INSTRUCTION MANUAL

Type 1191-Z
COUNTER

GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS 01781

INTRODUCTION

There are two versions of the 1191-Z Counter; 100 MHz and 500 MHz. The 100-MHz version is a combination of the 1191 Counter and a 10:1 frequency divider (the 1156 Decade Scaler) and the 500-MHz version is a combination of the 1191 Counter and a 100:1 frequency divider (the 1157 Scaler). Both versions provide all the features of the counter alone plus the extra benefits of higher-frequency operation and both versions are available in either bench-mount or rack-mount configurations.

Description	*Catalog Number*
1191-Z Counter (100-MHz), bench model	1191-9900
1191-Z Counter (100 MHz), rack model	1191-9901
1191-Z Counter (500 MHz), bench model	1191-9902
1191-Z Counter (500 MHz), rack model	1191-9903

Condensed information for the 1191-Z Counter is given on the next four pages. Complete information is contained in the instruction manuals for the individual instruments as follows:

	1191-Z (100 MHz)		1191-Z (500 MHz)	
	*1156 Decade Scaler page	1191 Counter page	**1157 Scaler page	1191 Counter page
Introduction	1	1-1	1-1	1-1
Installation	7	2-1	2-1	2-1
Operation	13	3-1	3-1	3-1
Principles	17	4-1	4-1	4-1
Maintenance	25	5-1	5-1	5-1
Parts and Diagrams	29	6-1	6-1	6-1

*Included with instructions for the 1191-Z Counter (100-MHz) only.
**Included with instructions for the 1191-Z Counter (500-MHz) only.

1191 Counter

CONTENTS

NOTE: This instrument is equipped with our new snap-on knob for added convenience and safety. Refer to the Service Section for details.

Type 1191 COUNTER

C

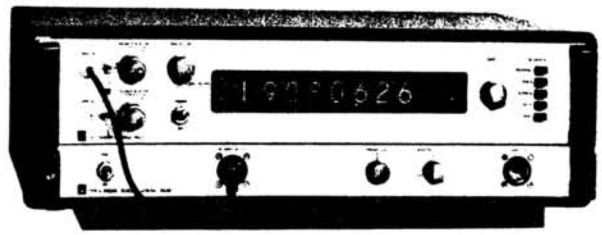
RWF-WBR-Anco

ID-B730 JULY 1968

Form 1191-0100C GENERAL RADIO COMPANY
West Concord, Mass., USA

100-MHz COUNTER DESCRIPTION

This is condensed information. Further details are contained in the instruction manuals for the individual instruments.



Bench model 1191-Z Counter (100 MHz).

CHARACTERISTICS

Frequency range .... Dc to 100 MHz
Input impedance .... 50Ω or 500Ω
Sensitivity .... 30 mV rms, 100 mV pk-pk
Maximum input ....

SENSITIVITY control setting	Maximum Inputs Dc	Pulse, peak	Sinewave, rms
0.1V	±2V	±2V	1.4V
0.2V	±4V	±4V	2.8V
0.5V	±5V	±10V	5V
1.0V	±5V	±20V	5V
1.0V (500Ω)	±15.8V	±20V	14V

The 1191-Z Counter (100 MHz) consists of an 1156 Decade Scaler, whose output frequency is one tenth of the input frequency, and an 1191 Counter, whose input is the divided-down output from the scaler. The conbination forms a general-purpose,dc-to-100-MHz,counter-timer for the measurement of frequency, period, period average, frequency ratio, time interval, and number of events. It provides an eight-digit visual register with automatic display of measurement dimensions and incorporates an internal storage feature that allows continuous correction of data without flicker.

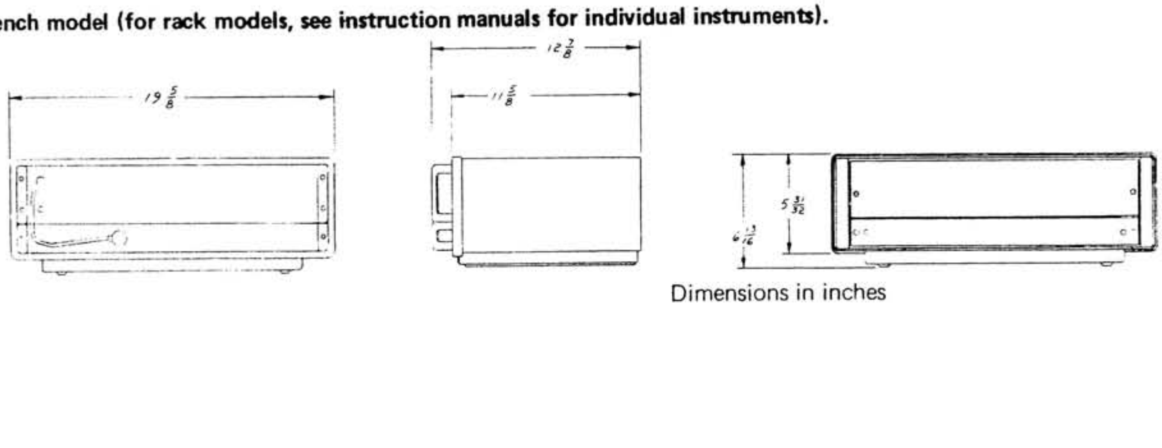
ACCESSORIES SUPPLIED

All of the accessories supplied with the individual instruments are included with the 1191-Z, plus the following:

Quantity	*Description*	*GR Part Number*
1	Instruction sheet	1191-0120
1	Cable assembly, GR874® to BNC	0874-2710
1	Bench-cabinet assembly (supplied with bench-model counter in lieu of bench cabinets for each instrument)	4177-1191

DIMENSIONS

Bench model (for rack models, see instruction manuals for individual instruments).



Dimensions in inches

1 SPECIFICATIONS

MEASUREMENT RANGES AND ACCURACY

Frequency: Dc to 20 MHz; 1-μs to 10-s counting gate times. Accuracy, ± 1 count ± time-base accuracy.

Single Period: 1 to 10^9 s measured by counting 0.1-μs to 10-s intervals derived from internal 10-MHz clock. Accuracy (see note).

Multiple Period: 1 to 10 periods measured by counting internal 10-MHz clock. Accuracy, (see note).

Time Interval: 0.1-μs to 10 s measured by counting 0.1-μs to 10-s intervals derived from internal 10-MHz clock. Accuracy (see note). Interval is measured between "start" and "stop" signals driving the input channels independently, or from a single signal with common connection between channels, as for pulse-duration measurements.

Frequency Ratio: 1 to 10^8. Frequency "A", dc to 20 MHz, is measured over 1 to 10^8 periods of frequency "B", dc to 10 MHz. Accuracy, ±1 count of "A" ± trigger error divided by number of "B" periods.

Count: Register capacity, 10^8. Events are accumulated between "start" and "stop" commands from manual panel buttons or, externally, from contact closures or solid-state switches. In "count", storage is automatically disabled.

INPUT

Frequency: Channel "A", dc to 20 MHz (3 Hz to 20 MHz ac-coupled); channel "B", dc to 10 MHz (3 Hz to 10 MHz ac-coupled).

Sensitivity: 10 mV rms sine wave, 30 mV pk-pk pulse; trigger level variable ± 100 mV.

Attenuator: x1, x10, x100 (0, 20, 40 dB); low-capacitance 10:1 probe available.

Voltage Rating: Input voltage should not exceed 150 V on x1 or 300 V on x10 or x100.

Impedance (all attenuator settings): Approx 1 MΩ shunted by 35 pF. At rear connectors (supplied mounted, unwired), shunt C increases to approx 70 pF.

Signal Polarity: Front-panel control permits selection of positive- or negative-going signal sense for triggering.

10-MHz TIME-BASE OPTIONS

Room-Temperature Oscillator

Stability: $< 2 \times 10^{-7}/{}^\circ C$ from 0° to $50^\circ C$. Drift less than $\pm 2 \times 10^{-6}$ per month. With ± 10% line-voltage variation, $< 2 \times 10^{-8}$.

Manual Adjustment Range: $\pm 1 \times 10^{-5}$ at rear-panel control.

High-Precision Oscillator (in proportional-control oven)

Stability: $< 2 \times 10^{-10}/{}^\circ C$ from 0° to $50^\circ C$ when operated continuously. Drift $\pm 1 \times 10^{-8}$ per week, approx 2×10^{-9} per day after 1 month of continuous operation. With ± 10% line-voltage variation, $< 2 \times 10^{-10}$

Manual Adjustment Range: $\pm 1 \times 10^{-6}$ at rear-panel control.

Time-Base Output: 10-MHz square wave, 2 V pk-pk behind 50 Ω at rear-panel BNC connector.

External Phase-Lock: Both time-base oscillators can be locked to external standard frequency at 0.1, 1, 2.5 5, or 10 MHz, of at least 1 V rms into 1 kΩ. A front-panel phase-lock indicator lamp is provided.

NOTE – Error in time meausrements: ± 0.3% of one period ÷ number of periods averaged, for a 40-dB input signal-to-noise ratio. This assumes no noise internal to the counter. For input signals of extremely high signal-to-noise ratio, the trigger error in μs will be < 0.0005 ÷ the signal slope in V/μs. Time measurements, in addition, are subject to the ± 1 count and time-base accuracy statements.

DATA PRESENTATION

Display: 8-digit display with automatically positioned decimal point and measurement dimensions. High-intensity neon readout tubes.

Storage: Display can be either stored or not. Operator can select from approx 100 μs to 10 s or infinity for display time (in normal mode) and for data holdoff time (in storage mode).

Data Output (in some models): Fully buffered 1-2-4-8 BCD output at standard DTL levels; data zero is 0.5 V max and data 1 approx 5 V behind 6 kΩ.

PROGRAMMING

Input: All instrument functions controllable by closure to ground within capabilities of DTL micrologic (2- to 6-mA sink current required), except:

PERIOD and TIME INTERVAL require approx 50-mA-capacity external closures for added load of dimension-display lamps.

Functions controlled by other than contact closure:
Input Threshold: Requires dc voltage of ± 100 mV corresponding to desired threshold level.

Display Time: Requires RC circuit to ground. Display/hold-off interval is approx one RC time constant.

Nonprogrammable functions: Input attentuator, input ac/dc coupling, separate/common switch, self-test, internal/external control of time-base oscillator, and frequency adjustment of time-base oscillator.

GENERAL

Environmental: Instrument operating range 0° to 50° C ambient air

Power Required: 100 to 125 or 200 to 250 V, 50 to 400 Hz, 32 W.

Accessories Supplied: Rack-mounting hardware set, power cord, spare fuses.

Accessories Available: Input probe, 1156 Decade Scaler for measurement to 100 MHz; 1157 Scaler (100-to-1) for measurement to 500 MHz; 1137 Data Printer, and other GR digital-data acquisition equipment.

Dimensions (width x height x depth): Bench model, 19 x 3-7/8 x 12-3/4 in. (485 x 99 x 325 mm); rack model, 19 x 3-1/2 x 11 in. (485 x 89 x 280 mm).

Net Weight (approx): 22 lb (10 kg).

SPECIFICATIONS – FOR INPUT PROBE – 1158-9600

Input Impedance: 10 MΩ shunted by approx 7 pF when used with 1191 counter.

Attenuation: X10 (20 dB).

Voltage: 600 V dc or ac pk-pk, max up to 5.7 MHz; less at higher frequencies.

Length: 3-1/2 ft.

Catalog Number	Description
	1191 Counter
1191-9700	Bench Model
1191-9701	Rack Model
1191-9702	Bench Model with Data Output Option
1191-9703	Rack Model with Data Output Option
1191-9704	Bench Model with High-Precision Time-Base Option
1191-9705	Rack Model with High-Precision Time-Base Option
1191-9706	Bench Model with both Options
1191-9707	Rack Model with both Options
1158-9600	P6006 Probe, Tektronix Catalog No. 010-0127-00 (not sold separately)

U. S. Patent number 3,328,564
GR Experimenter Nov-Dec 1967

2 CONDENSED OPERATION

Referenced paragraphs contain unabridged information.

CAUTIONS

Do not exceed maximum signal input ratings (150V on X1 or 300V on X10 or X100 without probe, 600V with probe).
Be sure line switch on rear of instrument is set for proper line voltage.
Turn off power before removing or replacing etched boards.

INPUT CHARACTERISTICS (3.4.1)

Frequency	INPUT A INPUT B	Dc coupled: dc to 20 MHz Dc coupled: dc to 10 MHz		Ac coupled: 3 Hz to 20 MHz Ac coupled: 3 Hz to 10 MHz	
Levels	POLARITY & ATTEN setting	*Without Probe*		*With Probe*	
		minimum	*maximum*	*minimum*	**maximum*
	EXT PRO	10mV rms, 30mV pk-pk	150Vdc or ac pk-pk	100mV rms, 300mV pk-pk	600Vdc or ac pk-pk
	1	10mV rms, 30mV pk-pk	150Vdc or ac pk-pk	100mV rms, 300mV pk-pk	600Vdc or ac pk-pk
	10	100mV rms, 300mV pk-pk	300Vdc or ac pk-pk	1V rms, 3V pk-pk	600Vdc or ac pk-pk
	100	1V rms, 3V pk-pk	300Vdc or ac pk-pk	10V rms, 3V pk-pk	600Vdc or ac pk-pk
Impedance		1MΩ shunted by 35pF		10MΩ shunted by 7pF	

* Less over 4.5 MHz: 500V at 5.5 MHz, 400V at 7 MHz, 300V at 9 MHz, 200V at 14 MHz, and 100V at 25 MHz.

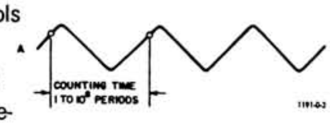
CONTROL SETTINGS

Signal connection	**INPUT A**	(3.4.2) Connect second signal to INPUT B for INTERVAL and RATIO measurements.
AC-DC	**AC**	(3.4.2, 3.4.3) Set to DC for very-low-frequency signals.
POLARITY & ATTEN	**+1**	(3.4.2, 3.4.3) Set POLARITY to - if it is desired to trigger on negative slopes. Set ATTEN to 10 or 100 for noisy signals or signals that exceed 150Vdc or ac pk-pk.
THRESHOLD	**centered**	(3.4.2, 3.4.3) Set cw or ccw (+ or -) when the input signal contains a dc component and the AC-DC switch is set to DC.
SEPARATE – COMMON	**SEPARATE**	(3.4.2) Set to COMMON for duration measurements.
DISPLAY TIME	**100μs to 10 SEC or SINGLE MEASURE**	(3.5) Set to 100μs through 10 SEC for automatically initiated measurements. Set to SINGLE MEASURE for manually initiated measurements (push SET 0 button to initiate measurement).
SET 0	**push to set zero or initiate measurement**	(3.5) With no input signal, push to set zero. With an input signal, push to initiate a new measurement.
SET 9	**push and hold to set nine**	(3.5) Push during a measurement (COUNTING lamp lit) and hold in until measurement is complete (COUNTING lamp extinguished) to set nine.
RANGE	**10^4 for FREQUENCY or 1 for PERIOD or 1 for INTERVAL or 10 for RATIO or — for COUNT**	(3.6) These initial settings provide either the maximum display capacity to prevent an accidental spill or a reasonable measurement time for most normally encountered signals. After the first measurement, the RANGE switch can be set as desired.

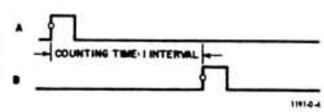
MEASUREMENTS

Frequency (3.7). Frequency can be measured from dc to 20 MHz with a resolution of up to 0.1 Hz. Push the FREQUENCY button, set the RANGE and DISPLAY TIME controls as desired, connect the signal to INPUT A, and set the input controls to obtain a measurement.

Period (3.8). Signal periods can be measured from 100ns to 1Gs with a resolution of up to 100ns. *For periods less than 10s:* Push the PERIOD button, set the RANGE and DISPLAY TIME controls as desired, connect the signal to INPUT A, and set the input controls to obtain a measurement. *For periods greater than 10s:* Push the INTERVAL button, set the RANGE and DISPLAY TIME controls as desired, connect the signal to INPUT A, and set the input controls to obtain a measurement.

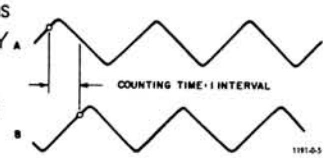


Interval (3.9). The time interval between two signals can be measured from 100ns to 1Gs with a resolution of up to 100ns. Push the INTERVAL button and set the RANGE and DISPLAY TIME controls as desired. Connect the first signal to INPUT A, connect the second to INPUT B, and set the input controls to obtain a measurement.

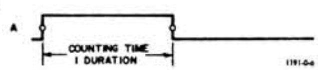


Phase (3.10). The phase difference between two signals can be measured indirectly from 0 to 360°. Push the INTERVAL button, set the RANGE control to 1, and set the DISPLAY TIME control as desired. Connect the reference signal to both INPUT A and INPUT B, set the A and B POLARITY & ATTEN controls to the same settings, and set the other A and B input controls to obtain a measurement. Use the THRESHOLD controls to zero the reading (set the visual register to within ± 1 count of zero). Disconnect the reference signal from INPUT B and connect the second signal in its place (do not disturb the settings of the input controls), and compute the phase angle from:

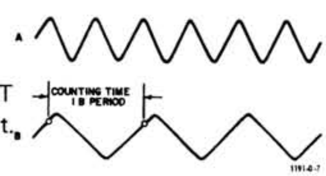
$$\Phi = \frac{\text{interval}}{\text{signal period}} \times 360°$$



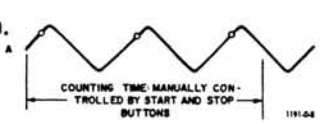
Duration (3.11). Pulse durations can be measured from 100ns to 1Gs with a resolution of up to 100ns. Push the INTERVAL button and set the RANGE and DISPLAY TIME controls as desired. Connect the signal to INPUT A and set the SEPARATE – COMMON switch to COMMON. *For positive pulses,* set the A POLARITY to + and the B POLARITY to -; *for negative pulses,* set the A POLARITY to - and the B POLARITY to +. Set the other input controls to obtain a measurement.



Ratio (3.12). The frequency ratio of the signal applied to INPUT A with respect to the signal applied to INPUT B can be measured to 10^8:1 with a resolution of 1 A count. Push the RATIO button and set the RANGE and DISPLAY TIME controls as desired. Connect one signal to INPUT A and connect the other to INPUT B, and set both sets of input controls to obtain a measurement.



Count (3.13). From 1 to 100 million events can be counted at rates up to 20 million per second. Push the COUNT button, set the DISPLAY TIME control as desired, and push the START button. Connect the signal to INPUT A, set the input controls so that counts register, and push the STOP button. If the DISPLAY TIME control is set to SINGLE MEASURE, push the SET 0 button to clear the registers (with any other setting of the DISPLAY TIME control, the registers will clear automatically). Push the START button to initiate the count and push the STOP button to terminate it.



100-MHz COUNTER OPERATION

PRELIMINARY

Be sure the line switch on the rear panel of each instrument is set for the proper line voltage, then connect them to a source of power and turn the POWER switches on. Connect the OUTPUT of the scaler to INPUT A of the counter, connect the signal to be measured to the INPUT of the scaler, and set the controls as follows:

Counter

AC-DC --------------------- AC
POLARITY & ATTEN ---------- +1
THRESHOLD ---------------- centered
SEPARATE-COMMON --------- SEPARATE

DISPLAY TIME ------------- 100μs to 10 SEC or SINGLE MEASURE. Set to 100μs through 10 SEC for automatically initiated measurements (push SET 0 button to initiate measurement).

SET 0 ------------------- Push to set zero or initiate measurement. With no input signal, push to set zero. With an input signal, push to initiate a new measurement.

SET 9 ------------------- Push and hold to set nine. Push during a measurement (COUNTING lamp lit) and hold in until measurement is complete (COUNTING lamp extinquished) to set nine.

RANGE ------------------- 10^4 for FREQUENCY
or 1 for PERIOD
or 10 for RATIO
or --- for COUNT

These initial settings provide either the maximum display capacity to prevent an accidental spill or a reasonable measurement time for most normally encountered signals. After the first measurement, the RANGE switch can be set as desired.

Scaler:

SENSITIVITY ------------- As required.
TRIGGER LEVEL ----------- Adjust for an indication on the counter.

Note: With no input signal to the scaler and with maximum counter sensitivity (POLARITY & ATTEN set to +1 or -1) and dc coupling (AC-DC set to DC), the counter may count 120 Hz due to hum. To avoid this, set the POLARITY & ATTEN switch to ±10 or set the AC-DC switch to AC.

MEASUREMENTS

Frequency. Push the FREQUENCY button, set the RANGE and DISPLAY TIME controls as desired, and set the TRIGGER LEVEL control to obtain a measurement. The measured value is 10X the indicated value; e.g., an indicated value of 3.876 MHz is actually 38.76 MHz.

Period. For periods less than 1s: Push the PERIOD button, set the RANGE and DISPLAY TIME controls as desired, and set the TRIGGER LEVEL control to obtain a measurement. The measured value is 1/10 the indicated value; e.g., an indicated value of 837.634ns is actually 83.7634ns. For periods greater than 1s : Push the INTERVAL button, set the RANGE and DISPLAY TIME controls as desired, and set the TRIGGER LEVEL control to obtain a measurement. The measured value is 1/10 the indicated value; e.g., an indicated value of 213.76s is actually 21.376s.

Interval, phase, and duration. To make these measurements, disconnect the scaler output from the counter input and use the counter alone as described in its instruction manual.

Ratio. Push the RATIO button and set the RANGE and DISPLAY TIME controls as desired. Connect the second signal to INPUT B of the counter and set the TRIGGER LEVEL and counter B input controls to obtain a measurement. The measured value is 10X the indicated value; e.g., an indicated value of A/B = 15.000:1 is actually 150.000:1.

Count. Push the COUNT button, set the DISPLAY TIME control as desired, and push the START button. Set the TRIGGER LEVEL control so that counts register and push the STOP button. If the DISPLAY TIME control is set to SINGLE MEASURE, push the SET 0 button to clear the registers (with any other setting of the DISPLAY TIME control, the registers will clear automatically). Push the START button to initiate the count and push the STOP button to terminate it. The measured value is 10X the indicated value; e.g., an indicator value of 7583 is actually 75830.

500-MHz COUNTER DESCRIPTION

This is condensed information. Further details are contained in the instruction manuals for the individual instruments.

Bench model 1191-Z Counter (500 MHz).

CHARACTERISTICS

Frequency range ----------- Dc to 500 MHz
Input impedance ----------- 50Ω
Sensitivity --------------- 100 mV rms, 300 mv pk-pk
Maximum input ----------- 5V rms.

The 1191-Z Counter (500 MHz) consists of an 1157 Scaler, whose output frequency is one hundreth of the input frequency, and an 1191 Counter, whose input is the divided-down output from the scaler. The combination forms a general-purpose, dc-to-500-MHz, counter/timer for the measurement of frequency, period, period average, frequency ratio, time interval, and number of events. It provides an eight-digit visual register with automatic display of measurement dimensions and incorporates an internal storage feature that allows continuous correction of data without flicker.

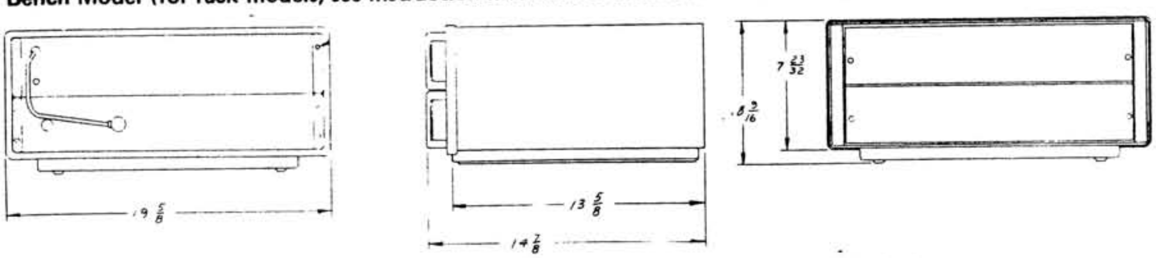
ACCESSORIES SUPPLIED

All of the accessories supplied with the individual instruments are included with the 1191-Z, plus the following:

Quantity	*Description*	*GR Part Number*
1	Instruction sheet	1191-0120
1	Cable assembly, GR874 to BNC	0874-2710
1	Bench-cabinet assembly (supplied with bench-model counters in lieu of bench cabinets for each instrument)	4177-2191

DIMENSIONS

Bench Model (for rack models, see instruction manuals for individual instruments).



Dimensions in inches

500-MHz COUNTER OPERATION

PRELIMINARY

Be sure the line switch on the rear panels of each instrument is set for the proper line voltage, then connect them to a source of power and turn the POWER switches on. Connect the OUTPUT of the scaler to INPUT A of the counter, connect the signal to be measured to the INPUT of the scaler, and set the controls as follows:

Counter:

AC-DC ------------- AC
POLARITY & ATTEN - +1
THRESHOLD -------- centered
SEPARATE-COMMON - SEPARATE

DISPLAY TIME ------ 100 μs to 10 SEC or SINGLE MEASURE. Set to 100 μs through 10 SEC for automatically initiated measurements. Set to SINGLE MEASURE for manually initiated measurements (push SET 0 button to initiate measurement).

SET 0 -------------- Push to set zero or initiate measurement. With no input signal, push to set zero. With an input signal, push to initiate a new measurement.

SET 9 ------------- Push and hold to set nine. Push during a measurement (COUNTING lamp lit) and hold in until measurement is complete (COUNTING lamp extinguished) to set nine.

RANGE ------------- 10^4 for FREQUENCY
or 1 for PERIOD
or 10 for RATIO
or --- for COUNT

These initial settings provide either the maximum display capacity to prevent an accidental spill or a reasonable measurement time for most normally encountered signals. After the first measurement, the RANGE switch can be set as desired.

Scaler:

SENSITIVITY -------- In the green on INPUT LEVEL meter. First set SENSITIVITY fully ccw (minimum sensitivity), apply signal, then turn cw until INPUT LEVEL needle is as close as possible to the center of the green shaded position.

MEASUREMENTS

Frequency. Push the FREQUENCY button, set the RANGE and DISPLAY TIME controls as desired, and set the A THRESHOLD control to obtain a measurement. The measured value is 100X the indicated value; e.g., an indicated value of 3.876 MHz is actually 387.6 MHz.

Period. For periods less than 100ms: Push the period button, set the RANGE and DISPLAY TIME controls as desired, and set the A THRESHOLD control to obtain a measurement. The measured value is 1/100 the indicated value; e.g., an indicated value 837.634 ns is actually 8.37634 ns. For periods greater than 100ms: Push the INTERVAL button, set the RANGE and DISPLAY TIME controls as desired, and set the A THRESHOLD to obtain a measurement. The measured value is 1/100 the indicated value; e.g., an indicated value of 213.76s is actually 2.1376s.

Interval, phase, and duration. To make these measurements, disconnect the scaler output from the counter input and use the counter alone as described in its instruction manual.

Ratio. Push the RATIO button and set the RANGE and DISPLAY TIME controls as desired. Connect the second signal to input B of the counter and set the A THRESHOLD and B input controls to obtain a measurement. The measured value is 100 X the indicated value; e.g., an indicated value of A/B = 15.000:1 is actually 1500.000:1.

Count. Push the COUNT button, set the DISPLAY TIME control as desired, and push the START button. Set the A THRESHOLD control so that counts register and push the STOP button. If the DISPLAY TIME control is set to SINGLE MEASURE, push the SET 0 button to clear the register (with any other setting of the DISPLAY TIME control, the register will clear automatically). Push the START button to initiate the count and push the STOP button to terminate it. The measured value is 100X the indicated value; e.g., an indicated value of 7583 is actually 758300.

Introduction SECTION 1

1.1 PURPOSE

The 1191 is a general-purpose, dc-to-20 MHz counter-timer for the measurement of frequency, period, period average, frequency ratio, time interval, and number of events.

1.2 DESCRIPTION

The counter employs an eight-digit visual register comprised of high-intensity gas-readout tubes, with automatic display of decimal point and measurement dimensions. An internal storage feature provides a continuous display of corrected data without flicker.

Models are available with high-speed buffered 1-2-4-8 BCD outputs from the internal storage to drive auxiliary data-handling equipment. All models offer remote programability of the measurement function, the range, and most of the secondary controls such as display time. The functions are dc controlled, the majority by simple contact closures to ground.

Two high-sensitivity input channels are incorporated, each with a high-impedance, low-noise FET circuit preceded by a three-position step attenuator and each with controls for trigger level, slope, polarity, and coupling. The 1-MΩ input impedance is independent of control settings and thus permits the use of general-purpose, low-capacitance oscilloscope probes.

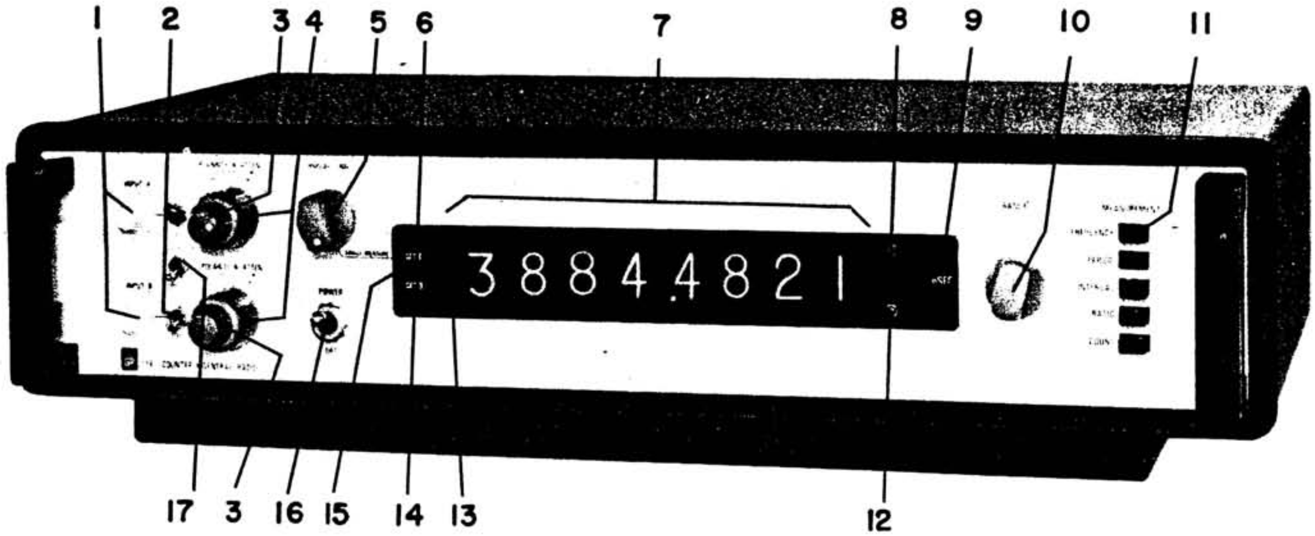
The 1191 is offered with one of two time bases, a room-temperature crystal oscillator which affords adequate stability for many applications, or a high-precision oscillator with proportional temperature control for greater accuracy. Either time base can be phase-locked to an external standard frequency of 0.1, 1, 2.5, 5, or 10 MHz.

Extensive use of integrated circuits offers a high degree of reliability and modular construction greatly simplifies repair to provide the user with the maximum in dependability as well as performance.

1.3 ACCESSORIES SUPPLIED

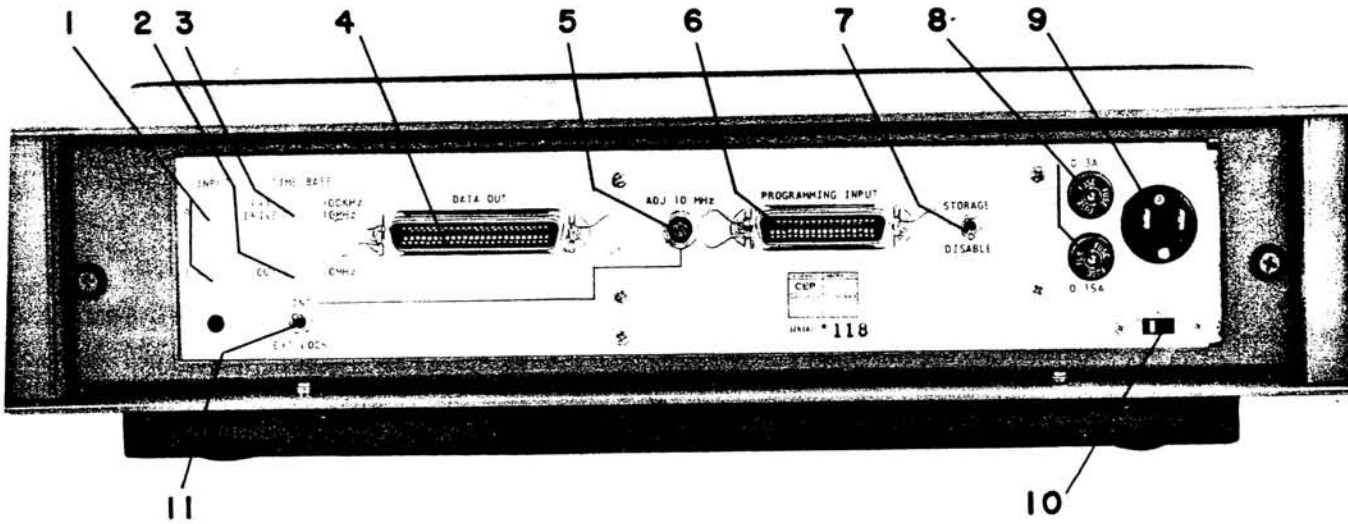
	Qty	*Description*	*GR Part Number*
	1	Instruction manual	1191-0100
	1	Power cord, 7-foot, 3-wire	4200-9622
	1	Spare fuse, 0.4A 3AG	5330-0900
	1	Spare fuse, 0.2A 3AG	5330-0600
	1	Board extender	4215-2034
Bench model:	1	Bench-cabinet assembly	4172-4004
Rack model:	1	Rack-cabinet assembly	4174-3040
	1	Hardware set	4174-2000

1.4 FRONT PANEL



1 INPUT	BNC connectors. For connection of input signal. Input signal can also be connected to rear-panel (see paragraph 1.5).
2 AC-DC	Two-position toggle switches. Select ac or dc coupling of input signal.
3 POLARITY & ATTEN.........	Eight-position rotary switches. Select polarity (+ or -) and attenuation (1X, 10X, or 100X) of input signal, or external programming of trigger threshold control, or internal 10-MHz test signal for presentation to input circuits.
4 THRESHOLD	Potentiometer with grounded center position, concentric with POLARITY & ATTEN switch. Sets trigger level from -100mV, through ground, to +100mV.
5 DISPLAY TIME.............	Twelve-position rotary switch. Sets interval between measurements from 100μs to 10s or infinity.
6 SET 0......................	Pushbutton switch. Sets registers to zero or, when DISPLAY TIME switch is set to SINGLE MEASURE, initiates measurement.
7 Visual register	Eight high-intensity gas readout tubes. Provide visual indication of measurement value including decimal point.
8 START	Pushbutton switch. Initiates count measurements.
9 Symbol lamps	Four incandescent lamps. One used to illuminate START and STOP button legends, and one each used to illuminate unit-of-measurement for frequency, period, and interval measurements.
10 RANGE	Ten-position rotary switch. Selects duration of measurement for frequency measurements, number of periods averaged for period measurements, counting rate for interval measurements, or rate of input-B periods counted for ratio measurements. Decimal point and unit-of-measurement are automatically controlled by RANGE switch.
11 MEASUREMENT	Five-button, mutually exclusive, push-button-switch assembly. Selects type of measurement to be made: frequency, period, interval, ratio, or count.
12 STOP	Push-button switch. Terminates count measurements.
13 Φ LOCK OUT	Neon lamp. Lights when time-base oscillator is not properly locked to external lock signal (if one is used).
14 COUNTING.................	Incandescent lamp. Lights when measurement is in progress.
15 SET 9......................	Push-button switch. Sets registers to nine.
16 POWER	Two-position toggle switch. Applies line voltage to instrument.
17 SEPARATE – COMMON......	Two-position toggle switch. SEPARATE setting keeps inputs separate. COMMON setting connects inputs together at attenuator output terminals.

1.5 REAR PANEL



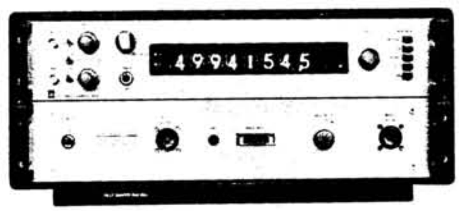
1 INPUT	BNC jack (mounted but not wired; see paragraph 2.8). For connection of input signal. Input signal is usually connected to front panel (see paragraph 1.4).
2 EXT DRIVE	BNC jack. For connection of external phase-lock signal.
3 OUT 10 MHz	BNC jack. 10-MHz time-base oscillator output to external equipment.
4 DATA OUT	50-pin connector (optional). 1-2-4-8 BCD measurement data and control signals to external equipment.
5 FREQ ADJ	Screwdriver-operated potentiometer. Adjust frequency of time-base oscillator.
6 PROGRAMMING INPUT	36-pin connector. For connection of remote-programming signals.
7 STORAGE – DISABLE	Two-position toggle switch. DISABLE position switches out storage feature.
8 Fuses	Upper fuse for 115-V operation, lower fuse for 230-V operation.
9 Power connector	Three-pin male connector. For connection to power line; accepts 3-wire power cord supplied.
10 Line	Two-position screwdriver-operated slide switch. Selects line-voltage, 100 to 125V or 200 to 250V.
11 TIME BASE	Two-position toggle switch. For selection of internal time base only or internal time base phase-locked to an external signal applied to EXT DRIVE connector.

1.6 EQUIPMENT AVAILABLE

1.6.1 100-MHz FREQUENCY RANGE

To extend the upper frequency to 100MHz, the counter can be used with the 1156 Decade Scaler. The scaler is a completely self-contained, 100-MHz, direct-counting frequency divider with a sensitivity of better than 30mV rms or 100mV pk-pk.

1.6.2 500-MHz FREQUENCY RANGE



To extend the upper frequency to 500MHz, the counter can be used with the 1157 Scaler. The scaler is a completely self-contained, 500-MHz, direct-counting frequency divider with a sensitivity of better than 100mV rms or 300mV pk-pk.

1.6.3 SIGNAL SCANNING

To automatically and sequentially connect a number of signals for measurement, the counter can be used with the 1770 Scanner System. The scanner selects one of up to 100 signals (dc to 100MHz) and presents it to the counter for measurement. The number of channels, the number of lines switched per channel, and the line terminations can be varied to suit the application and high-temperature cable (-75 to +250°C) can be supplied to connect to components in an environmental chamber.

1.6.4 GREATER ACCURACY

For greater stability and accuracy, the counter can be used with the 1115 Standard-Frequency Oscillator. The oscillator provides an output of 1V rms into 50Ω at frequencies of 100KHz, 1MHz, and 5MHz with a stability of approximately ten times better than that of a counter with the high-precision time-base option.

1.6.5 DIGITAL RECORDING

For digital records of the measurement data, counters with the data output option can be used with the 1137 Data Printer. The printer records up to twelve columns at print rates up to three lines per second.

1.6.6 ANALOG OUTPUT AND X-Y RECORDING

For analog measurement data, counters with the data output option can be used with the 1136 Digital-to-Analog Converter. The converter changes the digital data from the counter to a voltage or current proportional to the numerical value of any three consecutive digits or the last two digits of data. Storage circuits in the converter permit use with intermittent as well as continuous BCD data. If an X-axis input is provided, an X-Y recorder can then be used to record the measurements vs temperature or voltage, etc.

1.6.7 DC RECORDING

For dc records of the measurement data, counters with the data output option can be used with the 1136 Digital-to-Analog Converter (described above) and a 1521 Graphic Level Recorder. The recorder provides a 4-inch-wide continuous recording with an accuracy of ± 1% of full scale, a resolution of ± 0.25% of full scale, and recording speeds of from 2.5 inches per hour to 75 inches per minute.

1.6.8 SYSTEMS

Since additional equipment can expand the basic capability of the 1191 Counter to a complete measurement facility, General Radio has arranged to supply complete systems and inquiries are invited. Each system is custom tailored to individual requirements and includes only the equipment necessary to perform the required task; completely assembled and checked as a unit.

Such systems have wide application and can be used for laboratory development, production monitoring, final quality assurance, production-lot sorting, incoming inspection, environmental testing, reliability evaluation, etc., on an automatic or semi-automatic basis.

Installation SECTION 2

General

Signal Data

2.1 POWER

Power requirements are 100 to 125V or 200 to 250V, 50 to 400Hz, 32W. A line switch, S502 on the rear panel, selects the line-voltage range. For 115-V operation, F501 (0.4A, 3AG Slo-Blo) protects the instrument and for 230-V operation, F502 (0.2A, 3AG Slo-Blo) protects the instrument.

Connection to the power line is made by means of a 7-foot, 3-wire power cord, supplied, that attaches to the power connector, PL501 on the rear panel. The long cylindrical pin is connected directly to the chassis of the instrument (chassis ground, ⏚ , designated GND).

2.2 ENVIRONMENTAL

2.2.1 TEMPERATURE

Operating.................. 0 to +50°C
Nonoperating.............. -40 to +75°C

Test procedure: Unpacked, cabinet off. Instrument is off for 24 hours at +75°C, off for 4 hours at +50°C, and on for two hours at +50°C during which time performance is checked. Instrument is then off for 24 hours at -40°C, off for 4 hours at 0°C, and on for 2 hours at 0°C during which time performance is checked.

2.2.2 HUMIDITY

Operating.................. 95% RH and +40°C

Test procedure: Unpacked, cabinet off. Instrument is off for 24 hours at 50% RH and +40°C, off for 24 hours at 95% RH and +40°C, and on for 2 hours at 95% RH and +40°C during which time performance is checked.

2.2.3 VIBRATION

Nonoperating.............. 0.03 in. from 10 to 55 Hz

Test procedure: Unpacked, cabinet off. (A one-minute cycle is a scan of the specified frequency range from the lower limit to the upper limit and back to the lower limit in one minute.) Instrument is vibrated 0.03 in. pk-pk for 15 one-minute cycles over a frequency range of 10 to 55 Hz in each plane and for 5 minutes at any major resonance frequency, after which performance is checked.

2.2.4 BENCH HANDLING (MIL-STD-810A, procedure VI)

Nonoperating.............. 4 in. or 45°

Test procedure: Unpacked, cabinet off. Instrument is raised 4 in. or 45°, whichever occurs first, and allowed to drop freely on a wooden bench 4 times in each plane, after which performance is checked.

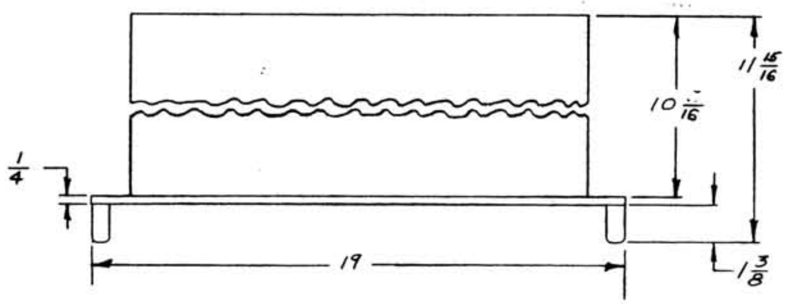
2.2.5 SHOCK

Nonoperating.............. 30G, 11ms

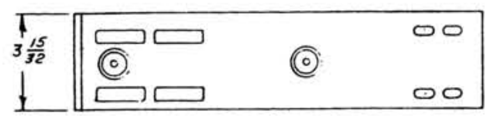
Test procedure: Unpacked, cabinet off. Instrument is subjected to three 30-G, 11–ms shocks in each plane, after which performance is checked.

2.3 DIMENSIONS

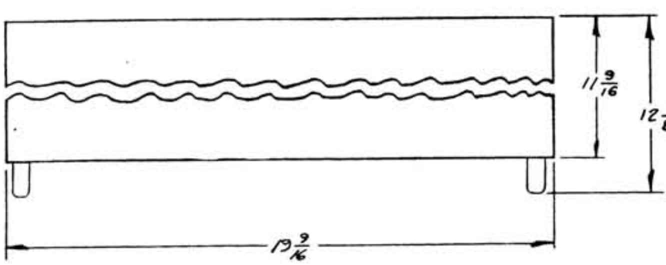
2.3.1 BENCH MODEL



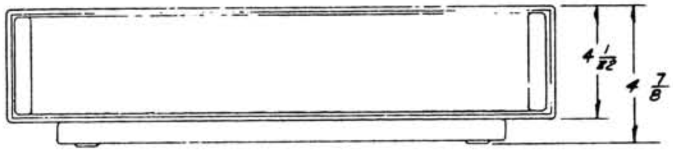
DIMENSIONS IN INCHES

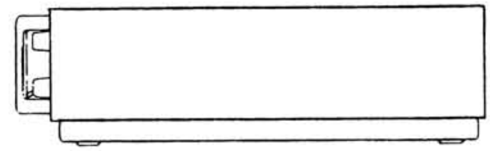


2.3.2 RACK MODEL



DIMENSIONS IN INCHES





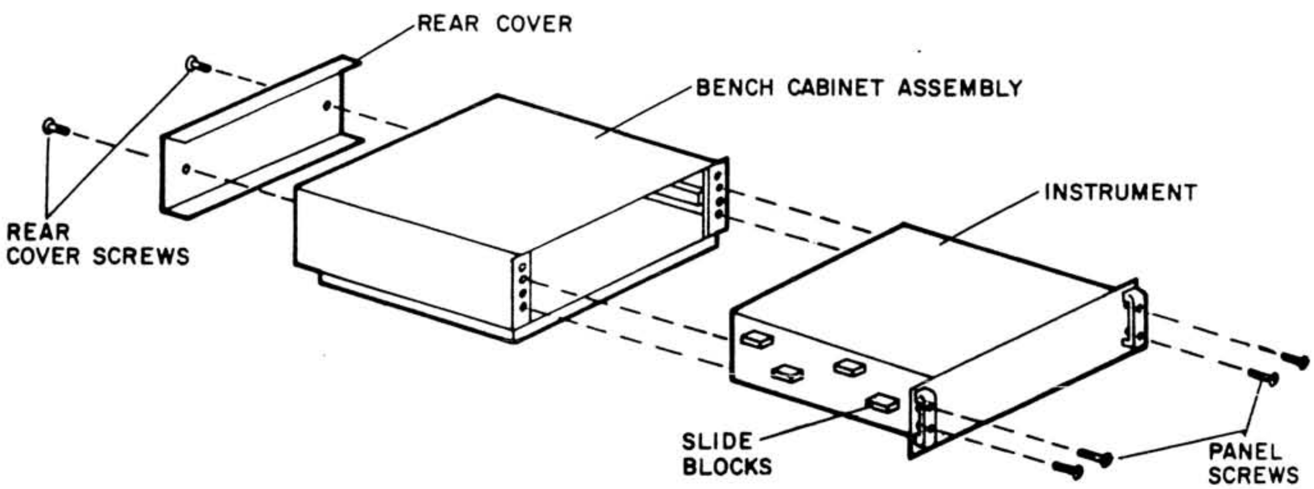
2.4 MOUNTING

2.4.1 BASIC DATA

The 1191 Counter is a rack-bench instrument with slide blocks, has a panel height of 3½ in. (2 units), a depth of 10 in., and dissipates 32W.

2.4.2 CABINET OPTIONS

Bench model. For bench use. Includes a tilt-base, nonvented, bench-cabinet assembly. To convert to a rack model, proceed as follows:



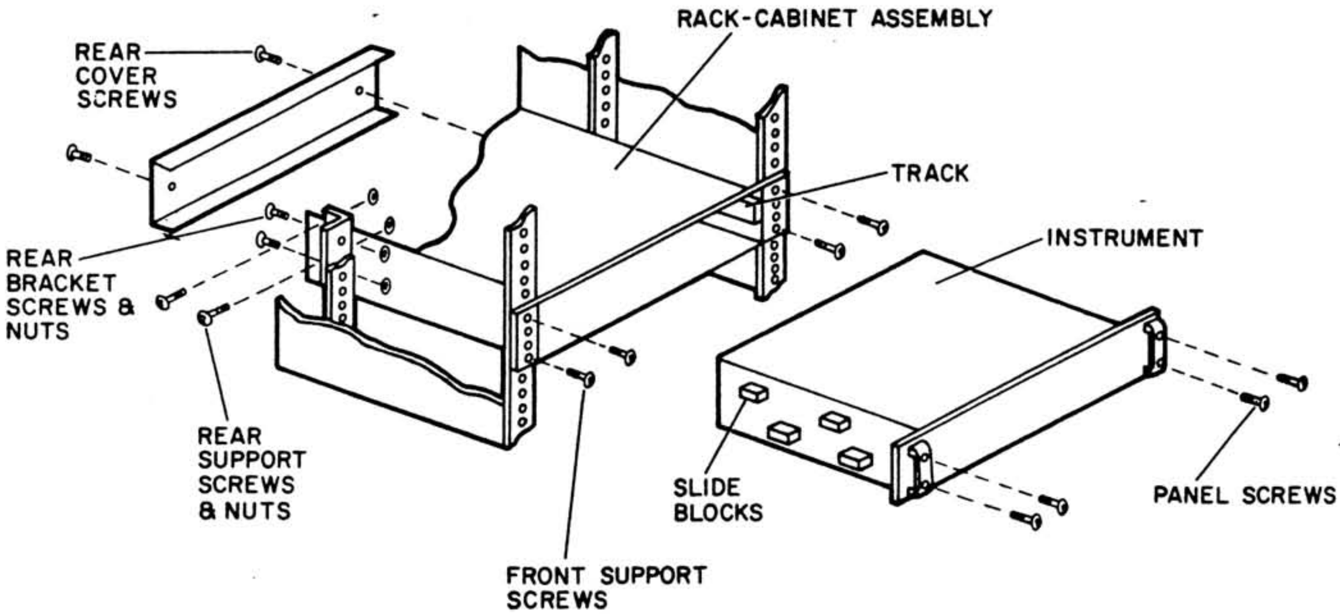
a. Order a 4174-3040 rack-cabinet assembly and a 4174-2000 hardware set.

b. Disconnect any cabling from the front and rear panels of the instrument, remove the panel screws from the front, and pull the instrument out of the bench cabinet.

c. Remove the rear-cover screws and remove the rear cover from the bench cabinet. Place the rear cover on the rear of the rack cabinet and secure it to the rack cabinet with the rear cover screws.

d. Install the rack cabinet in the relay rack and insert the instrument in it (see paragraph 2.4.3).

Rack model. For installation in an EIA standard 19-in. relay rack. Includes a rack-cabinet assembly. To convert to a bench model, proceed as follows:



a. Order a 4172-2642 bench-cabinet assembly, two 4171-8601 tracks, two 4171-8802 rear brackets, and eight 7170-1308 screws.

b. Install the tracks on the front and rear channels inside the bench cabinet; place the wide end of the tracks to the rear and the flat side against the channels; secure each track with two screws.

c. Install the brackets on the rear channels inside the bench cabinet; place the notch in the brackets around the tracks, secure each bracket with two screws.

d. Disconnect any cabling from the front and rear panels of the instrument, remove the panel screws from the front, and pull the instrument out of the rack cabinet.

e. Remove the rear-cover screws and remove the rear cover from the rack cabinet. Place the rear cover on the rear of the bench cabinet and secure it to the rear brackets with the rear-cover screws.

f. Insert the instrument in the bench cabinet; straddle the tracks with the slide blocks, and secure it to the cabinet with the panel screws.

2.4.3 RACK MOUNTING (rack models)

To install a rack-model instrument in an EIA standard 19-in. relay rack, proceed as follows:

a. Remove the panel screws, slide the instrument out until it stops, lift the front, and pull it out of the cabinet.

b. Insert the cabinet in the rack and secure it to the front of the rack with the front-support screws.

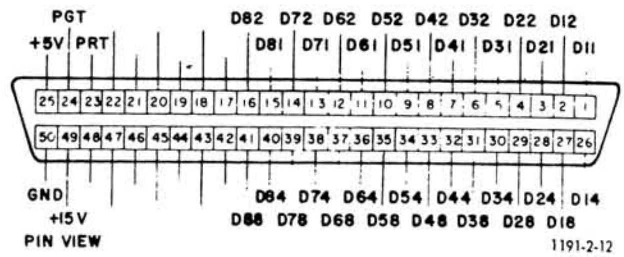
c. If the rack contains a rear support, remove the rear-cover screws and remove the cover. Attach the brackets to the cabinet with the rear-bracket screws and nuts; use the set of slots that most nearly aligns the bracket with the rear support. Secure the bracket to the rear support.

d. Push the tracks all the way in. Place the rear of the instrument in the cabinet, lift the rear so the rear slide blocks straddle the tracks, and push the instrument in until it stops. Lift the front, pull the instrument out so that the tracks follow, and then push in so that the front slide blocks straddle the tracks. Push the instrument all the way in and secure it to the rack with the panel screws.

2.5 DATA OUT SOCKET, S0901

2.5.1 CONNECTIONS

Measurement data are available at the DATA OUT socket, S0901 on the rear panel of instruments with this option, for use by auxiliary data-handling equipment. This socket is a 50-pin Amphenol Type 57 socket (GR part number 4230-4049) which mates with a 50-pin Amphenol Type 57 plug (GR part number 4220-3050, Amphenol part number 57-30500).



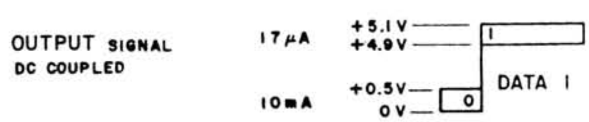
1191-2-12

2.5.2 DATA SIGNALS

	8	7	6	5	4	3	2	1	
	0	0	1	7	3	7	8	4	
S0901 pin **Signal**	15 **D81**	13 **D71**	11 **D61**	9 **D51**	7 **D41**	5 **D31**	3 **D21**	1 **D11**	1-BIT
S0901 pin **Signal**	16 **D82**	14 **D72**	12 **D62**	10 **D52**	8 **D42**	6 **D32**	4 **D22**	2 **D12**	2-BIT
S0901 pin **Signal**	40 **D84**	38 **D74**	36 **D64**	34 **D54**	32 **D44**	30 **D34**	28 **D24**	26 **D14**	4-BIT
S0901 pin **Signal**	41 **D88**	39 **D78**	37 **D68**	35 **D58**	33 **D48**	31 **D38**	29 **D28**	27 **D18**	8-BIT

Decimal	1-2-4-8 BCD
0	0000
1	1000
2	0100
3	1100
4	0010
5	1010
6	0110
7	1110
8	0001
9	1001

D11 thru D88 measurement data. (diagram G). Four 1-2-4-8 weighted BCD signals are available from each of the decades in the counter at standard DTL levels (data 0 ≈ ground with a 10-mA sink capability, data 1 ≈ +5V behind 6KΩ ±20%). Range data is not available.

