Oct. 2, 1956 E. R. CAPITA 2,765,361

VACUUM RESISTANCE FURNACE

Filed Nov. 13, 1953 3 Sheets-Sheet 1

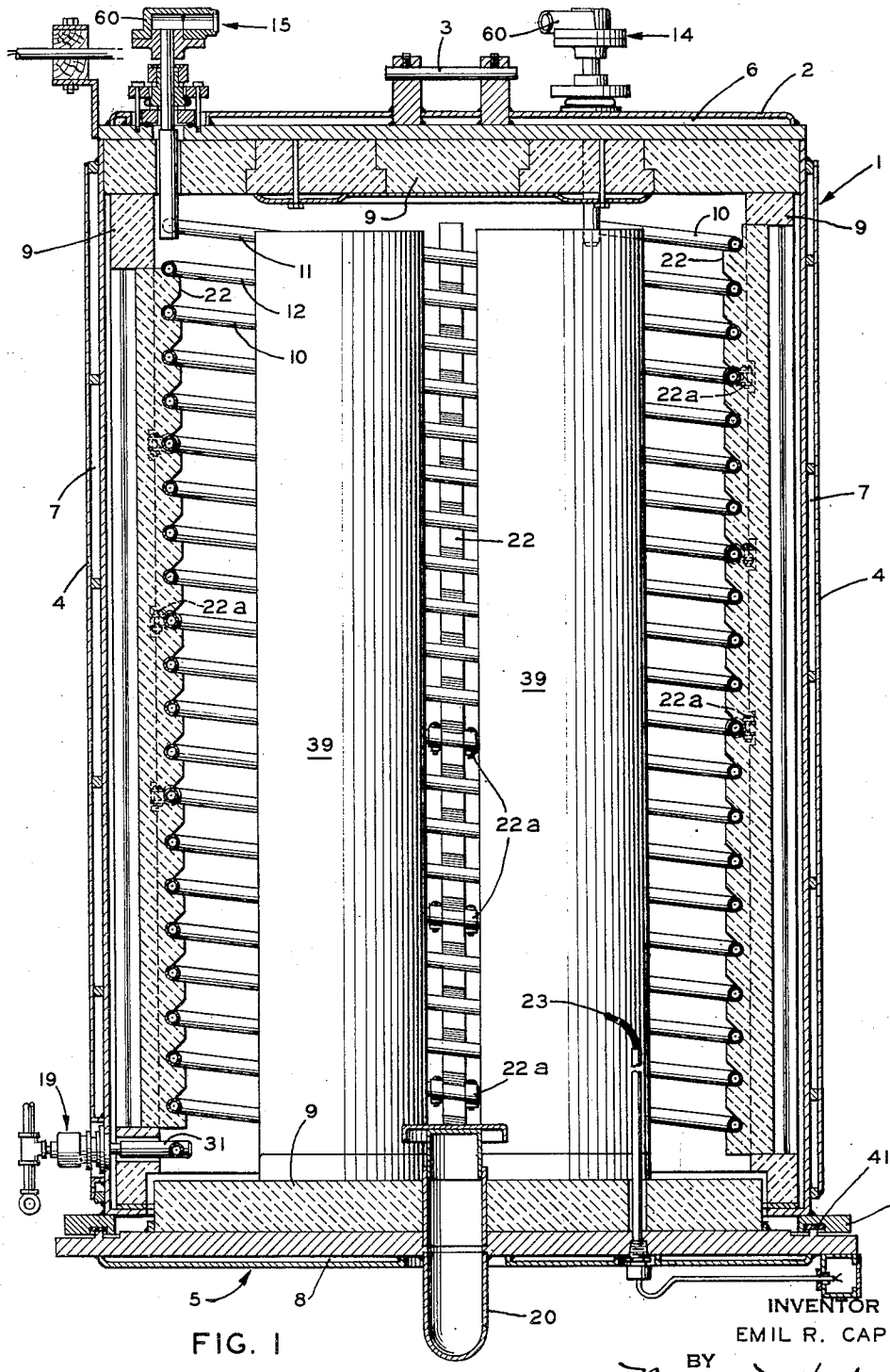


