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HIGH RESOLUTION MULTIWIRE PROPORTIONAL CHAMBERS AND A READOUT SYSTEM FOR SECONDARY BEAM LINE INSTRUMENTATION

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ABSTRACT

High spatial and time resolution multiwire proportional chambers[1,2] and a readout system has been developed. These chambers will be used at the secondary beam lines of NAL. Spatial resolution of ±0.25mm and time resolution of 16nsec at FWHM obtained from 0.5mm wire spaced chambers.

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The multiwire proportional chambers (MWPC) will be powerful tools[3] for observing NAL secondary beams at various locations on the beam lines. Among the beams are the neutral and 3.5 mr beams in Area 2, and the hadron and muon beams in Area 1. Intensity, divergence, profile, rotation and halo of the beams can be detected within 1msec to 1 sec, depending on the intensities of these beams. Observing time dependent intensity and profile within a beam spill may be important in some cases. These chambers have the capability of counting beam particles larger than 10^6 per wire per second with a time distribution of ±16nsec at FWHM, and the efficiencies of close to a unity using 0.5mm wire spacing. A spatial resolution of ±0.25mm enables us to observe secondary beam profiles instantaneously with a negligible multiple Coulomb scattering. Multiple Coulomb scattering from the total thickness of 0.002" Al windows, 8-10μm tungsten wires which are 0.5mm apart and 4mm width of 90% CH_4 and 10% Ar filling the gap at atmospheric pressure is negligibly small. The total mass in the beam is less than 20mg/cm^2. The root mean square projected angle, $\overline{\theta}$, due to multiple scattering of 200 BeV/c protons from this mass is about 0.002 mrad.

Profiles of 10^8-10^9 particles per second pencil beams can be observed by reducing the applied dc high voltage. The chambers can be operated in large magnetic fields, since they are insensitive to magnetic fields due to the narrow gap and high electron drift velocities under large electric fields applied to these chambers.

Figure 1 shows the cross sectional view of the MWPC with 4-inch diameter active area. The chamber and its associated electronics is enclosed in an aluminum shielding box with thin windows at the region of the active area. The readout cards are placed at each end of the MWPC to reduce the packing density of the electronics. The construction of this type of MWPC is explained in more detail in Ref. 1.

Figures 2 and 3 show some of the results obtained from a 10 cm^2 active area with 0.5mm wire spaced MWPC. For these results FET input stage amplifiers were used. The amplifiers were designed by T. A. Nunamaker of Enrico Fermi Institute. Figure 2 shows the time distribution of MWPC pulses using π^+ beam of 2.3 GeV/c at Argonne National Laboratory, and Figure 3 shows the time averaged profile of the beam which was defined with three thin scintillator telescope.

In the following we will outline a readout electronics system which is designed to be used for data acquisition from the MWPC in NAL secondary beam lines. The acquisition of data from the MWPC has been conceptually represented in Figure 4. The mode of operation for this scheme is one of multi-scaling. The outputs of all the amplifiers (one amp./wire) are gated into the readout logic for a specific amount of time and then the values of the latches in the readout logic are sequentially loaded into a multichannel analyzer. This procedure is repeated numerous times to obtain a statistical reading of the beam configuration. The accumulation of data in the multichannel can then be printed out or displayed on a CRT.

The amplifier used to detect a particle at or near a wire in the MWPC is shown in Figure 5, and has been designed to meet the requirements of the Preliminary Specifications for the Monolithic Integration of MWPC Electronics.[4] The following are some of the operational characteristics of this amplifier.

1. Input sensitivity: Variable - 1.0 mV min.
2. Input impedance: 470KΩ.
3. Channel separation: Greater than 40 db.
4. Threshold variation between amplifiers: ±1 db.
5. Threshold tracking: ±1.5 db.
6. Delay of output pulse (5mV input): 50nsec.
7. Output pulse: TTL compatible.
8. Max. operating frequency: 1.5 mHz.

