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PREAMPLIFIER FOR MULTI-WIRE PROPORTIONAL COUNTERS

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Preamplifier for Multi-wire Proportional Counters*

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This paper describes the characteristics of 54 small 14-channel preamplifiers for use with multi-wire proportional-counter detectors (MWPC). These detectors will be used at Adone, the e^+e^- colliding beam accelerator located at Frascati (Italy), inside the experimental magnet detector (MEA) which is to surround one of the e^+e^- interaction regions. Severe space limitations forced the placement of all logic circuits outside the magnet and restricted the size and physical configuration of these preamplifiers. One view of the arrangement at Adone for two of the MWPC with preamplifiers is shown in Fig. 1. (Chamber sense wires are parallel with the beams.) The limitation in the space available for electronics near the chambers is evident. Figure 2 shows a photograph of two L-shaped boards plugged into two smaller proportional chambers used for tests.

I. Mechanical Description.

14 individual preamplifier circuits were arranged on a single printed-circuit board (2.75 in. x 1.69 in.) on which a printed-circuit-board connector also was mounted. The connector plugged into a printed circuit board which was a part of the chambers and served to provide connections to each of a group of 14 adjacent wires, to the power supply, and to the ground. The width of each preamplifier board, 2.8 in., was given by the number of pre-amplifiers times twice the wire spacing of 0.1 in., since preamplifiers were placed on both ends of the chambers.

Two frontal views of the printed circuit boards are shown in Figs. 3a and 3b. The narrow dimensions of conductors and spacings made hand soldering techniques necessary in their production. The 15-dual-contact printed-circuit-board connector was soldered onto the board.

The output from each amplifier was connected to a 15-m length of 50-ohm coaxial cable (RG 174/U). These cables were clamped to the boards in two configurations; one coming out parallel to the board, as seen in Fig. 4a, and the other at a right angle to the board through drilled holes, as seen in Fig. 4b. The cables from each preamplifier board were terminated on an output board on which another printed-circuit connector was also mounted. A photograph of the output board is shown in Fig. 5.

II. Electrical Characteristics:

The circuit diagram for one 14-channel preamplifier unit is shown in Fig. 6. The principal components are MECL II integrated circuits,[1] i.e., three MC1020 and one MC1035. The power supply voltage required is Vcc[2] -5.2V. The reference voltage at which the differential amplifiers operate (V_{bb}) is -1.2V. This level, which also appears on the proportional wires, is generated within the MC1035 circuit and is power amplified by one of the amplifiers of this I.C. to drive the V_{bb} reference bus supplying all circuits.

The effective input impedance of each preamplifier is 1200 ohms. No diodes are used as circuit protectors on inputs, as these integrated circuits are found to be quite rugged and as sockets were installed making each I.C. easy to replace. For stability reasons, each preamplifier is back coupled to the inverting input via a 10 KΩ resistor. The pulse amplification is not affected, as this input is also bypassed to ground with a 0.01 μf. capacitor. Each output drives a 15 meter long 50 ohm cable which is terminated on the output board through a 0.01 μf disc capacitor. A negative-going input pulse relative to V_{bb}, produces a negative output pulse relative to ground.

The shape of the input pulse used in tests of these preamplifiers is shown in Fig. 7. The risetime of 15 nsec and the falltime of 800 nsec were chosen to simulate those observed on the wires of proportional chambers operated with "magic" gas mixture.[2] Saturation and pulse distortion are observed for input pulses with amplitudes greater than 0.05 Volts. The output pulse saturation voltage is $\sim$0.11V. Characteristic output pulses are also shown in Figs. 7a and 7b. The amplification, V_{out}/V_{in}, measured for a typical preamplifier is plotted vs the input pulse voltage, V_{in}, in Fig. 8a. The error bar at V_{in} = 10 mV is the characteristic root-mean-square deviation observed for all amplifiers. In Fig. 8b the characteristic output pulse width at half amplitude as a function of input peak voltage is given.

MWPC pulse signals appearing on one preamplifier channel induce pulses of the same polarity on adjacent channels. For input pulse heights below saturation, i.e. 50mV, the output crosstalk signals are $\sim$6% of the output signal appearing on a central channel. This fraction is seen to increase linearly with input pulse height after saturation is reached. The cross talk is principally due to capacitive coupling between the contacts of the input p.c. board connector. In our case, however, the crosstalk signal is more than cancelled by the positive signals induced on adjacent wires of MWPC's. The resulting positive output pulse is not detected by the logic circuits which follow.

III. Test of 756 Preamplifier Circuits

Using a 10 mV input pulse, a systematic study of amplification and delay time (measured at half amplitude) was made for all amplifiers. The results are presented in Figs. 9a and 9b. The measurements were made on the complete system including output board. Thus the measured delay spread includes the effect of cable-length variations which was found to be as much as 2 nsec. The precision of the measurements was ± 1.0 mV and ± 2.5 nsec, respectively. It was observed that, on the average, the MC1035 had an amplification which was ∿3% larger than that for the MC1020 and that differences in the geometry of the connections on the printed circuit board produced ∿3% variations in the amplification between different amplifiers on the same board.

The above tests were performed with $V_{cc} = -5.20 \pm 0.01$ Volts. The amplification changed when this voltage was altered. At $V_{in} \sim 10$ mV, the fractional change in V_{out} i.e. $\Delta V_{out}/V_{out}$ was equal to the fractional change in the supply voltage V_{cc} i.e. $\Delta V_{cc}/V_{cc}$. At saturation, for $V_{in} = 100$ mV, $(\Delta V_{cc}/V_{cc}) = 0.4\ (\Delta V_{out}/V_{out})$. Judging from the characteristics of the various components used, operation at elevated temperature up to 60°C is not expected to alter significantly the amplifier characteristics.

