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## (54) SHOCK ABSORBER IN COMBINATION WITH A NUCLEAR REACTOR CORE STRUCTURE

(71) We, GENERAL ATOMIC COMPANY, a partnership organised under the laws of the State of California, of 10955 John Jay Hopkins Drive, San Diego, California, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:–

This invention relates to a shock absorber in combinaction with a nuclear reactor core structure having a blind control rod passage. A shock absorber is used at the end of a blind control rod passage in a nuclear reactor core structure for absorbing the energy of a falling control rod during emergency shut-down of the reactor core. Typical prior art shock absorbers used in nuclear reactor structures are fabricated from metal and absorb impact energy by plastic deformation of thin-walled metal components.

In a hostile environment, such as in or near the core of a nuclear reactor, high levels of radiation or the presence of certain chemicals can cause degradation of the shock absorbing qualitites of typical prior art shock absorbers. For example, many metals undergo embrittlement after they are exposed to radiation for a prolonged period of time. As a result, frequent replacement of the shock absorbers has often been necessary, with a consequent loss of time due to reactor shut-down.

Accordingly, it is an object of the present invention to provide a shock absorber for use in a blind control rod passage of a nuclear reactor core structure which is not subject to degradation therein.

In accordance with the invention, there is provided a shock absorber in combination with a nuclear reactor core structure having a blind control rod passage, the shock absorber at least one rigid fracturable element extending axially in said passage and having a lateral size sufficient to occupy a substantial portion of the cross-sectional area of said passage, said element being positioned in said passage adjacent the blind end thereof, the element being made of a porous brittle carbonaceous material, a porous brittle ceramic material, or a porous brittle refractory oxide, said element having a plurality of parallel holes extending longitudinally therethrough and parallel with the longitudinal axes of the passage, said holes providing a void volume of between 30% and 70% of the total volume of the element for energy absorption by fracturing of the element due to impact loading of a control rod.

The invention will be explained further by way of example with reference to the accompanying drawings, wherein:

Figure 1 is a full section view of a portion of a nuclear reactor core structure employing a shock absorber in accordance with the invention and illustrating the lower portion of a control rod used in the reactor core; and

Figure 2 is a perspective view of a shock absorber element used in the shock absorber shown in Figure 1.

In the embodiment of Figure 1, the shock absorber comprises at least one shock absorbing element 11 having a lateral size sufficient to occupy a substantial portion of the cross-sectional area of a blind control rod passage 15, in which it is used. The longitudinal size of the element is sufficient to extend axially in the passage 15 a predetermined distance. The element is comprised of a porous brittle material which is substantially non-degradable in the hostile environment in which it is used. The element has a void volume therein of a magnitude and configuration corresponding to a predetermined level of energy absorption by the element upon being crushed during impact loading.

The shock absorber, in addition to the

element 11, also includes elements 12, 13 and 14. The elements are positioned in a stack at the bottom of the blind passage 15 in a reactor core structure indicated generally at 17.

As is known in the art, the control rod passage 15 may extend through the reactor core structure 17 including that portion thereof which is composed at least partially of fissionable material. The control rod 19 includes an elongated graphite structure which may comprise a series of flexibly connected elements. The control rod 19 terminates in an annulus 21 of slightly enlarged diameter for guiding the control rod in the passage 15, and a frustoconical nose 23, terminating in a flat end 25 of circular outline. Other suitable configurations of the control rod and, in particular, its end, may be used so long as they are capable of transmitting to and distributing in the shock absorber at the bottom of the blind passage, the energy of the falling control rod.

The elements 11, 12 and 13 are of identical construction and therefore only the element 11 is illustrated in Figure 2. The element 11 is of substantially cylindrical configuration, having two opposite and parallel end surfaces 27 and 29 of circular outline. The passage 15 is of circular cross-section and the axis of the cylindrical element 11 is coincident with the axis of the passage 15. In a case where the passage 15 is approximately 10 cm in diameter, it has been found that a diametral clearance of approximately 2.5 mm provides satisfactory results.

The axial dimension of the element 11 is selected, consistent with the energy absorbing characteristics thereof described in greater detail below, to correspond with the required level of energy absorption to halt the falling control rod 19 as desired. In a control rod passage 15 of approximately 10 cm in diameter, satisfactory results have been achieved with an axial dimension of approximately 7.5 cm for each of the elements 11, 12 and 13.

Each of the elements 11, 12 and 13 is provided with a void volume therein. The void volume is provided by a central hole 31 drilled on the axis in each element and of approximately 5 cm in diameter. Surrounding the hole 31 in each element are two rows of smaller diameter holes 33. These holes may, by way of example, be approximately 0.635 cm in diameter and the holes in each row may be spaced at about 10° intervals. The resulting holes 33 provide a void volume which, when added to the void volume provided by the central hole 31, comprises from 30% to 70% of the total volume occupied by the element 11 in the passage 15. Satisfactory results have been achieved when this volume was approximately 55%.

For the purpose of acting as a ram to transmit energy to the elements 11, 12 and 13, the element 14 remains unvoided, that is, with substantially no void volume. The element 14 contains the same exterior configuration as that of the elements 11, 12 and 13 and is positioned in the stack of elements furthest from the blind end of the passage 15. The solid nature of the element 14 also acts as a plug to prevent the dust and fragments of the crushed elements resulting from impact loading from entering the control rod channel 15 and hence from entering any coolant holes and causing blockage thereof for the flow of coolant through the core.

