

## Description

The present invention relates to nuclear densometers, and more particularly, to an apparatus for processing data to obtain a fast response to changes in the density of a fluid.

5 The prior art has developed digitally processed data for nuclear densometers, as illustrated by U.S. Patent No. 3,657,532. As set forth in that Patent, digital systems allow the incorporation of extremely reliable, inexpensive and compact integrated circuits and can be used to develop digital pulse counting techniques. However, in the prior art, there remains a substantially long time response to a change in density in the fluid sample being tested and as a consequence, a considerable volume of incorrect density  
10 fluid may be passed through the system for use before a correction in the density can be detected or made.

US 3551672 discloses apparatus for monitoring the flow rate of a substance in a conduit and for triggering an alarm should the flow rate fall below a predetermined value. The apparatus monitors pulses derived from emissions by radioactive materials which are passed through the conduit, and discriminates  
15 between different rates of occurrence of pulses by comparing the interval between successive pulses to a predetermined but variable interval and providing electrical pulses, "down pulses", corresponding to radiation pulses occurring at intervals greater than the predetermined interval and electrical pulses, "up pulses", occurring at intervals less than the predetermined interval. These up pulses and down pulses may be utilised, for example, to give an indication of a rate of radioactive emission or to actuate an alarm or  
20 control.

In oil well cementing operations, the density of the cementing slurry is an important factor. The bore hole cementing fluid typically is a slurry of chemical constituents mixed with water and has a certain density. Should the composition of the slurry mixture change during the pumping operation, the density obviously changes and a change in mixture can affect the desired results in the cementing operation. For  
25 that reason, it is desirable to be able to quickly sense changes in density, i.e. changes in the mixture and to be able to provide a correction to the mixture before a large volume of incorrect mixture is introduced into the system.

Similarly, in fracturing of wells, monitoring of the density of the fracturing fluid is desirable.

We have now devised an apparatus serving to obtain a relatively quick response time to a change of  
30 density of a fluid, for example in a cementing or fracturing fluid system, so that the fluid may be continuously monitored and corrected, if necessary, to obtain a consistent density for the fluid mixture.

Embodiments of the present invention involve sensing the density of a fluid by providing statistical count signals which are proportional to density and processing the count signals so that significant changes in density produce a quick response and indication of such change and so that statistical variations in the  
35 count signals are suppressed.

In embodiments of the present invention count signals are processed by a circuit means which has one or more fixed differential threshold detection levels so that the magnitude of the detected signals must exceed the fixed differential threshold level for a period of time.

Also in embodiments of the present invention, count signals are processed by a computer to determine  
40 a relationship. When the count signals over a time period indicate a significant change in density an indication of such change is developed by using both a large and a small weighting factor. For random changes in density an indication is developed with a small weighting factor normally. The computer processes the count signals to ascertain the magnitude and duration of any changes in the count signal and upon meeting pre-set criteria produces an indication of the change.

45 The present invention provides a nuclear densometer comprising a radioactive source, detector for detecting radiation produced by said source and set up for generating electrical pulses in response thereto, threshold and amplifying means coupled to the detector, and signal modifying means coupled to the threshold and amplifying means and set up for reducing the pulse rate, and for generating a count rate signal, characterised in that, the signal modifying means have a predetermined dead time for reducing the  
50 pulse rate and in that the densometer further comprises processor means coupled to the signal modifying means and set up for generating a modified count rate value from the count rate signal, a previously stored modified count rate value and a weighting factor, for generating a density value of the fluid from the modified count rate value, for increasing the weighting factor if significant changes of density occur for a sufficient period of time, for setting a small weighting factor if no significant changes of density occur, and  
55 for storing the modified count rate value, and in that recording means are coupled to the processor means for recording the density value of the fluid.

An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic block diagram illustrating an embodiment of the present invention;

Figure 2 is a graph illustrating density with respect to counting rate;

Figure 3 is a schematic illustration of the flow chart for use with the microprocessor to process the data for obtaining fast response times and indications to changes in densities.

