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UNIVERSITY of CALIFORNIA BERKELEY

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DELAY-LINE READOUT FOR PROPORTIONAL CHAMBERS*

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Abstract

A simple method for locating the position of particles which produce ionizing events in proportional wire chambers is described. The method involves the use of ferrite-loaded delay cable.

1. Introduction

Wire spark chambers with digitized readouts are widely used in high-energy and other fields of physics to locate the tracks of ionizing particles.[1)] One of the main restrictions of these spark chambers is the limited average rate with which particles can be detected due to the recovery time, which ranges from a few hundred to a few thousand microseconds in normal practice.[2)] Another difficulty is that a triggering signal from an external source such as a scintillator counter is usually needed, although the wire chambers can be made self-triggering by the use of a proportional-current grid.[3)]

In applications where high event rates are needed, the multi-wire proportional chambers developed recently[4)] would be useful. For these chambers, one of the main difficulties is that the presently used readout methods, which involve the use of individual amplifiers at each wire, are both tedious to construct and somewhat costly.[4,5)] In order to retain the simplicity of a delay-line readout method, together with the fast event rate which these proportional wire chambers are capable of recording, we have investigated the use of ferrite-loaded delay cables for this purpose. These cables, as described below, have high coupling efficiencies, with sufficient delay to enable present-day electronics to record track positions to an accuracy comparable to the wire spacing in a time which does not exceed the storage time of the event.

2. Delay-Cable Characteristics

All measurements described in this paper have been done on commercial delay cables, specifically the type-HH 1600 ferrite-loaded delay cable manufactured by the Columbia Technical Corporation.[6] Figure 1 shows a cross section of this cable. An inner conductor consisting of about 100 turns/cm of a 0.1-mm-diameter copper wire is wound helically around a 4-mm-diameter ferrite core. Surrounding the inner conductor is the outer conductor, consisting of loosely wound, 0.2-mm-diameter, longitudinal wires. The outer conductor does not shield the inner conductor very effectively. The cable has the following electrical characteristics: delay ≅ 0.033 μs/cm; characteristic impedance = 1700 ohms; attenuation = 0.4 db/μs; band pass = 6 MHz; dc resistance = 2.6 ohms/cm.

The readout method described below depends on the high coupling possible through external coils located at various positions on the cable. The efficiency of this coupling method can be seen from the graph in fig. 2, in which step-function signals with different rise times are coupled to the cable through a single-turn coil. The shape of the output signal is shown in fig. 3. Figure 3a shows the output pulses produced by input pulses having a long decay time compared to the rise time. Figure 3b shows the bipolar pulses produced when the rise and fall times are equal. These bipolar pulses are useful for "zero cross" timing measurements and are the ones we employed in the application described here.

Since the signals from the proportional counter wire chambers are quite small, it is necessary to amplify the injected pulse into the cable by a multiturn coil coupling. Figure 4 shows the output as a function of turns in the coupling coil.

3. Proportional-Chamber Measurements

Our measurements were done on a 10- by 10-cm CERN-type[4)] wire chamber with wires spaced 3 mm apart. A mixture of 93% argon and 7% methane at atmospheric pressure was circulated in the chamber. Output pulses with a rise time of about 200 ns were produced when the chamber was operated at about 3200 V.

Figure 5 is a block diagram showing the electronics for reading out the chamber wires through the cable. Amplitude information can be obtained from the common connection; the timing pulses are obtained from both ends of the cable. The zero-cross discriminators we used are the E G and G type T 140/N unit.[7)] The load resistor was chosen so that suitable bipolar pulses are fed into the timing discriminators.

The amplification factor in the chamber was between 10^5 and 10^6.

The accuracy of the timing measurements is shown in fig. 6. In this figure we show the spectrum obtained at the pulse-height analyzer when a collimated β source (^{90}Sr) is moved across four wires of the chamber. Thirty-turn coils were wound around the cable at a distance of 6 mm center to center; the coils have a width of about 1 mm. The distance between the peaks in fig. 6 represents 6 mm on the cable; it is clear that a resolution of at least 3 mm can be obtained.

