United States Patent [19]
Pozdnikov et al.
[11] 3,848,131
[45] Nov. 12, 1974

[54] RADIOACTIVE RADIATION DETECTION SYSTEM

[76] Inventors: **Vladimir Nikolaevich Pozdnikov,** ulitsa Kveles, 15, korpus 1, kv. 46; **Oleg Leonidovich Sazonov,** ulitsa Moskovskaya, 285, korpus 5, kv. 79; **Iegoshua Mikhailovich Taxar,** ulitsa Moskovskaya, 254, korpus 6, kv. 4; **Edgar Rikhardovich Tesnavs,** ulitsa Moskovskaya, 285, korpus 5, kv. 82; **Vladimir Alexandrovich Yanushkovsky,** ulitsa Vilisa, Latsisa, 2a, kv. 46; **Alexandr Pavlovich Gavrilov,** ulitsa Gospitalnaya, 29, kv. 5; **Valentin Petrovich Korkonosov,** prospekt Komarova, 23, kv. 72; **Alexei Vasilievich Peresypkin,** ulitsa Grivas, 11, korpus 32, kv. 14, all of Riga; **Eduard Parfentievich Shapovalov,** stantsiya Priedaine, prospekt Lielais, 8, kv. 4, Jurmala, all of U.S.S.R.

[22] Filed: **Aug. 16, 1972**

[21] Appl. No.: **281,009**

[52] **U.S. Cl.** **250/388,** 250/374
[51] **Int. Cl.** **G01t 1/16**
[58] **Field of Search** 250/374, 382, 388

[56] **References Cited**
UNITED STATES PATENTS

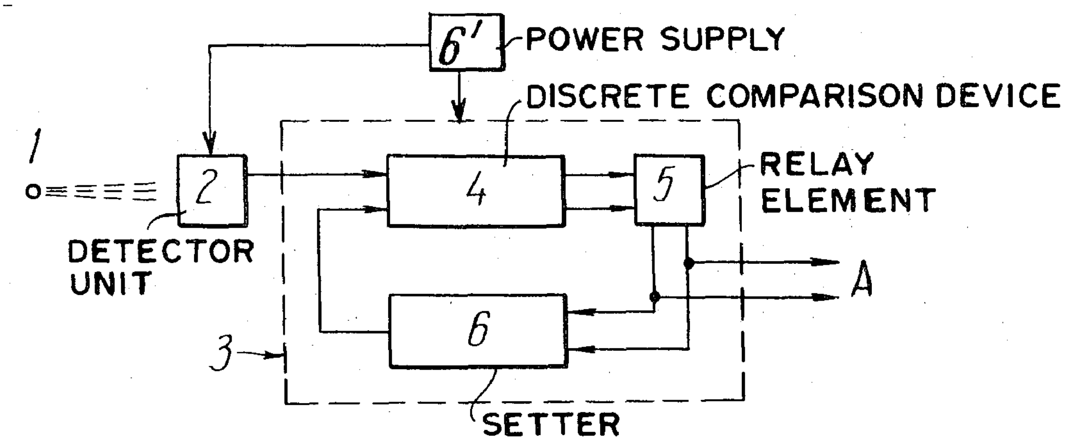
3,551,672	12/1970	Homer et al.	250/388 X
3,654,442	4/1972	Leonard et al.	250/388 X
3,665,180	5/1972	Guillot et al.	250/388
3,671,740	6/1972	Marshall et al.	250/388 X

Primary Examiner—Archie R. Borchelt
Attorney, Agent, or Firm—Waters, Roditi & Schwartz & Nissen

[57] ABSTRACT

A radioactive isotope relay device in which ionizing radiation is registered by a detector unit converting it into electric pulses fed to an electronic-relay unit. The latter comprises a discrete comparison device, a relay element and a setter of threshold frequencies of a regular series of electric pulses, the setter being characterized by two frequency thresholds. One input of the discrete comparison device is connected to the detector unit which delivers a statistic series of electric pulses. The outputs of the comparison device are connected to the relay element. The inputs of the threshold frequency setter are connected to the outputs of the relay element while the output of the former is connected to the second input of the discrete comparison device due to which arrangement the device will acquire either the "yes"- or the "no"-state depending upon the ratio between the compared frequencies of the statistic and regular pulse series.

