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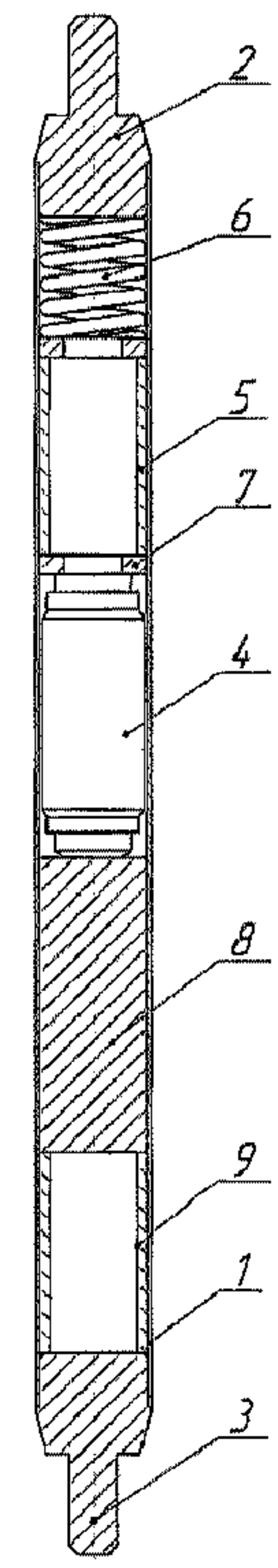

Fig. 1

(57) Abrégé/Abstract:
The invention relates to nuclear technology and is intended to provide for controlled reactor startup by bringing a reactor to working capacity after scheduled and unscheduled shutdown. The invention solves the problem of increasing the reliability of a working

(57) Abrégé(suite)/Abstract(continued):
neutron source by creating additional safety barriers between a coolant and the materials of the active part of the source. The present working neutron source is in the form of a steel casing having disposed therein a capsule containing active elements, namely antimony and beryllium, with a coaxial arrangement of separate antimony and beryllium chambers. The antimony is enclosed in a central casing made of a niobium-based alloy which does not react with antimony during filling and use. The beryllium, in the form of a powder filling, is disposed between the casing of the antimony and the casing of the capsule. The capsule casing is made of ferritic-martensitic grade steel, which is weakly reactive with beryllium. An upper gas reservoir is situated above the capsule and serves as a compensating reservoir space for gaseous fission products. The lower end of the capsule rests on a reflector and a lower gas reservoir. The gas reservoirs, reflector and washers are made of ferritic-martensitic grade steel.

Abstract

The invention relates to nuclear engineering and is designed for controlled reactor start-up by rising the reactor to the working power level after normal and abnormal shutdowns. The invention solves the problem of improving the reliability of the operational neutron source by creating additional safety barriers between the coolant and the source active part materials. The operational neutron source is designed as a steel enclosure inside of which there is an ampule containing active elements: antimony and beryllium with separate antimony and beryllium cavities positioned coaxially. The antimony is contained in the central enclosure made of a niobium-based alloy which does not react with the antimony during filling and operation. A beryllium powder bed is located between the antimony enclosure and the ampule enclosure. The ampule enclosure is made of martensite-ferrite steel poorly reacting with beryllium. An upper gas collector is located above the ampule, which serves as a compensation volume collecting gaseous fission products. At the bottom, the ampule is supported by a reflector and a bottom gas collector. The gas collectors, reflector and washers are made of martensite-ferrite grade steel. 12 dependent claims, 2 figures.

Operational Neutron Source

Field of the Invention

The invention relates to nuclear engineering and is designed for controlled reactor start-up by rising the reactor to the working power level after normal and abnormal shutdowns.

Background of the Invention

In order to improve the reactor safety and its dynamic properties, as well as to reduce consequences of start-up reactivity accidents, it is feasible to implement engineering measures to prevent "blind" start-up, because in subcritical reactor the neutron flux is the only and the most important variable parameter at reactivity rise. The controlled start-up means the possibility to measure the neutron flux in the reactor core depending on the position of standard control equipment compensating rods.

