Jan. 3, 1961 R. WELLER 2,967,243

RADIOACTIVE TIMING METHOD AND APPARATUS

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Fig. 1.

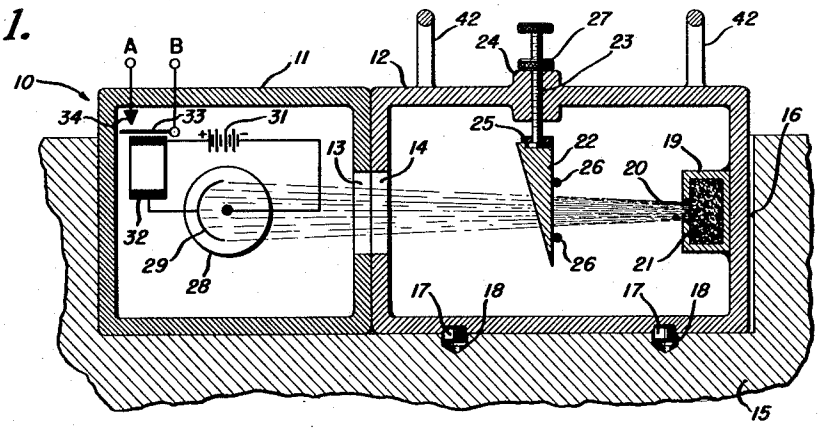
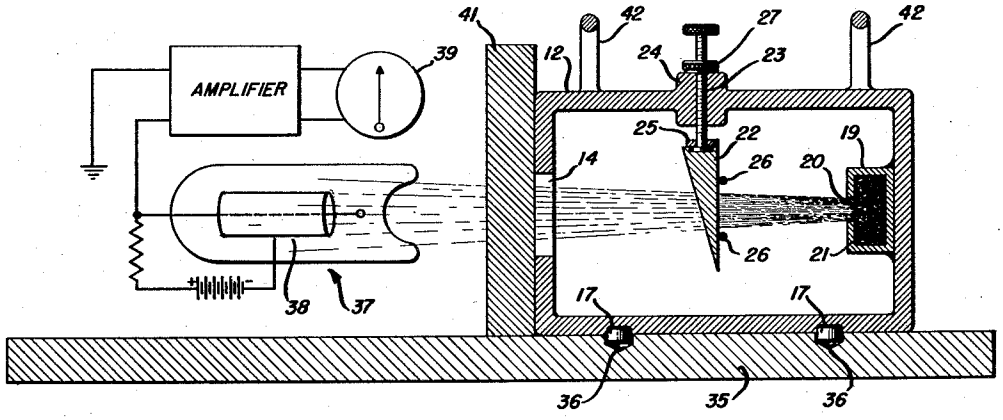


Fig. 2.



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Fig. 3.

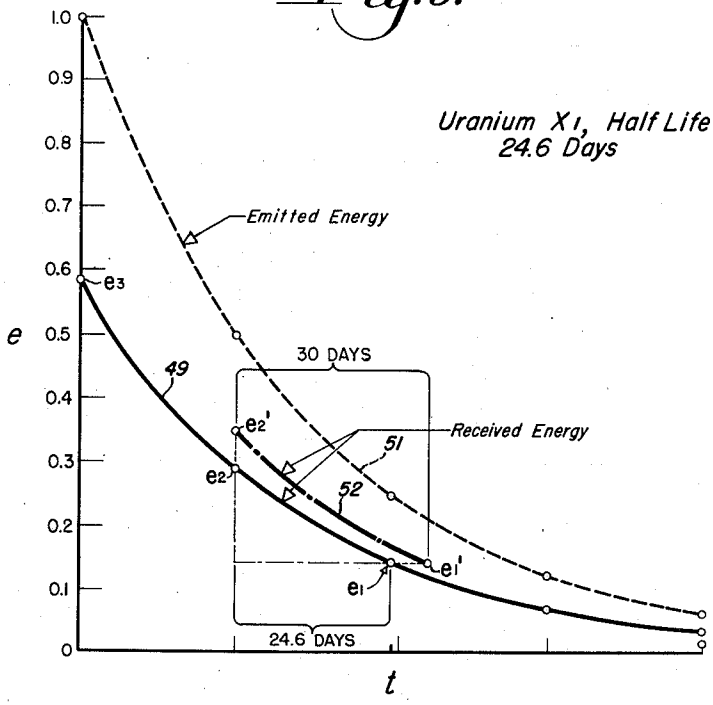


Fig. 4.

