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Butts et al.

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[54] **SUSPENSION SCHEME FOR FUEL PIN**

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[52] **U.S. Cl.** **176/78**; 211/60

[51] **Int. Cl.** **G21c 3/32**

[58] **Field of Search** ..... 211/68, 182, 60; 204/154.34, 2 R; 176/66, 76, 78

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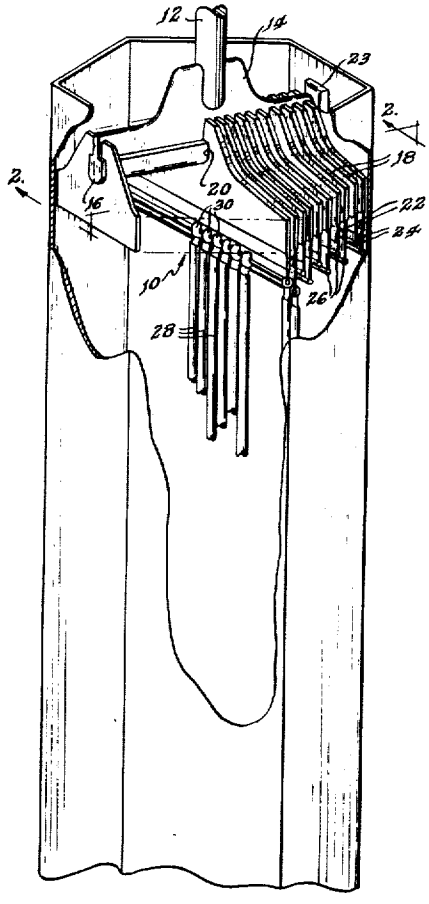
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[57] **ABSTRACT**

A nuclear fuel pin suspension arrangement comprising, in combination, a rod; a first beam member connected to said rod at one end thereof; a plurality of parallel-spaced slidable fuel support plates attached to said first beam member, the longitudinal axis of said first beam member being perpendicular to the longitudinal axis of each of said fuel support plates, a first coupling means disposed along the length of the first beam member for permitting said slidable fuel support plates parallel movement with respect to the longitudinal axis of said first beam member, a second coupling means located at one end of each of said slidable fuel plates for slidably engaging said first coupling means of said first beam member, a second beam member connected to the other end of each of said parallel-spaced slidable fuel support plates and providing an extension thereof, said second beam member being provided with a third coupling means disposed along the length of said second beam member at one end thereof; and a plurality of fuel pins provided with a fourth coupling means located at one end of each of said fuel pins for slidably engaging said third coupling means of said second beam member to permit each of said fuel pins parallel movement with respect to the longitudinal axis of said second beam member.

