Oct. 26, 1965 H. K. GLASER ETAL 3,213,532

METHOD OF FORMING TITANIUM AND ALUMINUM SEALS

Filed April 3, 1961

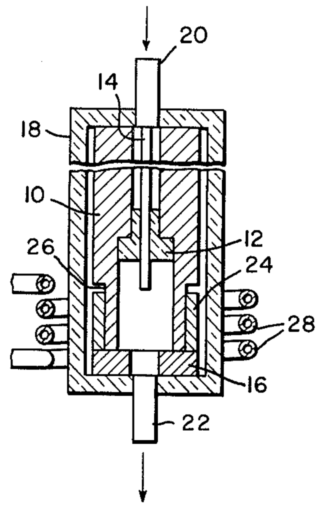

Fig. 1

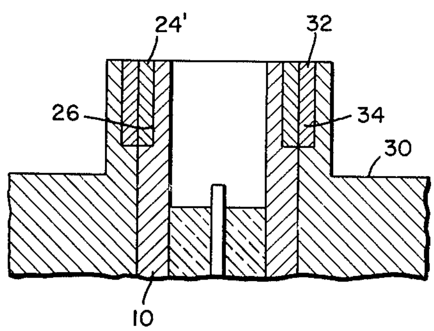

Fig. 2

WITNESSES

John F. Healy Jr.
Gordon H. Telfer

INVENTORS
Harold K. Glaser &
Louis A. Lupica
BY
Charles F. Renz
ATTORNEY

3,213,532
Patented Oct. 26, 1965

3,213,532

METHOD OF FORMING TITANIUM AND ALUMINUM SEALS

Harold K. Glaser, Horseheads, and Louis A. Lupica, Elmira, N.Y., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Filed Apr. 3, 1961, Ser. No. 100,298
5 Claims. (Cl. 29—482)

This invention relates to vacuum seals between a member of titanium or a base alloy of titanium and a member of aluminum or a base alloy of aluminum and, also relates to preparing the titanium member prior to sealing by forming a coating of aluminum thereon.

Although for simplicity only "aluminum" and "titanium" are referred to in most of the discussion hereinafter, it is to be expressly understood that the present invention is applicable to joining aluminum or base alloys thereof with titanium or base alloys thereof. Furthermore, aluminum or a base alloy thereof may be used in the coating of the titanium prior to joining.

In the prior art it is customary in the formation of titanium to aluminum seals to coat the titanium by dipping it into molten aluminum and then joining the aluminum member and the aluminum coated surface of the titanium member by soldering or brazing using flux and aluminum solder. In some applications this method is not satisfactory because the necessity of a dipping operation and also the use of a flux or the like makes it difficult to prevent material from flowing or being splashed over surrounding members.

For example, in electronic tube applications wherein ceramic insulating members are employed, it is essential that they retain their insulating properties. Therefore any conducting material which is deposited thereon must be removed or it substantially impairs the tube characteristics. One such application wherein the present invention is in the formation of titanium to aluminum seals in radiation detectors.

The importance of aluminum and titanium seals in radiation detectors results because of the requirement of operating at temperatures of about 300° C. or more. Therefore, conventional soft solder seals are not suitable. Titanium is selected for its ease in joining to insulating members. Both titanium and aluminum have low activation cross-sections suitable for use in nuclear devices. The relative expense of titanium is appreciably higher than that of aluminum. Therefore, a joint between a detector cell of titanium and a housing of aluminum is desired.

It is, therefore, an object of the present invention to provide an improved vacuum tight seal between titanium and aluminum and a method of making the same.

Another object is to provide an improved method of forming an aluminum coating on a titanium member.

Another object is to provide a method of forming seals between titanium and aluminum without requiring dipping operations or the use of flux.

Another object is to provide a seal between titanium and aluminum suitable for operation in a radioactive environment at ambient temperatures up to at least 300° C.

According to one feature of the invention, a method is provided for forming a coating of aluminum on a member of titanium prior to joining the members which involves the steps of placing a first aluminum member near the surface of the titanium member and heating it in an inert atmosphere to a temperature substantially greater then its melting point to cause it to wet the titanium surface. A seal may then be formed to a second aluminum member by any suitable method.

According to another feature of the invention, after the above-mentioned coating operation is performed, the aluminum coated titanium member is joined to an aluminum member by the use of an aluminum-silicon alloy as an intermediate. For a close fitting and neat appearing seal, the members may be machined to allow for the aluminum coating and the aluminum-silicon member between them.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention, both as to its organization and method of accomplishment, together with the above-mentioned and further objects and advantages thereof, may best be understood by reference to the following description, taken in connection with the accompanying drawings, in which:

FIGURE 1 is a cross-sectional view showing one manner in which a titanium member may be disposed so as to form an aluminum coating thereon in accordance with this invention; and,

FIG. 2 is a cross-sectional view of a completed titanium-aluminum seal formed in accordance with the present invention.

