Model 265A
Photomultiplier Base
Operating and Service Manual

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Manual Revision C

0905

Advanced Measurement Technology, Inc.

a/k/a/ ORTEC®, a subsidiary of AMETEK®, Inc.

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Before being approved for shipment, each ORTEC instrument must pass a stringent set of quality control tests designed to expose any flaws in materials or workmanship. Permanent records of these tests are maintained for use in warranty repair and as a source of statistical information for design improvements.

Repair Service

If it becomes necessary to return this instrument for repair, it is essential that Customer Services be contacted in advance of its return so that a Return Authorization Number can be assigned to the unit. Also, ORTEC must be informed, either in writing, by telephone [(865) 482-4411] or by facsimile transmission [(865) 483-2133], of the nature of the fault of the instrument being returned and of the model, serial, and revision ("Rev" on rear panel) numbers. Failure to do so may cause unnecessary delays in getting the unit repaired. The ORTEC standard procedure requires that instruments returned for repair pass the same quality control tests that are used for new-production instruments. Instruments that are returned should be packed so that they will withstand normal transit handling and must be shipped PREPAID via Air Parcel Post or United Parcel Service to the designated ORTEC repair center. The address label and the package should include the Return Authorization Number assigned. Instruments being returned that are damaged in transit due to inadequate packing will be repaired at the sender's expense, and it will be the sender's responsibility to make claim with the shipper. Instruments not in warranty should follow the same procedure and ORTEC will provide a quotation.

Damage in Transit

Shipments should be examined immediately upon receipt for evidence of external or concealed damage. The carrier making delivery should be notified immediately of any such damage, since the carrier is normally liable for damage in shipment. Packing materials, waybills, and other such documentation should be preserved in order to establish claims. After such notification to the carrier, please notify ORTEC of the circumstances so that assistance can be provided in making damage claims and in providing replacement equipment, if necessary.

CONTENTS

SAFETY INSTRUCTIONS AND SYMBOLS

This manual contains up to three levels of safety instructions that must be observed in order to avoid personal injury and/or damage to equipment or other property. These are:

DANGER Indicates a hazard that could result in death or serious bodily harm if the safety instruction is not observed.

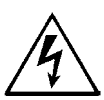
WARNING Indicates a hazard that could result in bodily harm if the safety instruction is not observed.

CAUTION Indicates a hazard that could result in property damage if the safety instruction is not observed.

Please read all safety instructions carefully and make sure you understand them fully before attempting to use this product.

In addition, the following symbol may appear on the product:

ATTENTION–Refer to Manual



DANGER–High Voltage

Please read all safety instructions carefully and make sure you understand them fully before attempting to use this product.

SAFETY WARNINGS AND CLEANING INSTRUCTIONS

DANGER	Opening the cover of this instrument is likely to expose dangerous voltages. Disconnect the instrument from all voltage sources while it is being opened.

WARNING	Using this instrument in a manner not specified by the manufacturer may impair the protection provided by the instrument.

Cleaning Instructions

To clean the instrument exterior:

- Unplug the instrument from the ac power supply.
- Remove loose dust on the outside of the instrument with a lint-free cloth.
- Remove remaining dirt with a lint-free cloth dampened in a general-purpose detergent and water solution. Do not use abrasive cleaners.

CAUTION	To prevent moisture inside of the instrument during external cleaning, use only enough liquid to dampen the cloth or applicator.

- Allow the instrument to dry completely before reconnecting it to the power source.


HIGH VOLTAGE
NEG ONLY
ANODE
DYNODE

ORTEC MODEL 265A
PHOTOMULTIPLIER BASE

1. DESCRIPTION

The ORTEC 265A Photomultiplier Base structure provides a mechanical assembly and resistive voltage divider network, with appropriate capacity decoupling, for operation of the Burle 8850 or Hamamatsu R1332 photomultiplier. This tube is a bi-alkali photocathode device with very good timing and energy resolution characteristics. The tube is capable of relatively high pulse currents when used in timing applications, and this base structure complements the tube characteristics by maintaining good pulse fidelity over a wide range of signal currents (see Fig. 1.1). The unit provides two outputs: the negative anode signal for timing applications and the linear signal from the ninth dynode. This linear signal is of special importance in any experiment in which energy measurements are desired.

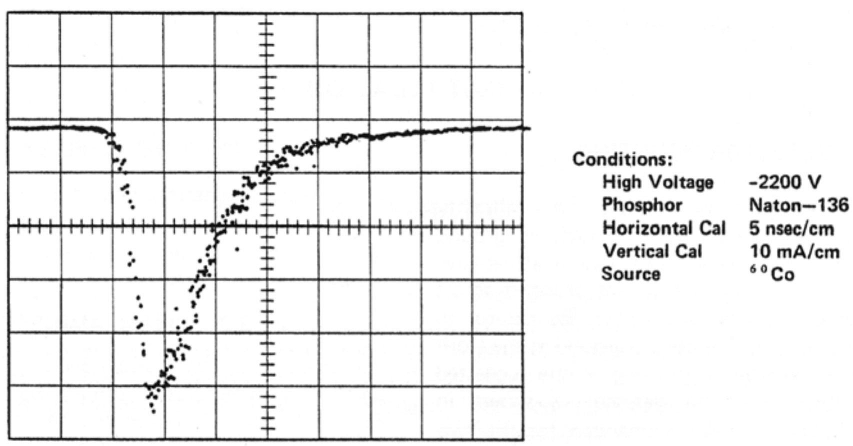


Fig. 1.1. Typical Anode Output Pulse.