The readout logic was designed to make use of the MWPC in most applications and is shown in Figure 6. This logic was realized with inexpensive TTL 74 series IC logic, but could be fabricated in a single monolithic package. The outputs are wire-OR' able for high fanout applications. Included in this logic are an inhibit amp in gate, a fast out gate, a variable delay one shot, a write gate, a data latch, a direct output, and a gated output. The cost of the components for the amplifier and readout logic is approximately $6.25/wire.

A flow chart for the main control logic is shown in Figure 7. The realization of this control logic was accomplished by the use of control point techniques.[5]

The multichannel analyzer is a practical, portable device for testing the MWPC (PHA, time distribution, MCS, etc.) and is useful in compiling raw data. Information in the multichannel memory can be transferred to external devices (i.e., computers, magnetic tape, etc.).

The authors express their appreciation to F. Hornstra, G. Chartrand and E. Scholefield for their contribution to this work.

References

[1]M. Atac and J. Lach, Nucl. Instr. and Meth. 86 (1970) 173-176.

[2]M. Atac, NAL Summer Study, SS-210 (1970) 109.

[3]CERN Courier, No. 8, Vol. 10 (Aug. 1970) 255.

[4] MULTIWIRE PROPORTIONAL CHAMBERS

Preliminary Specifications for a Monolithic
Integration of the Wire Electronics

Formulated at the Lawrence Radiation Laboratory, Berkeley, on November 9-10, 1970 by:

M. Atac, National Accelerator Laboratory, Batavia, IL.

F. Kirsten, Lawrence Radiation Laboratory, Berkeley, CA.

R. Lanza, Massachusetts Institute of Technology, Cambridge, MA.

R. Larsen, Stanford Linear Accelerator Center, Stanford, CA.

T. Nunamaker, University of Chicago, IL.

J-L. Pelligren, Stanford Linear Accelerator Center, Stanford, CA.

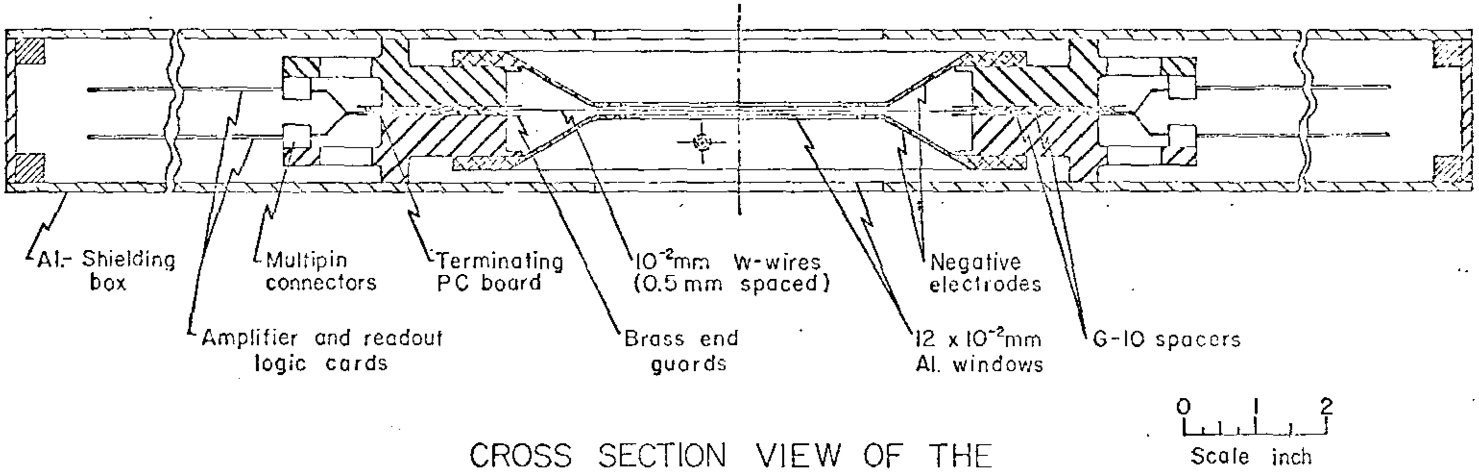
I. Pizer, European Organization for Nuclear Research (CERN), Geneva.

