

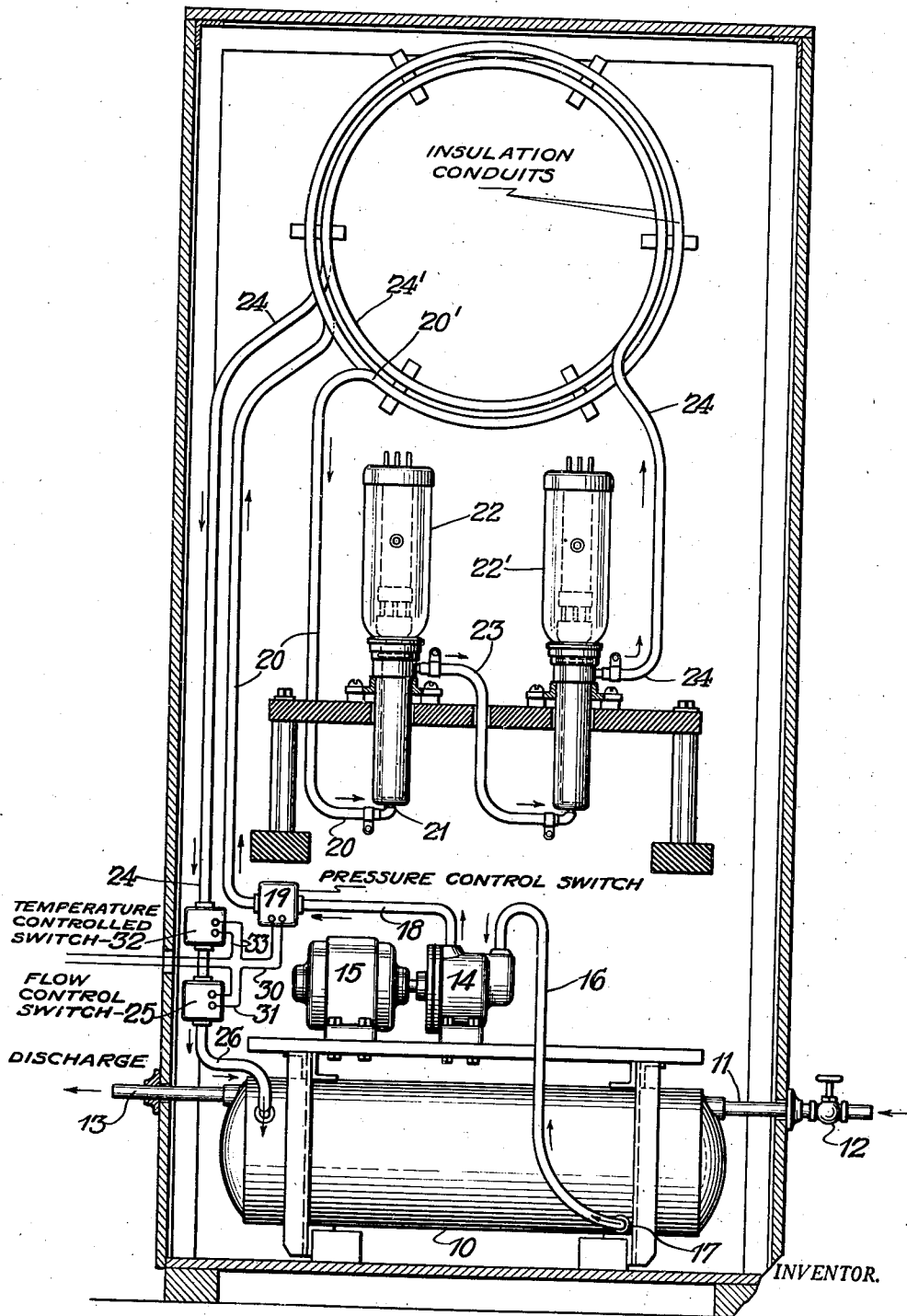
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COOLING SYSTEM FOR VACUUM TUBES

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COOLING SYSTEM FOR VACUUM TUBES

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This invention relates to cooling systems for vacuum tubes and the like.

