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PURIFICATION OF ALKALI METALS BY HEAT TRANSFER

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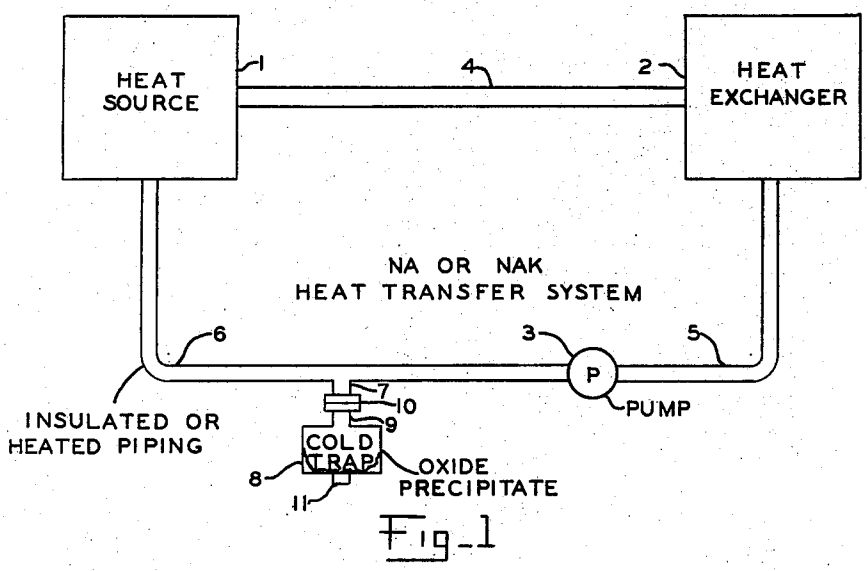


Fig-1

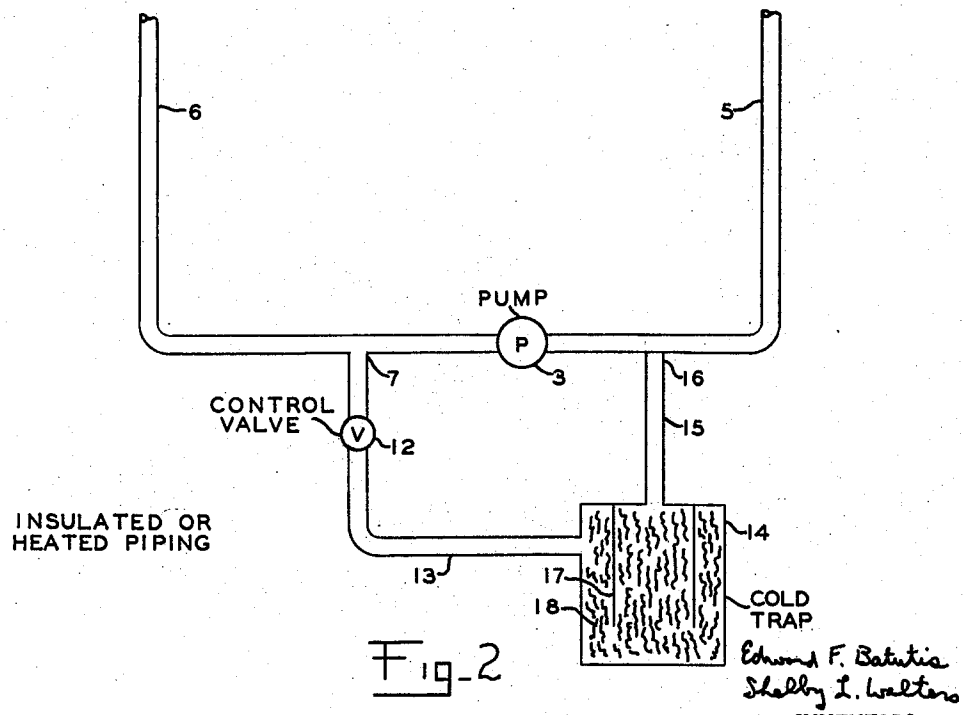


Fig-2

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PURIFICATION OF ALKALI METALS BY HEAT TRANSFER

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1 Claim. (Cl. 75—66)

This invention relates to new and useful improvements in liquid metal heat transfer systems and more particularly to a cold trap for removing impurities from the liquid metal in such systems.

