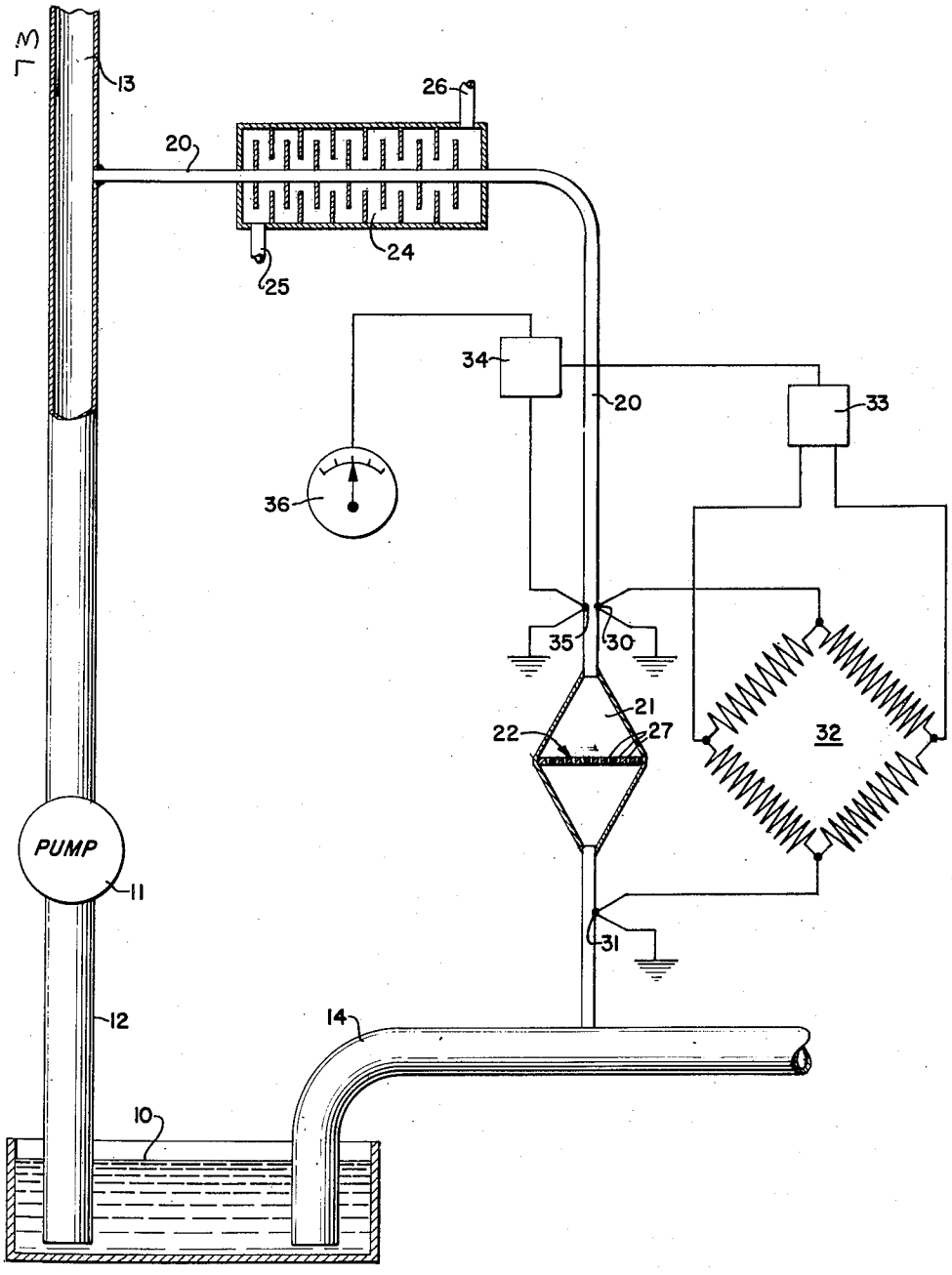
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OXIDE INDICATOR

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OXIDE INDICATOR

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This invention pertains to a device for determining the percentage of an oxide of an alkali metal dissolved in a solution of the alkali metal and more particularly to a device which determines the temperature at which the oxide is precipitated from the alkali metal solution.

