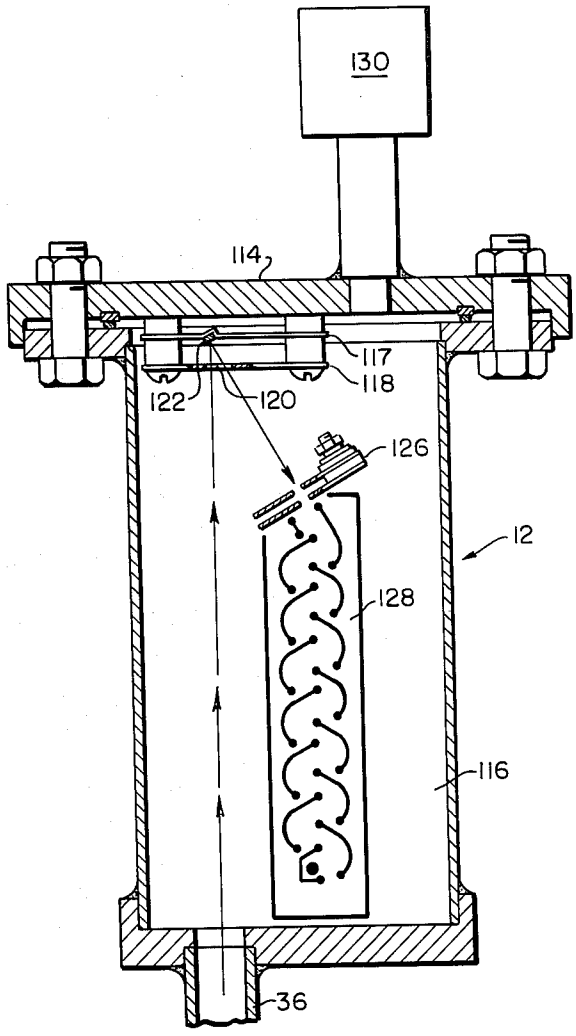
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CESIUM BEAM TUBE DETECTOR WITH NIOBIUM IONIZER

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CESIUM BEAM TUBE DETECTOR WITH NIOBIUM IONIZER

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My invention relates to an improved cesium beam tube detector and in particular concerns a niobium ionizing detector.

In a molecular beam such as that described in U.S. Patent 2,972,115 to J. R. Zacharias et al., issued on February 14, 1961, an ionizer detector is employed to convert the neutral atomic beam into ions for conversion into an electrical signal. Ionization of the beam of cesium atoms is accomplished by a ribbon of heated tungsten in the beam path. Cesium atoms on striking the heated surface of the tungsten ribbon are converted and re-evaporated as positive cesium ions. A mass spectrometer is used to separate residual impurities such as positive alkali metal ions from the positive cesium ions before directing the cesium ions to the anode of a staged electron multiplier.

The conversion of cesium atoms to cesium ions in a cesium beam tube apparatus has generally been accomplished by ionizer-detectors or hot wire detectors in which heated platinum, tungsten or tantalum wires or ribbon filaments have been used. Although effective, these materials have also required the use of mass spectrometers to remove metallic impurities converted into ions with the cesium. For example, a heated tungsten wire generates as an impurity potassium ions which degrade the signal to noise ratio unless removed by mass spectrometer means. Additionally, the variation of heater energy to the electrically heated tungsten ribbon or thermal or mechanical shocks would tend to produce bursts of potassium ion emissions. Furthermore, outgassing of the detector was often required during manufacture of the beam tubes to reduce the production of residual ion impurities by the detector.

It is an object of my invention to provide an improved ionizer detector for use in a cesium beam tube apparatus, which detector will eliminate the requirement for a mass spectrometer to remove potassium ion impurities, will significantly inhibit potassium ion bursts, and simplify the manufacture of a beam tube apparatus by reducing the need for outgassing the ionizer detector.

Other objects and advantages will be apparent to those skilled in the art from the following more detailed description of my invention when taken in conjunction with the accompanying drawing which is a schematic cross sectional elevation of a niobium ribbon detector in a molecular beam apparatus.

I have found that the objects of my invention are achieved by the use of niobium as the ionizing surface of an ionizer-detector in a cesium molecular beam apparatus. It has been found, quite unexpectedly, that niobium unlike tungsten does not produce bursts of potassium ions on variation of the heater power or by mechanical shocks such as excess vibration. The employment of niobium has also significantly improved the signal to noise ratio.

A niobium ionizing surface is shown in the drawing which illustrates an ionizer detector **12** at the one end of a conventional cesium beam tube **36** where the cesium beam emerges from the B magnet field. The tube **36** is attached to and communicates with the evacuated detector chamber **116**. The detector is of a completely sealed construction. Attached to the wall **114** are electrostatic plates **117** and **118**. A narrow slit **120** in the plates permits the cesium atoms entering the detector chamber to strike the ionizing ribbon **122**. The ionizing ribbon is a heated niobium ribbon filament which has a long axis aligned with the long axis of the cross-section of the beam of atoms. The width of the ionizing ribbon is such that it will not be struck except by those atoms in that portion of the beam area in which the atoms of the (4, 0) energy level are located. This hot ribbon is a "surface ionizer;" that is, neutral Cs^{133} particles strike the surface, are adsorbed, and quickly reevaporate as singly charged positive ions. As shown the ribbon **122** is mounted at a 30° angle from the normal of the cesium atoms striking the surface. After ionization, the particles are accelerated to an energy of about 15 e.v. thru the parallel plate system **117, 118**. The particles are deflected through a 30° angle and subsequently accelerated by a parallel plate lens **126**, to enter a 14 stage electron multiplier **128** which develops an electrical output signal. An ion pump **130** communicates with the detector chamber **116** to remove cesium atoms and gaseous impurities and to maintain the vacuum desired.