In recent years various liquid metals have been investigated quite thoroughly as possible heat transfer media for high temperature heat transfer of various kinds. Among the metals which have been investigated and which have proved the most satisfactory for a heat transfer medium are the alkali metals in general and more particularly the metals sodium and potassium and sodium-potassium alloys (sometimes referred to as NaK). In alkali metal heat transfer systems a considerable investigation has been made to determine the physical and chemical effects of the alkali metals in various heat transfer applications. It was soon found that while the liquid alkali metals are quite useful for the transfer of heat in high temperature heat transfer systems there are a number of difficulties which must be overcome. First of all, it was found that the alkali metals appeared to be corrosive in their action toward the metal piping used in high temperature heat transfer systems and that this corrosion could result in considerable damage to such a system. After considerable investigation it was found that the principal cause of corrosion in liquid metal heat transfer systems is the presence of soluble impurities in the liquid metal. The principal impurity in liquid metal systems which causes corrosion is an oxide impurity which is generally the monoxide of the alkali metal. It has also been found, however, that other soluble impurities such as alkali metal hydrides and chlorides as well as other soluble metals such as iron are present in liquid metal heat transfer systems and result in corrosion in the system or result in the formation of solid precipitates in the system which frequently plug the heat transfer lines and the heat exchanger and cause considerable damage to the system.

It is therefore one object of this invention to provide a new and improved liquid metal heat transfer system having a means to remove soluble impurities from the system.

Another object of this invention is to provide a new and improved liquid metal heat transfer system having a cold trap for removing soluble impurties located out of the main stream of flow of the heat transfer medium.

Another object of this invention is to provide a new and improved liquid metal heat transfer system having a cold trap for removal of soluble impurities located out of the main stream of flow of the liquid metal and having a means to force the circulation of a part of the liquid metal through the cold trap for removal of said impurities.

Another object of this invention is to provide a new and improved method for the removal of soluble impurities from liquid metals in a liquid metal heat transfer system.

Other objects of this invention will become apparent from time to time throughout the specification and claims as hereinafter related.

This invention comprises a new and improved liquid metal heat transfer system including an improved method for removal of soluble impurities from the liquid metals therein, which will be described more fully hereinafter and the novelty of which will be particularly pointed out and distinctly claimed.

In the accompanying drawings, to be taken as a part of this specification, there are shown two preferred embodiments of this invention, in which drawings:

Fig. 1 is a diagrammatic view of a liquid metal heat transfer system including a cold trap for removal of soluble imprities from the liquid metal heat transfer medium, and

Fig. 2 is a diagrammatic view of a portion of a heat transfer system of the type disclosed in Fig. 1 in which the cold trap is located in a by-pass loop and which includes an arrangement for forceably circulating a portion of the liquid metal through the cold trap.

Referring to the drawing by numerals of reference and more particularly to Fig. 1 there is shown diagrammatically a liquid metal heat transfer system which utilizes liquid alkali metals such as sodium, potassium or NaK for transfer of heat at a high temperature. In this heat transfer system there is shown a heat source 1, a heat exchanger 2, and a pump 3 connected in a closed circuit. The system may also, if desired, be provided with a filling tank or a surge tank for ease of handling of larger quantities of the heat transfer metal. The pump 3 is shown diagrammatically and may be a mechanically operated pump or may be an electromagnetic pump of the type which is in general use for the pumping of liquid metals. In the heat transfer system the heat source 1 is connected to the heat exchanger 2 by a pipe or conduit 4. The heat exchanger 2 is connected to the pump 3 by the pipe or conduit 5 and the pump 3 is connected back to the heat source by a pipe or conduit 6. The entire heat transfer system is maintained at a very high temperature (about 800° F.) as is conventional in the use of such liquid metal heat transfer systems. The connecting pipes 4, 5, and 6 in the heat transfer system are all maintained substantially at the temperature of the system by being insulated or by being provided with supplemental heating. In the pipe 6 between the pump 3 and the heat source 1 there is provided a T connection 7 to which there is connected a cold trap 8. The T connection 7 and the inlet pipe 9 to the cold trap 8 are either heavily insulated or are provided with supplemental heating to prevent solidification in the inlet to the cold trap 8.

It has been found in the operation of liquid metal heat transfer systems of this type that the liquid metal will not corrode the system appreciably if the concentration of oxygen in the form of alkali metal oxides in the system is maintained at a concentration less than about .01–.02 wt. percent. At higher oxide concentrations in the liquid metal it has been found that a considerable corrosion of the system results and that oxides and other impurities may precipitate in the main stream of the system and in the heat exchanger and cause considerable damage to the system. This invention therefore is based upon our discovery that it is not necessary to cool the main stream of liquid metal to precipitate the soluble oxides and other impurities which are present to remove them from the system.

