# INSTRUCTION MANUAL

# 420A TIMING SINGLE CHANNEL ANALYZER

Serial No. ______________________

Purchaser ______________________

Date Issued ______________________

ORTEC
AN EG&G COMPANY
100 MIDLAND ROAD
OAK RIDGE, TENN. 37830
PHONE—(615) 482-1006
TWX —— 810 - 572 - 1078



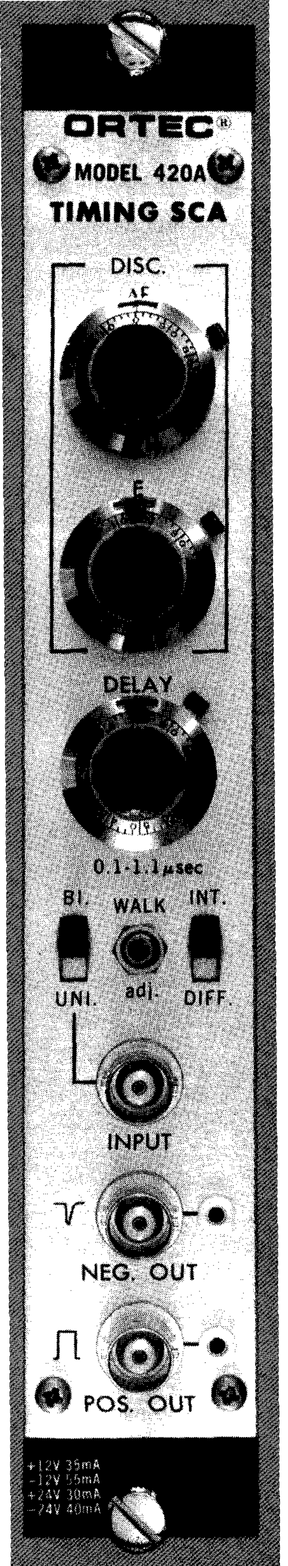


Printed in U.S.A.

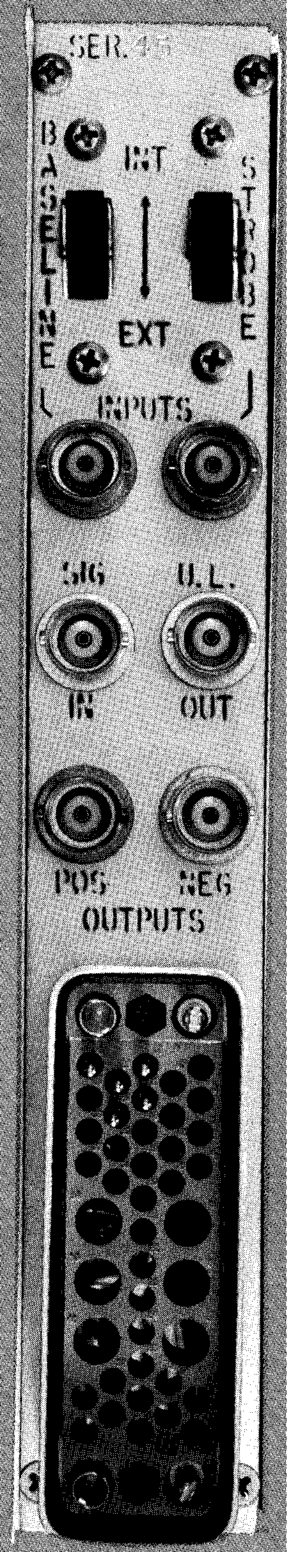
# TABLE OF CONTENTS



## LIST OF FIGURES AND ILLUSTRATIONS



ORTEC®
MODEL 420A
TIMING SCA
DISC.
ΔE
E
DELAY
0.1-1.1μsec
BI.
WALK
INT.
UNI.
adj.
DIFF.
INPUT
NEG. OUT
POS. OUT
+12V 35mA
-12V 55mA
+24V 30mA
-24V 40mA


SER. 45
BASELINE
INT
EXT
STROBE
INPUTS
SIG
U.L.
IN
OUT
POS
NEG
OUTPUTS

# ORTEC 420A TIMING SINGLE CHANNEL ANALYZER

## 1. DESCRIPTION

The ORTEC 420A Timing Single Channel Analyzer performs two functions; A) it is a single channel analyzer with both the lower level and the window width variable over the pulse height range, and B) for input signals which are doubly differentiated, it furnishes a timing output which is recommended for accurate time measurements. This timing output occurs at a known and precise time with respect to the input pulse. The unit will accept single or double delay line differentiated signals, or single or double RC differentiated signals, with pulse widths from 200 nanoseconds to 20 microseconds.

When the 420A is used for unipolar input pulses, the input selector must be set at the Unipolar position. This will cause the discriminator to reset at the same pulse height at which it was triggered, and therefore the time of the output pulse will depend upon the fall time of the signal input and the setting of the lower level discriminator. The unit includes a variable delay, selectable by a front panel control, of 100 to 1100 nanoseconds to allow time balance in coincidence circuitry and analyzer gating.

The 420A provides two outputs whose leading edges contain timing information. One is a negative spike, used for fast timing such as is associated with a time to pulse height converter. The other is a positive 5 volt, 500 nanosecond wide, pulse for slower applications such as coincidence circuits and analyzer gating. These output pulses are the standard logic pulses in the ORTEC 400 Series of modular instruments, and are compatible with all related input signal requirements. They are also identified as Fast Negative and Slow Positive logic pulses in the Preferred Practices provisions of AEC Report TID-20893 (Rev. 2).

# 2. SPECIFICATIONS

## SIGNAL INPUT

| | |
|---|---|
| Amplitude Range: | 50mV to 10V |
| Pulse Width Range: | 200 nsec to 20μsec |
| Polarity: | Positive Unipolar, or positive portion leading Bipolar |
| Input Impedance: | >1 000 ohms |

## EXTERNAL BASELINE INPUT

| | |
|---|---|
| Amplitude Range: | 0 to -lov |
| Input Impedance: | >1000 ohms, dc-coupled |

## EXTERNAL STROBE INPUT

| | |
|---|---|
| Pulse Shape: | Standard NIM positive signal, +2V min, +12V maximum |
| Pulse Width: | 75 nsec minimum |
| Input Impedance: | >1000 ohms, dc-coupled |

## SCA OUTPUTS

| | |
|---|---|
| Pulse Shape: | Both NEG and POS Outputs occur simultaneously, and may be delayed 0.1 to 1 .1μsec by the lo-turn Delay control, using Internal Strobe. For the External Strobe mode, the SCA Outputs are prompt with the strobe input |
| NEG. OUTPUTS: | -0.6V minimum, rise time ≤5nsec, width ≤20nsec, output impedance <1Ω, dc-coupled |
| POS. OUTPUTS: | +5V nominal, rise time ≤20nsec, width ~500nsec, output impedance <1 0Ω, dc-coupled |

## U. L. OUT (Upper Level Discriminator)

| | |
|---|---|
| Pulse Shape: | Positive 5V nominal, width equal to time the signal input exceeds E t AE level, output impedance <10Ω, dc-coupled |

