SLAC-PUB-2661
January 1981
(E/I/A)

A STAND-ALONE BEAM STEERING AND PROFILE MONITOR*

D. G. McShurley, G. Oxoby, S. Shapiro, Q. Trang, S. Williams

*Stanford Linear Accelerator Center, Stanford University,
Stanford, California 94305*

ABSTRACT

A system has been developed, the primary function of which is to continually display the position, shape, and intensity of the charged particle beam being delivered to the experiment. The system is modular for easy maintenance and is a stand-alone device independent of any computer.

Submitted to Nuclear Instruments and Methods

*Work supported by the Department of Energy under contract No. DE-AC03-76SF00515.

I. INTRODUCTION

A proportional chamber system has been developed to provide a stand-alone visual display of the position, shape, and intensity of the beam being delivered to the LASS spectrometer. System operation is automatic and requires only a gate signal for data entry and for spark chamber noise suppression.

The system is composed of three primary components:

A. The proportional chambers and their readout cables;

B. The amplifiers, and

C. The readout and display logic.

This paper will describe the individual components and the overall system performance.

II. SYSTEM COMPOSITION

A. Proportional Chamber and Cable

The detector is composed of two independent anode readout proportional wire chambers which have 4 mm half gaps and 2 mm anode wire spacings. Each of the chambers consists of one anode wire plane and two cathode high voltage planes operated at negative high voltage. The chamber, shown in Figure 1, measures 153.4 mm × 254 mm outside, has a 88.9 mm diameter aperture, and an active area of 48 mm square.

The anode plane has 24 gold plated tungsten, 20 μm diameter signal wires with five field tapering wires on each end. These wires are attached to a precision ground 4 mm thick, preetched and machined, copper clad G-10 printed circuit board by conventional solder and epoxy methods (Figure 2). The detector in use at LASS employs only the central 16 wires of this chamber.

The cathodes are fabricated of aluminum-mylar laminate which is stretched and bonded to the G-10 frames. An etched pattern on the laminate provides edge breakdown protection and the required interconnection to the current protection resistor.

The assembled detector (Figure 3) has one chamber oriented so that the wires are vertical (measuring the X coordinate) and the second chamber oriented so that the wires are horizontal (measuring the Y coordinate).

The chambers are mounted between two aluminum end caps which contain the gas porting. Aluminum-mylar laminate windows, bonded to these end caps, provide a common gas seal as well as RF shielding.

The amplifiers for sensing the chamber signals are mounted 40 feet away and are connected to the chamber by Brand Rex T5563 cables. The Brand Rex cable is a ribbon of eight miniature 95 ohm air core coaxial cables having good frequency response and attenuation characteristics. An additional aluminum-mylar sheath provides the necessary RF shielding and noise immunity. A 2 K ohm back termination is provided on the chamber for each wire.

B. Amplifiers

The amplifiers are an eight channel version of the anode amplifiers in use at LASS [1]. These are packaged in a single width "NIM" module (Figure 4). Power and a reference threshold voltage are provided by bussing in a standard "NIM" crate. The complete amplifier crate (Figure 5) consists of four eight channel modules, a cable interface, a reference voltage module, and a high voltage power supply in an "NIM" package for the proportional chamber.

Schematically, the amplifiers (Figure 6) transformer couple the PWC signal pulses to the input of a video amplifier (μ 733) providing a first stage gain of 200. The amplified pulse is then ac coupled to a fast differential comparator (μ 760) where the offset, generated by the external reference, provides an adjustable threshold for the system. The 760 output is a TTL pulse that drives a monostable pulse shaper, generating a standardized low true, 150 nsec pulse. A cable driver provides the current to transmit the signal over 150 feet of RG 58 coaxial cable to the readout and display logic located in the control room.

C. <u>The Readout and Display Logic</u>

The readout logic can be divided into three sections, the acquisition section, display update section, and the display control section [2]. Figure 7 is a block diagram of the readout and display logic being described.

1. Acquisition Section:

The acquisition section consists of 32 receivers having Schmitt trigger inputs and tristate outputs (74LS244), 32 eight bit binary counters (74393), and 32 eight bit latches (74LS374).

The incoming pulses from the amplifiers are received by the Schmitt trigger devices. Each output, which is pulled up to guarantee a TTL logic "level one" when in the high impendance state, drives the clock input of one of the acquisition counters. The "output enable" line of these receivers is driven by the gate signal which has also passed through a Schmitt trigger receiver. The timing of the gate must be carefully chosen to enable the receiver output at the beam arrival time and disable it before any electrical noise can be induced by the experiment.

The acquisition counters are reset by either a RESET push-button switch or the display update section. The count of each one is incremented by a negative transition of the clock input. The outputs are connected to the D inputs of an octal D type flip-flop used as an eight bit latch.

2. Display Update Section:

This section controls the number of beam pulses to be used for the display. The desired number of beam pulses is chosen via a set of three front panel thumbwheel switches. The thumbwheel switches are connected to the data inputs of three presettable up/down BCD counters (74190) cascaded together. This display update counter is parallel loaded when the RESET button is depressed or when its count is zero and the gate is off.