In order to cool vacuum tube apparatus such as power oscillator tubes, it is the common practice to connect the cooling fluid cavities directly with a municipal or public water supply, the water flowing to waste after passing from the tubes. This method involves several disadvantages. First, the large amount of water necessary becomes costly if the tubes are in use continuously for considerable periods of time, particularly in localities where the available water supply is limited. Also the water supply may vary rather widely from moment to moment due to the opening and closing of water taps at adjacent points on the water system, thus causing variations in pressure and consequent series variations in the rate of flow through the tubes. With power vacuum tubes it is important to maintain a predetermined rate of flow of the cooling water. Otherwise, the tubes may be quickly injured due to overheating. While it is possible to utilize flow control switches to shut off the electric power supply when the rate of flow falls below normal, and thus protect the tubes against injury, yet if sensitive flow switches are used for that purpose and the water pressure fluctuates considerably, then the operation of the tubes will be liable to frequent interruption under the control of the flow switch. Where vacuum tubes such as power oscillators are being used for purposes such as inductive heating, such interruptions may make it necessary to discard objects being heat-treated because of uncertainty as to the extent of the heat treatment. Thus even momentary fluctuations in the pressure of the water supply may involve a troublesome chain of events. Also generally similar difficulties are involved in case the water supply is entirely cut off even momentarily, due to breakage of city supply lines or when the connections therefor are being altered.

The present invention provides a system for overcoming the above noted difficulties. In accordance with this invention, means are provided for maintaining a substantially constant pressure and flow of the cooling water through the vacuum tubes and at the same time a system which may be kept in operation for at least a considerable period even though the city water supply is interrupted or varies widely in pressure.

Various further and more specific objects, features and advantages will appear from the detailed description given below taken in connection with the accompanying drawing which forms a part of this specification and illustrates merely

by way of example, a preferred form of the invention. The invention consists in such novel combinations of parts and method steps as may be shown and described in connection with the apparatus herein disclosed.

In the drawing the single figure illustrates a preferred embodiment of the invention as used in connection with a pair of power oscillator tubes forming a part of a high frequency generator for induction heating purposes.

There are two principal factors which determine the required minimum rate of flow of cooling water through vacuum tubes. The first and generally most important factor is that the velocity of flow should be great enough so that steam bubbles will not form in the water at the surfaces to be cooled. This is important because the formation of such steam would serve to insulate the hot surfaces from the cooling water and thus quickly result in destruction of the tubes. Another factor generally of lesser importance is that the cooling water as supplied be sufficient in quantity considering its temperature, to absorb the amount of heat which is to be dissipated in protecting the apparatus. When the cooling fluid conduits of the tubes are connected directly to the city water supply as heretofore, the controlling factor in determining the rate at which the water supply is used, has been the matter of maintaining the required velocity through the tubes. That is, except for the requirement of maintaining a relatively high velocity, the amount of water used could be considerably reduced even though the tubes might become heated to somewhat higher operating temperatures than have been customary.

The present invention provides an arrangement for maintaining the required high velocity of cooling water, at a value substantially the same as with the practice heretofore, but at the same time a considerable proportion of the water supply is recirculated and thus reused so that the amount of water which has to be purchased is greatly reduced. At the same time the recirculation system is designed to maintain a substantially constant pressure and rate of flow independently of fluctuations in the city water supply.

In the example of the invention shown in the drawing, an elongated tank 10 of substantial capacity, for example 5 gallons, is shown having an intake pipe 11 adapted to be connected through adjustable valve 12 to a city water supply. A discharge pipe 13 is provided at the other end of the tank remote from the inlet, for nor-

mally discharging water at substantially the same rate as supplied through the inlet. With the particular apparatus shown, for example, this intake and outlet rate may be from 1 to 2 gallons per minute, as contrasted with a rate of 4 to 6 gallons per minute required when the city water supply is passed directly through the cooling conduits of the tubes.

A small circulating pump is shown at 14, driven for example by a motor 15. The inlet conduit 16 of this pump may be connected at 17 into the tank 10 at a region preferably near and below the tank inlet pipe 11. The outlet conduit 18 from the pump 14 may be connected to a pressure controlled switch 19 hereinafter described, and thence by insulation conduit means 20 to the inlet 21 of the cooling fluid cavities of a vacuum tube 22. In the particular example shown, the vacuum tubes comprise a pair of #892 three-electrode power oscillators 22, 22'. From the water outlet of tube 22 the cooling water may pass through an insulation conduit 23 to the water inlet for tube 22'. From the water outlet of tube 22' the water may be conducted through an insulation conduit 24 to a flow controlled switch 25 hereinafter described, and thence by a conduit 26 to a point in tank 10 near the tank outlet connection 13. In order that the vacuum tubes will not be grounded by the stream of water flowing through conduits 20 and 24, these insulation conduits may be made of considerable length and if desired, partially formed into coils as at 20' and 24'.