4. Conclusions

The measurements described above show that the resolution of commercial ferrite-loaded delay lines is compatible with the accuracy of the proportional chambers that we are using. Several obvious improvements can be made; here we merely outline two of them on which we are continuing measurements. First, in place of bipolar pulses in which the zero-cross discriminator is affected somewhat by the limiting amplifier noise, nondifferentiated monopolar pulses can be used. The timing is then done by some form of integrating circuit which locates the center of gravity of the pulse.[8] This method is expected to perform better by integrating over the noise and the distortions in pulse shape caused by the dispersive characteristics of the cable.

Second, the flexible ferrite cable that we have been using for convenience does not have the optimum delay-unit length with minimum dispersion. Solid-ferrite and air-core cables that have better characteristics have been described in the literature.[9]

FOOTNOTE AND REFERENCES

* This work was done under the auspices of the U. S. Atomic Energy Commission.

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6) Columbia Technical Corporation, 24 Brooklyn-Queens Expressway West, Woodside, New York, N. Y.

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FIGURE LEGENDS

Fig. 1. Perspective view of the HH 1600 delay cable manufactured by the Columbia Technical Corp.

Fig. 2. Peak amplitude of the pulses at the output of the delay cable as a function of the rise time of the pulses introduced on a one-turn coil wound around the cable.

Fig. 3. Shape of output pulses at the cable for input pulses in the coil with (a) long decay time and (b) short decay time.

Fig. 4. Relative output at the cable as a function of number of turns wound around it.

Fig. 5. Black diagram of the electronics used for timing the pulses.

Fig. 6. Spectrum at the pulse-height analyzer obtained by moving a collimated β source across four wires of the chamber. The distance between the peaks represents 6 mm on the cable.

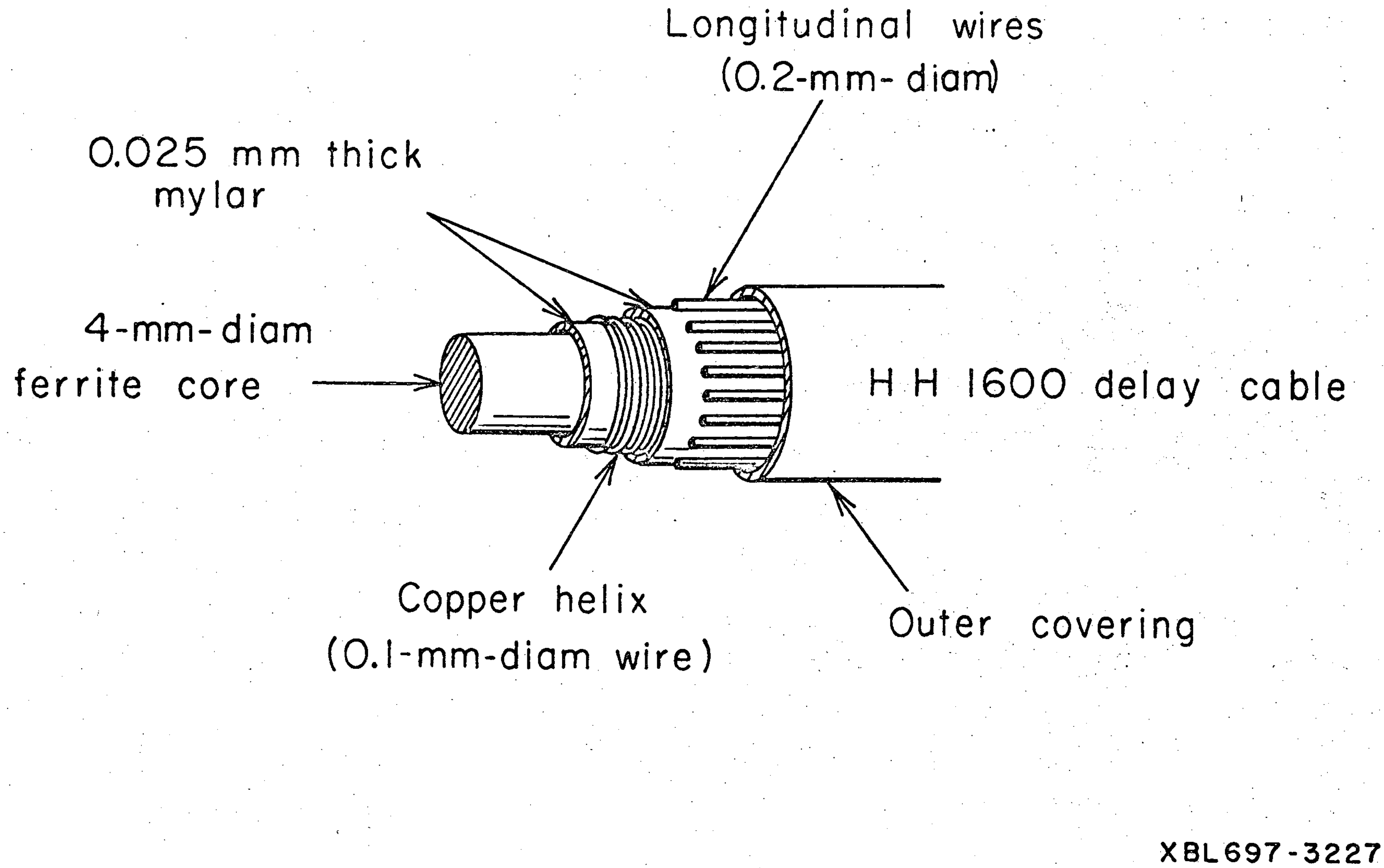
Longitudinal wires
(0.2-mm-diam)
0.025 mm thick
mylar
4-mm-diam
ferrite core
H H 1600 delay cable
Copper helix
(0.1-mm-diam wire)
Outer covering
XBL697-3227

