERT R. COLLINS

BY
Kegan, Bellamy & Kegan

ATTORNEYS

June 12, 1962

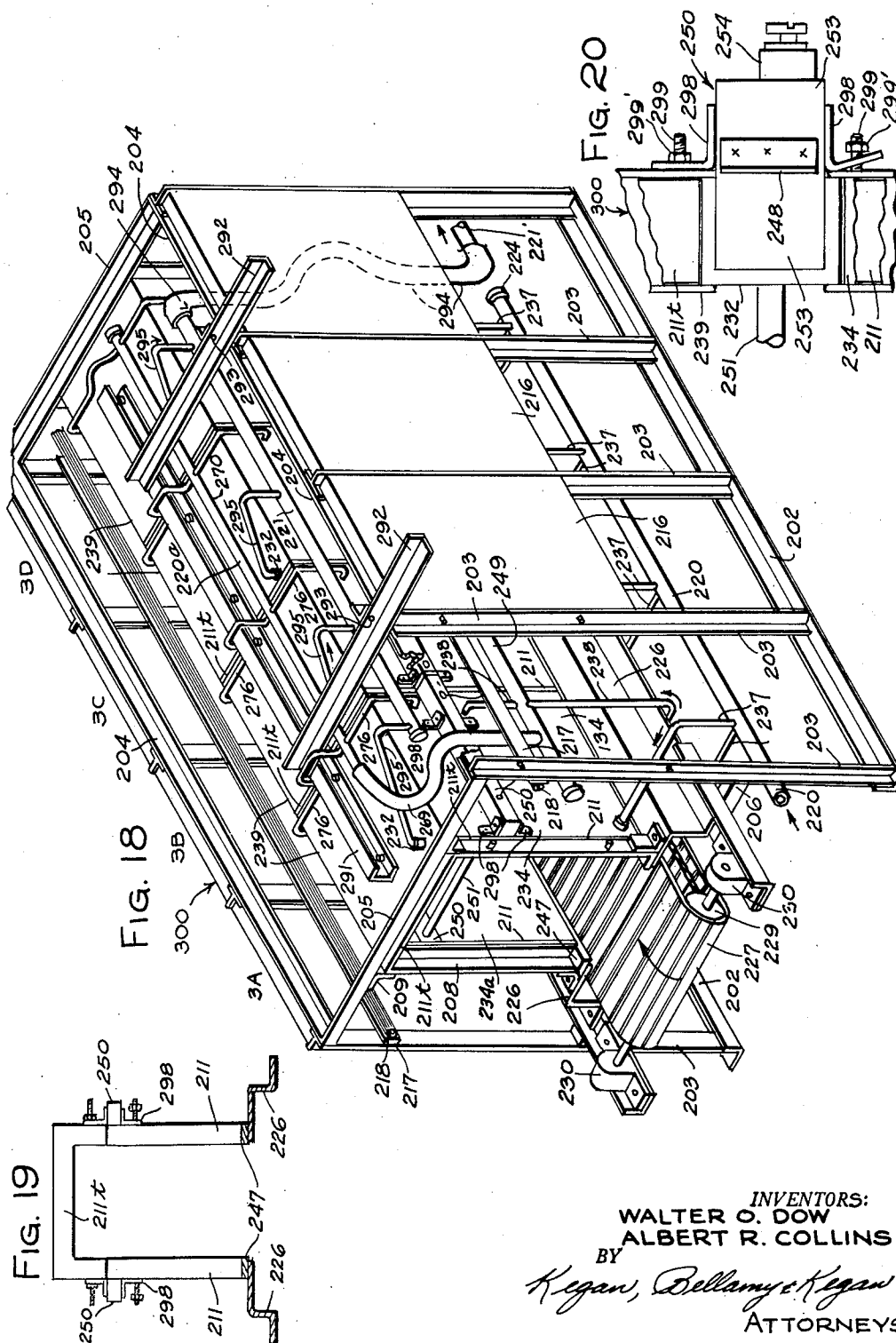
W. O. DOW ET AL

3,038,987

WATER-COOLED RADIANT-HEAT FURNACE

Filed Sept. 14, 1959

7 Sheets-Sheet 7



1

3,038,987

WATER-COOLED RADIANT-HEAT FURNACE
Walter Orville Dow, Wheaton, and Albert R. Collins,
Lombard, Ill., assignors to Arc Engineering Corpora-
tion, Lombard, Ill., a corporation of Illinois
Filed Sept. 14, 1959, Ser. No. 839,716
14 Claims. (Cl. 219—35)

This invention relates to radiant-heat furnaces, such as those heated by infrared electric lamps and reflector lined to conserve heat, and its principal object is to provide a new and improved construction for maintaining the reflective defining walls of a radiant-heat furnace cooled to preserve their physical form and reflectivity.

Heretofore, radiant-heat electric furnaces, as for soldering, brazing, annealing, and other heat treatments, have been heated by infrared electric lamps and constructed with internally polished and gold-plated metal side walls to lessen as far as possible the absorption of heat by such side walls, to the end that as much of the lamp-generated heat as possible is reflected onto the work pieces contained within, or being conveyed through, the furnace.

Outstanding advantages of furnaces of this type are that they quickly heat up to a stable operating temperature and are quickly cooled for inspection and servicing, and that they are relatively efficient in heat utilization, as compared to furnaces of thick-walled ceramic construction, for example. An outstanding difficulty, however, with these prior electric furnaces is the great tendency for the relatively small portion of heat absorbed by the reflective metal surfaces to destroy or seriously impair the reflectivity thereof, requiring frequent repolishing and replating.

Attempts have been made heretofore to preserve the reflective inner surfaces of the furnace walls by cooling the walls by fan-generated currents or blasts of air. This expedient, however, has proven to be inadequate in many instances, particularly for high-temperature brazing and annealing furnaces. In such furnaces, the reflective surfaces tend to become quickly heat-damaged, starting at certain spots or locations not capable of being supplied with a sufficient volume of cooling air, keeping in mind the relatively low specific heat of air.

According to the invention, the foregoing and other difficulties are overcome, and an economical and relatively service-free furnace construction is rendered feasible, by making the side walls of the furnace of hollow sealed construction and circulating a cooling liquid of high specific heat through the hollow portions, as by a suitable circulating water-supply system.

Features of the invention, of which three embodiments are herein disclosed, comprise (1) a sectionalized construction of the furnace wall components which permits making up a furnace comprising a desired number of successive sections, with the abutting portions of the sections joined by framelike internally reflective joining members which are maintained relatively cool by their contact with the water-cooled sections; (2) the provision of a regulatable and temperature-controlled recirculating water supply system which is maintained at a temperature below boiling but considerably above room temperature, whereby adequate cooling is maintained while insuring that condensation does not occur on the inner walls of a freshly heated furnace; (3) constructing each furnace section of separate parts between which receptacles for the heating lamps are snugly included and maintained cooled by contact with the adjacent water-cooled portions; and (4) providing a supporting frame structure which permits ready assembly and disassembly of the components of the furnace sections and which includes provisions for supporting readily demountable cover panels which protect workmen from accidental contact with the electric wiring through which the lamps are heated.

