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# PROJECT WHIRLWIND

Contract N5ori60  
Project NR-720-003

## II. TECHNICAL INFORMATION ON COMPUTER AND ASSOCIATED EQUIPMENT

c. Report R-143

### SPECIFICATIONS FOR STANDARD TEST EQUIPMENT

January 18, 1949

SERVOMECHANISMS LABORATORY  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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PROJECT WHIRLWIND

Report R-143

SPECIFICATIONS FOR  
STANDARD TEST EQUIPMENT

Submitted to the  
OFFICE OF NAVAL RESEARCH  
under Contract N5ori60  
Project NR-720-003

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January 18, 1949

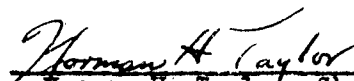
## PREFACE

During the development of the Whirlwind Computer, it became evident that the needs for testing the various component units - storage tubes, arithmetic circuits, control circuits, etc. - had a common basis in requiring certain sequences of pulses and gates. The differences in these requirements from one test setup to another were only those of frequency, amplitude, and, in a few cases, impedance level.

The Test Equipment Committee of the Project was formed to review these needs and provide a standard line of test equipment which would meet the requirements of all concerned. Such equipment would relieve the individual engineers of spending long periods of time designing their own equipment and further provide equipment flexible enough to be used as new ideas evolved in the computer program.

The equipment has been designed with maximum flexibility as its first requirement. The building-block approach enables the user to plug units together in large or small arrays as needed and to achieve a particular test setup in a few hours.

This booklet is issued as a guide to those who use the standard test equipment. It gives the performance requirements of each panel and other pertinent specification data. In addition, separate reports are being issued on each panel, giving complete circuit information, waveshapes, and typical uses.

  
Norman H. Taylor, Chairman  
Test Equipment Committee

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SPECIFICATIONS FOR  
STANDARD TEST EQUIPMENT

INTRODUCTION

STANDARD TEST EQUIPMENT

Definition of Standard Test Equipment

Standard test equipment may be defined broadly as any non-commercial test units which have been approved by the Test Equipment Committee. At present it includes building blocks designed for specific Laboratory needs, and many auxiliary units and smaller devices used with these blocks (see list on page 2).

Status of Commercial Equipment

Commercial test equipment (voltmeters, tube testers, etc.) is used in quantity by the Project, but is not considered as standard. A borderline case is the Sylvania Model 5 synchroscope which has been modified to meet Laboratory specifications.

Standard Construction Requirements

After the need for a specific test unit has been established and the design approved by the Test Equipment Committee, a prototype is constructed. If this prototype meets operational requirements, construction of the final model is authorized. The following construction specifications must then be met:

- (1) The test unit must operate from the central laboratory power source (described on page 2).
- (2) It must fit a standard panel rack (19 inches).
- (3) Output pulses must be 0.1 microsecond at a 93-ohm impedance level.
- (4) The input and output jacks must be regulation (readily interconnectable by coaxial cable).
- (5) The appearance must be uniform, i.e., panel finish, lettering, and designation of controls, switches, jacks, etc. should be consistent with established test-equipment policy.
- (6) Each model must be numbered serially and each tube marked in order that operational data may be kept by Maintenance.

All pieces of standard test equipment (except the clocks) will eventually be provided with 3-position output switches (positive, negative, or zero output) and bus-driver crystal rectifiers in the output. This will enable the operator to mix output circuits, thus minimizing the need for pulse mixers.

#### List of Standard Units

<u>Building Blocks</u>	<u>Auxiliary Units and Devices</u>
Variable-Frequency Clock-Pulse Generator	Cathode Follower Probe
Gate and Delay	Video Amplifier
Register Panels (a-c and d-c)	Video Switch
Scope Synchronizer	Rack Power Control
Pulse Mixer	Filament Power Panel
Coder	Holding Gun Power Supply
Gate Panel	Crystal Tester
Pulse Standardizer	Voltage Calibrator
Delay Line Panel	Jack Marker
95-Ohm Attenuator	Cable-Terminating Resistors
	Cable-Terminating Potentiometers

#### Typical Uses of Standard Test Equipment

The equipment described in the following sections has been assembled as building blocks to perform numerous tasks. During the design of the Whirlwind computer, this method proved extremely valuable in examining the behavior of basic circuits, such as flip-flops and gate tubes, under system conditions. Even more important has been its use in testing and simulating large computer elements (storage, arithmetic registers, and arithmetic control). This application alone has saved many months in computer installation by permitting testing of one element before an associated element was completed.

The test equipment instruction booklets which are now being written present typical test setups for examining basic circuits. A separate report will be prepared describing in detail specific component tests and simulation.

#### LABORATORY POWER SUPPLY

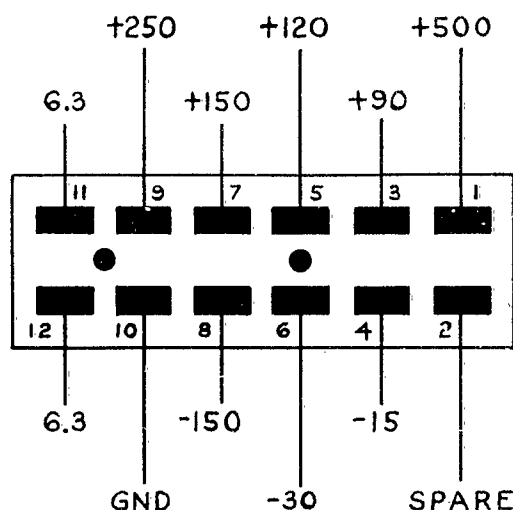
As one of the construction requirements for standard test equipment is to operate from the central laboratory power supplies, a description of that source is given below in order to clarify references in the specifications of each unit.

Each laboratory workbench is equipped with a power box which supplies the following voltages:



<u>B+</u>	<u>Bias</u>	<u>Fil.</u>
90	- 15	6.3 (a-c)
120	- 30	
150	-150	
250		

The front panel of the box has four outlets for Jones 12-pin cable connectors, an on-off switch and red indicator light for the B+ and bias voltages, and an on-off switch and green indicator light for the 6.3 v a-c. A drawing specifying the voltages at the twelve terminals is attached to the conduit under each box, and is reproduced below.



The B+ and bias voltages (except +500) are fed to the power box from a central power supply source located in the basement. The +500 must be supplied by local power supply. The a-c input to the central supplies and the +150, -15, and -30 outputs are regulated. Heinemann circuit breakers capable of switching in 1 millisecond are used in all lines and are located in remote circuit-breaker boxes. One such box can supply power to as many as six bench power boxes.

The 6.3 v a-c, supplied locally, is fed to the power box from a 20-amp transformer under the bench. Numerous 115-volt a-c outlets are provided, and an a-c circuit breaker has been installed at the main a-c entrance at each bench.

When racks of equipment are used, power is supplied through the rack power control unit described in Section 1.

#### SPECIFICATION SHEETS

At present, this booklet does not contain specification sheets for every unit listed on page 2. Additional specification sheets are

being prepared, however, and will be distributed to all holding this report. Each sheet will have a section number in the top right-hand corner to facilitate insertion. If succeeding issues for the same equipment are necessary, the corrected sheets will bear a letter following the section number. Brief addenda or errata will be issued in memorandum form and given the same distribution.

