Laboratori Nazionali di Frascati

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IIa.7. A FAST 20-CHANNEL PULSE-HEIGHT ANALYZER EMPLOYING LINE CODING

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Introduction

The problem of multichannel analyzers to be used in conjunction with pulsed accelerators becomes more challenging and intriguing as time goes by. In addition to the usual requirements of channel stability and over-all reliability, low resolving times are also necessary. It is the aim of this work to present an analyzer free of the drift usually encountered in much slower amplitude-to-time converters, coupled with speeds usually obtained only with "stacked discriminator" designs.

The basic idea of the analyzer appeared in the literature some time ago,[1] and is summarized in Fig. 1.

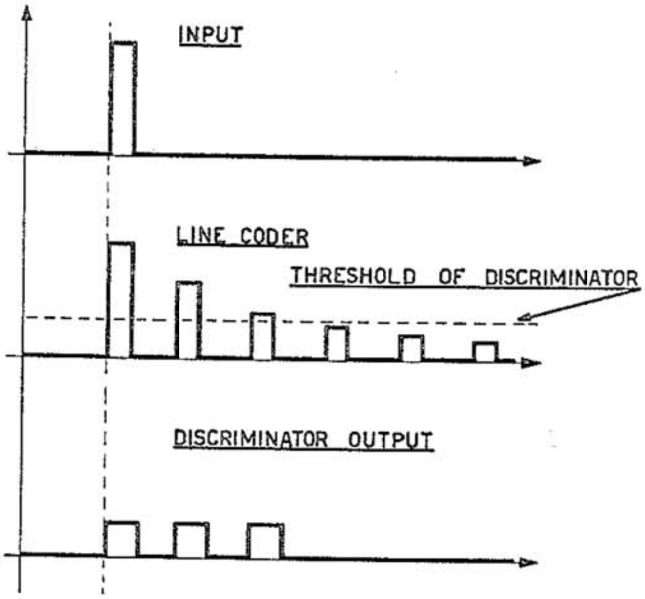

Fig. 1. Basic idea of analyzer.

If a pulse is injected into an open-circuited delay line, multiple reflections occur, resulting in a train of equally spaced pulses decreasing in amplitude. Hence if this pulse train is fed to an integral discriminator, the number of discriminator output pulses obtained depends on the amplitude of the original pulse. Single-channel analyzers employing this principle have already been built, using vacuum tubes[2] or transistors.[3] A multichannel device based on the above principles has also been built elsewhere.[4]

The analyzer about to be described employs 20 channels with an over-all dead time of the order of 3 μsec. Channel width is of course quite stable, since it is mainly determined by the attenuation characteristics of the delay line, a passive device.

Block Diagram of Pulse-Height Analyzer

The block diagram of the analyzer is shown in Fig.2 and its idealized waveforms in Fig. 3.

Input pulses are gated and amplified and then branch out to a fast trigger and to the line coder where the pulse train is formed. Discriminator output is fed to an anticoincidence, both directly and through a delay τ equal to the spacing between pulses in the pulse train. Inspection of Fig. IIa.7-3 shows that this ensures the selection of the last pulse in each train. This "last pulse" is compared with the pulse generated by the fast trigger that has been delayed by successive steps (all equal to τ). Channel selection is thus accomplished by coincidence circuits. Finally the paralysis generator prevents input pulses from reaching the delay-line coder while an input pulse is being analyzed.

RG-63U 125-Ω coaxial cable is used extensively in the "fast" part of the analyzer (i.e., in the delay-line coder and in all circuits up to the fast trigger and the

