APPENDIX III

HODOSCOPE DETECTORS AND ELECTRONICS

A. Introduction

Scintillation and Cerenkov counter assemblies are being constructed to be used in the focal planes of the 20-BeV/c and 8-BeV/c spectrometers. Each of these arrays will serve to detect pions and electrons selected by a spectrometer and will determine the position of selected particles trajectories at the focal plane. The position information along with other information that will allow a computer to identify electrons and, separately, pions with confidence is partially processed in a large array of electronics and stored for a few milliseconds in electronic buffer storage before being read into the computer. This appendix summarizes the design and operation of the detector system excluding the computer. In the next four sections we discuss the hodoscopes, the π-e discriminator, the electronics, and the monitor system.

B. The Hodoscopes

The hodoscope to be installed in the 8-BeV/c spectrometer will employ plastic scintillation counters in two arrays in order to determine both the momentum and the laboratory angle θ of a focused particle. There will be 41 p counters and 55 θ counters. We will have an astigmatic image in order that the p and θ counter banks can be conveniently separated along the central ray. The θ counter array is divided into two banks so that scintillation counter size is adequately large and so that there will be no edge effects; every particle passing through the array can in principle be detected and assigned a value of θ. Each θ scintillation counter is viewed by a single 6199 tube. The 41 p counters are similarly arrayed in two banks. Each counter is approximately 1/4" × 3/4" × 32" and is viewed at one end by an improved version of the 7767 phototube. Trigger counter arrays employing a total of 10 phototubes upstream and downstream of the θ and p counter banks are employed to identify the passage of a particle through the hodoscopes. The arrangement of the hodoscopes for the 8-BeV/c spectrometer is shown in Figs. 1 and 2.

Both phototube dynode and anode signals are brought by foam-filled 50 Ω signal cables back to the counting room. One of the signals is stored following the detection of a desired event in a manner to be described in section D, the other is available for on- or off-line checking of the equipment. Each phototube-scintillator combination is furnished with a small solid state light pulser which may be initiated from the counting room. These devices furnish signals which can be employed to check the gain, rise time, and signal delay of the phototube-cable-electronics systems and to test and adjust the coincidence and buffer storage arrays.

The scintillation counter dimensions are such that $\Delta p/p$ for each p-channel is 0.1% and $\Delta\theta$ for each angular channel is 0.3 mr. The latter value has been selected to match the value of $\Delta p/p$ for the kinematics of e-p scattering under worst case conditions. $(\Delta p/p)$ and $\Delta\theta$ were chosen so that e-p elastic scattering could be separated from electroproduction of the (3,3) resonance under all combinations of primary energy and scattering angle available at SLAC, when electrons only are detected. The 20-BeV/c spectrometer hodoscope has the same $\Delta p/p$ and $\Delta\theta$ per channel as the 8-BeV/c spectrometer. The total angular acceptances are, respectively, 9 mr and 16 mr.

C. The π-e Discriminator

We are presently constructing a single π-e discriminator that will be employed in the 8-BeV/c spectrometer. It will be constructed so that it can, with minor modifications, be employed in the 20-BeV/c spectrometer. It is designed to detect electrons with an efficiency of about 90% and to misidentify pions as electrons with a probability of less than 10^{-4}. It determines several different characteristics of π and e interactions, viz.:

1. Differences in opening angles of π and e showers.
2. Differences in the number of particles produced by pions or electrons when incident particles are passed through thin (~1 r.l.) absorbers.
3. Existence of penetrating components in a π shower, especially produced radiations that traverse more than 25 r.l. of material.
4. The differences in energy loss in a counter that will absorb totally an e shower but not a π shower.

