DIGITIZED SONIC SPARK CHAMBER FOR OPERATION WITH COUNTER HODOSCOPE, DATA HANDLING SYSTEM AND ON-LINE COMPUTER*)

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(presented by S.J. Lindenbaum)

1. INTRODUCTION

For some experiments which yield relatively low background and event counting rates but require a high spatial resolution, a spark chamber is a useful detector. In order to incorporate such detectors into our data handling system with on-line computer, we began development of a suitable sonic spark chamber system[1),2)]. We have tested, both in a test chamber and in air, various microphone designs, the necessary digitization electronics and a method of computation. The preliminary report on the tests will be made here. Figure 1 (a) and (b) shows a test chamber assembly.

2. THE MICROPHONES

All the microphones tested were of the capacitor type. The movable electrode is always made of .00025" aluminized mylar foil. This is stretched over a stationary electrode, charged to 300 volts.

i) Point Microphone. Figure 2 shows the construction of the point type microphones. The stationary electrode is a silver solder rod with the end shaped to give a 1/16" diameter contact area with the mylar foil. The tension with which the mylar is stretched over this rod may be adjusted to optimize the output signal pulse height and rise time.

ii) Cylindrical Microphone. Figure 3 shows the construction of a microphone which has slower response than the point microphone but has larger output and better geometrical properties. The stationary electrode is a $\frac{1}{4}$" diameter by 3/8" long brass cylinder with axis perpendicular to the spark chamber plane. A .0035" thick nylon cloth is stretched between this

*) Work performed under the auspices of the U.S. Atomic Energy Commission.

electrode and the mylar foil. This reduces the required tension on the mylar.

iii) Long Microphone[2]. Figure 4 shows the construction of the long microphone. This microphone gives a slow rise time, but less dependence of pulse height on the distance between spark and microphone. The stationary electrode is a long brass rod 1/8 x 1/4" in cross-section embedded in a plexiglass plate. Again the nylon cloth is stretched over the electrode before the mylar foil is applied. The tension of the mylar foil all along the rod may be adjusted to give uniform response over the length of the microphone.

A summary of the properties of the three types of microphones is given in Table I.

3. ELECTRONICS

Figure 5 shows a block diagram of the electronics used to determine the position of a spark. A signal from a counter telescope triggers the spark chamber. This also provides a pulse to set a flip-flop which provides a time gate signal. A sonic wave produced by the spark travels through the spark chamber gap and generates a pulse when it reaches the microphone. This pulse is amplified and then fed via a discriminator to reset the flip-flop previously set by the telescope signal. Thus, one gets a square output pulse of width essentially equal to the transit time of the sonic wave through the chamber gap. This time interval is measured by a 5 Mc/s oscillator clock. The scaler used for this purpose is 10 Mc binary scaler with a provision to feed the information to one data handling system.

In order to avoid electrical pick-up from the spark, the timing circuit is not activated until 45 μsec after the trigger to the spark chamber is generated. Also a provision was made to reset the timing system after $\sim$ 9 msec if no microphone signal arrives. A timing diagram is shown in Fig. 6.

4. METHODS OF LOCATING SPARKS

Several methods for locating sparks have been tried with a chamber gap involving four of the point probe microphones. The quantities to be determined are the x and y positions of the spark, the velocity of the sound wave, v, and the effective spark size δ. Since four microphone times are available there are four second order simultaneous equations which may be solved exactly for the four unknowns. However, small errors (.5 mm) in the microphone positions used in the calculations or in the scaler times (.1%) lead to large errors in spark position determinations. Since these parameters will typically be measured to this accuracy, this procedure does not seem very promising. A better result is obtained by an iteration procedure on an averaged solution. In this technique, it is assumed that the velocity and δ are known approximately. Using this velocity and δ four intersections of the four circles with centres at the microphone positions are calculated. These four intersections are used to calculate an average x and y. Using the average x and y, an average v and δ are calculated, which in turn are used to calculate a better value for x and y. It is found that by the second iteration, the difference between the average values of x and y and the true values is about the same as the error in the location of the microphone or in the scaler times.

