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TECHNICAL REPORT

"VELOCITY SELECTOR FOR AN ELECTROSTATIC HYPERVELOCITY ACCELERATOR"

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VELOCITY SELECTOR FOR AN ELECTROSTATIC HYPERVELOCITY ACCELERATOR

The TRW electrostatic hypervelocity accelerator[1] is capable of accelerating micron-size electrically charged dust particles to velocities in excess of 30 km/sec. Because obtaining high velocity data with the basic system alone is difficult and time consuming, the practical upper limit on particle velocity prior to development of a velocity selection system was about 15 km/sec. The velocity selector has raised this upper limit to that of the accelerator itself, or above 35 km/sec.

The detectors used with the electrostatic accelerator are described elsewhere.[2] The output of the detectors consists of a rectangular wave with a height proportional to the charge of the particle and a length inversely proportional to its velocity. This signal is amplified by a low-noise preamplifier[3] and then displayed on an oscilloscope. The trace is usually photographed so that the parameters of the particle may be precisely measured.

The faster particles generally carry a smaller charge and therefore generate smaller signals than those produced by the slower particles. The oscilloscope sweep is usually triggered internally so that all particles with less than a specified velocity v_o sweep the oscilloscope. Thus, in order to obtain data on high-speed particles, all particles with less than the desired velocity must also be recorded and the resulting traces sorted to isolate the high-velocity-particle pictures, which constitute a small fraction of the total number of traces recorded.

These difficulties are compounded because the dust powder available for acceleration does not have a uniform size distribution. The distribution curve peaks for particles of about 1 to 2 microns radius, and particle velocities correspondingly peak at around 5 to 7 km/sec. This peak is quite sharp and falls off particularly fast in the direction of decreasing radius and higher speed.

A further serious hindrance to obtaining high-velocity data is low-frequency noise. For accurate measurement of particle parameters, the frequency response of the preamplifier must be extended to low frequencies (10 kc or less). A great deal of low-frequency noise reaches the oscilloscope input despite the many precautions that are taken. This noise is not troublesome on an oscilloscope trace because its frequency is low compared to the sweep rate, but it can trigger the oscilloscope, causing it to sweep continuously. The trigger level must therefore be set well above this low-frequency noise level to avoid spurious triggering, with the result that very-low-charge particles do not sweep the oscilloscope. Since these low-charge particles are also the ones with high velocity, the effect of low-frequency noise is to place an upper limit on velocities that can be measured.

To alleviate the above problem a velocity selector system was designed and constructed. As can be seen in the logic diagram presented as Fig. 1, three particle detectors are used with the velocity selector; the first two are velocity detectors, while the third is a charge detector. For some applications only the velocity detectors are used, whereas in other experiments the entire system is required.

The velocity detectors have a relatively narrowband frequency response of 1 to 10 mc. The outputs of preamplifiers No. 1 and 2 are fed to pulse height discriminators, which are set so that they are triggered by noise at a rate of 20 to 50 pps. Discriminator No. 1 triggers a one-shot multivibrator that has an adjustable period. At the end of the period selected, a second one-shot multivibrator of variable period is triggered. A gate is opened for the period of this second one-shot, and pulses from discriminator No. 2 will pass through the gate if they appear