Figure 1.

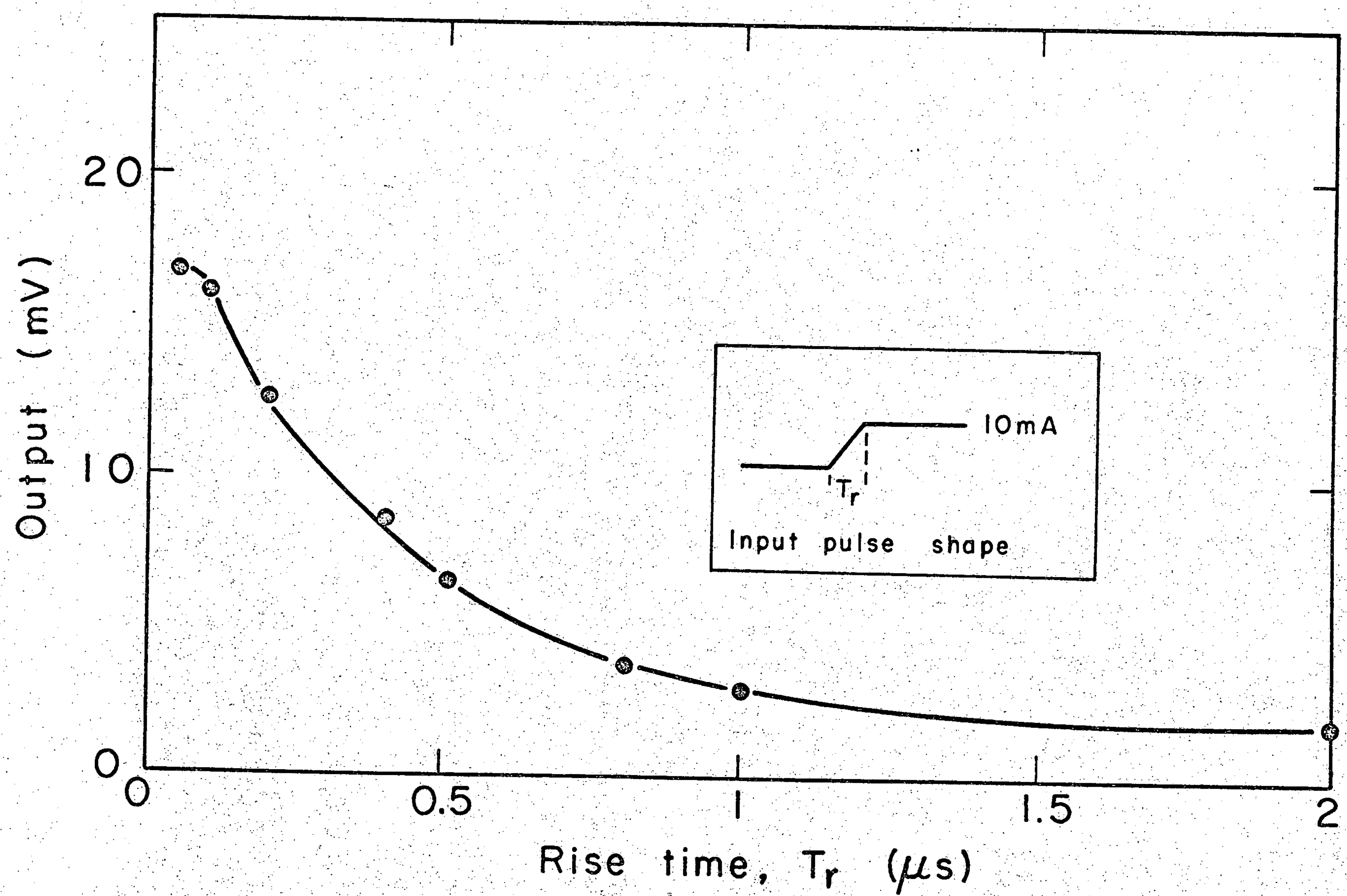
Output (mV)
20
10
0
0
0.5
1
1.5
2
Rise time, Tr (μs)
10mA
Tr
Input pulse shape
XBL697-3228

