PULSE SHAPE DISCRIMINATOR
MODEL 2160
OPERATING MANUAL

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BASIC WARRANTY

CANBERRA - MANUFACTURED EQUIPMENT

Equipment manufactured by Canberra Industries, Inc. is warranteed against defects in materials and workmanship for a period of twelve months from date of shipment, provided that the equipment has been used in a proper manner as detailed in the instruction manuals. During the warranty period, repairs or replacement will be made at Canberra's option on a return to factory basis. The transportation cost, including insurance, to and from Canberra, is the responsibility of the Customer. Except for defects discovered upon initial operation, shipping expense to Canberra is to be paid by the customer; shipping expense to return the repaired equipment will be paid by Canberra.

The customer must obtain shipping instructions, including an Authorized Return Number (ARN), before returning any equipment to the Canberra factory. *Compliance with this provision by the customer shall be a condition of this warranty.* In giving shipping instructions, Canberra shall not be deemed to have assumed any responsibility or liability in connection with the shipment. If, upon receipt of the equipment, Canberra determines that such equipment is not defective within the terms of this warranty, the customer shall pay to Canberra, upon invoice, the cost of diagnosis at the then prevailing Canberra repair rate and the cost of return transportation.

The Canberra Basic Warranty applies only to equipment manufactured by Canberra which is returned to the factory. If equipment must be repaired at the customer's site, the actual repair labor and parts will be provided at no charge during the warranty period. However, travel expenses to and from the customer's site, and living expenses while on site, shall be paid by the customer unless an On-Site Warranty Option has been purchased. This option may only be purchased prior to shipment of the equipment to the customer.

This warranty shall not apply to Canberra equipment that has been modified or serviced by other than Canberra Service Personnel, or to failures of Canberra equipment caused by defective equipment not manufactured by Canberra.

The Express warranties set forth herein are the only warranties with respect to the products, or any materials or components purchased from others and furnished by Canberra, and there are no other warranties, expressed or implied. The warranty of merchantibility is expressly limited as herein provided and all warranties of fitness are expressly disclaimed and excluded. Canberra shall have no liability for any special, indirect or consequential damages, whether from loss of production or otherwise, arising from any breach of warranty hereunder or defect or failure of any product or products sold hereunder.

EXCLUSIONS

Warranty service is contingent upon the proper use of all equipment and does not cover equipment which has been modified without Canberra's written approval or which has been subjected to unusual physical or electrical stress as determined by Canberra Service personnel. Canberra Industries shall be under no obligation to furnish warranty service (preventive or remedial): (1) if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electrical power, air conditioning, humidity control, transportation, or causes other than ordinary use: (2) if the equipment is maintained or repaired or if attempts to repair or service equipment are made by other than Canberra personnel without the prior approval of Canberra.

This warranty does not cover detector damage caused by warm-up or by neutrons or heavy charged particles. Damage from these causes is readily identifiable as described in the manual accompanying each detector.

EQUIPMENT NOT MANUFACTURED BY CANBERRA

Canberra's basic one-year warranty applies only to equipment manufactured by Canberra. Although Canberra may frequently supply, as part of systems, equipment manufactured by other companies, the only warranty that shall apply to such non-Canberra equipment is that warranty offered by the original manufacturer if any.

Canberra will, upon request, offer, as an option, warranty coverage for non-Canberra equipment such as computers and peripherals sold as part of a system supplied by Canberra. Quotations on this coverage may be obtained by contacting Canberra Nuclear Systems Division.

SOFTWARE

Canberra warrants proper system operation *only* with programs developed by Canberra using the operating system supplied to the customer. Canberra assumes no responsibility for user-written programs or programs published as part of information exchange in Canberra periodicals.

Engineering assistance for software development is available and can be contracted through the Canberra Nuclear Systems Division Sales Department.

INSTALLATION

Installation of equipment purchased from Canberra shall be the sole responsibility of the customer unless the installation is specifically contracted for at the prevailing Canberra field service rates. To insure timely installation after receipt of equipment, it is recommended that installation be contracted for at the time the equipment is ordered.

ON-SITE WARRANTY OPTION

The On-Site Warranty Option provides for free on-site warranty work (Canberra pays all travel and living expenses) within the first 90 days after delivery of equipment to the customer. If installation is ordered from Canberra, the 90 day period commences upon completion of the initial installation. After the 90 day period, labor and materials used on site will still be covered by the basic warranty, but the customer shall pay for all travel and living expenses incurred for any on-site service.