In all liquid metal systems it is necessary to determine the percentage of oxide of the liquid metal dissolved in the system to prevent undue corrosion of the materials of the system and to prevent plugging of restricted passages of the system.

It is well known that the percentage of an alkali metal oxide soluble in a liquid metal varies directly with the temperature of the liquid metal. Thus, if one can determine the temperature at which the oxide is precipitated from the solution, the percentage of the oxide in the solution can easily be determined from a suitable graph or other data.

This invention provides a device for determining the temperature at which the oxide is precipitated from the liquid metal utilizing a by-pass line to by-pass a portion of the liquid metal being circulated in the system. According to the invention, a plate having a quantity of small openings is mounted transversely in the by-pass line so that the openings will be plugged by the oxide when it is precipitated from the liquid metal. Mounted upstream from the plate is a suitable cooling means for cooling the liquid metal so as to precipitate the oxide therefrom. Suitable temperature sensing means are mounted on each side of the plate, such as thermocouples, to sense the temperatures of the liquid metal on each side of the plate. When the two temperatures vary by more than a set amount, it indicates that the openings in the plate have been plugged, thus preventing fluid flow past the plate. The plugging of the plate, of course, indicates the precipitation of the oxide from the liquid metal. At this point the temperature immediately upstream of the plate is observed, which temperature corresponds to the temperature at which the oxide is precipitated from the liquid metal.

Accordingly, it is the principal object of this invention to provide a simplified method of determining the amount of oxide dissolved in a liquid metal solution utilizing a flat plate having a quantity of small openings and temperature sensing means to determine when the openings in the plate are plugged by the oxide precipitated from the solution.

Another object of this invention is to provide a simplified method for determining the amount of oxide in a liquid metal solution, which method utilizes temperature responsive means to determine when the flow past the plate having the small openings ceases and also the temperature of the liquid metal solution at the point at which the flow stops.

These and other objects and advantages of this invention will be more easily understood by those skilled in the art from the following detailed description of a preferred embodiment when taken in conjunction with the attached drawing showing a schematic arrangement of a system constructed according to this invention for determining the percentage of an oxide dissolved in a liquid metal solution.

The indicating device of this invention is shown installed in a liquid metal system which includes a sump tank 10. A pump 11 is provided for circulating the liquid

metal from the sump through the remainder of the system, not shown. The pump suction is connected to the sump tank by means of a conduit 12 while the pump discharge is connected to the remainder of the system by means of conduit 13. A conduit 14 returns the liquid metal to the sump tank so that it may be recirculated by the pump.

A small by-pass line 20 is provided for by-passing a small portion of the liquid metal flow from the conduit 13 back to the conduit 14. A flat plate 22 having a plurality of small holes 27 is mounted transversely in an enlarged portion 21 of the by-pass line 20. The openings in the flat plate 22 are sized so that they will be plugged by the oxide which is precipitated from the liquid metal solution flowing in the by-pass line. In one particular design of this indicating device it was found that in a one-inch diameter plate, seventeen 3/64-inch diameter holes were adequate in a system handling a solution of liquid sodium and potassium. Of course, for other liquid metals a different size or number of holes may be desirable.

A wrap-around heat exchanger 24 is mounted so as to surround a portion of the by-pass line upstream from the flat plate 22. The heat exchanger is provided with an inlet opening 25 and an outlet 26 so that a suitable cooling fluid may be passed through the heat exchanger to cool the liquid metal solution. Thermocouple elements 30 and 31 are attached to the by-pass line on opposite sides of the flat plate 22 for sensing the temperature of the liquid metal flowing in the by-pass line on opposite sides of the plate. While thermocouples are shown in the attached drawing, other temperature sensing devices, such as thermometers, may also be used. The outputs from the two thermocouples 30 and 31 are connected to the opposite corners of the bridge circuit 32, the unbalance signal of which is connected to an amplifier or relay device 33. The amplifier or relay device 33 should be adjusted so that it will transmit a signal to close a switch 34 when the difference between the two temperatures sensed by the thermocouples 30 and 31 exceeds a small predetermined amount on the order of five to ten degrees Fahrenheit. The switch 34 closes to complete a circuit from the thermocouple 35 to the indicating device 36. The thermocouple 35 is attached to the by-pass line adjacent the upstream side of the flat plate to determine the temperature of the liquid metal solution at the instant in which a difference between the temperatures sensed by the thermocouples 30 and 31 exceeds the small predetermined value.

