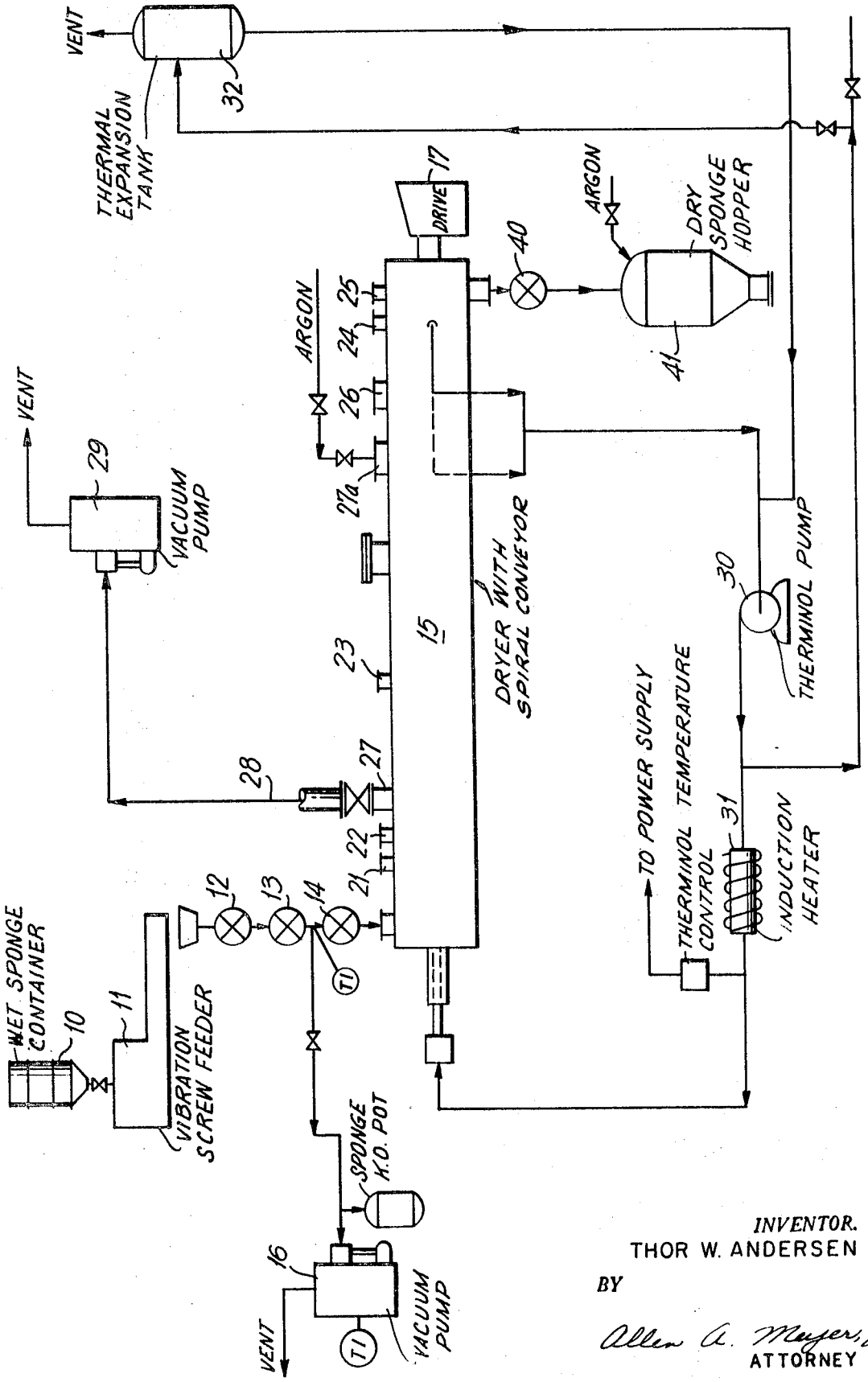
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CONTINUOUS PROCESS AND APPARATUS FOR DRYING TITANIUM SPONGE

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CONTINUOUS PROCESS AND APPARATUS FOR DRYING TITANIUM SPONGE

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ABSTRACT OF THE DISCLOSURE

A continuous process for drying titanium sponge in which wet sponge is continuously conveyed to an evacuated drying chamber. A continuous conveyor in the drying chamber transports the wet sponge through a heated zone toward a discharge end. Vaporized moisture from the sponge is condensed in the vacuum pump which is a liquid jet pump which acts as a highly efficient condensor. The dried sponge is then continuously moved into storage hoppers.

