ALARMING RATEMETER PM 1703 GN
OPERATING MANUAL

CONTENTS

1 APPLICATION and FEATURES

The alarming ratemeter PM 1703GN is designed to search, to detect and to locate gamma-emitting and neutron-emitting radioactive sources. It may be also used to measure Dose Equivalent Rate (hereinafter **DER**) of collimated ^{137}Cs gamma radiation.

The main principle of ratemeter operation is based on comparison of pulses count rate received from outputs of gamma and neutron radiation detector blocks with the threshold value, calculated on the base of measuring the count rate of current gamma and neutron background and set coefficients n number of meansquare deviation of current neutron and gamma radiation background).

The ratemeter operation history is stored in its non-volatile memory and may be transferred to a personal computer (PC) through an infrared (IR) interface.

The instrument may be used both indoor and outdoor by various users whose professional duties involve detection and location of radiation sources.

- ♦ New pager- type design
- ♦ Easy to use
- ♦ Dose rate indication
- ♦ Reference to the background
- ♦ Meets the ITRAP requirements
- ♦ Configuration via PC
- ♦ Shock-resistant plastic case
- ♦ Light weight

2 PRECAUTIONS

Before using this instrument, please read this operating manual carefully. Take special care to follow the safety instructions listed below.

The PM1703GN is water resistant, but care should be taken to avoid an immersion into water.

As any sensitive electronic instrument, the PM1703GN should not be subjected to severe mechanical shock.

Clean the PM1703GN with a soft, lightly wetted cloth. Do not use gasoline or any other strong chemicals.

Searching for radiation sources your site regulations for work with radioactive materials and other radiation sources, as well as the Standards of radiation safety should be followed.

Some changes may be introduced in the instrument electrical scheme, construction, design and software that do not influence the specifications and, therefore, may be not specified in this manual.

3 GENERAL DESCRIPTION

3.1 Introduction

The PM1703GN is an easy-to-use instrument with two buttons only.

To operate with PM1703GN the user does not need to be an expert in nuclear physics or radiation protection. After been switched ON, the instrument works automatically and alarms when finds a radiation source (gamma or neutron emitting isotopes).

However, to make proper settings of the instrument parameters, to transmit data from the instrument memory to PC and, especially, to interpret the data obtained, the user should have some knowledge of radiation and a procedure of searching for radioactive sources.

Accordingly, the present manual has two sections: *"Operating instructions to the user"* and *"Additional operating instructions to the advanced user"*.

3.2 Delivery kit

Standard kit of the PM1703GN corresponds to the table 3.1

Table 3.1 - Standard kit

Item	Quantity
Alarming ratemeter PM 1703GN	1
Battery PANASONIC POWER LINE AA (LR6) or similar	1
CD with software	1
Operating manual	1
Package for shipping	1

Options available by order correspond to the table 3.2

Table 3.2 - Options available by ordert

IR adapter AST-IR220L or similar	1
Carrying Case	1

3.3 Overview of control buttons and display

BUTTONS

The PM1703GN has two control buttons – MODE (1) and LIGHT (2), that are located at the top panel of the instrument (see Fig. 1).

These buttons perform different functions depending on the mode used. In general, the button main functions are:

1 - MODE button is used:

- to turn the instrument ON;
- to select the operation mode (*background updating mode; dose rate mode; set mode*);

2 - LIGHT button is used:

- to turn the LCD backlight ON;
- to initiate IR communication with PC.

In the *set mode* the button functions are:

1- MODE button is used:

- to select a set parameter (coefficient **n** for gamma radiation detection or turning ON/OFF the audio and/or vibration alarm devices);
- to decrease the coefficient **n** value in steps of 0.1 for gamma radiation detection;

2 - LIGHT button is used (for gamma radiation detection):

- to activate changing the coefficient **n**;
- to increase the coefficient **n** value in steps of 0.1 for gamma radiation detection;
- to change the audio and vibration alarm devices ON or OFF.

DISPLAY

4 - gamma radiation indicator, indicates:

- count rate value (in counts per second, hereinafter ***cps***) or DER value at gamma radiation detection;
- coefficient **n** value in the *set mode*;
- messages "test", "CAL", "OL", "OFF" etc.;
- turning ON/OFF the audio and/or vibration alarm device;

5 - the analog scale of 19 segments indicates:

- time left until self-tests are completed; a number of segments decreases until they completely disappear;
- time left until the background updating is completed; a number of segments increases until the scale is completely filled;
- relative value of the count rate excess over the calculated threshold in the case of alarm.

6 - battery discharge warning sign is indicated when the battery voltage drops below 1.1 V;

7 - RADIATION sign; it is indicated when the instrument alarms*;*
8 – neutron radiation indicator, indicates the count rate (”s^{-1}");
9 - unit of measurement:
“s^{-1}“ (counts per second, cps), in the *search mode*;
“µSv/h (or “µR/h” by a special order), in the *dose rate mode***.**

3.4 Overview of the operation modes

The PM1703GN operates in the following modes:
self-test mode;
background updating mode;
search mode;
dose rate mode at gamma radiation detection;
set mode;
PC communication mode.

The instrument will go into the *self-test mode* immediately after it is turned ON, and the LCD displays "test". Time left until the self-test completion is indicated in the relative units on the analog scale with a number of segments decreasing.

After the self-tests are completed the audio and/or vibration alarms are activated for approximately 1 second, the instrument will automatically go into the *background updating mode* and the LCD will display "CAL" (calibration). In this mode the instrument measures the background of gamma and neutron radiation and calculates the threshold. A time since the background updating began is indicated in the relative units on the analog scale with a number of segments increasing. The user may update the background value whenever it is necessary. Press and fix the MODE button for approximately 2-3 s. The LCD will display "CAL", and the background updating will restart.

When the background accumulation and necessary calculations (including threshold) are completed the PM1703GN will automatically go into the *search mode.* In this mode the instrument automatically compares the current pulse count (both for gamma and neutron radiation) with the threshold and alarms when the threshold value is exceeded. In the *search mode* the LCD displays the current average count rate in counts per second for each kind of radiation (gamma and neutron).

