

[72] Inventors Tetsuji Kobayashi
Yokohama-shi;
Takayanagi Seiichi, Tokyo, both of, Japan
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[73] Assignee Tokyo Shibaura Electric Co., Ltd.
Kawasaki-shi, Japan

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Primary Examiner—Anton O. Oechsle

Assistant Examiner—Marvin Siskind

Attorney—Stephen H. Frishauf

[54] **RADIATION DETECTOR FOR INSERTION INTO A BLOOD VESSEL**
10 Claims, 9 Drawing Figs.

[52] U.S. Cl. 128/2.05 F,
73/194 E, 250/43.5 MR, 250/83 R
[51] Int. Cl. A61b 5/02
[50] Field of Search 128/2, 2.05,
2.05 D, 2.05 F, 2.05 M, 2.05 P, 2.05 T, 2.1,
250/43.5 FC, 106 T, 83, 83.3

ABSTRACT: A radiation detector for medical use to be inserted into the blood vessel is provided with a blood channel disposed in parallel with the blood flow. A semiconductor element is placed in the blood channel to detect the radiations from the radioisotope introduced into the blood vessel, with the radiation-receiving face thereof exposed to the interior of the blood channel.

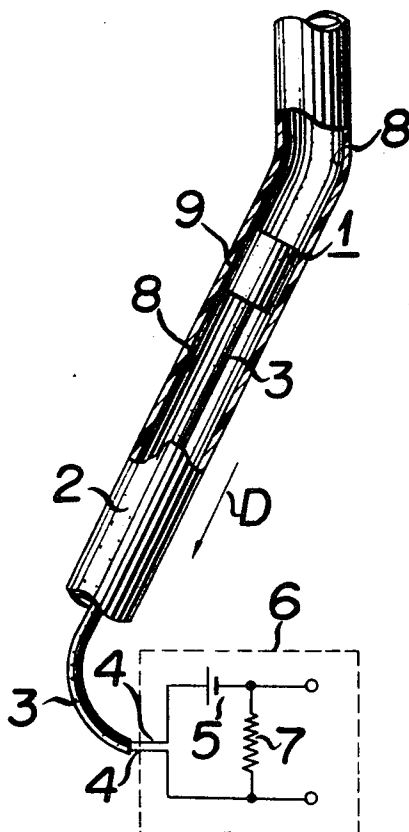


FIG. 1

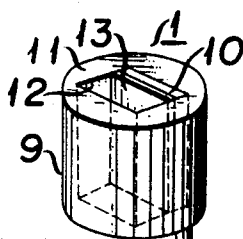
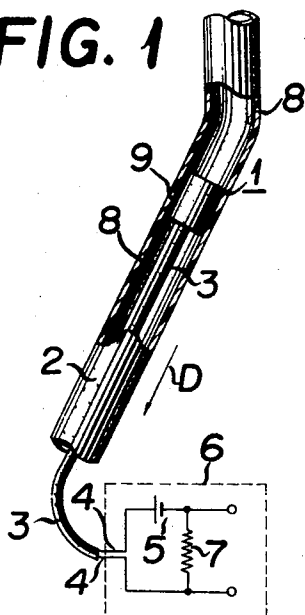