Counting occurs on the leading edge of the gate signal. Since the value of the thumbwheel switches is loaded, the display update counter is wired and used as a count down device. Upon reaching a count of zero, the data contained in the acquisition counters are latched into the 32 octal D flip-flops with tri-state outputs which are interconnected to make an eight bit bus. When the gate is disabled, the display update counter is reloaded with the value of the thumbwheel switches, and the acquisition counters are reset to zero and become ready to acquire new data.

3. Display Control:

This section generates the controls for the X and Y inputs of an X-Y display scope.

A free running oscillator clocks an eight bit address counter with an output which drives the digital to analog converter (DAC) for the horizontal axis directly. Since the maximum count of the address counter is 256, and only 32 data points are needed, eight counts are reserved for each data point. For the vertical axis, this is accomplished by decoding the five most significant address bits with two 4 line to 16 line decoders. The outputs of the decoder sequentially scan the output enable lines of the 32 eight bit latches. To prevent enabling several outputs at the time of address transition, the decoder is gated off for the half clock cycle of the oscillator preceding the change. When the decoder is gated off, none of the latches are selected. This provides the dotted base line of the display.

The eight bit bus from the latches is connected to one set of inputs of a two line to one line multiplexer. The other set of inputs of this multiplexer is driven by the graticule binary counter. The "select" line is controlled by the decoding of the six least significant bits of the address counter.

The multiplexer output, which drives the vertical axis DAC, corresponds to the eight bit bus, except when the six least significant bits of the address counter are zero. In this case the graticule counter is selected. This counter is held reset when not selected by the multiplexer. It is clocked by a fast oscillator. The effect is to generate a faint vertical line when the address counter counts Ø, 63, 127, and 191, namely, every eight data samples. These lines facilitate visual calibration of the beam position within the 32 bin display.

III. SYSTEM PERFORMANCE

The beam steering and profile monitor system has proven to be a very simple-to-use and reliable tool.

The proportional chambers, using a variant of the magic gas mixtures in use at LASS, are 100% efficient with a negative high voltage of 3.6 kV. The detector is precision aligned to the beam center line and indexed for easy removal and replacement.

The amplifiers operate in a "NIM" crate installed 40 feet from the detector. This was necessitated by the high local magnetic field and other mechanical constraints. The amplifier power, chamber high voltage, and system threshold voltage, which can be varied by a front panel potentiometer, are supplied at the "NIM" crate. The output signals from the amplifiers are transmitted over 32 RG-58 coaxial cables to the readout and display logic located in the LASS control room.

The readout logic receives the signals, forms a coincidence with the gate, and strobes this information into the correct registers. The number of beam pulses for a given display can be selected by front panel thumbwheel switches. The data are displayed, as a histogram on the X-Y scope, where the display is held until updated (Figure 8). Hardware generated vertical lines on the display, representing the expected position of the center lines of the X and Y PWC detectors, aid the eye in evaluating the quality of the beam. The histogram then displays the beam position with respect to the beam center line, its width (in 2 mm bins) and its intensity (by observing the height of the histogram and comparing it to the preselected number of pulses).

The system is expecially useful as a stand alone monitor during the setup of an experiment, or during short duration test runs. It is during these times that the myriad of computers necessary to running a large spectrometer might not all be working or available. The simple gating scheme employed has been successful in eliminating spark chamber induced noise from the system. The system is extremely useful in giving "at-a-glance" information on the quality of the beam incident to the spectrometer.

IV. CONCLUSION

The stand-alone beam steering and profile monitor described in this paper has been successfully used in the LASS spectrometer for the past three months. It has been a reliable source of information, seemingly immune to spark chamber noise, computer failure, and other experimental hazards. The ease with which we can evaluate the beam position, shape, and intensity of the beam being delivered to the spectrometer has significantly contributed to the efficiency of our efforts.

V. ACKNOWLEDGMENTS

The authors would like to thank their colleagues in Group B for their enthusiastic support of this project with special thanks to David Leith for his ideas and suggestions. In particular, the authors wish to thank Al Kilert, Frank Holst, Annette Nicholson, George Aiken and William Freet for their patience and help throughout the project.

REFERENCES

[1] S. L. Shapiro, M. G. D. Gilchriese and D. G. McShurley; A Proportional Chamber Front End Amplifier and Pulse Shaping Circuit. SLAC Pub. 1713 Feb 1976; IEEE Trans. Nucl. Sci. NS23 264-268 No. 1 (1976).

[2] The detailed schematic for the readout and display logic is available as SLAC Drawing No. SD-735-503-74-RØ (two sheets).

FIGURE CAPTIONS

1. Assembly drawing of the detector.
2. Close-up of an anode wire plane.
3. Photograph of a preassembled detector.
4. Photograph of an amplifier module.
5. Photograph of the NIM crate containing the amplifier, cable interface, H.V. power supply, and reference voltage module.
6. Amplifier schematic.
7. Readout and display logic block diagram.
8. Photograph of the histogram display.

