

Feb. 25, 1969

I. F. ANDERSEN ET AL
HEAT-TREATING QUENCH FURNACE

3,429,563

Filed Oct. 12, 1967

Sheet 1 of 5

Fig. 1.

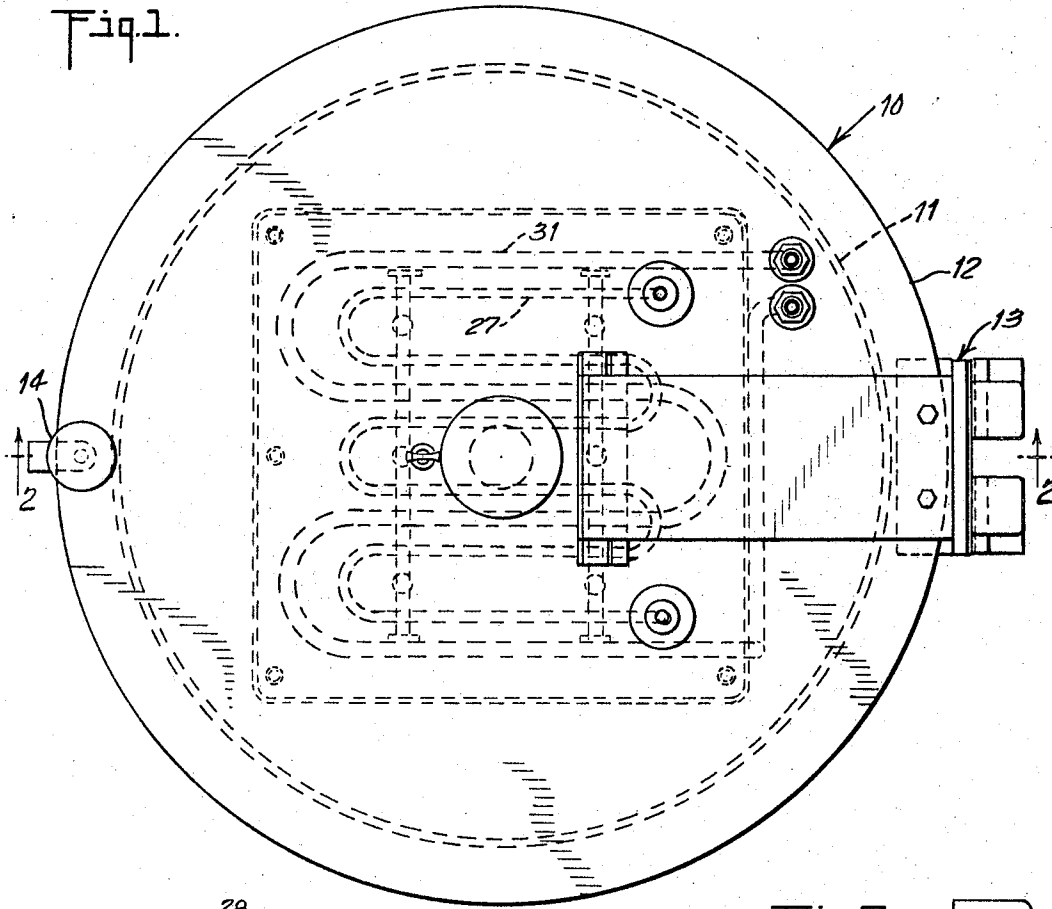


Fig. 8.

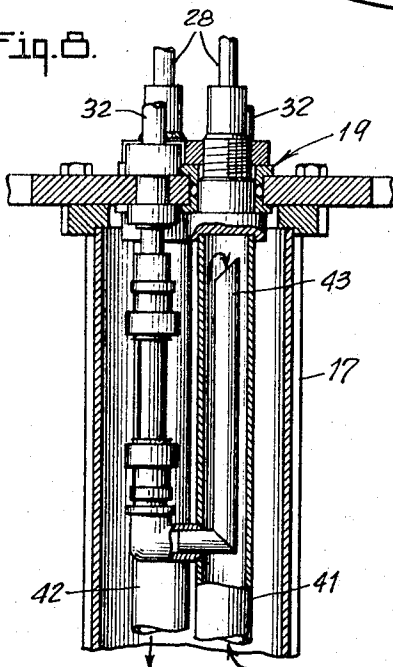
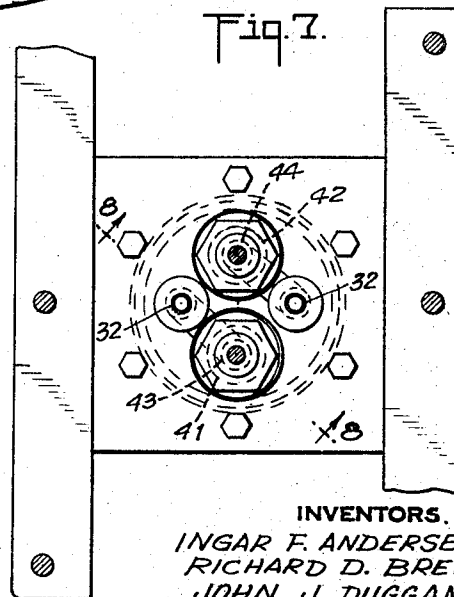


Fig. 7.



