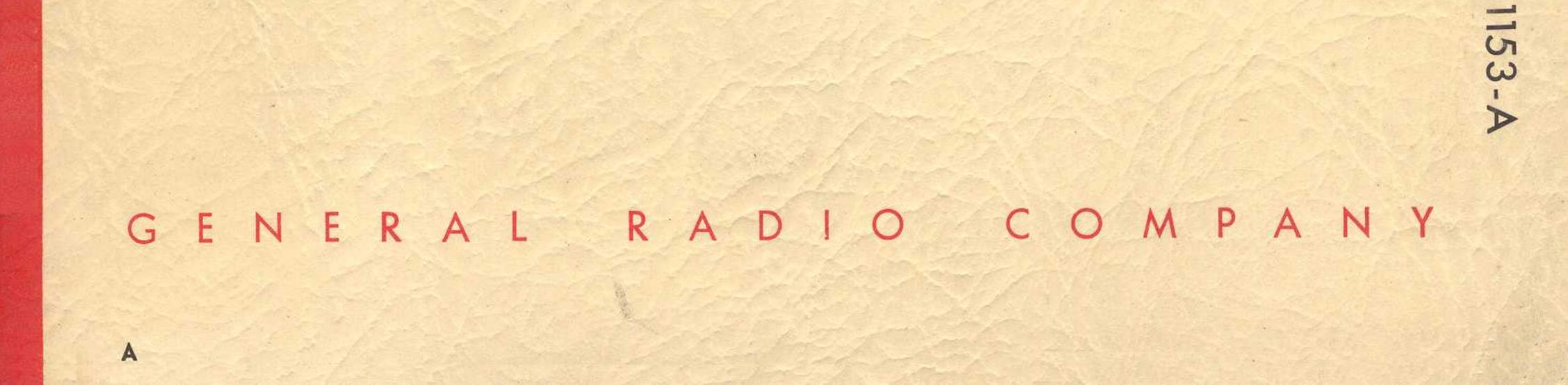
OPERATING INSTRUCTIONS



TYPE 1153-A,-AP

DIGITAL FREQUENCY METERS



CONDENSED OPERATING INSTRUCTIONS

• CHECK

Set controls as follows:

Input controls TRIGGER LEVEL . . . centered INPUT COUPLING . . . AC IMPEDANCE $100 \text{ k}\Omega$ MEASUREMENT. 100 kc TEST DISPLAY TIME 6 or 7 COUNTING TIME Display should read .01 SEC 0.1000 0.1 SEC 100.00 00000, SPILL lamp on SEC Τ 00000, SPILL lamp on 10 SEC

• CUMULATIVE-COUNT MEASUREMENT

Set controls as follows:

Input controls .	٠	. as required.
MEASUREMENT	•	. COUNT
DISPLAY TIME .	•	. any position, 0 through ∞

To start the count, set the COUNT/MULT INT switch to START. To stop the count, set the COUNT/MULT INT switch to STOP. To clear the register, push the RESET button.



Set controls as follows:

FREQUENCY MEASUREMENT

Set controls as follows:

Input controls .	•	. as required
MEASUREMENT	•	. FREQUENCY
DISPLAY TIME .	•	. as required

COUNTING TIME . . Right-Hand Indicator Reads

- .01 SEC hundreds of cycles per second
- 0.1 SEC tens of cycles per second
- 1 SEC cycles per second
- 10 SEC tenths of cycles per second

- Input controls . . . as required
- MEASUREMENT . . for frequency or cumulative-count measurements, as desired.
- DISPLAY TIME . . MULT INT
- COUNTING TIME . . 1 SEC or 10 SEC (ten seconds is the most practical increment).
- To start the count, set the COUNT/MULT INT switch to START and push the RESET button. To stop the count (assume an interval of 100 seconds is desired), wait a little over 90 seconds, then set the COUNT/MULT INT switch to STOP. To clear the register, push the RESET button.

OPERATING INSTRUCTIONS

TYPE 1153-A,-AP

DIGITAL FREQUENCY METERS

Form 1153-0100-A November, 1965

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GENERAL RADIO COMPANY WEST CONCORD, MASSACHUSETTS, USA

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• SPECIFICATIONS

INPUT

Frequency: Dc to 10 Mc/s.