A maintenance contract may be purchased covering the period after the 90 days on-site warranty period, or after initial installation of the equipment. This is to be contracted through Canberra's Nuclear Systems Division.

REPAIRS

Any Canberra-manufactured instrument no longer in its warranty period may be returned, freight prepaid, to our factory for repair and realignment. When returning instruments for repair, contact the Customer Service Department for shipping instructions and an Authorized Return Number (ARN).

All correspondence concerning repairs should include Model Number and a description of the problem observed.

Once repaired, all equipment passes through our normal pre-shipment checkout procedure. Return shipping expense on out-of-warranty repairs will be charged to the customer.

For instruments out of warranty, the customer must supply a purchase order number for the repair before the item will be returned to him.

SHIPPING DAMAGE

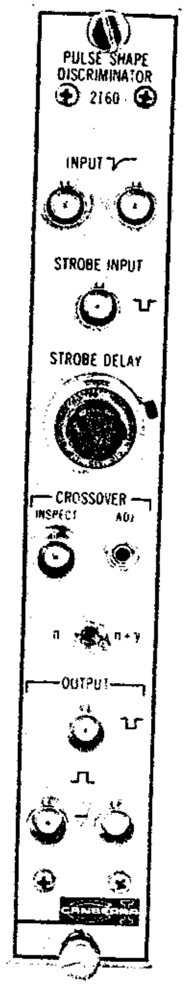
Shipments should be carefully examined when received for evidence of damage caused by shipping. If damage is found, immediately notify Canberra and the carrier making delivery, as the carrier is normally responsible for damage caused in shipment. Carefully preserve all documentation to establish your claim. Canberra will provide all possible assistance in processing damage claims.

Due to the delicate nature of cooled detectors [Ge(Li) and Si(Li)] Canberra requires that delivery to and from air freight terminals be handled with special care. Do not ship such Detectors without first obtaining advice from our Traffic Department.

Model 2160
Pulse Shape Discriminator

Features

- Optimum particle separation for plastic liquid scintillators (NE 213, NE 218)
- Useful dynamic range >500:1
- Z-identification for thick surface-barrier detectors
- Particle identification with proportional counters and phoswitch detectors. Can be directly connected to Model 1428 Constant Fraction discriminator (bridging input)
- Needs only anode signal
- Count rate capability >50kHz
- DC-coupling



Description

The Model 2160 is based on the development at TU-Munich, Garching. The unit provides optimum pulse shape separation for liquid scintillation counters. However the applications are not limited to n/γ separation, but the Model 2160 can also be used for particle separation with inorganic scintillators, phoswitches, thick SB-detectors and proportional counters.

The DC coupling allows high statistical countrate without affecting resolution, which has been a major problem of conventional designs. The single width module is easy to use, only the anode signal is required from the PM-tubes.

The Model 2160 can be used to generate identification spectra with a TAC and MCA (Models 1443A and 8100/e or 8100 or 8180) or an identification signal for one species of particle (refer to application diagrams).

Specifications

INPUT

INPUT - Negative 0 to - 5 volts linear signal; input impedance = 1k ohms (bridging input); protected to - 50 volts (limited by dissipation of input resistor)

STROBE INPUT - Negstive FAST-NIM signal from a Model 1428 (width <50nsec)

OUTPUTS

INSPECT - Displays output signal of Zero Cross discriminator, used to set Zero Cross discriminator with walk adjust potentiometer

FAST OUT - One FAST-NIM output, 800mV at 50 ohms

SLOW OUT - Two outputs, 2 volts at 50 ohms

CONTROLS

STROBE DELAY - Sets strobe of Zero Cross discriminator

ADJust - Sets the Zero Cross discriminator

n/n + γ SWITCH - POS n – generates an identification signal: Pos n + γ – generates identification spectrum

ERFORMANCE

INPUT AMPLITUDE RANGE - - 5mV to - 5 Volts

WALK - <1nsec for 100:1 range

COUNTRATE - >50kHz (limited by internal shaping constant of 1μsec)

OWER REQUIREMENTS

+12VDC	–	290mA*	-12VDC	–	340mA*
+24VDC	–	15mA	- 24VDC	–	15mA

EFERENCES

A simple pulse shape discrimination circuit by P. Sperr et al Nuclear Instruments and Methods 116 (1974) 55-59