3 Claims, 4 Drawing Figures



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SHEET 1

Fig - 1

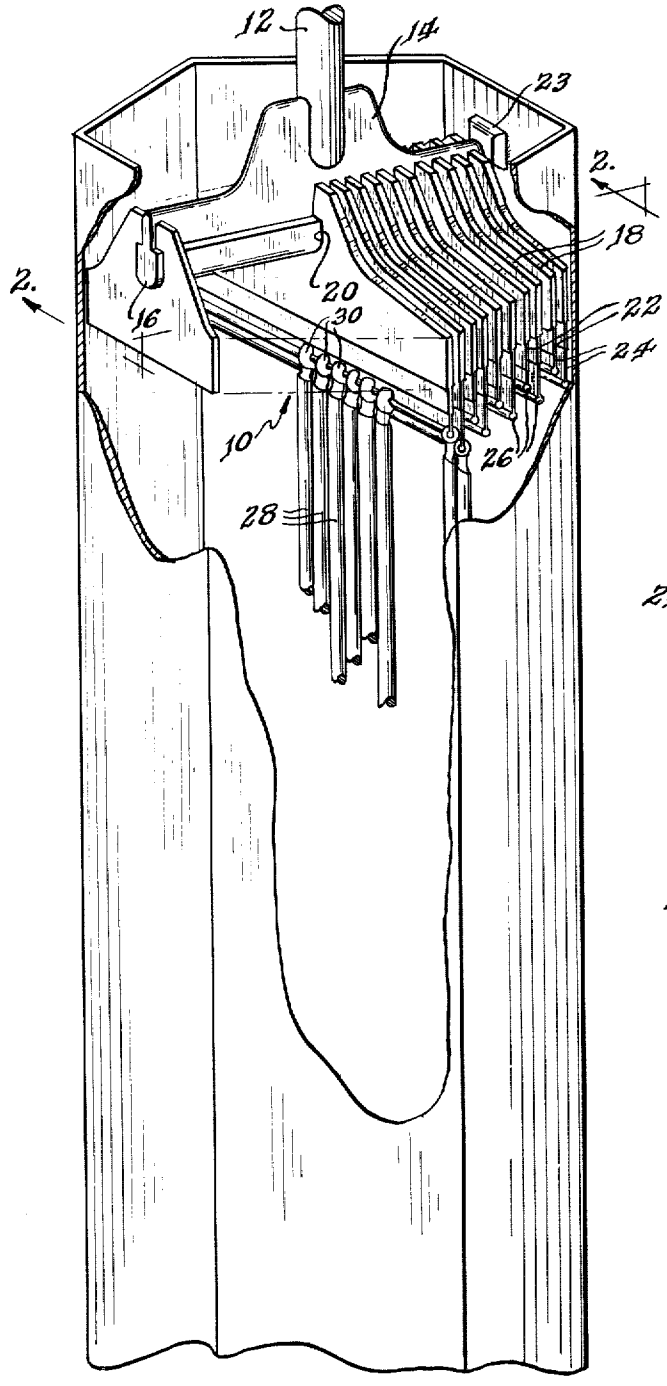
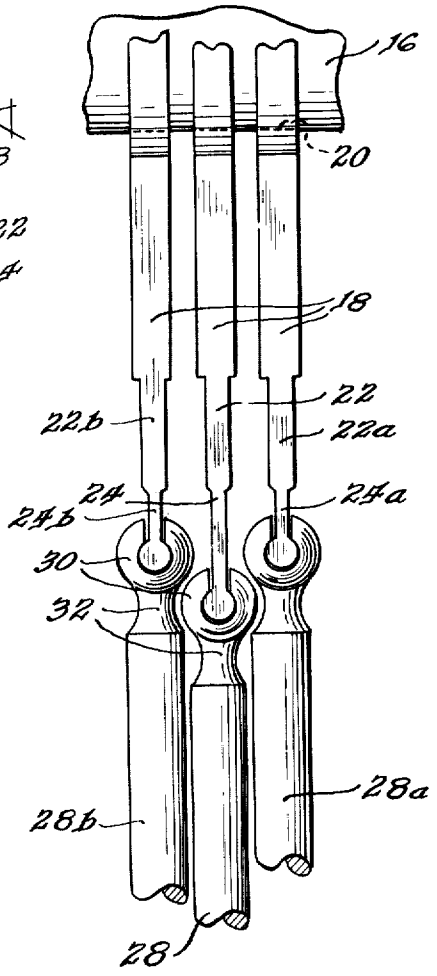


