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THE MULTIWIRE PROPORTIONAL CHAMBER SYSTEM OF FERMILAB SINGLE ARM SPECTROMETER

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1. - INTRODUCTION.

The system of multiwire proportional chambers we describe here has been developed as a particle coordinate detector for the focusing Single Arm Spectrometer (SAS) of Fermilab to be used as a general facility in different experiments. The system is composed of two groups of MWP chambers. The first group operates as a set of hodoscopes in the spectrometer arm (H and V chambers in Fig. 1). The second group, close to the target, measures multiplicity and angular distributions of charged particles in inelastic events.

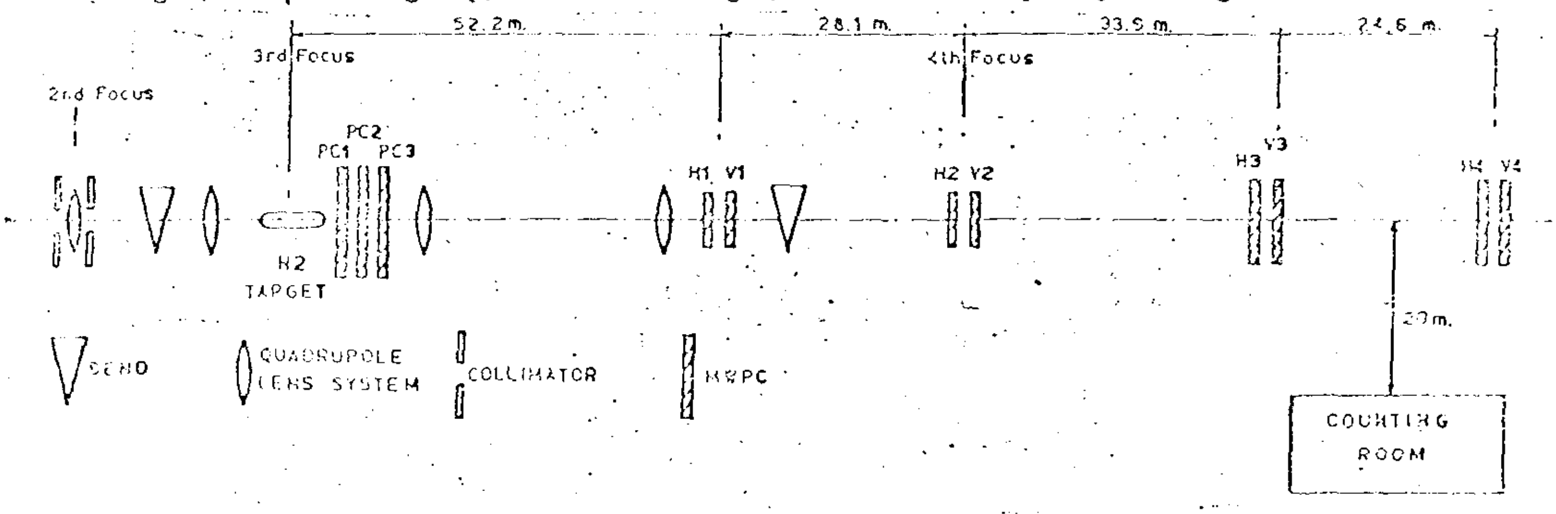

Fig. 1 - Position of the MWPC's in the Single Arm Spectrometer.

The MWPC design reflects some peculiar requirements of the SAS system. The detectors are distributed over the spectrometer length up to a distance of 120 meters from the counting-room: propagation time of particles and strobe pulse determine the effective dead time of the detectors. High detection efficiency is required to the MWPC's close to the target for unambiguous reconstruction of multitrack events, while operating at high background level (3×10^6 beam particles). Acquisition rate greater than 200 ev per beam spill is needed.

2. - HODOSCOPE CHAMBERS.

The hodoscope chambers determine the coordinates of the fast particle at several positions in the spectrometer arm. Single chambers give X or Y position with resolution of ± 1 mm. Pairs of adjacent chambers improve the resolution down to ± 0. 5 mm. Multiple scattering and magnetic transport uncertainties would not consent any better resolution.

The dimensions of the mechanical structure of the hodoscope chambers, made of G-10 fiberglass frames, are given in Table I. Using typical gas mixture of Argon-Isobutane-Freon, a pla

TABLE I - *Hodoscope Chambers Parameters*

Sensitive wire:	∅ = 20 μm gold plated tungsten 50 g. mechanical tension
Sensitive wire spacing:	2 mm
Gap:	7. 5 mm
High voltage Planes:	∅=50 μm gold plated tungsten wires, 1 mm spaced, 100 g. mechanical tension.
Gas:	"Magic" Mixture: Argon 67%; Isobutane 31. 5%; Freon 0. 5%, Methilal
Operating Voltage Plateau:	5700 - 6300 V
Average Efficiency:	98. 5%

teau of approximately 600V has been obtained, with output pulses of 20÷30 mV on 470 Ω load resistors. Amplifiers and read-out electronic, mechanically mounted on the chambers, are shown in Fig. 2. A typical input threshold of 3 mV has been used. Due to the distance between the MWPC