PHYSICAL

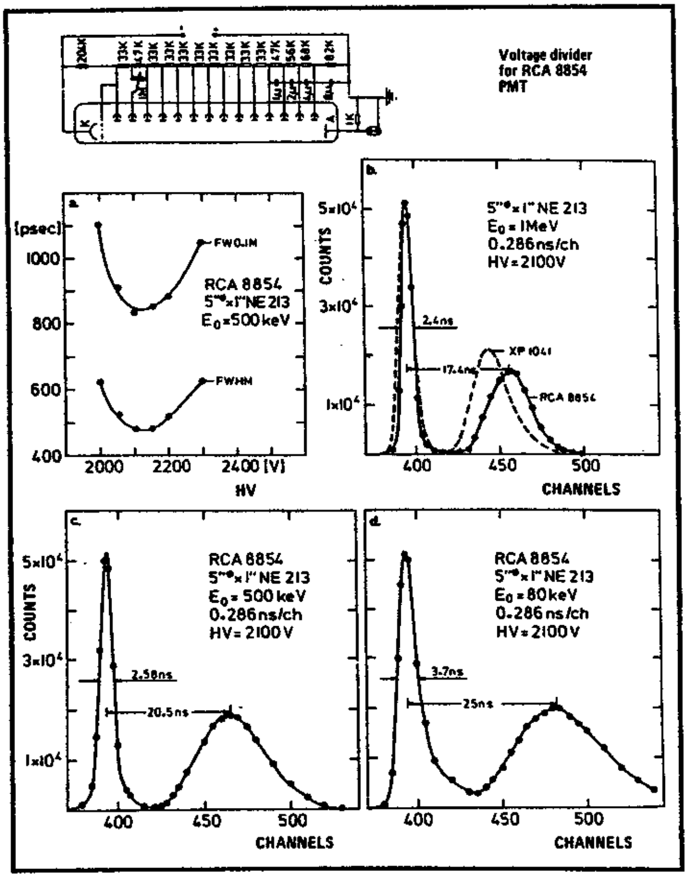
SIZE - Standard single-width NIM module (1.35 x 8.714 inches) per TID-20893 (3.43cm x 22.13cm)

NET WEIGHT - 2 lbs. (0.9 kgs)

SHIPPING WEIGHT - 7 lbs. (3.15 kgs)

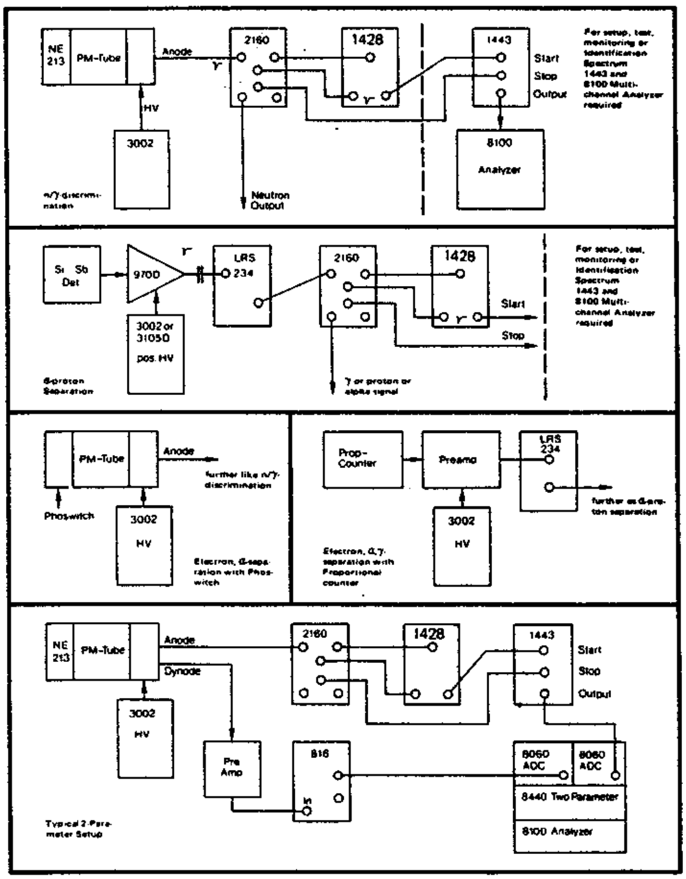
*This power exceeds the normal bin power allotment of 167mA for a single-width module.