2. SPECIFICATIONS

2.1. PERFORMANCE

All photomultiplier tube specifications are furnished by the manufacturer. The 265A Base accommodates the RCA-8575 or -8850 tube and includes an appropriate voltage divider network for the tube elements.

2.2. CONTROLS

Internal adjustments are included for the focus electrode and for the second and twelfth dynodes.

2.3. INPUTS

HIGH VOLTAGE -3 kV maximum at 2 mA maximum for bleeder network. Type SHV connector.

AUXILIARY Last four dynodes are available at pins in the Auxiliary connector for optional external voltage stabilization; type MS3112E12-10S or Bendix PT02E-12-10S connector.

2.4. OUTPUTS

ANODE Negative timing signal, 50Ω dc-coupled, back-terminated; very good pulse quality for signal currents to 0.5 A; type BNC connector.

DYNODE Positive linear signal from 9th dynode, capacity coupled, high impedance (Z_o ~ 1 MΩ); type BNC connector.

2.5. RELATED EQUIPMENT

The Anode timing signal can be furnished to a fast discriminator such as the ORTEC 453 or 436 when using either a NaI(Tl) or plastic scintillator. For plastic scintillators only, the Anode signal can be fed directly to the Start or Stop input of an ORTEC 437A, 447, or 457 Time to Pulse Height Converter.

The linear output from the 9^{th} dynode is normally processed through an ORTEC 113 Scintillation Preamplifier and a shaping amplifier such as the ORTEC 410, 450, 451, 452, 460, or 485.

2.6. MECHANICAL DATA

WEIGHT (Shipping)

265A PM Base 3 lb (1.37 kg).
218 Shield 2 lb (0.9 kg)
C36-12 Cable <1 lb (<0.46 kg).

WEIGHT (Net)

265A PM Base 1.4 lb (0.63 kg).
218 Shield 1 lb (0.46 kg).
C36-12 Cable <1 lb (<0.46 kg).

DIMENSIONS

265A PM Base 3-in. dia. x 8 in. long.
218 Shield 3-in. dia.; assembled 265A and 218 13 in long.
C36-12 Cable 12 ft long.

3. INSTALLATION

3.1. DETECTOR MOUNTING

The ORTEC 265A is designed for the best in pulse fidelity and requires that the anode be operated at ground potential. This means that the photocathode is at negative HV. Assure that this high voltage is not dropped across the glass envelope of the photomultiplier. Be careful to prevent the scintillator from imposing a ground at the front surface of the photocathode. A drawing of the suggested method of mounting a simple detector is shown in Fig. 3.1. (Scotch Type 33 is recommended for the two layers of electrical tape shown in Fig. 3.1 that are to be applied over the photomultiplier tube. This product not only affords the necessary electrical insulation but also minimizes noise that would be present because of extraneous light that could reach the tube structure. This tape wrapping should be extended beyond the physical body of the photomultiplier tube to include the tapered surface of the tube socket within the light-shielded configuration.)

3.2. PHOTOMULTIPLIER INSERTION

Remove the magnetic shield, if used. The tube may now be inserted directly into the light-tight socket. Place the felt washers around the photomultiplier and remount the magnetic shield.

3.3. INITIAL ADJUSTMENTS

Remove the high voltage divider cover. The controls of the unit are trimmed for optimum operation with a specific PM at the factory. However, the unit will probably need trimming again when a different PM is used. These adjustments need to be performed rarely more than once with a specific PM unless the operating HV is varied more than ±200 V.

