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PNEUMATIC RADIATOR OF TRANSITION RADIATION FOR LARGE WORKING AREA ARRANGEMENTS.*

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ԱՆՑՈՒՄԱՅԻՆ ՃԱՌԱԳԱՅԹՄԱՆ ՌԱԴԻԱՏՈՐ ՄԵԾ ԱՇԽԱՏԱՆՔԱՅԻՆ ՄԱԿԵՐԵՍՈՎ ՍԱՐՔԱՎՈՐՈՒՄՆԵՐԻ ՀԱՄԱՐ

Առաջարկված է անցումային ճառագայթման պարբերական ռադիատորի պատրաստման ոչ-ավանդական եղանակ, մեծ աշխատանքային մակերեսով՝ հիմնված հերմետիկ պարկերի խուրձի կիրառման վրա, որոնցում ստեղծվում են հելիումի առաձգական շերտերը։ Պատրաստված է ~1 մ^2 մակերեսով այդպիսի ռադիատորի փորձնական օրինակը՝ գործունեության առաջարկված սկզբունքի ստուգման համար։

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I. Introduction

For the amplification of X-ray transition radiation (XTR) effect it is required to construct multi-module sets of radiators containing thousands of heterogeneities and small quantity of material. The theory of XTR was originally developed for nonuniform media having strictly regular structure. As such, a stack of plane-parallel plates of "a" thickness with "b" spacing in vacuum was considered, the real characteristic dimension being $a \simeq (15 \div 30) \mu m$ and $b \lesssim 1mm$. Such a structure of radiation amplifiers did not much foster the development of XTR, as the formation of radiators of this design with the above parameters "a" and "b" for wide-aperture XTR detectors was a rather difficult problem.

The situation changed when first in the Yerevan Physics Institute the transition radiation generated in an inhomogeneous medium,- the foam plastic having chaotic distribution of pores-was detected [1,2].The theory of this effect soon followed [3]. The authors of ref. [2] believed, that the results of Ref. [1] would allow one to solve the expedient then problem of XTR radiators of desired form, area and thickness, especially as the experimental yield was sufficiently high and the theory maintained [3] that the irregular radiators could be even more efficient than the regular ones depending on the radiation frequency and the Lorentz factor of the particle. However, more accurate examinations of this problem show that, in general, the number of quanta in the frequency range essential for radiation detection decreases with the increase in the irregularity of the medium. Though at the first glance this decrease, which is estimated to be in all $(10 \div 20)\%$, seems not so great, in transition radiation detectors (TRD) with high rejection factor it can lead to tenfold reduction of resolution. That is presumably why in most experiments the preference is given to regular laminated radiators. The cross dimensions of TRD constructed up to now are not so great and one can consider them to be either small [4] or moderately large [5].

At present some new huge designs of TRD are developed for installation on supercolliders. The design of integrated TRD of the LHC [6] is a successful example of such project. Beside that, at different stages of realization are neutrino projects with fixed target WA96(NOMAD) at SPS [7] and GINES at UNK [8]. In both cases the effective area of TRD is $\sim 10m^2$. While in [6] the plastic foam radiator is preferred due to its structural stiffness and 4π geometry, in [7] a polypropylene laminar radiator is built [9].

The scales of new arrangements require original solutions to the problem of laminated radiators. In the present work we discuss an example of such an approach to the design of GINES setup radiators.

II. Strictly regular pneumatic XTR radiator.

The largest laminar radiator constructed to this date is the radiator of NA31 setup [5], where hundreds of films were stretched in eight directions with the help of springs on heavy frames. The gap between the laminations was set by thermal embossing made using special equipment. Nearly similar design was used for the WA96 arrangement radiator [7]. In both cases some artificial heterogeneities were introduced between the laminations to fight against the electrostatic forces.

One can avoid this problem, which is the main problem of large regular radiators by using an active type of radiators, in which the laminations are interleaved with elastic layers of gas. This eliminates the need for strong and heavy fit-out.

The design of new radiator is shown in Fig. 1. It consists of a pack of sealed polypropylene bags, which are simultaneously pumped up in parallel with helium under definite pressure. Two sides of adjacent bags make one lamination of the radiator and so $a=2d$, where d is the film thickness.

Besides the outer ones the pressure in all the bags reciprocally compensate making flat surfaces separated by "b" gaps. The excess of pressure in outer bags could be compensated by different means, depending on the type of XTR registrar. In case of MWPC it may be a buffer volume for mating the radiator and the detector [4,5]. In other cases the radiator could be prepared as a separate volume as shown in Fig.1, where the excess of pressure is compensated by a network of nylon strings stretched with 10cm steps on marginal frames. Thin sheets (~5mm) of foam plastic provide plain bordering and at the same time serve as radiators. To avoid relative displacement of bags in idle position, they are glued in some points to each other. When necessary, the surface network could be connected through the bags without deterioration of the sealing. At the excess pressure of $P \approx 0.1$Bar the force acting on the surface of $(3 \times 3)m^2$ plastic foam as a whole is ~100H and on a single string it is about 2H. The radiator is brought into an operating condition in short time by pumping helium to each bag from the common pipeline through individual connecting pieces. The gas exhaust system is of analogous design. In order that all the bags were filled evenly and independently, the pressure p_i on the inlets of connecting pieces should be equal, i.e. the pressure drop on the feeding pipeline should be small in comparison to the pressure drop Δp on the connected pieces. In other words the hydrodynamical resistance of connecting pieces should much exceed the resistance of the common pipeline. This condition is easily achieved, as $\Delta p \sim R^{-4} t^{-1}$, where R is the radius of the pipe, t is the filling time of the radiator. The diameters of feeding pieces are to be equal, as $\Delta p_1 / \Delta p_2 \sim (1 \pm 4 \Delta R/R)$ and if, for example, $\Delta R/R = 0.1$, then Δp will change by a factor of 1.4 and as the volume of gas passing through the connecting piece $V \sim \Delta p$, then the filling rate of this bag will be different as much.