## CONTROLS

| | |
|---|---|
| E DISC. (Lower Level): | 1 00mV to 1 OV, 1 O-turn precision potentiometer |
| AE DISC. (Window Width): | 0 to 1 OV, 10-turn precision potentiometer |
| INT. /DIFF.: | Mode selector switch; AE Discriminator disabled for Integral mode |
| BI./UNI.: | Switch, selects response time according to input pulse shape |
| WALK ADJ.: | Calibration for precise trigger response time |
| DELAY: | For Internal Strobe mode, delays output 0.1 to 1.1μsec after trigger; for External Strobe mode, delays automatic reset 5 to 50μsec after trigger; IO-turn precision potentiometer |
| BASELINE INT/EXT: | Switch, selects E DISC front panel control for Internal Baseline, or signal through adjacent connector for External Baseline |
| STROBE INT/EXT: | Switch, selectsinternal (INT) orexternal (EXT) strobe mode |

## CONNECTORS

| | |
|---|---|
| SIG IN: | BNC (UG-1094/U), front and rear |
| NEG. OUT: | BNC (UG-1094/U), front and rear |
| POS. OUT: | BNC (UG-1094/U), front and rear |
| U. L. OUT: | BNC (UG-1094/U), rear panel only |
| BASELINE INPUT: | BNC (UG-1094/U), rear panel only |
| STROBE INPUT: | BNC (UG-1094/U), rear panel only |

## PERFORMANCE

| | |
|---|---|
| Non-Linearity: | The non-linearity of the dial readings for E DISC and AE DISC controls is dependent upon the specified linearity of the IO-turn potentiometer, which is within ±0.25% of full scale. For the DELAY control, it is less than ±2%. |
| Temperature Stability: | For the E and AE Discriminator levels, ≤±0.015% of full scale per °C; for Delay, ≤±0.4nsec/°C |
| Time Shift vs. Pulse Height: | Using ORTEC 410 Amplifier, DDL Mode, Integrate ≤0.2 μsec, time shift is<br>≤±2nsec for 10: 1 amplitude ratio<br>≤±10nsec for 50:1 amplitude ratio |

## ELECTRICAL AND MECHANICAL

| | |
|---|---|
| Power Required: | +24V 30mA +12V 50mA<br>-12V 30mA -12V 40mA |
| Weight (Shipping): | 5 pounds (2.27 kg) |
| Weight (Net): | 2.5 pounds (1.1 kg) |
| Dimensions: | Standard single width module (1.35 by 8.714 inches) per TI D-20893 (Rev.) |

## RELATED EQUIPMENT

The 420A accepts signal input pulses from any linear shaping amplifier with an output compatible with the input requirements, such as ORTEC 410, 435A, 440A, 450, 451, or 485. The output can be used to drive timing instruments such as the ORTEC 414A, 437A, 409, 416, 418, 426, or 481, and is compatible with ORTEC scalers (430, 431, 707, 708) and ratemeters (434 or 441).

For a complete swept spectrometer system, add a ramp generator for an External Baseline input, and furnish the 420A output to a ratemeter and strip chart recorder. Correlate the ramp rate and the chart advance rate to record a spectrum.

# 3. INSTALLATION

## 3.1 General

The ORTEC 420A is designed for installation in an ORTEC 401A/402A Bin and Power Supply, which is intended for rack mounting. It is necessary to ensure that any vacuum tube equipment which may be operated in the same rack has sufficient cooling air circulating to prevent any localized heating of the all-transistor circuitry used throughout the 420A. The temperature of equipment mounted in racks can easily exceed the recommended maximum unless precautions are taken. The 420A should not be subjected to temperatures in excess of 120°F (50°C).

## 3.2 Connection to Power

The 420A contains no internal power supply, and must obtain power from a Nuclear Standard Bin and Power Supply such as the ORTEC 401A/402A. Turn off the Bin power supply before inserting or removing modules. The ORTEC 400 Series is designed so that it is not possible to overload the Bin power supply with a full complement of modules in the Bin. However, this may not be true when the Bin contains modules other than those of ORTEC design. In this case, power supply voltages should be checked after insertion of modules. The 401A/402A has test points on the power supply control panel to monitor the dc voltages.

## 3.3 Connection to a Linear Amplifier

The input to the 420A includes both a front and a rear panel BNC connector. Either may be used to accept outputs from all linear amplifiers capable of producing 10 volt unipolar or bipolar (positive lobe leading) signals onto a 2000 ohm load. The input operating range is from 50 millivolts to 10 volts. This unit may be used with vacuum tube amplifiers which are capable of output signals to 100 volts, if the amplifier output is attenuated so that it cannot exceed 10 volts. Simple resistive attenuators installed in the vacuum tube amplifiers will make them compatible with related transistor equipment.

## 3.4 Linear Output Signal Connections and Terminating Impedance Considerations

The source impedance of the 0 to 10 volt standard linear outputs of most ORTEC 400 Series modules is approximately 1 ohm. Interconnection of linear signals is, thus, non-critical since the input impedance of the 420A is high and is not important in determining the actual signal span, 0 to 10 volts, delivered into it. It is permissable to parallel several loads on a single output, while preserving the 0 to 10 volt signal span.

Short lengths of interconnecting cable (up to approximately&feet) need not be terminated. However, if a linear signal is to pass through more than approximately 4 feet of cable, it should be terminated in a resistive load equal to the cable impedance. Since the output impedance is not purely resistive, and is slightly different for each individual module, when a certain length of coaxial cable is connected and is not terminated in the characteristic cable impedance, oscillations will generally result. These oscillations can besuppressed for any length of cable by terminating the cable properly, either in series at the sending end or in shunt at the receiving end of the line.

To terminate a cable properly at the receiving end, it may be necessary to consider the input impedance of the driven circuit, choosing an additional parallel resistance to make the combination produce the desired termination resistance. Series terminating the cable at the sending end may be preferable in some cases where receiving end termination is not possible or desirable. Many ORTEC linear instruments include an alternate output connector for an output impedance of 93Ω, and this may be used when 93Ω cable is used for the interconnection, and the impedance match is complete without any compensation at the high impedance receiving end. When series terminating at the sending end, full signal span (amplitude) is obtained at the receiving end only when it is essentially unloaded, or is loaded with an impedance many times that of the cable. Since the input impedance of the 420A is 2000Ω, a series termination at the sending end of the cable will normally provide satisfactory results.

BNC Tee connectors, and connectors with internal resistive terminators are available from a number of connector manufacturers in nominal values of 50, 100, and 1000 ohms, to facilitate shunt termination at the receiving end of a cable. ORTEC stocks in limited quantity the following connector accessories, for this application.

| | |
|---|---|
| ORTEC C-27 | 100Ω Resistive Terminator |
| ORTEC C-28 | 50Ω Resistive Terminator |
| ORTEC C-29 | BNC Tee Connector |