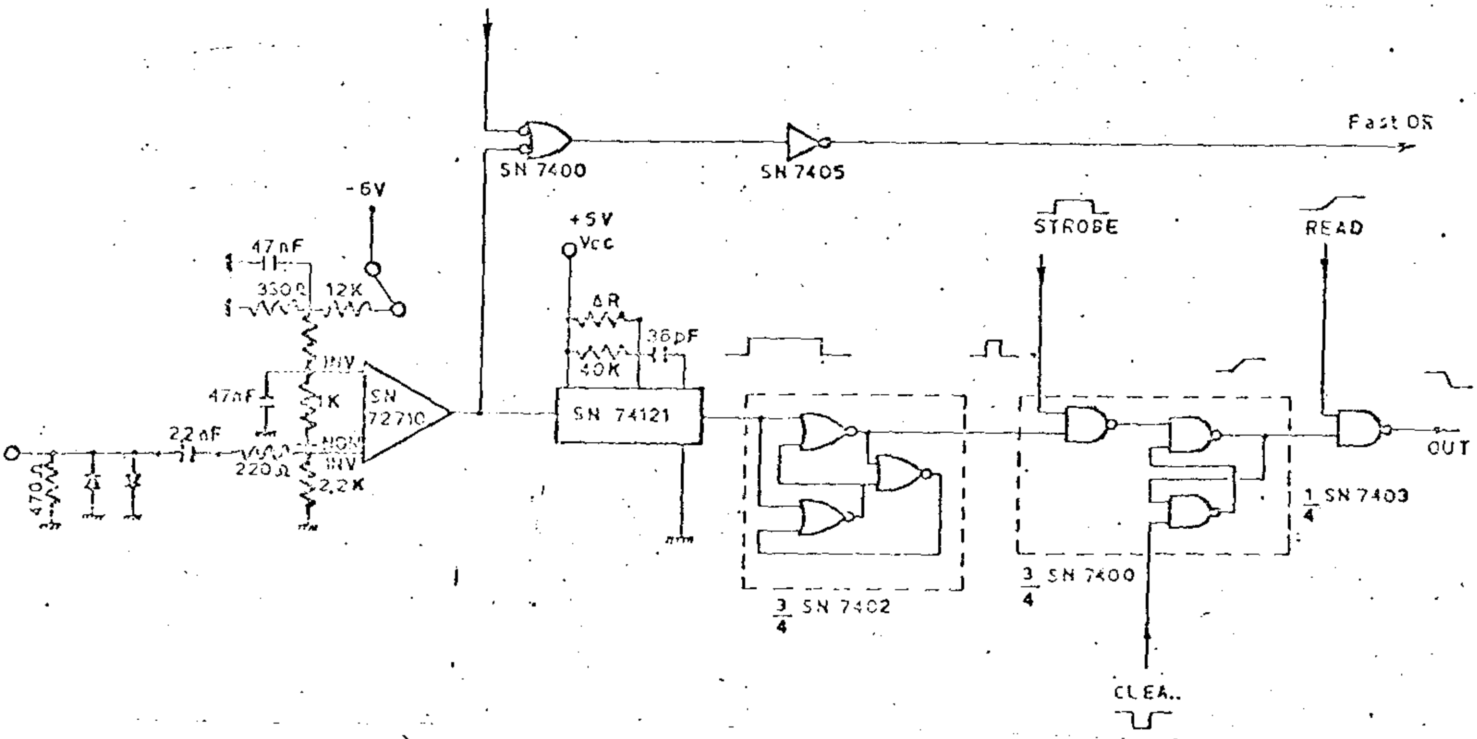

FIG. 2 - Read-out electronic card circuit for hodoscope chambers.

and the counting room, the strobe pulse is timed to reach read-out electronics 1. 2 μs after the crossing of the ionizing particle. Time resolution better than 80 nsec has been achieved on some thousand channels using high stability components in this delay circuit, made of an SN 74121 integrated one-shot on each channel.

3. - MULTIPLICITY HEXAGONAL CHAMBERS.

Hexagonal geometry has been selected to cover the maximum solid angle near the target with detectors of minimum size and weight. The hexagonal chambers were added to the system to measure the multiplicity and angular distribution of charged prongs associated with the fast particle entering the spectrometer arm (Fig. 3). Each of the three chambers (called PC1, PC2, PC3) has three

