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A TRIGGERED LIQUID TRACK CHAMBER WITH
SHORT RESOLVING TIME

G. Charpak *)

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*) On leave from Centre National de la Recherche Scientifique, Paris.

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The principle of a new type of track detector is described in a recent note¹⁾: bubbles of gas are produced in oil by injection through a porous surface^{*)} at the bottom of the oil container, which has transparent walls. An electric field can be applied to the liquid by means of plane electrodes, one of which is transparent (conductive glass or metallic grid). When a charged particle, detected by scintillation counters, traverses the liquid between the electrodes, the voltage is applied to the liquid. Those bubbles which have been ionized by the particle give rise to a discharge limited to the bubble so that all the track is made visible.

With neon bubbles of about 2 mm in paraffin oil one observes bright tracks, visible at several metres from the chamber and easy to photograph (Fig.1. shows typical results). The operation of the chamber has some features in common with that of an ordinary spark chamber^{2,3,4,5)} and of the neon tubes hodoscope⁶⁾.

The applied voltage ranges from a few kV/cm to 30 kV/cm. The brightness of the bubbles is, for a given liquid, mainly a function of the field strength. By making tests with pulses with exponential decay times ranging from 0.5 μ s to 30 μ s we observe first an increase in light output and then, from a value of 2 μ s very little dependence of the pulse width. However, with an oscillating pulse (of frequency 1 Mc/s) we observe an increased intensity. A saturation of the light produced in each bubble is probably reached when the space charge effects cancel the external field.

*) Porous ceramics, porous metallic sheets have been obtained from Electro-physique, 40 rue du Cherche-Midi, Paris.

Steady field or slowly varying field operation

Application of a steady field in the liquid or of a 50 c/s alternating field shows also some interesting features.

With bubbles of helium, argon and neon, the chamber behaves like a spark counter with self-quenching produced by the oil. Figure 2 shows the plateau obtained with helium bubbles, and a γ -ray source, the pulses being counted on a scaler. The length of the plateau decreases strongly with increasing intensity.

The spark, started in the bubbles under these conditions breaks through the liquid. The effect of bubbles on the minimum breakdown voltage in liquids is well known⁷⁾. It is still remarkable that this can occur at such a low voltage as 3.5 kV/cm in transformer oil which is supposed to stand very high voltages. It shows how the occurrence of a bubble, in any high voltage device making use of oil as an insulating medium can lead to unexpected breakdown when the bubble is ionized by a cosmic-ray or any source of radiation, even at voltages 100 times smaller than the supposed minimum breakdown potential. The efficiency of this liquid spark counter is low for γ -rays (between 10^{-3} and 10^{-4}). For charged particles, however, the efficiency is much higher and one may think of various applications for this type of counter. Figure 5 shows a picture obtained in a beam with d.c. voltage. When looking in the dark in the presence of a horizontal beam with a steady field or slowly varying field, one observes, beside the bright sparks, a smaller luminosity produced by the charged particles traversing the bubbles. To get rid of the sparks we cover one electrode with a thin layer of insulating material (mylar or araldite). One then observes that with the 50 c/s alternating field the bubbles keep their luminosity, moving up in the liquid, making it thus difficult to observe in a clear way the tracks produced by the beam, which are still visible. Another trouble is that the liquid starts foaming under the influence of the alternating field becoming rapidly opaque; this happens only when a layer of insulator covers one of the electrodes. Thus, it is the triggered mode of operation that seems the most promising for detection of the trajectory of charged particles.

Pulsed field operation

The source of pulsed field is a thyatron. The delay between the passage of the particle and the rising of the high-voltage pulse is 300 ns. An adjustable clearing field can be applied to the electrodes. The relative efficiency for the occurrence of a track, as measured visually, is a function of this field (Fig. 3), and exhibits a behaviour similar to the one observed in spark chambers, showing that the memory properties of the chamber are similar to those of a spark chamber. An essential difference, however, is that since the condenser made of the chamber and of the capacities in parallel is not discharged by a track, it is possible to adjust the sensitive time by adjusting the width of the applied pulse. For instance, by triggering the chamber by a counter telescope detecting pions entering and stopping in the chamber, the electron decay from the muon emitted by the stopped pion is observed with pulses of $4 \mu\text{s}$ duration (Fig. 4).

An attempt has also been made to use as liquid a scintillator showing a low vapour pressure at normal temperature and not attacking our lucite containers^{*)}. The tracks that can be observed visually are much fainter than with oil, due to the quenching action of the vapours of this liquid. However, this possibility of a self-triggered chamber seems worth mentioning.

The main weakness of the chamber is now the small depth of the sensitive volume. While all other dimensions can be made arbitrarily big, the depth is limited by the necessity to have a medium transparent enough to let the light from the luminous bubbles escape with a minimum of scattering. From that point of view, liquids with a low index of refraction like liquid hydrogen would be most favourable. If the light passing through a bubble is fully

^{*)} I am indebted to Messrs. H. Faissner, F. Ferrero, A. Ghani and M. Reinharz from CERN who have developed it, for the supply of this scintillator, called decalin.

lost, the maximum number of illuminated bubbles per cm, for a track parallel to the electrode at a depth δ , is $\ell = x e^{-\delta x}$ where $x = 0.75 v/\rho$, v is the fraction of the volume occupied by the bubbles and ρ is the radius of the bubbles. Also in order to have 100% efficiency for bubbles of small size, operation at pressures higher than the normal one would be preferable. It will also be better to trigger the chamber with a delay much shorter than the one used so far. The influence of all these factors is now under investigation.

It is a pleasure to acknowledge the collaboration and contributions of Mr. Massonnet at different stages of this work. The skilful technical assistance of Mr. Bouclier has allowed rapid construction of a great variety of experimental devices.

I am indebted to Dr. Meunier for interesting suggestions concerning the optical problems connected with this chamber. I am grateful to Professor Bernardini for his continuous and stimulating interest in this work, and many colleagues at CERN for fruitful discussions.

References

- 1) G. Charpak, CR Academie de Sciences, Paris, p. 3155, 254 (1962).
- 2) T.E. Cranshaw and J.F. De Beer, Nuovo Cimento 5, 1107 (1952).
- 3) G. Charpak, J. Phys. et le Radium, 18, 539 (1957) and
Proceedings of the International Conference on Mesons, Venice,
28 September 1957.
- 4) S. Fukui and S. Myamoto, Nuovo Cimento 11, 113 (1959).
- 5) O.C. Allkofer, E. Bagge, P.G. Henning and L. Schmieder,
Atomkernenergie 2, 88 (1957)
- 6) M. Conversi and A. Gozzini, Nuovo Cimento 2, 189 (1955).
- 7) A review article on this subject is found in "Progress in
Dielectrics", vol.1, 1959, p.99, by T.J. Lewis.

Figure Captions

- Fig. 1 : Tracks of muons in paraffin oil, bubbles of neon.
Chamber dimensions: width 210 cm, height 250 cm,
depth 0.6 cm. Aperture f/2 isopan record film.
- Fig. 2 : Counting rate versus d.c. voltage. Co^{60} source, 10 M Ω
resistor in series with the chamber.
- Fig. 3 : Relative efficiency versus clearing field.
- Fig. 4 : Pion stopping in the liquid. The decay electron from
the muon is visible. Pulse of 4 μs duration.
- Fig. 5 : Helium bubbles - d.c. voltage 5 kV/cm - Horizontal
beam of pions - f/20, 1/10th sec, daylight, polaroid film.

Fig. 1

FIG. 2

FIG. 3

Fig. 4

Fig. 5