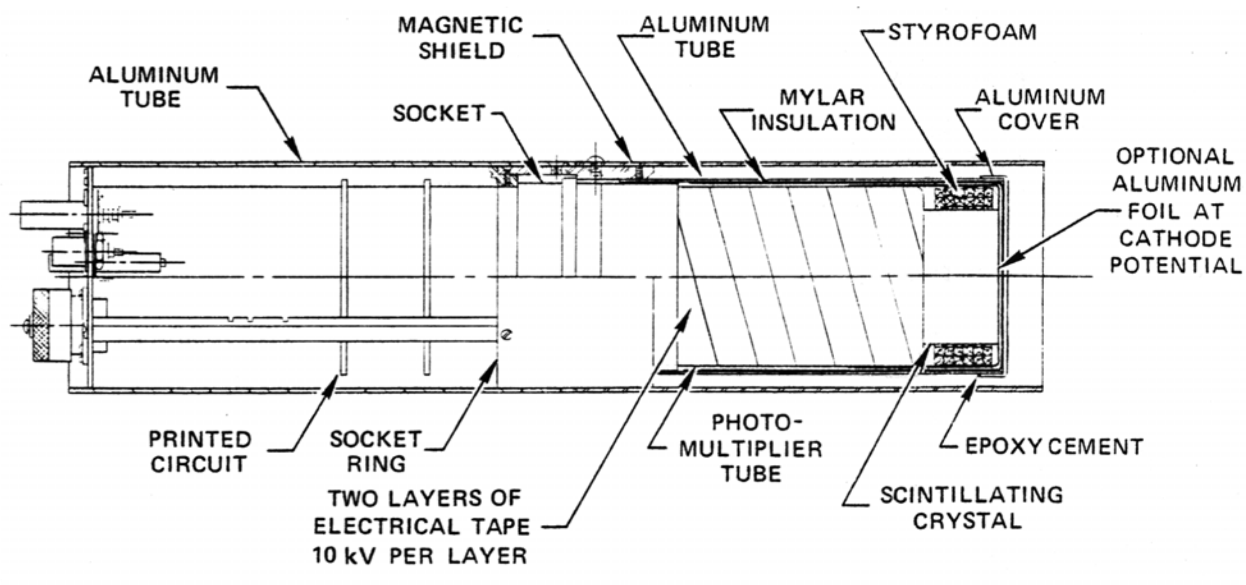


Fig. 3.1. Cutaway Drawing of PM - Scintillator Mounting.

WARNING
The voltages used in this network are dangerous so adjust the controls cautiously.

1. Observe the Anode output on a fast rise time oscilloscope (terminate the coaxial cables properly).

2. Apply negative 2200 V (or the voltage at which the tube is to be operated) to the high voltage connector.

3. Place a radiation source, appropriate to the chosen scintillator, near the detector.

4. Observe the output waveform and adjust the two bleeder string controls, i.e., the Focus (R17) and Dynode (R15) for maximum output signal. This assures that the input optics are adjusted properly for the specific photomultiplier used (see Fig. 3.1).

5. Adjust R26 for maximum signal output without pulse shape distortion.

6. Turn off the high voltage and replace HV divider cover The unit is now ready for operation.

3.4. CONNECTION INTO A SYSTEM

The linear dynode signal should be coupled through a scintillation preamplifier, such as the ORTEC 113, to a shaping amplifier if linear energy information is desired. The ORTEC 410, 450, 451, 452, 460, and 485 are typical shaping amplifiers for the linear signals. The timing signal from the anode can be connected through 50Ω cable (terminated) to an ORTEC 436 Fast Discriminator or 437A, 447, or 457 Time to Pulse Height Converter. Either output connector can be left with no external connection if its signal is not required.

4. OPERATION

Once the steps outlined in Section 3 of this manual have been performed the unit is ready for use. Negative high voltage may be applied and adjusted for the appropriate gain associated with the specific experiment. The gain will vary by a factor of approximately 2 with a high voltage change of 100 V.

4.1. TIMING WITH PHOTOMULTIPLIERS

Timing with photomultipliers implies some type of coincidence measurement. This measurement may be performed with standard coincidence circuits such as the pulse overlap type, which are essentially single channel time analyzers, or with time to pulse height converters, which are differential type, or with multichannel analyzers.

The response of the coincidence system to a prompt cascade always has finite width which comes from a variety of sources. The most important of these are as follows:

1. Variation of time of interaction of radiation with the scintillator and the amount of energy deposited therein,

2. Finite decay time of light-emitting states in the phosphor and variation of times of photon arrival at the multiplier cathode,

3. Variation of transit time of photoelectrons in the photomultiplier due to different path lengths and to variation of initial energy and angle of the secondary electrons,

4. Jitter and uncertainties of triggering times of the associated electronics.

The variation of the time of interaction can be minimized by appropriate geometry and small scintillators at a corresponding loss in efficiency and average energy deposition.

For a complete discussion of timing with photomultipliers, the reader is referred to some of the excellent literature available on the subject.[1-5]

4.2. APPLICATIONS

The different specific applications for the ORTEC 265A are essentially limitless, but since the unit was designed primarily for timing applications, a number of system block diagrams utilizing this unit are given. Some typical resolution curves for three of the systems are given separately, from which operational characteristics of other systems may be implied.

Typical Fast-Slow Coincidence System Using Plastic Scintillators Figure 4.1 is a block diagram of a system that might be used to perform lifetime measurements or to study the time dispersion associated with some prescribed coincidence events. It does not represent an optimum system if clean slopes of the coincidence curves are required to four or five decades, but will give clean spectra to at least three decades at moderately high count rates. The time spectrum shown in Fig. 4.2 represents what may be obtained under laboratory conditions using the ORTEC 265A and other appropriate equipment. It is important to remember that the resolution obtainable varies as 1√*n*. where *n* represents the number of photoelectrons created by the event and is therefore representative of the amount of energy deposited in the scintillating phosphor and is strongly influenced by PM optics.

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[1]A. Schwarmhild, "A Survey of the Latest Developments in Delayed Coincidence Measurements," ***Nuct. Instr. Methods 21*** **(1), 1** (1963).