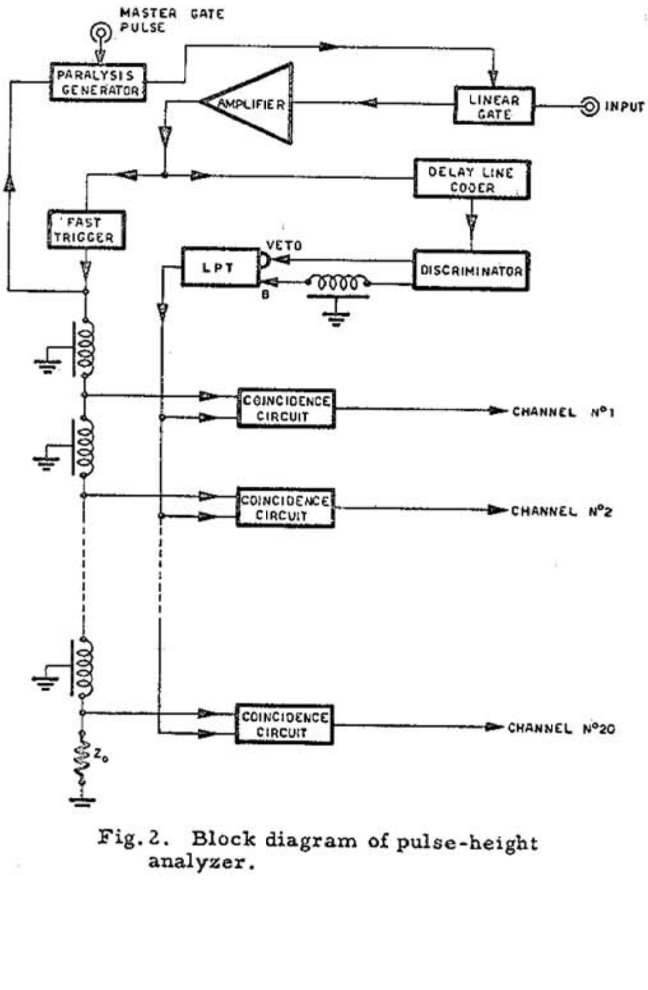

Fig. 2. Block diagram of pulse-height analyzer.

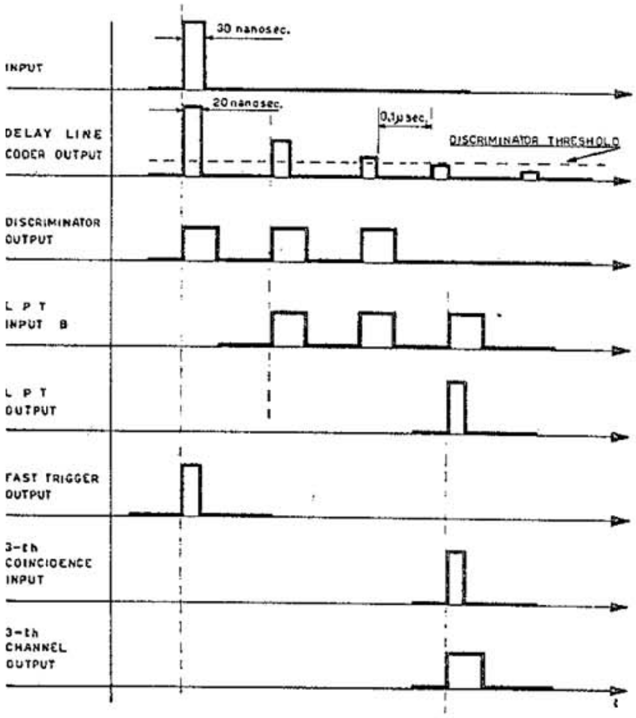

Fig. 3. Wave forms in pulse-height analyzer.

last-pulse trigger circuits. In the "slow" part (i. e., in the time-to-channel selection circuits). 1-kΩ delay line is used, because of its greater delay per unit length (0.1 μ sec/m).

Circuit Description

Linear Gate (Fig. 4)

It consists of a semiconductor diode drawing heavily through tube V2 and thereby short-circuiting input pulses. A positive pulse applied to the grid of V1 turns V2 and its associated diode off, allowing input pulses to reach the output. The pedestal is a few tenths of a volt in amplitude, while nonlinearity is quite small (≤ 25% up to 6 volts) and is limited by diode backward characteristics.

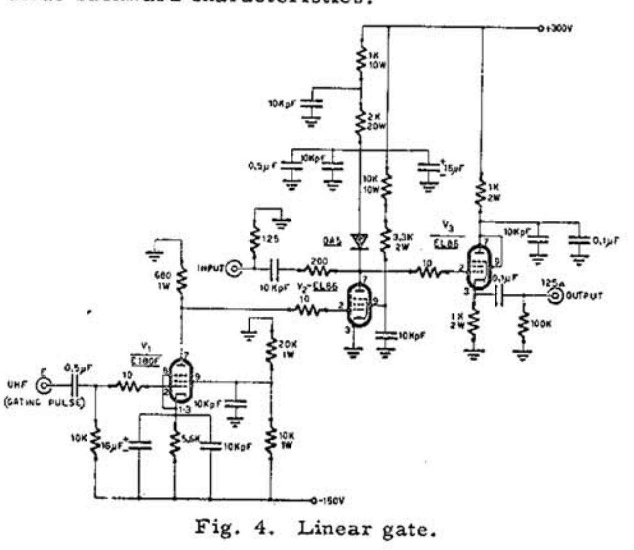

Fig. 4. Linear gate.

Amplifier (Fig. 5)

The amplifier is a conventional constant-k distributed design[5] employing eight power tubes, ensuring a ± 30-v linear swing on a 125-Ω load. Gain is about 6 (16 db), while rise time is about 3 nsec. Gain stability is ensured through a large amount of dc feedback (feedback factor is about 3) and through use of stabilized filament supply.

Delay-Line Coder (Fig. 6)

The input diode separates the preceding circuit (with its associated low output impedance) from the coding cable. Pulses in each train are cathode-followed, clipped by a shorted stub, and again cathode-followed. A semiconductor diode S570G is added to clip undesirable undershoots.

Discriminator (Fig. 7)

As the input-to-output delay of the discriminator must be constant to ensure satisfactory operation of the following circuits, a discriminator employing a distributed amplifier as the pulse-shaping element was chosen.[6] This allows pulses separated by 0.1 μsec to be handled with relative ease (discriminator dead time is less than 25 nsec).

