# United States Patent

**Bell, Jr et al.**

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[54] **SEPARATION OF MERCURY ISOTOPES**


[72] Inventors: **William A. Bell, Jr; Allen M. Veach,** both of Oak Ridge, Tenn.

[73] Assignee: **The United States of America as represented by the United States Atomic Energy Commission**



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[51] **Int. Cl.**.....**H01j 39/34**

[58] **Field of Search**....250/41.9 C, 41.9 SA, 41.9 SR, 250/41.9 S



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*Primary Examiner*—William F. Lindquist

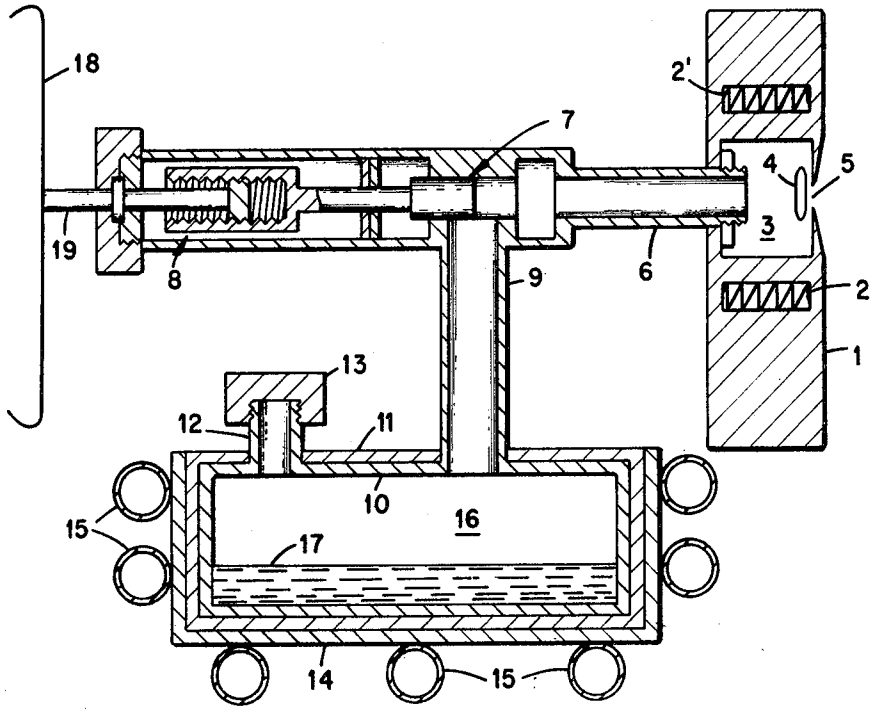
*Attorney*—Roland A. Anderson

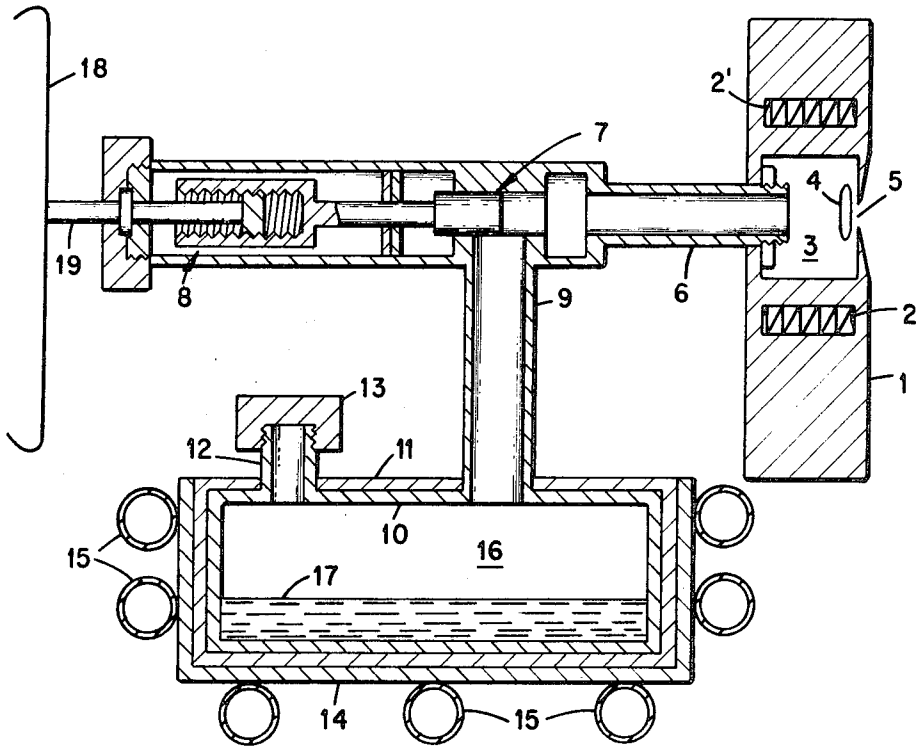


[57] **ABSTRACT**

An improvement in apparatus for the electromagnetic separation of the isotopes of mercury consists of a reservoir containing elemental mercury for placement within the ion source of the apparatus wherein the reservoir is enveloped in heating coils adapted for liquid flow therein and the assemblage is further enclosed in a soft-solder-filled outer shell of good thermal conductivity. Improved isotopic separations result from the thermal stabilization provided by the liquid flow in the heating coils as it removes spurious heat from the ion source and imparts the desired heat to the mercury charge material in the reservoir.


**4 Claims, 1 Drawing Figure**






INVENTORS.
William A. Bell, Jr.
BY Allen M. Veach
Raymond A. Robinson
ATTORNEY.

# SEPARATION OF MERCURY ISOTOPES

## BACKGROUND OF THE INVENTION

This invention was made in the course of, or under, a contract with the United States Atomic Energy Commission.

In the electromagnetic separation of isotopes, each run undergoes an operational cycle including pump-down, start-up, ion collection or innage, cool-down, and unit servicing. Mercury start-up is time consuming, the start-up period often taking as long as 10–12 hours and seldom less than 3–5 hours. The interruption of a run without the loss of vacuum (such as occurs with a 5-day schedule) is less demanding in start-up time but still requires 3–5 hours for optimization of parameters.