Accuracy: ± 1 count \pm time-base stability.

Sensitivity: 0.1 V, p-to-p, at 100 k Ω and 50 pF; 1.0 V at 1 M Ω and 20 pF. For narrow pulses, 0.1 V at 100 k Ω and >30-ns duration; 0.2 V at 100 k Ω and >15 ns; 1.0 V at 1 M Ω and >30 ns; 2.0 V at 1 M Ω and >15 ns. Max allowable input is ± 400 V (at 1 M Ω). Counting Interval: 0.01, 0.1, 1, or 10 s, extendible by multiplier switch, or as set manually. Input Trigger: Ac or dc coupled. Trigger level range is ± 1 V at 0.1-V sensitivity, ± 10 V at 1-V sensitivity. Trigger-level drift is typically 0.05 V, p-to-p, at 0.1-V sensitivity, 0.5 V, at 1-V sensitivity, from 0°C to 50°C. Auxiliary Connector: Inputs — reset, start-stop. Outputs — carry pulse from last decade, print command, zero set, 100 kc/s, +20-V test point.

Photoelectric Pickoff Input Connector: 3-terminal telephone jack with +20 V dc and connection to main input. **Data-Output Connector (Type 1153-AP only):** 10-line decimal for each digit — one wire binary 1 (+14-V level) and nine wires binary 0 (0 to +4-V level); source impedance 2.4 k Ω ; +20-V power; ground; and print-command pulse.

Self Test: TEST position of measurement switch disconnects input and applies 100 kc/s to check all functions.

DISPLAY 5-digit, in-line readout with decimal point and spill lamp, incandescent-lamp operated. Display time of 0.16, 0.32, 0.64, 1.28, 2.56, 5.12, 10.24 seconds, or infinity.

TIME BASE	Stability
100 kc/s, internal or external. Internal frequency derived from 200-kc, GT-cut, room temperature crystal; adjustment provided, ad- justed to within 1 ppm when ship- ped.	Cycling: None Temp Effects: <6 ppm, 0 to 50°C ambient rise; < ±0.1 ppm per °C, 20° to 30°C ambient rise. Aging: <0.1 ppm per week.

AUXILIARY CONNECTIONS (rear-mounted connectors) Time-Base Output: 100 kc/s, 4 V, p-to-p, behind 2 k Ω . External Time-Base Input: 100 kc/s at 1 V, p-to-p, into 1 k Ω .

GENERAL

Operating Temp: 0° to $+50^{\circ}$ C.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 70 W. Accessories Supplied: TYPE CAP-22 Power Cord, 8 replacement incandescent lamps, spare fuses.

Accessories Available: TYPE 1536-A Photoelectric Pickoff, TYPE 1133-A Frequency Converter and TYPE 1153-P1 Frequency Multiplier to extend range to 500 Mc/s, TYPE 1156-A Decade Scaler to extend range to 100 Mc/s. For TYPE 1153-AP only — TYPE 1136-A Digital-to-Analog Converter, TYPE 1137-A Data Printer, TYPE 1510-A Digital-to-Graphic Recording Assembly.

MECHANICAL DATA Rack-Bench Cabinet

Madal	W	idth	Height		De	pth	Ne	t Wt	Ship Wt		
	ın	mm	in	mm	ın	mm	lb	kg	lb	kg	
Bench	19	485	3 7/8	99	121/2	320	20	9.5	28	13	
Rack											

* Behind panel.

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INTRODUCTION





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\bullet 1.1 PURPOSE

The Type 1153 Digital Frequency Meters are compact, inexpensive laboratory or industrial counters for frequency measurements from dc to 10 Mc/s. With the Type 1156 Decade Scaler, the range is extended to 100 Mc/s, and, with the Type 1133 Frequency Converter, to 500 Mc/s.

The -AP models include data-output provision for use with the Type 1137 Data Printer, the Type 1510 Digital-to-Graphic Recording Assembly, the Type 1136 Digital-to-Analog Converter, and other recording or dataprocessing equipment.

The instrument measures frequency by counting the number of zero-crossings of the input signal during a time interval established by an internal 100-kc timebase. Provision is also made for an external time-base.