Referring now to the drawings, there is shown in FIG. 1 a titanium member **10**, having a generally cylindrical configuration, with a ceramic insulating member **12** therein through which a conductive lead **14** passes. The titanium member **10** is supported on a base **16** and is enclosed by an envelope **18** of a suitable material such as Vycor which has inlet and outlet tubulations **20** and **22**, respectively, for the flow of an inert gas therethrough.

Around the titanium member **10** at the end on the base **16** there is disposed a ring **24** of an aluminum containing material which may be disposed within a machined notch in the titanium member, which makes a portion **26** of the titanium member have a decreased outer diameter. Around the envelope **18** in the region of the aluminum ring **24** is disposed an RF induction heater **28** to provide heat for the coating of the aluminum onto the portion **26** of the titanium member **10**.

In experimental work which preceded the present invention, it was found that when the members **10** and **24** were disposed as shown in FIG. 1 and were heated to an extent that the aluminum melted, there was no wetting of the titanium surface but rather the aluminum would separate from the titanium and form a molten ring on the base member **16**. Therefore, the apparent consequence of these experiments was that this method of coating would not be successful. However, further experiments conducted with the members in the same configuration but with RF induction heating to a temperature not only sufficient to melt the aluminum ring but considerably higher, proved the method was successful. Specifically, it was found that while aluminum melts at about 660° C. and that no wetting of the titanium surface occurred when the aluminum was merely molten, continued heating to a temperature of about 800° C. or more, as measured by optical pyrometer, produced a sudden unexpected effect. At that temperature, the molten aluminum which had flowed away and was actually separated from the titanium member by a distance of about $\frac{1}{64}$ to $\frac{1}{32}$ of an inch, suddenly was caused to flow onto and thoroughly wet the surface of the titanium member **10** and form a suitable coating thereon for subsequent sealing to an aluminum member.

The reasons for this sudden effect are not fully understood but may be due in part to the reduction of the aluminum surface tension at the temperature employed and, also, may in part by due to the sustained RF bombardment at the high temperature which serves to clean the titanium surface of any trace of oxide that may be adhering thereto.

It has been found that a minimum temperature of about 800° C. is effective in practicing this invention. That is, considerably higher temperatures may be employed with success. Temperatures as high as 1200° C. have been actually used. However, the higher the temperature the less control there is in locating the coated material since the wetting action takes place so fast. Therefore to form a coating which may be accurately positioned by small movements of the titanium member 10 during the course of wetting, temperatures of from about 800° C. to about 825° C. are preferred.

Referring now to FIG. 2, there is shown the titanium cylinder 10 after the aluminum coating 24′ has been applied thereto. The titanium member was machined so that the aluminum would fill the notched portion 26. Also shown in FIG. 2 is an aluminum member 30 which is generally cylindrical and has an inner diameter about the same as the outer diameter of the titanium member 10. The seal is effected between the aluminum 30 and the aluminum coating 24′ on the titanium 10 by the insertion of an aluminum-silicon alloy in the form of a ring 32 which fits snugly in a machined notch in the aluminum member 30 which causes it to have a portion 34 of increased inner diameter at the same position as the portion 26 of diminished outer diameter of the titanium member. After the members are assembled as shown in FIG. 2 they may be heated in an inert atmosphere to effect sealing.

In the practice of the present invention, the titanium member 10 may be either pure titanium or a base alloy thereof such as an alloy having the composition 6% Al, 4% V and 90% Ti or an alloy having the composition 7% Al, 4% Mo and 89% Ti. The aluminum ring 24 and the aluminum member 30 may be either of pure aluminum or a base alloy thereof such as the following (composition in percent maximum unless shown as a range):

Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	Others	Al
EC	0.15	0.50	0.10	0.01	0.01	0.01	0.10	0.10	99.45
1100	1.0 Si and Fe		0.20	0.05	----------	----------	0.10	0.15	99.00
3003	0.6	0.7	0.20	1.0–1.5	----------	----------	0.10	0.15	Remainder
6061	0.4–0.8	0.7	0.15–0.4	0.15	0.8–1.2	0.15–.35	0.25	0.30	Remainder
6063	0.2–0.6	0.35	0.10	0.10	0.45–0.9	0.10	0.10	0.25	Remainder

All of the above materials have been successfully used in the practice of this invention and it is believed clear that other titanium base alloys and aluminum base alloys are also suitable for use.

As a specific example of the practice of the present invention, the following steps were performed. A clean titanium member 10 having a machined portion 26 is obtained and a ring of clean aluminum 24 is disposed about it within the notch as shown in the drawing. The assembly is supported by any suitable member such as a non-reactive base member 16 of a material such as aluminum oxide. Alternatively, the titanium member 10 may itself support the aluminum ring 24 with the titanium being supported by a suitable fixture. The assembly is disposed in a tube of Vycor. An atmosphere of argon or helium is flushed through the tubing to provide a neutral atmosphere, the direction of the flow of the protective gas being such as to aid in the cooling of the ceramic insulating member 12. An RF coil 28 around the tubing 18 is located to provide a concentration of heat in the region of the aluminum ring 24. Heating is continued until wetting of the titanium surface by the molten aluminum occurs, at a temperature of about 800° C. to about 825° C. The aluminum coated titanium part is then permitted to cool down to room temperature while within the protective atmosphere. The aluminum coated titanium part 10 is then assembled in position with an aluminum member 30 with which it is to be joined, as shown in FIG. 2, with a ring 32 of an aluminum-silicon alloy disposed within a machined notch 34 in the aluminum member 30. The alloy may be the aluminum-silicon eutectic. The joint is then formed by the use of a tungsten-inert gas weld in a manner similar to heliarc welding.