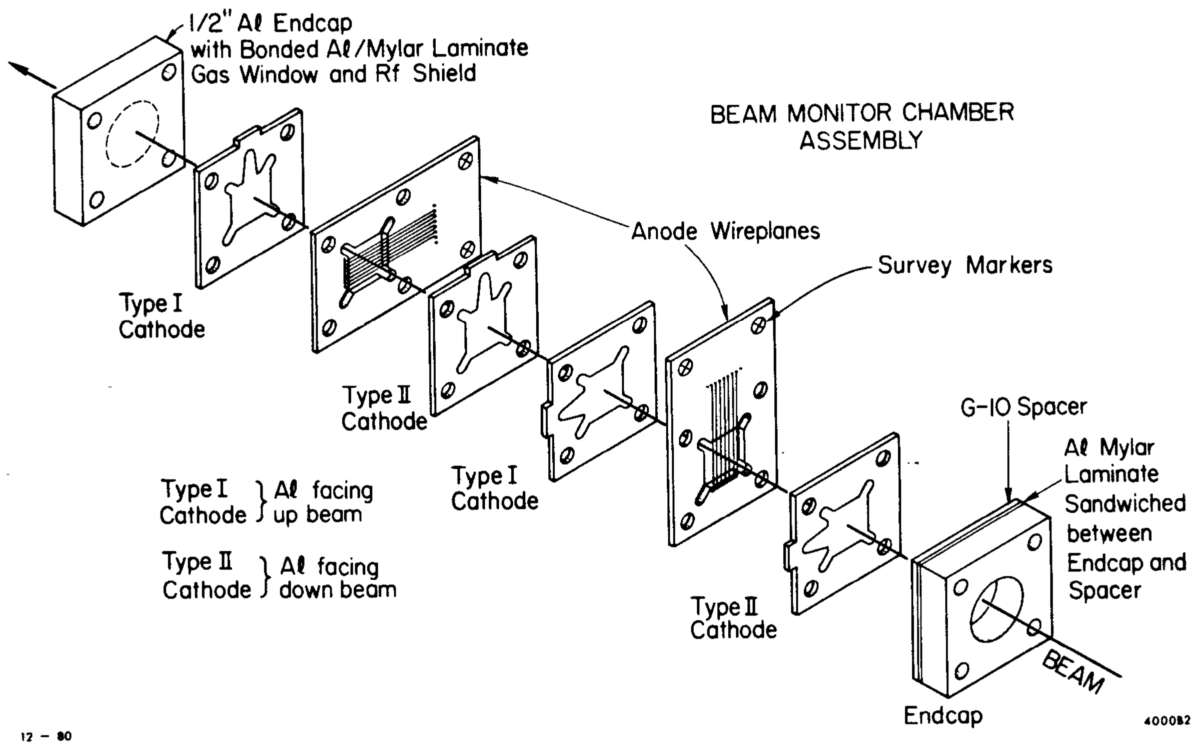
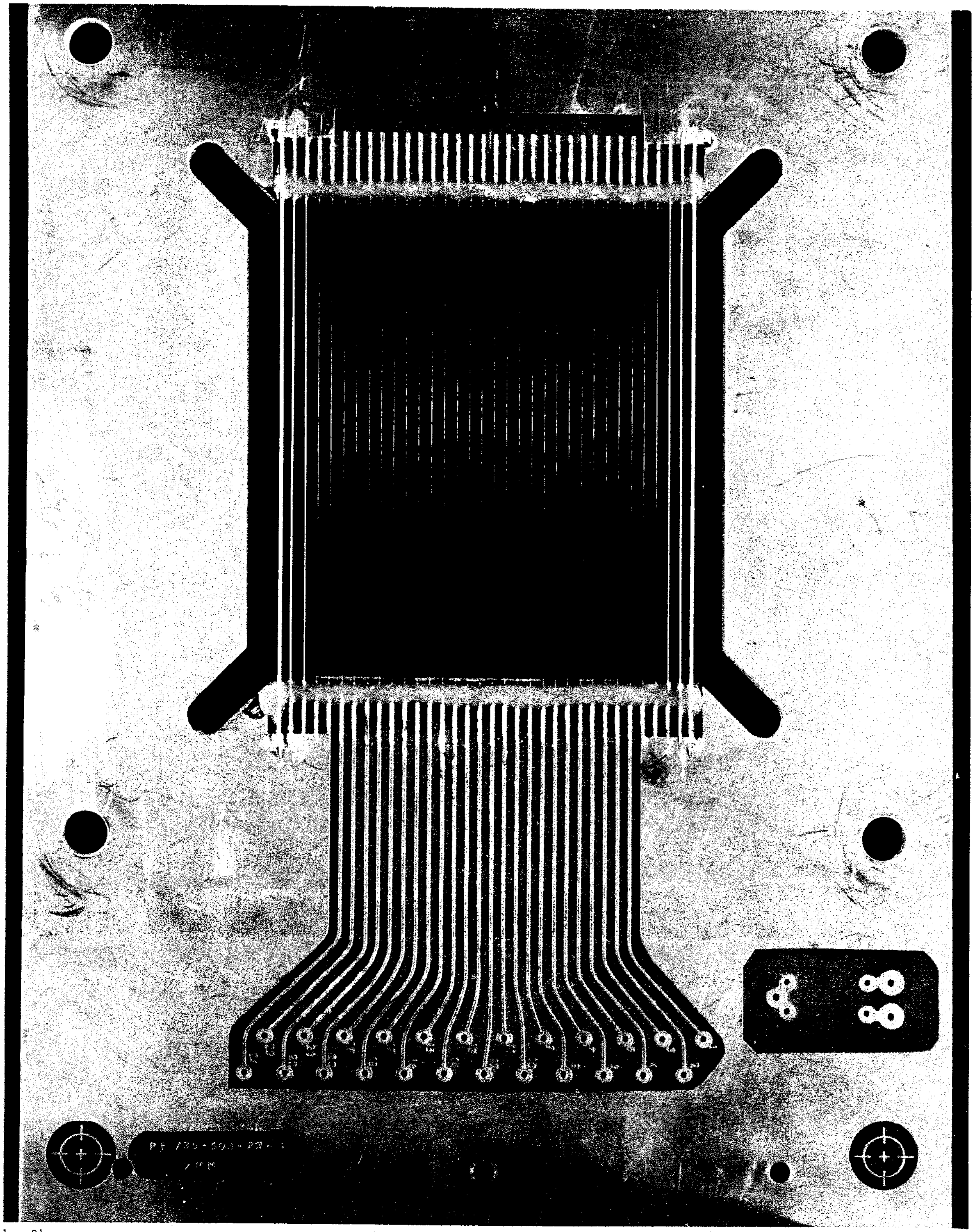