While the PM1703GN is in this mode, the user may search, detect and locate the radioactive sources. To evaluate the intensity of a radiation source (or background) press and release the MODE button and the instrument goes into the *dose rate mode*. The LCD will display dose rate in µS/h. The instrument may be switched between the *search* and *dose rate modes* at any time by pressing and releasing the MODE button.

The PM1703GN goes into the *set mode* by pressing and fixing the MODE button for more than 4 seconds. While in the *set mode* the user may check the preset value of the coefficient **n** for gamma radiation detection or set new value and may also check the current status (ON or OFF) of the audio and vibration alarm devices, or change it. To set new value of the coefficient **n** for neutron radiation detection the user should enter the *PC communication mode*.

The set and/or dose rate modes may be disabled using an application program installed on your PC.

The PM1703GN may be switched to the *PC communication mode* by pressing the LIGHT button. While in this mode it is possible to make the necessary configuration of your PM1703GN and to transfer the history of the instrument operation stored in its non-volatile memory to PC. For more details please refer to the section *"Additional operating instructions to the advanced user"*.

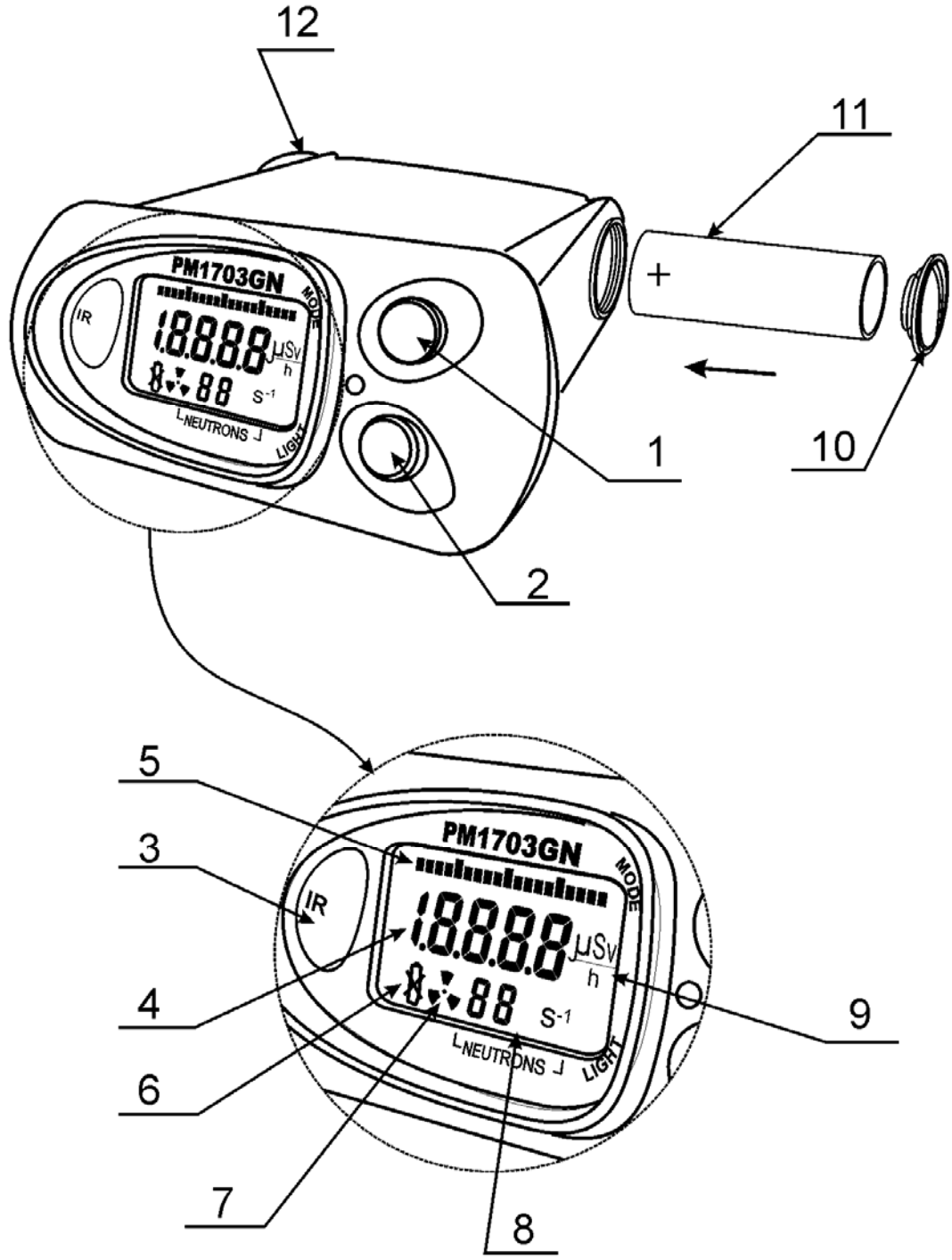
The PM1703GN is equipped with an automatic low battery detection circuit. If the voltage drops below 1.1 V, the battery discharge warning sign will be displayed in the LCD lower left corner. In this case the battery needs to be replaced (see section *"Maintenance"*). The detector block operation is also checked. If the count rate is higher than the factory preset upper limit, the LCD will display

"-OL-" (OverLoad) at gamma radiation detection;

"-99-" at neutron radiation detection.

To turn the instrument **ON** press the MODE button.

To turn the instrument **OFF** press the LIGHT button. While the backlight is ON, press and keep the MODE button until the LCD displays "OFF".