These preamplifiers have been tested with the MWPC and found to operate satisfactorily with the electronic system designed for the magnet experiment at Adone.[3]

References

*Work supported in part by U. S. Atomic Energy Commission

[1]The manufacturer is Motorola Semiconductor Products, Phoenix, Arizona.

[2]R. Bouclier, et al., Nucl. Inst. and Meth. 88, 149 (1970).

[3]This system was designed by W. W. Ash of Princeton Univ. and D. C. Cheng of Harvard Univ. and is based, in part, on the electronics in use by the Princeton Group headed by G. K. O'Neill.

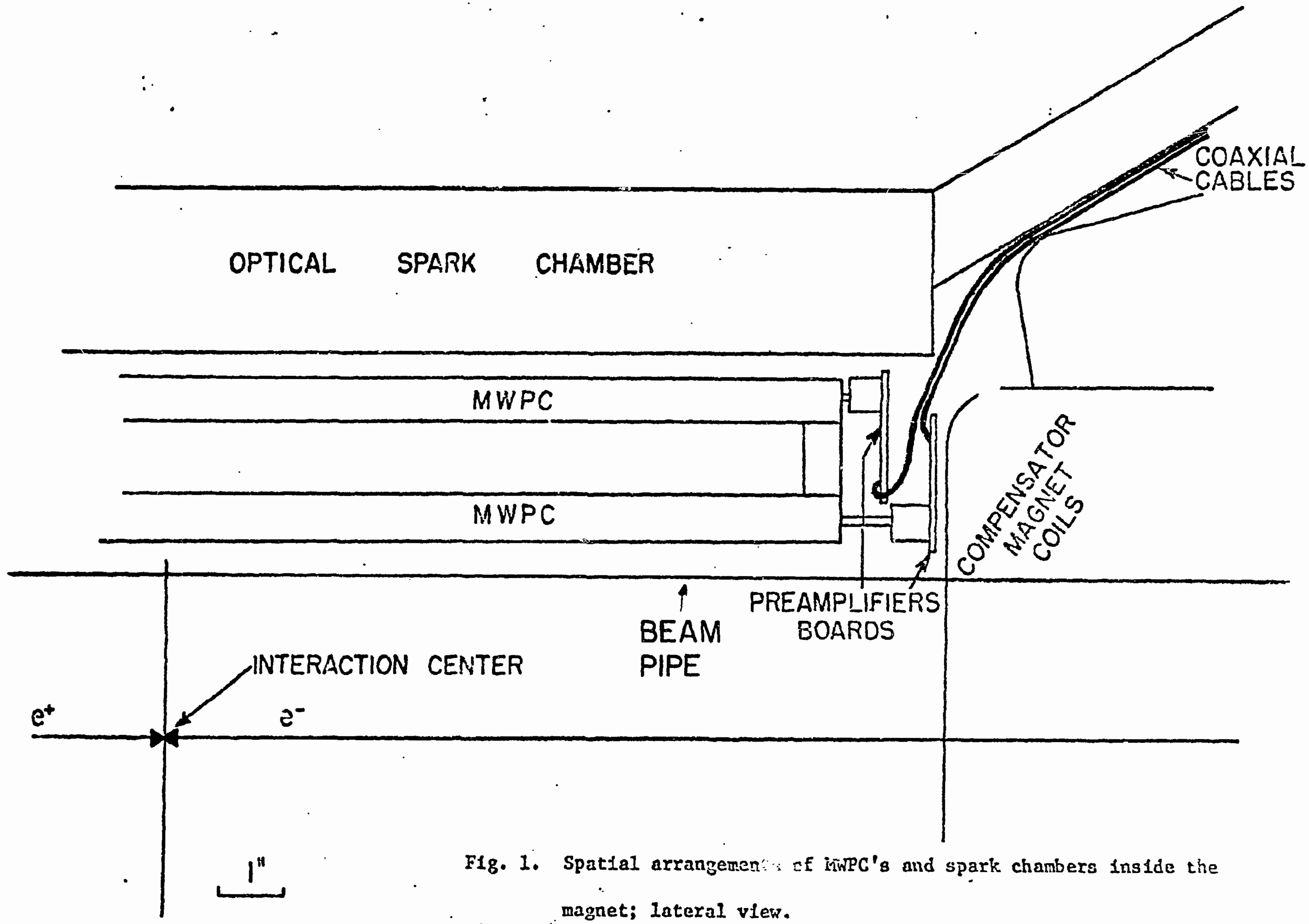


Fig. 1. Spatial arrangement of MWPC's and spark chambers inside the magnet; lateral view.