F. Sauli, European Organization for Nuclear Research, (CERN), Geneva.

H. Steiner, Lawrence Radiation Laboratory, Berkeley, CA.

Lawrence Radiation Laboratory, Berkeley, CA.
November 20, 1970.

[5]R. Martin, "Standardization of Control Point Realization", Report No. 400, Department of Computer Science, University of Illinois, May 21, 1970.



CROSS SECTION VIEW OF THE
BEAM PROPORTIONAL CHAMBER

Figure 1.

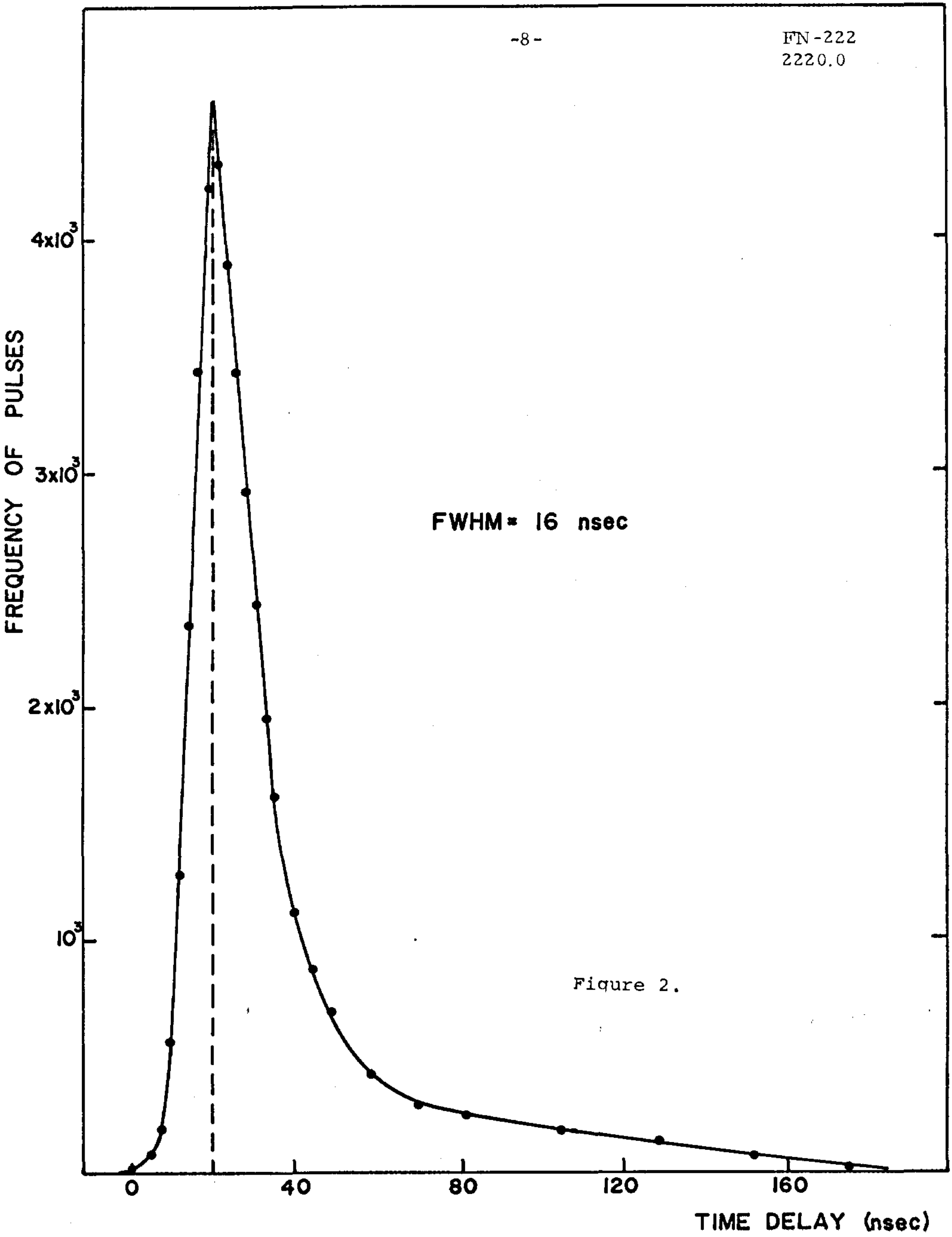

FREQUENCY OF PULSES
4x10³
3x10³
2x10³
10³
FWHM = 16 nsec
0
40
80
120
160
TIME DELAY (nsec)

Figure 2.