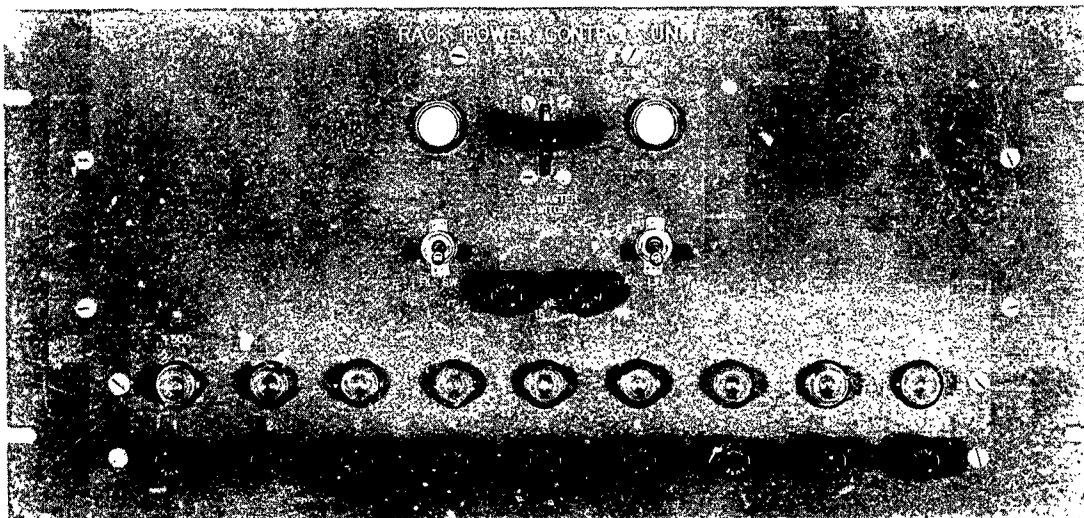
Signed

Robert R. Rathbone  
Robert R. Rathbone

Approved

Jay W. Forrester  
Jay W. Forrester

RACK POWER CONTROL UNIT  
(Model 2)



General Description

This unit provides 6.3 v a-c and a convenient means for switching all d-c power from the central supply to equipment mounted on a standard 19-inch relay rack. When fused properly, it prevents local short circuits or overloads from tripping the main circuit breakers, thereby allowing other racks to continue drawing power. In addition, the equipment has a time-delay relay which acts as a current-surge suppressor by shorting out series resistors in the +250 and +150 lines.

Specifications

Dimensions: 8 3/4 x 10 x 19 inches.

Input (rear chassis): D-C input from bench power box through a 12-pin male Jones plug.  
115-v, 60-cycle input through a flush motor plug.

Output (rear chassis): Standard d-c voltages (central power supply) to 4 female 12-pin Jones plugs.  
6.3 v a-c (40 amp) from 2 filament transformers (primaries tapped). Output from one through the 4 Jones plugs; output from the second (with center taps) brought out to 2 terminal strips.  
4 115-v a-c outlets on top rear of chassis.

Auxiliary Power: Filament Power Panel (Sect. 2) may be plugged into the 115-v a-c outlet marked "AUX. FIL" if additional filament power is needed.

+500 v may be fed into the unit through the Jones-plug input or a uhf coaxial jack (J2).

Maximum Loads: 2 amp for d-c voltages  
15 amp for 115 v a-c  
80 amp for 6.3 v a-c  
(80 amp additional with Fil. Power Panel)

Fusing (front panel):

- (1) D-C voltages - 3AG fuses up to 2 amp.
- (2) 115 v a-c - 4AG fuses, 15 amp, on both sides of line.

Controls (front panel):

- (1) Multi-contact D-C MASTER SWITCH.
- (2) Toggle Switch for a-c input, A-C LINE.
- (3) FIL. SWITCH, toggle switch controlling primary power to both fil. transformers and to 115-v a-c outlet, AUX. FIL.
- (4) Current-surge suppressor. Time-delay relay, energized by d-c master switch, cuts out series resistors in +250 and +150 lines. Optimum delay - 8 seconds.

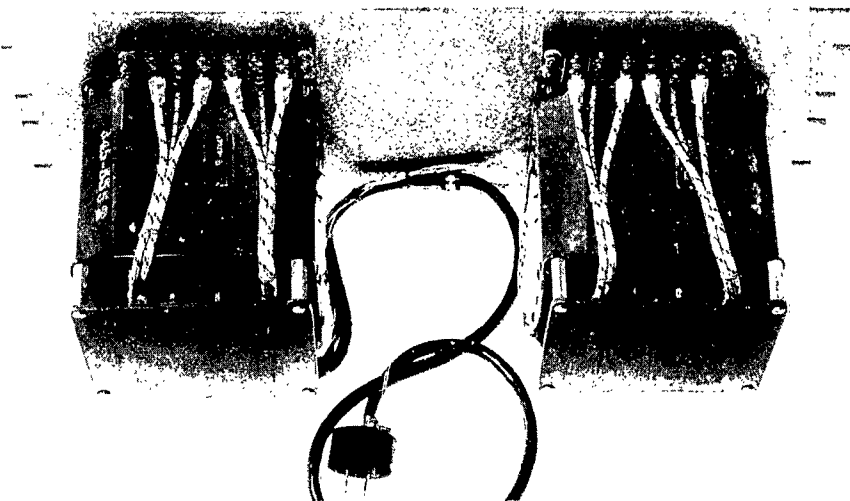
Indicators (front panel):

A-C line - Drake 60N Red Jewel  
Fil. - Drake 60N Green Jewel  
D-C (all)- NE51 neon lamps except -15 v, -30 v which use incandescent lamps.

#### References

Engineering Note E-118  
Circuit Schematic D-39467-1

FILAMENT POWER PANEL  
(Models 1 & 2)



General Description

This unit is used to supply auxiliary filament power when the amount from the rack power control unit is inadequate for test setups. It consists of two 40-amp filament transformers mounted on the rear of a panel. Model 1 is the same as Model 2 except that the transformers of the latter each have two center-tapped secondaries instead of four.

Specifications

Construction: Panel for rack mounting.

Dimensions: 8 3/4 x 19 inches.

Transformers: Two 40-amp, 6.3-v a-c filament transformers. Each transformer has two center-tapped 20-amp secondaries (Mod. 2), four center-tapped 10-amp secondaries (Mod. 1).

Input: 115-v a-c primary power from AUX. FIL. outlet on rack power control unit, controlled by fil. switch.

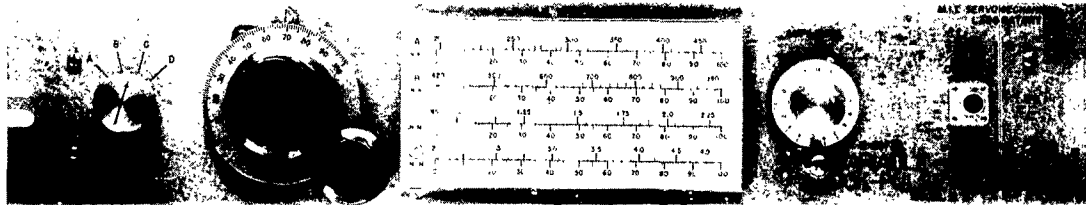
Output: Secondaries with center taps brought to Jones terminal strips on rear of panel. May be used in parallel to obtain more than 20 amp on one line.