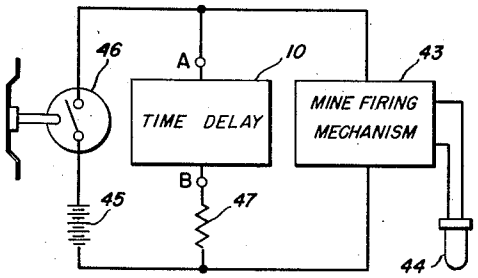
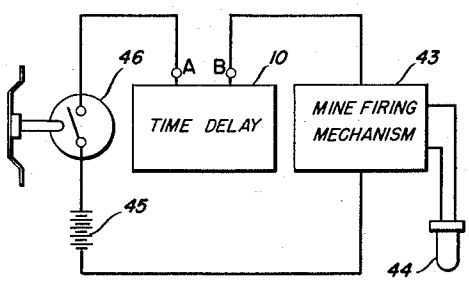


Fig. 5.



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RADIOACTIVE TIMING METHOD AND APPARATUS

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6 Claims. (Cl. 250—83.6)

(Granted under Title 35, U.S. Code (1952), sec. 266)

This invention relates to a timing method and apparatus which utilizes the known decay of radiation of radioactive materials to measure long periods of time without expending a considerable amount of power. More specifically, the present invention contemplates a timing method and apparatus of this character for delaying the sterilization or arming of a marine mine firing mechanism until the intensity of radiated energy received from a radioactive material arranged within the mine has been attenuated from an initially adjusted value to a predetermined value, thereby to measure a predetermined period of time prior to arming or sterilizing of the mine, as the case may be.

In devices of this class heretofore devised for sterilizing or arming a mine, it has been the general practice to employ various time delay mechanisms, such, for example, as single wind clock escapement mechanisms, electrolytic or water soluble devices, or the like, which are adapted to operate a circuit control device in time delayed relation with respect to the planting of the mine. Such devices have not proved to be entirely satisfactory under all conditions of service for the reason that the single wind clock mechanisms have failed to operate the circuit controlling mechanism by reason of the decrease in power which is applied to the escapement mechanism during the latter portion of the spring unwinding cycle and for this reason such devices have not proved entirely satisfactory for use with mechanisms in which the sterilization or arming thereof is delayed for a relatively long period of time such, for example, as several months.

Water soluble devices have not proved entirely satisfactory to effect delayed arming or sterilization when the soluble devices are subjected to relatively long exposures to water, such, for example, as a delay of several days or weeks, as the case may be, before the mine is armed or sterilized. Furthermore, in the case of the electrolytically controlled devices for sterilizing the mine, the rate of electrolytic action of these devices varies in accordance with several controlling factors, such, for example, as the temperature of the water within which the mine is planted, and for this reason the period of elapsed time between the planting of the mine and the sterilization thereof may vary considerably in accordance with the variations in each of the controlling factors, particularly when the sterilization of the mine is delayed for several months after the mine is planted.

The radiated energy controlled device of the present invention is particularly well adapted for use in arming or sterilizing the mine firing mechanism by controlling the electrical circuits connected thereto after a predetermined period of time has elapsed, as measured by the known rate of decay of a suitable radioactive material, after the mine has been planted in the target area thereby to arm the mine in time delayed relation with respect to the launching thereof or to render the mine firing mechanism harmless, if desired, at the expiration of a substantially greater period of time after the mine has been planted.

In accordance with the timing method and arrangement of the timing device of the present invention, a sensitive relay, arranged to arm or sterilize the mine firing mechanism, as the case may be, is maintained in an operated condition under control of the radiated energy received from a mass of a radioactive material arranged within the mine until the radiation therefrom has decayed to a predetermined value. The intensity of the radiated energy received from the radioactive mass at the beginning of a delay period to be measured is adjusted, preferably in the specific manner and by the specific means hereinafter to be described, to such an initial value that the energy received from the mass at the end of the delay period is insufficient to maintain the relay in operated condition, the delay period thus being controlled by the known decay of radiation of the mass of radioactive material.