FIG. 1

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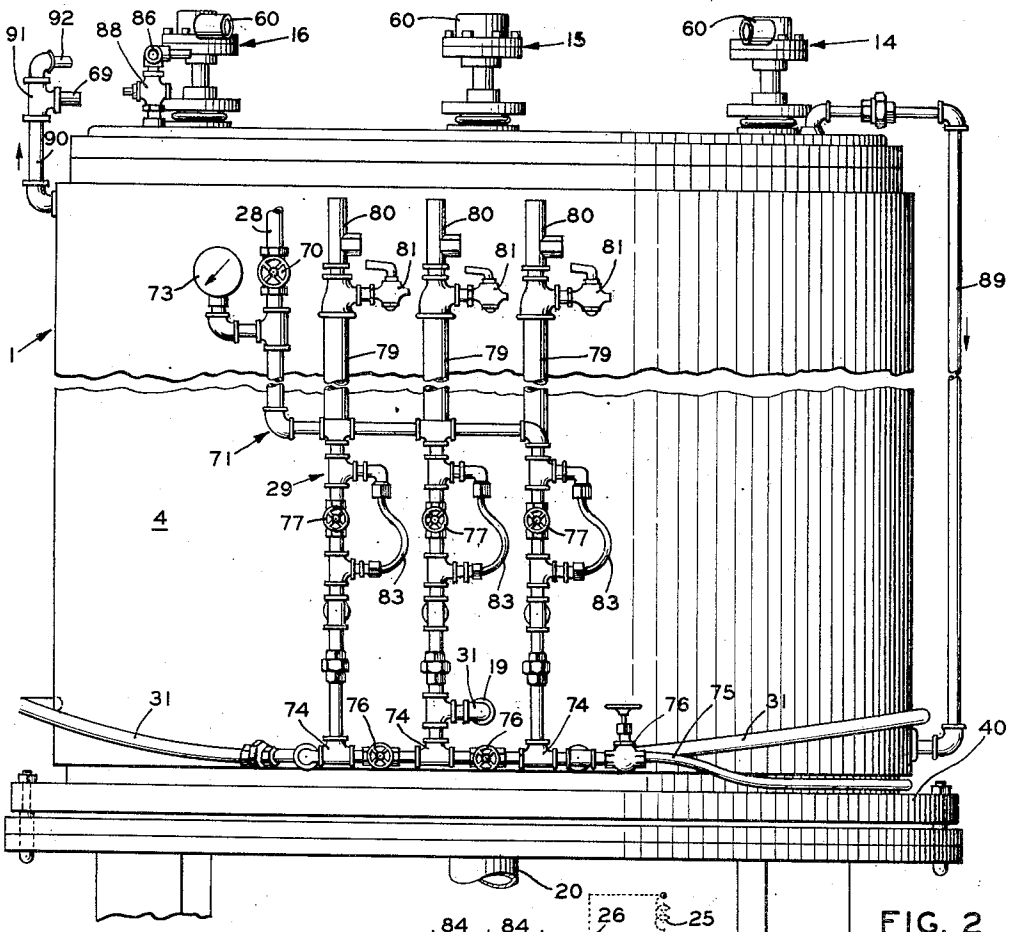