References

Circuit Schematic B-39759 (Model 1)  
B-40127 (Model 2)

Engineering Notes E-117 (Model 1)

VARIABLE-FREQUENCY CLOCK-PULSE GENERATOR  
(Model 2)



General Description

This unit is a primary pulse source for test setups of gate tubes, flip-flops, matrices, bus drivers, control-line drivers, and other components. It is also a basic building block for complete systems and special tests, providing standard output pulses 0.1 microsecond long at a 93-ohm impedance level with frequencies variable from 0.2 to 4.9 megacycles.

Specifications

<u>Construction:</u>	Panel and chassis for standard rack mounting.
<u>Dimensions:</u>	$3\frac{1}{2} \times 5\frac{1}{2} \times 19$ inches.
<u>Circuits:</u>	6SN7 cathode-coupled oscillator. 6AG7 inverter. 6L6 R-L-C peaker. 6L6 buffer amplifier.
<u>Output:</u>	0.1- $\mu$ sec half-sine-wave positive pulses at 93-ohm impedance level.
<u>Amplitude Control:</u>	0 to 40 volts, control linear but not calibrated.
<u>Frequency Range:</u>	0.2 to 4.9 megacycles in 4 bands. Calibra- tion chart on front panel.

Frequency Stability: 20 parts in 1,000,000.

Power Requirements: (standard laboratory power supply)

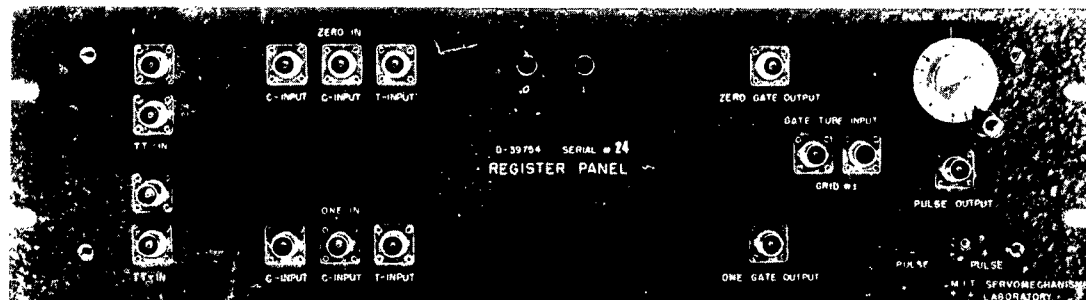
+250 v, 130 ma (maximum)  
-150 v, 1.3 ma  
6.3 v a-c, 3.05 amp

References

Circuit Schematic: B-39735-1  
Instruction Booklet: Report R-144  
Specification of Components: PL 39735



REGISTER PANEL  
(a-c coupled)



General Description

The register panel contains a d-c flip-flop, a gate tube a-c coupled through a cathode follower to one of the FF plates, two indicator circuits, a complementing input, and set and clear inputs (one input and zero input respectively). It provides two gate outputs from the flip-flop in addition to a gated-pulse output. The register panel is used for system mock-up, counting, synchronizing, and pulse distribution.

Specifications

Construction: Panel and chassis (5 x 5 $\frac{1}{2}$  x 19 inches).

Circuits: Trigger tube (7AD7) to pulse FF common cathode connection.  
Trigger-tube-input mixer (2 channels).  
0-input inverter ( $\frac{1}{2}$  6J6) to pulse FF grid.  
1-input inverter ( $\frac{1}{2}$  6J6) to pulse FF grid.  
2 inverter-input mixers (3 channels each).  
2 cathode followers from FF plates (each  $\frac{1}{2}$  5687).  
Gate tube (7AK7) a-c coupled to the 1 side of FF.  
Buffer amplifier (7AD7) for gated pulse.  
Indicator tube (6J6).  
2 R-C integrating circuits to indicator tube.

Input: Standard 0.1- $\mu$ sec half-sine-wave positive pulses -

- (a) To TT input.
- (b) To No. 1 grid of gate tube.

- (c) To the 0 inverter.
- (d) To the 1 inverter.

Input Amplitudes:

- (a) To trigger tube and FF -  
10 v min. (to obtain specified output amplitude range), 20 v max.
- (b) To gate tube -  
14 v min. (to obtain specified output amplitude range), 35 v max.

Resolution Time: 0.25  $\mu$ sec min. for trigger tube, and flip-flop.  
0.33  $\mu$ sec min. for gate tube.

Output: Gated pulse  
Half-sine-wave pulse, approx. 0.1  $\mu$ sec. Amplitude adjustable from 6 to 23 v. Polarity reversible. Minimum delay through gate circuit 0.06  $\mu$ sec.

Gates  
0 gate and 1 gate. Amplitude 22 v from cathode follower. Coupling to external gate tubes by coaxial cable. Rise and fall times 0.2  $\mu$ sec.

Visual Output  
0 and 1 neon indicator lamps (1/25 watt) to show content of FF.

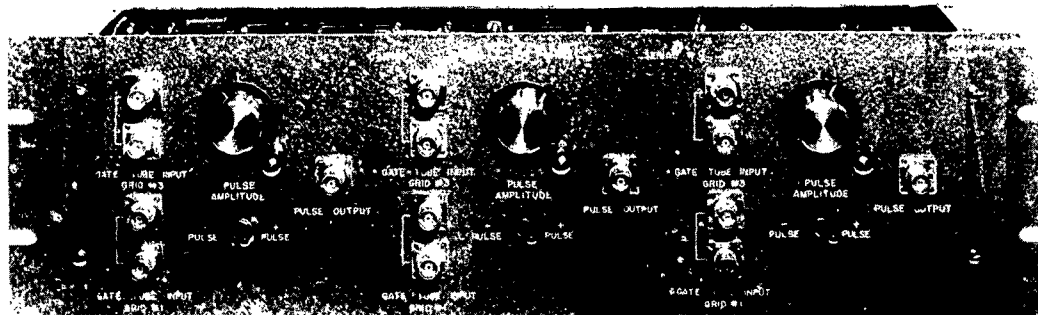
Power Requirements: (standard laboratory power supply)

+250 v,	4 ma	+ 90 v,	2.5 ma
+150 v,	120 ma	6.3 v a-c,	5 amp
+120 v,	7 ma	- 15 v,	36 ma

References

Block Schematic: A-39903-1  
Circuit Schematic: B-39754-1  
Instruction Booklet: Report R-145  
Specification of Components: PL 39754

GATE PANEL



General Description

The gate panel consists of three independent gate tubes and associated buffer amplifiers. The No. 3 grid of each gate tube is connected to paired jacks on the front panel so that externally generated gates can be utilized. The No. 1 grids also have paired input jacks for pulses to be gated. The polarity and amplitude of the output pulse can be selected by panel controls.

The gate panel was designed to provide auxiliary gate-tube circuits for the register panel (a-c or d-c). In applications where steady-state gate pulses are used, the gates can be obtained from the gate and delay unit.

Specifications

Construction: Panel and chassis for standard rack mounting.

Dimensions: 5 x 5½ x 19 inches.

Circuits: 3 7AK7 gate tubes.  
3 7AD7 buffer amplifiers.

Input: External gates  
Paired input jacks to the No. 3 grid of each 7AK7.  
0.1-microfarad coupling condenser extends lower repetition frequency range of gate.  
Switch for selecting input from a-c or d-c register panel.