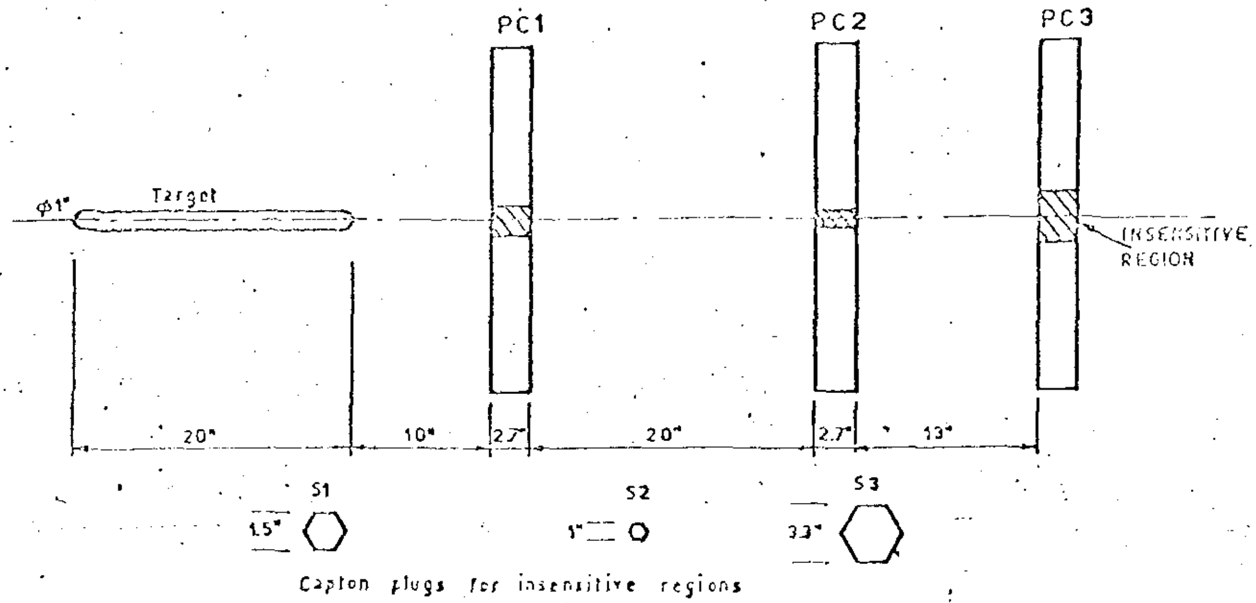

FIG. 3 - Location of hexagonal chambers near the target with insensitive regions.

sense planes with wire directions at 120°. In this way u, v, w, coordinates are determined for each particle in the chambers, and one can solve the ambiguities arising when two or more particles cross the same chamber. The three sensitive planes are in the same volume of gas and share the HV electrodes.

The mechanical structure of these chambers is shown in Fig. 4. The physical parameters are quite similar to those of the hodoscope chambers given in Table I. Being at 120 meters from the counting room, the strobe signal reaches these chambers 2 μsec after the particle signal. A 2 μsec delay is therefore introduced on the signal by a one-shot circuit. During this the read-out the channel is mute. The inefficiency originated by this dead time, due to the high background level near the target, has been reduced providing two reading channels per wire, as shown in the circuit of Fig. 5. The channel to be used is selected by the j-k flip-flop (SN 7473) that works like a "pointer" of the channel which is free and therefore available for storing a second pulse even if coming earlier than 2 μsec from the previous one. The trailing edge of the output, in coincidence with the strobe pulse, sets the storage flip-flop (SN 7474). The timing diagram of this circuit is shown in Fig. 6. To increase the chamber lifetime, the high voltage across the gap is reduced during the inter-spill period(4).

4. - INSENSITIVE REGIONS FOR THE BEAM.

As the chambers are crossed by 3×10^6 particles per beam pulse, an insensitive region was provided by plugs made of Capton foils (25μm) thick of suitable size glued on both sides of each sensitive plane (Fig. 3).