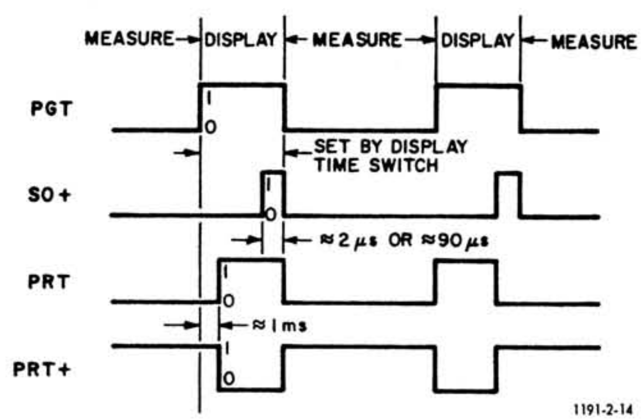


1191-2-13

2.5.3 PRINT COMMAND SIGNALS

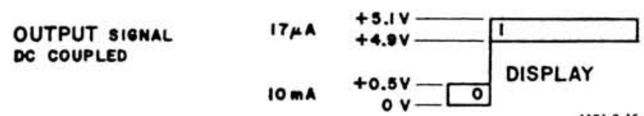
S0901 pin	24			23
S0950 pin		17	34	
Signal	**PGT**	**SO+**	**PRT +**	**PRT**

Most data handling equipment requires a signal to initiate its operation or to synchronize its operation with that of the counter. Four such signals are available from the counter:



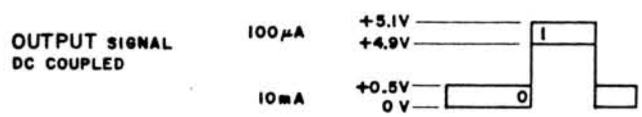
1191-2-14

PGT (diagram G). This is a buffered signal at a standard DTL level (data 0 ≈ ground with a 10-mA sink capability, data 1≈ +5V behind 6KΩ ± 20%) and is used to initiate the operation of data handling equipment such as digital-to-analog converters.



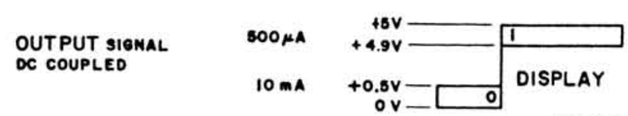
1191-2-15

SO+ (diagram H). This is a non-buffered, 2-μs pulse (with DISPLAY TIME of < 100ms) or 90-μs pulse (with DISPLAY TIME of ≥ 100ms), behind 1KΩ, whose trailing edge initiates the measurement in the counter. It is available from the PROGRAMMING INPUT socket, S0950 pin 17 and can be used to indicate the counter is about to make a new measurement.



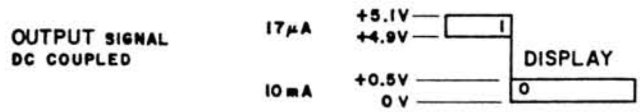
1191-2-16

PRT (diagram G). This is a buffered signal at a standard DTL level (data 0 ≈ ground with a 10-mA sink capability, data 1≈ +5V behind 6KΩ ± 20%) that goes to the 1-level 1ms after the end of a measurement and goes to the 0-level at the beginning of a measurement. The 1-ms delay allows the measurement data to settle before the positive transition initiates the operation of an external device, such as a printer.



1191-2-17a

PRT+ (diagram H). This is a nonbuffered 5-V signal behind 4.7KΩ with the same timing characteristics as PRT above, but is inverted.



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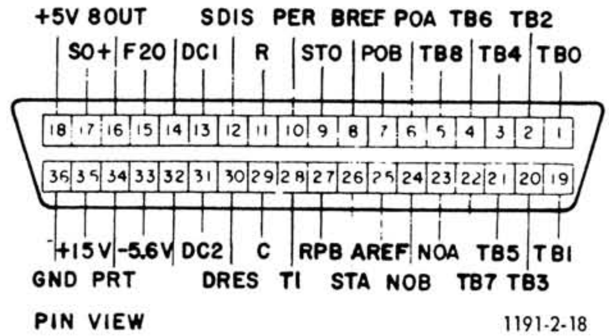
2.6 PROGRAMMING INPUT SOCKET, S0950

.1 CONNECTIONS



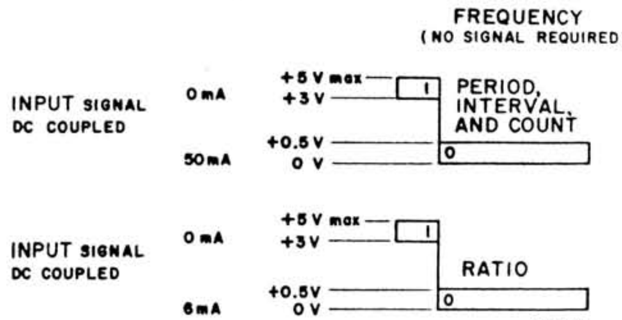
1191-2-18

ɜ functions of all front-panel controls, except the AC-DC, ᴾARATE – COMMON, SET 9, and POWER switches, and ː attenuator function of the POLARITY & ATTEN switch, ı be controlled remotely by means of connections to the OGRAMMING INPUT socket, S0950 on the rear panel. is socket is a 36-pin Amphenol Type 57 socket (GR part mber 4230-4036) which mates with a 36-pin Amphenol 'pe 57 plug (GR part number 4220-3036, Amphenol part ımber 57-30360). Examples of external programming are ıntained in paragraph 5.6.12.

6.2 MEASUREMENT CONTROL

S0950 pin **Signal** MEASUREMENT	 none FREQUENCY	10 **PER** PERIOD	28 **TI** INTERVAL	11 **R** RATIO	29 **C** COUNT

Diagrams D and L). To program the MEASUREMENT func-ion remotely push the FREQUENCY button and, except vhen the FREQUENCY program is desired, set the appro-ɔriate signal to 0 (ground). When the FREQUENCY button s pushed, the counter is programmed for frequency measure-nents, automatically and without need of any external signal. The 50-mA sink-current for PERIOD, INTERVAL, and COUNT measurements is used to enable the appropriate gates and to energize the symbols (MHz, msec, START-STOP, etc.) in the visual display. The 6-mA sink current for RATIO measurements needs only to enable the gates; no symbols are used in the visual display.



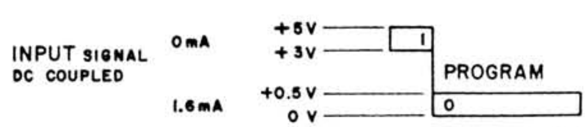
1191-2-19

NOTE: Visual register symbol and decimal-point indications are not valid when measurement or range is externally programmed: If the measurement is externally programmed but the range is not (i.e. if the FREQUENCY button is pushed but the RANGE switch is set to a position other than EXT PROG) the visual register will display the symbol and decimal point for frequency (even though a period, interval, ratio, or count external program signal is applied) in addition to the symbol for the measurement externally programmed. If both the measurement and range are externally programmed, the visual register will display the EXT PRO symbol but will display no decimal point at all.

2.6.3 RANGE CONTROL

FREQUENCY PERIOD INTERVAL RATIO COUNT	 .0000msec .0µsec	MHz .00000msec µsec .0	.0MHz .000µsec .00msec .00	.00MHz .0000µsec .0msec .000	.000MHz .00000µsec msec .0000	.0KHz .000nsec .00sec .00000	.00KHz .0000nsec .0sec .000000	.000KHz .00000nsec sec .0000000	.0Hz .000psec .00ksec .00000000
S0950 pin **Signal** RANGE	1 **TB0** 1	19 **TB1** 10	2 **TB2** 10	20 **TB3** 10	3 **TB4** 10	21 **TB5** 10	4 **TB6** 10	22 **TB7** 10	5 **TB8** 10

TB0 thru TB8 range inputs (diagram L). To program the RANGE switch function remotely, set the RANGE switch to EXT PROG and set the appropriate signal to 0. These are standard DTL-level inputs (data 0 ≈ ground with a 1.6mA sink capability, data 1 ≈ +5V behind 6KΩ ± 20%).



1191-2-20

NOTE: Visual register symbol and decimal-point indications are not valid when measurement or range is externally programmed: If the range is externally programmed but the measurement is not (i.e., if the RANGE switch is set to EXT PROG but a measurement button other than FREQUENCY is pushed) the visual register will display no symbol and no decimal point. If both the range and measurement are externally programmed, the visual register will display the EXT PRO symbol but will display no decimal point.

2.6.4 DISPLAY TIME CONTROL

S0950 pin **Signal**	30 **DRES**	13 **DC1**	31 **DC2**

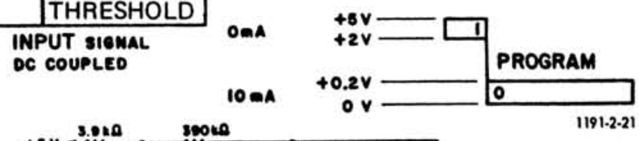
DRES, DC1, DC2 display time inputs (diagram H). To program the DISPLAY TIME control function remotely, set the DISPLAY TIME switch to EXT PROG, connect a resistor of the proper valve from DRES to ground, and set DC1 or DC2 to 0 (ground) as shown in the table. The diaplay time is approximately (within 20%) one circuit time constant. A 910-Ω resistor is in series with DRES so that DRES ≈ (10 T or 10 T) -900 where T is the display time desired. For example, for a 5-ms display time, DRES ≈ (10 x 5 x 10) -900 ≈ 50,000 -900 ≈ 49.1KΩ.

DISPLAY TIME desired	**DRES** *resistance to ground*	**DC1** *(10µF)*	**DC2** *(0.1µF)*
100µs	short		ground
1ms	9.1KΩ		ground
10ms	91KΩ		ground
50ms	430KΩ		ground
100ms	11KΩ	ground	
200ms	24KΩ	ground	
500ms	62KΩ	ground	
1s	120KΩ	ground	
2s	240KΩ	ground	
5s	620KΩ	ground	
10s	1.2MΩ	ground	

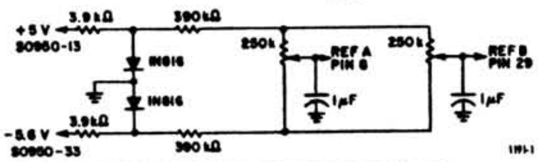
2.6.5 INPUT CONTROL

INPUT	INPUT A			INPUT B		
S0950 pin **Signal** Control	23 **NOA** +	6 **POA** -	25 **REF A** THRESHOLD	24 **NOB** +	7 **POB** -	8 **REF B** THRESHOLD

POA, NOA, POB, NOB polarity inputs (diagram C). To program the polarity function of the POLARITY & ATTEN switches remotely, set the POLARITY & ATTEN switch to EXT PROG and set the appropriate signal to 0 (ground).



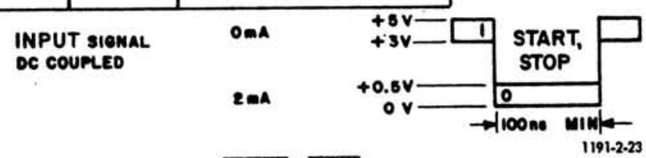
REF A, REF B threshold inputs (diagram C). To program the THRESHOLD control function remotely, set the POLARITY & ATTEN switch to EXT PROG and apply a dc level of from +0.1V to -0.1V to the appropriate signal input.



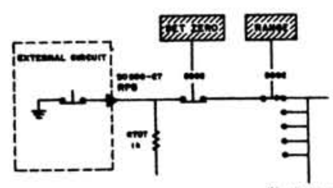
2.6.6 OTHER CONTROLS AND SIGNALS

S0950 pin **Signal** Function	26 **STA** START	9 **STO** STOP	27 **RPB** SET 0	12 **SDIS** STORAGE DISABLE	16 **8 OUT** SPILL	17 **SO+** PRINT COMMANDS	34 **PRT**

STA, STO start and stop inputs (diagram D). To control the START and STOP pushbutton functions remotely (to initiate and terminate count measurements), set the appropriate signal to 0 (ground) for at least 100ns.

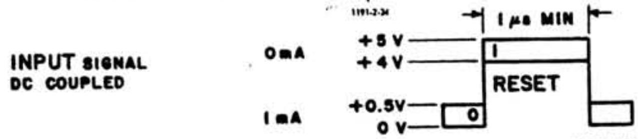


RPB set 0 input (diagram H). To control the SET 0 pushbutton function remotely (reset) proceed as follows:

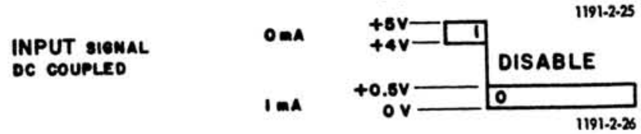


Method 1. Disconnect R949 from ground and add an external, normally closed switch as shown. To set zero (reset), momentarily open switch.

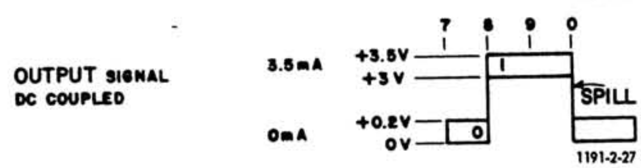
Method 2. Set RPB to 1 for at least 1µs; leave R949 connected to ground.



SDIS storage disable input (diagram H). To program the STORAGE-DISABLE switch function remotely (S951 on the rear panel), set the STORAGE-DISABLE switch to STORAGE and set SDIS to 1 (open circuit) to enable the storage feature or to 0 (ground) to disable it.



8 OUT spill output (diagram E, F). When the decade for the most significant digit changes from 7 to 8, 8 OUT goes to the 1-level. When the decade changes from 9 to 0, 8 OUT returns to the 0-level. Thus, when 8 OUT is at the 1-level, it indicates the counter registers are 98 to 100% full.



SO+, PRT print commands. See paragraph 2.5.3.

2.7 TIME BASE JACKS, J951, J952

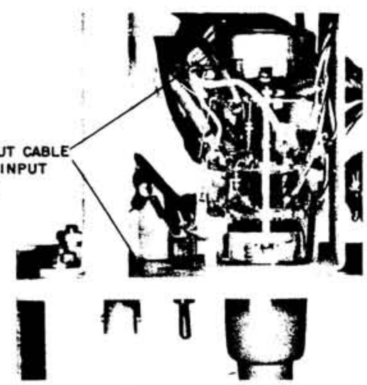
EXT DRIVE, J951. Both the room-temperature-oscillator and the high-precision-oscillator models can be phase-locked to a 0.1, 1, 2.5, 5, or 10-MHz signal of any waveshape and of at least 1V rms or 3V pk-pk into 1KΩ. Connect the signal to the EXT DRIVE jack, J951 on the rear panel, and set the TIME BASE switch, S952 also on the rear panel, to EXT LOCK. With the POWER switch on, the front-panel ΦLOCK OUT neon must be extinguished. If it is not, the internal oscillator is not properly locked to the external signal.

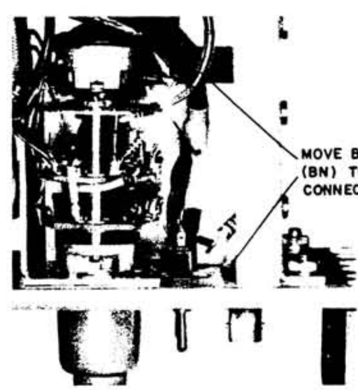
The room-temperature oscillator will lock on a stable external signal that is within approximately 100Hz of its nominal frequency and the high-stability oscillator will lock on a signal within 10Hz of its nominal frequency.

OUT 10MHz, J952. The internal clock signal is available as a 10-MHz square wave of 2V pk-pk behind 50Ω at the OUT 10MHz jack, J952 on the rear panel.

2.8 INPUT JACKS, J953, J954

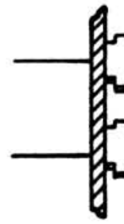
INPUTS A and B, J953 and J954. If it is desired to connect the A, the B, or both of the input signals to the rear, unsolder the appropriate cable from its storage position and solder it directly to the corresponding front-panel input connector. This raises the input capacitance to approximately 70pF.





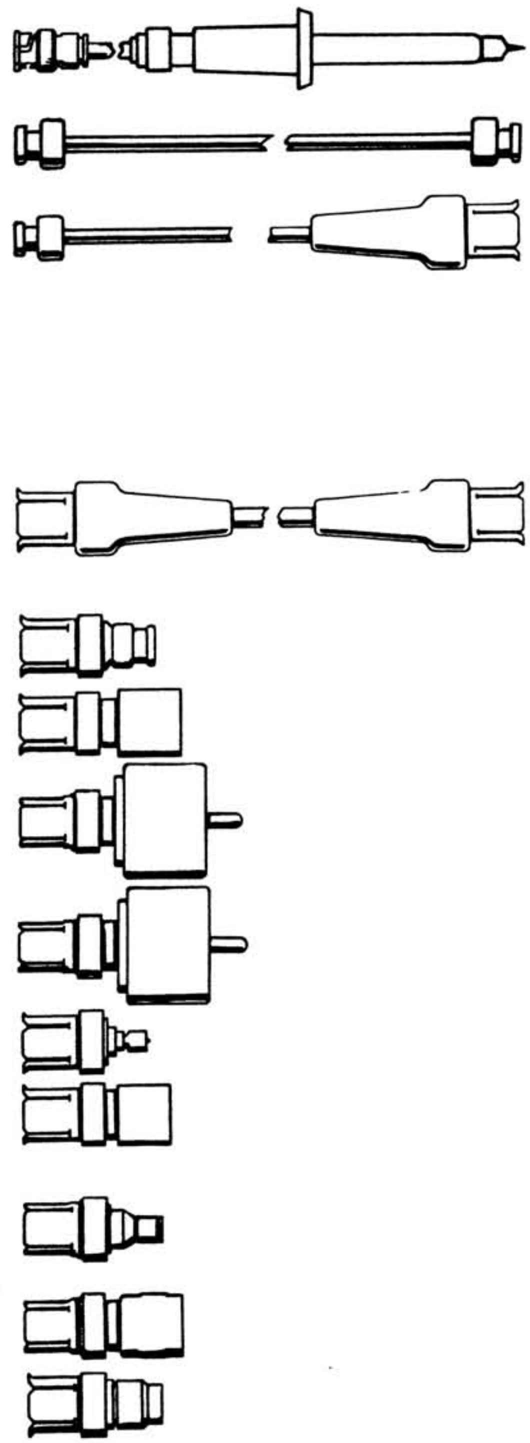
2.9 INPUT CONNECTION

The input terminals are BNC jacks and the input impedance is 1MΩ shunted by 35pF so that the inputs are compatible with many general-purpose oscilloscope probes. The input terminals can also be adapted to GR874 connectors, which are 50-Ω hemaphroditic and accept a broad line of adaptors to convert the terminals for use with most any commercial or military connector.



1191-2-29a

P6006	-Tektronix probe, 10X, 10MΩ -7pF, 3.5 ft	1158-9600
---	Coaxial jumper cable, BNC connectors	0776-2000
---	Coaxial output cable, BNC connector on one end, GR874 on the other	0874-2700
874-R20A	Coaxial patch cord, low loss cable	0874-9680
874-R20LA	Coaxial patch cord, same, locking connectors	0874-9681
874-R22A	Coaxial patch cord, general-purpose cable	0874-9682
874-R22LA	Coaxial patch cord, same, locking connectors	0874-9683
874-QBPA	Adaptor, GR874 to Type BNC	0874-9800
874-QHPA	Adaptor, GR874 to Type HN	0874-9804
874-QLPA	Adaptor, GR874 to Type LC	0874-9806
874-QLTP	Adaptor, GR874 to Type LT	0874-9808
874-QMDP	Adaptor, GR874 to Type Microdot	0874-9820
874-QNP	Adaptor, GR874 to Type N	0874-9810
874-QNPL	Adaptor, same, locking GR874 connector	0874-9811
874-QMMP	Adaptor, GR874 to Type OSM/BRM, NPM, STM	0874-9822
874-QMMPL	Adaptor, same, locking GR874 connectors	0874-9823
874-QSCP	Adaptor, GR874 to Type SC	0874-9812
874-QTNP	Adaptor, GR874 to Type TNC	0874-9816



1191-2-29b

Operation SECTION 3

General

Controls

Measurements

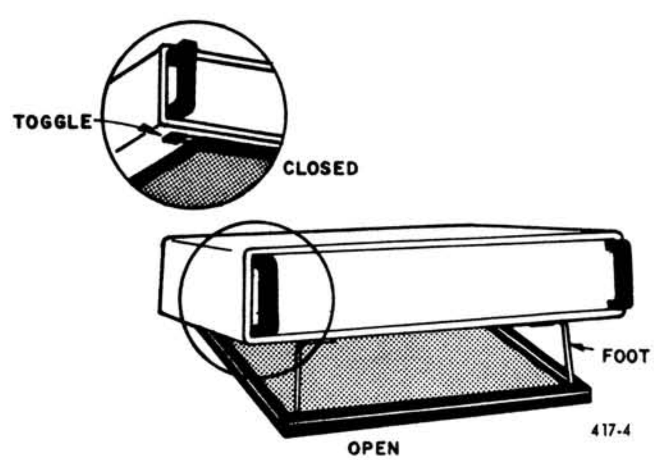
Miscellaneous

CAUTION: Do not exceed maximum signal input ratings (150V on X1 or 300V on X10 or X100 without probe, 600V with probe).
CAUTION: Be sure line switch on rear panel is set for proper voltage.

3.1 TILT BASE

Bench model 1191 Counters incorporate a tilt-base which, when opened and tilted, provides a convenient angle to view the visual register and control settings. The base itself is ¾-in. deep and allows for the storage of the instruction manual and other small accessories.

To open, push the toggles back (under the cabinet, in front, one on each side). To tilt, lift the front of the cabinet up and pull the foot forward. To close, push the foot back, lower the front of the cabinet, and pull the toggles forward.



3.2 OPERATIONAL CHECKS

This procedure can be used for incoming inspection, familiarization, or as a periodic check on the operation of the instrument.

3.2.1 CHARACTER INDICATION

Control settings:

A and B AC-DC	**AC**	**SEPARATE–COMMON**	**SEPARATE**
A and B POLARITY & ATTEN	**+1**	**DISPLAY TIME**	**SINGLE MEASURE**
A and B THRESHOLD	**fully cw**	**POWER**	**on**

1. Push each MEASUREMENT button and check decimal-point location and symbol for all RANGE settings as follows (digits may be other than 0):

MEASUREMENT button	***RANGE switch settings***									
	EXT PROG	***1***	***10***	***10^2***	***10^3***	***10^4***	***10^5***	***10^6***	***10^7***	***10^8***
FREQUENCY	EXT PRO		MHz	.0MHz	.00MHz	.000MHz	.0KHz	.00KHz	.000KHz	.0Hz
PERIOD		.0000msec	.00000msec	.000µsec	.0000µsec	.00000µsec	.000nsec	.0000nsec	.00000nsec	.000psec
INTERVAL		.0µsec	µsec	.00msec	.0msec	msec	.00sec	.0sec	sec	.00
RATIO			.0	.00	.000	.0000	.00000	.000000	.0000000	.00000000
COUNT		START STOP	START STOP	START STOP	START STOP	START STOP	START STOP	START STOP	START STOP	START STOP

3.2.2 TRIGGER CIRCUITS

Control settings:
(from previous step)

A and B AC-DC	AC	SEPARATE–COMMON	SEPARATE
A and B POLARITY & ATTEN	+1	DISPLAY TIME	SINGLE MEASURE
A and B THRESHOLD	fully cw	POWER	on

2. Set RANGE to 1, push INTERVAL button, and push SET 0 button; visual register will display 0000000.0µsec. Turn A THRESHOLD fully ccw; COUNTING lamp will light. Turn B THRESHOLD fully ccw; COUNTING lamp will extinguish and visual register will display some arbitrary number.

With no input signal applied, the input levels are at ground potential so that when the THRESHOLD controls are rotated, they simulate 200-mV negative input transition. For interval measurements, channel A initiates the measurement and channel B terminates it.

3.2.3 SET 0 AND SET 9 CONTROLS

Control settings: (from previous step)	A and B AC-DC	AC	SEPARATE–COMMON	SEPARATE
	A and B POLARITY & ATTEN	+1	DISPLAY TIME	SINGLE MEASURE
	A and B THRESHOLD	fully ccw	RANGE	1

3. Push COUNT button and push SET 0 button; visual register will display 00000000.

With no input signal applied, the SET 0 button sets the registers to zero.

4. Push SET 9 button; visual register will display 99999999.

With the COUNT button pushed, the SET 9 button immediately sets the registers to nine.

5. SET A POLARITY & ATTEN to TEST 10MHz and set RANGE to 10^7. Push FREQUENCY button and push SET 0 button; COUNTING lamp will light and visual register will display 00000.000KHz; after one second, COUNTING lamp will extinguish and visual register will display 10000.000KHz, ± 1 count.

With an input signal applied (in this case, the 10-MHz internal-clock signal), the SET 0 button initiates a new measurement for all MEASUREMENT button settings, except COUNT.

6. Push SET 0 button then immediately push SET 9 button and hold in until COUNTING lamp extinguishes; COUNTING lamp will light and visual register will display 00000.000KHz; after one second, COUNTING lamp will extinguish and visual register will display 99999.999KHz.

With an input signal applied, the SET 0 button initiates a measurement, the SET 9 button sets the counting register to nine, and, at the end of the measurement, a transfer signal transfers the nines from the counting register to the storage register for display.

3.2.4 DISPLAY TIME CONTROL

Control settings: (from previous step)	A and B AC-DC	AC	SEPARATE–COMMON	SEPARATE
	A POLARITY & ATTEN	TEST 10MHz	DISPLAY TIME	SINGLE MEASURE
	B POLARITY & ATTEN	+1	RANGE	10
	A and B THRESHOLD	fully ccw	MEASUREMENT	FREQUENCY

7. Set DISPLAY TIME to 1 sec; COUNTING lamp will repetitively light for one second and extinguish for one second; visual register will display 10000.000KHz, ± 1 count.

For all measurements, except COUNT, the DISPLAY TIME switch controls the time interval between measurements (COUNTING lamp extinguished) and the RANGE switch controls the measurement (COUNTING lamp lit).

3.2.5 MEASUREMENTS

Control settings: (from previous step)	A and B AC-DC	AC	SEPARATE–COMMON	SEPARATE
	A POLARITY & ATTEN	TEST 10MHz	DISPLAY TIME	1 sec
	B POLARITY & ATTEN	+1	RANGE	10
	A and B THRESHOLD	fully ccw	MEASUREMENT	FREQUENCY

8. Push PERIOD button; COUNTING lamp will repetitively light for one second and extinguish for one second; visual register will display 100.00000nsec, ± 1 count.

The visual register displays the period of the 10-MHz internal clock signal (0.1μs).

INTERVAL measurement was checked in step 2.

9. Push RATIO button and set B POLARITY & ATTEN to TEST 10MHz; COUNTING lamp will repetitively light for one second and extinguish for one second; visual register will dispaly 1.0000000, ± 1 count.

The visual register displays the ratio of A/B which, in this case, is 10MHz/10MHz = 1. For ratio measurements, channel B initiates the measurement and terminates it after a number of input B events have occurred as set by the RANGE switch; in this case 10^7 x the period of the 10-MHz internal clock signal = 1 second.

10. Push COUNT button and push STOP button. Push START button; COUNTING lamp will light and visual register will change rapidly. Push STOP button; COUNTING lamp will extinguish and visual register will display some arbitrary number for one second then set to zero.

For COUNT measurements, the START button initiates the measurement (in this case, the counter is counting the 10-MHz internal clock signal) and the STOP button terminates it.

3.3 REAR PANEL CONTROLS

3.3.1 CHARACTERISTICS

Line voltage. 100 to 125 or 200 to 250V, 50 to 400Hz, 32W.

Time-base external drive. Both the room-temperature-oscillator and the high-precision-oscillator models can be phase-locked to a 0.1, 1, 2.5, 5, or 10-MHz signal of any waveshape and of at least 1V rms or 3V pk-pk into 1KΩ. The room-temperature oscillator will lock on a stable external signal that is within approximately 100Hz of its nominal frequency and the high-stability oscillator will lock on a signal within 10Hz of its nominal frequency.

3.3.2 SETTINGS

Line .... **100-125V** — For line voltages of from 100 to 125V.
or 200-250V — For line voltages of from 200 to 250V.

TIME BASE .... **INT** — If internal oscillator is to be used alone.
or EXT LOCK — If internal oscillator is to be phase-locked to an external signal.

When the TIME BASE switch is set to EXT LOCK and an external signal is connected to the EXT DRIVE connector, the front-panel ΦLOCK OUT neon must be extinguished. If it is not, the internal oscillator is not properly locked to the external signal.

NOTE: If the TIME BASE switch is set to EXT LOCK and no external lock signal is applied, the oscillator frequency will be set to its low extreme and, therefore, will not be properly calibrated.

STORAGE-DISABLE .... **STORAGE** — If storage feature is desired.
or DISABLE — If storage feature is not desired.

The counter employs a storage register for all measurements except COUNT. This allows the visual register to change only after a measurement has been completed and thus prevents flicker. If this feature is not desired, set the STORAGE-DISABLE switch to DISABLE.

3.4 INPUT CONTROLS

3.4.1 CHARACTERISTICS

Frequency	INPUT A INPUT B	Dc coupled: dc to 20 MHz Dc coupled: dc to 10 MHz		Ac coupled: 3 Hz to 20 MHz Ac coupled: 3 Hz to 10 MHz	
Levels	POLARITY & ATTEN setting	*Without Probe*		*With Probe*	
		minimum	*maximum*	*minimum*	**maximum*
	EXT PRO	10mV rms, 30mV pk-pk	150Vdc or ac pk-pk	100mV rms, 300mV pk-pk	600Vdc or ac pk-pk
	1	10mV rms, 30mV pk-pk	150Vdc or ac pk-pk	100mV rms, 300mV pk-pk	600Vdc or ac pk-pk
	10	100mV rms, 300mV pk-pk	300Vdc or ac pk-pk	1V rms, 3V pk-pk	600Vdc or ac pk-pk
	100	1V rms, 3V pk-pk	300Vdc or ac pk-pk	10V rms, 3V pk-pk	600Vdc or ac pk-pk
		* Less over 4.5 MHz: 500V at 5.5 MHz, 400V at 7 MHz, 300V at 9 MHz, 200V at 14 MHz, and 100V at 25 MHz.			
Impedance		1MΩ shunted by 35pF		10MΩ shunted by 7pF	

3.4.2 GENERAL SETTINGS

These settings cover most cases. Exceptions are also noted here and in paragraph 3.4.3.

Signal connection........................ INPUT A — Connect second signal to INPUT B for INTERVAL and RATIO measurements.

AC-DC................................ AC — Set to DC for very-low-frequency signals.

POLARITY & ATTEN.................... +1 — Set POLARITY to - if it is desired to trigger on the negative slopes. Set ATTEN to 10 or 100 for noisy signals or signals that exceed 150Vdc or ac pk-pk.

If it is desired to use the internal 10-MHz test signal for channel A, set the A POLARITY & ATTEN to TEST 10MHz. If it is desired to use the internal test signal for channel B, set *both* the A and B POLARITY & ATTEN controls to TEST 10MHz.

NOTE: To use the 10-MHz test signal in channel B, both the A and B POLARITY & ATTEN controls must be set to TEST 10MHz.

THRESHOLD .... centered — Set cw or ccw (+ or -) when the input signal contains a dc component and the AC-DC switch is set to DC.

SEPARATE—COMMON .... SEPARATE — Set to COMMON for duration measurements.

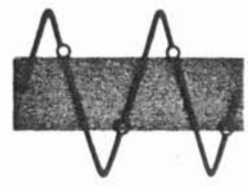
3.4.3 SPECIAL SETTINGS

These signals require input-control settings that may differ slightly from the general settings. The voltages shown are at the input to the triggering circuits; after attenuation by the probe and ATTEN switch.

Insufficient signal. Signal level is less than hysteresis; no triggering occurs.

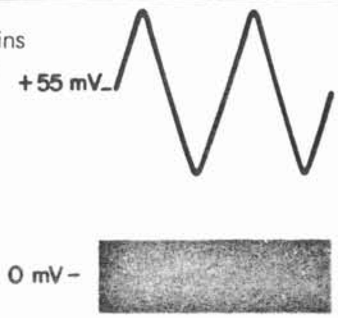
1191-3-4

Signal level increased or attenuation decreased (ATTEN set from 100 or 10 to 1; or X1 probe used instead of X10 probe); proper triggering occurs.



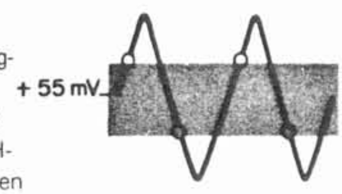
1191-3-7

Dc component. Signal contains positive dc component; with THRESHOLD control centered, no trigger occurs.



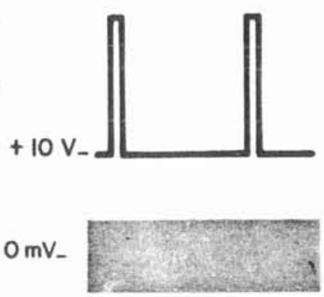
1191-3-5

Threshold level set to same value as dc component of signal (THRESHOLD control turned cw, if dc component had been negative, THRESHOLD control would have been turned ccw); proper triggering occurs.

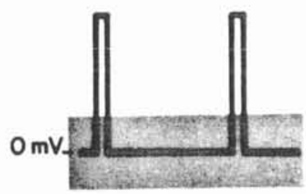


1191-3-8

Excessive dc component, low duty ratio. Signal contains a large positive dc component; no triggering occurs.

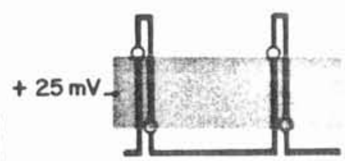


1191-3-6



1191-3-9

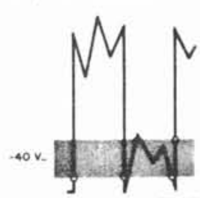
Ac coupling used to eliminate dc component; low duty ratio prevents triggering.



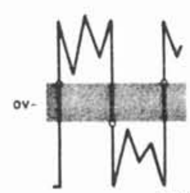
1191-3-10

THRESHOLD control turned cw, if pulses had been negative, THRESHOLD control would have been turned ccw; proper triggering occurs.

Noise. Noise peaks exceed hysteresis; erratic and erroneous triggering occurs.

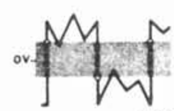


1191-3-11



1191-3-13

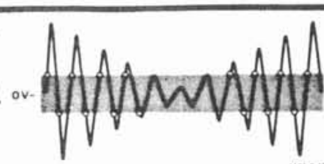
Threshold level set out of noise range; proper triggering occurs.



1191-3-14

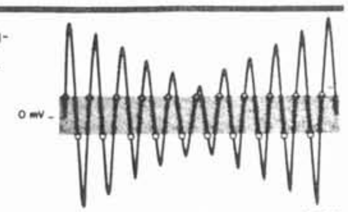
Or signal level decreased so that noise peaks do not exceed hysteresis; proper triggering occurs.

Am signal. Amplitude modulation reduces signal below hysteresis; counts are missed.



1191-3-12

Signal level increased or attenuation decreased; proper triggering occurs.



1191-3-15

3.5 DISPLAY TIME, SET 0, AND SET 9 CONTROLS

3.5.1 SETTINGS

DISPLAY TIME....... 100μs to 10sec or SINGLE MEASURE

For automatically initiated measurements.
For manually initiated measurements.

The DISPLAY TIME switch sets the hold-off time; i.e., the time between the end of one measurement and the beginning of the next. During this time the measurement data is retained unchanged to permit visual observation or data processing. The DISPLAY TIME can be set from 100μs to 10s or infinity as follows:

Setting	Display Time (approximate)	
100μs	100μs	*Automatic.* With these settings, the measurements are initiated automatically. At the end of the display time, a new measurement is started, proceeds for a time determined by the program conditions (MEASUREMENT and RANGE control settings) and the signal being measured, and then terminates. After the measurement terminates, the display time starts, ends, and a new measurement begins automatically. For COUNT measurements, the registers set to zero after the display time and a new measurement starts only when the START button is pushed.
---	1ms	
---	10ms	
---	50ms	
100ms	100ms	
---	200ms	
---	500ms	
1sec	1s	
---	2s	
---	5s	
10sec	10s	
SINGLE MEASURE	infinity	*Manual.* With this setting, the measurements are initiated manually. After a measurement has been completed, the registers retain the result indefinitely or until the SET 0 button is pushed. For all measurements except COUNT, the SET 0 button initiates a new measurement. For COUNT measurements, the SET 0 button sets the registers to zero.

The counter employs a storage register that stores and displays the results of one measurement while another measurement is being made. The ***total*** display time, therefore, is the sum of the display time, as set by the DISPLAY TIME control, and the measurement time, as determined by the program conditions and the signal being measured.

SET 0............... push to set zero or push to start measurement

With no input signal.
With an input signal.

With no input signal applied and with any settings of the DISPLAY TIME, RANGE, and MEASUREMENT controls, the SET 0 button sets the registers to zero.

With an input signal applied and with any settings of the DISPLAY TIME, RANGE (except EXT PROG), and MEASUREMENT controls, the SET 0 button initiates a new measurement; i.e., terminates any measurement in progress, sets the registers to zero, and starts a new measurement. With the RANGE switch set to EXT PROG, the SET 0 button simply sets the registers to zero.

SET 9............... push and hold to set nine

To set the registers to nine, push the SET 9 button during a measurement (COUNTING lamp lit) and hold it in until the measurement is complete (COUNTING lamp extinguished). With the COUNT button pushed or with the rear-panel STORAGE-DISABLE switch set to disable, the SET 9 button can be pushed and released at any time to set the registers to nine.

3.6 RANGE CONTROL

3.6.1 CHARACTERISTICS

Precision. The RANGE switch determines the precision (number of significant digits) with which the measurement is made. The higher the range, the greater the precision except for INTERVAL measurements where the reverse is true and COUNT measurements where the RANGE switch is not used. The effects of the RANGE switch on precision are tabulated under the various measurement procedures (paragraphs 3.7 through 3.12).

Spill. In exchange for precision however, significant digits may be dropped (spilled) from the registers since counting times are longer (except, again, for INTERVAL or COUNT measurements). The effects of the RANGE switch on precision are also tabulated under the various measurement procedures (paragraphs 3.7 through 3.12).

Accuracy. In addition to precision and spill, the RANGE switch also affects the significance of the ± 1 count uncertainty (paragraph 3.14.2) and the trigger error (paragraph 3.14.3).

3.6.2 SETTINGS

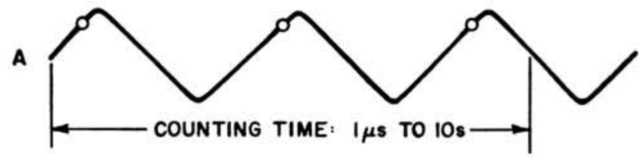
RANGE	**10**	for FREQUENCY
	or 1	for PERIOD
	or 1	for INTERVAL
	or 10	for RATIO
	or ---	for COUNT (has no effect)

These initial settings provide either the maximum display capacity to prevent an accidental spill or a reasonable measurement time for most normally encountered signals. After the first measurement, the RANGE switch can be set as desired.

3.7 FREQUENCY

3.7.1 CHARACTERISTICS

The frequency of sinewave signals or of pulse signals with greater than 50-ns separation can be measured from dc to 20MHz with a resolution of up to 0.1Hz. The pulses that are counted are derived from the input signal and the counting time is set by the RANGE switch in decade increments from 10 x the 0.1-μs internal clock period (1μs) to 10^8 x the clock period (10s).



	RANGE Switch Setting								
	1	*10*	*10^2*	*10^3*	*10^4*	*10^5*	*10^6*	*10^7*	*10^8*
Maximum count (spill)	not usable	---	---	---	---	---	---	---	10MHz
Minimum count (resolution)		1MHz	100KHz	10KHz	1KHz	100Hz	10Hz	1Hz	0.1Hz
Accuracy		± (1 count + time-base accuracy)							

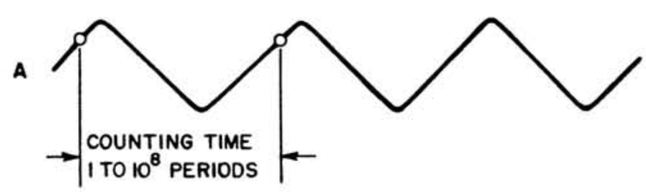
3.7.2 SETTINGS

Push the FREQUENCY button, set the RANGE and DISPLAY TIME controls as desired, connect the signal to INPUT A, and set the input controls to obtain a measurement.

3.8 PERIOD

3.8.1 CHARACTERISTICS

Signal periods can be measured from 100ns to 1Gs with a resolution of up to 100ns. For periods less than 10s, the pulses that are counted are the 10-MHz pulses derived from the internal clock and the counting time is set by the RANGE switch in decade increments from 1 period to 10^8 periods of the input signal. For periods greater than 10s, the pulses that are counted are the pulses derived from the internal clock and set by the RANGE switch in decade increments from 1 x 10MHz (10MHz) to 10^8 x 10MHz (0.1Hz) and the counting time is 1 period of the input signal.



	RANGE Switch Setting								
	1	*10*	*10^2*	*10^3*	*10^4*	*10^5*	*10^6*	*10^7*	*10^8*
< 10s maximum count (spill)	10s	1s	100ms	10ms	1ms	100μs	10μs	1μs	100ns
< 10s (resolution)	100ns	100ns	100ns	100ns	100ns	100ns	100ns	100ns	100ns
> 10s maximum count (spill)	10s	100s	1ks	10ks	100ks	1Ms	10Ms	100Ms	1G
> 10s minimum count (resolution)	100ns	1μs	10μs	100μs	1ms	10ms	100ms	1s	10s
Accuracy	+ (1 count + trigger error + time-base accuracy)								

3.8.2 SETTINGS

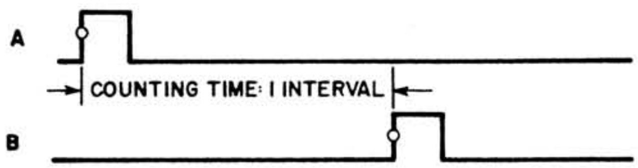
Periods less than 10 seconds. Push the PERIOD button, set the RANGE and DISPLAY TIME controls as desired, connect the signal to INPUT A, and set the input controls to obtain a measurement.

Periods greater than 10 seconds. Push the INTERVAL button, set the RANGE and DISPLAY TIME controls as desired, connect the signal to INPUT A, and set the input controls to obtain a measurement.

3.9 INTERVAL

3.9.1 CHARACTERISTICS

The time interval between two signals can be measured from 100ns to 1Gs with a resolution of up to 100n. The pulses that are counted are derived from the internal clock and set by the RANGE switch in decade increments from 1 x 10MHz (10MHz) to 10^{-8} x 10MHz (0.1Hz) and the counting time is the time interval between the two signals.



	RANGE Switch Setting								
	1	*10*	*10^2*	*10^3*	*10^4*	*10^5*	*10^6*	*10^7*	*10^8*
Maximum count (spill)	10s	100s	1ks	10ks	100ks	1Ms	10Ms	100Ms	1bs
Minimum count (resolution)	100ns	1µs	10µs	100µs	1ms	10ms	100ms	1s	10s
Accuracy	± (1count + trigger error + time-base accuracy)								

3.9.2 SETTINGS

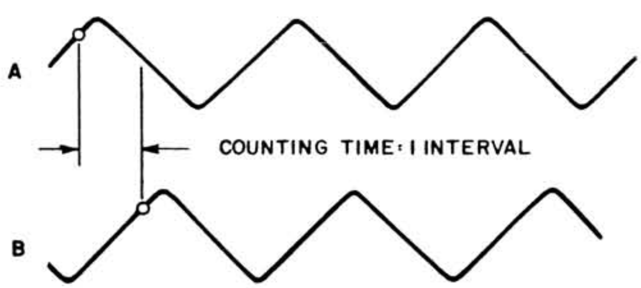
Push the INTERVAL button and set the RANGE and DISPLAY TIME controls as desired. Connect the first signal to INPUT A, connect the second signal to INPUT B, and set the input controls to obtain a measurement. For maximum accuracy, set the A and B POLARITY & ATTEN controls to 1.

NOTE: If another A event occurs before a B event, the counter measures the interval between the two A events; i.e., the counter measures the A period.

3.10 PHASE

3.10.1 CHARACTERISTICS

The phase difference between two signals of the same frequency and amplitude can be measured indirectly from 0 to 360°. The quantity measured is actually the time interval between the two signals and the measurement technique is the same as that for INTERVAL measurements (paragraph 3.9.1). It is important, for any degree of accuracy, that both signals be of the same amplitude and that the amplitudes be as high as possible.



3.10.2 SETTINGS

Push the INTERVAL button, set the RANGE control to 1, and set the DISPLAY TIME control as desired. Connect the reference signal to both INPUT A and INPUT B, set the A and B POLARITY & ATTEN controls to the same settings, and set the other A and B controls to obtain a measurement. Use the THRESHOLD controls to zero the reading (set the visual register to within ± 1 count of zero).

Disconnect the reference signal from INPUT B and connect the second signal in its place (do not disturb the settings of the input controls) and compute the phase angle from:

$$\Phi = \frac{\text{interval}}{\text{signal period}} \times 360^\circ$$

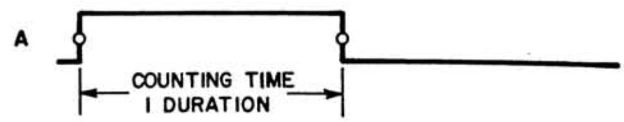
Representative measurements:

Input Frequency	*Interval* 100ns	*1µs*	*10µs*	*100µs*	*1ms*	*10ms*	*100ms*	*1s*
0.1Hz	3.6µ°	36µ°	360µ°	3.6m°	36m°	360m°	3.6°	36°
1Hz	36µ°	360µ°	3.6m°	36m°	360m°	3.6°	36°	
10Hz	360µ°	3.6m°	36m°	360m°	3.6°	36°		
100KHz	3.6m°	36m°	360m°	3.6°	36°			
1KHz	36m°	360m°	3.6°	36°				
10KHz	360m°	36°						

3.11 DURATION

3.11.1 CHARACTERISTICS

Pulse durations can be measured from 100ns to 1Gs with a precision of up to 100ns. The measurement technique is similar to that of INTERVAL measurements (paragraph 3.9.1). The pulses that are counted are derived from the internal clock and set by the RANGE switch in decade increments from 1 x 10MHz (10MHz) to 10^{-8} x 10MHz (0.1Hz) and the counting time is the pulse duration of the input signal.



	RANGE Switch Setting								
	1	*10*	*10^2*	*10^3*	*10^4*	*10^5*	*10^6*	*10^7*	*10^8*
Maximum count (spill)	10s	100s	1ks	10ks	100ks	1Ms	10Ms	100Ms	1bs
Minimum count (precision)	100ns	1μs	10μs	100μs	1ms	10ms	100ms	1s	10s
Accuracy	± (1 count + trigger error + time-base accuracy)								

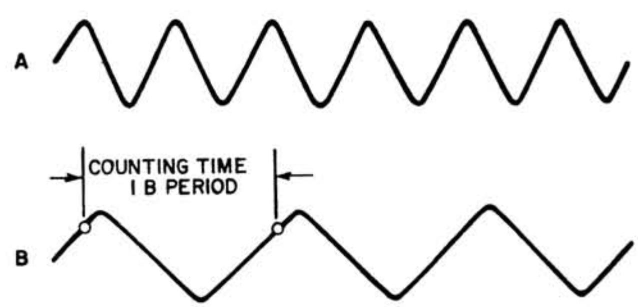
3.11.2 SETTINGS

Push the INTERVAL button and set the RANGE and DISPLAY TIME controls as desired. Connect the signal to INPUT A and set the SEPARATE—COMMON switch to COMMON. ***For positive pulses,*** set the A POLARITY to + and the B POLARITY to–; ***for negative pulses,*** set the A POLARITY to–and the B POLARITY to +. Set the other input controls to obtain a measurement.

3.12 RATIO

3.12.1 CHARACTERISTICS

The frequency ratio of the signal applied to INPUT A with respect to the signal applied to INPUT B can be measured to 10^8 : 1 with a resolution of 1 A count. The pulses that are counted are derived from the signal applied to INPUT A and the counting time is the period of the signal applied to INPUT B.



	RANGE Switch Setting								
	1	*10*	*10^2*	*10^3*	*10^4*	*10^5*	*10^6*	*10^7*	*10^8*
Maximum count (spill)	10^8:1	10^7:1	10^6:1	10^5:1	10^4:1	10^3:1	10^2:1	10:1	1:1
Minimum count (resolution) **Accuracy**	± (1 A count + B trigger error)								

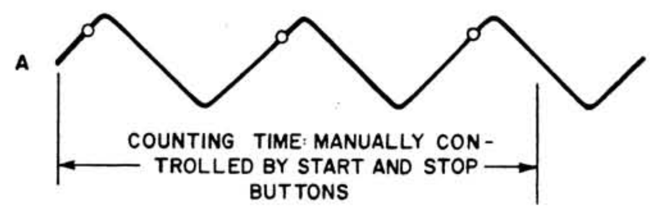
3.12.2 SETTINGS

Push the RATIO button and set the RANGE and DISPLAY TIME controls as desired. Connect one signal to INPUT A and connect the other to INPUT B, and set both sets of input controls to obtain a measurement.

3.13 COUNT

3.13.1 CHARACTERISTICS

From 1 to 100 million events can be counted at rates up to 20 million per second. The pulses that are counted are derived from the input signal and the counting time is controlled manually by the START and STOP buttons.



Maximum count (spill)	100 M
Minimum count	1

3.13.2 SETTINGS

Push the COUNT button, set the DISPLAY TIME control as desired, and push the START button. Connect the signal to INPUT A, set the input controls so that counts register, and push the STOP button. If the DISPLAY TIME control is set to SINGLE MEASURE, push the SET 0 button to clear the registers (with any other setting of the DISPLAY TIME control, the registers will clear automatically). Push the START button to initiate the count and push the STOP button to terminate it.

3.14 REMOTE PROGRAMING

Referenced paragraphs contain additional details.

Set:	*To:*	*To Remotely Program:*
A POLARITY & ATTEN	EXT PROG	(2.6.5, 5.6.12) A polarity (closure to ground) and A threshold (± 100mVdc voltage). AC-DC switch function and attenuator and TEST 10MHz functions of POLARITY & ATTEN switch are not remotely programmable.
B POLARITY & ATTEN	EXT PROG	(2.6.5, 5.6.12) B polarity (closure to ground) and B threshold (± 100mVdc voltage). AC-DC switch function and attenuator and TEST 10MHz functions of POLARITY & ATTEN switch are not remotely programmable.
DISPLAY TIME	EXT PROG	(2.6.4, 5.6.12) Display time (closure to ground and resistance to ground).
RANGE	EXT PROG	(2.6.3, 5.6.12) Range (closure to ground).
MEASUREMENT	FREQUENCY	(2.6.2, 5.6.12) Measurement (closure to ground).
STORAGE-DISABLE (rear)	STORAGE	(2.6.6, 5.6.12) To enable or disable storage feature (closure to ground).
No special settings necessary:		(2.6.6, 5.6.12) To set 0 (open from ground), to start (closure to ground), and to stop (closure to ground).
Other functions not programmable:		SEPARATE—COMMON switch, SET 9 pushbutton, TIME-BASE (rear) and FREQ ADJ (rear).

3.15 ACCURACY

3.15.1 ERROR SOURCES

Accuracy is determined by up to three factors depending upon the measurement:

Frequency ± (1 count + time-base accuracy)
Period ± (1 count + trigger error + time-base accuracy)
Interval ± (1 count + trigger error + time-base accuracy)
Ratio ± (1 count + trigger error + time-base accuracy)

3.15.2 1-COUNT UNCERTAINTY

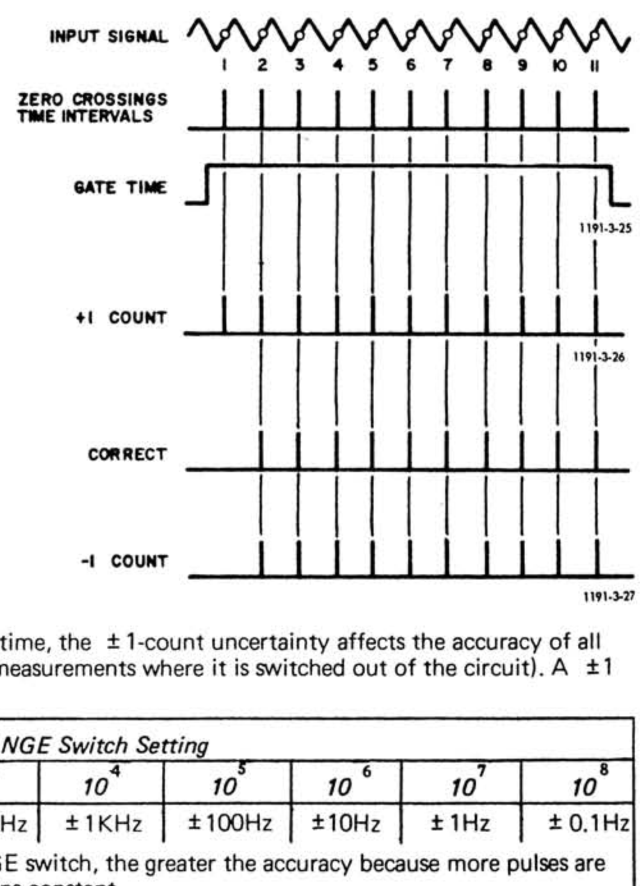
The ± 1-count uncertainty is a concomitant of the measurement process used in counters. It occurs with all measurements (except COUNT where the quantity or event is represented by a brief pulse) but will be explained in terms of a frequency measurement only:

Zero crossings counted. In all counters, frequency is measured in terms of pulses that represent the signal zero crossings. What we would like to measure to define frequency, is the precise number of intervals, representative of cycles, of the unknown frequency that occur within a known time interval, but this is not possible.

+1 count. An input frequency of 10 units, with respect to the gate time, is applied to the counter. If the gate is enabled just before the first pulse, the counter's register accumulates a count and indicates 1, but a full time interval has not yet elapsed. If the gate is then inhibited just after the eleventh pulse, the register indicates 11, 1 count high since it is representative of only ten intervals.