Fig - 4



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Fig-2

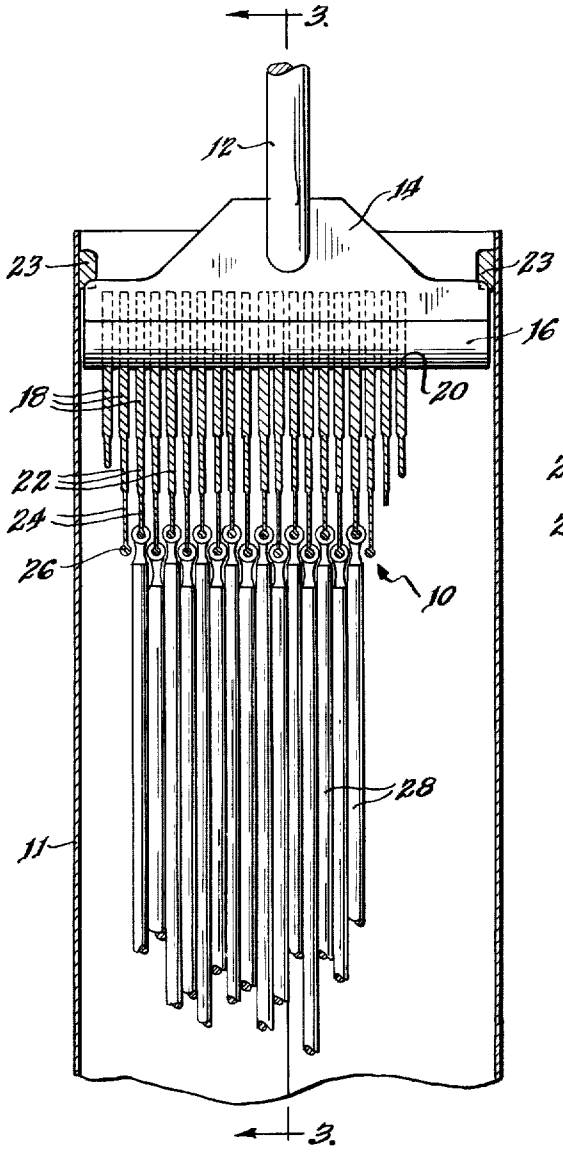
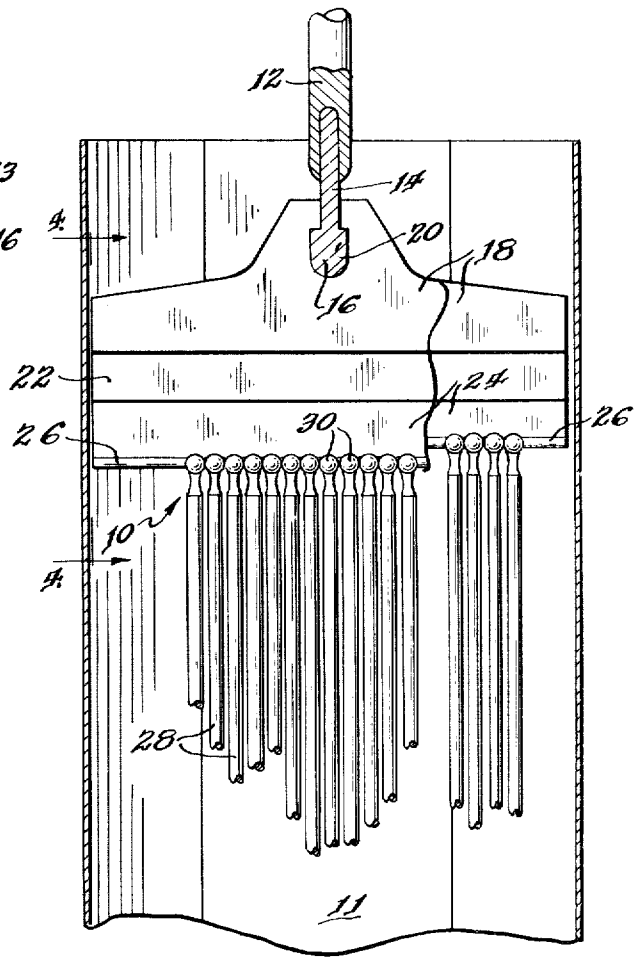


Fig-3



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SUSPENSION SCHEME FOR FUEL PIN

The present invention relates in general to nuclear reactors, and more particularly, to an improved reactor fuel pin suspension arrangement.

In nuclear reactors of any type, the fuel comprises a neutron-fissionable isotope, such as U^{233}, U^{235}, or Pu^{239} which is subjected to fission by neutron bombardment and a self-sustaining chain reactor is established by the neutrons evolved by the fission. The theory and operation of such reactors is well known.

The nuclear reactor fuel is usually fabricated into fuel elements which can be manufactured in many shapes, depending on the requirements that have to be met. One type of fuel element is the fuel pin which is an elongated, clad rod of fuel material. Such fuel pins are usually assembled within a container or can to form a fuel assembly and a group of such fuel assemblies may be assembled together to form the core of a nuclear reactor.

One of the problems encountered in the past is the development of a suspension system for fuel pins mounted within the container or can which would permit three degrees of freedom for each pin. Large amounts of heat or energy are generated in the nuclear fuel pin during reactor operation and such heat causes three dimensional expansion of each nuclear fuel pin. Therefore, providing a fuel pin suspension arrangement with each pin permitted three degrees of freedom is desirable and advantageous since such an arrangement would greatly minimize the danger of rupture of one or more fuel pins which is present in prior art fuel pin arrangements lacking three degrees of freedom due to the additional stresses and strains which arise from the contact of adjacent expanding fuel pins.