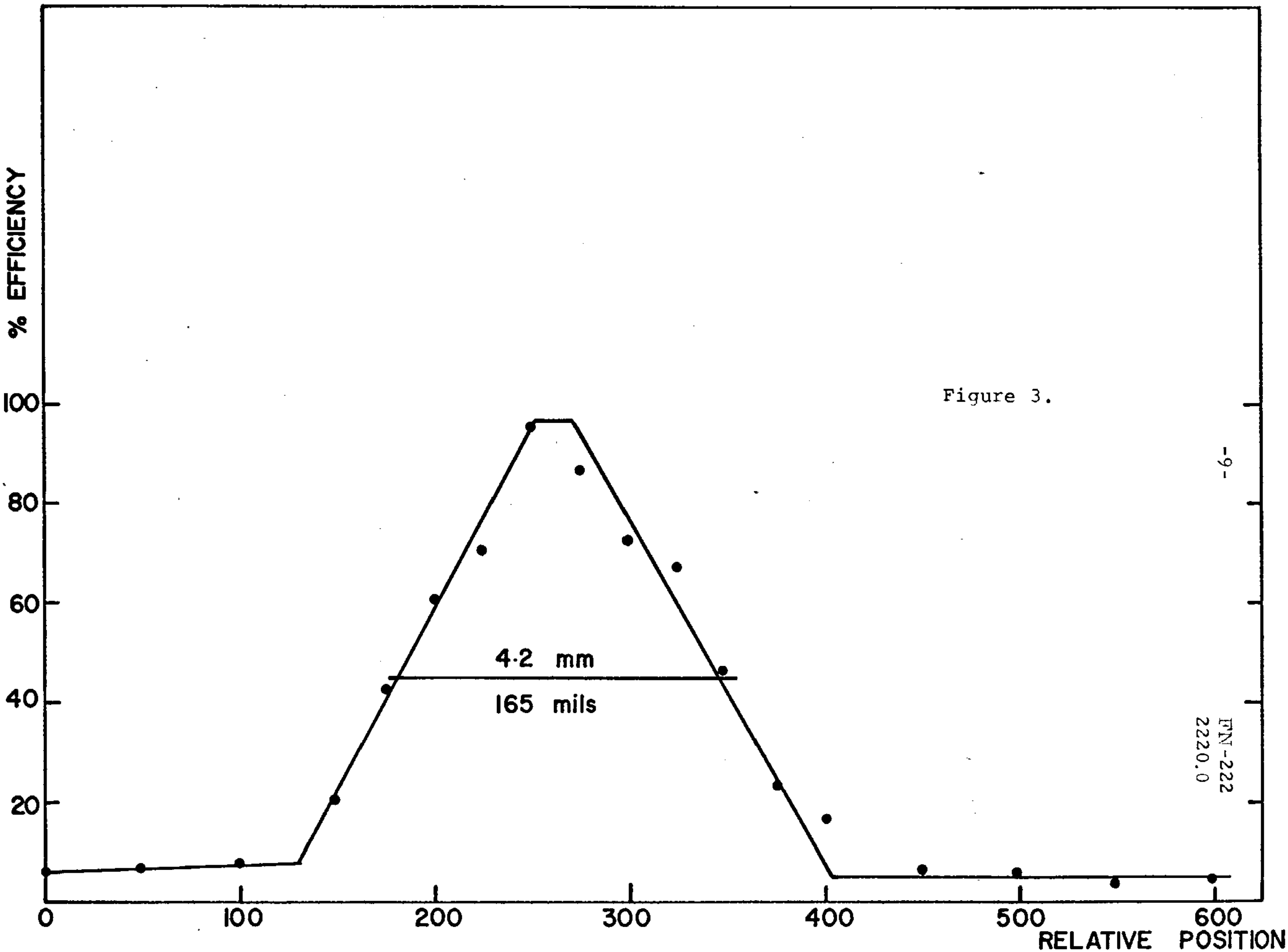