In order to operate the above-described indicating device, one first must establish a flow of liquid metal through the by-pass line 20. When there is a continuous flow through the by-pass line 20, the two thermocouples 30 and 31 will indicate substantially the same temperatures. Thus, the relay device 33 will not close and no temperature will be recorded on the device 36 from the thermocouple 35. Next, a cooling fluid is circulated through the heat exchanger 24 to lower the temperature of the liquid metal below the temperature of the liquid metal being circulated in the main system. As the temperature of the liquid metal is lowered, a temperature will be reached at which the oxide is precipitated from the liquid metal. The temperature at which the oxide is precipitated, of course, is proportional to the amount of oxide dissolved in the liquid metal. The point at which the oxide is precipitated from the solution is determined by the difference between the temperatures sensed by the thermocouples 30 and 31. As pointed out above, these temperatures will be substantially equal as long as there is a flow through the openings 27 and the plate 22 but will differ by a substantial amount when the flow is stopped by oxide plugging the openings 27 in the plate 22.

When the flow past the plate is stopped by the precipi-

tated solids of the oxide plugging the openings the temperatures on opposite sides of the plate will differ, with the downstream temperature exceeding the upstream temperature. This results from the fact that the heat transfer through the plugged plate is poor, compared with the transfer when flow exists. Thus, the hotter liquid metal flowing in the return conduit 14 will increase the temperature on the downstream side of the plate while the upstream side remains cool.

The relay device 33 can be set so that when this difference in temperature is reached it will close the switch 34 so as to indicate the temperature of the liquid metal upstream of the plate 22 at this instant. From this temperature one can easily determine the amount of oxide in the liquid metal.

After the desired oxide reading has been taken, the openings in the plate 22 can be unplugged by stopping the flow of cooling fluid to the heat exchanger 24. This will increase the temperature of the liquid metal in the by-pass line 20 in order to redissolve the oxide in the liquid metal solution. If desired, the oxide content of the liquid metal can be determined by observing the temperature at which the oxide redissolves in the liquid metal instead of using the temperature at which it precipitates from the liquid metal.

While the above invention was described as using three thermocouples to determine the stoppage of flow through the plate 22 and the temperature at which the flow was actually stopped, these conditions could also be determined by using only two thermocouples and visually observing the difference between the two thermocouple readings. When the difference between the two readings exceeds a small value on the order of five to ten degrees Fahrenheit, one can visually observe the temperature indicated by the thermocouple 30 mounted upstream from the plate 22. This temperature, of course, is the temperature at which the oxide is precipitated from the solution. In cases where it is only necessary to know the temperature at which the system would plug due to oxide being precipitated from the system, it would be unnecessary, of course, to convert this temperature to an oxide reading.

This invention thus provides a simple means using only temperature sensing elements to determine both when the flow past the plate 22 is stopped by the precipitated oxide plugging up the openings in the plate, as well as to indicate the temperature at which this plugging occurs. Temperature sensing devices such as thermocouples are very rugged and relatively simple to build and maintain, thus eliminating a major source of trouble with previous indicating devices which depended upon other means for determining when the flow past the plate 22 stopped.

While but one preferred embodiment of this invention has been described in detail, many modifications and improvements will occur to those skilled in the art within its broad spirit and scope.

I claim:

1. In a method of determining the amount of an oxide of an alkali metal dissolved in a solution of the metal, the steps comprising: passing a liquid solution of the metal through a passage means containing a flow restriction; cooling said liquid solution upstream of said flow restriction; measuring the temperatures of said solution on each side of said flow restriction; and recording the temperature of said solution upstream of said flow restriction at the instant the temperatures on opposite sides of said flow restriction differ by more than a predetermined amount.

2. A device for determining the amount of an oxide of an alkali metal dissolved in a solution of the metal comprising: a conduit; a plate member mounted transversely in said conduit, said plate having a plurality of small openings; means for establishing a flow of a liquid solution of the metal and oxide through the conduit; temperature responsive means disposed to sense the temperature of said solution on opposite sides of said plate; a heat exchanger disposed adjacent said conduit upstream of said plate to cool said solution; means for sensing the difference between the temperatures of the solution on opposite sides of said plate; and indicating means rendered operative when a predetermined difference between such temperatures is exceeded.