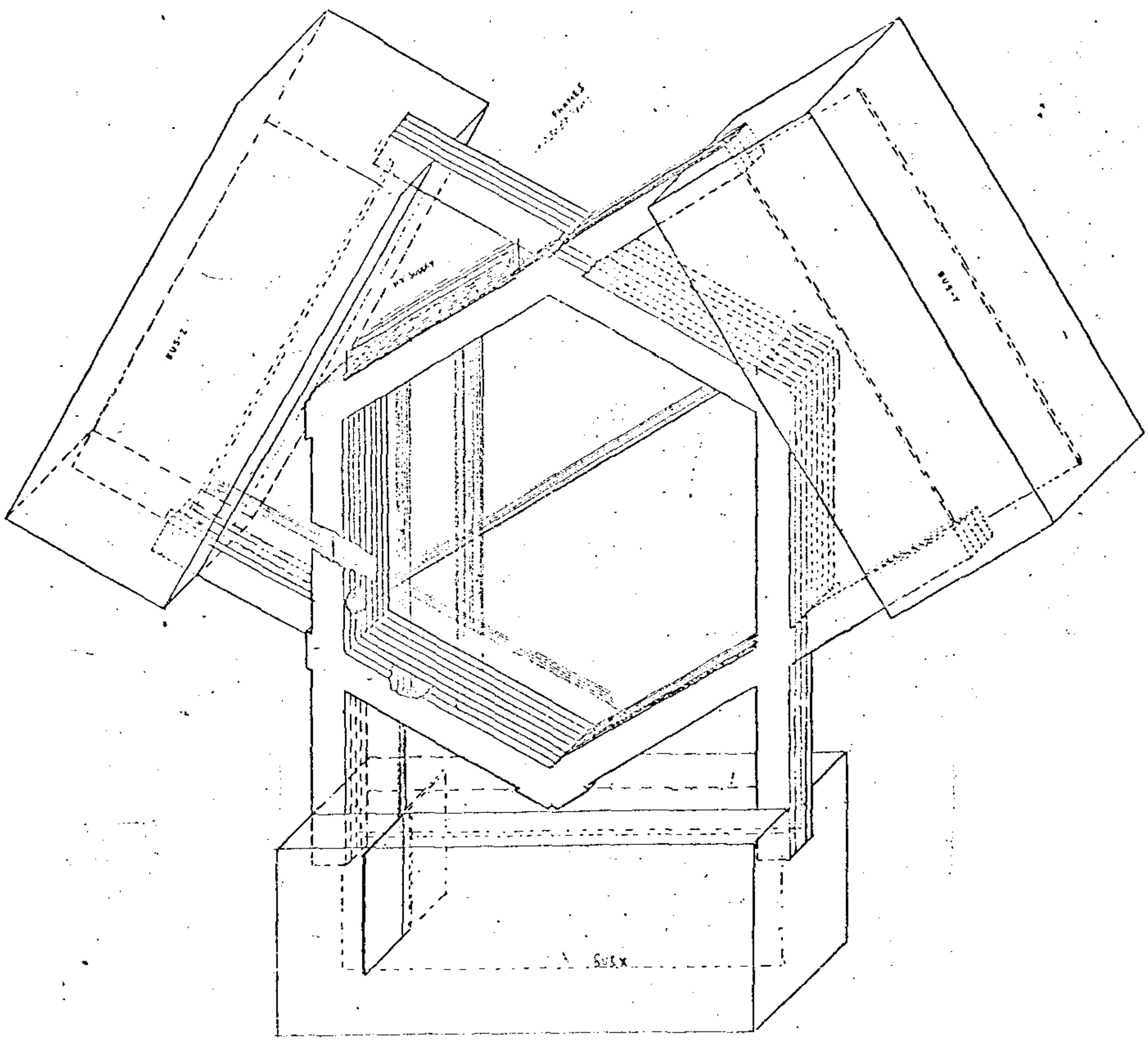

FIG. 4 - Mechanical structure of hexagonal chambers.

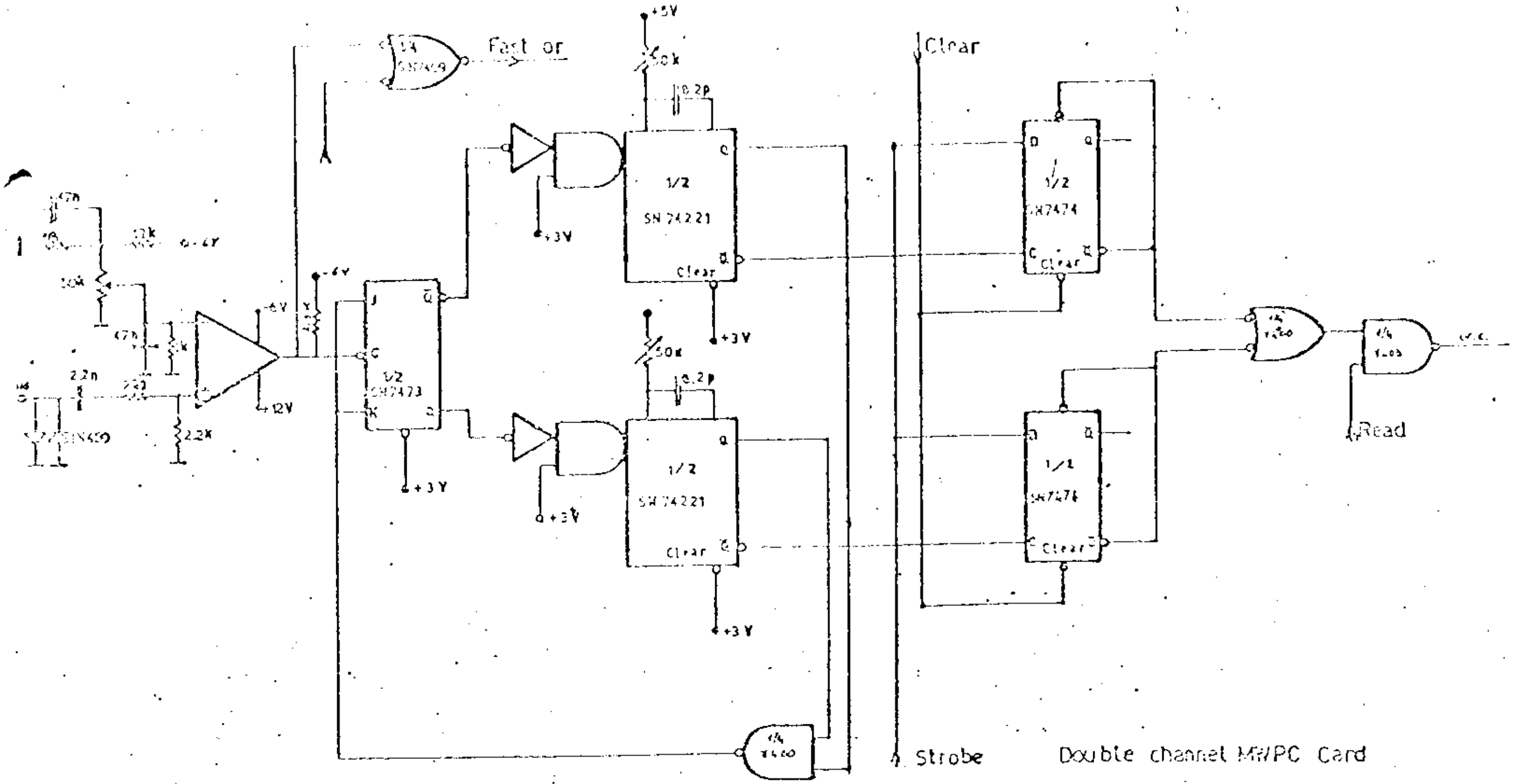

FIG. 5 - Read-out electronic card circuit for hexagonal chambers with double reading channel.