The problem with mercury is not in achieving maximum ion output as it commonly is with other elements; the ion sources are capable of about 30 ma, but receiver limitations necessitate holding the source output to approximately 4 ma. The problem is that the mercury compounds best suited for use in existing ion sources—the oxide and the sulfide—both require the application of very low heater power. Under conditions such as this, temperature is the most critical single factor in the separation; since the amount of feed vapor entering the arch chamber must be very carefully controlled, the feed rate is controlling the effectiveness of the entire operation. In the case of mercury, the very narrow heating range makes operation even more difficult because the ion beam will not focus below or above this temperature range and, further, the usual ion source indication of over-heating such as increasing electrical drains is absent. During typical runs, power line fluctuation, changes in electron drains to the ion source, and changes in arc conditions represent a rather large and random percentage of the total power input to the charge material. Operation is consequently far more unstable than is desirable. Suitable heat sinks for power dissipation are difficult to install and improvement in control circuitry is likewise difficult to achieve.

Thus, there exists a need for a better system for closely regulating the temperature of the mercury charge vapor being fed to the ion source during a separation run and also permitting faster start-ups to be achieved, both from initial installation and from a simulated shut-down without loss of vacuum. The present invention was conceived to meet this need in a manner to be described hereinbelow.

## SUMMARY OF THE INVENTION

It is the object of the present invention to provide an improved means for heating the charge vapor fed to the ion source of an apparatus for the electromagnetic separation of the isotopes of mercury while at the same time providing thermal stabilization in the operation of the ion source and permitting faster start-ups in the operation of the apparatus.

The above object has been accomplished in the present invention by providing a charge container which is in a soft-solder-filled supporting box with the charge temperature of the container being regulated by passing hot water through heat transfer coils that are attached directly to the outside of the charge container housing. The reservoir of heating water is quite large to minimize temperature fluctuations, and under these conditions the water both heats the mercury within the container to produce charge vapor and withdraws any additional heat being conducted to the charge region from varying electron drains or arc conditions within the ion source. Thus, the temperature of the charge vapor can be closely and accurately regulated.