Last-Pulse Trigger (LPT) (Fig. 8)

This circuit is a conventional anticoincidence whose inputs are suitably delayed: the circuit is derived from the well-known Garwin coincidence circuit[7] with obvious modifications.

Fast Trigger (Fig. 9)

Once again the requirements on input-to-output delay were such (i. e., the delay should not be a function of pulse heights) as to prohibit the use of regenerative trigger circuits.[8] Since the speed of the device was not so important as in the discriminator, conventional RC amplifier stages were used. The device gives constant output for input pulses ranging from 0.2 to 80 v in amplitude.

Decoder (Delays and Coincidence Units) (Fig. 10)

As mentioned before, in the "slow" part of the analyzer HFK 5614 delay lines are used to generate suitable delays.

The coincidence circuits have been designed so as to employ a minimum number of tubes and minimum stand-by current; the positive pulse generated by the fast trigger travels down the delay lines and is repeatedly cathode-followed. By itself it can not have any effect, because of the limiting action of semiconductor diode S570G biased by cathode follower V2. A negative pulse from the LPT circuit turns V1 and all the diodes off. It is therefore necessary that two pulses be present (e. g., at the grid of V3 and at the cathode of its associated diode) before an output may be produced (at terminal U1).

Vacuum tubes V23 + V42 are used to cut off noncoincident pulses and to amplify and invert the pulses so as to drive the output scalers.

Paralysis Generator (Fig. 11)

Upon receipt of an external gating signal this circuit clears the linear gate for a time equal to the duration of the signal itself, then effectively blocks the linear gate for a time equal to the analyzer dead

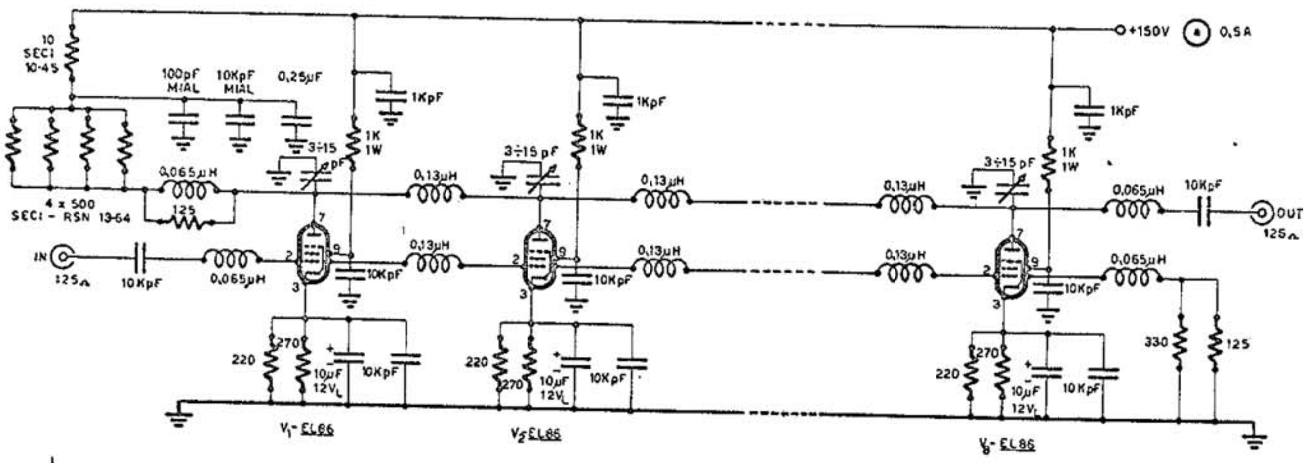

Fig. 5. Amplifier.

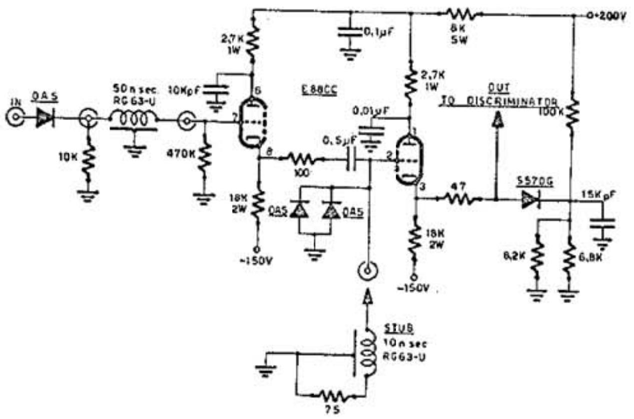

Fig. 6. Delay-line coder.