1 – MODE button;
2 – LIGHT button;
3 – window of IR- transceiver;
4 – gamma radiation indicator;
5 – analog scale;
6 – battery discharge warning sign;
7 – RADIATION sign;
8 – neutron radiation indicator(”s^{-1}");
9 – unit of measurement: “s^{-1}“ (counts per second, cps), in the *search mode;* “μSv/h (or “μR/h” by a special order), in the *dose rate mode;*
10 – lid of battery compartment;
11 – battery;
12 – outlet of audio alarm device

Fig.1 - The alarming ratemeter PM 1703GN. General view

4 SPECIFICATIONS

Type of detector: gamma radiation detection neutron radiation detection	 CsI(Tl) scintillator LiI (Eu) scintillator
Detection of gamma radiation sources	meets the ITRAP requirements *
Detection of neutron radiation sources	meets the ITRAP requirements *
Energy range of gamma radiation	from 0.033 to 3.0 MeV
Energy range of neutron radiation	from thermal to 14.0 MeV
Gamma energy response differs from the typical one	no more than - 25 %
Frequency of false alarms at *gamma radiation* detection at the radiation background 0.2 μSv/h	no more than 1 for 12 hours **
Frequency of false alarms at the *neutron radiation* detection	no more than 1 for 12 hours **
Measurement time	0.25 s
Range of coefficient n (used to calculate threshold for gamma or neutron radiation)	from 1 to 9.9 (step 0.1)
DER indication range (at collimated ^{137}Cs radiation)	from 0.01 to 70 μSv/h
Accuracy of dose rate measurements (at collimated ^{137}Cs radiation)	± 30 %
Count time (factory preset) : • in the background mode • in the search mode	 36 s 2 s
Additional accuracy of dose rate measurements (at collimated Cs-137 radiation) • at changing ambient humidity or temperature from normal to high • at changing ambient temperature from normal to low • at edge value of voltage supply • at influence of stationary/alternating magnetic field up to 400A/m • at influence of radio frequency electromagnetic fields up to 30V/m	 ± 40 % ± 15 % ± 5 % ± 5 % ± 5 %

Battery lifetime	1000 hours
Communication with PC through the IR interface on the distance of	up to 0.2 m
Environmental: temperature range humidity	 -30 ^{0}C to +50 ^{0}C (-15 ^{0}C to +50 ^{0}C for *LCD*) up to 98% at 35 ^{0}C
Drop test	0.7 m on concrete surface
Water tightness	IP65
Alarm types	audio tone and/or vibration
Power requirements	1,5 V, one PANASONIC POWER LINE AA (LR6) battery *** or the similar
Weight including the battery in package	 200 g 450 g
Dimensions (without clip) with clip in package	87*72*35 mm 87*72*45 mm 180*135*71 mm

* *more details about the ITRAP program are available on the ARCS web site to the address* http://www.arcs.ac.at/G *or on the POLIMASTER web site to the address* http://www.polimaster.com/

** *the manufacturer guarantees the validity of the technical features in case the coefficients* **n** *have the factory preset* values ***n*=5,3** *(for gamma radiation) and* ***n*= 5** *(for neutron radiation*

*** *other type of non rechargeable battery or a rechargeable battery may be used (AA size, 1.1-1.6V). However, battery lifetime and/or range of operating temperatures may differ from these stated above.*

5 OPERATING INSTRUCTIONS TO THE USER

5.1 The instrument operation check up

Turn the PM1703GN ON by pressing and releasing the MODE button. If the PM1703GN is operative and the battery voltage is normal, the instrument will go through a series of self-tests with all segments, signs and indicators displayed on the LCD. Then the LCD will display "test" and the analog scale with a number of segments decreasing in time. After the self-tests are completed the alarm (audio and/or vibration) will be activated and the instrument will go into the *background updating mode*. The LCD will display "CAL" and the analog scale with a number of segments increasing in time. After the analysis of the gamma and neutron radiation background is completed, the LCD will display for a while an average value of the count rate, and the instrument will go into the *search mode*. The PM1703GN is ready for operation. If the battery voltage drops below 1.1 V, the LCD will indicate the battery discharge warning sign. **The battery needs to be replaced!** (see section "*Maintenance").*

5.2 Searching for gamma and/or neutron radiation sources

Refer to you site regulations and Operating Procedures prior to search operation. The following may serve as a general guidelines:

- *The PM1703GN is intended firstly for efficient searching, detection and location of gamma and neutron radiation sources. It is not energy compensated and so it has a high sensitivity at low energies (33-300 keV, see Appendix A), which allows efficient detection of nuclear materials.*

- *When the PM1703GN operates at temperatures below -15 °C, the LCD normal operation cannot be guaranteed. In this case the audio and/or vibration alarm devices only should be used to detect radiation sources. When the normal conditions with temperatures higher than -15°C are restored, the LCD will resume its normal operation.*

The PM1703GN is provided with a clip and may be fasten to the belt. The clip may be removed using a screwdriver (see Fig.2). A carrying case is also available as an option.

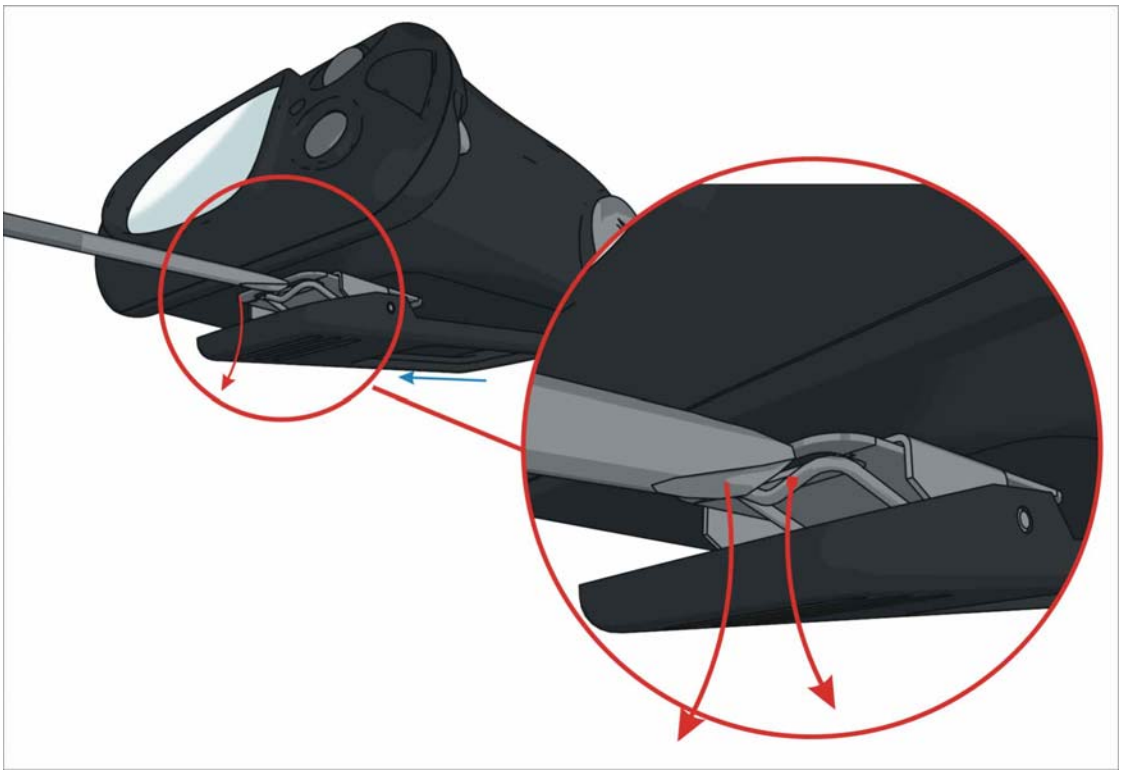


Fig.2 - The PM1703GN with a removable clip

5.3 Detection of gamma and/or neutron sources

When detecting radiation sources the instrument should be held so that the audio alarm device is directed onto the scanned object.