3. A method for determining the amount of an oxide of an alkali metal dissolved in a liquid solution of the metal comprising the following steps: establishing a flow of a liquid solution of the metal through a conduit containing a flow restricting means; cooling the solution upstream of said flow restricting means; measuring the temperature of the solution on opposite sides of said flow restricting means; measuring the temperature of the solution upstream of said flow restriction when the temperatures on opposite sides of said flow restriction vary by a predetermined amount; and comparing the temperature of the solution upstream of said flow restriction with previously established data to determine the amount of oxide in the solution when the temperatures at the upstream and downstream sides of the flow restricting means vary by a predetermined amount.

4. In a method for determining the amount of an oxide of an alkali metal dissolved in a solution of the metal, the steps comprising: establishing a flow of a liquid solution of the metal and oxide through a conduit having a flow restricting means; stopping said flow by cooling the solution to precipitate the oxide from the solution to plug said flow restricting means; sensing the temperature difference across said flow restricting means to determine the stopping of said flow; and comparing the temperature of the solution when said flow is stopped with known standard data to determine the amount of oxide present in the solution.

5. In a method of determining the amount of an oxide of an alkali metal dissolved in a solution of the metal, the steps comprising: establishing a flow of the solution through a conduit containing a flow restricting means; cooling the solution upstream of said flow restricting means until the oxide is precipitated from the solution; and detecting the thermal point at which the oxide is precipitated by sensing the temperatures on opposite sides of the flow restricting means.

6. In a liquid metal system of the type having a sump, a pump, a pressure conduit leading to said pump and thence to the system, and a return conduit leading from the system to said sump, an oxide indicator comprising: a by-pass conduit extending from the pressure conduit at the outlet side of the pump to the return conduit; means forming a chamber in said by-pass conduit; wall means extending across said chamber, said wall means having a plurality of restricted openings extending therethrough; means between said pressure conduit and said chamber forming means for reducing the temperature of fluid flowing to said chamber; temperature sensing means supported by said by-pass conduit at each side of said wall means; and temperature indicating means operatively connected with said by-pass conduit at one side of said wall, said temperature indicating means being connected in circuit with said temperature sensing means and responsive to a predetermined temperature differential between the liquid metal at opposite sides of said wall means to indicate the temperature of the liquid metal at one side thereof.

7. In a liquid metal system of the type having a sump, a pump, a pressure conduit leading to said pump and thence to the system, and a return conduit leading from the system to said sump, an oxide indicator comprising: a by-pass conduit extending from the pressure conduit at the outlet side of the pump to the return conduit; means forming a chamber in said by-pass conduit; wall means extending across said chamber, said wall means having a plurality of restricted openings extending therethrough; means between said pressure conduit and said chamber forming means for reducing the temperature of fluid

flowing to said chamber; temperature sensing means supported by said by-pass conduit at each side of said wall means; a second temperature sensing means supported by said by-pass conduit at one side of said wall means; an indicator; and an electrical circuit including a Wheatstone bridge connected with the first-mentioned temperature sensing means; a relay device connected for control by said Wheatstone bridge; and a switch electrically connected between the second temperature sensing means and said indicator, said switch being connected for control by said relay device.

8. In a liquid metal system of the type having a sump, a pump, a pressure conduit leading to said pump and thence to the system, and a return conduit leading from the system to said sump, an oxide indicator comprising: a by-pass conduit extending from the pressure conduit at the outlet side of the pump to the return conduit; wall means extending across said by-pass conduit, said wall means having a restricted opening extending therethrough; means adjacent said pressure conduit for reducing the temperature of fluid flowing to said restricted opening; temperature sensing means supported by said by-pass conduit at each side of said wall means; additional temperature sensing means operatively disposed adjacent said by-

pass conduit at one side of said wall; an indicating device in circuit with said additional temperature sensing means; and switch means between said indicating device and said additional temperature sensing means, said switch means being operative to connect said additional sensing means and said indicating device in response to a predetermined differential in temperatures sensed at opposite sides of said wall means.

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