One of the objects of the present invention is to provide a method and apparatus for measuring long periods of time with negligible expenditure of energy and with a fair degree of accuracy.

Another object resides in the provision of timing methods and apparatus which utilize the known rate of decay of radiation of radioactive materials to measure long intervals of time with a fair degree of accuracy.

Another one of the objects of the present invention is the provision of a new and improved device for delaying operation of a circuit while the energy received from a radioactive material decays from an initial adjusted value to a predetermined value.

Another object is to provide a radioactive timing apparatus and method having provision for adjusting the intensity of radiated energy received from a radioactive mass to such an initial value that a predetermined period of time to be measured by the apparatus is terminated when the radiation from the mass has become attenuated to a predetermined value.

A further object is to provide a radioactive timing device for delaying the arming or sterilizing of a mine firing mechanism which possesses all of the advantages of the prior art time delay devices employed for this purpose and obviates the aforedescribed difficulties thereof.

Another of the objects is to provide a new and improved time delay device adapted to arm or sterilize a mine when the energy received from a radioactive mass has decayed from an initial adjusted value to a predetermined value after a predetermined interval.

Still other objects, advantages and improvements will be apparent from the following description taken in connection with the accompanying drawings of which:

Fig. 1 illustrates in diagrammatic form the time measuring device of the present invention which utilizes the attenuation of radiation of a radioactive particle for operating a control circuit when the radiated energy received from the particle has attenuated to a predetermined amount at the expiration of a measured interval controlled by the known rate of decay of the particle;

Fig. 2 illustrates in diagrammatic form a suitable calibrating device for adjusting and measuring the amount of radiated energy received from a radioactive particle which is subsequently employed to operate the control circuit of Fig. 1;

Fig. 3 illustrates in graphic form the manner in which the attenuation of radiation of a radioactive substance is utilized to measure a given period of time;

Fig. 4 illustrates in diagrammatic form a circuit arrangement employing the time measuring device of the present invention to sterilize the firing mechanism of a marine mine a predetermined interval after the mine has been planted in a body of water; and

Fig. 5 illustrates in diagrammatic form a circuit arrangement employing the time delay measuring means to

arm the firing control mechanism of a marine mine at the expiration of a predetermined interval after the mine has been planted in a body of water.

Referring now to the drawings in which like numerals of reference are employed to designate like parts throughout the several views and more particularly to Fig. 1 thereof the numeral 10 generally designates a timing apparatus which has been constructed according to the best mode thus fare devised for practicing the timing method and principle of the present invention. The timing apparatus comprises a pair of chamber enclosing casings 11 and 12 which are arranged in abutting engagement, as illustrated, so that openings 13 and 14 respectively arranged within the abutting walls thereof are arranged in coaxial alignment. The casings preferably are maintained in this mutually abutting position as by any suitable support 15 which is provided with a recess 16 for receiving the casings therein. The casing 12 also preferably is provided with a pair of dowel pins 17 which are arranged to be received in recesses 18 arranged in the bottom of recess 16, thereby to provide the casing 12 with a specific means of position orientation for an additional purpose more fully to appear as the description proceeds.

On the opposite wall from the opening 14 in casing 12 is secured in any suitable manner a radioactive unit comprising a lead casing 19 for enclosing a radioactive particle or mass 21 which may be composed of any radioactive material suitable for the purpose, such, for example, as Uranium X1, or radio activated magnesium or phosphorous. The casing 19 has an opening 20 therein arranged in coaxial alignment with the aforesaid openings 13 and 14 in casing 11 and 12. The rays emitted from the particle through these openings preferably are filtered within casing 12 to a variable extent according to the amount of energy required to operate the timing apparatus 10 over the period of time to be measured thereby.

A filtering or attenuating means suitable for the aforementioned purpose is provided in the form of a wedge-shaped mass 22 of any suitable radiated energy filtering or absorbing material, such, for example, as lead, aluminum, or the like. Wedge 22 is arranged with a vertical surface facing the particle 21 and arranged to be moved transversely of the rays emitted therefrom as by the screw 23 which is threadedly supported within the hub portion 24 of the chamber enclosing casing 12. The screw 23 is swivelly connected to the wedge 22 as at 25 and is prevented from rotating with the screw as by the horizontally disposed guide pins 26. A lock nut 27 preferably is carried on the screw for locking the same to the hub portion 24 in an adjusted position of the wedge with respect to the radiated rays.