This application is a continuation of Ser. No. 704,801, filed Feb. 12, 1968, now abandoned.

This invention relates to a process for drying moisture-containing metals of the reactive type and more particularly relates to a process for drying titanium sponge in a continuous process.

It is frequently necessary to dry metallic particles before they are placed in storage or shipping containers. Where the metals are in the form of reactive metal sponge of titanium, zirconium and hafnium, the material must be dried without application of excessive heat or contact with air because of fire hazard and danger of contamination of the metals with oxygen or nitrogen.

In the past, such drying has been performed on a batch process. Thus, limited quantities of material are loaded into a vessel and the vessel is evacuated. The vessel is then heated, dried, cooled and the material is removed from the vessel and loaded into storage containers. This process is obviously subject to danger of fire, contamination of the product, and loss of product through spillage. Moreover, in view of the numerous handling steps needed, the process has a high labor cost.

Other known processes have used rotary vacuum vessels. This process causes an excessive amount of fine particles due to mechanical abrasion, and an extreme fire hazard when discharging the batch.

In accordance with the present invention, a continuous process is provided for the drying of reactive metal sponge which allows the uninterrupted processing of material without fire hazard or danger of chemical degradation of the material being dried.

Accordingly, a primary object of this invention is to reduce labor costs for drying reactive metal sponge.

A further object of this invention is to dry metal sponge on a continuous basis.

Another object of this invention is to reduce fire hazard during the drying of reactive metal sponge.

Yet another object of this invention is to reduce the danger of chemical contamination of reactive metal sponge during the drying thereof.

A further object of this invention is to provide a novel continuous drying process for metal sponge which does not cause excessive mechanical abrasion of the product.

These and other objects of the invention will become apparent from the following description taken in connection with the drawing which shows a process flow diagram of the invention.

Referring to the drawing, wet titanium sponge is supplied from any source, such as a container **10** to a vibration screw feeder **11** which may be of any commercially

available type. The sponge is then fed, in a controlled manner through suitable rotary valves **12**, **13** and **14** to a drying chamber **15**. In order to evacuate as much air as possible from the sponge before it enters the dryer **15**, a vacuum pump **16** is connected to the sponge feed line between valves **13** and **14**. Suitable pressure gauges (not shown) may be connected in the feed line to monitor the pressures therein.

Dryer **15** is a "Holoflite" processor manufactured by Western Precipitation Company, equipment No. ID 1220–5. This dryer consists of a chamber containing rotatable feed spirals, driven by motor drive **17** to move particles from the left hand end of the unit toward the right at a controlled speed. The chamber is a stainless steel tube, about 30 inches in diameter and about 20 feet long, and is provided with glass inspection ports **21**, **22**, **23**, **24** and **25**, a rupture disk **26** and vapor ports **27** and **27***a*. Vapor port **27** is connected to line **28** of vacuum pump **29**. Vapor port **27***a* is connected to a source of argon for filling tank **15** in the event of a leak or the like. Ports **27** and **27***a* are preferably located at a distance from their respective ends equal to ⅓ the length of tank **15**.

The interior of dryer **15** is heated by a heating fluid circulated in heating coils so that the heating fluid does not contact the sponge moving through the dryer. A satisfactory heating fluid is Therminol FR–2, a chlorinated biphenyl liquid sold by Monsanto Corporation. This heating fluid is pumped through the heating jacket of dryer **15** by pump **30**, through a suitable induction heater **31** connected to an appropriate power supply. Pump **30** is also suitably connected to a thermal expansion tank **32** as indicated. Suitable pressure gauges and temperature indicators may be placed in the heating system.

The heating system may be arranged such that the input temperature of the heating fluid is 500° F. and the outlet temperature is 460° F. This gives a temperature profile to the sponge being dried of from 400 to 450° F. at the left end or input end of dryer **15** with a temperature of from 300–350° F. in the center and about 300° at right hand discharge portions thereof. It has been found that the drying rate is proportional to temperature but that a temperature of more than about 400° F., in zones where the sponge is partly dried, causes discoloration due to absorption of oxygen and nitrogen. Therefore, in these latter zones, sponge material temperature should be below 400° F. While the sponge is still wet however, at the beginning of the dryer, higher temperatures can be used.