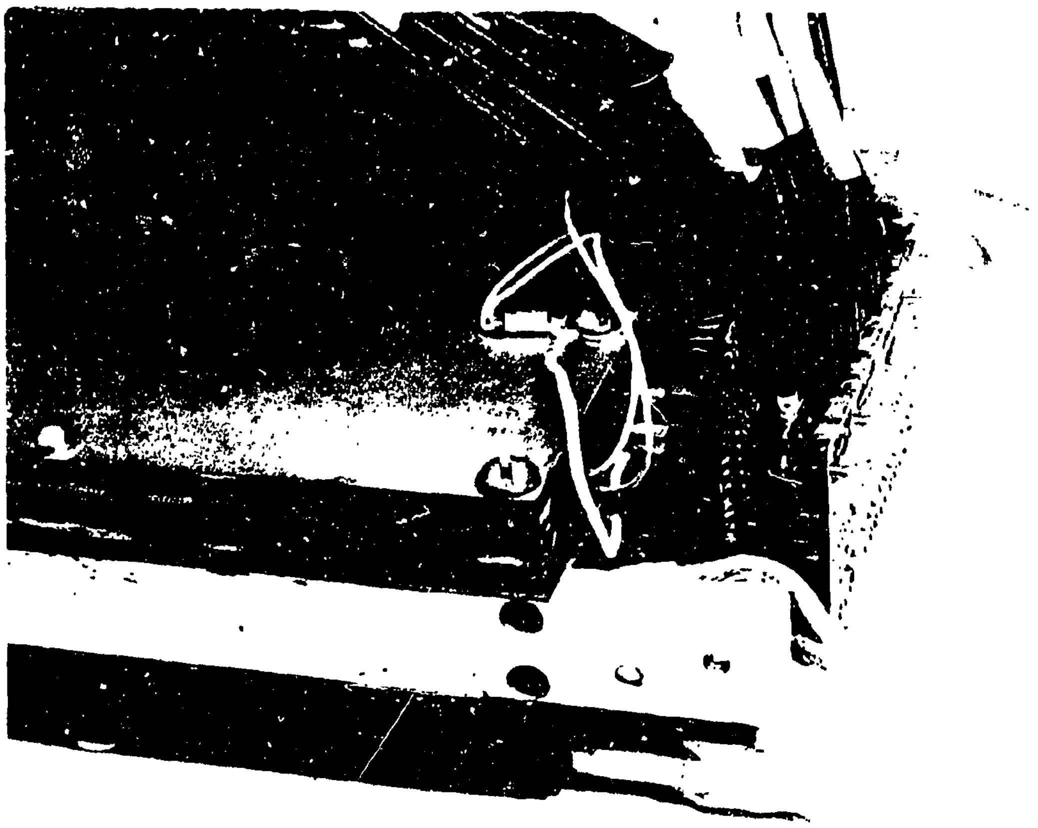
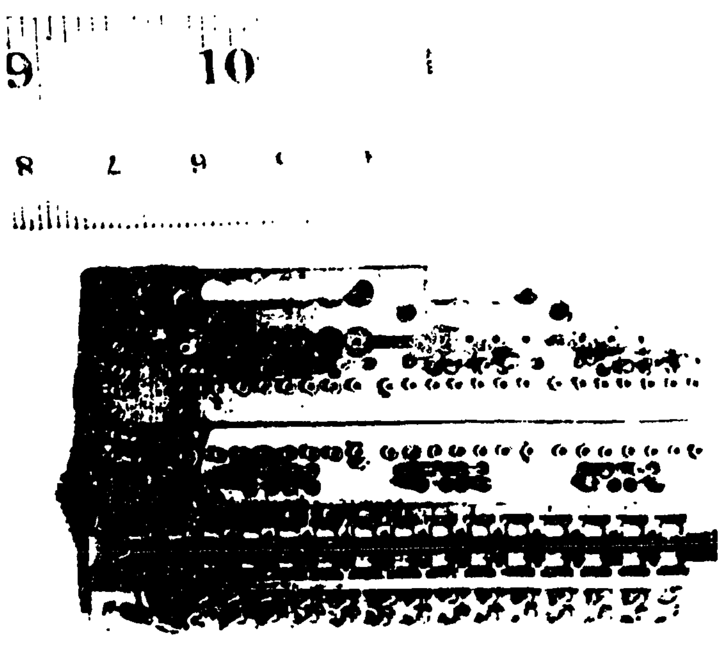
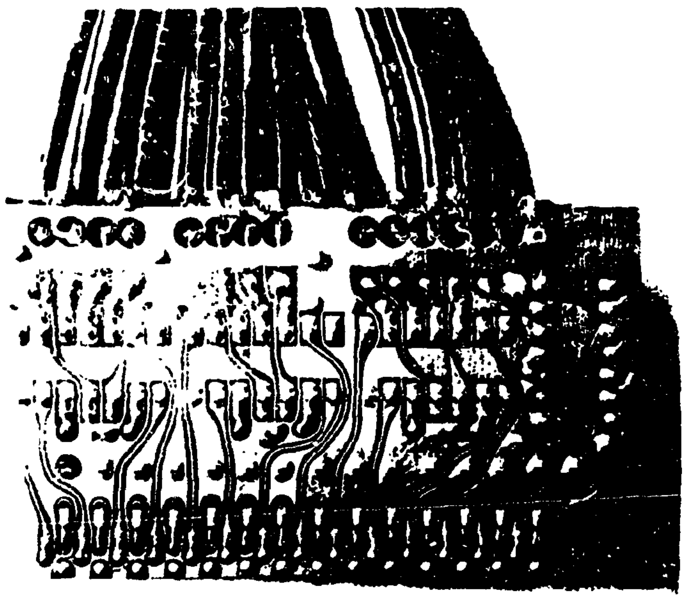


Fig. 2. Sandwich of two small MWPC's used for tests with two preamplifier boards.

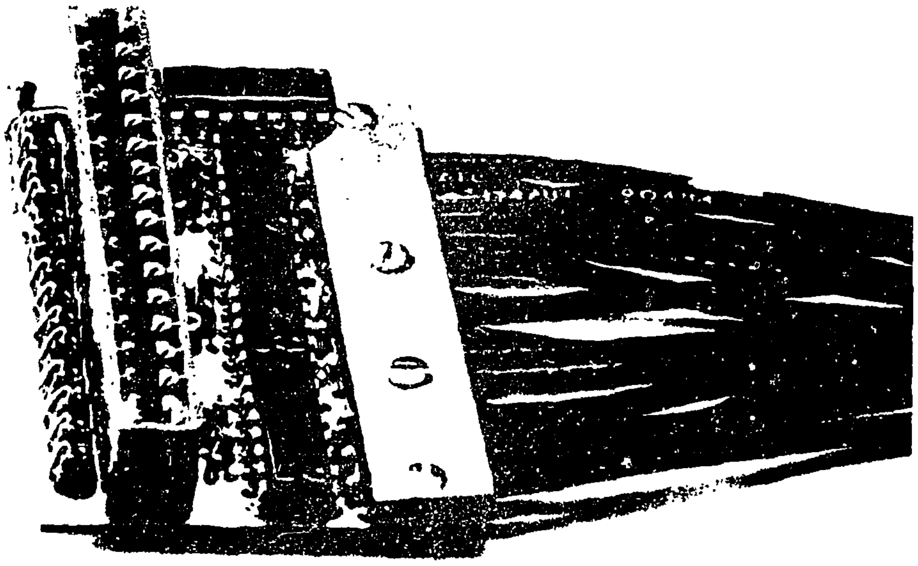
Fig. 3. Printed circuit board for 14 channel preamplifier:



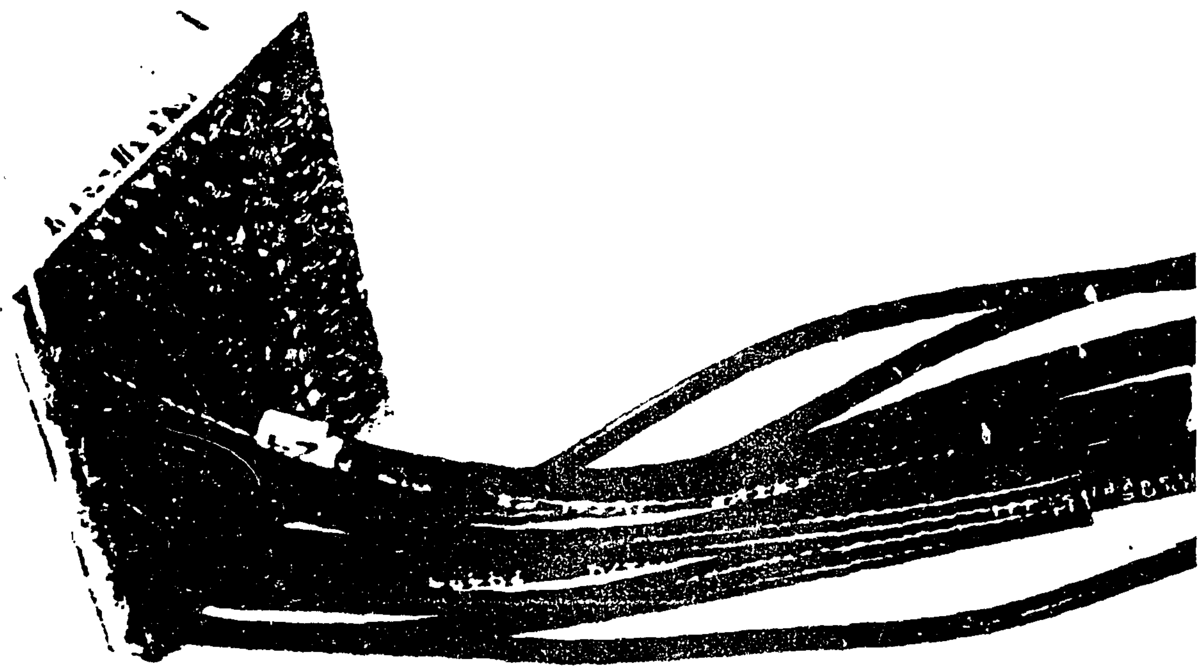
a) Component side, without integrated circuits, cables and cable clamp.



b) Socket side with all components installed.



a) First configuration: cables coming out parallel to the board.



b) Second configuration: cables coming out perpendicular to the board through drilled holes.

Fig. 4. Fully assembled preamplifier boards.