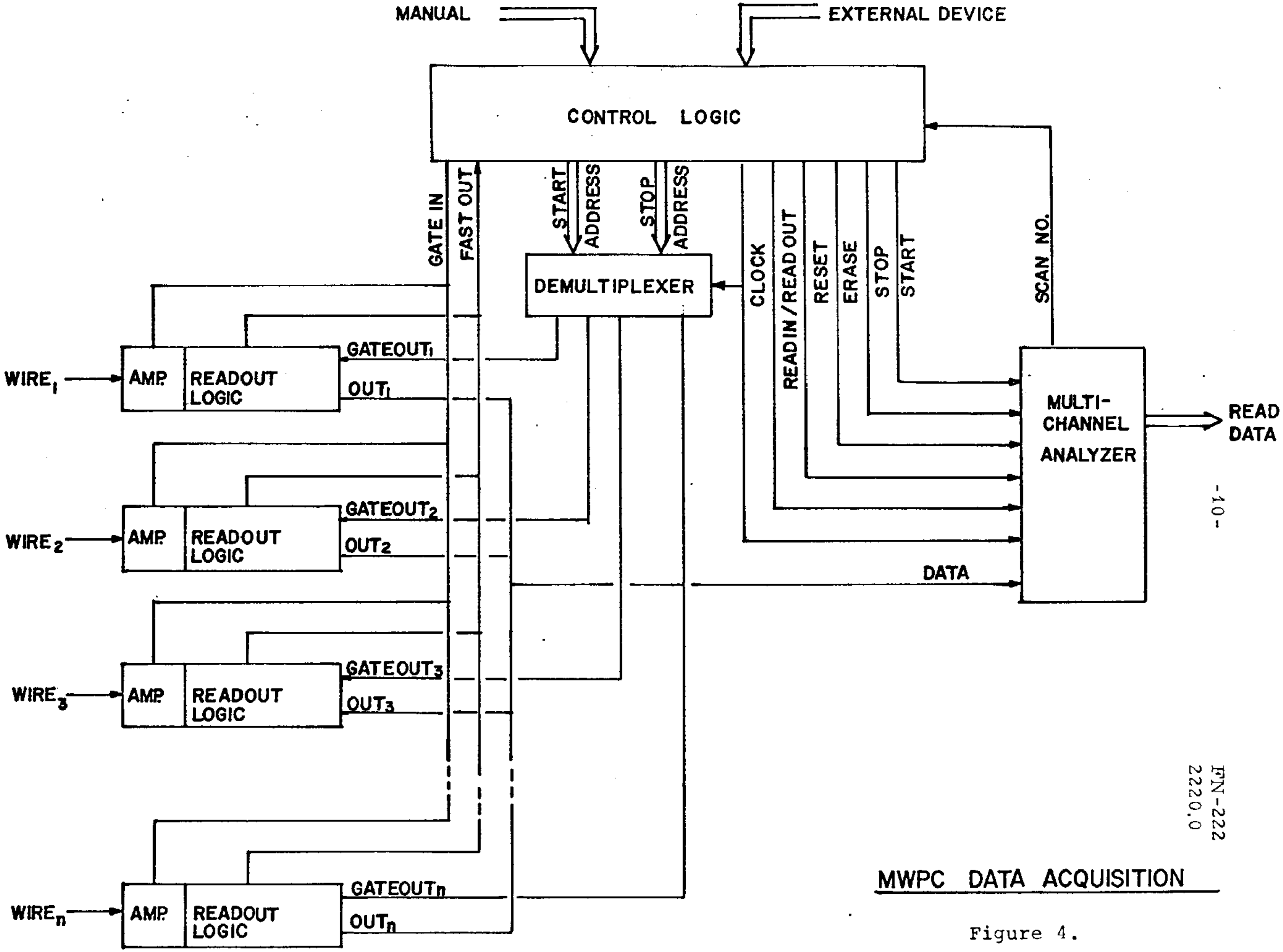