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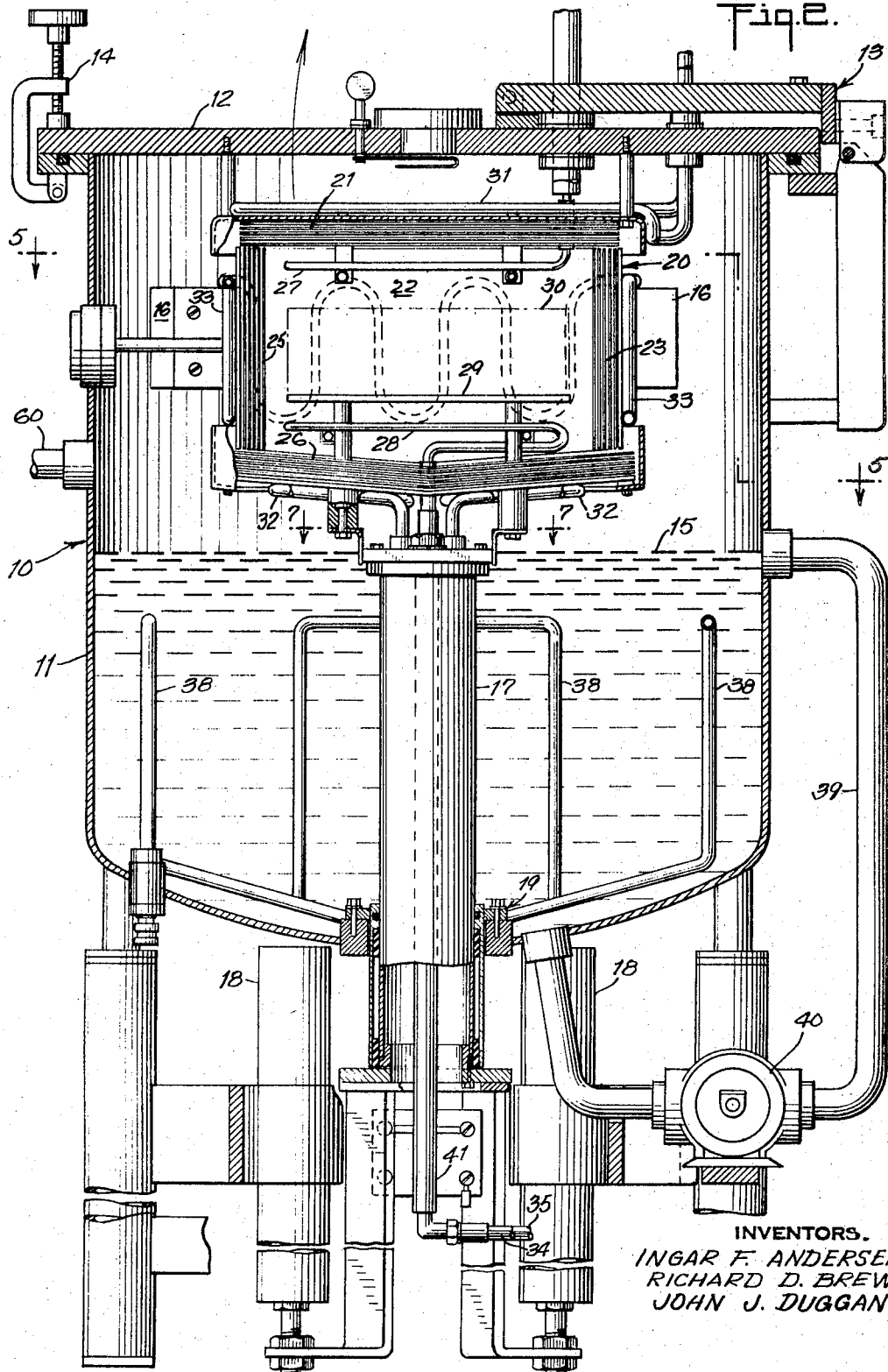
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Filed Oct. 12, 1967