After the radiator is brought into an operating state, the flow rate of helium is extremely insignificant and variations of the atmospheric pressure are compensated by an appropriate equipment with an accuracy to several microbar [5]. To eliminate the accumulation of electrostatic charges on the internal walls of the bags, the helium was preliminarily passed through a water humidifier where the concentration of water vapour is some share of one per cent. The gap "b" between the laminations is determined by the number of bags "n" and the distance "l" between the plastic foam sheets; $b=(l/n)-2d$. When necessary, one can promptly change the gap "b" by varying the value of "l". One can easily obtain a configuration with linearly changing "b" by placing the frames at some angles. Besides, the radiator could be easily rolled up into a "barrel" or "semibarrel" for experiments with 4π geometry.

At present we have constructed an operating model of $\sim 1 m^2$ area radiator made of 15μm-thick bags and functioning adequately to the principle described.

III. Conclusions

In this novel design the problem of electrostatic charges is easily solved and, hence, the introduction of heterogeneities between neighboring laminations, which provide the constancy of the gap, is not necessary. Besides, there is no need in strong frames providing the required tension of the films. This greatly reduces the weight of the radiator as well as its insensitive area, that is essential for positioning the TRD within the magnet.

The operation principle and the properties of the radiator in question allow one to define it as a pneumatic radiator with dynamical properties. This design permits the prompt change and even linear variation of the gap. Besides, it is easy to curl it into a "barrel" or "semibarrel" configuration for collider experiments.

This design may find wider applications as it permits one to construct a system consisting of a large number of narrow gaseous spans which could serve as multi-layer narrow gap ionization detectors of particles, and, in particular, of the transition radiation.

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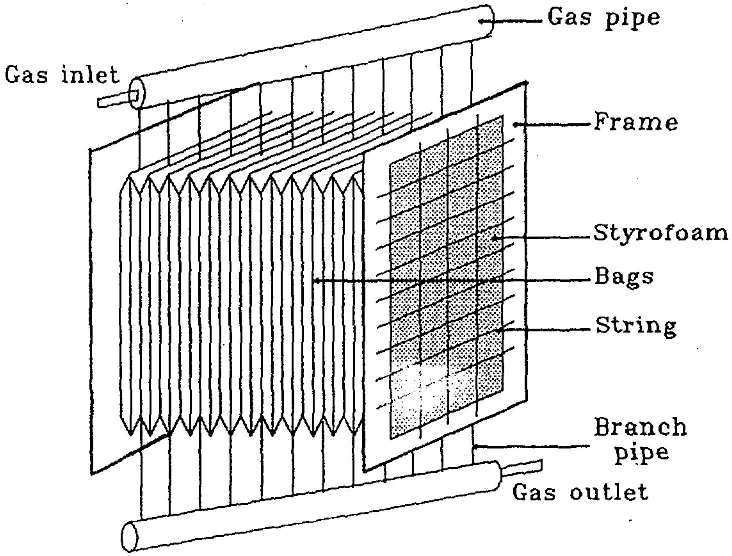

Fig.1

Schematic View of Pneumatic Radiator (unscaled).

Предложен нетрадиционный способ изготовления регулярного радиатора рентгеновского переходного излучения с большой рабочей площадью, основанный на использовании пачки герметичных мешков, в которых создаются упругие слои гелия. Изготовлен опытный образец такого радиатора площадью $\sim 1 м^2$ для проверки предложенного принципа действия.

An unconventional approach to the construction of large area regular radiator of X-rays transition radiation is proposed based on the use of a pack of hermetically sealed bags, in which elastic helium layers are formed. A prototype of such a radiator of about $1 m^2$ area was made for test of the proposed device.

References

1.A.I.Alikhanian et al., Phys.Rev.Lett., 1970, 25, 635.

2.K.K.Shikhliarov, M.P.Lorikian, Patent # 1411630,1970, BI, 17, 1971.

3.G.M.Garibian et al., JETF,66,62,1974, 552.

4.V.A.Andreev et al., Proc. of the Iternational Simposiun on Coordinate Detectors in High Energy Physics, Dubna, 22-25 September 1987, Dubna, 1988, 319.

5.Barr G.D. et al., Preprint CERN-EP/90-62, 1990.

6.V.A.Polychronakos et al., Preprint CERN/DRDC/90-39, 1990.

7.P.Astier et al., Preprint CERN-SPSLC/91-21, 1991.

8.R.O.Avakian et al., Proc. Third workshop "Physics at UNK" Protvino, September 25-28, 1990, p.165

9.H.Pessard; LAPP, Private communication, December 1992.

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ПНЕВМАТИЧЕСКИЙ РАДИАТОР ПЕРЕХОДНОГО ИЗЛУЧЕНИЯ ДЛЯ УСТАНОВОК С БОЛЬШОЙ РАБОЧЕЙ ПЛОЩАДЬЮ

(на английском языке, перевод Папяна Г.А.)

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