Calculations were also made with the output from a chamber using four of the long microphones. Because the four equations in four unknowns are linear, their solution is greatly simplified. The greater complexity of the equations for the point microphones presents no problem for a digital computer. Because of the non-linearity of the equations, however, small errors in the parameters (microphone positions, times) propagate and become greatly magnified. This trouble does not occur in the solution for the long microphones. It should be noted, however, that the sum of the times for the two opposite pairs must be different since the difference of these two sums appears in the denominators of the expressions for x, y, v and δ.

Tests have been made with cosmic rays through two-gap spark chambers with four point microphones in each gap and also with four long microphones in a one-gap chamber. Fig. 7 shows a diagram of an arrangement planned for an experiment using spark chamber, hodoscope, data handling system and on-line computer.

TABLE I

COMPARISON OF DIFFERENT TYPES OF CAPACITOR MICROPHONES *)

	Point Microphone	Cylindrical Microphone	Long Microphone (3')
Nylon Mesh	No	Yes	Yes
Risetime and Output Voltage (.2 Joule Spark)			
at 3.5 cm	0.2 μs, 70 mV	1.5 μs, 140 mV	3 μs, 100 mV
at 31 cm	1 μs, 7 mV	4 μs, 20 mV	3.5 μs, 32 mV
at 100 cm	--------	--------	3.5 μs, 14 mV
Dependence on distance of output voltage (beyond 10 cm)	$\sim 1/r^{1.5}$	$\sim 1/r^{1.7}$	$\sim 1/r^{0.58}$
Angular dependence of output voltage	± 25% in $-45^{o} \sim +45^{o}$	± 10% in $-90^{o} \sim +90^{o}$	--------
Uniformity of output along the length	--------	--------	± 5%
After-ringing	Strong	Small	Small

*) These tests were performed with a test spark without plates.

References

1. B.C. Maglic and F.A. Kirsten, Nucl. Instrum. Meth. 17, 49 (1962).

2. B.D. Jones, J. Malos, W. Galbraith and G. Manning, Nucl. Instrum. Meth. (to be published).

Figure captions

Fig. 1 a) Sonic spark chamber using four "point" microphones.

b) Sonic spark chamber using four "long" microphones.

Fig. 2 Construction drawing of "point" microphone.

Fig. 3 Construction drawing of cylindrical microphone.

Fig. 4 Construction drawing of "long" microphone.

Fig. 5 Block diagram of spark chamber electronics.

Fig. 6 Spark chamber timing diagram.

Fig. 7 Experimental arrangement for planned sonic spark chamber experiment.

Fig. 8 a) Scope trace of point microphone. Signal is negative; it shows fraction of a μsec rise time (sweep time 10 μsec/cm) and considerable ringing.

b) Scope trace of long microphone. Signal is negative. Sweep time 10 μsec/cm.