Sheet 2 of 5



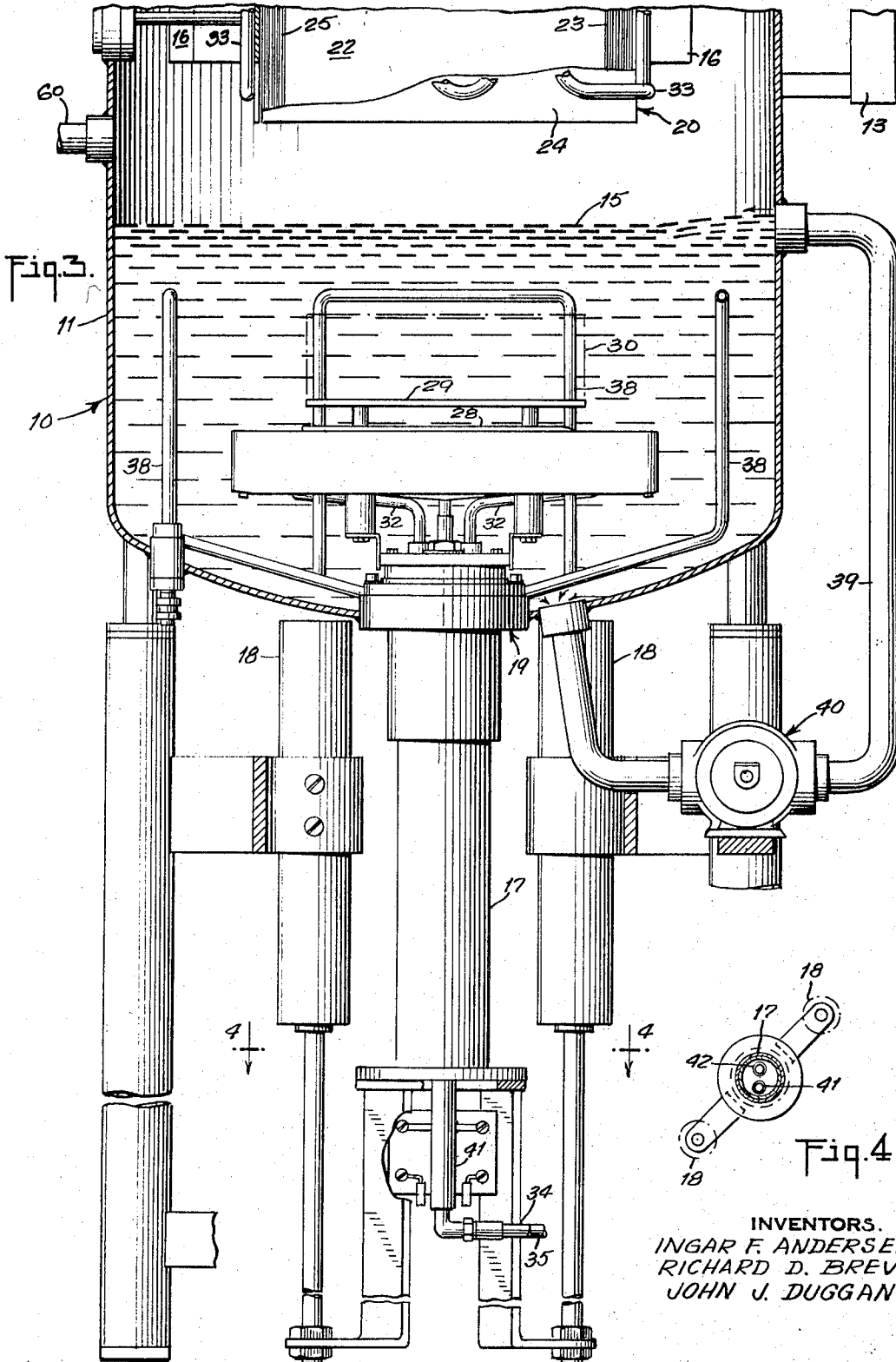
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Filed Oct. 12, 1967

Sheet 3 of 5



Feb. 25, 1969

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Sheet 4 of 5

Fig. 5.