2

The foregoing and other objects and features of this invention and the manner of attaining them will become more apparent, and the invention itself will be best understood, by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, comprising FIGS. 1 to 20, wherein:

FIG. 1 is a diagonal view of a batch-type furnace according to the invention, with certain parts omitted for simplicity of illustration;

FIGS. 2 and 3 are a top view and a right-side view respectively, of the furnace of FIG. 1 showing certain of the parts omitted from FIG. 1;

FIG. 4 is a front view of the furnace of FIGS. 1 to 3 with the closing doors dismounted;

FIG. 5 is a front view of the structure with the front closing door in place and closed;

FIG. 6 is a partial top view of the front portion of the structure with the closing door in open position;

FIGS. 7 and 8 are diagonal views of the construction of respective water-cooled portions of a wall section;

FIG. 9 is a top sectional view of a portion of the furnace construction showing a set of heating lamps retained in position between overlying and underlying water-cooled wall portions, and also showing certain aspects of the construction of the lamp holders;

FIGS. 10 to 12 show one of the lamp holders respectively in a top view partly in section, in a front view partly in section, and in end view;

FIG. 13 is a diagrammatic view of an installation of a furnace according to FIGS. 1 to 12, showing the preferred elevated location of the furnace, and showing the cooling-water supply system;

FIG. 14 is a circuit diagram showing the conductors through which heating current is supplied to the lamps of the furnace of FIGS. 1 to 13;

FIG. 15 is a diagonal view of a conveyor form of furnace construction according to the invention;

FIG. 16 shows a disposable door-closure member having a cut-out portion for receiving conveyed work pieces of a predetermined size and shape to minimize heat loss through the door openings;

FIG. 17 is a partial front sectional view showing the intermediate retaining-frame structure for water-cooled portions of the furnace sections of FIG. 15;

FIG. 18 is a diagonal view of a further conveyor form of furnace construction according to the invention, with the top wall portion of the several sections secured together and arranged to be raised and rotated out of position to permit ready servicing access to the furnace interior;

FIG. 19 is a partial end view of the structure of FIG. 18 showing the segmented retaining-frame structure for the water-cooled members of the furnace; and

FIG. 20 is a fragmentary view illustrating how the lamp holders are selectively attached to the raisable top portion for movement therewith, and to the stationary lower portion of the furnace construction, to avoid the necessity of removing the lamps from their lamp holders when cleaning or servicing access to all interior parts of the furnace is desired.

First Embodiment—FIGS. 1 to 14

Referring now to FIGS. 1 to 14, the first embodiment comprises batch-type furnace 100 of FIGS. 1 to 6, employing details as shown in FIGS. 7 to 12, and installed according to FIGS. 13 to 14.

As shown best in FIGS. 1 to 6, furnace 100 comprises four similar aligned sections 1A to 1D, four sections being chosen merely for illustrative purposes. Any section 1A to 1D includes water-cooled bottom and top pans (or portions) 31 and 39, water-cooled side pans (or portions)

34 and 34a, and upper and lower pairs of interposed lamp holders 50 which hold an upper and lower set of heating lamps 51 therein.

The noted components of the sections 1A to 1D are supported in their illustrated assembled position by structure adjustably attached to the illustrated welded-steel framework. The framework comprises two base angle bars 2, ten T-bar uprights 3, and a top structure comprising two side angle bars 4 and two end angle bars 5. The welded framework further includes a separate end angle bar 6 for each end of the frame, between which is supported a longitudinal intermediate U-bar 7, preferably welded in inverted position (see FIG. 4) against the underside of the horizontal web of angle bars 6. Lower support bar 7 is preferably drilled and tapped medially of each section 1A to 1D to receive a separate adjusting screw 14 for each section to provide temporary support for the bottom pans 31 during the preliminary stages of the assembly of the defining wall structure of the furnace.

Frame 100 further includes two cable-support slats 17 welded to the inner face of upright bars 3 to support electric lamp-supply cables 18, which may be tapped, clipped, or laced to slats 17, as desired.

As seen best in FIGS. 1 to 5, the stem web of each upright T-bar 3 is pierced to rigidly receive two mounting pins 15 which protrude a short distance beyond each surface of such stem web to detachably receive a separate protecting cover plate 16 for each side of each furnace section. Each cover plate 16 preferably has side, top and bottom portions inwardly turned and welded together at the corners to provide rigidity, with the inwardly turned side portions provided with diagonal slots (not shown) into which the protruding ends of pins 13 are received when the cover is brought into position at a location slightly above its illustrated final location and allowed to move downwardly and inwardly to a securely hooked location from which it can be readily removed by lifting it upwardly and outwardly. One form of the noted cover slots is illustrated for a switchboard base plate in FIG. 200 of *Telephony Including Automatic Switching*, by Arthur Bessey Smith, Drake & Co., 1924.

Access to the interior of furnace 100 is through two similar door frames 8 to the furnace ends (FIGS. 1, 4, and 5), illustrated as of mitered welded construction. Each door frame 8 is adjustably held in position by four angle brackets 9 welded to the sides of the door frame and secured between angle bars 5 and 6 as by bolts 10. As seen best in FIG. 1, the horizontal portion of brackets 9 is open-slotted or bifurcate to adjustably receive bolts 10, permitting a substantial amount of longitudinal adjustment of either door frame to occur within the range of bolts 10. Thereby, either or both door frames 8 may be loosened and slid apart as needed for assembly or disassembly of the separate portions of any section 1A to 1D. When assembly is completed, the door frames may be brought toward each other before bolts 10 are tightened, thereby holding the sections 1A to 1D closely together in their illustrated assembled relationship.

Referring to FIGS. 7 and 8, it will be observed that the side pans 34 (FIG. 7) and the top and bottom pans 31, 39 (FIG. 8) are constructed with shallow channel-like marginal recesses 72 and 82 which face each other in the assembled position of the furnace portions and sections. Each door frame 8 is snugly received within the outwardly facing channel recess of pans 31, 39, 34, and 34a of its associated end section 1A or 1D, locking the associated pan ends in position against lateral movement out of adjustment.

An intermediate rectangular holding frame 11 is provided at each of the three junctions between sections 1A to 1D. Each frame 11 has a profile longitudinally of the furnace of the size and shape of that of the door frames 8. As indicated in cross-sectional view in FIG. 9, each intermediate frame 11 is made of fairly thick stock to provide a portion on each side of the frame to be received within

the facing marginal channel of the associated water-cooled members, leaving a central portion of frame 11 wide enough for support arms 12 to be weldingly attached. Each frame 11 has two pairs of support arms 12, as is illustrated best in FIGS. 1, 4 and 5.

The intermediate frames 11 and their attached support bars 12 are located generally opposite the intermediate ones of the vertical T-bars 3. Each bar 12 has its outer portion offset and bent to provide an end-slotted foot portion which is supported in its desired position of longitudinal adjustment by bolts 13 (FIGS. 1 to 5).