The π-e discriminator is shown schematically in Fig. 3. It consists of an initial radiator in which an electron in the energy range from 2 BeV to 20 BeV will start to shower, producing on the average more than 3 particles. The initial radiator is followed by three dE/dx counters each required to detect more than 2 particles. The angular size of the incipient shower is determined in two hodoscopes that follow a 1.5 meter total drift space. The incipient shower must be contained within 1^{o} or 2^{o} of the shower axis in order to be accepted. Control of the lower shower-particle energy that can initiate a count in the various counters is exercised by the use of selective absorbers. A 16 element total absorption counter furnishes a signal that in itself can be used to discriminate powerfully against pions, for pion showers penetrate very much more deeply than electron showers and much of their energy escapes from the total absorption counter. Very penetrating particles from a pion shower will trigger an anti-coincidence telescope.

The device employs a total of 120 phototubes and four of the signals it develops are pulse height analyzed and sent to the computer. As in the hodoscopes each phototube is furnished with a solid state light pulser for testing and calibration.

D. The Electronics

The electronic instrumentation for the hodoscopes selects events to be stored in the computer, puts all the information concerning them in a buffer storage which, under computer command, is transferred to computer storage in the interval between accelerator pulses (at least 2.8 msec). A schematic layout of the electronic system for the 8-BeV/c spectrometer is shown in Fig. 4.

An electron passing through the hodoscope and π-e discriminator of the 8-BeV/c spectrometer (to give an example) would generate a fast coincidence between the hodoscope fast trigger counters, give appropriately large pulses in the three dE/dx counters, not cause too many of the shower angle hodoscope counters to fire and give an appropriate size pulse in the total absorption counter. Rather loose identification criteria will, in appropriate electronics, develop what is called a master trigger pulse which is available at 150 outputs of a large fan-out circuit. The master trigger pulse is put in coincidence with the output of discriminators each driven by the phototube output of a counter about which information is desired. A coincidence during beam time then initiates an element of the buffer storage. The combinations of discriminator, coincidence circuit and buffer are referred to as DCB's. The electronic system for the 8-BeV/c spectrometer will include 120 DCB's. These will store all the information from the p-counters, the θ-counters, the shower angle hodoscopes, the anti-coincidence telescope, and some other circuits. Pulse height information from each of the three dE/dx counters and the summed output from elements of the total absorption counter are pulse height analyzed in commercial PHA's whose address registers form their own buffers. Rigorous criteria for pion rejection are established by the computer after transfer of all the relevant information; the electronics criteria being set only to reject obviously spurious "electrons." Extra buffer elements will allow us to flag various preset experimental conditions or special class events as signalled by electronic signals.

Approximately 90 DCB's will be employed in the electronics for the 20-BeV/c spectrometer. Some sharing of electronics between the instrumentation of the two spectrometers is expected.

E. Monitor System

The electronics is being designed to furnish electrical access to the circuits for testing and inspection during experimental runs. In combination with the light pulser arrays we will be able to check out the system rapidly and to diagnose and correct malfunctions efficiently with a minimum of down time. The monitoring system will be manually operated at first but is being designed so that it can be operated under computer control at a later date.