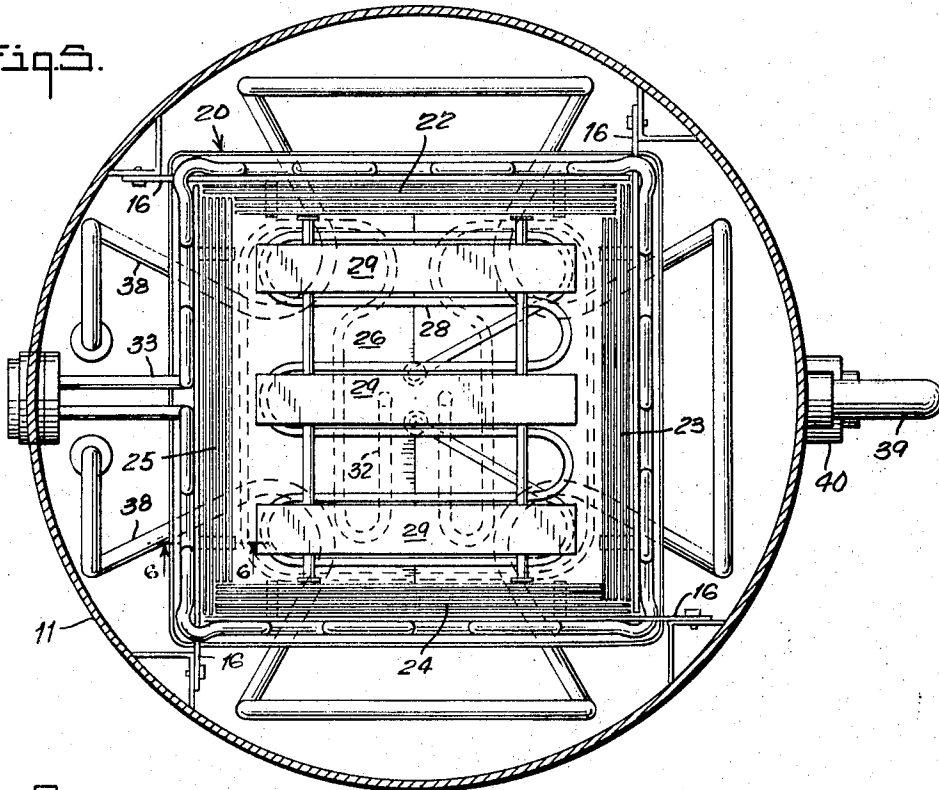


Fig. 9.

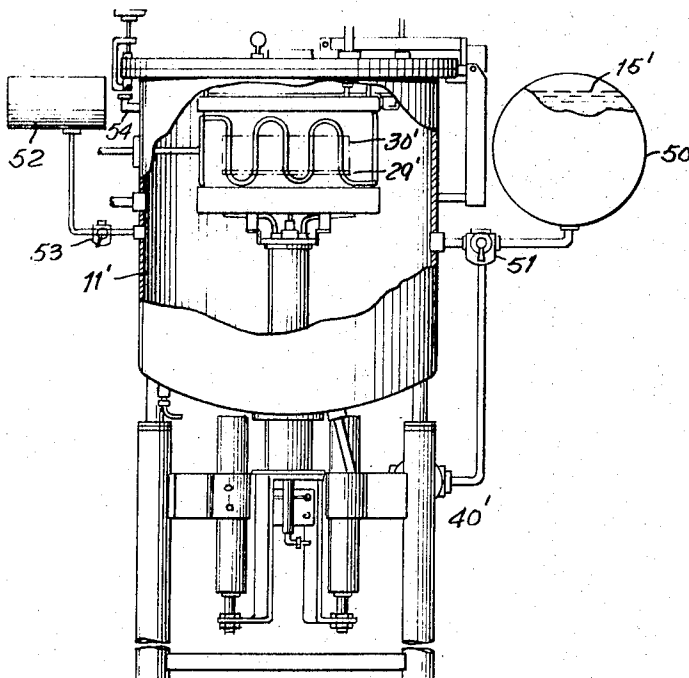
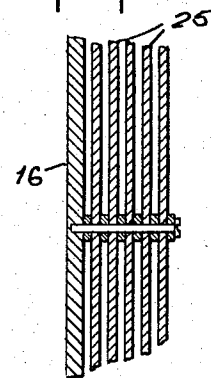


Fig. 6.