Referring now to Figure 1, a housing 10 is mounted on a tubular pipe with a bore 12 through which a well cementing fluid 13 is caused to flow between cementing tanks or trucks (not shown) and a well bore to be cemented (not shown). A source of radiation 14 is located on one side of the bore 12 and, on an opposite side, a radiation detector 15 is located. The radiation provided by the source 14 is a constant intensity over a long period of time (random intensity over a finite period) of gamma ray emissions. The gamma rays are transmitted through the material surrounding the bore 12, the slurry of cement 13 within the bore and to the detector 15. The detector 15 may be, for example, a crystal of sodium or cesium iodide (thallium activated) or other material capable of scintillating under irradiation and may include an electron photo multiplier tube for converting light flashes of the scintillation of the crystal into an electrical pulse. As will be apparent, the only variable with respect to density between the source 14 and detector 15 is the cement slurry 13. A percentage of the gamma rays emitted by the source 14 are absorbed or attenuated by the cement slurry 13 and do not reach the detector 15. Thus the counting rate of the output signal from the photo multiplier tube of the detector 15 is similarly related to the density of cement slurry 13 through which the rays must pass to reach the crystal in the detector 15 and the intensity of the source 14.

The detector 15 is powered by a high voltage power supply 16 and the output signals from the detector 15 are supplied to a comparator circuit 17. The comparator circuit 17 eliminates extraneous noise signals below a selected amplitude level determined by a reference level set by potentiometer 17A, and amplifies the output signals which are passed through the circuit. The output of the comparator circuit 17 represents count pulses above the threshold level set by the comparator 17.

The output signals from the comparator 17 are applied to a one-shot 20 which linearizes the relationship of the comparator output as shown by the sloped line 19 in Figure 2. Because of the dead time of the one-shot 20, the output frequency of one shot 20 is reduced more at the higher counting rates than at the low counting rates. The output of the one-shot 20 is supplied to a counter register 25 and the counter register 25 outputs to a computer 26. The computer may be a ZYLOG 16 Bit microprocessor. The counter register 25 is keyed by a clock 28 to systematically and regularly process the counts in the register 25 to the computer 26. The computer 26, upon processing of the data, provides an output to a recorder 27.

Before detailing the present invention in respect to processing of data by the computer 26, some background information may be helpful to an understanding of the present invention.

The number of pulses detected by the detector 15 may be shown to be:

$$N = S r_1 \quad (1)$$

Where N is the number of pulses counted during a time period S for randomly generated pulses from a detector and where the counting rate  $r_1$  is related to the density of material.

For a fluid material having a given density, the following relationship exists:

$$N = K I e^{-\alpha t} \quad (2)$$

Where N is the number of pulses detected; K is a constant;  $I e^{-\alpha t}$  is the activity of the source at time "t" for a decay factor  $\alpha$ .

The intensity I may also be stated to be:

$$I = I_k e^{-K/D(u/D)} \quad (3)$$

Where  $u/D$  is the mass absorption coefficient of the substance of the bore,  $I_k$  is the radiation intensity at the detector with the bore empty, K is a constant dependent upon the width of the bore and D equals the density of the fluid material.

Rewriting equation 3 gives the following:

$$\frac{I}{I_k} = e^{-K/D(u/D)} \dots \dots \dots (4)$$

A plot of the counting rate versus density is illustrated by the curve 18 in Figure 2.

In the operation of the present invention, the detected counts are processed by the one shot 20 which produces a responsive output count signal to the count register 25 and to the computer 26 on a periodic basis. So long as the density of the slurry is constant, as shown by the vertical line 28 in Figure 2, the count rate signal is processed using a relatively small factor ( $\frac{1}{32}$ ). However, if there is a large change in density, a large weighting factor ( $\frac{1}{4}$ ) is used to process the count rate signal. The computer 26 samples the accumulated count signals each tenth of a second and develops a smoothing variable or weighting factor. The smoothing variable or weighting factor is a function of the density of the slurry and if large changes of density occur for a sufficient period of time, then the smoothing variable or weighting factor is changed to provide an indication of the change in density.