9 Claims, 5 Drawing Figures



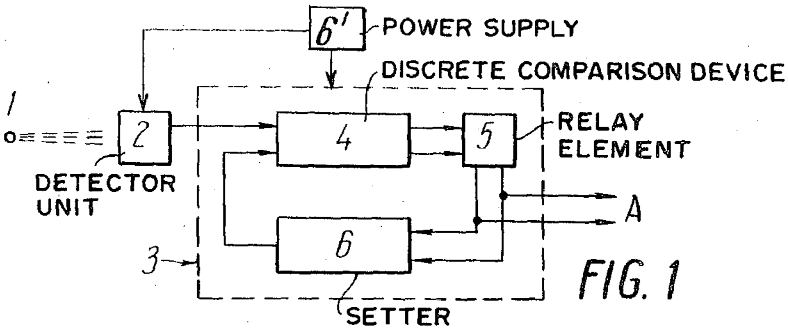


FIG. 1

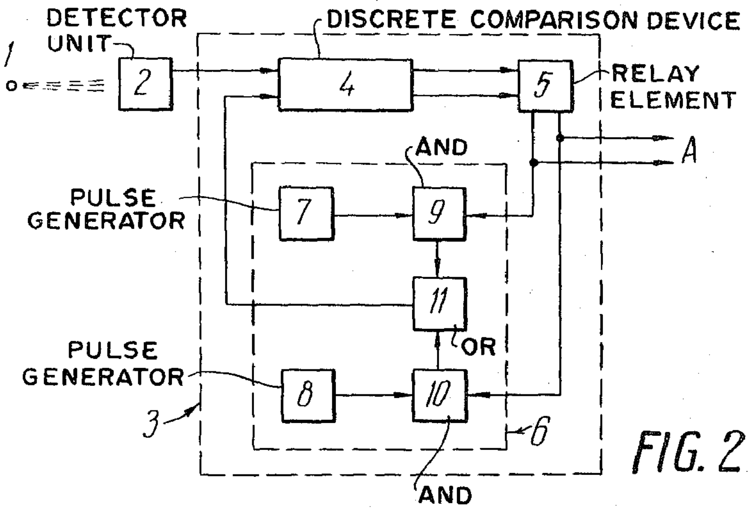


FIG. 2

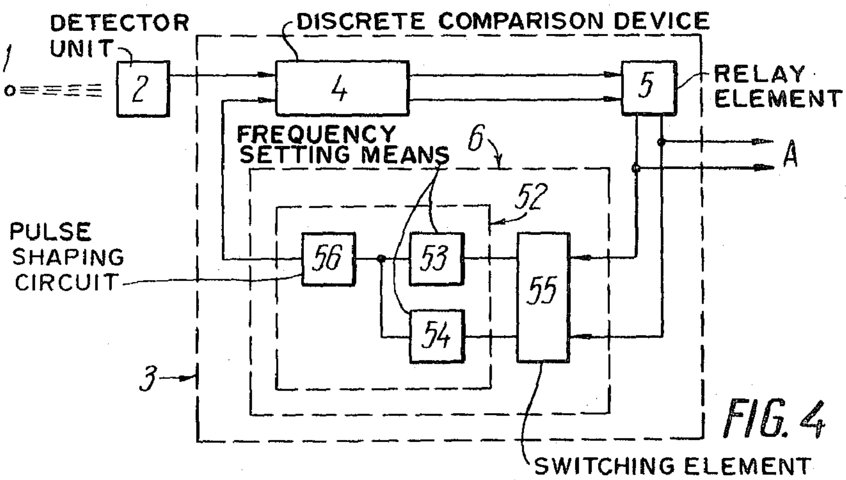


FIG. 4

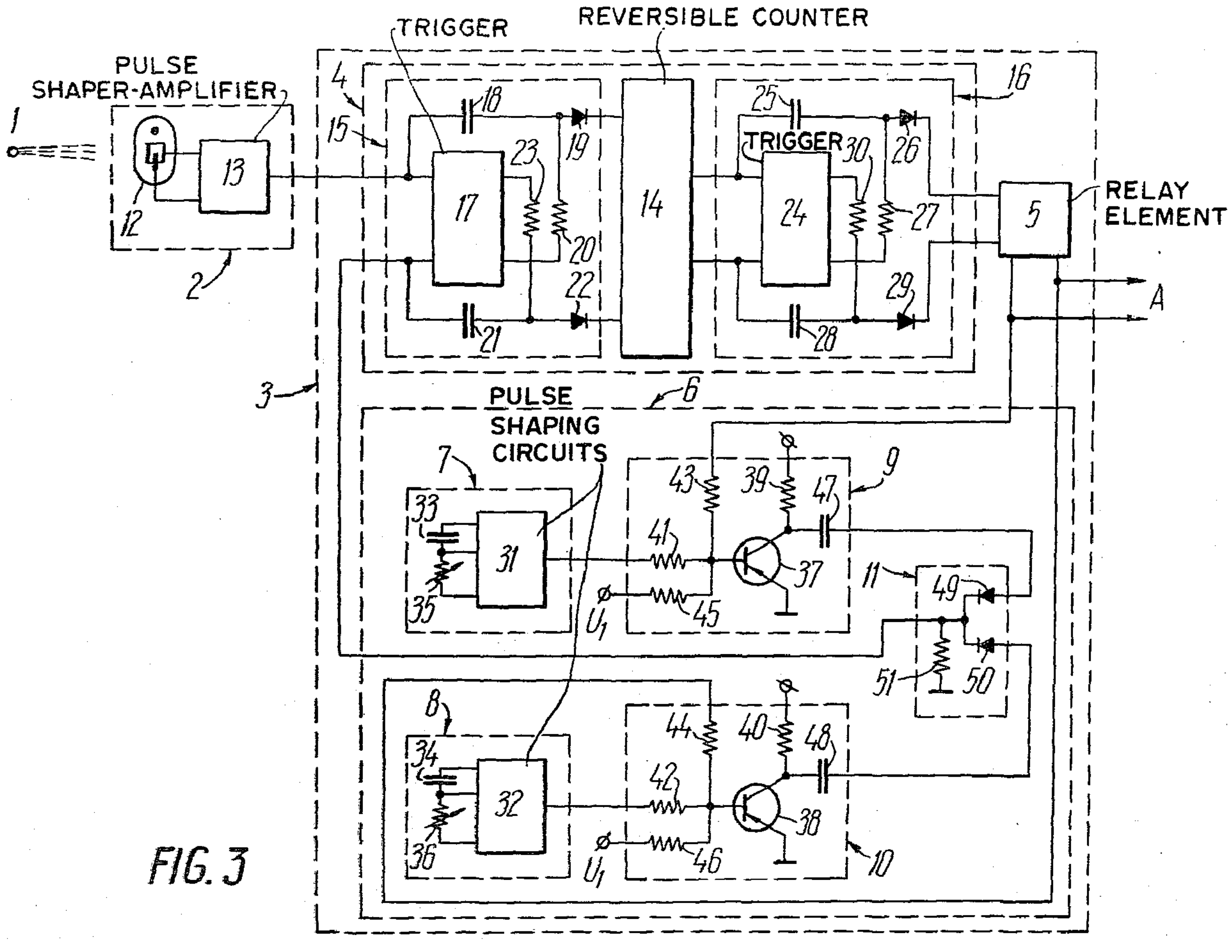

PULSE SHAPER-AMPLIFIER
TRIGGER
REVERSIBLE COUNTER
TRIGGER
RELAY ELEMENT
PULSE SHAPING CIRCUITS
A
U_1
U_1

FIG. 3

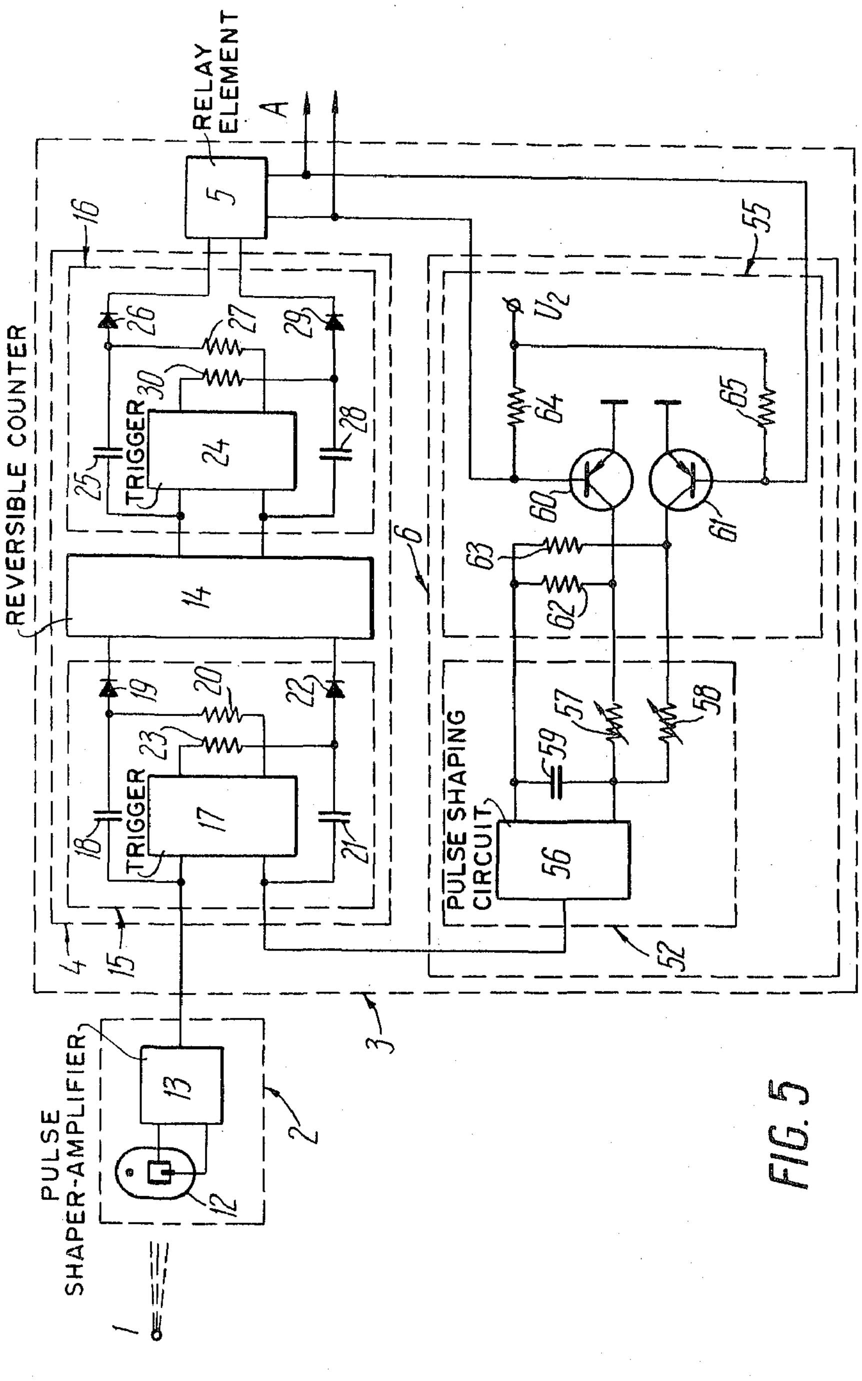

RELAY ELEMENT
A
REVERSIBLE COUNTER
TRIGGER
TRIGGER
PULSE SHAPING CIRCUIT
PULSE SHAPER-AMPLIFIER
V_2

FIG. 5

RADIOACTIVE RADIATION DETECTION SYSTEM

The present invention relates to radioactive isotope devices and, in particular, to radioactive isotope relay devices used to control and automate technological processes in various industries, transport and agriculture.

Known in the art are relay devices in which the ionizing radiation is registered by a detector unit which converts it into electric pulses fed to an electronic-relay unit.

Such an isotope relay device uses an analog electronic - relay unit and a direct signal converter designed around an integrating RC-network. The presence of this network prevents the relay devices from having highly stable response and release thresholds and a high statistic reliability of operation in case of small ionizing radiation differences. Besides, this RC-network limits the range of the response and release threshold adjustment in the device and makes it impossible to raise the ratio between the speed of operation and the statistic reliability. And finally, when a broad range of