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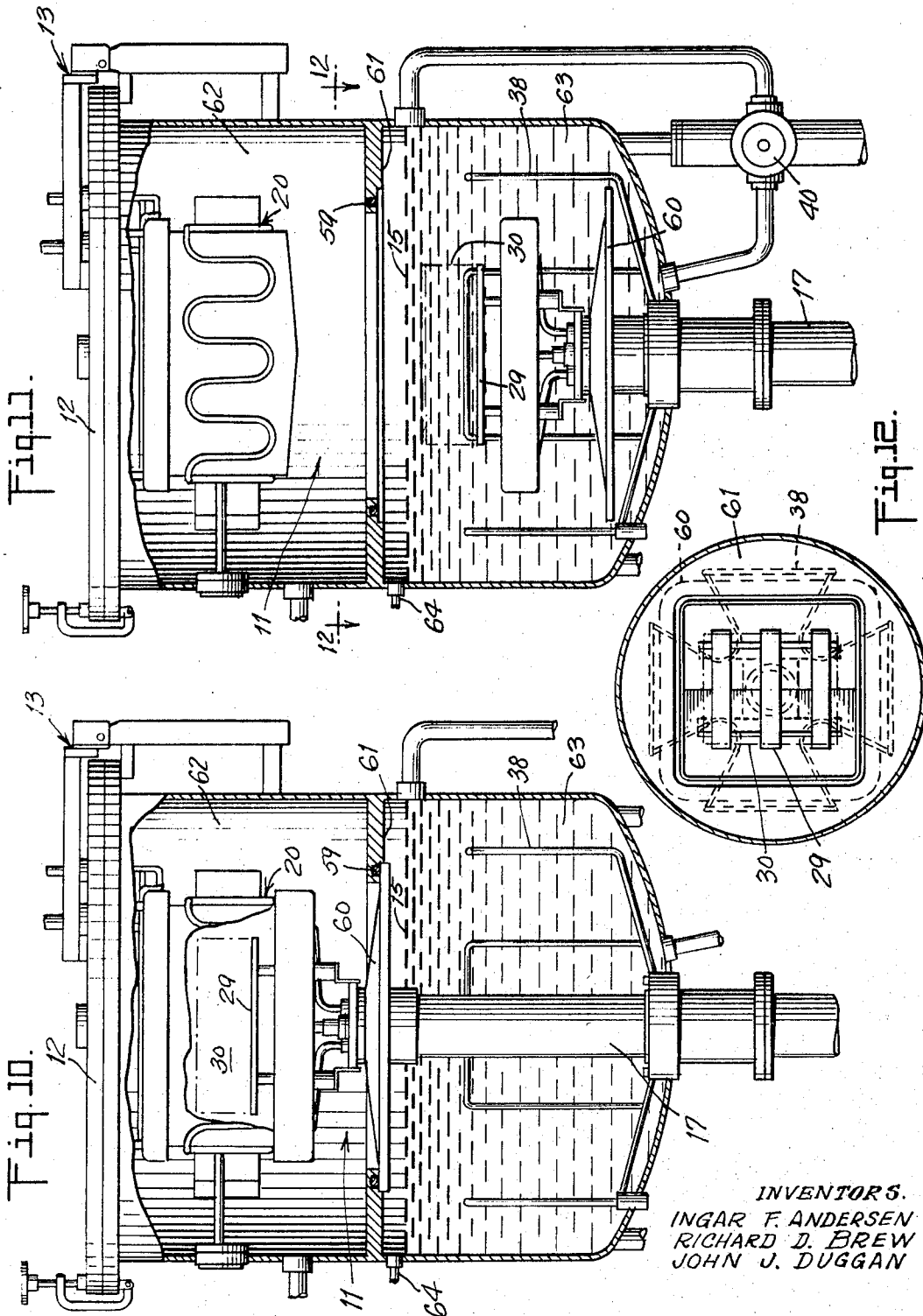
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3,429,563

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Filed Oct. 12, 1967

Sheet 5 of 5



1

3,429,563

HEAT-TREATING QUENCH FURNACE

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Filed Oct. 12, 1967, Ser. No. 674,977

U.S. Cl. 266—4

6 Claims

Int. Cl. C21d 1/66

ABSTRACT OF THE DISCLOSURE

This disclosure relates to vacuum heat treating furnaces wherein the heating and quenching are done within a single, unpartitioned sealed chamber partially filled with quenching fluid. The heating of the metal specimen is done in the vacuum region above the liquid level, and at some predetermined time is immersed with its support into the quenching liquid.

This invention relates to a single chamber heat-treating and quenching furnace and more particularly relates to an electrically-heated vacuum furnace carrying a temperature-controlled quenching medium within the unpartitioned vacuum chamber immediately adjacent to the heating zone for rapid heat treatment and quenching of metal.

Generally, heat treatment may be defined as an operation or combination of operations involving the heating and cooling of a metal or alloy in the solid state for the purpose of obtaining certain desirable conditions or properties.

In the heat-treatment of metals requiring special environments such as vacuum, the time lag encountered in transferring the metal from the heating environment to the quenching medium is oftentimes a very critical factor, since quenching must start before any ambient cooling of the metal workpiece takes place. Further, once the metal is immersed in the quenching medium, the rate of cooling is important and must therefore be closely controlled within narrow temperature limits.

The prior art techniques for attempting to control these vacuum conditions have largely been limited to an enclosed heating chamber adjacent a quenching chamber, each separated from one another by one or more vacuum-tight doors through which the heated metallic load is horizontally moved. In such prior art devices the construction not only imposes undesirable time lags in transferring the metallic load, which may affect its final characteristics, but also results in equipment which requires complicated components for opening such internal access doors and other components for transporting the metallic load from one chamber into the other. Further, horizontal conveyors cannot simply and inexpensively transfer large, heavy loads.

The present invention overcomes these deficiencies which the prior art devices exhibit by generally providing a single, unpartitioned, environmental-controlled chamber which is itself partially filled with a temperature-controlled quenching medium, such as a gas or liquid. The term "environmental controlled" is intended to embrace selective control of atmosphere, or vacuum, and temperature. Generally, this invention comprises a hermetically sealable chamber carrying one or more electric heating elements disposed within a radiant heat-shield

2

enclosure suspended interiorly in the upper portion of this chamber so as to form what is conventionally called a "hot zone" within which the metal load being heated is supported by a movable platform means. This movable platform means or elevator is adapted to move from the "hot-zone" into the quenching medium thereby immersing the load. The platform means itself is comprised of a support member to carry the workpiece charge being treated, an electric heating element which provides heat to the bottom portion of the hot zone, and a conventional radiant heat-shield pack. For ease of description, this disclosure will relate specifically to a single-chamber vacuum-quenching furnace, though it is to be understood that vacuum is but one form of environment control, which this disclosure contemplates.