In addition, the fuel pins in the past have generally been connected to a fuel pin support or suspension member in such a manner that the occurrence of a defective fuel pin caused a great deal of reactor operating time to be lost in disconnecting the defective fuel pin from the fuel pin assembly and connecting an operable fuel pin in place of the defective one.

Prior art fuel pin support or suspension systems generally necessitated welding or brazing of the fuel pins to a fuel pin support or suspension member which resulted in areas having structural weaknesses due to the heat used in the welding or brazing operation. These weak areas could cause rupture of the fuel pin or destruction of the support member upon the use of the system in a reactor.

It is an object of this invention to provide a fuel pin suspension arrangement which permits three degrees of freedom for each nuclear fuel pin.

It is a further object of this invention to provide a nuclear fuel pin suspension arrangement which permits rapid coupling and uncoupling of each fuel pin with the nuclear fuel pin suspension arrangement.

A still further object of this invention is to provide a fuel pin suspension arrangement which can be adapted to be disposed within a container having a wide range of geometric configurations.

Additional objects will become apparent hereinafter.

FIG. 1 is an isometric view of a hexagonal fuel element container with parts broken away to disclose the nuclear fuel pin suspension arrangement;

FIG. 2 is a cross-sectional view taken along line 2—2 of FIG. 1;

FIG. 3 is a cross-sectional view taken along line 3—3 of FIG. 2; and,

FIG. 4 is an enlarged partial cross-sectional view taken along line 4—4 of FIG. 3.

Referring to FIGS. **1, 2,** and **3,** a nuclear fuel pin suspension arrangement **10** contained within a hexagonal can or container **11** comprises suspension means in the form of a rod **12** which can be attached to a reactor core support plate by means (not shown) whereby a coolant or a coolant moderator fluid could be passed in either direction along the axis of the rod. A first beam member **14** is connected to the rod **12** by a welding or brazing operation. The first beam member **14** has a first coupling means in the form of a first male coupling element **16** which is substantially U-shaped and is located along the length of the first beam member **14** at one end thereof. A plurality of parallel-spaced slidable fuel support plates **18** are slidably attached to the first male coupling element **16** of the first beam member **14** by a second coupling means in the form of an inwardly directed spade shaped first female coupling element **20** located at one end of the fuel support plates **18.** The longitudinal axis of the first beam member **14** is perpendicular to the longitudinal axis of the fuel support plates **18.** A second beam member **22** is connected to the other end of each of the parallel-spaced slidable fuel support plates **18,** and provides an extension thereof. The second beam member **22** can be an individual piece which was welded or brazed to each of the plates **18,** or it can be an integral member formed with each of the plates **18.** The upper portion of the first beam member **14** contacts two extension lugs **23** projecting from the container **11** as shown in FIG. **2.** Applying a tensile load on rod **12** by means (not shown) will firmly retain the nuclear fuel pin suspension arrangement **10** between the lugs **23.** The application of the tensile load will also tend to prevent the rod **12** from bending or bowing since the rod **12** will be under tension.

Nuclear fuel pins **28** are connected at one end only to the second beam member **22** and the other end of the pins **28** are unconnected or suspended at a distance from the end of the can **11** to allow for expansion of the fuel pins **28** along the direction of their longitudinal axis during the operation of the pins **28** in a reactor.

Referring to FIG. **4,** each of the second beam members **22, 22***a* or **22***b* have respectively a reduced extended portion **24, 24***a*, or **24***b*. Along the end of each reduced extended portion **24, 24***a*, or **24***b* in the direction parallel to the longitudinal axis of the respective second beam members **22, 22***a*, or **22***b*, a third coupling means in the form of a second male coupling element **26** is provided which is substantially U-shaped. A plurality of fuel pins **28, 28***a* and **28***b* are connected to the second beam members **22, 22***a*, and **22***b*. Each of the fuel pins **28, 28***a*, and **28***b* are provided with attaching means in the form of a fourth coupling means or a second slidable female coupling element **30** for slidably engaging the second male coupling element **26** of each second beam member **22, 22***a* and **22***b*. The second slidable female coupling element **30** of each of the fuel pins **28, 28***a*, or **28***b*, has an inwardly directed substantially spade-shaped configuration. The reduced extended portions **24***a* and **24***b* of alternate second beam members **22***a* and **22***b* are shorter in width than the inbetween or adjacent reduced extended portion **24** of second beam member **22.** Each of the fuel pins **28, 28***a*,

and **28***b* are provided with an annular concave portion **32** located adjacent the second slidable female coupling element **30.** The annular concave portions of alternate fuel pins **28***a* and **28***b* provide a substantially spherical configuration whereby the end of the inbetween or adjacent fuel pin **28** is substantially located within the spherical configuration provided by the concave portions of the alternate fuel pins **28***a* and **28***b*.