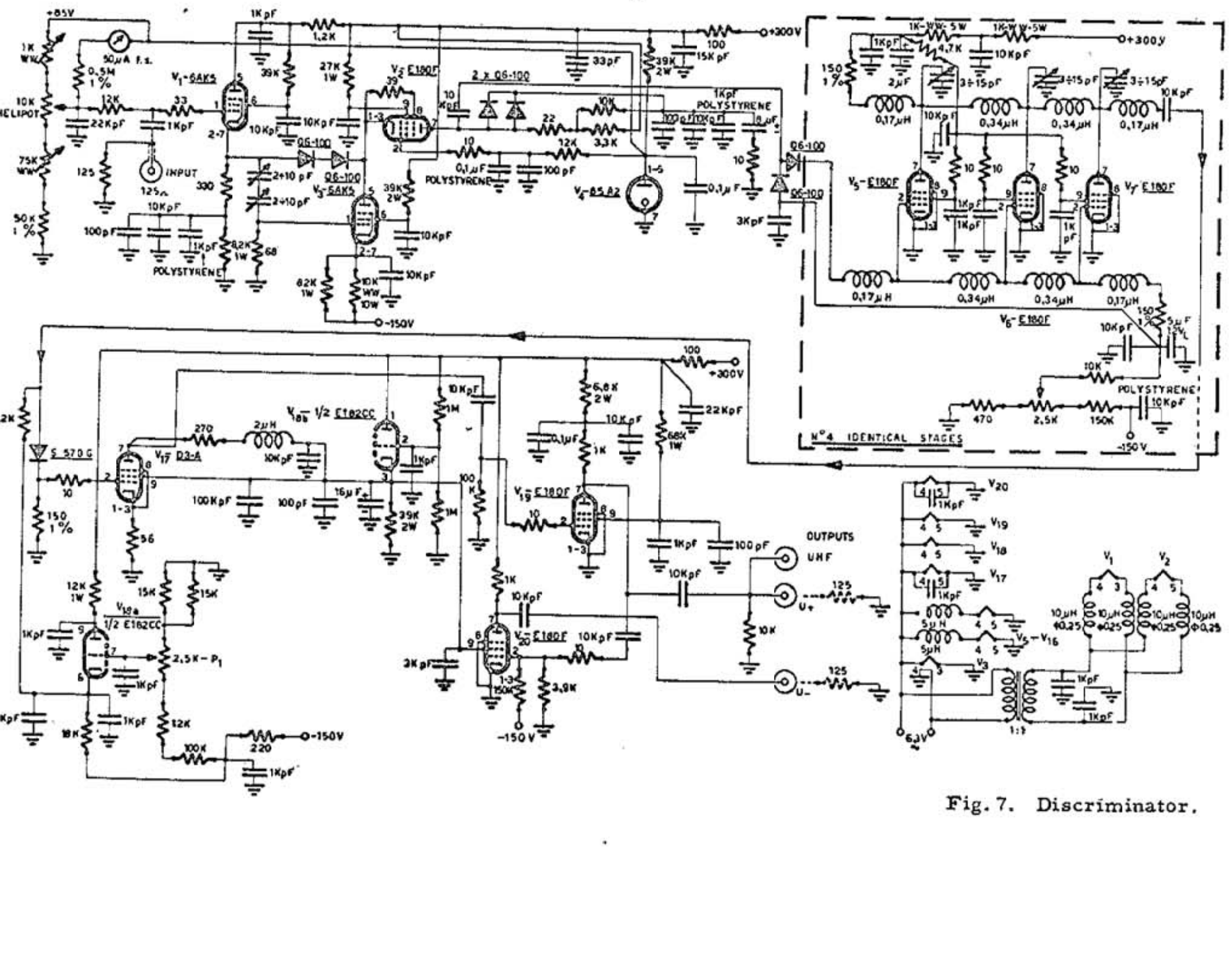

Fig. 7. Discriminator.

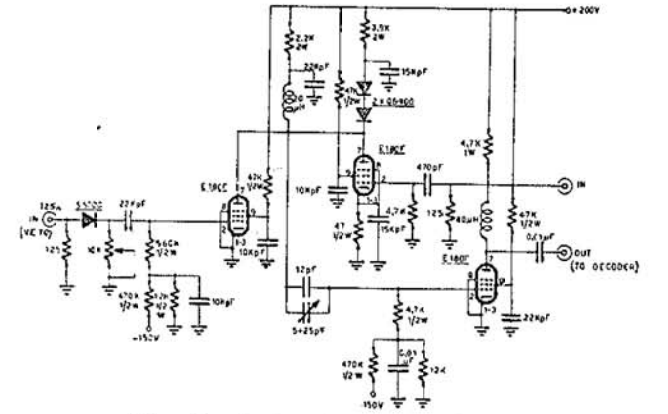

Fig. 8. Last-pulse trigger (LPT).

time (3 μsec). This is done with an anticoincidence circuit fed by a monostable multivibrator and by the gating signal. The monostable multivibrator is triggered by the analyzer's fast trigger and inhibits gating signals from reaching the linear gate for the duration of its quasi-stable state. This circuit employs a secondary emission tube (V2), normally biased well below cutoff with a length of delay line (Hackethal HH 2500), as the pulse-shaping element. This ensures an excellent stability of the pulse duration and a very low recovery time (about 0.2 μsec).