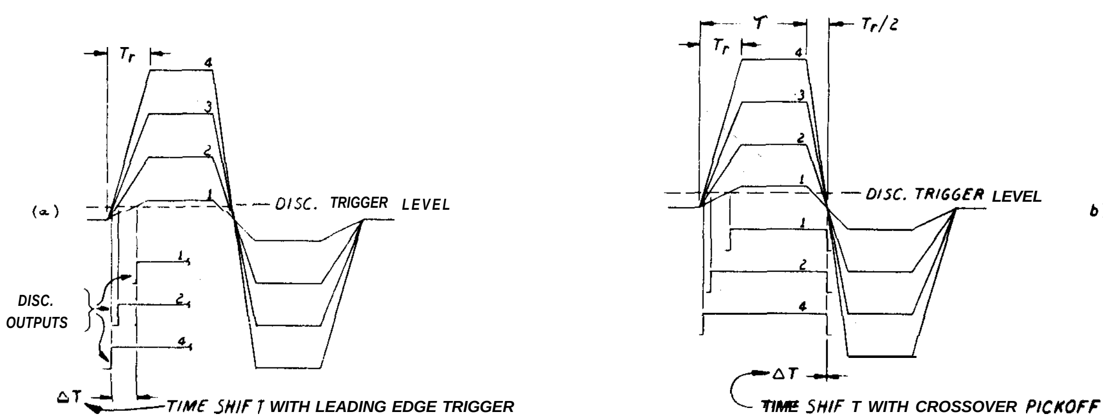
# 4. OPERATING INSTRUCTIONS

## 4.1 Introduction to Fast Timing with Linear Signals

Precise determination of the time of occurence of nuclear events is often complicated. Detection of these events usually results in a voltage pulse with an amplitude which is a function of the energy loss in the detector, and with a rise time which is a function of the conversion process from detector energy to charge. When the time determination is derived from the leading edge of such a pulse by means of a Schmitt trigger type discriminator, there is a time shift of the discriminator output that depends on both the pulse rise time and the range of amplitudes involved (see Figure 4-1a). The rise time of the pulses is usually limited by the linear amplifier required for pulse height analysis, such as the ORTEC 410, 435A, 440A, 450, or 451. For those amplifiers which have variable rc shaping, the rise time and fall time will vary directly with the chosen integration and differentiation time constants, and the zero crossing will vary in real time. When classical double rc differentiation is used and equal time constants are selected for integration and differentiation, the real time for zero crossing is approximately 2 time constants after the detector event. Zero crossing is about 50% later for active filter amplifiers.

Figure 4-1b shows a series of idealized output pulses from a double delay line clipped amplifier, superimposed upon each other. All of these pulses pass through the baseline at the same time because, in the amplifier clipping process, the voltage forming the pulse shape goes from a positive value (+E) to an equal negative value (-E) in the same amount of time that was required for the rise from 0 to +E. The pulses, therefore, pass through the zero baseline at a time corresponding to $t_r/2$, but displaced along the time axis by one clipping time, $\tau$. The time $t_r/2$ corresponds to the point at which the pulse height is half of the maximum amplitude. Since, in linear amplifiers, the rise time is constant and is independent of pulse height, the time at which the pulses reach half-height is also constant and independent of the pulse height.

The discriminator in the ORTEC 420A is designed to trigger at a selected voltage level on the leading edge of the pulse, and is forced to reset when the pulse passes through zero volts. The output timing pulse is generated by the discriminator reset.




The realization of both optimum timing and optimum energy resolution are mutually exclusive when using the crossover pickoff method of time derivation, but a satisfactory compromise can usually be obtained. for optimum timing, the amplifier should be operated with a wide bandwidth, resulting in fast rise and fall times. For optimum energy resolution, the amplifier should be operated with narrow bandwidth so the bandpass of the noise spectrum can be selected at a particular location in the frequency spectrum.

For example, when using an ORTEC 410 Amplifier and 420A Timing Single Channel Analyzer, to optimize timing, the 410 would be operated: 1) with a minimum of integration and double delay line differentiation, or 2) in the double RC shaping mode, with 0.1 $\mu$sec time constants for both integration and differentiation, and the optimized timing would be obtained at the expense of energy resolution. In order to optimize the energy resolution while retaining requisite timing characteristics, the 410 would be operated: 1) with an integration time constant of 1 or 2 μsec and double delay line differentiation, or 2) in the double RC shaping mode with 1 or 2 μsec time constants for both integration and differentiation. When using the latter set of adjustments, the rate of change for voltage as it passes through zero is very much less than it is in the former case, and noise modulation of the linear amplifier output signal causes a larger time jitter of the timing output signal. In the former case, the rate of change of voltage per unit time is quite high, and the jitter in the timing output due to linear amplifier noise modulation is minimized.

## 4.3 Front Panel Control Functions

"E" DISC. The function of the "E" (energy) lower level discriminator is to prevent triggering by all signals with peak ampljtudes less than the adjusted threshold. The adjustable range of the threshold, using this control, is approximately*50 millivolts to 10 volts, direct reading on the dial. This control is effective only when the rear panel Baseline switch is set at Internal.

"ΔE" DISC. The "ΔE" discriminator forms the upper level of the single channel analyzer. The dial of this control reads directly the difference in voltage, or energy, between the "E" discriminator or External Baseline input and the upper level; this is the adjusted window width "ΔE". To obtain an output from the 420A, a signal amplitude must be greater than the "E" level, and less than "E" + "ΔE". Since this forms the upper level of the single channel analyzer, the "ΔE" discriminator output is placed in anticoincidence with the output from the "E" lower level discriminator so that, when both are triggered, there is no output. When the DIFF/INT (Differential/Integral) switch is set at INT, the "AE" function is disabled, and the unit operates as an integral discriminator rather than as a single channel analyzer.

DELAY. The Delay control permits the output signal to be adjusted in time with respect to the input signal when the rear panel Strobe switch is set at Internal. The range for the delay is 100 to 1100 nsec, measured from the time of the internal logic decision, and this is selected by the BI/UNI (Bipolar/Unipolar) input selector switch. When the rear panel Strobe switch is set at External, the Delay control adjusts the time from the internal logic decision to an automatic internal reset, and the SCA Output should be triggered within this interval. For this operating mode, the range of the Delay control is approximately 5 to 50 μsec and it should be set at maximum for normal operation.

UNI/BI. This switch selects the method by which an internal logic decision will be made, and should be set to correspond to the input signal shape, either Unipolar or Bipolar. When it is set at UNI, the internal logic decision generates a pulse at the "E" discriminator reset, unless this is inhibited by the "AE" discriminator having been triggered. When the switch is set at BI, the internal logic decision generates a pulse at baseline crossover, provided the "E" discriminator had been triggered and the "ΔE" discriminator had not been triggered. Precise timing is available only when the input is bipolar and the switch is set at 'its BI position.

DIFF/INT. This switch selects the operating characteristics of the 420A. When it is set at DIFF (Differential), the unit operates as a single channel analyzer and generates an output pulse if the input signal amplitude triggers the "E" discriminator without also triggering the "ΔE" discriminator. When the switch is set at INT (Integral), the unit operates as an integral discriminator, the "AE" discriminator is disabled, and an output is generated if the input signal amplitude triggers the "E" discriminator.

WALK adj. In general, various amplifiers will have a "true" crossover at slightly different values of voltage, but all are very near zero. The front panel WALK Adj. control is provided to adjust for minimum time walk, using a specific amplifier. This control is adjusted for an optimum setting with an ORTEC 410 Amplifier before it leaves the factory. See "Calibration Adjustment" in Section 6.2 of this manual for further information.

## 4.4 Rear Panel Control Functions

BASELINE INT/EXT. When this switch is set at INT (Internal), the threshold level for the "E" lower level discriminator is determined by the setting of the "E" DISC control on the front panel. When the switch is set at EXT (External), the front panel control is disconnected, and the threshold level is determined directly by the bias level furnished through the adjacent BNC Baseline Input connector. An External Baseline input permits operation of the 420A as a swept spectrometer, by varying the 0 to

-IOV level either continuously or step-wise to permit the accumulation of a spectrum by a ratemeter with a display on a strip chart recorder.

STROBE INT/EXT. Ohtput pulses from the 420A are strobed either Internally or Externally, as selected by this switch. The Internal Strobe is generated at either the "E" discriminator reset or the baseline crossover (see UNI/BI above), and delayed 100 to 1100 nsec (see DELAY above). An External Strobe is a Slow positive logic pulse, furnished through the adjacent BNC Strobe Input connector, and the Output is timed in prompt coincidence with this pulse. When the switch is set for External Strobe, the function of the front panel Delay control is to adjust an automatic internal reset time for the Single Channel Analyzer within the range of 5 to 50 μsec, and will be operated normally at its maximum setting. The strobe pulse must be timed to occur within the interval between the point of decision and automatic internal reset, or the Output will occur at reset.