performance characteristics is required the presence of this network leads to increased complexity of the design which narrows the field of applications of such radioactive isotope relay devices to control and automate technological processes.

An object of the present invention is to provide a radioactive isotope relay device allowing the control of the levels of liquid and bulk materials in containers of various shapes having a preset thickness and made of a specified material.

Another object of the present invention is to provide a radioactive isotope relay device making it possible to control positions and displacements of items, parts of mechanisms and means of transportation.

Still another object of the present invention is to provide a radioactive isotope relay device allowing the control of the density of fluids.

These objects are achieved by means of designing a radioactive isotope relay device in which ionizing radiation is registered by a detector unit converting it into electric pulses to be fed to an electronic-relay unit and in which, according to the invention, the electronic-relay unit comprises a discrete comparison device having two inputs, one of which is connected to the detector unit delivering a statistic series of electric pulses; a relay element connected to the outputs of the discrete comparison device as well as a setter of threshold frequencies of electric pulse regular series characterized by two frequency thresholds and having its two inputs connected to the outputs of the relay element serving as the output of the device, and having its output connected to the second input of the discrete comparison device, which insures that the device acquires either the "yes"-state or the "no"-state depending upon the ratio between the frequencies of the statistic and regular pulse series that are being compared.

The threshold frequency setter may comprise two pulse generators, two logical AND-elements with two inputs and one output and a common logical OR-element with two inputs and one output, the output of each generator being connected to one input of its logical AND-element, while the outputs of the logical AND- elements are connected, via the logical OR-element, to the second input of the comparison device and while each logical AND-element has its other input connected to the relay element so that the respective frequency threshold is ensured either from one or from the other generator depending upon the state of the relay element ("yes" or "no").

To increase the reliability of the device and to raise the stability of the hysteresis ratio it is feasible that the threshold frequency setter should contain a pulse generator with two frequency setting means connected to the second input of the discrete comparison device, as well as a switching element connected to the outputs of the relay element and coupled with the first and second frequency setting means so that the respective frequency threshold is ensured depending upon the state of the relay element ("yes" or "no").