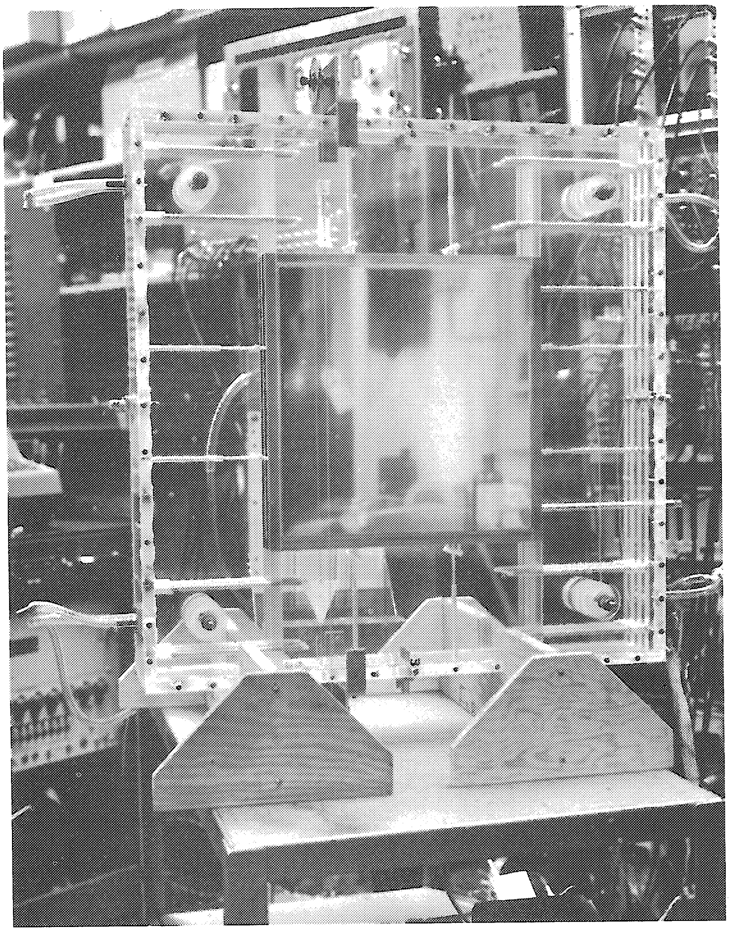


Fig. 1a

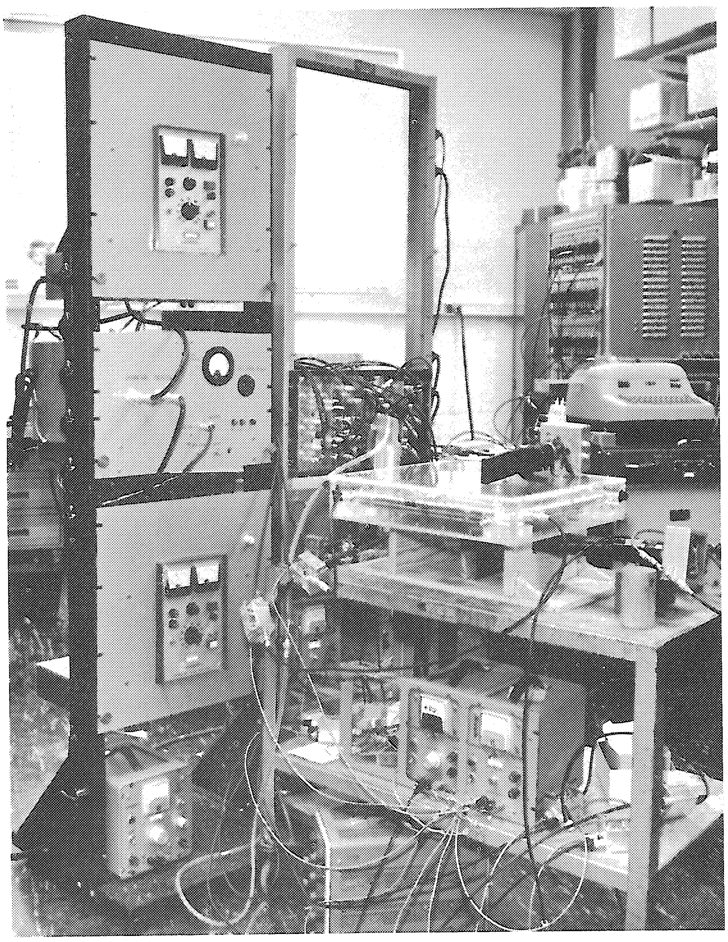
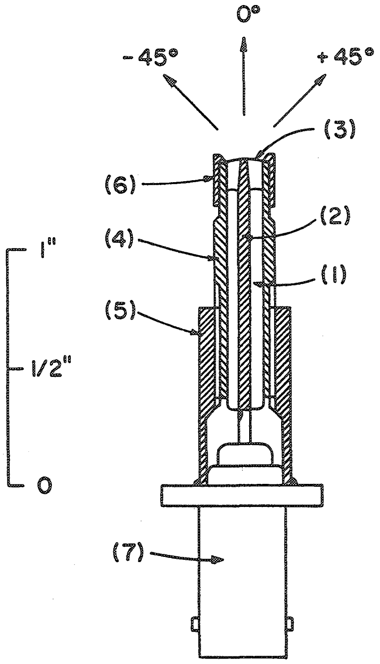