Specifically, the computer 26 is programmed to determine the following:

$$\rho_{s,n} = \rho_{s,n-1} + \frac{1}{\tau} (\rho_{r,n} - \rho_{s,n-1}) \quad (5)$$

where

$\rho_{s,n}$  =  $n^{\text{th}}$  smoothed point value of sampled count rate data

$\rho_{r,n}$  =  $n^{\text{th}}$  raw data point value of current count rate data

$\frac{1}{\tau}$  = a weighting factor with one of two values dependent upon the following factors:

1.  $\tau = 4$  if the absolute value of the difference between a new count rate and an old count rate average is equal to, or greater than,  $1/128$  of the old count rate average value for ten times in succession without a change in sign.

2. If  $\tau$  is not 4, then the value of  $\tau$  is set to 32.

If the raw count rate data is being processed for the first time, then a program step 44 sets a prior smoothed value " $\rho_{s,n-1}$ " as equal to the raw count rate data value and the sign (SIGN<sub>1</sub>) is set by a program step 45.

The difference "S" between the smoothed value and the raw data value is determined by a program step 46 where

$$S = \rho_{r,n} - \rho_{s,n-1}$$

and

a) if this value exceeds zero (0), the program step 47 maintains the sign positive and the absolute of the difference "S" is compared to the value of

$$\frac{1}{128} \rho_{s,n-1}$$

in program step 30;

b) if the difference value "S" is less than or equal to zero (0), the program step 48 changes the sign to negative and the absolute of the difference "S" is compared to the value of

$$\frac{1}{128} \rho_{s,n-1}$$

in program step 30.

In the program, to initialize the program the sign is set to "1" (a positive value) in step 45 and in step 43, the program is set equal to zero (0) for the first time processing of data.

The service request step 41 is initiated by a clock 49 set to initiate requests at 0.1 second intervals.

In the program, if ten successive samples of accumulated count signals of the data  $[\rho_{r,n} - \rho_{s,n-1}]$  are equal to or greater than  $1/128 \rho_{s,n-1}$  and the sign (positive or negative) does not change, then the weighting factor is set to a value of  $\frac{1}{4}$  in equation 5 which produces a faster indication of the change in density.

The weighting factor is set equal to  $\frac{1}{32}$  for any sample period when the output signal is indicative that no significant changes of density are occurring.

As shown in Figure 3, the program for the computer 26 provides a fast response to changes in density.

In the program the basis of the determination of a large change in density is upon a determination of the absolute value of "S" relative to a predetermined relationship which is expressed;

(1)

$$|S| = > \frac{1}{128} \rho_{s,n-1} \text{ or } |\rho_{r,n} - \rho_{s,n-1}| = > \frac{1}{128} \rho_{s,n-1}$$

5 where

$\rho_{r,n}$  is the raw data value of count rate

$\rho_{s,n-1}$  is the old smoothed data value of count rate preceding an nth raw data value

This determination as shown in the program step 30 of the flow chart.

(2) If the absolute value of  $|\rho_{r,n} - \rho_{s,n-1}|$  exceeds, or is equal to,

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$$\frac{1}{128} \rho_{s,n-1}$$

15 or "yes", then the program follows to an "exclusive or" gate 31 which determines the sign (positive or negative) of the absolute value. If the sign of the absolute value is the same as the sign of the immediately preceding absolute value ("yes") then the counter 32 value is incremented by one ( $N = N + 1$ ) which counts the number of successive times of this occurrence without a change of sign (positive or negative) occurring. If the sign does not change, and the counter 32 value (N) is equal to ten  
20 (10) or greater, then this determination by the program step 33 ("yes") sets a weighting factor ( $\frac{1}{7}$ ) to ( $\frac{1}{4}$ ) in the program step 34. If the sign changes, or S is less than

$$\frac{1}{128} \rho_{s,n-1}$$

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then N is set to zero (0) in 35 and the weighting value is also set equal to ( $\frac{1}{32}$ ) in a program step 36.