The anticoincidence is a conventional difference amplifier (V4).

Performance

The tests and performance figures to be stated are only preliminary and are therefore not to be taken as definite; they may be taken, however, as indicative of circuit performance.

Figure 12 shows the calibration curve of the analyzer, taken with 25-nsec pulses generated by a mercury relay generator.

It is quite evident that channel width is not constant but varies logarithmically with channel position. This may be an advantage in certain cases (e.g., it allows detailed examination of a part of a spectrum) but renders certain calculations necessary in going from channel contents to spectrum. Specifically it is necessary to divide the number of pulses counted by each channel by a number proportional to channel width, so that a flat spectrum is reproduced as a flat graph. These calculations could of course be done automatically by suitably processing the data from each channel.

Figure 13 shows a spectrum plotted with this technique. By insertion of suitable attenuators the peak of the spectrum was moved to the lower channels, thereby showing greater detail.

Figure 14 shows the same spectrum taken at different times. It is apparent that the position of the peak of the spectrum changed by only one channel.

Finally, Fig. 15 shows the dependence of analyzer calibration on input pulse width.

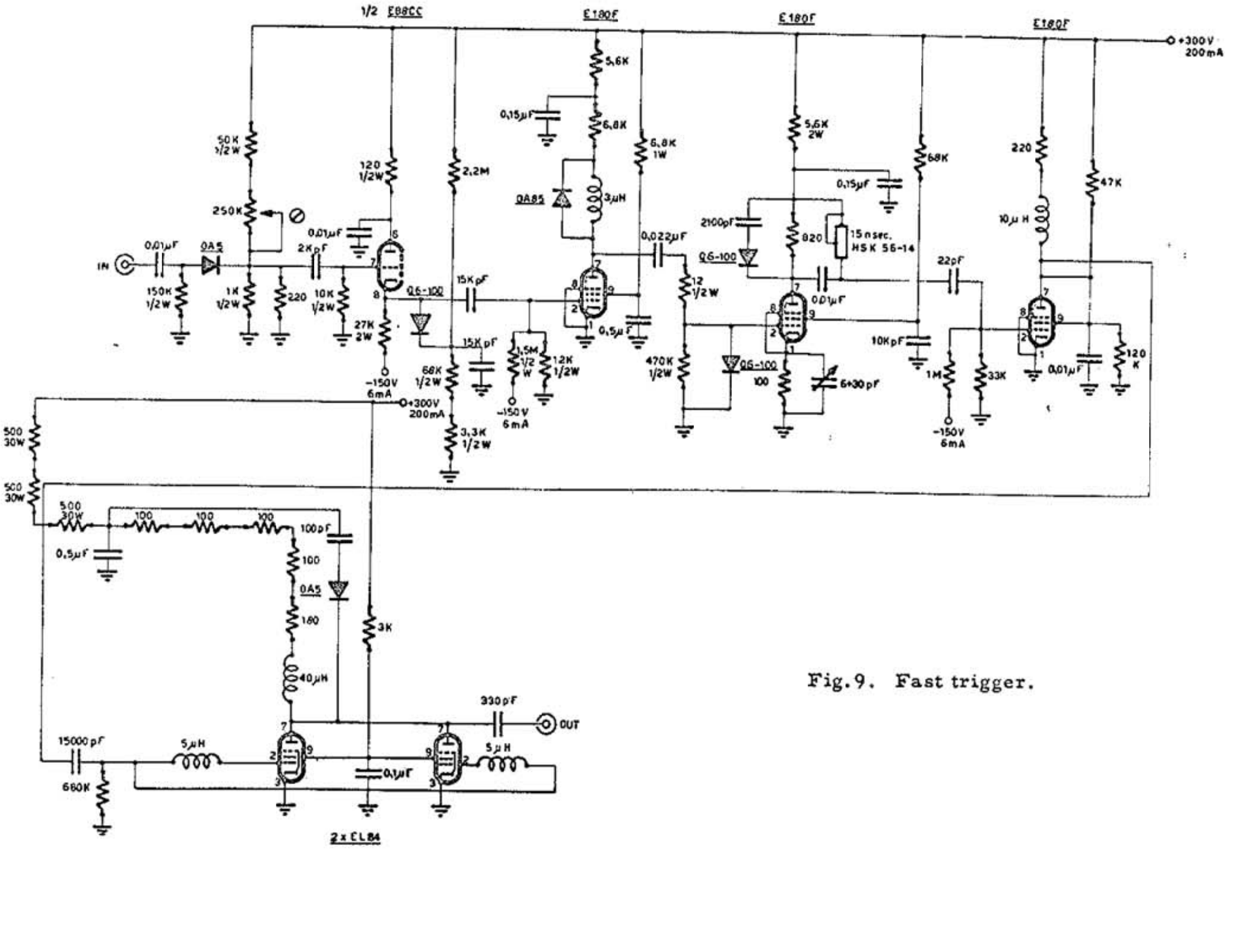

Fig. 9. Fast trigger.