Correct count. If the gate is enabled a short time after the first pulse, the first pulse is not counted and the register indicates the correct value of 10.

-1 count. If the gate is inhibited a short time before the eleventh pulse, the eleventh pulse is not counted and the register indicates 9, 1 count low since it is representative of ten intervals.

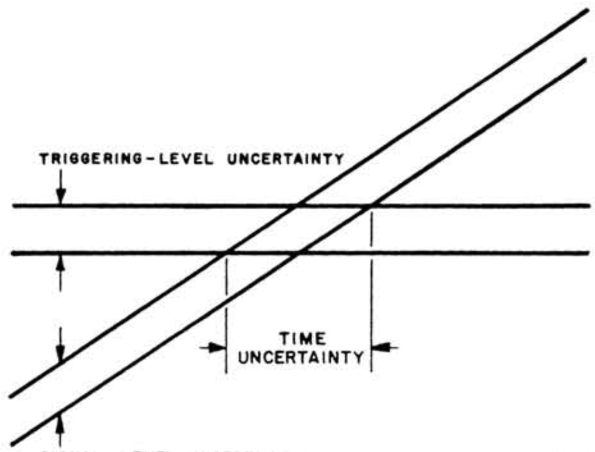


Affects on measurements. Since the RANGE control sets the gate time, the ± 1-count uncertainty affects the accuracy of all measurements in direct proportion to its setting (except COUNT measurements where it is switched out of the circuit). A ± 1 count amounts to the following errors:

MEASUREMENT	*RANGE Switch Setting*								
	1	10	10^2	10^3	10^4	10^5	10^6	10^7	10^8
Frequency		±1MHz	±100KHz	±10KHz	±1KHz	±100Hz	±10Hz	±1Hz	±0.1Hz
	The longer the gate time, as set by the RANGE switch, the greater the accuracy because more pulses are accumulated while the ± 1-count error remains constant.								
Period	±100ns	±10ns	±1ns	±100ps	±10ps	±1ps	±100fs	±10fs	±1fs
	The longer the gate time. as set by the RANGE switch, the greater the accuracy because more pulses are accumulated while the ± 1-count error remains constant.								
Interval	±100ns	±1μs	±10μs	±100μs	±1ms	±10ms	±100ms	±1s	±10s
	The longer the time between counted pulses, as set by the RANGE switch, the lesser the accuracy because the accumulated pulses represent greater periods of time while the ± 1-count error remains constant.								
Ratio	±1:1	$\pm 10^{-1}$:1	$\pm 10^{-2}$:1	$\pm 10^{-3}$:1	$\pm 10^{-4}$:1	$\pm 10^{-5}$:1	$\pm 10^{-6}$:1	$\pm 10^{-7}$:1	$\pm 10^{-8}$:1
	The longer the gate time, as set by the RANGE switch, the greater the accuracy because more pulses are accumulated while the ± 1-count error remains constant.								

3.15.3 TRIGGER ERROR

The accuracy of period, interval, and ratio measurements is affected by trigger error which is a time uncertainty associated with triggering. This uncertainty is due to the triggering-level crossings of the signal which can vary because of drift, hum pickup, noise, etc., and to the trigger level of the counter itself which can also vary because of similar reasons.



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Normal inputs. When the input signal contains noise, trigger error is primarily a function of the input signal-to-noise ratio and the number of periods averaged. Trigger error in % = $\frac{30V_n}{pV_s}$ where V_n = peak noise voltage, V_s = peak noise voltage, and p = number of periods of averaged. The greater the signal-to-noise ratio and the higher the RANGE switch setting, the lesser the trigger error; as follows:

Signal-to-Noise Ratio	*RANGE Switch Setting*								
	1	*10*	*10^2*	*10^3*	*10^4*	*10^5*	*10^6*	*10^7*	*10^8*
20dB (10:1 voltage)	3 %	3×10^{-1}%	3×10^{-2}%	3×10^{-3}%	3×10^{-4}%	3×10^{-5}%	3×10^{-6}%	3×10^{-7}%	3×10^{-8}%
40dB (100:1 voltage)	3×10^{-1}%	3×10^{-2}%	3×10^{-3}%	3×10^{-4}%	3×10^{-5}%	3×10^{-6}%	3×10^{-7}%	3×10^{-8}%	3×10^{-9}%
60dB (1,000:1 voltage)	3×10^{-2}%	3×10^{-3}%	3×10^{-4}%	3×10^{-5}%	3×10^{-6}%	3×10^{-7}%	3×10^{-8}%	3×10^{-9}%	3×10^{-10}%
80dB (10,000:1 voltage)	3×10^{-3}%	3×10^{-4}%	3×10^{-5}%	3×10^{-6}%	3×10^{-7}%	3×10^{-8}%	3×10^{-9}%	3×10^{-10}%	3×10^{-11}%

Low-noise inputs. When the input signal is noise free, the trigger error is a function of the internal noise in the counter which is < 500μV. Trigger error in μs is less than 0.0005/S where S is the signal slope in V/μs at the input to the triggering circuit (after the probe and attenuator). The faster the risetime or the greater the amplitude, the lesser the trigger error; as follows:

Signal Slope		*Signal Amplitude (pk-pk)*							
Risetime	*Frequency*	*50mV*	*100mV*	*500mV*	*1V*	*5V*	*10V*	*50V*	*100V*
350ns	1MHz	4.5ns	2.2ns	450ps	220ps	45ps	22ps	4.5ps	2.2ps
175ns	2MHz	2.2ns	1.1ns	220ps	110ps	22ps	11ps	2.2ps	1.1ps
70ns	5MHz	880ps	450ps	88ps	45ps	8.8ps	4.5ps	880fs	450fs
35ns	10MHz	450ps	220ps	45ps	22ps	4.5ps	2.2ps	450fs	220fs
17.5ns	20MHz	220ps	110ps	22ps	11ps	2.2ps	1.1ps	220fs	110fs

3.15.4 TIME-BASE ACCURACY

The accuracy of frequency, period, and interval measurements is affected by time-base accuracy which is dependent on the type of time base used, oscillator drift, ambient temperature, and line voltage as follows:

Time Base		*Specifications*	
	Drift after 30 days continuous operation	*Line Variation with ± 10% line-voltage variation*	*Temp. Variation from 0°C to +50°C*
Room-temperature oscillator	< $\pm 2 \times 10^{-6}$/mo	< $\pm 2 \times 10^{-8}$	< $\pm 2 \times 10^{-7}$/°C
High-stability oscillator	< $\pm 1 \times 10^{-8}$/wk	< $\pm 2 \times 10^{-10}$	< $\pm 2 \times 10^{-10}$/°C
1115-B external drive	< $\pm 5 \times 10^{-10}$/dy	< $\pm 1 \times 10^{-11}$	< $\pm 1 \times 10^{-11}$/°C

Calibration. Set the rear-panel TIME BASE switch to INT, push the FREQUENCY button, and set the RANGE switch to 10^8. Connect a known frequency to INPUT A, set the input controls to obtain a measurement, and adjust the FREQ ADJ, R950 on the rear panel, until the visual register displays exactly the value of the known frequency. For maximum accuracy, use a known frequency of 10MHz, allow the counter to warm up for one to two hours before adjustment, and adjust the oscillator at the line voltage and ambient temperature under which the counter is normally operated.

NOTE: The self-test procedure (TEST 10MHz) does not check the accuracy of the time-base (clock) oscillator.

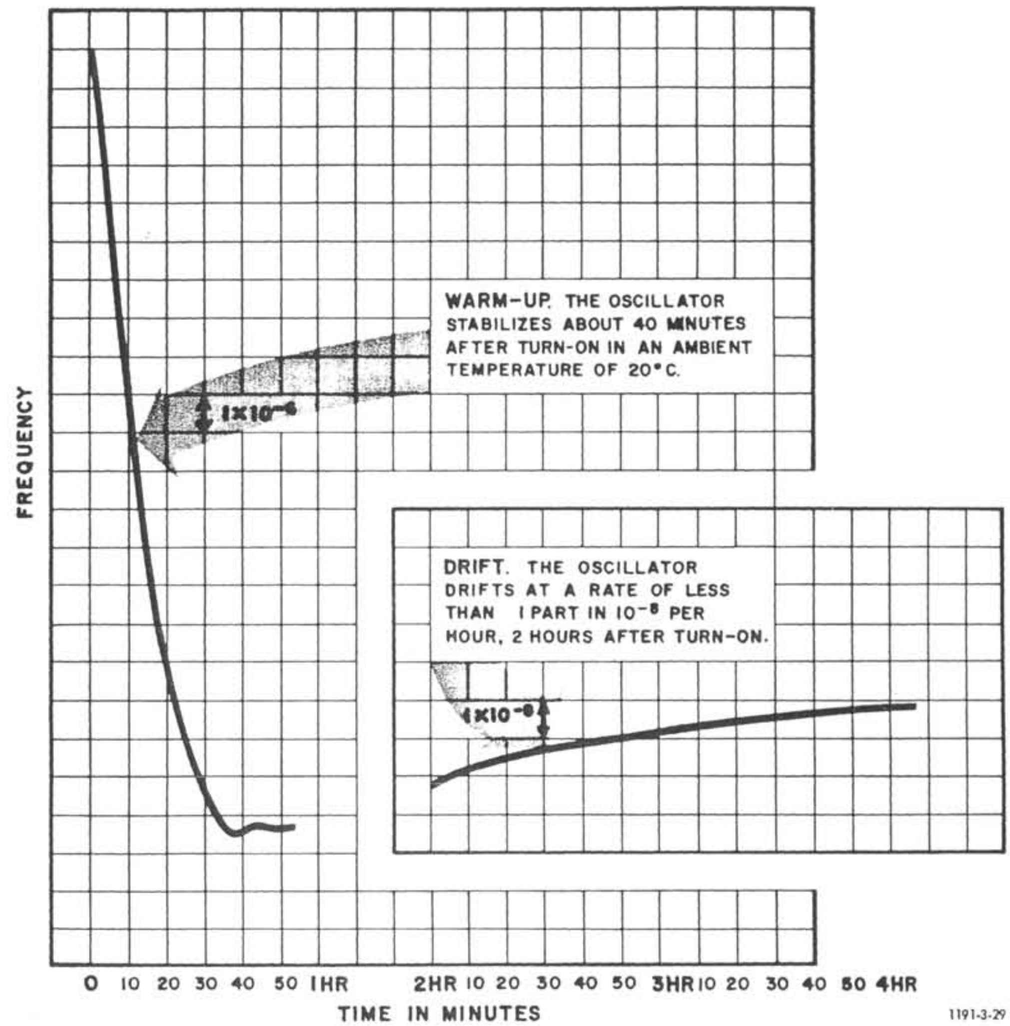
High-precision-oscillator additional data.

Warm-up. The oscillator stabilizes about 40 minutes after turn-on in an ambient temperature of 20°C. For lower temperatures, warm-up time increases about one minute per °C.

Drift. After one-month continuous operation so the aging rate is less than 2×10^{-9} per day, the oscillator will drift less than 1×10^{-8} per hour, 2 hours after turn-on.

Temperature. The specification of less than $2 \times 10^{-10}/°C$ is taken from the maximum slope at the high or low temperatures of the frequency-vs-time curve. This is typically a parabolic curve with a maximum value and a zero slope at about 35°C.

Short-term stability. For a one-second averaging time, short-term stability = $(\Delta f/f) < 1 \times 10^{-10}$ rms.

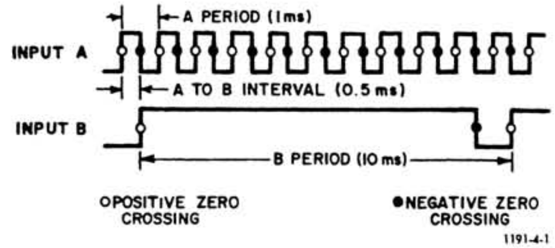


Principles

SECTION 4

4.1 BLOCK DESCRIPTION

ɟram AQ.



.1 INTRODUCTION

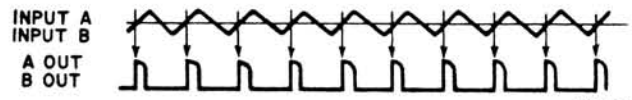
electronic counter counts electrical pulses, one at a time, ɟ displays the total. The total is equal to the rate at which ɜ pulses occur (for periodic signals) multiplied by the time ɜ counter is allowed to count.

ıe type of measurement made depends on the source of the pulses and the source of control for the counting time. The pulse urce may be the signal to be measured (input signal) or the internal 10-MHz oscillator (clock signal). The counting-time conol source may be manually-operated pushbuttons, the input signal, or the clock signal as follows:

leasurement	*Counting (pulse source)*	*Timing (control source)*	*Count (pulse rate x counting time)*	*Example*
:OUNT	Input A	Manual	Input A rate x START-to-STOP time	A 1-KHz symmetrical square-wave input signal is applied, the START button is pushed, and, after 10 seconds, the STOP button is pushed. Count = $10^3 \times 10 = 10^4$ = 10,000.
?ERIOD	Clock	Input A	Clock rate x input A period	A 1-KHz symmetrical square-wave input signal is applied, the count starts automatically with one positive zero-crossing and stops with the next. Count = $10^7 \times 10^{-3} = 10^4$. Since each clock period is 10^{-7}s; measurement = $10^4 \times 10^{-7} = 10^3$ = 1ms.
FREQUENCY	Input A	Clock	Input A rate x clock period (or decade multiple of clock period)	A 1-KHz symmetrical square-wave input signal is applied, the count starts automatically and stops precisely 10^7 clock periods ($10^7 \times 10^{-7}$ = 1s) later. Count = $10^3 \times 1 = 10^3$ = 1000 counts in one second; measurement = 1KHz.
INTERVAL	Clock	Inputs A and B	Clock rate x input interval	A 1-KHz symmetrical square-wave input signal is applied to input A and a 100-Hz pulsed input signal, derived from the 1-KHz signal, is applied to input B. The count starts automatically with one positive zero-crossing of input A and stops with the next positive zero crossing of input B. Count = $10^7 \times 0.5 \times 10^{-3} = 5 \times 10^3$. Since each clock period is 10^{-7}s; measurement = $5 \times 10^3 \times 10^{-7} = 5 \times 10^{-4}$ = 0.5ms.
RATIO (A/B)	Input A	Input B	Input A rate x input B period	A 1-KHz symmetrical square-wave input signal is applied to input A and a 100-Hz pulsed input signal is applied to input B. The count starts automatically with one positive zero-crossing of input B and stops with the next. Count = $10^3 \times 10^{-2}$ = 10; i.e., input A is ten times the frequency of input B.

4.1.2 INPUT SIGNALS (input board C)

A OUT, B OUT. The signals to be measured are applied to the input board where they are processed to form positive pulses at the desired triggering threshold (zero-crossing).



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4.1.3 CLOCK (clock board J)

CLK. The clock signal is the output of a precise 5-MHz oscillator doubled to 10-MHz.

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4.1.4 TIMING (time-base board L)

N OUT. Timing, in part, is controlled by the time-base board which contains eight cascaded decades. By means of the RANGE switch, the output from any one of the decades can be selected as the output from the time-base board.

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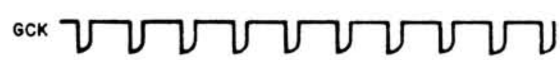
Before each measurement, an SO+ pulse from the program board presets all time-base decades to 9. The first input pulse (N IN) to the time-base board, therefore, sets all decades to 0 and produces an output pulse from each decade.

Since the output from one decade is always selected by the RANGE switch as the output from the time-base board, the first N IN pulse produces an output (N OUT) from the time-base board. The occurance of the next N OUT pulse is determined by the setting of the RANGE switch; e.g., if it is set to 10, the next N OUT pulse occurs after 10 N IN pulses.

4.1.5 COUNTING (register board E and display circuit F)

GCK. The pulses to be counted (GCK) are processed by the format board and are applied to the register board. The register board contains a counting register that counts the GCK pulses and a storage register that stores the count.



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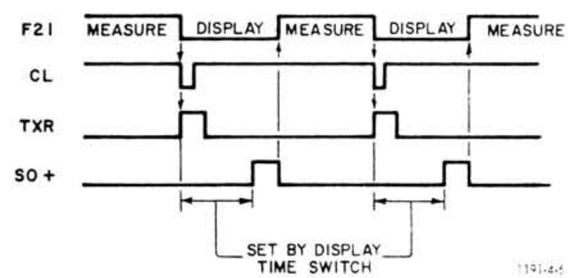
The stored count is applied to the display circuit which contains the decoders and readout tubes used to display the count visually.

4.1.6 DISPLAY TIME (program board H)

CL, TXR. After a measurement has been completed, a negative F21 pulse is generated by the format board. The negative F21 transition triggers a clear pulse (CL) and a transfer pulse (TXR) from the program board that are used to transfer the data from the counting register to the storage register on the register board.



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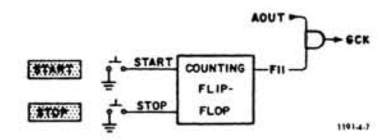
SO+. The negative F21 transition also triggers a delay whose duration is controlled by the DISPLAY TIME switch. During this delay, no new measurements can be made. After the delay, an SO+ pulse occurs which sets the counting register to zero, sets the time-base decades to 9, and resets the timing flip-flop on the format board in preparation for a new measurement.

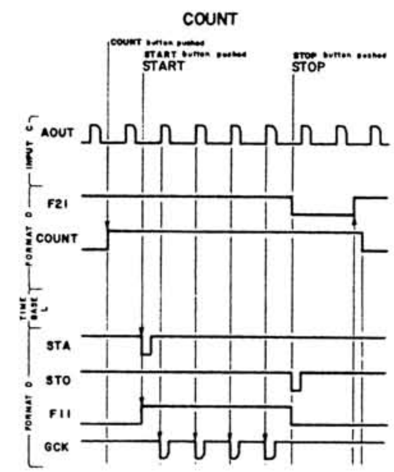
4.1.7 MEASUREMENTS (format board D)

The format board determines the type of measurement to be made and is controlled by five pushbutton switches. These pushbuttons control several gates (represented on the block diagram as switch sections A through D) that route the various signals to the timing and counting circuits as follows:

Count. Before a measurement, **F11** is 0 which inhibits the counting gate.



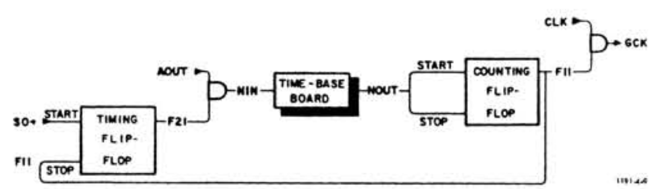
Start. With the COUNT button pushed, the START button is connected to the counting flip-flop start input and **A OUT** is connected to the counting gate. When the START button is pushed, it sets **F11** to 1 which enables the counting gate and allows the A OUT pulses to pass through, emerge as **GCK,** and go on to the register board to be counted.



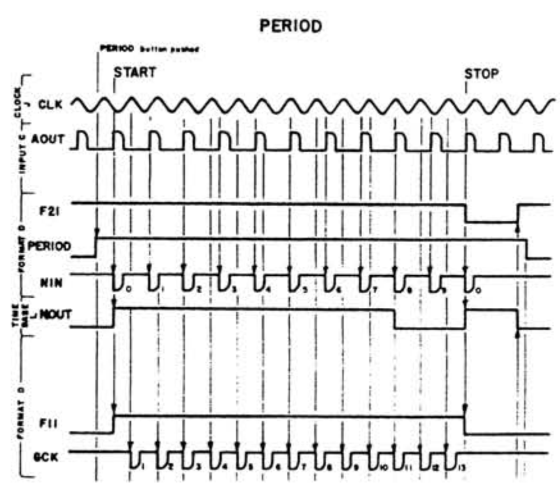
Stop. With the COUNT button pushed, the STOP button is connected to the counting flip-flop stop input. When the STOP button is pushed, it sets **F11** to 0 which inhibits the counting gate and stops the count.

Result. Input-A events are counted from the time the START button is pushed to the time the STOP button is pushed.

Period. Before a measurement, **SO+** from the program board sets **F21** to 1 which enables the timing gate; **F11** is 0 which inhibits the counting gate.



Start. With the PERIOD button pushed, **A OUT** is connected to the timing gate. The first A OUT pulse passes through the timing gates, emerges as **N IN,** and is applied to the time-base board. The first N IN pulse causes an **N OUT** positive transition which is applied to the counting flip-flop with the PERIOD button pushed. N OUT sets **F11** to 1 which enables the counting gate and allows the **CLK** clock pulses, applied to it with the PERIOD button pushed, to pass through, emerge as **GCK,** and go on to the register board to be counted.



Stop. If the RANGE switch has been set to 10, the second **N OUT** positive transition occurs with the tenth **N IN** pulse. With the PERIOD button pushed, N OUT is applied to the counting flip-flop stop input and the second N OUT positive transition sets **F11** to 0 which inhibits the counting gate and stops the count. The negative F11 transition sets **F21** to 0 which inhibits the timing gate.

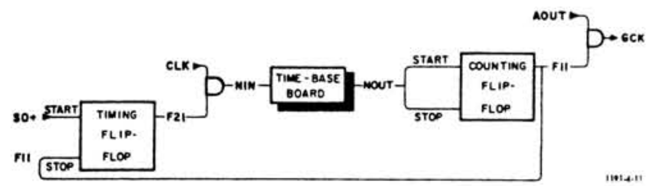
Result. Clock pulses are counted during the time of the input-A period or decade multiple of the input-A period.

Frequency. Before a measurement, **SO+** from the program board sets **F21** to 1 which enables the timing gate; **F11** is 1 which inhibits the counting gate.

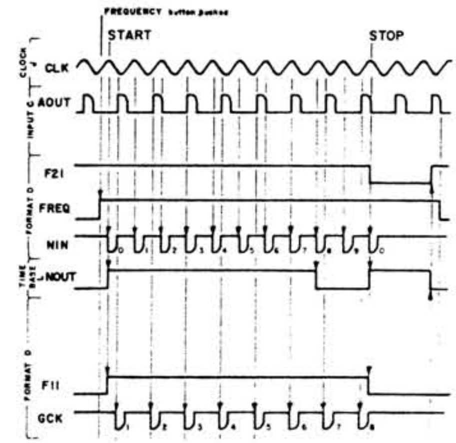
Start. With the FREQUENCY button pushed, the **CLK** clock pulses are applied to the timing gate. The first CLK clock pulse passes through the timing gate, emerges as **N IN,** and is applied to the time-base board. The first N IN pulse causes an N OUT positive transition which is applied to the counting flip-flop start input with the FREQUENCY button pushed. N OUT sets **F11** to 1 which enables the counting gate and allows **A OUT,** applied to it with the FREQUENCY button pushed, to pass through, emerge as **GCK,** and go on to the register board to be counted.

Stop. If the RANGE switch has been set to 10, the second **N OUT** positive transition occurs with the tenth **N IN** pulse. With the FREQUENCY button pushed, N OUT is applied to the counting flip-flop stop input and the second N OUT positive transition sets **F11** to 0 which inhibits the counting gate and stops the count. The negative F11 transition sets **F21** to 0 which inhibits the timing gate.

Result. Input-A events are counted during the time of a decade multiple of the clock period.



FREQUENCY

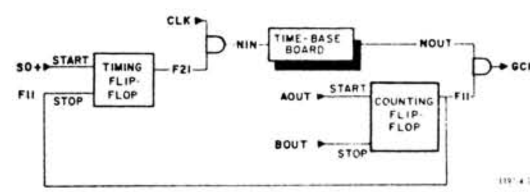


Interval. Before a measurement, **SO+** from the program board sets **F21** to 1 which enables the timing gate; **F11** is 0 which inhibits the counting gate.

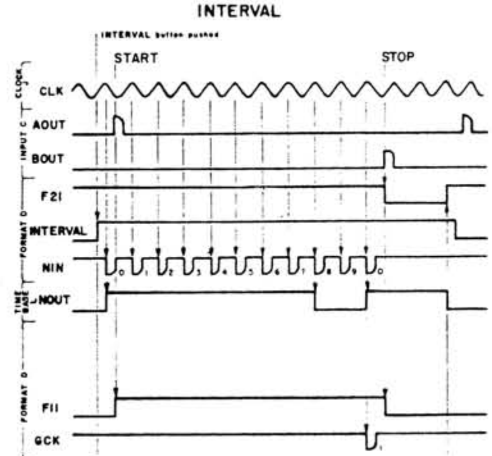
Start. With the INTERVAL button pushed, the **CLK** clock pulses are applied to the timing gate. They pass through the timing gate, emerge as **N IN,** and are applied to the time-base board. If the RANGE switch has been set to 10, **N OUT** is one-tenth the rate of N IN. With the INTERVAL button pushed, **A OUT** is applied to the counting flip-flop start input. When an A OUT pulse occurs, it sets **F11** to 1, which enables the counting gate and allows N OUT, applied to the counting gate with the INTERVAL button pushed, to pass through, emerge as **GCK,** and go on to the register board to be counted.

Stop. With the INTERVAL button pushed, **B OUT** is applied to the counting flip-flop stop input. When a B OUT pulse occurs, it sets **F11** to 0, which inhibits the counting gate and stops the count. The negative F11 transition sets **F21** to 0 which inhibits the timing gate.

Result. Decade increments of the clock frequency are counted from the time of an input-A event to the time of an input-B event.



INTERVAL

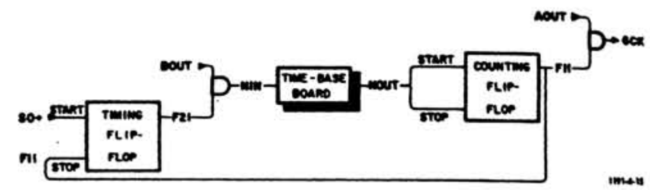


Ratio (A/B). Before a measurement, **SO+** from the program board sets **F21** to 1 which enables the timing gate, **F11** is 0 which inhibits the counting gate.

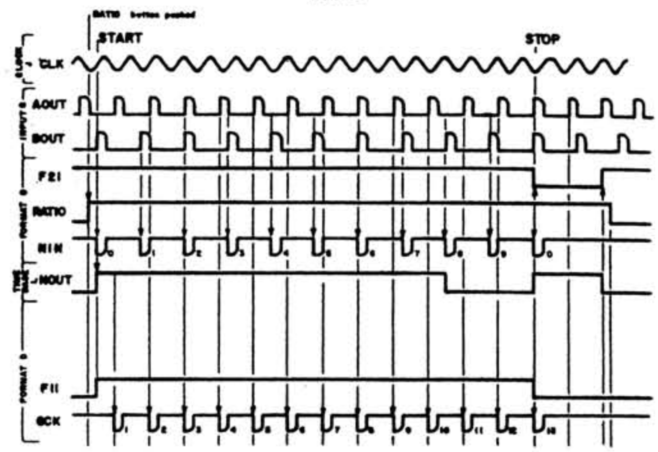
Start. With the RATIO button pushed, **B OUT** is applied to the timing gate. The first B OUT pulse passes through the timing gate, emerges as **N IN,** and is applied to the time-base board. The first N IN pulse causes an **N OUT** positive transition which is applied to the counting flip-flop start input, with the RATIO button pushed. N OUT sets **F11** to 1 which enables the counting gate and allows **A OUT,** applied to it with the RATIO button pushed, to pass through, emerge as **GCK,** and go on the register board to be counted.

Stop. If the RANGE switch has been set to 10, the second **N OUT** positive transition occurs after the tenth **N IN** pulse. With the RATIO button pushed, N OUT is applied to the counting flip-flop stop input and the second N OUT positive transition sets **F11** to 0, which inhibits the counting gate and stops the count. The negative F11 transition sets **F21** to 0 which inhibits the timing gate.

Result. Input-A events are counted during the time of an input-B period or decade multiple of the input-B period.



RATIO



4.2 INPUT BOARD C

Diagram C. The input board contains two separate channels, A and B, that generate positive pulses when the input signal crosses a preset triggering threshold, generally at or near the input zero-crossing. A set of switches for each channel provides a choice of coupling, attenuation, polarity, and triggering threshold. The channels are identical, except for frequency response, and the circuit action will be described in terms of channel A.

4.2.1 COUPLING AND ATTENUATION

ASIG attenuator output. The signal to be measured is applied to the INPUT A connector, J901 on the front panel, and passes through the AC-DC switch, S910, when the switch is set to DC or through C901 when it is set to AC. The signal is then applied directly to the symmetrical trigger stage or through a X10 or X100 attenuator to the symmetrical trigger, depending on the setting of the POLARITY & ATTEN switch.

The POLARITY & ATTEN switch, S908 on the front panel, has eight positions. The first (fully ccw) position, EXT PRO, is used when external programming of polarity and threshold is desired and allows the input signal to pass directly to the symmetrical trigger without attenuation. The next three positions are used when it is desired to trigger on the negative slope, and the next-to-the-last-three positions are used when it is desired to trigger on the positive slope. The last position, TEST 10MHz, blocks the normal input signal and provides, instead, a 10-MHz test signal, **TST,** from the clock board. The output from S908, **ASIG,** is applied to the symmetrical trigger.

The SEPARATE—COMMON switch, S912 on the front panel, disconnects **BSIG** from the B symmetrical trigger and connects, instead, **ASIG,** when the switch is set to COMMON. This allows two points on the same signal to be selected for triggering; e.g., for duration measurements, channel A can be set to trigger on the positive slope and channel B can be set to trigger on the negative slope.

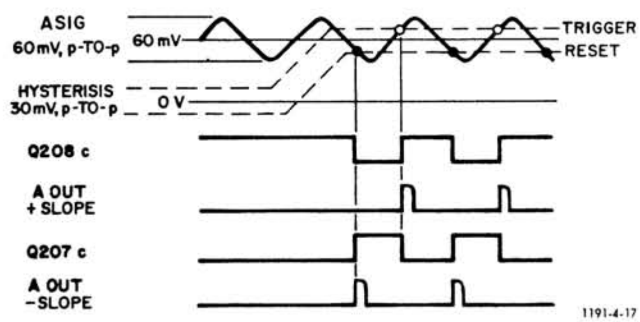
4.2.2 SYMMETRICAL TRIGGER

Input and reference. The input signal, **ASIG,** is applied to the input transistor, Q201 an n-channel FET in the input side of the symmetrical trigger stage, which provides a high input resistance. CR201 and CR202 are voltage limiters to protect Q201 from excessive input amplitudes.

The bias for Q201 is set by its source potential which, in turn, is set by the conduction of Q202, an n-channel FET in the reference side of the symmetrical trigger. The conduction of Q202 is set by the threshold potential at its gate, **AREF** (or **REFA** from an external source when the POLARITY & ATTEN switch is set to EXT PRO).

THRESHOLD control. The THRESHOLD control, R908 concentric with the POLARITY & ATTEN switch on the front panel, sets **AREF** from -0.1V through ground, to +0.1V. This voltage determines the threshold for triggering and, together with the 30mV pk-pk hysteresis of the stage, determines the **ASIG** voltage necessary for an output from the symmetrical trigger.

For example, an input signal, ASIG, with a 60-mV pk-pk amplitude and a 60-mV dc component is applied to Q201 gate. The THRESHOLD control is set for a 0-V (ground) AREF potential. In this case, ASIG is always more positive than the upper hysteresis level (trigger) and Q201 remains on. This holds Q203 off, Q205 on, and Q207 off. With Q207 held off, Q208 is held on and the output from the trigger flip-flop at Q208 collector is held at the 1-level; no trigger action is possible.



The THRESHOLD control is now rotated cw to a point where AREF is 60mV. ASIG can now drop below the lower hysteresis level (reset) and turn off Q201 which turns off Q208 and sets Q208 collector to the 0-level. Another output is taken from the other side of the flip-flop (Q207 collector) and is inverted with respect to Q208 collector.

4.2.3 OUTPUT

A OUT channel output. The outputs from the trigger flip-flop are applied to two amplifiers, Q210 and Q211. Only one amplifier is enabled at a time. If the POLARITY & ATTEN switch is set to one of the - positions, an emitter return, **NOA**, is supplied to Q211 and it is enabled; if the POLARITY & ATTEN switch is set to one of the + positions, an emitter return, **POA**, is supplied to Q210 and it is enabled.

Either transistor conducts with a positive (1-level) input. If the POLARITY & ATTEN switch is set to one of the - positions, Q210 is enabled and the output from Q207 is amplified and inverted by Q210, amplified and inverted again by Q209, and appears as a positive pulse at Q209 collector, **A OUT**, coincident with the threshold level on the negative slope of the input signal. If the POLARITY & ATTEN switch had been set to one of the + positions a similar but reverse action would have occurred and A OUT would have been coincident with the threshold level on the positive slope of the input signal.

4.3 CLOCK BOARD J

Diagram J. The clock board generates a 10-MHz clock signal that is counted by the register board for period or interval measurements or is used by the time-base board to obtain precise time intervals for frequency measurement. The clock signal is also applied to the input board for use as a test signal and to a rear-panel connector for use by external equipment. The clock frequency can be phase-locked to an external source for greater accuracy if desired.

4.3.1 FREQUENCY CONTROL

VCFA frequency control. The clock signal originates in a 5-MHz crystal-controlled oscillator, Q409. The frequency is adjusted by C410 and a dc voltage, VCFA, applied to a varactor, CR402. The capacitance of CR402 is determined by the VCFA potential which, in turn, is set by the Freq Adj, R950 on the rear panel, which will vary the frequency ± 100Hz.

JECK 10-MHz output. The 5-MHz output from the oscillator is doubled and amplified by a differential amplifier, Q410 and Q411, and applied to a paraphase amplifier, Q412. The output from Q412 collector is the JECK 10-MHz signal which is amplified by another differential amplifier, Q413 and Q414, and applied to another paraphase amplifier, Q415.

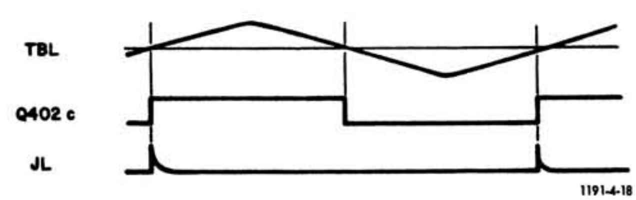
OCK clock output. The output from Q415 collector is applied through C423 to the OUT 10MHz connector, J952 on the rear panel, for use by an external device.

TST test signal. One output from Q415 emitter is applied through R444 to the input board for use as a test signal.

CLK clock signal. A second output from Q415 emitter is applied through R443 to either the format board, where it is gated to the time-base board for frequency and interval measurements, or to the register board, where it is counted for period measurements.

4.3.2 PHASE LOCK

TBL external drive. By means of a sampling phase detector, an externally applied signal, of any waveshape, with a frequency of 0.1, 1, 2.5 5, or 10MHz, and with an amplitude of at least 1V rms into 1KΩ, can be used to control the clock frequency. This signal, TBL, is applied to the EXT DRIVE connector, J951 on the rear panel, to a Schmitt circuit, Q401 and Q402, which converts the input waveshape to a square wave of the same frequency as the input.



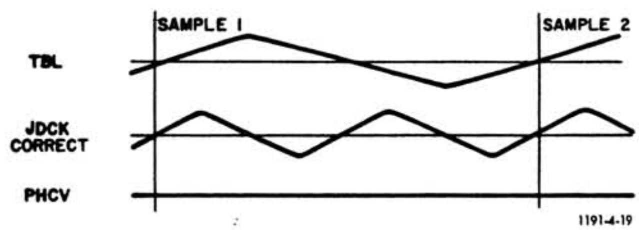
JL interogate pulse. The output from the Schmitt circuit is taken from Q402 collector, amplified by Q403, shaped by Q404, and again amplified by Q405. The output from Q405 collector through R415 is the JL interogate pulse.

JCKL sample signal. The **JL** interogate pulse is applied to Q406 emitter and momentarily enables Q406. The amount of conduction of Q406 is determined by the **JDCK** 10-MHz clock signal at its base which, in turn, determines the level of JCKL at Q406 emitter.

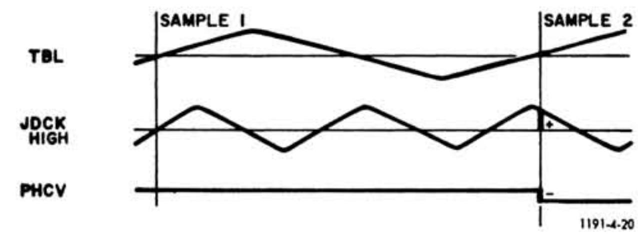
PHCV frequency control. JCKL is buffered by Q407, filtered by C406, C407, and R420, and emerges as a dc signal, PHCV, which is applied to the TIME-BASE switch, S952 on the rear panel. When this switch is set to EXT LOCK, PHCV becomes the **VCFA** level that controls the oscillator frequency.

For example, a 5-MHz external-lock signal, **TBL**, is applied:

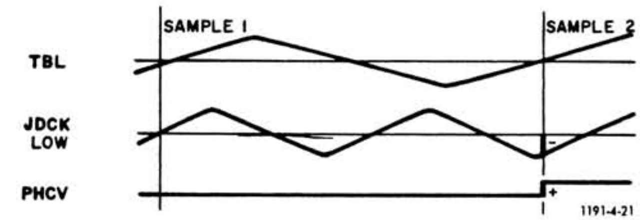
Correct clock frequency. When the clock frequency is correct, **JDCK** will be in-phase with **TBL** and the samples will always be taken at the positive zero-crossings of JDCK. Since all samples are taken at the same JDCK level, **PHCV** remains constant.



High clock frequency. When the clock frequency is high, **JDCK** will be out-of-phase with **TBL** and the samples will be taken at different points of JDCK. The first is taken at the positive zero-crossing as before so there is no change in **PHCV.** But the second is taken on the positive portion of JDCK; Q406 conducts less and PHCV decreases. When PHCV decreases, it decreases the oscillator frequency to bring JDCK back on phase with TBL.



Low clock frequency. When the clock frequency is low, **JDCK** will be out-of-phase with **TBL** and the samples will be taken at different points of JDCK. The first is taken at the positive zero-crossing as before so there is no change in **PHCV.** But the second is taken on the negative portion of JDCK; Q406 conducts more and PHCV increases. When PHCV increases, it increases the oscillator frequency to bring JDCK back in phase with TBL.



PLMN out-of-lock. From the example above it can be seen that whenever the **JDCK** clock signal is out-of-phase with the **TBL** external lock signal, **PHCV** changes from a dc signal to an ac signal whose frequency is the difference between JDCK and TBL. This ac signal, passes through C408 to Q408 whose output, PLMN, drives the ΦLOCK OUT neon, V959 on the front panel, to provide a visual indication of an out-of-lock condition whenever JDCK differs from TBL by over approximately 1Hz.

4.4 OSCILLATOR CIRCUIT I

No diagram. The oscillator circuit is part of the circuitry used for the high-precision time-base counters. It is a 10-MHz oscillator that serves the function of the oscillator portion of the clock board, which is replaced by an amplifier board JA to complete the circuitry of the high-precision time-base option.

4.5 AMPLIFIER BOARD JA

Diagram JA. The amplifier board is part of the circuitry used for the high-precision time-base counter. It is the same as the clock board J except it contains no oscillator stage. Instead, it is driven by a 10-MHz signal from the oscillator circuit J which completes the circuitry of the high-precision time-base option.

4.6 TIME BASE BOARD L

Diagram L. The time-base board controls the timing of the counter (the length of time the counting register is allowed to count). It, in turn, is controlled by the RANGE switch which also, in conjunction with the MEASUREMENT pushbuttons, controls the measurement characters, i.e., the unit of measurement (symbol) and the decimal-point location.

The exact function of the time-base board depends on which MEASUREMENT button has been pushed and may be to generate precise time periods, to count-down the clock frequency, or to count-down the input-A or input-B events. The basic function, however, is that of a decade divider.

4.6.1 DECADE OPERATION

Count. The time-base board contains eight cascaded IC decades, each of which consists of four flip-flops. The flip-flops respond only to negative pulses applied to their CP inputs which occur only when the output of the preceding flip-flop changes from 1 to 0.

The CP input normally is a complementing input; i.e., when an input pulse arrives, the flip-flop changes state, if it was in the Q state (A, B, C, or D = 1) it changes to the $\overline{Q}$ state ($\overline{A}$, $\overline{B}$, $\overline{C}$, or $\overline{D}$ = 1) or if it was in the $\overline{Q}$ state it changes to the Q state. However, additional signals are applied to the J input of ffB and to the R and S inputs of ffD to convert what normally would be simple binary counting (division by 16) to 1-2-4-8 binary-coded-decimal counting (division by 10).

The decade counting action is as follows:

Decade outputs. After ten input pulses, a decade produces an output which is applied to the input of the next decade. The input to the first decade is **N IN** from the format board, therefore the negative output transition from decade 1 occurs after ten N IN pulses, the negative output transition from decade 2 occurs after 100 N IN pulses, and so on. Since there are eight decades, the time-base board can count-down N IN by up to 10^8.

Input Pulse	ffA (1) In A Out	ffB (2) In B Out	ffC (4) In C Out	ffD (8) In D Out	Decimal	Notes
none	0	0	0	0	0	B and C = 0 which sets S input of ffD to 0 and prevents it from setting to D D = 0 which sets R input of ffD to 0 and prevents it from setting to $\overline{D}$ $\overline{D}$ = 1 which sets J input of ffB to 1 and allows it to set to B
1st	1	0	0	0	1	
2nd	0	1	0	0	2	
3rd	1	1	0	0	3	
4th	0	0	1	0	4	
5th	1	0	1	0	5	
6th	0	1	1	0	6	B and C = 1 which sets S input of ffD to 1 and allows it to set to D
7th	1	1	1	0	7	
8th	0	0	0	1	8	B and C = 0 which sets S input of ffD to 0 and prevents it from setting to D D = 1 which sets R input of ffD to 1 and allows it to set to D $\overline{D}$ = 0 which sets J input of ffB to 0 and prevents it from setting to B. D is set to 1 directly by A
9th	1	0	0	1	9	
10th	0	0	0	0	0	D is set to 0 directly by A. B (and therefore C) is prevented from setting to 1 by the 0 level at its J input.

4.6.2 TIMING

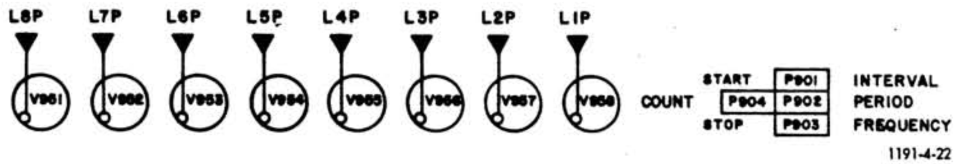
TB1 thru TB8 range signals. The output from the last flip-flop of each decade is connected to a two-input positive nand-gate (range gate). The second and enabling input to each range gate is from the RANGE switch (TB1 thru TB8) via an inverter (range inverter). The RANGE switch is mutually exclusive, i.e., it enables one, and only one, range gate at a time.

N OUT timing signal. The outputs of all range gates are connected together (wired or logic) and leave the time-base board as the N OUT signal. Before a measurement starts, an **SO+** signal from the format board sets all decades to 9.

The first **N IN** pulse, therefore, sets all decades to 0. Since all decades produce an output on the 9-0 transition and since the RANGE switch always enables one range gate, the first N IN pulse produces an N OUT pulse (positive N OUT transition). The occurrence of the next N OUT pulse is determined by the RANGE switch; e.g., if the RANGE switch is set to 10^2, the next N OUT pulse occurs after 100 N IN pulses.

4.6.3 CHARACTER INDICATION

The RANGE switch and MEASUREMENT pushbuttons automatically select the proper unit-of-measurement or symbol and decimal point (characters) for the measurement being made.



RANGE	MEASUREMENT									
	FREQUENCY		PERIOD		INTERVAL		RATIO		COUNT	
	Decimal	Symbol	Decimal	Symbol	Decimal	Symbol	Decimal	Symbol	Decimal	Symbol
EXT	–	EXT PRO	–	–	–	–	–	–	–	START-STOP
1	–	–	L4P	ms	L1P	μs	–	–	–	START-STOP
10	–	MHz	L5P	ms	–	μs	L1P	–	–	START-STOP
10	L1P	MHz	L3P	μs	L2P	ms	L2P	–	–	START-STOP
10	L2P	MHz	L4P	μs	L1P	ms	L3P	–	–	START-STOP
10	L3P	MHz	L5P	μs	–	ms	L4P	–	–	START-STOP
10	L1P	KHz	L3P	ns	L2P	s	L5P	–	–	START-STOP
10	L2P	KHz	L4P	ns	L1P	s	L6P	–	–	START-STOP
10	L3P	KHz	L5P	ns	–	s	L7P	–	–	START-STOP
10	L1P	Hz	L3P	ps	L2P	–	L8P	–	–	START-STOP

Symbol. A 3-inch plastic disc is attached to the RANGE switch behind the front panel. This disc contains a set of symbols for each setting of the RANGE switch: one set for frequency measurements, one for period measurements, and one for interval measurements. A START-STOP symbol, separate from the disc, is illuminated for count measurements to indicate the fact that the START and STOP pushbuttons are to be used only when the COUNT button is pushed. No symbol is necessary for ratio measurements.

Behind the disc is a set of three lamps, one of which is energized by the appropriate signal (**PER**, **F**, or **TI**) from the MEASUREMENT pushbuttons. Each lamp illuminates the proper symbol for the measurement being made. The MEASUREMENT pushbuttons are mutually exclusive; only one at a time can be depressed.

Decimal point. In addition to the contacts that enable the range gates, the RANGE switch also contains four sets of contacts to energize the decimal points in the readout tubes: one set is for frequency measurements, one is for period measurements, one is for interval, and one is for ratio. No decimal point is necessary for count measurements.

Since the decimal points are actually cathodes in the readout tubes, they are energized by returning them to ground. The ground-level signals are the same signals used to energize the symbol lamps (**F**, **PER**, **TI**, or, in this case, **R**) and are applied to the appropriate section of the RANGE switch to energize the proper decimal point.

4.7 REGISTER BOARD E

Diagram E, F. The register board contains a counting register that counts the pulses applied to it and a storage register that holds the count while the counting register proceeds with another measurement.

4.7.1 COUNTING REGISTER

Count. The counting register contains eight cascaded IC decades which are the same type of decades and operate in the same manner as those used in the time-base board (paragraph 4.6.1) with the following exceptions:

Input decade. The first, or input, decade consists of two ICs instead of one, IC102 and IC101. The counting register must be capable of operating up to 20MHz but the normal IC decades operate only up to 10MHz (as specified under worst-case conditions). Therefore, a 20-MHz flip-flop is used at the input which divides the input signal by two. This flip-flop, IC102, operates in the same manner as flip-flop A in the normal decade.

Decade outputs. Only the outputs from the last flip-flops (D or 8-weighted) are used from the time-base decades but the outputs from all flip-flops are used from the counting-register decades to provide a full 1-2-4-8 BCD output.

Set zero. Before a measurement starts, an **SO+** signal from the program board sets the time-base decades to 9. This same signal is applied to the opposite reset input of the counting-register decades and sets them, instead, to 0. An **SO-** signal, concurrent with SO+ and also from the program board, sets the input flip-flop to 0. Thus, before a measurement, all counting-register decades are set to 0.

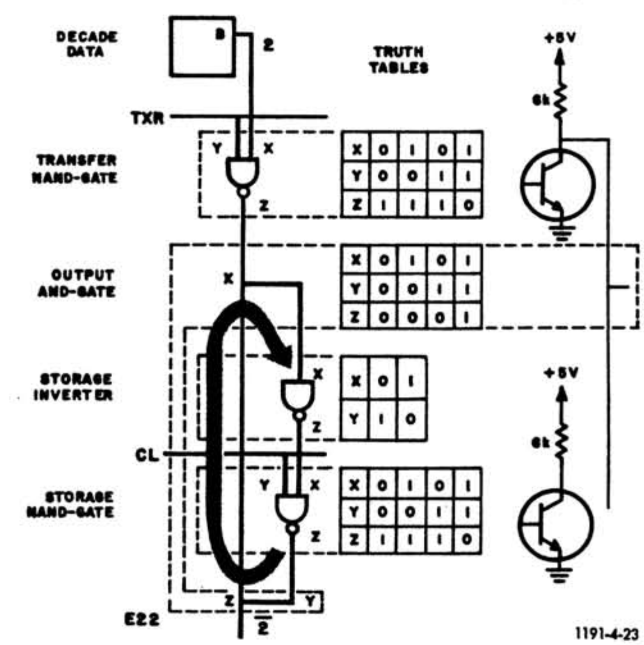
SET 9 push-button. When the SET 9 button, S906 on the front panel, is pushed it sets **S9-** to 0, which sets the output of the input flip-flop to 1, sets **S9+** to 1, which sets the output of ffA and ffD of each decade to 1 and the output of ffB and ffC to 0. Thus, when the SET 9 button is pushed, it sets each decade to 9 (1-2-4-8 BCD 1001).

Input. The counting register counts the **GCK** pulses from the format board. The source of these pulses depends on which MEASUREMENT button is pushed and may be the input signal, the clock signal, or the clock signal counted down.

4.7.2 STORAGE REGISTER

General. Each data line from the decades in the counting register is applied to the storage register which contains a NAND-gate, a wired AND-gate, an inverter, and another NAND-gate for each line. The output AND-gate function (wired-AND) is obtained by connecting the output of the second NAND-gate back to the output of the first NAND-gate and can be explained as follows:

The equivalent output circuit of each NAND-gate is that of an npn-transistor amplifier with a 6-KΩ collector load. A 1-level output, therefore, is behind 6KΩ (through the collector load to +5V) and a 0-level output is behind ≈ 0Ω (through the transistor to ground). When the outputs from two such NAND-gates are connected together, the 0-level output predominates because it is behind a much lower impedance; e.g., if one NAND-gate output is 1 and one is 0, the resultant output at their junction is 0 and the associated truth table is that of an AND-gate.



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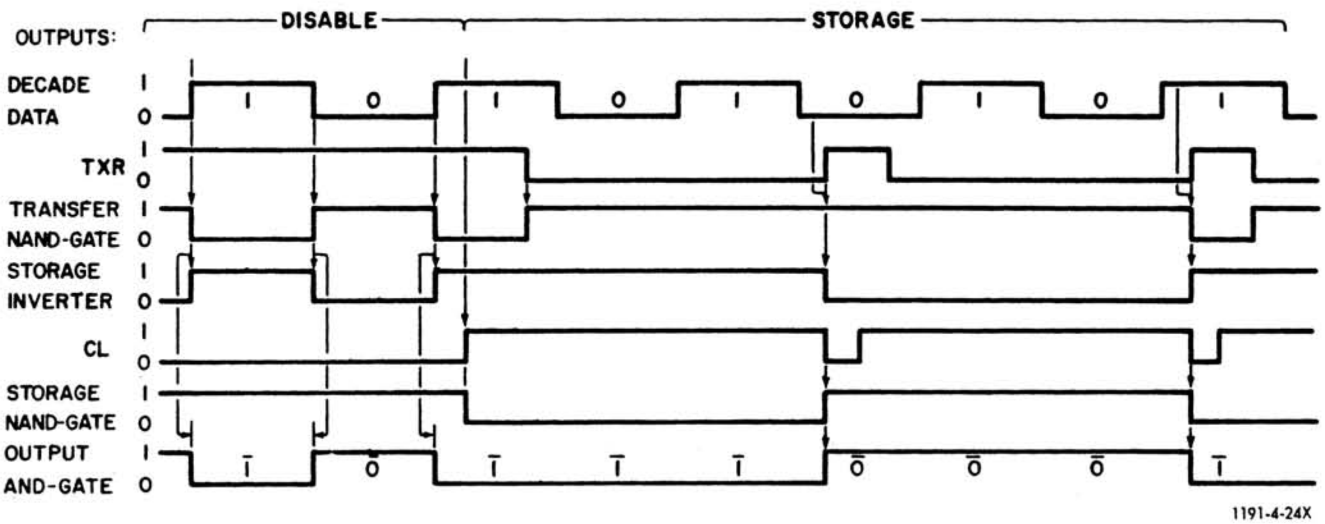


Disable. When the STORAGE-DISABLE switch, S951 on the rear panel, is set to DISABLE or when the COUNT button is pushed, **CL** from the program board is set to 0 and **TXR** from the program board is set to 1.

Storage inhibit. From the NAND-gate truth tables it can be seen that whenever one input is zero, the output is 1. And from the AND-gate truth table it can be seen that whenever one input is 1, the output follows the second input. Thus, when **CL** is 0, the storage NAND-gate output is 1 and since this 1-level is applied to the output AND-gate, the output of the AND-gate will follow the input supplied to it by the transfer NAND-gate.

Transfer enable. From the NAND-gate truth tables it can be seen that whenever one input is 1, the output is the complement of the second input. Thus, when **TXR** is 1, the transfer NAND-gate output is the complement of the decade data. This complemented decade data passes through the output AND-gate to become the storage register output.

Thus, when storage is disabled, the storage register output is from the transfer NAND-gate and since this gate accepts data directly from the decade, the storage register is constantly corrected as the decade data changes.

Storage. When the STORAGE-DISABLE switch is set to STORAGE and when any MEASUREMENT button except COUNT is pushed, **CL** is set to 1 and later **TXR** is set to 0.

Storage enable. The complemented decade data from the output AND-gate is applied to the storage inverter which complements the data and applies it to the storage NAND-gate. When **CL** is 1, the storage NAND-gate complements this input and applies it to the output AND-gate where it is applied back through the inverter to the storage NAND-gate in a regenerative loop that holds the data in the storage NAND-gate.

Transfer inhibit. When **TXR** is 0, the transfer NAND-gate output is 1 and since this 1-level is applied to the output AND-gate, the output of the AND-gate will follow the input supplied to it by the storage NAND-gate. And, since the 0-level TXR signal has inhibited the transfer NAND-gate, its output is independent of the decade data.

Thus, when storage is enabled, the storage register output is from the storage NAND-gate. Since this gate accepts data from the transfer NAND-gate, which is inhibited and unable to correct as the decade data changes, except during the clear-and-transfer period, the storage register corrects only when the clear-and-transfer occurs and not when each decade data change occurs.

Jam transfer. A clear-and-transfer period (jam transfer) occurs at the end of each measurement. The **CL** pulse clears the storage NAND-gate of previous data and the **TXR** pulse reads in the new data. After the TXR pulse, the transfer NAND-gate is inhibited and prevents any further changes in the decade output from affecting the stored data until the next jam transfer. Note that with jam transfer the storage register changes directly from the old data to the new data with no intermediate step, such as a zero-set as is common in many storage-type counters. Advantages of jam transfer are less rf noise from the counter due to readout-tube switching and less noise in the output data.

4.8 DISPLAY CIRCUIT F

Diagram E, F. The display circuit converts the $\overline{\text{BCD}}$ data from the register board to decimal data and applies it to gas readout tubes to provide a visual display of the measurement value.