FIG. 2

FIG. 3

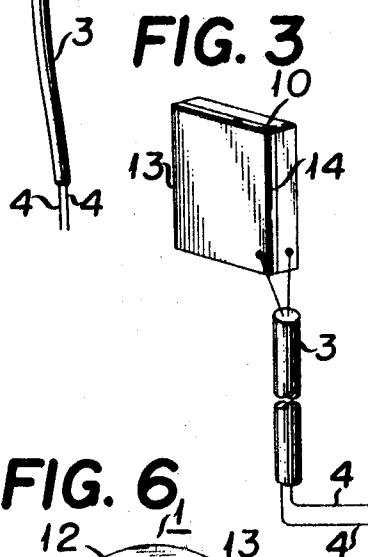


FIG. 4A

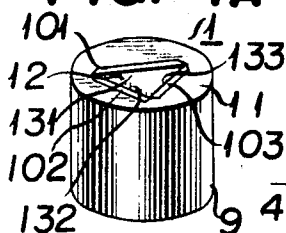


FIG. 4B

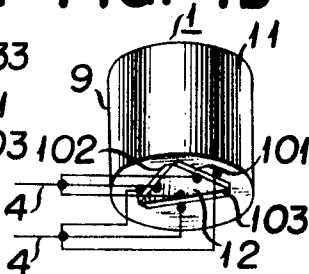


FIG. 6

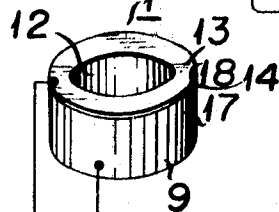


FIG. 7

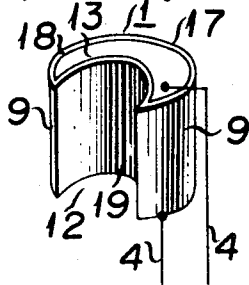


FIG. 5

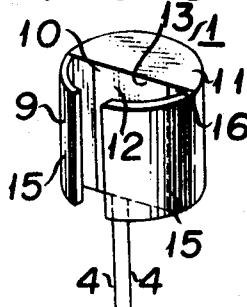
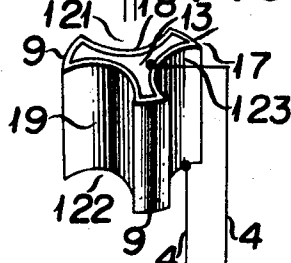


FIG. 8



BY *Tetsuji KOBAYASHI*
Seiichi TAKAYANGI,
 INVENTORS

by *Robert A. Trish*
Attorney

RADIATION DETECTOR FOR INSERTION INTO A BLOOD VESSEL

BACKGROUND OF THE INVENTION

The present invention relates to an apparatus for detecting the radiations emitted from the radioisotopes purposely introduced into the blood of a living body by being fixedly inserted into the prescribed position of the blood vessel.

In recent years, due to advance in nuclear medicine, approaches have been made to the diagnosis of the functions of various organs contained in a living body by introducing in advance into the interior thereof appropriate doses of radioisotopes harmless to the living body, and measuring the radiations from said radioisotopes by means of a radiation detector located at the prescribed position within the living body. Among these methods there is one which comprises introducing radioisotopes into the blood and determining the radiations therefrom within the blood vessel.

Detailed description will now be given of this procedure. First, radioisotopes of, for example, iodine, potassium and krypton are purposely taken into the blood vessel from an appropriate part of the living body, and the radiations from the radioisotope carried along with the blood is determined by a radiation detector disposed at a point within the blood vessel spaced from the place where said radioisotope is initially introduced. These determinations are used in checking the evidence of abnormal developments in the function of organs such as the heart and liver by ascertaining the speed and condition of blood circulation and the extent of absorption in the living body of the radioisotope thus introduced. What is the most important in such diagnosis is the accurate and definite measurement of the radiations present in the blood vessel. If mere detection of the evidence of radiations is all that is required, then it may be contemplated to use the Geiger-Muller counter (GM counter) as commonly called. However, this device requires a high operating voltage of 300 to 400 v., that it is not only incapable of being substantially miniaturized but also of short life, thus presenting extreme difficulties in inserting it into the blood vessel of the living body.