Dryer **15** is then mounted so that its longitudinal axis is tilted upward at about 15° so that material therein moves upwards. With this type arrangement for dryer **15** and with the screw of the dryer **15** advanced at about 1.6 r.p.m. to give a 55-minute residence time, about 1000 pounds per hour of wet sponge was dried to about 0.02% by weight of moisture with less than 2.0% of the sponge tending to granulate while within the dryer.

An important feature of the invention is in the use of a liquid jet pump for vacuum pump **29**. A suitable pump is a Kinney model KLJD–240. The use of such a pump permits highly efficient condensation of moisture withdrawn from chamber **15**, the water stream at the pump venturi being held below 85° F. A pumping speed of about 100 c.f.m. held the pressure of dryer **15** below 28″ Hg vacuum.

After drying, the sponge is discharged through rotary valve **40** to a suitable storage or shipping hopper **41**. An argon source is provided to load argon into hopper **41** during filling. Obviously suitable means are provided to place new hoppers in position as other hoppers are being loaded.

In another embodiment of the invention, steam can be used in place of the Therminol as a heating medium with the heating medium having a lower inlet temperature than

that given above and about 330° F. The use of cooling fluid having an inlet temperature of 330° F. permitted a reduction of the necessary vacuum in dryer **15** to about 600 mm. of mercury. The screw speed was then set for a residence time of about 35 minutes. The system was then operated at an input rate of about 266 pounds per hour of wet sponge, with the following results.

The weight by percent of moisture in the input sponge was 23.2% and about 0.009% in the dried product. There was no increase in the oxygen content of the sponge, which was 580 p.p.m. in the wet and dried sponge and there was no significant change in Brinell hardness number. A typical screen analysis was as follows:

Mesh size	Dryer feed, wt. percent	Dryer product, wt. percent
+½"----------	2.1	1.1
+⅜"----------	15.4	11.2
+20----------	67.9	73.8
+60----------	8.7	8.6
+100----------	2.4	2.0
+200----------	2.0	1.6
−200----------	1.5	1.7

Thus it is seen that the dryer caused little granulation of the sponge.

Although this invention has been described with respect to its preferred embodiments, it should be understood that many variations and modifications will now be obvious to those skilled in the art, and it is preferred, therefore, that the scope of the invention be limited not by the specific disclosure herein, but only by the appended claims.

The embodiments of the invention in which an exclusive privilege or property is claimed are defined as follows:

1. A process for drying reactive metal sponge comprising the continuous loading of wet metal sponge into an evacuated chamber, heating the interior of said evacuated chamber so that the temperature therein decreases uniformly from the input to the output end thereof, heating said metal sponge in said chamber while continuously moving said metal sponge through said chamber by means of a rotatable spiral conveyor at a rate to cause substantial drying of said sponge when it reaches the output end of said chamber, and continuously discharging said dried sponge into a container.

2. The process of claim **1** wherein the air evacuated from said chamber contacts a liquid passing through a venturi restriction whereby moisture from said air condenses on said liquid.

3. The process of claim **1** wherein said metal sponge is heated to no more than 450° F. at the beginning of said chamber and to no more than about 350° F. at the end of said chamber.

4. The process of claim **1** wherein the temperature of the sponge is maintained below 400° F. in zones where it is partly dried.

5. The process of claim **1** wherein said chamber is evacuated to a vacuum of more than about 600 mm. of mercury.

6. Apparatus for drying wet metal sponge comprising first continuous conveyor means for continuously moving wet metal sponge; first and second rotating valve means for serially and continuously receiving wet metal sponge from said first conveyor means and delivering said wet metal sponge to a drying chamber; an upwardly inclined and sealed drying chamber having a rotatable spiral continuous conveyor therein for moving said metal sponge from the input end to the output end of said drying chamber; said second rotating valve means being positioned adjacent said input end; controlled heating means for heating the interior of said drying chamber so that the temperature therein gradually decreases from the input to the output end thereof; storage means for receiving dried metal sponge adjacent said output end of said drying chamber; and vacuum pump means connected to said drying chamber for evacuating the interior thereof.

7. The apparatus of claim **6** which includes second vacuum pump means connected between said first and second rotating valve means.

8. The apparatus of claim **6** wherein said vacuum pump means is a liquid jet type pump.

9. The apparatus of claim **7** wherein third rotating valve means are located between said first and second rotating valve means.

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