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[54] **RAPID SHUTDOWN SYSTEM FOR WATER-COOLED NUCLEAR REACTORS**
4 Claims, 1 Drawing Fig.

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[56] **References Cited**

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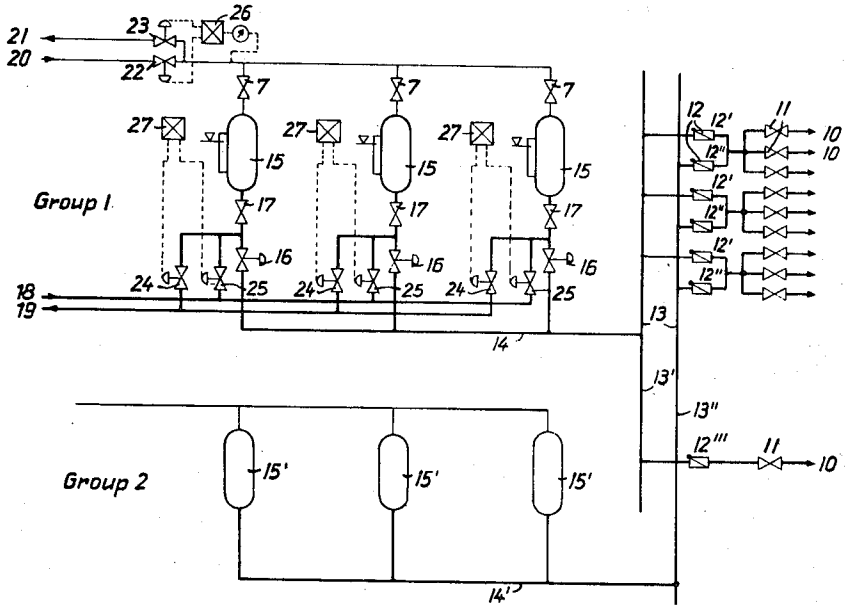
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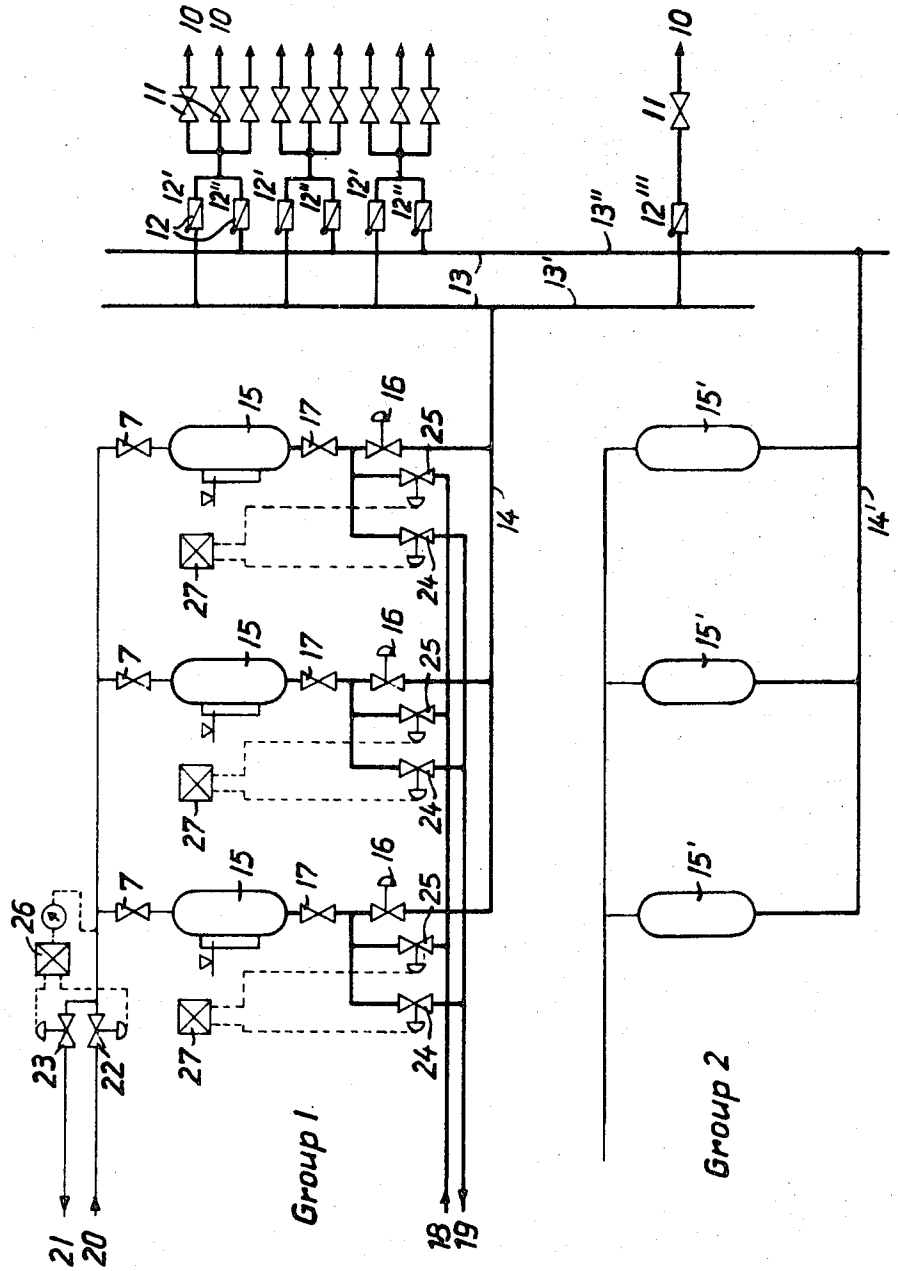
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ABSTRACT: A rapid shutdown system for nuclear reactors of the type having a plurality of neutron-absorbing control rods. The system includes a plurality of hydraulic drives, each of which is connected to a separate control rod, a plurality of hydraulic fluid pressure tanks, each of which is partially filled with fluid and partially filled with a gas under pressure, and means connecting all of the tanks with all of the hydraulic drives through at least one one-way check valve.





