

Dec. 9, 1958

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NEUTRONIC REACTOR FUEL ELEMENT

2,863,814

Filed Sept. 26, 1952

FIG. 1

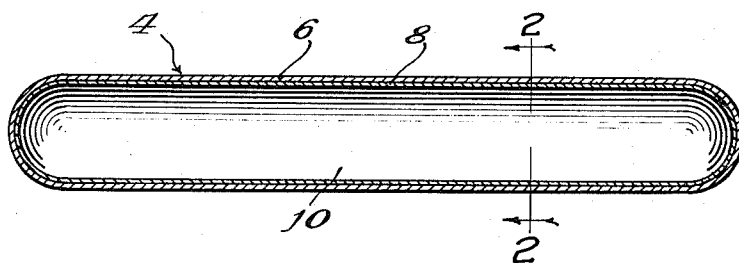
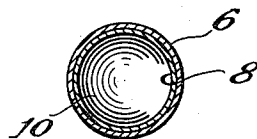


FIG. 2



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NEUTRONIC REACTOR FUEL ELEMENT

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Application September 26, 1952, Serial No. 311,574

5 Claims. (Cl. 204—193.2)

This invention relates to a fuel element for neutronic reactors. More particularly it pertains to capillary tubes having thin walls with an interior coating of material containing an isotope fissionable by neutrons of thermal energy, e. g., Pu^{239} , U^{235} and U^{233} .

The objectives in the design of a fuel element are (1) the removal of heat from the fuel by a coolant, (2) the prevention of contamination of the coolant by fission products, and (3) the prevention of migration of fuel particles in the reactor.

This invention is directed primarily to the last objective. As the fission process occurs, a combination of fission products and minute particles of fissionable material tend to separate from the main body of fuel and migrate away. To minimize this tendency, it is proposed that a very small hollow element be used in great numbers, said hollow element having a fuel coating therein and being completely sealed. Any migration that does occur within such element is thereby rendered immaterial.

Since this invention is concerned with the structure and manufacture of very small fuel elements, rather than with the operation of a neutronic reactor, reference is made to U. S. Patent 2,708,656, issued to Enrico Fermi and Leo Szilard, on May 17, 1955.

For a better understanding of the invention, reference is made to the following description and the appended drawing in which:

Figure 1 is a vertical sectional view of the fuel element of this invention; and

Figure 2 is a cross sectional view taken on the line 2—2 of Figure 1.

The use in a reactor of a great number of small fuel elements satisfies the migration problem. Reference is made to Figures 1 and 2. A fuel element constituting one embodiment of this invention is generally indicated at 4. It is an elongated, cylindrical body having an exterior jacket 6. The jacket 6 may be fabricated from a segment of metal tubing which is sealed in a fluid-tight manner at each end thereof, such as by welding. On the interior surface of the jacket 6 is a coating 8 of material which is a fissionable isotope, such as U^{235} . The interior of the fuel element 4 is occupied by a void space 10 in which the fission products, such as xenon, and particles of fissionable material accumulate.

As the fission process proceeds, fission gases and great quantities of heat are evolved. This presents a dual problem of providing a jacket material which is thick enough to withstand the internal pressure of the accumulating gases and which is thin enough to conduct away the heat present on the exterior surface of the element 4.

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Fortunately, very small diameter cylinders are good pressure vessels because the ratio of diameter to wall thickness is small. Since the wall thickness of small diameter cylinders can be very thin, it is evident that the removal of heat or thermal energy is also achieved satisfactorily, that is, there is a lower temperature drop across the jacket or wall resulting in less stress than with a thicker walled cylinder.

By selecting a fuel element small enough, a great number of elements may be used in various geometrical relationships with respect to each other. As shown in Stahl's copending application, supra, the elements usually are disposed in an end-to-end relationship within a conduit having a larger inside diameter than the outside diameter of the element which fact permits the flow of a liquid coolant, such as sodium, through the conduit.

Fabrication of the fuel element involved consists of various factors. Metals molybdenum, titanium and zirconium in the form of tubing are satisfactory. A body of U^{235} -enriched uranium in the form of a wire is placed into the capillary tube 6 and both ends of the tube or jacket are sealed in an inert atmosphere. After sealing, the fuel element 4 is heated to a temperature of 1250°C . which temperature is above the melting point of uranium. The element 4 is then spun at a high rate of speed, such as 2200 R. P. M., causing a coating 8 of the uranium to cover the entire interior of the jacket. In addition to spinning, the fuel element 4 may be agitated or tumbled in order to secure the coverage of the entire inner surface of the jacket 6. The fuel element is then held at this elevated temperature until a bond is formed between the jacket 6 and the coating 8. The metals molybdenum, titanium and zirconium were found to be particularly desirable because they form a boundary alloy with the uranium without the formation of brittle or hard compounds which would tend to scale or flake off during subsequent use in a reactor. The dimensions of the uranium body inserted into the tubing can be varied widely and it is clear that the larger the body the thicker the final coating 8.

Molybdenum is preferred because of its low neutron absorption especially when compared with stainless steel. In addition, the thermal conductivity of molybdenum is roughly five times that of stainless steel and its strength is appreciably higher at elevated temperatures. This fact allows for higher unit heat fluxes without producing unsafe stresses.

With the use of titanium and zirconium, no evidence of uranium scaling or of surface oxidation appeared and no difficulties were encountered in spinning the uranium thereon. Examination of control samples of spun uranium-titanium and uranium-zirconium indicated a uniform coating on the inner surface and a solid bond therebetween. Further, the uranium appeared to have penetrated approximately 0.0002" into the jacket walls during the spinning operation.

The preferred dimensions of the tubing or jackets 6 are 0.06" I. D. and 0.08" O. D. The lengths can vary widely, e. g., from 1" to 20".

Other variations in the fuel element will be apparent and may be made without departing from the spirit and scope of the invention.

We claim:

1. A fuel element comprising a fluid-tight jacket of a metal of the group consisting of titanium, zirconium,

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and molybdenum, and a coating of U^{235} -enriched uranium on the inner surface of the jacket.

2. A fuel element comprising an elongated fluid-tight jacket of titanium, and a coating of U^{235} -enriched uranium on the inner surface of the jacket.

3. A fuel element comprising an elongated fluid-tight jacket of zirconium, and a coating of U^{235} -enriched uranium on the inner surface of the jacket.

4. A fuel element comprising an elongated fluid-tight jacket of molybdenum, and a coating of U^{235} -enriched uranium on the inner surface of the jacket.

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5. A fuel element comprising an elongated fluid-tight jacket of molybdenum having an inside diameter of 0.060 inch and an outside diameter of 0.080 inch, and a coating of U^{235} -enriched uranium on the inner surface of the jacket.

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