[2]G. Present ***et al.,*** "Fast Delayed Coincidence Technique: The XPI020 Photomultiplier and Limits of Resolving Times Due to Scintillator Characteristics," ***Nucl. Instr. Methods*** **31(l),** 71 (1964).

[3]E. Gatti and V. Svelto, "Revised Theory of Time Resolution in Scintillation Counters," ***Nuct. Instr. Methods*** **30,** 213 (1964).

[4]D.A. Godcke and C.W. Williams, ***High Resolution Time Spectroscopy. 1. Scintillation Detectors,*** ORTEC publication, August 1968.

[5]"Timing with Ge(Li) Detectors," ORTEC ***Application Note 31,*** 1970.

Typical Fast-Slow Coincidence Using NaI(TI)

The block diagram of Fig. 4.1 applies equally well here. The difference in the two systems is the. scintillator and its decay characteristic. This decay time constant is 0.25 µsec, whereas the same time constant for Naton-136 is approximately 2 nsec. With NaI(TI) much more total light is produced per equivalent energy event, but the collection of this light is over such a wide period of time, as indicated, that the time resolution is poorer than that of plastic. Figure 4.3 is a typical spectrum taken with a 1½-in. by 1-in. NaI (TI) on one side of the coincidence system.

Fast Coincidence Using Ge(Li-Drifted) Detectors

Some recent experiments have been performed using a 1½-in. by 1-in. NaI(TI) in a gamma-gamma coincidence arrangement with an ORTEC 10-cm^3 Ge(Li-drifted) coaxial detector, as shown in Fig. 4.4. In this case the radiant energy from the source was not collimated at all, so that the time is given by collection from all parts of the detector. The source viewed one end of a germanium detector. Side channels selected the energy region of interest, which was the photopeak on each side. The full time spectrum is given in Fig. 4.5. Full width at half maximum and full width at one-tenth maximum are indicated. This, when compared with published timing curves[6] indicates a very good detector design for timing purposes.

[6]R.L. Graham ***et al.,*** "Timing Characteristics of Large Coaxial Ge(Li) Detertors for Coincidence Experiments," ***IEEE Trans. Nucl. Sci.*** **NS-13(l),** 72 (1966).

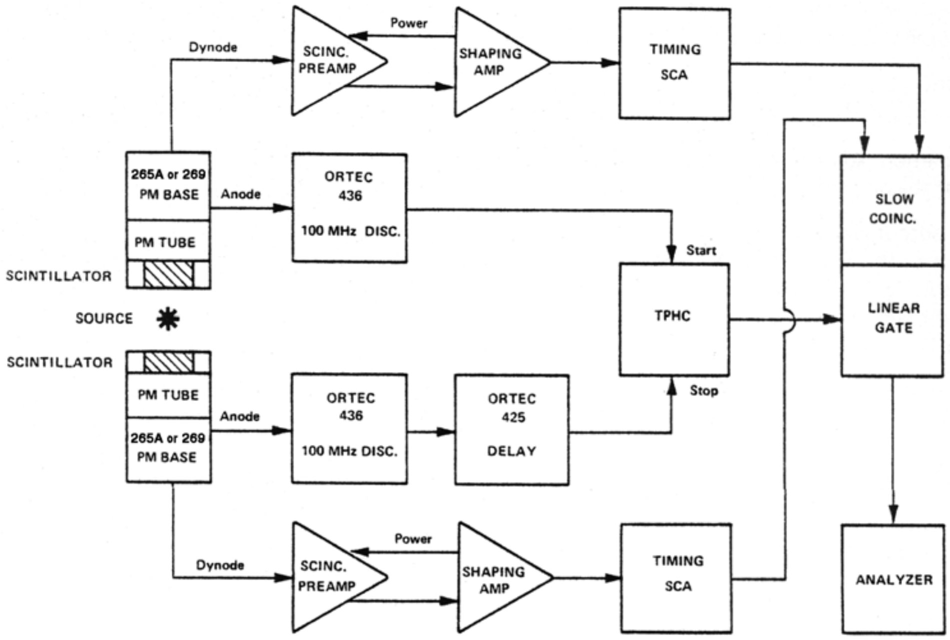

Fig. 4.1. Simple Fast-Slow Timing System.

