INSTRUCTION MANUAL: SUPERSNAPPER PULSE-HEIGHT ANALYZER

Larsh, Almon E.

1957-09-29

UCRL 3945

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

BERKELEY, CALIFORNIA

DISCLAIMER

UCRL-3945

UNIVERSITY OF CALIFORNIA

Radiation Laboratory
Berkeley, California

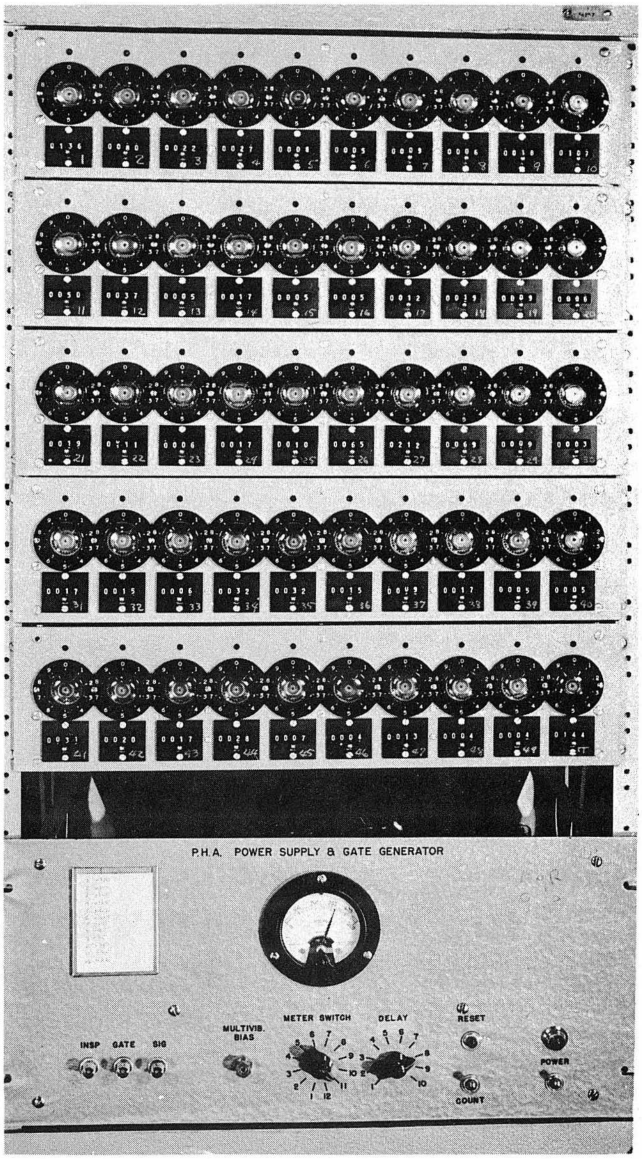
Contract No. W-7405-eng-48

INSTRUCTION MANUAL: SUPERSNAPPER PULSE-HEIGHT ANALYZER

Almon E. Larsh

September 29, 1957

Printed for the U. S. Atomic Energy Commission



ZN-1790

Supersnapper pulse-height analyzer

INSTRUCTION MANUAL: SUPERSNAPPER PULSE-HEIGHT ANALYZER

Contents

INSTRUCTION MANUAL: SUPERSNAPPER PULSE-HEIGHT ANALYZER

Almon E. Larsh

Radiation Laboratory
University of California
Berkeley, California

September 29, 1957

ABSTRACT

The supersnapper differential-discriminator pulse-height analyzer is described, along with installation, operation, and maintenance instructions.

The philosophy of the unique discriminator operation is explained.

INSTRUCTION MANUAL: SUPERSNAPPER PULSE-HEIGHT ANALYZER

Almon E. Larsh

Radiation Laboratory
University of California
Berkeley, California

September 29, 1957

GENERAL DESCRIPTION

Introduction

A pulse-height analyzer is a device used to measure and sort any physical quantity that can be expressed as a voltage pulse. The most common use of a pulse-height analyzer is the measurement of nuclear-radiation energy spectra. Through an amplitude analysis of pulses that originate in suitable gamma or particle detectors, information can be obtained about the nuclear reactions involved. Because each nuclear event produces from a detector an output pulse that has an amplitude linearly proportional to the energy of the event, a tabulation of counts vs amplitude indicates the amount of energy released in the reactions under observation.

A pulse-height analyzer must analyze accurately the amplitudes of the individual pulses and store this information until the experimenter is ready for it. The information must then be available for read-out and evaluation by the experimenter.

The supersnapper fills the above requirements in a very stable and reliable fashion.

Auxiliary equipment needed with the supersnapper includes a detector, a linear amplifier, and associate power supplies.

Input-Pulse Requirements

The signal to be analyzed must be positive, at least two microseconds (μsec) wide for a rectangular shaped pulse, and be in the amplitude range of two to 102 volts (v). All signals greater than 102 v amplitude will be integrated in Channel 50. For most reliable operation the signal pulse-rise time should not be less than 0.2 μsec. Pulses to be analyzed should have a rise time of not more than 1 μsec for maximum-speed operation, and a fall time of not less than 25 μsec or equivalent slope for a rectangular delay-line-shaped or stretched pulse. The linear amplifier supplying the signal to the supersnapper should have a stable gain and a linear output of at least 110 v.

Gate-pulse and inspect-pulse signals are required by the analyzer. These are generated internally in normal analysis but may be triggered from a separate signal source for coincidence analysis.

Input impedance of the supersnapper is approximately 1000 ohms.

Function of the Individual Chassis

Analyzer. The differential amplitude analysis of the signal pulses is performed by a series of stable gated univibrators biased with successively increasing negative voltages on their signal, or limiter, grids. The discriminator corresponding to the maximum amplitude of a signal pulse drives a glow-transfer scaler tube followed by a mechanical register.

Power Supply and Gate Generator. The power supply provides the regulated and unregulated B+ and bias voltages necessary for the operation of the analyzer chassis and gate generator. The power-supply voltages are metered as a check on proper operation of the analyzer.

Gate pulses and inspect pulses are required by the analyzer. In normal operation these are supplied by the gate-and inspect-pulse generators located in the power-supply chassis. These pulses may be triggered from a separate signal source for coincidence analysis.

The Count-Stop switch and the Reset button are on the front panel of the power supply.

INSTALLATION: GENERAL PRECAUTIONS

The supersnapper operates from a 117-v, 60-cy power source. For protection of personnel, never operate the equipment unless an equipment ground wire is connected to a good building ground.