Figure 2.

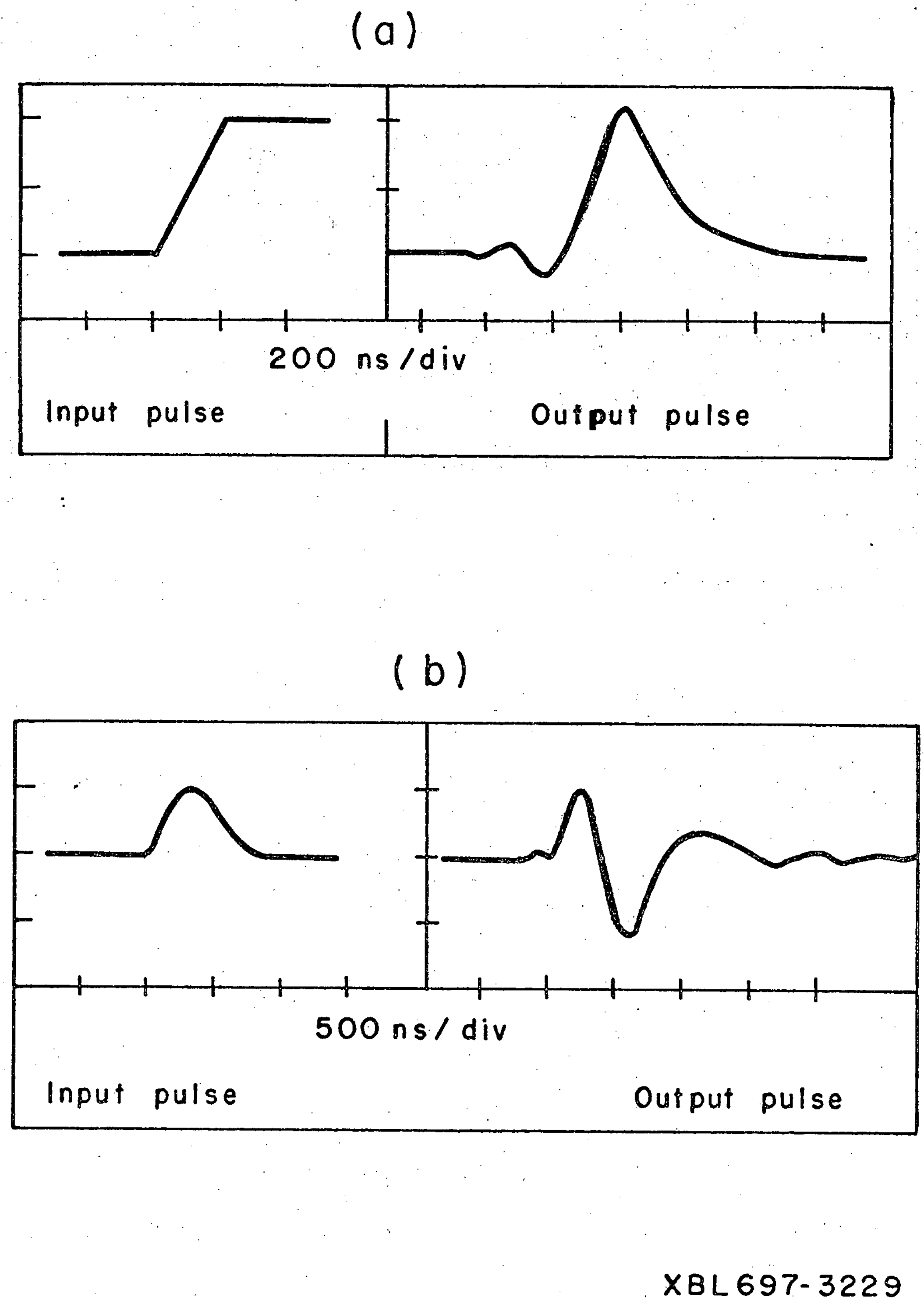
(a)
200 ns/div
Input pulse
Output pulse
(b)
500 ns/div
Input pulse
Output pulse
XBL 697-3229

Figure 3.