FIG. 2

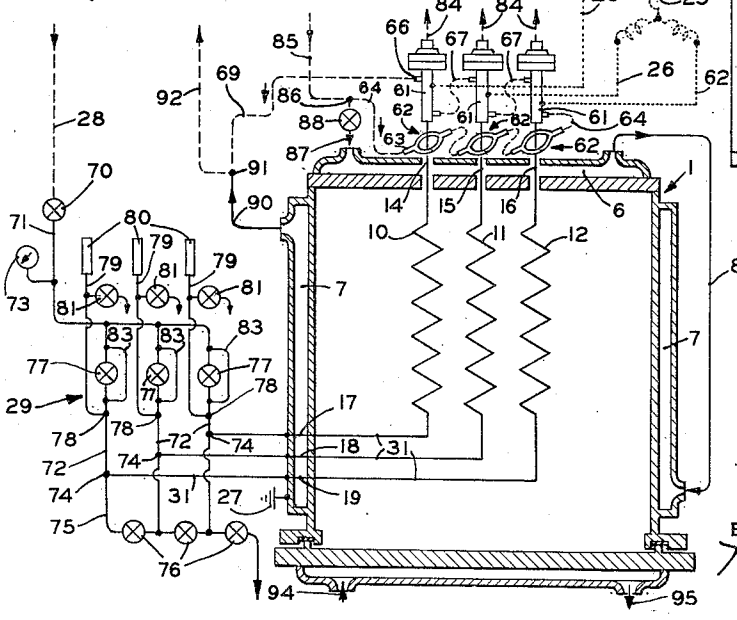


FIG. 4

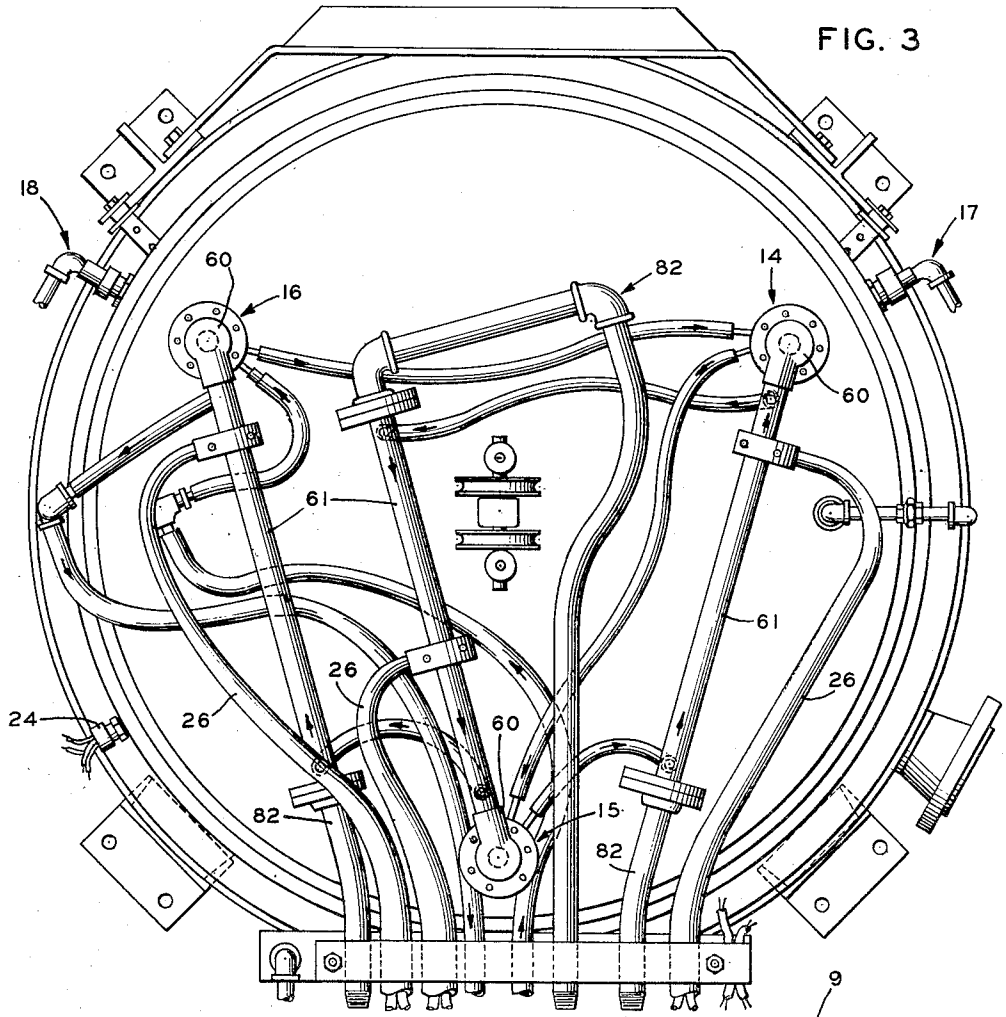
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VACUUM RESISTANCE FURNACE