For the foregoing reason, use has begun to be made of a compact semiconductor radiation detector requiring only a low-operating voltage. This semiconductor device is characterized in that it is compact and rigid and only requires as low an operating voltage as about 10 to 30 v. or less, so that it is seemed to be a very excellent radiation detector for medical use. However, unlike other purposes, the medical application for which the present invention is intended dictates that the semiconductor radiation detector to be used in the blood vessel, be of as compact construction as possible, extremely sensitive to radiations and also be free from appreciably disturbing the blood circulation when inserted into the blood vessel. However, mere miniaturization of the semiconductor detector will not serve the purpose, because the close attachment of the inner wall of the blood vessel to the outer circumferential surface of the detector causes the natural blood flow to be obstructed and delayed. In other words, the volume of the detector itself gives rise to an unnatural blood flow in the vessel, eventually presenting difficulties in final diagnosis. In some cases, the insertion of such detector may completely block the blood flow, exposing life to substantial danger. The smaller the inner diameter of the blood vessel thus affected, the more prominent will be this tendency. Furthermore, unless aided by any appropriate additional device, mere miniaturization of the prior art semiconductor detector would only serve to reduce the radiation-sensitive area, i.e., the sensitive face where radiations are to be detected, with the resultant degradation of detecting efficiency. Due to the aforementioned unsolved problems, the commonly used radiation detector has been incapable of offering satisfactory performance when inserted into the blood vessel just as it is produced.

SUMMARY OF THE INVENTION

It is accordingly an object of the present invention to provide a radiation detector for medical use which, when inserted into the blood vessel, is not likely to disturb or block the blood circulation.

Another object of the present invention is to offer a radiation detector for medical use which will not affect the blood flow, even when it is inserted into a relatively narrow blood vessel to cause part of the outer circumferential surface thereof to be closely attached to the inner wall of the blood vessel.

A further object of the present invention is to offer a radiation detector for medical use which displays a sufficient detecting efficiency, even though it may be miniaturized as far as possible.

These and other objects and advantages of the present invention will be more fully understood by reference to the following detailed description of certain preferred embodiments thereof in connection with which reference may be had to the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the condition in which the radiation detector of the present invention is disposed in the blood vessel;

FIG. 2 is a slantwise perspective of the radiation detector for medical use according to one embodiment of the present invention;

FIG. 3 is a particularly enlarged slantwise view of the semiconductor element used in the radiation detector of FIG. 2;

FIGS. 4A and 4B are slantwise perspective views of the radiation detector according to another embodiment of the present invention, FIG. 4A mainly illustrating the upper side and FIG. 4B the lower side; and

FIGS. 5 to 8 respectively show slantwise views of the radiation detectors according to other embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the accompanying drawings, more particularly to FIG. 1, the apparatus 1 of the present invention is placed in the prescribed blood vessel 2 of a living body by being fitted to the end of a catheter-type guide cord 3, which comprises a conductor covered with insulation or enclosed in an insulating tube. While, in this case, the living body may represent that of either a human being or animal, the following description will solely deal with the human being by way of simplification of explanation. The blood vessel 2 is, for example, a venous tube in the arm or an arterial tube near the inlet to the liver, the inner diameter of these tubes being about 2 to 3 mm. Radioisotopes such as ^{32}P and ^{35}K are introduced from other blood vessels connected to said blood vessel 2. These radioisotopes are carried through the blood vessel 2 along with the blood. While they are passing therethrough, their radiations are determined by the radiation detector 1 for medical use positioned therein, the circumferential wall 9 of which is generally close or in contact with the inner wall 8 of the blood vessel 2. As described later, the radiation detector 1 is provided with a radiation-sensitive area comprising a semiconductor element, so that the detector can measure the radiations of the radioisotope entering the radiation-sensitive area. Of course, the detector 1 is supplied with bias voltage, and the detection output is taken outside of the living body. For this purpose, the guide cord 3 has coaxial conductors 4, 4 enclosed therein. One end of the guide cord 3 containing these conductors 4, 4 is connected to the semiconductor element and the other end thereof is led outside of the blood vessel 2, namely, the living body. Connected to said other end is a source 5 to supply the conductors with bias voltage. The radiation detection outputs from the detector 1 are presented in the form of voltage variations between the conductors 4-4 or

variations in the current passing through the system. The outputs or variations are measured by an electric output measuring section 6. Thus this output measuring unit is constructed in such a manner that the electric output, for example, from the output resistor 7 connected as shown is measured and indicated by an instrument (not shown) such as an indicator. This arrangement makes it possible to find the time required for the blood flow to run from the place where the radioisotope is initially introduced to the point at which the detector 1 is positioned, namely, the speed of blood circulation, or to ascertain the absorption of the radioisotope in transit through the blood vessel, thus eventually carrying out the diagnosis of the function of the desired organs such as the heart and liver contained in the living body. As previously mentioned, to check the natural condition of the living body, the detector 1 is of such construction as to permit the accurate and definite determination of radiations from the radioisotope introduced therein without disturbing or obstructing the natural blood flow.