In the particular example shown, the pump 14 and associated circulating conduits are arranged to circulate water from and back to the tank 10 at the required rate of from 4 to 6 gallons per minute to insure the same velocity of flow through the tubes as with the practice heretofore. This is sufficient, but not very substantially greater than required to provide the necessary velocity through the tube cooling cavities for preventing formation of steam bubbles therein. It will be noted that heat from the circulated cooling water is efficiently transferred to the water flowing into and out of the tank 10 by mixing directly therewith. And since the pump intake is located near the intake for the supply of cool water, and the return conduit 26 is connected near the hot water outlet from the tank, the maximum practically possible transfer of heat from the circulating water to the water entering and leaving the tank is assured.

In the example shown, the water supplied from the pump to the tubes may be of a temperature in the neighborhood of 85° F. assuming the city water supply is at a temperature for example of 50-60° F. The water as returned from the tubes to the tank may be at a temperature in the neighborhood of 110° F. With the practice heretofore, such vacuum tubes were commonly operated at maximum temperatures of from 55-90° F. Such relatively low temperatures were not necessary for protection of the tubes, but were brought about by the necessity of maintaining a high velocity of flow of the cooling water through the tubes, for the reason above explained. The operation at a temperature of say 110° F., with the present invention is however still well below the permissible maximum operating temperature of tubes of this type (about 150° F.) and yet generally makes possible a saving of well more than two-thirds of the required water expense. The flow at a rate of one or two gallons per minute into and out

of the tank or reservoir 10 is ample to normally prevent rise of the tank water outlet temperature above a safe tube operating temperature of 110° F. for example.

At the same time the circulating pump arrangement insures that the pressure of the water supply to the tubes will remain substantially free of fluctuations, as will consequently also the rate of flow and velocity. Furthermore, if the city water supply should be cut off, for a considerable period thereafter the circulating pump may be kept in operation and maintain proper cooling of the tubes, at least for a period long enough to complete the treatment of the particular work pieces being heated in the induction heating apparatus, so that such work does not have to be discarded.

Use of the invention is also advantageous in locations where the public water supply pressure is normally too low to safely provide the necessary velocity through the tube cooling cavities and the long insulation conduits.

The pressure controlled switch 19 may be of any suitable known type adapted to disconnect circuit wires as at 30, in case for any reason the pressure of the water supplied to the tubes should fall very substantially below a predetermined value, for example 40-45 pounds per square inch with the particular apparatus shown. The circuit wires 30 may be connected in suitable known ways to control the electric power supply to the vacuum tubes, to thus cut off the power under the control of the pressure switch. This pressure switch is located at a point between the circulating pump and the vacuum tubes, as this is the part of the fluid circuit in which the high pressure has to be maintained to insure the proper velocity through the tube cooling cavities.

The flow controlled switch 25 may be of a suitable known type adapted to disconnect circuit wires 31 whenever the rate of flow from the tubes falls below a predetermined value. The circuit wires 31 as shown may be in series with the wires 30 whereby the electric power to the tubes is under the control of both the pressure switch and flow switch. The flow switch is preferably located in the conduit running from the tubes to the tank, as this is the portion of the circulating system through which at least a predetermined flow must be constantly passing from the tubes to insure removal of sufficient heat for their protection. If any previous part of the fluid circuit should become blocked, even though the pressure may be maintained adequate at the pressure switch 19, still the electric power to the tubes will be cut off by the flow switch. The pressure switch, in turn, insures that the power will be cut off upon an abnormal drop of cooling water pressure, even though the flow switch should fail to operate.

If desired, to further safeguard the tubes against damage from overheating, a temperature control switch 32 may be inserted in the circulating water return conduit at a point adjacent the flow switch. This temperature control switch may be of a suitable known type which, in response to a water temperature exceeding a predetermined value, will act to open the circuit between wires 33, the wires 33 being a part of the same circuit as wires 30 and 31 if desired. If the temperature of the water supply should cause the temperature at the inlet portion of the tank 10 to become too high for safety, then the temperature control switch will serve to automati-

cally cut off the power supply. Also in cases where the water supply becomes shut off and the apparatus continues to operate with the circulation of water from and to the tank, the temperature control switch will serve to automatically shut down the machine when the tank temperature becomes too high for further safe operation.