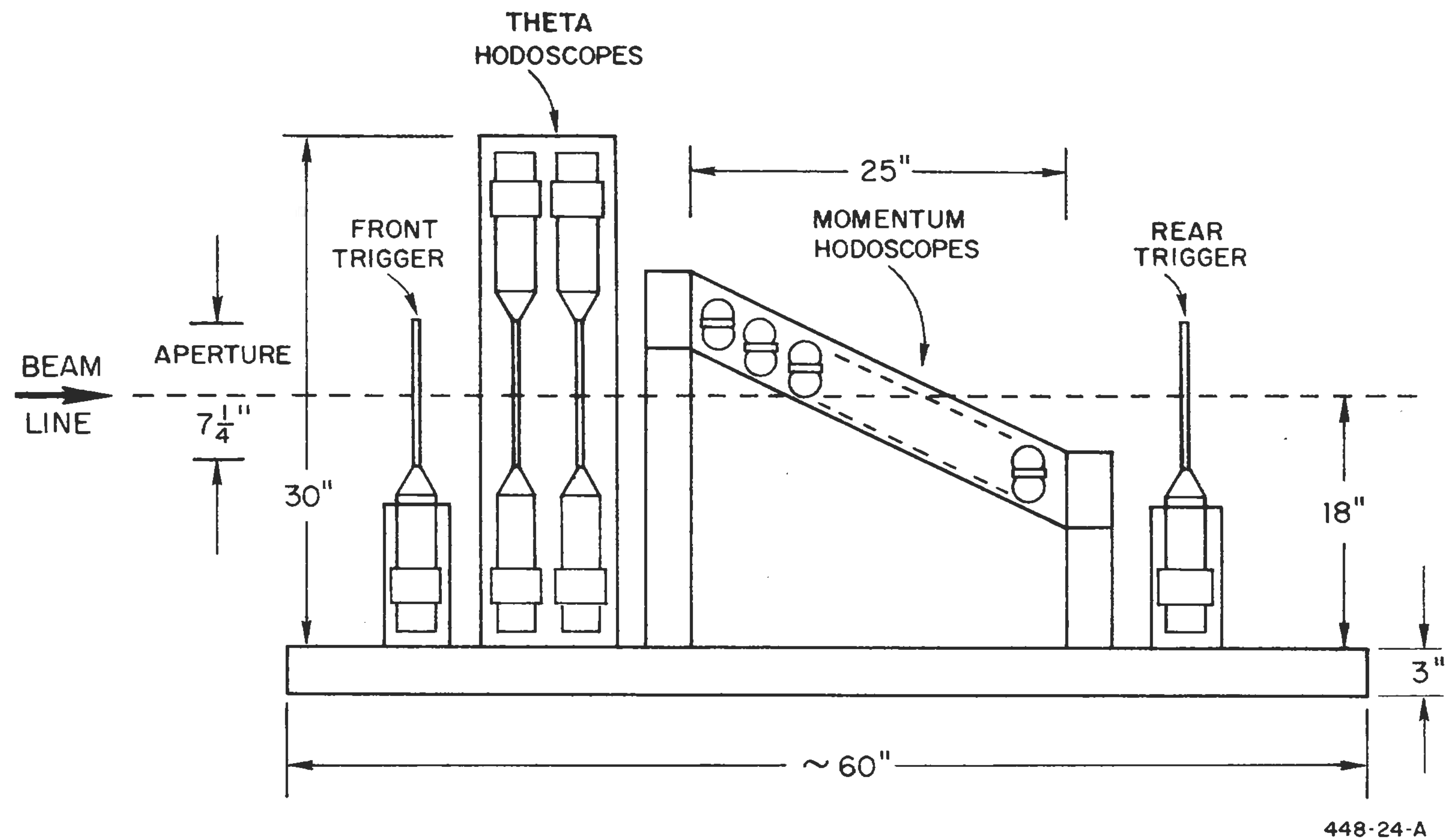


FIG. 1 -- SIDE VIEW OF THE HODOSCOPES FOR THE 8-BeV/c SPECTROMETER

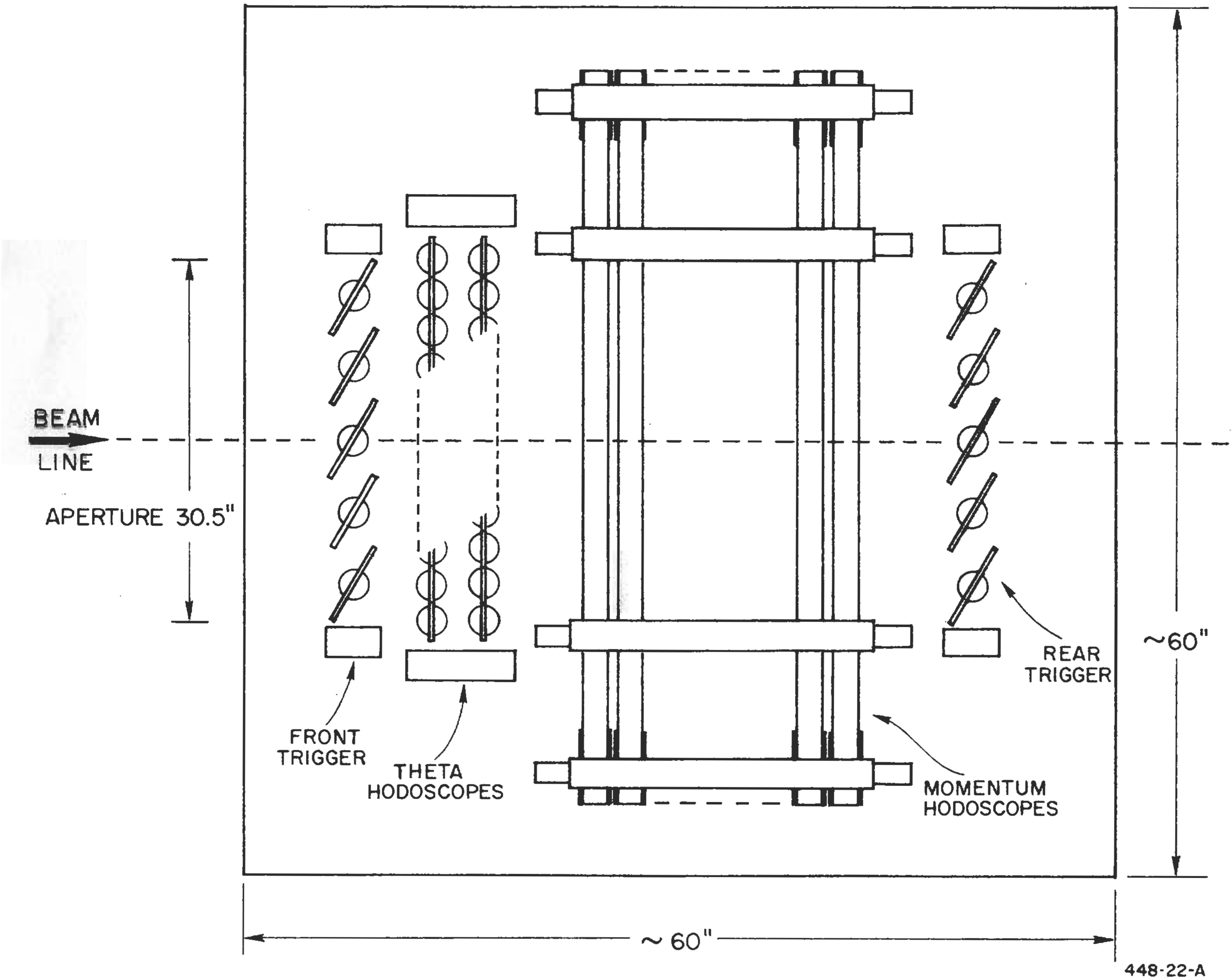