For most stable operation, any electronic circuit should be operated, as nearly as possible, under constant-temperature conditions. In the case of pulse-height analyzers, a constant room temperature is essential for maximum stability of the analyzer and its associated amplifiers. A refrigerating-type air conditioner used in a pulse-height analyzer room will not only improve over-all amplifier stability but also will account for lengthened component life. To provide maximum stability, cooling air is moved through the supersnapper analyzer. This air flow should not be obstructed.

OPERATING INSTRUCTIONS

Front-Panel Controls

Analyzer. Coarse-channel bias voltages are provided by a string of precision resistors in the analyzer chassis. Fine adjustments required by the calibration procedure, below, are made with a potentiometer in each channel. A small hole above each glow-transfer scaler tube allows one to reach the fine adjustment control for the corresponding channel with a screwdriver.

Power Supply. The power supply switch turns on the high voltage and bias supplies. These supplies are checked on the panel meter by selecting the desired voltage with the meter switch. The univibrator bias control adjusts the sensitivity of the glow-transfer tube scalers. The count-stop switch controls analyzer operation by allowing the generation of gate pulses. The reset button resets both the glow-transfer tubes and the mechanical registers. The "Inspect-Pulse Delay" switch allows positioning the inspect pulse for optimum operation.

Rear Connectors

The rear connectors on both the power-supply and analyzer chassis are labeled to indicate proper interconnection and signal and power inputs.

Power Turn-On Procedure

The supply should be 60-cy 115 v ac power, preferably regulated. With power supply switch off, make sure cooling blower is moving air through the analyzer. All analyzer-chassis tube heaters should come on at the same time as the blower.

Turn on power-supply switch and allow time for high-voltage delay relay to operate, approximately 30 sec. When high voltage comes on, switch meter through all positions to check for proper voltages. The readings should be:

Power supply voltages

Switch position	Voltage
1	370
2	350
3	300
4	165
5	1.2
6	-200
7	-105
8	-105
9	- 35
10	- 35
11	- 30 (approx.)
12	- 22

Connect the output of the signal amplifier to the signal input of the analyzer. Set all rear controls to maximum.

Feed in signal pulse. Check position of inspect pulse relative to signal and gate (Fig. 1). To set the time delay on the inspect pulse, trigger an oscilloscope with the signal pulse. Observe the signal pulse. Observe the inspect pulse and set its position relative to the signal pulse such that there is time for the signal pulse to rise to maximum value before the inspect pulse occurs. This will allow the supersnapper discriminator time to operate and supply a channel-signal pulse to the diode inspection matrix.

The gate-generator input control is set such that a gate pulse will be generated by a signal pulse that is not quite large enough to operate the Channel-1 supersnapper discriminator. This will assure a slight safety factor in the generation of gate pulses, yet will prevent spurious gates from being generated by amplifier noise.

The inspect-generator input control is set such that an inspect pulse is generated every time a gate is generated in normal analysis. In coincidence analysis this control can be used to discriminate against unwanted low-level signals that might generate spurious random inspect pulses.

The gate- and inspect-pulse output controls are set to give pulse amplitudes approximately as shown in the wave-form photograph (Fig. 1).

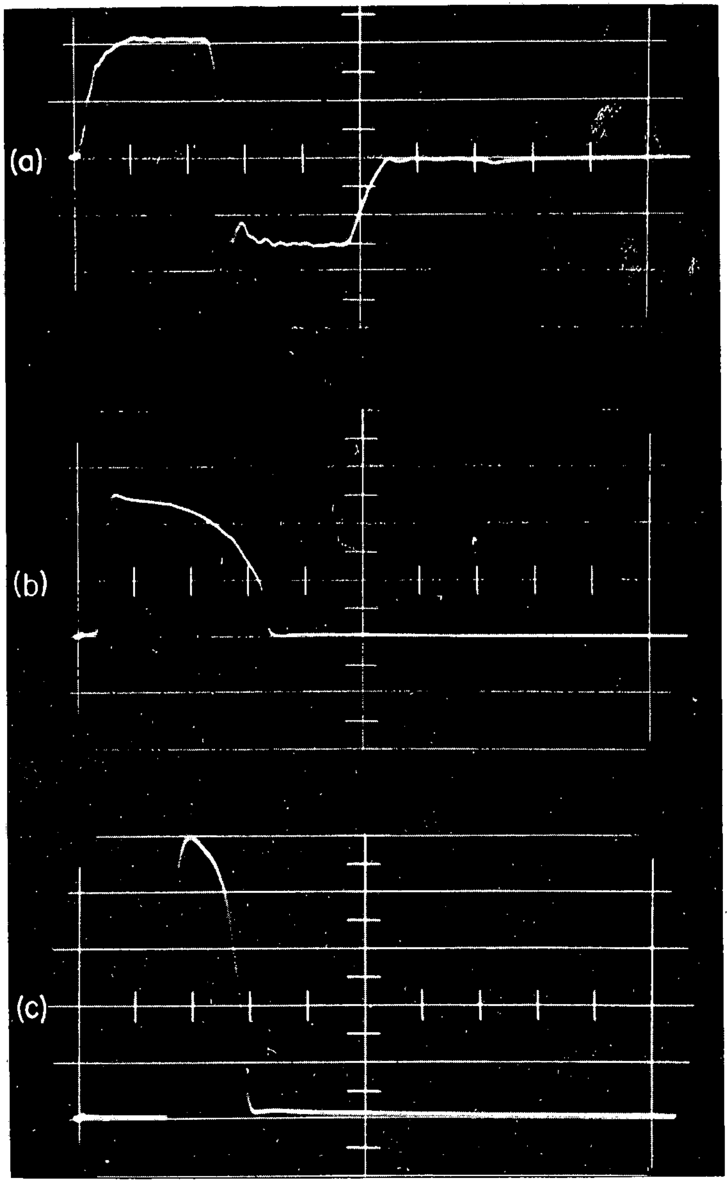
Adjust the univibrator bias voltage to proper value. To set the univibrator bias control to the proper value, reduce the bias voltage with the count switch off until one or more channels free-run. Increase the bias to stop the free-running. Supply an inspect pulse but not a signal pulse to the analyzer. If one or more channels operate, increase the bias until they stop. Supply a signal pulse to the analyzer. Increase the signal until Channel 50 is operating. None of the lower channels should be operating. If there are any operating channels, increase bias slightly until they stop. This is the minimum bias for reliable operation.