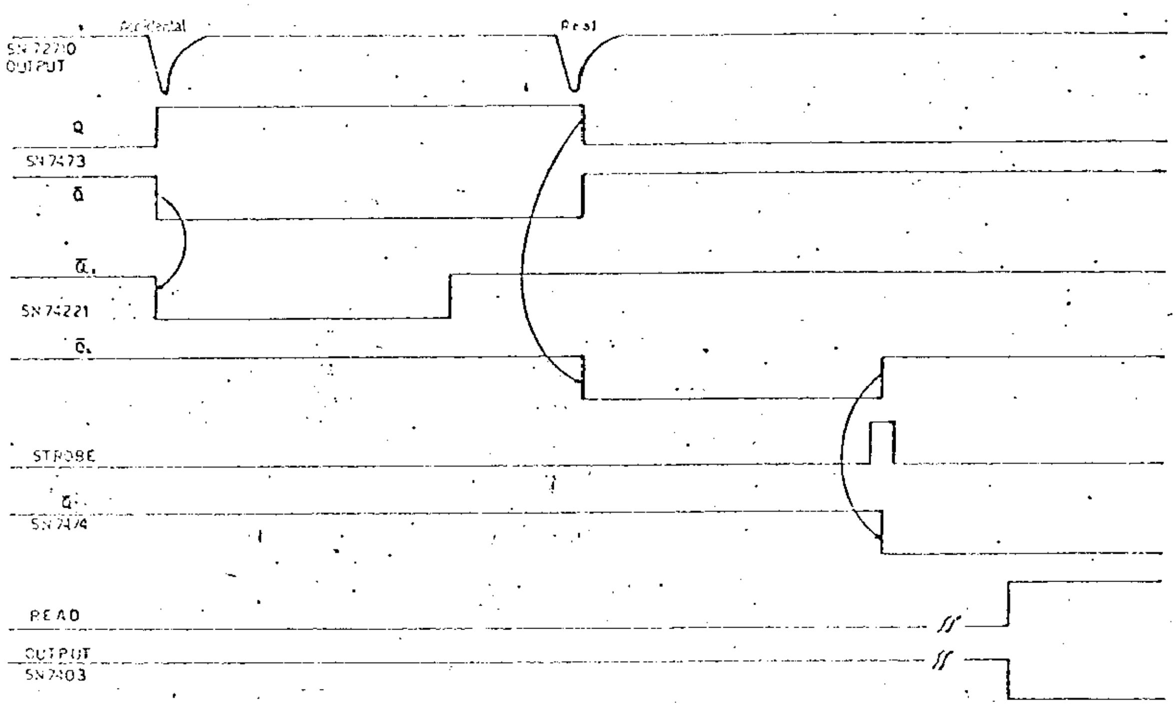

FIG. 6 - Timing diagram for the double-channel read-out circuit.

To measure the degree of inefficiency provided by these plugs, the chambers were illuminated by a flux of particles coming from scattering of a 100 GeV proton beam on a H_2 target. Since the plug on PC2 covers a solid angle smaller than that covered by the plug on PC3 and the interaction vertex is known, the histogram of hit position on PC2 can be projected from the interaction vertex on PC3 and a bin per bin division accomplished. This could be done also for PC2 and PC1. The result is shown in Fig. 7 and gives the efficiency distribution of PC3 scaled to PC2. It seems that the

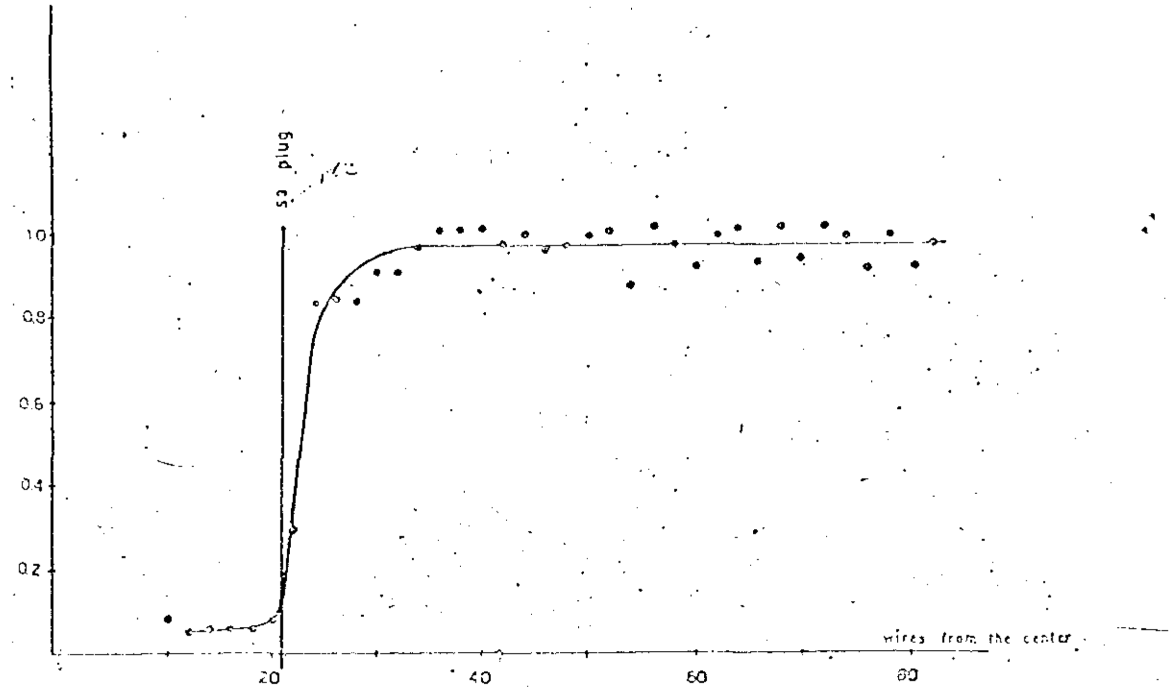

FIG. 7 - Plug study. PC3 particles per wire distribution's divided by PC2 particles per wire distribution scaled on PC3.

edge effect of the plug covers a distance of the order of one gap. Quite similar result has been obtained moving a beam across the insensitive regions.

5. - READOUT SYSTEM.