The construction of a radiation detection 1 for medical use according to one embodiment of the present invention will now be described by reference to FIG. 2. In the different drawings appended, like parts are denoted by like reference numerals. In FIG. 2, the detector 1 consists of a semiconductor 10 and a supporter (or holder) 11 thereof. The supporter 11 is composed of such material as plastics and the like, and is in a columnar form, about 2 mm. in diameter and 5 mm. high. When inserted into the blood vessel 2 as shown in FIG. 1, the supporter 11 has its outer circumferential surface 9 disposed adjacent to the inner wall 8 of the blood vessel 2. Perforated throughout the inside of the circumferential wall section 9, namely, the central part of the supporter 11 is an opening having a rectangular cross section, the shorter side being about 1 mm. to define a blood channel 12 therein. When the detector is inserted into the blood vessel 2 in a manner to bring the circumferential wall section 9 of the former in contact with the inner wall 8 of the latter, the blood channel 12 is aligned with the lengthwise direction of the blood vessel 2. Said lengthwise direction of the blood vessel 2 substantially corresponds with the direction of blood flow as indicated by the broken line arrow D of FIG. 1. Fitted to a part of the inner wall 8 of the blood vessel 2 surrounding the blood channel 12 of the detector 1 is a semiconductor element 10 in the form of a thin rectangular sheet with its radiation-sensitive area 13 exposed at the top. It will be noted that the radiation-sensitive area 13 as used in this specification means the surface of a semiconductor which is capable of detecting the radiations from the radioisotope introduced into the blood vessel 2. The rectangular dimensions of the semiconductor element are such that the shorter side is about 1 mm. and the longer side is about 3 mm., its thickness being less than 0.2 mm. The semiconductor 10 may consist of silicon, germanium, gallium arsenide, etc. However, since a germanium diode has high magnitude to the reverse saturation current arising from the reverse bias voltage and gallium arsenide is relatively costly, silicon is preferred in practical application. The semiconductor element may be a type having one or more P-N junctions or a nonjunction type of extremely high resistivity with an inherent resistivity of about $10^9 \Omega\text{-cm}$. However, where a P-N junction type semiconductor is used, the P-N junction 14 will be formed in such a manner that it is disposed in parallel with the surface of the semiconductor 10, that is, the radiation-sensitive area 13 thereof. In other words, the P-N junction 14 will be aligned in parallel with the axis of the columnar supporter 11. The exposed portion of said P-N junction 14 will be protected with silicon dioxide film (not shown). The semiconductor 10 itself may be of the mesa type, planar type or other type.

The material of the supporter 11 may be selected suitably in accordance with the type of radiations which it is desired to detect by the detector 1 as a whole. For instance, where the gamma rays are the major radiations requiring detection, the supporter 11 may be composed of metals or synthetic resins. And where it is desired mainly to check the beta rays, the sup-

porter 11 may consist of synthetic resins containing powders of heavy metals such as lead and cadmium.

The bias voltage to be applied on the semiconductor element 10 is generally of the order of less than about 35 volts. The impression of the bias voltage may be carried out by connecting one end of the guide cord 3 containing the coaxial conductors 4-4 to the semiconductor 10 by an ohmic contact. The conductors 4-4 coated with insulation constitute the guide cord 3. The end of said guide cord 3 opposite to that end which contacts the semiconductor 10 is connected to the aforesaid source 5 of bias voltage so as to apply an appropriate degree of bias voltage on the semiconductor 10. Upon such impression, the radiation entering through the radiation-sensitive area 13 cause pairs of electrons and positive holes to be produced within the semiconductor 10 in accordance with the doses of radiations thus introduced, thereby allowing an electric current as a detection output to flow through the conductors 4-4. This detection output appears more prominently when the semiconductor 10 is a P-N junction type than when it is a nonjunction type. The detection output obtained is conducted outside of the blood vessel 2 through the conductors 4-4 and measured by an output measuring section 6.