4.8.1 DECODING

Decimal data. The $\overline{1}$-$\overline{2}$-$\overline{4}$-$\overline{8}$ BCD data (**E11 thru E88**) from the storage register on the register board are applied to an associated decoder (IC951 through IC958) on the display circuit. The decoders convert the BCD data to decimal data and apply it to the appropriate cathode of an associated cold-cathode gas-readout tube (V951 through V958), which ionizes the surrounding gas to illuminate the proper number.

L1P thru L8P decimal-point signals. The proper decimal point is automatically energized by the RANGE switch and MEASUREMENT pushbuttons (paragraph 4.6.3).

4.9 BUFFER CIRCUIT G

Diagram G. The buffer circuit is used for the data-output option counters. It provides 1-2-4-8 BCD measurement data to the DATA OUT socket, S0901 on the rear panel, for use by a printer or other piece of data-handling equipment.

4.9.1 OPERATION

D11 thru D88 buffered data. The buffer circuit consists of six ICs, each of which contains six inverters. A set of four inverters is used to buffer the output from each of the storage NAND-gates on the register board.

The $\overline{\text{BCD}}$ data (**E11 thru E88**) from the storage NAND-gates is applied to the buffer-circuit inverters, is complemented, and emerges as BCD data (D11 thru D88) which is applied to the DATA OUT socket.

PGT and PRT print commands. Two print commands are also available (paragraph 2.5.3), PGT which is a buffered and inverted **F21** signal from the format board (paragraph 4.11.2) and PRT which is a buffered and inverted **PRT+** signal from the program board (paragraph 4.10.3).

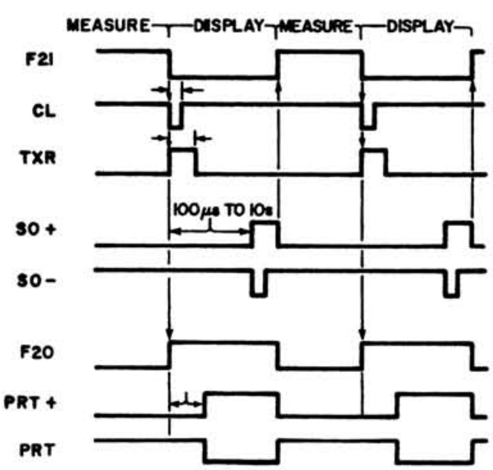
4.10 PROGRAM BOARD H

Diagram H. The program board generates the store signals used for the jam-transfer function, the reset signals used to control display time, and the print command signals used to initiate external devices.

4.10.1 STORE

CL clear. At the end of a measurement, **F21** from the format board goes to 0 and turns on Q712 in the clear and transfer generator which turns on Q713 and sets CL to 0. The 0-level CL signal clears the storage nand-gate, on the register board (paragraph 4.7.2) of previous data.

TXR transfer. The negative **CL** transition turns off Q714 and sets TXR to 1. C709 maintains the 0-level at Q714 base for about 800ns and thus causes the TXR 1-level to be about 200ns longer than the CL 0-level. The 1-level of the TXR pulse reads in new data to the storage NAND-gate and the 0-level of the TXR pulse prevents any further changes in the decade output from affecting the stored data (paragraph 4.7.2).



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Storage disable. When the STORAGE-DISABLE switch, S951 on the rear panel, is set to DISABLE, it sets **SDIS** to 0 which holds on Q712. With Q712 held on, Q713 is held on which sets **CL** to 0. With CL at 0, Q714 is held off which sets **TXR** at 1. With CL at 0 and TXR at 1, the storage register is by-passed and the visual register accepts the counted data directly from the counting register (paragraph 4.7.2).

Also, when the COUNT button is pushed, **C** is set to 0 which causes the same action as when the STORAGE-DISABLE switch is set to DISABLE, i.e., it by-passes the storage register and allows the visual register to accept data directly from the counting register.

4.10.2 DISPLAY TIME

SO+ reset. During a measurement, SO+ is held at 0 by Q707 which is held on by Q705. Q705 is held on by Q704 which, in turn, is held off by Q702. And Q702 is held on by Q701, which is held on by the 1-level **F21** signal from the format board. At the end of a measurement, F21 falls to 0 and turns off Q701 which turns off Q702.

Q702 collector cannot fall immediately to 0 (ground) however, because of C703 and C701 or C702 that have charged to 1 (≈ +15V). After a period of time, determined by the RC time constant connected to Q702 collector, the capacitors discharge sufficiently towards 0 to turn on Q704. When Q704 turns on, it turns on Q705, which turns off Q707 and sets SO+ to 1.

The length of time SO+ remains 1 is determined by the size of the capacitance connected to Q702 collector and the resistance in its charge path. The capacitance is made up of C703 and the capacitor switched on by the DISPLAY TIME control, C701 or C702. The resistance is the emitter-to-collector resistance of Q702 and is essentially constant. For the first four settings of the DISPLAY TIME control, the 1-level duration of SO+ is ≈ 2μs and for the last eight settings it is 90μs.

SO- reset. SO+ is also applied through C708 to Q708, is inverted, and appears at Q708 collector as SO-. The SO+ and SO- signals are coincident but SO+ is always longer.

Display time control. During the time between the end of a measurement and the occurrence of the SO+ and SO- reset signals, the counter is prevented from starting a new measurement (SO+ enables the timing gate on the program board; if it is not enabled, measurements are inhibited, paragraph 4.11.2). This time is determined by the size of the RC network connected to Q702 collector which, in turn, is controlled by the DISPLAY TIME switch, S907. The DISPLAY TIME switch thus controls a holdoff time between measurements to allow for the observation of the visual register or to allow for the operation of external devices, such as a printer or other piece of data-handling equipment.

RPB set zero. When the SET 0 button is pushed, it allows RPB to rise to 1 and turn on Q703 which turns on Q704. Q704 turns on Q705 which turns off Q707 and sets **SO+** to 1 and **SO-** to 0. This resets the counter immediately without the delay (holdoff time) normally caused by the DISPLAY TIME control.

Also, when the RANGE switch setting is changed, it momentarily allows RPB to rise to 1, which causes the same action as when the SET 0 button is pushed, i.e., it immediately resets the counter.

4.10.3 PRINT COMMAND

PRT+ print command. During a measurement, **F20** from the format board is 0 which holds off Q709. With Q709 off, Q710 is on and their common-emitter potential is set at ≈ +5V by the divider action of R722, Q710, R723, CR712, and R724. This +5-V level keeps Q711 on which sets PRT+ to 0.

At the end of a measurement, F20 rises to 1 which turns on Q709. With Q709 on, Q710 is off and their common-emitter potential is set at ≈ 0V by the divider action of R721, Q709, R723, CR712, and R724. This 0-V level turns off Q711 which sets PRT+ to ≈ +5V. PRT+ is applied directly to the PROGRAMMING INPUT socket, S0950 on the rear panel, and via an inverter on the buffer circuit as PRT to the DATA OUT socket, S0901 on the rear panel of counters with that option.

4.11 FORMAT BOARD D

Diagrams AW and D. The format board is controlled by the MEASUREMENT pushbuttons and controls the signals to the time-base board and register board to determine the type of measurement to be made.

4.11.1 MEASUREMENT SELECTION

Measurement push-buttons. The type of measurement made is determined by nine gates on the format board. These gates are controlled by format levels from the MEASUREMENT pushbuttons; one level (**PER**, **TI**, **R**, and **C**) from each push-button except FREQUENCY. Each level is isolated by an RC network and all except C are buffered by inverters on IC601 and then applied to the measurement gates as shown in the table.

GATE	LEVELS APPLIED	MEASUREMENT FREQUENCY	PERIOD	INTERVAL	RATIO	COUNT	SUMMARY (measurements for which gate is enabled)
1	PERN TIN	1 1	0 1	1 0	1 1	1 1	FREQUENCY, RATIO, COUNT
2	PERP	0	1	0	0	0	PERIOD
3	TIP	0	0	1	0	0	INTERVAL
5	TIP	0	0	1	0	0	INTERVAL
6	TIP	0	0	1	0	0	INTERVAL
7	TIN *TBOP	1	1	0	1	1	FREQUENCY, PERIOD, RATIO, COUNT WHEN RANGE SWITCH IS SET TO 1
8	*TBOP	1	1	1	1	1	ALL WHEN RANGE SWITCH IS SET TO 1
9	RP	0	0	0	1	0	RATIO
10	PERP	0	1	0	0	0	PERIOD
11	PERN RN CN	1 1 1	0 1 1	1 1 1	1 0 1	1 1 0	FREQUENCY, INTERVAL

* TBOP is 1 when RANGE switch is set to 1

The MEASUREMENT pushbuttons, in conjunction with the RANGE switch, also energize the character lamps (unit-of-measurement or symbol and decimal point) for the measurement to be made (paragraph 4.6.3).

In order to simplify the discussions that follow, the PER, TI, R, and C format levels will be replaced by **FREQ, PERIOD, INTERVAL, RATIO,** and **COUNT** equivalent format levels. Thus, for example, when the FREQUENCY button is pushed, it sets the FREQ equivalent format level to 1 and enables gates 1 and 11 (and 7 if the RANGE switch is set to 1).

4.11.2 TIMING

N IN time-base input signal. The input to the time-base board is N IN from the timing gates (positive NAND-gates 9, 10, and 11) which are controlled by the format levels and **F21** from the timing flip-flop, IC602. Before each measurement, F21 is set to 1 by the **SO+** signal from the program board (paragraph 4.10.2) which is applied to IC602 at the end of the display-time interval. The signal input to gate 11 is the **CLK** 10-MHz clock signal, to gate 10 is the **A OUT** shaped input-A signal, and to gate 9 is the **B OUT** shaped input-B signal.

Since timing is controlled by the **N OUT** signal, which is derived from the N IN signal (paragraph 4.6.2), the timing gates allow the clock signal to control timing for frequency and interval measurements, the input-A events to control timing for period measurements, and the input-B events to control timing for ratio measurements. Timing is controlled manually for count measurements.

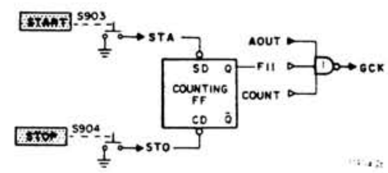
4.11.3 COUNTING

GCK counting register input signal. The input to the counting register on the register board is GCK from the counting gates (positive NAND-gates 1, 2, and 3) which are controlled by the format levels and **F11** from the counting flip-flop, IC603. Before each measurement, F11 is set to 0 by the **SO-** signal from the program board (paragraph 4.10.2) which is applied to IC603 at the end of the display-time interval. The signal input to gate 2 is the **CLK** 10-MHz clock signal, to gate 3 is the **N OUT** time-base output, and to gate 1 is the **A OUT** shaped input-A signal.

Since the input to the counting register is the GCK signal, the count is derived from the clock signal for period measurements, from the counted-down clock signal for interval measurements, and from input-A for frequency, ratio, and count measurements.

COUNTING lamp. When **F11** is 1, one of the counting gates is enabled which provides the counting register with pulses to count. The 1-level F11 signal is also applied to Q604, is amplified, and emerges as **GL**, which drives the COUNTING lamp, P905 on the front panel, to indicate a count is in progress.

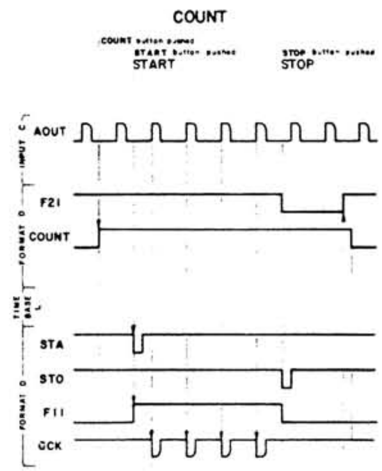
4.11.4 COUNT



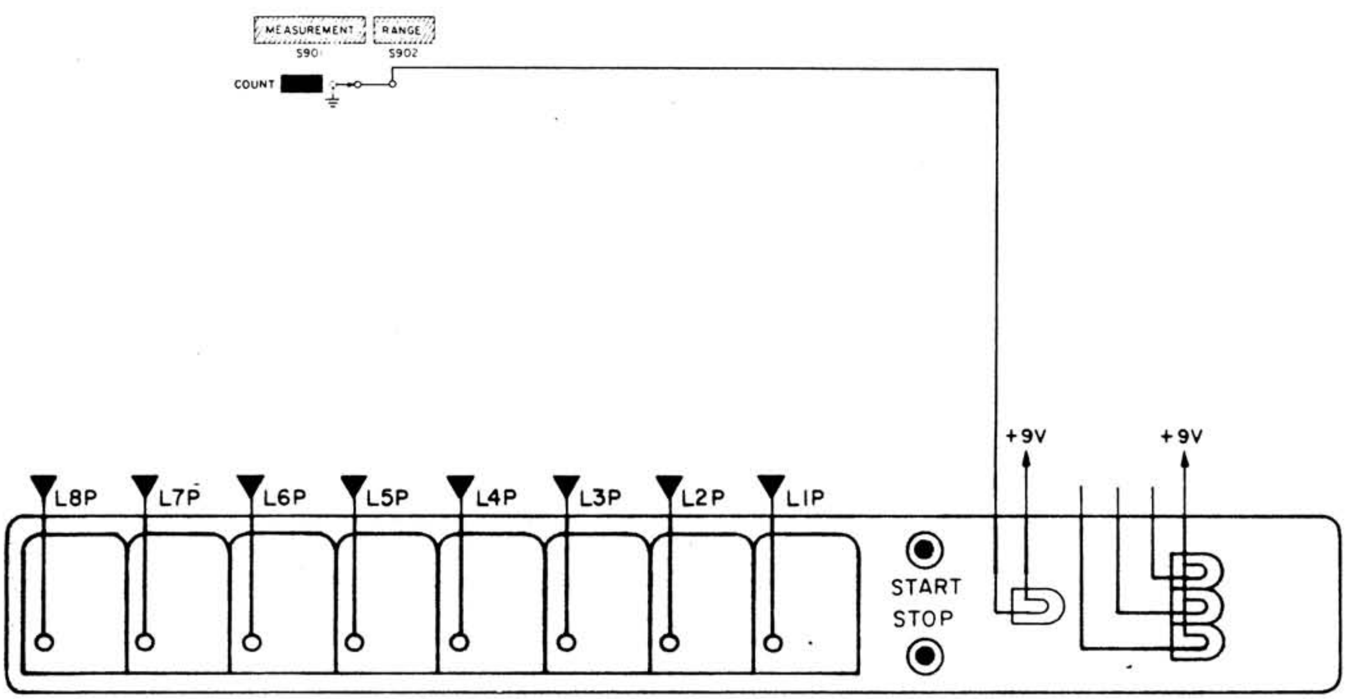
Quiescent. Before a measurement, **F11** is 0 which inhibits all counting gates including gate 1. When the COUNT button is pushed, it sets the **COUNT** equivalent format level to 1, which provides an enabling input to gate 1.

Start. When the START button is pushed, it sets **STA** to 0. This sets the counting flip-flop to Q which sets **F11** to 1 and enables gate 1. The shaped input-A events, **A OUT** from the input board, pass through gate 1, emerge as **GCK**, and are counted by the counting register on the register board.

Stop. When the STOP button is pushed, it sets **STO** to 0. This sets the counting flip-flop to Q̄ which sets **F11** to 0 and inhibits gate 1. Since this deprives the register board of an input, the count stops.



Visual register at end of measurement:



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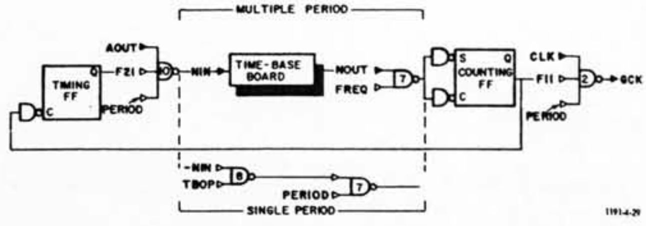
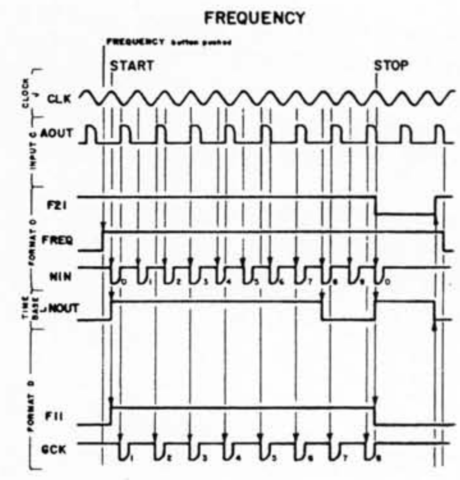
4.11.5 PERIOD



Quiescent. Before a measurement, **F11** is 0, which inhibits all counting gates including gate 2, and **F21** is 1, which provides an enabling input to all timing gates including gate 10. When the PERIOD button is pushed, it sets the **PERIOD** equivalent format level to 1, which enables gates 10 and 7. When the RANGE switch is set to any position except EXT PRO or 1, one of its outputs (**TB1 thru TB8**) enables a range gate on the time-base board; assume the RANGE switch is set to 10, which allows an **N OUT** pulse (positive N OUT transition) coincident with the first and tenth **N IN** pulse (paragraph 4.6.2).

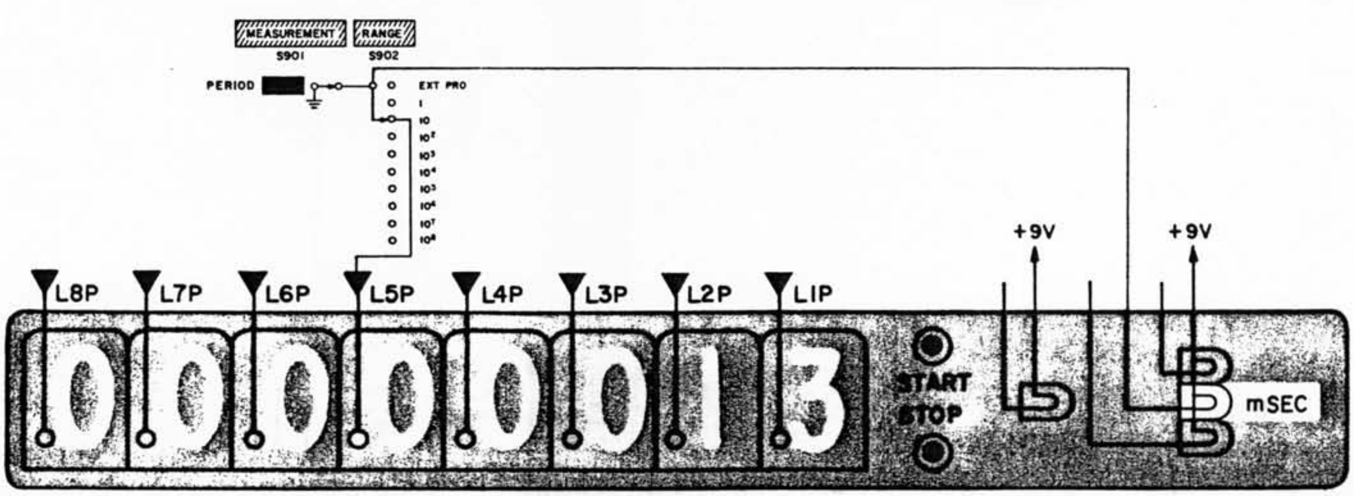


Start. When a shaped input-A event, **A OUT** from the input board, arrives, it passes through gate 10 emerges as **N IN**, and is applied to the time-base board, which produces an **N OUT** pulse. N OUT passes through gate 7 and complements the counting flip-flop (sets it from $\bar{Q}$ to Q) which sets **F11** to 1 and enables gate 2. **CLK** clock pulses pass through gate 2, emerge as **GCK**, and are counted by the counting register on the register board.

Stop. Succeeding shaped input-A events, **A OUT**, also pass through gate 10, emerge as **N IN**, and are applied to the time-base board where they are simply counted down. The tenth A OUT pulse, however, produces an **N OUT** pulse from the time-base board. N OUT passes through gate 7 and again complements the counting flip-flop (this time it resets it from Q to $\bar{Q}$) which sets **F11** to 0 and inhibits gate 2. Since this deprives the register board of an input, the count stops. The negative **F11** transition resets the timing flip-flop to $\bar{Q}$, which resets **F21** to 0 and inhibits gate 10. This blocks A OUT and completes the measurement.

Single period. The action for single-period measurements differs slightly; the time-base board is by-passed. Instead, when the RANGE switch is set to 1 (single period), it sets **TBOP** (via an inverter on IC601) to 1 which enables gate 8. **N IN** pulses pass through gate 8 (and thus by-pass the time-base board) and are applied to gate 7 in lieu of N OUT pulses. Single-period measurements are also possible when the INTERVAL button is pushed (paragraph 4.11.7).

Visual register at end of measurement:



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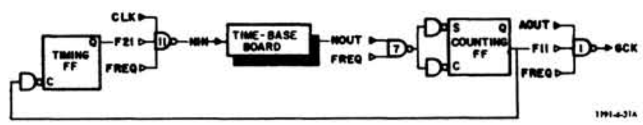
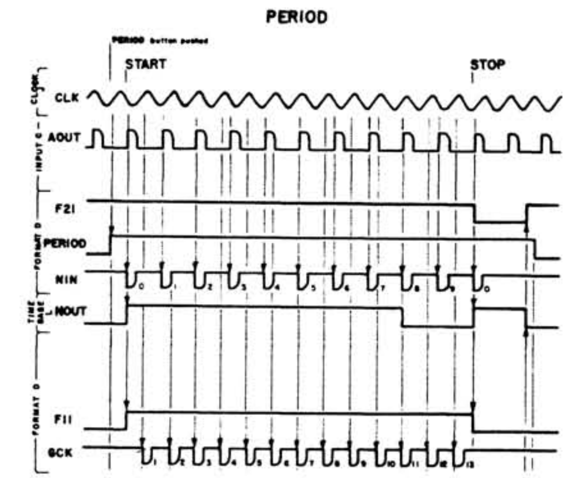
4.11.6 FREQUENCY

Quiescent. Before a measurement, **F11** is 0 which inhibits all counting gates including gate 1, and **F21** is 1 which provides an enabling input to all timing gates including gate 11. When the FREQUENCY button is pushed, it sets the **FREQ** equivalent format level to 1 which enables gates 11 and 7. When the RANGE switch is set to any position except EXT PRO or 1, one of its outputs (**TB1 thru TB8**) enables a range gate on the time-base board; assume the RANGE switch is set to 10, which allows an **N OUT** pulse (positive N OUT transition) coincident with the first and tenth **N IN** pulse (paragraph 4.6.2).

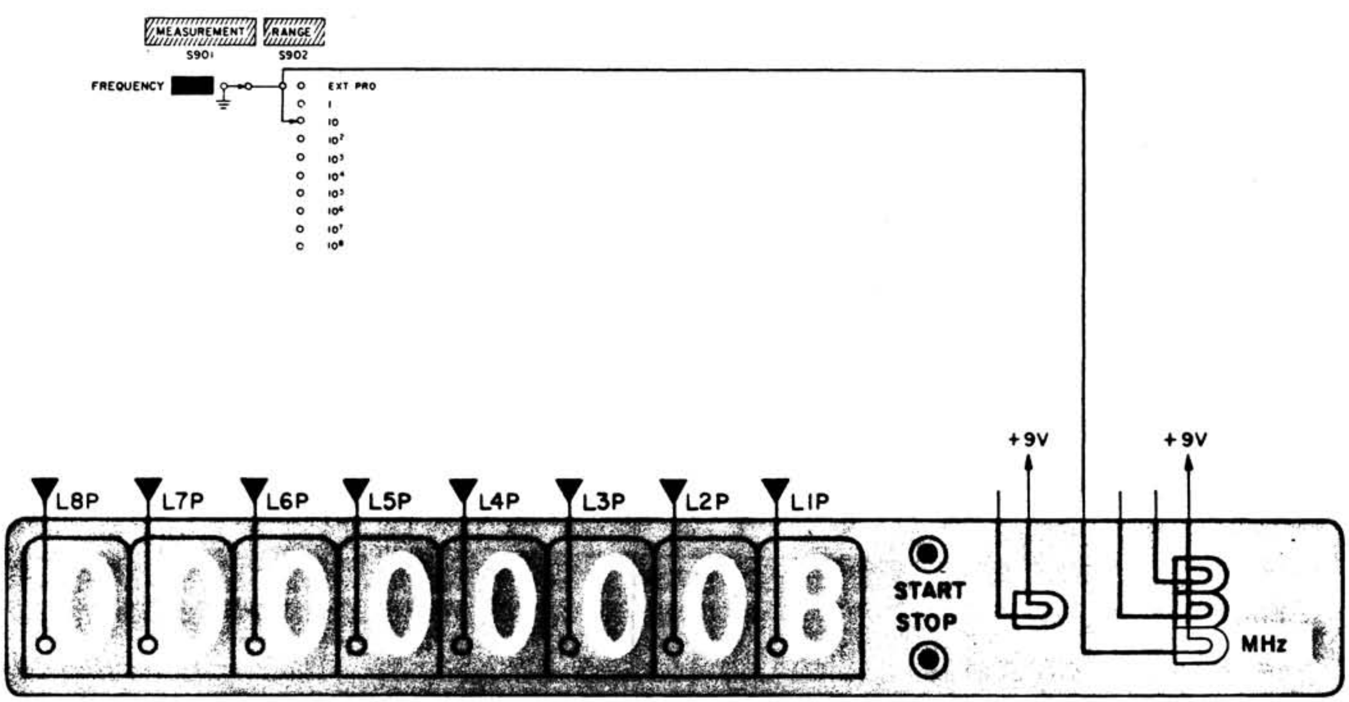


Start. When a **CLK** clock pulse arrives, it passes through gate 11, emerges as **N IN**, and is applied to the time-base board which produces an **N OUT** pulse. N OUT passes through gate 7 and complements the counting flip-flop (sets it from $\overline{Q}$ to Q) which sets **F11** to 1 and enables gate 1. Shaped input-A events, **A OUT** from the input board, pass through gate 1, emerge as **GCK**, and are counted by the counting register on the register board.



Stop. Succeeding **CLK** clock pulses also pass through gate 11, emerge as **N IN**, and are applied to the time-base board where they are simply counted down. The tenth CLK pulse, however, produces an **N OUT** pulse from the time-base board. N OUT passes through gate 7 and again complements the counting flip-flop (this time it resets it from Q to $\overline{Q}$) which sets **F11** to 0 and inhibits gate 1. Since this deprives the register board of an input, the count stops. The negative F11 transition resets the timing flip-flop to $\overline{Q}$ which resets **F21** to 0 and inhibits gate 11. This blocks CLK and completes the measurement.

Visual register at end of measurement:



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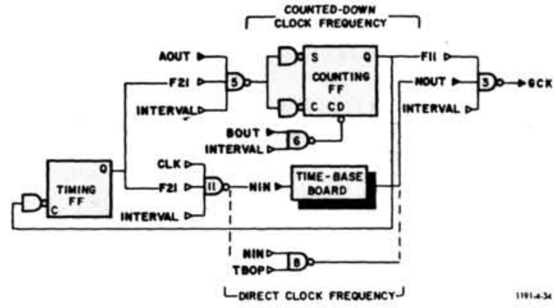
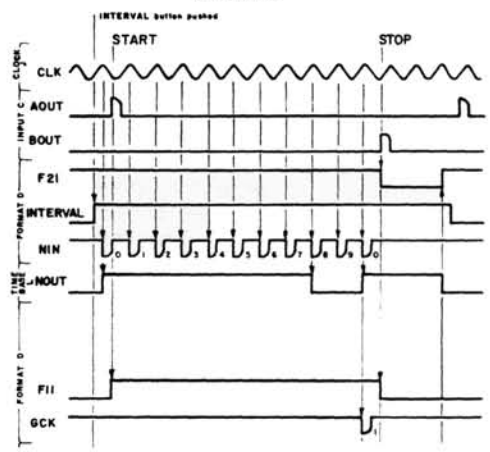
4.11.7 INTERVAL



Quiescent. Before a measurement, **F11** is 0 which inhibits all counting gates including gate 1, and **F21** is 1, which provides an enabling input to gate 5 and all timing gates including gate 11. When the INTERVAL button is pushed, it sets the **INTERVAL** equivalent fromat level to 1 which enables gates 5, 6, and 11. When the RANGE switch is set to any position' except EXT PRO or 1, one of its outputs (**TB1 thru TB8**) enables a range ga+e on the time-base board; assume the RANGE switch is set to 10, which allows an **N OUT** pulse (positive N OUT transition) coincident with every tenth **N IN** pulse (paragraph 4.6.2).

Start. When a shaped input-A event, **A OUT** from the input board, arrives it passes through gate 5 and complements the counting flip-flop (sets it from $\overline{Q}$ to Q) which sets **F11** to 1 and enables gate 3. **CLK** clock pulses pass through gate 11, emerge as **N IN**, and are applied to the time-base board, which counts them down by ten and applies them as **N OUT** to gate 3. They pass through gate 3, emerge as **GCK**, and are counted by the counting register on the register board.

INTERVAL

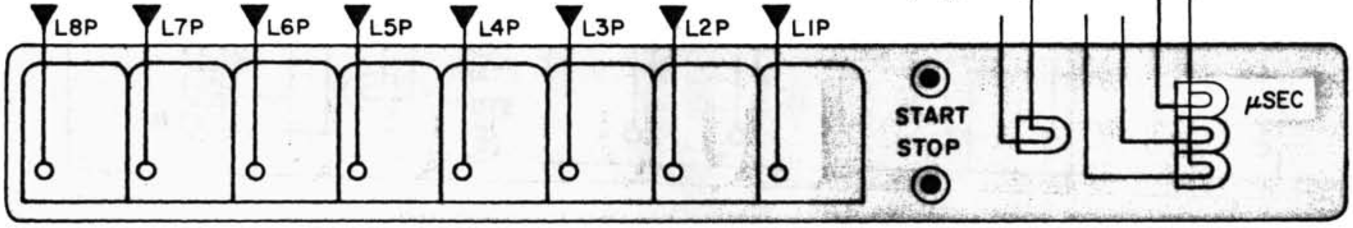


Stop. When a shaped input-B event, **B OUT** from the input board, arrives, it passes through gate 6 and sets the counting flip-flop to $\overline{Q}$, which sets **F11** to 0 and inhibits gate 3. Since this deprives the register board of an input, the count stops. The negative F11 transition resets the timing flip-flop to Q which resets **F21** to 0 and inhibits gate 11. This blocks **CLK** and completes the measurement.

Direct clock frequency. The action for direct-clock-frequency count differs slightly; the time-base board is by-passed. Instead, when the RANGE switch is set to 1 (direct clock frequency), it sets **TBOP** (via an inverter on IC601) to 1 which enables gate 8. **N IN** pulses pass through gate 8 (and thus by-pass the time-base board) and are applied to gate 3 in lieu of N OUT pulses.

Single period measurements. When the INTERVAL button is pushed, single period measurements are also possible. If no input B signal is applied or if another input-A event occurs before an input-B event, **A OUT** passes through gate 5 and again complements the counting flip-flop (this time it sets it from Q to $\overline{Q}$) which sets **F11** to 0 and inhibits gate 3. Since this is the same action normally produced by **B OUT** to stop the count, the count stops. However, instead of a measurement of the interval between A and B being made, a measurement of the interval of one A to the next A is made, i.e., a measurement of a single A period is made.

Visual register at end of measurement:



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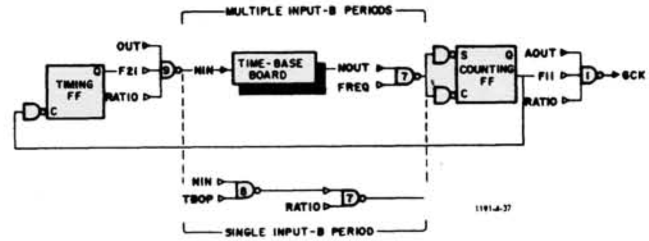
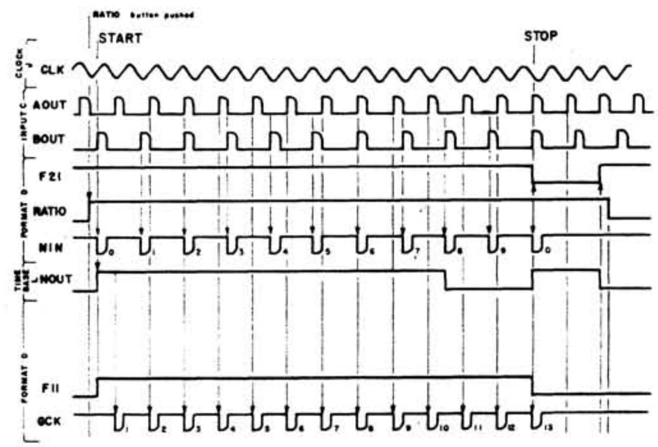
4.11.8 RATIO (A/B)

Quiescent. Before a measurement, **F11** is 0 which inhibits all counting gates including gate 1, and **F21** is 1, which provides an enabling input to all timing gates including gate 9. When the RATIO button is pushed, it sets the **RATIO** equivalent format level to 1, which enables gates 7 and 9 and provides an enabling input to gate 1. When the RANGE switch is set to any position except EXT PRO or 1, one of its outputs (**TB0 thru TB8**) enables a range gate on the time-base board; assume the RANGE switch is set to 10 which allows an **N OUT** pulse (positive N OUT transition) coincident with every tenth **N IN** pulse (paragraph 4.6.2).



Start. When a shaped input-B event, **B OUT** from the input board, arrives, it passes through gate 9, emerges as **N IN**, and is applied to the time-base board which produces an **N OUT** pulse. N OUT passes through gate 7 and complements the counting flip-flop (sets it from $\overline{Q}$ to Q) which sets **F11** to 1 and enables gate 1. Input-A events, **A OUT** from the input board, pass through gate 1, emerge as **GCK**, and are counted by the counting register on the register board.

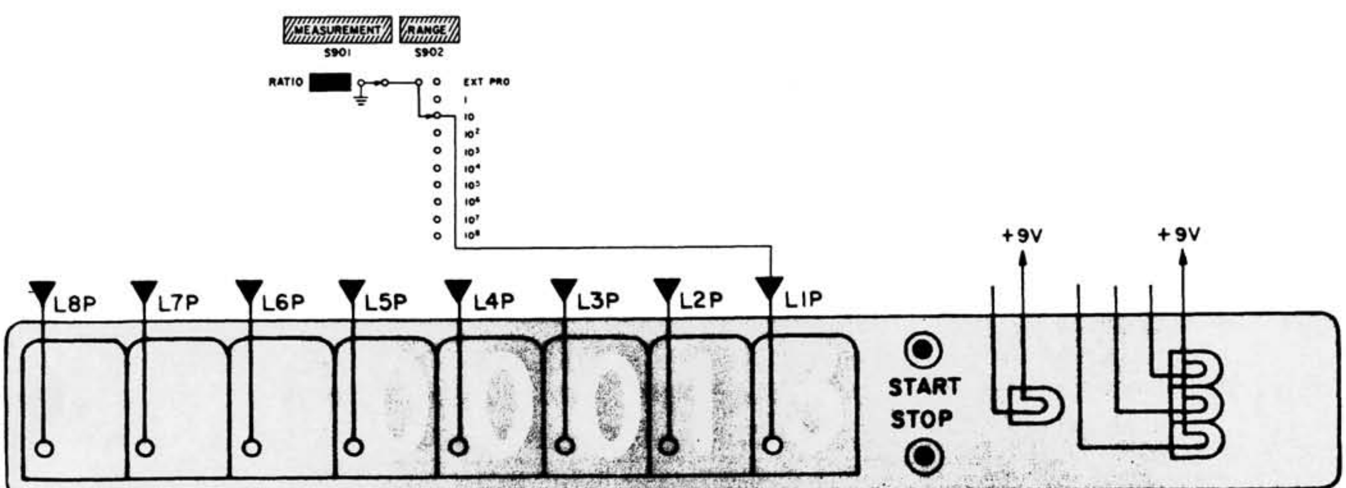
RATIO



Stop. Succeeding input-B events, **B OUT**, also pass through gate 9, emerge as **N IN**, and are applied to the time-base board where they are simply counted down. The tenth B OUT event, however, produces an **N OUT** pulse from the time-base board. N OUT passes through gate 7 and again complements the counting flip-flop (this time it resets it from Q to $\overline{Q}$) which sets **F11** to 0 and inhibits gate 1. Since this deprives the register board of an input, the count stops. The negative F11 transition resets the timing flip-flop to $\overline{Q}$ which sets **F21** to 0 and inhibits gate 9. This blocks B OUT and completes the measurement.

Single input-B period. The action for single input-B period count differs slightly; the time-base board is by-passed. Instead, when the RANGE switch is set to 1, it sets **TBOP** (via an inverter on IC601) to 1 which enables gate 8. **N IN** pulses pass through gate 8 (and thus by-pass the time-base board) and are applied to gate 7 in lieu of N OUT pulses.

Visual register at end of measurement:



1191-4-39

4.12 POWER SUPPLY V

Diagram V. The power supply provides three regulated low voltages (-5.6V, +5V, and +15V), one unregulated low voltage (+9V), and one unregulated high voltage (+250V).

4.12.1 FIFTEEN-VOLT BOARD VH

+15 volts. CR501 through CR504 from a bridge rectifier that supplies an unregulated dc voltage to the emitter of the series regulator, Q500, whose collector provides the regulated +15-V output to the other circuits in the instrument. This output is also divided down by R501, R502, and R507 and is applied to a set of error amplifiers (Q502 and Q501 and Q503) which control the conduction of the series regulator to maintain a constant +15-V output over a broad range of load and input-line-voltage variations.

For example, if the +15-V output at Q500 collector tries to go more positive, Q502 base goes more positive and causes Q502 to conduct more heavily. Its collector goes less positive which causes Q501 to conduct more heavily and brings Q501 collector more positive. This causes Q500 to conduct less which brings the +15-V output back down.

4.12.2 FIVE-VOLT BOARD VL

+9 volts. This is the unregulated dc voltage for the +5-volt supply.

+5 volts. This supply operates the same as the +15-V supply except the first error amplifier is a voltage comparator.

-5.6 volts. This supply is regulated by a 5.6-V Zener diode to ground and is supplied by a half-wave rectifier, CR556.

+250 volts. This supply is an unregulated dc voltage supplied by a half-wave rectifier, CR555, and filtered by C552 and R554. It supplies the readout tubes on the visual register and the ΦLOCK OUT neon bulb.

CAUTION: **Turn off power before removing or replacing etched boards. Do not apply excessive heat to etched boards. Use thermal-contact compound for series-regulator power transistors.**

5.1 WARRANTY

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

5.2 SERVICE

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest District Office, requesting a "Returned Material Tag." Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

5.3 ROUTINE MAINTENANCE

5.3.1 CLOCK CALIBRATION

Every six months, check and, if necessary, readjust the frequency of the internal clock oscillator as follows:

Set the rear-panel TIME BASE switch to INT, push the FREQUENCY button, and set the RANGE switch to 10 . Connect a known frequency to INPUT A, set the input controls to obtain a measurement, and adjust the FREQ ADJ, R950 on the rear panel, until the visual register displays exactly the value of the known frequency.

For maximum accuracy, use a known frequenty of 10MHz, allow the counter to warm up for one or two hours before adjustment, and adjust the oscillator at the line voltage and ambient temperature under which the counter is normally operated.

5.4 REPAIR NOTES

5.4.1 KNOB REPLACEMENT

To remove a knob, grasp it securely and pull—hard. The knob should pull off the bushing attached to the shaft. If, by some chance, the bushing should come off, insert a tap of the same size as the hole in the bushing (1/8, 1/4, or 3/8") a few threads into the hole and pull the bushing out of the knob. Reinstall the bushing on the shaft and tighten the set screws.

To replace a knob, place it over the bushing and push. The 1191 includes the following knobs:

Knob	*GR Part Number*	*Knob*	*GR Part Number*	*Knob*	*GR Part Number*
A POLARITY & ATTEN A THRESHOLD	5520-5331 5520-5131	B POLARITY & ATTEN B THRESHOLD	5520-5331 5520-5131	DISPLAY TIME RANGE	5500-5321 5500-5321

5.4.2 ETCHED BOARDS

Extenders. The counter features modular construction which greatly simplifies troubleshooting and repair. Most of the circuitry is mounted on plug-in etched boards that can be raised above the instrument by means of board extenders for access to components and test points. One such board extender is supplied as an accessory and is stored in the spare socket, S0980 the rear-most socket on the right-hand side of the chassis. It is a 24-pin extender GR part number 4215-2034, and will accommodate all plug-in boards except the register board and the power supply boards. To use the extender, install it so the arrow labeled "left" points to the left-hand side as viewed from the front.

Replacement. For minimum down-time, a defective board can be replaced immediately and thus keep the instrument on-line while the defective unit is being repaired. Defective boards may be repaired in your facility or sent to the nearest General Radio Repair Center (see rear cover) for repair or replacement. The 1191 contains the following etched boards:

Etched Board	*Type*	*Socket*	*GR Part Number*	*Etched Board*	*Type*	*Socket*	*GR Part Number*
*C Input	plug-in	S0920	1191-4720	I Oscillator[2]	wired-in	—	1158-4010
D Format	plug-in	S0960	1191-4760	J Clock	plug-in	S0940	1191-4740
E Register	plug-in	S0910, S0911	1191-4710	JA Amplifier[2]	plug-in	S0940	1191-4780
F Display	wired-in	—	1191-2700	L Time-Base	plug-in	S0930	1191-4730
G Buffer[1]	wired-in	—	1191-2790	*VH Fifteen-Volt	plug-in	S0501	1158-4751
H Program	plug-in	S0970	1191-4770	*VL Five-Volt	plug-in	S0550	1191-2756

*Adjustment recommended: see paragraph 5.6.4 for input board, paragraph 5.6.2 for fifteen-volt board, and paragraph 5.6.2 for five-volt board.

1 Installed only in models with data-output option.

2 Installed only in models with high-precision time-base option.

Repair. Excessive heat can ruin an etched board by stripping off (delaminating) the etched wiring. To remove a transistor or integrated circuit, unsolder each pin with a 20 to 30-W soldering iron and use a desoldering tool (such as a Soldapullt ®, Edsyn Inc., Box 868, Arleta, Calif.) to remove as much solder as possible. Then use a screwdriver or similar tool to gently push each pin away from the side of the hole and separate it from any remaining solder. After all pins have been freed, the component can be lifted from the boards; easily and without application of excessive heat.

5.4.3 OSCILLATOR CIRCUIT I

The oscillator circuit (installed in models with the high-precision time-base option) is a sealed unit and must be replaced if defective; it cannot be repaired.

5.4.4 POWER SUPPLY V

The series-regulator power transistors, Q500 and Q550 mounted on the chassis in the left rear corner, are each electrically isolated from the chassis by a mica insulator. If one of these transistors is replaced, be sure the mica insulator is installed between the transistor and the chassis and is coated on both sides with Dow Corning no. 5 silicone thermal-contact compound or equivalent.

5.5 TROUBLESHOOTING PROCEDURE

CAUTION: Turn off power before removing or replacing etched boards;

Diagram AJ. Additional information contained in paragraphs 3.2 Operational Checks, 5.6 Calibration Procedure, and 6.1 Signal Index.

5.5.1 PRELIMINARY

Introduction. These steps should localize most troubles to a specific board and, in some cases, to a specific stage. Each step must be performed in the order given and must pass before proceeding to the next step (unless noted otherwise) because each one serves as the foundation for the next. Defective boards may be repaired in your facility or sent to the nearest General Radio Repair Center (see rear of book) for repair or replacement. **Unless trouble is encountered, perform only the bold-face portion of each step.**

When a board is indicated as the source of trouble, the problem can also be the socket connections to the board (the board is not seated properly in the socket or the contacts are dirty or misaligned). If a board is intermittent or if a replacement board fails to work, remove the board then reinsert it.

When a transistor is indicated as the source of trouble, the problem can also be the components or wiring associated with the transistor.

Equipment required. The specifications given are those necessary for the troubleshooting of the instrument and are not necessarily those of the suggested equipment.

	Characteristics	*Suggested Equipment*
Voltmeter	Range: 4 to 250Vdc Impedance: 20,000Ω/V min	The 1806 Electronic Voltmeter

Counting lamp. The COUNTING lamp can be used as a visual indication of the operation of the counter if the measurement time (COUNTING lamp on) or display time (COUNTING lamp off) is 100ms or greater. The lamp cannot respond faster than 100ms.

Sequential counting. The counter can be set to provide its own controlled-repetition-rate pulses so that the count can be visually observed, even in the least-significant digit: Set the rear-panel STORAGE-DISABLE switch to DISABLE, set the A and B POLARITY & ATTEN switches to + 100, and push the INTERVAL button. To start the action, turn the A THRESHOLD control back and forth through its full range. Use the RANGE control to set the repetition rate (repetition rate equals clock frequency divided by range, e.g., for RANGE 1 repetition rate = $10^7/1$ = 10MHz, for RANGE 8, repetition rate = $10^7/10^8$ = 0.1Hz). To stop the action, turn the B THRESHOLD control back and forth through its full range.

5.5.2 POWER

This step checks certain settings of the MEASUREMENT and RANGE controls for the presence of the outputs from the five-volt board in the power supply.

1. Set controls as indicated:

A and B POLARITY & ATTEN	**+ 100**	**DISPLAY TIME**	**SINGLE MEASURE**
A and B THRESHOLD	**centered**	**RANGE**	**10^2**
A and B AC-DC	**AC**	**MEASUREMENT**	**FREQUENCY**
SEPARATE-COMMON	**SEPARATE**	**POWER**	**OFF**

Turn POWER on; if visual register displays 0000000.0MHz (digits may be other than 0), proceed to next step.

If a readout tube displays no number, interchange it with one that does; if indication changes, trouble is **display board** readout tube (diagram E, F); if indication does not change, trouble is circuitry associated with readout tube (note digit and proceed to next step).

If digits and decimal point are not lit, check fuse; if ok, trouble is **five-volt board** + 250-V supply (diagram V).

If decimal point is not lit but MHz symbol is, turn RANGE switch cw to other positions; if other decimal points light, trouble is **display board** readout tube V958 (diagram E, F). If other decimal points do not light, push RATIO button; if decimal point lights, trouble is **FREQUENCY push-button** (diagram L); if decimal point still does not light, trouble is **RANGE switch** (diagram L).

If MHz symbol is not lit but decimal point is, push PERIOD button; if mSEC symbol does not light, trouble is **five-volt board** + 9-V supply (diagram V; if + 9-V supply has failed, so has + 5-V supply and when the + 5V is missing, all ten figures in each readout tube will be lit and will be fuzzy); if mSEC symbol lights, trouble is **visual register** P903 (diagram L).

If MHz symbol and decimal are not lit, trouble is **FREQUENCY push-button** (diagram L).

5.5.3 CLEAR AND TRANSFER

This step checks the program board clear and transfer stages.

Control settings: (from previous step)

A and B POLARITY & ATTEN	+ 100	DISPLAY TIME	SINGLE MEASURE
A and B THRESHOLD	centered	RANGE	10
A and B AC-DC	AC	MEASUREMENT	FREQUENCY
SEPARATE-COMMON	SEPARATE	POWER	on

2. Push COUNT button then push SET 9 button; if visual register displays 99999999 START/STOP, proceed to next step.

If one or two digits are not 9, trouble is circuitry associated with readout tube (note digit and proceed to next step).

If most digits are not 9, trouble is **program board** Q712, Q713, or Q714 (diagram H).

If START-STOP symbol is not lit, trouble is **visual register** P904 (diagram L).

5.5.4 RESET

This step checks the program board reset stages.

Control settings: (from previous step)

A and B POLARITY & ATTEN	+ 100	DISPLAY TIME	SINGLE MEASURE
A and B THRESHOLD	centered	RANGE	10^2
A and B AC-DC	AC	MEASUREMENT	COUNT
SEPARATE-COMMON	SEPARATE	POWER	on

3. Push SET 0 button; if visual register displays 00000000 START/STOP, proceed to next step.

If one or two digits are not 0, trouble is circuitry associated with readout tube (note digit and proceed to next step).

If most digits are not 0, trouble is **program board** Q703, 4, 5, 6, 7, or 8 (diagram H).

5.5.5 COUNTING FLIP-FLOP

This step checks the format board counting flip-flop and COUNTING lamp driver.

Control settings: (from previous step)	A and B POLARITY & ATTEN .... + 100	DISPLAY TIME	SINGLE MEASURE
	A and B THRESHOLD .... centered	RANGE	10^2
	A and B AC-DC .... AC	MEASUREMENT...	COUNT
	SEPARATE-COMMON .... SEPARATE	POWER	on

4. Push START button then push STOP button; if COUNTING lamp lights when START button is pushed and extinguishes when STOP button is pushed, proceed to next step.

If COUNTING lamp does not light, trouble is **START button** (diagram D), **format board** IC603, Q604, or Q606 (diagram D), or **visual register** COUNTING lamp P905 (diagram D).

If COUNTING lamp does not extinguish, trouble is **STOP button** (diagram D), or **format board** IC 603, Q604, or Q605 (diagram D).

5.5.6 TIMING FLIP-FLOP AND A CHANNEL

This step checks the format board timing flip-flop and gates 7, 8, and 10, and the input board A channel.

Control settings: (from previous step)	A and B POLARITY & ATTEN .... + 100	DISPLAY TIME	SINGLE MEASURE
	A and B THRESHOLD .... centered	RANGE	10^2
	A and B AC-DC .... AC	MEASUREMENT....	COUNT
	SEPARATE-COMMON .... SEPARATE	POWER	on

5. Push PERIOD button, set RANGE to 1, and push SET 0 button. Turn A THRESHOLD back and forth through full range twice. If COUNTING lamp lights when A THRESHOLD is turned the first time and extinguishes when it is turned the second, proceed to next step.

If COUNTING lamp does not light, set A POLARITY to -100 and turn A THRESHOLD; if COUNTING lamp lights, trouble is **input board** Q210 (diagram C); if COUNTING lamp does not light:

Push RATIO button and turn B THRESHOLD; if COUNTING lamp lights, trouble is **input board** Q201, 2, 3, 4, 5, 6, 7, 8, 9, or 10.(diagram C), **A THRESHOLD control** R908 (diagram C), **PERIOD button** (diagram L), or **format board** Q610 or IC601 (diagram D); if COUNTING lamp does not light, trouble is **format board** Q607, Q608, IC601, or IC602 (diagram D).

If COUNTING lamp does not extinguish, trouble is **format board** IC602 (diagram D).

5.5.7 B CHANNEL

This step checks the input board B channel and the format board gate 9.

Control settings: (from previous step)	A and B POLARITY & ATTEN .....+100	DISPLAY TIME	SINGLE MEASURE
	A and B THRESHOLD............ —	RANGE	1
	A and B AC-DC .... AC	MEASUREMENT....	PERIOD
	SEPARATE-COMMON .... SEPARATE	POWER	on

6. Push RATIO button and push SET 0 button. Turn B THRESHOLD back and forth through full range twice. If COUNTING lamp lights when B THRESHOLD is turned the first time and extinguishes when it is turned the second, proceed to next step.

If COUNTING lamp does not light, set B POLARITY & ATTEN to - 100 and turn B THRESHOLD; if COUNTING lamp lights, trouble is **input board** Q261 (diagram C); if COUNTING lamp does not light, trouble is **input board** Q251, 2, 3, 4, 5, 6, 7, 8, 9, or 60 (diagram C), **B THRESHOLD control** R909 (diagram C), **RATIO button** (diagram L), or **format board** IC601 or Q609 (diagram D).

5.5.8 CLOCK, TIME-BASE, AND DISPLAY

The step checks the clock board (or oscillator circuit and amplifier board in counters with the high-precision time-base option), the time-base board, the register board, and the display circuit.

Control settings: (from previous step)			
A and B POLARITY & ATTEN .... + 100		DISPLAY TIME .... SINGLE MEASURE	
A and B THRESHOLD .... —		RANGE 1	
A and B AC-DC .... AC		MEASUREMENT.... RATIO	
SEPARATE-COMMON .... SEPARATE		POWER .... on	

7. Set A and B POLARITY & ATTEN to TEST 10MHz, center A and B THRESHOLD, and set RANGE as indicated below (after each RANGE change, push SET 0 button to initiate measurement); if indications are proper; proceed to next check.

RANGE **Visual register** Measurement time (COUNTING lamp lit)	10 1.0 1μs	10^2 1.00 10μs	10^3 1.000 100μs	10^4 1.0000 1ms	10^5 1.00000 10ms	10^6 1.000000 100ms	10^7 1.000000 1s	10^8 .00000000 10s
	If COUNTING lamp fails to extinguish on all of these ranges, trouble is **time-base board** IC304 (diagram L).				If COUNTING lamp fails to extinguish on all of these ranges, trouble is **time-base board** IC309 (diagram L).			
	If COUNTING lamp fails to extinguish on all of these ranges, trouble is **time-base board** IC306 (diagram L).							
	If COUNTING lamp fails to extinguish on one of the following ranges, trouble is **time-base board** (diagram L):							
	IC304 or IC306	IC304 or IC306	IC304 or IC306	IC304 or IC306	IC309 or IC306	IC309 or IC306	IC309 or Q301	IC309 or Q302
	If most-significant digit is constant but too low, trouble is **time-base board** decade (diagram L) at which improper digit first appears (e.g., if indication is 1, 1.0, .800, .8000, etc., trouble is IC303):							
	IC302	IC301	IC303	IC305	IC307	IC308	IC310	IC311
	If most-significant digit is constant but too high, trouble is **register board** decade (diagram E, F) at which improper digit first appears (e.g., if indication is 1, 1.0, 1.00, 2.000, 2.0000, etc., trouble is IC117):							
	IC101 or IC102	IC109	IC110	IC117	IC118	IC125	IC126	IC133
	If one or two digits are improper, check levels to associated display circuit decoder (diagram E, E; AT951 thru AT982):							

Decimal	0				1				9			
BCD	$\overline{1}$	$\overline{2}$	$\overline{4}$	$\overline{8}$	$\overline{1}$	$\overline{2}$	$\overline{4}$	$\overline{8}$	$\overline{1}$	$\overline{2}$	$\overline{4}$	$\overline{8}$
level	+5V	+5V	+5V	+5V	0V	+5V	+5V	+5V	0V	+5V	+5V	0V

If levels to decoder are proper, trouble is **display circuit** decoder (diagram E, F) associated with improper digit; if levels are improper, trouble is **register board** transfer or storage stages (diagram E, F) associated with improper digit.

If COUNTING lamp fails to light on all RANGES, trouble is **clock board** (diagram J) or, in counters with high-precision time-base option, **oscillator circuit** or **amplifier board** (diagram JA).

