Sept. 13, 1960 E. R. BOLLER ET AL 2,952,603

JACKETED FISSIONABLE MEMBER

Filed May 5, 1947

Fig. 1.

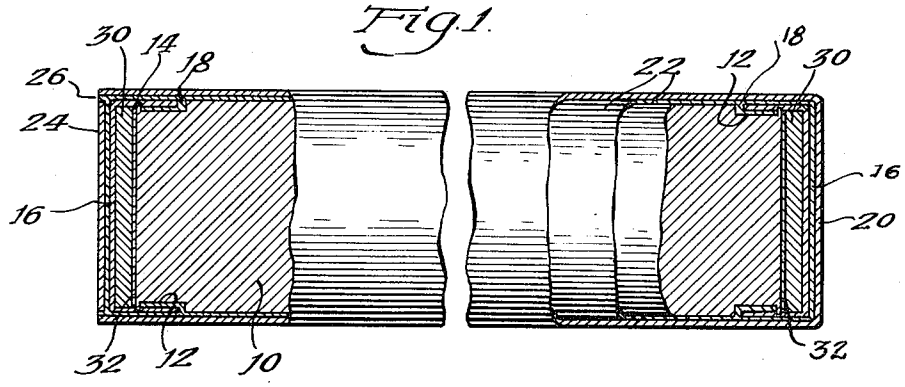


Fig. 2.

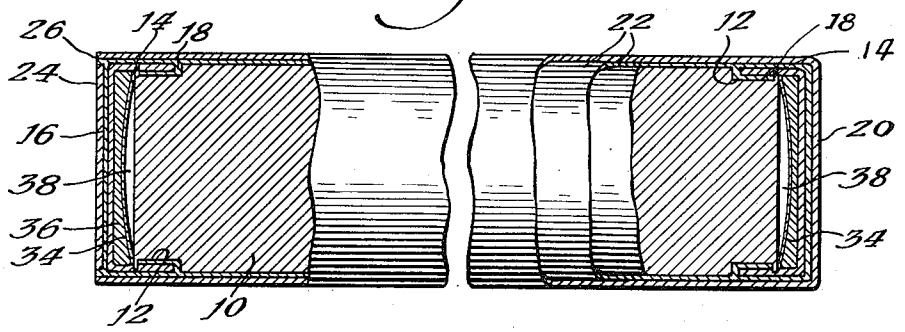
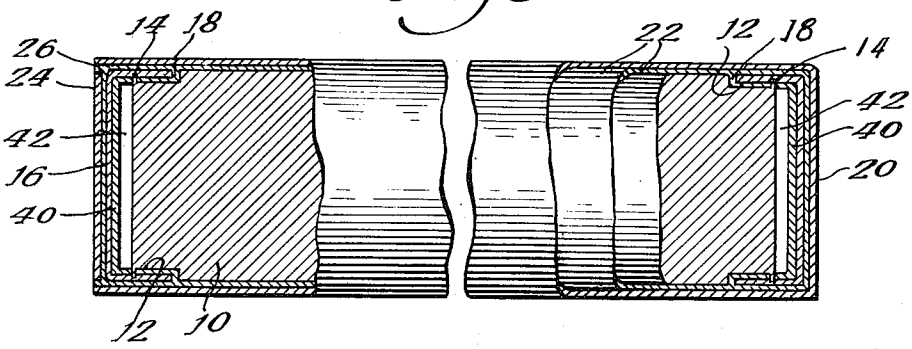


Fig. 3.



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JACKETED FISSIONABLE MEMBER

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2 Claims. (Cl. 204—193.2)

This invention relates to an improved construction of a jacketed member of fissionable material. More specifically, the invention relates to an improvement in the jacketing of fissionable materials such as uranium to prevent escape of fissionable material from the jacket and to prevent corrosion of the fissionable material when used in a neutronic reactor.

In neutronic reactors of any type, a neutron-fissionable isotope such as U^{233}, U^{235}, or Pu^{239} is subjected to fission by neutron bombardment and a self-sustaining chain reaction is established by the neutrons evolved by the fission. The theory and operation of such reactors are described in the co-pending application of Enrico Fermi and Leo Szilard, Serial No. 568,904, filed December 19, 1944, now Patent No. 2,708,656, dated May 17, 1955.