Arranged within the chamber enclosing casing 11 is a photoelectric tube 28 which is so arranged within the chamber that the anode 29 thereof is impinged by the radiated rays passing through openings 13 and 14 of casings 11 and 12. The photoelectric tube is arranged in a series circuit including the battery 31 and a sensitive relay 32 having a minimum operating or holding current of predetermined value such that the armature 33 of the relay is held out of engagement with the fixed contact 34 thereof as long as the current passing through the operating winding of the relay equals or exceeds the minimum operating current thereto. Conductors or leads extend from the armature and contact of the relay to external terminals A and B for connecting the timing device 10 into a circuit to be controlled such, for example, as the arming or sterilizing circuits of a mine firing mechanism hereinafter more fully to be described.

The construction and arrangement of the photoelectric tube 28 and the sensitive relay 32 is such that a predetermined amount of radiated energy must be received by the photoelectric cell in order to supply the minimum operating current to the relay from battery 31. As will appear more fully hereinafter, when this amount of received radiated energy is known and the decay rate of the radioactive particle 21 is also known, it is possible to adjust the setting of wedge 22 such that a predetermined interval of time will be measured by the time measuring device 10 during the time required to decrease the energy received by the tube to the value corresponding to that which produces the minimum operating current for the sensitive relay.

In Fig. 2 there is shown an arrangement for measuring the intensity of the radiated energy passing through opening 14 of casing 12. According to this arrangement, the casing 12 is placed on a support 35 having recesses 36 for receiving the dowel pins 17 whereby the casing 12 is accurately located on the support in predetermined spaced relation with respect to the Geiger counter which is also positioned on the support and generally designated by the numeral 37, the counter tube 38 thereof being arranged in the manner illustrated in radiated energy receiving relation with respect to the rays passing through opening 14 in casing 12. The intensity of the radiated energy impinging on counter tube 38 is indicated by the meter 39 of the Geiger counter. For further reference as to details of construction and operation of the Geirger counter reference may be made to the text book of Dunning and Paxton, first edition, entitled "Matter Energy and Radiation," page 585. It will be understood that a Geiger counter may not have a sufficient range of intensity measurement to measure directly the intensity of the rays emitted from chamber 12. The Geiger counter is rendered suitable for use for such purpose by inserting one or more of a plurality of blocks such, for example, as block 41, of variable thickness according to the degree of attenuation required for a particular radioactive particle 21 to reduce the intensity of the rays emitted therefrom to a value which will fall within the range of meter 39 of the Geiger counter. The attenuator blocks may be of any suitable radiated energy absorbing or filtering material such, for example, as lead or aluminum or the like, and being of such thickness that a standard amount of energy is absorbed thereby. Thus, in measuring the intensity of a particle 21 for a particular setting of wedge 22, various blocks are interposed between the Geiger counter and the casing 12 until a block is obtained which attenuates the radiated energy from the particle in an amount sufficient to fall within the full scale of meter 39, a measure of the intensity of the radiated energy emitted from casing 12 is thus taken as the sum of the reading of meter 39 and the value of energy filtered by the attenuating block 41. Casing 12 preferably is provided with a pair of handles 42 for facilitating movement thereof between the supports 15 and 35.

Referring now to Fig. 4 wherein the time delay device 10 is employed to sterilize the mine firing mechanism 43 a predetermined interval of time after the mine has been planted into a body of water, 44 denotes an electro-responsive detonator which may be arranged in the usual manner so as to be fired under control of the mine firing mechanism when the same has been operated in accordance with the principle thereof, 45 denotes a battery for operating the mine firing mechanism, and 46 denotes any suitable hydrostatically operated switch for connecting the battery to the mine firing mechanism in response to the pressure of the surrounding water as the mine descends therein. At the end of the period of time measured by the time delay device 10, contact 34 is engaged by armature 33 thereof to close a circuit for short circuiting the battery 35 whereby the mechanism 43 is sterilized when the potential of the battery drops below the operating potential of the firing mechanism, a resistor 47 being employed in some cases to further delay the drop in potential of the battery 45.