As shown in FIG. 7, each pan 34, 34a, of FIG. 1 comprises a frame 74, which may be formed of bent angle stock butt-welded as at 74' to provide a welded one-piece frame. The structure 34, 34a is completed by applying outer and inner side plates 71 and 72 to the frame member and welding each of them to the frame member 74 along their exposed coincident edges.

Preferably all parts of pan structure 34, 34a are composed of sheet nickel or equivalent metal or alloy which is corrosion-resistant, which readily takes a high polish, and which accepts and retains a corrosion-resistant plated reflecting surface, as of gold, which is highly reflective for infrared rays. The illustrated and described edge-welded construction has been found to be particularly free from warpage tendencies incident to the welding operation.

Outer side plate 71 of pan structure 34, 34a is provided with a lower welded-in threaded nipple 35 for receiving cooling water and a similar upper nipple 36 for discharging the received water, the two nipples preferably being diagonally disposed as illustrated and each being very near the outer edge of the pan. This is particularly important for the upper nipple 36, since it avoids entrapment of air within the enclosure when water is circulated therethrough.

After the side pan of FIG. 7 is assembled and welded, the inside surface (the surface opposite the one shown in FIG. 7) is preferably polished and gold plated.

The pan structure 31, 39 of FIG. 8 is generally similar to the structure of FIG. 7, except for the U-shaped cross-section of the pan of FIG. 8 to adapt it to comprise the U-shaped upper or lower water-cooled pan 39 or 31 of a furnace section. The frame of 31, 39 comprises two mitered U-shaped formed channel members 81 and two mitered straight channel members 80 welded together at locations 83 to form a unitary frame, to which U-shaped outer and inner closure plates are welded at the exposed coincident edges. Two threaded water-passage nipples 33 are welded to outer plate 78 at the ends of the short side arms of 31, 39, and a single threaded nipple 32 (seen in dotted outline in FIG. 8 and in full view in FIG. 1) is welded to the flat common portion of plate 78.

Referring to FIGS. 1 to 8, when the components of furnace sections 1A to 1D are to be installed in the welded frame, the door frames 8 and the intermediate frames 11 with their support arms 12 are first installed, as with only one door frame 8 (such as the front one) being firmly bolted in position. The other door frame 8, and the three intermediate frames 11 are adjusted toward the opposite end of the furnace frame a sufficient distance to permit the components of section A to be installed.

Section 1A may be installed by first installing a bottom pan 31 (of the structure shown at FIG. 8) with its short arms disposed upwardly, the associated screw 14 (FIGS. 2 and 3) being checked for a temporary-support setting at the approximate level desired for the bottom pan. The installed bottom pan 31 is preferably brought snugly against the rigidly bolted front door frame 8 to receive the inner lower portion of that door frame within the outwardly facing portion of channel 82 (FIG. 8), to the previously noted locking relationship.

Second, two lower lamp holders 50 of the construction illustrated best in FIGS. 9 to 12 are installed in the upwardly facing section of each bottom pan channel 82

5

(FIG. 8), with the terminal portion of the lamp holders facing outwardly as illustrated in FIG. 9, and with clips 48 on the concerned end of lamp holders 50 overlapping the inwardly facing edge portion of front door frame 8.

Third, the two side pans 34 and 34a (FIGS. 1, 3, and 7) are installed, each in resting position on a separate one of the installed lower lamp holders 50, the top portion of each such lamp holder 50 being received within the lower channel 73 (FIG. 7) of the installed side pan.

Fourth, the lamp holders 50 of the upper pair are next installed in the position indicated in FIG. 1, with the bottom portion of each encompassed within the top channel 73 (FIG. 7) of side pans 34 or 34a and in abutting locking relationship to the front door frame 8.

Fifth, top pan 39 of FIGS. 1 to 3 and 8 is installed atop the upper pair of lamp holders 50 in locking relation thereto and is slid longitudinally into locking relation with the upper portion of the front door frame 8 to complete the assembly of section 1A.

Sixth, the rear portion of installed front section 1A is locked in place by sliding the associated first intermediate frame 11 toward front door frame 8 until the leading first portion thereof is encompassed in the rearwardly facing channel 73 (FIG. 7) of side pans 34 and 34a and within the rearwardly facing channel 82 (FIG. 8) of bottom pan 31 and top pan 39.

Seventh, retaining bolts 13 are tightened to hold support arms 12 of the first intermediate frame 11 firmly in position.

The succeeding sections 1B to 1D may be assembled successively as described for section 1A, each assembled section being tightened and finally locked in position as described. When section 1D is assembled, it is locked by sliding the rear door frame 8 toward the front door frame 8 and tightening the frame by its bolts 10.

It is relatively important that a substantial metal-to-metal contact be maintained throughout the length of the completely assembled furnace in order that frames 8 and 11 be maintained cooled by metal-to-metal contact with the adjoining water-cooled portions or pans, but the section-to-section contact should not be so tight as to cause the expansion-induced buckling when the furnace is heated nor prevent the parts of an assembled section from settling down snugly together to firmly and coolingly contact lamp holders 50 under the added weight when the water-cooled pans become water filled.

It should be observed that the disclosed adjustable retaining arrangement for frames 8 and 11 permits disassembly of the components of sections 1A to 1D, as by a reversal of the described assembly operations, and that the disclosed construction also permits any desired section to be disassembled without disassembling any other section. For example, if disassembly of section 1B is desired, with the other sections remaining assembled, it suffices to loosen the bolts 10 and 13 which hold the frames for section 1A in place and to slide these two loosened frames and the components of section 1A longitudinally away from section 1B until the first intermediate frame 11 clears the water-cooled pans of section 1B sufficiently to permit the components of that section to be removed.

When the components of the last named section are re-assembled, the described loosened and longitudinally-moved frames 8 and 11 are reversely moved to locking position whereupon their holding bolts 10 and 13 are re-tightened.

Following the described assembly of the water-cooled pans and lamp holders of section 1A to 1D, lamps 51 may be installed in the lamp holders 50 by operations hereinafter described, and the lead wires 19 (FIGS. 1 to 4) carried in cables 18 may be connected electrically to the screw terminals 30 (FIGS. 9, 10, 12) of the lamp holders 50.

Next, the water connections are made through which cooling water is passed through the installed water-cooled pans. These connections include two tubular U-shaped

6

transfer connections 37 and two similar connections 38 (FIGS. 1 to 3 and 5) for each furnace section. Each transfer connection 37 is from outlet nipple 33 of bottom pan 31 (FIG. 3) to inlet nipple 35 of its associated side pan 34 or 34a, and each transfer connection 38 is from outlet nipple 36 of side pan 34 or 34a to the associated one of two inlet nipples 33 of top pan 39.