## 4.5 Initial Testing and Obsewation of Waveforms

Refer to Section 6.1 for information on testing performance and observing waveforms.

## 4.6 Connector Data

INPUT (front and rear panel BNC). Each Signal Input has an input impedance of 1000 ohms, ac-coupled, and a maximum rated input of 10 volts. To minimize reflections when driving from a low impedance voltage source, such as the output of an ORTEC 410 Amplifier, the input should be terminated externally in the characteristic impedance of the connecting coaxial cable.

NEG. OUTPUT (front and rear panel BNC). A standard ORTEC (and NIM) Fast negative logicsignal is available through these connectors, for optimum timing resolution. The output driving source impedance is less than 10 ohms, and the signal is dc-coupled and starts from zero volts.

POS. OUTPUT (front and rear panel BNC). A standard ORTEC (and NIM) Slow positive logic signal is available through these connectors, for applications such as coincidence timing and analyzer gating. The output driving source impedance is less than 10 ohms, and the signal is dc-coupled and starts from zero volts.

U.L. OUT (rear panel BNC). A standard ORTEC (and NIM) Slow positive logic signal is furnished through this connector for each Input signal which triggers the "ΔE" discriminator, and these can be counted in a scaler and added to the number of Pos or Neg Output signals to obtain total counts. The output driving source impedance is less than 10 ohms, and the signal is dc-coupled and starts from zero volts.

BASELINE INPUT (rear panel BNC). The input impedance is >1000 ohms for the dc-coupled circuit which accepts an External Baseline input through this connector. The adjacent Baseline switch must be set at External in order to use the dc level, 0 to -10 volts, as the lower level discriminator threshold.

STROBE INPUT (rear panel BNC). The input impedance of >1000 ohms for the dc-coupled circuit which accepts an External Strobe input through this connector. The adjacent Strobe switch must be set at External in order to use the input pulse. A standard Slow positive logic pulse enables an Output pulse from the SCA promptly, providing the internal logic has been satisfied and internal reset has not yet occurred.

Output Test Points. Oscilloscope test points for monitoring output signals are available at each front panel Output connector. Each test point is connected to its respective Output connector through a 470 ohm series resistor.

# 5. CIRCUIT DESCRIPTION (See Drawings 420A-0101-S1 and 420A-0002-B1)

Resistors RI and R5 from a resistive voltage divider which divides the input signal from a maximum of IO volts to a maximum of 5 volts at the base of Q1 and Q9. Q1 and Q2 form a long-tail pair which is the lower level discriminator. Transistors Q3 through Q8 are necessary to obtain the control desired on the hysteresis of the circuit. Q3 and Q5 are normally ON in the absence of an input signal and hold the base of Q2 at zero volts. When an input signal exceeds the threshold level set by the "E" discriminator, R2, the trigger pair Q1 and Q2, regenerates and triggers another trigger pair formed of Q7 and Q8. Q7 turns ON and Q8 turns OFF. When Q8 turns OFF, this allows the emitter of Q4 to fall toward -12 volts and it is caught at -E. When the emitter of Q4 and base of Q6 fall negative, Q6 turns ON and Q5 turns OFF, which sets the base of Q2 at-E. Since the base of Q1 has a baseline voltage equal to -E and the base of Q2 has a baseline voltage of -E in the presence of the signal, the trigger pair will reset when the signal makes the transition from the positive condition to the negative condition, i.e., zero crossing point. The signal at the collector of Q7 is differentiated by means of L3 and is fed to the base of Q15. The negative portion of the signal will cause Q15 to conduct if the upper level discriminator has not been triggered. A signal from the collector of Q6 is used to reset the upper discriminator when it has been triggered, and this signal is fed to the base of Q1 1.

R14, the zero adjust trimpot, is used to zero the "E" pulse height dial. The adjustment of the walk adjust potentiometer, R69, will be explained in Section 6.1. Switch S1 is used to obtain operation in either bipolar or unipolar mode. In the bipolar position, transistor Q4 has the value of -E imposed on its base at all times; however, in the unipolar position this base sees a constant -75mV dc voltage. This dc voltage is the amount of hysteresis on the lower level discriminator in the unipolar mode.

Switch S3 is the Baseline Int/Ext selector switch on the rear panel. When it is set at Internal, the -E level for the lower level threshold is obtained from the "E" Disc. control, as explained above. When the switch is set at External, the -E level is obtained from a signal through CN5, the External Baseline input connector; the 0 to -10 volt Baseline Input signal is divided by resistors R74 and R76, so 50% of this level is actually furnished to the Q1 and Q9 bases for equivalent control of the effective threshold level.

The upper level discriminator is formed by Q9 and Q10. The output from Q10 is differentiated and fed to the base of Q12. When switch S2 is in the Diff. position, this signal is sufficiently large to trigger the multivibrator Q12 and Q13. If, however, S2 is set at Int., this pulse cannot trigger the multivibrator Q12 and Q13. Once this multivibrator is triggered, it could recover with an RC recovery time of approximately 100 microseconds; however, it is reset at essentially zero crossing time by means of the reset pulse which is present by way of Q1 1. Due to the long time constant involved with this multivibrator, this circuit can handle pulse widths which are very wide, e.g., 20 microseconds. An output from the collector of Q13 is fed through Q24 to the U. L. Out connector, CN4, to permit scaling of over-range signals. An output from Q13 will cause Q14 to inhibit any signal that appears at the base of 015; thus, the inhibit function is performed by the "ΔE" discriminator. This inhibit function assures that the input pulse must be within the selected window to obtain an output.

016, Q17, Q18, and Q19 form a delay generator. Basically it is a monostable multivibrator which will be set by a trigger pulse through Q15. and will trigger the SCA Output when it resets. Since it can be set only by a decision in the lower level discriminator which is not inhibited by the upper level discriminator, reliable Output pulse triggering is assured. When switch S4 on the rear panel is set for Internal Strobe, Delay control R46 will vary the output logic signal over a range of approximately 1000 nsec, and the delay is essentially linear with respect to the dial divisions of the lo-turn potentiometer. When the switch, S4, is set at External Strobe C34 is connected in parallel with C19 to increase the natural period of the monostable to a range of 5 to 50 μsec, approximately. The monostable can be forced to reset by an External Strobe input through connector CN9, via Q25 and 026, to determine SCA Output pulse promptly at External Strobe time. The delay generator triggers with an input pulse from Q15, and then resets when forced by an External Strobe. The natural recovery time constant is set by capacitor Cl9 (and C34, if External) and constant current generator Q19.

The pulse from the collector of Q17 is differentiated, and the negative portion is fed out through Q20, through CN2 and CN7 as a standard Fast Output signal. An inversion of this same signal appears at the collector of Q20, and triggers the monostable, Q21 and 022. The signal from the collector of Q22 is buffered by emitter-follower Q23 as a positive 5 volt signal, 0.5 μsec wide and furnished as a standard Slow Output through CN3 and CN8.

# 6. MAINTENANCE INSTRUCTIONS

## 6.1 Testing Performance

### 6.1.1 Introduction

The following paragraphs are intended as an aid in the installation and checkout of the 420A. These instructions present information on front panel controls, waveforms, test points, and output connectors.