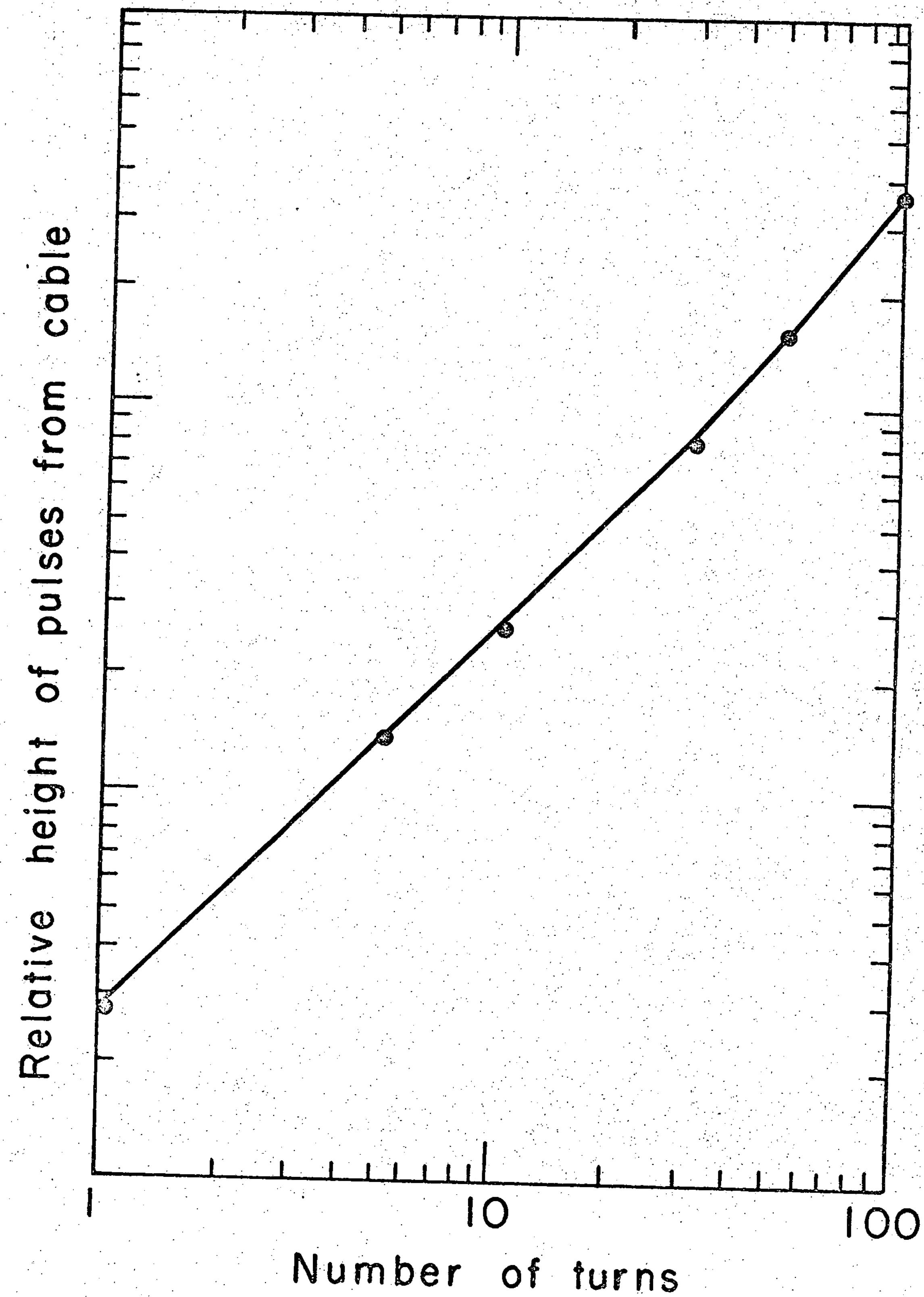

Figure 4.