The effective center of gamma radiation detector is situated inside the instrument housing symmetrically to both sides and also to the upper and lower sides in approximately 30 mm from the end point of curved surface forming the battery compartment in the rear part of the instrument.

The effective center of neutron radiation detector is situated inside the instrument housing symmetrically to the upper and lower sides in approximately 12 mm from the left side (if look at the LCD) and in approximately 60 mm from the end point of curved surface forming the battery compartment in the rear part of the instrument.

When detecting of radiation sources under conditions when the audible signals produced by the instrument are not heard (for example, are damped by noise) the vibration alarm device should be used. The efficiency of radiation sources detection is the higher, the closer is the instrument to the scanned object (article, person, container, vehicle, etc) and the smaller is the velocity of its movement along the object.

It should be remembered that both a sensitivity of the instrument and a rate of false alarms depend not only on the preset coefficients **n** (for more details see section *"Design and theory of operation*"), but also on the background value, which the instrument stored while in the *background updating mode*. As the changes of the natural background level may be significant, it is recommended to perform the background updating just before inspection. Press and fix the MODE button when the instrument is turned ON, and the instrument will automatically perform the background updating according to its new level.

If in the *PC communication mode* the auto background updating is turned ON the instrument will take into account the slow changes of background level and will perform background updating in approximately every 10 minutes, when the background decreases, and in a little bit more period of time when the background increases. But the auto background updating will be performed only in case of absence the device alarms or significant changes of the background level for the period of time stipulated by the algorithm.

It should be noted that false signals (audio or vibration) are not regular and, therefore, may be easily distinguished from alarm signals produced by the existing gamma and neutron radiation sources as far as their rate is constant or increases when the instrument moves closer to a radiation source.

5.4 Locating gamma radiation sources

When the gamma radiation source is detected by the PM1703GN fixed installed monitor, the gamma radiation source is to be located**.** To locate the gamma radiation source the instrument should be held at a distance no more than 10 cm from the scanned object. The velocity of movement along the scanned object should not be more than 10 cm per second. As the PM1703GN moves closer to a gamma radiation source, the frequency of audio signals (the frequency of pulsation when the vibration alarm device is turned ON) will increase.

When the maximum frequency is achieved a continuous audio alarm sounds, and if vibration alarm device is turned ON the frequency of pulsation is constant. In this case further locating of gamma radiation source is not possible without background updating. Press the MODE button **trying to keep a distance to the scanned object unchanged**. The instrument will automatically perform the background updating and then the gamma radiation source locating may be continued. If necessary, this procedure may be repeated several times until a gamma radiation source is located.

ⓘ *If necessary to locate neutron radiation source or combined radiation source (both gamma and neutron) it is not allowed to use sound and vibration alarm devices, as the instrument will produce the signals characterizing exceed of neutron count rate threshold, without a reaction to the source approach or removal. In this case it is recommended to perform source localization by observing the count rate change on the LCD upper scale (gamma radiation indicator) or the change of segments number on the LCD analog scale.*

5.5 Dose rate indication for gamma radiation

Press and release the MODE button to switch to the *dose rate mode*. The LCD will display a dose rate in μSv/h (at ^{137}Cs) on the upper scale.

If during the instrument operation in the *dose rate mode*, a value of the dose rate exceeds approx. 70 μSv/h, the LCD will display "-OL-".

ⓘ *While in the dose rate mode, the alarm signals are disabled. They are automatically enabled after returning to the search mode.*

ⓘ *The PM1703GN is calibrated at collimated ^{137}Cs radiation only. Thus, its readings in the dose rate mode may differ from readings of energy compensated dosimeters; this is not considered to be due to the improper operation of the PM1703GN.*

6 ADDITIONAL OPERATING INSTRUCTIONS TO THE ADVANCED USER

6.1 Parameters setting

The instrument is supplied with the preset parameters and the modes:
- *dose rate mode* - **enabled**;
- *set mode* - **enabled;**
- coefficient n = **5,3** (for gamma radiation);
- coefficient n = **5** (for neutron radiation);
- audio alarm device - **ON**;
- vibration alarm device – **ON**;
- auto background updating – **ON**.

Thus, the user may see dose rate values and change the coefficient **n** value for gamma radiation detection and status of alarm devices using the buttons. However other settings may be changed using an application program only (see section *"Communication with PC"*).

To change a coefficient **n** value for gamma radiation detection, enter the *set mode* by pressing the MODE button and keeping it for more than 4 s. The LCD will display "CAL" and then the preset value of the coefficient **n** for gamma radiation detection. To activate changing the coefficient **n** value, press and release the LIGHT button during3 s. The preset coefficient **n** value will flash indicating that this value may be changed. If the LIGHT button is not pressed during 3 s, the instrument will automatically go into the *background updating mode* (LCD will display "CAL"). While digits are flashing, a repeated pressing the MODE button will decrease the value of the coefficient **n** by 0.1 and a repeated pressing the LIGHT button will increase it by 0.1. Keep the buttons pressed to change the numbers rapidly. After the necessary value of the coefficient **n** for gamma radiation is set the instrument will automatically go into the *background updating mode* in 6 s after the last pressing of any button.

