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INVESTIGATION OF THE OPERATIONAL STABILITY OF PLASTIC STREAMER TUBES AFTER POLISHING OF THEIR GRAPHITE CATHODE

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In recent times plastic streamer tubes with resistive graphite cathodes [1] have become very popular detectors. However from experience gained it is established that detectors with a large cathode resistivity are rather unstable in operation. This instability shows up as a short counting plateau restricted by the appearance of selfsustaining discharges leading to large increases of dark current.

In previous work [2] this phenomenon was investigated and possible explanations were given. More recent work [3] observed similar behaviour of tubes for a particular method of graphite painting of the cathodes. It should be emphasized that the details of the mechanism of the appearance and development of the selfsustaining discharge aren't clear.

All qualitative explanations of selfsustaining discharges in tubes with resistive cathodes [2-4] are based on the Malter effect [5] which is well known and often mentioned also for the explanation of selfsustaining discharges in normal wire chambers (see, for example references [7,8]). The main idea is that small centers ("bad" points) with too high a resistivity exist on the cathode. Thus, ion charge is accumulated on these centers leading to the emission of electrons from the cathode.

Available data shows that the operational stability of plastic streamer tubes depends not only on the resistivity of the cathode surface but also on the method of making this. One may point out the following aspects which influence the operational stability: kind of plastic [2], kind of resistivity (volume or surface), conductive material, value[3] and uniformity of resistivity, the method of making the cathode surface and any additional treatment, and finally the gas mixture used.

To avoid instabilities several suggestions were already mark. First coverless tubes with small profile resistivity (less or about 10 kΩ/□) may be used as in the experiment UA1 /6/. Secondly the use /4/ of an additional "antistatic" cover on the cathode surface. It is not yet quite clear what the long-term stability of such surfaces may be.

Guided by the idea that instability is connected with some non-uniformity of the graphite painting, leading to the existence of "bad" points, a mechanical polishing of the graphite cathode surfaces has been used for the DELPHI hadron calorimeter /9/. The aim of the present work was to check the effectiveness of this method.

In this investigation streamer tubes (Fig. 1) were used with a cathode resistivity in the range of 50-2000 kOhm/□ . The gas mixture was composed of argon and isobutane in the proportion 1:3. To begin with the cathodes of these tubes were unpolished.

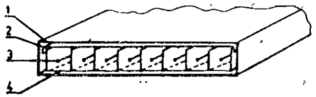


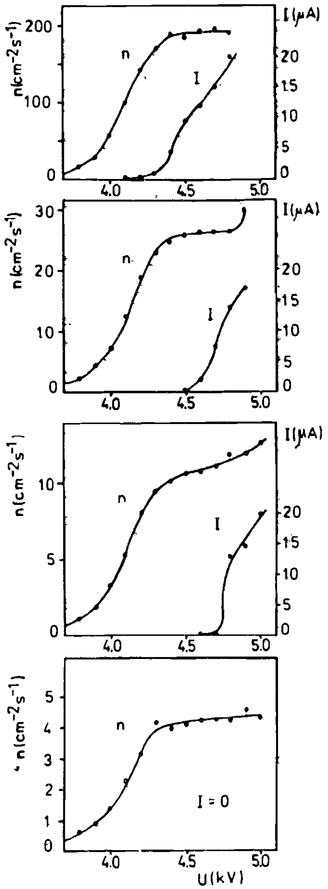
Fig. 1. Sketch of a plastic streamer tube of the DELPHI hadron calorimeter: 1 - container, 2 - cover, 3 - anode wire 80 μm in diameter, 4 - profile.

The "bad" points are easily located by an abrupt increase (by an order of magnitude and more) of the current through a tube upon scanning its surface with a β-source.

It should be emphasized that the notion of a "bad" point is not absolute. Whether some point on a cathode surface of a detector is "bad" or "good" depends on the radiation intensity and the high voltage applied to the detector. In Fig. 2 the behaviour of an unpolished tube operating in the self-quenching streamer mode under the different radiation intensities in the region of a "bad" point is seen. It is evident that the larger the intensity the lower the threshold high voltage for the appearance of a selfsustaining discharge. The current of a selfsustaining discharge has a typical hysteresis behaviour, i.e. after decreasing the high voltage the discharge does not disappear after passing below the point of the discharge threshold. It should be observed that a sharp increase of current hardly influences the counting characteristic, i.e. this current is due to very small pulses which were even impossible to see on the oscilloscope. Similar behaviour was noticed in the paper /2/ in the case of volume resistivity of cathode.