It is accordingly among the various objects of this invention to provide a single-chamber, vacuum-quenching furnace in which the heating of a workpiece and the quenching thereof are done within the same unpartitioned chamber.

It is a further object of this invention to provide an electrically-heated vacuum-quenching furnace in which the quenching medium is temperature controlled throughout the heat-treating cycle.

It is a still further object of this invention to provide a vacuum quenching furnace which may selectively employ environmental control with a variety of quenching media depending on the metallurgical results desired.

One feature of this invention is that the time lag between heat-treating and quenching can be reduced to less than one second.

Another feature of this invention is that because the heating is performed in a vacuum environment, there will be no oxidizing of the specimen load being heated, nor will there be any products of combustion generated by immersing the heated metal into the quenching medium since there is no atmosphere available to support such combustion.

A further feature of this invention is that, contrary to popular belief, no detrimental effects accrue to furnace components or operation, by subjecting the quenching medium to environmental control or to quenching in the same, unpartitioned chamber in which workpiece heating takes place.

Still another feature of this invention is that even though a portion of the heating apparatus may be repeatedly immersed in the quenching medium every time a quenching operation is performed, no significantly adverse structural effects are exhibited by this portion of the heating zone.

With these and other objects and features in mind as will hereinafter more fully appear and which will be more particularly pointed out in the appended claims, reference is now had to the following description taken in conjunction with the accompanying drawings in which:

FIGURE 1 illustrates a top plan view of the quench furnace of this invention;

FIGURE 2 illustrates a vertical cross-sectional view of this furnace taken on line 2—2 of FIGURE 1;

FIGURE 3 illustrates the view depicted in FIGURE 2 with the heated specimen and its carrying platform immersed in the quenching fluid;

FIGURE 4 is a cross-sectional view of the movable piston rod taken on line 4—4 of FIGURE 3;

FIGURE 5 is a sectional plan view taken on line 5—5 of FIGURE 2;

FIGURE 6 is an enlarged sectional view of a typical heat shield pack, taken on line 6—6 of FIGURE 5;

FIGURE 7 is a plan sectional view taken on line 7—7 of FIGURE 2;

FIGURE 8 is an enlarged vertical cross-sectional view of the upper portion of the piston rod taken on line 8—8 of FIGURE 7;

FIGURE 9 schematically illustrates a second embodiment of this invention; and

FIGURES 10, 11, and 12 illustrate an alternate embodiment employing water as a quenching medium.

Referring now with greater particularity to the drawings, a first embodiment of this invention is shown in FIGURE 2 of a vertical cross-sectional view of a heat-treating vacuum-furnace 10 comprised generally of a single, unpartitioned vacuum-chamber 11 and access door 12 hingedly connected thereto by hinge means 13. Removable clamp means 14 are used to secure door 12 in closed, vacuum sealed relation with chamber 11.

The interior of chamber 11 carries a hot-zone or heater-assembly 20 in the upper portion, and a measured amount of temperature-controlled quenching fluid 15 in the bottom portion thereof. The heater assembly is formed of three general sub-assemblies as follows (a) upper electric heating element 27 in spaced relation with upper heat-shield pack 21 both of which are connected to the underside of cover 12 as an integral unit and thereby swing with the cover as it is opened and closed; (b) side heat-shield packs 22, 23, 24, 25 attached by clamp members 16 to the wall of chamber 11 in peripheral relation; and (c) lower heat-shield member 26, lower electric heating element 28, and platform member 29 for supporting a metal load 30 to be heat treated, which are connected in integral spaced relation and secured to the top of movable piston rod 17. Piston rod 17 is pneumatically actuated by one or more motor means 18 thereby permitting the immediate and direct immersion of the work-piece or metal load 30 (along with heat shield 26 and heating element 28 since they are all integrally connected) into the temperature-controlled quench fluid 15. This immersed condition is more clearly observed by referring to FIGURE 3.

Conventional vacuum sealing means, generally indicated as 19 surround piston rod 17 at its point of exit from chamber 11 thereby preventing leakage of fluid 15 at this point from the chamber when it is at atmospheric or above atmospheric pressures, and likewise, prevents the admission of atmosphere when the chamber interior is at less than atmospheric pressure.