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FIG. 3



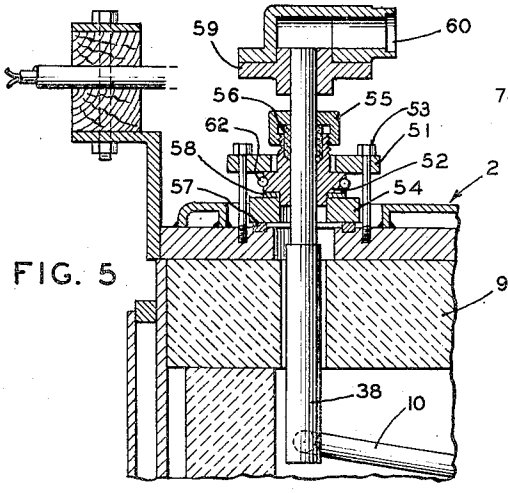


FIG. 5

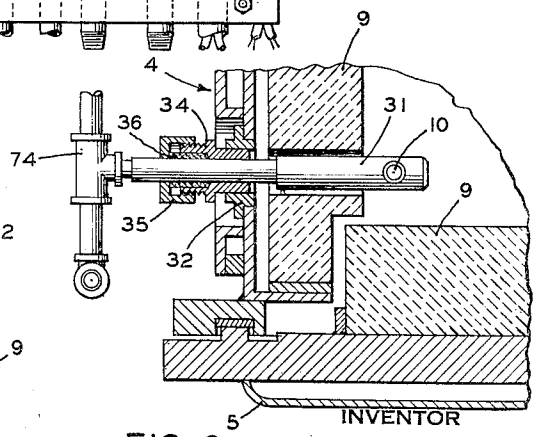


FIG. 6

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VACUUM RESISTANCE FURNACE

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10 Claims. (Cl. 13—31)

The present invention relates generally to vacuum or preferred atmosphere heat treating furnaces of the electric resistance type and more particularly to an improved resistance furnace which contains dual-purpose heater-cooler elements.

Vacuum resistance type heating furnaces are well known which have heating as well as cooling elements. Previous types, however, had separate heating and cooling elements. This required either that both the heating and cooling elements be positioned near the articles or that the heating coils be located at one point and the cooling elements at another point and that the heated articles be moved from one point to the other. The former alternative produces interference between the heating coils and the cooling coils preventing efficient heat transfer and cooling. The latter alternative requires a moving mechanism inside the sealed furnace, requires a furnace of approximately twice the size of one with stationary heated articles and also subjects the load to jars or bumps during the move.

The present invention overcomes these difficulties by providing a dual-purpose element which both heats and cools the interior of the furnace.

An object of the invention is to provide a new and improved type of vacuum or preferred atmosphere resistance furnace.

Another object of the invention is to provide an improved vacuum resistance furnace with a dual-purpose heater-cooling element.

Another object of the invention is to provide a vacuum resistance furnace of minimum size.

Another object of the invention is to provide a simple and relatively inexpensive vacuum resistance furnace with heating and cooling facilities.

Another object is to provide a resistance heated vacuum type electric furnace with a high speed cooling system to increase its work capacity.

Another object is to provide a resistance heated water cooled vacuum furnace of minimum size and weight.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

A preferred embodiment of the invention has been chosen for purposes of illustration and description and is shown in the accompanying drawings, forming a part of the specification, wherein:

Fig. 1 is a side elevational view in section of the vacuum resistance furnace;

Fig. 2 is a front elevational view partially cut away of the furnace of Fig. 1;

Fig. 3 is a plan view of the furnace of Fig. 1;

Fig. 4 is a schematic diagram of the furnace heating and cooling systems;

Fig. 5 is an enlarged fragmentary sectional view showing the details of an upper terminal of the furnace of Fig. 1;

Fig. 6 is an enlarged fragmentary sectional view showing the details of a lower terminal of the furnace of Fig. 1.

Described generally and with particular reference to Fig. 1, the furnace comprises an outer airtight casing **1** with top 2, sides 4 and a bottom 5. The top sides and bottom are made of a suitable metal construction such as stainless steel and have hollow water jacket portions 6, 7, and 8, respectively, through which water is circulated to cool the casing 1. The top 2 and sides 4 which are welded together are removable as a hood unit from bottom 5. They are lifted vertically from bottom 5 by handle 3 when the containers 39 holding the articles to be heat treated are loaded or unloaded from the furnace.

The inside walls of the furnace are lined with a suitable refractory material 9. The hollow dual-purpose heater-cooler coils 10, 11, and 12 are wound in interlocking spirals adjacent the refractory lining 9 on the side walls 4. These coils are supported on vertical comblike brackets 22 of refractory material set into the refractory lining at intervals of a few feet.

Coils 10, 11, and 12 connect to upper terminals 14, 15, and 16 (Fig. 3), respectively, on the top 2 and to lower terminals 17, 18, and 19 (Fig. 3), respectively, in the side walls 4. Coils 10, 11, and 12, which will be described more fully below, are made of a resistance metal and are formed with a hollow core. One suitable resistance metal is "Nichrome," which is approximately 15–16% chromium, 59–62% nickel, 24% iron and 1% carbon. Other known resistance metals may be used. The upper and lower terminals conduct both electric current and water to the coils so that during the heating period the coils act as electrical resistance heaters and during the cooling period act as cooling coils when the current is removed from the coils and water is circulated through them. Conventional thermocouples are used to measure the furnace temperatures. Standard thermocouple 23 is used to measure the load temperature and a thermocouple 24 is used to measure the coil temperature.