FIG.2 -- PLAN VIEW OF THE HODOSCOPES FOR THE 8-BeV/c SPECTROMETER

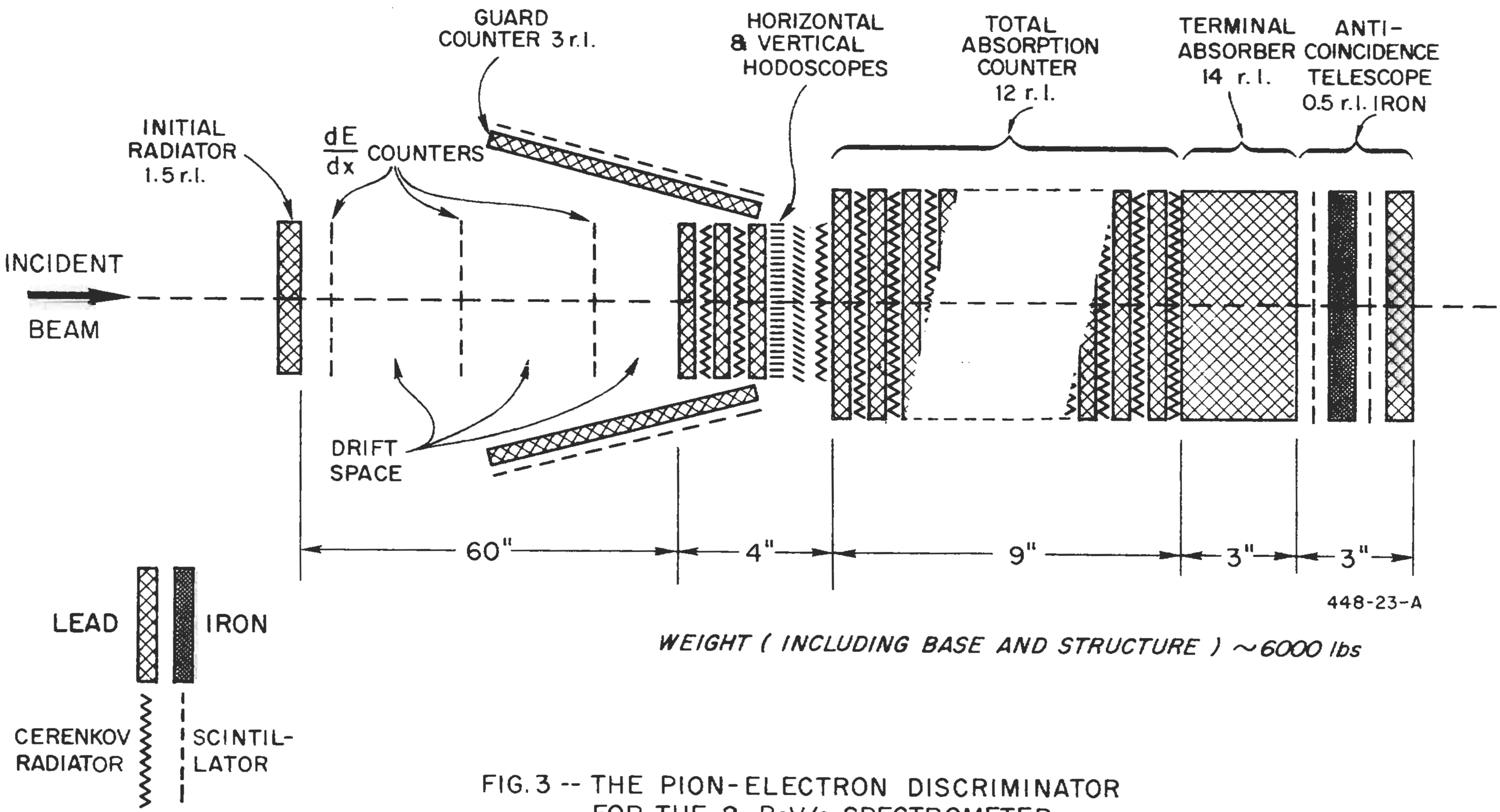
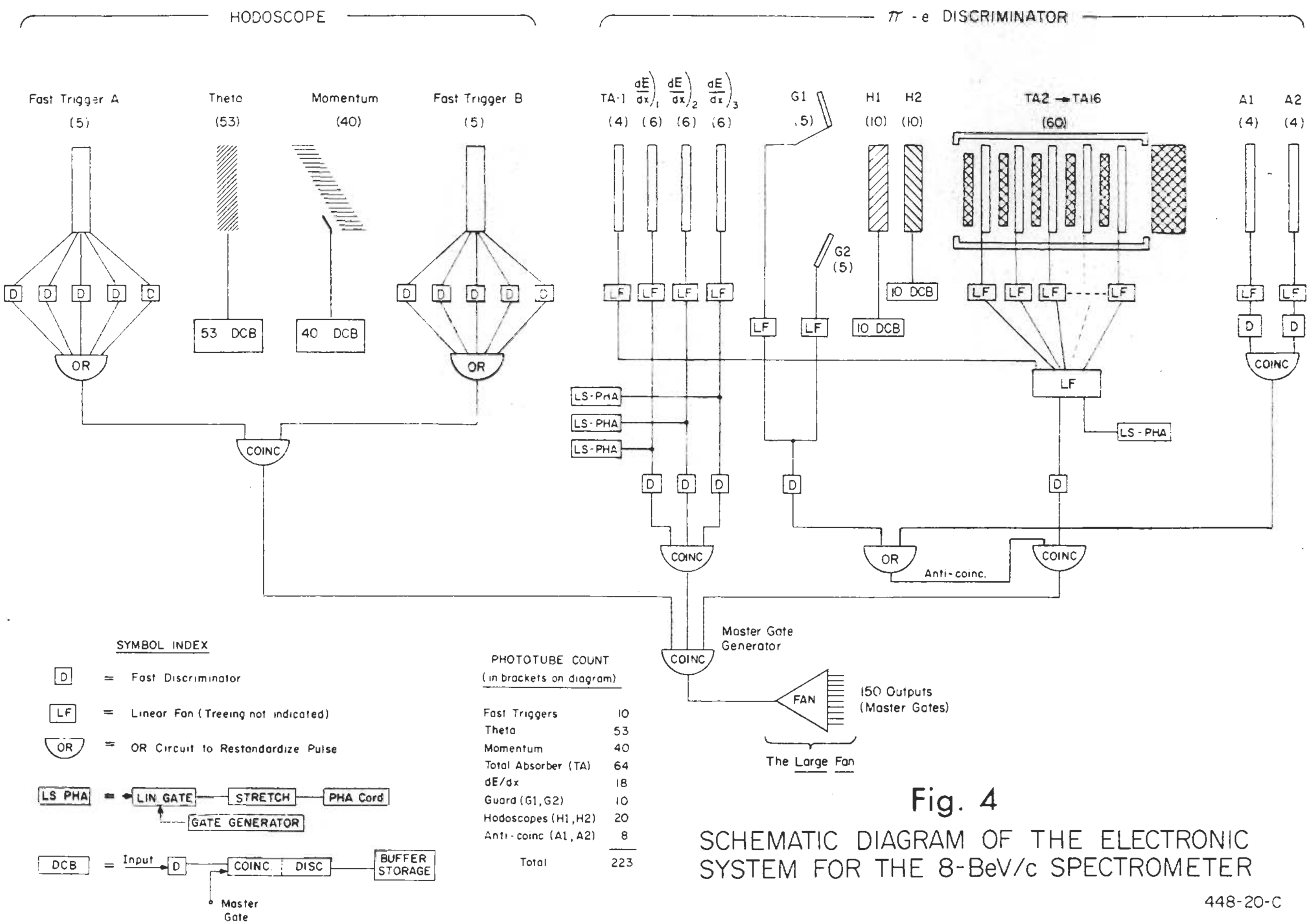


FIG. 3 -- THE PION-ELECTRON DISCRIMINATOR FOR THE 8-BeV/c SPECTROMETER.



PHOTOTUBE COUNT
(in brackets on diagram)

Fast Triggers	10
Theta	53
Momentum	40
Total Absorber (TA)	64
dE/dx	18
Guard (G1, G2)	10
Hodoscopes (H1, H2)	20
Anti-coinc (A1, A2)	8
Total	223

Fig. 4

SCHEMATIC DIAGRAM OF THE ELECTRONIC SYSTEM FOR THE 8-BeV/c SPECTROMETER

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