The guide cord 3 holds the conductors in an electrically insulated relationship with respect to the inner wall of the blood vessel 2 and has an adequate degree of rigidity due to the inclusion of the conductors. Therefore, the cord acts as a guide in introducing the detector 1 into the blood vessel 2 by fitting it to the end of said cord 3.

A description will now be given of the practical operation of the radiation detector 1 for medical use having the aforementioned construction. As shown in FIG. 1, the prescribed blood vessel 2 is partially broken away and a radiation detector 1 is introduced through this part and the guide cord 3 integrally fitted thereto is forced in until the detector 1 reaches an appropriate depth in the blood vessel 2. The semiconductor element 10 of the detector 1 is impressed in advance with bias voltage from a bias voltage source 5. Then radioisotopes are taken into the blood vessel 2 at a point spaced from the place where the detector is positioned. Needless to say, the blood streams run through the blood vessel 2 at a pressure of about 90 to 100 mm. Hg. However, since the detector 1 of the present invention has a blood channel 12 perforated throughout in parallel with the blood vessel 2, namely, in the direction of blood circulation, this permits the blood to flow through the channel 12 freely without any interruption even though the outer circumferential surface 9 of the detector 1 may closely touch the inner wall 8 of the blood vessel 2. While the inner diameter of the blood channel 12 is slightly smaller than the original diameter of the blood vessel 2, the blood flows under pressure as described above, so that it runs through said blood channel 12 under almost natural conditions without being obstructed, provided the channel 12 is perforated with a certain diameter in the form of an opening penetrating throughout the detector in parallel with the blood flow.

Thus when a radioisotope carried along with this natural blood flow reaches the detector 1, the radiation-sensitive area 13 of the semiconductor 10 thereof disposed along the lengthwise direction of the blood vessel 2 definitely detects radiations from the radioisotope. While the most prominent characteristic of the apparatus according to the present invention is the provision of a blood channel 12 in the detector 1 itself, the additional advantage is that the radiation-sensitive area 13 of the semiconductor element 10 positioned in parallel with the lengthwise direction of the blood vessel 2 offers an extremely high detecting efficiency. The inventors conducted experiments varying the angles which the radiation-sensitive area 13 of the semiconductor 10 bears to the blood flow. As a result it has been confirmed that a parallel arrangement of the radiation-sensitive area 13 with the blood flow, namely, the lengthwise direction of the blood vessel 2 offered a maximum detecting efficiency. For example, this arrangement increased the detecting efficiency more than about 10 times over the

case where the radiation-sensitive area 13 was disposed perpendicular to the lengthwise direction of the blood vessel 2. While the reason for this result still remains to be seen, it may be explained by assuming that the parallel arrangement of the radiation-sensitive area 13 with the lengthwise direction of the blood vessel 2 will help to extend the area of said area contacting the blood and/or the duration of such contact. In either case, the advantage is that the parallel disposition will considerably elevate the detecting efficiency, even though the semiconductor element 10 and consequently the radiation-sensitive area 13 may be reduced in size.

The aforementioned radiation-sensitive area 13, i.e., the surface of the semiconductor element 10 is shown as coming in direct contact with the blood. However, the radiation-sensitive area 13 may be coated with a thin radiation-permeable film, for example, a mica sheet to effect indirect contact with the blood through such sheet. It is to be understood, therefore, that while the radiation-sensitive area 13 as used in this specification, of course, means the surface of the semiconductor element 10 as described above, it also includes the surface coated with a radiation-permeable substance.