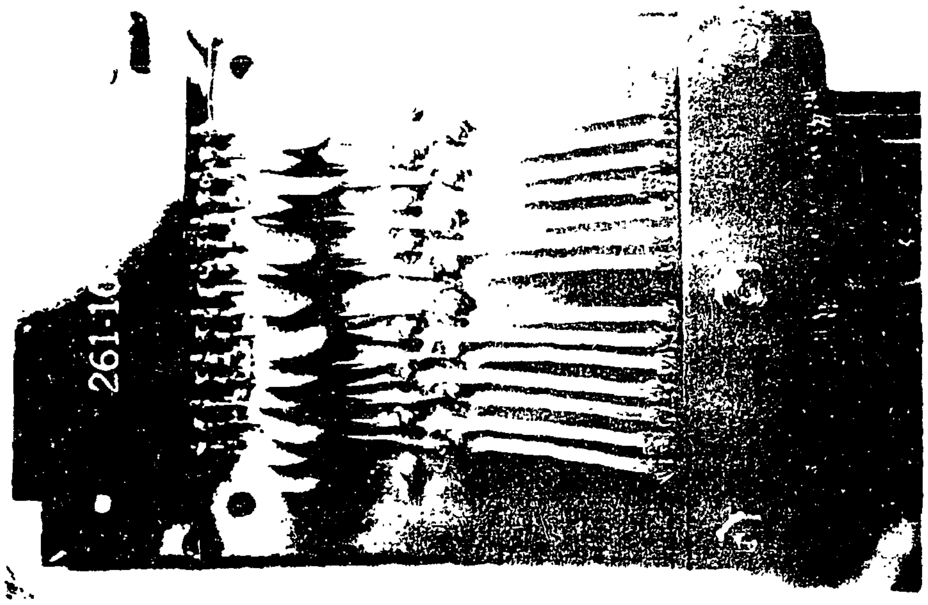
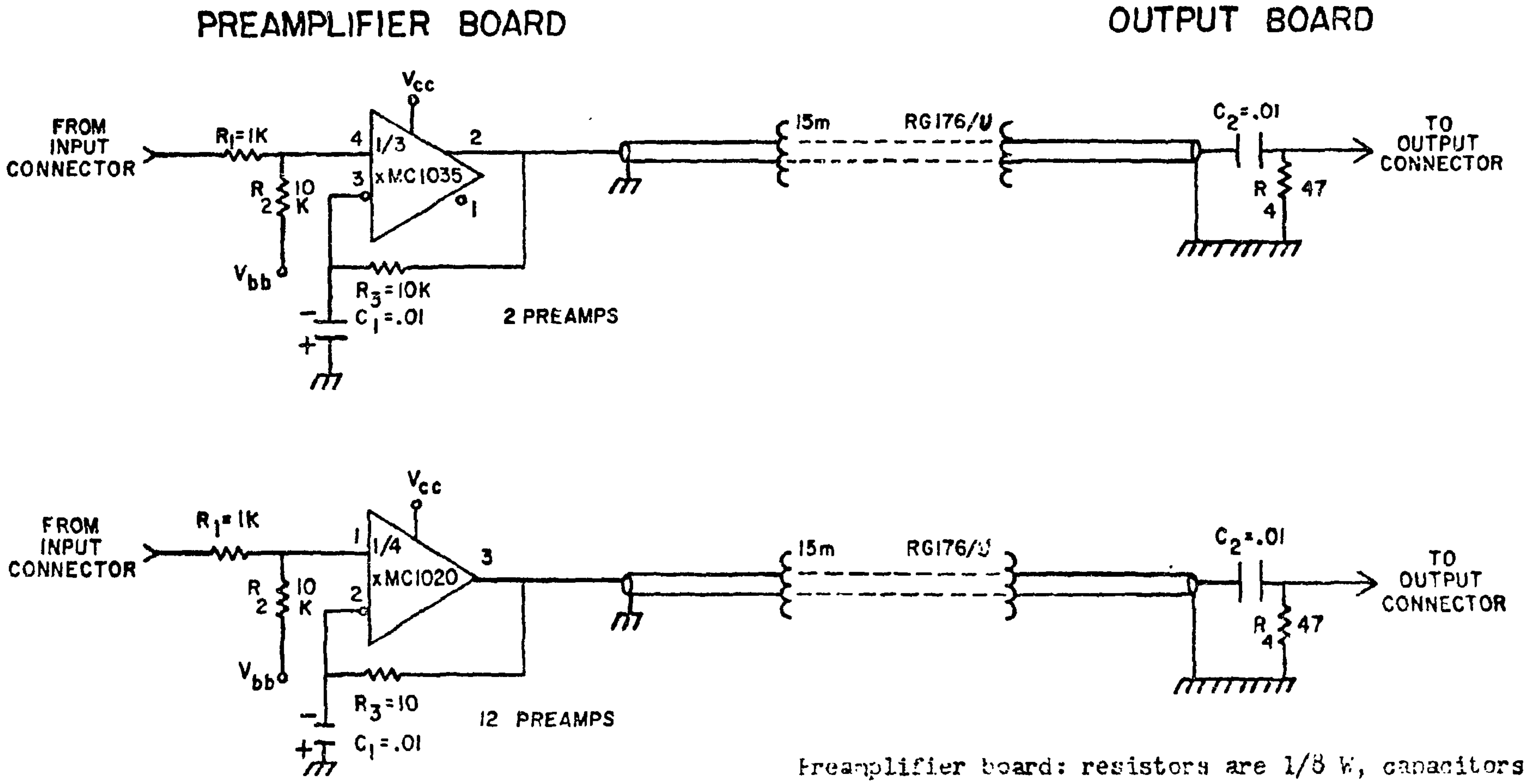
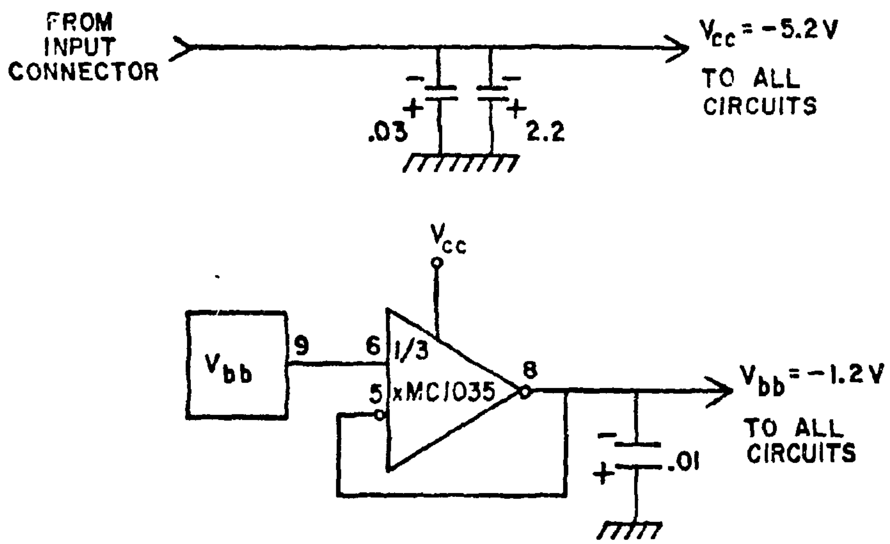


Fig. 5.
Output board, fully assembled. The 50 ohm termination resistors are soldered directly to the pins of the p.c. board connector.

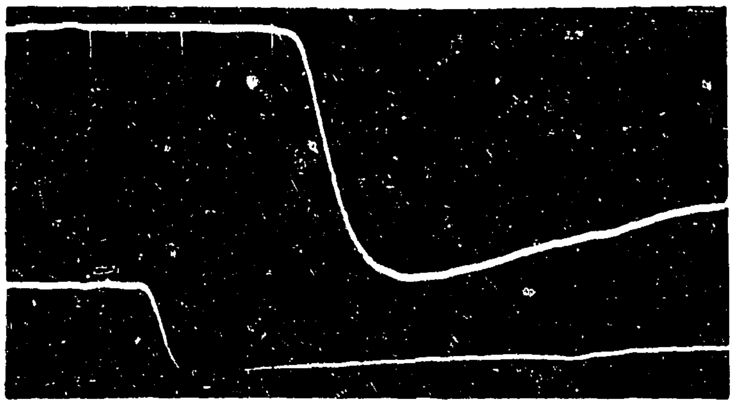




Preamplifier board: resistors are 1/8 W, capacitors are miniature tantalum capacitors (Corning/Components, Inc.), input connector is a 2 x 15 contact p.c. board connector (Cinch 50-30P-10).