The discrete comparisons device may comprise a reversible counter with the required memory capacity and two similar comparison elements to sense the one-sign difference between numbers of pulses, one of said comparison elements having one of its inputs connected to the detector unit and the other input connected to the inputs of the reversible counter, while in order to ensure unambiguous operation of the latter in case of memory overflow it has its outputs connected to the inputs of the other comparison element which, in its turn, has its outputs connected to the inputs of the relay element.

It is also preferable that each comparison element should comprise a trigger with separated inputs and two gates with two inputs and one output having their inputs connected in parallel to the respective inputs and outputs of the trigger.

The proposed radioactive isotope relay device has a high speed of operation with a high statistic reliability in a wide range of ionizing radiation differences, a wide range of response and release threshold adjustment and a high stability of the response and release thresholds within a wide range of ambient temperature and supply voltage variations.

The invention will be better understood from the following description of its embodiments given by way of example with reference to the accompanying drawings, in which:

FIG. 1 presents a block diagram of the radioactive isotope relay device according to the invention,

FIG. 2 presents a version of the proposed radioactive isotope relay device with two pulse generators;

FIG. 3 presents a schematic diagram of the device as shown in FIG. 2;

FIG. 4 presents a block diagram of another version of proposed radioactive isotope relay device with one pulse generator;

FIG. 5 presents a schematic diagram of the device as shown in FIG. 4.

The radioactive isotope relay device according to the invention comprises a source **1** (FIG. 1) of ionizing radiation (in the version to be described it is gamma-radiation but it can as well be any other type of radiation) and a detector unit **2** registering this radiation and converting it into electric pulses to be fed to an electronic-relay unit **3**.

The electronic-relay unit **3** contains a discrete comparison device **4** having two outputs and two inputs one of which is connected to the detector unit **2** delivering a statistic series of electric pulses, and a relay element **5** coupled with said outputs of the comparison device **4**. The unit **3** contains also a setter **6** of threshold frequencies of the electric pulse regular series. The setter is peculiar in that it has two frequency thresholds and its two inputs are connected to the outputs of the relay element 5 serving as the output of the device itself (the output of the device is indicated by the direction of arrows A in the drawing). The output of the setter **6** is connected to the second input of the comparison device **4.** Due to this arrangement the device will be either in the "yes" or in the "no" — state depending upon the ratio between the frequencies of the statistic and regular pulse series that are being compared. The power supply is provided by unit **6'**.

In the first embodiment version of the radioactive isotope relay device the frequency threshold setter **6** (FIG. **2**) comprises two pulse generators **7, 8,** two logic AND-elements **9, 10** with two inputs and one output, and a common logic OR-element **11** with two inputs and one output. The output of the generator **7** is connected to one input of the logic AND-element **9** while the output of the generator **8** is connected to one input of the logic AND-element **10.** The outputs of the logic AND-elements **9, 10** are connected to the inputs of the logic OR-element **11** the output of which is connected to the second input of the comparison device **4.** The other inputs of the logic AND-elements **9, 10** are connected to the respective output of the relay **5** so that one of the generators **7** or **8** will have a frequency threshold corresponding to the state of the relay element **5** ("yes" or "no").

In the embodiment version of the device that is being described the detector unit **2** (FIG. **3**) contains an ionizing radiation detector **12** coupled with a pulse shaper-amplifier **13.**

The discrete comparison device **4** comprises a reversible counter **14** with the required memory capacity determined by the number of its digits, and two similar comparison elements **15, 16** to sense the one-sign difference between numbers of pulses. The comparison element **15** has one of its inputs connected to the shaper-amplifier **13,** while its other input is connected to the logic OR-element **11** of the setter **6.** The outputs of the comparison element **15** are coupled with the inputs of the reversible counter **14.** To ensure unambiguous operation of the counter **14** in case of memory overflow the comparison element **16** has its inputs connected to the outputs of the reversible counter **14** while the outputs of the element **16** are coupled with the inputs of the relay element **5** arranged as a trigger.

The comparison element **15** contains a trigger **17** with separated inputs and two gates everyone of which has two inputs and one output. The inputs of the gates are connected in parallel to the respective inputs and outputs of the trigger **17.** One of the gates contains a capacitor **18,** a diode **19** and a resistor **20** while the other gate uses a capacitor **21,** a diode **22** and a resistor **23.**

The comparison element **16** contains a trigger **24** with separated inputs and two gates everyone of which has two inputs and one output. The inputs of the gates are connected in parallel to the respective inputs and outputs of the trigger **24.** One of the gates contains a capacitor **25,** a diode **26** and a resistor **27,** while the other gate uses a capacitor **28,** a diode **29,** and a resistor **30.** The diodes **26, 29** are coupled with the inputs of the relay element **5.**