While sweeping the signal source up and down across the analyzer, gradually increase the univibrator bias until some channel fails to operate. Reduce bias until all channels operate. This is the maximum bias for reliable operation. Set the operating bias approximately in the middle of the determined range. There should be a range of at least 5 v between the limits when the analyzer is properly adjusted.

In the event that information from Channel 50 is of little value, because of high count loss or undesired high-energy activity, the Channel 50 register circuit may be disabled. This should be done to minimize excess wear on the mechanical register. Disabling is accomplished by connecting a cable from the cancel-out jack of the first chassis to the cancel-in jack of the last. The Channel 50 discriminator still operates to produce cancel pulses for Channel 49, but the Channel 50 glow tube and register are prevented from operating.

Analyzer Calibration Procedure

The analyzer can be calibrated directly from a pulse generator, but most



ZN-1794

Fig. 1. Power supply output wave forms (1μsec/cm, 10 v/cm).
(a) Typical input signal pulse,
(b) Gate pulse, and
(c) Inspect pulse.

satisfactory calibration and operation is obtained by feeding the calibration pulse from a precision mercury pulser through the entire amplifier chain to simulate as nearly as possible a normal signal pulse. In particular the rise time of the calibration pulse should be the same as that of a signal pulse.

The following has proven to be the most practical method of aligning the analyzer. Set all fine-bias-adjustment potentiometers in the middle of their ranges. Turn on the pulser and the analyzer-count switch. Adjust the pulser so that Channel 1 is just being operated. Record the pulser setting. Repeat for Channels 2 through 50. Plot the pulser dial readings against channel number. Draw the best straight line through the plot. Returning to the analyzer, set the pulser to correspond to the value shown on the curve as being the desired firing point for a channel and adjust the fine bias of that channel so that it just fires. Repeat for all channels. The same process can be done mathematically if the output amplitude of the pulser is sufficiently flexible.

The above procedure has the advantage of correcting the analyzer for any small nonlinearities in the amplifier.

Coincidence Analysis

If it is desired to analyze a spectrum in coincidence with a second radiation, this may be done by removing the inspect-generator input cable on the back of the power-supply chassis. A coincidence signal from a particle detector or single-channel analyzer is then fed into the inspect-generator input. The analyzer is then allowed to operate only when an inspect pulse occurs in coincidence with a signal pulse.

When the analyzer is used for coincidence analysis, it may be desirable to reposition the inspect pulse with respect to the signal pulse for best operation. The "Inspect-Pulse Delay" switch on the front panel of the power supply allows for this adjustment.

Dead-Time Corrections

The dead time, or statistical count loss, in each channel is a function of the rate at which counts are being stored in that channel. A calculation of count loss can be made, based on a glow-transfer-tube dead time of 250 μsec.

The maximum rate at which counts can be stored in any channel is 15,000 counts per minute, limited by mechanical-register dead time.

Servicing

The power-supply and gate-generator circuits are conventional. Liberal use is made of selenium and germanium rectifiers in the power supply to reduce heating and improve reliability.

The gate-and inspect-pulse generators are simple blocking oscillators that should be subject only to normal tube-life failures.

The analyzer circuits are less familiar and will be treated in detail in the next section. Here again, any trouble that might occur will probably be the result of a tube aging.

TECHNICAL CIRCUIT DESCRIPTION

Preface

Discussion will be limited to circuits of unusual design or application. No mention will be made of adjustment procedures, as these have been covered in other sections. It will be assumed that maintenance personnel will be familiar with such standard pulse circuits as the univibrator, cathode-follower, blocking-oscillator, and amplifier circuits.

All components are specified on the drawings or parts list and should be replaced by units of equivalent value if failure occurs.

Power Supply and Gate Generator

The power supplies are all conventional. All important voltages can be measured by means of a switch and meter on the front panel. The voltages are shown on the circuit diagram. Any voltages that might affect the stability of analyzer operation are regulated with glow-discharge regulator tubes.

The gate and inspect pulses are produced by blocking oscillators. These units have sufficiently low output impedance that they will drive the analyzer circuits directly.

The signal to be analyzed is fed in parallel to the analyzer and gate generator. The minimum signal height that will produce a gate is determined by control R-1 in the gate generator. This control prevents amplifier noise from generating spurious gates.

Tube V-1 is a cathode-coupled limiter amplifier which drives the gate-pulse generator. The size of the output gate pulse is determined by control R-19. Part of the gate-pulse signal is brought out through a connector that can be connected to the inspect-pulse-generator input. This is the connection used for normal single-signal analysis. For coincidence analysis, the jumper is removed and the coincident signal is fed into the inspect-pulse-generator circuit. This allows for some time delay in fast-slow coincidence units and single-channel analyzers used in coincidence analysis. If there is no delay in the coincidence circuit, the coincident pulse can be applied to the gate-pulse-generator input and the jumper to the inspect-pulse generator can be left in normal position. In the latter case, the signal to be analyzed is fed directly from its amplifier to the analyzer chassis. Only the coincident signal for gating purposes would be fed into the gate generator on the power-supply chassis.

The amplitude of signal required to produce an inspect pulse is determined by the setting of R-14. Tube V-2A is a cathode follower which drives the delay line that determines the delay of the inspect pulse.

Amplitudes of gate and inspect pulses are shown in the photographs below. Settings are not critical but should approximate values shown. The delay of the inspect pulse relative to the signal and gate is controlled by Sw-2 which takes a signal from a delay line at 0.5 μsec per step. Normal delay is 2 to 3 μsec, but more or less delay may be desired for longer pulses or coincidence analysis use.

In normal analysis, the count-stop switch controls the generation of gate pulses (and hence inspect pulses). In coincidence analysis, the count switch can be left on if the inspect-pulse input is controlled. But, because the timer switch is part of the count-stop switch, the normal procedure may be preferred.

Analyzer

The supersnapper is a differential analyzer of the biased-discriminator type. A gated univibrator, the supersnapper, consisting of a 6BN6 and a 5963 accomplishes the discrimination and drives a glow-transfer scaler whose output actuates a register circuit.