In the operation of such reactors at high power, difficulty may be encountered due to elements of the reactor other than the fissionable material becoming contaminated with radioactive fragments of fissionable material. Therefore, such reactors now commonly have the fissionable materials covered by non-fissionable jackets which are sealed so that radioactive substances may not escape. When such jackets are employed, it becomes necessary, where high-temperature operation of the reactor is to be undertaken, to insure excellent heat transfer between the fissionable material, in which heat is generated, and the jacket, in order that the heat may be carried off. This is necessary both from the point of view of utilization of the heat and from the point of view of avoiding the development of excessively high temperatures within the fissionable material.

It has been found convenient to use the fissionable materials in the form of "slugs" which are commonly cylindrical in shape and of a length which renders their fabrication and use practical and convenient. Such slugs of fissionable material are commonly placed end-to-end in the reactor in channels provided for this purpose. The reactor is provided with a liquid or gas coolant which is circulated past the jacketed slugs and carries off the heat generated in the fissionable material and transmitted to the jacket material. The jacket material is usually of high thermal conductivity and low neutron absorption, such as aluminum, and is commonly bonded to the fissionable material by a bonding layer of a suitable thermally conductive material.

Such jackets must be completely pressure-tight in order to prevent leakage of the coolant into the jacket and consequent corrosion, and likewise to prevent leakage of radioactive materials from the interior of the jacket into the coolant. It has been found that ordinary pressure-tight containers cannot sufficiently accomplish this purpose because of the extremely adverse conditions of temperature to which such jackets, as above described, are exposed. Therefore, it is necessary, to provide a jacket which constitutes an enclosure which is hermetic to an extent heretofore not known.

It is the principal object of this invention to provide a jacket for fissionable material adapted to maintain a

pressure-tight seal under the conditions occurring in a neutronic reactor described above.

More specifically, it is an object of this invention to provide an assembly of a fissionable material within a protective jacket which minimizes the possibility of leakage between the exterior of the jacket and the fissionable material contained therein.

Generally speaking the above objects of this invention are achieved by maximizing the length of the potential leakage path from the exterior of the jacket to the fissionable material. The possibility of the development of leakage is greatest through the seal or bond which effects closure of the jacket. The present invention prevents such leakage by providing a structure in which leakage cannot be caused by development of slight defects in the seal or bond. For a more complete understanding of the invention, reference is made to the attached drawing, in which:

Figs. 1, 2, and 3 are each longitudinal sectional views, shown partially in elevation, of jacketed cylindrical members of thermal neutron fissionable material, each embodying the teachings of this invention.

Referring to all of the figures of the drawing, the numeral **10** designates a cylindrical body of fissionable material such as uranium. At each end of the fissionable body **10** is a shoulder portion **12** of smaller diameter than the remainder of the body **10**. At the extreme outer end of the shoulder portion is an annular flange **14**. Over the shoulder portion **12** is fitted a cup-shaped end cap **16** having an outer diameter corresponding to the outer diameter of the central portion of the body **10** and an inner diameter slightly larger than the outer diameter of the shoulder portion **12**.

The end caps **16** have on the internal surfaces thereof grooves which cooperate with the annular flanges **14**. The caps **16** are preferably bonded to the fissionable body **10** by a bonding layer **18** of a material of low neutron absorption, for example an aluminum-silicon alloy. The cap **16** is preferably of a material of high thermal conductivity and low neutron absorption such as aluminum. It will be understood that the thickness of the bonding layer **18** is exaggerated in the drawing for clarity.

It will be seen that the fissionable body **10**, having over the ends thereof the end cap **16**, constitutes a cylindrical assembly of substantially uniform diameter. The body **10** is surrounded by a cup-shaped jacket **20**, preferably of aluminum, likewise exaggerated in thickness in the drawing. The jacket **20** is likewise bonded to the body **10** and to the caps **16** by a bonding layer **22**, for example of an alloy of aluminum and silicon, similar to the bonding layer **18**.

Within the open end of the cup-shaped jacket **20** is a closure disc **24**, likewise preferably of aluminum and preferably bonded to the outer end cap **16** by a portion of the bonding layer **22**. The sealing of the closure disc **24** to the open end of the cup-shaped jacket **20** to effect closure thereof may be made, for example, by welding or, as illustrated in the drawing, the closure may be effected by the bonding layer **22**.