All the terminals for the coils and thermocouples are made airtight and the joint between the side walls 4 and the bottom 5 is fitted with an airtight gasket 41 on flange 40 so that a vacuum may be maintained within the furnace during the heating and cooling operations. Air is withdrawn through an exhaust pipe 20 by a suitable pump (not shown) to create the vacuum after the containers 39 have been placed and the top and side unit of the furnace has been lowered into place.

Heater-cooler coils and terminals

The heater-cooler coils 10, 11, and 12 are made of a resistance metal which is formed into hollow tubes and bent into a spiral form. The preferred embodiment shown in Fig. 1 uses three separate coils wound in interlocking spirals. The upper ends of the coils are coupled to the upper terminals 14, 15, and 16 and the lower ends of the coils are coupled to the lower terminals 17, 18, and 19. Several sets of stainless steel clamps 22*a* are placed on each coil. Each set comprises two clamps, one put on each side of a bracket 22 to prevent circumferential movement of the coils. As before noted, the upper and lower terminals pass electric current and water alternately to the coils for the heating and cooling cycles which will be more fully described below under "Operations."

The details of a preferred form of lower terminal are shown in Fig. 6. A hollow pipe 31 with good electrical conductivity such as a brass or copper pipe is coupled to the lower end of one of the coils, such as

coil 10, and passes through the side wall 4 to T connector 74 which is in the coil water supply system as will be more fully described below. To provide an airtight seal a metal flange 32 is fastened in an airtight manner by threads or welding to the casing side 4. Sleeve 34 is screwed into flange 32, and cap 35 threaded onto sleeve 34 holds packing 36 in place to complete the airtight terminal. The lower terminal need not be electrically insulated from the casing 1, since the lower ends of the coils are connected together and grounded, as will be described below.

The details of a preferred form of upper terminal are shown in Fig. 5. The upper terminals must be electrically insulated from the metal casing, since they are electrically above ground potential during the heating process. A hollow metal pipe 38 having good electrical conductivity is coupled to the upper end of one of the coils, such as coil 10, and run out through the casing 2 to a pipe connection 60. The pipe 38 is fastened to and electrically insulated from top 2 by an airtight terminal assembly comprising a flanged sleeve 52 held between electrically insulating flanges 51 and 54 by bolts 53. Cap 55 on sleeve 52 holds packing 56 in place, which together with gaskets 57 and 58 provides an airtight seal. Flanges 51 and 54 are made of a suitable dielectric to electrically insulate pipe 38 from the metal casing top 2. A flange 59 is screwed to the top of pipe 38 and on it is screwed a pipe connector 60 which conducts the cooling water to a jacketed terminal connector pipe 61. Surrounding sleeves 52 are terminal cooling rings 62. Connector pipes 61 and rings 62 will be more fully described below with the "Cooling System."

Electrical and water cooling systems

Fig. 4 is a schematic diagram of the electrical system and the water cooling system. The coils 10, 11, and 12 and the terminals 14, 15, and 16 and 17, 18, and 19 have been described above. Solid lines on the schematic diagram outside the furnace represent electrical conducting metal water piping, and dashed lines indicate flexible water tubing made of an insulating material such as rubber or plastic. Dotted lines represent electrical conductors.

The electrical circuit includes a three phase A. C. input supply such as the star connected transformer secondary 25 connected by leads 26 to the coils 10, 11, and 12 through the conducting terminal connector pipe 61 and upper terminals 14, 15, and 16. The coils 10, 11, and 12 are connected in a star with the lower terminals as the center point. The lower terminals are electrically connected to the sides 4 of casing 1 which may be grounded by a suitable ground cable 27. As before noted, terminals 14, 15, and 16 are insulated from the metal casing 1. The invention is not limited to the above type of electrical circuit, since any source of current for the resistance coils is satisfactory and since no specific number of coils need be used. Among the other types of electrical inputs which would prove satisfactory are single phase A. C. or D. C. inputs with the heating coils connected in parallel or series.