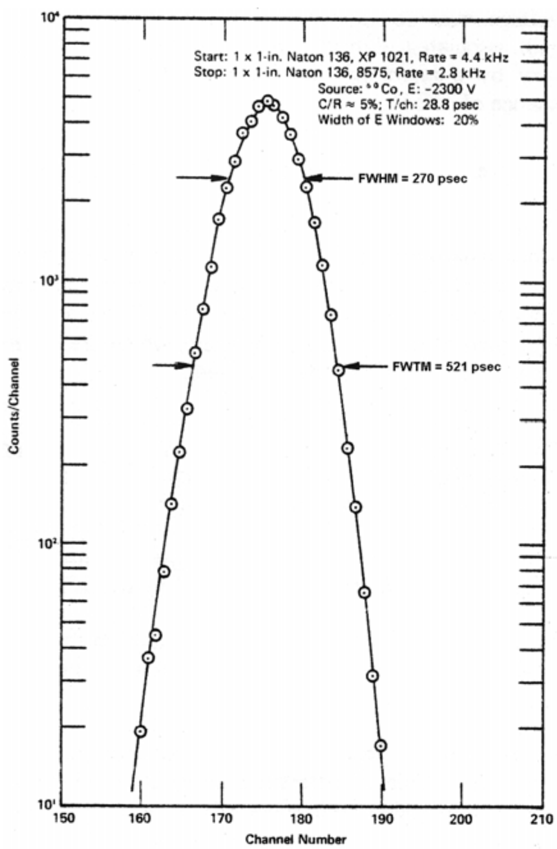

Fig. 4.2. Typical Coincidence Spectrum Using Plastic Scintillators.

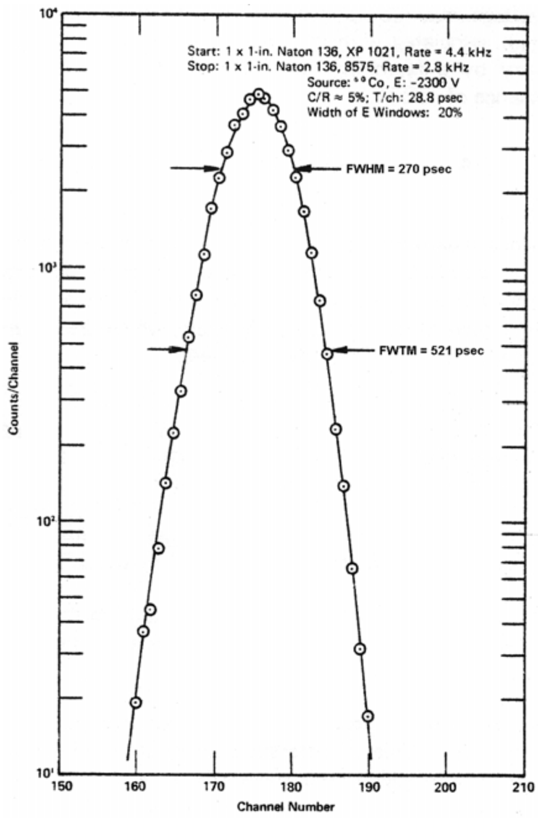

Fig. 4.3. Typical Coincidence Spectrum Using NaI(Tl) Scintillator.

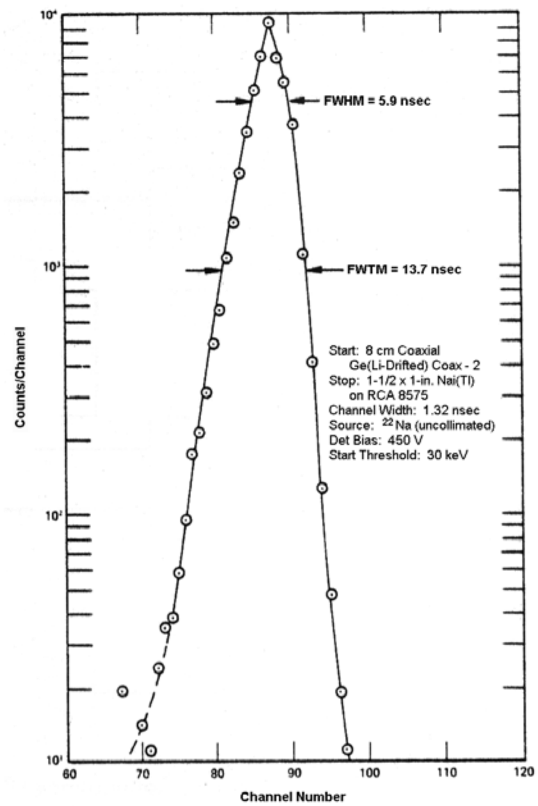

Fig. 4.5. Timing Spectrum with Ge(Li-Drifted) Detector.