As shown in FIGS. 2 to 5, the right side of the frame of furnace 100 carries water-supply pipe 20 and water-return pipe 21. At each section of the assembled furnace, a supply tube 40 is extended from an outlet of supply pipe 20 to the inlet nipple 32 of bottom pan 35 to supply water which flows upwardly through both outlets 33 (see FIG. 8) of the bottom pan, through both transfer connections 37, into the side pans 34 and 34a, and through the two transfer connections 38 into both inlet nipples 33 (see FIG. 8) of top pan 39, for discharge at upper nipple 32 of top pan 39.

A return tube 41 (seen best in FIGS. 2 and 3) extends from outlet nipple 32 of top pan 39 of each section into a separate entrance nipple 23 in return pipe 21, whereby water circulated through the section is returned to the system through return pipe 21.

Through their described series-parallel connection between supply and return pipes 20 and 21, each of the described installed furnace sections is kept cooled during operation by a constant flow of water.

Referring to FIGS. 4 to 6, each of the door openings at 8 of the assembled batch-type furnace 100 is controlled by a separate furnace door, of which the hinged door 55 is illustrated in FIGS. 5 and 6 for the front door opening of the furnace. Bracket 58 on which the furnace door is hingedly mounted may be screw-attached between the associated door frame 8 and the right corner upright bar 3. In FIG. 5, the hinged door 55 is shown in closed position, wherein it is received within the outwardly extending angular portions of door frame 8 and in flat closing contact with the inwardly disposed webs of the angle members of which the mitered door frame 8 is composed. FIG. 6 shows the door 55 of FIG. 5 swung to open position.

The supporting hinge for door 55 is of available commercial construction. As shown best in FIG. 6, it comprises a base member 57 which may be screw-attached to bracket 58, and lever arm 60 pivoted at one end to base member 57 and held adjustably in place at the other end by nuts 66 threaded onto horizontal stem 65 of the T structure which includes a vertical stem 64 pivoted in bracket 63 weldingly attached to the outer face of door 55. The hinged arrangement further includes a handle member 60 pivoted at one end to base member 57 and pivoted at an intermediate point to one end of link 62 of which the other end is pivoted to an intermediate portion of weight-carrying arm 60.

The door 55 is water-cooled and is preferably of generally the same welded hollow construction shown in FIG. 7 for side pans 34 and 34a, in that it comprises a formed and welded channel frame 68 (FIG. 5) overlaid by front and rear plates.

Door 55 preferably has the disclosed centrally located inspection port 66, which may be plugged if desired when not in use. The space around inspection port 66 is preferably closed by an inner frame member 67 (FIG. 5) similar to outer frame 68 but with the frame channel facing inwardly to permit edge welding to the door plates around the port opening.

Each door 55 is maintained cool by the flow of water from supply pipe 20, through a nipple 22, flexible supply hose 42, into angular inlet fitting 57. The water return is through the upper angular fitting 57, flexible return tube 43, and nipple 23, to return pipe 21.

In the use of the batch-type furnace 100, work supports, not shown (as of ceramic construction), may be located along the furnace interior, as by being supported on the bottom thereof and extending upwardly alongside

of and between lamps 51 to provide a desired work-holding level at which work pieces requiring treatment may be supported of a length up to the length of the furnace. When any such work piece exceeds the length of the furnace, it may be treated a section at a time by allowing it to protrude through one or both inspection openings in the doors 55 (FIG. 5).

FIG. 9 illustrates a partially broken away top sectional view of installed sections 1A to 1C of the furnace construction of FIGS. 1 to 8. The section line for this view may be considered as taken just above the lower lamp holders 50, of FIGS. 1 and 3, which is somewhat above the lower support arms 12 of the first and second intermediate holding frames 11. The three infrared lamps 51 supported in the lower lamp holders 50 of section 1B are illustrated with parts associated with each lamp broken away to show structure otherwise hidden. Each lamp 51 is of available commercial construction, and includes an evacuated quartz tube which may contain the usual tungsten filament 29 (shown for the intermediate lamp), the ends of the quartz tube being flattened and supplied with the usual metal end cover 27, to which the usual stranded lead-in conductor 28 is attached. The lamp holders 50 are channel shaped and each has a separate opening through the channel base to receive the tubular portion of each lamp 51. The flattened terminal portion of each lamp 51 may be provided with a loose fitting ceramic tube or thimble 26 which is intended to afford some protection against mechanical injury of the lamp terminal.

It will be observed that the principal or channel portion of each lamp holder 50 fits snugly endwise between the adjacent faces of the locking frame 11; that the illustrated locking frames 11 are lockingly received within the facing channel portions of the water-cooled pans of section 1A to 1C; and that stop members 43 of lamp holders 50 contact the outer walls of frames 11 in the assembled lamp position which has been found to be of some aid to avoid inadvertently dropping the lamp holder within the furnace opening during assembly or disassembly of the components of a section.

Referring particularly to FIGS. 10 to 12, any lamp holder 50 comprises a base channel member 52, as of bright polished aluminum, having three openings through the bottom web for receiving respective lamps 51. Holder 50 further comprises a thin punched sheet-metal bracket formed into a main channel-shaped bracket portion having strengthening side walls 45, and two channel-shaped outwardly protruding arms 53. Terminal bar 54, of insulating material, is screw-attached to the outer end of arms 53. Tabs 44 formed inwardly from the side portions of arms 53 may be spot-welded to the web of the main channel portion for strength. Three terminal screws 30 are threadedly secured in insulating terminal bar 54 to serve as attachment points for lead-in conductors 28 (FIG. 9) of the lamps 51 and for supply conductors 19. A stop bracket 48 is welded to the end face of each arm 53 to serve the purpose explained in connection with FIG. 9.

As seen in FIG. 9, the flattened portion at the end of any lamp 51 is somewhat wider than the principal tubular portion of the lamp. Consequently, the round lamp openings through channel member 52, which are sized to closely receive the tubular portion of a lamp, are provided with oppositely disposed keyhole slots 47 (FIG. 11) through which the flattened end portion of a lamp 51 can be received when the lamp is rotated to a matching angular position.

The escape of radiant heat through keyhole slots 47 is undesirable because of the consequent heat loss and the tendency of escaping infrared rays to unduly warm insulating terminal bar 54. Accordingly, the lamp-receiving openings through the channel base of the main portion of the bracket member are sized to match the openings through channel member 52 and thus block key-

hole slots 47. The bracket member is normally attached to channel member 52 by a pair of screws 53'.

When the lamps 51 are to be installed in a pair of opposed lamp holders 50, either before or after the lamp holders are installed in the furnace, the bracket members with attached terminal bar 54 (if in place) are removed from each lamp holder by loosening screws 53', permitting the lamps to be inserted through the respective openings in the channel members 52, with the flattened end portion of the forward end of each lamp passing through its lamp opening in channel member 52 by virtue of the widening slots 47. When all three lamps are longitudinally in position, each is then rotated about 90 degrees to cause the flattened end portions to align with the slots 46 in the formed insert member of the lamp holder. Thereupon, each of the insert members may be placed in position and tightened by screws 53', thimbles 26 (FIG. 9) being slid in place during the assembly operation. Following this installation in the lamp holders 50 of lamps 51, the lead-in conductors 28 of lamps 51 are brought around their respective terminal screws 30, in position to receive current from supply conductors 19 (of cables 18) when such supply conductors are also passed around screws 30, and such screws are tightened.

