PATENT SPECIFICATION

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(54) DEVICE FOR MEASURING NEUTRON-FLUX DISTRIBUTION DENSITY

(71) We, NATALYA DMITRIEVNA ROZENBLJUM, of kvartira 42, B.Dorogomilovskaya ulitsa 58, MIKHAIL GRIGORIEVICH MITELMAN, of kvartira 70, ulitsa Kibalchicha 2, ALINA ALEXANDROVNA KONONOVICH, of kvartira 71, M.Schukinskaya ulitsa 17, VLADIMIR SEMENOVICH KIRSANOV, of kvartira 27, Metrostroevskaya ulitsa 7, and VLADIMIR ANDREEVICH ZAGADKIN, of kvartira 411, korpus 1, Orekhovy bulvar 11, all of Moscow, all Union of Soviet Socialist Republics, all Citizens of the Union of Soviet Socialist Republics, 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:—

The present invention relates to an arrangement for measuring the distribution of neutron-flux density over the height of a nuclear reactor core. The device may find application at operational nuclear reactors for energy release monitoring or for detecting deviations of neutron-flux from an optimal level so that subsequent balance can be achieved.

It is an object of the invention to provide a device for measuring the distribution of neutron-flux density over the height of the core of a nuclear reactor, wherein the mutual interference of detectors is obviated.

According to the invention there is provided a device for measuring the distribution of neutron-flux density over the height of a nuclear reactor core, comprising a plurality of self-powered detectors for measuring neutron-flux density, each of which includes a sensitive element for detecting neutron-flux and a communication line coupled thereto for providing an output indicative of the neutron-flux incident on the sensitive element, the detectors being positioned one above the other and screened with respect to one another such that the communication line of each respective detector is protected against the high-energy charged particles emitted by the sensitive element of that other detector disposed nearest thereto.

The arrangement may be provided with a slotted screening cylinder, the slots being formed in the surface of the cylinder along the generatrix thereof, and each slot accommodating one detector.

In an alternative embodiment of the invention, series of tubular members may be provided individually for each detector, each tubular member enveloping the sensitive element of the respective detector and being coupled to the communication line of the detector disposed immediately therebelow.

In yet another embodiment of the invention a concave screening plate may be provided having openings therein, with the sensitive elements of the detectors being secured to one side of the plate whereas the communication lines of the detectors being led out to the other side of the plate through said openings.

The sensitive elements of the detectors which are secured to the screen are preferably arranged coaxially.

The foregoing design of the device for measuring the distribution of neutron-flux density over the height of a nuclear reactor core permits accurate information of the density distribution of neutron fluxes to be obtained.

The invention will now be described by way of example with reference to the accompanying drawings, wherein:—

Figure 1 is a front view of the device for measuring the distribution of neutron-flux density, in accordance with the invention;

Figure 2 is a sectional view of the device of Figure 1 taken on the line II—II in Figure 1;

Figure 3 is a longitudinal sectional view of a self-powered detector of the device for measuring the distribution of neutron-flux density,

Figure 4 is a front view of an alternative embodiment of the device for measuring the distribution of neutron-flux density, in accordance with the invention;

Figure 5 is a front view of yet another embodiment of the device for measuring the distribution of neutron-flux density, in accordance with the invention;

Figure 6 is a rear view of the device shown in Figure 5;

Figure 7 is a sectional view of the device shown in Figure 5 taken on the line VII—VII in Figure 5;

Figure 8 is a front view of a fourth embodiment of the device for measuring the distribution of neutron-flux density, in accordance with the invention;

Figure 9 is a rear view of the device shown in Figure 8;

Figure 10 is a sectional view of the device shown in Figure 8 taken on the line X—X in Figure 8;

Figure 11 illustrates an electric circuit for measuring the signals of the self-powered detectors of the device for measuring the distribution of neutron-flux density shown in Figure 1.

The device for measuring the distribution of neutron-flux density shown in the drawings, over the core of a nuclear reactor (not shown), comprises a self-powered detectors 1 (Figures 1 and 2) each of which comprises a sensitive element 2 and a communication line 3, both said components being secured to a screen 4.