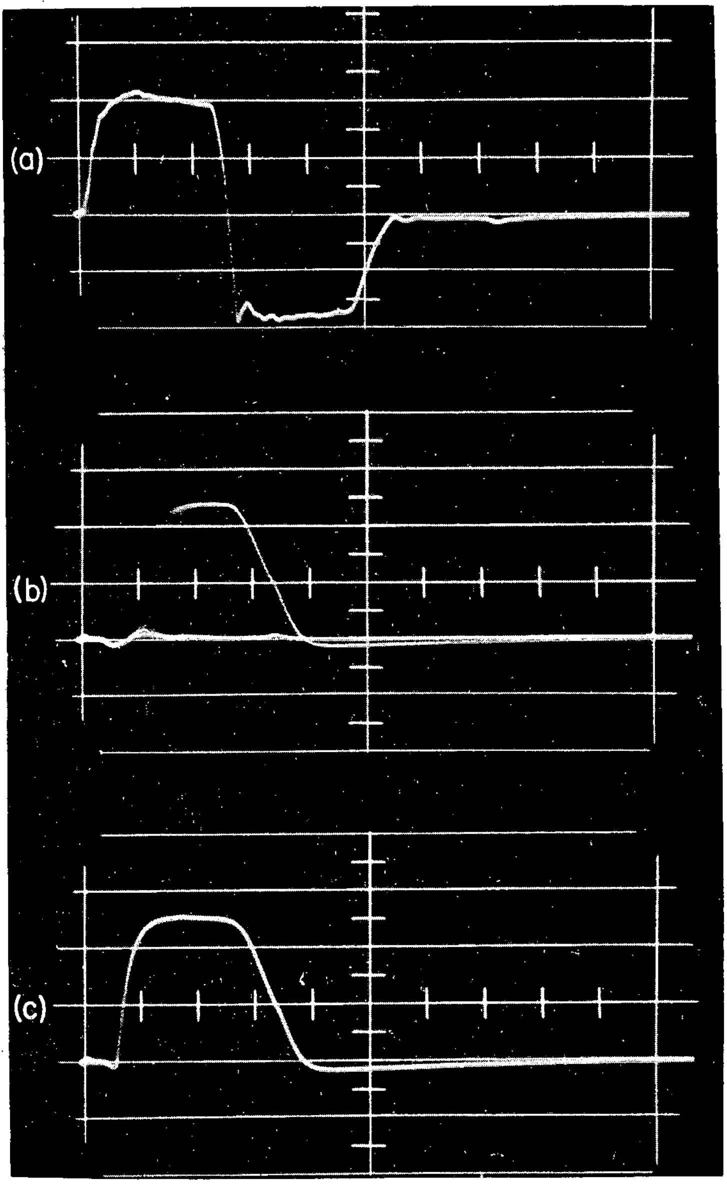
The supersnapper depends for its stability on the sharp cut-off characteristic of the 6BN6 limiter grid. The unique construction of the tube with its two independent control grids allows the tube to be used in a gated univibrator circuit. The actual snap in the circuit, the transition from nonconduction to conduction in the 6BN6, results from the rapid positive feedback through the accelerator-to-limiter grid interelectrode capacitance. To minimize integration of signal rise time, the signal should be applied to the limiter grid through a low impedance. To minimize snap rise time and maximize snap sensitivity, the positive fed-back signal should see a high impedance when looking out from the limter grid. The crystal diode in the limiter-grid circuit of the 6BN6 provides these necessary circuit conditions.

When a signal is applied to the supersnapper circuit, it finds the 6BN6 cut off by both grids, channel bias on the limiter grid, and gate bias on the quadrature grid. As the signal starts to rise, a gate pulse is generated and applied to the quadrature grid, establishing conditions for permissible conduction. As the signal pulse just exceeds the cut-off bias level of the limiter grid, an amplified signal appears on the 6BN6 plate and is fed to V-2 for further amplification and positive feedback to the accelerator of the 6BN6. This produces a snap in conduction, as shown in Fig. 2. A fraction of the accelerator signal is used as a cancel signal for the next lower channel.

A tap in the plate-load resistor of V-2 provides a signal for the diode inspector matrix. This circuit is a computor "and" circuit and allows a channel-signal pulse, if one exists, to trigger the glow-tube-driver univibrator if an inspect pulse is also present. The output of the matrix without and with a channel-signal pulse is shown in Fig. 3.

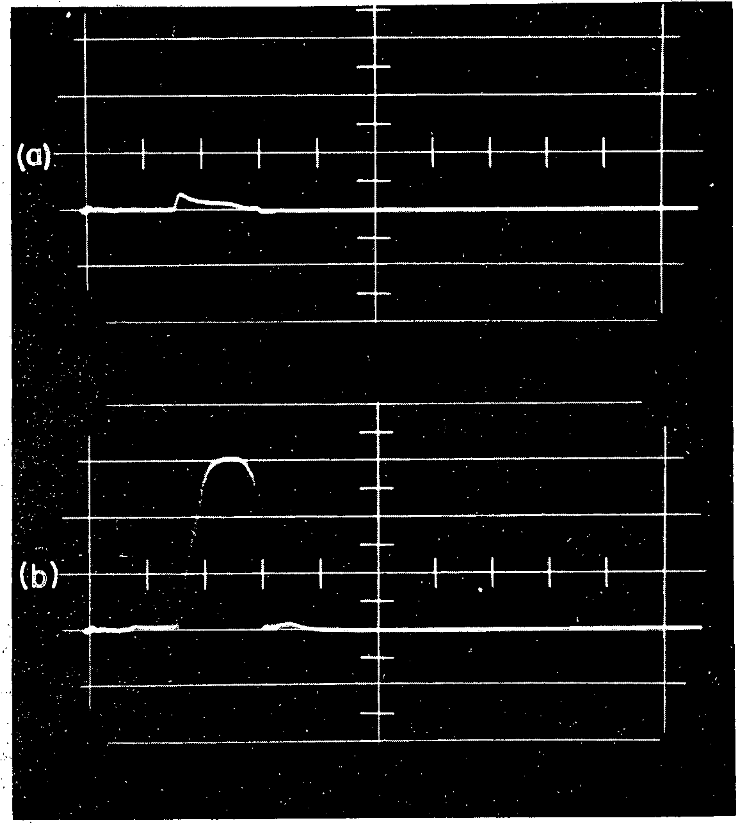
The output of the matrix is applied to a grid of V-3, the glow-transfer-tube univibrator. If there is no cancel signal from the next higher channel, the univibrator fires. If there is a cancel signal from the next higher channel, it is applied to the cathode of V-3 and prevents V-3 from operating. The V-3 cathode signals for these conditions are shown in Fig. 4.

