A POSSIBLE "NEW" DETECTION TECHNIQUE

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I wish to report on some thoughts I have had since I started facing the fact that it seems we cannot do very well using a big hydrogen bubble chamber with storage rings.

Professor Burhop has faced us with the nightmare of fireballs that fill out a periodic table. For some of you who have been around a while, I will face you with another nightmare; namely, it may be that there is room for use with the storage rings of the Wilson expansion chamber. I started looking into this because of the fact that I would like to trigger the hydrogen bubble chamber, and I do not see any way to do it. I would like to trigger it after some particle has gone through and made a track and still find something left on which to make bubbles.

Incidentally, I have raised a nightmare for myself in this talk; namely, I cannot distinguish in my own mind between bubbles and droplets. So if I call bubbles droplets and droplets bubbles, please use it in the appropriate way. It is something like plus and minus signs, but not exactly. One person to whom I have been talking lately has suggested that we try to make a chamber that would make the kind of bubbles that Lawrence Welk has and then we would all be happy if the droplets were hollow. I have been studying the problem in some detail and I have made some calculations which I believe give meaningful answers, but I am not going to show you those calculations. I would be glad to talk to you

TABLE I

Comparison of Some Chamber Parameters

	Space Resolution Δs	Timing			Detector Thickness (1 meter)
		Minimal Delay	Minimal Sensitive	Minimal Resolving	
"Large" Spark Chamber	0.2 mm	30 nsec	300 nsec	100 nsec	0.2 grams/cm^2
Hydrogen Bubble Chamber	0.07	Not Trigger-able	2 msec	0.5 msec	6
Conventional Wilson Cloud Chamber	0.1	10 msec	100 msec	5 msec	0.04 (2 atms. of He)
"New" Wilson Cloud Chamber	0.1	1 msec	2 msec	0.1 msec	0.04 (½ atm. of H_2O vapor)

about it. I have a Table which is the result and which I hope is neither too optimistic nor too pessimistic. The big bugaboo to the chamber man is of course the spark chamber, so I will put that first. Let me put "large" in quotation marks after the discussions we have been having about sizes. In particular, I want to put the smallest number under the Δs of precision measurements that I can, so maybe this chamber is not really so large. Let me accept 0.2 mm for Δs as a typical jitter in the position of a spark in the spark chamber. I would like to try to maintain that in the bubble chamber one can do 0.07 mm for the corresponding quantity. Next in the Table consider a conventional expansion cloud chamber or Wilson chamber.

We need the triggerable feature, so the numbers refer to "counter age" tracks. One must remember that these tracks in an expansion chamber are diffuse.

L.M. Lederman: I think you ought to describe the Wilson chamber for the younger people in the audience.

E.C. Fowler: I will give a reference.[1]

About 0.1 mm is a reasonable number. The last instrument listed in the Table is a "new" expansion chamber, and in this column we will still use 0.1 mm.

Since I am concentrating on the triggering feature, this new expansion chamber is to use all the most modern techniques that have been developed for bubble chambers. It is to use the fastest possible expansion and straight-through illumination. Probably it is to use vapor only, so that one can get very rapid droplet growth. The conventional expansion chamber has a noncondensable gas and a condensable vapor. The result is that droplet growth is controlled largely by diffusion of vapor to the droplets through the gas. If you eliminate the noncondensable gas, then you can presumably get very rapid droplet growth - not as fast as in the bubble chamber, but it is similar in operation to the bubble chamber.

That brings us to the next column, namely the timing. Under timing I have the delay, which refers to the delay from the time the counters might tell you that you should look for something until the time that you can take the photograph. The spark chamber I judge can be around 30 nsec.

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1. N.N. Das Gupta and S.K. Ghosh, Revs. Modern Phys. 18, 225 (1946); J.G. Wilson, "The Principles of Cloud-Chamber Technique", Cambridge University Press, Cambridge, England, 1951.

The H_2 bubble chamber is not triggerable so these considerations do not apply to it. The conventional expansion chamber takes around 10 msec and that is a minimum. I do not know of anyone who has ever done quite that well. The new chamber, I believe, might gain a factor of 10. Since there is a factor of 10^6 between nanoseconds and milliseconds, one may not expect that the expansion chamber will really compete with the spark chamber in making a big momentum spectrometer that covers wide angles where one is really trying to pick out one event from a sea of particles. However, there may be intermediate experiments, and I judge that with the storage rings there will be, provided one can get a good enough vacuum.