The pulse generators **7, 8** comprise pulse shaping circuits **31, 32** respectively and frequency setting means using capacitors **33, 34** and variable resistors **35, 36.**

The logic AND-elements **9, 10** comprise transistors **37, 38** respectively, the collector circuits thereof containing resistors **39, 40,** while the bases of the transistors are connected, via resistors **41, 42** and **43, 44,** to the pulse shaping circuits **31, 32** and to the outputs of the relay element **5,** respectively. The bases of the transistors **37, 38** are fed with a bias voltage U_1, which arrives via resistors **45, 46.** The collectors of the transistors **37, 38** are coupled, via capacitors **47, 48,** with the inputs of the logic OR-element **11.**

The logic OR-element **11** contains diodes **49, 50,** each having one of its leads connected to capacitors **47, 48,** respective while their common lead is connected to the input of the trigger **17.** The common lead of the diodes **49, 50** is connected, via a resistor **51,** to the body (shown in the drawing out of true position) of the electronic-relay unit **3.**

The second embodiment version of the proposed radioactive isotope relay device is identical to the first embodiment version described above.

The difference consists in that the threshold frequency setter **6** (FIG. **4**) comprises only one pulse generator **52** with two frequency setting means **53, 54,** the generator being coupled with the second input of the comparsion device **4.** Besides, the setter **6** comprises also a switching element **55** connected to the outputs of the relay element **5** and coupled with the frequency setting means **53, 54** so that the required frequency threshold is obtained depending on the state of the relay element **5** ("yes" or "no").

The pulse generator **52** (FIG. **5**) comprises a pulse shaping circuit **56** the output of which is connected to the trigger **17** and which has its input connected to the first **53** and to the second **54** frequency setting means. The means **53, 54** use variable resistors **57, 58** (FIG. **5**), respectively, and a common capacitor **59.**

The functions of the switching element **55** are performed by transistors **60, 61** whose collectors are connected to the variable resistors **57, 58,** respectively, and whose bases are connected to the outputs of the relay element **5.** The collector circuits of the transistors **60, 61** contain resistors **62, 63** the common point of which is coupled with the capacitor **59.** The bases of the transistors **60, 61** are fed with a bias voltage U_2 which arrives via resistors **64, 65.**

The functions of the switching element **55** can be performed by thyristors, switching diodes or electromagnetic relays.

The operation of the first embodiment version of the proposed radioactive isotope relay device can be described as follows.

The energy of gamma-ray quanta emitted by the source **1** (FIG. **3**) is received by the ionizing radiation detector **12** and converted into electric pulses to be formed and amplified in the pulse shaper-amplifier **13** from the output of which they are fed to one of the inputs of the trigger **17** of the comparison element **15.** Unlike the statistic series of electric pulses produced by the detector unit **2,** the second input of the trigger **17** is fed with a regular series of electric pulses delivered from the threshold frequency setter **6.**

The response threshold is set by the frequency of the regular pulse series produced by the pulse generator **8** while the release threshold is set by the pulse generator **7.** The response and release thresholds are adjusted in the pulse generators **7, 8** with the help of the variable resistors **35, 36,** respectively.

The stability of the electronic-relay unit 3 is determined in terms of stability of the response and release threshold frequencies which depend upon supply voltage fluctuations (the supply voltage source is not shown in the drawing) and ambient temperature variations. Regular pulse series from the outputs of the generators **7, 8** are applied respectively to the bases of the transistors **37, 38** in the logic AND-elements **9, 10** via the resistors **41, 42.**

When the relay element **5** is in the "no"-state the base of the transistor **37** will receive a negative voltage arriving from an output of the relay element **5** via the resistor **43** and a voltage approaching zero arriving from the other output of the relay element **5** via the resistor **44,** while the second input of the trigger **17** will be fed with a regular pulse series which arrives from the pulse generator **8** via the logic OR-element **11.**

When the relay element **5** passes to the "yes"-state the voltages applied to the bases of the transistors **37, 38** from the outputs of the relay **5** via the resistors **43, 44** will be switched over. In this case the second input of the trigger **17** will be fed with a regular pulse series arriving from the generator **7** via the logic OR-element **11.**

One of the functions of the discrete comparison device **4** is to compare statistic pulse series with regular pulse series and to control the relay element **5** driving it either to the "yes"-state or to the "no"-state depending upon the ratio between the compared frequencies. The second function of the comparison device **4** is to average the statistic pulse series, the degree of averaging being determined by the memory capacity of the reversible counter **14,** i.e., by the number of its digits.

The comparison device **4** is designed to operate so that a pulse can appear at the output of one of its channels only after the pulses that were registered earlier in the opposite channel will have all be written off.

Three characteristic situations can occur in the course of operation of the radioactive isotope relay device.