Fig. 1b

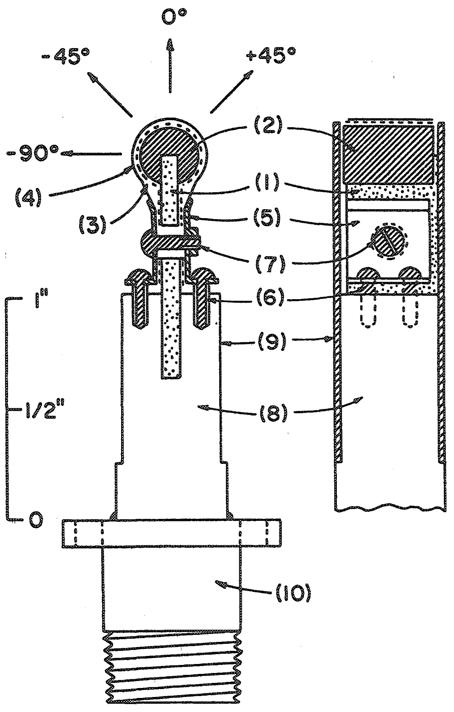
STRUCTURE OF POINT MICROPHONE



(1) POLYETHYLENE SPACER
(2) INTERNAL ELECTRODE, 62.5 mil ϕ AT TOP
(3) 1/4 mil OUTSIDE ALUMINIZED MYLAR FOIL CEMENTED TO TOP OF (4)
(4) MOVABLE BODY TO STRETCH (3)
(5) BASE
(6) PRESS FIT CAP TO HOLD (3)
(7) BNC CONNECTOR

Fig. 2

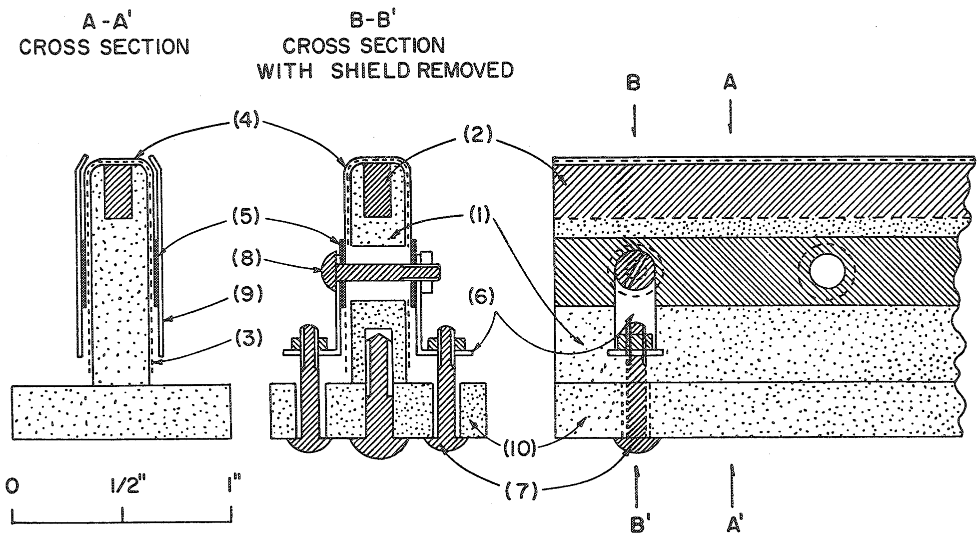
STRUCTURE OF CYLINDRICAL MICROPHONE



(1) MICARTA SUPPORT
(2) 1/4" ϕ x 3/8" BRASS CYLINDRICAL ELECTRODE
(3) 3.5 mil NYLON CLOTH, STRETCHED & CEMENTED TO (1)
(4) 1/4 mil OUTSIDE ALUMINIZED MYLAR FOIL, CEMENTED TO (5) WITH SILVER EPOXY RESIN
(5) BRASS ANGLE TO STRETCH (4)
(6) BOLT TO PULL (5)
(7) BOLT AND NUT TO FIX (5)
(8) BASE
(9) SHIELD
(10) UG 58U CONNECTOR

