

Aug. 24, 1965

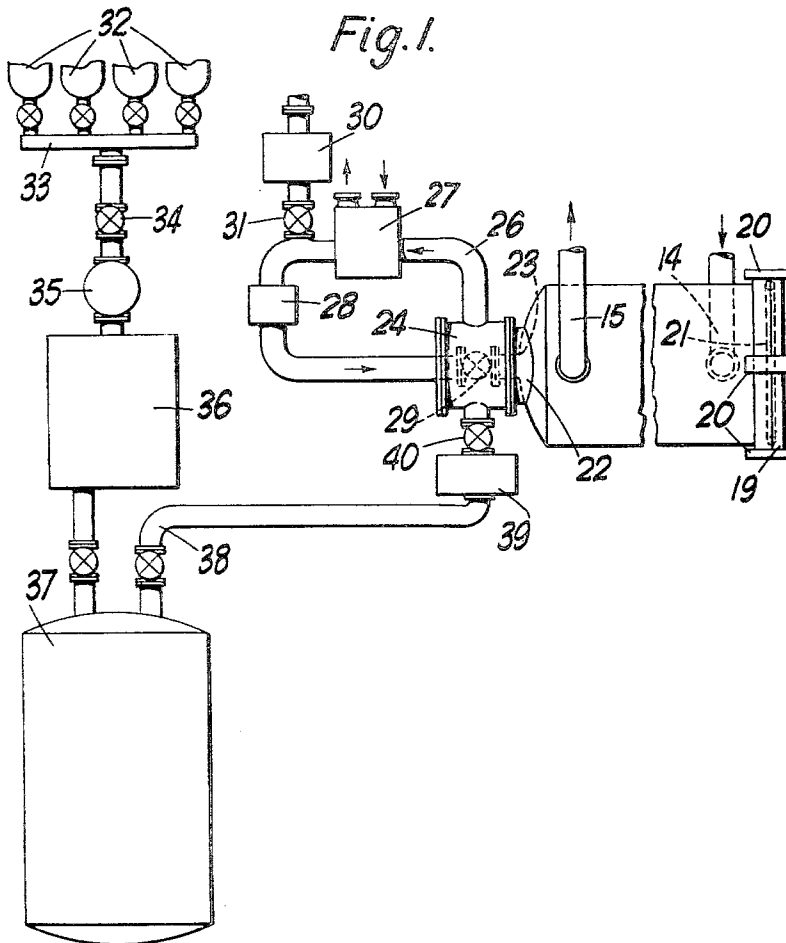
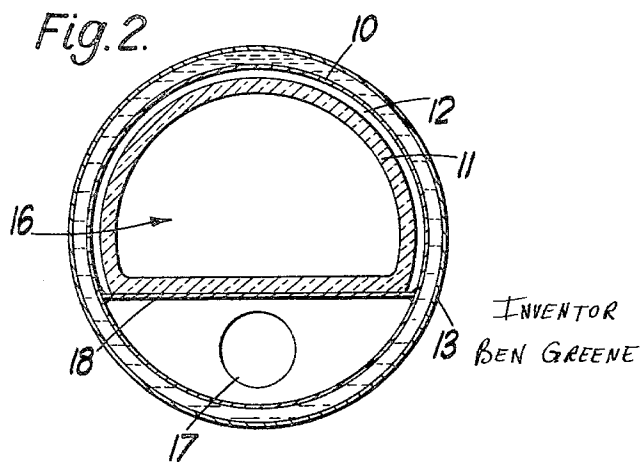
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METHODS OF HEAT TREATING ARTICLES