In Fig. 5 the time delay device 10 is employed to delay the arming of the firing mechanism 43 for a predeter-

mined interval of time following launching of the mine thereof, the terminals AB of the timing device for this purpose being connected in the arming circuit between the mine firing mechanism and the hydrostatic arming device **46** whereby the mine is fully armed as armature **33** of the timing device moves to engage contact **34** thereof as relay **32** releases the armature at the end of the time interval measured by the timing device.

The manner in which the timing device **10** is adjusted or conditioned so as to measure the predetermined interval of time required for sterilizing or arming the mine, as the case may be, will now be described with particular reference being made to Fig. 3. It will be understood that the particles of radioactive material which may be available for use in the timing device at the time of launching very likely will not all emit the same amount of radiated energy and the amount of energy radiated by each particle will be of fortunitous value at the time it is to be used in the timing device. Accordingly, the methods presently to be described for adjusting the amount of radiated energy which must be received from the radioactive particle by the photoelectric tube to be employed therewith at the beginning of an interval to be measured may be employed to adjust the received energy to such a value that the amount of energy received by the tube at the end of the interval to be measured is just sufficient to maintain the current to the sensitive relay at the minimum operating value thereof.

According to one method of adjusting the amount of energy received by the photoelectric tube to the required value at the beginning of the controlled time period, it may be assumed that the amount of received energy at the tube just sufficient to supply the minimum operating current to the sensitive relay is known, this amount of energy being designated as *e*1 in Fig. 3, and it further may be assumed that the rate of decay of radiation of the particle is also known, the particle, for example, being Uranium X1 which has a half-life of 24.6 days.

Assuming further, in a simple case, that the control period coincides with the half-life of the particle, i.e., 24.6 days in the case of Uranium X1, it merely is necessary to place the casing **12** in the position of Fig. 2 and thereafter adjust wedge **22** and select the proper size of block **41** such that the block and meter **39** together indicate an intensity of received radiated energy *e*2 which is twice the value of the aforementioned received energy *e*1. Casing **12** thereafter is replaced in the position of Fig. 1 whereupon the proper amount of energy is received by the photoelectric tube such that at the expiration of the control period of 24.6 days the energy received by the tube will have diminished to value *e*1 whereupon the armature of the sensitive relay will be released to complete the timing interval.

It will be noted in Fig. 3 that the amount of energy designated *e*2, which is equal to twice the value of the energy designated *e*1, decreases by the known rate of decay of the material along curve **49** thereof to the value *e*1 at the termination of 24.6 days, the abscissas being plotted in units of half-life of the material and the ordinates being plotted in units of radiated energy whereby *e*3 would be the value of radiated energy which would have been received 24.6 days previous to the time of measurement of value *e*2. It will further be noted that if the wedge **22** were to be moved fully out of the path of the rays emitted from the particle **21**, the energy received therefrom might be indicated as by the curve **51** in Fig. 3.

When it is desired to measure an interval of time, such as 30 days, which does not coincide with the half-life of the material, point *e*1 is projected to point *e*1′ and the characteristic decay curve of the material **52** corresponding to point *e*1′ is constructed therethrough to give the point *e*2′ which indicates the amount of energy which must be measured by meter **39** and block **41** after adjustment of wedge **22** if the energy received at the tube at the termination of the 30 day interval is to be equal to *e*1 or *e*1′.

According to another method of adjusting the initial amount of radiated energy to be received by the photoelectric tube at the beginning of the interval to be controlled, wedge **22** is adjusted with casing **12** in the position of Fig. 1 until the armature of relay **32** is released. Casing **12** is then placed in the position of Fig. 2 and the intensity of the radiated energy emitted therefrom is measured by meter **39** and block **41**, these steps being performed when it is not known what amount of radiated energy is required for the photoelectric tube just prior to release of the armature of the sensitive relay. Thereafter, the wedge is adjusted until the material and block read an intensity equal to twice the value measured for producing release of the relay for the case in which the time interval to be controlled coincides with the half-life of the material, or the wedge is adjusted until an intensity reading is obtained which corresponds, for example, to the value *e*2′ in the case in which a 30 day time delay is desired.