Another embodiment of the present invention which has further increased the radiation detecting efficiency will now be described by reference to FIG. 4. As previously noted, the same parts of FIG. 4 as those of FIG. 2 are denoted by the same numerals. The radiation detector 1 illustrated in FIG. 4 is characterized in that the inside of the outer circumferential wall section 9 of the supporter 11 is penetrated by a blood channel opening 12 having a triangular cross section and that the inner wall of each of the three sides of the channel 12 is fitted with the components 101, 102 and 103, which respectively correspond to semiconductor elements 10. In other words, the blood channel 12 is formed in a manner to be surrounded by the radiation-sensitive areas 131, 132 and 133 of the aforementioned components 101, 102 and 103. Of course, connected to the semiconductor components 101, 102 and 103 are conductors 4-4-4 in a manner as shown in FIG. 4B so as to apply the prescribed bias voltage on each of the components. As in the preceding embodiments, the radiation detector 1 thus constructed is inserted into the blood vessel 2 by being fitted to one end of the guide cord 3 containing the triple conductor 4-4-4 to supply bias voltage. Then the blood flows freely through the blood channel 12, though the outer circumferential wall section 9 of the supporter 11 may be tightly attached to the inner wall 8 of the blood vessel 2 and at the same time radiations from the radioisotope carried along with the blood are detected by the aforementioned semiconductor three components 101, 102 and 103. Experiments show that this embodiment displayed such good performance as offering a detecting efficiency more than twice as high as that of the type of detector shown in FIG. 2.

The blood channel 12 involved in each of the embodiments so far described is perforated in the form of a circumferentially continuous opening. As shown in FIG. 5, however, this channel may be formed in a partially broken away type. The detector 1 of this figure will now be described. The detector 1 similarly consists of a semiconductor element 10 and a supporter 11, and the blood channel 12 is formed from curved platelike protuberances 15 projecting integrally from the supporter 11. First fitted to a flat surface 16 of the columnar supporter 11 having a semicircular cross section is a semiconductor element 10 with the radiation-sensitive area 13 thereof disposed on the surface. The integrally from both ends of the supporter 11 there are projected a pair of curved platelike protuberances 15-15. These protuberances enclose the radiation-sensitive area 13, so that when the semiconductor assembly is inserted into the blood vessel 2, the radiation-sensitive area 13 thereof is prevented from directly contacting the inner wall 8 of the blood vessel 2. Defined by the surface of the radiation-sensitive area 13 and the inner walls of the protuberances 15-15 projecting from the supporter 11 is a blood channel 12 in the axial direction of the supporter 11. Between the ends of the protuberances 15-15 there is formed

a gap. However, when the entire detector 1 is inserted into the blood vessel 2, the circumferential surface 9 of the supporter 11 is contacted with the inner wall 8 of the blood vessel 2 to have this gap plugged therewith. Thus essentially, the partially broken away blood channel 12 constitutes a circumferentially continuous penetrating opening, thereby allowing the blood to flow therethrough without any difficulties. As in the preceding embodiments, the semiconductor element 10 is connected to one end of the guide cord 3 containing conductor 4-4. When the semiconductor assembly is inserted into the blood vessel 2 the radiation-sensitive area 13 thereof is disposed in parallel with the lengthwise direction of the blood vessel 2 as is the case with the foregoing embodiments.