Because radiant heat-shield packs conventionally do not perform with 100% efficiency (i.e. though most of the thermal energy striking the heat shield is reflected, a portion is absorbed and conducted throughout) some form of cooling means for the structural members supporting the heat shields is generally provided. In the described embodiment, cooling coils 31 and 32 are brazed or otherwise connected to the exterior surface of heat-shield packs 21 and 26 respectively and circulate cooling water in a conventional manner from an external source of supply not shown. A similar cooling coil arrangement 33 is appended to the exterior of heat shields 22 to 25, inclusive.

Referring now to FIGURES 2 and 8, water-cooled conductors 41, 42 located within piston rod 17 carry the electrical power to lower heating element 28 and also serve to carry coolant water interiorly therein to feed bottom cooling coil 32 in a manner well known in the art. As seen in the enlarged view of FIGURE 8, water traveling up conductor 41 flows into conduit 43 which is of lesser diameter than 41, but concentrically located there-within. Conduit 43 thence carries this coolant flow into cooling coil 32 which after circulating therethrough discharges the coolant into conduit 44, and water-cooled conductor 42 in a flow direction opposite to that depicted in FIGURE 8. Flexible tubing 34, 35 are connected to conductors 41, 42 acting as inlet and discharge conduits

respectively. Cooling coil 31 and upper heating element 27 are similarly arranged.

As shown in FIGURE 2, a temperature-controlled element 38 acting as a heat exchanger wholly submerged within quench-fluid 15 conventionally communicates through the wall of chamber 11. This element may be a conduit carrying a temperature-controlled fluid from an external source therethrough for maintaining the quench fluid at a prescribed temperature or may be in the form of a resistance or thermo-electric element for heating and/or cooling, depending on the requirements.

To maintain a uniform temperature distribution within the quench-fluid 15, a conduit 39 carrying a pump 40 circulates the quench-fluid.

In operation the device would function as follows: With piston rod 17 in its fully raised position so that platform 29 is well above the level of quench fluid 15, cover member 12 is opened and carries with it heat shield 21 and heating element 27. The metal specimen or load 30 is then placed on platform 29 and the cover 12 lowered and securely fastened with clamp 14. The chamber interior is then evacuated of air through port 60 to the desired vacuum level. The heating elements 27, 28 are then energized raising the temperature within the heating assembly 20 to the desired temperature level. In some cases these temperatures may reach as high as 3500° F. At such time as the specimen load has attained the desired temperature level, pneumatic cylinders 18 are actuated and piston rod 17 with its appurtenant connections, i.e. heat shield 26, heater element 28, and platform 29 with its load 30, are quickly lowered into quench fluid 15. This immersion can be effected in less than one second thereby effectively preventing any undesirable thermal losses from the specimen before it reaches the quenching medium. To maintain the quench fluid at a reasonable uniform temperature level which will in turn determine the metallurgical characteristics of the specimen following this heat treating, provision is made by means of temperature-controlled element 38 to maintain the quench fluid at a uniform temperature, and as mentioned previously, conduit 39 and pump 40 act so as to provide a uniform temperature distribution throughout the quenching medium. It should also be noted at this point that generating such a flow condition within the quench bath, especially with a vacuum environment immediately above it, produces a highly beneficial result of rapidly dislodging and removing any vapor bubbles which may be generated on the surface of the metallic specimen. Any prolonged presence of such vapor bubbles act so as to insulate the metal surface from the quenching fluid hindering the lowering of specimen temperature. Hence, the vacuum environment and the circulation of the quench fluid together act to quickly remove and/or tend to prevent such conditions from arising thus providing effective quench control.

Referring now to the embodiment of FIGURE 9, there are some circumstances which require using a quenching-fluid which, because of its vapor-pressure characteristics, cannot be maintained in a liquid state in a vacuum environment. Typical of such fluids is water. In those situations requiring the use of water or similarly behaving fluids as a quenching medium, provision is made to perform the process with apparatus as schematically illustrated in FIGURE 9. Because fluids such as water change their state as pressures are sufficiently lowered, the heating of a metallic specimen, e.g. titanium, can be done within chamber 11' from which the quenching fluid 15' has been pumped into a holding tank 50 by pump means 40' and sealed from chamber 11' by a conventional vacuum valve or seal 51. Tank 52 holds a supply of inert gas, e.g. argon or the like, suitably retained therein by a vacuum valve or seal 53. Metallic specimen 30', carried on raised platform 29' is heated to the prescribed temperature within chamber 11' which is completely under vacuum with no quenching fluid whatever

therewithin. Preparatory to quenching, valve 53 is opened to admit a measured amount of argon gas into the chamber sufficient to raise its pressure to a level at which water will remain liquid. Concurrently with this inert gas admission, valve 51 is also opened permitting the water or other fluid in holding tank 50 to dump into chamber 11'. Platform 29' is then lowered submerging specimen 30' into the quench bath. One consequence of quenching in a water medium will be the generation of substantial amounts of water vapor, i.e. steam with an accompanying increase in pressure. This pressure is permitted to escape from chamber 11' through pressure release valve 54 suitably mounted on furnace 10'.