In the first characteristic situation, when the average frequency of the statistic pulse series is less than the frequency of the regular pulse series, pulses of the difference frequency (negative difference between numbers of pulses) are applied to the input of the reversible counter **14** via the capacitor **21** and the diode **22** of the comparison element **15.** In case the memory capacity of the reversible counter **14** gets overflown by data arriving through one of the channels a pulse from its output is fed, via the capacitor **28** and the diode **29** of the comparison element **16,** to the input of the relay element **5.** The pulse will either confirm the "no"-state of the relay element **5** or drive the latter to this state, provided the input of the comparison element **16** has received no pulses arriving to it earlier via the opposite channel, the appearance of a pulse at the output of the reversible counter **14** causing the simultaneous erasing of previously registered data. If the opposite channel was registering pulses before, the pulse from the output of the reversible counter **14** will drive the trigger **24** of the comparison element **16** to the opposite. state. Simultaneously, the gate containing the capacitor **28,** the diode **29** and the resistor **30** will unlock and in case of another overflow of the reversible counter **14,** a pulse from the output of the latter will pass through this gate to the input of the relay element **5** driving it to the "no" state.

In the second characteristic situation, when the average frequency of the statistic pulse series exceeds the frequency of the regular series, pulses of the difference frequency (positive difference between the number of pulses) are applied to the input of the reversible counter **14** via the capacitor **18** and the diode **19** of the comparison element **15.** A pulse appearing at the output of the reversible counter **14** will cause the erasing of data registered in it before. Simultaneously, this pulse is fed, via the capacitor **25** and the diode **26,** to the input of the relay element **5** confirming its "yes" state or driving it to this state if there were no pulses arriving to it via the opposite channel of the comparison device **4.** In case pulses did arrive via the opposite channel, a pulse from the output of the reversible counter **14** will drive the trigger **24** to the opposite state. Simultaneously, the gate containing the capacitor **25,** the diode **26** and the resistor **27** will unlock and pass pulses after another overflow of the reversible counter **14.**

In case of the third characteristic situation, when the average frequency of the statistic pulse series is equal to the frequency of the regular pulse series with the hysteresis ratio (the ratio of the release threshold frequency to the response threshold frequency) being 1, the comparison device **4** will register the difference frequencies caused by fluctuations of the instant frequency of the statistic pulse series about its average value. The probability of a pulse appearing at the output of this or that channel of the comparison device **4** depends upon the memory capacity of the reversible counter **14** and upon the values of the frequencies that are being compared.

In case the hysteresis ratio is less than 1, when the average frequency of the statistic pulse series lies between the response threshold frequency and release threshold frequency, the probability of pulses appearing in this or that channel will be still less and this is what determines the statistic reliability of the device as a whole.

The operation of the second embodiment version of the proposed radioactive isotope relay device is similar to that of the first embodiment version.

The difference consists in that relay element **5** (FIG. **4**) controls the switching element **55** which, in its turn, depending upon the state ("yes" or "no") of the relay element **5,** will connect either the first **53** or the second **54** frequency setting means to the pulse shaping circuit **56.** The first frequency setting means **53** ensures that the pulse generator **52** produces a regular pulse series at its output with the response threshold frequency. The second frequency setting means **54** insures that the generator **52** produces a regular pulse series at its output with the release threshold frequency.

When the relay element **5** (FIG. **5**) is in the "no" state one of its outputs produces a voltage approaching zero which is applied to the base of the transistor **61,** while the other output produces a negative voltage applied to the base of the transistor **60** driving the latter to conduction and saturation. The transistor **61** is cut off by the positive bias voltage U_2. The output of the generator **52** produces a regular pulse series with the response threshold frequency.

When the relay element **5** is in the "yes" state one of its outputs produces a negative voltage applied to the base of the transistor **61** while the base of the transistor

60 is fed with a voltage approaching zero. The generator 52 produces at its output a regular pulse series with the release threshold frequency.

The second version of the proposed radioactive isotope relay device differs from the first version in that it has a higher stability of the hysteresis ratio which is quite important in case the device is used to react to small differences in the ionizing radiation intensity.

The proposed radioactive isotope relay device has a number of advantages if compared against its known counterparts using analog electronic-relay units. Thus, it allows:

to detect a relative radiation difference of 10 percent of the limit value whereas the respective figure for the known devices will be 100 percent; to raise the speed of operation by a factor of 10; to bring the instability of the response and release threshold frequencies down to 5 percent (instead of 40–50 percent) and 0.05 percent (instead of 10–15 percent) respectively within the total range of threshold adjustments irrespective of supply voltage fluctuations, and to increase the gamma-ray radiation sensitivity up to 0.04 mR/h.