I take the sensitive time for the spark chamber to be something like 300 nsec; the bubble chamber about 2 msec; the conventional expansion chamber about 100 msec, which may be optimistic; and the new expansion chamber around 2 msec.

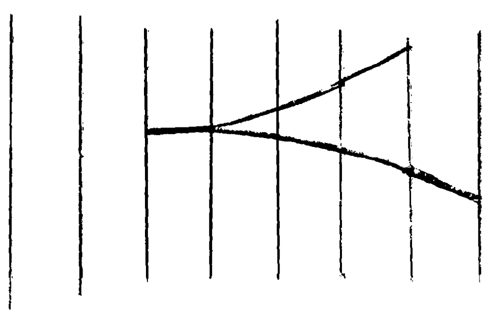
The resolving time for the Wilson chambers is rather better than the numbers 100 nsec, 1/2 msec, $\sim$ 5 msec and 0.1 msec, would indicate. In these, one judges counter tracks versus post-expansion tracks largely on the basis of the diffusion widths of the tracks in the chamber before any droplets are made. The ions in the tracks diffuse out until droplets are formed. These are so heavy that they do not diffuse any more.

Finally, the last column shows the thickness of a one-meter path in grams per cm^2. The numbers are 0.2, 6, 0.04 (for 2 atmospheres of He), and 0.04 (for 1/2 atmosphere of H_2O in the new chamber) grams/cm^2.

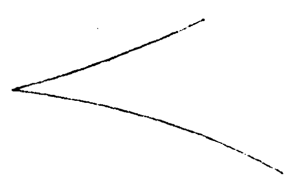
Experimentally, one is not sure what to take for the cycle time of the chamber, but it does look as though one can move an appreciable distance toward the kind of operation we have become accustomed to for bubble chambers. It may be that a system of this type, with the modern speeds of expansion and compression or cycling might be able to cycle very rapidly.

There are many pitfalls in expansion chambers and one may run across one which stops this development entirely. I have looked for some of those. One is the following: the question in the case of pure water is the old idea that there are such things as droplets on ions which re-evaporate down to sizes which are too small to fall out but too large to sweep; consequently, a fog background gradually builds up with which you cannot cope. If this happens, then clearly you just cannot make a fast-cycling device.

The advantages of this chamber are largely that even in a modern spark chamber in a magnetic field you may get an event which looks like this:



However, I take it that it is still hard to get a V decay in the gas like this:



Another advantage may be that, with the very low density of gas, there is the possibility of exploring a region of very short range, corresponding, say, to hyperfragments, that is very difficult by the other techniques. These are two purely empirical things which I think, however, are definite advantages.

The chief disadvantage, I believe, is the fact that, particularly in going to this new type of device, one needs a rather large expansion ratio and we are talking about expanding very fast. The distortion of the tracks due to the actual motion of the gas between the expansion and the photography may render this estimate very optimistic.

The other disadvantage is that it may turn out that you cannot cycle very fast and so the chamber would be dead a good bit of the time. One does not know for sure about that. Finally, a Wilson chamber is no doubt more difficult to build and keep in regular operation than a big spark chamber of the same size and general characteristics. Incidentally, the path length and my estimates on the spark chamber are based mainly on Martin Perl's discussion in the SLAC summer study last year. Now I want to give you a reference to this new expansion chamber.[2]

I wish to mention one last item. As far as the straight-through illumination goes, I started off believing that we would take this technique back to the expansion chambers from the bubble chambers. It turns out, of course, almost as always, that most of the major developments in chamber techniques have been made by C.T.R. Wilson. In 1935 he described a falling expansion chamber in which he used straight-through illumination.[3] A more modern reference is to work by Ronald Rau who used a straight-through illumination technique which worked very well on expansion chambers which he was flying in balloons up to 100,000 feet.[4]

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2. F. Joliot, J. Phys. Radium 5, 216 (1934).
3. J.G. Wilson and C.T.R. Wilson, Proc. Roy. Soc. Ser. A 148, 523 (1935).
4. R.R. Rau, Rev. Sci. Instr. 23, 443 (1952).