Only for the channel corresponding to the maximum height of the signal



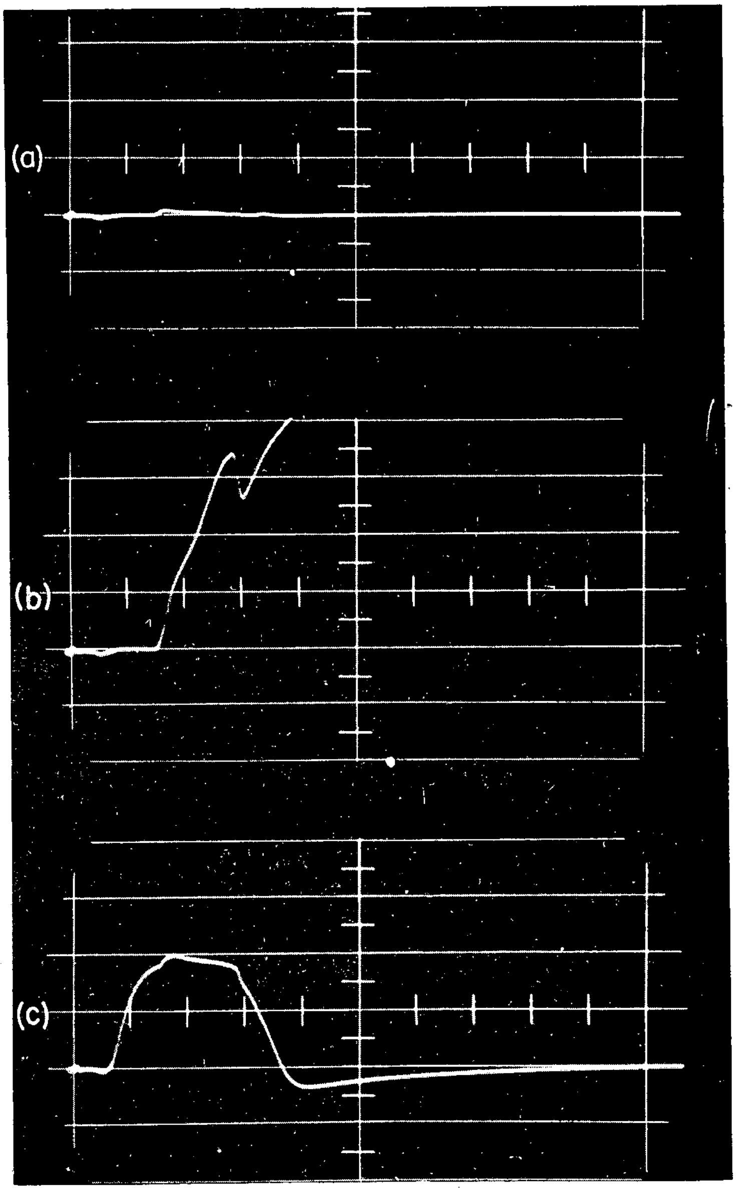
ZN-1795

Fig. 2. Discriminator signals (1μsec/cm, 30v/cm).
(a) Typical input signal pulse,
(b) 6BN6 accelerator signal, input signal at channel edge (V-1, Pin 5), and
(c) 6BN6 accelerator, full snap (V-1, Pin 5).



ZN-1796

Fig. 3. Matrix junction wave forms (1μsec/cm, 3v/cm, crystal 3, k).
(a) Inspect pulse only, and
(b) Channel-signal plus inspect pulse.



ZN-1797

Fig. 4. Univibrator cathode signals (1μsec/cm, 3v/cm, V-3, Pin 8).
(a) Inspect pulse only to diode matrix,
(b) Inspect pulse plus channel-signal pulse, and
(c) Inspect, channel-signal, and cancel pulses.

pulse, therefore, is the glow-transfer-tube univibrator allowed to operate. Its plate-signal wave forms, along with the differentiated guide signals of the GC 10 B, V-4, are shown in Fig. 5.

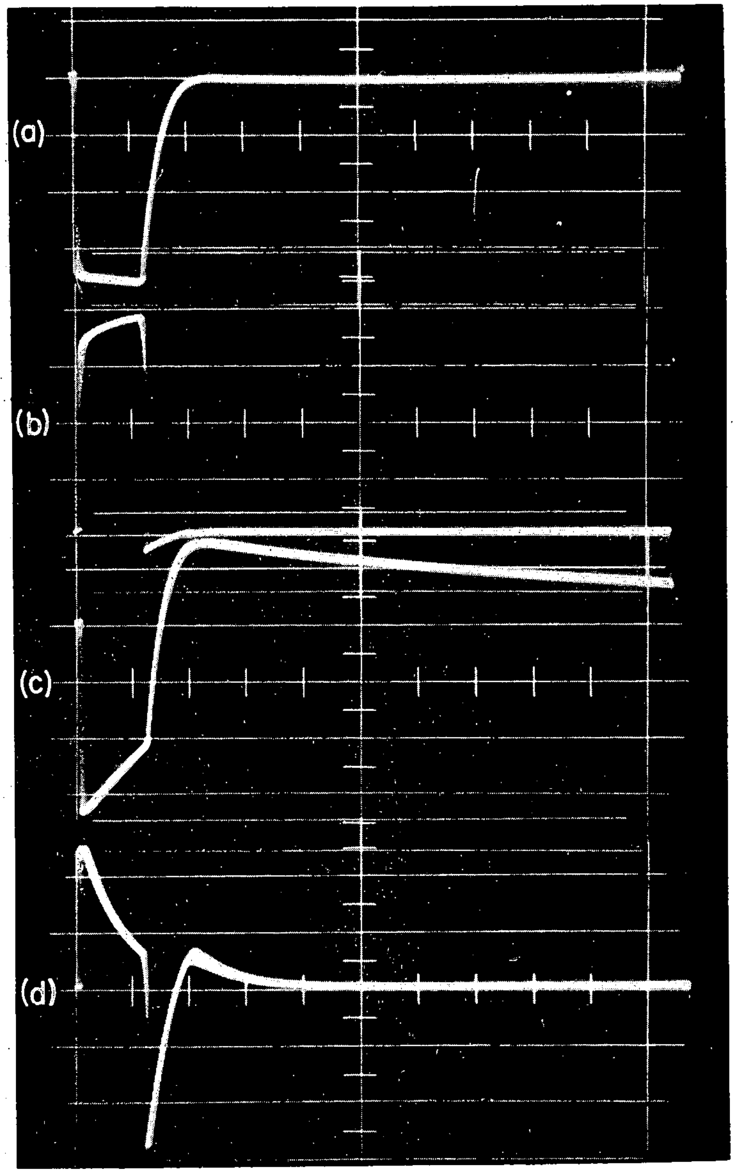
The output of the tenth cathode of V-4 is fed to V-5. The first half of V-5 is a pulse stretcher; the second half is the register drive tube. In the operation of the pulse stretcher, a positive pulse from the tenth cathode of V-4 is applied to the grid of the first half of V-5. This grid is running near zero bias and acts like a diode when a positive pulse is applied, charging capacitor C-14 to signal potential. The tube is normally conducting so the plate of the tube is near ground potential, approximately 9 v. Driving the grid to conduction has little effect on plate voltage. When the driving signal disappears, the charge on C-14 produces a voltage negative enough to reduce greatly the plate current of the first half of V-5, raising the plate potential; The Ne2 between the plate of the first half of V-5 and the grid of the second half ionizes and brings the second half of V-5 into conduction, operating the mechanical register. The width of the stretched pulse is determined by C-14 and R-22. The wave forms of V-5 are shown in Fig. 6. The width of the register pulse should be at least 25 milliseconds (msec).