To change the current status (ON/OFF) of either audio, or vibration alarm device enter the *set mode* by pressing the MODE button and fixing it for more than 4 s. The LCD will display "CAL" and then the preset value of the coefficient **n**. Press and release the MODE button again. The LCD will display "1-on". The figure 1 indicates the audio alarm device, and "on" shows that the audio alarm device is ON. Press the LIGHT button to change the status of the audio alarm device (ON/OFF). Press and release the MODE button once again. The LCD will display "2-on". The figure 2 indicates the vibration alarm device, and "on" shows that the vibration alarm device is ON. Press the LIGHT button to change the status of the vibration alarm device (ON/OFF).

The instrument will exit this mode if the MODE button is pressed, or automatically if no button is pressed for 6 s.

6.2 Communication with PC

In addition to parameters mentioned above, the PM1703GN has the following factory settings by default:

- password - **1**;
- data storage interval - **60 min**;
- count time in the *background updating mode* - **36 s**;
- count time in the *search mode* - **2 s**.

An application program should be used to configure your PM1703GN according to your requirements and site regulations.

An application program PM17XX is supplied on the installation CD together with the IR adapter (available as an option).

Minimum requirements to a computer and its software:

- P100;
- 32 Mb RAM;
- Windows 98\2000\XP (small font in Windows settings);
- 2 Mb free on the hard disk and an adequate space available to install the database;
- 800X600 resolution of a monitor;
- IrDA.

To use an IR adapter connect the adapter cable to a communication port of the PC.

To setap the application program use the software disk included into the delivery kit. Run the SETUP.EXE program.

The help file and the attached text document that are supplied on the installation disk describe how to run the application program.

7 DESIGN AND THEORY OF OPERATION

The **block diagram** of the PM1703GN is shown in Fig. 3.
The instrument consists of:
- gamma radiation detector block;
- neutron radiation detector block;
- neutron radiation processing block;
- processing block;
- audio alarm device;
- vibration alarm device.

The **gamma radiation detector block** consists of:
- a CsI(Tl) scintillator with a photodiode;
- amplifier.

The **neutron radiation detector block** consists of:
- a LiI(Eu) scintillator with a photodiode;
- amplifier.

The scintillator-photodiode assembly (in each detector block) transforms gamma and neutron radiation to electric pulses that come to the input of the amplifier-shaper. The amplifier-shaper (in each detector block) converts electric signals coming from the photodiode output to quasi-Gauss pulses that come to the input of the processing block.

The **neutron radiation processing block** includes the processor module which processes the data obtained by neutron radiation detector block.

The **processing block** consists of:
-processor module;
-non-volatile memory module;
-LCD module;
-control buttons;
-IR transceiver;
-power supply module.

The *processor module* performs:
-testing of the instrument every time as it is turned ON;
-mathematical processing of data obtained from the gamma radiation detector block;
-control over all the operation modes;
-output of the data processing results (obtained from both detector blocks) to the LCD;
-control over the operation of the audio and vibration alarm devices;
-battery voltage control.

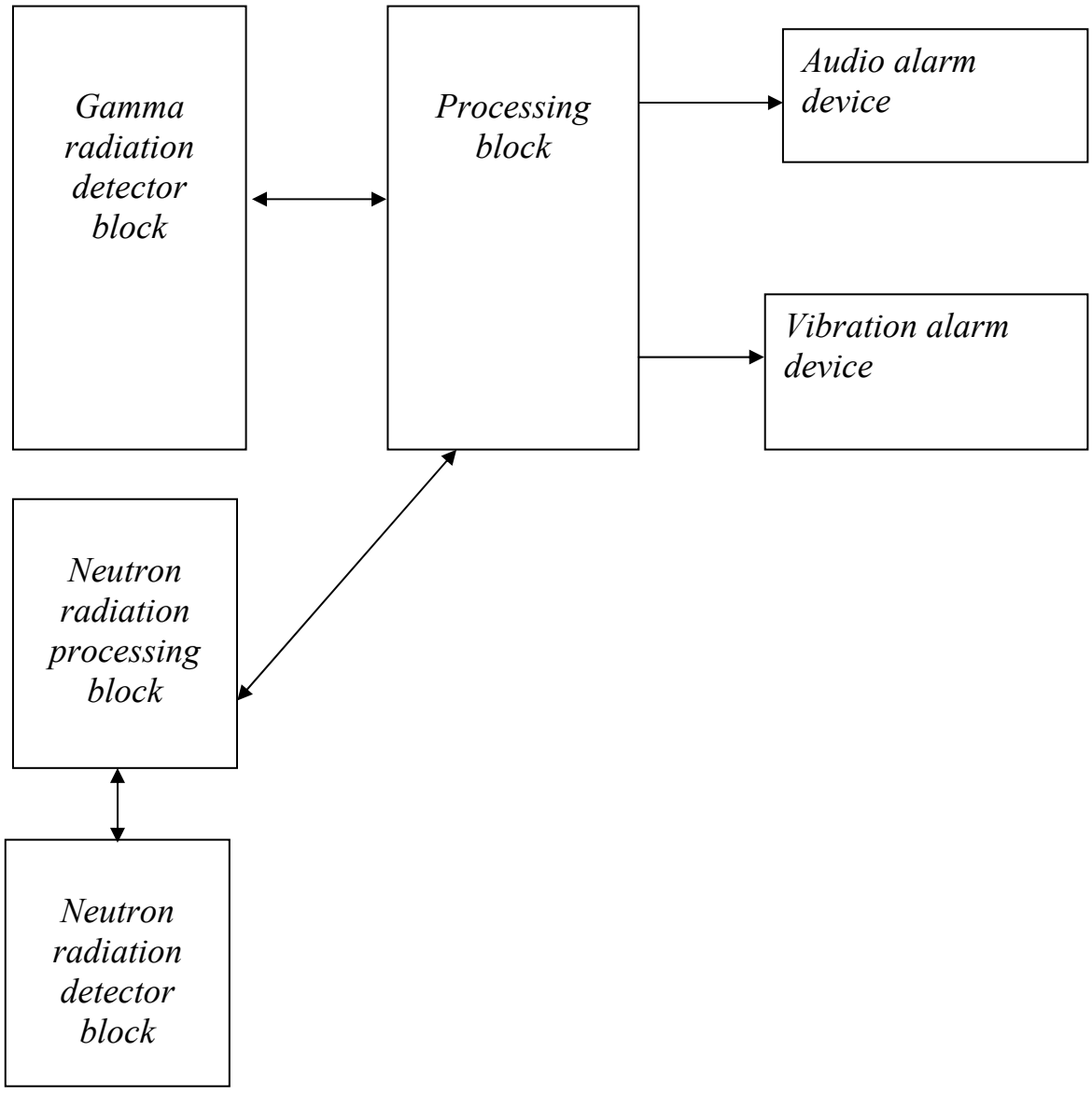


Fig. 3 - Block diagram of the PM1703GN

A *non-volatile-memory module* is designed to store the PM1703GN operation history that involves:

-current values of the count rate in data storage intervals;
-cases when the alarm threshold is exceeded;
-cases of background updating;
-time when the instrument is turned ON/OFF.