The errors introduced for very short pulses are probably due to the excessive length of the shorting stub in the delay-line coder, to pulse-deterioration effects in the coder itself, and to ballistic effects in the discriminator.

Acknowledgments

The authors wish to acknowledge the help of Mr. C. Dardini in building and testing the circuits just described.

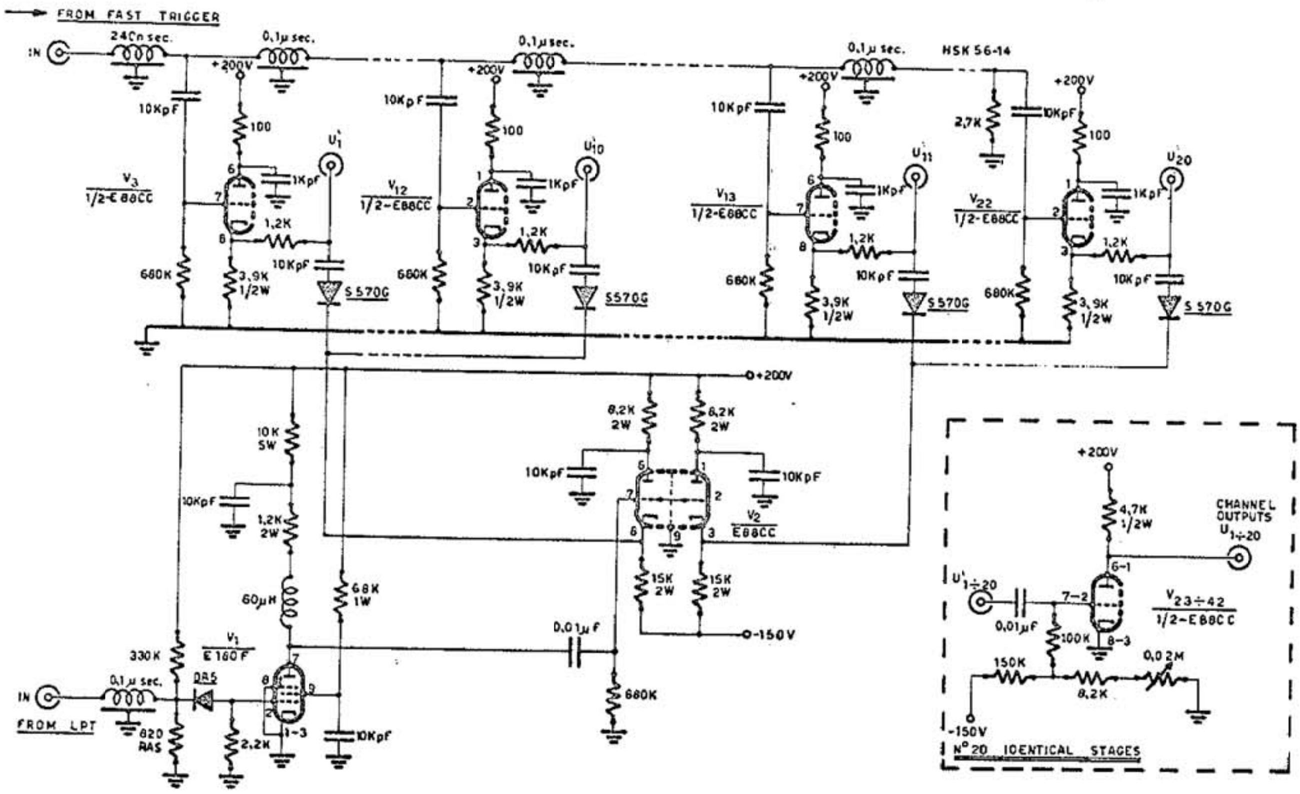

Fig. 10. Decoder (delays and coincidence units).