Filed Dec. 19, 1960

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

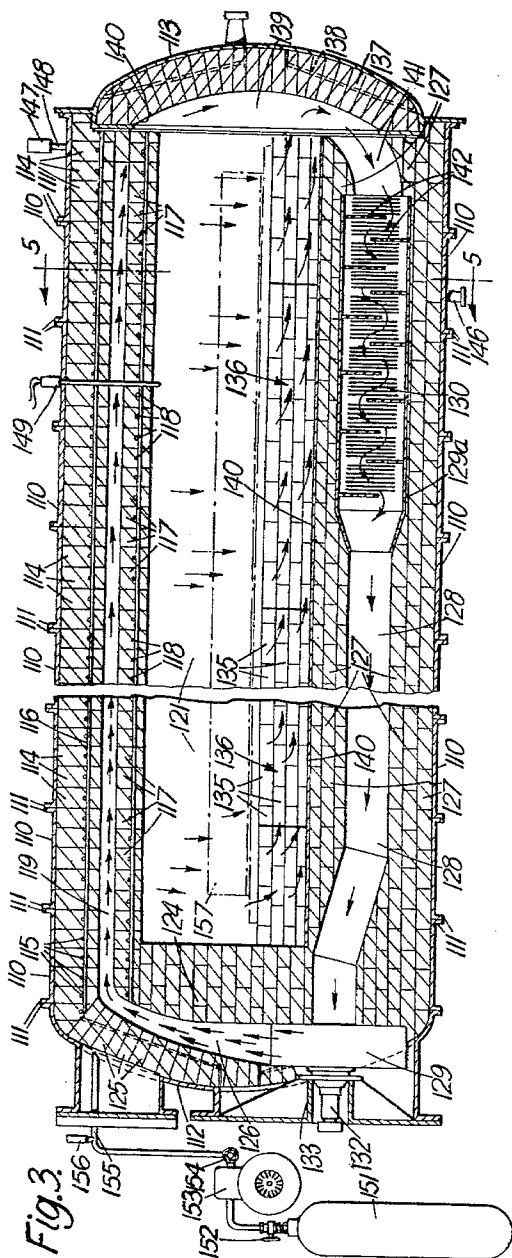


Fig. 3.

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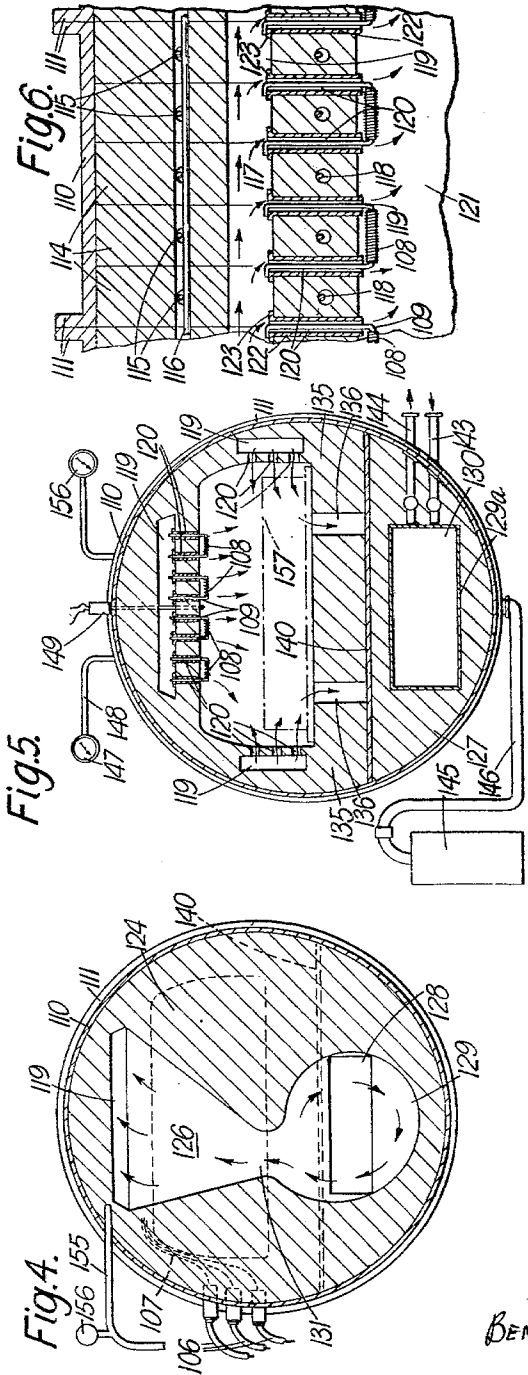
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METHODS OF HEAT TREATING ARTICLES

Filed Dec. 19, 1960

3 Sheets-Sheet 3



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METHODS OF HEAT TREATING ARTICLES

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Filed Dec. 19, 1960, Ser. No. 76,906

10 Claims. (Cl. 148—20.3)

This invention relates to methods of and apparatus for brazing and heat treating articles. Hereinafter these processes will be referred to as heat treating.