### 6.1.2 Test Equipment

The following, or equivalent, test equipment is needed:

(1) ORTEC 419 Pulse Generator
(2) Tektronix 545 Series Oscilloscope
(3) 100-ohm BNC terminators
(4) ORTEC 410 Amplifier
(5) Schematics and Block Diagrams for the 420A Timing Single Channel Analyzer

### 6.1.3 Preliminary Procedures

(1) Visually check module for possible damage due to shipment.
(2) Plug module into Nuclear Standard Bin and Power Supply, e.g., ORTEC 401A/402A, and check for proper mechanical alignment.
(3) Connect ac power to Bin.
(4) Switch on ac power and check the dc power voltages at the test points on the 402A Power Supply control panel.

### 6.1.4 Testing the Single Channel Function

(1) Connect the direct output of the pulse generator to the scope trigger. Connect the attenuated output of the pulse generator to the input of the 410 Amplifier. Place all attenuator switches on the pulse generator to the OUT position except one switch, which should be a X10 switch. Set the 410 Amplifier DIFFERENTIATION control to double delay line. Set the INTEGRATION control to the .1 μsec position. Adjust the pulse generator output and/or amplifier gain control to achieve an amplifier output pulse height of approximately 10 volts.

(2) Connect the amplifier output to the single channel analyzer input. Set the 420A DIFF./INT. switch to the INT. position, and set the BI./UNI. switch to the BI. position. Set the rear panel BASELINE and STROBE switches at INT. Adjust the "ΔE" dial to read 500/1000 divisions. There should now be an output from both Fast and Slow Outputs of the single channel analyzer. Turn the "E" dial to read 1000, then adjust the pulse height dial on the pulse generator so that the single channel half-triggers. Now set the X2 attenuator switch on the pulse generator. The single channel should again half-trigger at 500 dial divisions. Next, set the DIFF./INT. switch to the DIFF. position, and turn the "E" dial to 400 divisions. Turn the "ΔE" dial toward zero and observe when the single channel again begins to half-trigger. This should be approximately 100 dial divisions on the "ΔE" dial. This assures that the single channel analyzer is operating as a single channel in the bipolar mode. These same steps may be repeated for the unipolar mode if desired, and other points of the pulse height vs dial curves may be observed.

### 6.1.5 Testing the Timing Function

(1) It is assumed for this test that the steps in 6.1.4 have been performed and that switch S1 is in the BI. position. Connect the direct output of the pulse generator to the trigger input to the "B" sweep on the scope and set the scope for "A" triggered by "B". Obtain such triggering of the "A" sweep that the delay control in the "B" sweep section may be used.

(2) Turn the DELAY control on the 420A to 0 and observe the output pulse either at TP1 or at TP2, then adjust the scope sweep speed and "B" sweep delay to observe the leading edge of this pulse with a sweep speed of 20 nanoseconds/cm or less. Set the DIFF./INT. switch to the INT. position on the 420A. Set the pulse generator switches as described in Section 6.1.4, step (4). Place the "E" discriminator at 10 divisions. Attenuate the pulse height by factors of 2, 5, and 10 by means of the attenuator switches on the pulse generator, and observe the time shift of the output pulse; the time shift should be less than 4 nanoseconds over this pulse height range. It may be necessary to trim the time shift by means of the WALK adj. screwdriver adjustment (R69) on the front panel. For those users who have critical dynamic range problems, the single channel may be checked and adjusted to achieve less than ±10 nanoseconds timeshift over a dynamic range of 59: 1, i.e., from 200mV to 10 volts. Operation with this wide a range becomes quite critical and R69 may have to be slightly readjusted to achieve this characteristic. Of course, at very low pulse heights the amount of jitter observed will be large; this is due to the amplifier noise modulation of the crossover point.

(3) Set the scope sweep speed at 50 nanoseconds/cm. Observe the output signal and turn the DELAY control (R46) through its range. The output should shift approximately 1000 nanoseconds.

### 6.1.6 Timing in the Unipolar Mode

When switch S1 is set in the UNI position, the lower level discriminator is forced to fire and reset at essentially the same voltage; thus, the time of the output pulse will vary directly with the signal amplitude and fall time of the input pulse. This means that timing in the unipolar mode can be no better than the fall of the pulse times the proportion of the dynamic range used. NOTE: Timing in UNI position is not recommended.

## 6.2 Calibration Adjustment

It is assumed for this adjustment that all the steps outlined in Section 6.1 have been completed. To force the lower level, i.e., the "E" discriminator, to extrapolate to zero, an adjustment is provided on the printed circuit board. To perform this adjustment, set the pulse generator controls as given in Section 6.1.4, step (3). Set the 420A DIFF./INT. switch to the INT. position. Adjust the pulser to achieve half-triggering with the "E" dial placed at 1000; then, adjust the pulse height dial of the pulse generator to 100 and set the 420A "E" dial to 100, adjusting the zero potentiometer (R14) to achieve half-triggering. Other points at lower pulse heights may be checked if desired.

## 6.3 Troubleshooting Suggestions

In situations where the 420A is suspected of malfunction, it is essential to verify such malfunction in terms of simple pulse generator pulses at the input and output. For this reason, the 420A must be disconnected from its position in any system, and routine diagnostic analysis performed with a test pulse generator and oscilloscope. It is imperative that testing not be performed with a source and detector until the amplifier and single channel analyzer system perform satisfactorily with a test pulse generator. The testing instructions in Section 6.1 of this manual and the circuit descriptions in Section 5 should provide assistance in locating the region of trouble and repairing a malfunction. The side covers may be completely removed from the module to enable oscilloscope and voltmeter observation with a minimal chance of accidentally short-circuiting portions of the etched board.

The 420A may be returned to ORTEC for repair service at nominal cost; our standardized procedure requires that each repaired instrument receive the same extensive quality control tests that a new instrument receives.

## 6.4 Tabulated Test Point Voltages on Etched Boards

The following voltages are intended to indicate typical dc voltages measured on the etched circuit board and are intended to serve as an aid in troubleshooting.

NOTES:

1. All voltages are measured from ground with vtvm having impedance of 10 megohms or greater.
2. All voltages are dc values with no input signals.
3. Set all dials to read 100 divisions.
4. Set DIFF./INT. switch to DIFF., BI./UNI. switch to BI., and both Baseline and Strobe switches to Internal.