The input controls provide a choice of sensitivity, ac or dc coupling, and triggering level and permit operation with input signals as small as 100 millivolts, peakto-peak.

The readout includes a spill lamp, which provides an indication when the register capacity has been filled. A stable, GT-cut, room-temperature crystal is incorporated in the time-base oscillator. Since the time-base crystal operates at room temperature, there is no frequency shift due to oven cycling. This is most important when the counter is used with the Type 1133 Frequency Converter for measurements up to 500 Mc/s.

• 1.3 ACCESSORIES SUPPLIED

Quantity Description

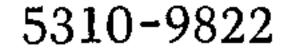
- Instruction book
- Power cord, 3-wire, Type CAP-22
- Plug, 8-contact. For connection to AUX connector on rear panel.
- Fuses, 1 amp for 115-V operation or 2 0.5 amp for 215 or 230-V operation

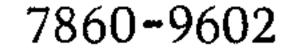
Part No. 1153-0100 4200-9622

4220-5000 5330-1400 5330-1000

For bench model: End-frame set

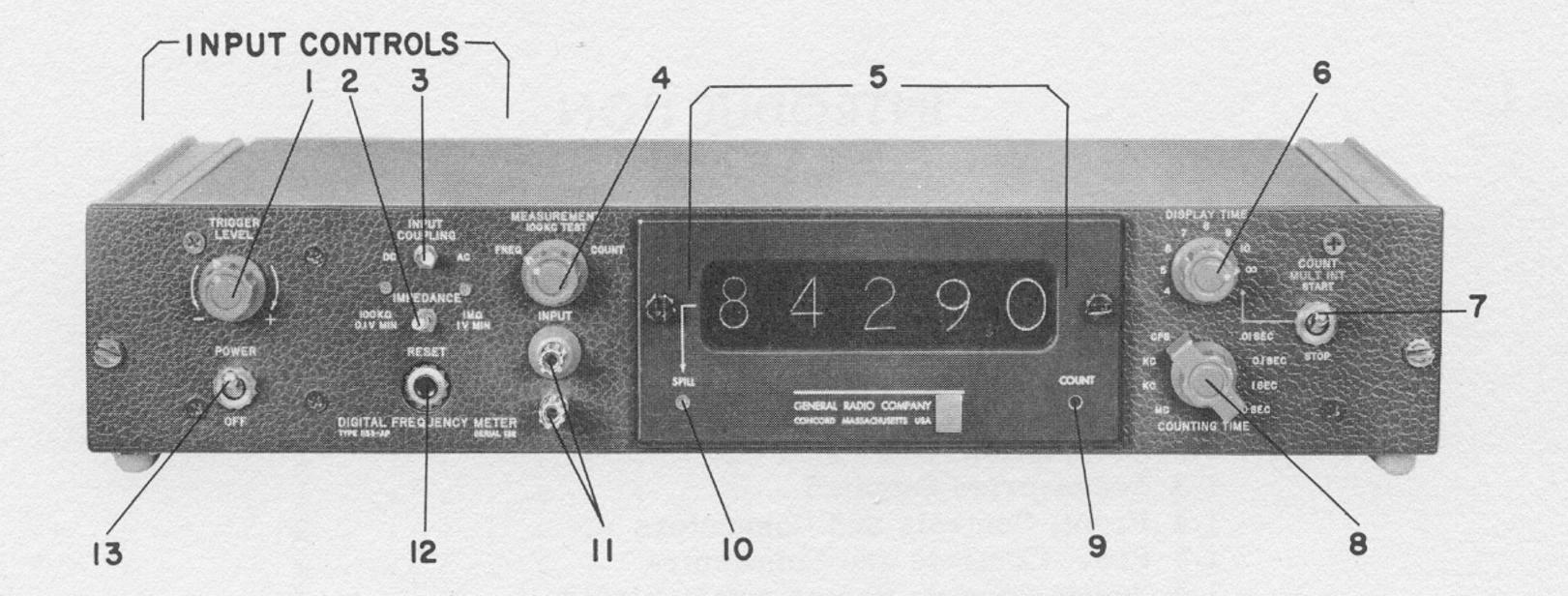
For rack model: Rack-support set







1.4 FRONT, CONTROLS AND CONNECTORS



TRIGGER LEVEL

- Continuously adjustable potentiometer. Optimizes the input sensitivity for differ-1 ent input waveforms by offestting the trigger level between +1 and -1 volt (100-k Ω input impedance) or between +10 and -10 volts (1-M Ω input impedance).
- INPUT COUPLING Two-position toggle switch. Permits removal of any dc component associated 2 with the input signal. Since the input circuits are dc coupled, a large dc component could prevent a desired, superimposed ac signal from triggering.