According to one broad aspect of the invention there is provided a method of heat-treating articles in which the articles after being heated are cooled by circulating a cooling gas round a closed circuit which comprises the furnace chamber and a heat exchanger arranged to cool the cooling gas.

Clearly in some cases the gas employed must be selected so as not to have a deleterious effect on the articles during cooling. For example, in heat treatment of metal articles a gas which avoids oxidation of the article is usually selected; the gas in this case is preferably hydrogen, which has a high heat conductivity.

In some cases the gas is under high pressure.

According to another aspect of the invention there is provided a method of heat-treating articles comprising the steps of heating the articles in a pressure-tight vacuum-tight furnace either in a vacuum or in a gaseous atmosphere which does not have a deleterious effect on the articles, and cooling the articles by circulating a cooling gas which is at a pressure greater than atmospheric pressure round a closed circuit comprising the furnace chamber, a circulating pump and a heat exchanger arranged to cool the gas.

According to another broad aspect of the invention there is provided a method of heat-treating articles comprising the steps of heating the articles in a pressure-tight furnace chamber which is lined with an insulating refractory material and cooling the articles by circulating a cooling gas which is at a pressure greater than atmospheric pressure round a closed circuit comprising the furnace chamber, a circulating pump and a heat exchanger arranged to cool the gas.

By an insulating refractory material is meant herein one which provides a temperature difference of over 1000° C. at atmospheric pressure between its hot and cold faces when the temperature of the hot face is about 1300° C. and the thickness of the material (i.e. the distance between the hot and cold faces) is less than 6 inches. A suitable material for this purpose is a refractory supplied under the trade name Morgan M128.

In another aspect the invention provides a method of operating a furnace having a pressure-tight vacuum-tight furnace chamber comprising the steps of evacuating the furnace chamber in which are contained articles to be heat treated, heating the articles under vacuum and cooling the articles and the furnace by circulating a non-deleterious gas whereof the pressure is greater than atmospheric pressure around a closed circuit in which the gas is cooled before being passed through the chamber.

In yet another aspect of the invention there is provided a method of operating a furnace which comprises a metal shell lined internally with an insulating refractory material and forming a pressure-tight vacuum-tight furnace chamber comprising the steps of placing articles to be treated in the furnace chamber, evacuating the chamber, passing into the chamber a gas having no deleterious effect on the articles heating the articles in the presence of the gas, and cooling the articles by circulating a non-deleterious gas at a pressure greater than atmospheric pressure around a closed circuit in which the gas is cooled before being passed through the chamber.

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According to another aspect the invention provides heat treatment apparatus comprising a vacuum-tight pressure-tight furnace chamber for containing the articles to be heat treated, and cooling means for the articles comprising a closed circuit for a cooling gas which circuit includes the furnace chamber, a circulating pump and a heat exchanger arranged to cool the gas.

According to yet another aspect of the invention there is provided heat treatment apparatus comprising a metal shell lined internally with insulating refractory material and forming a vacuum-tight pressure-tight furnace chamber for containing the articles to be heat treated, and cooling means for the articles comprising a closed circuit for a pressurized cooling gas which circuit includes the furnace chamber, a circulating pump and a heat exchanger arranged to cool the gas. Preferably a gap, for example three inches wide, is provided between the insulating refractory material and the shell of the furnace.

The metal shell may be surrounded by a jacket to enable the shell to be water-cooled. Alternatively piping may be welded to the metal shell through which piping cooling water can be passed.

The hydrogen or other gas may be obtained from a tank and pressurized to a required pressure by a compressor which is arranged with its outlet connected through a valve to the closed circuit.

The apparatus may also comprise a vacuum pump for evacuating the furnace chamber and the valve means for opening and closing communication between the vacuum pump and the chamber. Preferably a heat-exchanger is connected between the vacuum pump and the furnace chamber so as to cool gases from the chamber before they pass to the vacuum pump. Conveniently a single heat exchanger may serve for cooling the cooling gas in the closed circuit and for cooling gases passing to the vacuum pump.

The furnace chamber is preferably electrically heated.

In an alternative arrangement the heat exchanger is arranged within the structure of the furnace.

In such an arrangement a heat insulating hearth may isolate the furnace chamber from a space containing the heat exchanger.