The non-volatile memory of the instrument stores the following parameters:

- the number of an instrument ;
- information about the audio or vibration alarm devices turning ON/OFF;
- information about auto background updating turning ON/OFF;
- the preset values of the coefficients **n**;
- the current time and date;
- the preset successive intervals in that the current count rate values are stored in the non-volatile memory of the instrument;
- count time in the *background updating mode;*
- count time in the *search mode;*
- other parameters according to description of user program .

The *LCD module* is designed to display the information about the self-test, the instrument operation modes and registered values. The LCD module also contains a control circuit of the luminescent backlight, which is turned ON/OFF under the control of the processor module and is done by the LIGHT button.

The *IR transceiver* is designed to make possible an exchange of information of the PM1703GN with PC.

The *power supply module* is a built-in power source including a battery and voltage transformers and electronic switches that are controlled by the processor module and supply the necessary voltage to the instrument blocks.

The *audio alarm device* is designed to produce audible sound in the *self-test, search modes* and in case of exceed the count rate threshold. In the *search mode* a rate at which audible tone repeats will increase when the instrument comes nearer to a gamma radiation source.

When the alarm threshold is exceeded at gamma radiation detection the instrument produces audible sounds which are different from the sounds produced in case of neutron radiation detection, therefore it is possible to define audibly at what kind of radiation the exceed of alarm threshold has happened.

The *vibration alarm device* is designed to produce signals that the user senses as vibrations inside the case of the instrument when the *self-test mode* is completed, or when the alarm threshold is exceeded in the *search mode.* In the *search mode* a rate of

pulsation will increase when the instrument comes nearer to a gamma radiation source. It allows a secret search for gamma radiation sources and is good in situations when sound tones are damped by noise.

The audio or vibration alarm devices can be turned ON/OFF using software in the *PC communication mode* or manually using the buttons if the *set mode* is enabled.

The PM1703GN operates in the following modes:
- *self-test mode*;
- *background updating mode*;
- *search mode*;
- *dose rate mode*;
- *set mode*;
- *PC communication mode*.

Self-test mode

The PM1703GN will go into this mode immediately after it is turned ON, and the LCD will display the message "test". The following tests are performed:
- LCD test;
- detector block test;
- processor test;
- non-volatile memory test;
- alarm device test.

The time left until the self-test completion is indicated in the relative units on the analog scale shown in decreasing a number of indicated segments.

After the self-tests are completed, the audio or vibration alarms will be activated for approximately 1 s, and the instrument will go into the *background updating mode.*

Background updating mode

ⓘ *The below mentioned main principals of instrument operation refer to the gamma radiation detection. An algorithm of the neutron radiation detection is more sophisticated and is not described in the present operating manual.*

The instrument will automatically go into this mode when the *self-test mode is* completed and the LCD will display the message "CAL" (calibration). In the *background updating mode* the analysis of gamma and neutron radiation background value is performed. The processors count pulses coming from the detector blocks. A time since the background updating began is indicated in the relative units on the analog scale with a number of segments increasing. The scale completely filled with segments indicates that the background updating is completed. Later on when the user makes the

instrument update the background, the background count time will automatically decrease with increasing the background level.
Processor calculates the average count rate N_b during the background count time and the threshold value P

$$P = N_b*T_c+n*\sigma, \quad (1)$$

with

$$\sigma = \sqrt{N_b*T_c} \quad (2)$$

where T_c - count time in the *search mode;*

σ - meansquare deviation of the value calculated using the equation (2) for Poisson distribution of pulses;

n - number of meansquare deviations (coefficient **n**).

The coefficient **n** changes the threshold value according to equation (1). It is obvious that the *lower* is the coefficient **n**, the *lower* is the threshold value, the *higher* is the instrument sensitivity in the *search mode.* However, in this case a probability of false alarms will increase.

When the background accumulation is completed the instrument will display for several seconds the average count rate (in counts per second) during the background accumulation, calculate and store in memory the value of quantities which are necessary for further operations and will automatically go into the *search mode.*

To update the background value, press and keep for more than 2 s the MODE button. The LCD will display "CAL", and the background accumulation will restart.

In *PC communication mode* the *auto background updating* option may be set. Auto background updating allows to keep automatically the high sensitivity of the instrument when the background level decreases “slowly”, and to avoid false alarms when the background level increases “slowly”.

Search mode

In the *search mode* the processor will count pulses coming from the detector blocks in 0.25 s periods and store in memory a sum of pulses for the count time T_c (mathematical processing of the data obtained is separately performed for gamma and neutron radiation). A number of pulses for the last (recent) period is added to the sum every 0.25 s and the oldest count is discarded. Therefore, a number of pulses N_c stored in the processor memory is updated every 0.25 s.
The current value of N_c is compared to the alarm threshold P every 0.25 s. If the current value of the pulse count (at one or both types of radiation) exceeds the threshold value, i.e. $N_c>P$, then the audio and/or vibration alarm will be produced and the LCD will

display the radiation danger sign. The rate at which audio tone repeats will increase, when an excess of N_c over P becomes more important, i.e. when the ratemeter comes closer to a gamma radiation source. If the threshold exceed is found at neutron radiation detection or at both gamma and neutron radiation detection the different sound alarms are produced.

When the audio alarm device is turned ON, the audible signals are produced. When the vibration alarm device is turned ON, the mechanical vibration is produced (the device case vibrates). In the *search mode* the LCD will indicate the current average count rate in counts per second.