A PDP 11/45 computer provides on-line control and data taking of the complete spectrometer. The interface of the MWPC's with the PDP 11 was designed using DEC flip-chips. Each wire in the system is recognized by a wire address consisting in a word of 15 bits: bits 10÷14 give the chamber, bits 5÷9 the group and bits 0÷4 give the wire address within the groups. So the system is built on a basic structure of groups of 32 wires and can be expanded up to 32 chambers of 32 groups each. At each event the addresses of the hit wires are sent to the computer via DMA. The chambers are connected in parallel and linked to the Interface Unit via a Main Bus, and the reading of a particular chamber is done after a positive addressing of that chamber. This two facts provide the flexibility and the expandibility of the system. In Fig. 8 the flow diagram of the acquisition process is shown. The system is started by a Main-Start signal generated by the Event Trigger. This signal loads the address of the first chamber to be read in the ChAS, resets the GAS and presets the WAS to $(11111)_2$. The contents of the ChAS and GAS are also sent to the chambers via the Main Bus together with a timing signal (Test Pulse). The chamber and the group addressed send back a Group Presence Signal with the content of the 32 wire Buffer which is loaded into the 32 bit MSR.

The presence of hit wires in the group is detected by the Main OR, which then enables Clock 2 (running at 7 MHz), to shift the bits in the MSR. Clock 2 thicks are counted by the WAS. When the first 1 (hit wire) is found, the wire address, i.e. ChAS - GAS - WAS, is transferred to the computer via DMA. The process will continue until all 1's in the group are transferred. Another group is then called in, and so on until all groups in the chamber are read. When this is done the readout continues with next chamber. When the scanning of the last chamber is completed an END interrupt is sent to the computer.

In Fig. 9a and 9b the block diagrams of readout system are shown with the signal and data flow. Seven interrupts on two different bus request lines can be generated and there are 6 registers addressable by the computer. They are:

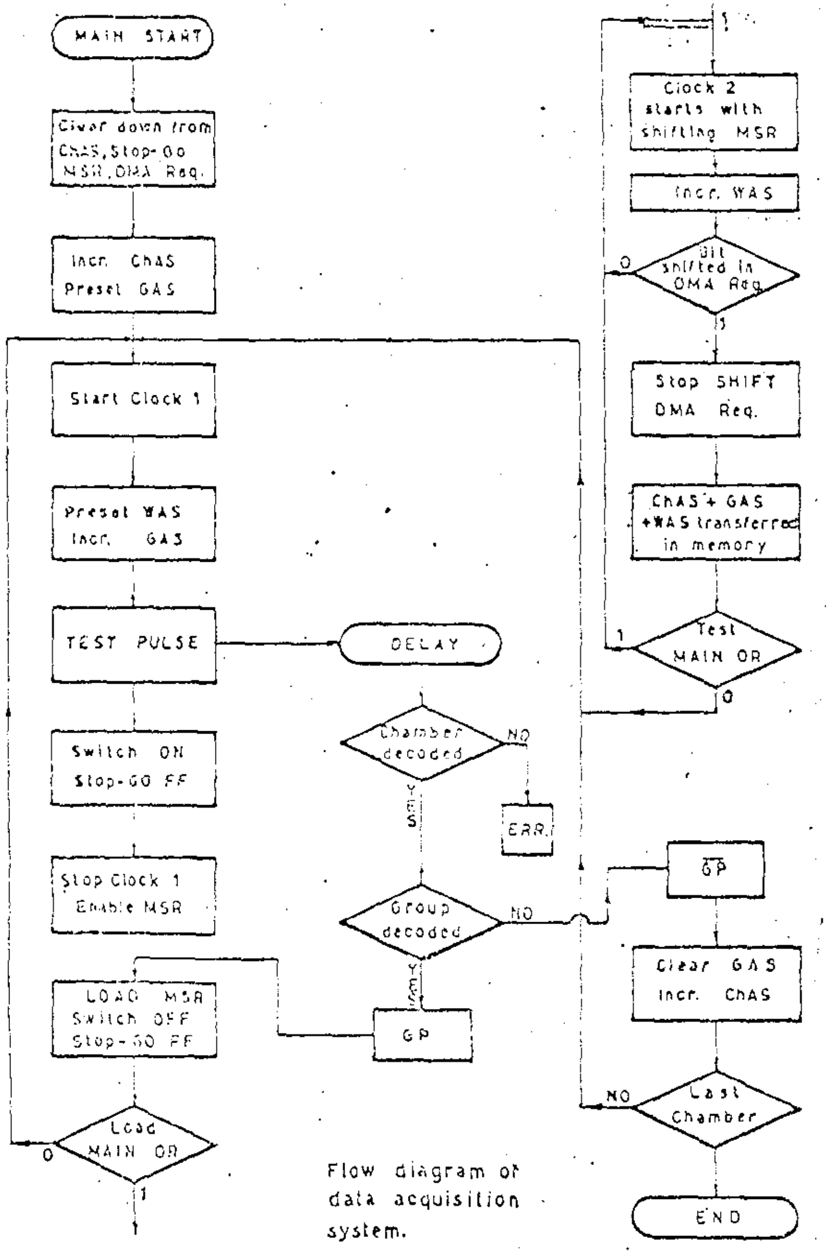

FIG. 8 - Flow diagram of the data acquisition system.