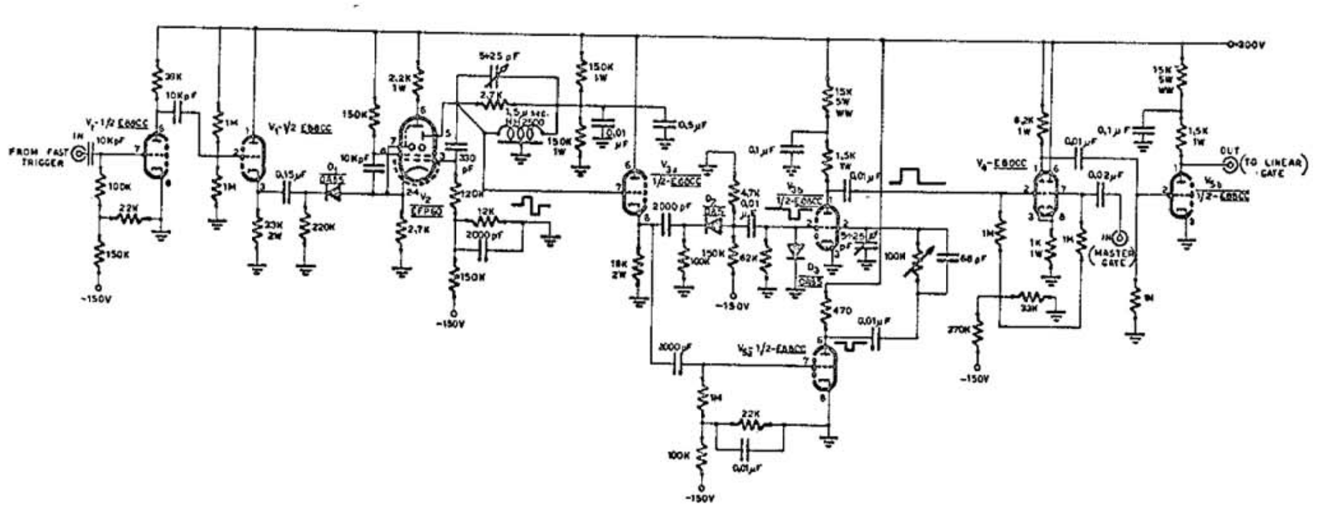

Fig. 11. Paralysis generator.

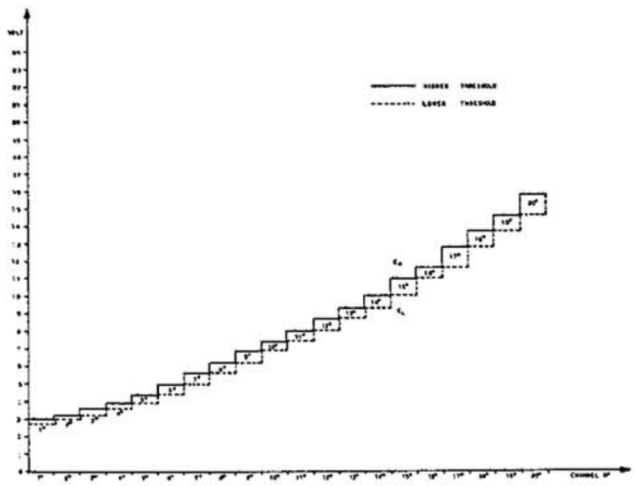

Fig. 12. Calibration of analyzer 25-nsec pulses.

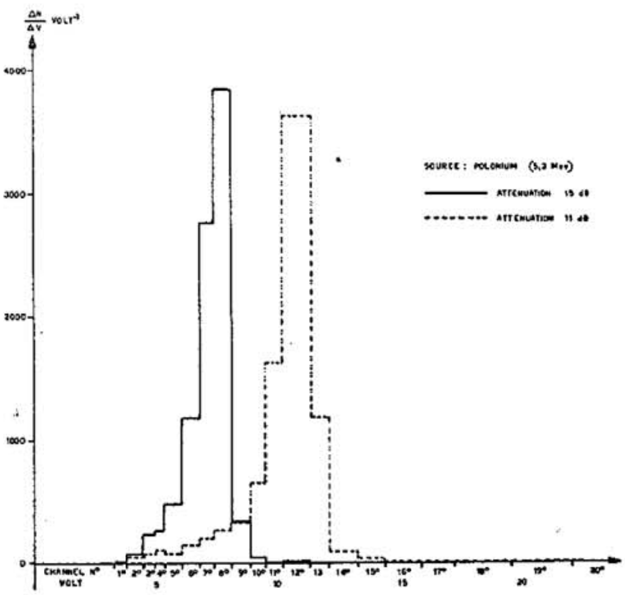

Fig. 13. α Spectrum of radioactive source.

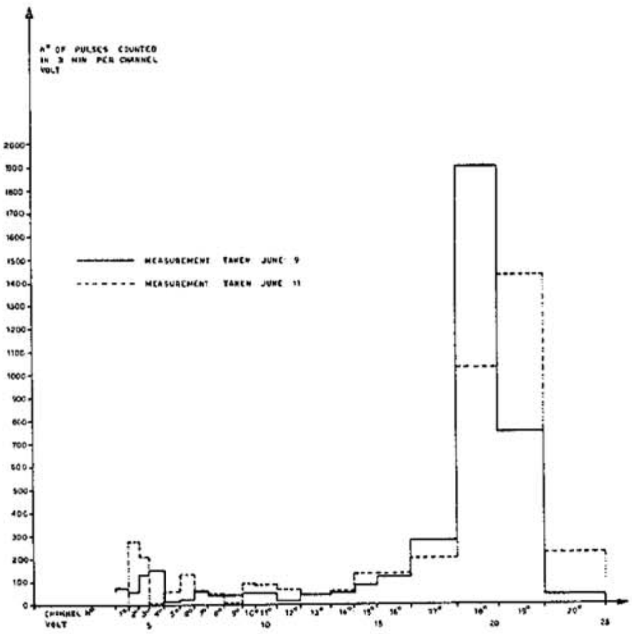

Fig. 14. Alpha spectrum of radioactive source (polonium).