The aforesaid circulating pump may be within or outside the structure of the furnace and heat insulated from the furnace chamber.

By these means the rate of cooling can be controlled to a wide degree, not only by controlling the rate of circulating the atmosphere but also by controlling its pressure. It is found in practice that it makes little or no difference to the cooling rates by increasing the velocity of circulation without pressure but a high pressure with a small velocity gives a high rate of cooling.

Two embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

FIGURE 1 shows diagrammatically in plan view the general arrangement of the components of the apparatus;

FIGURE 2 shows a diagrammatic cross-section of the furnace chamber;

FIGURE 3 is a vertical longitudinal section through the furnace;

FIGURE 4 is a vertical section through the closure wall at the left hand end of the furnace chamber;

FIGURE 5 is a vertical section through the furnace on the line 5—5 of FIGURE 1; and

FIGURE 6 is a section through the upper wall of the furnace on an enlarged scale.

Referring to the drawings, the furnace is for heat treating metal tubes and comprises a cylindrical metal shell lined internally with an insulating refractory material as hereinbefore defined. A gap of approximately

three inches is formed between the shell and the lining. The shell is surrounded by a cooling water jacket 13 and the jacket has an inlet 14 at the bottom and an outlet 15 at the top.

In the arrangement shown the cylindrical chamber within the shell is divided by a partition wall 18 into two segments, a major segment which affords the heat treatment chamber 16 and a minor segment through which is passed a gas supply tube 17, the purpose of which will be explained presently. The partition wall 18 between the segments is lined with insulating refractory material. Electrical heating elements (not shown) are provided for heating the furnace chamber.

The cylindrical chamber is pressure-tight and vacuum-tight and for this purpose is provided at one end with a sealed door 19 held against the pressure within the furnace by clamps 20 and provided with an annular O-ring 21 to render it vacuum-tight. The other end wall of the cylinder is formed by a stout domed member. The domed end has two flanged apertures therein arranged one above the other. The larger diameter aperture 22 communicates with the chamber 16, and the smaller aperture 23 communicates with the gas supply tube 17.

The heat treatment chamber communicates through a connecting pipe 24 and pipe 26 with the inlet of a heat-exchanger 27 arranged to cool hot gases from the chamber before the gases are passed to a circulating pump 28 and thence through valve 29 back to the lower aperture 23 in the furnace chamber. The connecting pipe 24 and pipe 26 are either water-cooled or lined with insulating refractory material to enable them to withstand the hot gas passing through.

A vacuum pump 30 for evacuating the furnace chamber is connected through a check valve 31 to the pipe interconnecting the heat exchanger 27 and the circulating pump 28, so that the heat exchanger cools gases passing to the vacuum pump in order to provide for more efficient working of the pump.

After heat treatment of the articles, particularly where the tubes are of stainless steel, it is necessary in certain cases that cooling should be effected rapidly, but cooling the articles by plunging them into water or oil or other cooling liquids causes formation of a layer of scale on the articles which, in many cases, must be removed by pickling and machining.

In the present arrangement, the cooling of the articles is effected by pressurised gas, preferably hydrogen, which, being a reducing agent, prevents the formation of oxide scale. For this purpose there are provided cylinders 32 of hydrogen under high pressure which communicate through a manifold 33, a reducing valve 34, a purifying chamber 35 and a drying chamber 36 with a reservoir tank 37, the outlet 38 from which communicates through a compressor 39 and a stop valve 40 with the connecting pipe 24. Thus by opening the valve 40 hydrogen may be supplied to the furnace chamber under pressure whereafter the valve 29 may be opened and there is thus formed a closed circuit for the pressurised hydrogen including the furnace chamber, the heat exchanger 27 and the circulating pump 28 for the pressurised hydrogen. Cool hydrogen from the heat exchanger 27 is pumped into the aforesaid pipe 17 in the minor segment of the furnace through a sealed flange joint round the aperture 23. The hydrogen passes along the tube 17 to the end of the furnace chamber adjacent the door 19 and passes thence through the wall 18 and back towards the closed end of the furnace over the articles being heat treated, and through the aperture 22 in the fixed end wall, the heat exchanger 27 and the circulating pump 28.