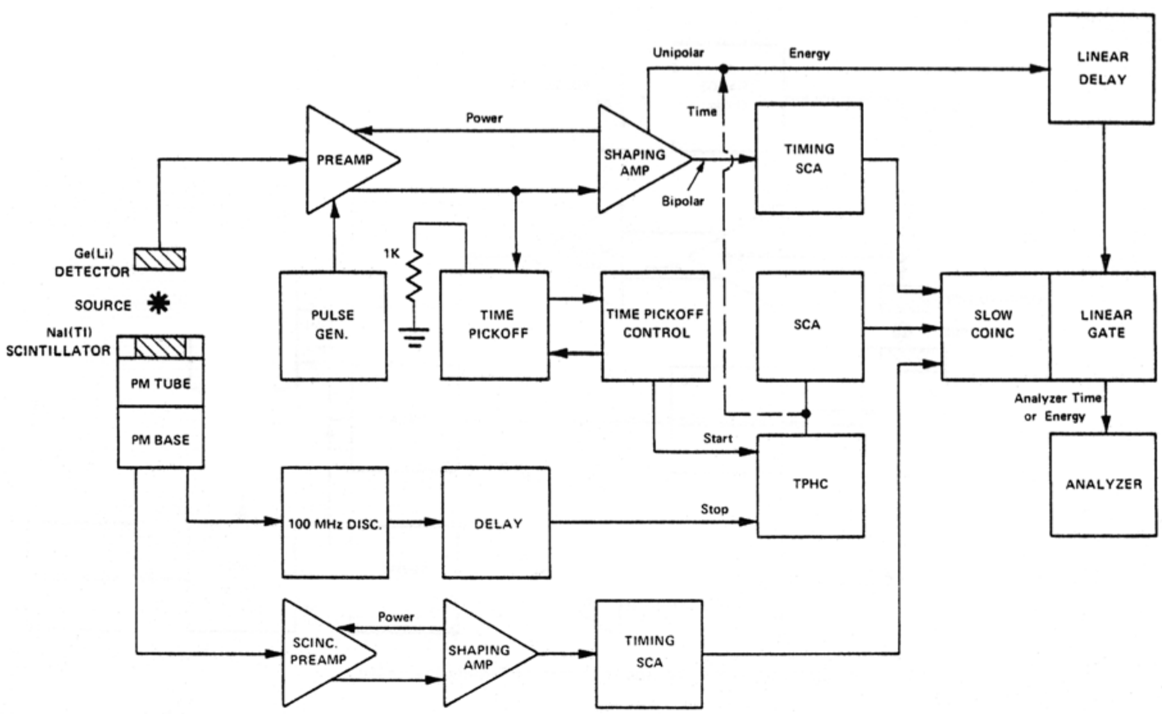

Fig. 4.4. Gamma-Gamma Coincidence System with a Ge(Li-Drifted) Detctor.

System Block Diagrams A number of experimental systems are shown in Figs. 4.6–4.9 for the aid of the user.

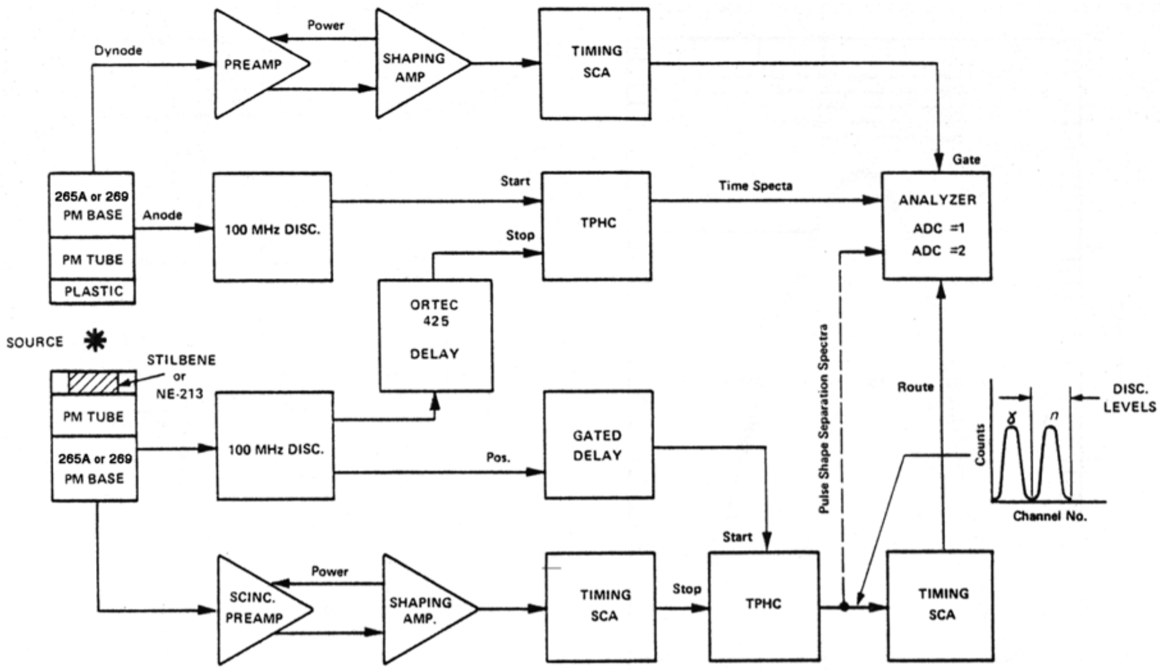

Fig. 4.6. Fast-Fast Coincidence (Photomultiplier Tube) with Pulse Shape Discrimination.