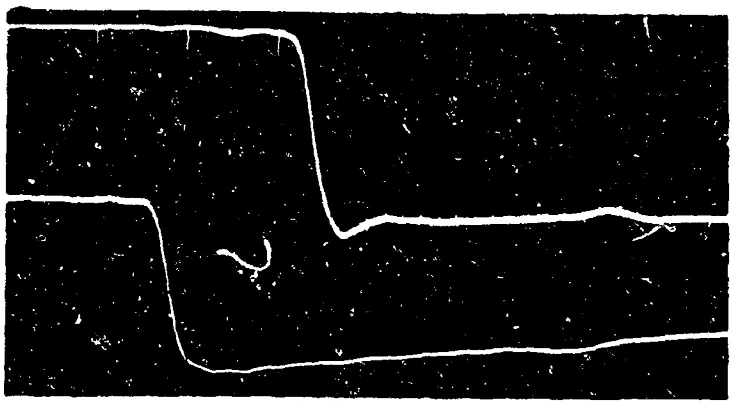
Output board: resistors are 1/8 W, capacitors are ceramic disc type, output connector is a 2 x 15 contact p.c. board connector (Amphenol 261-10015-2).

Fig. 6. Circuit diagram of one 14-preamplifier unit; resistor values are in ohm, capacitor values in μF.



10 mV/div 50 nsec/div

a) Output unsaturated



50 mV/div 50 nsec/div

b) Output saturated

Fig. 7. Input and output pulse shapes.

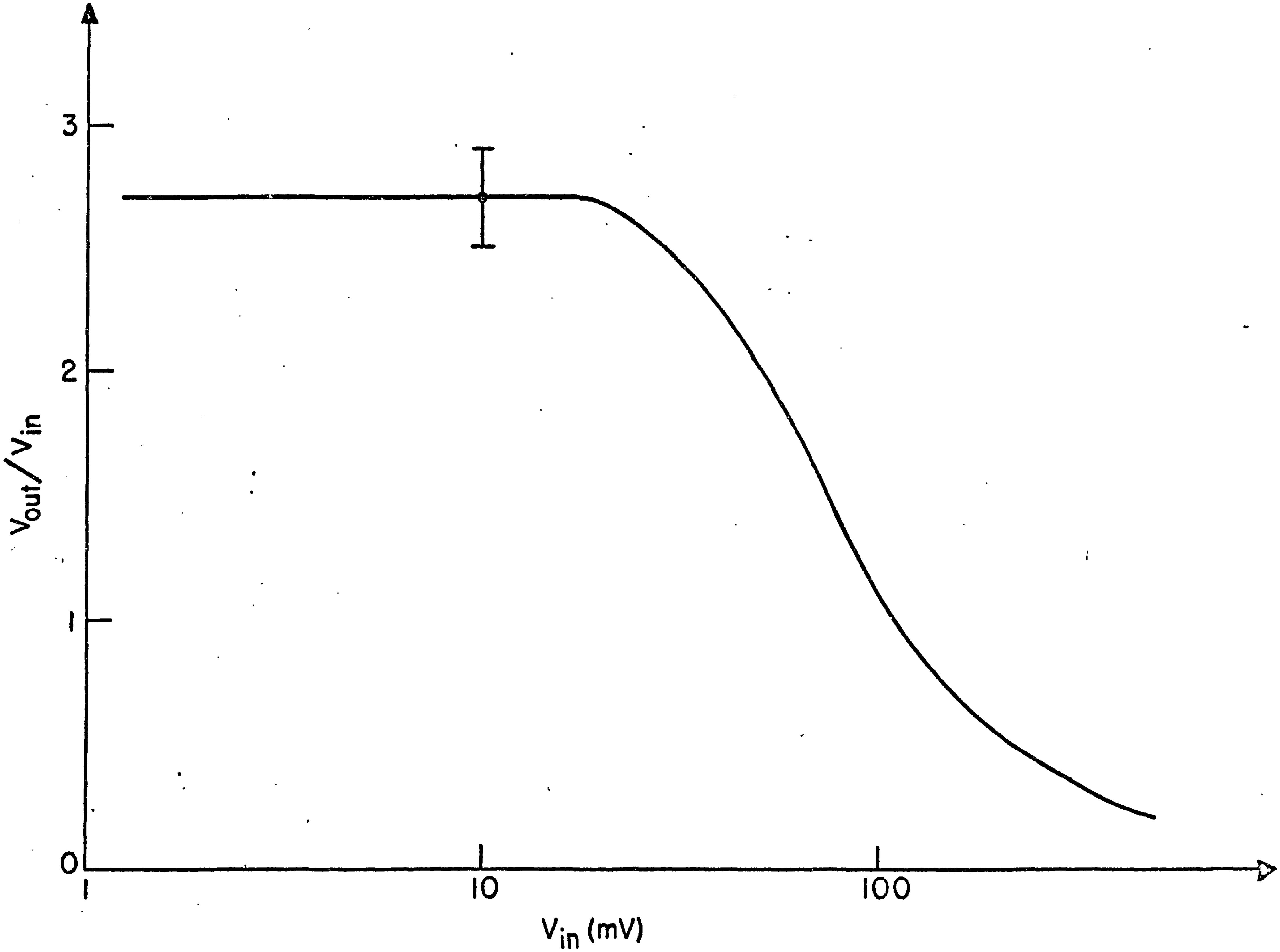


Fig. 8a. Tests on a typical preamplifier: Amplification (V_{out}/V_{in}) vs input voltage (V_{in}).