When operated at standard full rated voltages, the filaments 29 of any lamp 51 may be at an incandescent operating temperature in excess of 2500 degrees Fahrenheit, radiating about 1000 watts for each ten inches of length. A major portion of the radiated energy, however, is in the invisible infrared portion of the spectrum, as is the radiation from the usual incandescent electric lamp.

The inside face of intermediate frame members 11 preferably presents a relatively efficient reflecting surface, as does the inwardly exposed portion of any lamp holder 50 and the inwardly exposed surfaces of door frames 8. It is usually satisfactory if parts 8, 11, and 50 comprise polished aluminum, as they represent only a small portion of the total inside surface of the furnace and are in metal-to-metal contact with the water-cooled pans 31, 39, 34, and 34a.

FIG. 13 illustrates furnace 100 of FIGS. 1 to 12 installed on an elevated surface, such as that provided by a sturdy table 83, and included in a water-cooling supply system which comprises combined cooling tank and reservoir 84, pump 86 driven by electric motor 87, water heater 88 controlled by thermostat 89, the previously described supply pipe 20, the previously described door-cooling and section-cooling connections within furnace 100, and the previously described return pipe 21, which discharges into cooling reservoir 84, as above water level 85.

Water heater 88 is preferably controlled through thermostat 89 to maintain the water therein heated to a desired water-supply temperature, such as 160 degrees Fahrenheit, whereby undesired temperature-induced condensation of water on the inside walls of the furnace (which would otherwise occur under high humidity conditions upon the starting of the furnace into operation) are precluded if heated water from tank 88 is started into circulation through the water system of furnace 100 shortly before the electric power is supplied, as at switch box 94 (FIG. 14), to the infrared lamps 51 through which the furnace is heated.

The rate at which water is pumped through the cooling system by pump 86 may be controlled (as by conventional throttle and/or by-pass valves, not shown, or by conventional regulation of the speed of motor 87) so that the temperature of the furnace-heated water returning over pipe 21, while raised, is well below the boiling point of water, as between 160 and 205 degrees Fahrenheit.

When the furnace 100 has been in operation for a substantial interval, the temperature of the water in the cooler-reservoir 84 may tend to exceed the maximum desired supply-water temperature (such as 180 degrees

Fahrenheit). In that event, immersed cooler or heat exchanger 90 within reservoir 84 is caused to cool the water in the reservoir by circulating a desired cooling medium through intake and discharge pipes 90 and 92 by any suitable or desired arrangement. The coolant circulated through 90 may be water which has been cooled by an above-roof cooling tower of conventional construction or by any other desired arrangement. Cooling the water in reservoir 84 by this arrangement rather than by supplying fresh cool water as required for cooling purposes is preferred because the same water continues to be recirculated through the water-cooled portions of furnace 100 and thus avoids mineral-deposit and related problems encountered with the water in some localities. It is feasible to use distilled water in the closed furnace cooling system if the locally available water contains too much depositable material.

Under normal operating conditions, as after a short cold starting period, thermostat 89 precludes the supply of heat at heater 88, since the water thus supplied from reservoir 84 is at or above the cut-off temperature of 89.

Referring again to the piping and water distribution system of the furnace 100 as indicated in FIGS. 2 to 6, and 13, the desirability of supplying an equal rate of flow of cooling water through both doors 55 (FIGS. 5 and 6) and of supplying an equal rate of flow through each of the sections 1A to 1D of the furnace, led to the disclosed arrangement wherein the water supply through 20 is connected at one end of the furnace and the water return through 21 is connected at the other end. Thus, with pipes 21 and 20 being of the same internal diameter, as is desired, increased supply-pressure loss along 20 to a distant section or door is offset because of a correspondingly decreased return-pressure loss along 21 from such distant section or door. Further, to insure accurate control over the equal flow of water through the several sections, each of the lower transfer nipples 37 of each side of each section (through which water entering a bottom pan 31 reaches the side pans 34, 34a of the section) may be of relatively small or controlling internal diameter (such as $\frac{1}{4}$ inch), while the smallest internal diameter of all other water passages is substantially larger (such as $\frac{3}{8}$ inch), whereby the principal pressure drop between the supply pipe 20 and return pipe 21 within any water-cooled section is at the noted lower transfer connection 37. It is, of course, not desirable to subject the bottom pans 31 to a sufficiently great water pressure to tend to cause bulging thereof, which can be readily avoided by making all openings sufficiently ample (while maintaining the noted proportioning) compared to the relatively small rate of flow of water required through any furnace section that only a small pressure loss occurs at flow-control lower transfer connections 37. This objective is readily attained because of the well-known relatively high specific heat of water.

The indicated water level 85 within reservoir 84 may be taken as that when the furnace 100 is not in operation and is drained (as by stopping the pump 86 to allow the water to drain back through supply pipe 20, heater 88, and pump 86). When, with the water drained from the furnace 100, pump 86 is started into operation, water level 85 is lowered toward the middle of reservoir 84 before the water-cooled pans of furnace 100 become filled to provide a full return flow through return pipe 21, following which the water level in reservoir 84 is expected to remain substantially constant during the remainder of the initiated use of furnace 100.

FIG. 14 shows a circuit diagram of a simple 3-phase electrical supply system by way of cables 18 (FIGS. 1 and 4) for the infrared heating lamps 51 of the furnace 100 of FIGS. 1 to 13. From the indicated 3-phase supply, three conductors 93 extend through a conventional switch box and fuse box 94 to supply conductors 95, which are connected in the indicated order to the three supply conductors in one supply cable 18, and are connected in the shifted order indicated at 96 to the respective supply con-

ductors in the other supply cable 18, to the end that the potential of a separate one of the three phases is supplied across each lamp 51 in any indicated group of three. It may be noted that each lamp holder 50 may support any desired number of lamps 51, according to the length of a furnace section and according to the wattage intensity desired in the furnace. For 3-phase work, however, it is preferred that the lamps be connected in groups of three, somewhat as indicated.

Any feasible or desired switching arrangement may be employed to cause a variable number of the lamps of the furnace to be lighted to correspond generally to the heat-intensity requirements from time to time, as by disconnecting one or more lamps of each furnace section, preferably according to a pattern that will leave the lamp load generally balanced among the three phases of the supply source.

Second Embodiment—FIGS. 15 to 17

The furnace 200 of FIGS. 15 to 17 may be similar to the furnace 100 of FIGS. 1 to 14, except for the herein-after described modifications thereof to provide continuous action through conveyor 17.

For convenience and clarity, the reference numerals applied in FIGS. 15 to 17 are, in general, each 100 numbers higher than respectively corresponding reference numerals used in the described drawings illustrating the first embodiment. By way of example, frame members 2 to 6 in the first embodiment correspond respectively to frame members 102 and 106 in the second embodiment.