I have directly compared the performance of a tungsten and niobium ionizing surface in a conventional cesium beam tube apparatus. The cesium beam tube comprises a cesium oven source at the one end of an evacuated beam tube with the ionizer-detector at the other end. The beam tube included: a collimator to form the heated cesium atoms into a beam of predetermined form; externally mounted C-shaped "A" and "B" magnets to produce a strong inhomogeneous "A" and "B" magnetic field; and means to create an intermediate weak homogeneous "C" magnetic field; with a dual cavity microwave guide structure in the weak "C" field whereby the cesium atoms passing through the cavities are subject to an intense oscillating magnetic field.

The ionizer detector apparatus included a supported ionizing surface of niobium formed in a ribbon channel to provide mechanical strength and made of 99.9% pure niobium metal of 0.0011" thickness. The detector is aligned with the beam of cesium atoms from the "B" magnetic field and is in an evacuated region of 10^{-7} mm. of mercury or less. The long axis of the niobium ribbon is aligned with the long axis of the beam cross-section. In front of and to the rear of the niobium ribbon were disposed parallel electrostatic plates with a narrow slit in the front plate to permit a predetermined portion of the neutral cesium beam to strike the niobium ionizing surface. With the niobium ionizing surface a mass spectrometer was not required, rather the positive cesium ions from the ionizing surface were accelerated through the parallel plates to the anode of a 10 or more stage electron multiplier to convert the cesium into a proportional electric D.C. signal.

This signal is handled by a servo control system such as described in U.S. Patent 2,883,546 to E. F. Grant, issued April 21, 1959; U.S. Patent 2,960,663 to W. A. Mainberger, issued November 15, 1960, and U.S. Patent 2,994,836 to J. H. Holloway, issued August 1, 1961. The control system to maintain the frequency as close as possible to the desired frequency commonly includes: a basic frequency oscillator, one output going to a multiplier to give a frequency of 9180 mc. and the other output to a synthesizer to provide a frequency of 12.631840 mc.p.s. The output of the synthesizer is frequency modulated at about 100 c.p.s. by a generator. Power for the R.F. excitation of the beam tube is obtained by a glystron oscillator, the output of which is mixed and amplified to obtain the frequency of the atomic resonance by a means now well known.

The niobium ionizing surface was heated to about 800 to 1200° C. in operation by the use of the niobium ribbon channel as a resistance element in electrical heating

circuit with the niobium being in electrical communication with a power supply. The temperature of the niobium ionizing surface is commonly kept sufficiently high to follow the modulations of the R.F. signal used in the beam tube. Thus, if the cesium atoms are perturbed out of the microwave structure at 100 cycles per second, the temperature of the ionizing surface should be sufficiently high so that the cesium atoms spend less than $\frac{1}{100}$ of a second on the surface. The heated niobium surface thus controls the rate of emission of the cesium ions. Further elevated temperatures keep the reduction of any oxides of niobium at a high rate which aids in promoting a relatively constant work function for the niobium surface.

The niobium ionizing surface can be any form or shape such as a hollow rod with external heating of the rod accomplished by separate heating means, or can be in the form of solid cylinders, etc.

In operation the neutral cesium atoms on striking the heated niobium surface are adsorbed and quickly converted to positive cesium ions and then boiled off as ions, which pass through the plates into the electron multiplier. In an evacuated cesium beam tube apparatus employing a niobium heated ionizing surface, I have found that despite mechanical shocks and variation in the electric heater power supply, bursts of potassium ion emissions were not observed. Further extensive outgassing of the detector was not required for satisfactory operation. In the beam tube apparatus satisfactory operation was accomplished without the need for a bulky and costly mass spectrometer to separate potassium impurities. In normal operation with a 99.9% pure niobium element, potassium ion emission was found to represent less than 10^{-14} amps or 10^5 ion particles/sec.

Operation of a cesium beam tube with a conventional heated tungsten ionizing surface required, the use of a

mass spectrometer, and gave potassium ion bursts on thermal or mechanical shocks to the detector.

My invention thus considerably improves the operation of a cesium molecular beam tube apparatus by reducing undesired potassium emission by a factor of 100 or more, while avoiding potassium emission bursts. As described, my invention provides for a significant improvement in use and the cost of manufacturing cesium beam tube apparatus.

Having thus described my invention, I claim:

1. An atom ionizer which includes a heated element consisting essentially of niobium in the path of a beam of atoms.

2. A detector which includes: an evacuated detector chamber adapted to receive a beam of atoms; means to maintain the vacuum in the chamber; a heated ionizing surface consisting essentially of pure niobium in the path of the beam; and means to convert the ionized atoms into an electrical output signal.

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