Water temperature must be $\geq 180°$ F. to provide adequate vapor transport into the arc region of the ion source and vapor flow is regulated by a non-magnetic gate-type valve inserted in the line connecting the charge container and the ion source arc chamber. Faster start-ups can be effected with this system, both from initial installation and from a simulated shut-down without loss of vacuum. In an initial start-up, the waiting period is reduced in that optimization of temperature is not approached slowly and cautiously as was necessary in the operation of prior art systems.

## BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE in the drawing is a sectional view of the charge container, the arc chamber, and the gate-type valve connected therebetween in the improved charge temperature regulating means of the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

The structure illustrated in the single FIGURE in the drawing is only part of a complete system which is utilized for the electromagnetic separation of the isotopes of various elements, particularly the isotopes of mercury. Such a complete system is described in the E. O. Lawrence U.S. Pat. No. 2,709,222. In the system, as described in the patent, there is provided an ion producing means wherein a feed or charge material is converted into ions for subsequent acceleration through a magnetic field and separation into the respective masses of the isotopes present in the charge material for subsequent collection by an ion receiver. Since most charge materials are not gaseous in form, the charge must first be heated in a vaporizer or oven to produce a charge vapor. Vapor from the vaporizer or oven passes to an arc chamber where a stream of electrons (commonly called the arc or arc discharge) is passed through these vapors, ionizing them for subsequent acceleration.

It should be understood that a magnetic field producing means, an ion source arc producing means, accelerating electrodes, an ion receiver, and an enclosing vacuum tank, such as disclosed in the above Lawrence patent, are utilized with the structure shown in the single FIGURE of the present invention to provide a complete electromagnetic separation system.

Referring now specifically to the present drawing, an arc chamber **3** is provided in an arc housing member **1** in which is mounted heater means **2** and **2'**. Chamber **3** is provided with an ion exit slit **5** and an arc discharge **4** is adapted to pass through the chamber **3**, parallel to the direction of the magnetic field, not shown, in a conventional manner. The direction of the magnetic field is perpendicular to the face of the drawing.

A corrosion resistant charge container **10**, such as stainless steel, for example, defines a chamber **16** in which elemental mercury charge material **17** is adapted to be placed through a tubular member **12** commu-

nicating with the chamber **16**. A cap member **13** seals off the tubular member **12** after the charge material **17** has been placed within the chamber **16**. The container **10** is enclosed with a layer **11** of soft solder. A copper jacket **14** in turn encloses the side walls and bottom wall of the soft solder **11**, as shown. A plurality of hot water lines **15** are attached to the outside of the copper jacket **14** and hot water is circulated through these lines **15** from a large heated reservoir, not shown.

Chamber **16** is connected by a tubular member **9** by way of a stainless steel gate valve **7** and a tubular member **6** to the arc chamber **3** of the ion source. The position of the gate valve is controlled by a threaded assembly **8** which is activated by a rotatable shaft **19** in a conventional manner. The shaft **19** is controlled by means, not shown, beyond a high-voltage insulator **18**.

The charge material **17** is adapted for vaporization and ionization in the ion source by utilizing the single heat source provided by the hot water, heat transfer lines **15** that also act as a heat sink for the ion source. The charge temperature of the charge vapor created in the chamber **16** is regulated by passing hot water through the heat transfer, hot water lines **15**. As mentioned hereinabove, water temperature must be $\geq$ 180° F. to provide adequate vapor transport into the arc region **3**. Any constant temperature in excess of 185° F. is not objectionable in that vapor flow can then be regulated by the non-magnetic gate-type valve **7** (about ½ in.$^2$ cross section) inserted in the line connecting the charge chamber **16** and the arc chamber **3**.

As mentioned above, faster start-ups can be achieved with the present invention. Response of vapor flow to valve position is virtually instantaneous and optimum flow can be established routinely in less than one hour. Another one hour allocated to outgassing of components results in an average start-up time of about 2 hours. The time savings for a one-week run is at least 3 hours per week per separator. More recently, the improved start-up time has allowed mercury to be restarted on a daily basis; start-ups each morning are routinely achieved in 15–20 minutes with no bake-out of components.