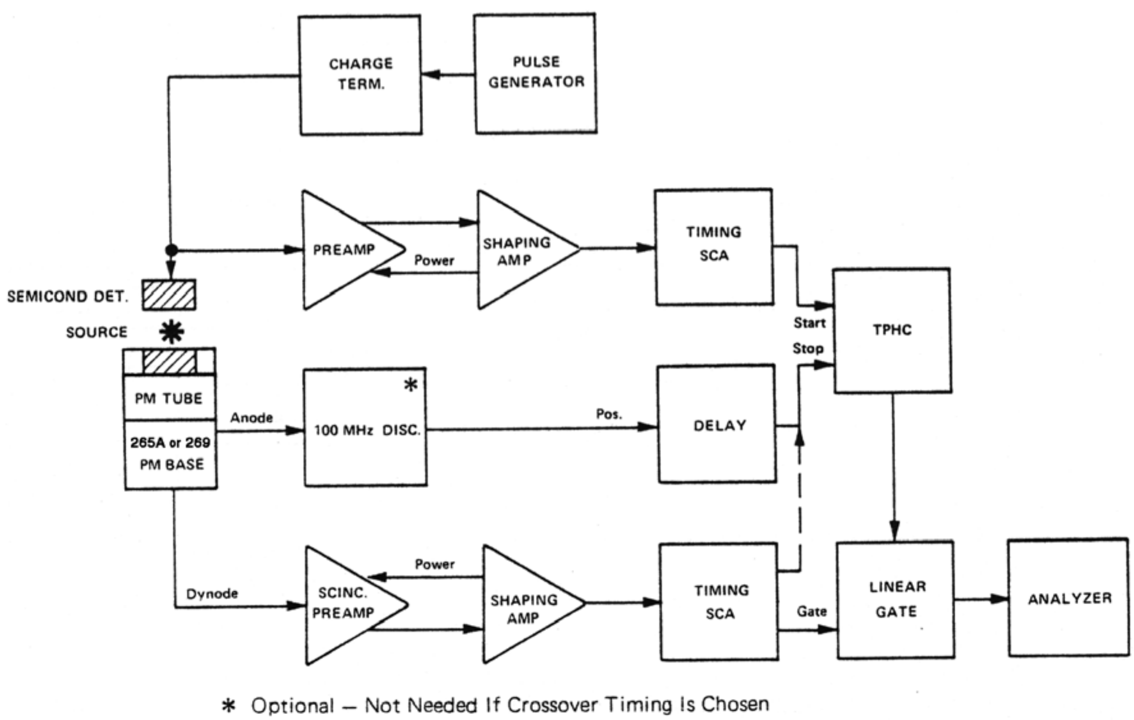

Fig. 4.7. Fast Timing System (Semiconductor Detector - Photomultiplier Tube) for Coincidence Using Crossover Pickoff Techniques.

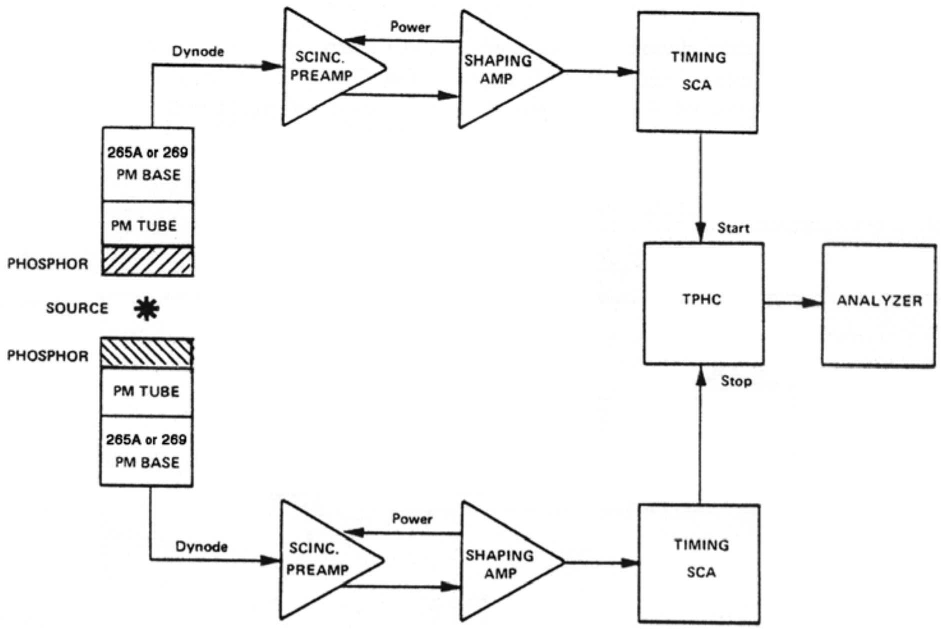

Fig. 4.8. Semiconductor-PM Coincidence Using Conventional Crossover Timing.