% EFFICIENCY
100
80
60
40
20
0
100
200
300
400
500
600
RELATIVE POSITION
4·2 mm
165 mils

Figure 3.



MWPC DATA ACQUISITION

Figure 4.

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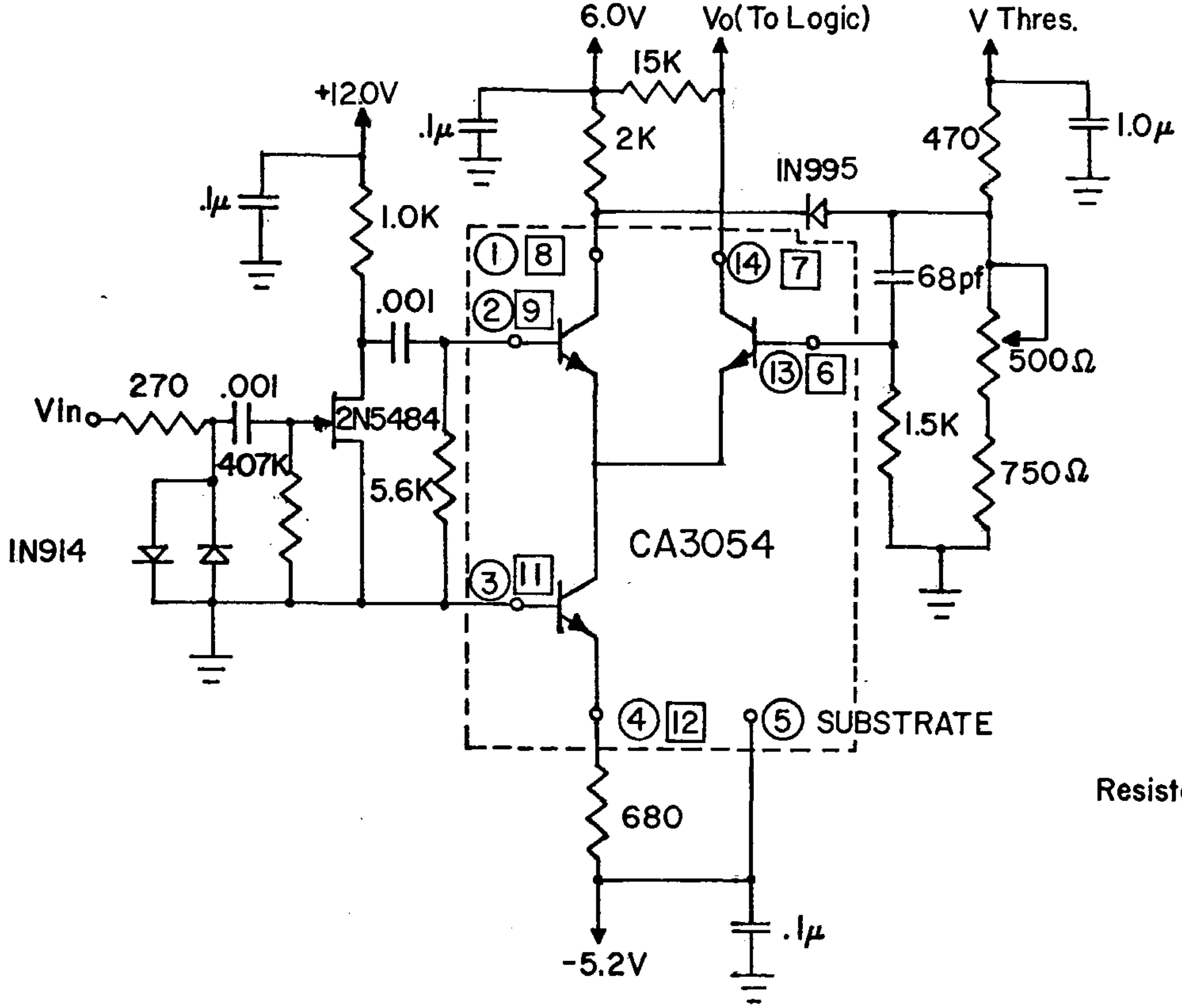
MWPC DETECTOR AMPLIFIER



Resistors: 1/4w 5%

Figure 5.