Specifications(continued)



a. Time resolution as function of High Voltage

b.,c.,d. n — γ — Spectra with different threshold energies



Typical Applications for 2160 Pulse-Shape Discriminator

1. Introduction

The purpose of this Instrument (PSD) is to suppress gamma rays in neutrondetection systems utilizing organic scintillators. The method used is somewhat similar to a zero-crossing circuit. The main advantages of this method are its large dynamic range (> 1:500) and the feasibility of quickly checking system capabilities with minimum adjustment. Furthermore, the degree of gamma rejection can be determined and reproduced in a simple and straightforward manner. The circuit was especially designed for use at the neutron time-of-flight facility at the Munich MP tandem accelerator where the neutron energies of interest range from 0.5 MeV to about 30 MeV. In this system we use the anode pulse of the photomultiplier for the neutron–gamma discrimination.

2. Principle of operation

Fig. 1 shows the block diagram of the circuit. The anode pulse of the photomultiplier (PM) is integrated and differentiated in a preamplifier A1 so that the zero-crossing point of the output pulse is determined by the fall time of the input pulse. The shaped signal is then fed to a high-gain limiting amplifier A2. The separation of the zero-crossing points corresponding to gammas or neutrons is now greatly enhanced (fig. 2). The overlap of the amplifier signal and the strobe pulse is formed in a gate G. If the strobe signal is placed between the crossing points of gamma and neutron pulses (fig. 2a) only pulses caused by neutrons will produce an output pulse. In our set-up the strobe signal is triggered by the output pulse of a constant fraction trigger (CFT), which is delayed and stretched in D.

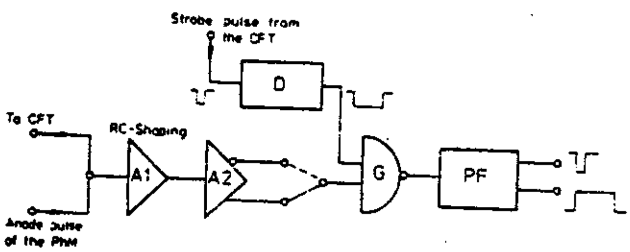


Fig. 1. Block diagram of the circuit.

3. Adjustment procedure

To adjust the unit the inverted output of A2 is used (fig. 2b). The time relation of the gamma and neutron pulses at the output of the PSD unit (in strobe position 1) can be monitored with a time-to-amplitude converter (TAC) (start signal from the CFT, stop signal from the PSD) and a multichannel analyser (fig. 2b). Since the strobe delay is variable, the gamma-rejection ratio can be adjusted (strobe position 2). The onset of the strobe signal appears as a sharp "needle" in the time spectrum since the gate has already been opened by a gamma signal.

After determining the discrimination point the gate input is switched back to the non-inverted output of A2 (fig. 2a). The positive output signal is derived 300 ns after the input pulse.

4. Circuit details

Basically the shaping amplifier consists of an RC integrator followed by an active pole-zero compensated differentiator, i.e. differentiation is performed in the feedback loop of the amplifier (SA). This provides good isolation between the two shaping networks. High count rate capability and good overload characteristics are major design criteria in this stage. The circuit is therefore dc coupled throughout. Good overload performance is achieved by using a differential pair biased from a constant current source in the input stage. This stage is followed by a class A pre-driver which is in turn coupled to a class AB complementary