A further embodiment of this invention employing water or similar liquids as the quenching medium is schematically depicted in FIGURES 10, 11, and 12. The apparatus illustrated therein is intended to generally operate in the same mode hereinbefore described with reference to FIGURES 1-8 with the additional feature of mounting a closure member 60 on the upper portion of piston rod 17 which is adapted for sealable engagement with seal 59 carried by flange 61, thereby providing selective temporary partitioning of chamber 11 into a heating zone generally designated as 62, and a quenching zone generally designated as 63. There are circumstances as mentioned earlier where certain quenching liquids, because of their characteristics, experience a phase change or a change in state when subjected to environmental extremes of partial pressure and/or temperature. To preclude such changes, a temporary separation of environment between the vacuum heating zone 62, and the quenching zone 63 is therefore required. In the embodiment of FIGURES 10-12, a closure member 60 in the form of a structural plate or the like is rigidly attached to piston rod 17 at a suitable location and adapted to come into continuous sealing engagement with seal 59 carried by flange member 61 which forms an integral part of chamber 11. Accordingly, when piston rod 17 is in its elevated position placing specimen load 30 in proper location within heating assembly 20, closure member 60, because of its relative location on piston rod 17, is in sealing engagement with seal 59 thereby effectively partitioning chamber 11 into heating zone 62 and quenching zone 63. The respective environment in either of these zones may then be selectively controlled as to pressure, temperature and atmosphere. Accordingly, in the case of heat treating, for example titanium, piston rod 17 is raised into position which simultaneously brings plate 60 into sealing engagement with seal 59. Specimen load 30 is placed on platform 29 and cover 12 lowered and secured as hereinbefore described. Heating zone 62 is then suitably evacuated of atmosphere and heating assembly 20 energized to bring the titanium to temperature. While the heating phase is progressing, the quenching zone 63 containing the quench fluid has its environment controlled in any way desired through port 64; it may, for example, be purged of air with an inert gas, as for example argon, retaining whatever pressure is required to maintain liquidity of the quench fluid, or it may also be partially evacuated, depending on the circumstances. When the load is ready for quenching, a measured amount of argon or other inert gas may then be bled into heating zone 62 to raise its pressure slightly, and piston rod 17 is then quickly lowered carrying the titanium specimen into the quench bath immediately.

Though we have described one form of the last embodiment as having inert gas present in each of the zones 62, 63 preparatory to quenching, it should be understood that the relative amounts in each chamber during this time are of minor importance. It is only important that at such time as the sealing relation between plate 60 and seal 59 is broken during the lowering of platform 29 in the quenching operation, the ambient pressure within chamber 11 (at this point in time unpartitioned) be sufficient

to maintain the quench fluid in a liquid state, precluding any phase changes.

It will be understood that various changes in the details, materials, setups, and arrangements of parts which have been herein illustrated in order to explain the nature of the invention may be made by those skilled in the art within the principle and scope of the appended claims.

We claim:

1. A controlled environment heat-treating quench furnace comprising:

- (a) a single hermetically sealable chamber;
- (b) means for heating a zone disposed in an upper portion of said chamber;
- (c) means for providing a body of quenching fluid in said lower portion of said chamber;
- (d) means for supporting and moving a workpiece substantially vertically between said zone and a lower portion of said chamber;
- (e) a closure member integrally connected to and carried by the aforesaid means for supporting and moving; and
- (f) means selectively coacting with said closure member so as to sealingly separate the said portions when said workpiece is in said zone.

2. The structure of claim 1 wherein port means are provided for independent access into each respective portion.

3. The structure of claim 1 wherein the aforesaid means selectively coacting with said closure member comprises: a continuous seal carried by a flange member extending inwardly from the wall portion of said chamber.

4. The structure of claim 1 wherein the aforesaid means for supporting and moving a workpiece comprises:

- (a) a movable piston rod mounted within said sealable chamber; and
- (b) a heat-shield member and a workpiece supporting platform connected in integral spaced relation carried atop said movable piston.

5. A controlled environment heat-treating quench furnace comprising:

- (a) a single, unpartitioned, hermetically sealable chamber;
- (b) means providing a quenching medium in the lower portion of said chamber;
- (c) a radiant heat-shield assembly carried in the upper portion of said chamber forming an enclosed zone;
- (d) means for heating said enclosed zone;
- (e) a support platform integrally connected to a portion of said heat-shield assembly, for supporting a workpiece within said zone;
- (f) means extending downwardly from the aforesaid support platform for vertically moving said workpiece support platform and its integrally connected portion of said radiant heat-shield assembly from said zone into said quenching medium.

6. The apparatus set forth in claim 6 wherein the said support platform integrally connected to a portion of said heat-shield assembly additionally carries as a component part thereof an electric heating element.

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U.S. Cl. X.R.

118—50.1; 134—141