Dose rate mode

While in the *dose rate mode* the PM1703GN indicates the dose equivalent rate (DER) of photon radiation H*(10) at ^{137}Cs in collimated radiation. The LCD will display the dose rate value (DER) in μSv/h, which is calculated according to formula

$$DER = Nc / (K \times Tc), \qquad (3),$$

where Nc - total number of pulses during count time;

Tc - count time;

K - detector sensitivity (is set by the manufacturer during its adjustment in the process of production or when the detector unit is changed).

Set mode

While in the *set mode* the user may perform the following operations:

- to check the preset value of the coefficient **n** for gamma radiation detection (a number of mean-square deviations) or to set the new one; a range of the coefficient **n** settings is from 1 to 9.9 in a step of 0.1;
- to check the current status of the audio and vibration alarm devices or to change it (to turn ON or OFF) if changing is enabled in the *PC communication mode*.

The instrument will go into this mode after the MODE button is pressed and kept for more than 4 s.

The ***PC communication mode*** was described in the section "*Additional operating instruction to the advanced user"*.

8 PERFORMANCE EVALUATION

The evaluation of the instrument performance includes the check-up of the following:

- the dose rate range and accuracy of dose rate measurements (at collimated ^{137}Cs radiation),
- the instrument sensitivity in the *search* mode (at ^{137}Cs for gamma radiation and Pu-α-Be for neutron radiation)

This evaluation is performed under the normal conditions stated below.

Influenced quantity	Range of values
Temperature	20 ^{0}C (± 5 ^{0}C)
Atmospheric pressure	101.3 kPa (+5.5 kPa; -15.3 kPa)
Relative humidity	60 % (+20 %;-30 %)
Gamma radiation background	no more than 20 μSv/h

In process of evaluation your site regulations for work with radioactive materials and other radiation sources, as well as the Standards of radiation safety should be followed.

The dosimetric verification equipment with the source of ^{137}Cs is to be used for checking. The equipment should be verified and the source should be certified.

Check-up of the dose rate range and accuracy of dose rate measurements

Turn the instrument ON, turn the audio and vibration alarm devices OFF and switch the instrument to the *dose rate mode*.
Place the instrument into the dosimetric verification equipment with the ^{137}Cs source so that the calibration direction is coincident with the radiation field axis passing through the geometrical center of the detector. After that in no less than 120 s read three dose rate values at the background in 15 s and calculate the average background value $\dot{H}_b$

$$\dot{\overline{H}}_b = \frac{1}{3}\sum_{i=1}^{3} \dot{H}_{bi},$$

Place the instrument in the point coinciding with the geometrical center of the detector and having the conventional true value of the dose rate H_t = 0.8μSv/h and irradiate the instrument. In no less than 120 s after irradiation read three dose rate values in 15 s and calculate the average background value

$$\dot{\overline{H}}_j = \frac{1}{3}\sum_{i=1}^{3} \dot{H}_{ji}$$

Repeat the above procedures for the conventional true of the dose rate of 8.0 μSv/h and 30.0 μSv/h.

Check if the found values are in the following range

$$\dot{H}_{oj} - 0.3\,\dot{H}_{oj} \le (\dot{H}_j - \dot{H}_b) \le \dot{H}_{oj} + 0.3\cdot\dot{H}_{oj}.$$

The results of check-up are considered to be satisfactory if the relative error of indication is in the range from -30 % to +30 %.

Check-up of the instrument sensitivity.

Check-up of the instrument sensitivity to gamma radiation.

Turn the instrument ON, turn the audio and vibration alarm devices OFF and switch the instrument to the *search mode*. Place the instrument into the dosimetric verification equipment as described above.

When the instrument is in the *search* mode no less than 120 s read three count rate values of the background (in cps) N_{bi} in 15 s. Calculate the average background value $\overline{N}_b$

$$\overline{N}_b = \frac{1}{3}\sum_{i=1}^{3} N_{bi}$$

Place the instrument in the point coinciding with the geometrical center of the detector and having the conventional true value of the dose rate at ^{137}Cs $\dot{H}_{oj}$ = 0.8 μSv/h. Irradiate the instrument. In 120 s after the irradiation read three count rate values (in cps) in 15 s and calculate the average value Nc

$$\overline{N}_c = \frac{1}{3}\sum_{i=1}^{3} N_{ci}$$

Calculate the instrument sensitivity ξ

$$\xi = \frac{\overline{N}_c - \overline{N}_b}{\dot{H}_{oj}}.$$

Repeat the above procedures for the conventional true of the dose rate of 8.0 μSv/h and 30.0 μSv/h.

The results of check-up are considered to be satisfactory if the sensitivity is no less than 100 s^{-1} /μSv/h at ^{137}Cs .

Check-up of the instrument sensitivity to neutron detection (fast neutrons)

The check-up procedure is performed using the special verification equipment with the Pu-α-Be source by direct measuring.

Turn the instrument ON and switch to the *search* mode.

Place the instrument on a special movable carriage of the verification equipment so that the geometrical center of neutron detector is situated on the symmetric axis of

collimated neutron radiation with the precision ± 5 mm and the instrument front side is directed to the neutron radiation source.

Note - When check the instrument the geometrical center of the neutron detector is considered to be the effective center.

To cover the instrument with the cadmium shields by the thickness of 0.1 mm from all the sides. In the point of the geometrical center of the detector create a density **φ** of neutrons so to achieve the instruments readings from 0.5 to 0.8 of the final count rate range, that is 50-80 s^{-1}, then irradiate the instrument.

In no less than 60 s after irradiation read three instrument's indications in 15 s and calculate the average value N_m

$$N_m = \frac{\sum_{i=1}^{3} N_i}{3} .$$

Place the shield in the form of a cone between the instrument and the source, irradiate the instrument.

In no less than 60 s after irradiation read three instruments indications in 15 s and calculate the average value N_{mk}

$$N_{mk} = \frac{\sum_{i=1}^{3} N_i}{3} .$$

Calculate the instrument sensitivity

$$\xi = \frac{(N_m - N_{mk}) \cdot B}{\varphi},$$

where B - the coefficient reflecting the influence of the diffused neutron radiation on the instrument readings (preset when the equipment is verified).

The results of checking are considered to be satisfactory if the sensitivity is no less than 0.05 counts sm^2/neutron at Pu-α-Be.