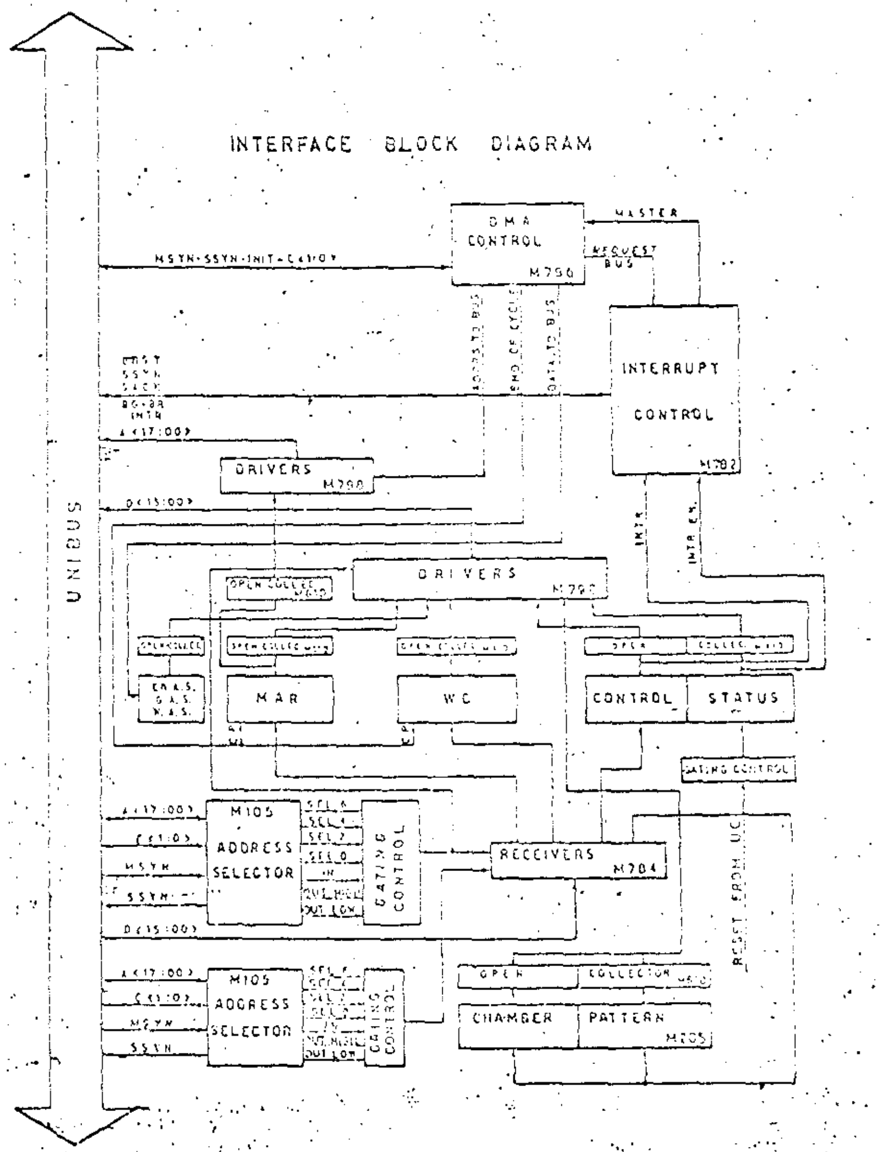

FIG. 9a - Diagram of the read-out interface.