Fig. 3

STRUCTURE OF LONG MICROPHONE



(1) 1/4" PLEXIGLASS BASE PLATE
(2) 1/8" x 1/4" BRASS INTERNAL ELECTRODE
(3) 3.5 mil NYLON CLOTH, STRETCHED AND CEMENTED AT BOTTOM
(4) 1/4 mil OUTSIDE ALUMINIZED MYLAR FOIL, CEMENTED TO (5) WITH SILVER EPOXY RESIN
(5) 40 mil Al STRIP
(6) LUG TO STRETCH (4) THROUGH (5)
(7) BOLT AND NUT TO PULL (6)
(8) BOLT AND NUT TO FIX (5)
(9) SHIELD
(10) PLEXIGLASS ASSEMBLY PLATE REMOVED LATER

Fig. 4

SPARK CHAMBER ELECTRONICS

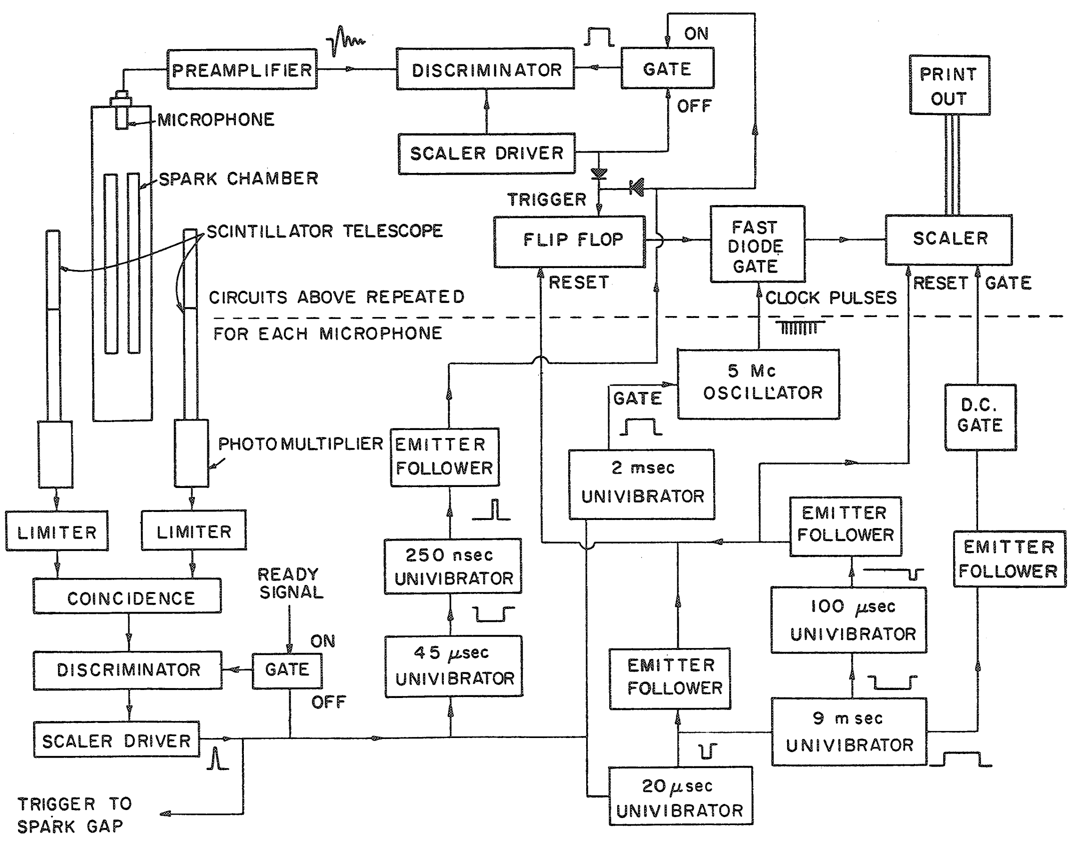


Fig. 5

SIS/R/8814

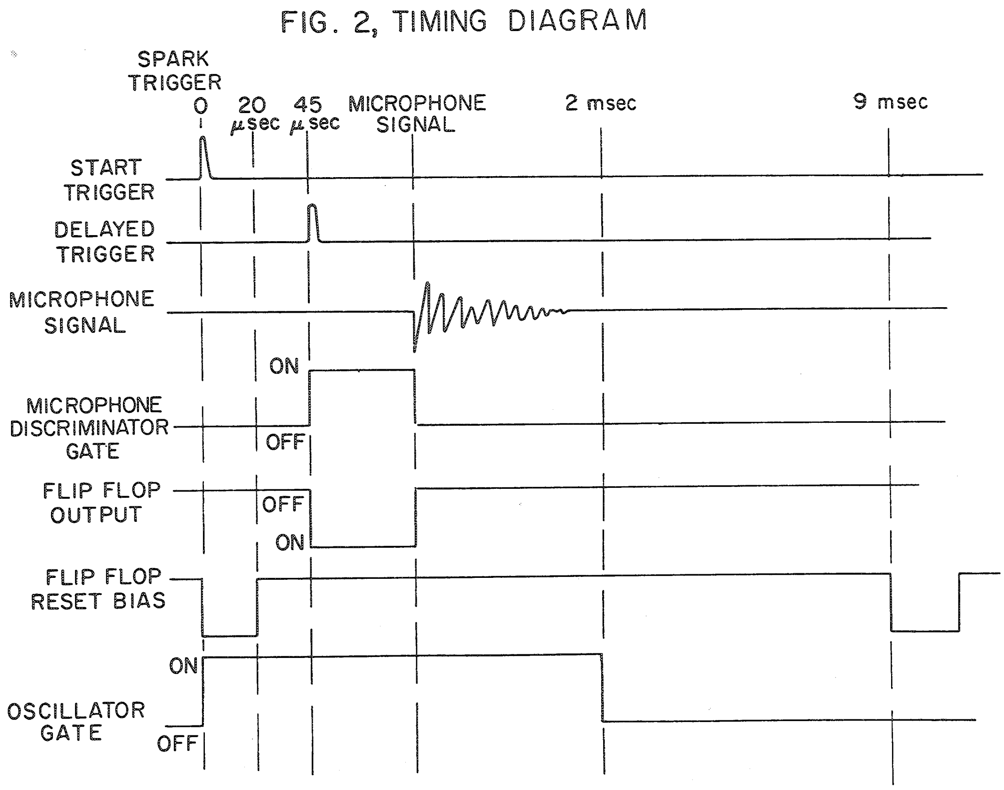


FIG. 2, TIMING DIAGRAM
SPARK TRIGGER
0
20 μsec
45 μsec
MICROPHONE SIGNAL
2 msec
9 msec
START TRIGGER
DELAYED TRIGGER
MICROPHONE SIGNAL
ON
MICROPHONE DISCRIMINATOR GATE
OFF
FLIP FLOP OUTPUT
OFF
ON
FLIP FLOP RESET BIAS
ON
OSCILLATOR GATE
OFF