It will be observed that upright T-bars 103 of the second embodiment are somewhat longer than the upright T-bars 3 of the first embodiment, which raises the furnace further above the base angle bars 102 of FIG. 15 to permit floor mounting of the structure while leaving the endless belt conveyor 127 at a convenient working height above floor level.

Because of the presence of endless belt conveyor 127 in the furnace structure of FIG. 15, the bottom pan and the lower lamp holders 50 and lamps 51 of the first embodiment are omitted, leaving each of the furnace sections 2A to 2D of furnace 200 (FIG. 15) as comprising side pans 134, 134a, a single set of holders 50 and lamps 51, and top pan 139.

As a consequence, the longitudinal intermediate support bar 7 and screws 14 of the first embodiment have no counterpart in the second embodiment, wherein side pans 134 and 134a of each section are supported on longitudinal reflective bars 147 which are received within the downwardly facing channel portions of the side pans. Bars 147 are supported in inwardly overhanging relation on the top flange of two Z-bars 126, supported in turn by extension angle bars 127 resting on cross angle bars 106, to which 126 and 127 may be bolted or riveted.

The conveyor apparatus at each end of furnace 200 is supported on extension angle bars 127 through bearings 130 which support the illustrated conventional conveyor shaft on which are chain gears 129 over which a pair of endless conveyor chains 128 of usual construction are trained. The active part of conveyor 127 comprises an endless succession of cross slats riveted or otherwise secured between the conveyor chains 128. A suitable driving motor (not shown) may be provided for driving the similar conveyor cross shaft (not shown) at the discharge end of the conveyor, and may operate the conveyor at a desired speed which will give any work piece deposited thereon the desired length of treatment during its passage through the furnace 200. The conveyor cross slats may be composed of any desired material of the general character of asbestos of suitable strength and which will withstand the comparatively high temperatures to which the belt is subjected and will reasonably reflect radiant heat.

The lamps 151 supported in lamp holders 150 are supplied with electric current from the two side cables 118 over terminal conductors 119, as described for the first embodiment. Cooling water is supplied to each of the

sections 2A to 2D of furnace 200 over supply and return pipes (not shown) generally as described for the first embodiment. From the noted supply pipe, two supply tubes extend to the intake nipple 135 of each of the side pans 134 and 134a, such supply tubes preferably being each of the same length to secure the same rate of flow through each side pan of the same section and each being preferably equally sized (as 1/4 inch internal diameter) for the flow-control purpose stated for lower transfer connections 37 of furnace 100.

From the side pans 134, 134a, the circulated water passes upwardly through transfer connections 138 to the inlets of top pan 139, and thence outwardly through return nipple 132.

Each of the door frames 108 of furnace 200 has retaining pins 146 supported on each side as shown in FIGS. 15 and 16. It is contemplated that door 144 (FIG. 16) will be provided in the form of a supply of low-cost discardable sheets, such as of bright aluminum foil. Any such sheet is preferably somewhat longer and wider than the door frame. It may be applied over the frame 108 and held in place by folding the excess length back over the top of 108, and by folding the width excess back along the sides of 108 and forcing it over, or crumpling it around, the retaining pins 146.

After a high-heat use period of some length, a door 144 usually oxidizes and discolors, whereupon it may be readily stripped off, discarded as scrap, and replaced by a new one.

It will be observed that door 144 has a lower open-slot cutout opening 145. This opening is sized and contoured as desired to match the size and contour of the work pieces currently being treated. Replaceable door 144 thus closes most of the door opening not needed for work pieces being conveyed by 127, thereby minimizing the heat loss from the furnace by radiation and by convection. It is contemplated that door pieces 144 will be provided in lots having cutouts 145 of respective sizes and contours according to the sizes and shapes of work pieces to be treated from time to time.

It will be observed that the door frames 108 are open-bottom three-sided frames resting on longitudinal bars 147, and that, as shown best in FIG. 17, the intermediate frames 111 are of similar open-bottom three-sided construction and rest on longitudinal bars 127 for sliding adjustment as necessary, through the attached support bars 112. Frames 108 and 111 are longitudinally adjustable, as described for frames 11 and bars 12 of the first embodiment.

Third Embodiment—FIGS. 18 to 20

Referring to FIGS. 18 to 20, conveyor-type furnace 300 shown therein may be similar to the furnace 200 of FIGS. 15 to 17 except for the hereinafter described modifications thereof, (1) to permit easier assembly and disassembly of the components of any and all sections thereof, (2) to permit ready servicing access to the entire interior surface, and (3) to facilitate handling of the lamp holders and assembled lamps of the section without likelihood of lamp breakage incident to servicing the furnace interior.

The reference numerals applied in FIGS. 18 to 20 are in general each 100 numbers higher than the respectively corresponding reference numerals applied in the drawings of the second embodiment, and 200 numbers higher than the respectively corresponding reference numerals applied in the drawings illustrating the first embodiment.

For example, frame members 2 to 6 of the first embodiment, which correspond respectively to frame members 102 to 106 in the second embodiment, correspond to frame members 202 to 206 in the third embodiment.

The third embodiment is particularly desirable for furnaces used extensively for brazing and other operations which require the use of flux which, when heated to operating temperature, gives off smoke and fumes

which tend to deposit a smoky or smoke-like film on the reflective inner surfaces of the furnace, necessitating comparatively frequent wiping or polishing of the interior furnace walls and of the infrared heating lamps 251.

To this end, the top pans 239 of the sections 3A to 3D of furnace 300 are connected together in common, as through welded threaded studs thereon through which they are removably secured to the rigid supporting channel bar 291, pivoted through welded-on angle bars 292 to be rotated upwardly and sidewardly through more than 90 degrees to an open position, with or without carrying the lamp holders 250 and assembled lamps 251 with the pivoted assembly.

The second and fourth right-hand upright T-bars 203 are longer than the remaining upright T-bars 203, with the additional upwardly extending portion having the front flange removed therefrom, leaving only an angle-bar upward extension to which the angle bars 292 are intermediately pivoted at points 293.

The locking frame structure between and at the ends of sections 3A to 3D is modified as hereinafter described to permit the top pans to be lifted freely in the noted pivoting-open movement, and the supply and discharge water connections are through flexible supply and discharge hoses 269 and 294 to permit the pivoting operation to occur without requiring the opening of any of the water connections to the water-cooled top pans. Pivot points 293 are preferably so located as to allow the assembly comprising parts 239, 291, and arms 292 to be pivoted upwardly and to the right more than 90 degrees (with the righthand covers 216 for sections 3A and 3C removed), to an over-balanced stable position wherein the free end portions of arms 293 contact the outer surface of the front web of the upright T-bars 203 to which they are pivoted.