Operation of the Nuclear Fuel Pin Suspension Arrangement

The nuclear fuel pin suspension arrangement thus permits one degree of freedom for each fuel pin in a direction along the longitudinal axis of the fuel pin towards its unattached end, a second degree of freedom for each fuel pin in a direction parallel to the longitudinal axis of the fuel support plate by means of the pins slidable coupling element and a third degree of freedom for each fuel pin in a direction parallel to the longitudinal axis of the first beam member by means of the slidable fuel support plate's movement because of its slidable coupling element in a direction parallel to the axis of the first beam member. Thus, the subject fuel pin suspension arrangement permits each fuel pin expansion under thermal influences in any direction within any one of three mutually perpendicular planes of expansion.

It should be noted that the system or arrangement described above is merely exemplary, and not limiting insofar as our invention is concerned, since it will be apparent that other similar arrangements will be suggested to those skilled in the art. Hence, my invention is limited only insofar as is set forth in the following claims.

I claim:

1. A nuclear fuel pin suspension arrangement comprising, in combination, a rod; a first beam member connected to said rod at one end thereof; a plurality of parallel-spaced slidable fuel support plates attached to said first beam member, the longitudinal axis of said first beam member being perpendicular to the longitudinal axis of each of said fuel support plates, a first coupling means disposed along the length of the first beam member for permitting said slidable fuel support plates parallel movement with respect to the longitudinal axis of said first beam member, a second coupling means located at one end of each of said slidable fuel plates for slidably engaging said first coupling means of said first beam member, a second beam member connected to the other end of each of said parallel-spaced slidable fuel support plates and providing an extension thereof, said second beam member being provided with a third coupling means disposed along the length of said second beam member at one end thereof; and a plurality of fuel pins provided with a fourth coupling means located at one end of each of said fuel pins for slidably engaging said third coupling means of said second beam member to permit each of said fuel pins parallel movement with respect to the longitudinal axis of said second beam member.

2. A nuclear fuel pin suspension arrangement as defined in claim **1** wherein said first coupling means comprises a first male coupling element, said second coupling means comprises a first slidable female coupling element, said third coupling means comprises a second male coupling element, and said fourth coupling means comprises a second slidable female coupling element.

3. A nuclear fuel pin suspension arrangement comprising, in combination, a rod; a first beam member connected to said rod at one end thereof, the longitudinal axis of said first beam member being perpendicular to the longitudinal axis of said rod; said first beam member being provided with a first male coupling element at one end of said first beam member, said first male coupling element being substantially U-shaped and located along the length of said first beam member; a plurality of parallel-spaced slidable fuel support plates each having a first slidable female coupling element at one end of each of said support plates engaging said first male coupling element of said first beam member, said first slidable female coupling element defined by an inwardly directed substantially spade-shaped configuration; a second beam member located at the other end of each of said parallel-spaced slidable fuel support plates and providing an extension thereof; each of said second beam members being provided with a second male coupling element at one end thereof, said second beam member of each of said fuel support plates having a reduced portion located adjacent to said second male coupling element, said reduced portions of alternate second beam members being shorter in width than the reduced portions of the other adjacent second beam members, said second male coupling element being substantially U-shaped and located along the length of said second beam member; and a plurality of fuel pins each being provided with a second slidable female coupling element at one end thereof engaging said second male coupling element of said second beam member, said second slidable female coupling element defined by an inwardly directed substantially spade-shaped configuration, each of said fuel pins being provided with an annular concave portion adjacent said second slidable female coupling element, said annular concave portions of the fuel pins attached to alternate second beam members providing a substantially spherical configuration, said one end of each of said fuel pins attached to the other adjacent second beam members substantially located within said spherical configuration provided by the concave portions of said fuel pins attached to alternate second beam members.

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