In this system we have found that a cold trap which consists of any suitable container for collecting the oxides and other temperature soluble impurity may be connected to the main stream of the liquid metal heat transfer system through a suitable pipe connection and maintained at a temperature substantially below that of the main stream of the heat transfer metal with the result that impurities are collected therein. The cold trap must be maintained at a temperature below the temperature at which the impurities dissolved in the system become appreciably soluble in the liquid metal. The connection

to the cold trap however must be maintained at a temperature sufficiently high that the impurities are not precipitated in the connection and thus plug the entrance to the cold trap. When the system is operated with the liquid metal circulating from the heat source to the heat exchanger and back to the pump the portion of liquid metal which passes through the T connection 7 is depleted of soluble impurities by precipitation of those impurities in the cold trap 8. The cold trap 8 is filled with the same liquid metal which is in the system but is in contact with the cold walls of the trap which results in the precipitation of oxides and other soluble impurities on the walls of the trap. This precipitation of impurities lowers the concentration of those impurities in the liquid metal in the trap. The liquid metal which is passing through the T connection 7 will have soluble impurities at a higher concentration than the liquid metal in the cold trap and those impurities will diffuse into the liquid metal in the cold trap and will continuously precipitate on the walls of the trap. In this manner the impurities which are dissolved in the main stream of liquid metal can be removed without requiring that the entire stream of metal be cooled to a point at which the impurities would precipitate. In this manner the impurities are precipitated in a cold trap which is located outside the main stream and thus will prevent the precipitation of those impurities at any point in the main stream of the flow of the liquid metal.

In several experiments this type of cold trap was used for the removal of oxide and other soluble impurities from sodium and from NaK which was circulated in the system. In these experiments it was found that over a period of several days it was possible to reduce the oxide concentration of a liquid metal system from .12 wt. percent oxygen, or higher, to a value less than .01 wt. percent oxygen (and in some cases as low as .002 wt. percent oxygen). The results of some of these experiments are set forth in Table I.

Table I

Liquid Metal	System Temp., ° F.	Trap Temp., ° F.	Oxide Concentration		
			Initial, percent	Final, percent	Time
NaK (78% K)	1,000	300	0.100	0.015	7 days.
NaK (78% K)	1,000	400	0.150	0.014	3 days.
Na	1,000	350	0.100	0.009	14 days.
		390	0.043	0.009	28 days.
Na	1,000	250	0.009	0.006	8 days.
		175	0.006	0.002	3 days.
Na	1,000	250	0.012	0.003	1 day (24 hrs.).

When it is desired to clean out the cold trap this may be accomplished by opening the outlet 11 from the cold trap and flushing the trap with hot liquid metal from the main system which will re-dissolve the main impurities. The trap may also be cleaned by disconnection of the joint or union 10 and removal of the trap for cleaning or other disposal.

In Fig. 2 of the drawings there is shown a diagrammatic view of a slight modification of the system shown in Fig. 1. In this view the heat source and heat exchanger are not shown but the connecting piping to those units is shown. The reference numerals for the connecting piping and pump are the same as used in Fig. 1. In the system shown in Fig. 2, the pipe 6 is provided with a T connection 7 as in the system shown in Fig. 1. The T 7 is connected to one side of a control valve 12. The other side of the control valve 12 is connected by a pipe or conduit 13 to the inlet side of a cold trap 14. The outlet from the cold trap 14 is connected by a pipe or conduit 15 to a T connection 16 in the pipe 5 on the inlet side of the pump 3. The cold trap is preferably a cylindrical container which is provided with an internal cylindrical baffle 17 and is packed with a suitable filtering material such as a metal wool 18. In this system the valve 12, pipes 13 and 15 and cold trap 14 form a separate loop in parallel with the main heat transfer system. The valve 12 may be opened whenever the concentration of impurities requires and a portion of the liquid stream circulated through the cold trap by the pump 3. In the system shown in Fig. 1 the circulation of liquid into the cold trap was entirely by diffusion. In this form of the invention the arrangement shown provides for a forced circulation of the liquid metal through the cold trap. In this form of the invention as in Fig. 1 the piping to the cold trap is maintained at substantially the same temperature as the rest of the system so that impurities will not be precipitated in the piping or in the valve. The cold trap 14 is maintained at a considerably lower temperature so that the oxides and other impurities in the liquid metal will be precipitated on the walls of the trap.

Although there have been described two principal embodiments of this invention it will be obvious to those skilled in the art that other embodiments of this invention are possible and that within the scope of the appended claim this invention may be practiced otherwise than as specifically described.

Having thus described the preferred embodiments of our invention, what we desire to claim and secure by Letters Patent of the United States is:

A method of removing soluble impurities from a hot liquid alkali metal which consists of circulating said hot liquid metal past a cold surface positioned out of direct contact with said flowing liquid metal and separated therefrom by a static or stagnant portion of the same liquid alkali metal, whereby impurities diffuse into said stagnant liquid metal from said hot liquid alkali metal and said circulating hot liquid alkali metal is purified while in use.

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