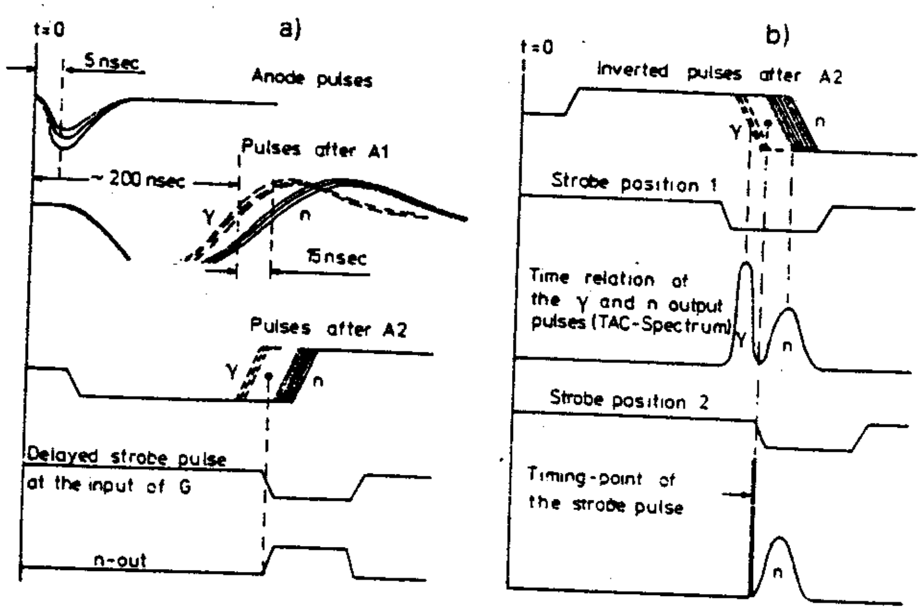


Fig. 2. Time relationship between the pulses at various points of the PSD circuit. a) Normal operation, b) during adjustment.

bipolar output stage. The feedback loop is closed by returning the output via the shaping network to the second input of the differential input stage.

A cascode circuit was chosen for the input half of the differential pair to minimize Miller capacitance at the input of the amplifier. This is important because Miller capacitance at the input is also determined by stray capacitance at the output of the stage which can change appreciably due to minute flexing of the circuit board or of the sides of the NIM cassette. The change in input capacitance alters the integration time constant leading to a corresponding shift of the zero-crossing point. The cascode input circuit makes the mechanical requirements in this respect less stringent and contributes significantly to the long-term stability of the unit.

The balanced bridge type operation of the circuit ensures a stable dc level at the output of the amplifier. Use of a dual transistor for the differential pair takes care of thermal tracking problems which would give rise to a drift in the dc output level. An offset voltage is applied at the feedback input to adapt the dc output level to the input bias requirements of the high-gain limiting amplifier.

It is of the utmost importance that this stage be :xtremely "clean" and free of spurious responses at all nput levels. We therefore carefully checked the open oop response and also performed extensive measurenents with both sine wave and pulse inputs.

The fast limiting amplifier (in ZL,ICA,ICB) consists of the hree cascaded differential amplifier stages of an MC 10216. To increase the dynamic range the supply oltages V_{CC1} and V_{CC2} are connected to +6 V and +0.8 V respectively. The three stages of the MC 10216 ave a double-ended voltage gain of about 10^3. The isetime of the trailing edges of the gamma and neutron pulses (see fig. 2) at the output of the amplifier is about 4 ns. To monitor the amplifier output a unity-gain amplifier (one stage of an MC 10216) is included. This is convenient for adjustment of the dc offset so that the baseline at the output of the limiting amplifier lies in the middle of the output range. The normal and the inverted pulses of A2 are fed together with the split strobe-signal in two NAND-enable gates (each one a quarter of an MC 1010) (IC 1 and IC 2). The leading edge of the output is always defined by the pulse which comes last, provided both pulses overlap.

The gate output derived from either the inverted (IC 1) or non-inverted output (IC 2) of the limiting amplifier can be selected by switching between the two wired-or connected NAND-gates (IC 3 and IC 4).

The negative going output of the MC 1010 stages is translated from MECL levels to fast NIM compatible levels by an emitter-follower. The output of the selector gates is also fed to a simple one-shot (MC 1004) which drives a MECL-to-TTL translator to provide a NIM standard pulse for slow logic applications.

After being translated to MECL levels the output of the CFT drives a one-shot (ICS in SL) which generates a pulse of width d. The inverted output of the one-shot is in effect delayed by the integrator R_1C_1 and combined with the non-inverted output in a NOR gate. The output of this gate yields a pulse whose width is defined by R_1C_1 and which is delayed by the time d relative to the input of the one-shot.

The whole circuit is built on a printed circuit board with a ground plane on one side and fits easily into a single width NIM module. The three stages A1, A2 and the strobe circuit are well separated on the board. Great care must also be taken in decoupling the dc-supply voltages between the stages to avoid crosstalk which may give rise to spurious oscillations.