Fig. 6

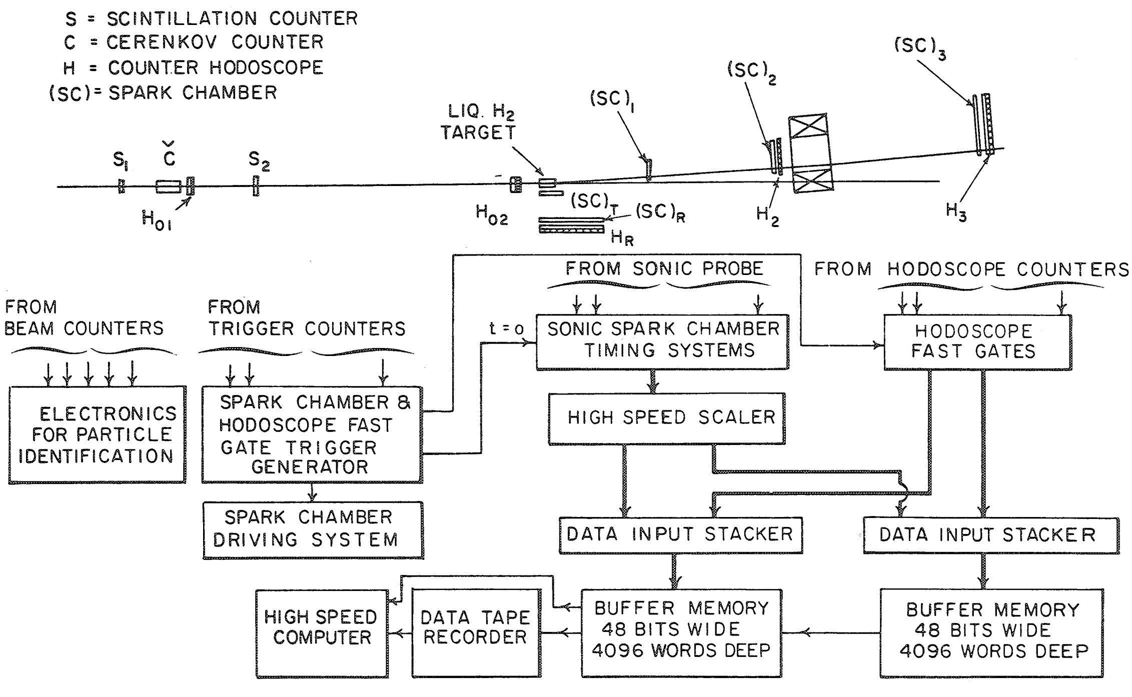

S = SCINTILLATION COUNTER
C = CERENKOV COUNTER
H = COUNTER HODOSCOPE
(SC) = SPARK CHAMBER
LIQ. H2 TARGET
(SC)1
(SC)2
(SC)3
S1
C
S2
H01
H02
(SC)T
(SC)R
HR
H2
H3
FROM BEAM COUNTERS
FROM TRIGGER COUNTERS
FROM SONIC PROBE
FROM HODOSCOPE COUNTERS
t = o
ELECTRONICS FOR PARTICLE IDENTIFICATION
SPARK CHAMBER & HODOSCOPE FAST GATE TRIGGER GENERATOR
SONIC SPARK CHAMBER TIMING SYSTEMS
HODOSCOPE FAST GATES
HIGH SPEED SCALER
SPARK CHAMBER DRIVING SYSTEM
DATA INPUT STACKER
DATA INPUT STACKER
HIGH SPEED COMPUTER
DATA TAPE RECORDER
BUFFER MEMORY 48 BITS WIDE 4096 WORDS DEEP
BUFFER MEMORY 48 BITS WIDE 4096 WORDS DEEP