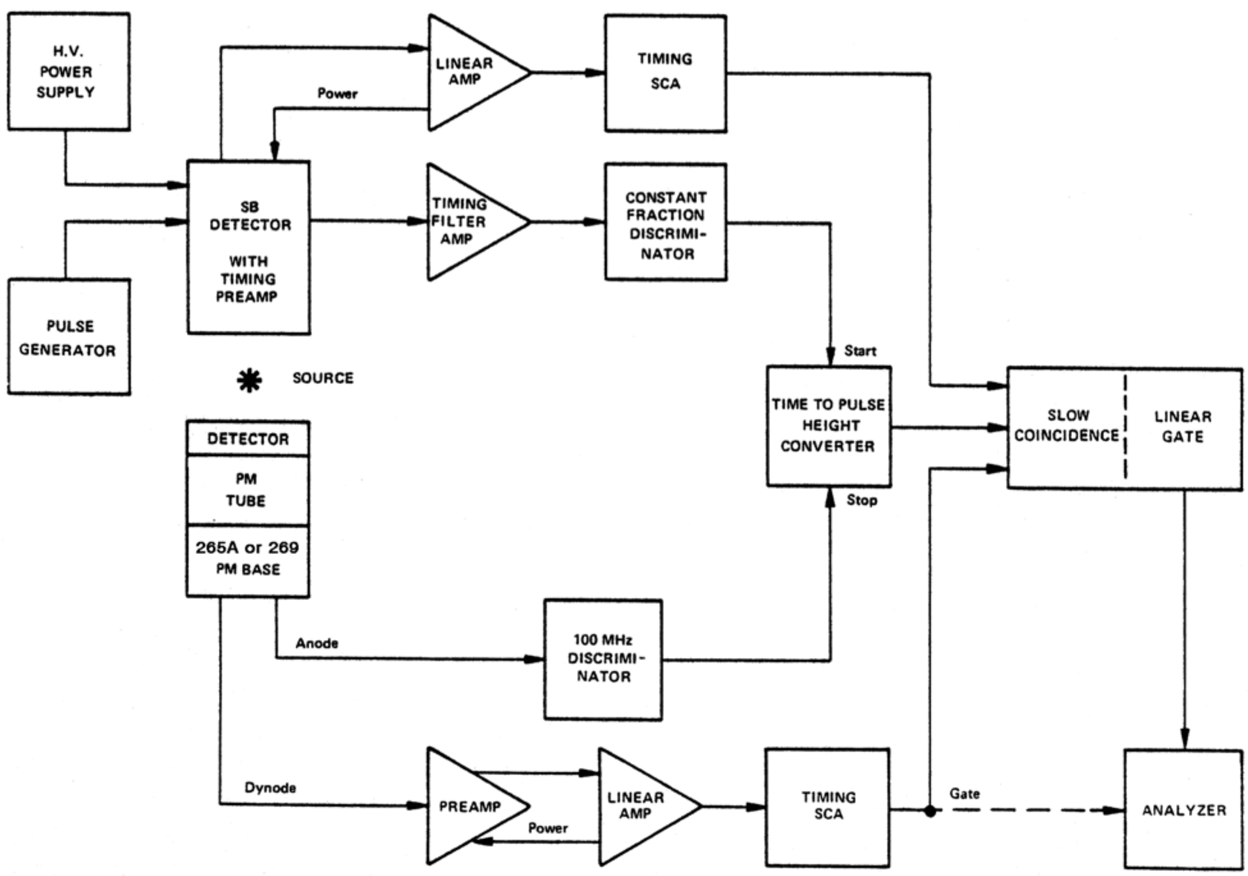

Fig. 4.9. Subnanosecond Timing System (Semiconductor - Photomultiplier Tube).

5. CIRCUIT DESCRIPTION

The divider is a “graded” resistance divider whose gain and signal quality have been carefully considered. R15 and R17 perform the function of optimizing the input optics. An open view of the 265A showing these controls is given in Fig. 5.1.

The last four dynodes are directly available at J4 for external dc control or additional capacitance if desired.

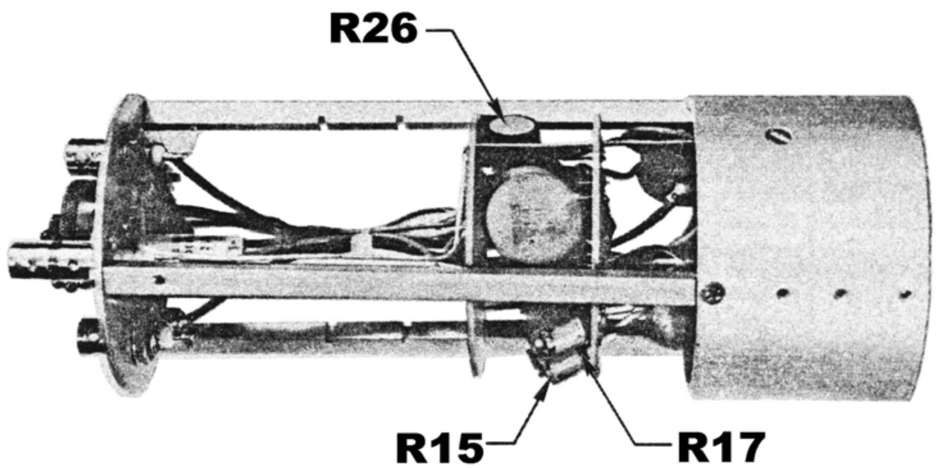

Fig. 5.1. Open Unit Showing Picture of Controls.