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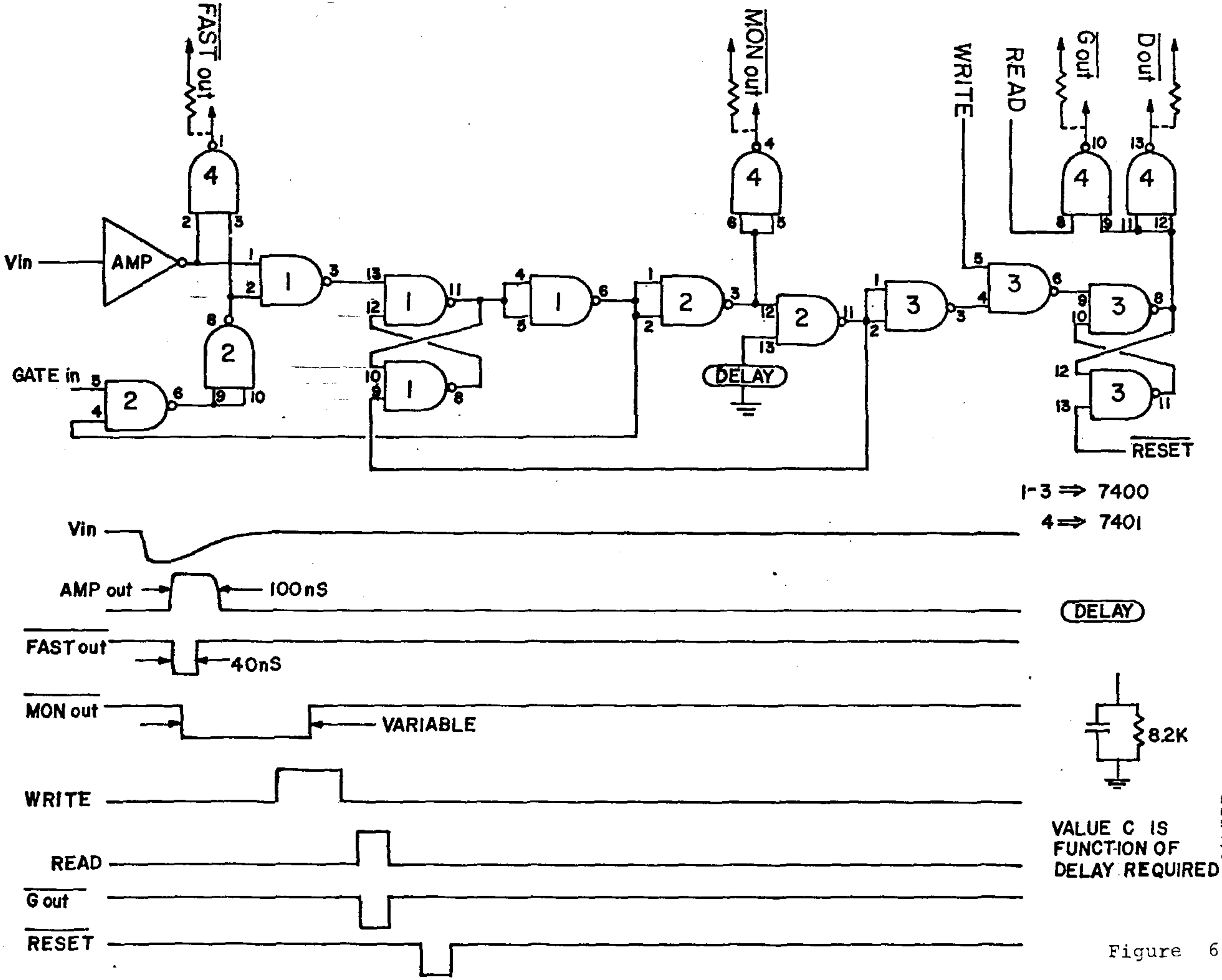

Figure 6.