5.5.9 FORMAT BOARD GATES

The step checks the remaining format board gates.

Control settings:	A and B POLARITY & ATTEN	TEST 10MHz	DISPLAY TIME	SINGLE MEASURE
(from previous step)	A and B THRESHOLD	centered	RANGE	10^8
	A and B AC-DC	AC	MEASUREMENT....	RATIO
	SEPARATE-COMMON	SEPARATE	POWER	on

8. Push FREQUENCY button, set DISPLAY TIME to 1 SEC, and set RANGE to 10^7; if COUNTING lamp repetitively lights for one second and extinguishes for one second and visual register displays 10000.000 kHz, ±1 count, proceed to next check.

If digits are improper, trouble is **format board** IC601 or Q611 (diagram D).

9. Push PERIOD button; if COUNTING lamp repetitively lights for one second and extinguishes for one second and visual register displays 100.0000 nSEC, ±1 count, proceed to next check.

If digits are improper, trouble is **format board** IC601 or Q602 (diagram D).

10. Push COUNT button and push STOP button. Push START button then, a second or two later, push STOP button; if COUNTING lamp lights and visual register changes rapidly when START button is pushed and if COUNTING lamp extinguishes and visual register displays some arbitrary number for one second then resets to zero after STOP button is pushed, proceed to next check.

If display does not change, trouble is **format board** IC601.

11. Push INTERVAL button, set A and B POLARITY & ATTEN to + 100, and set RANGE to 10^5. Turn A THRESHOLD back and forth through full range then, a second or two later, turn B THRESHOLD back and forth through full range; if COUNTING lamp lights when A THRESHOLD is turned and if COUNTING lamp extinguishes and visual register displays some arbitrary number after B THRESHOLD is turned, instrument is operating properly in all major respects.

If display does not change, trouble is **format board** IC601, Q603, Q603, or Q606 (diagram D).

5.6 CALIBRATION PROCEDURE
and Minimum Performance Standards

CAUTION: Turn off power before removing or replacing etched boards.

Diagram AJ. Additional information is contained in paragraphs 3.2 Operational Checks, 5.5 Troubleshooting Procedure, and 6.1 Signal Index.

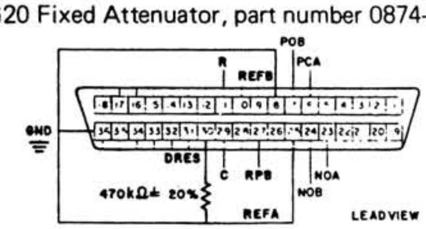
5.6.1 PRELIMINARY

Introduction. This procedure can be used for calibration or for verification of minimum performance standards. In either case, the steps must be performed in the order given and must pass before proceeding to the next step (unless noted otherwise) because each one serves as the foundation for the next. Defective boards may be repaired in your facility or sent to the nearest General Radio Repair Center 'see rear of book) for repair or replacement.

Calibration. The 1191 Counter incorporates the high reliability inherent in conservatively-designed solid-state digital circuitry and routine calibrations are unnecessary except for clock calibration (paragraph 5.6.11).

Minimum Performance Standards (MPS). For incoming inspection or for other situations where it is desired simply to verify the counters' primary specifications and not to adjust, correct, or otherwise optimize the circuits or check such secondary characteristics as power supply voltages, only the MPS steps (MPS1, MPS2, etc.) need be performed.

Equipment required. The specifications given are those necessary for the performance of the calibration procedure or minimum performance standard and are not necessarily those of the suggested equipment.

Equipment	*Characteristics*		*Suggested (GR equipment unless noted otherwise)*
*Autotransformer	Output:	100 to 125 Vac, 32W	W5MT3VM, W5MT3A, W5MT3W, or W5MT3AW
	Meter:	±3% accuracy	Metered Variac® Autotransformer.
Voltmeter	Range:	0.09 to 250 Vdc, ±2% accuracy	1806 Electronic Voltmeter.
	Impedance:	20,000Ω/V min	
Oscilloscope	Bandwidth:	50MHz, dual trace	Tektronix 453, or 544, 546, 547, or 556 with a 1A1 plug-in.
	Sensitivity:	50mV/div including 10X probe	
	Impedance:	10MΩ including 10X probe	
Pulse generator	PRF:	1KHz, 20% accuracy	1398 Pulse Generator or 1217 Pulse Generator and 1201 or 1203 Power Supply.
	Duration:	300ns to 200μs, ±20% accuracy	
	Amplitude:	200mV to 20V pk-pk into 1MΩ	
Signal generator	Frequency:	1 to 20MHz, ±1% accuracy	1001 or 1003 Standard Signal Generator or 1205 Standard Sweep-Frequency Generator.
	Amplitude:	10 to 20mV rms into 50Ω	
Frequency synthesizer .	Frequency:	4Hz to 10MHz, ±1% accuracy	1163 Coherent Decade Frequency Synthesizer.
	Amplitude:	1V rms into 50Ω	
Known frequency ...	Frequency:	0.1, 1, 2.5, 5, or 10MHz; $< 5 \times 10^{-11}$ stability	1115 Standard Frequency Oscillator.
	Amplitude:	20mV rms into 50Ω	
Coaxial patchcord	3-foot, 50Ω, GR874 connector		874-R20A Coaxial Patch Cord, part number 0874-9680
Tee connectors (2)	GR874 connectors		874-T Tee, part number 0874-9910
Adapter	GR874 to BNC		874-QBPA Adaptor, part number 0874-9800
Termination	50Ω, GR874 connector		874-W50B Resistive Termination, part number 0874-9954
Attenuator	10X (20dB voltage), 50Ω, GR874 connectors		874-G20 Fixed Attenuator, part number 0874-9572
Test plug	Amphenol Type 57, 36-pin, Amphenol part number 57-30360, GR part number 4220-3036, wired as shown.		

*Not necessary for minimum performance standards.

5.6.2 POWER SUPPLY

This step checks the supply voltages from the fifteen-volt board and five-volt board in the power supply (diagram V).

Setup. Connect counter to autotransformer, set autotransformer for 115-V output, and set counter as follows:

A and B POLARITY & ATTEN . . . . + 1	DISPLAY TIME . . . . . SINGLE MEASURE
A and B THRESHOLD . . . . centered	RANGE 1
A and B AC-DC . . . . DC	MEASUREMENT . . . . FREQUENCY
SEPARATE-COMMON . . . . SEPARATE	POWER . . . . on

Procedure	*Indication*
+ 15 volts. Connect voltmeter and scope to + 15V (S0501-5).	+ 15V must be + 15Vdc; if not, adjust R502.
Vary line voltage from 100 to 125V.	+ 15V must be + 14.85 to + 15.15Vdc. Ripple must not exceed 50mV pk-pk.
+ 5 volts. Set line voltage to 115V and connect voltmeter and scope to + 5V (S0550-13).	+ 5V must be + 5Vdc; if not, adjust R560.
Vary line voltage from 100 to 125V.	+ 5V must be + 4.95 to + 5.05Vdc. Ripple must not exceed 50mV pk-pk.
-5.6 volts. Connect voltmeter and scope to -5.6V (S0550-5) and vary line voltage from 100 to 125V.	-5.6V must be -5.3 to -5.9Vdc. Ripple must not exceed 50mV pk-pk.
+ 250 volts. Connect voltmeter and scppe to + 250V (S0550-15) and vary line voltage from 100 to 125V.	+ 250V must be + 210 to + 290Vdc. Ripple must not exceed 200mV pk-pk.
Set line voltage to 115V and disconnect voltmeter and scope.	

MPS 1 5.6.3 INPUT ATTENTUATORS

This step checks the attenuator function of the A and B POLARITY & ATTEN controls (diagram C).

Control settings: (from previous step)	A and B POLARITY & ATTEN .... + 1	DISPLAY TIME ..... SINGLE MEASURE
	A and B THRESHOLD .... centered	RANGE 1
	A and B AC-DC .... DC	MEASUREMENT.... FREQUENCY
	SEPARATE-COMMON .... SEPARATE	POWER .... on

Setup. Set rear-panel STORAGE-DISABLE switch to STORAGE and TIME-BASE switch to INT. Set pulse generator for 1-KHz, 300-ns, positive pulses.

Procedure	*Indication*
A attenuator. Set A POLARITY & ATTEN to + 1. Connect scope channel 1 to INPUT A connector behind panel and connect channel 2 to ASIG (output of attenuator, S0920-1). Connect pulse generator to INPUT A and set output for exactly 200mV pk-pk (4 div on scope channel 1).	ASIG amplitude must be exactly 200mV with no overshoot or undershoot (4 div on scope channel 2).
Set A POLARITY & ATTEN to -1.	ASIG must be same as above.
Set A POLARITY & ATTEN to -10 and set generator amplitude for exactly 2V pk-pk (4 div on scope channel 1).	ASIG amplitude must be 180 to 220mV and undershoot must be less than 40mV (amplitude 3.6 to 4.4 div, undershoot <0.8 div on scope channel 2).
Set A POLARITY & ATTEN to + 10.	ASIG must be same as above.
Set A POLARITY & ATTEN to + 100 and set generator amplitude for exactly 20V pk-pk (4 div on scope channel 1). (amplitude 3.6 to 4.4 div, overshoot < 0.3 div, noise < 0.5 div on scope channel 2).	ASIG amplitude must be 180 to 220 mV, overshoot must be less than 60mV, and noise must be less than 50mV pk-pk (amplitude 3.6 to 4.4 div, overshoot < 0.3 div, noise < 0.5 div on scope channel 2).
Set A POLARITY & ATTEN to -100.	ASIG must be same as above.
B attenuator. Set B POLARITY & ATTEN to + 100. Connect scope channel 1 to INPUT B connector behind panel and connect channel 2 to BSIG (output of attenuator, S0920-16). Connect pulse generator to INPUT B and set output for exactly 4V pk-pk (4 div on scope channel 1).	BSIG amplitude must be 180 to 220mV, overshoot must be less than 60mV, and noise must be less than 50mV pk-pk (amplitude 3.6 to 4.4 div, overshoot <0.3 div, noise <0.5 div on scope channel 2).
Set B POLARITY & ATTEN to -100.	BSIG must be same as above.
Set B POLARITY & ATTEN to -10 and set generator amplitude for exactly 2V pk-pk (4 div on scope channel 1).	BSIG amplitude must be 180 to 220mV and undershoot must be less than 40mV (amplitude 3.6 to 4.4 div, undershoot <0.8 div on scope channel 2).
Set B POLARITY & ATTEN to + 10.	BSIG must be same as above.
Set B POLARITY & ATTEN to + 1 and set generator amplitude for exactly 200mV pk-pk (4 div on scope channel 1).	BSIG amplitude must be exactly 200mV with no overshoot or undershoot (4 div on scope channel 2).
Set B POLARITY & ATTEN to -1.	BSIG must be same as above.

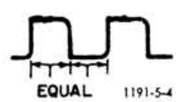
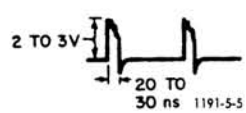
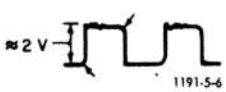
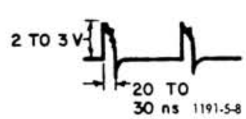
Disconnect scope and pulse generator.

5.6.4 INPUT TRIGGER

This step checks the symmetrical trigger, output stage, and THRESHOLD voltages on the input board (diagram C). Sensitivity is checked in paragraph 5.6.10.

Control settings: (from previous step)	A and B POLARITY & ATTEN	—	DISPLAY TIME.....	SINGLE MEASURE
	A and B THRESHOLD	centered	RANGE	1
	A and B AC-DC	DC	MEASUREMENT....	FREQUENCY
	SEPARATE-COMMON	SEPARATE	POWER	on

Setup. Turn off counter POWER, remove clock board J (or amplifier board JA in high-precision oscillator counters) and time-base board L. Turn POWER on and set A and B POLARITY & ATTEN to -1.

Procedure		*Indication*
A threshold. Turn A THRESHOLD fully ccw and connect voltmeter to AREF (S0920-6).		AREF must be -0.09 to -0.11Vdc.
Turn A THRESHOLD fully cw.		AREF must be + 0.09 to + 0.11Vdc.
B threshold. Turn B THRESHOLD fully ccw and connect voltmeter to BREF (S0920-21).		BREF must be -0.09 to -0.11Vdc.
Turn B THRESHOLD fully cw.		BREF must be + 0.09 to + 0.11Vdc.
Disconnect voltmeter.		
● **B channel.** Terminate cable from standard signal generator in 50Ω, connect it to INPUT B, and set generator for 1-MHz, 10V rms at input to counter. Connect scope to Q258 collector (on right-hand side of input board).		Rounding of corners must be equal; if not, adjust Current R274 (lower potentiometer). Use B THRESHOLD to maintain proper triggering.
● Center B THRESHOLD.		Counter must trigger; if it doesn't, adjust Balance R254 (upper potentiometer). R274 and R254 interact, repeat adjustments if necessary.
Connect scope to BOUT (S0920-24).		BOUT must contain a minimum of spurious oscillations and noise.
Set B POLARITY & ATTEN to + 1.	BOUT must be same as above.	
● **A channel.** Connect generator to INPUT A and connect scope to Q208 collector (on left-hand side of input board).		Rounding of corners must be equal; if not, adjust Current R224 (lower potentiometer). Use A THRESHOLD to maintain proper triggering.
● Center A THRESHOLD.		Counter must trigger; if it doesn't, adjust Balance R204 (upper potentiometer). R224 and R204 interact, repeat adjustments if necessary.
Connect scope to AOUT (S0920-9).		AOUT must contain a minimum of spurious oscillations and noise.
Set A POLARITY & ATTEN to + 1.	AOUT must be same as above.	
Disconnect standard signal generator and scope. Turn POWER OFF, replace clock board (or amplifier board) and time-base board, and turn POWER on.		

5.6.5 CLOCK OUTPUT

This step checks the clock board doubler output (diagram J) for room-temperature-oscillator counters or the amplifier board amplifier output (diagram JA) for high-precision-oscillator counters. Frequency accuracy is checked in paragraph 5.6.11.

Control settings: (from previous step)			
A and B POLARITY & ATTEN .... +1		DISPLAY TIME ..... SINGLE MEASURE	
A and B THRESHOLD .... centered		RANGE 1	
A and B AC-DC .... DC		MEASUREMENT .... FREQUENCY	
SEPARATE-COMMON .... SEPARATE		POWER .... on	

Setup. Lock frequency synthesizer to a known frequency, connect synthesizer to rear-panel EXT DRIVE connector, and set synthesizer for 10MHz, 1V rms.

Procedure	*Indication*
Doubler or amplifier. Set rear-panel TIME-BASE switch to EXT LOCK and connect scope to JECK (Q412 collector on clock board or amplifier board).	JECK must be maximum (8 to 10V pk-pk) with minimum distortion; if not, adjust L403.
OUT 10MHz. Connect scope to OCK (rear-panel OUT 10MHz connector).	OCK must be ≈2V pk-pk.
Oscillator (room-temperature-oscillator counters only). Set rear-panel TIME-BASE switch to INT, connect voltmeter to VCFA (S0940-24), and set rear-panel FREQ ADJ to center of voltage range then disconnect voltmeter.	ΦLOCK OUT lamp must be extinguished; if not, adjust C410.
Disconnect scope.	

MPS 2 5.6.6 CLOCK PHASE LOCK

This step checks the clock board phase-lock stages (diagram J) for room-temperature-oscillator counters or the amplifier board phase-lock stages (diagram JA) for high-precision-oscillator counters. Frequency accuracy is checked in paragraph 5.6.11.

Control settings: (from previous step)	
A and B POLARITY & ATTEN .... +1	DISPLAY TIME ..... SINGLE MEASURE
A and B THRESHOLD .... centered	RANGE 1
A and B AC-DC .... DC	MEASUREMENT .... FREQUENCY
SEPARATE-COMMON .... SEPARATE	POWER .... on

Setup. (for MPS procedure only, calibration procedure setup is same as previous paragraph, 5.6.5). Lock frequency synthesizer to a known frequency, connect synthesizer to rear-panel EXT DRIVE connector, and set synthesizer for 10MHz, 1V rms.

Procedure	*Indication*
Lock range. Set rear-panel TIME-BASE switch to EXT LOCK and lower synthesizer frequency until ΦLOCK OUT lamp lights; note frequency. Raise frequency, through point where ΦLOCK OUT lamp extinguishes, to point where it again lights; note frequency.	Range between lower and upper frequency must be at least 200Hz for room-temperature-oscillator and at least 20Hz for high-precision oscillator.
Disconnect frequency synthesizer and set TIME-BASE switch to INT.	

5.6.7 REGISTER AND DISPLAY

This step checks the régister board decades, transfer gates, and storage stages (diagram E, F), the display circuit decoders and readout tubes (diagram E, F), and the format board counting flip-flop and gate 1 (diagram D).

Control settings: (from previous step)	A and B POLARITY & ATTEN .... + 1	DISPLAY TIME .... SINGLE MEASURE
	A and B THRESHOLD .... centered	RANGE 1
	A and B AC-DC .... DC	MEASUREMENT .... FREQUENCY
	SEPARATE-COMMON .... SEPARATE	POWER .... on

Setup. Connect frequency synthesizer to INPUT A and set synthesizer for ≈ 4Hz and 1V rms (minimum). Connect voltmeter to 8OUT spill (rear-panel PROGRAMMING INPUT socket, S0950-16).

Procedure	*Indication*
Set A POLARITY & ATTEN to + 10 and push COUNT button.	START-STOP lamp must light.
Push START button.	COUNTING lamp must light. Least-significant (right-hand) digit must count (advance sequentially) and carry to the next digit on the 9-0 transition (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, etc.). Each of the eight digits in the visual register must count and carry properly. Increase synthesizer frequency, as necessary, to speed count. 8OUT must be 0 when most-significant (left-hand) digit is 0, 1, 2, 3, 4, 5, 6, or 7 and ≈ + 5V when most-significant digit is 8 or 9.
Push STOP button.	COUNTING lamp must extinguish.
Push SET 9 button	Visual register must display 999999999.

Disconnect frequency synthesizer and voltmeter.

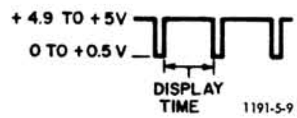
MPS 3 5.6.8 PROGRAM AND TIME BASE

This step checks the program board display time generator (diagram H), the time-base board decades and range gate (diagram L), and the format board timing flip-flop and gates 7 and 11 (diagram D).

Control settings: (from previous step)

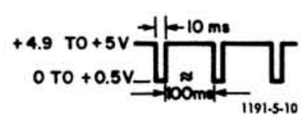
A POLARITY & ATTEN	+ 10	DISPLAY TIME	SINGLE MEASURE
B POLARITY & ATTEN	+ 1	RANGE	1
A and B THRESHOLD	Centered	MEASUREMENT	COUNT
A and B AC-DC	DC	POWER	on
SEPARATE-COMMON	SEPARATE		

Setup. Set A POLARITY & ATTEN to TEST 10MHz and connect scope to PGT print command (rear-panel DATA OUT socket, S0901-24 on counters with data output option or to F21 signal, S0960-17 on counters without data output option).

Procedure	*Indication*
Time base. Set RANGE as follows and push SET 0 button for each new measurement:	Visual register must display (within ± 1 count):
10	00000010 MHz
10^2	0000010.0 MHz
10^3	000010.00 MHz
10^4	00010.000 MHz
10^5	0010000.0 kHz
10^6	010000.00 kHz
10^7	10000.000 kHz
10^8	0000000.0 Hz
Set RANGE to 10 and ground SDIS storage disable (rear-panel PROGRAMMING INPUT socket, S0950-12). Remove ground.	Visual register must show counts accumulating during measurement (storage disabled).
Display time. Push FREQUENCY button and set DISPLAY TIME and RANGE as follows:	 PGT (or F21) must be as shown.

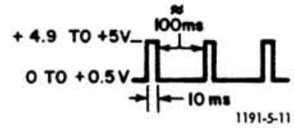
DISPLAY TIME	RANGE	Display time must be as follows:
100μs	10^3	80 to 120μs
—	10^3	0.8 to 1.2ms
—	10^3	8 to 12ms
—	10^3	40 to 60ms
100ms	10^6	80 to 120ms
—	10^6	160 to 240ms
—	10^6	400 to 600ms
1SEC	10^6	0.8 to 1.2s
—	10^6	1.6 to 2.4s
—	10^6	4 to 6s
10SEC	10^6	8 to 12s

Print commands. (PGT checked above.) Set DISPLAY TIME to 100ms, set RANGE to 10, and connect scope to PRT + print command (rear-panel DATA OUT socket, S0901-23 on counters with data-output option).



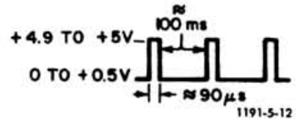
PRT+ must be as shown.

Connect scope to PRT print command (rear-panel PROGRAMMING INPUT socket, S0950-34).



PRT must be as shown.

Connect scope to S0+ print command (rear-panel PROGRAMMING INPUT socket, S0950-17).



S0+ must be as shown.

Disconnect scope.

MPS 4 5.6.9 FORMAT

This step checks the format board remaining gates (diagram D).

Control settings: (from previous step)	A POLARITY & ATTEN .... TEST 10MHz	DISPLAY TIME 100ms
	B POLARITY & ATTEN .... + 1	RANGE .... 10^5
	A and B THRESHOLD ..... centered	MEASUREMENT .... FREQUENCY
	A and B AC-DC .... DC	POWER .... on
	SEPARATE-COMMON ..... SEPARATE	

Setup. Set A POLARITY & ATTEN to + 1, DISPLAY TIME to SINGLE MEASURE, and RANGE to 1.

Procedure	*Indication*
Period. Push PERIOD button, push SET 0 button, and turn A THRESHOLD back and forth through full range.	COUNTING lamp must light.
Interval. Push INTERVAL button, push SET 0 button, and turn A THRESHOLD back and forth through full range.	COUNTING lamp must light.
Ratio. Push RATIO button, push SET 0 button, and turn B THRESHOLD back and forth through full range.	COUNTING lamp must light.

MPS 5 5.6.10 INPUT SENSITIVITY

This step checks the input board A and B channel sensitivity (diagram D).

Control settings: (from previous step)	A and B POLARITY & ATTEN .... + 1	DISPLAY TIME .... SINGLE MEASURE
	A and B THRESHOLD .... centered	RANGE 1
	A and B AC-DC .... DC	MEASUREMENT .... RATIO
	SEPARATE-COMMON .... SEPARATE	POWER .... on

Setup. Connect a tee-connector to output of standard signal generator. Terminate a cable from tee connector in 50Ω and connect it to INPUT A. Terminate a second cable from tee connector with a X10, 50-Ω attenuator and connect it to INPUT 8. Set DISPLAY TIME to 100μs, set RANGE to 10^5, and push FREQUENCY button.

Procedure	*Indication*
A channel. Set generator for 20MHz, 10mV rms at INPUT A and set A THRESHOLD to obtain a measurement.	Visual register must display generator frequency (0020000.0kHz) ± 1 count.
B channel. Set generator for 10MHz, 10mV rms at INPUT B, push RATIO button, and set B THRESHOLD to obtain a measurement.	Visual register must display generator frequency (001.00000) ± 1 count.

Disconnect standard signal generator.

MSP 6 5.6.11 CLOCK FREQUENCY

This step checks the clock board oscillator accuracy (diagram J) for room-temperature-oscillator counters or the oscillator circuit accuracy (no diagram) for high-precision-oscillator counters.

Control settings: (from previous step)	A and B POLARITY & ATTEN .... + 1	DISPLAY TIME 100μs
	A and B THRESHOLD .... centered	RANGE .... 10^5
	A and B AC-DC .... DC	MEASUREMENT .... FREQUENCY
	SEPARATE-COMMON .... SEPARATE	POWER .... on

Setup. Lock frequency synthesizer to a known frequency, connect synthesizer to INPUT A, and set synthesizer for 10MHz, 1V rms. Set DISPLAY TIME to 1SEC and RANGE to 10^8.

Procedure	*Indication*
Frequency. Set A THRESHOLD to obtain a measurement.	Visual register must display 1 (spill) 0000000.0 Hz; if it doesn't, adjust rear-panel FREQ ADJ R950 until it does.

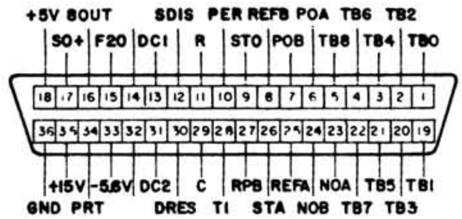
Disconnect frequency synthesizer.

MPS 7 5.6.12 EXTERNAL PROGRAMMING

This step checks the ability of the counter to be externally programmed and is primarily a check of the wiring to the rear-panel PROGRAMMING INPUT socket, S0950. 8OUT was checked in paragraph 5.6.7, and SDIS and PRT were checked in paragraph 5.6.8.

Control settings:	A and B POLARITY & ATTEN .... + 1	DISPLAY TIME 1SEC
(from previous step)	A and B THRESHOLD .... centered	RANGE .... 10^8
	A and B AC-DC .... DC	MEASUREMENT .... FREQUENCY
	SEPARATE-COMMON .... SEPARATE	POWER .... on

Setup. Connect test plug (see paragraph 5.6.1) to rear-panel PROGRAMMING INPUT socket.
Set DISPLAY TIME to SINGLE MEASURE and RANGE to 10^6.



1191-5-13

Procedure		*Indication*
Measurement. Ground pins on PROGRAMMING INPUT socket as follows (push SET 0 button for each new measurement):		The following symbols must light:
No ground.		000000.00 kHz nSEC
Ground PER period	(S0950-10).	000000.00 kHz SEC
Ground TI interval	(S0950-28).	000000.00 kHz
Ground C count	(S0950-29, keep ground connected).	000000.00 START/STOP kHz
Ground STA start	(S0950-26).	COUNTING lamp must light.
Ground STO stop	(S0950-9).	COUNTING lamp must extinguish.
Push SET 9 button.		999999.99 START/STOP kHz
Connect RPB set zero (S0950-27) to + 5V (S0950-18).		000000.00 START/STOP kHz

Disconnect S0950-29 from ground and disconnect S0950-27 from S0950-18).

Range. Ground R ratio (S0950-11, keep ground connected), set RANGE to 10, set A and B POLARITY & ATTEN to TEST 10MHz, push SET 0 button, and set A and B THRESHOLD to obtain a measurement.	Visual register must display 00000010MHz = 1 count
Set RANGE to EXT PROG and ground pins on PROGRAMMING INPUT socket as follows (push SET 0 button for each new measurement):	Visual register must display (within ± 1 count):

Ground TB0 range 1 (S0950-1)	00000001 EXT PRO
Ground TB1 range 10 (S0950-19)	00000010 EXT PRO
Ground TB2 range 10^2 (S0950-2)	00000100 EXT PRO
Ground TB3 range 10^3 (S0950-20)	00001000 EXT PRO
Ground TB4 range 10^4 (S0950-3)	00010000 EXT PRO
Ground TB5 range 10^5 (S0950-21)	00100000 EXT PRO
Ground TB6 range 10^6 (S0950-4)	01000000 EXT PRO
Ground TB7 range 10^7 (S0950-22)	10000000 EXT PRO
Ground TB8 range 10^8 (S0950-5)	00000000 EXT PRO

Display time. Set RANGE to 10^7 and ground pins on PROGRAMMING INPUT socket as follows:

Ground DC2 0.1-μF capacitor (S0950-31).	COUNTING lamp must repetitively light for 1s and extinguish briefly ($\approx$ 50ms).
Ground DC1 10-μF capacitor (S0950-13).	COUNTING lamp must repetitively light for 1s and extinguish for $\approx$ 3 or 4s.

Disconnect S0950-11 from ground.

Input Control. Push INTERVAL button, set A POLARITY & ATTEN to + 1, B POLARITY & ATTEN to -1, SEPARATE-COMMON to COMMON, and RANGE to 10. Set pulse generator for 1-kHz, 200-μs, positive pulses, connect it to INPUT A, and set A and B THRESHOLD to obtain a measurement.	Visual register must display $\approx$ 00000200μs.
Set A and B POLARITY to EXT PROG. Ground P0A positive A (S0950-6) and N0B negative B (S0950-24).	Visual register must display same as above.
Ground N0A negative A (S0950-23) and P0B positive B (S0950-7).	Visual register must display $\approx$ 00000800μs.

Disconnect pulse generator and test plug.

MPS 8 5.6.13 DATA OUTPUT (data output counters only)

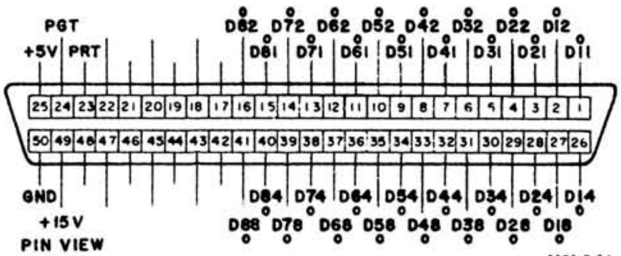
This step checks the availability of the measurement data and is primarily a check of the buffer circuit (diagram G) and the wiring to the rear-panel DATA OUT socket on counters with the data out option. PGT and PRT were checked in paragraph 5.6.8.

Control settings: (from previous step)	A and B POLARITY & ATTEN	EXT PROG	DISPLAY	SINGLE MEASURE
	A and B THRESHOLD	—	RANGE	10
	A and B AC-DC	DC	MEASUREMENT....	INTERVAL
	SEPARATE-COMMON	COMMON	POWER	on

Note. This procedure uses a voltmeter to measure the data out. If a printer, compatible with the 1191, is available, a quicker and simpler method to check the data out is to connect the printer to the DATA OUT socket and observe the data directly in decimal form on the printer.

Procedure — *Indication*

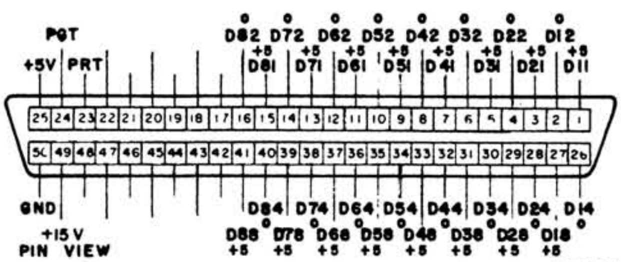
Zero. Push COUNT button and SET 0 button. Connect voltmeter to each data line (D11 thru D88).



1191-5-14

All bits 0V.

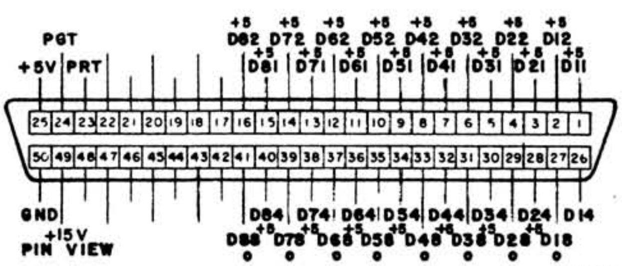
Nine. Push SET 9 button. Connect voltmeter to each data line (D11 thru D88).



1191-5-15

All 1 and 8 bits + 5V and all 2 and 4 bits 0V.

Seven.* Set visual register to seven and connect voltmeter to each data line (D11 thru D88).



1191-5-16

All 1, 2, and 4 bits + 5V and all 8 bits 0V.

*To set visual register to seven either (1) Connect a synthesizer to INPUT A and set synthesizer to 07, 777, 777. Set RANGE to 10^7 , push FREQUENCY button, and set A THRESHOLD to obtain a measurement. This method checks all except the last (8th) decade buffer. Or (2) use the sequential counting mode; i.e., Set the rear-panel STORAGE-DISABLE switch to DISABLE, set the A and B POLARITY & ATTEN switches to + 100, and push the INTERVAL button. To start the action, turn the A THRESHOLD control back and forth through its full range. Use the RANGE control to set the count rate. To stop the action after a count of 77777777, turn the B THRESHOLD control back and forth through its full range.

Parts and Diagrams

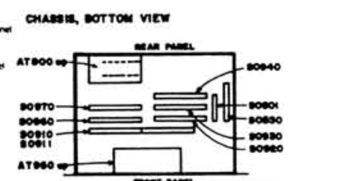
SECTION 6

6.1 SIGNAL INDEX

Signal	*Description* **Connections*	***Characteristics*	*Diagram* (*source in parenthesis*)	*Principles*
AOUT	A channel output S0920-9, S0960-1	P, + 200mV, + 3.5V, 25ns, —, 100ns. See 5.6.4.	(C), D	(4.2.3),4.11
AREF	A channel threshold S908-202F, S0920-6	DC, 0V. See 5.6.4.	(C)	(4.2.2)
ASIG	A channel attenuator output S908-209F-R, S0920-1	AC, 300mV pk-pk, 10MHz. See 5.6.3	(C)	(4.2.1),4.2.2
BOUT	B channel output S0920-24, S0960-11	¯P, + 200mV, + 3.5V, 25ns, —, 100ns. See 5.6.4.	(C), D	(4.2.3),4.11
BREF	B channel threshold S909-202F, S0920-21	DC, 0V. See 5.6.4.	(C)	(4.2.2)
BSIG	B channel attenuator output S909-209-F-R, S0920-16	AC, 300mV pk-pk, 10MHz. See 5.6.3.	(C)	(4.2.1),4.2.2
C	Count program P904, S0950-29, S0960-7, S0970-5	DC, + 8.5V with 2-V pk-pk 120-Hz ripple. See 2.6.2, 5.6.12.	(L), D	(4.11.1),4.10.1
CL	Clear storage S0911-5, S0970-3	P, + 5V, -5V, 50ns, 100ns, 600ns.	(H), E, F	(4.10.1),4.7.2
CLK	10-MHz clock to timing and winding gates S0930-11, S0940-12, S0960-5	SW, + 200mV, + 2.5V, 15ns, 15ns, 100ns.	(J or JA), D	(4.3.1),4.11
CN	Count program, isolated		(D)	(4.11.1)
DC1	Display time program 10-μF capacitor S907-108F, S0950-13, S0970-7	See 2.6.4, 5.6.12.	(H)	(4.10.2)
DC2	Display time program 0.1-μF capacitor S907-104F, S0950-31, S0970-8	DC, 0V. See 2.6.4, 5.6.12.	(H)	(4.10.2)
DRES	Display time program resistor S907-101R, S0950-30, S0970-9	DC, 0V. See 2.6.4, 5.6.1.	(H)	(4.10.2)
D11	1st digit 1-bit buffered AT882, S0901-1	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D12	1st digit 2-bit buffered AT881, S0901-2	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D14	1st digit 4-bit buffered AT880, S0901-26	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D18	1st digit 8-bit buffered AT879, S0901-27	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D21	2nd digit 1-bit buffered AT874, S0901-3	DC, + 5V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D22	2nd digit 2-bit buffered AT877, S0901-4	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D24	2nd digit 4-bit buffered AT876, S0901-28	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D28	2nd digit 8-bit buffered AT875, S0901-29	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D31	3rd digit 1-bit buffered AT874, S0901-5	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D32	3rd digit 2-bit buffered AT873, S0901-6	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D34	3rd digit 4-bit buffered AT872, S0901-30	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D38	3rd digit 8-bit buffered AT871, S0901-31	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D41	4th digit 1-bit buffered AT870, S0901-7	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D42	4th digit 2-bit buffered AT869, S0901-8	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D44	4th digit 4-bit buffered AT868, S0901-32	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D48	4th digit 8-bit buffered AT867, S0901-33	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D51	5th digit 1-bit buffered AT866, S0901-9	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D52	5th digit 2-bit buffered AT865, S0901-10	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D54	5th digit 4-bit buffered AT864, S0901-34	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D58	5th digit 8-bit buffered AT863, S0901-35	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D61	6th digit 1-bit buffered AT862, S0901-11	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D62	6th digit 2-bit buffered AT861, S0901-12	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)

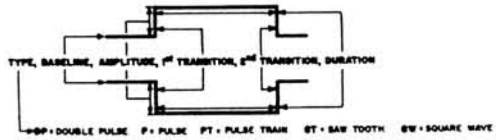
***Connections:**

AT900 up	Buffer Circuit G, chassis
AT960 up	Display Circuit F, chassis
J901	INPUT A, front panel
J902	INPUT B, front panel
J951	EXT DRIVE, rear panel
J952	OUT 10MHz, rear panel
J953	INPUT A, rear panel
J954	INPUT B, rear panel
S901	MEASUREMENT, front panel
S902	RANGE, front panel
S903	START, front panel
S904	STOP, front panel
S905	SET 0, front panel
S906	SET 9, front panel
S907	DISPLAY TIME, front panel
S908	A POLARITY & ATTEN, front panel
S909	B POLARITY & ATTEN, front panel
S910	A AC-DC, front panel
S911	B AC DC, front panel
S912	SEPARATE-COMMON, front panel
S951	STORAGE-DISABLE, rear panel
S952	TIME BASE, rear panel
[illegible]	Fifteen Volt Board VH, chassis
[illegible]	Five Volt Board VL, chassis
S0901	DATA OUT, rear panel
S0910	Register Board E, chassis
S0911	Register Board E, chassis
S0920	Input Board C, chassis
S0930	Time-Base Board L, chassis
S0940	Clock Board J or Amplifier Board JA, chassis
S0950	PROGRAMMING INPUT, rear panel
S0960	Format Board D, chassis
S0970	Program Board H, chassis



****Characteristics measured under following conditions:**

A and B POLARITY & ATTEN	TEST 10MHz
A and B THRESHOLD	centered
A and B AC-DC	AC
SEPARATE-COMMON	SEPARATE
DISPLAY TIME	100μs
RANGE	10
MEASUREMENT	FREQUENCY
STORAGE DISABLE (rear)	STORAGE
TIME-BASE (rear)	EXT
Connect OUT 10MHz to EXT DRIVE (rear)	



115-Vac line voltage, all signals measured with respect to chassis ground (T GND) with 20-kΩ/Voltmeter or 10MΩ oscilloscope probe.

6.1 SIGNAL INDEX (cont)

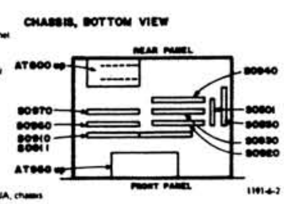
Signal	*Description* **Connections*	***Characteristics*	*Diagram*	*Principles* *(source in parenthesis)*
D64	6th digit 4-bit buffered AT860, S0901-36	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D68	6th digit 8-bit buffered AT859, S0901-37	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D71	7th digit 1-bit buffered AT858, S0901-13	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D72	7th digit 2-bit buffered AT857, S0901-14	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D74	7th digit 4-bit buffered AT856, S0901-38	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D78	7th digit 8-bit buffered AT855, S0901-39	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D81	8th digit 1-bit buffered AT854, S0901-15	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D82	8th digit 2-bit buffered AT853, S0901-16	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D84	8th digit 4-bit buffered AT852, S0901-40	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
D88	8th digit 8-bit buffered AT851, S0901-41	DC, 0V. See 2.5.2, 5.6.13.	(G)	(4.9.1)
E11	1st digit 1-bit complement AT832, AT982, S0910-16	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E12	1st digit 2-bit complement AT831, AT981, S0910-15	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E14	1st digit 4-bit complement AT830, AT980, S0910-14	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E18	1st digit 8-bit complement AT829, AT979, S0910-13	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E21	2nd digit 1-bit complement AT828, AT978, S0910-2	DC, 0V.	(E, F)	(4.7.2),4.8.1,4.9.1
E22	2nd digit 2-bit complement AT827, AT977, S0910-11	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E24	2nd digit 4-bit complement AT826, AT976, S0910-1C	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E28	2nd digit 8-bit complement AT825, AT975, S0910-9	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E31	3rd digit 1-bit complement AT824, AT974, S0910-8	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E32	3rd digit 2-bit complement AT823, AT973, S0910-7	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E34	3rd digit 4-bit complement AT822, AT972, S0910-6	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E38	3rd digit 8-bit complement AT821, AT971, S0910-5	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E41	4th digit 1-bit complement	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E42	4th digit 2-bit complement	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E44	4th digit 4-bit complement	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E48	4th digit 8-bit complement	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E51	5th digit 1-bit complement	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E52	5th digit 2-bit complement	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E54	5th digit 4-bit complement	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E58	5th digit 8-bit complement	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E61	6th digit 1-bit complement	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E62	6th digit 2-bit complement	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E64	6th digit 4-bit complement	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E68	6th digit 8-bit complement	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E71	7th digit 1-bit complement AT808, AT958, S0911-16	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E72	7th digit 2-bit complement AT807, AT957, S0911-15	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E74	7th digit 4-bit complement AT806, AT956, S0911-14	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E78	7th digit 8-bit complement AT805, AT955, S0911-13	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E81	8th digit 1-bit complement AT804, AT954, S0911-12	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E82	8th digit 2-bit complement AT803, AT953, S0911-11	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E84	8th digit 4-bit complement AT802, AT952, S0911-10	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
E88	8th digit 8-bit complement AT801, AT951, S0911-9	DC, + 5V.	(E, F)	(4.7.2),4.8.1,4.9.1
F10	Counting gate control complement S0960-21	P, + 5V, -5V, 10ns, 40ns, 1.2μs, with 500mV pk-pk 10-MHz noise.	(D)	(4.11.3),4.11
F11	Counting gate control complement S0960-17, S0970-1	P, + 200mV, + 4.5V, 50ns, 10ns, 1.2μs with 500mV pk-pk 10-MHz noise.	(D)	(4.11.3)
F20	Timing gate control complement S0960-20, S0970-22	P, + 5V, -5V, 12ns, 50ns, 1.2μs with 200mV pk-pk 10-MHz noise.	(D), H	(4.11.2),4.10.2
F21	Timing gate control	P, + 200mV, + 4.5V, 75ns, 10ns, 1.2μs with 200mV pk-pk 10-MHz noise	(D), H	(4.11.2),4.9.1, 4.10.1,4.10.2,4.11
GCK	Counting pulses S0910-22, S0960-3	PT, + 5V, -6V, 6ns, 20ns, 30ns, train of 11	(D), E, F	(4.11.3),4.7.1, 4.11

6.1 SIGNAL INDEX (cont)

Signal	*Description* **Connections*	***Characteristics*	*Diagram*	*Principles* *(source in parenthesis)*
GL	Counting lamp drive P905, S0960-24	P, + 9.5V, -9.5V, —, —, 1.25µs with 2V pk-pk 120-Hz ripple.	(D)	(4.11.3)
GND	Chassis ground, AT850, AT901, AT903, C502 case, S904-C, S908 ground lug, S0901-50, S0910-3, S0911-6-8, S0920-2-10-11-15-17, S0930-3-5, S0940-5-13-21, S0950-36, S0960-2-15, S0970-17		C, D, E, F, G, H, I, J, JA, L, V	
G1	Clock oscillator ground AT910, S0940-23		(J)	
JDCK	Clock 10-MHz to detector	AC, + 13V, 4V pk-pk, 10-MHz	(J)	
JECK	Clock 10-MHz amplifier output	AC, + 3V, 6V pk-pk, 10-MHz. See 5.6.5.	(J)	(4.3.1)
JCKL	Clock sample signal	P, + 200mV, + 2 to + 3V, —, —, 100ns.	(J or JA)	(4.3.2)
JL	Clock interogate puls	P, + 8V, + 6V, —, —, 100ns.	(J or JA)	(4.3.2)
L1P	1st digit decimal point S902-102F	DC, + 13V.	(L)	(4.6.3),4.8.1
L2P	2nd digit decimal point S902-103F	DC, + 13V.	(L)	(4.6.3),4.8.1
L3P	3rd digit decimal point S902-104F	DC, + 13V.	(L)	(4.6.3),4.8.1
L4P	4th digit decimal point S902-109F	DC, + 13V.	(L)	(4.6.3),4.8.1
L5P	5th digit decimal point S902-106F	DC, + 13V.	(L)	(4.6.3),4.8.1
L6P	6th digit decimal point S902-107F	DC, + 13V.	(L)	(4.6.3),4.8.1
L7P	7th digit decimal point S902-108F	DC, + 13V.	(L)	(4.6.3),4.8.1
L8P	8th digit decimal point S902-109F	DC, + 13V.	(L)	(4.6.3),4.8.1
NIN	Timing pulses S0930-4, S0960-6	P, + 5V, -6V, 50ns, 5ns, 60ns.	(D), L	(4.11.2),4.6.1, 4.11
NOA	A channel negative slope program S908-112F, S0920-7, S0950-6	DC, + 1.8V. See 2.6.5, 5.6.12.	(C)	(4.2.3)
NOB	B channel negative slope program S909-112R, S0920-22, S0950-7	DC, + 1.8V. See 2.6.5, 5.6.12.	(C)	(4.2.3)
NOUT	Timing pulses scaled S0930-6, S0960-4	DP, + 5.2V, -4.8V, —, —, 1.8µs; 800-ns interval; + 5.2V, -4.8V, —, —, 200ns	(L), D	(4.6.2),4.11
OCK	10-MHz clock to external jack AT904, J952, S0940-15	SW, 0V, ±1.25V, 15ns, 10ns, 100ns. See 5.6.5.	(J or JA)	(4.3.1)
OUT	Register spill S0911-3	DC, 0V.	(E, F)	
PER	Period program P902, S0950-10, S0960-9	DC, + 3.8V. See 2.6.2, 5.6.12	(L), D	(4.6.3)
PERN	Period program buffered	DC, + 5V.	(D)	(4.11.1)
PERP	Period program complement	DC, + 200mV.	(D)	(4.11.1)
PGT	Timing gate control buffered complement AT885, S0901-24	P, + 5V, -4.8V, 7ns, 250ns, 1.3µs. See 2.5.3, 5.6.8.	(G)	(4.9.1)
PHCV	Phase-lockfrequency control S952-1, S0940-8	DC, + 3 to + 4V.	(J or JA)	(4.3.2)
PLMN	Phase-lock-out lamp drive AT983, S0940-10	DC, + 13V with 4 to 10V pk-pk 120-Hz ripple.	(J or JA)	(4.3.2)
POA	A channel positive slope program S908-111F,	DC, 0V. See 2.6.5, 5.6.12.	(C)	(4.3.2)

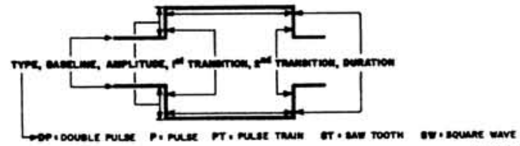
*Connections:

AT800 up	Buffer Circuit G, chassis
AT860 up	Display Circuit F, chassis
J901	INPUT A, front panel
J902	INPUT B, front panel
J951	EXT DRIVE, rear panel
J952	OUT 10MHz, rear panel
J953	INPUT A, rear panel
J954	INPUT B, rear panel
S901	MEASUREMENT, front panel
S902	RANGE, front panel
S903	START, front panel
S904	STOP, front panel
S905	SET 0, front panel
S906	SET 9, front panel
S907	DISPLAY TIME, front panel
S908	A POLARITY & ATTEN, front panel
S909	B POLARITY & ATTEN, front panel
S910	A AC DC, front panel
S911	B AC DC, front panel
S912	SEPARATE-COMMON, front panel
S951	STORAGE-DISABLE, rear panel
S952	TIME-BASE, rear panel
S0901	Fifteen-Volt Board VH, chassis
S0900	Five-Volt Board VL, chassis
S0951	DATA OUT, rear panel
S0910	Register Board E, chassis
S0911	Register Board E, chassis
S0920	Input Board C, chassis
S0930	Time-Base Board L, chassis
S0940	Clock Board J or Amplifier Board JA, chassis
S0950	PROGRAMMING INPUT, rear panel
S0960	Format Board D, chassis
S0970	Program Board H, chassis



**Characteristics measured under following conditions:

A and B POLARITY & ATTEN	TEST 10MHz
A and B THRESHOLD	centered
A and B AC-DC	AC
SEPARATE-COMMON	SEPARATE
DISPLAY TIME	100µs
RANGE	10
MEASUREMENT	FREQUENCY
STORAGE-DISABLE (rear)	STORAGE
TIME-BASE (rear)	EXT
Connect OUT 10MHz to EXT DRIVE (rear)	



115-Vac line voltage, all signals measured with respect to chassis ground (⏚, GND) with 20-kΩ/Voltmeter or 10MΩ oscilloscope probe.