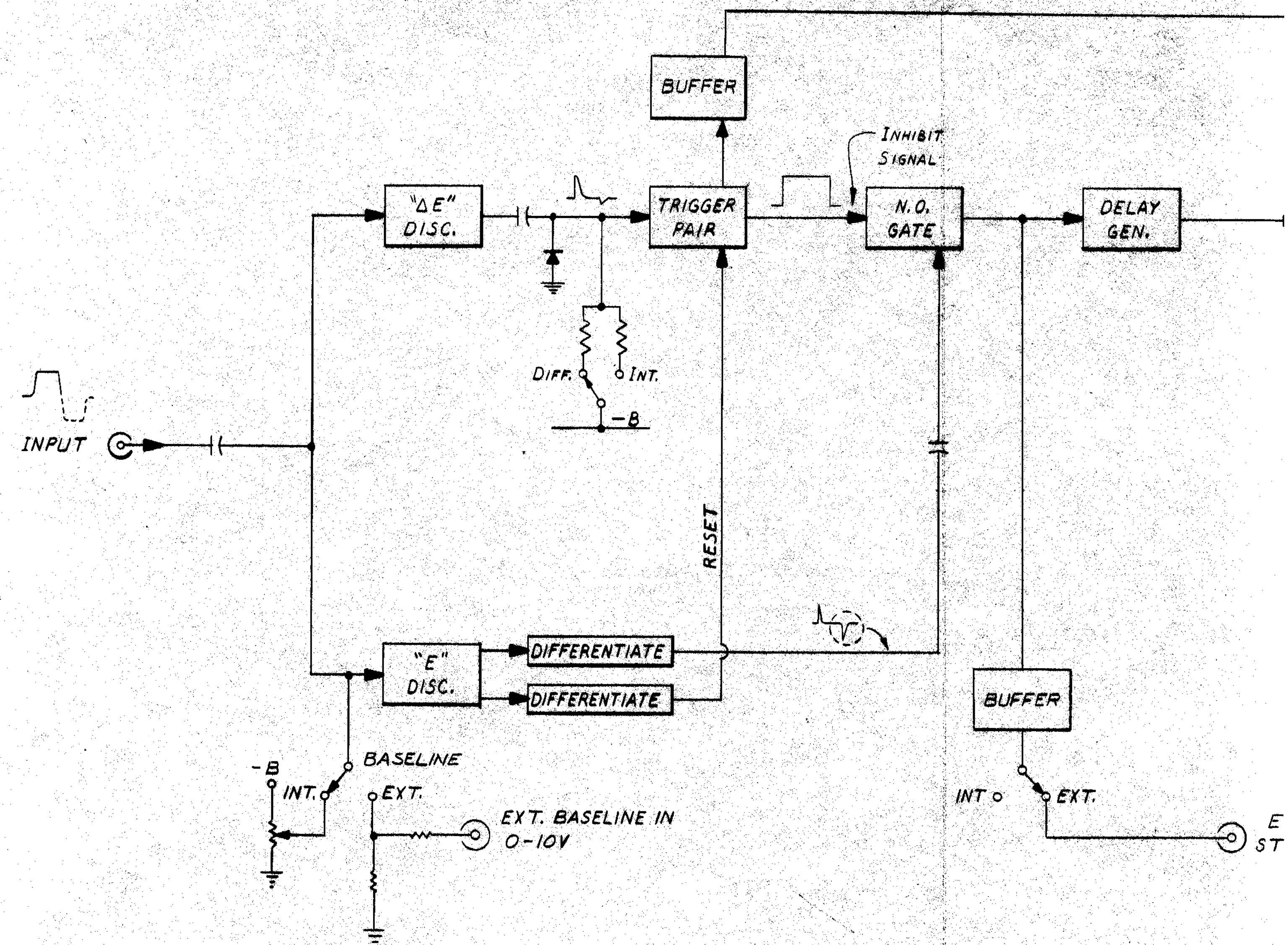
Table 6.1 Typical DC Voltages

| Test Point | Typical Voltages |
|---|---|
| +24 bus | 24.0 |
| +12 bus | 12.0 |
| -12 bus | -12.0 |
| -24 bus | -24.0 |
| Junction of R2 & R3 | -4.9 |
| Junction of R30 & R31 | 5.0 |
| Q1-C | 11.8 |
| Q4-E | 1.7 |
| Junction of R21 & R22 | -0.080 |
| Q9-C | 11.5 |
| Q12-C | 11.6 |
| Q15-C | 0.0 |
| Q16-C | 16.6 |
| 019-B | 17.7 |
| Q21-C | 0.0 |
| Q22-C | 0.54 |
| Q23-E | 0.0 |

# BIN/MODULE CONNECTOR PIN ASSIGNMENTS
# FOR AEC STANDARD NUCLEAR INSTRUMENT MODULES
# PER TID-29893

| Pin | Function | Pin | Function |
|---|---|---|---|
| 1 | +3 volts | 23 | Reserved |
| 2 | - 3 volts | 24 | Reserved |
| 3 | Spare Bus | 25 | Reserved |
| 4 | Reserved Bus | 26 | Spare |
| 5 | Coaxial | 27 | Spare |
| 6 | Coaxial | *28 | +24 volts |
| 7 | Coaxial | *29 | - 24 volts |
| 8 | 200 volts dc | 30 | Spare Bus |
| 9 | Spare | 31 | Carry No. 2 |
| *10 | +6 volts | 32 | Spare |
| *11 | - 6 volts | *33 | 115 volts ac (Hot) |
| 12 | Reserved Bus | *34 | Power Return Ground |
| 13 | Carry No. 1 | 35 | Reset |
| 14 | Spare | 36 | Gate |
| 15 | Reserved | 37 | Spare |
| *16 | +12 volts | 38 | Coaxial |
| *17 | - 12 volts | 39 | Coaxial |
| 18 | Spare Bus | 40 | Coaxial |
| 19 | Reserved Bus | *41 | 115 volts ac (Neut.) |
| 20 | Spare | *42 | High Quality Ground |
| 21 | Spare | G | Ground Guide Pin |
| 22 | Reserved | | |

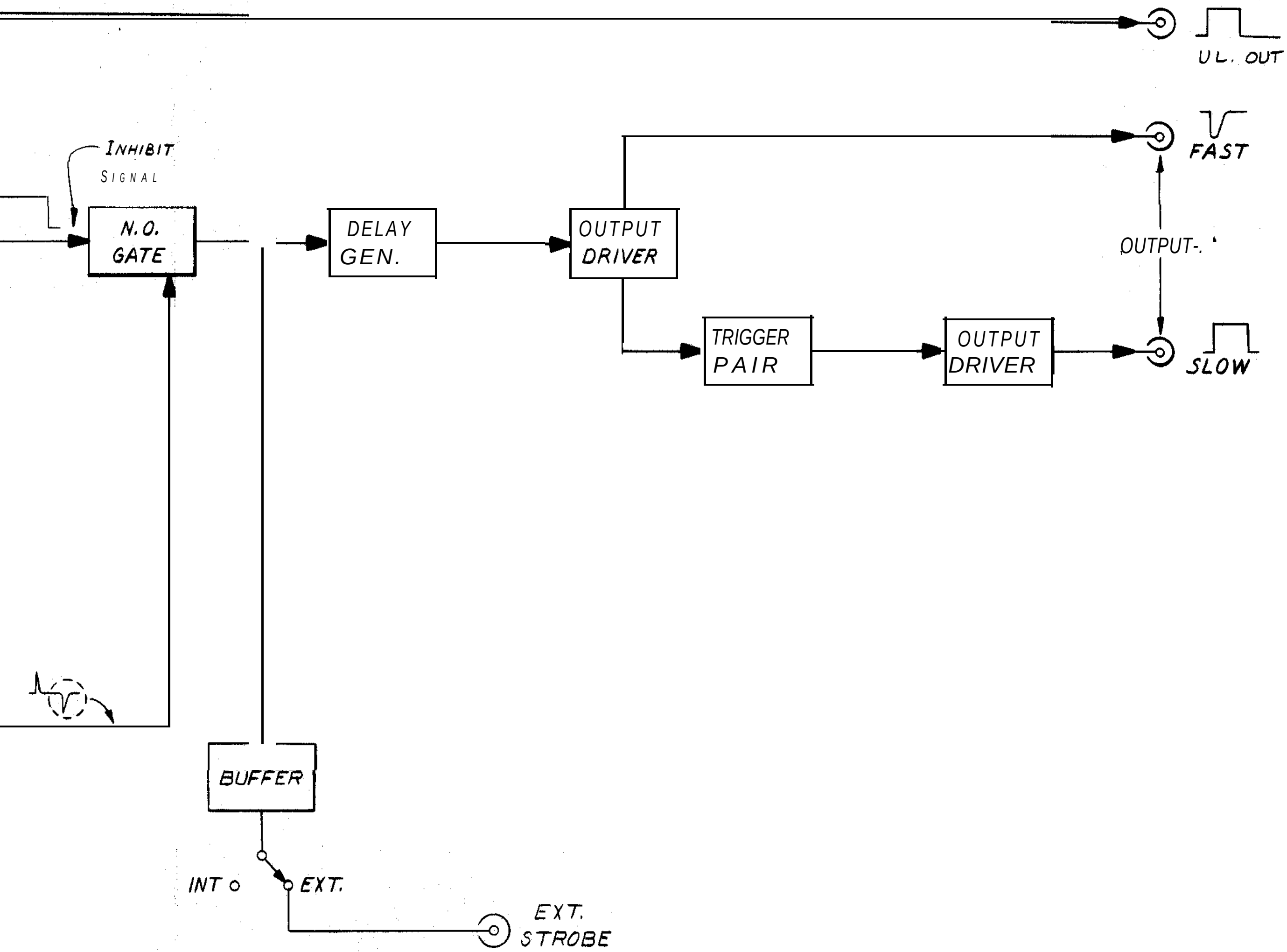
**These pins are installed end wired in parallel in the ORTEC 401A Modular System Bin.*