When the stainless steel tubes have been placed in the furnace chamber as aforesaid and the cylinder has been evacuated by the vacuum pump 30, a quantity of hydrogen is passed into the furnace chamber to purge the cylinder of air and is subsequently evacuated from the cylinder by the vacuum pump 30.

The vacuum pump 30 is then disconnected from the furnace chamber by means of the check valve 31. After heat treatment, when the tubes must be cooled quickly, the stop valve 40 between the compressor 39 and the closed circuit is opened and the circuit is charged by the compressor with hydrogen at the required pressure, for example, above about 30 lbs./sq. in. Pressurised hydrogen is then forced round the closed circuit by the circulating pump 28 and is cooled by heat exchanger 27, and the compressor serves to counteract the reduction of volume of the hydrogen as the furnace cools and to maintain the pressure at the same value.

In an alternative method of operating the furnace, after the furnace chamber has been purged, hydrogen is passed into the furnace chamber under pressure from the tank 37 and the heating of the articles is performed in an atmosphere of compressed hydrogen.

Where quantity production is required the furnaces may be arranged in banks of say three which are operated in conjunction. Thus the first furnace chamber may be charged with articles to be heat treated and then purged, whilst the second furnace chamber is heated and the third chamber is being cooled by pressurised hydrogen.

The furnace is substantially cylindrical in shape and is built up of a number of outer cylindrical steel sections 110 having flanges 111 at their ends which are bolted or welded together. The left hand end of the furnace has a domed outer steel shell 112 while the other end of the outer shell is left open and a movable door fitted with a spy hole operates therewith having an outer domed steel shell 113. The door which is fitted with clamps (not shown) and O ring seal (also not shown) may be supported on rollers (not shown) or on guideways either to move horizontally or in an up and down direction. The cylindrical sections 110 are lined with an outer course of insulating refractory bricks 114 which are slung from the outer shell by rods passing through holes 115 in the bricks and in supports in the shell. Holes 116 are also formed in the bricks (as best seen in FIGURE 6) through which refractory supports extend and register the refractory bricks face to face rendering cement unnecessary.

The refractory bricks 117 of an inner course are likewise suspended from the outer shell, being provided with holes 118 for supporting rods which engage the shell. The inner course of bricks are so shaped and spaced as to provide a duct 119 extending along the full length of the upper wall of the furnace, other ducts 119 are formed in the side walls of the furnace. The abutting faces of certain of the bricks 117 of the inner course are spaced to provide passages 120 leading from the duct 119 into the interior 121 of the furnace chamber. The suspended refractory bricks may each be bound with one, two or more molybdenum or steel wire hoops (not shown) to reduce thermal shocks on very rapid cooling cycles. Fused alumina tubes 122 extend through these passages and are provided with flanges 123 at their upper ends. Supports 109 for electrical heating elements 108 extend through the tubes in the upper part of the furnace together with conductors (not shown) for the electric heating elements or the supports 109 may comprise the conductors. The leads 107 for the conductors are shown to the left of FIGURE 4 and arranged for connections with a source of supply 106. The left hand end of the furnace chamber 121 is permanently closed by an end wall 124 also built up from insulating refractory bricks and likewise the end domed wall 112 is lined with insulating refractory bricks 125. The bricks 124 and 125 are arranged to provide between them a passageway 126 which, as it extends away from the centre portion of the furnace (as viewed from the end of the furnace) and meets the ends of the ducts 119. The bottom portion of the furnace contains a comparatively large conduit 128 extending along the length of the furnace and

which at the left hand end communicates with a circular chamber 129 for accommodating a circulating fan (not shown) and corresponding to the fan 23 of FIGURE 1. The right hand end of the conduit 128 communicates with a chamber 129a for a heat exchanger 130 corresponding to the heat exchanger 27 of FIGURE 1. The upper part of the circular fan chamber 129 communicates through a throat 131 with the passageway 126. A shaft 132 driving the fan passes through a pressure-tight, vacuum-tight oil sealed housing 133 on the outside of the domed shaped end wall 112 and is connected to an electric motor mounted outside the furnace. The motor however, could be mounted within the metal shell of the furnace in which case it might be provided with a cooling water jacket.

