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DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN OR RELATING TO NUCLEAR REACTOR SHUT-DOWN SYSTEMS

(71) We, BRITISH NUCLEAR DESIGN & CONSTRUCTION LIMITED, of Cambridge Road, Whetstone, Leicester LE8 3LH, a British Company, 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 nuclear reactor shut-down systems.

With nuclear reactors having a shut-down system in which a plurality of control rods of a neutron absorbent material can be inserted into the core in order to shut the reactor down it has been realised that to guard against the possibility of failure of the control rod system a secondary system is necessary which is not prone to the same failure possibilities. Thus there have been proposals for a secondary system providing for the injection into the core of a neutron absorbent gas such as nitrogen.

Such a secondary system however suffers from the disadvantage that the neutron absorbent gas must be maintained at high pressure and the system is therefore dependent upon the integrity of the core pressurisation and also that after an emergency shut-down it is desirable to de-pressurize the reactor as soon as possible to reduce the possibility of leakage of radio active material. Such depressurisation will necessarily involve the removal from the core of the neutron absorbent gas injected by the secondary system.

In such a case a need arises for a tertiary system which can be activated after the secondary system has operated and which can provide a residual neutron absorbency to maintain the reactor in a sub-critical condition during and after depressurisation of the reactor.

Alternatively, in the absence of the gas injection shut-down system mentioned above, a need will arise for an alternative fast acting secondary shut-down system.

According to the invention a nuclear reactor shut-down system includes a plurality of channels defined in the core of the reactor, and injection means for injecting particles of a neutron absorbent material into the channels, the particles, during injection, passing below the core before entering the channels.

Preferably, during injection, the particles pass upwardly through an injection duct within or alongside each channel and are then released within the channel at or near the top thereof.

Preferably also a retrieval duct communicates between the outside of the reactor and a point at or near the bottom of a channel.

During injection and/or retrieval a gas may be induced to flow through the system to encourage movement of the particles.

One embodiment of the invention will now be described with reference to the accompanying drawing which is a fragmentary sectional elevation of part of the core of a gas-cooled nuclear reactor.

Referring to the drawing the core of the reactor comprises a plurality of parallel columns 10 of graphite moderator bricks, each column generally comprising five principal sections: top shield 12, top reflector 14, fuelled length 16, bottom reflector 18, and bottom shield 20. The columns are supported by a core support grid 22 above a bottom coolant gas plenum 24 below which is a steel lined concrete pressure vessel bottom cap 26.

Defined within some of the columns 10, e.g. columns located in positions interstitial to the columns containing fuel elements and/or control rod channels, is a cylindrical channel 28 whose upper end is terminated by the top reflector 14, but whose lower end extends, at a reduced diameter, through the bottom reflector 18 and shield 20 and is closed by removable cover 30. The reduced diameter portion of the channel 28 is joined to the main portion by a frusto conical portion having a purpose discussed below.

Extending upwardly through the bottom pile cap 26 and into the channel 28 is an injection duct in the form of a feed tube 32 whose upper end terminates in a semi-toroidal portion 34

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having an open end facing down into the channel. The feed tube 32 is supported radially within the channel 28 by three spiders 36 having resilient arms which permit the tube 32 limited radial movement with respect to the channel. At its lower end the feed tube 32 is connected to a source (not shown) of gas under pressure and to a hopper (not shown) which contains a large number of neutron absorbent particles in the form of spheres having a diameter less than one-sixth of the diameter of the tube 32. The hopper and gas source are disposed outside the reactor pressure vessel. The spheres may for example consist of boron steel, mild or stainless steel with a boron carbide coating, or a high temperature glass having a high boron content. The gas is preferably neutron absorbent and may, for example, be nitrogen.

The system is activated by releasing gas from the high pressure source such that it flows past the bottom of the hopper and draws from it spheres which become entrained in the gas flow and pass upwardly through the feed pipe 32. The semi-toroidal portion 34 directs the spheres downwardly from the top of the channel 28 and they fall toward the removable cover 30. The frusto conical portion of the channel 28 guides the spheres into the reduced diameter portion which fills rapidly whilst the gas is able to escape from the channel by flowing through a port (not shown) defined at the top of the channel. The injection of spheres into the channel 28 continues until the hopper load of particles has been transferred to the channel and the channel is almost full. When all of the channels 28 in the reactor core have been similarly filled the reactor may safely be depressurised since the spheres provide sufficient neutron absorbency to maintain the reactor in a sub-critical condition irrespective of the removal from the core of any neutron absorbent gas which may have been injected into the core earlier in the shutdown process.

Should it subsequently be decided that the reactor may safely be operated again it is merely necessary to retrieve the spheres by removing the covers 30 and allowing the spheres from each channel 28 to discharge under gravity into a container which, with its contents, can then be removed from the core. The retrieval process may be carried out manually or remotely.

In an alternative retrieval arrangement (not shown) a retrieval duct in the form of a pipe, parallel to the feed pipe 32, communicates between the reduced diameter portion of the channel 28 and the hopper in which the spheres are stored when not in use. Movement of the spheres through the retrieval pipe may be assisted by a positive gas pressure difference between the channel 28 and the hopper. The retrieval pipe may be disposed alongside the feed pipe 32, or alternatively may enclose the feed pipe and define an annular passage around it.

As an alternative (not shown) to the feed pipe 32, a duct may be defined in the columns 10 adjacent and parallel to the channel 28, the duct communicating at its upper end with the top of the channel 28 and at its lower end with a pipe connected to the hopper.

It will be appreciated that by virtue of this provision for the complete retrieval of the spheres from the core the reactor shutdown system described above is highly advantageous in that its activation does not render the core permanently useless.

WHAT WE CLAIM IS:—

1. A nuclear reactor shutdown system including a plurality of channels defined in the core of the reactor, and injection means for injecting particles of a neutron absorbent material into the channels, the particles, during injection, passing below the core before entering the channels.

2. A system according to Claim 1, wherein, during injection, the particles pass upwardly through an injection duct within or alongside each channel and are then released within the channel at or near the top thereof.

3. A system according to Claim 1 or Claim 2, wherein a retrieval duct communicates between the outside of the reactor and a point at or near the bottom of a channel.

4. A system according to any preceding claim, wherein during injection and/or retrieval a gas is induced to flow through the system to encourage movement of the particles.

5. A nuclear reactor shutdown system substantially as herein described with reference to the accompanying drawing.

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1291618 COMPLETE SPECIFICATION
1 SHEET *This drawing is a reproduction of the Original on a reduced scale*