During the reset operation the grid of the first half of V-5 is tied to B+ to prevent the reset output of the glow-transfer tube from actuating the mechanical register through the stretcher circuit. The reset microswitches must be properly phased such that the grid is tied to B+ before the glow-transfer tube is reset, and held there until the reset signal is removed from the glow-transfer tube. The microswitches are actuated by the bar that resets the mechanical registers and may be adjusted independently of one another.

TROUBLE SHOOTING

Socket Voltages

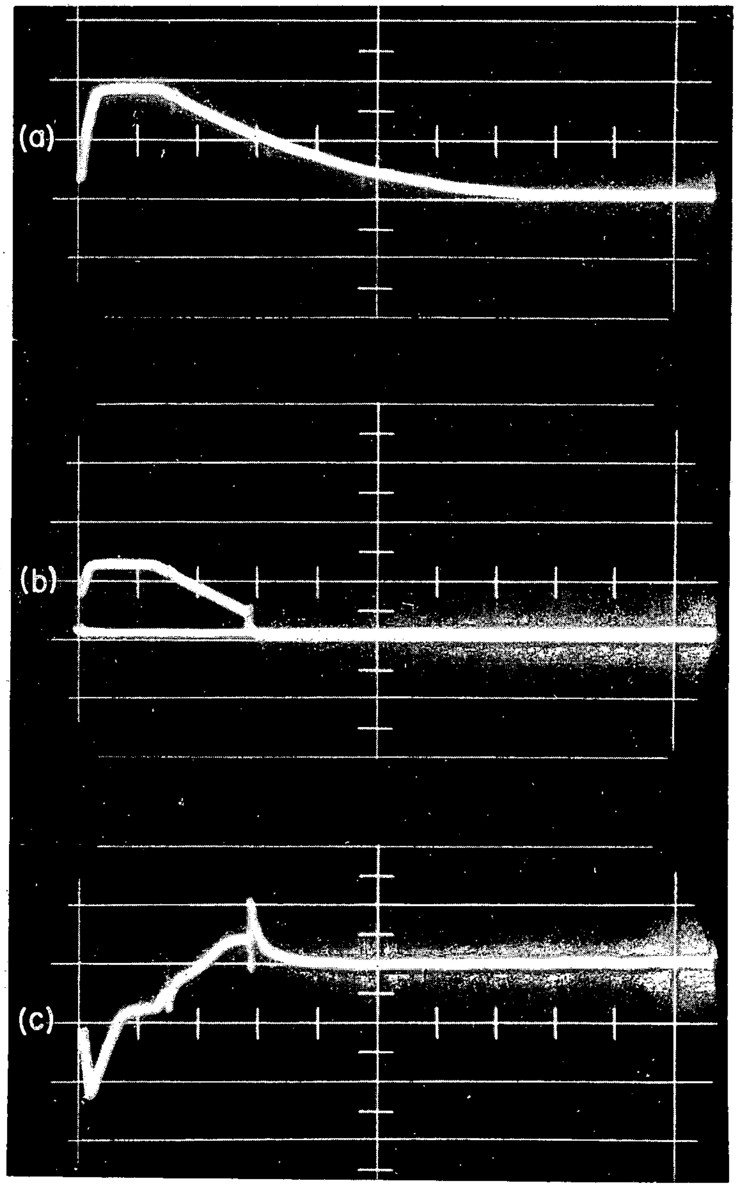
Important socket voltages are tabulated in Table I below. All are read with a 20,000-ohm-per-volt meter and include normal deviations resulting from component and tube variations. Pin 7 of V-1 will read a little low from meter-current IR drop in R-2.



ZN-1798

Fig. 5. Glow tube drive-pulse wave forms (100 µsec/cm, 30 v/cm).

(a) Univibrator plate 1 (V-3, Pin 6),
(b) Univibrator plate 2 (V-3, Pin 1),
(c) GC 10B guide 1 (V-4, Pin 3), and
(d) GC 10B guide 2 (V-4, Pin 5).



ZN-1799

Fig. 6. Register-drive wave forms (10 msec/cm).
(a) Stretcher plate (30 v/cm, V-5, Pin 1),
(b) Register-driver grid (30 v/cm, V-5, Pin 7), and
(c) Register-driver plate (100 v/cm, V-5, Pin 6).

Table I

Pin voltages, B+ = 167 volts

Tube	Pin number	Volts
6BN6, V-1	5	51 ± 3
	6	-22
	7	167
5963, V-2	1, 7	46 ± 3
	2	0.5 ± 0.1
	8	51 ± 3
5963, V-3	1	46 ± 1
	2	0.5 ± 0.1
	6	145 ± 7
	7	-5.5 ± 0.5
	8	1.9 ± 0.1
5963, V-5	1	9 ± 1

Wave Forms

Important and useful wave forms are shown in Fig. 1 – 6. They are identified as to tube number, pin number, and axis scale values. These wave forms are not critical and some variation is normal.

Some Possible Troubles

Symptom	Correction
Register turning over half or whole number on reset	Adjust microswitch phasing
Glow-tube free running	Increase univibrator bias. Change V-3
Glow tube not scaling	Decrease univibrator bias. Change V-3. Change V-4.
Channel not being cancelled	Check discriminator of channel above for proper operation. Adjust univibrator bias. Change V-3
Holes or overlaps between channels	Check power supply voltages. Check wave shapes. Adjust univibrator bias. Change tubes.
Can't align channel	Check trim bias, +1.2V. Change V-1 and/or V-2.