The hearth 135 consisting of heavy steel plates 140 supported on the sides of the casing by flanges is placed above the bricks 127 and is covered with insulating refractory bricks 135 in which two open topped channels 136 extend along the length thereof. The domed shell 113 is also provided with a lining of bricks 137 slung from it by rods 138 and so shaped as to provide a concavity 139. The channels 136 also terminate opposite the concavity 139 and the lower brickwork 127 is formed with a passage 141 leading into the heat exchanger 130. The heat exchanger may be of known form provided with two sets of passages, one set of passages being provided with baffles 142 past which the atmosphere to be cooled flows and the other set of passages have cooling water circulated through them by means of cooling water inlet and outlet pipes 143, 144. A vacuum pump 145 corresponding to the vacuum pump 39 of FIGURE 1 disposed outside the furnace is connected by a pipe 146 extending up through the bottom of the furnace and lower brickwork 127 so as to communicate either with the conduit 128 or with the interior of the furnace chamber. A vacuum gauge 147 is also arranged to communicate with the interior of the furnace chamber through a pipe 148. Similarly the thermo-couple 149 of a pyrometer is arranged to extend into the furnace chamber through the casing and upper brickwork 114, 118. A gas such as hydrogen, helium, nitrogen or argon may be supplied to the furnace chamber from a pressure vessel 151 having a control valve 152 and may pass either direct therefrom or through purifying and drying chambers corresponding to 35 and 36 of FIGURE 1 and a reservoir corresponding to 37 and then to a booster pump 153 corresponding to the pump 39 of FIGURE 1 having a control valve 154 corresponding to the valve 40 of FIGURE 1 and then to a pipe 155 leading to the passage 119. A pressure gauge 156 may be associated with the supply pipe 155. Instead of providing separate pumps at 129 and 153 respectively for raising the pressure of gas and circulating it in the furnace one and the same pump could be used in which case it would be located at the locality of the bricks indicated at 125.

The hearth on which the articles to be heat treated are placed may be mounted on a trolley (not shown) so that it may be introduced or withdrawn through the doorway. Alternatively, the articles 157 to be heated may be introduced into the furnace on the arms of a fork lift truck so arranged as to extend into the aforesaid channels 136 and when the articles are in the furnace the fork arms are lowered into the channels depositing the articles on the hearth across or between the channels whereafter the arms can be withdrawn.

The hydrogen or inert gas before entering the furnace chamber may be passed through a purifying chamber and drying chamber (not shown) corresponding to the chamber 36 of FIGURE 1 which may be disposed on the inlet side of the pump 153. After the insertion of the articles into the furnace the door is clamped tight on the O ring and before heat treatment commences the furnace must be purged of air either by being expelled by the inert gas or preferably by the vacuum pump. When

purging is complete the heating elements may be switched on and the protective or inert atmosphere is introduced into the furnace, for example, at atmospheric or sub-atmospheric pressure. When heating is complete as determined by the pyrometer the heating elements are switched off, the hydrogen inlet valve 152 is opened, and the circulatory fan in the chamber 129 is started and atmosphere of gas is circulated through the heat zone and heat exchanger, and the pressure is regulated to above 30 lbs./sq. in. by the introduction of additional atmosphere of gas as desired. When cooling is complete as shown by the pyrometer the various units are switched off, the atmosphere under pressure in the furnace is released either to air or to a gas holder and when atmospheric pressure has been achieved the vacuum pump 145 is brought into operation after being connected with a gas holder (not shown) into which the cold inert gas is pumped from the furnace casing back to the aforesaid chambers corresponding to 35, 36 for purification and to the reservoir corresponding to 37 of FIGURE 1 for re-use. When the furnace casing is cleared and therefore under vacuum, air is let into the casing and the door of the furnace opened and the articles withdrawn.

It will be appreciated that various modifications may be made to the details of construction without departing from the scope of the invention, for example the furnace may be of vertical construction either of bell shape which may be lifted off a fixed hearth but is sealed when resting on the hearth or may be fixed and have a sealed door at its top end. The inner surface of the inner course of the refractory bricks of the furnace chamber may also be lined with steel or for high temperature conditions by molybdenum which lining is provided with openings for the aforesaid tubes through which the supports and conductors for the electric heating elements extend.