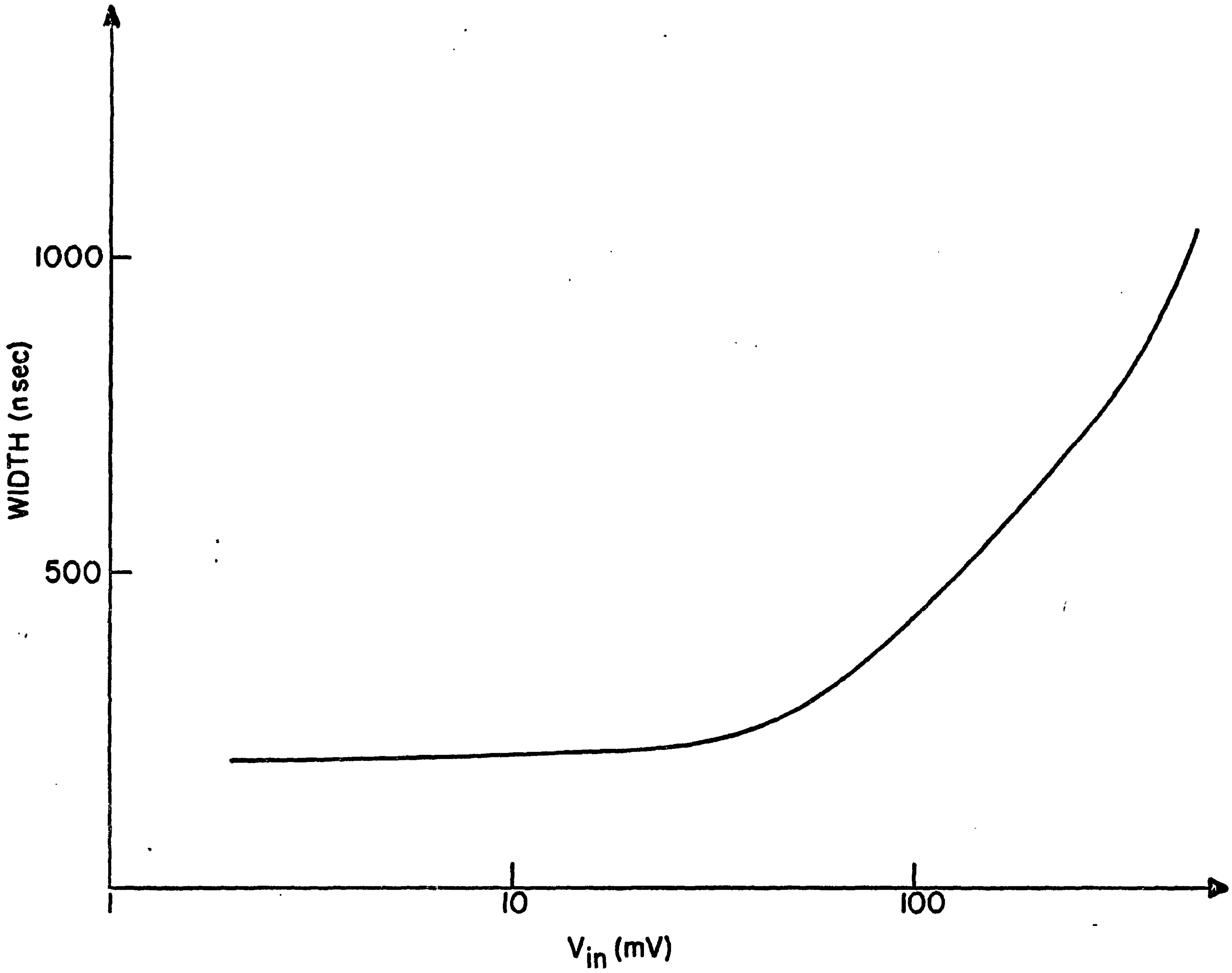


Fig. 8b. Tests on a typical preamplifier: Pulse width at half amplitude vs V_{in}.

