March 31, 1959 E. C. KING ET AL 2,880,065

METHOD FOR DISPOSING OF ALKALI METALS

Filed July 28, 1955 2 Sheets-Sheet 1

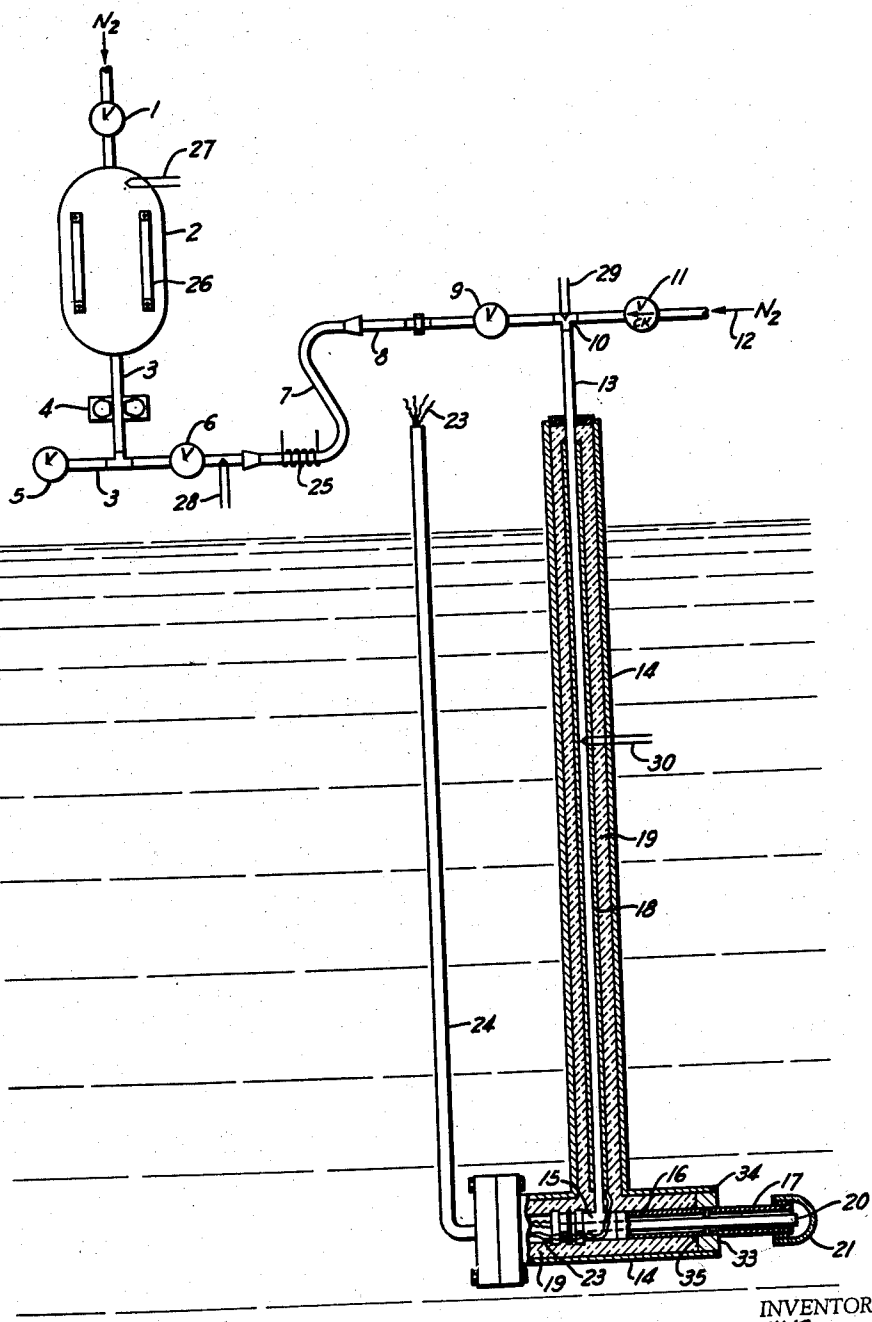


Fig. 1

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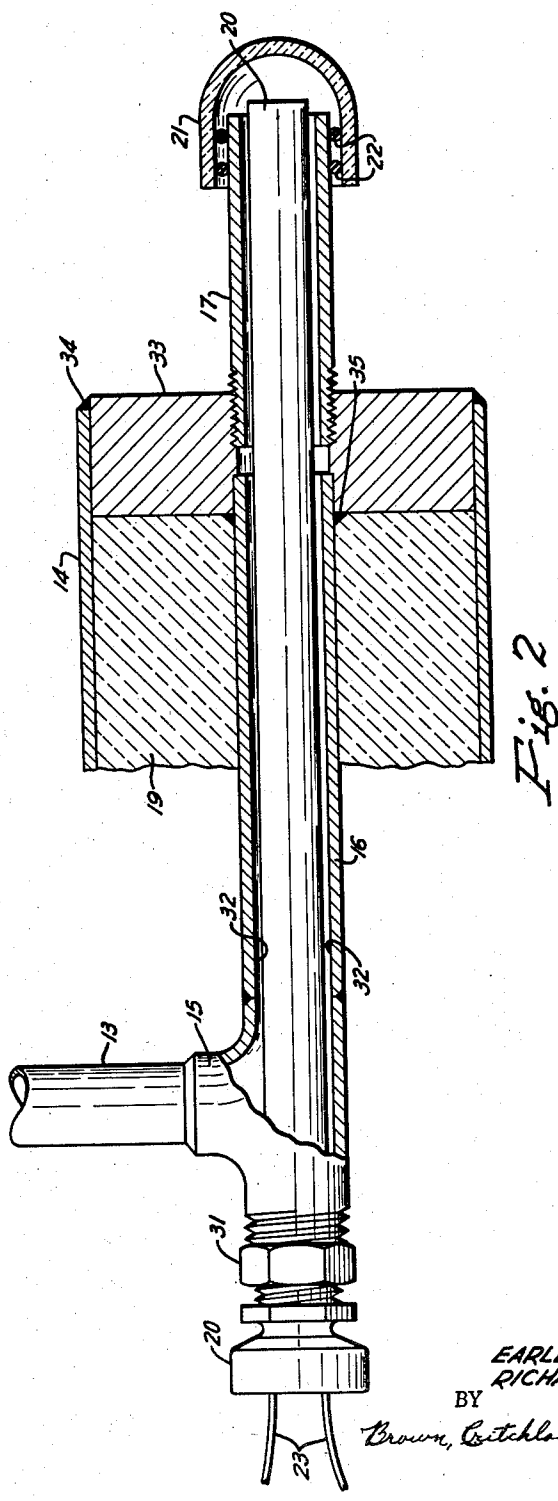


Fig. 2

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METHOD FOR DISPOSING OF ALKALI METALS

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3 Claims. (Cl. 23—184)

This invention relates to a method for disposing of alkali metals under water. More particularly, it relates to a method whereby alkali metals such as sodium are broken up into a fine spray and react instantly with water thus ensuring complete reaction at a uniform rate without spasmodic explosions.

The development of nuclear reactors and other systems which use liquid alkali metals for heat transfer has produced a considerable problem as to the disposal of large quantities of sodium and other alkali metals. It is well known that when sodium comes into contact with water, hydrogen is liberated which immediately ignites with explosive violence. Because of this, sodium disposal has been a difficult problem especially on a large scale. The former disposal procedure was to drop a barrel of sodium open at one end from a high cliff into a large body of water and allow it to react at will upon contact with the water. This method of disposal was haphazard and dangerous to both wildlife and working personnel. However, all other methods were too slow for practical use when the disposal of large quantities of sodium was required. It, therefore, became apparent that a more efficient and less hazardous method for disposing of alkali metals was necessary.

It is one object of this invention to provide a new and improved method for disposing of large amounts of alkali metals such as sodium and potassium.

Another object is to provide an underwater method for disposing of sodium which is safe, rapid, efficient and complete.