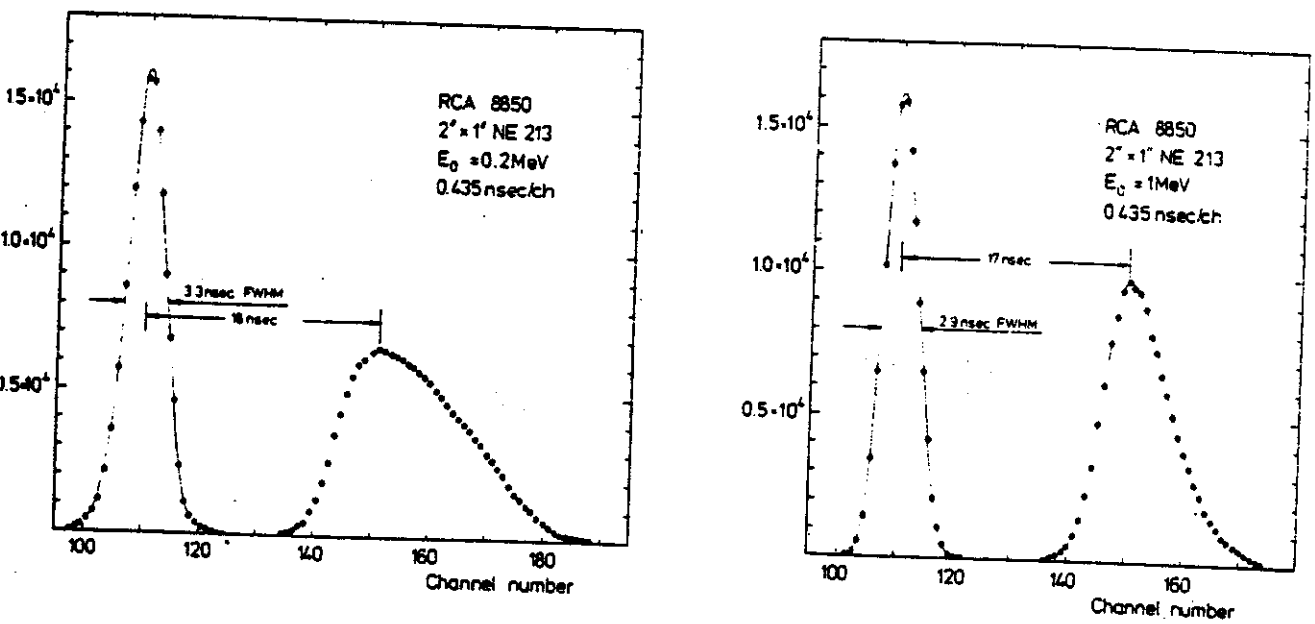


Fig. 3. Neutron–gamma timing distributions with a small scintillator (2" diam. × 1") for two threshold energies.