A cooling jacket may also be associated with the outer steel casing and the steel casing for the end wall and door. The fixed end wall 124 may also be provided with passages leading from the passage 126 to the inner face thereof so as to direct the cooling gases onto the ends of the articles on the hearth, this is applicable where pipes are being cooled in which case cooling gas may be introduced to the ends of the pipes. By this means it is possible to group the controls of the three furnaces and to render the operating of the furnaces more efficient.

Instead of the hydrogen being cooled by an external heat exchanger this can be disposed within the furnace chamber as shown in FIGURES 3 to 6.

I claim:

1. A method of heat-treating articles in which the articles, after being heated by direct exposure to heating means within a furnace chamber, are cooled while still in the furnace chamber by circulation through the furnace chamber of a cooling gas made up of any of the gases hydrogen, helium, nitrogen and argon at a pressure above thirty pounds per square inch absolute.

2. A method of heat-treating articles comprising the steps of exposing the articles directly to heating means within a pressure-tight vacuum-tight furnace under vacuum and cooling the articles by circulating a non-deleterious cooling gas made up of any of the gases hydrogen, helium, nitrogen and argon at a pressure above thirty pounds per square inch absolute.

3. A method of heat-treating articles comprising the steps of exposing the articles to the direct action of heating means within a pressure-tight furnace chamber containing any of the gases hydrogen, helium, nitrogen and argon at super atmospheric pressure and cooling the articles by circulating over them a cooling gas made up of any of the gases hydrogen, helium, nitrogen and argon at a pressure greater than thirty pounds per square inch absolute.

4. Heat treatment apparatus comprising a vacuum-tight

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pressure-tight furnace chamber for containing the articles to be heat treated and containing heat radiating elements to which the articles are directly exposed, and cooling means for the articles comprising a closed circuit for a cooling gas which circuit includes the furnace chamber, a circulating pump and a heat exchanger arranged to cool the gas, and means for supplying the gas to said circuit at a pressure greater than thirty pounds per square inch.

5. A heat treatment apparatus according to claim 4 wherein a vacuum pump is connected to the furnace chamber through a control valve.

6. Heat treatment apparatus comprising a vacuum-tight pressure-tight furnace chamber for containing the articles to be heat treated and cooling means for the articles which cooling means comprises a closed circuit for a cooling gas which circuit includes the furnace chamber, a circulating pump and one part of a heat exchanger within the furnace chamber, means for supplying gas to said circuit at a pressure greater than atmospheric pressure, a vacuum pump for evacuating the furnace chamber, and the suction side of which vacuum pump is connected to said part of the heat exchanger through which the gas flows whereby it is cooled before reaching the suction pump.

7. A heat treatment apparatus according to claim 6 wherein the heat exchanger and pump are arranged away from the heat zone within the furnace chamber and between its end closures.

8. A heat treatment apparatus comprising a cooled metal shell which shell is lined internally with an insulating refractory material to provide a gap of about three inches and which lined metal shell forms a vacuum-tight pressure-tight furnace chamber for containing the articles to be heated, heat radiating elements in the refractory lining exposed directly to the articles being heated, cooling means for the articles embodying a closed circuit for a cooling gas, which circuit includes the furnace chamber, a circulating pump and a heat exchanger arranged to cool the gas and means for supplying the gas at a pressure of thirty pounds per square inch to the circuit.

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9. A heat treatment apparatus comprising a vacuum-tight pressure-tight furnace chamber for containing the articles to be heat treated and cooling means for the articles comprising a closed circuit for cooling gas, which circuit includes the furnace chamber, a motor driven rotary fan and a part of a heat exchanger for cooling the gas, means for supplying the gas to said circuit under a pressure greater than atmospheric pressure which fan is located within a compartment in the furnace structure and which motor is located within the furnace structure and is provided with a cooling jacket.

10. Heat treatment apparatus comprising a vacuum-tight pressure-tight furnace chamber for containing the articles to be heat treated and cooling means for the articles which cooling means comprises a closed circuit for a cooling gas which circuit includes the furnace chamber, a circulating pump and one part of a heat exchanger, means for supplying gas to said circuit at a pressure greater than atmospheric pressure, a vacuum pump for evacuating the furnace chamber, and the suction side of which vacuum pump is connected to said part of the heat exchanger through which the gas flows whereby it is cooled before reaching the suction pump, and which heat exchanger is arranged within the furnace structure in a space separated from the furnace chamber by a heat insulating hearth.

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