Signal	*Description* **Connections*	***Characteristics*	*Diagram* (*source in parenthesis*)	*Principles*
	S0920-3, S0950-23			
POB	B channel positive slope program S0909-111R, S0920-18, S0950-24	DC, 0V. See 2.6.5, 5.6.12.	(C)	(4.3.2)
PRT	Print command buffered AT886, S0901-23	P, 0V, + 5V, —, —, 900ns. See 2.5.3, 5.6.8.	(G)	(4.9.1)
PRT+	Print command AT836, S0950-34, S0970-23	P, + 5V, -5V, —, —, 900ns. See 2.5.3, 5.6.8.	(H)	(4.10.2),4.9.1
R	Ratio program S901D-6, S0950-11, S0960-14	DC, + 1.8V with 800mV pk-pk noise. See 2.6.2, 5.6.12.	(L), D	(4.6.3)
REFA	A channel external threshold S909-108F, S0950-25	DC, open. See 2.6.5.	(C)	(4.2.2)
REFB	B channel external threshold S909-109F, S0950-8	DC, open. See 2.6.5.	(C)	(4.2.2)
RN	Ratio program isolated	DC, + 1.8V with 200mV pk-pk noise.	(D)	(4.11.1)
RP	Ratio program complement	DC, 0V with 100mV pk-pk noise.	(D)	(4.11.1)
RPB	Set zero S902-302R, S905-NC, S906-NC, S0940-6, S0950-27, S0970-20	DC, 0V.	(H)	(4.10.2)
SDIS	Storage disable S951-1, S0950-12, S0970-4	DC, 0V.	(H)	(4.10.1)
SSG	Time-base detector output isolated S0940-11	P, 0V, 200 to 300mV.	(J or JA)	
STA	Start S903-NO, S0950-26, S0960-23	DC, + 5V.	(D)	(4.11.4)
STO	Stop S904-NO, S0950-9, S0960-19	DC, + 5V.	(D)	(4.11.4)
SO+	Set S0911-1, S0930-1, S0950-17, S0960-16, S0970-21	P, 0V, + 5.5V, 600ns, 20ns, 1.6μs. See 2.5.3, 5.6.8.	(H), D, E, F, L	(4.10.2),4.6.2,4.7.1
SO-	Reset	P, + 5V, -5V, 15ns, 400ns, 1μs.	(H), D, E, F, L	(4.10.2),4.7.1
S9+	Set nine S906-NC, S0911-2	DC, 0V.	(E, F)	(4.7.1)
S9-	Set 9 complement S906-NO, S0910-18	DC, + 5V with 600mV pulse at measurement rate	(E, F)	(4.7.1)
TBL	Time-base external drive J951, S0940-2	SW, 0V ± 1.25V, 15ns, 10ns, 100ns.	(J or JA)	(4.3.2)
TBO	Range 1 program S902-302F, S0950-1, S0960-13	DC, + 2V. See 2.6.3, 5.6.12.	(L), D	
TBOP	Range 1 program complement	DC, 0V.	(D)	(4.11.1),4.11
TB1	Range 10 program S902-303F, S0930-13, S0950-19	DC, 0V. See 2.6.3, 5.6.12.	(L)	(4.6.2),4.11
TB2	Range 10^2 program S902-304-F, S0930-15, S0950-2	DC, + 2V. See 2.6.3, 5.6.12.	(L)	(4.6.2),4.11
TB3	Range 10^3 program S902-305F, S0930-16, S0950-20	DC, + 2V. See 2.6.3, 5.6.12.	(L)	(4.6.2),4.11
TB4	Range 10^4 program S902-306F, S0930-14, S0950-3	DC, + 2V. See 2.6.3, 5.6.12.	(L)	(4.6.2),4.11
TB5	Range 10^5 program S902-307F, S0930-17, S0950-21	DC, + 2V. See 2.6.3, 5.6.12.	(L)	(4.6.2),4.11
TB6	Range 10^6 program S902-308F, S0930-18, S0950-4	DC, + 2V. See 2.6.3, 5.6.12.	(L)	(4.6.2),4.11
TB7	Range 10^7 program S902-309F, S0930-19, S0950-22	DC, + 2V. See 2.6.3, 5.6.12.	(L)	(4.6.2),4.11
TB8	Range 10^8 program S902-310F, S0930-21, S0950-5	DC, + 2V. See 2.6.3, 5.6.12.	(L)	(4.6.2),4.11
TI	Interval program P901, S0950-28, S0960-10	DC, + 8.5V. See 2.6.2, 5.6.12.	(L), D	(4.6.3)
TIN	Interval program buffered	DC, + 5V.	(D)	(4.11.1)
TIP	Interval program complement	DC, + 200mV.	(D)	(4.11.)
TST	10-MHz test clock to input channels S908-111F, S0940-14	AC, 300mV pk-pk 10MHz	(J or JA), C	(4.3.1),4.2.1
TXR	Transfer to storage S0911-4, S0970-6	P, + 200mV, + 4V, 500ns, 200ns, 800ns.	(H), E, F	(4.10.1),4.7.2
VCFA	Oscillator frequency control S952-2, S0940-24		(J)	(4.3.1)
+ 5V	Supply voltage ATVCC, AT+ 5, AT800, S908-109F, S0550-13, S0551-13, S0901-25, S0910-17, S0920-8-23, S0930-2, S0950-18, S0960-22, S0970-2	DC, + 5V with 200mV pk-pk noise. See 5.6.2.	(V), C, D, E, F, G, H, L	(4.12.2)
-5.6V	Supply voltage S0909-102F, S0550-5, S0920-5-20	DC, -5.6V with 200mV pk-pk noise. See 5.6.2.	(V), C	(4.12.2)
8 OUT	Register spill isolated S0911-7, S0951-16	DC, 0V. See 2.6.2, 5.6.7.	(E, F)	
+ 15V	Supply voltage AT501, S907-109F, S0501-5-10, S0920-4-19, S0940-1, S0950-35, S0970-24	DC, + 15V with 400mV pk-pk noise. See 5.6.2.	(V), C, H, J, JA	(4.12.1)
+ 250V	Supply voltage	DC, + 250V with 12V pk-pk 120-Hz ripple. See 5.6.2.	(V), E, F, J, JA	(4.12.2)

6.2 ELECTRICAL PARTS

Reference Designation	*Description*	*GR Part Number*	*FMC (see 6.4)*	*Manufacturers Part Number*	*Federal Stock Number*
SUBASSEMBLIES					
C	Input board	1191-4720	24655	1191-4720	
D	Format board	1191-4760	24655	1191-4760	
E	Register board	1191-4710	24655	1191-4710	
F	Display circuit	1191-2700	24655	1191-2700	
•G	Buffer circuit	1191-2790	24655	1191-2790	
H	Program board	1191-4770	24655	1191-4770	
•I	Oscillator circuit	1158-4010	24655	1158-4010	
J	Clock board	1191-4740	24655	1191-4740	
•JA	Amplifier board	1191-4780	24655	1191-4780	
L	Time-Base board	1191-4730	24655	1191-4730	
VH	Fifteen-Volt board	1158-4751	24655	1158-4751	
VL	Five-Volt board	1191-2756	24655	1191-2756	
CAPACITORS					
C101	Electrolytic, 4.7μF ± 20% 10V	4450-4700	56289	150D475X0015B2	5910-813-8160
C102	Electrolytic, 4.7μF ± 20% 10V	4450-4700	56289	150D475X0015B2	5910-813-8160
C103	Electrolytic, 4.7μF ± 20% 10V	4450-4700	56289	150D475X0015B2	5910-813-8160
C201	Ceramic, 82pF ± 10% 500V	4404-0828	72982	831, 82pF ± 10%	
C202	Ceramic, 68pF ± 10% 500V	4404-0688	72982	831, 68pF ± 10%	
C203	Ceramic, 6.8pF ± 10% 500V	4400-0800	78488	GA, 6.8pF ± 10%	
C204	Ceramic, 6.8pF ± 10% 500V	4400-0800	78488	GA, 6.8pF ± 10%	
C205	Ceramic, 200pF ± 10% 500V	4404-0208	72982	831, 20pF ± 10%	
C206	Ceramic, 220pF ± 10% 500V	4404-1228	72982	831, 220pF ± 10%	
C207	Electrolytic, 1μF ± 20% 35V	4450-4300	56289	150D105X0035A2	5910-726-5003
C208	Electrolytic, 1μF ± 20% 35V	4450-4300	56289	150D105X0035A2	5910-726-5003
C210	Ceramic, .01μF + 80-20% 500V	4401-3100	80131	.01μF + 80-20%	5910-974-5697
C211	Ceramic, .01μF + 80-20% 500V	4401-3100	80131	.01μF + 80-20%	5910-974-5697
C251	Ceramic, 82pF ± 10% 500V	4404-0828	72982	831, 82pF ± 10%	
C253	Ceramic, 6.8pF ± 10% 500V	4400-0800	78488	GA, 6.8pF ± 10%	
C254	Ceramic, 6.8pF ± 10% 500V	4400-0800	78488	GA, 6.8pF ± 10%	
C255	Ceramic, 20pF ± 10% 500V	4404-0208	72982	831, 20pF ± 10%	
C256	Ceramic, .001μF ± 20% 500V	4404-2109	72982	831, 0.001μF ± 20%	5910-983-9994
C257	Electrolytic, 1μF ± 20% 35V	4450-4300	56289	150D105X0035A2	5910-726-5003
C258	Electrolytic, 1μF ± 20% 35V	4450-4300	56289	150D105X0035A2	5910-726-5003
C260	Ceramic, .01μF ± 80-20% 500V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C261	Ceramic, .01μF + 80-20% 500V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C301	Electrolytic, 4.7μF ± 20% 10V	4450-4700	56289	150D475X0015B2	5910-813-8160
C401	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C402	Ceramic, 27pF ± 10% 500V	4404-0278	72982	831, 27pF ± 10%	
C403	Ceramic, 27pF ± 10% 500V	4404-0278	72982	831, 27pF ± 10%	
C404	Ceramic, 100pF ± 10% 500V	4404-1108	72982	831, 100pF ± 10%	
C405	Ceramic, 120pF ± 10% 500V	4404-1128	72982	831, 120pF ± 10%	
C406	Ceramic, .0047μF + 80-20% 500V	4405-2479	72982	801, 0.0047μF + 80-20%	
C407	Ceramic, .0047μF + 80-20% 500V	4405-2479	72982	801, 0.0047μF + 80-20%	
C408	Ceramic, .1μF ± 20% 25V	4400-2050	80183	5C13, 0.1μF ± 20%	5910-974-5695
C409	Mica, 100pF ± 1% 500V	4710-0010	14655	22A, 100pF ±1%	
C410	Trimmer, 7-to-25pF	4910-2032	72982	538-006, 7-to-25pF	

•Optional

Reference Designation	*Description*	*GR Part Number*	*FMC (see 6.4)*	*Manufacturers Part Number*	*Federal Stock Number*
CAPACITORS (cont)					
C412	Mica, 121pF ± 1% 500V	4710-0031	14655	22A, 121pF ± 1%	
C413	Ceramic, .0033μF ± 10% 500V	4406-2338	72982	811, 0.0033μF ± 10%	5910-836-5740
C414	Mica, 965pF ± .5% 300V	4710-1965	14655	22A, 965pF ± ½%	
C415	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C416	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C417	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C418	Mica, 130pF ± 1% 500V	4710-0130	14655	22A, 130pF ± 1%	
C419	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C420	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C421	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C422	Electrolytic, 1μF ± 20% 35V	4450-4300	56289	150D105X0035A2	5910-726-5003
C423	Ceramic, .01μF + 80-20% 500V	4406-3109	72982	811, 0.01μF + 80-20%	5910-977-7579
C501	Electrolytic, 3200μF 15V	4450-6220	80183	32D322G015AA0B	
C502	Electrolytic, 400X400μF 35V	4450-5621	37942	TT, 400/400μF	
C551	Electrolytic, 120μF ± 20% 10V	4450-5616	56289	150D127X0010R2	
C552	Electrolytic, 16μF + 100-10% 150V	4450-0200	37942	D33104	5910-829-3313
C553	Electrolytic, 16μF + 100-10% 150V	4450-0200	37942	D33104	5910-829-3313
C554	Electrolytic, 6.8μF ± 20% 6V	4450-4800	56289	150D685X0010A2	
C601 thru C605	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C606	Electrolytic, 4.7μF ± 20% 10V	4450-4700	56289	150D475X0015B2	5910-813-8160
C701	Electrolytic, 10μF ± 10% 25V	4450-5800	80183	D15955	5910-781-7372
C702	Ceramic, .1μF ± 20% 25V	4400-2050	80183	5C13, 0.1μF ± 20%	5910-974-5695
C703	Ceramic, .01μF + 80-20% 500V	4406-3109	72982	811, 0.01μF + 80-20%	5910-977-7579
C704	Ceramic, .1μF ± 20% 25V	4400-2050	80183	5C13,0.1μF ± 20%	5910-974-5695
C705	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C706	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C707	Ceramic, 100pF ± 10% 500V	4404-1108	72982	831, 100pF ± 10%	
C708	Ceramic, 150pF ± 10% 500V	4404-1158	72982	831, 150pF ± 10%	
C709	Ceramic, .001μF + 80-20% 500V	4404-2109	72982	831, 0.001μF + 80-20%	5910-983-9994
C710 thru C713	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C714	Ceramic, 330pF ± 10% 500V	4404-1338	72982	831, 330pF ± 10%	5910-974-5702
C715	Ceramic, 47pF ± 5% 500V	4404-0475	72982	831, 47pF ± 5%	
C801	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C802	Ceramic, 27pF ± 10% 500V	4404-0278	72982	831, 27pF ± 10%	
C803	Ceramic, 27pF ± 10% 500V	4404-0278	72982	831, 27pF ± 10%	
C804	Ceramic, 100pF ± 10% 500V	4404-1108	72982	831, 100pF ± 10%	
C805	Ceramic, 120pF ± 10% 500V	4404-1128	72982	831, 120pF ± 10%	
C806	Ceramic, .0047μF + 80-20% 500V	4405-2479	72982	801, 0.0047μF + 80-20%	
C807	Ceramic, .0047μF + 80-20% 500V	4405-2479	72982	801, 0.0047μF + 80-20%	
C808	Ceramic, .1μF ± 20% 25V	4400-2050	80183	5C13, 0.1μF ± 20%	5910-974-5695
C817	Ceramic, .01μF + 80-20% 50V	4401-3100	80183	CC61, 0.01μF + 80-20%	5910-974-5697
C818	Mica, 130pF ± 1% 500V	4710-0130	14655	22A, 130pF ± 1%	

Reference Designation	*Description*	*GR Part Number*	*FMC (see 6.4)*	*Manufacturers Part Number*	*Federal Stock Number*
CAPACITORS (cont)					
C819	Ceramic, .01μF + 80-20% 50V	4401-3100	80183	CC61, 0.01μF + 80-20%	5910-974-5697
C820	Ceramic, .01μF + 80-20% 50V	4401-3100	80183	CC61, 0.01μF + 80-20%	5910-974-5697
C821	Ceramic, .001μF + 80-20% 500V	4404-2109	72982	831, 0.001μF + 80-20%	5910-983-9994
C822	Electrolytic, 1μF ± 20% 35V	4450-4300	56289	150D105X0035A2	5910-726-5003
C823	Ceramic, .01μF + 80-20% 500V	4406-3109	72982	811, 0.01μF + 80-20%	5910-977-7579
C824	Ceramic, .001μF + 80-20% 500V	4404-2109	72982	831, 0.001μF + 80-20%	5910-983-9994
C901	Ceramic, .047μF + 80-20% 500V	4409-3479	72982	3851, 0.047μF + 80-20%	
C902	Ceramic, .047μF + 80-20% 500V	4409-3479	72982	3851, 0.047μF + 80-20%	
C903	Electrolytic, 4.7μF ± 20% 10V	4450-4700	56289	150D475X0015B2	5910-813-8160
C904	Electrolytic, 47μF ± 20% 20V	4450-5614	56289	150D476X0020R2	
C925	Ceramic, 20pF ± 5% 500V	4410-0250	72982	801, 20pF ± 5%	
C926	Ceramic, 1800pF ± 10% 500V	4406-2188	72982	811, 1800pF ± 10%	
C927	Ceramic, 22pF ± 5% 500V	4410-0225	72982	811, 22pF ± 5%	
C928	Ceramic, 220pF ± 5% 500V	4404-1225	72982	831, 220pF ± 5%	
C929	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C930	Ceramic, 20pF ± 5% 600V	4410-0250	72982	801, 20pF ± 5%	
C931	Ceramic, 1800pF ± 10% 500V	4406-2188	72982	811, 1800pF ± 10%	
C932	Ceramic, 22pF ± 5% 500V	4410-0255	72982	811, 22pF ± 5%	
C933	Ceramic, 220pF ± 5% 500V	4404-1225	72982	831, 220pF ± 5%	
C940	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C941	Ceramic, .01μF + 80-20% 50V	4401-3100	80131	CC61, 0.01μF + 80-20%	5910-974-5697
C942	Electrolytic, 1μF ± 20% 35V	4450-4300	56289	150D105X0035A2	5910-726-5003
DIODES					
CR201	Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR202	Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR203	Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR204	Type 1N4009	6082-1012	24446	1N4009	
CR251	Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR252	Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CF253	Type 1N3604	6082-1001	24446	1N3604	5960-995-2199
CR301	Type 1N4009	6082-1012	24446	1N4009	
CR302	Type 1N118A	6082-1006	98925	1N118A	
CR303	Type 1N118A	6082-1006	98925	1N118A	
CR304	Type 1N4009	6082-1012	24446	1N4009	
CR401	Type 1N4009	6082-1012	24446	1N4009	
CR402	Type V-100A	6084-1006	84411	1N953	
CR403	Type 1N4009	6082-1012	24446	1N4009	
CR501 thru CR504	Type 1N4140	6081-1014	13327	1N4140	
CR505	Type 1N4009	6082-1012	24446	1N4009	
CR506	Type 1N959B	6083-1010	72699	1N959B	
CR551 thru CR554	Type 1N4140	6081-1014	13327	1N4140	

Reference Designation	Description	GR Part Number	FMC (see 6.4)	Manufacturers Part Number	Federal Stock Number
DIODES (cont)					
CR555	Type 1N3253	6081-1001	79089	1N3253	5961-814-4251
CR556	Type 1N3253	6081-1001	79089	1N3253	5961-814-4251
CR557	Type 1N752	6083-1004	07910	1N752	
CR558	Type 1N4009	6082-1012	24446	1N4009	
CR601	Type 1N995	6082-1002	80368	1N995	
CR602	Type 1N995	6082-1002	80368	1N995	
CR603	Type 1N995	6082-1002	80368	1N995	
CR604	Type 1N4009	6082-1012	24446	1N4009	
CR605 thru CR608	Type 1N995	6082-1002	80368	1N995	
CR609	Type 1N4009	6082-1012	24446	1N4009	
CR610	Type 1N995	6082-1002	80368	1N995	
CR611	Type 1N995	6082-1002	80368	1N995	
CR612	Type 1N995	6082-1002	80368	1N995	
CR613	Type 1N4009	6082-1012	24446	1N4009	
CR614	Type 1N995	6082-1002	80368	1N995	
CR615	Type 1N4009	6082-1012	24446	1N4009	
CR616	Type 1N995	6082-1002	80368	1N995	
CR617	Type 1N995	6082-1002	80368	1N995	
CR618	Type 1N995	6082-1002	80368	1N995	
CR619	Type 1N4009	6082-1012	24446	1N4009	
CR620	Type 1N995	6082-1002	80368	1N995	
CR621	Type 1N995	6082-1002	80368	1N995	
CR622	Type 1N995	6082-1002	80368	1N995	
CR623	Type 1N4009	6082-1012	24446	1N4009	
CR624	Type 1N995	6082-1002	80368	1N995	
CR625	Type 1N995	6082-1002	80368	1N995	
CR626	Type 1N995	6082-1002	80368	1N995	
CR627	Type 1N4009	6082-1012	24446	1N4009	
CR628	Type 1N995	6082-1002	80368	1N995	
CR629	Type 1N995	6082-1002	80368	1N995	
CR630	Type 1N995	6082-1002	80368	1N995	
CR631	Type 1N4009	6082-1012	24446	1N4009	
CR632	Type 1N995	6082-1002	80368	1N995	
CR633	Type 1N995	6082-1002	80368	1N995	
CR634	Type 1N4009	6082-1012	24446	1N4009	
CR635	Type 1N995	6082-1002	80368	1N995	
CR636	Type 1N995	6082-1002	80368	1N995	
CR637	Type 1N995	6082-1002	80368	1N995	
CR638	Type 1N4009	6082-1012	24446	1N4009	
CR639	Type 1N995	6082-1002	80368	1N995	
CR640	Type 1N995	6082-1002	80368	1N995	
CR641	Type 1N995	6082-1002	80368	1N995	
CR642	Type 1N4009	6082-1012	24446	1N4009	
CR643 thru CR649	Type 1N995	6082-1002	80368	1N995	
CR701	Type 1N995	6082-1002	80368	1N995	

Reference Designation	Description	GR Part Number	FMC (see 6.4)	Manufacturers Part Number	Federal Stock Number
DIODES (cont)					
CR702 thru CR721	Type 1N4009	6082-1012	24446	1N4009	
CR801	Type 1N4009	6082-1012	24446	1N4009	
CR802	Type 1N4009	6082-1012	24446		
CR901	Type 1N816	6083-1001	14433	1N816	
CR902	Type 1N816	6083-1001	14433	1N816	
FUSES					
F501	0.4A 3AG Slo-Blo for 115-V operation	5330-0900	71400	MDL, 0.4 Amp	5920-537-6654
F502	0.2A 3AG Slo-Blo for 230-V operation	5330-0600	71400	MDL, 0.2 Amp	
INTEGRATED CIRCUITS					
IC101	Type SN7490N Texas Instruments	5431-8190	01295	SN7490N	
IC102	Type DTμL950 Fairchild	5431-9502	07263	DTμL950	
IC103	Type DTμL945 Fairchild	5431-9452	07263	DTμL945	
IC104 thru IC108	Type DTμL949 Fairchild	5431-9492	07263	DTμL949	
IC109	Type SN7490N Texas Instruments	5431-8190	01295	SN7490N	
IC110	Type SN7490N Texas Instruments	5431-8190	01295	SN7490N	
IC111 thru IC116	Type DTμL949 Fairchild	5431-9492	07263	DTμL945	
IC117	Type SN7490N Texas Instruments	5431-8190	01295	SN7490N	
IC118	Type SN7490N Texas Instruments	5431-8190	01295	SN7490N	
IC119 thru IC124	Type DTμL 949 Fairchild	5431-9492	07263	DTμL949	
IC301	Type SN7490N Texas Instruments	5431-8190	01295	SN7490N	
IC302	Type SN7490N Texas Instruments	5431-8190	01295	SN7490N	
IC303	Type SN7490N Texas Instruments	5431-8190	01295	SN7490N	
IC304	Type DTμL946 Fairchild	5431-9462	07263	DTμL946	
IC305	Type SN7490N Texas Instruments	5431-8190	01295	SN7490N	
IC306	Type DTμL936 Fairchild	5431-9362	07263	DTμL936	
IC307	Type SN7490N Texas Instruments	5431-8190	01295	SN7490N	
IC308	Type SN7490N Texas Instruments	5431-8190	01295	SN7490N	
IC309	Type DTμL946 Fairchild	5431-9462	07263	DTμL946	
IC310	Type SN7490N Texas Instruments	5431-8190	01295	SN7490N	
IC311	Type SN7490N Texas Instruments	5431-8190	01295	SN7490N	

Reference Designation	Description	GR Part Number	FMC (see 6.4)	Manufacturers Part Number	Federal Stock Number
INTEGRATED CIRCUITS (cont)					
IC601	Type DTμL936 Fairchild	5431-9362	07263	DTμL936	
IC602	Type DTμL950 Fairchild	5431-9502	07263	DTμL950	
IC603	Type DTμL950 Fairchild	5431-9502	07263	DTμL950	
IC801 thru IC806	Type DTμL946 Fairchild	5431-9462	07263	DTμL946	
IC951 thru IC958	Type CμL960 Fairchild	5431-9602	07263	CμL960	
JACKS					
J901	BNC connector Input A	4230-2301	09408	UG-1094A/U	
J902	BNC connector Input B	4230-2301	09408	UG-1094A/U	
J951	BNC connector Time Base Ext Drive	4230-2300	81349	UG-1094/U	
J952	BNC connector Out 10MHz	4230-2300	81349	UG-1094/U	
J953	BNC connector rear Input A	4230-2300	81349	UG-1094/U	
J954	BNC connector rear Input B	4230-2300	81349	UG-1094/U	
INDUCTORS					
L201	10μH ± 10%	4300-2200	99800	1537, 10μH ± 10%	
L202	10μH ± 10%	4300-2200	99800	1537, 10μH ± 10%	
L203	.68μH ± 20%	4300-0500	99800	1537, .68μH ± 20%	
L204	.68μH ± 20%	4300-0500	99800	1537, .68μH ± 20%	
L205	3.9μH ± 10%	4300-1500	99800	1537-26, 3.9μH ± 10%	
L206	1.2μH ± 10%	4300-0900	99800	1537, 1.2μH ± 10%	
L251	10μH ± 10%	4300-2200	99800	1537, 10μH ± 10%	
L252	10μH ± 10%	4300-2200	99800	1537, 10μH ± 10%	
L253	.68μH ± 20%	4300-0500	99800	1537, .68μH ± 20%	
L254	.68μH ± 20%	4300-0500	99800	1537, .68μH ± 20%	
L255	3.9μH ± 10%	4300-1500	99800	1537-26, 3.9μH ± 10%	
L401	1.5μH ± 10%	4300-1000	99800	1537, 1.5μH ± 10%	
L402	22μH ± 10%	4300-2600	99800	1537, 22μH ± 10%	5950-668-5867
L403	Variable conductor	1191-2150	24655	1191-2150	
L404	22μH ± 10%	4300-2600	99800	1537, 22μH ± 10%	5950-668-5867
L405	5.6μH ± 10%	4300-1800	99800	1537-30, 5.6μH ± 10%	
L801	1.5μH ± 10%	4300-1000	99800	1537, 1.5μH ± 10%	
L803	Variable inductor	1191-2150	24655	1191-2150	
L804	22μH ± 10%	4300-2600	99800	1537, 22μH ± 10%	5950-668-5867
L805	4.7μH ± 10%	4300-1600			
L901	39μH ± 10%	4300-3000	99800	2150-38, 39μH ± 10%	
L902	1.8μH ± 10%	4300-1100	99800	1537, 1.8μH ± 10%	
L903	1.8μH ± 10%	4300-1100	99800	1537, 1.8μH ± 10%	
LAMPS					
P901 thru P905	Type 330, 14V, 80mA, size T 1-¾	5600-0309	71744	#330	

6.2 ELECTRICAL PARTS (cont)

Reference Designation	*Description*	*GR Part Number*	*FMC (see 6.4)*	*Manufacturers Part Number*	*Federal Stock Number*
PLUGS					
PL501	3-terminal power plug, consists of:				
	2-terminal power plug	4240-0600	24655	4240-0600	5935-816-0254
	Ground pin	4240-0800	24655	4240-0800	
TRANSISTORS					
*Q201	Type 2N4416 matched	*1191-2900	24655	1191-2900	
*Q202	Type 2N4416 matched	*1191-2900	24655	1191-2900	
Q203	Type 2N4275	8210-1126	23342	2N4275	
Q204	Type 2N4275	8210-1126	23342	2N4275	
Q205 thru Q209	Type 2N4258	8210-1136	93916	2N4258	
Q210	Type 2N4275	8210-1126	23342	2N4275	
Q211	Type 2N4275	8210-1126	23342	2N4275	
*Q251	Type 2N4416 matched	*1191-2900	24655	1191-2900	
*Q252	Type 2N4416 matched	*1191-2900	24655	1191-2900	
Q253	Type 2N4275	8210-1126	23342	2N4275	
Q254	Type 2N4275	8210-1126	23342	2N4275	
Q255 thru Q259	Type 2N4258	8210-1136	93916	2N4258	
Q260	Type 2N4275	8210-1126	23342	2N4275	
Q261	Type 2N4275	8210-1126	23342	2N4275	
Q301	Type 2N3646	8210-1119	07263	2N3646	
Q302	Type 2N3646	8210-1119	07263	2N3646	
Q401	Type 2N4275	8210-1126	23342	2N4275	
Q402	Type 2N4275	8210-1126	23342	2N4275	
Q403	Type 2N3905	8210-1114	04713	2N3905	
Q404	Type 2N4275	8210-1126	23342	2N4275	
Q405	Type 2N4258	8210-1136	93916	2N4258	
Q406	Type 2N4258	8210-1136	93916	2N4258	
Q407	Type 2N4275	8210-1126	23342	2N4275	
Q408	Type 2N3416	8210-1138	93916	2N3416	
Q409	Type 2N4275	8210-1126	23342	2N4275	
Q410	Type 2N4275	8210-1126	23342	2N4275	
Q411	Type 2N4275	8210-1126	23342	2N4275	
Q412	Type 2N3905	8210-1114	04713	2N3905	
Q413	Type 2N4275	8210-1126	23342	2N4275	
Q414	Type 2N4275	8210-1126	23342	2N4275	
Q415	Type 2N3905	8210-1114	04713	2N3905	
Q500	Type 2N1544	8210-1014	75491	2N1544	
Q501	Type 2N3638	8210-1096	07263	2N3638	
Q502	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q503	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q550	Type 2N1544	8210-1014	75491	2N1544	

*Q201-202 and Q251-252 are matched pairs; the bias voltage of the transistors in each pair are within 0.2V of each other. If one transistor in a pair is defective, replace it with an 1191-2900 transistor that has the same colored dot painted on the top.

6.2 ELECTRICAL PARTS (cont)

Reference Designation	*Description*	*GR Part Number*	*FMC (see 6.4)*	*Manufacturers Part Number*	*Federal Stock Number*
TRANSISTORS (cont)					
Q551	Type 2N3905	8210-1114	04713	2N3905	
Q553	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q554	Type 2N3646	8210-1119	07263	2N3646	
Q555	Type 2N3646	8210-1119	07263	2N3646	
Q601	Type 2N4275	8210-1126	93916	2N4275	
Q602	Type 2N4275	8210-1126	93916	2N4275	
Q603	Type 2N4275	8210-1126	93916	2N4275	
Q604	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q605 thru Q611	Type 2N4275	8210-1126	93916	2N4275	
Q701	Type 2N3646	8210-1119	07263	2N3646	
Q702	Type 2N3638	8210-1096	07263	2N3638	
Q703	Type 2N3646	8210-1119	07263	2N3646	
Q704	Type 2N3906	8210-1112	93916	2N3906	
Q705	Type 2N3646	8210-1119	07263	2N3646	
Q706	Type 2N3905	8210-1114	04713	2N3905	
Q707 thru Q711	Type 2N3646	8210-1119	07263	2N3646	
Q712	Type 2N4258	8210-1136	93916	2N4258	
Q713	Type 2N3646	8210-1119	07263	2N3646	
Q714	Type 2N3646	8210-1119	07263	2N3646	
Q801	Type 2N4275	8210-1126	23342	2N4275	
Q802	Type 2N4275	8210-1126	23342	2N4275	
Q803	Type 2N3905	8210-1114	04713	2N3905	
Q804	Type 2N4275	8210-1126	23342	2N4275	
Q805	Type 2N4258	8210-1136	93916	2N4258	
Q806	Type 2N4258	8210-1136	93916	2N4258	
Q807	Type 2N4275	8210-1126	23342	2N4275	
Q808	Type 2N3416	8210-1138	93916	2N3416	
Q810	Type 2N3933	8210-1122	93916	2N3933	
Q811	Type 2N4275	8210-1126	23342	2N4275	
Q812	Type 2N3905	8210-1114	04713	2N3905	
Q813	Type 2N4275	8210-1126	23342	2N4275	
Q814	Type 2N4275	8210-1126	23342	2N4275	
Q815	Type 2N3905	8210-1114	04713	2N3905	
RESISTORS					
R201	Composition, 100KΩ ± 5% ¼W	6099-4105	75042	BTS, 100KΩ ± 5%	
R202	Composition, 910KΩ ± 5% ¼W	6099-4915	75042	BTS, 910KΩ ± 5%	
R203	Composition, 330Ω ± 5% ¼W	6099-1335	75042	BTS, 330Ω ± 5%	
R204	Potentiometer, composition, 500Ω ± 30%	6049-0105	98474	62TR500	
R205	Composition, 330Ω ± 5% ¼W	6099-1335	75042	BTS, 330Ω ± 5%	
R206	Composition, 200Ω ± 5% ¼W	6099-1205	75042	BTS, 200Ω ± 5%	5905-892-0107
R207	Composition, 200Ω ± 5% ¼W	6099-1205	75042	BTS, 200Ω ± 5%	5905-892-0107
R208	Composition, 2.2KΩ ± 5% ¼W	6099-2225	75042	BTS, 2.2KΩ ± 5%	
R209	Composition, 3.3KΩ ± 5% ¼W	6099-2335	75042	BTS, 3.3KΩ ± 5%	
R210	Composition, 3.3KΩ ± 5% ¼W	6099-2335	75042	BTS, 3.3KΩ ± 5%	

6.2 ELECTRICAL PARTS (cont)

RESISTORS (cont)

Reference Designation	*Description*	*GR Part Number*	*FMC (see 6.4)*	*Manufacturers Part Number*	*Federal Stock Number*
R211	Composition, 2.2KΩ ± 10% ¼W	6099-2229	75042	BTS, 2.2KΩ ± 10%	
R212	Composition, 2.2KΩ ± 10% ¼W	6099-2229	75042	BTS, 2.2KΩ ± 10%	
R213	Composition, 510Ω ± 5% ¼W	6099-1515	75042	BTS, 510Ω ± 5%	
R214	Composition, 510Ω ± 5% ¼W	6099-1515	75042	BTS, 510Ω ± 5%	
R215	Composition, 39Ω ± 5% ¼W	6099-0395	75042	BTS, 39Ω ± 5%	
R216	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R217	Composition, 39Ω ± 5% ¼W	6099-0395	75042	BTS, 39Ω ± 5%	
R218	Composition, 560Ω ± 5% ¼W	6099-1565	75042	BTS, 560Ω ± 5%	
R219	Composition, 200Ω ± 5% ¼W	6099-1205	75042	BTS, 200Ω ± 5%	5905-892-0107
R220	Composition, 2KΩ ± 5% ¼W	6099-2205	75042	BTS, 2KΩ ± 5%	5905-279-4629
R221	Composition, 2KΩ ± 5% ¼W	6099-2205	75042	BTS, 2KΩ ± 5%	5905-279-4629
R222	Composition, 120Ω ± 5% ¼W	6099-1125	75042	BTS, 120Ω ± 5%	
R223	Composition, 120Ω ± 5% ¼W	6099-1125	75042	BTS, 120Ω	
R224	Potentiometer, composition, 1KΩ ± 30%	6049-0106	98474	62PR1K	
R225	Composition, 100Ω ± 10% ¼W	6099-1109	75042	BTS, 100Ω ± 10%	
R227	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R251	Composition, 100KΩ ± 5% ¼W	6099-4105	75042	BTS, 100KΩ ± 5%	
R252	Composition, 910KΩ ± 5% ¼W	6099-4915	75042	BTS, 910KΩ ± 5%	
R253	Composition, 330Ω ± 5% ¼W	6099-1335	75042	BTS, 330Ω ± 5%	
R254	Potentiometer, composition, 500Ω ± 30%	6049-0105			
R255	Composition, 330Ω ± 5% ¼W	6099-1335	75042	BTS, 330Ω ± 5%	
R256	Composition, 200Ω ± 5% ¼W	6099-1209	75042	BTS, 200Ω ± 5%	
R257	Composition, 200Ω ± 5% ¼W	6099-1209	75042	BTS, 200Ω ± 5%	
R258	Composition, 2.2KΩ ± 5% ¼W	6099-2225	75042	BTS, 2.2KΩ ± 5%	
R259	Composition, 3.3KΩ ± 5% ¼W	6099-2335	75042	BTS, 3.3KΩ ± 5%	
R260	Composition, 3.3KΩ ± 5% ¼W	6099-2335	75042	BTS, 3.3KΩ ± 5%	
R261	Composition, 2.2KΩ ± 10% ¼W	6099-2229	75042	BTS, 2.2KΩ ± 10%	
R262	Composition, 510Ω ± 5% ¼W	6099-1515	75042	BTS, 510Ω ± 5%	
R263	Composition, 510Ω ± 5% ¼W	6099-1515	75042	BTS, 510Ω ± 5%	
R264	Composition, 2.2KΩ ± 5% ¼W	6099-2225	75042	BTS, 2.2KΩ ± 5%	
R265	Composition, 39Ω ± 5% ¼W	6099-0395	75042	BTS, 39Ω ± 5%	
R266	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R267	Composition, 39Ω ± 5% ¼W	6099-0395	75042	BTS, 39Ω ± 5%	
R268	Composition, 560Ω ± 5% ¼W	6099-1565	75042	BTS, 560Ω ± 5%	
R269	Composition, 200Ω ± 5% ¼W	6099-1205	75042	BTS, 200Ω ± 5%	5905-892-0107
R270	Composition, 2KΩ ± 5% ¼W	6099-2205	75042	BTS, 2KΩ ± 5%	5905-279-4629
R271	Composition, 2KΩ ± 5% ¼W	6099-2205	75042	BTS, 2KΩ ± 5%	5905-279-4629
R272	Composition, 120Ω ± 5% ¼W	6099-1125	75042	BTS, 120Ω ± 5%	
R273	Composition, 120Ω ± 5% ¼W	6099-1125	75042	BTS, 120Ω ± 5%	
R274	Potentiometer, composition, 1KΩ ± 30%	6049-0106	98474	62PR1K	
R275	Composition, 100Ω ± 10% ¼W	6099-1109	75042	BTS, 100Ω ± 10%	
R276	Composition, 47Ω ± 5% ¼W	6099-0475	75042	BTS, 47Ω ± 5%	
R277	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R301	Composition, 4.7KΩ ± 10% ¼W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R302	Composition, 4.7KΩ ± 10% ¼W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R401	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R402	Composition, 11KΩ ± 5% ¼W	6099-3115	75042	BTS, 11KΩ ± 5%	
R403	Composition, 10KΩ ± 5% ¼W	6099-3105	75042	BTS, 10KΩ ± 5%	
R404	Composition, 330Ω ± 5% ¼W	6099-1335	75042	BTS, 330Ω ± 5%	

Reference Designation	Description	GR Part Number	FMC (see 6.4)	Manufacturers Part Number	Federal Stock Number
RESISTORS (cont)					
R405	Composition, 1.2KΩ ± 5% ¼W	6099-2125	75042	BTS, 1.2KΩ ± 5%	
R406	Composition, 680Ω ± 5% ¼W	6099-1685	75042	BTS, 680Ω ± 5%	
R407	Composition, 1.5KΩ ± 5% ¼W	6099-2155	75042	BTS, 1.5KΩ ± 5%	
R408	Composition, 330Ω ± 10% ¼W	6099-1339	75042	BTS, 330Ω ± 10%	
R409	Composition, 100Ω ± 10% ¼W	6099-1109	75042	BTS, 100Ω ± 10%	
R410	Composition, 270Ω ± 5% ¼W	6099-1275	75042	BTS, 270Ω ± 5%	
R411	Composition, 51Ω ± 5% ¼W	6099-0515	75042	BTS, 51Ω ± 5%	
R412	Composition, 220Ω ± 10% ¼W	6099-1229	75042	BTS, 220Ω ± 10%	
R413	Composition, 68Ω ± 5% ¼W	6099-0685	75042	BTS, 68Ω ± 5%	
R414	Composition, 47Ω ± 5% ¼W	6099-0475	75042	BTS, 47Ω ± 5%	
R415	Composition, 100Ω ± 10% ¼W	6099-1109	75042	BTS, 100Ω ± 10%	
R416	Composition, 5.6KΩ ± 5% ¼W	6099-2565	75042	BTS, 5.6KΩ ± 5%	
R417	Composition, 820Ω ± 10% ¼W	6099-1829	75042	BTS, 820Ω ± 10%	
R418	Composition, 56Ω ± 5% ¼W	6099-0565	75042	BTS, 56Ω ± 5%	
R419	Composition, 39KΩ ± 5% ¼W	6099-3395	75042	BTS, 39KΩ ± 5%	
R420	Composition, 56KΩ ± 5% ¼W	6099-3565	75042	BTS, 56KΩ ± 5%	
R421	Composition, 200KΩ ± 5% ¼W	6099-4205	75042	BTS, 200KΩ ± 5%	
R423	Composition, 11KΩ ± 5% ¼W	6099-3115	75042	BTS, 11KΩ ± 5%	
R424	Composition, 39KΩ ± 5% ¼W	6099-3395	75042	BTS, 39KΩ ± 5%	
R425	Composition, 56KΩ ± 5% ¼W	6099-3565	75042	BTS, 56KΩ ± 5%	
R426	Composition, 4.7KΩ ± 10% ¼W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R427	Composition, 3.3KΩ ± 10% ¼W	6099-2339	75042	BTS, 3.3KΩ ± 10%	
R428	Composition, 100Ω ± 10% ¼W	6099-1109	75042	BTS, 100Ω ± 10%	
R429	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R430	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R431	Composition, 330Ω ± 10% ¼W	6099-1339	75042	BTS, 330Ω ± 10%	
R432	Composition, 11KΩ ± 5% ¼W	6099-3115	75042	BTS, 11KΩ ± 5%	
R433	Composition, 2.4KΩ ± 5% ¼W	6099-2245	75042	BTS, 2.4KΩ ± 5%	
R434	Composition, 820Ω ± 5% ¼W	6099-1825	75042	BTS, 820Ω ± 5%	
R435	Composition, 200Ω ± 5% ¼W	6099-1205	75042	BTS, 200Ω ± 5%	5905-892-0107
R436	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R437	Composition, 390Ω ± 5% ¼W	6099-1395	75042	BTS, 390Ω ± 5%	
R438	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R439	Composition, 6.2KΩ ± 5% ¼W	6099-2625	75042	BTS, 6.2KΩ ± 5%	
R440	Composition, 18KΩ ± 5% ¼W	6099-3185	75042	BTS, 18KΩ ± 5%	
R441	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R442	Composition, 51Ω ± 5% ¼W	6099-0515	75042	BTS, 51Ω ± 5%	
R443	Composition, 120Ω ± 5% ¼W	6099-1125	75042	BTS, 120Ω ± 5%	
R444	Composition, 20KΩ ± 10% ¼W	6099-3205	75042	BTS, 20KΩ ± 10%	
R445	Composition, 56Ω ± 5% ¼W	6099-0565	75042	BTS, 56Ω ± 5%	
R446	Composition, 330Ω ± 10% ¼W	6099-1339	75042	BTS, 330Ω ± 10%	
R447	Composition, 51Ω ± 5% ¼W	6099-0515	75042	BTS, 51Ω ± 5%	
R501	Composition, 22Ω ± 5% ½W	6100-0225			
R502	Potentiometer, wire-wound, 500Ω ± 10%	6059-1059			
R503	Composition, 330Ω ± 5% 1W	6100-1335			
R504	Composition, 750Ω ± 5% ½W	6100-1755			
R505	Composition, 330Ω ± 5% ½W	6100-1335			
R506	Composition, 39Ω ± 5% ½W	6100-0395			
R507	Composition, 240Ω ± 5% ½W	6100-1245			
R508	Composition, 100KΩ ± 10% ¼W	6099-4109			

6.2 ELECTRICAL PARTS (cont)

Reference Designation	*Description*	*GR Part Number*	*FMC (see 6.4)*	*Manufacturers Part Number*	*Federal Stock Number*
RESISTORS (cont)					
R551	Composition, 18KΩ ± 5% ¼W	6099-3185	75042	BTS, 18KΩ ± 5%	
R552	Composition, 10KΩ ± 10% ¼W	6099-3109	75042	BTS, 10KΩ ± 10%	
R553	Composition, 160Ω ± 5% ¼W	6099-1165	75042	BTS, 160Ω ± 5%	
R554	Composition, 240KΩ ± 5% ½W	6099-4245	75042	BTS, 240KΩ ± 5%	
R555	Composition, 82Ω ± 5% ¼W	6099-0825	75042	BTS, 82Ω ± 5%	
R556	Composition, 82Ω ± 5% ¼W	6099-0825	75042	BTS, 82Ω ± 5%	
R557	Composition, 10KΩ ± 10% ¼W	6099-3109	75042	BTS, 10KΩ ± 10%	
R558	Composition, 5.6KΩ ± 5% ¼W	6099-2565	75042	BTS, 5.6KΩ ± 5%	
R559	Composition, 5.6KΩ ± 5% ¼W	6099-2565	75042	BTS, 5.6KΩ ± 5%	
R560	Potentiometer, wire-wound, 1KΩ ± 10%	6057-2109	07999	992P, 1KΩ ± 10%	
R561	Composition, 6.2KΩ ± 5% ¼W	6099-2625	75042	BTS, 6.2KΩ ± 5%	
R562	Composition, 15KΩ ± 5% ¼W	6099-3155	75042	BTS, 15KΩ ± 5%	
R563	Wire-wound, 1Ω ± 10% 2W	6760-9109	75042	BWH, 1Ω ± 10%	
R564	Wire-wound, .47Ω ± 10% 2W	6760-8479	75042	BWH, .47Ω ± 10%	
R601	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R602	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R603	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R604	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R605	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R606	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R607	Composition, 220Ω ± 5% ¼W	6099-1225	75042	BTS, 220Ω ± 5%	
R608	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R609	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R610	Composition, 100KΩ ± 10% ¼W	6099-4109	75042	BTS, 100KΩ ± 10%	
R611	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R612	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R613	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R614	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R615	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R616	Composition, 100KΩ ± 10% ¼W	6099-4109	75042	BTS, 100KΩ ± 10%	
R617	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R618	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R619	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R620	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R621	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R622	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R623	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R624	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R625	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R626	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R627	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R628	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R629	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R630	Composition, 51Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R631 thru R634	Composition, 51Ω ± 5% ¼W	6099-0515	75042	BTS, 51Ω ± 5%	
R701	Composition, 10KΩ ± 10% ¼W	6099-3109	75042	BTS, 10KΩ ± 10%	
R702	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R703	Composition, 330Ω ± 10% ¼W	6099-1339	75042	BTS, 330Ω ± 10%	

Reference Designation	Description	GR Part Number	FMC (see 6.4)	Manufacturers Part Number	Federal Stock Number
RESISTORS (cont)					
R704	Composition, 5.6KΩ ± 5% ¼W	6099-2565	75042	BTS, 5.6KΩ ± 5%	
R705	Composition, 910Ω ± 10% ¼W	6099-1915	75042	BTS, 910Ω ± 10%	
R706	Composition, 120Ω ± 5% ¼W	6099-4125	75042	BTS, 120KΩ ± 5%	
R707	Composition, 39KΩ ± 5% ¼W	6099-3395	75042	BTS, 39KΩ ± 5%	
R708	Composition, 100KΩ ± 10% ¼W	6099-4109	75042	BTS, 100KΩ ± 10%	
R709	Composition, 100KΩ ± 10% ¼W	6099-4109	75042	BTS, 100KΩ ± 10%	
R710	Composition, 8.2KΩ ± 10% ¼W	6099-2825	75042	BTS, 8.2KΩ ± 10%	
R711	Composition, 100KΩ ± 10% ¼W	6099-4109	75042	BTS, 100KΩ ± 10%	
R712	Composition, 6.8KΩ ± 10% ¼W	6099-2689	75042	BTS, 6.8KΩ ± 10%	
R713	Composition, 270Ω ± 5% ¼W	6099-1275	75042	BTS, 270Ω ± 5%	
R714	Composition, 47KΩ ± 10% ¼W	6099-3479	75042	BTS, 47KΩ ± 5%	
R715	Composition, 10KΩ ± 10% ¼W	6099-3109	75042	BTS, 10KΩ ± 10%	
R716	Composition, 100Ω ± 10% ¼W	6099-1109	75042	BTS, 100Ω ± 10%	
R717	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R718	Composition, 4.7KΩ ± 10% ¼W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R719	Composition, 10KΩ ± 10% ¼W	6099-3109	75042	BTS, 10KΩ ± 10%	
R720	Composition, 200KΩ ± 5% ¼W	6099-4205	75042	BTS, 200KΩ ± 5%	
R721	Composition, 20KΩ ± 5% ¼W	6099-3205	75042	BTS, 20KΩ ± 5%	
R722	Composition, 4.7KΩ ± 10% ¼W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R723	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R724	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R725	Composition, 4.7KΩ ± 10% ¼W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R726	Composition, 10KΩ ± 10% ¼W	6099-3109	75042	BTS, 10KΩ ± 10%	
R727	Composition, 3KΩ ± 5% ¼W	6099-2305	75042	BTS, 3KΩ ± 5%	
R728	Composition, 4.7KΩ ± 10% ¼W	6099-2479	75042	BTS, 4.7KΩ ± 10%	
R729	Composition, 2.4KΩ ± 5% ¼W	6099-2245	75042	BTS, 2.4KΩ ± 5%	
R730	Composition, 10KΩ ± 10% ¼W	6099-3109	75042	BTS, 10KΩ ± 10%	
R731	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R732	Composition, 2.7KΩ ± 10% ¼W	6099-2279	75042	BTS, 2.7KΩ ± 10%	
R733	Composition, 51Ω ± 5% ¼W	6099-0515	75042	BTS, 51Ω ± 5%	
R734	Composition, 51Ω ± 5% ¼W	6099-0515	75042	BTS, 51Ω ± 5%	
R735	Composition, 5.1KΩ ± 5% ¼W	6099-2515	75042	BTS, 5.1KΩ ± 5%	5905-279-4623
R736	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R737	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R738	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R801	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R802	Composition, 11KΩ ± 5% ¼W	6099-3115	75042	BTS, 11KΩ ± 5%	
R803	Composition, 10KΩ ± 5% ¼W	6099-3105	75042	BTS, 10KΩ ± 5%	
R804	Composition, 330Ω ± 5% ¼W	6099-1335	75042	BTS, 330Ω ± 5%	
R805	Composition, 1.2KΩ ± 5% ¼W	6099-2125	75042	BTS, 1.2KΩ ± 5%	
R806	Composition, 680Ω ± 5% ¼W	6099-1685	75042	BTS, 680Ω ± 5%	
R807	Composition, 1.5KΩ ± 5% ¼W	6099-2155	75042	BTS, 1.5KΩ ± 5%	
R808	Composition, 330Ω ± 10% ¼W	6099-1339	75042	BTS, 330Ω ± 10%	
R809	Composition, 100Ω ± 10% ¼W	6099-1109	75042	BTS, 100Ω ± 10%	
R810	Composition, 270Ω ± 5% ¼W	6099-1275	75042	BTS, 270Ω ± 5%	
R811	Composition, 51Ω ± 5% ¼W	6099-0515	75042	BTS, 51Ω ± 5%	
R812	Composition, 220Ω ± 10% ¼W	6099-1229	75042	BTS, 220Ω ± 10%	
R813	Composition, 68Ω ± 5% ¼W	6099-0685	75042	BTS, 68Ω ± 5%	
R814	Composition, 47Ω ± 5% ¼W	6099-0475	75042	BTS, 47Ω ± 5%	
R815	Composition, 100Ω ± 10% ¼W	6099-1109	75042	BTS, 100Ω ± 10%	

6.2 ELECTRICAL PARTS (cont)

Reference Designation	*Description*	*GR Part Number*	*FMC (see 6.4)*	*Manufacturers Part Number*	*Federal Stock Number*
RESISTORS (cont)					
R816	Composition, 5.6KΩ ± 5% ¼W	6099-2565	75042	BTS, 5.6KΩ ± 5%	
R817	Composition, 820Ω ± 10% ¼W	6099-1829	75042	BTS, 820Ω ± 10%	
R818	Composition, 56Ω ± 5% ¼W	6099-0565	75042	BTS, 56Ω ± 5%	
R819	Composition, 39KΩ ± 5% ¼W	6099-3395	75042	BTS, 39KΩ ± 5%	
R820	Composition, 56KΩ ± 5% ¼W	6099-3565	75042	BTS, 56KΩ ± 5%	
R821	Composition, 200KΩ ± 5% ¼W	6099-4205	75042	BTS, 200KΩ ± 5%	
R823	Composition, 11KΩ ± 5% ¼W	6099-3115	75042	BTS, 11KΩ ± 5%	
R831	Composition, 330Ω ± 10% ¼W	6099-1339	75042	BTS, 330Ω ± 10%	
R832	Composition, 11KΩ ± 5% ¼W	6099-3115	75042	BTS, 11KΩ ± 5%	
R833	Composition, 2.4KΩ ± 5% ¼W	6099-2245	75042	BTS, 2.4KΩ ± 5%	
R834	Composition, 820Ω ± 5% ¼W	6099-1825	75042	BTS, 820Ω ± 5%	
R835	Composition, 200Ω ± 5% ¼W	6099-1205	75042	BTS, 200Ω ± 5%	5905-892-0107
R836	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R837	Composition, 390Ω ± 5% ¼W	6099-1395	75042	BTS, 390Ω ± 5%	
R838	Composition, 470Ω ± 10% ¼W	6099-1479	75042	BTS, 470Ω ± 10%	
R839	Composition, 6.2KΩ ± 5% ¼W	6099-2625	75042	BTS, 6.2KΩ ± 5%	
R840	Composition, 18KΩ ± 5% ¼W	6099-3185	75042	BTS, 18KΩ ± 5%	
R841	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R842	Composition, 51Ω ± 5% ¼W	6099-0515	75042	BTS, 51Ω ± 5%	
R843	Composition, 120Ω ± 5% ¼W	6099-1125	75042	BTS, 120Ω ± 5%	
R844	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R845	Composition, 56Ω ± 5% ¼W	6099-0565	75042	BTS, 56Ω ± 5%	
R847	Composition, 51Ω ± 5% ¼W	6099-0515	75042	BTS, 51Ω ± 5%	
R848	Composition, 13KΩ ± 5% ¼W	6099-3135	75042	BTS, 13KΩ ± 5%	
R849	Composition, 2KΩ ± 5% ¼W	6099-2205	75042	BTS, 2KΩ ± 5%	5905-279-4629
R850	Composition, 270KΩ ± 5% ¼W	6099-4275	75042	BTS, 270KΩ ± 5%	
R903	Composition, 3.9KΩ ± 5% ¼W	6099-2395	75042	BTS, 3.9KΩ ± 5%	
R904	Composition, 3.9KΩ ± 5% ¼W	6099-2395	75042	BTS, 3.9KΩ ± 5%	
R905	Composition, 390KΩ ± 5% ¼W	6099-4395	75042	BTS, 390KΩ ± 5%	
R906	Composition, 390KΩ ± 5% ¼W	6099-4395	75042	BTS, 390KΩ ± 5%	
R908	Potentiometer, composition, 250KΩ ± 10% A Threshold	6045-1061	01121	JT, 250KΩ U Taper	
R909	Potentiometer, composition, 250KΩ ± 10% B Threshold	6045-1061	01121	JT, 250KΩ U Taper	
R910	Composition, 9.1KΩ ± 5% ¼W	6099-2915	75042	BTS, 9.1KΩ ± 5%	
R911	Composition, 82KΩ ± 5% ¼W	6099-3825	75042	BTS, 82KΩ ± 5%	
R912	Composition, 330KΩ ± 5% ¼W	6099-4335	75042	BTS, 330KΩ ± 5%	
R913	Composition, 12KΩ ± 5% ¼W	6099-3125	75042	BTS, 12KΩ ± 5%	
R914	Composition, 36KΩ ± 5% ¼W	6099-3365	75042	BTS, 36KΩ ± 5%	
R915	Composition, 62KΩ ± 5% ¼W	6099-3625	75042	BTS, 62KΩ ± 5%	
R916	Composition, 120KΩ ± 5% ¼W	6099-4125	75042	BTS, 120KΩ ± 5%	
R917	Composition, 360KΩ ± 5% ¼W	6099-4365	75042	BTS, 360KΩ ± 5%	
R918	Composition, 510KΩ ± 5% ¼W	6099-4625	75042	BTS, 510KΩ ± 5%	
R919	Composition, 120KΩ ± 5% ¼W	6099-4125	75042	BTS, 120KΩ ± 5%	
R920	Composition, 2KΩ ± 5% ¼W	6099-2205	75042	BTS, 2KΩ ± 5%	5905-279-4629
R922	Composition, 51Ω ± 5% ¼W	6099-0515	75042	BTS, 51Ω ± 5%	
R924	Composition, 1KΩ ± 10% ¼W	6099-2109	75042	BTS, 1KΩ ± 10%	
R925	Composition, 1MΩ ± 5% ¼W	6099-5105	75042	BTS, 1MΩ ± 5%	
R944	Composition, 10KΩ ± 5% ¼W	6099-3105	75042	BTS, 10KΩ ± 5%	
R945	Composition, 1MΩ ± 5% ¼W	6099-5105	75042	BTS, 1MΩ ± 5%	

Reference Designation	Description	GR Part Number	FMC (see 6.4)	Manufacturers Part Number	Federal Stock Number
RESISTORS (cont)					
R946	Composition, 1MΩ ± 5% ¼W	6099-5105	75042	BTS, 1MΩ ± 5%	
R947	Composition, 620Ω ± 5% ¼W	6099-1625	75042	BTS, 620Ω ± 5%	
R948	Composition, 51Ω ± 5% ¼W	6099-0515	75042	BTS, 51Ω ± 5%	
R949	Composition, 1KΩ ± 5% ¼W	6099-2105	75042	BTS, 1KΩ ± 5%	
R950	Potentiometer, composition, 20KΩ ± 10% ADJ 10MHz	6010-1000	01121	JU, 20KΩ ± 10%	
R951 thru R958	Composition, 30KΩ ± 5% 1W	6110-3305	01121	RC32GF303J	5905-299-2017
R959	Composition, 220KΩ ± 5% ¼W	6099-4225	75042	BTS, 220KΩ ± 5%	
R960	Composition, 1KΩ ± 5% ¼W	6099-2109	75042	BTS, 1KΩ ± 5%	
R961	Composition, 150Ω ± 5% ¼W	6099-1135	75042	BTS, 150Ω ± 5%	
R962	Composition, 150Ω ± 5% ¼W	6099-1135	75042	BTS, 150Ω ± 5%	
SWITCHES					
S501	Toggle, dpst POWER	7910-1300	04009	83053-SA	5930-909-3510
S502	Slide, screwdriver operated, dpdt line	7910-0831	42190	4603	
S901	Assembly of 5 mutually exclusive push-button switches MEASUREMENT	7880-2060	71590	2KBC050000028	
S902	Rotary, 10-position, 3-section RANGE	7890-5140	76854	265268-BA3	
S903	Pushbutton, momentary START	7870-1519	81073	46YY2102-3	
S904	Pushbutton, momentary STOP	7870-1519	81073	46YY2102-3	
S905	Pushbutton, momentary SET 9	7870-1519	81073	46YY2102-3	
S906	Pushbutton, momentary SET 0	7870-1519	81073	46YY2102-3	
S907	Rotary, 12-position, 1-section DISPLAY TIME	7890-4970	24655	7890-4970	
S908	Rotary, 8-position, 3-section A POLARITY & ATTEN	7890-5130	76854	265266-F1	
S909	Rotary, 8-position, 3-section B POLARITY & ATTEN	7890-5120	76854	265265-F1	
S910	Toggle, spdt A AC-DC	7910-0790			
S911	Toggle, spdt B AC-DC	7910-0790	95146	MST-105D	
S912	Toggle, spdt SEPARATE-COMMON	7910-0790	95146	MST-105D	
S951	Toggle, spdt STORAGE-DISABLE	7910-0790	95146	MST-105D	
S952	Toggle, spdt TIME BASE	7910-0790	95146	MST-105D	
SOCKETS					
SO501	Etched-board, 10-contact	4230-2710	95354	91-6010-1201-00	
SO550	Etched-board, 15-contact	4230-2715	95354	91-6015-1201-00	
SO901	External connection, DATA OUT	4230-4049	93916	57-40500	
SO910 thru SO940	Etched-board, 24 contact	4230-2724	95354	91-6024-1201-00	
SO950	External connection, PROGRAMMING INPUT	4230-4036	93916	57-40360	