The solid lines in Fig. 4 connecting to the outside of lower terminals 17, 18, and 19 indicate the coil water cooling supply system 29. These pipes are also shown in Fig. 2 attached to the side 4 of casing 1. This system is connected to a water source by a flexible hose 23. Hose 23 connects to pipe 71 through a flow control valve 70. Pressure guage 73 on pipe 71 indicates the input water pressure. Pipe 71 branches into three parallel coil feed lines 72 which each connect by T connections 74 to one of the lower terminals 17, 18, and 19 through pipe 31 and to a common drain line 75. Valves 76 cut off the drain line. Each of the three coil feed lines 72 contains a flow control valve 77 which is by-passed by a constricted pipe 83 whose function will be described under "Operation." T connections 78 on the coil feed lines 72 connect to relief valve lines 79 containing relief valves 80 and relief drain valves 81.

As noted above, the upper terminals 14, 15, and 16 connect to terminal connector pipe 61. Connector pipe 61 connects through suitably-shaped pipe sections 82 to flexible coil drain hoses 84.

Fig. 4 also shows the upper terminal and furnace casing water cooling supply system. A flexible water input line 85 connected to a suitable water source connects to T connector 86 which divides the flow between the casing water jackets and the upper terminal cooling system.

The casing water jacket cooling branch pipe 87 has a flow control valve 88. As seen in Fig. 4, the top water jacket 6 connects to the side water jacket 7 by pipe 89. Side water jacket 7 is connected to a flexible drain hose 92 by pipe 90 and T connector 91. With water supplied through input line 85 and valve 88 open, it can be seen that water will flow through top water jacket 6, to pipe 89, to side jacket 7 and out through pipe 90 to drain 92. The inlet 94 and drain 95 of stationary bottom jacket 8 are connected to suitable water supply and drains by conventional piping.

In order to keep the upper terminals cool during the heating cycle, terminal cooling rings 62 are mounted on sleeves 52 (Fig. 5). Terminal cooling rings 62 have an annular shape with suitable water inlet and outlet connectors 63. Water is run from connector 86 through the rings 62 through series connected hoses 64. To further cool the upper terminals the terminal connector pipes 61 (Figs. 3 and 5) have a water jacket surrounding the inner water tube. The connector pipe 61 water jackets have suitable connectors 66 which are connected in series with each other by flexible hoses 67 and in series with the rings 62 by a connector 64. Flexible hose 69 connects between a connector 66 and T connector 91 to drain the series connected rings 62 and the connector pipes 61 through drain hose 92.

Operation

Articles to be heat treated are placed within the furnace after the hood portion comprising the top 2 and sides 4 has been raised by a suitable hoist attached to handle 3. The articles, if small in size, may be placed into containers 39 which are properly spaced on bottom 5 so that they will fit within the coils 10, 11, and 12 when the hood is lowered. The hood is now lowered and a vacuum is drawn within it by pumping the air out through air exhaust 20 by a suitable pump, not shown.

At the beginning of a heating cycle it is necessary to remove all water which may have remained in the heating coils from the last cooling cycle. To do this valve 70 is kept closed and drain valves 76 and 81 are opened.

Water is now circulated through the base plate jacket and through the terminal cooling rings 62 and the terminal connectors 61. Casing water jacket control valve 88 is left closed during the heating cycle, since the furnace top and side jackets are not cooled during the heating cycle. The heating current is now turned on. The coil temperature may be controlled by interrupting the current flow at suitable intervals or by controlling the input voltage by any well known voltage control device.

When the load has been heated for the desired periods and at the desired temperatures, the current is turned off and the cooling cycle is commenced.

Valves 81 and 76 are closed to seal the coil water cooling supply system 29. Valve 88 is opened to permit water to circulate through the top and side jackets. Valves 77 are closed to require the cooling water in coil feed lines 72 to flow through the restricted diameter pipes 83 and valve 70 on the coil water supply is opened a slight amount to admit the cooling water to the coils 10, 11, and 12.

The restricted diameter portion 83 is used to limit the amount of original flow of cooling water into the hot coils 10, 11, and 12, since the first water which enters the coils is turned into steam. As the coils continue to

cool, additional water pressure is applied by opening valve **70** further. When the temperature of the coils reaches a low valve such as 600°, the restricted diameter portions **83** are no longer needed and control valves **77** as well as the water inlet valve **70** are opened wide to allow the maximum flow of cooling water through the coils. The coils will now be rapidly cooled and they will in turn cool the interior of the furnace.