The amount of neutrons generated in the core as a result of spontaneous uranium fission (~2 10^3 n/s), is not sufficient to provide a controlled neutron flux in measuring chambers during the start.

The reactor subcriticalilty and power control is one of the most important nuclear safety tasks. In order to provide controlled reactor start-up, it is essential to ensure that the core neutron power is consistent with the response of ionization chambers monitoring the neutron flux which are located in a specific area near the core.

In order to ensure the control, the neutron flux in a subcritical reactor shall be increased significantly, or the start-up equipment response shall be increased accordingly. The most appropriate solution of the reliable power control problem of reactors (in the initial subcritical state) equipped with pulse start-up equipment is the allocation of neutron sources in the core.

Neutron sources designed as cluster assemblies are currently in use. The assembly includes two types of rods: rods with antimony filling, and rods with a hot-pressed beryllium bed.

Such designs are very large and occupy a considerable area in the core.

Neutron sources based on antimony-beryllium composition pellets enclosed in a single housing are currently in use. At present, such neutron source design is used at naval nuclear facilities.

The shortage of this design is potential antimony melting during the source manufacture and operation, resulting in the stratification of the antimony-beryllium composition and source efficiency degradation.

A monoenergetic neutron source is currently in use, disclosed in Patent RU No. 1762676, MPK G21G4/00 of 8/30/1994. This neutron source is designed as radioactive antimony in a beryllium enclosure which is placed in the iron layer, with varying thickness of the beryllium and ferrum layers, which thickness is determined by the calculated ratios.

The device contains a photon source, cylinder-shaped antimony, a photoneutron source, beryllium shaped as a cylindric tube, a neutron filter, barrel-shaped ferrum, in which an antimony-beryllium system is placed, and then capped with an iron plug.

The shortage of this design is also potential antimony melting during the source manufacture and operation, resulting in the stratification of the antimony-beryllium composition and source efficiency degradation.

Invention Disclosure

The invention solves the task of improving the reliability of the operational neutron source.

The technical result of the invention is the provision of additional safety barriers between the coolant and neutron source active part materials, the improvement of fail-free operation of the neutron source, its reliability and durability.

The above technical results are achieved by the following distinctive features of the invention.

As a solution to the stated problem, we claim an operational neutron source designed as an enclosure of a durable material, such as steel, inside of which there is an ampule containing active elements: antimony and beryllium with separate antimony and beryllium cavities positioned coaxially. The antimony is housed in the central ampule enclosure made of a material which does not react with the antimony during filling and operation, for example, a niobium-based alloy. The central enclosure of the ampule is leak tight. A beryllium powder bed is located between the antimony enclosure and the ampule enclosure. The beryllium powder bed porosity is 45 %, with particle size from 60 to 200 micron. The ampule enclosure is made of a material poorly reacting with beryllium, for example, martensite-ferrite grade steel.

An upper gas collector is located above the ampule, which serves as a compensation volume collecting gaseous fission products. The gas collector is pressed against the ampule through washers with a spring.

At the bottom, the ampule is supported by a reflector and a bottom gas collector. The gas collectors, the reflector and the washers are made of a durable material, such as martensite-ferrite grade steel.

The neutron source enclosure inner cavity is filled with helium to ensure heat transfer.

The neutron source enclosure is sealed with two shanks: upper and lower ones. It is sealed by argon arc welding.

The ampule is placed in the neutron source enclosure with a 0.1 mm clearance.

The ampule is positioned in a four-ribbed enclosure in order to provide an additional safety barrier.

The operational neutron source ensures controlled reactor start-up from the subcritical state with fully submerged CPS rods at any time during the entire service life of the core, except for its initial start-up.

Brief Description of the Drawings

Fig. 1 shows the operational neutron source cross-section, general view.
Fig. 2 shows the cross-section of the operational neutron source ampule.