**Part number includes positioning washer, lockwasher, and two nuts.

6.2 ELECTRICAL PARTS (cont)

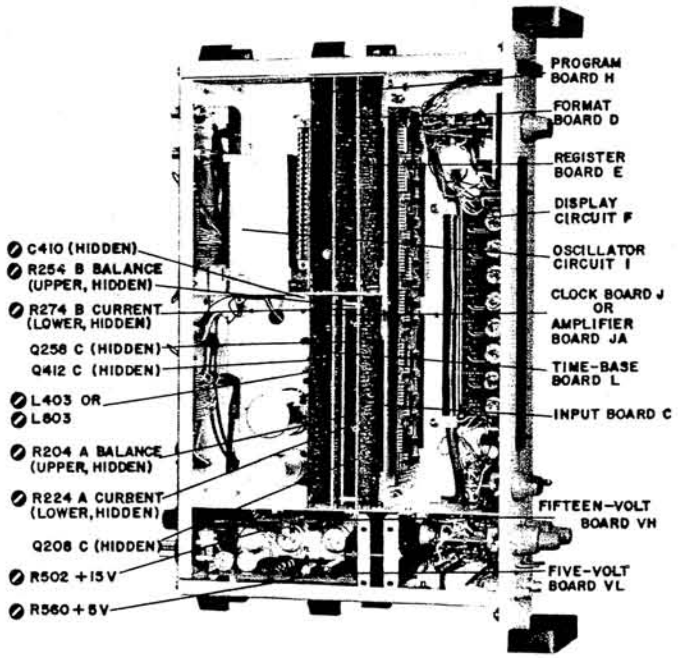
Reference Designation	Description	GR Part Number	FMC (see 6.4)	Manufacturers Part Number	Federal Stock Number
SOCKETS (cont)					
S0951 thru S0958	Tube,	7540-3465	83781	RTS-12	
S0960	Etched-board, 24 contact	4230-2724	95354	91-6024-1201-00	
S0970	Etched-board, 24 contact	4230-2724	95354	91-6024-1201-00	
S0980	Etched-board, 24 contact	4230-2724	95354	91-6024-1201-00	
TRANSFORMER					
T501	Power transformer	0345-4025	24655	0345-4025	
TUBES					
V951 thru V958	visual register	5437-0845	83781	NL-845	
V959	ΦLOCK OUT	8390-0200	24446	NE-2	6240-179-1811
CRYSTAL					
X-401		1213-0440	24655	1213-0440	5955-997-3324

6.3 MECHANICAL PARTS

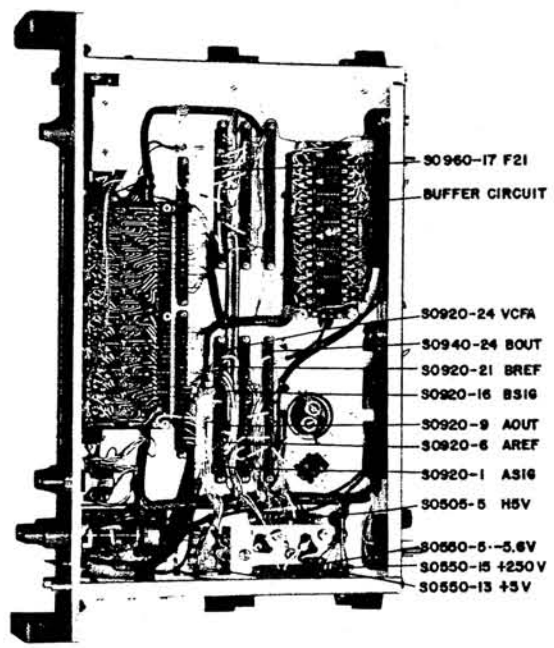
Quantity	Description	GR Part Number	FMC (see 6.4)	Manufacturers Part Number	Federal Stock Number
BENCH CABINET for bench models:		4172-4004	24655	4172-4004	
1	Bench-cabinet assembly, till-base, nonvented:	4172-2642	24655	4172-2642	
1	gasket, black neoprene	5331-2156	24655	5331-2156	
2	Foot, extruded black neoprene	4171-7008	24655	4171-7008	
1	Foot assembly	4171-1010	24655	4171-1010	
1	Hinge, aluminum painted black	4171-8007	24655	4171-8007	
Not included with 4172-4004 but attached to it:					
1	Rear cover, aluminum painted gray	4171-1191	24655	4171-1191	
2	Screws, 10-32 x 3/8" with black nylon washers; secure rear cover to cabinet	7270-6190	24655	7270-6190	
RACK CABINET for rack models:		4174-3040	24655	4174-3040	
2	Side pan assemblies	4174-1040	24655	4174-1040	
Not included with 4174-3040 but attached to it:					
1	Rear cover, aluminum painted gray	4171-1191	24655	4171-1191	
2	Screws, 10-32 x 3/8" with black nylon washers; secure rear cover to cabinet	7270-6190	24655	7270-6190	
Not included with 4174-3040:					
1	Hardware set; to mount rack cabinet to rack	4174-2000	24655	4174-2000	
FRONT PANEL					
1	Dress panel	1191-1000	24655	1191-1000	
1	Window, 9 3/32" x 1 5/8", yellow plastic, for visual register	1191-7001	24655	1191-7001	
2	Handles, aluminum with black epoxy finish	5360-2007	24655	5360-2007	
4	Panel screws, 10-32 x 5/8" binder head with white nylon washers, secure instrument to cabinet or rack	7270-6310	24655	7270-6310	
A and B POLARITY & ATTEN switches (S908, S909):					
2	Bushing assemblies, attach to switch shafts	4143-3121	24655	4143-3121	
2	Knob assemblies, snap-fit over bushings	5520-3331	24655	5520-3331	
A and B THRESHOLD controls (R908, R909):					
2	Bushing assemblies, attach to pot shafts	4143-1131	24655	4143-1131	
2	Knob assemblies, snap-fit over bushings	5520-5131	24655	5520-5131	
DISPLAY TIME switch (S907):					
1	Bushing assembly, attaches to switch shaft	4143-3121	24655	4143-3121	
1	Knob assembly, snap-fits over bushing	5500-5321	24655	5500-5321	
POWER switch (S501):					
1	Nut, 15/32" – 32 dress, secures switch to panel	5800-0800	24655	5800-0800	
RANGE switch (S902):					
1	Dial assembly	1191-1010	24655	1191-1010	
1	Knob assembly, snap-fits over bushing	5500-5321	24655	5500-5321	

6.3 MECHANICAL PARTS (cont)

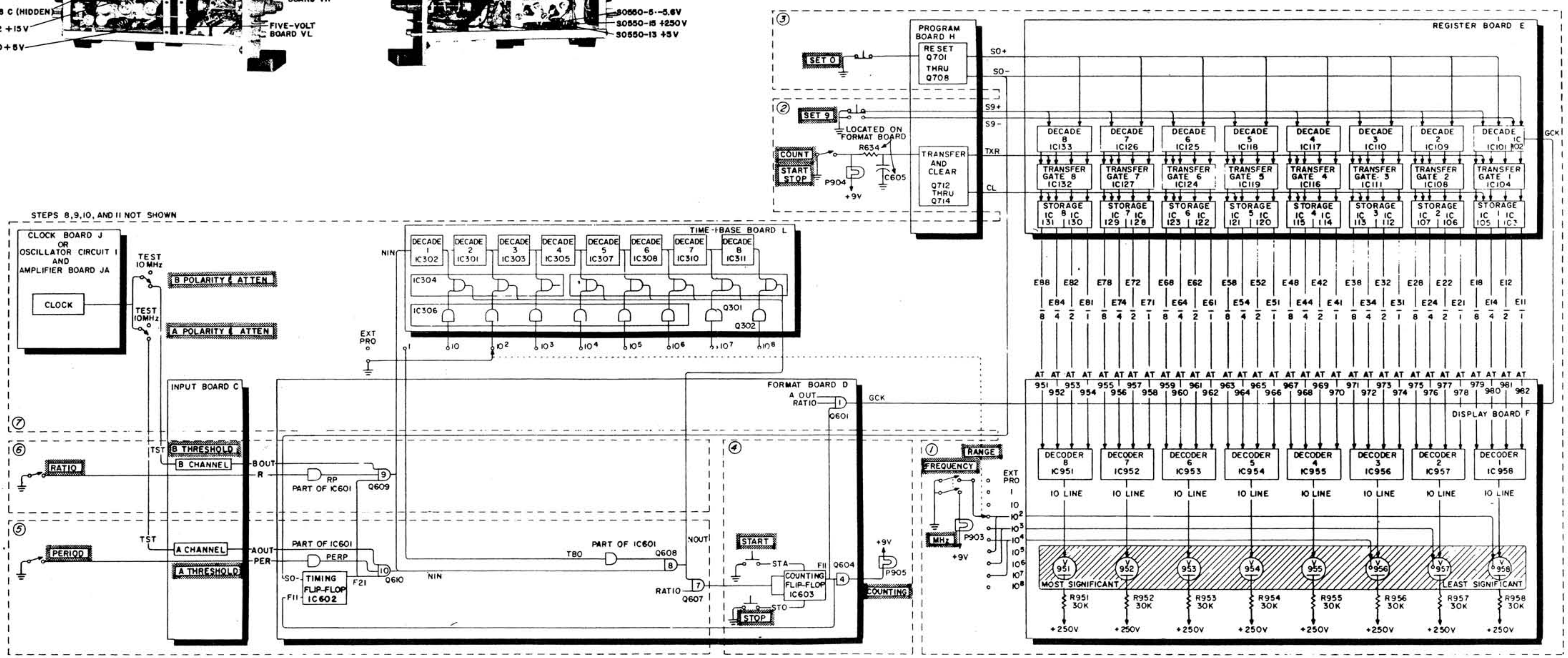
Quantity	Description	GR Part Number	FMC (see 6.4)	Manufacturers Part Number	Federal Stock Number
REAR PANEL					
Fuses (F501, F502):					
2	Fuseholders, include nuts	5650-0100	71400	HKP-H	5920-284-7144
2	Insulaters, black neoprene, over fuseholder terminals	5451-2250	24655	5451-2250	
LEFT–SIDE PANEL					
1	Slide stop, black nylon, riveted to side panel	4171-7040	24655	4171-7040	
4	Slide blocks, black nylon	7260-0750	24655	7260-0750	
RIGHT–SIDE PANEL					
1	Slide stop, black nylon, riveted to side panel	4171-7040	24655	4171-7040	
4	Slide blocks, black nylon	7260-0750	24655	7260-0750	
SHELF					
2	Sockets, power transistor, for Q501, Q550	7540-2267	71785	24246	
6	Terminals (AT503, 901, 903, 910, 911), no. 6 hole	7930-2100	78189	2106-06-00	5940-502-7462
2	Grommets, 1/4" hole, 1/8" groove, rubber	4110-1100	24655	4110-1100	5325-964-3644
2	Insulators, mica, for Q501, Q550	7530-2000	16037	#111	



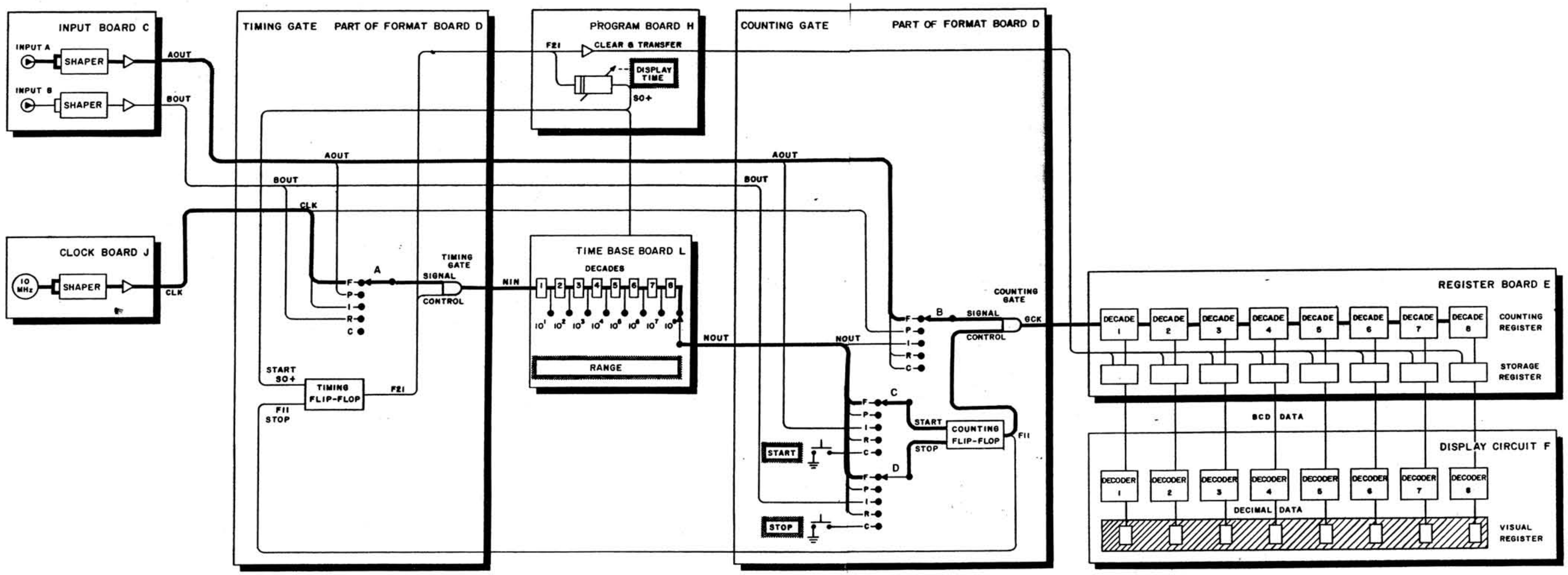
PROGRAM BOARD H
FORMAT BOARD D
REGISTER BOARD E
DISPLAY CIRCUIT F
OSCILLATOR CIRCUIT I
CLOCK BOARD J OR AMPLIFIER BOARD JA
TIME-BASE BOARD L
INPUT BOARD C
FIFTEEN-VOLT BOARD VH
FIVE-VOLT BOARD VL
C410 (HIDDEN)
R254 B BALANCE (UPPER, HIDDEN)
R274 B CURRENT (LOWER, HIDDEN)
Q258 C (HIDDEN)
Q412 C (HIDDEN)
L403 OR L803
R204 A BALANCE (UPPER, HIDDEN)
R224 A CURRENT (LOWER, HIDDEN)
Q208 C (HIDDEN)
R502 +15V
R560 +5V



S0960-17 F21
BUFFER CIRCUIT G
S0920-24 VCFA
S0940-24 BOUT
S0920-21 BREF
S0920-16 BSIG
S0920-9 AOUT
S0920-6 AREF
S0920-1 ASIG
S0505-5 H5V
S0550-5 -5.6V
S0550-15 +250V
S0550-13 +5V



STEPS 8,9,10, AND 11 NOT SHOWN
REGISTER BOARD E
PROGRAM BOARD H
RESET Q701 THRU Q708
TRANSFER AND CLEAR Q712 THRU Q714
SET 0
SET 9
COUNT
START STOP
LOCATED ON FORMAT BOARD
R634
C605
P904
+9V
S0+
S0-
S9+
S9-
TXR
CL
GCK
DECADE 8 IC133
DECADE 7 IC126
DECADE 6 IC125
DECADE 5 IC118
DECADE 4 IC117
DECADE 3 IC110
DECADE 2 IC109
DECADE 1 IC101 IC102
TRANSFER GATE 8 IC132
TRANSFER GATE 7 IC127
TRANSFER GATE 6 IC124
TRANSFER GATE 5 IC119
TRANSFER GATE 4 IC116
TRANSFER GATE 3 IC111
TRANSFER GATE 2 IC108
TRANSFER GATE 1 IC104
STORAGE 8 IC 131 IC 130
STORAGE 7 IC 129 IC 128
STORAGE 6 IC 123 IC 122
STORAGE 5 IC 121 IC 120
STORAGE 4 IC 115 IC 114
STORAGE 3 IC 113 IC 112
STORAGE 2 IC 107 IC 106
STORAGE 1 IC 105 IC 103
CLOCK BOARD J OR OSCILLATOR CIRCUIT I AND AMPLIFIER BOARD JA
CLOCK
TEST 10MHz
B POLARITY & ATTEN
A POLARITY & ATTEN
TIME-BASE BOARD L
NIN
DECADE 1 IC302
DECADE 2 IC301
DECADE 3 IC303
DECADE 4 IC305
DECADE 5 IC307
DECADE 6 IC308
DECADE 7 IC310
DECADE 8 IC311
IC304
IC306
Q301
Q302
EXT PRO
INPUT BOARD C
FORMAT BOARD D
A OUT
RATIO
Q601
B THRESHOLD
B CHANNEL
BOUT
R
RP
PART OF IC601
Q609
RATIO
TST
PERIOD
A CHANNEL
AOUT
PER
PERP
A THRESHOLD
TIMING FLIP-FLOP IC602
F21
F11
Q610
NIN
TBO
Q608
NOUT
RATIO
Q607
START
STA
STOP
STO
COUNTING FLIP-FLOP IC603
Q604
P905
COUNTING
RANGE
FREQUENCY
MHz
P903
DISPLAY BOARD F
DECODER 8 IC951
DECODER 7 IC952
DECODER 6 IC953
DECODER 5 IC954
DECODER 4 IC955
DECODER 3 IC956
DECODER 2 IC957
DECODER 1 IC958
10 LINE
MOST SIGNIFICANT
LEAST SIGNIFICANT
R951 30K
R952 30K
R953 30K
R954 30K
R955 30K
R956 30K
R957 30K
R958 30K
+250V

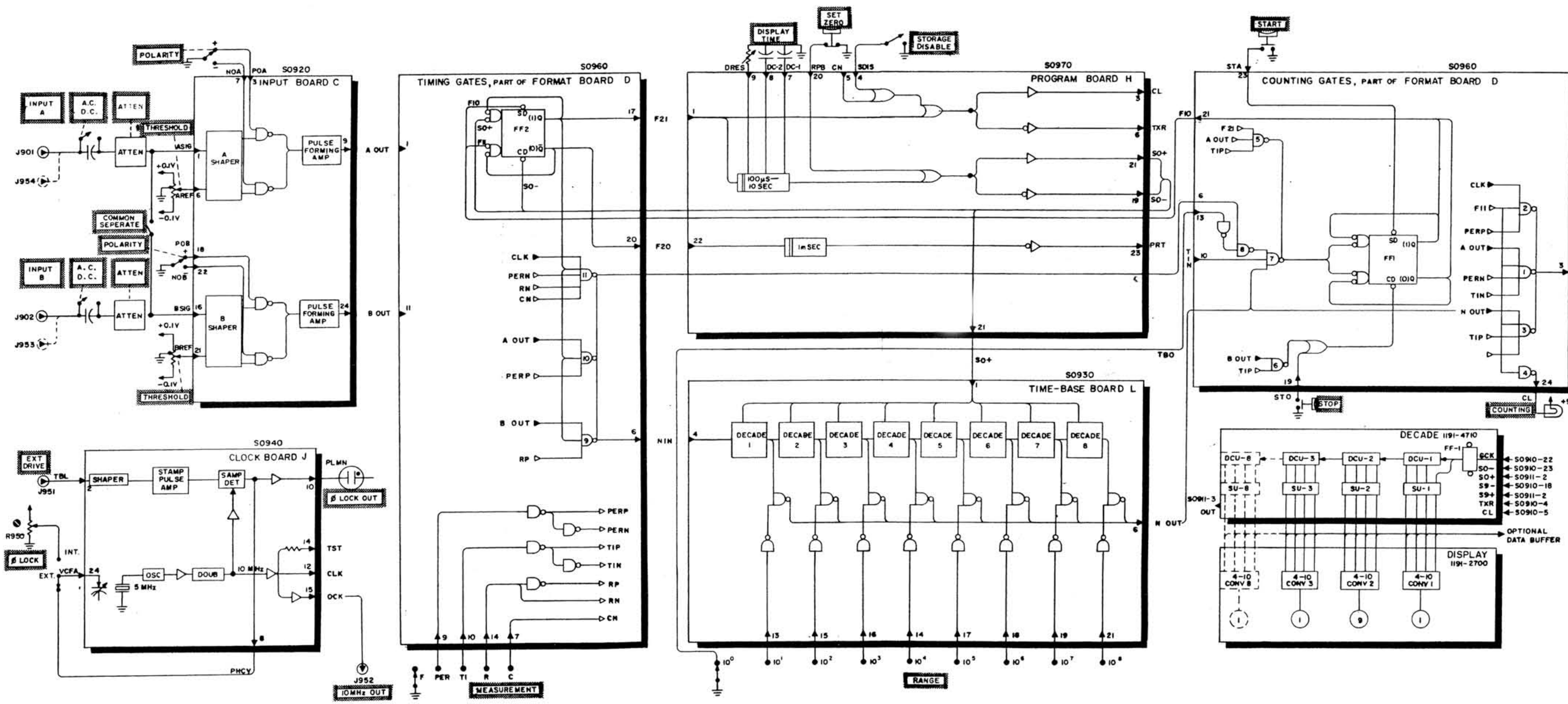


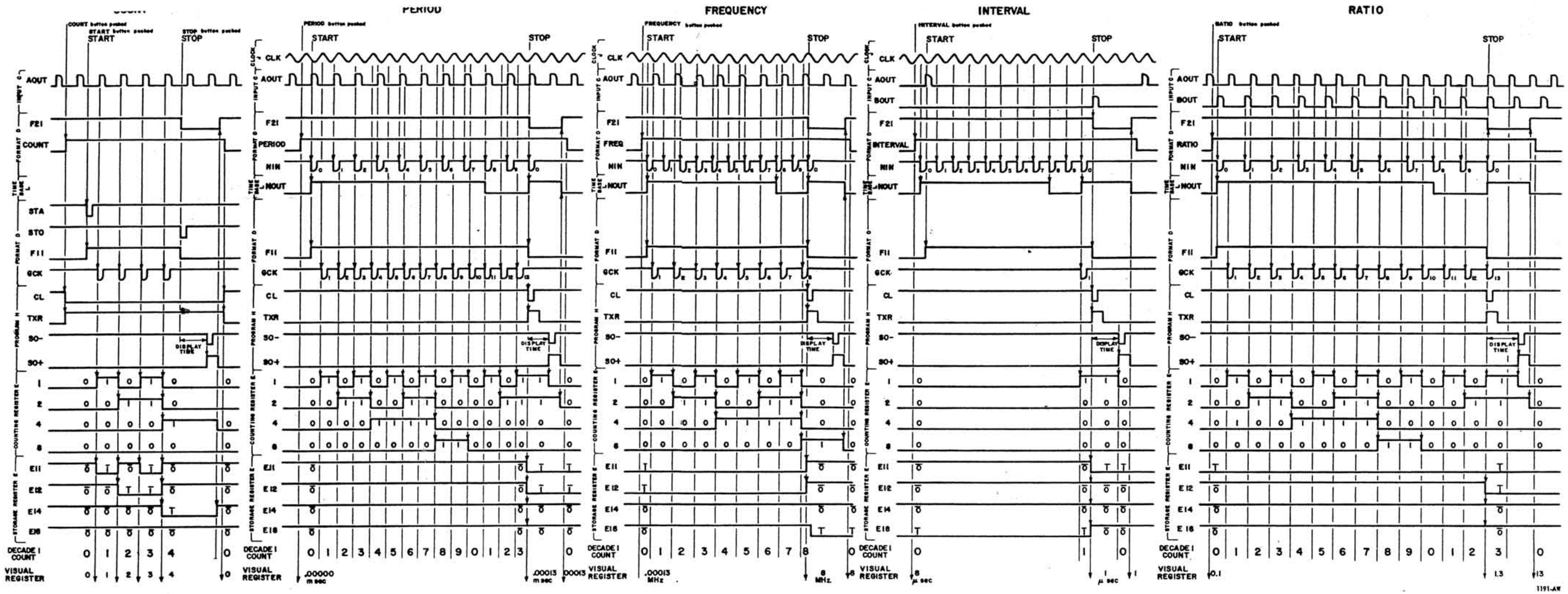
F FREQUENCY
P PERIOD
I INTERVAL
R RATIO
C COUNT

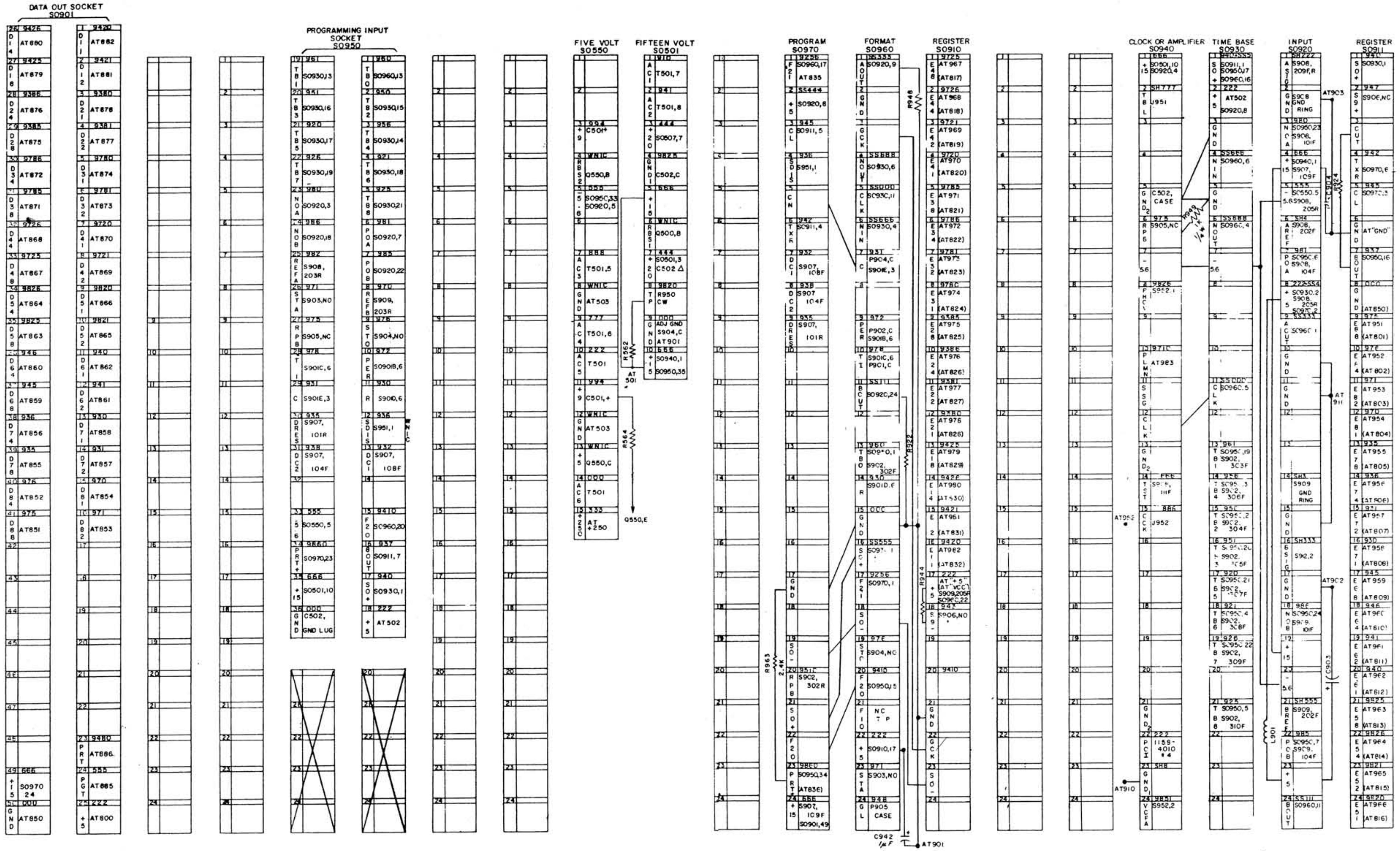
SIGNAL FLOW SHOWN FOR FREQUENCY MEASUREMENT

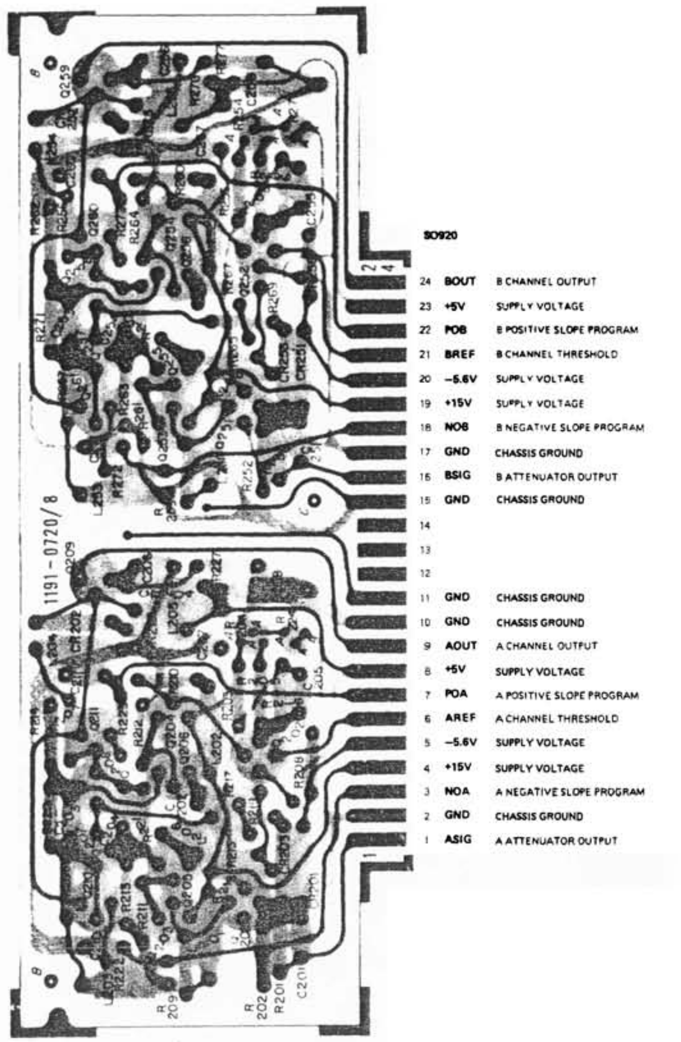
CONNECTIONS
- OUTPUT LEAVES SUB ASM
- INPUT FROM ANOTHER SUB ASM
- OUTPUT REMAINS ON SUB ASM
- INPUT FROM SAME SUB ASM

NUMBER ADJACENT IS SO- PIN NO.




PERIOD
FREQUENCY
INTERVAL
RATIO
START
STOP
CLK
AOUT
BOUT
F21
COUNT
PERIOD
FREQ
INTERVAL
RATIO
NIN
NOUT
STA
STO
F11
GCK
CL
TXR
SO-
SO+
E11
E12
E14
E18
DECADE I COUNT
VISUAL REGISTER
DISPLAY TIME
1191-AW

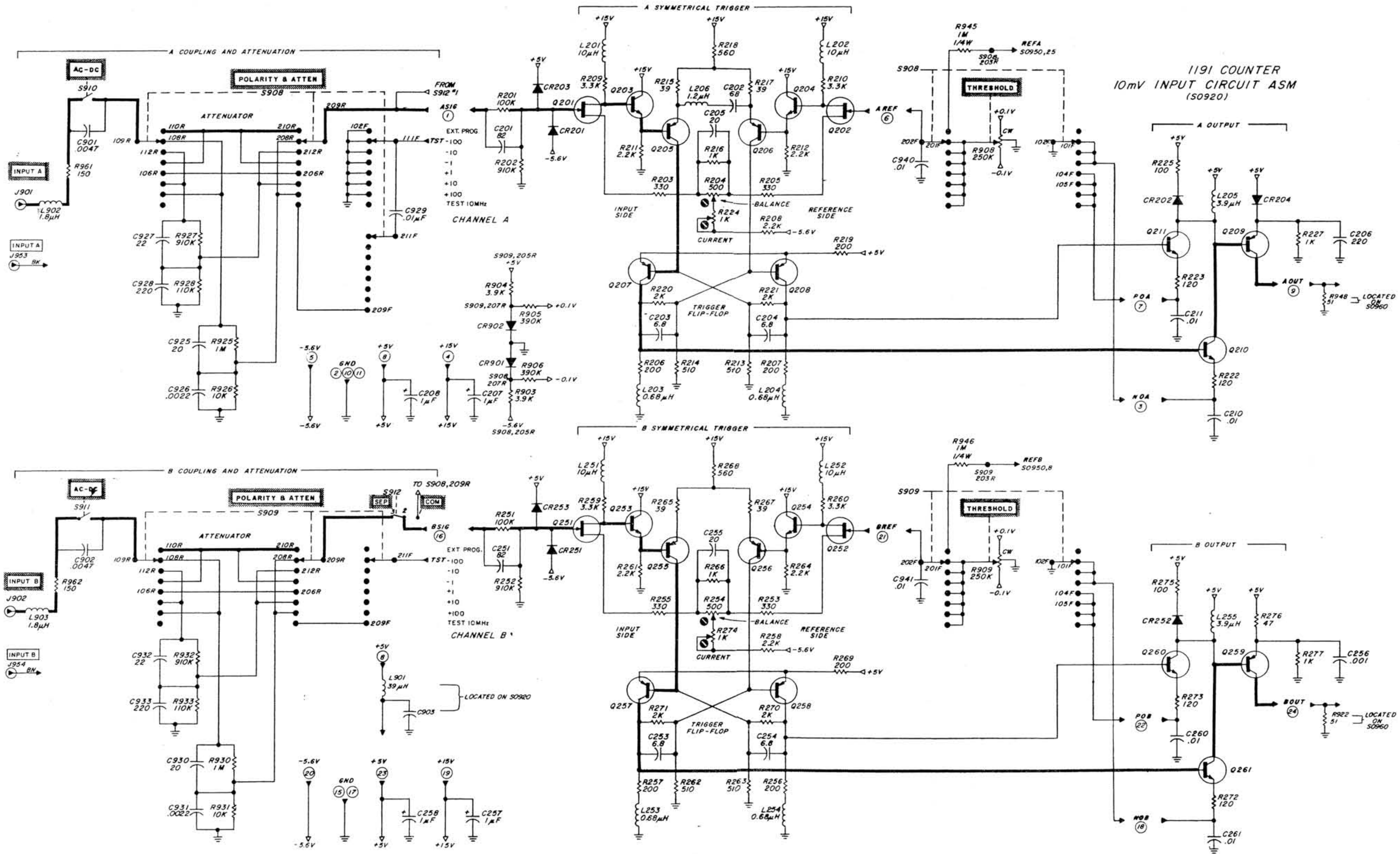

DATA OUT SOCKET
S0901
PROGRAMMING INPUT
SOCKET
S0950
FIVE VOLT
S0550
FIFTEEN VOLT
S0501
PROGRAM
S0970
FORMAT
S0960
REGISTER
S0910
CLOCK OR AMPLIFIER
S0940
TIME BASE
S0930
INPUT
S0920
REGISTER
S0911



INPUT BOARD C

Part number 1191-4720 (the number that appears on the foil side is not the part number). The dot on the foil at the transistor socket indicates the collector lead.

See paragraph 4.2 for principles.



COMPONENTS

'apacitor values with no decimal point are pF 10^{-12} F) and with decimal point are μF (10^{-6} F). 'esistor values with k are kΩ (10^{3} Ω) and with 1 are MΩ (10^{6} Ω). ▒ indicates front-panel access. ▭ indicates rear-panel access. ⊘ indicates screw-river- or alignment-tool operated.

CONNECTIONS

- ➔ Output leaves subassembly.
- ▶ Input from different subassembly.
- ▷ Output remains on subassembly.
- ▷ Input from same subassembly.

SWITCHES

404F

- F — Front, Rear.
- 04 — Contact: First contact cw from strut is 01.
- 4 — Section: Section nearest panel is 1.

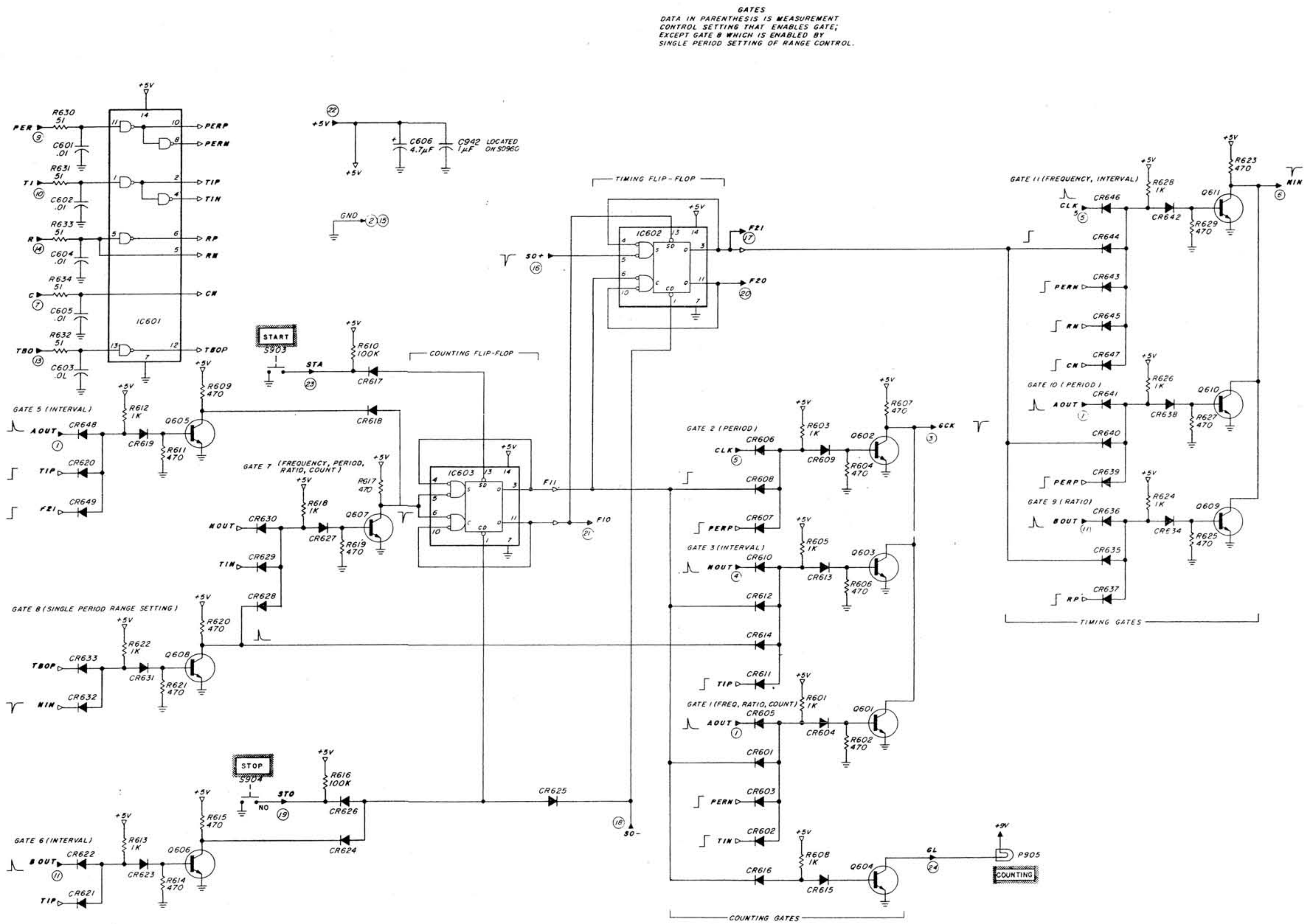
SO960

24	GL	COUNTING LAMP DRIVE
23	STA	START
22	+5V	SUPPLY VOLTAGE
21	F10	COUNTING GATE CONTROL COMPLEMENT
20	F20	TIMING GATE CONTROL COMPLEMENT
19	STO	STOP
18	SO–	RESET
17	F21	TIMING GATE CONTROL
16	SO+	SET
15	GND	CHASSIS GROUND
14	R	RATIO PROGRAM
13	TBO	RANGE 1 PROGRAM
12		
11	BOUT	B CHANNEL OUTPUT
10	TI	INTERNAL PROGRAM
9	PER	PERIOD PROGRAM
8		
7	C	COUNT PROGRAM
6	NIN	TIMING PULSES
5	CLK	10 MHz CLOCK
4	NOUT	TIMING PULSES SCALED
3	GCK	COUNTING PULSES
2	GND	CHASSIS GROUND
1	AOUT	A CHANNEL OUTPUT

FORMAT BOARD D

Part number 1191-4760 (the number that appears on the foil side is not the part number). The dot on the foil at the transistor socket indicates the collector lead.

See paragraph 4.11 for principles.



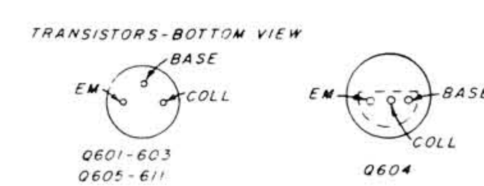
COMPONENTS

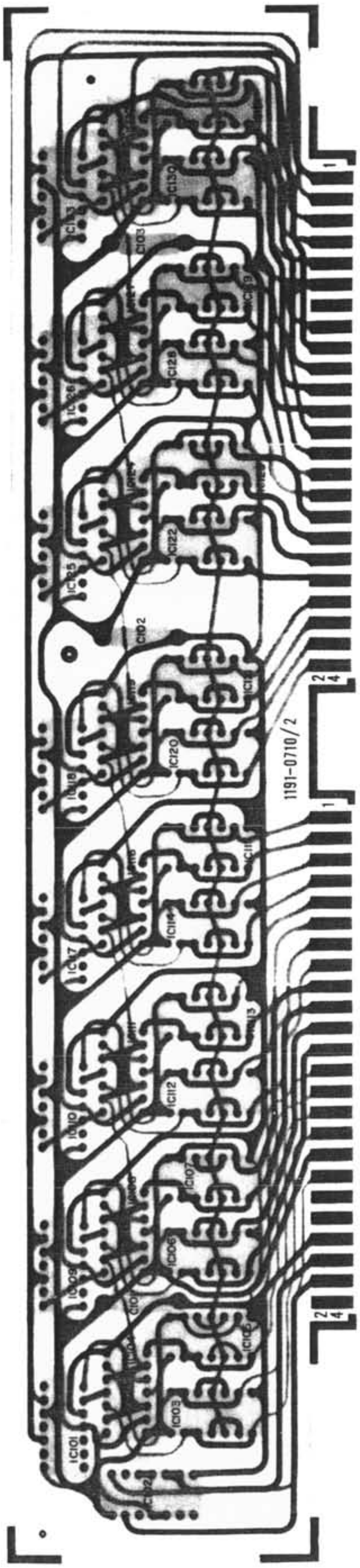
Capacitor values with no decimal point are pF (10^{-12} F) and with decimal point are μF (10^{-6} F). Resistor values with k are kΩ (10^3 Ω) and with M are MΩ (10^6 Ω). ▭ indicates front-panel access. ▭ indicates rear-panel access. ● indicates screwdriver- or alignment-tool operated.

CONNECTIONS

- Output leaves subassembly.
- Input from different subassembly.
- Output remains on subassembly.
- Input from same subassembly.

TRANSISTOR BASING



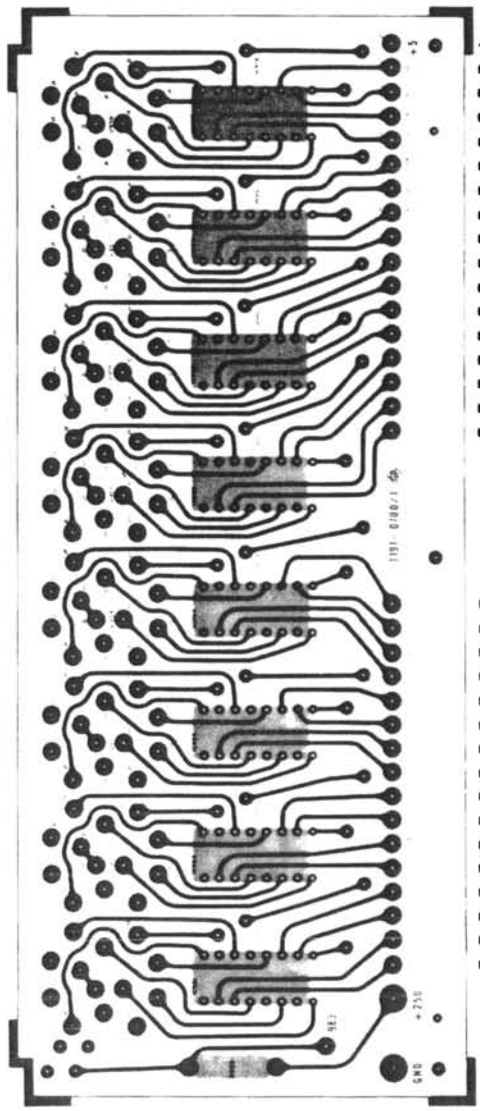


SO911 LEFT

1	S0+	SET
2	S9+	SET NINE
3	OUT	REGISTER SPILL
4	TXR	TRANSFER TO STORAGE
5	CL	CLEAR STORAGE
6	GND	CHASSIS GROUND
7	BOUT	REGISTER SPILL ISOLATED
8	GND	CHASSIS GROUND
9	E88	8th DIGIT 8-BIT COMPLEMENT
10	E84	8th DIGIT 4-BIT COMPLEMENT
11	E82	8th DIGIT 2-BIT COMPLEMENT
12	E81	8th DIGIT 1-BIT COMPLEMENT
13	E78	7th DIGIT 8-BIT COMPLEMENT
14	E74	7th DIGIT 4-BIT COMPLEMENT
15	E72	7th DIGIT 2-BIT COMPLEMENT
16	E71	7th DIGIT 1-BIT COMPLEMENT
17	E68	6th DIGIT 8-BIT COMPLEMENT
18	E64	6th DIGIT 4-BIT COMPLEMENT
19	E62	6th DIGIT 2-BIT COMPLEMENT
20	E61	6th DIGIT 1-BIT COMPLEMENT
21	E58	5th DIGIT 8-BIT COMPLEMENT
22	E54	5th DIGIT 4-BIT COMPLEMENT
23	E52	5th DIGIT 2-BIT COMPLEMENT
24	E51	5th DIGIT 1-BIT COMPLEMENT

SO910 RIGHT

1	E48	4th DIGIT 8-BIT COMPLEMENT
2	E44	4th DIGIT 4-BIT COMPLEMENT
3	E42	4th DIGIT 2-BIT COMPLEMENT
4	E41	4th DIGIT 1-BIT COMPLEMENT
5	E38	3rd DIGIT 8-BIT COMPLEMENT
6	E34	3rd DIGIT 4-BIT COMPLEMENT
7	E32	3rd DIGIT 2-BIT COMPLEMENT
8	E31	3rd DIGIT 1-BIT COMPLEMENT
9	E28	2nd DIGIT 8-BIT COMPLEMENT
10	E24	2nd DIGIT 4-BIT COMPLEMENT
11	E22	2nd DIGIT 2-BIT COMPLEMENT
12	E21	2nd DIGIT 1-BIT COMPLEMENT
13	E18	1st DIGIT 8-BIT COMPLEMENT
14	E14	1st DIGIT 4-BIT COMPLEMENT
15	E12	1st DIGIT 2-BIT COMPLEMENT
16	E11	1st DIGIT 1-BIT COMPLEMENT
17	+5V	SUPPLY VOLTAGE
18	S9–	SET NINE COMPLEMENT
19		
20		
21	GND	CHASSIS GROUND
22	GCK	COUNTING PULSES
23	S0–	RESET
24		



+5V	SUPPLY VOLTAGE
E11	1st DIGIT 1-BIT COMPLEMENT
E12	1st DIGIT 2-BIT COMPLEMENT
E14	1st DIGIT 4-BIT COMPLEMENT
E18	1st DIGIT 8-BIT COMPLEMENT
E21	2nd DIGIT 1-BIT COMPLEMENT
E22	2nd DIGIT 2-BIT COMPLEMENT
E24	2nd DIGIT 4-BIT COMPLEMENT
E28	2nd DIGIT 8-BIT COMPLEMENT
E31	3rd DIGIT 1-BIT COMPLEMENT
E32	3rd DIGIT 2-BIT COMPLEMENT
E34	3rd DIGIT 4-BIT COMPLEMENT
E38	3rd DIGIT 8-BIT COMPLEMENT
E41	4th DIGIT 1-BIT COMPLEMENT
E42	4th DIGIT 2-BIT COMPLEMENT
E44	4th DIGIT 4-BIT COMPLEMENT
E48	4th DIGIT 8-BIT COMPLEMENT
E51	5th DIGIT 1-BIT COMPLEMENT
E52	5th DIGIT 2-BIT COMPLEMENT
E54	5th DIGIT 4-BIT COMPLEMENT
E58	5th DIGIT 8-BIT COMPLEMENT
E61	6th DIGIT 1-BIT COMPLEMENT
E62	6th DIGIT 2-BIT COMPLEMENT
E64	6th DIGIT 4-BIT COMPLEMENT
E68	6th DIGIT 8-BIT COMPLEMENT
E71	7th DIGIT 1-BIT COMPLEMENT
E72	7th DIGIT 2-BIT COMPLEMENT
E74	7th DIGIT 4-BIT COMPLEMENT
E78	7th DIGIT 8-BIT COMPLEMENT
E81	8th DIGIT 1-BIT COMPLEMENT
E82	8th DIGIT 2-BIT COMPLEMENT
E84	8th DIGIT 4-BIT COMPLEMENT
E88	8th DIGIT 8-BIT COMPLEMENT

REGISTER BOARD E

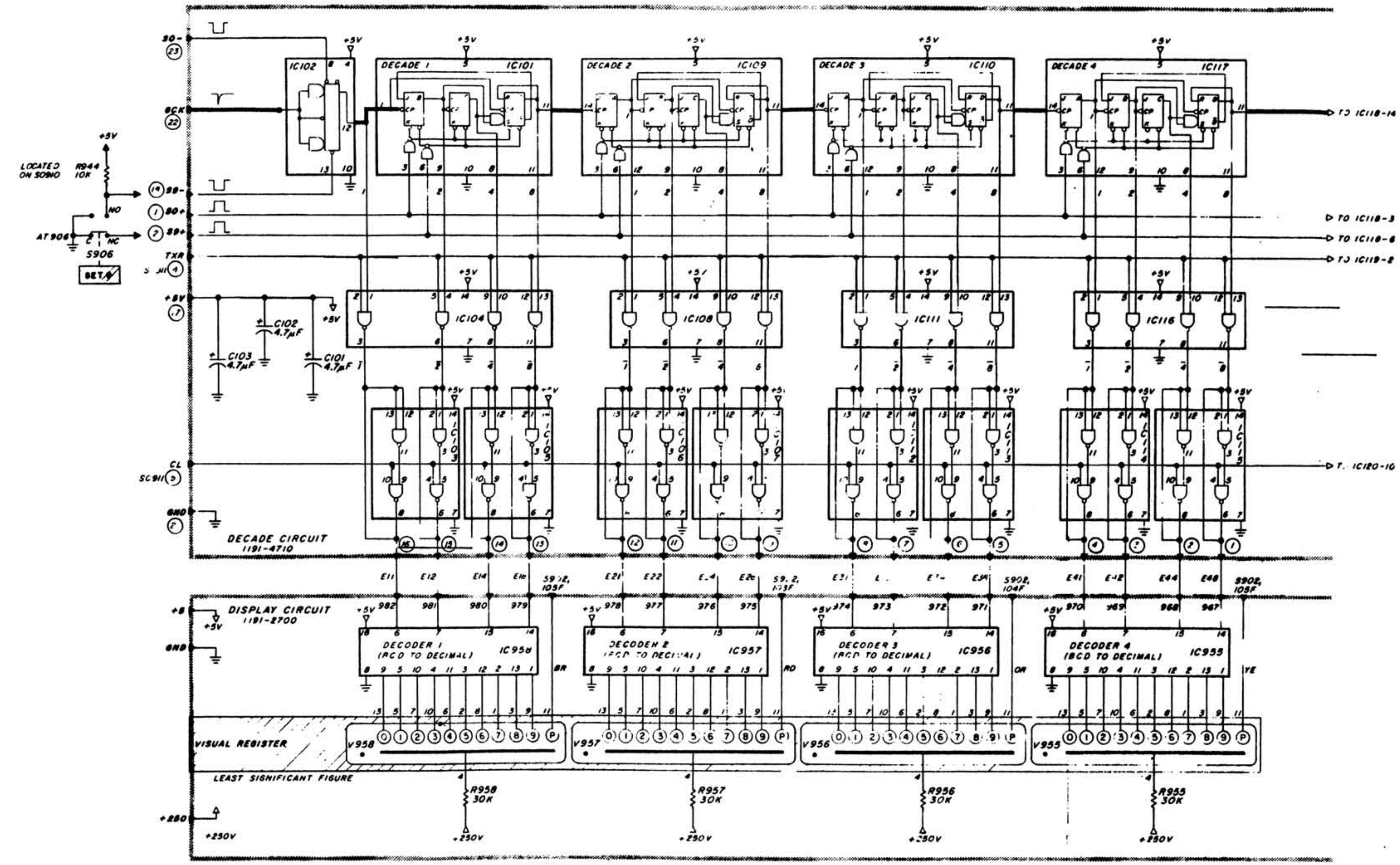
Part number 1191-4710 (the number that appears on the foil side is not the part number). The dot on the foil at the transistor socket indicates the collector lead.

See paragraph 4.7 for principles.

DISPLAY CIRCUIT F

Part number 1191-2700 (the number that appears on the foil side is not the part number). The dot on the foil at the transistor socket indicates the collector lead.

See paragraph 4.8 for principles.