The sensitive element 2 of the self-powered detector 1 comprises an emitter 5 (Figure 3), a collector 6 constructed from stainless steel, and an insulator 7 constructed from quartz, the insulator 7 serving to separate the emitter 5 from the collector 6. The emitter 5 is constructed from any material which is activated in a neutron-flux to form charged particles. The materials from which the other structural elements are constructed are selected in accordance with the criterion that the number of charged particles induced therein in a neutron flux is far smaller than that in the emitter 5. The communication line 3 of the self-powered detector 1 comprises a cable 8 with a current-carrying core 9, a mineral insulating member 10 and a stainless steel sheathing 11. The sheathing 11 of the cable 8 is coupled to the collector 6 in sealing relationship therewith. On the side opposite to the emitter 5 the communication line 3 is sealed with the aid of a compound 12. The current-carrying core 9 of the communication line 3 which is connected to the emitter 5 passes through the compound 12 and serves as a leadout.

The self-powered detectors 1 (Figure 1) are secured to the screen 4 so that the communication line 3 of each self-powered detector 1 is protected by the screen 4 against the charged particles emitted by the emitter 5 (Figure 3) of the other detector, the thickness of the screen being sufficient for total absorption of all charged particles. The screen 4 must be constructed from a sufficiently tough material capable of withstanding exposure to the conditions obtaining within the reactor core and resistant to activation in a neutron flux.

The screen 4 may be formed in a variety of configurations. Thus, Figures 1 and 2 illustrate a screen 4 common to all the self-powered detectors 1 which is formed as a slotted cylinder 13 whereof the slots 14 are formed in the exterior surface of the cylinder along the generatrix thereof. Each slot 14 accommodates, at a predetermined level along the nuclear reactor core, one self-powered detector 1 (the sensitive element 2 and the communication line 3).

The screen 4 shown in Figure 4 is formed of pieces of pipe 15 provided individually for each detector 1. The sensitive elements of each self-powered detector 1 are fitted into said pieces of pipe 15, the communication lines 3 of the detectors 1 being rigidly coupled to the respective members 15 of the above-disposed detectors and passing on the exterior surfaces thereof.

In the device for measuring the distribution of neutron-flux density illustrated in Figures 5, 6 and 7, the screen 4 is formed as a plane plate 16 with openings 17 (Figures 5 and 6) formed along the axis of the plate. Secured to one side of the plate 16 (Figure 7) are the sensitive elements 2 of the self-powered detectors 1, whereas the communication lines 3 of the detectors 1 are led out the other side of the plate 3 through the openings 17.

The screen 4 may be further formed as a concave plate 18 (Figures 8, 9 and 10) with openings 19 accommodating the sensitive elements 2 of the detectors 1, the communication lines 3 being led out through the openings 19 to the exterior side of the plate 18 (Figure 10).

The design of the device illustrated in Figures 5, 6 and 7 as well as in Figures 8, 9 and 10 enables the sensitive elements 2 of the self-powered detectors 1 to be arranged in coaxial relationship.

The signals furnished by the self-powered detectors 1 are measured by the circuit shown in Figure 11 with the aid of a measuring instrument 20 having a low input impedance (not exceeding 1 Kohm). The detectors 1 are either connected to the measuring instrument 20 *via* a switch 21 or shorted to earth *via* a resistor 22 whose resistance is equal to that of the measuring instrument 20.

The device for measuring the distribution of neutron flux density operates as follows.

The device for measuring the distribution of neutron-flux density (Figures 1 and 2) incorporating the screen 4 whereto are rigidly secured the self-powered detectors 1 is lowered into one of the reactor core channels.

As a neutron flux impinges on the emitter 5 (Figure 3) of the self-powered detector 1, a nuclear reaction takes place (η, γ), with the material of the emitter 5 forming a beta-active isotope. The beta-active isotope undergoes fission, and the high-energy beta-particles emitted thereby pass through the insulator 7 and impinge on the earthed collector 7. The beta particles leaving the emitter 5 give the latter a positive charge; and impinging on the collector 6, impart thereto a negative charge, so that a potential difference emerges between the emitter 5 and the collector 6. As the emitter 5 and the earthed collector 6 are shorted *via* the measuring instrument (Figure 11), a current flows therebetween proportional in magnitude to the density of the neutron flux. The emitters 5 of the self-powered detectors 1 which are secured to the screen 4 are disposed at predetermined positions along the reactor core. Since the screen 4 obviates the mutual interference of the self-powered detectors 1, the current reading furnished by each self-powered detector 1 gives the true density of the neutron flux at the side of the sensitive element 2 of the detector 1.