The method of checking the effectiveness of polishing was as follows. "Bad" points had been found by slowly scanning a β-source along the unpolished detectors with a radiation intensity of about 1000 $cm^{-2}s^{-1}$ and a high voltage of 4.7 kV (the knee of the counting curve for the gas mixture is in the region 4.4-4.5 kV). The tubes were then disassembled and the regions of "bad" points (on the profile and the cover) were polished (5-6 moves with suede). The resistivity decreased on average by a factor 1.5-4 and became 50-300 kOhm/□ for profiles and 200-900 kOhm/□ for covers.

It was found that this way of improving the detectors is rather effective: after the assembling of the detectors there was only one "bad" point from 10 "bad" points found initially, and this point disappeared after short (about 5 min) operation



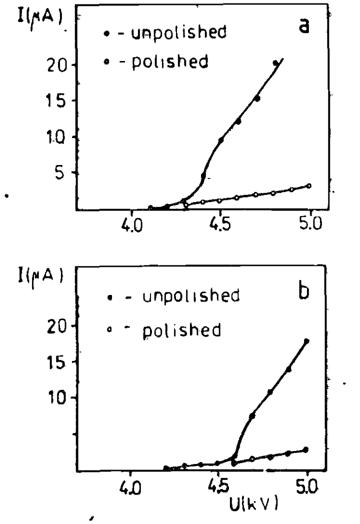


Fig. 3. Currents through the tubes for two typical "bad" points before and after polishing; β - source ^{90}Sr, intensity n ~ 200 cm^{-2}s^{-1}.

Fig. 2. Counting characteristics and currents of unpolished tubes for a typical "bad" point under different radiation intensities; β-source ^{90}Sr, 150 μA threshold, dead time of shaper - 700 ns.

under high voltage on plateau (4.5 kV) and a radiation intensity of about 1000 cm^{-2}s^{-1}. Typical behaviour of the currents through a tube with respect to the high voltage is shown in Fig. 3. It is seen that after polishing the current became small and smooth and compatible with the level of the radiation intensity; hysteresis, of course, is absent.

In practice, of course, it is not reasonable to reassemble tubes after finding "bad" points and polish these points individually. In mass production it is convenient to polish a whole surface of profiles and covers before assembling. It should be noted that the polishing does not change the resistivity critically and the cathode is still transparent for pad readout (Fig. 4). To check the effectiveness of such a procedure the following was done.[9]

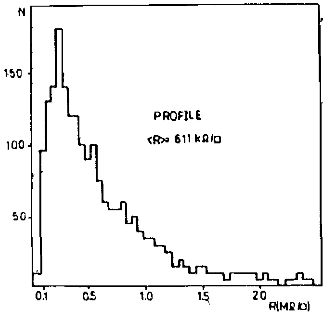


Fig.4. Resistivity distribution of DELPHI streamer tubes cathodes after polishing.

48 tubes 1.6 m long with unpolished profiles and covers was assembled. The high voltage was increased to the operational level and if a tube dark current exceeded 1 μA this tube was considered to be "bad". There were 14 "bad" tubes in this group of tubes.

Next 48 tubes with polished profiles and covers were assembled and tested, only 3 "bad" were found.

It should be noted that the improvement was obtained without any considerable complication of manufacture.

After assembling and testing about 13000 3.6 m long tubes (polished) for the DELPHI hadron calorimeter we rejected less than 5% of them. The tests were carried out with an X-ray source (gas mixture Ar : CO_2 : C_5H_{12} = 1 : 2 : 1, the high voltage being 200 V above the knee of the counting curve, the radiation intensity was about 100 $cm^{-2}s^{-1}$, and the scanning was arranged so as to radiate each point of the surface during 0.1 s).

To summarise we find that the polishing procedure gives a large improvement in operation of plastic streamer tubes with graphite painted cathodes.

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Исследование влияния полировки графитового
катода пластиковых стримерных трубок
на стабильность их работы

Показано, что полировка поверхности графитового катода пластиковых стримерных трубок увеличивает стабильность их работы.

Работа выполнена в Лаборатории ядерных проблем ОИЯИ.

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Investigation of the Operational
Stability of Plastic Streamer Tubes
after Polishing of Their Graphite Cathode

It is shown the polishing of the graphite cathodes of plastic streamer tubes increases their operational stability.

The investigation has been performed at the Laboratory of Nuclear Problems, JINR.

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