- IMPEDANCE Two-position toggle switch. Provides a choice of input sensitivities. For most 3 applications the lower input impedance position (100 k Ω) is tolerable and its highersensitivity (100 mV) is desirable. The higher impedance position (1 M Ω) provides minimum signal loading.
- MEASUREMENT Three-position rotary switch. Arranges the instrument circuits for the specified 4 type of measurement.
- Visual register Five incandescent-lamp-operated indicators with one-inch-high numerals and gray 5 Polaroid filters; includes decimal points. Provides visual display of measurement.
- DISPLAY TIME Nine-position rotary switch. Sets the duration of the display interval from 0.16 6 to 10.2 second in a binary sequence. When set to ∞ , retains any reading until RESET button is pushed. Permits manual counting-time control for count and multiple-interval measurements.
- COUNT/MULT INT Two-position toggle switch. Sets the counting time when the MEASUREMENT switch is in the COUNT position. Counting time is manually controlled and is adjustable in increments determined by the COUNTING TIME control when the DIS-PLAY switch is set to MULT INT.
- COUNTING TIME Four-position rotary switch. Establishes a precise interval of 0.01, 0.1, 1 or 10 8 seconds during which time the input zero crossings are counted.

COUNT 9 Green incandescent lamp. Lights during the counting time.

10 SPILL Red incandescent lamp. Lights when the capacity of the last (left-hand) indicator has been exceeded.

11 INPUT

Binding-post pair; 3/4-inch spaced. Main terminals for connection of the signal to be measured.

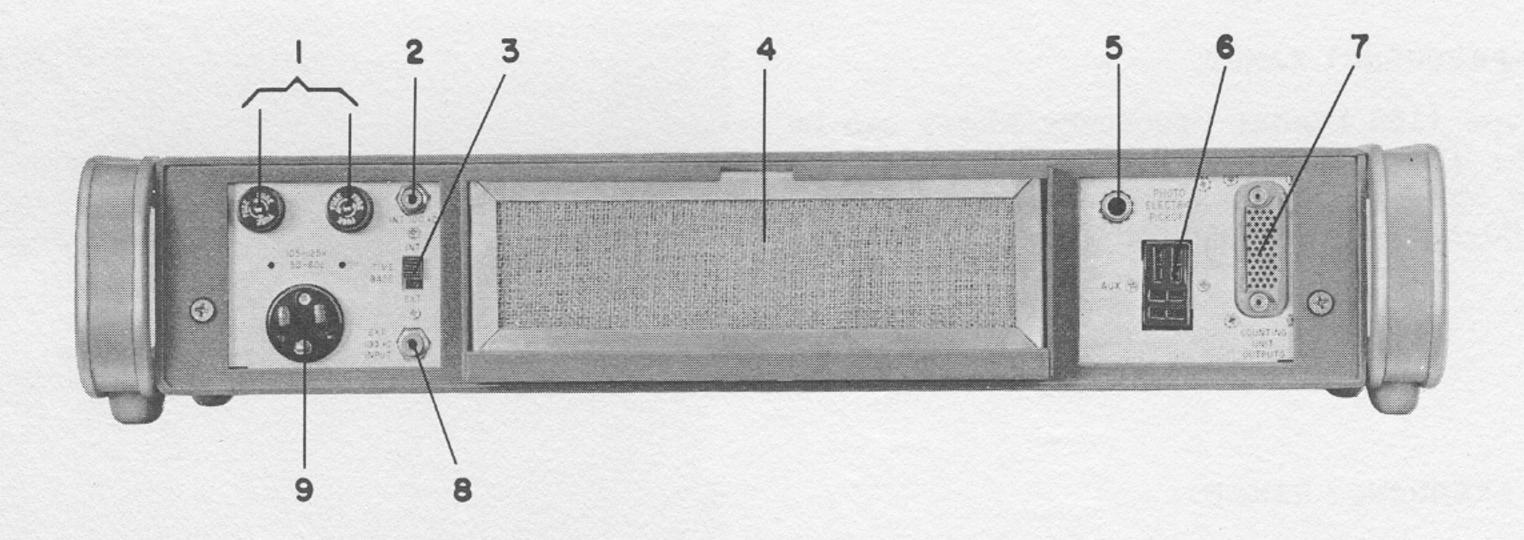
12 RESET

Momentary push-button switch. Terminates the display or counting interval in progress and starts a new counting interval.