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RAPID SHUTDOWN SYSTEM FOR WATER-COOLED NUCLEAR REACTORS

BACKGROUND OF THE INVENTION

The present invention relates to so-called "scram" systems, or systems effecting the rapid shutdown of water-cooled nuclear reactors of the type having a plurality of neutron absorbing control rods.

More particularly, the present invention relates to drive systems for controlling the position of the neutron absorbing rods; these systems consist of a plurality of combined drives, one for each control rod, having a mechanical drive component for normal positioning movements and an overriding hydraulic drive component for effecting a high-speed shutdown of the reactor. The hydraulic drive components are connected to pressure tanks that are filled, in part, with a hydraulic medium or fluid and contain, in addition, a cushion of gas under pressure above the level of the fluid. Equipment is provided to regulate the fluid level and to regulate the pressure of the gas. The pressure tanks are connected with the various hydraulic drive components through a number of one-way "check valves."

The German Auslegeschrift DAS 1,169,596 discloses a scram system for boiling water reactors which employ mechanical drives for normal positioning movements and hydraulic drives for rapid operation of their control rods. Hydraulic pressure tanks are connected through check valves to supply hydraulic fluid to the hydraulic control rod drives. The two independently operative systems are employed for reasons of safety. The mechanical drives make it possible to move the neutron-absorbing rods to desired positions with accuracy during the normal operations of the reactors while the hydraulic drives serve, in cases of emergency, to insure the safety of the reactors by rapidly inserting the rods into the reactor cores.

In the system described in the above-mentioned Auslegeschrift, the hydraulic medium is simultaneously used as the reactor coolant. This hydraulic fluid is maintained at the necessary pressure within the pressure tanks by a cushion of gas located above the fluid level. When a signal is give to "-scram," or rapidly shut down the nuclear reactor, the hydraulic medium is emptied from the pressure tanks into the hydraulic drives.

The Auslegeschrift noted above also teaches that every hydraulic drive is to be supplied hydraulic fluid by its own associated pressure tank. Each pressure tank is then provided with the instrumentation necessary for maintaining the pressure of the gas therein and for adding or refilling the necessary hydraulic fluid. This arrangement of individual pressure tanks and instrumentation is provided for reasons of safety but, at the same time, is extremely expensive.