Footnotes and References

*Now at Columbia University, New York, New York.

1. A. Alberigi Quaranta, C. Bernardini, and I. F. Quercia, Nuclear Instr. Methods 5, 201 (1958).

2. A. Alberigi Quaranta, C. Bernardini, C. Infante, and I. F. Quercia, Nuclear Instr. and Methods 5, 120 (1959).

3. A. Alberigi Quaranta and B. Righini, Fast Transistorized Pulse-Height Analyzer, Nuclear Instruments (to be published).

4. I. K. Alimov and A. S. Kusnetzov, Joint Institute for Nuclear Research, Dubna, Report R-436, 1959.

5. E. L. Ginzton, W.R. Hewlett, J.H. Jasberg, and J.D. Noe, Proc. I.R.E. 36, 956 (1948).

6. C. Infante, Pulse-Height Discriminator Employing Distributed Amplification. Nuclear Instr. and Methods (to be published).

7. R. L. Garwin, Rev. Sci. Instr. 24, 618 (1953).

8. J. Mey, L'onde electrique 38, 622 (1958).

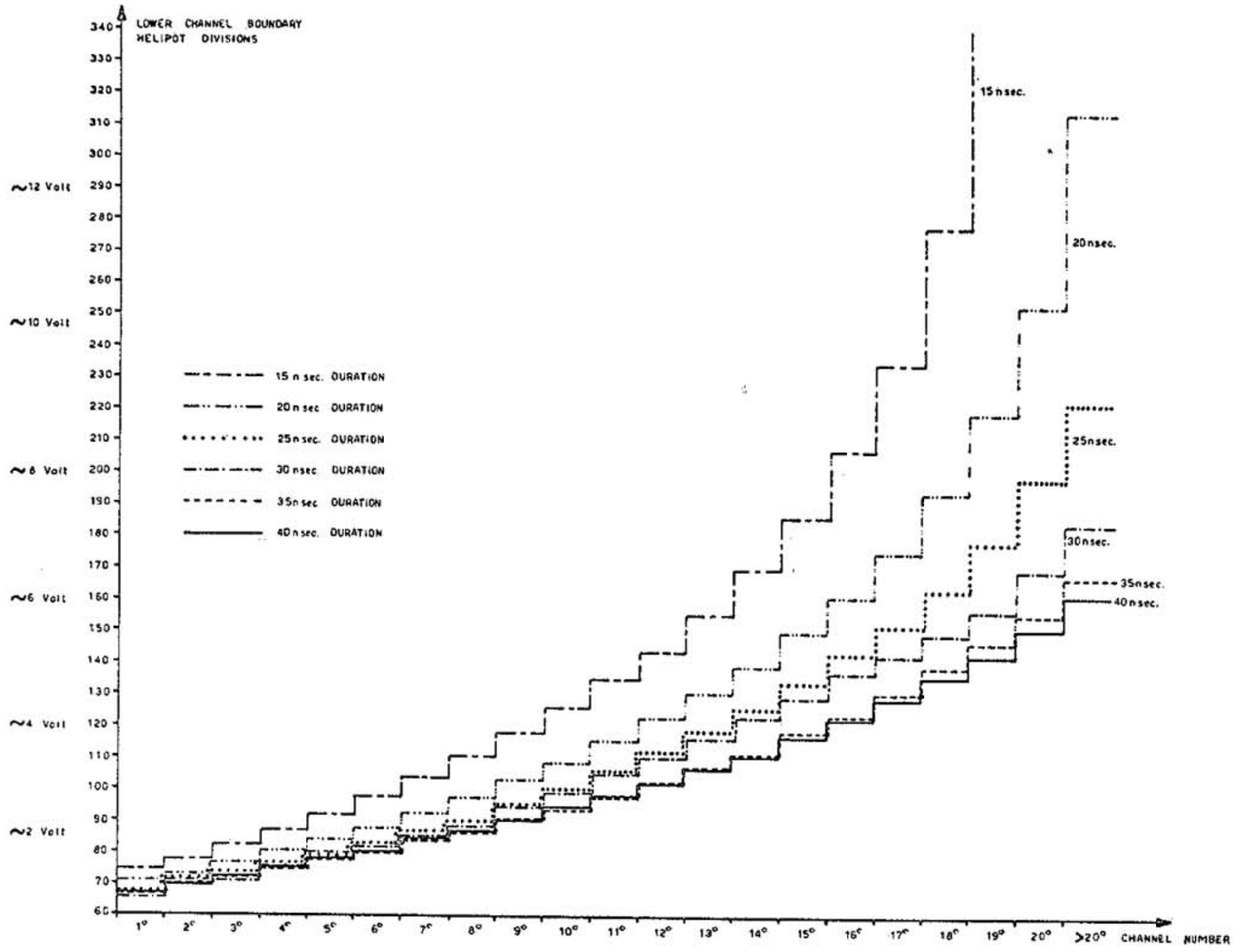

Fig. 15. Analyzer calibration vs input-pulse duration.