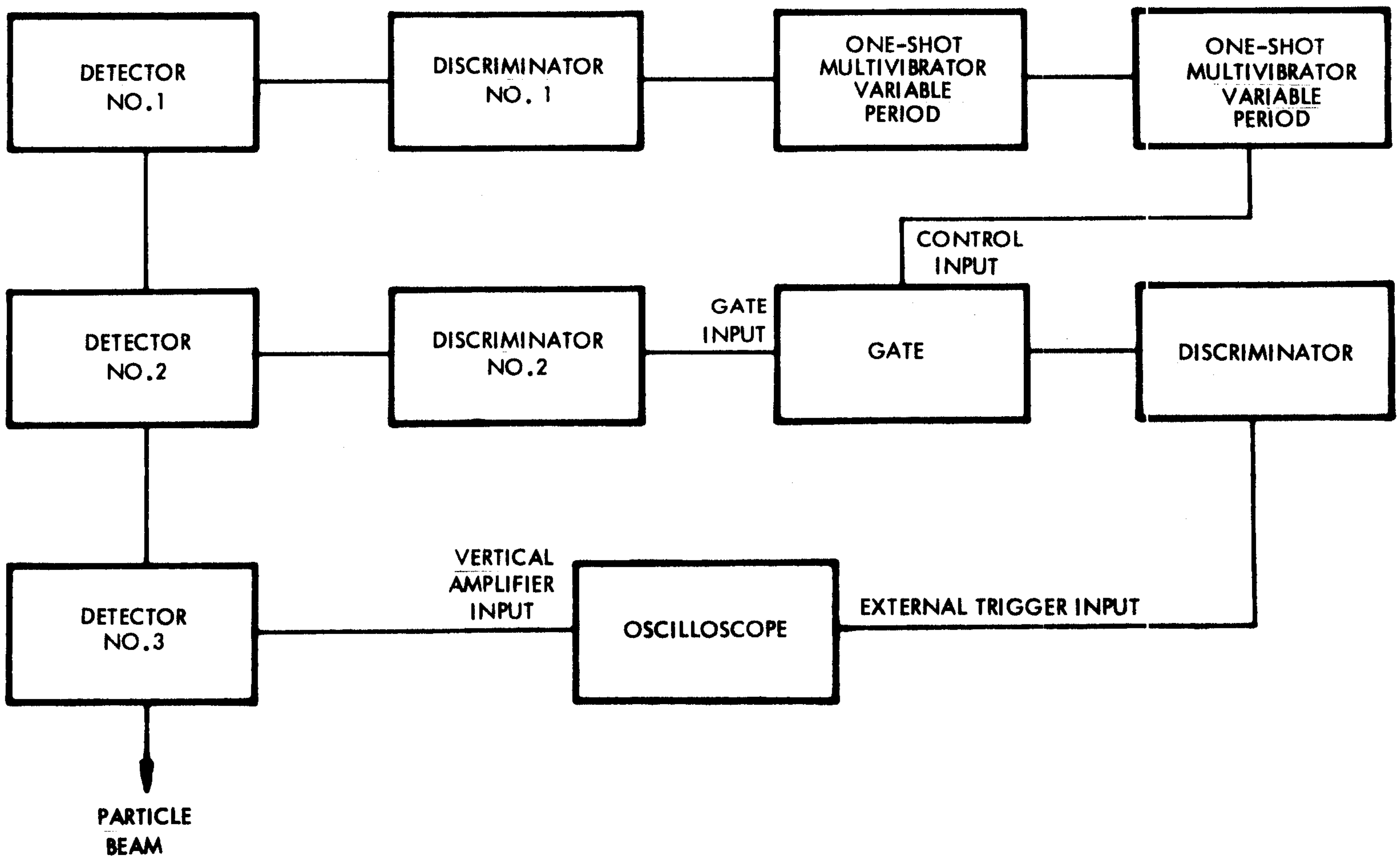

Figure 1. Logic Diagram of Velocity Selector

during this time. Pulses that come through the gate are detected by a discriminator whose output ordinarily sweeps the oscilloscope but may also be used for other purposes, such as activation of a particle-deflection system that is described in some detail elsewhere.[4]

The accidental rate of the velocity selector is calculated from the standard coincidence accidental formula

$$R_{acc} = R_1 R_2 \Delta t \quad ,$$

where R_1 and R_2 are the rates of disciminators Nos. 1 and 2. For R_1 and R_2 equal to 50 pps and Δt equal to 10^{-5} sec, $R_{acc} = 2.5 \times 10^{-2}$, which is a very acceptable rate for most conditions. The value of Δt chosen for this example is larger than required for all but the widest velocity windows (1 to 40 km/sec.)

If a precise determination of particle mass is necessary for an experiment, a pulse height window discriminator may be placed on the output of detector No. 3 to specify a particle charge interval, just as the velocity selector is used to specify a particle velocity interval. The simultaneous specification of charge and velocity is equivalent to specifying a mass interval, since the specification of charge and velocity together with the accelerator voltage allows the mass of the particle to be calculated.

The velocity selection system is used for experiments requiring data over a small particle-velocity interval. For tests of transient phenomena, such as impact ionization, behavior of particles under free-molecular-flow conditions, etc., the velocity-selecting section of the system is all that is needed. However, for experiments on phenomena such as cratering the particle-deflection system is used. When this system is used with the velocity selector, the crater structure can be related accurately to the impacting particle parameters.

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