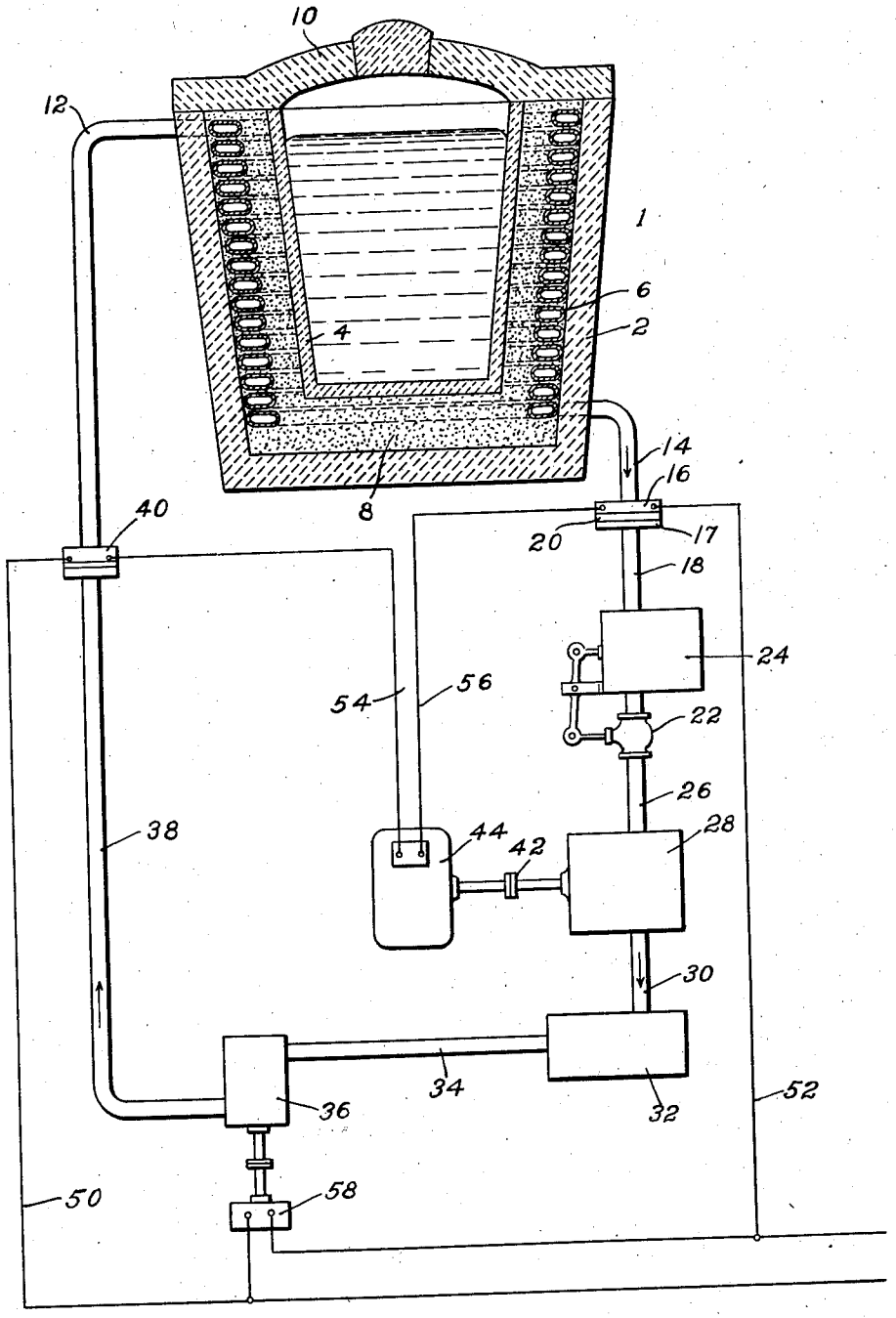
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P. H. BRACE

INDUCTION FURNACE

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WITNESSES:

C. J. Weller.

G. E. Saltzman

INVENTOR

Porter H. Brace.

BY

Wesley G. Carr

ATTORNEY

Patented Aug. 14, 1928. 1,680,407

UNITED STATES PATENT OFFICE.

PORTER H. BRACE, OF WILKINSBURG, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

INDUCTION FURNACE.