Pulses to be gated

Paired input jacks to No. 1 grid of gate tube.  
Input pulse must be positive.

Input Amplitudes:

Min. 14 v, (to obtain specified output amplitude range) max. 35 v.

Output:Gated pulses

Each gate tube has a single output jack.

Polarity reversible.

Amplitude control in cathode of 7AD7, 6 to 23 volts.

Minimum Delay: (all sections) 0.06  $\mu$ sec.

Resolution Time: (all sections) 0.33  $\mu$ sec.

Power Requirements (all sections):VoltagesCurrent with  
no signalCurrent with  
1-mc clock pulses

+250 v

1.2 ma

17.0 ma

+150 v

1.5 ma

6.1 ma

+ 90 v

0.5 ma

8.3 ma

- 15 v

0

2.2 ma

6.3 v a-c

4.2 amp

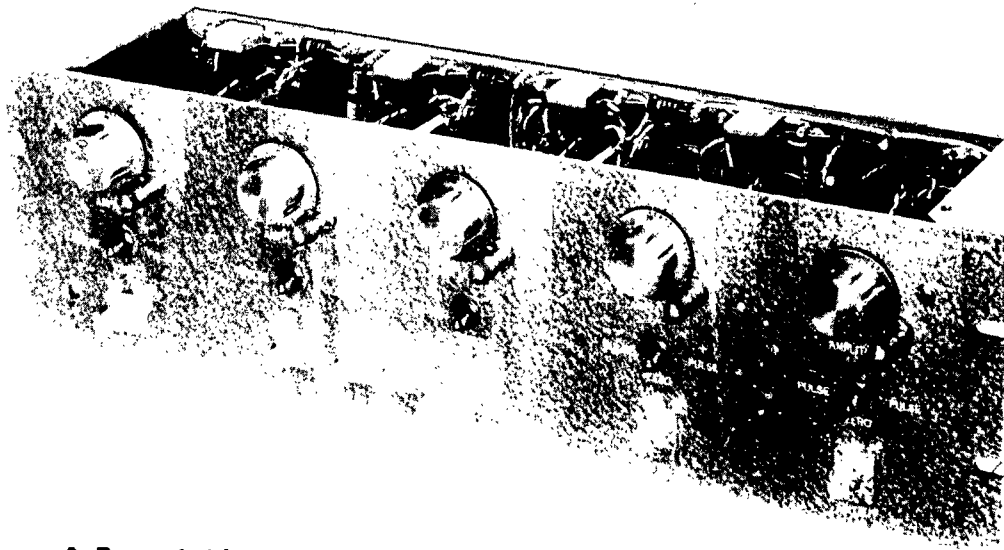
4.2 amp

References

Circuit Schematic: C-32496

Instruction Booklet: Report R-151

CODER



General Description

The coder is principally used for system testing and mock-up. Two of its functions have been to store binary numbers and to simulate the pulse-distribution element of control, i.e., reading numbers into arithmetic registers and presetting a step counter. It is also useful for feeding several units which may require different input amplitudes.

The coder will deliver up to five 0.1-microsecond half-sine-wave output pulses for a single input pulse. A three-position toggle switch at each output provides a positive pulse (position 1), zero output (position 2), and a negative pulse (position 3). The operator may then set up whatever five-digit binary code may be required for a specific operation.

Specifications

Dimensions: 4-1/2 x 5 x 19 inches.

Circuits: 6AG7 inverter.  
Two 6AG7's in parallel as an RLC peaker.  
Five 6AG7 buffer amplifiers.  
The inverter-peaker circuit is used as a pulse standardizing circuit with a resolving time of 0.5 microsecond for 0.1-microsecond pulses.

Input: Single input, paired jacks. Input pulse must be positive and have at least a 12-volt amplitude to obtain full range of output. Max. input 50 v.

Resolution Time: 0.5  $\mu$ sec (all sections).

Minimum Delay: 0.05  $\mu$ sec (through all sections).

Output: Five single output jacks. Each output has a 3-position toggle switch for positive and negative pulses, or zero output. Amplitude of each output variable from 4 to 19 volts.

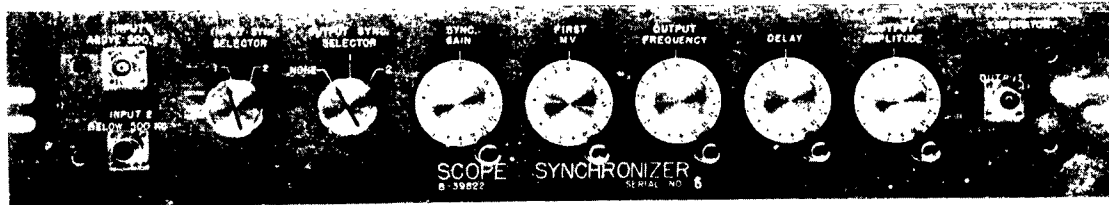
Power Required: (1-mc pulses, steady state):

<u>Voltages</u>	<u>Currents</u>	
	No Sig.	Signal
+250 v d.c.	4.7 ma	57 ma
+150 v d.c.	83 ma	70 ma
+120 v d.c.	20 ma	17 ma
- 15 v d.c.	0 ma	0.2 ma
6.3 v a.c.	5.2 amp	5.2 amp

References

Memorandum: M-440  
Circuit Schematic: D-32590

SCOPE SYNCHRONIZER



General Description

The scope synchronizer is used in conjunction with a synchroscope to view high-frequency pulse sequences. By dividing the high frequencies to some value between 0.5 and 30 kc, it produces positive pulses suitable for triggering the synchroscope. The unit provides two methods for adjusting the delay of its output pulses, and has a control for output amplitude.

Specifications

Construction: Panel and chassis

Dimensions:  $3\frac{1}{2} \times 5\frac{1}{2} \times 19$  inches.

Circuits: (all tubes type 5687).  
2 synchronized multivibrators.  
Delay multivibrator.  
R-L-C Peaker (output circuit).

Input: Input pulse must be positive, prf between 500 cycles and 6 megacycles. No. 1 input jack for frequencies above 500 kc. No. 2 jack for frequencies below 500 kc.

Output: Positive half-sine-wave pulse, 0.5  $\mu$ sec long. Amplitude variable from 0 to 175 volts. Output should be coupled with unterminated cables. Pulse may be delayed from 5-15  $\mu$ sec by either smooth delay control or sync delay (trailing edge of gate synchronous with an input pulse, delay in steps equal to time between pulses).