The design of the proposed radioactive isotope relay device can be used to develop radioactive isotope devices for various purposes, e.g., liquid dispensers, servo level indicators for fluids, level controllers for bulk materials, liquid density regulators, item counters for conveyers, meter counters, tachometers, etc.

What we claim is:

1. A radioactive radiation detection device comprising: a detector unit registering ionizing radiation and converting said ionizing radiation into electric pulses; an electronic relay unit coupled electrically to said detector unit; a discrete comparision device in said electronic-relay unit and having two outputs and two inputs a first one of which is connected to said detector unit producing a statistical series of pulses; a relay element having two inputs and two outputs serving as the output of said device, the inputs of said relay element being connected to the outputs of said discrete comparison device; a setter of threshold frequencies of a regular series of electric pulses in said electronic unit and having two inputs and one output, said setter having two frequency thresholds, said threshold frequency setter having two inputs connected to said two outputs of said relay element and having its output connected to the second input of said discrete comparison device whereby said device acquires a first or second state depending on the ratio between the frequencies of the statistical and regular series of said pulses.

2. A device as claimed in claim 1 in which said threshold frequency setter comprises: a first pulse generator, a first logic AND-element with one output and two inputs one of which is connected to the output of the first generator; a logic OR-element with one output and two inputs having one of its inputs connected to said output of the first logic AND-element and its output connected to the second input of said comparison device; a second logic AND-element with two inputs and one output coupled with the second input of said logic OR-element; a second pulse generator the output of which is connected to one of said inputs of the second logic AND-element; the second inputs of the first and second logic AND-elements being compled with said relay element so that a respective frequency threshold is obtained from either the first or the second generator depending upon the state of said relay element.

3. A device as claimed in claim 1 in which said threshold frequency setter comprises: one pulse generator connected to the second input of said comparison device, said pulse generator having a first and a second frequency setting means; a switching element connected to said outputs of said relay element and coupled with the first and second frequency setting means so that a respective frequency threshold is obtained depending upon the state of said relay element.

4. A device as claimed in claim 1 in which said discrete comparison device comprises: a reversible counter having a required memory capacity, two inputs and two outputs; a first comparison element to sense the one-sign difference between numbers of pulses having two inputs and two outputs one of the inputs of which is connected to said detector unit, the other input of which is connected to said threshold frequency setter and the outputs of which are connected to said inputs of said reversible counter; a second comparison element to sense the one-sign difference between numbers of pulses having two inputs and two outputs the inputs of which are connected to said outputs of said reversible counter to ensure unambiguous operation of the latter in case of memory overflow and the outputs of which are connected to said inputs of said relay element.

5. A device as claimed in claim 2 in which said discrete comparison device comprises: a reversible counter having a required memory capacity, two inputs and two outputs; a first comparison element to sense the one-sign difference between numbers of pulses having two inputs and two outputs, one of the inputs being connected to said detector unit, and the other to said threshold frequency setter and the outputs, to said inputs of said reversible counter; a second comparison element to sense the one-sign difference between numbers of pulses having two inputs and two outputs, the inputs being connected to said outputs of said reversible counter to ensure unambiguous operation of the latter in case of memory overflow, and the outputs being connected to said inputs of said relay element.

6. A device as claimed in claim 3 in which said discrete comparison device comprises: a reversible counter having a required memory capacity, two inputs and two outputs; a first comparison element to sense the one-sign difference between numbers of pulses having two inputs and two outputs, one of the inputs being connected to said detector unit, the other input, to said threshold frequency setter, and the outputs, to said inputs of said reversible counter; a second comparison element to sense the one-sign difference between numbers of pulses having two inputs and two outputs, the inputs being connected to said outputs of said reversible counter to ensure unamibguous operation of the latter in case of memory overflow and the outputs being connected to said inputs of said relay element.

7. A device as claimed in claim 4 in which every said comparison device comprises: a trigger having two outputs and two separated inputs; a first gate having two inputs and one output the inputs of which are connected in parallel to the respective inputs and outputs of said trigger; a second gate having two inputs and one output the inputs of which are connected in parallel to the respective inputs and outputs of said trigger.

8. A device as claimed in claim 5 in which every said comparison element comprises: a trigger having two outputs and two separated inputs; a first gate having two inputs and one output, the inputs being connected in parallel to respective inputs and outputs of said trigger; a second gate having two inputs and one output, the inputs being connected in parallel to the respective inputs and outputs of said trigger.

9. A device as claimed in claim 6 in which every said comparison element comprises: a trigger having two outputs and two separated inputs; a first gate having two inputs and one output, the inputs being connected in parallel to the respective inputs and outputs of said trigger; a second gate having two inputs and one output, the inputs being connected in parallel to the respective inputs and outputs of said trigger.

* * * * *