Note - At a higher temperate the instrument sensitivity may be by 40 % less than the sensitivity at a normal conditions.

9 MAINTENANCE

Maintenance of the instrument involves preventive treatment, battery replacement and regular check up of the ratemeter operation (as described in the section 5.1).

The preventive treatment involves external examination of the instrument, dust removing and deactivation in the case of the radioactive contamination. Deactivation of the case is done with a tissue impregnated with ethyl alcohol.

To replace a battery:

- turn the instrument OFF;
- remove a lid 10 (Fig. 1) of the battery compartment using a screwdriver, or coin;
- remove an exhausted battery and insert the new one into the compartment observing the polarity symbols ("+" of the battery should be faced inwards of the unit);
- close the battery compartment with the lid.

When the battery is replaced, the LCD will display all segments and the instrument will go into the *self-test mode* (see section 5.1).

10 TROUBLESHOOTING

Problem	Possible cause	Solution
In any mode the LCD displays “00” or “E01”	1 Gamma radiation detector block failure 2 Processing block failure	The instrument needs repair. Send the unit to the nearest service center
In any mode the LCD displays "-OL-"	1 Gamma radiation detector block failure 2 Processing block failure 3 A gamma radiation source close to the unit	1, 2 - The instrument needs repair. Send the unit to the nearest service center. 3 - Remove the source
The audio and/or vibration alarm devices are not operating	1. Device is turned OFF. 2. Device is not operative	1- Turn the device ON. 2 - The instrument needs repair. Send the unit to the nearest service center
The LCD displays the battery discharge warning sign	Exhausted battery	Replace the battery (see section 9)
In any mode the LCD displays “E02”	Neutron radiation detector block failure	The instrument needs repair. Send the unit to the nearest service center
The device does not exit the self-test mode	Neutron radiation detector block failure	The instrument needs repair. Send the unit to the nearest service center

11 STORAGE AND SHIPPING

Storage

Ratemeters are to be stored in the manufacture's package at the air temperature from -15 °C to +50 °C and humidity up to 95 % at a temperature of +35 °C. The storage time should not exceed the lifetime of the ratemeter, that is 8 years.

Ratemeters without package are to be stored at the air temperature from 10°C to 35°C and humidity of 80 % at a temperature of 25 °C. The storage place should be free of dust, vapors of strong chemicals that may cause corrosion.

Shipping

Ratemeters in package may be shipped by any kinds of transport at the air temperature from - 50 °C to +50 °C.

Ratemeters in package should be fastened in a vehicle. They must be arranged and fastened in transport so as to ensure their stable position and to avoid possibility of shocks against each other and the walls of a vehicle as well.

When carried by sea, ratemeters in package should be placed in hermetic plastic bags with silicagel.

When carried by air, the ratemeters in package should be placed in hermetic compartments.

12 WARRANTY

The manufacturer warrants this ratemeter to meet specifications provided that the user observes the guidelines of the ratemeter operation, shipping and storage described in the operating manual.

The warranty period is 18 months since the date of sale.

The warranty storage period is 6 months since the date of the ratemeter acceptance by the quality control department officer. Warranty and after-warranty repairs are carried out by the manufacturer or by a company authorized by the manufacturer. Warranty does not cover ratemeter:

- which warranty period is expired if the ratemeter was purchased by the user within the limits of the warranty storage period;
- which were subjected to the user's service (the evidence of opening the device);
- with mechanical damages, if the requirements of operation and storage were not satisfied;
- without an operating manual.

The warranty period is prolonged for a period of warranty repair.

Warranty does not cover batteries. The battery replacement is not considered as the warranty repair.

ATTACHMENT A

Energy response of the PM1703GN

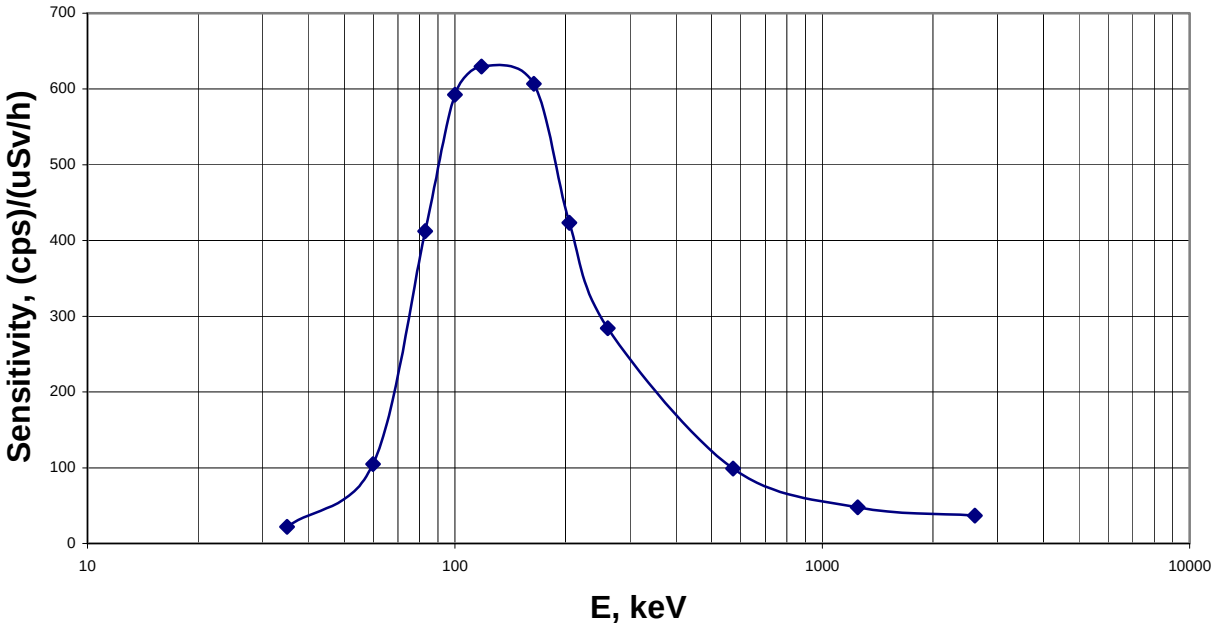


Fig.A.1 - Typical energy response of the PM1703GN (at gamma radiation detection)