Power Requirements: (standard laboratory power supply)

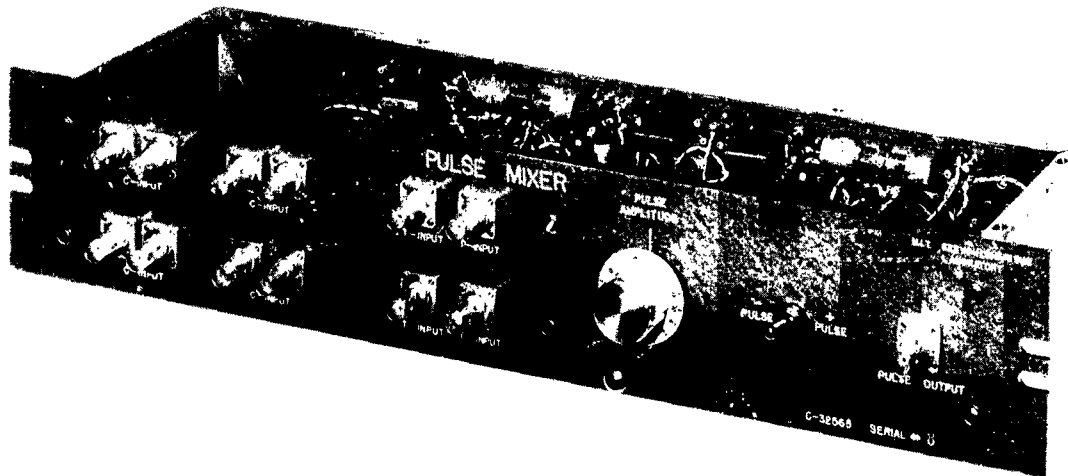
+150 v	96 ma
-150 v	1.3 ma
6.3 v a-c	3.6 amp

References

Circuit Schematic: B-39822  
Engineering Notes: E-126



PULSE MIXER



General Description

The pulse mixer can take pulses from as many as 8 external lines, mix them into a pulse standardizing circuit, and produce a single chain of standard pulses. A major use of the equipment is to mix numerous external pulses intended to trigger the same flip-flop.

Specifications

Construction: Panel and chassis.

Dimensions:  $3\frac{1}{2} \times 4\frac{1}{2} \times 19$  inches.

Circuits: 7AD7 inverter  
6AG7 RLC peaker  
6AG7 buffer amplifier  
The inverter-RLC peaker circuit is employed as a pulse standardizing circuit.

Input: 8 input channels mixed into 7AD7 inverter. 4 channels present high impedance and are provided with paired jacks to enable termination or continuance of incoming line. Remaining 4 channels utilize 3:1 step-up transformers so that the unit may be driven directly from gate tubes. Input pulses must be positive. Min. amplitude 12 volts to obtain full output range; max. amplitude 50 volts.

Resolution Time: 0.5  $\mu$ sec.

Output: Standard 0.1- $\mu$ sec output pulses. Pulse polarity reversible. Output amplitude variable from 12 to 35 volts.

Minimum Delay: (through unit) 0.08  $\mu$ sec.

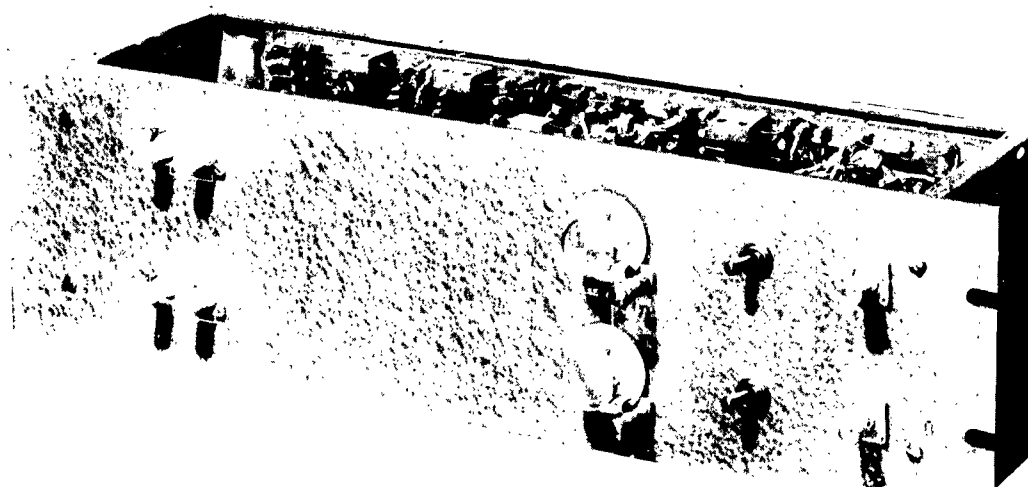
Power Requirements (1-mc pulses, steady state):

	<u>No Sig.</u>	<u>Signal</u>
+250	0.4 ma	16 ma
+150	47 ma	44 ma
+120	13 ma	12 ma
- 15	16 ma	16 ma
6.3 v a-c		1.9 amp

References

Circuit Schematic: C-32565-2  
Memorandum: M-458

PULSE STANDARDIZER



General Description

The pulse standardizer is used to convert positive pulses of different amplitudes and shapes to standard 0.1- $\mu$ sec half-sine-wave pulses whose amplitude and shape are independent of the input amplitude and shape. It is used to provide standard pulses for test equipment, computer components, and for making measurements on basic circuits. The unit is constructed in duplicate on a single panel and chassis.

Specifications

Dimensions: 4-1/2 x 5-1/2 x 19 inches.

Circuits: 5687/2 buffer amplifier  
5687/2 inverter  
6AG7 RLC peaker  
6AG7 buffer amplifier

Input (each unit): 2 parallel jacks.  
Input pulse must be positive, but  
amplitude may vary from 12 v min. to  
50 v max. Resolution time: 0.45  $\mu$ sec.

Output (each unit): Standard 0.1- $\mu$ sec pulse. Polarity  
reversible. Amplitude range 12 to  
35 volts, controlled by potentiometer  
in final buffer. Bus-driver crystal  
rectifier in output.

Minimum Delay (through each unit): 0.1  $\mu$ sec

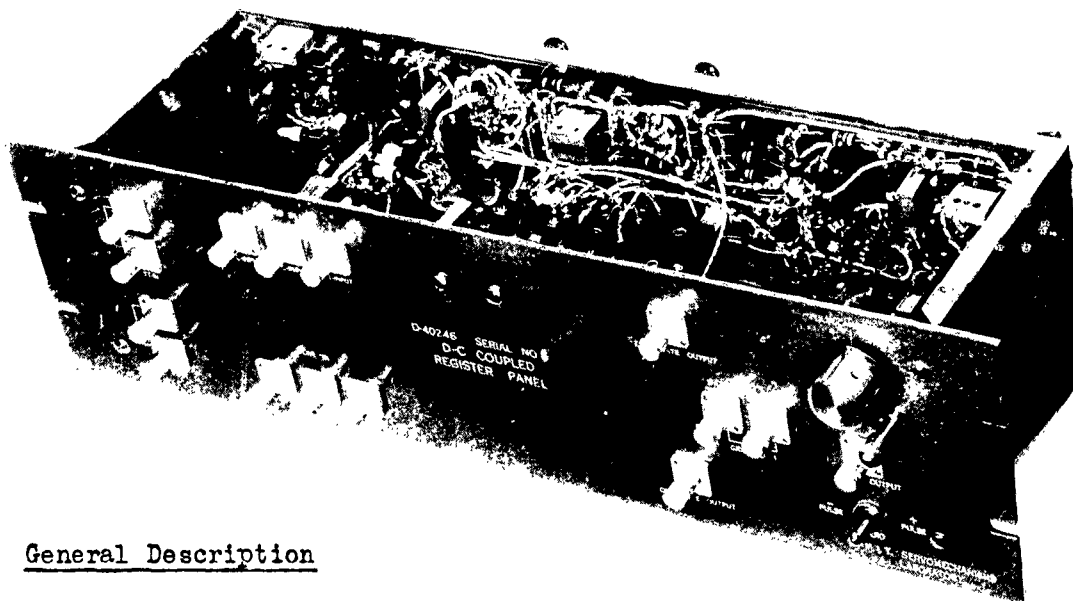
Power Requirements (both units):

<u>Voltages</u>	<u>Currents</u>	
	No Sig.	1-mc pulse
+250 v d.c.	1.75 ma	25 ma
+150 v d.c.	105.0 ma	175 ma
- 15 v d.c.	30 ma	30 ma
6.3 v a.c.	4.4 amp	4.4 amp

References

Circuit Schematic: C-33001

REGISTER PANEL  
(D-C Coupled)



General Description

The d-c coupled register panel contains a flip-flop, a gate tube d-c coupled to the flip-flop through a buffer amplifier, and associated circuits. In appearance, it closely resembles the a-c coupled register panel described in Section 4. Functionally, it can be put to more general use, differing from the a-c model in that its flip-flop can remain in either the 0 or 1 position for any length of time. This important characteristic, made possible by the d-c coupling between flip-flop and gate tube, eliminates the need for complementing the flip-flop periodically with pairs of restorer pulses, as is required when the a-c model is used at low frequencies.