Reference is now made to FIGS. 6, 7 and 8. These Figures respectively represent the embodiments wherein the radiation detector 1 consists of a semiconductor element alone without a supporter and a blood channel 12 is provided within the semiconductor element itself. The detector 1 of FIG. 6 will first be described. A semiconductor element body 17 about 3 mm. in outer diameter and 2 mm. high is fabricated by processing a P-type single crystal silicon wafer by supersonic or other machining means. Perforated throughout the central part of the semiconductor element body 17 is a circular opening 12 about 1 mm. in inner diameter. When, after ordinary chemical treatment of the semiconductor body 17, an N-type layer 18 is formed at least on the top of the semiconductor body 17 by diffusing, for example, phosphorus, then there will be created a P-N junction 14. The upper surface of the N-type layer 18 is used as the radiation-sensitive area 13 to receive radiations from the radioisotope introduced. The exposed part of the P-N junction 14 is protected by a silicon dioxide film (not shown). The aforementioned circular opening 12 is disposed inside of the circumferential wall section 9 of the semiconductor element body 17 to constitute a blood channel 12. Connected to the P-type body 17 and the N-type layer 18 of the semiconductor element respectively are conductors 4-4 by ohmic contact. The coaxial extensions of these conductors 4-4 are inserted into the guide cord 3, which concurrently acts as a guide in introducing the radiation detector into the blood vessel 2. The external contour of the semiconductor element body is not always required to be cylindrical. The detector of the aforesaid construction is used in a relatively fine blood vessel 2. Even though the outer circumferential wall section 9 of the semiconductor element body 17 is closely attached to the inner wall 8 of the blood vessel 2. The blood is allowed to run freely through the aforesaid blood channel 12, a penetrating opening perforated inside of said circumferential wall section 9 of the semiconductor element body itself. Where the detector of FIG. 6 is actually inserted into the blood vessel 2, it is preferably disposed in such a manner that the circumferential wall section 9 is placed along the inner wall 8 of the blood vessel 2 and that the blood flowing toward the detector first directly contact the radiation-sensitive area 13. Thus the blood first touches the radiation-sensitive area 13, allowing the radiations from the radioisotope carried along with the blood to be detected immediately. After passing through the blood channel 12, the blood flow continues its course as quickly as before in the direction of the blood flow. In this case, the radiation-sensitive area 13 is disposed perpendicular to the lengthwise direction of the blood vessel so that the radiation detecting efficiency is slightly lower than in the foregoing embodiments. However, the radiation detector according to the embodiment of FIG. 6 has excellent directivity, because its radiation-sensitive area 13 is positioned at the foremost end and so is thus capable of checking the incident direction of the radiations.

If a semiconductor element is an extremely small columnar body less than about 2 mm. in diameter, it will sometimes be difficult to perforate a hole throughout the central part thereof. The only requirement in such case would be, as shown in FIGS. 7 and 8, to cut out a part of the semiconductor element body throughout the entire length inwardly from the circumferential wall section, and use the resultant cavity or

cavities as a blood channel. More concretely, some portions of the inside of the circumferential wall section of the P-type columnar silicon semiconductor element body 17 are broken away to form a grooved blood channel or channels 12 in such a manner that the upper and lower surfaces of the semiconductor element body 17 thus cut have a flat crescent plane or a combination thereof as illustrated in FIG. 8. Next the top surface of the semiconductor element body 17 is coated with an oxide film of silicon dioxide, and this film, except that on the circumferential edge section, is removed in the following step. Then phosphorus is diffused by a known process through all the inner surface of the circumferential edge section to form a junction of planar-type construction, using the surface thereof as a radiation-sensitive area 13. With the P-N junction as a border line, conductors 4-4 are connected to the P-type and N-type regions respectively of the semiconductor element body 17. The impression of bias voltage on these conductors 4-4 radioisotope the withdrawal of detection outputs therefrom are carried out mechanical the same manner as in the preceding embodiments. When the detector 1 thus constructed is inserted into the blood vessel 2 by means of a guide cord 3 as shown in FIG. 1 the blood will flow through a grooved blood channel 12 perforated inside of the outer circumferential wall section 9 of the semiconductor element body 17, so that the natural blood streams will not interrupted. The radiation-sensitive area 13 formed in the aforementioned manner detects radiations from the radioisotope introduced into the blood vessel 2. For increasing the mechanical strength of the semiconductor element body 17, it is permissible to coat the outer circumferential wall section 9 thereof with reinforcing material or to fit the semiconductor element body 17 itself tightly into a cylindrical metal sleeve. Also the plane of P-N junctions, namely, the radiation-sensitive area 13 may be located on the arched inner surface 19 of the grooved blood channel 12.