LIST OF DRAWINGS AND CHASSIS PHOTOGRAPHS

Schematics

Dwg. No.	Title
1	Analyzer (1X 9254E)
2	Power Supply and Gate Generator (2X 2984E)

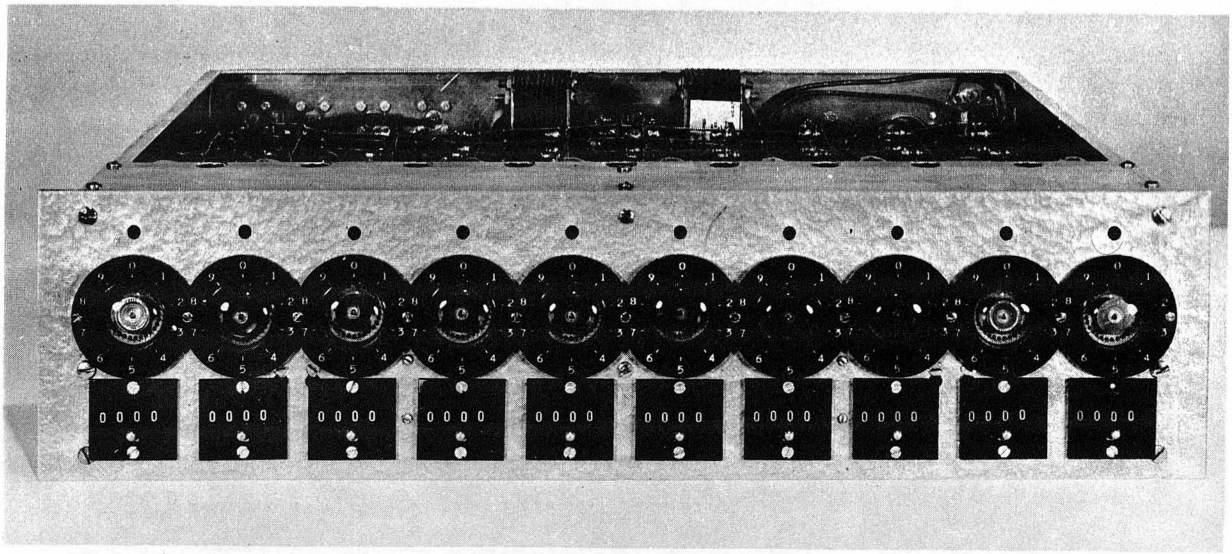
Chassis Photographs

Frontispiece	Supersnapper pulse-height analyzer
Page 21	Analyzer chassis, front view
Page 22	Analyzer chassis, bottom view
Page 23	Analyzer chassis, rear view

* * * * * *

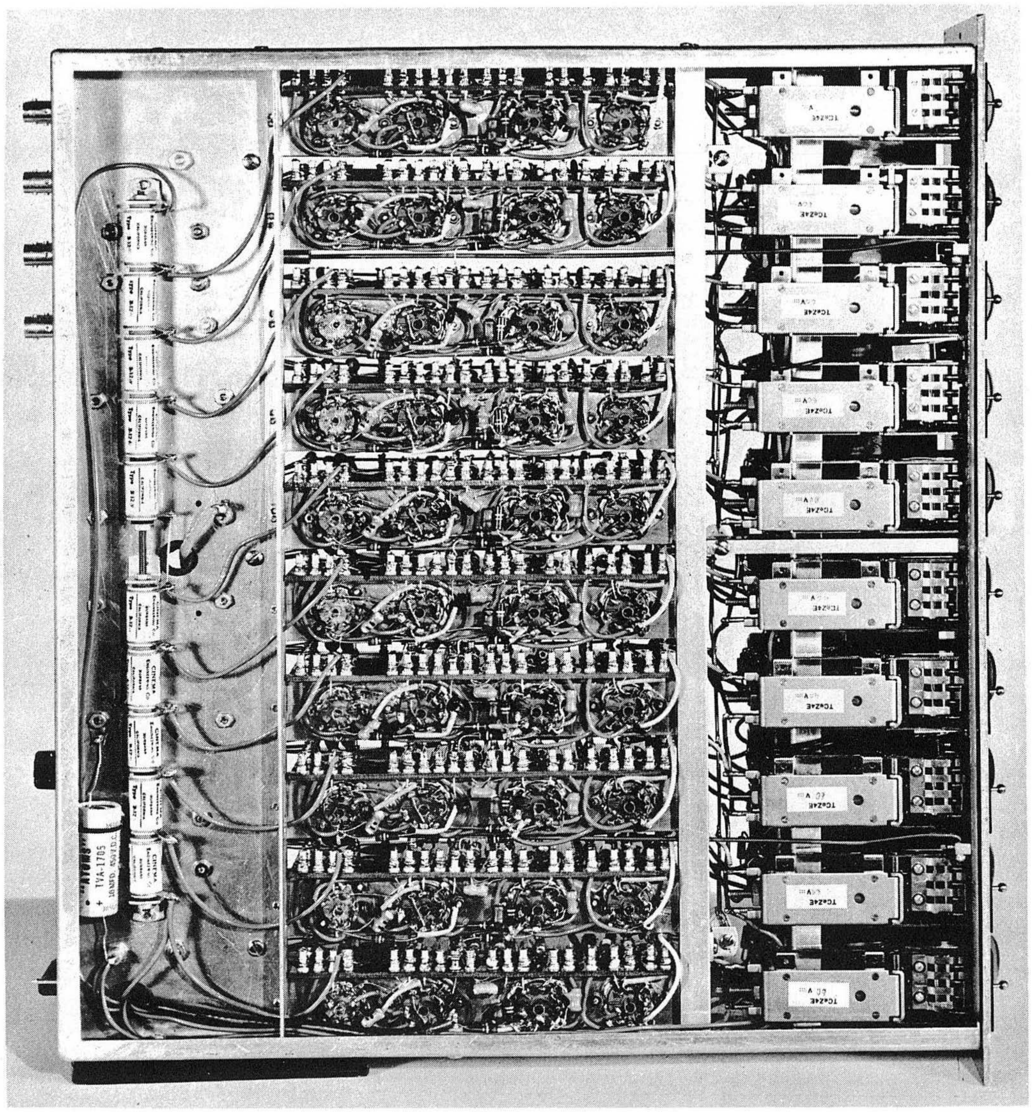
This work was performed under the auspices of the U. S. Atomic Energy Commission.