SUMMARY OF THE INVENTION

An object of the present invention, therefore, is to provide a rapid shutdown system for water-cooled nuclear reactors, of the type described above, which requires considerably fewer pressure tanks and attendant instrumentation without impairment or reduction of the factor of safety of the system.

In particular, it is an object of the present invention to reduce the number of pressure tanks and to reduce the instrumentation in a system of this type in such a way that, out of a plurality of hydraulic drives, only one or at most a very small number will be permitted to fail, thus insuring a safe shutdown of the reactor.

These as well as other objects which will become apparent in the discussion that follows, may be achieved, according to the present invention, by simultaneously connecting all the pressure tanks to all the hydraulic drives at once.

In this way, if the total hydraulic fluid capacity of all the tanks exceeds, by a large factor of safety, the total amount of fluid required to operate the drives, one or more of the tanks can be allowed to fail without impairing the operation of the system. The total number of tanks each with its attendant instrumentation, can therefore be reduced while the overall factor of safety of the system is actually increased.

According to a preferred embodiment of the present invention the various pressure tanks are divided into at least two groups, each of which groups is connected to all of the hydraulic drives through at least one separate check valve. Then, if the total tank capacity in each of the groups is made sufficiently high to operate all the hydraulic drives, the hydraulic lines connecting an entire group with the hydraulic drives can fail without causing a failure of the system.

BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE is a schematic diagram of the rapid shutdown system for water-cooled nuclear reactors, according to a preferred embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawing, there is shown a single FIGURE which illustrates one preferred embodiment of the rapid shutdown or scram system according to the present invention. Two groups of pressure tanks **15** and **15'** are connected in parallel to feed separate common tank supply lines **14** and **14'**, respectively. These tank supply lines are connected through ring lines **13'** and **13''**, respectively, and through check valves **12** and input shutoff valves **11** to the individual inputs **10** of the hydraulic drives. A number of hydraulic drive inputs **10** with their associated shutoff valves **11** are connected through a common check valve **12'** to the ring line **13'** and through a common check valve **12''** to the ring line **13''**. It is also possible, of course, to connect only a single hydraulic drive input **10** with its associated input valve **11** to one of the ring lines **13** through a single check valve **12'''** as shown in the FIGURE.

Each of the pressure tanks **15** is connected to the common tank discharge line **14** through a fast opening valve **16**, which may be opened in case of emergency to allow the pressure medium to flow out to the hydraulic drives. The pressure tanks **15** are only partly filled with a pressure medium, such as water. This medium is placed under pressure by a cushion of gas, such as nitrogen, which occupies the top portion of each tank.

The pressure medium is supplied to the pressure tanks through the input line **18** and the pressure medium supply valves **25**. The pressure medium may also be emptied from the tanks through the outlet valves **24** and the outlet line **19**.

The fluid level with each pressure tank is automatically controlled by level regulators **27** which operate the two vales **24** and **25** in dependence upon the quantity of pressure medium in the tank.

The gas is supplied or withdrawn from the pressure tanks via the gas inlet line **20** and inlet valve **22** and, respectively, the gas outlet line **21** and outlet valve **23**. The setting of the two valves **22** and **23** is controlled by the pressure regulator **26** in dependence upon the gas pressure supplied to all of the tanks **15**.

Each of the tanks **15** can be separated from the gas or hydraulic fluid supply lines by means of tank shutoff valves **7** and **17**, respectively. These valves permit a particular tank to be isolated from the remaining tanks in the group in the event of failure.

The second group of pressure tanks **15'** is provided to insure that the rapid shutdown system will remain operative even upon failure of the tank outlet line **14** or the ring line **13'**. These pressure tanks are connected through the separate and parallel outlet line **14'** and ring line **13''** to all the individual hydraulic drives. The pressure tanks **15'** of Group **2** are instrumented with valves and regulators in the same manner as the pressure tanks **15** of Group **1**.

