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IONIZATION CHAMBER HAVING AN AIR EQUIVALENT WALL OF BERYLLIUM ALLOY

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U.S. Cl. 313—93 7 Claims

ABSTRACT OF THE DISCLOSURE

An ionization chamber is disclosed in which a gaseous atmosphere of air is employed. The outer chamber wall is formed of an alloy of beryllium. The wall is air equivalent and of such a thickness as to absorb substantially the same amount of radiation as does the tissue which protects the crystalline lens of the human eye.

This application is a continuation of copending application Ser. No. 590,535, filed Oct. 31, 1966 now abandoned.

This invention relates to ionization chambers and especially to ionization instruments of the class of "pocket dosimeters," namely pen-type dosimeters, condenser-meters and all similar pocket-size monitoring devices which are worn by radiation workers and serve to determine radiation dosages received by such persons.

The object of the invention is to provide an ionization chamber in which the absorption of β, γ and X radiations is in close and well-defined relation to the absorption of said radiations by body tissues so that the biological effect of radiation on the wearer of the instrument may thus be determined, said ionization chamber being insensitive to neutrons.

The condition last mentioned implies that the atmosphere of the chamber is constituted by elements having a low thermal-neutron and fast-neutron capture cross-section and excluding hydrogen. The easiest solution evidently consists in utilizing air in which the coefficient R of response to β, γ and X radiations with respect to human body tissues (said coefficient being defined as the ratio of energy absorbed per unit volume in the atmosphere of the ion chamber to the energy absorbed in the body tissues) is 0.92 ± 0.02 (and varies slightly as a function of the energy of the photons).

It is also known that those parts of the human body which are most sensitive to radiation are not the superficial areas but, in the case of the body as a whole, the crystalline lens of the eye and, in the case of the skin tissues, the basal layer of the epidermis. Consequently, in order that the chamber should constitute a detector having a correct biological effect, it will prove necessary to ensure that the chamber wall has an absorption of the same order as that of the tissues which protect the sensitive parts of the body. This in turn makes it necessary to fabricate this wall of a material having a response coefficient R which is not too far removed from one unit. It is also preferable to ensure that said response coefficient R is of the same order as that of the atmosphere. Moreover, should it be found desirable to eliminate the influence of neutrons, the wall must in that case be composed only of elements which have a low neutron capture cross-section.

The object of this invention is to provide an inonization chamber which meets the above requirements. Accordingly, the invention proposes an inonization chamber in which the gaseous atmosphere employed is air and in which the chamber wall is formed of an alloy of beryllium with at least one of the elements of the group constituted by aluminum, magnesium and silicon, said alloy being of nuclear purity in the elements which have a high atomic number and the proportion of beryllium being such that the coefficient of response of the wall to β radiation and to γ and X photons is substantially identical with the coefficient of response of the air.

Inasmuch as said coefficient of response is of the order of 0.90, it then becomes relatively easy to produce a detector having a correct biological effect by endowing the wall with a thickness which is slightly greater than that which protects the most sensitive parts of the human body.

In order to achieve this equivalence with a generally sufficient approximation, the following alloys can be employed:

Be-Al containing between 1 and 89% by weight of Be;
Be-Mg containing between 77 and 85% by weight of Be;
Be-Si containing between 84 and 92% by weight of Be;
Be-Alpax containing between 81 and 89% by weight of Be.

By way of example, four specific compositions which are contemplated for the purpose of endowing the constituent material of the wall with a satisfactory response will now be defined, it being understood that the percentage contents of said material may differ slightly from those indicated (to within approximately $\pm 0.5\%$) without thereby producing any marked modification of properties.

In the case of all these alloys, the effect of the addition element or elements is to increase the coefficient of response to photons which, in the case of high-purity beryllium, increases from 0.01 to 0.82 when the energy of the photons received increases, and to stabilize said coefficient at a mean value in the range of energy which corresponds to hard X-radiations and γ radiations.

EXAMPLE 1

	Percent by weight
Beryllium	85
Aluminum	15

This alloy has a response coefficient with respect to body tissues of $R = 0.90 \pm 0.05$. The coefficient varies slightly about the mean value of 0.90, depending especially on the energy of the photons.

EXAMPLE 2

	Percent by weight
Beryllium	81
Magnesium	19

This alloy has a response coefficient of 0.90 ± 0.04.

EXAMPLE 3

	Percent by weight
Beryllium	88
Silicon	12

This alloy has a response coefficient of 0.90 ± 0.06.

