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Portable radiation monitoring system on the base of $CdWO_4$ scintillator

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A portable high-sensitivity monitor for the detection of radioactive materials is developed and manufactured on the base of $CdWO_4$ scintillation crystal. The monitor has an independent power supply which provides continuous operation at least during 120 hours.

Разработан и изготовлен портативный высокочувствительный портал для обнаружения радиоактивных материалов на базе сцинтилляционного кристалла $CdWO_4$. Портал оснащен собственным источником питания, который обеспечивает его непрерывную работу в течение 120 часов.

There are known different radiation monitoring systems including the ones controlling transportation of radioactive substances. Among them, the radiation monitor Yantar - 1P3 (R&D Center "Aspect", Dubna, Russian Federation) [1] and the system made by TSI Incorporated [2], are distinguished by possessing good technical characteristics. These systems are based on plastic and alkali halide scintillators. Plastic scintillators have a number of advantages, but their dimensions are large due to rather low efficiency of gamma-radiation registration. Alkali halide scintillators have sufficiently high scintillation characteristics, but their low stability to stringent climatic conditions while working in the systems of radiation monitoring is a serious disadvantage. Thus, for overcoming the mentioned difficulties it is necessary to search for new scintillators without such drawbacks.

$CdWO_4$ crystals have an essential advantage over plastic and alkali halide scintillators in the efficiency of ionizing radiation registration at low background of their own radiation [3]. Moreover, they effectively register thermal and fast neutrons [4], that considerably widens technical potentialities of radiation detection. A significant feature of $CdWO_4$ crystal is the fact that its light output weakly depends on ambient temperature that permits to use this crystal both indoors and in the field. For the obtaining of large-size optically homogeneous $CdWO_4$ crystals we worked out the technology [5] which made it possible to grow the crystals with high scintillation characteristics.

Taking into account the above said we developed and manufactured the detection unit for small-size monitor on the base of $CdWO_4$ scintillator.

The block diagram of the developed monitor on the base of $CdWO_4$ crystal is shown in Fig.1. The external appearance of the monitor is shown in Fig.2.

The monitor consists of ~ 700 mm rack 1 mounted on the base *5* with the dimensions 220x230x100 mm^3. The upper part of the

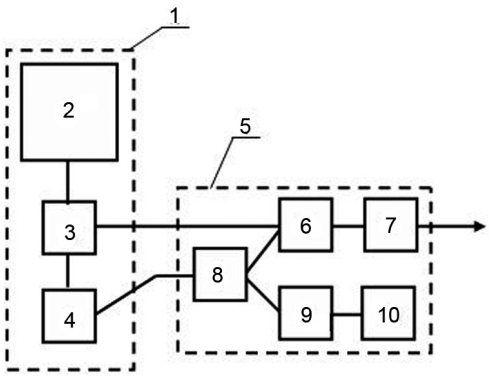

Fig.1. Block diagram of the monitor based on of $CdWO_4$ single crystal: *1* – housing, *2* – scintillation detector, *3* – high-voltage power supply, *4* – charge-sensitive preamplifier, *5* – base, *6* – battery, *7* – charging device, *8* – signal processing unit, *9* – display, *10* – light and audio alarm.

Fig.2. Appearance of the radiation monitoring system based on $CdWO_4$ crystal.

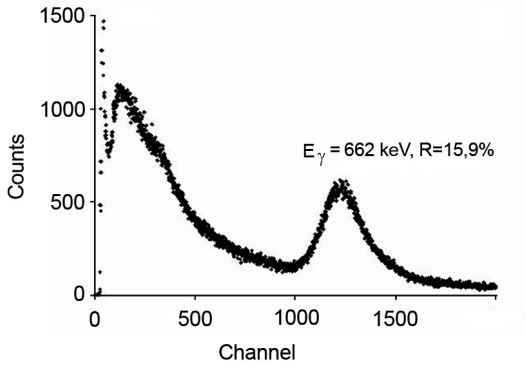

Fig.3. ^{137}Cs energy spectrum measured by $CdWO_4$ detector.

rack holds the scintillation detector *2*, which consists of ∅ 60 мм x 100 mm $CdWO_4$ crystal, R1307 (Hamamatsu) PMT, charge-sensitive preamplifier and PMT high-voltage power supply. The power for the whole of the system is provided by +5 -5V battery located in the base 5. The current consumption is not higher than 70 mA. Moreover, the base holds the signal processing unit with light and audio alarm. The alarm is activated in the case when a radiation source occurs in the vicinity of the monitor. The described detector works in spectrometric mode and identifies the type of radionuclide from its energy.

Fig. 3 presents the energy spectrum from ^{137}Cs source with the energy resolution in the total absorption spectrum equal to 15.9%.

The operation of the system is based on the estimation of the statistical parameters of the natural radiation background (the counting rate and dispersion) in the absence of the checked object in the controlled space with subsequent comparison of such parameters with those of the radiation from the checked object.

The detection can be realized using a) the total counting rate of the pulses exceeding the low-level threshold and b) the counting rate in four energy windows: 30 - 300; 300 - 1000; 1000 - 1500; 1500 - 3000 keV. This permits to improve the sensitivity of the system at the detection of radiation sources and to estimate the type of isotope. Moreover, for 30 - 300 keV energy window a special procedure of the subtraction of the counting rate from a neighboring channel makes it possible to detect neutrons and fissile nuclear materials.

Table 1 contains the comparative technical characteristics of the portals manufactured on the base of $CdWO_4$ oxide scintillator and plastic scintillator (Yantar -1P3).

As follows from the presented table, the monitor based on $CdWO_4$, single crystal possesses high efficiency of gamma-radiation registration, especially in the range of 10 - 300 keV. This permits to achieve an essential (~ tenfold) increase of the efficiency of the detection of transuranic radiation materials.

Thus, the radiation monitoring system based on $CdWO_4$, single crystal is developed and manufactured. Due to its small dimensions and high sensitivity such a portal can be used for hidden supervision of radiation situation.

Table 1. Comparative characteristics of radiation monitoring systems based on plastic and oxide scintillators.

Type of scintillator		$CdWO_4$	Plastic
Detection threshold		Width of controlled zone – 1 m	
	Cs-137	0,76 μCi	1,84 μCi
	Co-60	0,38 μCi	0,92 μCi
	Am-241	7 μCi	—
	Pu-239	0,02 g	—
	U-235	9 g	12,5 g
	U-238	12 g	100 g
	Shielded Pu-α-Be		
Registration channels		Gamma-neutron	Comparative characteristics
Gamma		Detection units based on $CdWO_4$ crystal	gamma
Neutron			—
Parameters of controlled zone	width	1 m	0,7-1,5 m
	height	2 m	2 m
Velocity of travel of controled objects		5 km/h	5 km/h
Power consumption from 12 V source		12 W	45 W
Weight of equipment unit		2.6 kg	200 kg
Dimension of equipment unit		∅100 mm x 900 mm	560x1750x250 mm^3

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Портативний радіаційний монітор на основі сцинтилятора $CdWO_4$

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Розроблено і виготовлено портативний високочутливий портал для виявлення радіоактивних матеріалів на базі сцинтиляційного кристала $CdWO_4$. Портал має власний блок живлення, який забезпечує його безперервну роботу протягом 120 годин.