| 4-8-69 | A | ECN 420-17B |
|---|---|---|
| DATE | NO. | REVISION |

DESIGN C. W. Williams
DRAWN E. C. Keith

420-0002A-B

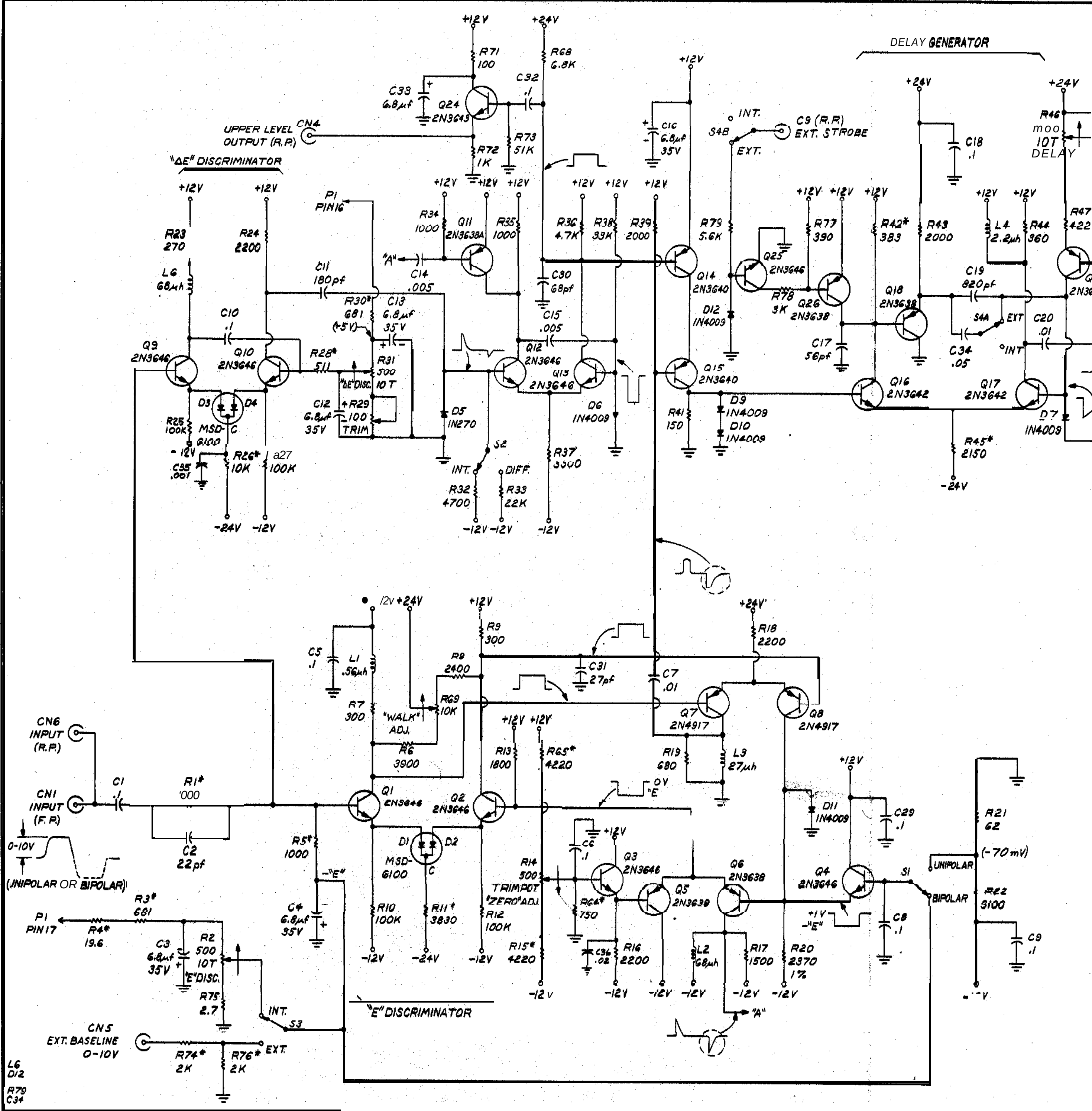


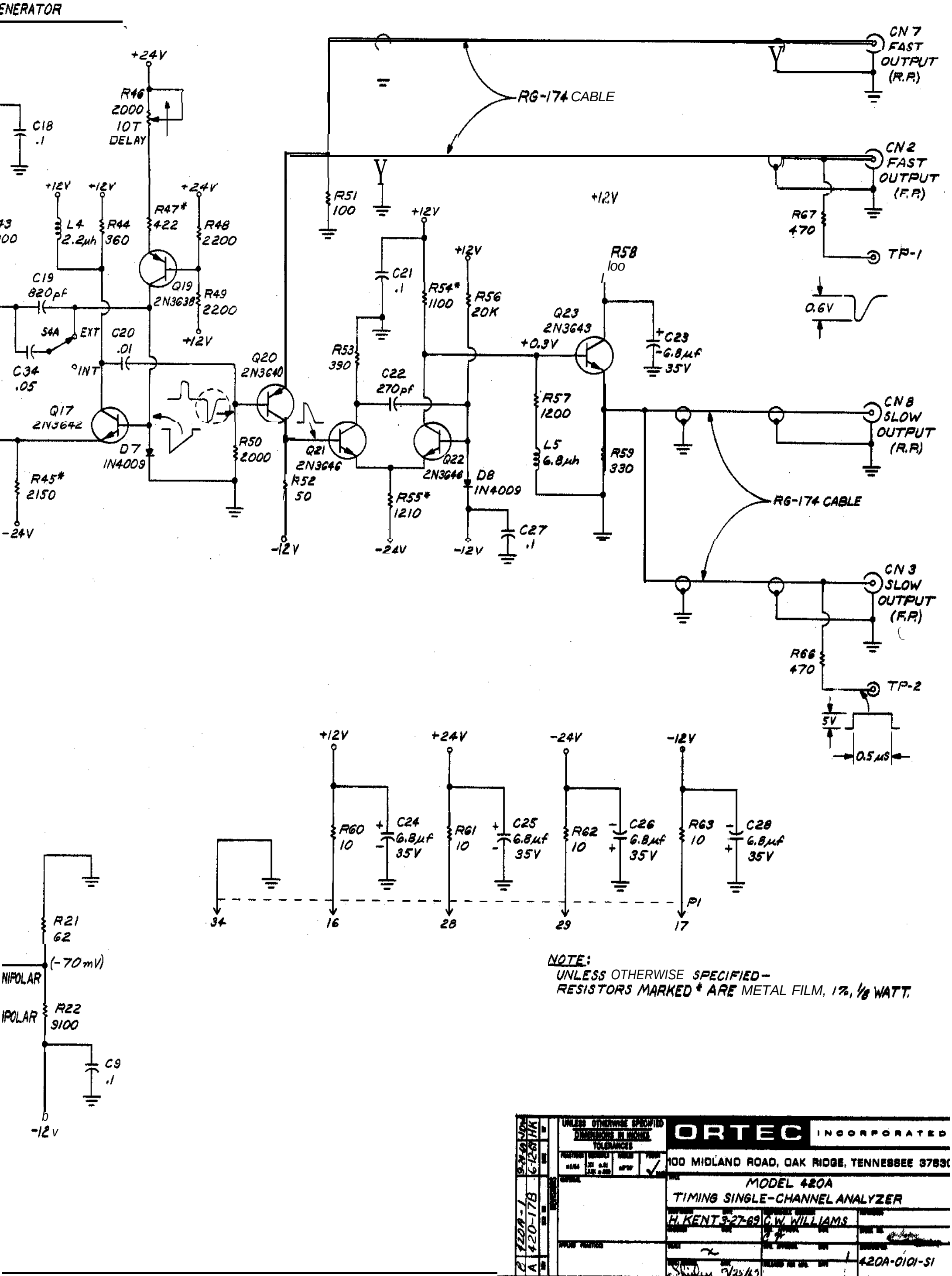

**OAK RIDGE TECHNICAL ENTERPRISES CORP.**
OAK RIDGE, TENN.

MODEL 420A
TIMING SINGLE-CHANNEL ANALYZER
BLOCK DIAGRAM

| DATE | NO. | REVISION | BY |
|---|---|---|---|
| 4-2-69 | A | ECN 420-17B | HK |

| DESIGN | DRAWN | DATE | RESP. ENGR. | APPR. | SCALE | DRAWING NO. |
|---|---|---|---|---|---|---|
| C.W. Williams | E.C. Keith | 8-7-65 | C W W | [illegible] | | 420A-0002-B |


DELAY GENERATOR
"ΔE" DISCRIMINATOR
"E" DISCRIMINATOR
UPPER LEVEL OUTPUT (R.P.)
CN4
P1 PIN16
P1 PIN17
CN6 INPUT (R.P.)
CN1 INPUT (F.P.)
0-10V
(UNIPOLAR OR BIPOLAR)
CN5 EXT. BASELINE 0-10V
C9 (R.P.) EXT. STROBE
S4B INT. EXT.
S4A EXT INT
S2 INT. DIFF.
S3 INT. EXT.
S1 UNIPOLAR BIPOLAR
+12V
+24V
-12V
-24V
R71 100
R68 6.8K
C33 6.8μf
Q24 2N3643
C32 .1
R72 1K
R73 51K
C16 6.8μf 35V
C18 .1
R46 1000 10T DELAY
R23 270
R24 2200
L6 68μh
C10 .1
Q9 2N3646
Q10 2N3646
D3 D4 MSD-6100
R25 100K
R26* 10K
R27 100K
C35 .001
C11 180pf
C14 .005
"A"
R30* 681
(+5V)
C13 6.8μf 35V
R28* 511
R31 500 10T "ΔE" DISC.
C12 6.8μf 35V
R29 100 TRIM
R34 1000
Q11 2N3638A
R35 1000
C15 .005
Q12 2N3646
Q13 2N3646
D5 1N270
D6 1N4009
R32 4700
R33 22K
R37 3300
R36 4.7K
R38 33K
R39 2000
C30 68pf
R79 5.6K
Q14 2N3640
D12 1N4009
Q15 2N3640
R41 150
D9 1N4009
D10 1N4009
Q25 2N3646
R77 390
R78 3K
Q26 2N3638
C17 56pf
R42* 383
R43 2000
Q18 2N3638
Q16 2N3642
Q17 2N3642
L4 2.2μh
R44 360
C19 820pf
C34 .05
C20 .01
D7 1N4009
R45* 2150
R47 422
C5 .1
L1 .56μh
R7 300
R9 300
R8 2400
R69 10K "WALK" ADJ.
R6 3900
C31 27pf
C7 .01
R18 2200
Q7 2N4917