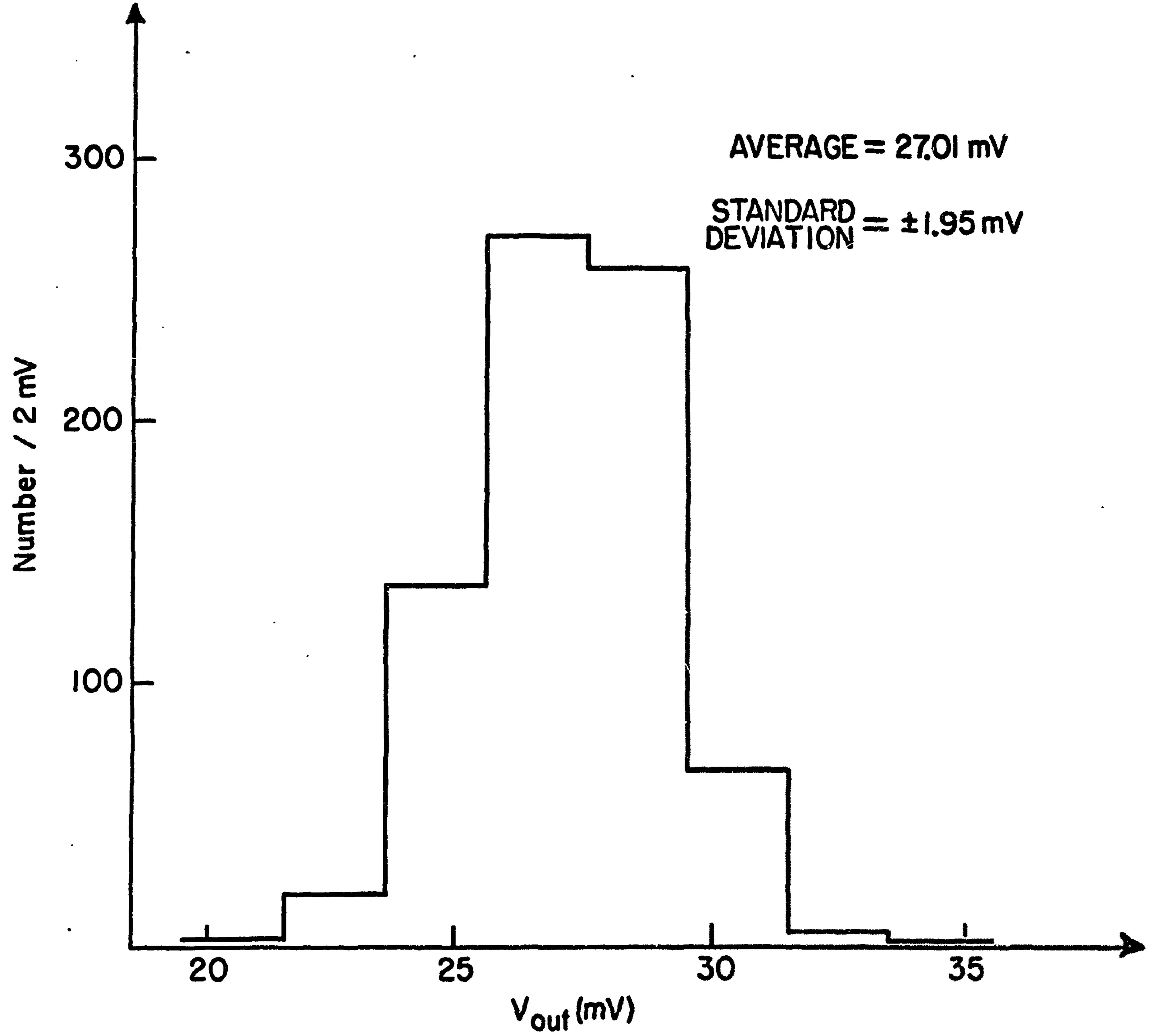


Fig. 9a. Variations in the response of 756 preamplifiers with V_{in}=10 mV: Output pulse height distribution.

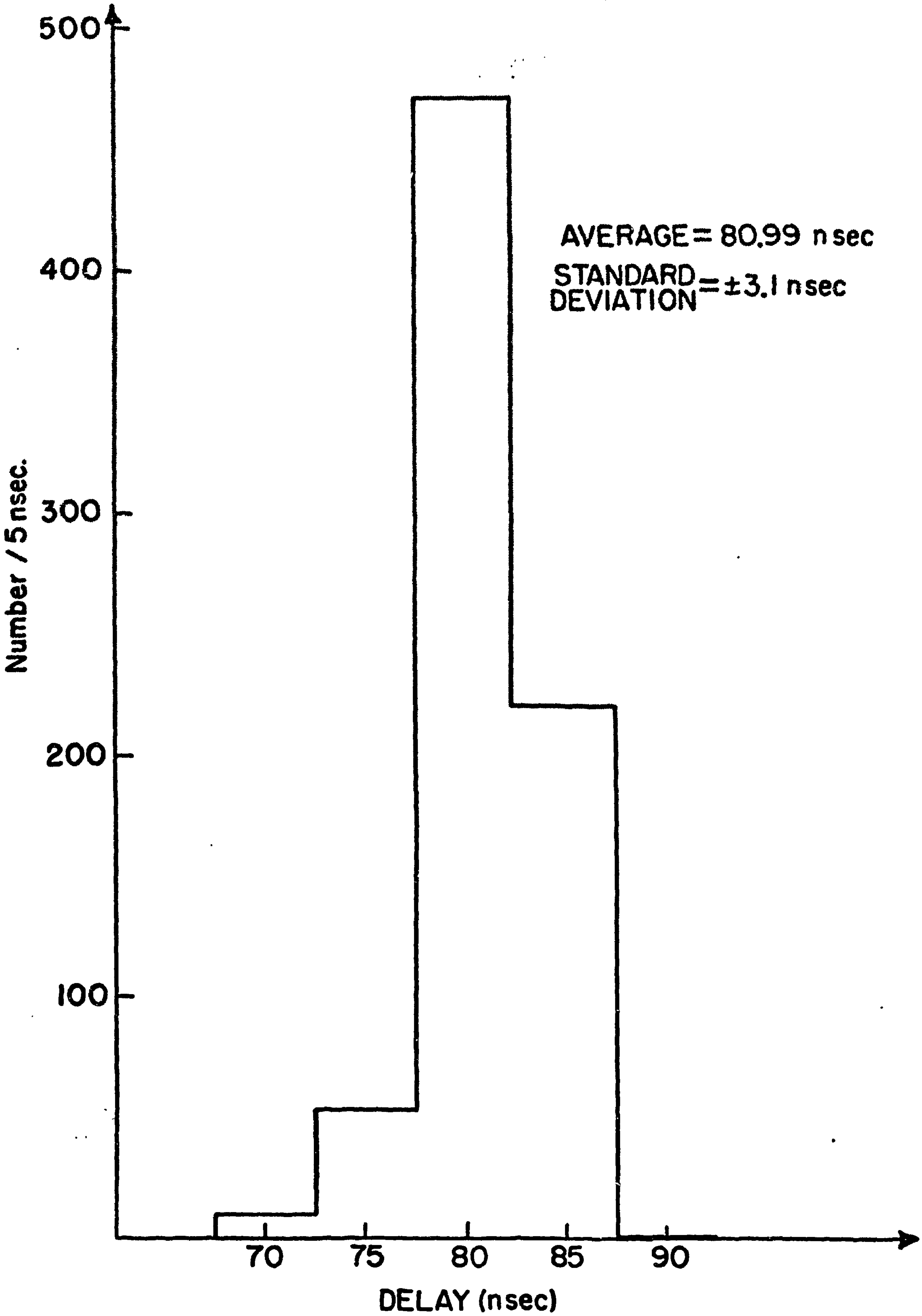


Fig. 9b. Variations in the response of 756 preamplifiers with V_{in}=10 mV: Distribution of delays measured at half height.