After the load has been cooled to the desired point as shown by thermocouple **23**, air is admitted to the furnace through pipe **20**. Valve **70** is closed and drain valves **76** opened to drain the coils and the hood is lifted to permit removal of the load from the furnace.

Thus it can be seen that a vacuum resistance heater type of electric furnace has been provided which has dual-purpose heater-cooler coils. By using the dual-purpose coils the heating and the cooling cycles are run without the necessity for moving the load within the furnace between a heating and a cooling position. In addition, the use of the dual-purpose coils allows the furnace to be of a minimum size for a given load. The stationary load may be closely surrounded by the dual-purpose coils and no other elements are required within the furnace.

The efficiency of the heating and cooling cycles is high, since the coils may closely surround the load and since by using a single element the interference in heat transmission which existed where cooling elements were placed nearby the heating elements is eliminated.

The cooling action is also made more efficient due to the direct cooling of the heating elements themselves by the water flow through them. This eliminates the residual heat source from the interior of the furnace which exists where the coils are cooled by less direct methods and continue to impart heat to the interior furnace during the general cooling of the furnace atmosphere.

As noted above, the embodiment shown is a preferred one, however it is clear that the electric supply system, the water supply system, and the number and arrangement of the heater-cooler coils may be varied without departing from the spirit and scope of the invention.

As various changes may be made in the form, construction and arrangement of the parts herein without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, I claim:

1. An electric resistance furnace comprising an airtight casing, a refractory lining and a tubular resistance metal heating element within said casing adapted for connection with a source of electricity and with a source of coolant whereby said element may be alternately heated by the flow of electric current and cooled by the passage of a coolant therethrough.

2. The furnace as claimed in claim 1 wherein said casing has a hollow space adapted for connection to a source of coolant for allowing a coolant to circulate therein.

3. The furnace as claimed in claim 1 wherein said casing comprises a top portion, a side portion and a bottom portion, said top and said side portions, supporting said heating element and being removable as a unit therewith from said bottom portion.

4. An electric vacuum resistance furnace comprising an airtight casing, a refractory lining, a tubular resistance metal heating element within said furnace, terminals connected to said element and passing through said casing adapted for connection to a source of electricity, and said terminals being hollow and adapted for connection to a source of coolant to pass said coolant to and from said element.

5. The furnace as claimed in claim 4 wherein said heating element is coiled and slidably supported by brackets whereby said element may freely expand or contract as its temperature changes.

6. An electric resistance vacuum furnace comprising an outer airtight casing, a tubular resistance metal coil within said casing, one end of said coil connected to a first hollow metal terminal, said terminal adapted for connection to a source of electricity and passing through and insulated from said casing, a connection between the opposite end of said coil and a second hollow terminal, said second hollow metal terminal passing through and electrically connected to said casing, and a hollow coolant feed line connected to said second metal terminal.

7. The furnace as claimed in claim 6 wherein said first hollow metal terminal is connected to a connector pipe, said connector pipe comprising a hollow conductor connected to said first hollow metal terminal and having a separate coolant jacket surrounding said hollow conductor.

8. An electric resistance furnace comprising an outer airtight casing, an inner refractory lining, a plurality of first hollow airtight terminals on said casing electrically insulated from said casing and each adapted for connection to a source of electricity, a plurality of second hollow airtight terminals on said casing electrically connected together and adapted for connection to a common source of coolant, a resistance heater element connecting each one of said first terminals with one of said second terminals, said resistance elements having a hollow core which connects the hollow portion of said first terminals with the hollow portion of said second portions.

9. An electric resistance furnace comprising an airtight casing, a tubular resistance metal heater within said casing, a first hollow terminal mounted on said casing and connected to one end of said heater and adapted for connection to a source of electricity, a second hollow terminal mounted on said casing and connected to the other end of said heater, one of said terminals electrically insulated from said casing, a coolant feed line connected to one of said terminals, a control valve for said feed line, and a by-pass conduit for said valve having a smaller hollow center than said feed line.

10. An electric resistance furnace comprising an airtight casing, a plurality of tubular resistance metal heaters within said casing, a plurality of first hollow terminals mounted on said casing, each connected to one end of one of said heaters and being electrically insulated from said casing and each other, a plurality of second hollow terminals mounted on said casing, each connected to an opposite end of one of said heaters, a coolant feed line connected to each of said second terminals at one end, a control valve in each of said feed lines, a by-pass conduit around each of said valves having a smaller coolant carrying capacity than said feed lines.

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