While the invention has been described in detail with respect to certain preferred examples, it will be understood by those skilled in the art after understanding the invention that various changes and modifications may be made without departing from the spirit and scope of the invention, and it is intended therefore in the appended claims to cover all such changes and modifications.

What is claimed as new and desired to be secured by Letters Patent is:

1. Apparatus for supplying and circulating water for water-cooled power vacuum tubes, comprising a circulating pump, a mixing tank, and conduits for circulation of water to and from spaced points in the tank, through the pump and the cooling cavities of the vacuum tubes, a cool water inlet to the system connected near the intake for the pump, and a warm water outlet connection for discharging water from a point in the tank remote from the pump intake connection, said pump and circulating connections being constructed and arranged to circulate water through the tube cavities at a rate substantially greater than the rate of supply and discharge of water to and from the system, flow controlled switch means located along the conduit which conducts warm water from the tube cavities to the tank, and electrical connections controlled by said switch means for disconnecting the vacuum tube power supply when the flow of said warm water is less than a predetermined rate.

2. Apparatus for supplying and circulating water for water-cooled power vacuum tubes, comprising a circulating pump, a mixing tank, and conduits for circulation of water to and from spaced points in the tank, through the pump and the cooling cavities of the vacuum tubes, a cool water inlet to the system connected near the intake for the pump, and a warm water outlet connection for discharging water from a point in the tank remote from the pump intake connection, flow controlled switch means located along the conduit which conducts warm water from the tube cavities to the tank, electrical connections controlled by said switch means for disconnecting the vacuum tube power supply when the flow of said warm water is less than a predetermined rate, and a pressure controlled switch means located along the conduit which conducts water from the pump to the tube cavities, said electrical connections being also controlled by said pressure switch means for disconnecting said power supply when the pressure from the pump is less than a predetermined value.

3. Apparatus for supplying and circulating wa-

ter for water-cooled power vacuum tubes, comprising a circulating pump, a mixing tank, and conduits for circulation of water to and from spaced points in the tank, through the pump and the cooling cavities of the vacuum tubes, a cool water inlet to the system connected near the intake for the pump, and a warm water outlet connection for discharging water from a point in the tank remote from the pump intake connection, said pump and circulating connections being constructed and arranged to circulate water through the tube cavities at a rate substantially greater than the rate of supply of cool water to the system, flow controlled switch operating means both located along the conduit which conducts warm water from the tube cavities to the tank, and switches operated by said means for disconnecting the vacuum tube power supply when the flow of said warm water is at less than a predetermined rate or above a predetermined temperature.

4. Apparatus for supplying and circulating water for water-cooled power vacuum tubes, comprising a circulating pump, a mixing tank, and conduits for circulation of water to and from spaced points in the tank, through the pump and the cooling cavities of the vacuum tubes, a cool water inlet to the system connected near the intake for the pump, and a warm water outlet connection for discharging water from the tank, said pump and circulating connections being constructed and arranged to circulate water through the tube cavities at a rate substantially greater than the rate of supply and discharge of water to and from the system, flow controlled switch means located along the conduit which conducts warm water from the tube cavities to the tank, and electrical connections controlled by said switch means and adapted for disconnecting the vacuum tube power supply when the flow of said warm water is less than a predetermined rate.

5. Apparatus for supplying and circulating water for water-cooled power vacuum tubes, comprising a circulating pump, a mixing tank, and conduits for circulation of water to and from spaced points in the tank, through the pump and the cooling cavities of the vacuum tubes, a cool water inlet to the system connected near the intake for the pump, and a warm water outlet connection for discharging water from the tank, said pump and circulating connections being constructed and arranged to circulate water through the tube cavities at a rate substantially greater than the rate of supply and discharge of water to and from the system, and a pressure controlled switch means located along the conduit which conducts water from the pump to the tube cavities, and electrical connections controlled by said switch means adapted for disconnecting the vacuum tube power supply when the pressure from the pump is less than a predetermined value.

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