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BEAM MONITOR CONTROL FLOW

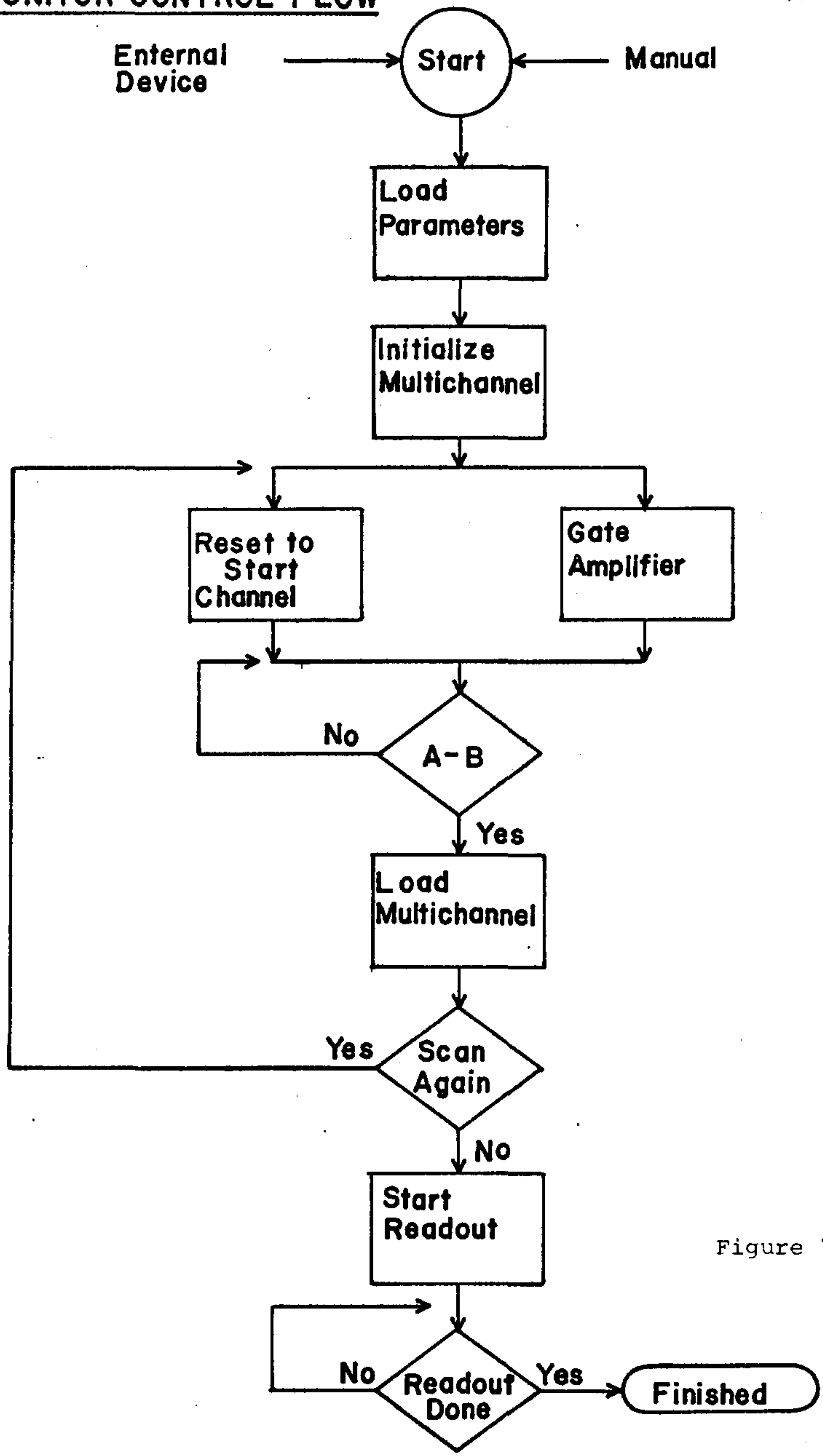

Figure 7.