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My invention relates to electric furnaces and more particularly to furnaces of the induction type.

In coreless, or ironless, induction furnaces, operable on relatively low frequency alternating current of the order of 60 cycles per second, it is necessary to energize the inductor coil at rather a high current density with resultant high I^2R losses. It becomes necessary therefore, to artificially cool the inductor coil, and this is usually accomplished by making the coil of tubing to provide a passage for the flow of a cooling fluid therethrough.

Since the inductor coil completely surrounds the charge, the greater portion of the heat lost by the charge is also absorbed by the cooling fluid and carried off.

It is an object of my invention, therefore, to provide, in combination with a fluid cooled inductor coil, means for converting the heat absorbed by the cooling fluid into electrical energy, and for returning the electrical energy to the circuit of the inductor coil.

Another object of my invention is to provide means operated by the heat energy contained in the cooling fluid effluent from a fluid cooled inductor coil, for correcting the inherently unfavorable power factor of the furnace.

In practicing my invention I provide, in conjunction with an induction furnace employing a hollow water cooled inductor coil, a complete mechanical circuit for the cooling water outside the furnace which directs the water from the coil successively through a steam turbine, a condenser, and a centrifugal pump back to the input end of the coil. The steam turbine is operatively connected to a synchronous generator which, in turn, is electrically connected in parallel with the main source of electrical energy for the inductor coil.

In the drawing, the single figure shows an induction furnace in vertical section and a schematic showing of the elements and mechanism employed in conjunction therewith for carrying out my invention.

Referring more particularly to the drawing, an ironless induction furnace, indicated broadly as 1, comprises a shell or casing 2 of suitable refractory heat-insulating material, and a crucible 4 coaxial therewith and supported in spaced relation with the inner face thereof. In the space between the crucible 4 and casing 2 is positioned a substantially helical inductor coil 6 embedded in a quantity of granular refractory material 8, completely filling said space. The inductor coil 6 is formed of flattened copper tubing to provide a passage therethrough for a cooling fluid as hereinafter described. The top of the furnace is closed by a removable cover 10 in the usual manner.

Since the particular details of the furnace structure form no part of the present invention, further description thereof is not deemed necessary.

Inlet and outlet conduits 12 and 14, respectively, for supplying a cooling fluid, preferably water in the present embodiment, to the inductor coil, extend through the side wall of the casing 2 and operatively communicate with the ends of the hollow coil 6.

Conduit 14 terminates in a flange 16 which is adapted to be clamped to a flange 17 on a section of conduit 18 communicating with a thermostatically controlled valve 22, to provide a passage for the cooling fluid therethrough. Between the cooperating faces of flanges 16 and 17 is an apertured plate 20 of suitable electrical insulating material, for breaking the otherwise complete electrical circuit afforded by the mechanical circuit for the cooling fluid, as hereinafter described.

The valve 22 is operated in accordance with the temperature of the cooling fluid by means of any well-known type of thermally responsive mechanism 24 operatively connected to the stem of valve 22.

A conduit 26 connected to the other side of valve 22 communicates with the inlet opening of a steam turbine 28 which is operable in the usual manner by steam effluent therefrom.

From the exhaust side of turbine 28 the cooling fluid is conducted through a conduit 30 and steam condenser 32, conduit 34 and motor driven centrifugal pump 36 and conduit 38 back to the inlet conduit 12 which is operatively connected to conduit 38 by means of a coupling 40.

A complete and a continuous passage for the cooling water is thereby afforded connecting the two ends of the inductor coil.

As indicated in the drawing, the showing of the thermostatically controlled valve, the steam turbine, the condenser and centrifugal pump are merely diagrammatic, and since

they are all elements in common commercial usage, a further and more detailed description thereof is not necessary. Quite obviously, additional means in the fluid circuit may be added as found necessary for varying operating conditions. For example, it may be desirable to employ traps to separate the steam and water, and to incorporate a pressure responsive means in the fluid circuit to protect the coil. The employment of such means, if desired, is obvious to one skilled in the art, and therefore the illustration and description thereof is not deemed necessary.

The rotor of the steam turbine 28 is operatively connected through a suitable coupling 42 to a synchronous generator 44 driven thereby.