The weakest portion of the jacket covering the fissionable body **10** as regards leakage is likely to be the seam between the closure cap **24** and the end of the cup-shaped jacket **20**. In this past, the jacketed body **10** has been made uniform in diameter. With such construction, any development of a fault in the seam **26** may immediately cause leakage between the fissionable body and the exterior, thus permitting both the escape of fissionable material from the jacket and the corrosion of the fissionable material, both of which effects are extremely undesirable in the operation of a neutronic reactor. In the present invention, as may be seen, it is necessary for

leakage that a fault develop not only in the seam **26** but along the entire portion of the bonding layer **22** lying along the wall of the outer end cap **16**. It will be seen that this effect is accomplished without the addition of the substantial amounts of material non-fissionable by thermal neutrons which would be required if the purpose of this invention were to be achieved by adding a very thick closure disc **24** instead of employing the end cap **16**, or by adding an additional outer jacket to the structure.

In addition to the advantages above stated, the provision of the end caps **16** permits ready assembly of such jacketed bodies containing devices for preventing the development of high temperatures at the ends of the cylindrical bodies. As stated above, the jacketed bodies or "slugs" of fissionable material are commonly placed end-to-end in the neutronic reactor. As is well known, the fluid coolant which is circulated past the jacketed slugs is relatively ineffective in removing heat from the abutting end surfaces of adjoining slugs. Therefore, precautions must be taken to prevent the development of "hot spots" at the inner surfaces between the jacketed slugs. Such precautions usually take one of two forms. One device for accomplishing this purpose is to provide in the end of the jacket a mass of material of high thermal conductivity so that heat is quickly carried from the end surfaces to the side walls. Another device is the thermal insulation of the ends of the jacket from the fissionable body contained therein so that all of the heat generated within the jacket is conducted to the walls, rather than to the ends, thereof.

In the illustration of Fig. 1, there is placed within the top of the cup-shaped end cap **16** a thick disc **30**, of aluminum, which is bonded to the end of the fissionable body **10** by a bonding layer **32** similar to the bonding layers described above. In this manner heat is conducted away from the end portions to the walls of the jacket.

In the embodiment of Fig. 2, there is placed within the cup-shaped cap **16** a recessed disc **34**, for example of iron or beryllium, back by a body **36** of aluminum. The recess in the disc **34** forms an air gap **38** at the ends of the fissionable body **10**. The air gap **38** serves to insulate thermally the ends of the jacketed slug from the heat-generating fissionable body **10**. In the embodiment of Fig. 3, there is fitted within the cup-shaped end cap **16** a small cup-shaped disc **40**, for example of beryllium, the lips of the cup-shaped disc **40** resting against the ends of the jacketed body **10** and the cavity thus formed constituting an air gap **42** insulating the ends of the jacket from the fissionable body **10**.

It will be noted that in the illustrations of the drawing the end caps **16** are employed at both ends of the jacketed body **10**. Obviously the end cap **16** at the end of the jacket **20** opposite the closure disc **24** does not serve to lengthen the leakage path between the exterior of the assembly and the fissionable body **10** through the seam **26**, as does the end cap **16** at the end at which closure is made by the closure disc **24**. The end cap **16** is employed in the former position because of the second advantage described above, i.e., the simple assembly incorporating the insulating or conducting device for preventing high temperatures at the end of the jacket **20**. It will be understood that the end cap **16** may advantageously be used at the closure end of the body for the sole purpose of lengthening the leakage path as described above, in cases where the illustrated thermally conducting and insulating devices are not employed.

The teachings of the invention shall not be deemed to be limited to the embodiments illustrated in the drawing and described above. Many equivalent devices employing the teachings will readily be devised by persons skilled in the art. Therefore, the present invention shall be deemed to be limited only by the appended claims.

What is claimed is:

1. As an article of manufacture, an elongated body comprising thermal neutron fissionable material having a shoulder portion at an end thereof, the shoulder having an annular flange at the extreme outer end, a substantially cup-shaped cap fitted over the shoulder, and having an annular groove on the internal surface alignable with the flange, a jacket having an open end and fitted over the body and the cap and bonded to the cap over their entire interface by a bonding layer, and a closure disc sealed to the open end of the jacket, said open end of the jacket being at the end of the body having the cap, and said layer, cap, disc and jacket comprising materials of low neutron absorption.

2. In combination, a cylinder of uranium having end portions of smaller diameter than that of the central portion and having flanges at the end thereof, two cup-shaped end-caps of aluminum having an outer diameter substantially the same as that of said center portion, said end-caps being adapted to fit over said ends and having internal annular grooves adapted to receive said flanges, said end-caps being adapted to prevent the concentration in said end-caps of heat generated in the uranium, a covering jacket of aluminum having one open end, and a closure disc covering the open end of the jacket and being bonded to said open end and to an end cap said end-caps being bonded to the uranium and to said jacket over their entire interface, and said jacket being bonded to the structure thus formed by an alloy of aluminum and silicon.

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