The material of which the elements 11 through 14 are composed may be a carbonaceous material, a ceramic material, or a refractory oxide material. For the purpose of absorbing impact loads in the event a reactor control rod is dropped into a graphite moderated nuclear reactor core, carbonaceous material such as carbon or graphite is preferably employed. Successful results have been achieved by using a carbon preferably having a porosity ranging from about 30% to about 70% dense. The element 14 may be of the same porosity, or may be of different porosity, or may be fully dense. Successful results have been achieved with elements fabricated from a 45% dense porous carbon.

When the control rod 19 falls through the passage 15 and strikes the element 14, the impact loading thereof is transferred to the elements 11, 12 and 13. This causes the elements 11, 12 and 13 to fracture and compress and, in so doing, the energy of the falling control rod is absorbed. In actual tests, shock absorbers constructed along the lines as described previously are capable of absorbing impact loads amounting to energy levels of 5,400 Newton metres.

It may be seen, therefore, that the improved shock absorber is capable of absorbing high energy levels of impact loads and is not subject to degradation even over long periods of time in the hostile environment. Energy absorption is achieved by fracturing and compression. The crush strength, collapse volume and stack height is selected in accordance with the required energy absorption.

WHAT WE CLAIM IS:–

1. A shock absorber in combination with a nuclear reactor core structure having a blind control rod passage, the shock absorbers comprising at least one rigid fracturable element extending axially in said passage and having a lateral size sufficient to occupy a substantial portion of the cross-sectional area of said passage, the element being positioned in said passage adjacent the blind end thereof, the element being made of a porous brittle carbonaceous material, a por-

ous brittle ceramic material, or a porous brittle refractory oxide, said element having a plurality of parallel holes extending longitudinally therethrough and parallel with the longitudinal axis of the passage, said holes providing a void volume of between 30% and 70% of the total volume of the element for energy absorption by fracturing of the element due to impact loading, by a control rod.

2. A shock absorber combination according to claim 1, wherein the element is cylindrical and made of carbonaceous material.

3. A shock absorber combination according to claim 1 or 2, including a plurality of said elements to form a stack in the passage.

4. A shock absorber combination according to any one of claims 1 to 3, having at least one ram element having substantially no void volume; acting on the stack or element.

5. A shock absorber combination according to claim 1, substantially as described with reference to the accompanying drawings.

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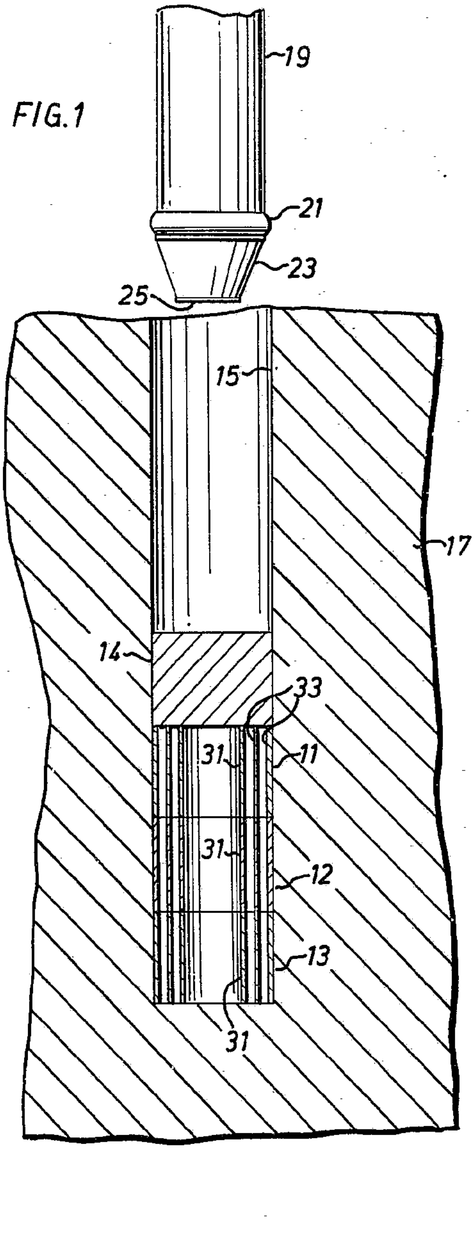
FIG.1



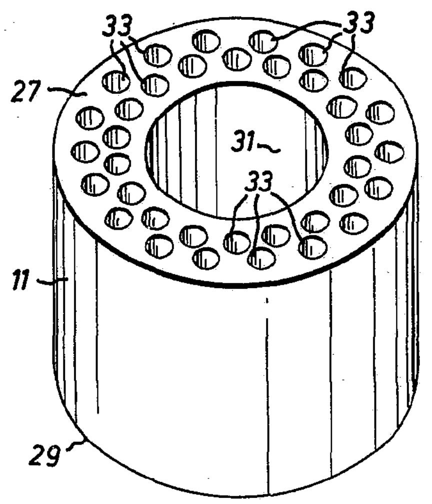



FIG. 2