Energization of coil 6 is effected by a suitable source of commercial frequency alternating current (not shown), through leads 50 and 52 connected to the coupling 40 and flange 16, respectively. A flux is thereby induced in the metallic charge in crucible 4, and the charge is heated and melted in the usual manner.

The synchronous generator 44 is electrically connected through leads 54 and 56 to the coupling 40 and flange 16, respectively, so that the electrical energy generated thereby is returned to the circuit of the inductor coil.

The centrifugal pump 36 is driven by an electrical motor 58 connected across the leads 50 and 52 for continuous operation coincident with the operation of the furnace, as indicated.

In operation, upon the energization of coil 6, the cooling fluid contained therein is heated responsive to the I^2R loss in the coil and the heat lost from the charge in crucible 4, and a sufficient temperature will be attained to form steam therein. When the steam has attained a desired temperature the valve 22 is automatically opened responsive to the action of the thermal control device 24, and the steam passes into the turbine 28 to cause the operation thereof and the consequent operation of the synchronous generator 44.

The steam then is conducted through conduit 30 into condenser 32, where it is reduced to a liquid state, and from thence through the centrifugal pump 36 back into the inductor coil.

The operation of the synchronous generator 44 converts the mechanical energy of the turbine into electrical energy, and supplies the electrical energy to the terminals of the inductor coil. The generator thereby serves to supply the wattless component of the inductor current which tends to correct the unfavorable power factor of the furnace with respect to the primary electrical power supply.

By my invention I have devised a means for recovering a large portion of the waste heat from a water cooled inductor coil at a relatively slight increased investment in apparatus. The temperature of the cooling fluid is automatically reduced during its expansion into steam and passage to the turbine, but the heat remaining in the water is not lost since it merely tends to increase the rate of circulation required to maintain the desired outlet temperature, thereby increasing the amount of steam supplied to the turbine.

While I have shown and described a particular combination of elements for converting the heat energy of the cooling water into electrical energy, it is clearly within the scope of my invention to use various other combinations and arrangements of elements for effecting the desired results.

Modifications may be made in my invention without departing from the spirit and scope thereof and I desire, therefore, that only such limitations shall be placed thereon as are imposed by the prior art and set forth in the appended claims.

I claim as my invention:

1. In an induction furnace, the combination with a water-cooled inductor coil, of means for converting the heat energy of steam effluent from said coil into electrical energy, and means for returning said electrical energy to the electrical circuit of said inductor coil.

2. In an induction furnace, the combination with a water-cooled inductor coil, of means for converting the heat energy of steam effluent from said coil into electrical energy, comprising a steam turbine mechanically cooperating with said inductor coil, an electrical generator driven thereby, and means for electrically connecting said generator with said inductor coil.

3. In an induction furnace, the combination with a water-cooled inductor coil and an energizing circuit therefor, of means for correcting the power factor of said coil, comprising a synchronous electrical generator electrically connected across said energizing circuit, and means operated by steam effluent from said coil for driving said generator.

4. In an induction furnace, the combination with a hollow, water-cooled, inductor coil and an energizing circuit therefor, of means for supplying a leading current to said coil, comprising a synchronous generator electrically connected to the terminals of said coil, and means responsive to steam effluent from said coil for driving said generator, comprising a steam turbine operatively connected to the exhaust end of said coil.

5. In an induction furnace, the combination with a water-cooled inductor coil and an energizing circuit therefor, of means for

supplying a leading current to said coil, comprising a synchronous generator electrically connected to the terminals of said coil, and means responsive to steam effluent from said coil for driving said generator, comprising a steam turbine operatively connected to the exhaust end of said coil, and thermostatic means between said coil and turbine for controlling the flow of steam therethrough.

6. In an induction furnace, the combination with a hollow induction coil and means for energizing the same, of a complete mechanical circuit, connecting the ends of said coil providing a path for the circulation of cooling water therethrough, and including in series a steam turbine, a condenser, and a pump, whereby steam effluent from the exhaust end of said coil operates said turbine, is condensed in said condenser, and forced back into the coil inlet by said pump, and a synchronous generator driven by said turbine and connected electrically in the circuit of said inductor coil, in parallel therewith.

In testimony whereof, I have hereunto subscribed my name this 19th day of August, 1927.

PORTER H. BRACE.