Specifications

Construction: Panel and chassis.

Dimensions: 5 x 5 1/2 x 19 inches.

Circuits: Trigger tube 6J6 (both halves in cascade as an inverter-limiter).  
Trigger-input mixer (2 channels).  
0-input inverter (1/2 6J6).  
1-input inverter (1/2 6J6).

Two inverter-input mixers (3 channels each).  
Flip-flop (2 6AN5's).  
Two 6AN5 buffer amplifiers for flip-flop.  
Gate tube (7AK7).  
Buffer amplifier (7AD7).  
Indicator tube (6J6).

Input: 0.1- $\mu$ sec half-sine-wave positive pulses:

- (a) To TT input (2 mixer channels).
- (b) To No. 1 grid of gate tube.
- (c) To the 0 input)
- (d) To the 1 input) 3 mixer channels each.

FF Resolution Time: 0.33 microsecond (minimum).

Output: Output pulse from gate tube:

Half-sine-wave, approx. 0.1 microsecond.  
Amplitude adjustable from 8 to 30 volts.  
Polarity reversible.

Gate from Flip-Flop:

0-gate and 1-gate outputs.  
Amplitude 20 volts.  
Will feed 93-ohm unterminated line.

Visual Output:

0 and 1 neon indicator lamps to show state  
of flip-flop. External terminals provided  
for remote indicator lights.

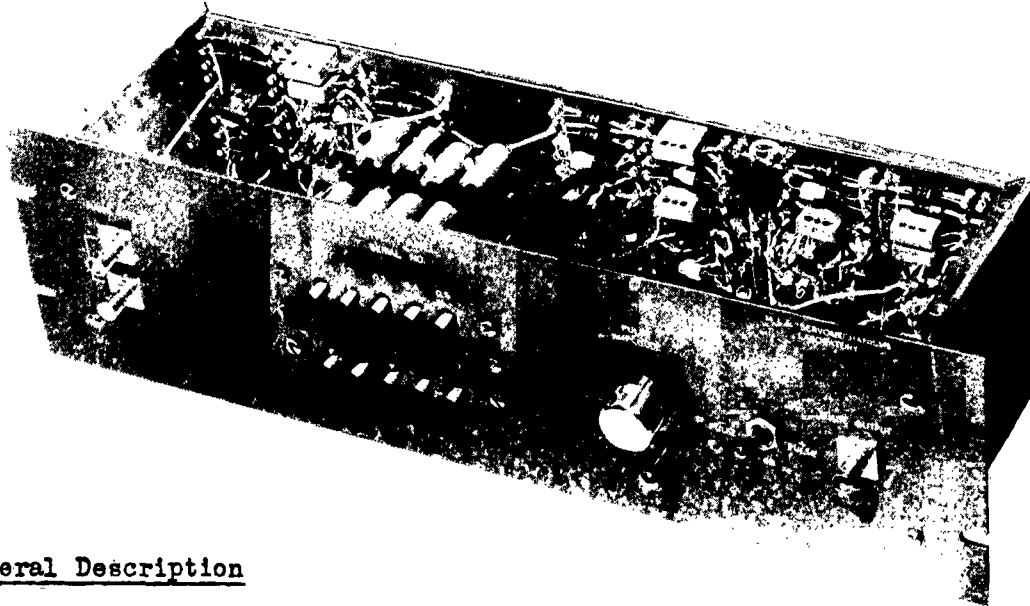
Power Requirements:

<u>Voltages</u>	<u>Currents</u>	
	No Sig.	1-mc input to TT
+250 v d.c.	2 ma	2 ma
+150 v d.c.	14 ma	20 ma
+ 90 v d.c.	0 ma	0 ma
-150 v d.c.	125 ma	112 ma
- 15 v d.c.	56 ma	55 ma
6.3 v a.c.	4.75 amp	4.75 amp

References

Instruction Booklet: Report R-171  
Circuit Schematic: D-40246

DELAY LINE PANEL



General Description

The delay line panel is used to delay 0.1-microsecond pulses, in steps of 0.1 microsecond, up to a maximum of 1 microsecond. External terminals are provided for adding extra delay lines.

Specifications

Dimensions: 4 1/2 x 5 1/2 x 19 inches.

Delay: 9 delay lines, each 0.1  $\mu$ sec.  
Inherent delay of unit 0.1  $\mu$ sec.  
Terminals on rear of chassis for additional delay lines.

Circuits: 6AG7 input buffer amplifier.  
9 delay lines, each 0.1  $\mu$ sec 1100 ohms, can be switched in series.  
1/2 5687 buffer amplifier.  
1/2 5687 inverter.  
6AG7 R-L-C peaker.  
6AG7 output buffer amplifier.

Input: Positive 0.1- $\mu$ sec half-sine-wave pulse.  
Minimum pulse amplitude 8 volts.  
Resolution time of equipment 0.45  $\mu$ sec.

Output: 0.1- $\mu$ sec pulses, polarity reversible,  
amplitude variable up to 36 volts with a  
15-volt input pulse. Output circuit is  
transformer coupled to match 93 ohms.

Power Requirements:

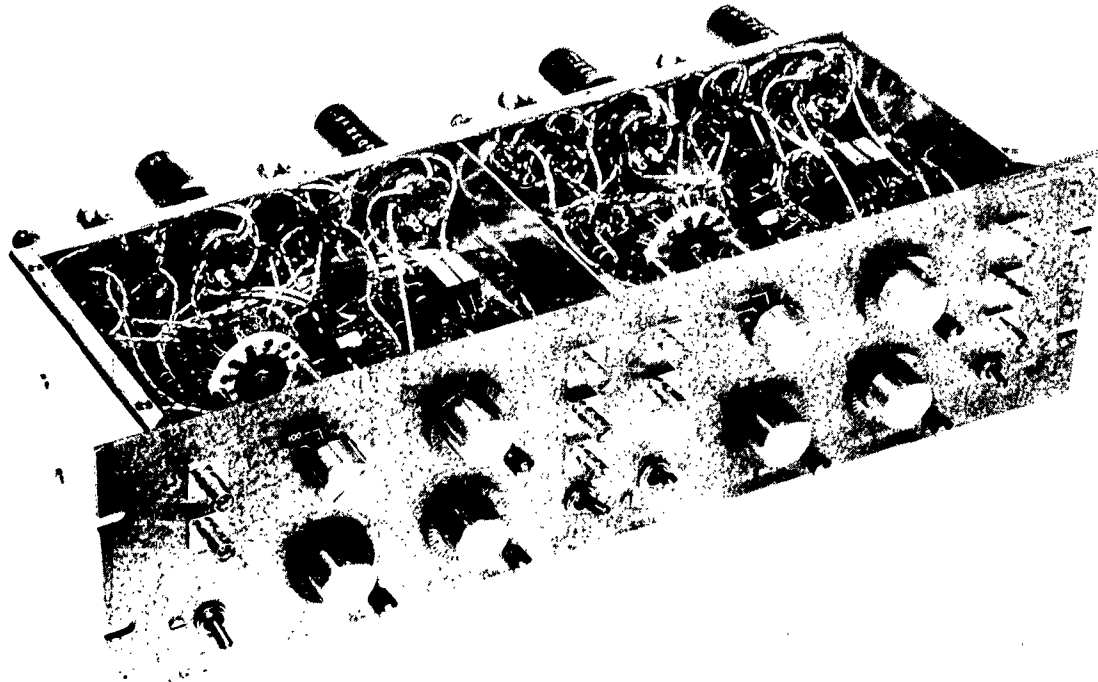
<u>Voltages</u>	<u>Currents</u>	
	No Sig.	I-mc input
- 15 v d.c.	28 ma	25 ma
+120 v d.c.	11 ma	11 ma
+150 v d.c.	46 ma	62 ma
+250 v d.c.	9 ma	29 ma
6.3 v a.c.	2.85 amp	2.85 amp

References

Photograph: F-689  
Circuit Schematic: D-40307



THE GATE AND DELAY UNIT



General Description

The purpose of the gate and delay unit is to provide a test equipment building block which can supply a gate pulse, a delayed pulse, or both, to external test blocks or complete systems.

Specifications

Dimensions: length - 19 inches  
width - 5 1/2 inches  
depth - 6 1/4 inches

Circuits (duplicate sections): 6AX5 trigger tube.  
1/2 5687 delay multivibrator.  
6L6 cathode follower.  
6L6 R-L-C peaker.  
6L6 buffer amplifier

Input (each section): 0.1-μsec half-sine-wave positive pulses of at least 20 volts amplitude.

Output (each section): Unclipped gate:  
Amplitude +40 volts.  
Rise time 0.2 μsec.  
Fall time 0.1 μsec.

Clipped gate -

Rise time 0.3  $\mu$ sec.

Fall time 0.1  $\mu$ sec.

Gate length continuously variable from 0.5  $\mu$ sec to 2500  $\mu$ sec in four overlapping ranges.

Delayed (output) pulse:

0.1-μsec half-sine-wave pulse across a 93-ohm impedance.

Pulse amplitude is continuously variable from 0 to approximately 40 volts.

Polarity reversible.

Delay time equal to gate length.

Resolution Time: For coarse delay setting of 10  $\mu$ sec: 1  $\mu$ sec.

50  $\mu\text{sec}$ : 2  $\mu\text{sec}$ .

450  $\mu\text{sec}$ : 10  $\mu\text{sec}$ .

2500  $\mu\text{sec}$ : 70  $\mu\text{sec}$ .

**Power Requirements:** (both sections)

<u>Voltages</u>	<u>Currents</u>	
	No Sig.	4-kc Signal
+250 v d.c.	115 ma	110 ma
+150 v d.c.	220 ma	195 ma
-150 v d.c.	8.5 ma	8.5 ma
6.3 v a.c.	7.55 amp	7.55 amp

### Voltage Regulation:

The voltages of the multivibrator are filtered sufficiently to allow operation with an unregulated power supply which is reasonably stable.

Any low-frequency variations, of the order of 5 cps, in the power supply will change the delay time of the unit.

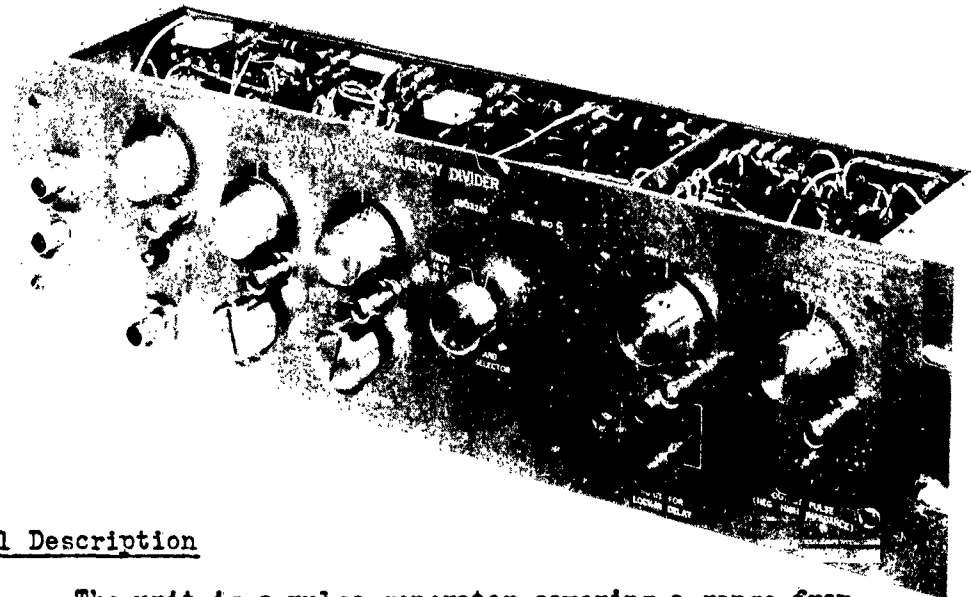
## References

Engineering Note: E-121

Circuit Schematic: D-37148

Photograph: F-679

MULTIVIBRATOR FREQUENCY DIVIDER



General Description

The unit is a pulse generator covering a range from 200 kc to 60 cps and which may be synchronized with any frequency equal to or greater than the output frequency. Two output pulses are provided: one a standard 0.1- $\mu$ sec pulse, the other a high-impedance negative pulse used to trigger a synchroscope.

Specifications

Dimensions: 5 1/4 x 6 x 19 inches, for rack mounting.

Circuits: 2 input pulse amplifiers (each 1/2 5687).  
High-freq. multivibrator (5687).  
Low-freq. multivibrator (2051).  
Pulse generator for 0.1- $\mu$ sec pulses (1/2 5687).  
Delay multivibrator (5687).  
Output amplifier for 0.1- $\mu$ sec pulses (6AG7).  
Output amplifier for high-impedance pulses (1/2 5687).

Input to Dividers: Input pulses - positive, 0.1  $\mu$ sec or longer.  
Pulse amplitude - 15 v min.  
PRF - 60 cps to approx. 5 mc.  
Multivibrator ranges overlap between 2.5-3 kc.

Input to Lock-in Delay: For synchronized delay, positive pulses may be fed to this input. These are amplified and fed to the delay multivibrator.

Standard Pulse Output: 0.1- $\mu$ sec half-sine-wave pulses, polarity reversible; amplitude adjustable up to 25 v when output feeds a 93-ohm terminated line.