It will be understood that in some cases the radiated energy received from the particle may fluctuate over short periods of time and it may be necessary in such cases to employ large enough quantities of the material to prevent premature release of the sensitive relay.

Stated briefly in summary, the present invention contemplates the provision of a time measuring apparatus and method comprising a control circuit including means arranged to be maintained in operation as long as a predetermined amount of radiated energy is received from a particle of radioactive material and wherein the radiated energy received from the particle is initially adjusted to such a value which by the known decay of radiation of the particle will have become decreased to the amount just sufficient to maintain operation of the control circuit at the expiration of a period of time to be measured by the timing apparatus.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. The method of measuring a predetermined period of time by the decay of radiation of a mass of radioactive material having a known rate of decay which comprises the steps of subjecting a device operable in response to a predetermined amount of radiated energy to the energy emitted from the mass, adjusting the amount of radiated energy received from the mass to said predetermined amount required for operation of the device at the end of the period of time to be measured, measuring the intensity of said adjusted amount of energy, and thereafter readjusting the energy received from the mass to an amount having an intensity which by the known rate of decay of radiation of the mass will have decreased to said measured intensity at the end of said period of time.

2. The method of operating a timing device during a period of time to be measured thereby under control of the radiated energy received from a mass of radioactive material having a known decay of radiation which comprises the steps of adjusting the amount of energy received from the mass to an amount just sufficient to maintain operation of the device, and thereafter re-adjusting the amount of energy received from the mass to an amount which by the known decay of radiation thereof will have decreased to said initially adjusted amount at the end of said period of time.

3. A time measuring device comprising a sensitive relay adapted to be maintained in operation until the operating current thereto is decreased below a predetermined value, a particle of radioactive material having a known decay of radiation, a photoelectric tube arranged in energy receiving relation to said particle, a circuit including said relay and said photoelectric tube whereby said relay is operated until the intensity of the radiated energy received by the tube from the particle has decreased below a predetermined value corresponding to said predetermined operating current, and means for adjusting the energy received from the particle at the beginning of an interval to be measured by said device to an amount which by the known decay of radiation of the particle will be reduced to said predetermined value of received energy at the end of said interval.

4. A time measuring device of the character disclosed comprising a particle of radioactive material having a known decay of radiation, a photoelectric tube arranged in energy receiving relation with respect to said particle, a sensitive relay, a source of electrical energy, a circuit having said photoelectric tube, said source and said relay in series therewith, said photoelectric tube adapted to energize said relay from said source under control of the radiated energy received by the tube from the particle, and a radiated energy absorbing mass interposed between said tube and said radioactive particle to limit the radiated energy received therefrom by said tube at the beginning of an interval to be timed by the device to an amount which will be decreased by the rate of decay of radiation of the particle to an amount insufficient to maintain operation of the relay at the end of a predetermined period of time.

5. A time measuring device of the character disclosed comprising a particle of radioactive material having a known rate of decay of radiation, means arranged in energy receiving relation with respect to said particle and adapted to pass a current therethrough proportional to

the amount of radiated energy received thereby, a relay adapted to be operated until the current thereto is decreased below a predetermined value, a source of electrical energy, a circuit having said current passing means, said relay and said source in series therewith whereby said relay is operated from said source until the radiated energy received by said means has decayed to a predetermined value corresponding to said predetermined current value, and a radiated energy absorbing means for limiting the radiated energy received therefrom by said current passing means at the beginning of an interval to be timed by the device to an amount which will be decreased by the known decay of radiation of the particle to said predetermined value of received energy at the termination of said predetermined interval of time.

6. A time measuring device of the character disclosed comprising, a particle of radioactive material having a known rate of decay, a control circuit including a source of electrical energy, a relay and means arranged in energy receiving relation with respect to said particle and adapted to maintain operation of said relay until the radiated energy received thereby from said particle has decayed to a predetermined value, and means including a radiated energy absorbent element adjustable at will for limiting the radiated energy received by said energy receiving means at the beginning of an interval to be timed by the device to an amount which will be decreased by the known decay of radiation of the particle to said predetermined value of received energy at the termination of said predetermined interval.

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