EXAMPLE 4

	Percent by weight
Beryllium	85.35
Alpax	14.65

It is known that Alpax is a casting alloy which contains 88.3% aluminum and 11.7% silicon. This alloy has the advantage of being readily melted and therefore facilitates production of beryllium-base alloy. The composition of said alloy will be:

	Percent by weight
Beryllium	85.35
Aluminum	13.25
Silicon	1.40

The response coefficient of this alloy is 0.90±0.05.

It is of course possible to mix the alloys hereinabove defined in practicaly all proportions. Among these alloys, the composition given in Example 4 appears to be the most advantageous whilst the alloy of Example 3 appears on the contrary to be the least satisfactory.

It should naturally be borne in mind that the compositions given above only ensure the response coefficient which is indicated on condition that the constituents are of nuclear purity. In the event that beryllium and above all the material with which beryllium is alloyed were to introduce even a low percentage of impurities (such as, for example, iron, beryllium oxide and the like), it would in that case prove advisable to take this addition of impurities into account by modifying the composition to a slight extent. Moreover, it always remains necessary to avoid the presence in the alloy of an amount of elements having high atomic numbers sufficient to result in distortion of the response, i.e., nuclear purity insofar as these elements are concerned must be maintained.

The alloys which have been defined above can be employed for the purpose of forming, for example, the walls of pen-type dosimeters of the type described in section 3.1 of Chapter C VII, vol. 1 of the "Cours de Genie Atomique" (Nuclear Engineering Course published by the I.N.S.T.N., Saclay, France, 1960;) in this case, the alloys must be fabricated in the form of tubes having an internal diameter of approxmiately one centimeter and a thickness of approximately one millimeter. This fabrication process can be carried out especially by powder metallurgy, recourse being had to conventional methods.

It should be noted that the problem of toxicity of fine particles which is created by beryllium of high purity is reduced to a considerable extent by all of the above-mentioned alloys owing to the presence of the addition element.

It is apparent that the invention is not limited to the modes of execution which have been described in the foregoing solely by way of example and that the scope of this patent extends to all alternative forms which remain within the scope of equivalent means.

We claim:

1. An ionization chamber in which the gaseous atmosphere employed is air and in which the outer chamber wall is formed of an electrically conductive alloy of beryllium with at least one of the elements selected from the group consisting of aluminum, magnesium and silicon, said alloy being of nuclear purity in elements having a high atomic number and the proportion of beryllium being such that the coefficient of response per mass unit of the wall alloy to beta radiation and to gamma and X photons is substantially constant and identical with the coefficient of response of the air and the thickness of said wall being such that its absorption is substantially equal to that of the tissues which protect the crystalline lens of the human eye.

2. An ionization chamber according to claim 1, wherein the chamber wall is formed of an alloy of beryllium and Alpax containing between 81 and 89% by weight of beryllium.

3. An ionization chamber in accordance with claim 1, wherein the chamber wall is formed of an alloy of beryllium and aluminum containing 85%±0.5% by weight of beryllium.

4. An ionization chamber in accordance with claim 1, wherein the chamber wall is formed of an alloy of beryllium and magnesium containing 81%±0.5% by weight of beryllium.

5. An ionization chamber in accordance with claim 1, wherein the chamber wall is formed of an alloy of beryllium and silicon containing 88%±0.5% by weight of beryllium.

6. An ionization chamber in accordance with claim 1, wherein the chamber wall is formed of an alloy of beryllium and Alpax containing approximately 85.35% by weight of beryllium.

7. An ionization chamber in which the gas atmosphere is air and in which the outer chamber wall is formed of an electrically conductive alloy selected from the group consisting of an alloy of beryllium and aluminum containing between 81 and 89% by weight of beryllium, an alloy of beryllium and magensium containing between 77 and 84% by weight of beryllium and an alloy of beryllium and silicon containing between 84 and 92% by weight of beryllium, the thickness of said wall being such that its absorption of beta radiation and of gamma and X-ray photons is substantially equal to that of the tissues which protect the crystalline lens of the human eye.

References Cited

UNITED STATES PATENTS

2,193,364	3/1940	Adamoli	75—150
2,573,999	11/1951	Victoreen	250—83.6
2,639,389	5/1953	Landsverk	250—83.3
3,067,331	12/1962	Hess et al.	250—83.3
3,334,997	8/1967	Caillet et al.	75—150

FOREIGN PATENTS

256,679 3/1963 Australia.

OTHER REFERENCES

McKinney: "New Beryllium Sheet Offers Greater Ductility, Ease of Fabrication," Publicity Dept., Harris D. Kiney, Inc. BRL 6418 February 1965.

Sawyer et al.: "Beryllium and Some of Its Aluminum Alloys," Metals and Alloys, June 1940.

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