XBL 697-3230

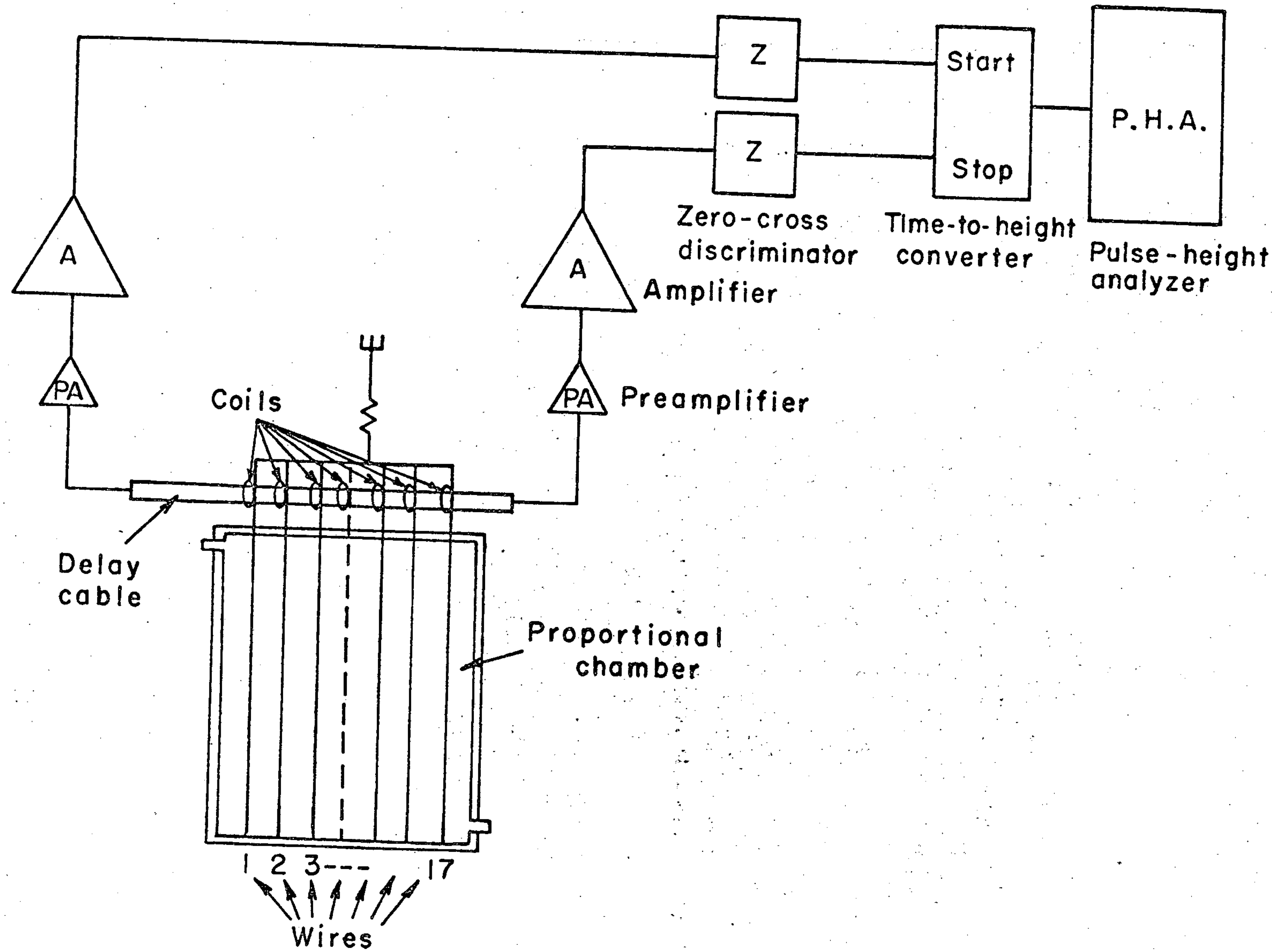

Figure 5.

XBL697-3231

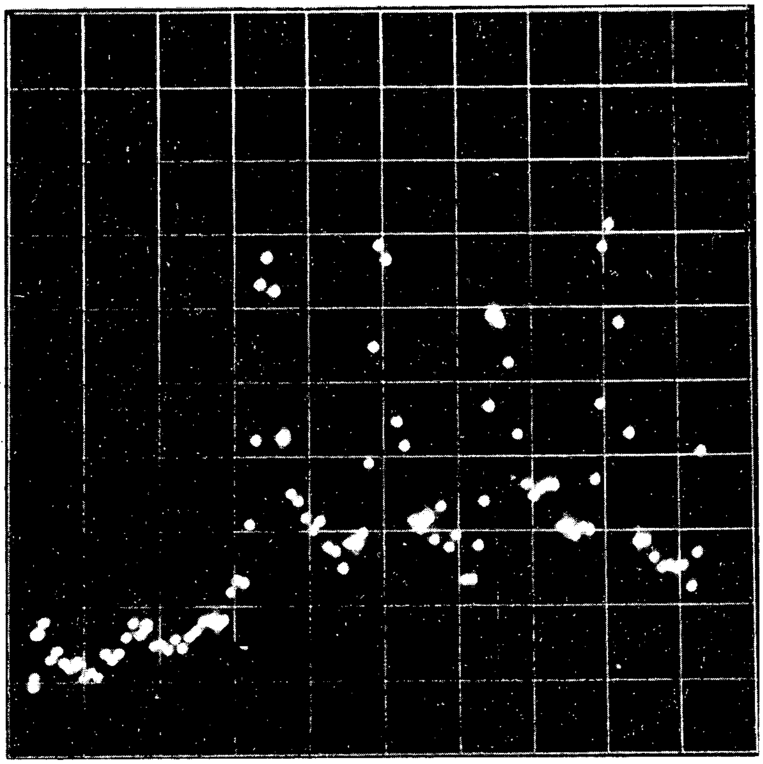

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Figure 6.

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