Fig. 7

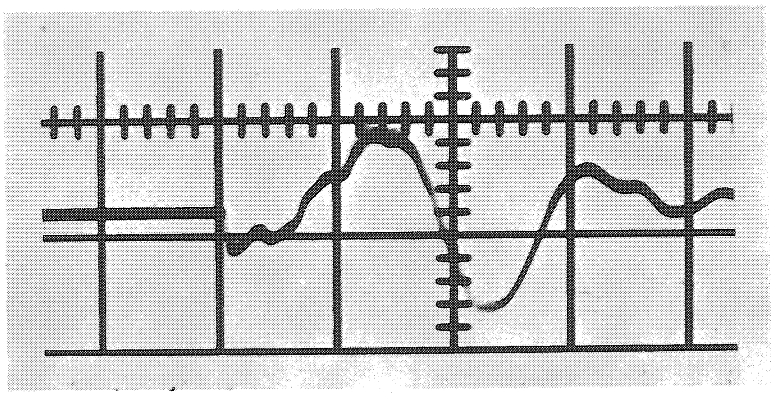


Fig. 8a

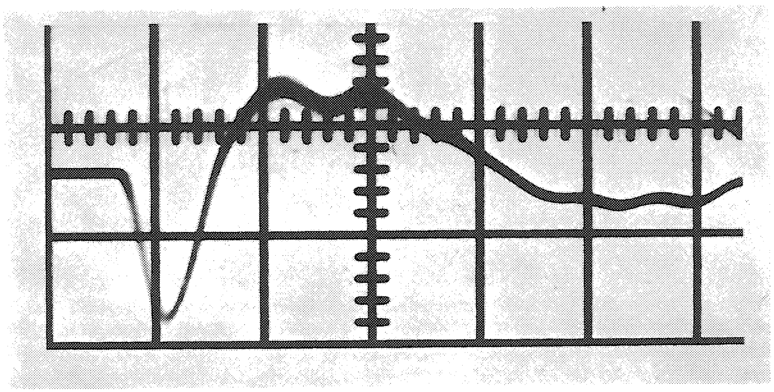


Fig. 8b

DISCUSSION

ZANELLA: When you are calculating the spark position you use a value of Vo and ΔT and I can understand then why you have to stop your iteration. But in the method I explained yesterday I don't use any Vo or ΔT value; we used the program in the region where the iteration converges.

LINDENBAUM: I think I could say we ran into the same problem as you. We tried an experimental way of getting comparable errors. The program was written by Willen of our group and he tried many iterative procedures. We stopped at a point where he felt he was able to get comparable errors with the errors introduced.

FESSEL: In connection with the last system you showed if you want to use that for inelastic events, it seems to me you are going to be plagued continually by having more than one event per chamber.

LINDENBAUM: That set-up was only for elastic scattering. We will get some inelastic events as a by-product because of the magnetic spectrometer. In these series of experiments the inelastic are always in a by-product category. But we do have one limit and that's why we backed it up with scintillators. The limit is that when we get more than one track per chamber we have to reject that event. So there is sort of a happy medium, and we will run at that rate where things are optimised.

LIPMAN: The ringing time on your slab microphones look very short. Could you give me the figure for it to get some idea when you could fire a chamber again ?

LINDENBAUM: I would like to emphasize that we didn't concentrate on the ringing properties of the microphones. I would not like to quote a figure because we didn't investigate this aspect. For instance, a change in the screw tensions might change everything.

ANDREWS: I think you will find if you use nylon chiffon you can account for all the wave shake entirely by air compression. I don't think the mechanical properties of the tension of the diaphragm come into it.

LINDENBAUM: Well we found otherwise. The slab microphone has set screws all along its length, and we found that adjusting the tension affects, not only the rise time in signal but, what is more important, the uniformity.

NEUMANN: Would it be of interest to make a combination spark chamber and wire chamber ? If one could make a wire chamber where the wires are not used to retrieve information but to hold this spark for a number of milliseconds on weak intensity which does not strike your microphone, and then strengthen them one after the other and pick up the signal with sonic probes.

LINDENBAUM: Well it certainly sounds like an interesting idea. I don't know enough about this kind of thing to have an opinion on it but we are certainly after a device which can handle multiple tracks. There are several candidates for this, - one is the sonic chamber itself, putting in more microphones, as Maglić and other people mentioned. Another is the wire chamber and that is, I think, the hot candidate. Then what you mentioned is another one, and there may even be others. We have an open mind on all the detectors and we are interested in anything which can handle multiple events.