In FIG. 18, left and right water-supply tubes 237 are extended from outlets of supply pipe 220 to the inlet nipples of side pans 234 and 234a. In one desirable arrangement, the left and right supply tubes 237 are of the same length to avoid flow unbalance through pans 234 and 234a, as by locating supply pipe 220 centrally below the conveyor 227. Supply pipe 220 is illustrated as attached along the right-hand side of the furnace frame for clarity of illustration. When it is preferred that supply pipe 220 be in the illustrated location, the excess length required in the right-hand supply tubes 237 to make them equal to the left-hand supply tubes 237, may be taken up by curving or coiling them (not shown).

In order to reduce the flexible-hose water-supply connections to the pivoted top-pan assembly to the single illustrated hose connection 269, an intermediate supply pipe 249 is fixed to the furnace frame to collect the water discharged, through right-side and left-side discharge tubes 226, from all of the water-cooled side pans 234 and 234a. With supply tubes 237, all of the same length as described, tubes 238 should all be of the same length for equality of water distribution, with the excess length of right-side tubes taken up by curving or coiling.

The cooling water received by intermediate distribution pipe 249 is carried through flexible hose 269 to top pan supply pipe 220a, which is part of the pivoted top-pan assembly. From pipe 220a, equal-length right and left supply tubes 276 for each section 3A and 3D are extended to the right and left supply nipples of the pivoted top pans 239.

In order to reduce the number of flexible discharge connections from the pivoted top pans to the illustrated single flexible hose connection 294, discharge pipe 221 is fixed with the pivoted assembly and receives the water discharged through nipples 232 of the top pans 239 through a separate discharge tube 295 for each furnace section. From pipe 221, the discharge water is carried through flexible hose connection 294 to pipe 221', which may extend to a reservoir such as 84 of FIG. 13.

It will be observed that each of the flexible connections

269 and 294 is indicated as having excess length in the illustrated closed position of furnace 300, thereby precluding undue stretching of 269 and 294 when the top assembly of the furnace is pivoted to its described open position.

When desired, as for furnaces of such width and height dimensions as would render it unfeasible to lean over the side-pan section of the opened furnace to service the inside of the top pans when opened only slightly more than 90 degrees, the outer ends of pivoted arms 292 may be terminated just outwardly of the pivot locations 293 to permit the top pans to be opened as much further as desired, as up to 180 degrees, or to approach to pendant position at 270 degrees.

Clearly, overhead power-lift apparatus (not shown) may be used for large furnace installations, but is often not required in view of available simple furnace-draining provisions, such as described for the first embodiment.

Referring to FIG. 19, along with FIGS. 18 and 20, the frame structure for use between adjacent sections and at the door end of each of the sections 3A and 3D comprises a pair of upright bars 211, resting on foundation lock bars 247 and secured thereto as by welding, end about even with the top surface of the lamp holders 250. Each such frame includes a bridging inverted-U top member 211t which may contact the top of its associated upright members 211 when the furnace 300 is in its illustrated closed position. The portions 211t of the three intermediate furnace frames (between 3A and 3D, 3B and 3C, 3C and 3D) are preferably held in place merely by being assembled in the space provided by the mutually facing channel portions of the adjacent top pans 239. The two end or door-facing top frame members 211t may be welded or otherwise secured to top pans 239 of end sections 3A and 3D, lying partially received within their door-facing channel portions.

When the furnace 300 is to be opened, as to clean and polish the inside walls of the furnace, the lamp holders 250 for each of the sections 3A and 3D may be selectively carried with the pivoted assembly or left behind, as desired. For this purpose, the selective clamping arrangement illustrated best in FIG. 20 is employed. To each upper and lower face of each side arm 253 of each lamp holder 250, may be welded an angle clamp bracket 298, having a vertically disposed open-end slot (not separately shown) in the vertical portion thereof which overlaps the outside portion of a top pan 239 and of a side pan 234 or 234a. Each top pan and side pan is provided with a welded-on threaded stud 299 normally received in the associated one of the noted unillustrated slots in brackets 298. Normally, nuts 299' may be tightened, as shown for the upper nut 299' in FIG. 20, to fixedly attached holders 250 to the overlying top pan and underlying side pan.

When the top-pan assembly is to be pivoted open as described, it may be elected first to carry the lamp holders 250 and their contained lamps 251 upwardly with the top-pan assembly. In this event, the nuts 299' associated with the top pans (if tightened) are all to be left tightened, while the nuts 299' associated with the side pans 234 and 234a (if tightened) are loosened as to the position shown in FIG. 20 to free the associated brackets 298 from the side pans. Then, all the lamp holders and their contained lamps are carried upwardly with the opened top-pan assembly, permitting free servicing access to the inside walls of the side pans and associated exposed inside surfaces, as well as providing cleaning or polishing access to the lower side of the raised lamps 251.

When the wiping or polishing operations have been completed for the side pans and associated surfaces, the top-pan assembly may be tentatively closed, following which the upper nuts 299' are loosened to free the associated upper brackets 298, and the lower nuts 299' are tightened to grippingly engage the lower brackets 298. Then, when the top-pan assembly is again pivoted to open

position, the lamp holders 250 and lamps 251 are left behind. Wiping, polishing and other inspection access is thus now freely afforded to the top of lamps 251 and to the inside portion of the opened top-pan assembly.

It may be observed that the individual lamp-supply conductors from cables 218 to the lamp holders 250 are not illustrated. These conductors may be similar to those illustrated at 19 of the first embodiment or at 119 of the second embodiment, but those for the pivoted right side are preferably sufficient long and flexible that they may be left attached without injury when the lamp holders and lamps are pivoted open and closed during the described servicing operations. Those for the left side are preferably provided with plug-in terminals (not shown) to permit their ready detachment when the lamp holders and lamps are to be swung open as described, and to permit their ready attachment when the furnace is reclosed.

While we have described above the principles of our invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of the invention.

We claim:

1. A water-cooled furnace having a defining wall structure comprising a series of similar wall-structure sections arranged end-to-end, each section having at least one inlet port and at least one outlet port interconnected by at least one passageway within the wall structure of the section, conduit means for supplying cooling water to all said inlet ports and for receiving discharge water from all said outlet ports, whereby all said sections are maintained cooled, means for holding the sections lockingly in their assembled end-to-end relationship comprising a separate locking frame interposed between the sections at each section juncture and contactingly and overlappingly keyed with each adjoining section to limit relative movement between each locking frame and its adjoining sections in directions parallel to the plane of contact between the locking frame and a section, heat received from the furnace by the locking frames being conducted therefrom by contact with the adjoining sections.

2. An electrically heated water-cooled radiant-heat furnace comprising a series of similar wall-structure sections arranged end-to-end to provide a desired furnace length, the wall structure of each section having a pair of opposed openings therethrough, at least one electrically heated radiant-heat unit extending across the section and supported in said openings, each section including inlet and outlet water ports interconnected by at least one passageway contained within the wall structure of the section for a flow of cooling water therethrough, each of the said opposed openings of any section containing a separate heat-unit holder, the holders of any section supporting a plurality of the said heat units disposed in a row extending along the furnace.