A still further object is to provide a method of disposing of alkali metals which utilizes a special type nozzle that disperses the molten metal into a fine spray underwater thereby ensuring a rapid reaction with water and eliminating dangerous explosions which might otherwise occur.

A further object is to provide an improved apparatus for disposal of molten alkali metals in large quantities.

Other objects will become apparent throughout the following specifications and appended claims.

This invention comprises a new and improved process for disposing of alkali metals 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 is shown in Fig. 1 a schematic and sectional diagram of the complete apparatus used in this method of disposal, and in Fig. 2 there is shown a detailed sectional view of the nozzle used to inject an alkali metal into water under high velocity.

This invention is based upon the discovery that alkali metals can be safely and efficiently disposed of by forcing molten alkali metal through a nozzle underwater at a sufficient velocity to cause the alkali metal to break up into a fine spray which will react instantly with the water. This method eliminates the explosive hazards of prior methods and prevents any metal from reaching the surface of the water where combustion would produce a dense oxide smoke.

Referring now to Fig. 1 of the accompanying drawings, there is shown a high pressure supply of an inert gas, such as nitrogen, connected through a control valve 1 to the top of a suitable sodium supply tank 2. The bottom of the sodium supply tank is connected by stainless steel pipe 3 to a flowmeter 4, a charging valve 5 and a control valve 6. The control valve 6 is connected to one end of a length of flexible copper tubing 7. The opposite end of the copper tubing 7 is connected by a stainless steel pipe 8 to a control valve 9. The control valve 9 is connected to a T 10 which in turn is connected to check valve 11. The check valve 11 is connected to a low pressure nitrogen supply 12. Between control valve 9 and check valve 11 there is connected to the T 10 a length of stainless steel pipe 13 surrounded by a steel casing 14. In normal use of this apparatus about 10 feet of the steel casing is underwater. The submerged end of the pipe 13 is connected by means of a T 15 to a short section of stainless steel pipe 16 and a threaded pipe nozzle 17. Between the pipe 13 and the steel casing 14 is a tubular electrical heater 18 surrounded by thermal insulation 19. A tubular electrical heater 20 is inserted through the pipe nozzle 17. The nozzle 17 is initially protected from the water by a glass cap sealed by O rings 22. Electricity for the heaters 18 and 20 is supplied through wires 23 enclosed in an electrical conduit 24. All sections of pipe above the surface of the water from the sodium supply tank 2 to the steel casing 14 are heated with an external electric resistance heater 25 wrapped around the pipe. The sodium supply tank 2 is heated by means of two external strip heaters 26. Thermocouples 27, 28 and 29 are inserted in the system at the tank 2, valve 6, and T 10, respectively, and thermocouples 30 are positioned every 6" in the section of pipe 13 below the water level.

In Fig. 2 there is shown in more detail the construction of the discharge nozzle 17. The stainless steel pipe 13 is connected by a stainless steel T 15 to the stainless steel pipe 16. In the pipe 16 there is inserted the electrical tubular heater 20 which extends all the way through the pipe 16 and the threaded nozzle 17. A stainless steel reducing bushing 31 secures the heater 20 in place and prevents sodium from entering the electrical conduit 25 which extends above the surface of the water. Between the heater 20 and the pipe 16 there is an annular space 32 which restricts the passage of the molten alkali metal and provides the high velocity necessary for rapid dispersion of the metal upon contact with water when the glass cap 21 is removed. While the nozzle assembly is being lowered into the water the O rings 22 provide a watertight seal between the glass cap 21 and the nozzle 17. The nozzle and heater assembly are welded to a plug 33 in the casing 14 as indicated at 34 and 35.