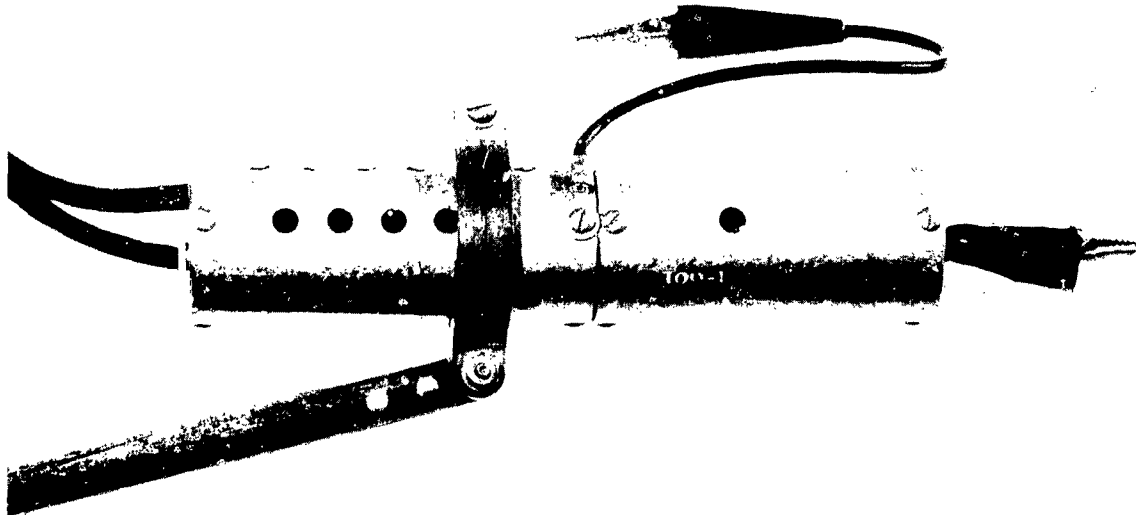
Output Pulse (Neg. High Impedance): 0.2- $\mu$ sec leading edge, amplitude adjustable up to 100 volts. Will drive an unterminated 93-ohm line of reasonable length. Occurs at the end of a delay interval variable from 5 to 100  $\mu$ sec.

Power Requirements: +250 v d.c. at 115 ma  
+150 v d.c. at 6.4 ma  
-150 v d.c. at 8.4 ma  
6.3 v a.c. at 4.5 amp

References

Engineering Note: E-281  
Circuit Schematic: D-33285  
Photograph: F-1301

VIDEO PROBE



General Description

The video probe is used in conjunction with a video amplifier and synchroscope to permit pulse measurement and observation. It is designed to feed a terminated cable having a characteristic impedance of 93 ohms. The cable may be up to 100 feet in length without introducing reflections.

Specifications

- Construction: The probe is 7 inches long and 1 1/2 inches in diameter, and has two sections: the attenuator and cathode follower. Each section is encased in brass tubing to provide shielding against hand capacitance and pickup of stray voltages. A "unipod" overcomes the difficulty of using the probe to test a vertical panel.
- Input: Signal amplitude  $\pm 1.8$  volts max.,  $\pm 0.15$  volt min. (both determined by video amplifier).
- Gain: Approximately 1/3.

Circuits:

The cathode-follower circuit has a high-frequency response usable to 50 megacycles, an input impedance level of 10 megohms within the usable range, and an output impedance of 93 ohms. A type CS-968 sub-miniature triode was selected because of the tube's small size, high mutual conductance, and high dissipation ratings. Since the tube overloads at voltages greater than 1 or 2 volts at the input, plug-in attenuators are provided so that a wide range of input voltages can be accommodated. These attenuators include 10:1, 30:1, and 100:1 types; all have input impedance representable by a resistance of 10 megohms shunted by a capacitance of 2 to 8 micromicrofarads.

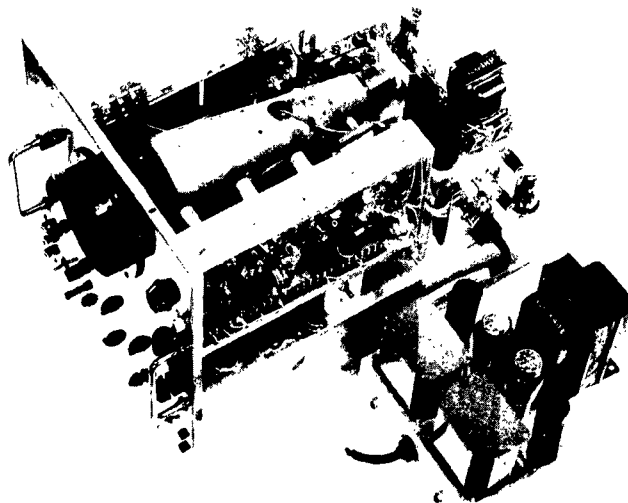
Power Supply:

If the probe is used near its video amplifier and synchroscope, power is obtained from a supply mounted on the synchroscope chassis; if it is used at a remote distance from the synchroscope and amplifier, a portable power supply is available. Voltages used are +75 v d.c. and 6.3 v a.c.

References

Instruction Manual:	R-164
Circuit Schematic:	B-33328
Power Supply Schematic:	B-33410
Attenuator Schematic:	B-33401

VIDEO AMPLIFIER



General Description

The video amplifier is a wide-band amplifier constructed to fit inside the cabinet of a commercial synchroscope. It is used with a video probe and synchroscope to permit pulse measurement and observation.

Specifications

Circuits: First stage - input amplifier (6AH6).  
Second stage - push-pull phase inverter (2-6AH6's).  
Third stage - push-pull amplifier (2-6AH6's).  
Fourth stage - push-pull driver amplifier (2-6AH6's).  
Fifth stage - push-pull final amplifier (829-B).

Design Characteristics:

Frequency response: +1 db: 25 cps to 20 mc.  
-3 db points: 17 cps and 28 mc.

Transient and test response:

Amplifier rise time (from 10 to 90%) 0.013  $\mu$ sec.  
Maximum square-wave droop: 5% in 600  $\mu$ sec.  
Half-sine-wave pulse 0.07  $\mu$ sec long decreased  
in amplitude 5%.

Input:

Input-signal amplitude approximately 0.05 peak-to-peak volt minimum (depending on vertical sensitivity of scope tube); approximately 0.6 peak-to-peak volt maximum (depending on linearity requirements).

Input circuit:

33,000 ohms shunted by 17- $\mu$ f stray capacitance. Grid coupled to 1- $\mu$ f 200-volt condenser. Probe cable is terminated by a 25-ohm gain-control potentiometer in series with a 68-ohm resistor.

Output:

Output voltage 120 to 150 peak-to-peak volts.  
Over-all gain 45 db.

Power Supply:	<u>Voltages</u>	<u>Currents</u>
	-225 v d.c.	230 ma
	+180 v d.c.	200 ma
	6.3 v a.c.	6 amp
	6.3 v d.c.	450 ma

Construction:

Mounting:

Chassis, 5 x 6 x 14 inches, mounted vertically, one end flush to synchroscope panel. Wiring is accessible for testing.

Power supply:

Constructed on separate chassis, not mounted inside synchroscope cabinet. Connected to amplifier by power cable; unregulated.

Controls:

Amplifier: input jack and gain control located on synchroscope panel.

Power Supply: on-off switch mounted inside synchroscope. If this switch is left on, a-c power may be controlled by the synchroscope on-off switch.

References

Instruction Manual:	R-164
Amplifier Circuit Schematic:	B-33501
Power Supply Circuit Schematic:	B-33357