The size of current through each self-powered detector 1 is measured by the measuring instrument 20, the other self-powered detectors being shorted to earth *via* the resistor 22 with the aid of the switch 21.

The devices for measuring the distribution of neutron-flux density illustrated in Figures 5, 6 and 7 as well as in Figures 8, 9 and 10 operate similarly to the device of Figure 1.

Thus, the screen permits a true picture of neutron-flux density distribution over the height of the nuclear reactor core. The screen constructed from metal of sufficient thickness to absorb high-energy beta-particles, protects the communication line of the self-powered detector against the beta-particles emitted by the emitter of the self-powered detector disposed immediately above.

The screen formed as a flat or concave plate permits a coaxial arrangement of the sensitive elements of the self-powered detectors. With the sensitive elements of the self-powered detectors arranged in coaxial relationship, it is possible to obtain a more accurate picture of neutron-flux density distribution in reactors having radial neutron flux density gradients.

WHAT WE CLAIM IS:—

1. An arrangement for measuring the distribution of neutron-flux density over the height of a nuclear reactor core comprising a plurality of self-powered detectors for measuring neutron-flux density, each of which includes a sensitive element for detecting neutron-flux and a communication line coupled thereto for providing an output indicative of the neutron-flux incident on the sensitive element, the detectors being positioned one above the other and screened with respect to one another such that the communication line of each respective detector is protected against high-energy charged particles emitted by the sensitive element of that other detector disposed nearest thereto.

2. An arrangement as claimed in claim 1, wherein the detectors are positioned in slots of a slotted screening cylinder, the slots being formed in the surface of the cylinder along the generatrix thereof, each slot accommodating one of said detectors.

3. An arrangement as claimed in claim 1, having a series of tubular screening members individually provided for each of said detectors, each tubular member enveloping the sensitive element of a respective detector and being coupled to the communication line of a said detector disposed immediately therebeneath.

4. An arrangement as claimed in claim 1, having a screening plate common to all detectors provided with openings, the sensitive elements of the detectors being secured to one side of the plate and the communication lines of the detectors being led through said openings to the other side of the plate.

5. An arrangement as claimed in claim 4, in which the sensitive elements of the detectors are arranged in coaxial relationship.

6. An arrangement for measuring the distribution of neutron-flux density over the height of a nuclear reactor core, substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

MARKS & CLERK,
Chartered Patent Agents,
57—60 Lincolns Inn Fields,
London WC2A 3LS.
Agents for the Applicants.

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4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