In the embodiment shown in the FIGURE, therefore, two groups of three tanks each are connected to the hydraulic drives through two separate ring lines **13**. The three pressure tanks in each group, taken together, should be able to provide

both the total quantity of pressure medium and gas which would be necessary if individual tanks were employed with every hydraulic drive.

The quick-opening valves **16** provided in both groups, should be of the type which open to a large average cross section in a short time. The required short opening times can be obtained by using hydraulic valves. Every pressure tank must also be provided with means for closing its outlet opening after a prescribed minimum pressure has been reached. This quick closing can be effected by the valves **16** or by separate quick-closing valves, not shown, arranged in series with the quick-opening valves **16**. This arrangement is necessary to prevent large quantities of gas from flowing out of the tanks.

When the pressure tank system shown in the FIGURE is used to rapidly shutdown a nuclear reactor, all six pressure tanks are normally operative on all the hydraulic drives. This makes available twice the quantity of pressure fluid that was available in the scram systems of the prior art, since already only three pressure tanks contain the volume of fluid and gas which is necessary to operate the drives. As a result, this scram system will be able to hold the neutron absorbing rods in the shutdown position until the mechanical drive mechanism can be run down to this position with a considerable reduction in the risk of failure. Barring the possibility of a very severe accident—namely, a break in one of the ring lines—the protection against the loss of one or more tanks, for example, by failure of a quick opening valve **16**, will be extraordinarily high.

Also, a break in one of the hydraulic drive inputs **10** or in a connecting line between an input valve **11** and a check valve **12** will not be dangerous since only the particular drive or drive group will be placed out of operation. The outflow of pressure medium through the broken line may be fully compensated by the large volume of pressure medium which stands available. It is necessary, for this purpose, to construct these lines with the smallest possible cross section and to choose a sufficiently high hydraulic pressure so that a sufficient quantity of fluid will be transported to quickly move the neutron rods. On the other hand, the cross section of the ring lines must be made sufficiently large to permit the quick flow of fluid.

The worst imaginable type of breakdown in the scram system of the present invention, would be a break in an entire ring line of one group. Were this to occur, the check valves **12'**, **12''** or **12'''** of the respective group would prevent the backflow of fluid from the still operative ring line to the broken one, so that 100 percent of the fluid volume necessary to operate the hydraulic drives would still be available.

It is even possible, with the apparatus according to the present invention, to tolerate the break in a ring line of one group and the failure of one of the three tanks in the other. This would means that only two thirds of the hydraulic fluid volume of one group would be made available to the control rod drives. Though this quantity would be absolutely sufficient to initially shutdown the control rods, the scram system would not, with certainty, be able to hold the control rods in the shutdown position until the mechanical drives could also be run into the shutdown position. For this eventuality, it is possible to provide a ratchetlike arresting mechanism with each control rod, having a pawl which is operative to be inserted in sawtooth-shaped recesses in a member connected with the control rod to prevent the control rod from slipping and to hold it in the shutdown position.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations.

We claim:

1. Apparatus for controlling a water-cooled nuclear reactor having a plurality of control rods, comprising, in combination:

a. a plurality of combined drive means, each of said drive means being connected to one of said rods and including a mechanical drive component for normal rod positioning movements and a hydraulic drive component for rapid shutdown rod movements;

b. a plurality of pressure tanks, each of said tanks being partially filled with a hydraulic fluid and having a cushion of gas under pressure located therein above the level of said fluid;

c. means, connected to each of said tanks, for regulating the level of fluid and the pressure of said gas;

d. means for connecting the hydraulic fluid in each of said tanks with the hydraulic drive component of each of said drive means for supplying hydraulic fluid from the tanks to the hydraulic drive component of each of said drive means; and

e. at least one check valve arranged in said connecting means in the path between each of said pressure tanks and each of said drive means.

2. The apparatus defined in claim **1**, wherein said connecting means connects all of said tanks to all of said hydraulic drive components through a single check valve.

3. The apparatus defined in claim **1** wherein said plurality of pressure tanks is arranged in a plurality of groups, and said connecting means connects the tanks in each of said groups to all of said hydraulic drive components through at least one separate check valve.

4. The apparatus defined in claim **3**, wherein the tanks in each of said groups together have sufficient capacity to operate said hydraulic drive components.

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