Joints attempted without the use of the intermediate aluminum-silicon alloy 32 are not generally successful because the developement of a pin hole in the seal is a permanent defect which cannot be repaired. The use of the alloy provides a leakproof vacuum joint which can be made by heliarc welding and if pin holes do develop in the joint it is only necessary to further heat the seal to close the pin holes.

It is therefore seen that this invention provides a method of forming a vacuum seal between titanium and aluminum in a relatively small area without using techniques which cause conductive material to be spattered around on nearby members. Configurations as shown in the drawing have been successfully sealed with the ceramic insulating member 12 remaining free of conductive matter. Seals formed by the present invention also are economical in the use of materials and do not require a high degree of skill by a human operator.

While the present invention has been shown and described in certain forms only, it will be obvious to those skilled in the art that it is not so limited but is susceptible of various changes and modification without departing from the spirit and scope thereof.

We claim as our invention:

1. The method of forming a coating of aluminum or an aluminum base alloy on a member of titanium or a titanium base alloy comprising the steps of: placing a first member of a first material selected from the group consisting of aluminum and base alloys thereof near the surface of a second member of a material selected from the group consisting of titanium and base alloys thereof; and RF induction heating said first member in an inert atmosphere to a temperature of at least about 800° C. to cause said first material to flow upon and to wet the surface of said second member.

2. The method of forming a coating of aluminum or an aluminum base alloy on a member of titanium or a titanium base alloy comprising the steps of: placing a first member of a first material selected from the group consisting of a aluminum and base alloys thereof near the surface of a second member of a material selected from the group consisting of titanium and base alloys thereof, and heating said first member in an inert atmosphere by RF induction heating to a temperature in the range of from about 800° C. to 825° C. to cause it to flow upon and to wet the surface of said second member.

3. The method of forming a titanium to aluminum seal comprising the steps of: placing a first member of a first material selected from the group consisting of aluminum and base alloys thereof near the surface of a second member of a material selected from the group consisting of titanium and base alloys thereof to which the seal is to be made, RF induction heating said first member in an inert atmosphere to a temperature in excess of about 800° C. to cause said first material to flow upon and to wet the surface of said second member and form a coating thereon, and joining said coated second member to a third member of a material selected from the group consisting of aluminum and base alloys thereof.

4. The method of forming a titanium to aluminum seal comprising the steps of: placing a first member of a first material selected from the group consisting of aluminum

and base alloys thereof near the surface of a second member of a material selected from the group consisting of titanium and base alloys thereof to which the seal is to be made, RF induction heating said first member in an inert atmosphere to a temperature of from about 800° C. to about 825° C. to cause said first material to flow upon and to form a coating on said second member, placing a third member of an aluminum-silicon alloy in contact with the coated surface of said second member, placing a fourth member of a material selected from the group consisting of aluminum and base alloys thereof in contact with said third member, and heating said members in an inert atmosphere to a temperature sufficient to join said members.

5. The method of forming a titanium to aluminum vacuum seal comprising the steps of: obtaining a first hollow cylinder of a first material selected from the group consisting of titanium and base alloys thereof having a portion of diminished outside diameter at one end thereof, disposing said first cylinder in an envelope containing an inert gas with a ring of a second material selected from the group consisting of aluminum and base alloys thereof disposed around said first cylinder on the portion of diminished outside diameter, heating said ring by RF induction heating from about 800° C. to about 825° C. to cause said second material to flow upon and to form a coating on the surface of the portion of diminished outside diameter of said first cylinder, permitting said first cylinder to cool to room temperature, obtaining a second hollow cylinder of a material selected from the group consisting of aluminum and base alloys thereof having a portion of increased inner diameter at one end thereof, placing said second cylinder around said first cylinder so said portion of increased inner diameter faces the coated surface of said first cylinder, placing a member of a eutectic alloy of aluminum and silicon in the space between the portion of increased inner diameter of said second cylinder and the coated surface of said cylinder, and heating in an inert atmosphere to bond said members together.

References Cited by the Examiner

UNITED STATES PATENTS

2,528,758	11/50	King	219—9.5
2,925,647	2/57	Jones et al.	29—527 X
2,992,135	7/61	Finlay	29—197 X
3,010,198	11/61	Hanink et al.	29—527

OTHER REFERENCES

Product Engineering, February 1943, page 103.

Iron Age, July 11, 1946, page 54.

JOHN F. CAMPBELL, *Primary Examiner.*