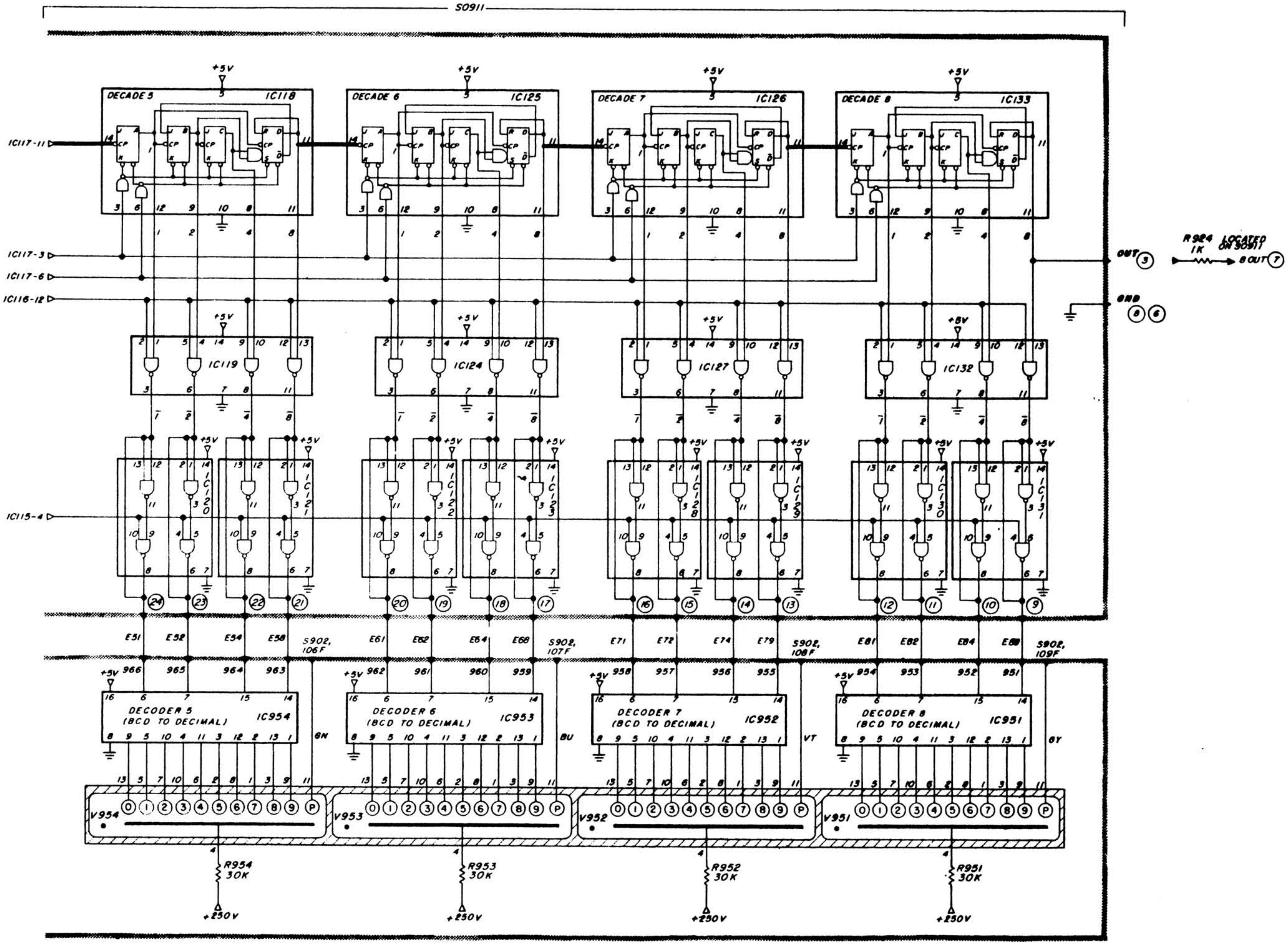


COMPONENTS

values with no decimal point are pF and with decimal point are μF (10^{-6} F). values with k are kΩ (10^3 Ω) and with (10^6 Ω). ▭ indicates front-panel access. ates rear-panel access. ● indicates screw- alignment-tool operated.

CONNECTIONS

- ⟶ Output leaves subassembly.
- ▶— Input from different subassembly.
- —▷ Output remains on subassembly.
- ▷— Input from same subassembly.

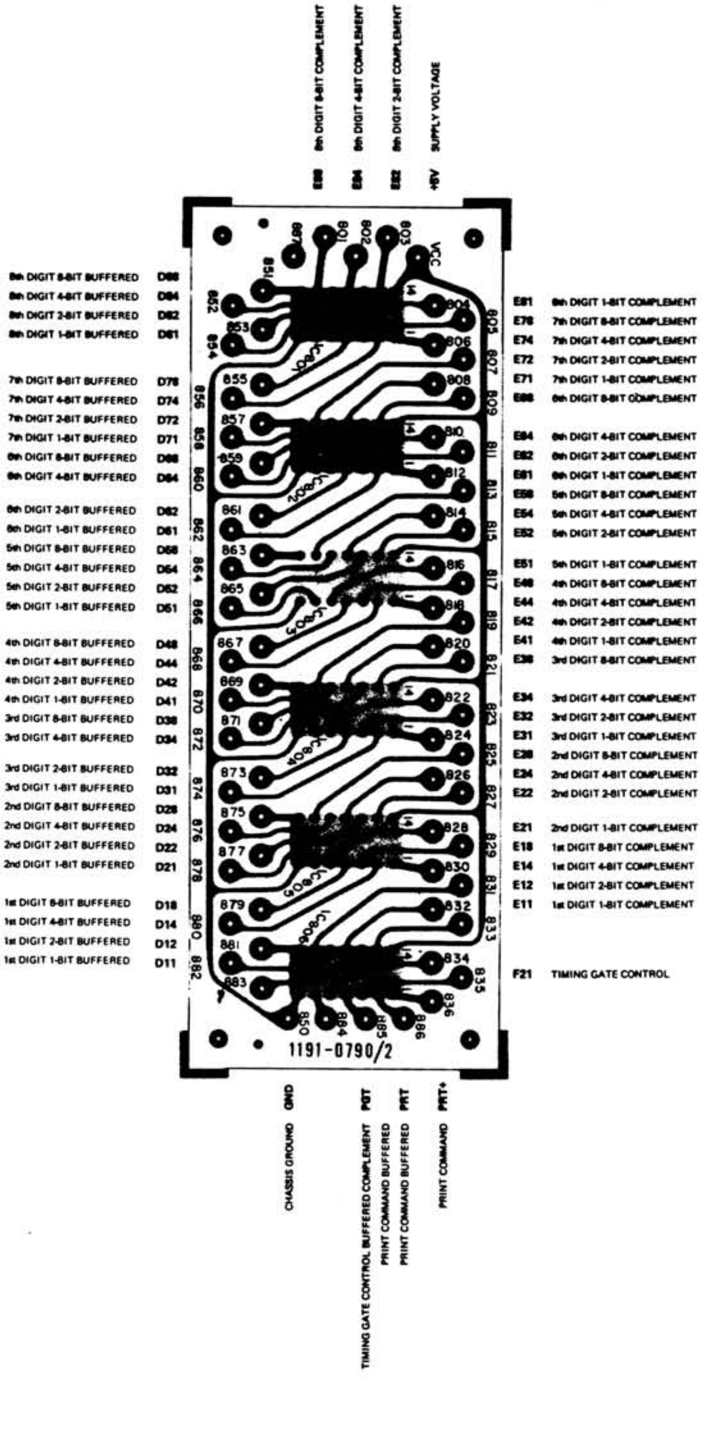


G

er that appears on

·). The dot on the

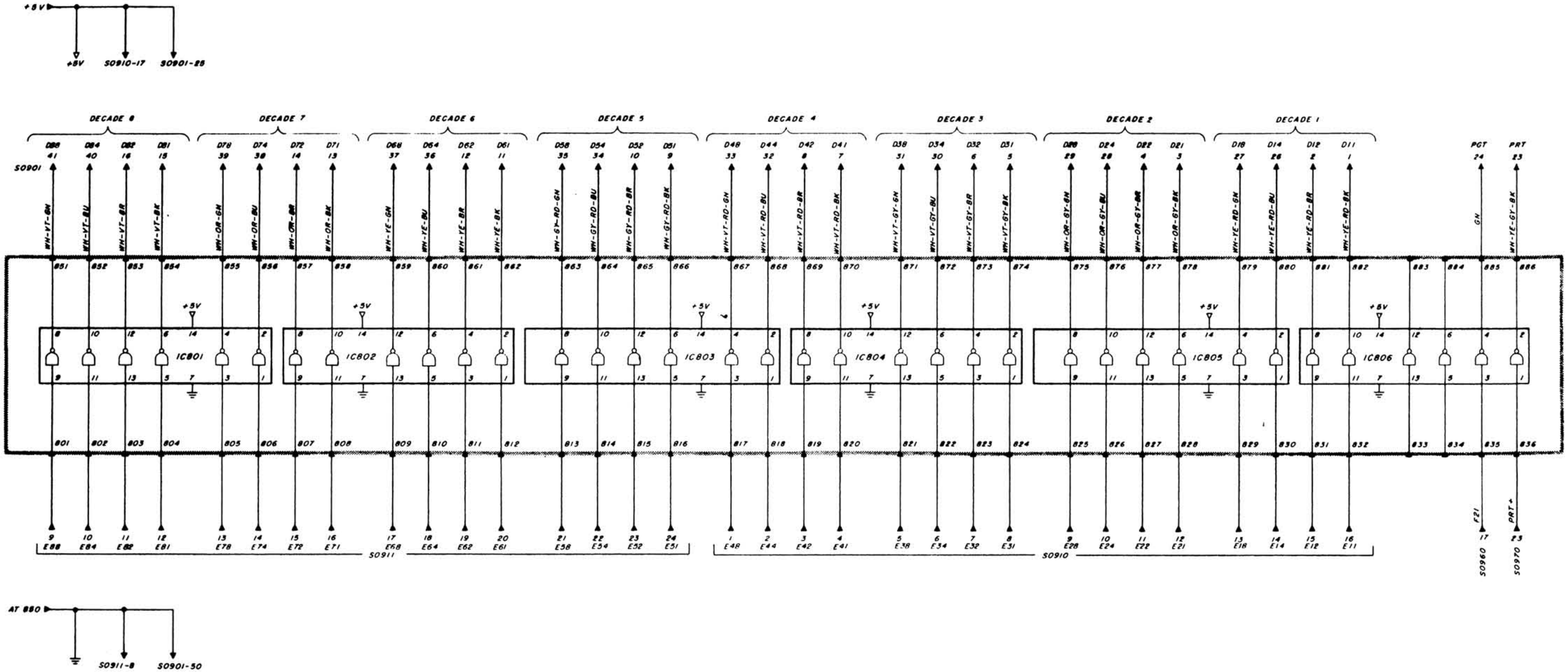
ates the collector

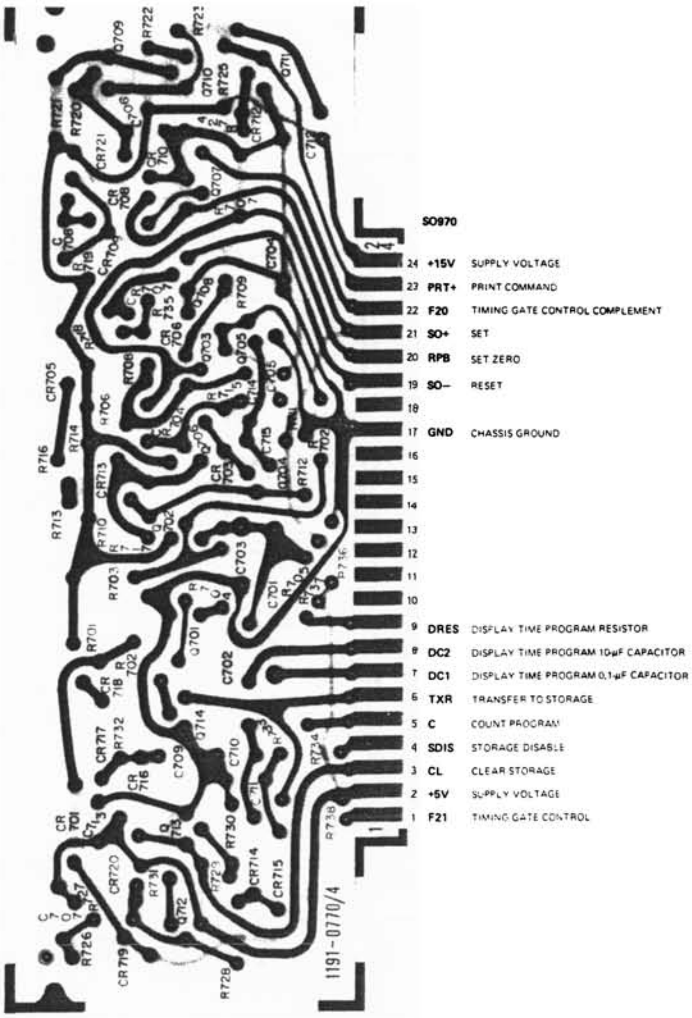


BUFFER CIRCUIT G

Part number 1191-2790 (the number that appears on the foil side is not the part number). The dot on the foil at the transistor socket indicates the collector lead.

See paragraph 4.8 for principles.

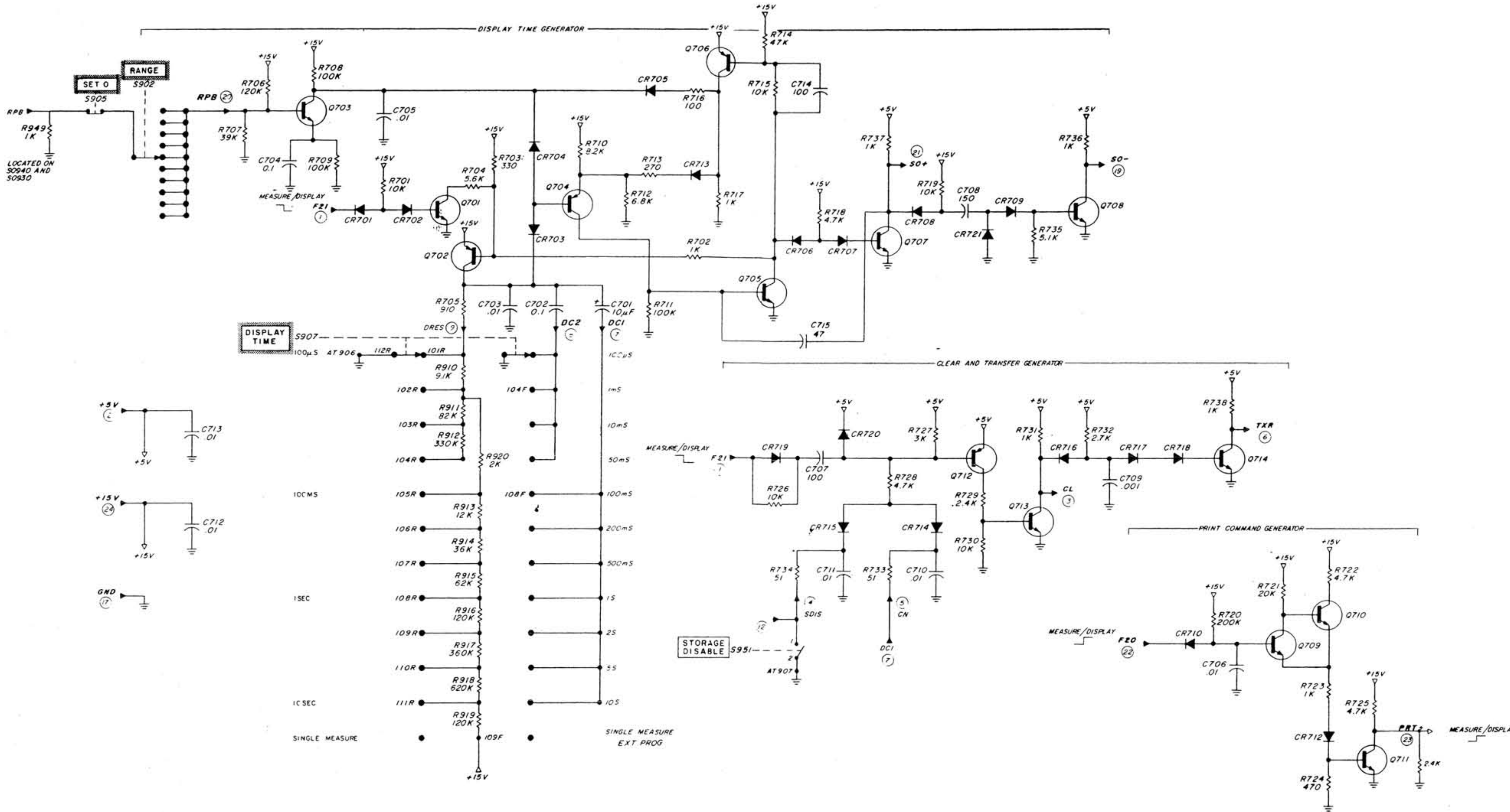

DECADE 8
DECADE 7
DECADE 6
DECADE 5
DECADE 4
DECADE 3
DECADE 2
DECADE 1
PGT
PRT
IC801
IC802
IC803
IC804
IC805
IC806
+5V
S0911
S0910



PROGRAM BOARD H

Part number 1191-4770 (the number that appears on the foil side is not the part number). The dot on the foil at the transistor socket indicates the collector lead.

See paragraph 4.10 for principles.



COMPONENTS

Capacitor values with no decimal point are pF (10^{-12} F) and with decimal point are μF (10^{-6} F). Resistor values with k are kΩ (10^3 Ω) and with M are MΩ (10^6 Ω). ▒ indicates front-panel access. ▭ indicates rear-panel access. ● indicates screwdriver- or alignment-tool operated.

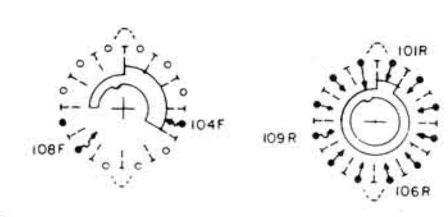
CONNECTIONS

- ➡ Output leaves subassembly.
- ▶ Input from different subassembly.
- ▷ Output remains on subassembly.
- ▷ Input from same subassembly.

SWITCHES

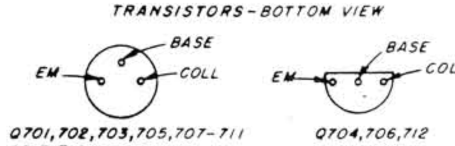
404F

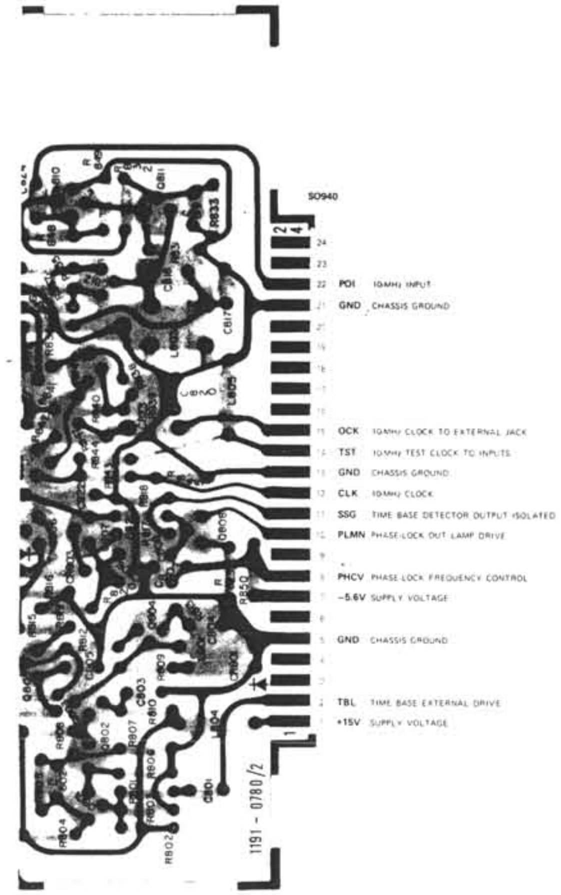
- F — Front, Rear.
- 04 — Contact: First contact cw from strut is 01.
- 4 — Section: Section nearest panel is 1.

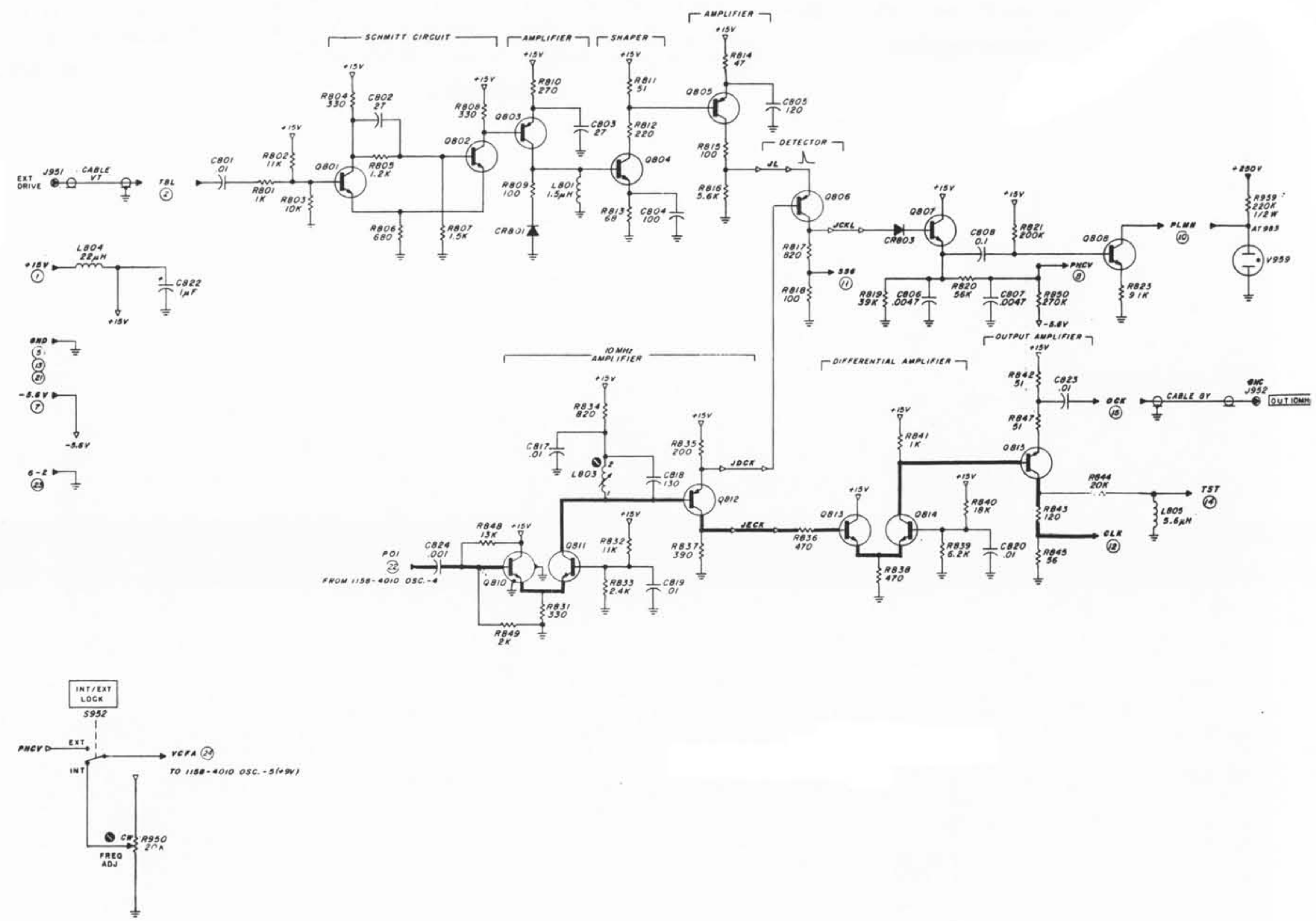


TRANSISTOR BASING

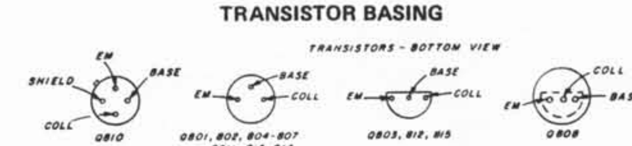
TRANSISTORS–BOTTOM VIEW







TRANSISTOR BASING



AMPLIFIER BOARD JA

Part number 1191-4780 (the number that appears on the foil side is not the part number). The dot on the foil at the transistor socket indicates the collector lead.

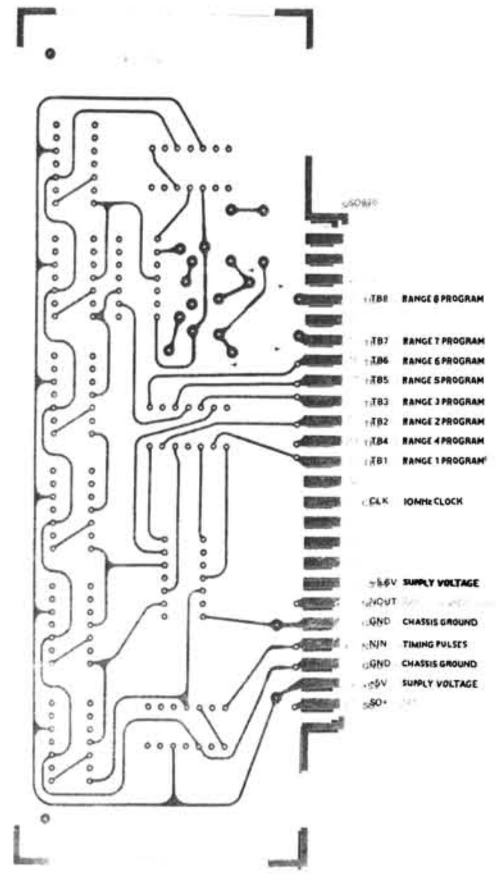
See paragraph 4.5 for principles.

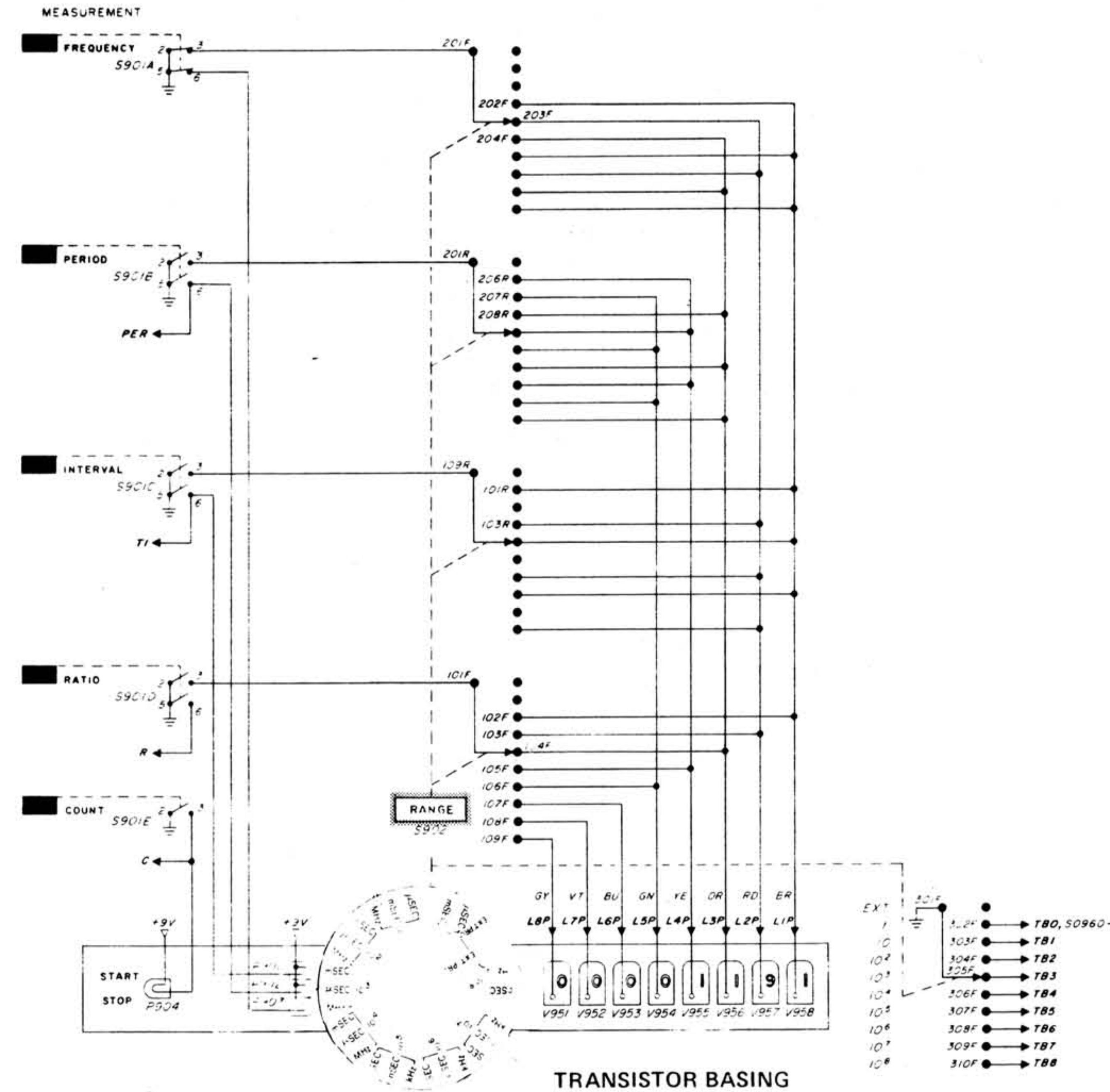
COMPONENTS

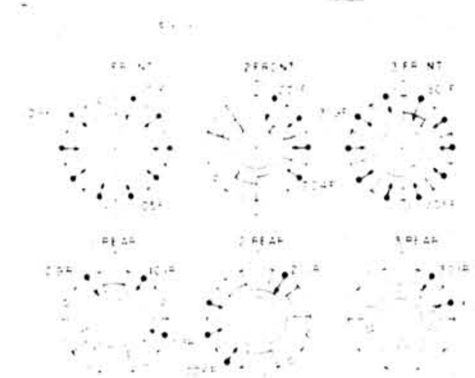
Capacitor values with no decimal point are pF (10^{-12} F) and with decimal point are μF (10^{-6} F). Resistor values with k are kΩ (10^3 Ω) and with M are MΩ (10^6 Ω). ▭ indicates front-panel access. ▭ indicates rear-panel access. ● indicates screw-driver- or alignment-tool operated.

CONNECTIONS

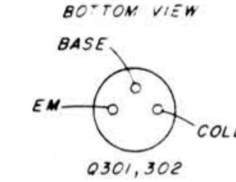
- ➞ Output leaves subassembly.
- ▶— Input from different subassembly.
- —▷ Output remains on subassembly.
- ▷— Input from same subassembly.







TRANSISTOR BASING



/ from strut is 01.
is 1.

issue 4 **TIME-BASE BOARD L-1**

TIME-BASE BOARD L

Part number 1191-4730 (the number that appears on the foil side is not the part number). The dot on the foil at the transistor socket indicates the collector lead.

See paragraph 4.6 for principles.

COMPONENTS

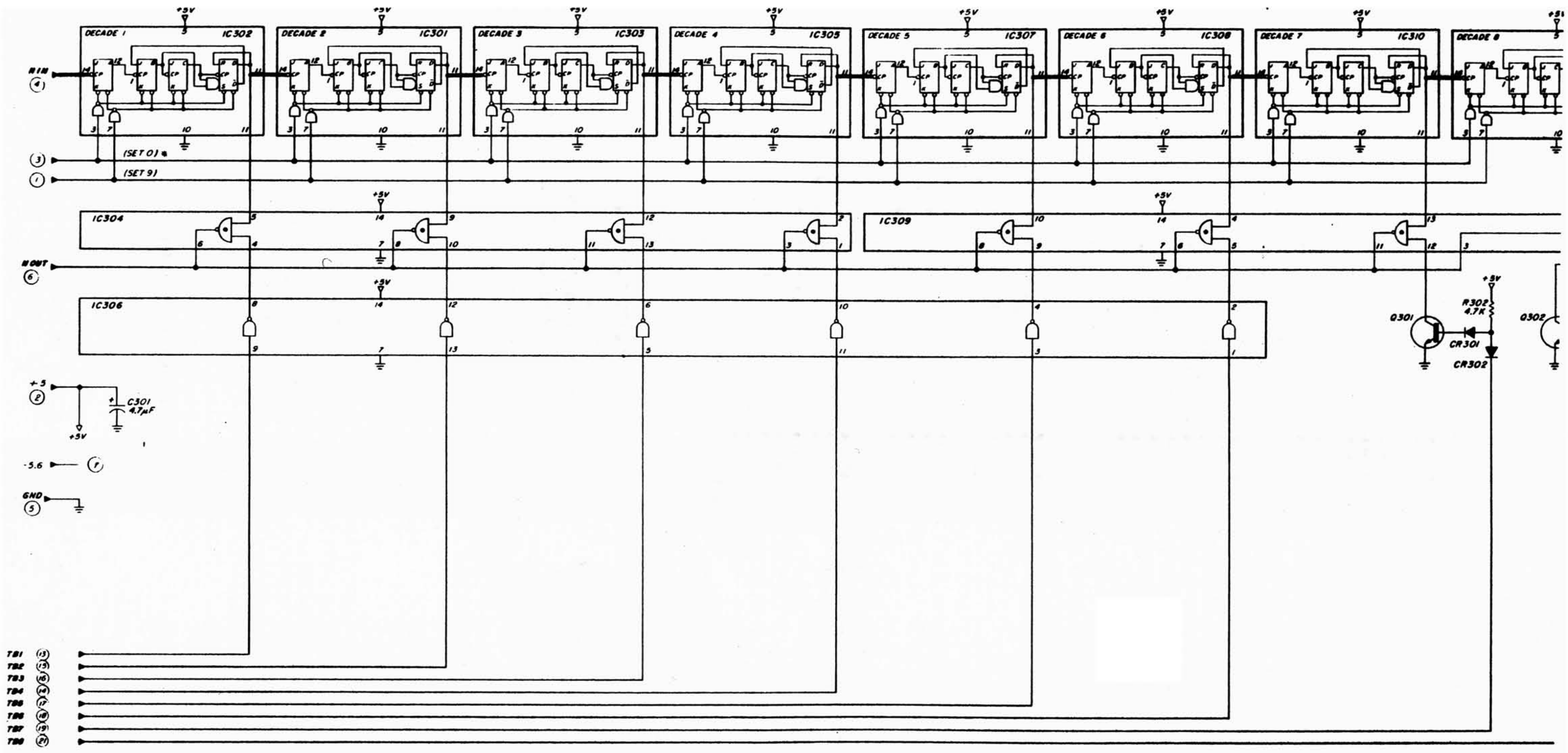
Capacitor values with no decimal point are pF (10^{-12} F) and with decimal point are μF (10^{-6} F). Resistor values with k are kΩ (10^3 Ω) and with M are MΩ (10^6 Ω). ▭ indicates front-panel access. ▭ indicates rear-panel access. ⊘ indicates screwdriver- or alignment-tool operated.

CONNECTIONS

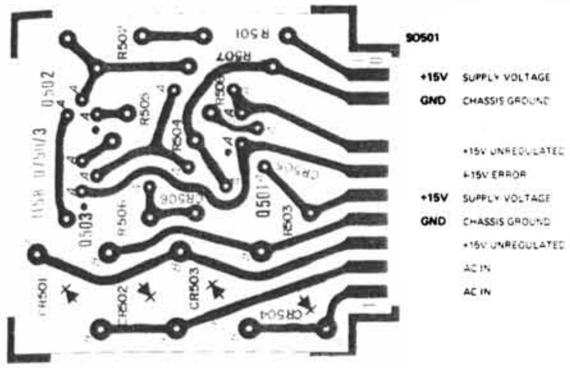
- ➔ Output leaves subassembly.
- ▶— Input from different subassembly.
- —▷ Output remains on subassembly.
- ▷— Input from same subassembly.

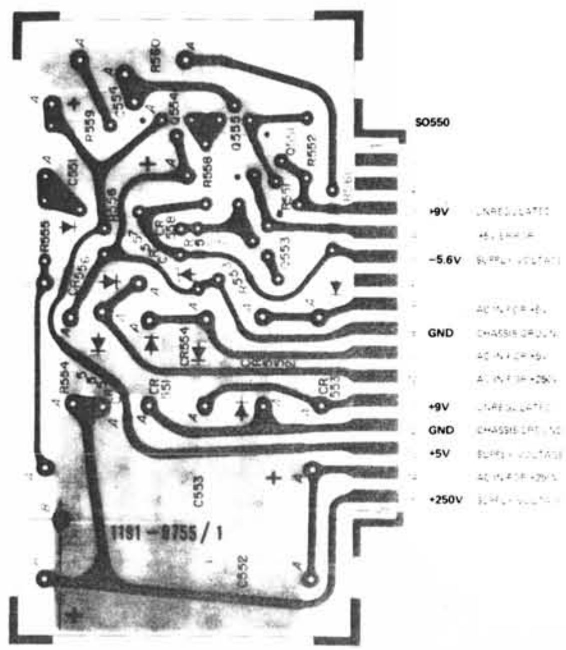
SWITCHES

404F
- F: Front, Rear.
- 04: Contact: First contact cw
- 4: Section: Section nearest panel



DECADE 1
IC302
DECADE 2
IC301
DECADE 3
IC303
DECADE 4
IC305
DECADE 5
IC307
DECADE 6
IC308
DECADE 7
IC310
DECADE 8
+5V
(SET 0)
(SET 9)
IC304
IC309
IC306
Q301
Q302
R302
4.7K
CR301
CR302
C301
4.7μF
-5.6
GND
TB1
TB2
TB3
TB4
TB5
TB6
TB7
TB8





FIFTEEN-VOLT BOARD VH

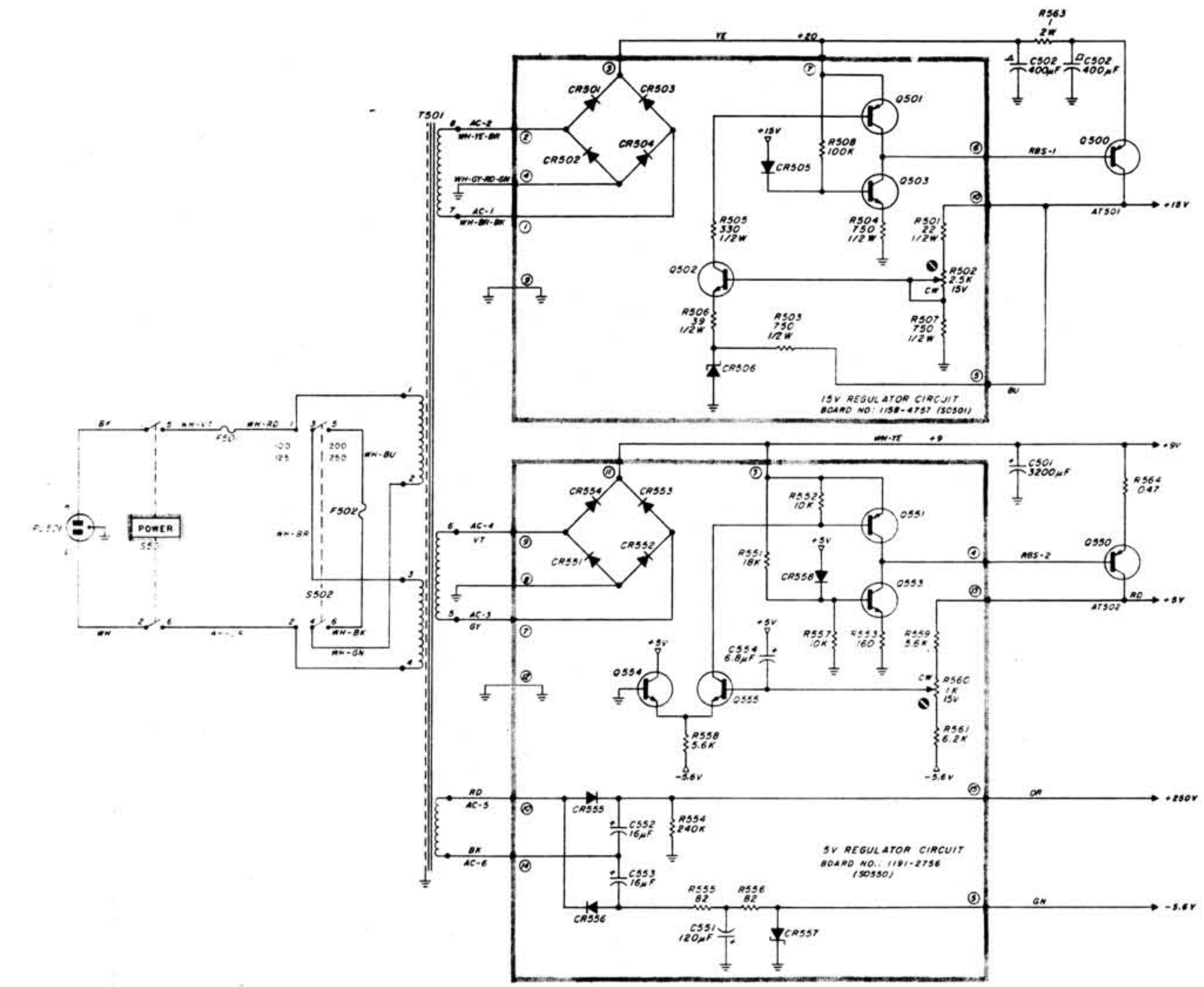
Part number 1158-4751 (the number that appears on the foil side is not the part number). The dot on the foil at the transistor socket indicates the collector lead.

See paragraph 4.12 for principles.

FIVE-VOLT BOARD VL

Part number 1191-2756 (the number that appears on the foil side is not the part number). The dot on the foil at the transistor socket indicates the collector lead.

See paragraph 4.12 for principles.



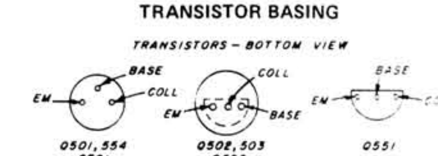
COMPONENTS

Capacitor values with no decimal point are pF (10^{-12} F) and with decimal point are μF (10^{-6} F). Resistor values with k are kΩ (10^3 Ω) and with M are MΩ (10^6 Ω). ▒ indicates front-panel access. ▭ indicates rear-panel access. ● indicates screw-driver- or alignment-tool operated.

CONNECTIONS

- ⟶▶ Output leaves subassembly.
- ▶— Input from different subassembly.
- ⟶▷ Output remains on subassembly.
- ▷— Input from same subassembly.

TRANSISTOR BASING



FEDERAL MANUFACTURERS CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) as supplemented through June, 1967.

Code	Manufacturers Name and Address
00192	Jones Mfg. Co., Chicago, Illinois
00194	Walsco Electronics Corp., Los Angeles, Calif.
00656	Aerovox Corp., New Bedford, Mass.
01009	Alden Products Co., Brockton, Mass.
01121	Allen-Bradley, Co., Milwaukee, Wisc.
01295	Texas Instruments, Inc., Dallas, Texas
02114	Ferroxcube Corp. of America, Saugerties, N. Y. 12477
02606	Fenwal Lab. Inc., Morton Grove, Ill.
02660	Amphenol Electronics Corp., Broadview, Ill.
02768	Fastex Division of Ill. Tool Works, Des Plaines, Ill. 60016
03508	G. E. Semiconductor Products Dept., Syracuse, N. Y. 13201
03636	Grayburne, Yonkers, N. Y. 10701
03888	Pyrofilm Resistor Co., Cedar Knolls, N. J.
03911	Clairex Corp., New York, N. Y. 10001
04009	Arrow, Hart and Hegeman Electric Co., Hartford, Conn. 06106
04713	Motorola Semi-Conduct Product, Phoenix, Ariz. 85008
05170	Engineered Electronics Co., Inc., Santa Ana, Calif. 92702
05624	Barber-Colman Co., Rockford, Ill. 61101
05820	Wakefield Eng., Inc., Wakefield, Mass. 01880
07127	Eagle Signal Div. of E. W. Bliss Co., Baraboo, Wisc.
07261	Avnet Corp., Culver City, Calif. 90230
07263	Fairchild Camera and Instrument Corp., Mountain View, Calif.
07387	Birtcher Corp., No. Los Angeles, Calif.
07595	American Semiconductor Corp., Arlington Heights, Ill. 60004
07828	Bodine Corp., Bridgeport, Conn. 06605
07829	Bodine Electric Co., Chicago, Ill. 60618
07910	Continental Device Corp., Hawthorne, Calif.
07983	State Labs Inc., N. Y., N. Y. 10003
07999	Amphenol Corp., Borg Inst. Div., Delavan, Wisc. 53115
08730	Vemaline Prod. Co., Franklin Lakes, N. J.
09213	General Electric Semiconductor, Buffalo, N. Y.
09408	Star-Tronics Inc., Georgetown, Mass. 01830
09823	Burgess Battery Co., Freeport, Ill.
09922	Burndy Corp., Norwalk, Conn. 06852
11236	C.P.S. of Berne, Inc., Berne, Ind. 46711
11599	Chandler Evans Corp., W. Hartford, Conn.
12498	Teledyn Inc., Crystalonics Div., Cambridge, Mass. 02140
12672	RCA Commercial Receiving Tube and Semi-conductor Div., Woodridge, N.J.
12697	Clarostat Mfg. Co. Inc., Dover, N. H. 03820
12954	Dickson Electronics Corp., Scottsdale, Ariz.
13327	Solitron Devices, Tappan, N. Y. 10983
14433	ITT Semiconductors, W. Palm Beach, Florida
14655	Cornell Dubilier Electric Co., Newark N. J.
14674	Corning Glass Works, Corning, N. Y.
14936	General Instrument Corp., Hicksville, N. Y.
15238	ITT, Semiconductor Div. of Int. T. and T, Lawrence, Mass.
15605	Cutler-Hammer Inc., Milwaukee, Wisc. 53233
16037	Spruce Pine Mica Co., Spruce Pine, N. C.
19644	LRC Electronics, Horseheads, New York
19701	Electra Mfg. Co., Independence, Kansas 67301
21335	Fafnir Bearing Co., New Briton, Conn.
24446	G. E. Schenectady, N. Y. 12305
24454	G. E., Electronic Comp., Syracuse, N. Y.
24455	G. E. (Lamp Div), Nela Park, Cleveland, Ohio
24655	General Radio Co., W. Concord, Mass 01781
26806	American Zettler Inc., Costa Mesa, Calif.
28520	Hayman Mfg. Co., Kenilworth, N. J.
28959	Hoffman Electronics Corp., El Monte, Calif.
30874	International Business Machines, Armonk, N.Y.
32001	Jensen Mfg. Co., Chicago, Ill. 60638
35929	Constanta Co. of Canada Limited, Montreal 19, Quebec
37942	P. R. Mallory and Co. Inc., Indianapolis, Ind.
38443	Marlin-Rockwell Corp., Jamestown, N. Y.
40931	Honeywell Inc., Minneapolis, Minn. 55408
42190	Muter Co., Chicago, Ill. 60638
42498	National Co. Inc., Melrose, Mass. 02176
43991	Norma-Hoffman Bearings Corp., Stanford, Conn. 06904
49671	RCA, New York, N. Y.
49956	Raytheon Mfg. Co., Waltham, Mass. 02154

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53021	Sangamo Electric Co., Springfield, Ill. 62705
54294	Shallcross Mfg. Co., Selma, N. C.
54715	Shure Brothers, Inc., Evanston, Ill.
56289	Sprague Electric Co., N. Adams, Mass.
59730	Thomas and Betts Co., Elizabeth, N. J. 07207
59875	TRW Inc. (Accessories Div), Cleveland, Ohio
60399	Torrington Mfg. Co., Torrington, Conn.
61637	Union Carbide Corp., New York, N. Y. 10017
61864	United-Carr Fastener Corp., Boston, Mass.
63060	Victoreen Instrument Co., Inc., Cleveland, Ohio
63743	Ward Leonard Electric Co., Mt. Vernon, N. Y.
65083	Westinghouse (Lamp Div), Bloomfield, N. J.
65092	Weston Instruments, Weston-Newark, Newark, N. J.
70485	Atlantic-India Rubber Works, Inc., Chicago, Ill. 60607
70563	Amperite Co., Union City, N. J. 07087
70903	Belden Mfg. Co., Chicago, Ill. 60644
71126	Bronson, Homer D., Co., Beacon Falls, Conn.
71294	Canfield, H. O. Co., Clifton Forge, Va. 24422
71400	Bussman Mfg. Div. of McGraw Edison Co., St. Louis, Mo.
71590	Centralab, Inc., Milwaukee, Wisc. 53212
71666	Continental Carbon Co., Inc., New York, N. Y.
71707	Coto Coil Co. Inc., Providence, R. I.
71744	Chicago Miniature Lamp Works, Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div., Chicago, Ill. 60624
71823	Darnell Corp., Ltd., Downey, Calif. 90241
72136	Electro Motive Mfg. Co., Willmington, Conn.
72259	Nytronics Inc., Berkeley Heights, N. J. 07922
72619	Dialight Co., Brooklyn, N. Y. 11237
72699	General Instrument Corp., Capacitor Div., Newark, N. J. 07104
72765	Drake Mfg. Co., Chicago, Ill. 60656
72825	Hugh H. Eby, Inc., Philadelphia, Penn. 19144
72962	Elastic Stop Nut Corp., Union, N. J. 07083
72982	Erie Technological Products Inc., Erie, Penn.
73138	Beckman, Inc., Fullerton, Calif. 92634
73445	Amperex Electronics Co., Hicksville, N. Y.
73559	Carling Electric Co., W. Hartford, Conn.
73690	Elco Resistor Co., New York, N. Y.
73899	J. F. D. Electronics Corp., Brooklyn, N. Y.
74193	Heinemann Electric Co., Trenton, N. J.
74861	Industrial Condenser Corp., Chicago, Ill.
74970	E. F. Johnson Co., Waseca, Minn. 56093
75042	IRC Inc., Philadelphia, Penn. 19108
75382	Kulka Electric Corp., Mt. Vernon, N. Y.
75491	Lafayette Industrial Electronics, Jamaica, N.Y.
75608	Linden and Co., Providence, R. I.
75915	Littelfuse, Inc., Des Plaines, Ill. 60016
76005	Lord Mfg. Co., Erie, Penn. 16512
76149	Malloy Electric Corp., Detroit, Mich. 48204
76487	James Millen Mfg. Co., Malden,Mass. 02148
76545	Mueller Electric Co., Cleveland, Ohio 44114
76684	National Tube Co., Pittsburg, Penn.
76854	Oak Mfg. Co., Crystal Lake, Ill.
77147	Patton MacGuyer Co., Providence, R. I.
77166	Pass-Seymour, Syracuse, N. Y.
77263	Pierce Roberts Rubber Co., Trenton, N. J.
77339	Positive Lockwasher Co., Newark , N. J.
77542	Ray-O-Vac Co., Madison, Wisc.
77630	TRW, Electronic Component Div., Camden, N. J. 08103
77638	General Instruments Corp., Brooklyn, N. Y.
78189	Shakeproof Div. of Ill. Tool Works, Elgin, Ill. 60120
78277	Sigma Instruments Inc., S. Braintree, Mass.
78488	Stackpole Carbon Co., St. Marys, Penn.
78553	Tinnerman Products, Inc., Cleveland, Ohio
79089	RCA, Commercial Receiving Tube and Semi-conductor Div., Harrison, N. J.
79725	Wiremold Co., Hartford, Conn. 06110
79963	Zierick Mfg. Co., New Rochelle, N. Y.
80030	Prestole Fastener Div. Bishop and Babcock Corp., Toledo, Ohio
80048	Vickers Inc. Electric Prod. Div., St. Louis, Mo.
80131	Electronic Industries Assoc., Washington, D.C.
80183	Sprague Products Co., N. Adams, Mass.
80211	Motorola Inc., Franklin Park, Ill. 60131
80258	Standard Oil Co., Lafeyette, Ind.
80294	Bourns Inc., Riverside, Calif. 92506

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83033	Meissner Mfg., Div. of Maguire Industries, Inc. Mount Carmel, Illinois
80431	Air Filter Corp., Milwaukee, Wisc. 53218
80583	Hammarlund Co. Inc., New York, N. Y.
80740	Beckman Instruments, Inc., Fullerton, Calif.
81073	Grayhill Inc., LaGrange, Ill. 60525
81143	Isolantite Mfg. Corp., Stirling, N. J. 07980
81349	Military Specifications
81350	Joint Army-Navy Specifications
81751	Columbus Electronics Corp., Yonkers, N. Y.
81831	Filton Co., Flushing, L. I., N. Y
81860	Barry Controls Div. of Barry Wright Corp., Watertown, Mass.
82219	Sylvania Electric Products, Inc., (Electronic Tube Div.), Emporium, Penn.
82273	Indiana Pattern and Model Works, LaPort, Ind.
82389	Switchcraft Inc., Chicago, Ill. 60630
82647	Metals and Controls Inc., Attleboro, Mass.
82807	Milwaukee Resistor Co., Milwaukee, Wisc.
83058	Carr Fastener Co., Cambridge, Mass.
83186	Victory Engineering Corp (IVECO), Springfield, N. J. 07081
83361	Bearing Specialty Co., San Francisco, Calif.
83587	Solar Electric Corp., Warren, Penn.
83740	Union Carbide Corp., New York, N. Y. 10017
84411	TRW Capacitor Div., Ogallala, Nebr.
84835	Lehigh Metal Products Corp., Cambridge, Mass. 02140
84971	TA Mfg. Corp., Los Angeles, Calif.
86577	Precision Metal Products of Malden Inc., Stoneham, Mass. 02180
86684	RCA (Electrical Component and Devices) Harrison. N. J.
86800	Continental Electronics Corp. Brooklyn, N.Y. 11222
88140	Cutler-Hammer Inc., Lincoln, Ill.
88219	Gould Nat. Batteries Inc., Trenton, N. J.
88419	Cornell Dubilier Electric Corp., Fuquay-Varina, N. C.
88627	K and G Mfg. Co., New York, N. Y.
89482	Holtzer Cabot Corp., Boston, Mass.
89665	United Transformer Co., Chicago, Ill.
90201	Mallory Capacitor Co., Indianapolis, Ind.
90750	Westinghouse Electric Corp., Boston, Mass.
90952	Hardware Products Co., Reading, Penn. 19602
91032	Continental Wire Corp., York, Penn. 17405
91146	ITT Cannon Electric Inc., Salem, Mass.
91293	Johanson Mfg. Co., Boonton, N. J. 07005
91598	Chandler Co., Wethersfield, Conn. 06109
91637	Dale Electronics Inc., Columbus, Nebr.
91662	Elco Corp., Willow Grove, Penn.
91719	General Instruments, Inc., Dallas, Texas
91929	Honeywell Inc., Freeport, Ill.
92519	Electra Insulation Corp., Woodside, Long Island, N. Y.
92678	Edgerton, Germeshausen and Grier, Boston, Mass.
93332	Sylvania Electric Products, Inc., Woburn, Mass.
93916	Cramer Products Co., New York, N. Y. 10013
94144	Raytheon Co. Components Div., Quincy, Mass.
94154	Tung Sol Electric Inc., Newark, N. J.
95076	Garde Mfg. Co., Cumberland, R. I.
95146	Alco Electronics Mfg. Co., Lawrence, Mass.
95238	Continental Connector Corp., Woodside, N. Y.
95275	Vitramon, Inc., Bridgeport, Conn.
95354	Methode Mfg. Co., Chicago, Ill.
95412	General Electric Co., Schenectady, N. Y.
95794	Ansconda American Brass Co., Torrington, Conn.
96095	Hi-Q Div. of Aerovox Corp., Orlean, N. Y.
96214	Texas Instruments Inc., Dallas, Texas 75209
96256	Thordarson-Meissner Div. of McGuire, Mt. Carmel, Ill.
96341	Microwave Associates Inc., Burlington, Mass.
96791	Amphenoe Corp. Jonesville, Wisc. 53545
96906	Military Standards
97966	CBS Electronics Div. of Columbia Broadcasting Systems, Danvers, Mass.
98291	Sealectro Corp., Mamaroneck. N. Y. 10544
98821	North Hills Electronics Inc., Glen Cove, N. Y.
99180	Transitron Electronics Corp., Melrose, Mass.
99378	Atlee Corp., Winchester, Mass. 01890
99800	Delevan Electronics Corp., E. Aurora, N. Y.