Embodiment of the Invention

The container-type operational neutron source has an enclosure 1 made of martensite-ferrite grade steel with a diameter of 12 mm in the smooth part, and the wall thickness of 0.4 mm, with four spiral ribs located on the outer side of the enclosure. The diameter along the ribs is 13.5 mm, the rib winding pitch is 750 mm. (Not shown in the drawing)

The enclosure houses an ampule 4 with active elements: antimony and beryllium. The active components are located in separate antimony and beryllium cavities of coaxial design.

An upper gas collector is located above the ampule 5, which serves as a compensation volume collecting gaseous fission products. The gas collector 5 is pressed against the ampule through washers 7 with a spring 6.

At the bottom, the ampule is supported by a reflector 8 and a bottom gas collector 9.

The neutron source enclosure inner cavity is filled with helium to ensure heat transfer.

The neutron source enclosure is sealed with two shanks: upper and lower ones 3.

It is sealed by argon arc welding.

The source enclosure, gas collectors, reflector and washers are made of martensite-ferrite grade steel.

Fig. 2 shows the ampule of a coaxial design with the antimony 10 in the ampule central enclosure 11. The ampule central enclosure 11 is made of a niobium-based alloy which does not react with antimony during filling and operation. A beryllium bed (not shown) is located between the ampule central enclosure 11 and the ampule enclosure 12. Beryllium is a powder with particle size from 60 to 200 micron, and the beryllium powder bed porosity is 45 %.

The ampule enclosure 12 is made of martensite-ferrite steel poorly reacting with beryllium.

The central ampule enclosure containing the antimony is leak tight. The ampule central enclosure and its elements may be made, for example, of the VN-2AE alloy.

The ampule 4 is placed in the enclosure 1 of martensite-ferrite grade steel with a 0.1 mm clearance. The length of the ampule active part is 190 mm, the overall length of the operational neutron source (active part) is 1,720 mm.

Due to provision of additional safety barriers between the coolant and the source active part materials, the operational neutron source of the claimed design, its active part, provides reliable operation of the reactor plant for a campaign of 53,000 effective hours (approximately 8 years).

Claims

1. The operational neutron source containing an enclosure with active elements inside (antimony and beryllium isotopes), wherein the active elements are placed in an ampule of a coaxial design.

2. The operational neutron source according to Claim 1, wherein antinomy is contained in the ampule central enclosure.

3. The operational neutron source according to Claim 1, wherein beryllium is located between the ampule central enclosure and the ampule enclosure.

4. The operational neutron source according to Claim 1, wherein the ampule central enclosure is made of an alloy which does not react with antimony during filling and operation.

5. The operational neutron source according to Claim 4, wherein the ampule central enclosure is made of a niobium-based alloy.

6. The operational neutron source according to Claim 1, wherein beryllium is a powder with particle size from 60 to 200 micron, and the beryllium powder bed porosity is 45 %.

7. The operational neutron source according to Claim 4, wherein the ampule enclosure is made of a material poorly reacting with beryllium.

8. The operational neutron source according to Claim 7, wherein the ampule enclosure is made of martensite-ferrite grade steel.

9. The operational neutron source according to Claim 1, wherein the ampule is installed in the neutron source enclosure with a 0.1 mm clearance.

10. The operational neutron source according to Claim 1, wherein there is an upper gas collector above the ampule, which serves as a compensation volume collecting gaseous fission products.

11. The operational neutron source according to Claim 1, wherein the gas collector is pressed against the ampule through washers with a spring.

12. The operational neutron source according to Claim 1, wherein at the bottom, the ampule is supported by a reflector and a bottom gas collector.

13. The operational neutron source according to Claim 1, wherein the neutron source enclosure inner cavity is filled with helium to ensure heat transfer.

14. The operational neutron source according to Claim 1, wherein its enclosure is leak tight.

15. The operational neutron source according to Claim 14, wherein the enclosure is sealed with two shanks: upper and lower ones.