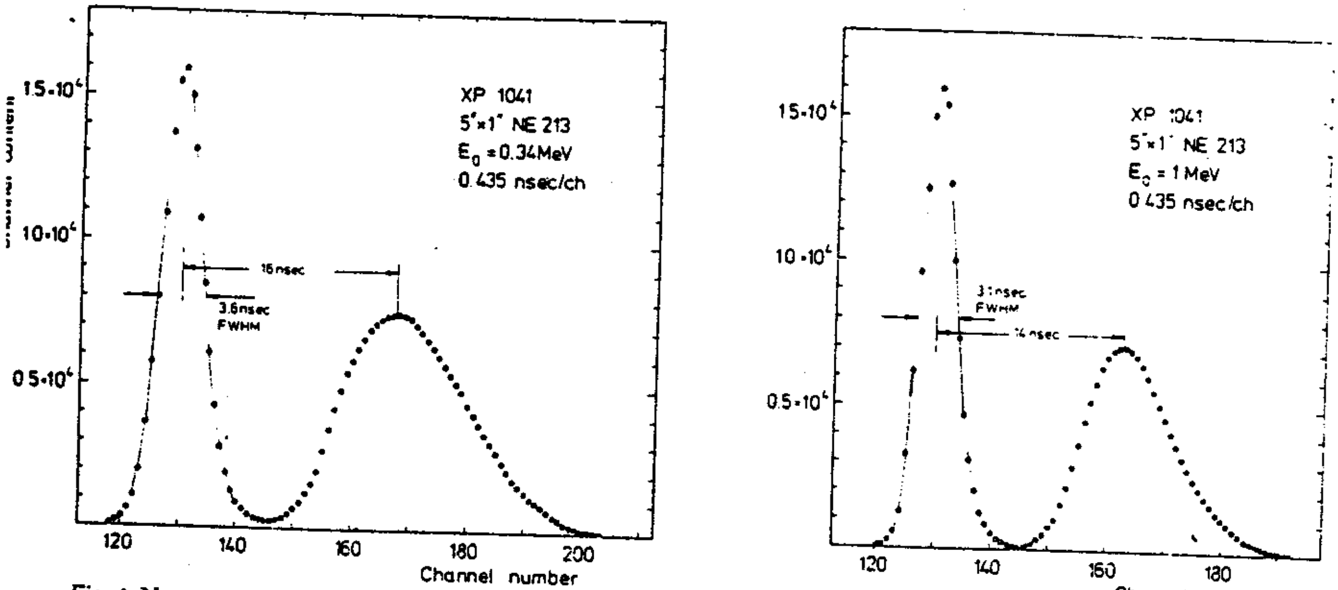


Fig. 4. Neutron–gamma timing distributions with a 5" diam. × 1" scintillator for two threshold energies.

. Results

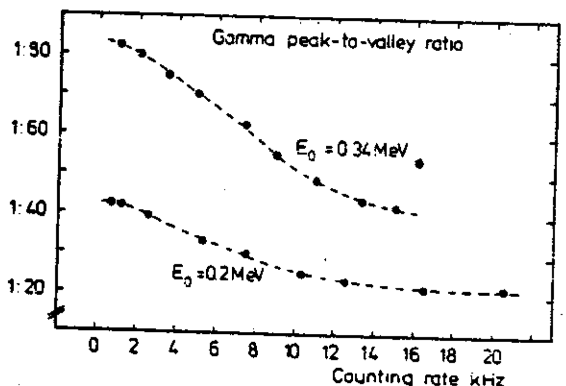
The measurements were performed with a 100 mCi m–Be source filtered by 3 mm of lead in order to :duce the intense 60 keV gamma radiation. An E213* organic liquid scintillator was used because of its good pulse shape characteristics. The neutron–gamma discrimination properties of the unit were tested using different scintillator sizes. The results obtained with a small scintillator (2" diam. × 1") mounted on an RCA 8850 PM tube are given in fig. 5. A clear separation of the neutron and gamma distributions is obtained. The gamma peak-to-valley ratio is 1:350 for a lower threshold $E_0 = 0.2$ MeV and shows no strong dependence on energy (1:450 for $E_0 = 1$ MeV). The counting rate in both cases was about 3 kHz. Here and in the following all threshold energies correspond to electron energies.

NE-Nuclear Enterprises, Edinburgh, Scotland.

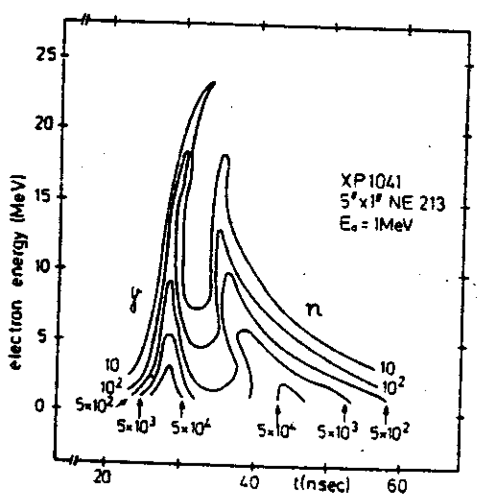
The PSD properties with larger scintillators are given in fig. 6. A 5" diam. × 1" NE213 scintillator mounted on an XP 1041 PM tube was used. The peaks for gammas and neutrons are somewhat broadened and the gamma peak-to-valley ratio shows a stronger dependence on the threshold energy. At about 5 kHz counting rate the peak-to-valley ratio is 1:70 for $E_0 = 0.34$ MeV and 1:120 for $E_0 = 1$ MeV. These values improve for lower counting rates (see fig. 5). The time distributions are well separated and for $E_0 = 1$ MeV a gamma-rejection ratio of 1:1000 without losing neutrons is obtained.

The dependence of the gamma peak-to-valley ratio on the counting rate (for two lower energy thresholds) is given in fig. 5. The indicated counting rates refer to the strobe-signal. The shapes of the gamma and neutron peaks remain the same for all counting rates. Only the valley between them fills up due to pile-up effects which distort the form of the input pulses.