3. A sectional furnace according to claim 2, wherein each section comprises at least two segments separated to provide said openings between them, the said holders lying between segments and serving to key them together against relative in-and-out movement, each segment having its own passageway-connected inlet and outlet cooling-water openings to permit passage of cooling water through all segments of a section despite their separation by the said holders.

4. A water-cooled furnace comprising water-cooled side walls and a removable water-cooled top portion, means including supply and return conduits connected to said side walls and to said top portion for circulating cooling water through them, and means including flexible water connections between the top portion and the conduits for permitting the removal of the top portion for servicing access to the furnace interior while said conduits remain connected thereto, a furnace-supporting framework including side structure extending along the

15

furnace, and means pivoting the said top portion on the side structure for movement upwardly and outwardly away from the said side walls, the furnace comprising a series of separate sections disposed end-to-end, each section including side walls and a top portion, the said pivoting structure including means for securing the top portion of the sections together to undergo the said pivoting movement as a unit.

5. A radiant-heat electric furnace employing electric lamps as the source of radiant heat, the furnace including opposed side walls and a bridging top portion removably assembled therewith, lamp holders interposed between respective side walls and the top portion, the electric lamps being mounted in the lamp holders and extending across the furnace between them, means including selective fastening means for either fastening the lamp holders to the top portion for removal therewith or for leaving them unfastened to the top portion to remain assembled with the side walls when the top portion is removed.

6. Segmented wall structure for a water-cooled radiant-heat furnace comprising a wall composed of adjoining segments assembled in edge-to-edge relationship, each segment comprising opposed inner and outer metal plates each sealingly attached to a metal frame member which extends continuously along the edge of the segment, the plates being spaced apart by the frame member to leave a sealed water compartment between them, the outer plate containing at least two ports for the circulation of cooling water, the said frame member of each said segment presenting an outwardly facing open channel, opposed to a similar channel of any adjoining segment, to permit adjoining segments to be locked together against substantial relative in and out movement by a member lying between adjoining segments and having portions received within their mutually facing open channels.

7. A water-cooled radiant-heat furnace having segmented wall structure according to claim 6, the segments being assembled in a series of sections in end-to-end relationship, structural framework for supporting the wall structure, a pair of end frames received in said channels of the segments of the end sections to hold the extreme ends of the wall structure against in an out movement, a separate intermediate frame at each junction of two sections, each intermediate frame having opposed channel-engaging portions received in the respective facing channels of the sections to hold the sections against relative in and out movement, and means for securing said frames to said frame structure while permitting at least a plurality of the frames to be adjusted longitudinally of the frame structure to facilitate assembly and disassembly of the said sections.

8. In combination, a water-cooled radiant-heat furnace comprising wall structure having a heat-reflective surface defining the furnace cavity and containing a passageway for cooling water for reducing the temperature of the wall structure, a cooling-water-supply system including a supply conduit leading to said passageway, and external means for heating the water supplied to said passageway to a temperature which will heat the wall structure sufficiently to inhibit condensation of moisture on the said heat-reflective surface when the furnace is being started into operation.

9. A combination according to claim 8, which further includes means including a pump for recirculating the supplied water, and means including a heat exchanger for maintaining the recirculated water substantially below its boiling point.

10. In combination, a water-cooled radiant-heat furnace comprising furnace-wall sections disposed end-to-end, each section including a cooling-water passageway connecting an inlet port with an outlet port, a supply conduit of a given size extending to and along the sections in a given direction and having outlets at respective sec-

16

tions similarly connected to the inlet ports thereof, a discharge conduit of said given size extending to and along the furnace sections in a direction opposite to said given direction and having inlets at the respective sections similarly connected to the outlet ports thereof, whereby the drop in water pressure from supply-conduit outlet to discharge-conduit inlet is the same for all sections.

11. In combination, a water-cooled radiant-heat electric furnace comprising an end-to-end assembly of furnace sections each having a water-cooling passageway there-through, each passageway extending from an inlet port local to the section to an outlet port local to the section, means including a supply conduit for supplying cooling water to the inlet ports, means including a return conduit for returning the supplied cooling water from the outlet ports, means connected between the return and supply conduits for continuously circulating the same supply of cooling water through the conduits during furnace operation, the temperature of the returned cooling water being higher in the return conduit than it is in the supply conduit, heat-exchange means connected between the return conduit and said circulating means for cooling the returned cooling water, and a thermostatically controlled water heater, connected in series with said circulating means and said heat-exchange means, for heating the water circulated therethrough sufficiently to inhibit condensation of moisture on the inside of the furnace when the furnace is being started into operation.

12. In combination, a water-cooled radiant-heat electric furnace comprising an end-to-end assembly of furnace sections each having a water-cooling passageway there-through, each passageway extending from an inlet port local to the section to an outlet port local to the section, means including a supply conduit for supplying cooling water to the inlet ports, means including a return conduit for returning the supplied cooling water from the outlet ports, means connected between the return and supply conduits for continuously circulating the same supply of cooling water through the conduits during furnace operation, the temperature of the returned cooling water being higher in the return conduit than it is in the supply conduit, means connected between the return and supply conduits for cooling the returned cooling water, and heating means serially related to the supply conduit for heating the supplied water for the beginning of a furnace operation.

13. In a combination as set forth in claim 12, means including thermostat means for preventing the heating of the supplied water above the boiling point thereof.

14. In combination, a water-cooled radiant-heat electric furnace comprising an end-to-end assembly of furnace sections each having a water-cooling passageway therethrough, each passageway extending from an inlet port local to the section to an outlet port local to the section, means including a supply conduit for supplying cooling water to the inlet ports, means including a return conduit for returning the supplied cooling water from the outlet ports, means connected between the return and supply conduits for continuously circulating the same supply of cooling water through the conduits during furnace operation, the supply and return conduits being of similar size to provide similar drops in pressure therealong, the conduits extending along the furnace in opposite directions to cause the pressure drop from one to the other to be of the same value all along the furnace to insure the same flow through all furnace sections, the inlet and outlet ports of any section being connected to the respective conduits by respective inlet and outlet branch conduits which have substantially the same total length at any section as at any other section in furtherance of the arrangement for insuring the uniformity of flow through the several sections.

17

References Cited in the file of this patent

UNITED STATES PATENTS

664,866	Howatt	Jan. 1, 1901	1,830,318
1,181,283	Batchell	May 2, 1916	2,469,253
1,231,196	Rankin et al.	June 26, 1917	2,721,736
1,438,936	Eimer	Dec. 12, 1922	2,844,699
1,499,317	Beyer	June 24, 1924	2,981,819
1,598,779	McArthur	Sept. 7, 1926	484,199
1,686,100	Okell et al.	Oct. 2, 1928	415,725

18

Harlan	Nov. 3, 1931
Achey	May 3, 1949
Reece	Oct. 25, 1955
Miskella	July 22, 1958
Gregory	Apr. 25, 1961

FOREIGN PATENTS

Great Britain	Apr. 28, 1938
Italy	Oct. 28, 1946