An unexpected benefit is associated with the present system. Calcium pumping, the boiling off of calcium into the ion beam in the source region, has been in routine use in the prior mercury separations to reduce pressure and achieve the desired isotopic purity in accordance with U.S. Pat. No. 3,376,414. An anomalous situation occurs, however, that is not experienced in other separations; acceptable focal conditions disappear when a calcium-pumped elemental-mercury-feed system is let down to air and restarted. In the new separation system of the present invention, if calcium is never used, the system performs consistently and yields >90 percent $^{201}Hg$ at an $Hg^+$ output of about 4 ma. The four most recent assays of 96.6 percent, 96.1 percent, 95.6 percent, and 96.6 percent purity are comparable to prior assays from calcium-pumped systems.

By making it possible to run without the calcium, liner usage is extended to many months before it must be washed, compared with every 3 weeks when calcium is used. Each freshly washed liner requires 15–20 hours of start-up time over that associated with normal ion source and receiver servicing. Thus, in a 12-week interval, the elimination of the use of calcium has introduced a time savings of 45–60 hours per separator.

The present invention provides for the following additional advantages:

1. No drift in feed rate, showing effectiveness of the common heat sink — heat supply in regulating the charge temperature in a region influenced by varying electrical power inputs.

2. Instant response of feed flow rate with movement of the vapor control valve in contrast with the slow response associated with conventional heaters.

3. No sideband beams of oxygen or sulfur which, when present, increase the system pressures by adding to the load on the vacuum pumps (note that elemental mercury is used in the present system).

4. Drift-free operation is established; there is no requirement for repeated adjustments.

5. Improved ion output per unit area of exit slit aperture is achieved.

6. Reduction in hashiness of the collected ion beam is noted in all runs.

7. Setting aside the practice of calcium pumping, elemental Hg does not absorb moisture during servicing like the sulfide and the oxide when calcium-pumped, thus resulting in less bake-out time.

Considering the total effect of liner washing and unit start-up, a time savings per separator per year of $\geq$ 300 hours ( $\geq$ $3000) should result from use of the improved mercury source and elemental mercury feed in the system of the present invention as described hereinabove.

This invention has been described by way of illustration rather than limitation and it should be noted and be apparent that the unique heat sink - heat supply may be equally applicable to isotope separations other than mercury and in fields other than those described.

What is claimed is:

**1.** In a system for the electromagnetic separation of the isotopes of a charge material element, including an ion source provided with an arc chamber, a vaporizing oven for vaporizing said element and means for feeding the charge vapor from said oven to the arc chamber of said ion source; the improvement comprising an improved vaporizing oven for vaporizing said charge material element and means for controlled feeding of vapor from said oven to said arc chamber, said improved oven comprising a corrosion resistant metallic box defining a vapor chamber for containing said charge material element, said metallic box being provided with a top, closeable opening for the introduction of said charge material element into said vapor chamber, a layer of soft solder encompassing all of the exterior of said metallic box, a metallic jacket encompassing the exterior side walls and bottom wall of said soft-solder layer, and a plurality of tubular hot water lines mounted in heat transferring relation to the exterior of said metallic jacket, said hot water lines adapted to circulate hot water of a constant selected temperature therethrough, said means for controlled feeding of vapor from said oven to said arc chamber including a nonmagnetic gate valve provided with means for the selectable positioning thereof, a first vapor feed tube connected between the interior of said vapor chamber and said gate valve, and a second vapor feed tube connected between said gate valve and said arc chamber, said hot water lines associated with said oven and containing circulating hot water therein serving as a means for vaporizing said charge material element within said

vapor chamber and acting as a heat sink for any extraneous heat developed in the operation of said ion source, whereby the charge vapor created within said oven vapor chamber being fed by way of said gate valve into said arc chamber is maintained at a substantially constant temperature for the more efficient operation of said ion source in producing ions within said arc chamber for subsequent acceleration therefrom.

2. The system set forth in claim 1, wherein said metallic box is stainless steel, and said metallic jacket is copper.

3. The system set forth in claim 1, wherein the selected constant temperature of the circulating hot water within said hot water tubular lines is maintained at a value of at least 180° F.

4. The system set forth in claim 3, wherein said charge material element is elemental mercury.

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