(3) The program utilizes either the weighting factor of  $\frac{1}{4}$  or  $\frac{1}{32}$  as the case may be, sets  $SIGN_2$  equal to  $SIGN_1$  (positive or negative) at step 37 and determines the new smoothed value at step 38 by the relationship

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$$\rho_{s,n} = \rho_{s,n-1} + \frac{1}{7} (\rho_{r,n} - \rho_{s,n-1})$$

where

$\rho_{s,n}$  = the new smoothed value

35  $\rho_{s,n-1}$  = the old smoothed value

$\rho_{r,n}$  = the new raw data value

The new or updated smoothed value  $\rho_{s,n}$  is curve fitted to the count rate curve 18 (See Fig 2). when this is complete then the result is converted to a density representation prior to display on the recorder supplied to recorder circuitry and also recycled in the program to the output of point 39. The program is in a loop at  
40 step 40 until a service request occurs at program step 41, the raw data (count rate value) is loaded into the program by the program step 42. Upon loading of the raw data, the program step 43 determines if the raw data is appearing for the first time in the program.

### Claims

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1. A nuclear densometer comprising a radioactive source (14), detector (15) for detecting radiation produced by said source and set up for generating electrical pulses in response thereto,

threshold and amplifying means (17) coupled to the detector, and

50 signal modifying means (20) coupled to the threshold and amplifying means and set up for reducing the pulse rate and for generating a count rate signal,

characterised in that,

the signal modifying means have a predetermined dead time for reducing the pulse rate and in that the densometer further comprises

55 processor means (26) coupled to the signal modifying means (20) and set up for generating a modified count rate value from the count rate signal, a previously stored modified count rate value and a weighting factor, for generating a density value of the fluid from the modified count rate value, for increasing the weighting factor if significant changes of density occur for a sufficient period of time, for setting a small weighting factor if no significant changes of density occur, and for storing the modified



$$|S| = > \frac{1}{128} \rho_{s,n-1} \text{ or } |\rho_{r,n} - \rho_{s,n-1}| = > \frac{1}{128} \rho_{s,n-1}$$

5 where

$\rho_{r,n}$  is the raw data value of count rate

$\rho_{s,n-1}$  is the old smoothed data value of count rate preceding an nth raw data value

This determination as shown in the program step 30 of the flow chart.

10 (2) If the absolute value of  $|\rho_{r,n} - \rho_{s,n-1}|$  exceeds, or is equal to,

$$\frac{1}{128} \rho_{s,n-1}$$

15 or "yes", then the program follows to an "exclusive or" gate 31 which determines the sign (positive or negative) of the absolute value. If the sign of the absolute value is the same as the sign of the immediately preceding absolute value ("yes") then the counter 32 value is incremented by one ( $N = N + 1$ ) which counts the number of successive times of this occurrence without a change of sign (positive or negative) occurring. If the sign does not change, and the counter 32 value (N) is equal to ten (10) or greater, then this determination by the program step 33 ("yes") sets a weighting factor ( $\frac{1}{4}$ ) to ( $\frac{1}{32}$ ) in the program step 34. If the sign changes, or S is less than

$$\frac{1}{128} \rho_{s,n-1}$$

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then N is set to zero (0) in 35 and the weighting value is also set equal to ( $\frac{1}{32}$ ) in a program step 36.

(3) The program utilizes either the weighting factor of  $\frac{1}{4}$  or  $\frac{1}{32}$  as the case may be, sets  $SIGN_2$  equal to  $SIGN_1$  (positive or negative) at step 37 and determines the new smoothed value at step 38 by the relationship

30

$$\rho_{s,n} = \rho_{s,n-1} + \frac{1}{7} (\rho_{r,n} - \rho_{s,n-1})$$

where

$\rho_{s,n}$  = the new smoothed value

35  $\rho_{s,n-1}$  = the old smoothed value

$\rho_{r,n}$  = the new raw data value

The new or updated smoothed value  $\rho_{s,n}$  is curve fitted to the count rate curve 18 (See Fig 2). when this is complete then the result is converted to a density representation prior to display on the recorder supplied to recorder circuitry and also recycled in the program to the output of point 39. The program is in a loop at step 40 until a service request occurs at program step 41, the raw data (count rate value) is loaded into the program by the program step 42. Upon loading of the raw data, the program step 43 determines if the raw data is appearing for the first time in the program.