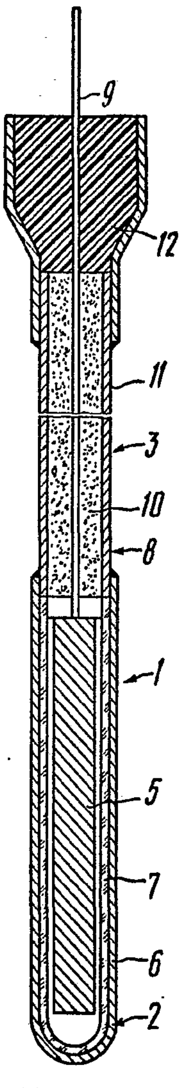

FIG. 3

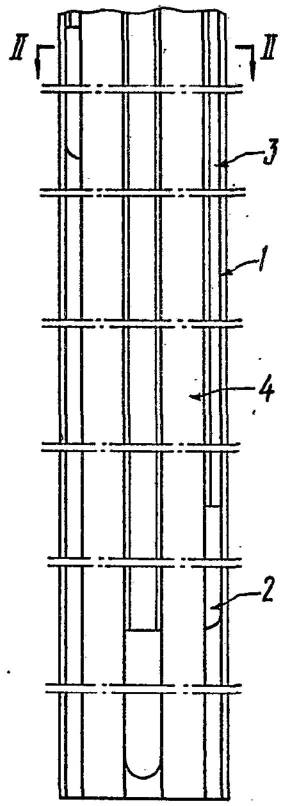

FIG. 1

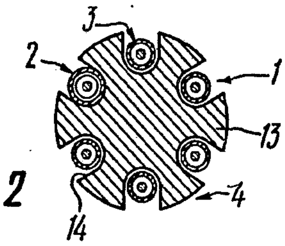

FIG. 2

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Sheet 2

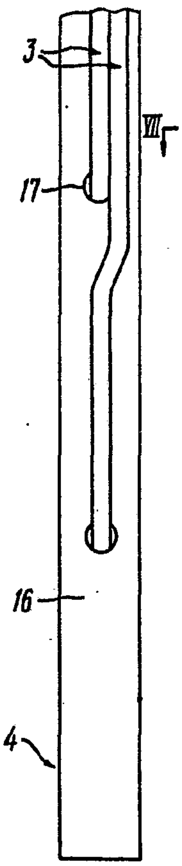

FIG. 6

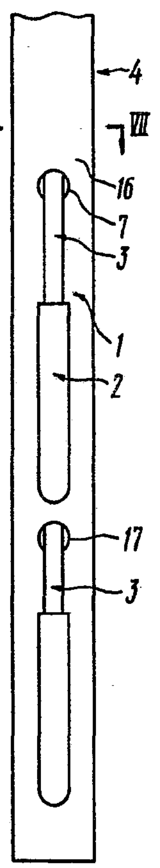

FIG. 5

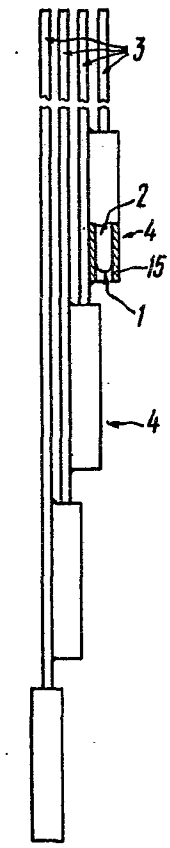

FIG. 4

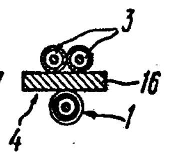

FIG. 7

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Sheet 3

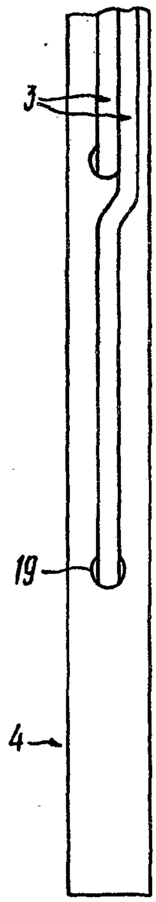

FIG. 9

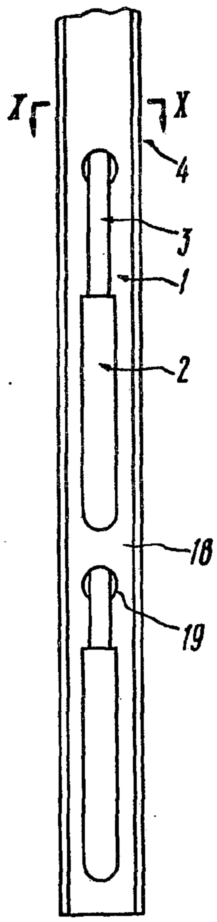

FIG. 8

FIG. 10

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Sheet 4

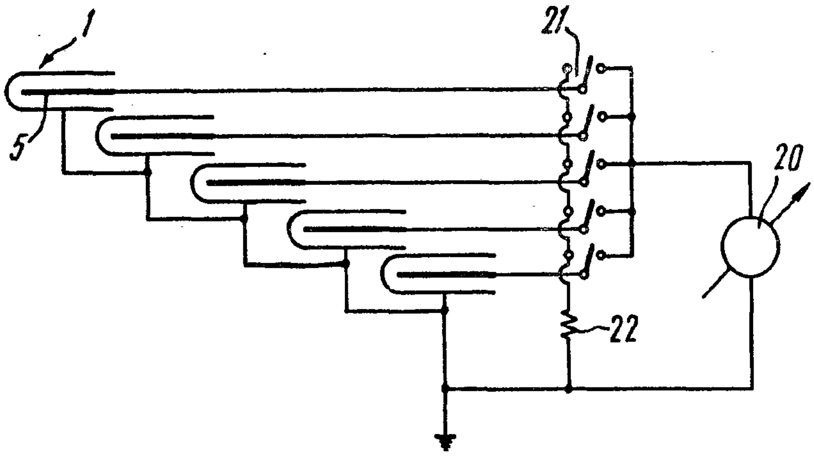

FIG. 11