1/2" Al Endcap
with Bonded Al/Mylar Laminate
Gas Window and Rf Shield
BEAM MONITOR CHAMBER
ASSEMBLY
Anode Wireplanes
Survey Markers
Type I
Cathode
Type II
Cathode
Type I
Cathode
G-10 Spacer
Al Mylar
Laminate
Sandwiched
between
Endcap and
Spacer
Type I
Cathode } Al facing
up beam
Type II
Cathode } Al facing
down beam
Type II
Cathode
BEAM
Endcap
12 - 80
400082

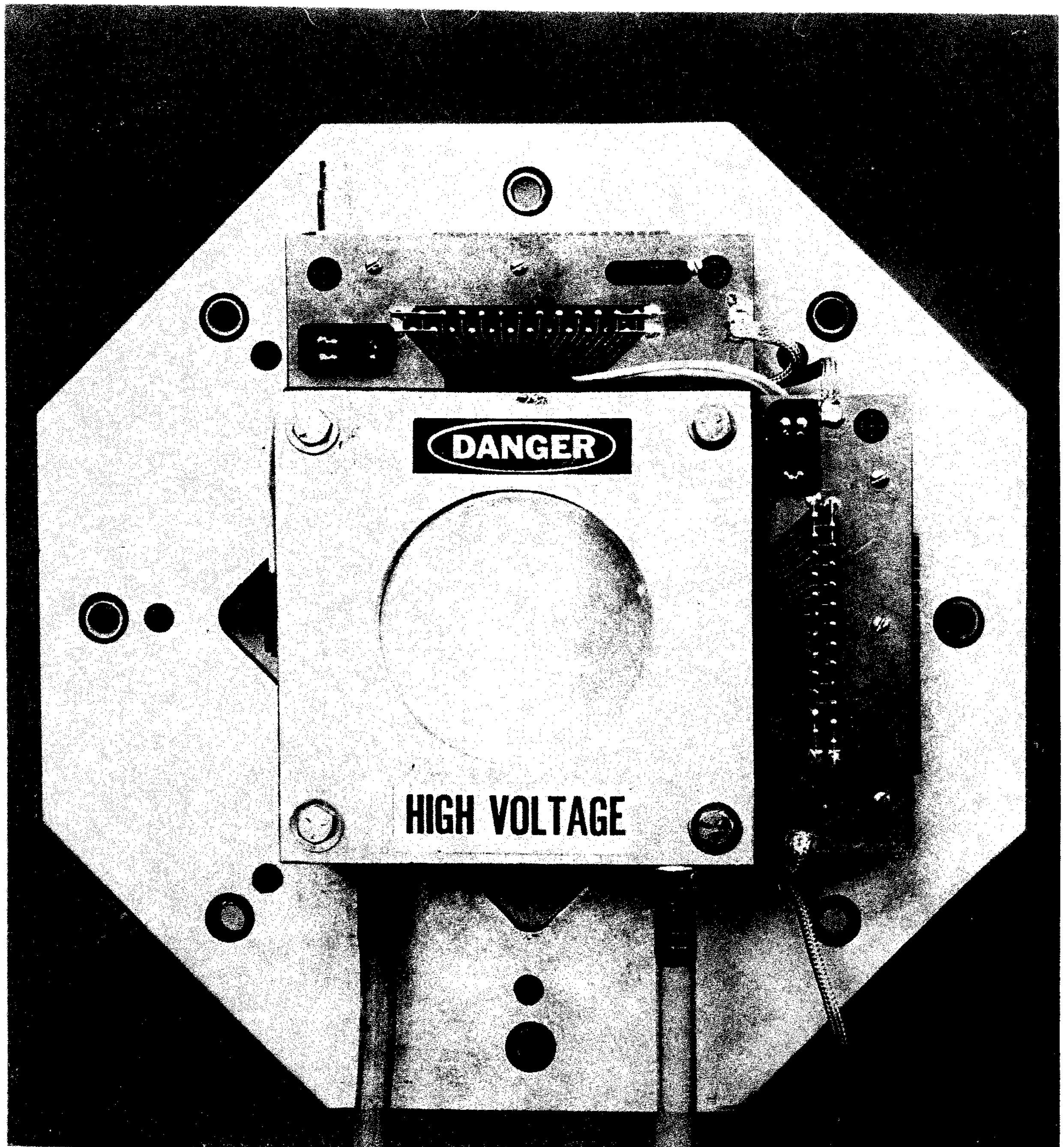