## Claims

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1. A nuclear densometer comprising a radioactive source (14), detector (15) for detecting radiation produced by said source and set up for generating electrical pulses in response thereto, threshold and amplifying means (17) coupled to the detector, and signal modifying means (20) coupled to the threshold and amplifying means and set up for reducing the pulse rate and for generating a count rate signal, characterised in that, the signal modifying means have a predetermined dead time for reducing the pulse rate and in that the densometer further comprises processor means (26) coupled to the signal modifying means (20) and set up for generating a modified count rate value from the count rate signal, a previously stored modified count rate value and a weighting factor, for generating a density value of the fluid from the modified count rate value, for increasing the weighting factor if significant changes of density occur for a sufficient period of time, for setting a small weighting factor if no significant changes of density occur, and for storing the modified

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count rate value, and in that

recording means are coupled to the processor means for recording the density value of the fluid.

2. A nuclear densometer according to claim 1, further including:

counter means (25) coupled to the signal modifying means (20) and to the processor means (26).

3. A nuclear densometer according to claim 1 or 2, further including:

clock means (28), coupled to the counter means (25) and to the processor means (26), generating a clock signal of predetermined frequency.

4. A nuclear densometer according to claim 1, 2 or 3, wherein:

the processor means (26) are set up for determining the absolute value of a difference value S, where the difference value S is equal to the previously stored modified count rate value subtracted from the count rate signal and for setting the weighting factor at a relatively high value when

a) the absolute value of the difference value S is greater than or equal to the product of a predetermined scaling factor and the previously stored modified count rate value,

b) condition (a) is satisfied for a predetermined time period, and

c) the sign of the difference value S is unchanged for the pre-determined time period, the processor means otherwise setting the weighting factor at a relatively low value.

5. A nuclear densometer according to claim 4, wherein:

the processor means (26) are set up for determining the modified count rate signal from the relationship

$$\rho_{S,n} = \rho_{S,n-1} + \frac{S}{T}$$

where  $\rho_{S,n}$  is the modified count rate signal,

$\rho_{S,n-1}$  is the previously stored modified count rate value,

S is the difference value, and

$\frac{1}{T}$  is the weighting factor.

6. A nuclear densometer according to claim 4, wherein:

the relatively low value is  $\frac{1}{32}$  and the relatively high value is  $\frac{1}{4}$ .

7. A nuclear densometer according to any of claims 4 to 6, wherein:

the predetermined time period is equal to the duration of 10 cycles of the clock signal.

8. A nuclear densometer according to any of claims 3 to 7, wherein:

the predetermined frequency of the clock signal is such that the counter means (25) generates a count rate signal every 0.1 seconds.

9. A nuclear densometer according to any of claims 4 to 8, wherein:

the predetermined scaling factor is 1/128.

#### Revendications

1. Un densitomètre nucléaire comprenant une source radioactive (14), un détecteur (15) de radiation produite par ladite source et agencés pour engendrer des impulsions électriques en réponse à celle-ci, des moyens à seuil et d'amplification (17) couplés au détecteur, et des moyens de modification de signal (20) couplés aux moyens à seuil et d'amplification et agencés pour réduire la cadence des impulsions et pour engendrer un signal de comptage de cadence, caractérisé en ce que les moyens de modification de signal ont un temps mort prédéterminé pour réduire la cadence d'impulsions en ce que le densitomètre comprend en outre des moyens de traitement (26) couplés aux moyens de modification de signal (20) et agencés pour engendrer une valeur de comptage de cadence modifiée à partir du signal de comptage d'impulsions d'une valeur de comptage de cadence modifiée mémorisée précédemment et d'un facteur de pondération, pour engendrer une valeur de densité de fluide à partir de la valeur de comptage modifiée, augmenter le facteur de pondération si des changements de densité significatifs se produisent pour une période de temps suffisante, établir un facteur de pondération faible



si aucun changement de densité significatif ne se produit, et mémoriser la valeur de comptage de cadence modifiée, et en ce que des moyens d'enregistrement sont reliés aux moyens de traitement pour enregistrer la valeur de la densité du fluide.