Q8 2N4917
R19 680
L3 27μh
C1 .1
R1* 1000
C2 22pf
Q1 2N3646
Q2 2N3646
D1 D2 MSD-6100
R5* 1000
C4 6.8μf 35V
"E"
R10 100K
R11* 3830
R12 100K
R13 1800
R65* 4220
R14 500 TRIMPOT "ZERO" ADJ.
R64* 750
R15* 4220
C6 .1
Q3 2N3646
Q5 2N3638
Q6 2N3638
Q4 2N3646
C36 .02
R16 2200
L2 68μh
R17 1500
R20 2370 1%
D11 1N4009
C29 .1
C8 .1
+1V -"E"
0V "E"
R21 62
(-70mV)
R22 3100
C9 .1
R3* 681
R4* 19.6
C3 6.8μf 35V
R2 500 10T "E" DISC.
R75 2.7
R74* 2K
R76* 2K
L6 D12
R79 C34



ENERATOR
+24V
R46 2000 10T DELAY
C18 .1
+12V
+12V
+24V
L4 2.2μh
R44 360
R47* 422
R48 2200
C19 820pF
Q19 2N3638
R49 2200
+12V
S4A
EXT
INT
C20 .01
C34 .05
Q17 2N3642
D7 1N4009
Q20 2N3640
R50 2000
R45* 2150
-24V
RG-174 CABLE
CN 7 FAST OUTPUT (R.P.)
CN 2 FAST OUTPUT (F.P.)
R51 100
+12V
C21 .1
R54* 1100
+12V
R56 20K
R53 390
C22 270pF
Q21 2N3646
Q22 2N3646
R52 50
-12V
R55* 1210
-24V
D8 1N4009
-12V
C27 .1
+12V
R58 100
Q23 2N3643
+0.3V
C23 6.8μf 35V
R57 1200
L5 6.8μh
R59 330
R67 470
TP-1
0.6V
CN 8 SLOW OUTPUT (R.P.)
RG-174 CABLE
CN 3 SLOW OUTPUT (F.P.)
R66 470
TP-2
5V
0.5μS
+12V
+24V
-24V
-12V
R60 10
C24 6.8μf 35V
R61 10
C25 6.8μf 35V
R62 10
C26 6.8μf 35V
R63 10
C28 6.8μf 35V
P1
34
16
28
29
17
R21 62
(-70mV)
NIPOLAR
IPOLAR
R22 9100
C9 .1
-12V
NOTE:
UNLESS OTHERWISE SPECIFIED—
RESISTORS MARKED * ARE METAL FILM, 1%, 1/8 WATT.
ORTEC INCORPORATED
100 MIDLAND ROAD, OAK RIDGE, TENNESSEE 3783
MODEL 420A
TIMING SINGLE-CHANNEL ANALYZER
H. KENT 3-27-69
C.W. WILLIAMS
420A-0101-S1
420A-1
420-17B

The transistor types installed in your instrument may differ from those shown in the schematic diagram. In such cases, necessary replacements can be made with either the type shown in the diagram or the type actually used in the instrument.