16. The operational neutron source according to Claim 14, wherein it is sealed by argon arc welding.

17. The operational neutron source according to Claim 1, wherein its enclosure has four spiral ribs providing an additional safety barrier.

18. The operational neutron source according to Claim 1, wherein the neutron source enclosure, gas collectors, reflector and washers are made of martensite-ferrite grade steel.

Operational Neutron Source

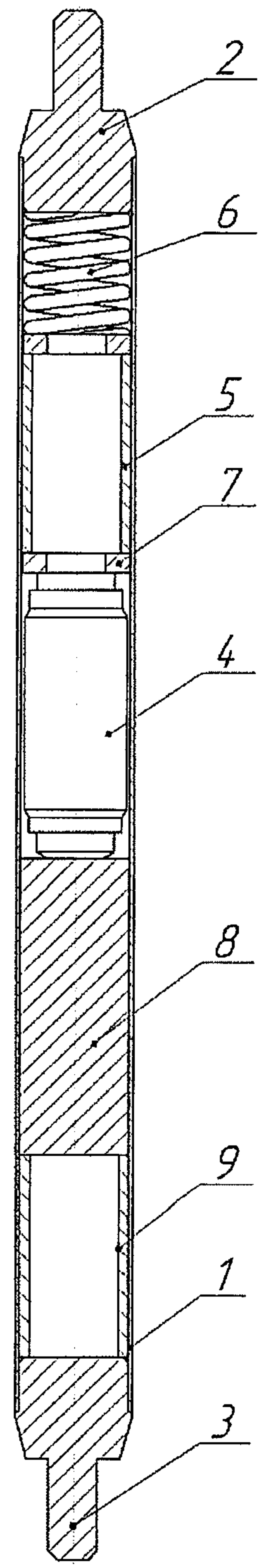

Fig. 1

Operational Neutron Source

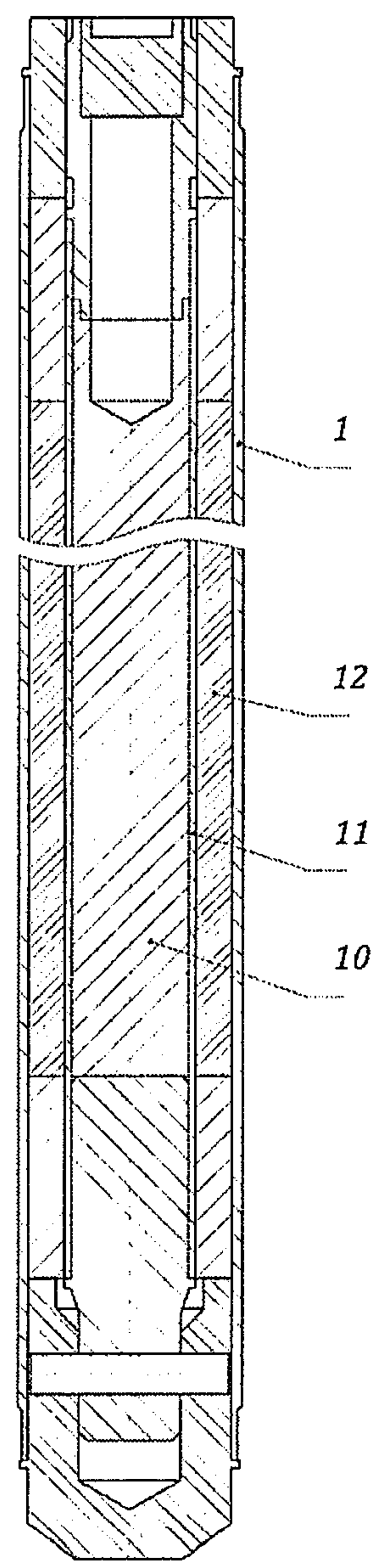

Fig. 2