FIG. 8 illustrates a semiconductor radiation detector wherein grooved blood channels 12 are formed by cutting out three parts of the inside of the circumferential wall section of the semiconductor element body 17 contacting the inner wall of the blood vessel. The parts of the detector shown in FIG. 8 which corresponds to those of the foregoing figures are denoted by the same reference numerals and a detailed description thereof is omitted here. The increased blood channels 121-123 as illustrated in FIG. 8 will ensure the freer flow of the blood through the detector assembly. Thus when the detector is inserted into the blood vessel 2 as shown in FIG. 1, the blood will flow through the three blood channels 121, 122 and 123, thus allowing the blood to flow in a more natural condition than is possible with the foregoing embodiments. In this case, too, the detection of radiations is effected by the radiation-sensitive area 13. However, if said face 13 is provided on the inner surface 19 of each of the three blood channels 121, 122 and 123, then the detecting efficiency will be more improved.

As described above, the radiation detector of the present invention enables the radiations from the radioisotope introduced into the blood vessel to be determined accurately without interrupting the blood flow due to the provision of a blood channel having a certain cross-sectional area, even when the detector is inserted into a relatively narrow blood vessel. Since the parallel arrangement of a radiation-sensitive area with the lengthwise direction of the blood vessel offers a higher detecting efficiency, the detector can be considerably reduced in size by using a small semiconductor element.

It will be evident from the foregoing description that many modifications and variations are feasible in the light of the aforementioned techniques.

We claim:

1. A radiation detector for medical use adapted to be inserted into a blood vessel comprising: a guide cord including

conductors enclosed therein; a source of bias voltage coupled to said conductors; a detection member coupled to said guide cord and having

an outer circumferential wall section and
a blood channel formed in said wall section extending in a direction longitudinally of said member and substantially parallel with the lengthwise direction of the blood vessel into which said detection member is adapted to be inserted,

whereby, upon insertion of said member into a blood vessel, blood may flow through said blood channel,

said detection member including a semiconductor element coupled to said bias voltage via said conductors and having a radiation-sensitive area, said semiconductor element being disposed such that said radiation-sensitive area directly contacts with blood flowing through said blood channel, the radiation emitted from the blood flowing through said blood channel being detected by said semiconductor element.

2. A radiation detector according to claim 1 wherein said semiconductor element has P-N junction and said radiation-sensitive area is disposed adjacent to and along a surface of said semiconductor element.

3. A radiation detector for medical use according to claim 2 wherein the surface of the radiation-sensitive area is positioned substantially in parallel with the lengthwise direction of said blood channel, and directly contacts blood flowing through said blood channel.

4. A radiation detector according to claim 1 wherein the outer surface of the wall section of said detection member is dimensioned to contact the inner wall of the blood vessel into which it is adapted to be inserted.

5. A radiation detector according to claim 1 wherein said detection member includes a support member having said blood channel formed therein and wherein said semiconductor element is disposed within said blood channel and is supported by said support member so that said radiation-sensitive area directly contacts blood flowing through said blood channel.

6. A radiation detector according to claim 5 wherein said semiconductor element comprises a rectangular thin semiconductor element having a P-N junction formed substantially adjacent to and in parallel with the surface thereof, the radiation-sensitive area of said semiconductor element being the surface thereof parallel to said P-N junction, said semiconductor element being positioned so that said radiation-sensitive area is substantially in parallel with the lengthwise direction of said blood channel.

7. A radiation detector according to claim 1 wherein the outer circumferential wall section of said detection member is formed by said semiconductor element and said blood channel is formed in the semiconductor element itself, the outer surface of said wall section being dimensioned to contact the inner wall of the blood vessel into which said detection member is adapted to be inserted.

8. A radiation detector according to claim 7 wherein said radiation-sensitive area is disposed substantially perpendicular to the lengthwise direction of said blood channel and directly contacts blood flowing through said blood channel.

9. A radiation detector for medical use according to claim 7 wherein said blood channel is a grooved channel formed by cutting out a part of the semiconductor element body inwardly from the outer circumferential wall section thereof, said radiation-sensitive area comprising the surface of the semiconductor element body disposed adjacent to and in parallel with the P-N junction formed therein.

10. A radiation detector according to claim 9 wherein said radiation-sensitive area is disposed substantially perpendicular to the lengthwise direction of said blood channel and directly contacts blood flowing through said blood channel.