Fig. 1



1 — 81

4000A6

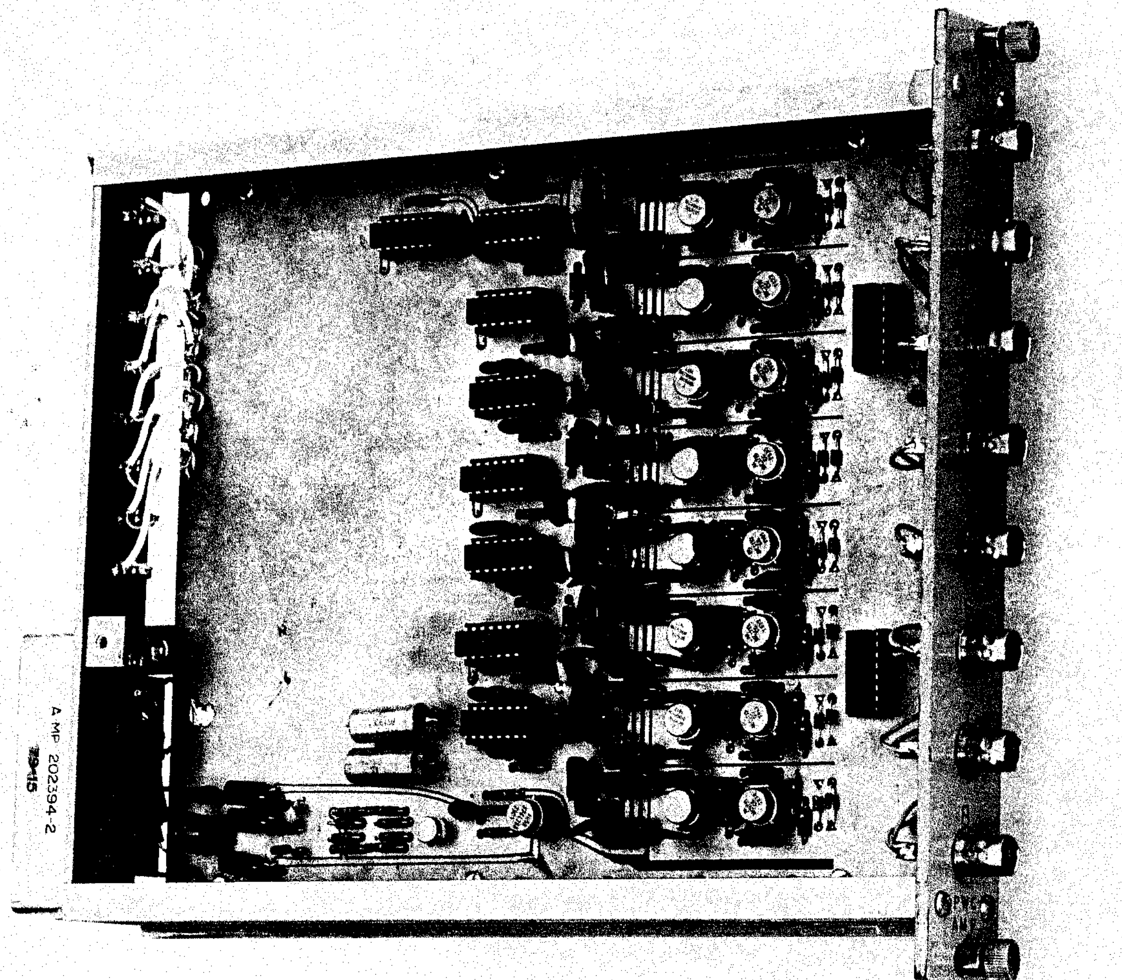
Fig. 2



1 — 81

4000A8

Fig. 3



1 — 81

4000A7

Fig. 4

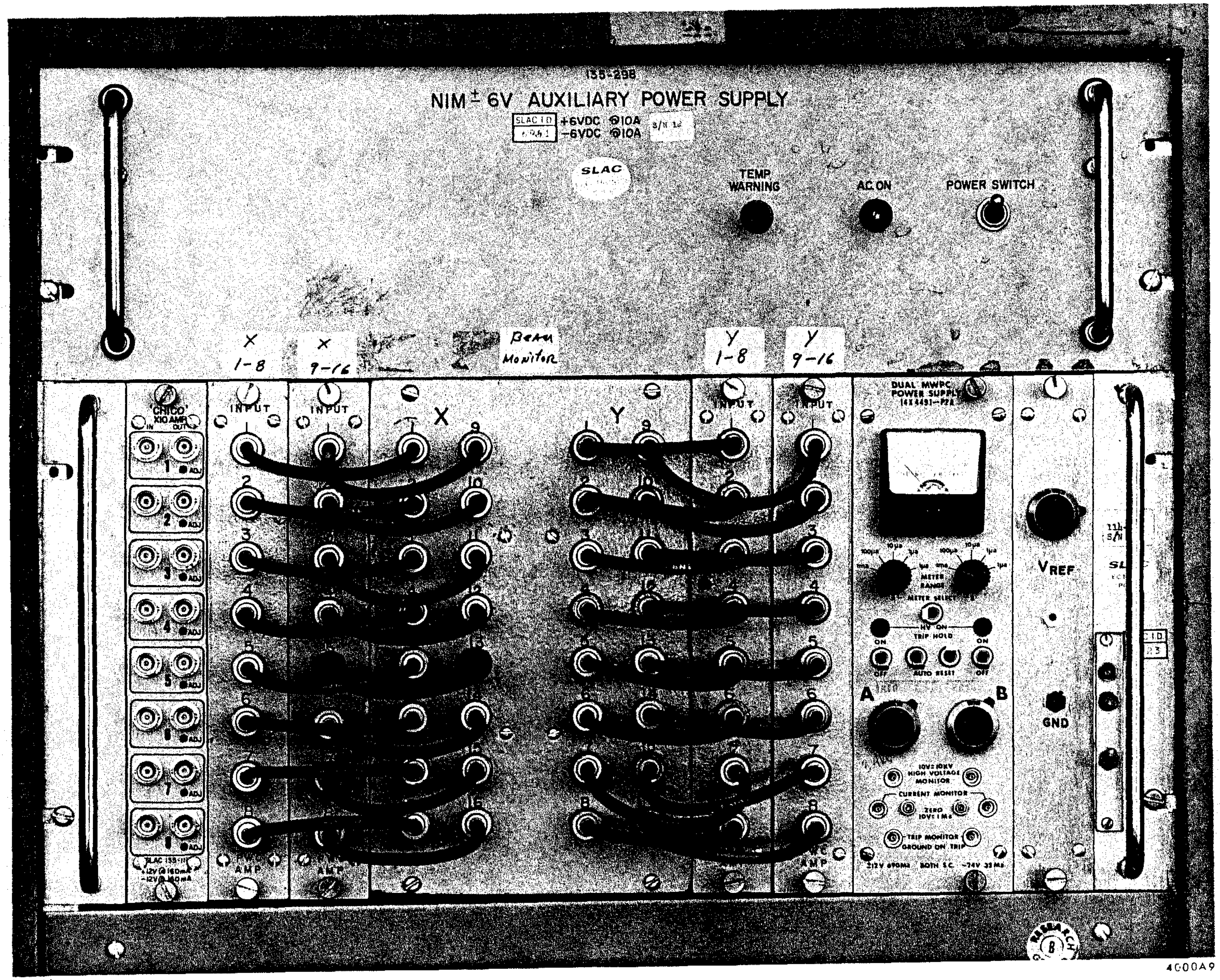

135-298
NIM ± 6V AUXILIARY POWER SUPPLY
+6VDC @10A
-6VDC @10A
SLAC
TEMP WARNING
AC ON
POWER SWITCH
X 1-8
X 9-16
Beam Monitor
Y 1-8
Y 9-16
INPUT
X
Y
DUAL MWPC POWER SUPPLY
A
B
VREF
GND
4000A9
1 - 81