2. Un densitomètre nucléaire selon la revendication 1, comprenant en outre : des moyens de comptage (25) couplés aux moyens de modification de signal (20) et aux moyens de traitement (26)
3. Un densitomètre nucléaire selon les revendications 1 ou 2, comprenant en outre : des moyens à horloge (28) couplés aux moyens de comptage (25) et aux moyens de traitement (26), engendrant un signal d'horloge de fréquence prédéterminée.
4. Un densitomètre nucléaire selon les revendications 1, 2 ou 3, dans lequel : les moyens de traitement (26) sont agencés pour déterminer la valeur absolue de la différence S, la différence S étant égale au signal de comptage de cadence diminué de la valeur de cadence précédemment mémorisée, et pour établir le facteur de pondération à une valeur relativement élevée lorsque:
  - a) la valeur absolue de la différence S est supérieure ou égale au produit d'un facteur d'échelle prédéterminé par la valeur de comptage de cadence modifiée précédemment mémorisée,
  - b) la condition a) est satisfaite pour une période de temps prédéterminée, et
  - c) le signe de la différence S n'est pas modifié pendant la période de temps prédéterminée, les moyens de traitement affectant sinon une valeur relativement faible au facteur de pondération.
5. Un densitomètre nucléaire selon la revendication 4, dans lequel les moyens de traitement (26) sont agencés pour déterminer le signal de comptage de cadence modifié à partir de la relation
 
$$\rho_{S,n} = \rho_{S,n-1} + \frac{S}{T}$$

où  $\rho_{S,n}$  est le signal de comptage de cadence modifié.

$\rho_{S,n-1}$  est la valeur de comptage de cadence modifié précédemment mémorisé.

S est la valeur de la différence  $\frac{1}{T}$  et est le facteur de pondération.
6. Un densitomètre nucléaire selon la revendication 4, dans lequel : la valeur relativement faible est 1/32, et la valeur relativement élevée est 1/4.
7. Un densitomètre nucléaire selon l'une quelconque des revendications 4 à 6, dans lequel : la période de temps prédéterminée est égale à la durée de 10 cycles d'horloge.
8. Un densitomètre nucléaire selon l'une quelconque des revendications 3 à 7, dans lequel : la fréquence prédéterminée du signal d'horloge est telle que les moyens de comptage (25) engendrent un signal de comptage de cadence toutes les 0.1 secondes.
9. Un densitomètre nucléaire selon l'une quelconque des revendications 4 à 8, dans lequel : le facteur d'échelle prédéterminé est 1/128.

#### Patentansprüche

1. Nuklearstrahlungsdensitometer enthaltend
  - eine radioaktive Strahlungsquelle (14),
  - einen Detektor (15), der die von der Strahlungsquelle erzeugte Strahlung erfaßt und zur Erzeugung von elektrischen Impulsen beim Ansprechen auf die Strahlung eingerichtet ist,
  - an den Detektor angeschlossene Schwellwert- und Verstärkermittel (17), und
  - an die Schwellwert- und Verstärkermittel angeschlossene Signalumformmittel (20), die zur Verringerung der Pulsrate und zur Erzeugung eines Zählratensignals eingerichtet sind,



dadurch gekennzeichnet, daß die Signalumformmittel eine vorgegebene Totzeit zur Verringerung der Pulsrate haben,