In operating this system to dispose of sodium the following procedure was used. The equipment shown are supported by a raft above the water level and controlled from shore. The casing 14 containing the pipe 13 and nozzle 17 was lowered from the raft until the nozzle reached a depth of about 10 feet. The sodium supply tank 2 was charged with 40 lbs. of sodium through the valve 5, then attached to the raft and all piping connected. The control valve 9 was closed. All heating elements were turned on and the thermocouples observed during the heating process. When the sodium reached a temperature of 350° F. and all piping in the system was heated to at least 250° F., nitrogen at 50 p.s.i.g. was supplied to the sodium supply tank 2 through valve 1. At the same time, 30 p.s.i.g. nitrogen pressure was supplied to the nozzle 17 through check valve 11 thus blowing the glass cap 21 off the nozzle. Nitrogen bubbles appeared on the surface at this time. The control valve 9 was then opened and the sodium was forced by nitrogen pressure through the pipes and out through nozzle 17. The nitrogen used

in blowing off the glass cap 21 was stopped to ensure that only sodium was passing through the nozzle. The check valve 11 prevented sodium from backing up through the nitrogen line. The time when the reaction was complete was indicated by nitrogen bubbles from the empty sodium tank appearing at the surface of the water. The control valve 9 was then closed and nitrogen pressure was supplied through check valve 11 to prevent water from entering the nozzle and piping. The sodium supply tank 2 was removed and the piping was flushed with water by cutting off the nitrogen pressure and opening the control valve 9. A pump (not shown) was connected to the piping and water circulated through the entire system to remove all residual traces of sodium. The nozzle was raised above the surface of the water and the piping dried by turning on the heating elements and flushing with nitrogen. The nozzle was finally capped in preparation for the next experiment.

In two experiments which were carried out with the apparatus described using sodium, the following data were obtained:

Lbs. Sodium Reacted	Reaction Time (Seconds)	Nozzle Depth (ft.)	Sodium Temp. (° F.)	Flow Rate, lbs./hr.	Nozzle Velocity (ft./sec.)
43	30.4	10	350	5,100	15.9
40.5	26.3	10	350	5,540	17.3

It can be readily observed from these experiments that underwater disposal of large quantities of sodium is practical with the equipment and procedure described. Under the disposal conditions used the reaction took place smoothly and continuously. There was little smoke produced and no hydrogen fires or detonations were observed. A minimum depth of 10 feet should be maintained to ensure complete underwater reaction and no flame or smoke above the surface of the water. The discharge velocities attained with an open end pipe nozzle are sufficiently high to produce nearly instantaneous reaction underwater and to prevent nozzle plugging.

In this method of disposal, the reaction of liquid metal with water is substantially instantaneous because of the high surface area and rapid linear movement of the dispersed metal. The surface area is a function of the shearing action at the nozzle. Thus, at high flow rates (at a Reynolds number of the order of 45,000) the turbulence in the nozzle will break up the liquid metal as it is discharged into a spray having a large interfacial area and rapid linear velocity which results in nearly instantaneous reaction with the water. If the flow rate be constant and rapid, the reaction will be limited and continuous. At lower flow rates, the rate of creating new interfacial area may become spasmodic since the forces that determine the character of the flow at the nozzle discharge are neither small enough to produce an unbroken stream of small area nor large enough to produce a spray of nearly infinite area, at which time the reaction is also spasmodic. The apparatus and method described herein are suitable for the disposal of large quantities of sodium or other alkali metals. Nozzle plugging presented no problem when the immersion heater was used as described.

Other modifications of this invention will become apparent to those skilled in the art. Thus, it should be understood that within the scope of the appended claims, this invention may be practiced otherwise than as specifically described.

What is desired to be claimed and secured by Letters Patent of the United States is:

1. A method of disposing of alkali metal which comprises discharging said metal at a temperature of about 350° F. under pressure of an inert gas under the surface of a large body of liquid consisting essentially of water which is opened to the atmosphere through a turbulent flow nozzle at a velocity having a Reynolds number of about 45,000, thus insuring complete and continuous reaction with water and eliminating the hazard of hydrogen fires and the appearance of alkali metal oxide smoke on the surface.

2. A method in accordance with claim 1 in which said alkali metal is selected from the group consisting of sodium, potassium, and sodium-potassium alloys.

3. A method in accordance with claim 1 in which the inert gas used is nitrogen.

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