Fig. 5

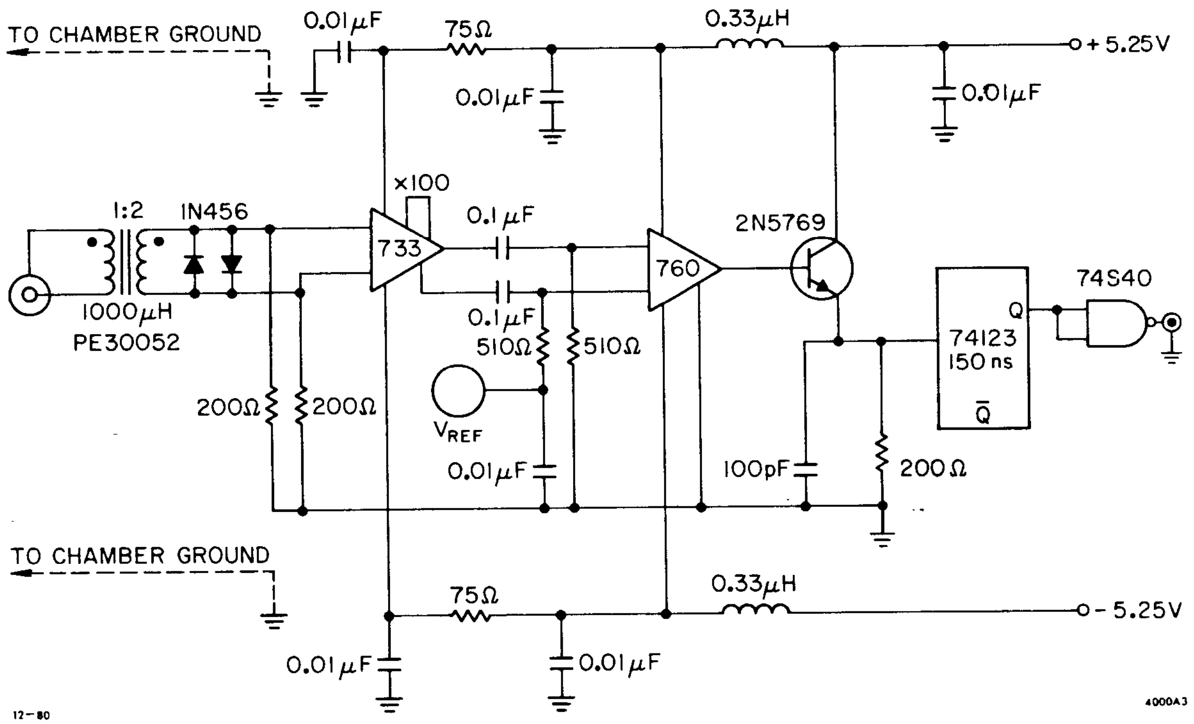

TO CHAMBER GROUND
0.01μF
75Ω
0.33μH
+5.25V
0.01μF
0.01μF
×100
1:2
1N456
733
0.1μF
760
2N5769
1000μH
PE30052
0.1μF
510Ω
510Ω
74S40
Q
74123
150 ns
Q̄
200Ω
200Ω
V_REF
0.01μF
100pF
200Ω
TO CHAMBER GROUND
75Ω
0.33μH
-5.25V
0.01μF
0.01μF
12-80
4000A3