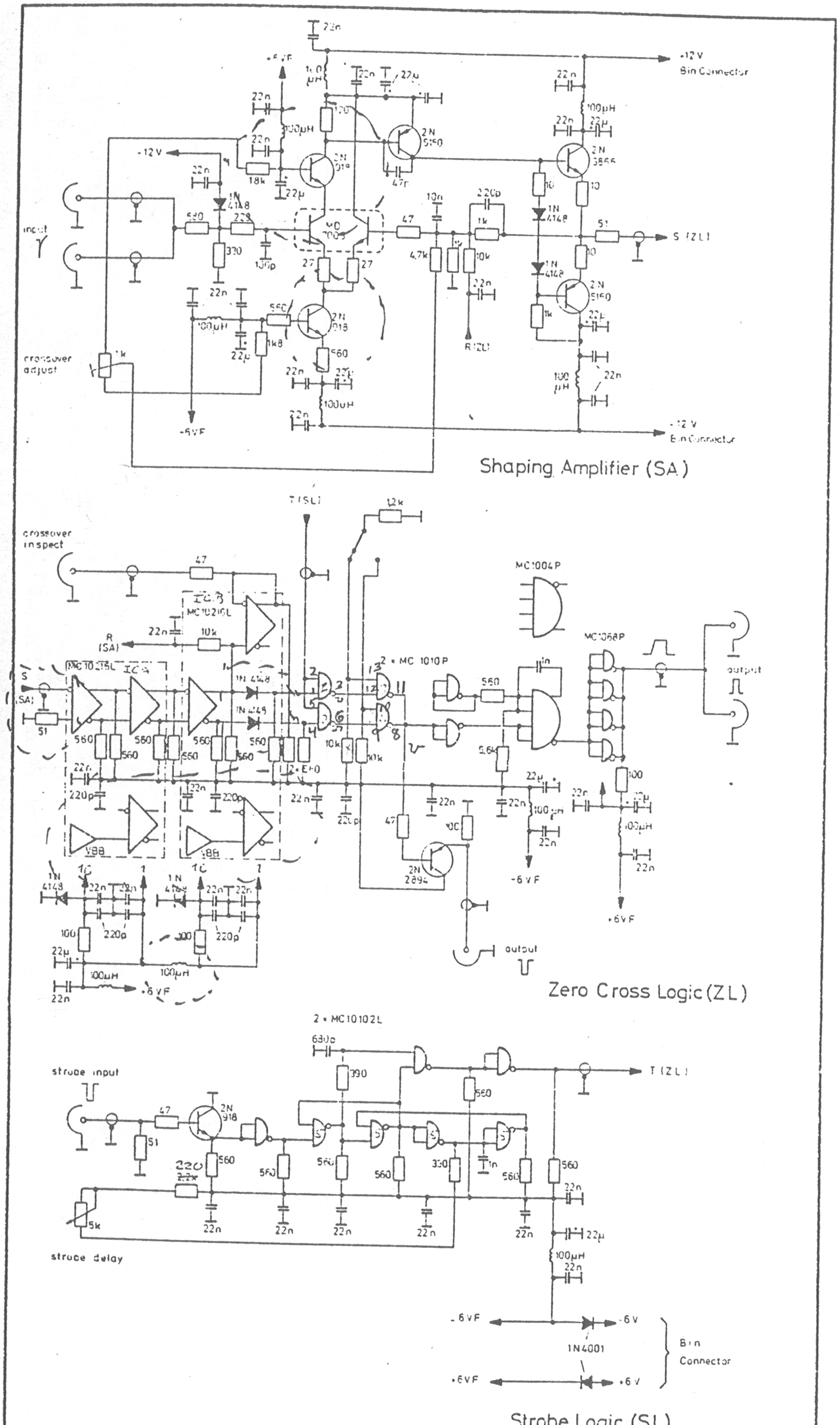
Fig. 6 shows a contour plot of a two parametrical neutron–gamma timing distribution versus energy obtained in a $^{26}Mg(^3He, n)^{28}Si$ experiment at $E_{(^3He)} = 18$ MeV. Gammas and neutrons are clearly separated even for neutron energies up to 27 MeV. The bending of the gamma distribution at higher energies (> 20 MeV) into the neutron region is due to saturation effects in the photomultiplier tube.



;. 5. Counting rate dependence of the gamma peak-to-valley ratio for two lower energy thresholds.



6. Contour plot of a two-parametrical neutron–gamma ti- g distribution vs energy obtained in a $^{26}Mg(^3He,n)^{28}Si$ experiment at $E_{(^3He)} = 18$ MeV.



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