- 5 daß das Densitometer weiterhin an die Signalumformmittel angeschlossene Verarbeitungsmittel (26) aufweist, die zur Erzeugung eines modifizierten Wertes der Zählrate aus dem Zählratensignal, einem vorher gespeicherten modifizierten Wert der Zählrate und einem Gewichtungsfaktor, zur Erzeugung eines Dichtewertes des Fluids aus dem modifizierten Wert der Zählrate, zur Vergrößerung des Gewichtungsfaktors, wenn über eine ausreichende Länge der Zeit signifikante Dichteänderungen  
10 auftreten, zur Einstellung eines kleinen Gewichtungsfaktors, wenn keine signifikanten Dichteänderungen auftreten, und zur Speicherung des modifizierten Wertes der Zählrate eingerichtet sind, und

daß mit den Verarbeitungsmitteln Aufzeichnungsmittel zur Aufzeichnung des Dichtewertes des Fluids verbunden sind.

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2. Nuklearstrahlungsdensitometer nach Anspruch 1, gekennzeichnet durch mit den Signalumformmitteln (20) und den Verarbeitungsmitteln (26) verbundene Zählermittel (25).

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3. Nuklearstrahlungsdensitometer nach Anspruch 1 oder 2, gekennzeichnet durch mit den Zählermitteln (25) und den Verarbeitungsmitteln (26) verbundene Taktgebermittel (28) zur Erzeugung eines Taktsignals einer vorgegebenen Frequenz.

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4. Nuklearstrahlungsdensitometer nach Anspruch 1, 2 oder 3, dadurch gekennzeichnet, daß die Verarbeitungsmittel (26) zur Bestimmung des Absolutwertes eines Differenzwertes S, der gleich dem von dem Zählratensignal abgezogenen, vorher gespeicherten modifizierten Wert der Zählrate ist, und zum Einstellen eines relativ hohen Wertes des Gewichtungsfaktors eingerichtet ist, wenn

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- (a) der Absolutwert des Differenzwertes S größer als oder gleich dem Produkt aus einem vorgegebenen Normierungsfaktor und dem vorher gespeicherten modifizierten Wert der Zählrate ist,  
(b) die Bedingung (a) innerhalb eines vorgegebenen Zeitabschnittes erfüllt ist, und  
(c) das Vorzeichen des Differenzwertes S über den vorgegebenen Zeitabschnitt unverändert ist, und  
daß die Verarbeitungsmittel den Gewichtungsfaktor sonst auf einen relativ niedrigen Wert einstellen.

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5. Nuklearstrahlungsdensitometer nach Anspruch 4, dadurch gekennzeichnet, daß die Verarbeitungsmittel (26) zur Bestimmung des modifizierten Wertes der Zählrate aus der Beziehung

$$p_{s,n} = p_{s,n-1} + \frac{S}{T}$$

eingerichtet sind, worin

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$p_{s,n}$  das modifizierte Zählratensignal,

$p_{s,n-1}$  der vorher gespeicherte modifizierte Wert der Zählrate,

S der Differenzwert und

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$\frac{1}{T}$  der Gewichtungsfaktor ist.

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6. Nuklearstrahlungsdensitometer nach Anspruch 4, dadurch gekennzeichnet, daß der relativ niedrige Werte  $\frac{1}{32}$  und der relativ hohe Wert  $\frac{1}{4}$  ist.

7. Nuklearstrahlungsdensitometer nach einem der Ansprüche 4 bis 6, dadurch gekennzeichnet, daß der vorgegebene Zeitabschnitt gleich der Dauer von 10 Takten des Taktsignals ist.

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8. Nuklearstrahlungsdensitometer nach einem der Ansprüche 3 bis 7, dadurch gekennzeichnet, daß die vorgegebene Frequenz des Taktsignals so ist, daß die Zählermittel (25) alle 0,1 Sekunden ein Zählratensignal erzeugen.

9. Nuklearstrahlungsdensitometer nach einem der Ansprüche 4 bis 8, dadurch gekennzeichnet, daß der



vorgegebene Normierungsfaktor

$$\frac{1}{128}$$

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ist.

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