Fig. 6

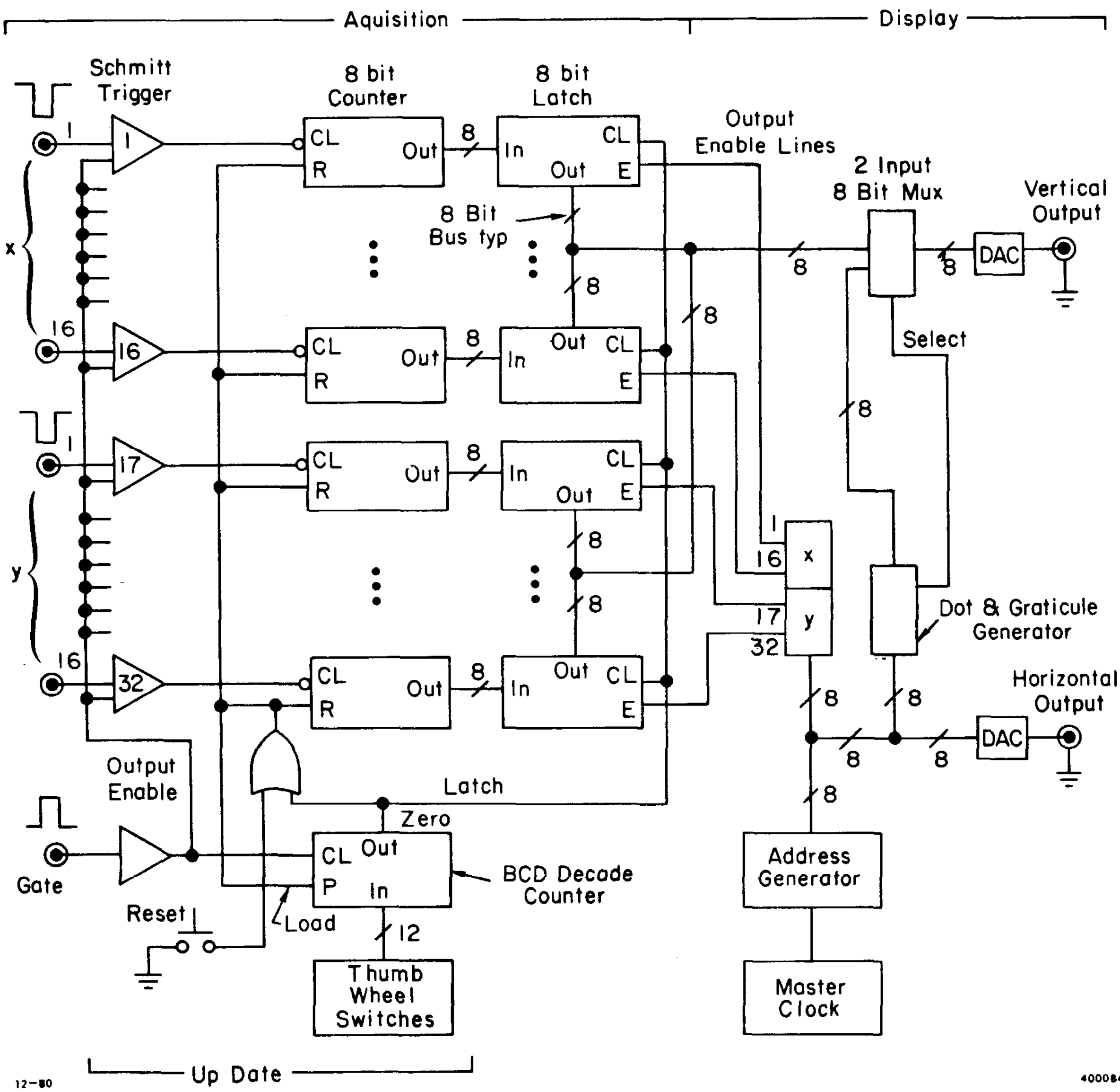
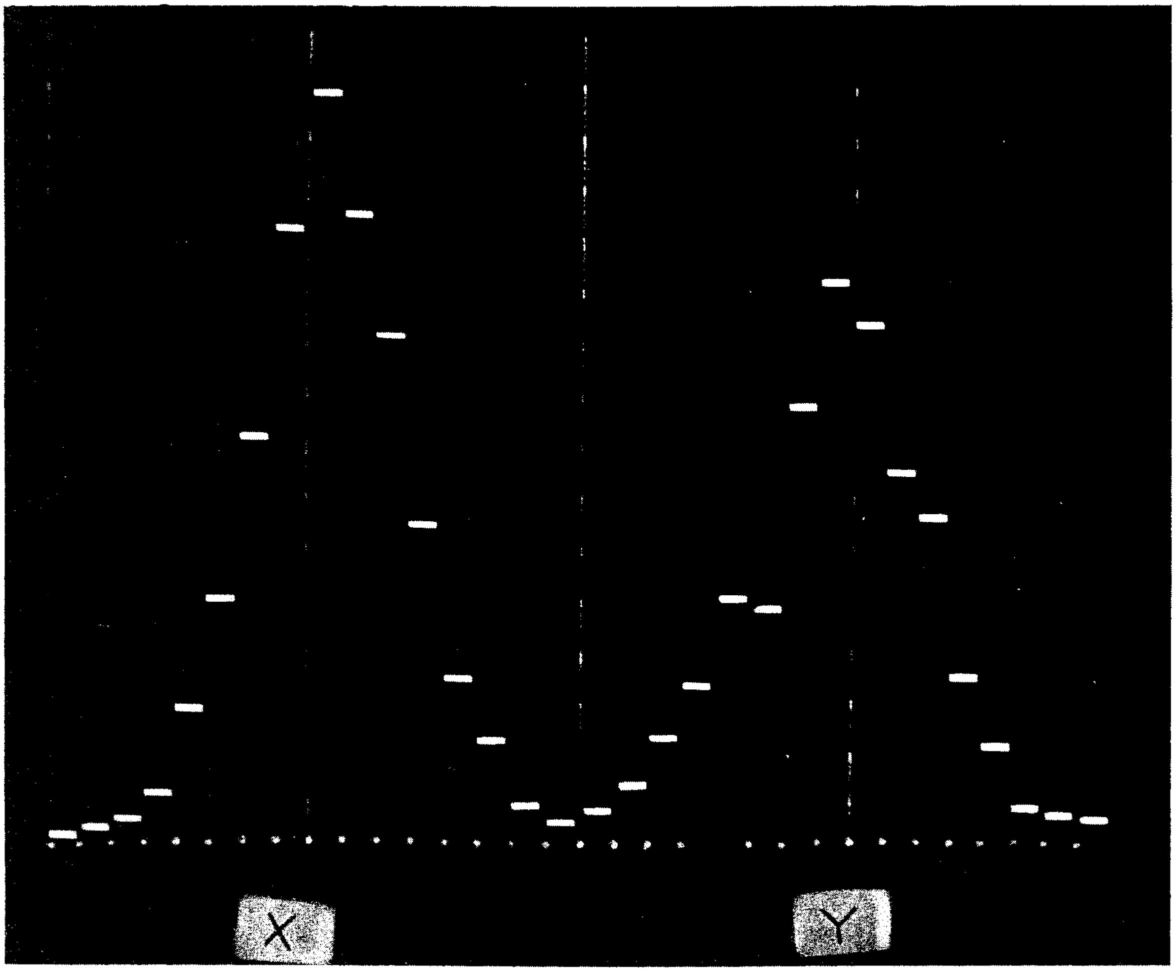

Aquisition
Display
Schmitt Trigger
8 bit Counter
8 bit Latch
Output Enable Lines
2 Input 8 Bit Mux
Vertical Output
DAC
8 Bit Bus typ
CL
R
Out
In
E
x
y
1
16
17
32
Select
Dot & Graticule Generator
Horizontal Output
Output Enable
Gate
Latch
Zero
BCD Decade Counter
P
Load
Reset
12
Thumb Wheel Switches
Address Generator
Master Clock
Up Date
12-80
400084

Fig. 7



1-81

4000A5

Fig. 8