Information Division
10/31/57 db



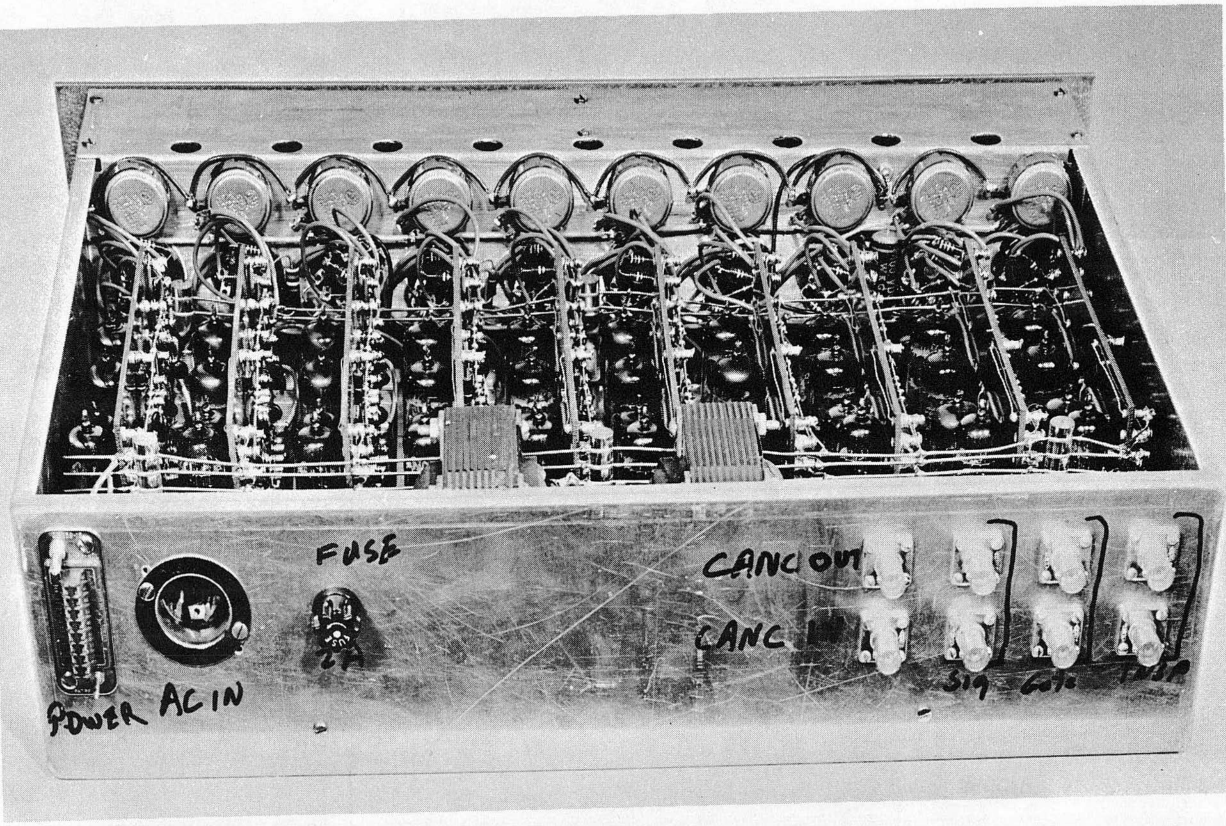
ZN-1789

Analyzer chassis, front view



ZN-1788

Analyzer chassis, bottom view



ZN-1787

Analyzer chassis, rear view

MATERIAL

SHOWN ON		
SHOWN ON	1X9261	1X9273

CHANGE LETTER	DRAWN BY	CHECK BY	DATE	CHANGE
A	GY	JBS	8-24-56	CORR. CHART
B	GY	JBS	9-17-56	MISC. ADD.
C	GY		10-16-56	CH- R-40
D	GY	JBS	7-4-56	ADD'D C18
E	WGF	JBS	2/28/57	GEN CHGS

1. Y-Y To CHAN. 1 THRU 5
X-X To CHAN. 6 THRU 10
2. ALL RESISTORS ½ WATT EXCEPT AS SPECIFIED
3. ALL CAPACITORS 500V DISK EXCEPT AS SPECIFIED

2-LARSH
3 Ctng

50 CHANNEL PULSE ANALYZER
10 CHANNEL UNIT
SCHEMATIC
("SUPER SNAPPER")

FIRST USED ON

ROUGH ∅ FINISH FINE ff FINISH
GOOD f FINISH GRIND G FINISH

TOLERANCES WHERE NOT OTHERWISE GIVEN ±.010

RADIATION LABORATORY
UNIVERSITY OF CALIFORNIA

DRAWN BY G. YUEN
CHECK BY
DATE 7-17-56
APPROVED BY
SCALE NA
DRG. NO. 1X9254E

ISSUED TO
DATE ISSUED
DELIVER TO
ACC'T NO.
DATE REQ'D
MAKE

MATERIAL

SHOWN ON 2X2971

CHANGE LETTER	DRAWN BY	CHECK BY	DATE	CHANGE
A	GY		11-19-56	CH. PG 5.8. TRIG-IN. OUT
B	GY	JBS	11-29-56	ADDED SOCKET NO. T3
C	GY	JBS	2-4-57	CH. R-39
D	WSS	JBS	2/28/57	GEN CHGS
E	YD	SM	4/9/57	PER M.U.

ME-1

Pos.	Function
1	+370V Registers
2	+325V Glow Tubes
3	+330V Gate Gen.
4	+165V Analyzer B+
5	+1.2V Trim Bias.
6	-250V Unreg Bias
7	-105V Glow Tubes
8	-75V Disc. Bias
9	-35V Register Bias
10	-35V Gate Gen
11	-30V Nom. M.V. Bias
12	-22V 6BN6 Bias

All Resistors ½ watt &
All Capacitors 600V
Unless Stated Otherwise

2-LARGE

3-COUNT'G

8 ¾" Panel

50 CHANN PULSE HEIGHT
ANALYZER
PWR SUPPLY & GATE GENERATOR
SCHEMATIC

RADIATION LABORATORY
UNIVERSITY OF CALIFORNIA

FIRST USED ON

ROUGH FINISH FINE FINISH
GOOD FINISH GRIND FINISH

TOLERANCES WHERE NOT OTHERWISE GIVEN ± .010

DRAWN BY G. YUEN CHECK BY DATE 11-8-56

APPROVED BY

SCALE

DRG. NO. 2X2984E

ISSUED TO | DATE ISSUED | DELIVER TO | ACC'T NO. | DATE REQ'D | MAKE