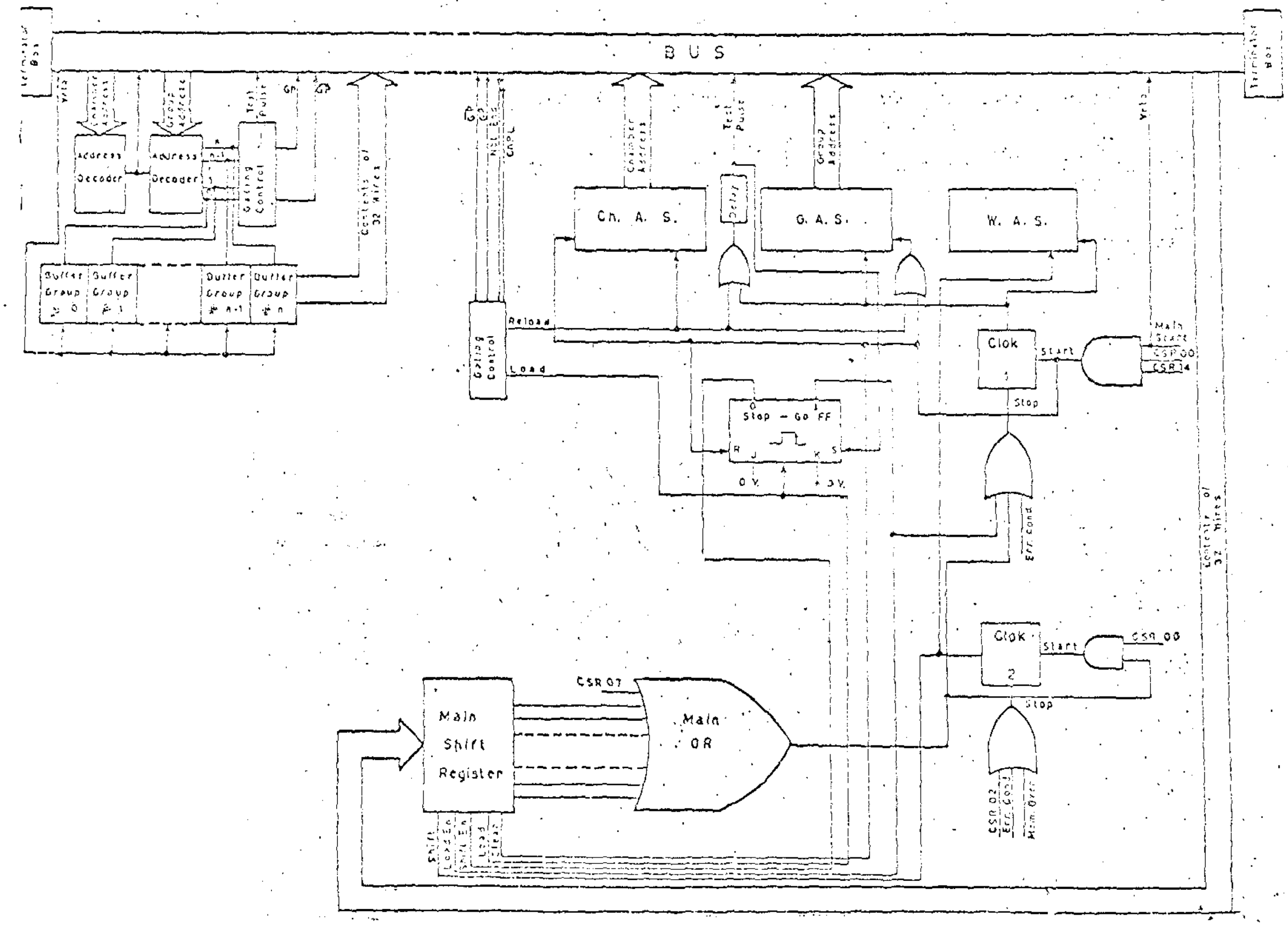

FIG. 9b - Diagram of the read-out interface.

a) Control & Status Register (CSR) for control and status function of the system;
b) Memory Address Register (MAR), its content is the memory address where data will be stored;
c) *Word Count Register* (WCR), its content represents the size of memory buffer for data. When the buffer is full an interrupt is generated;
d) Chamber Pattern Register (ChPR), this is a 32 bit register; it contains the pattern of chambers to be read.

Fig. 10 shows the flow charts of the software for data acquisition. The system starts by clearing and presetting scalers and registers, and enabling the acquisition interrupt. When an interrupt arrives, the system inhibits further trigger interrupts and enables DMA requests, End and Error interrupts. The readout system is provided with several testing features useful for on line and off line tests. With a "Test 0" is possible to find out all oscillating channels if any: in fact an Event Trigger can be generated with or without high voltage on the chamber. With "Test 1" is possible to look for bad channels, pulsing the voltage plane. Bad channels are shown on a display in both cases.

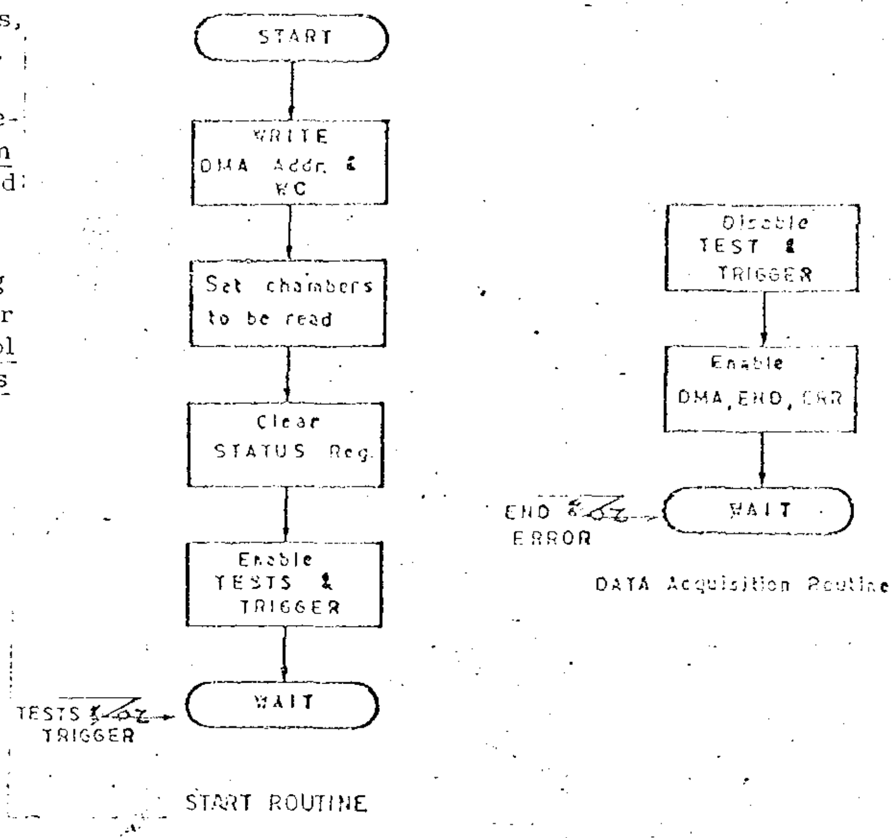

FIG. 10 - Flow chart for the *system handling.*

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REFERENCES.

(1) D. S. Ayers et al., FNAL Report No. NAL-73/83 - EXP. 7100. 096 (1973) (unpublished).
(2) Fermilab Single Arm Spectrometer Group, Phys. Rev. Letters 35, 1195 (1975); Also, Phys. Rev. to be published.
(3) P. La Vopa and G. Maggi, A High efficiency card for a multiwire proportional chamber, Report INFN/TC -75/13 (1975).
(4) A modular power supply for this use was developped by T. Droege of Fermilab.