13 POWER

Two-position toggle switch. Applies or interrupts the line voltage supplied to the instrument.

1.5 REAR, CONTROLS AND CONNECTORS



1 Line fuses Two1-A fuses for 115-V operation or two 0.5-A fuses for 215- or 230-V operation.

2 INT 100 kc	in jack. Internal 100-kc output from time-base oscillator (4v, p-to-p, bellind 2
	(Ω) .

- 3 TIME BASE Two-position slide switch. When set to INT, the time base is provided by the internal oscillator. When set to EXT, the time base is provided by an external 100kc signal applied to the EXT 100 kc INPUT jack. When no external time base is connected the slide switch should be set to INT. Operation without an external time base and with the switch set to EXT will yield incorrect results.
- 4 Air filter Cooling air inlet.
- 5 PHOTOELECTRIC Telephone jack. Provides connections to the internal +20 V and main INPUT ter-PICKOFF minals. For direct connection to an optical transducer such as the General Radio Type 1536-A Photoelectric Pickoff.
- 6 AUX Eight-contact Jones-type socket. For connection to auxiliary equipment.
- 7 COUNTING UNIT (Type 1153-AP only.) Fifty-two-contact socket. For connection to printer, digital-OUTPUTS to-analog converter, or other data processing equipment.
- 8 EXT 100 kc INPUT Pin jack. For connection of an external time-base signal; 100 kc/s at 1 V, p-to-p, minimum, or 200 kc/s at slightly higher input.
- 9 Power Three-pin connector. Accepts the Type CAP-22 Power Cord supplied. For connection to power line.

INTRODUCTION 3

1.6 SUPPLEMENTARY EQUIPMENT AVAILABLE

1.6.1 100 Mc/s FREQUENCY RANGE

The Type 1153 Digital Frequency Meter can be used with the Type 1156 Decade Scaler to extend the range to 100 Mc/s. The combination is known as the Type 1144 100-Mc Digital Frequency Meter.



1.6.2 500 Mc/s FREQUENCY RANGE

The Type 1153 Digital Frequency Meter can be used with the Type 1133 Frequency Converter to extend the range to 500 Mc/s. The combination is known as the Type 1143 Frequency Measuring Assembly.



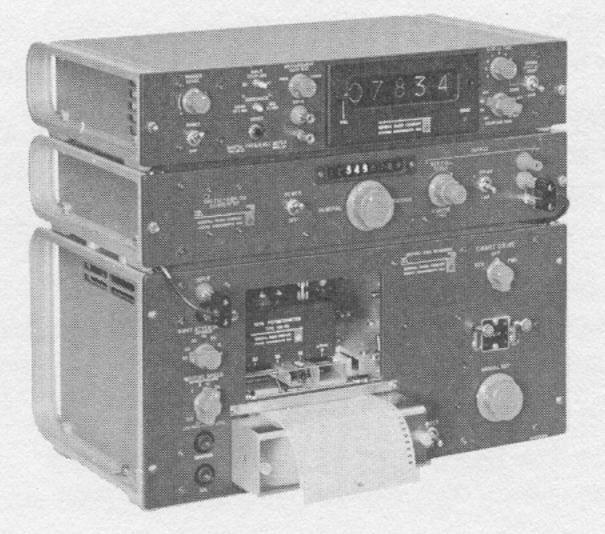
1.6.3 DIGITAL RECORDING

The Type 1153 Digital Frequency Meter, the Type 1144 100-Mc Digital Frequency Meter, or the Type 1143 Frequency Measuring Assembly can be used with the Type 1137 Data Printer to record data permanently in digital form.

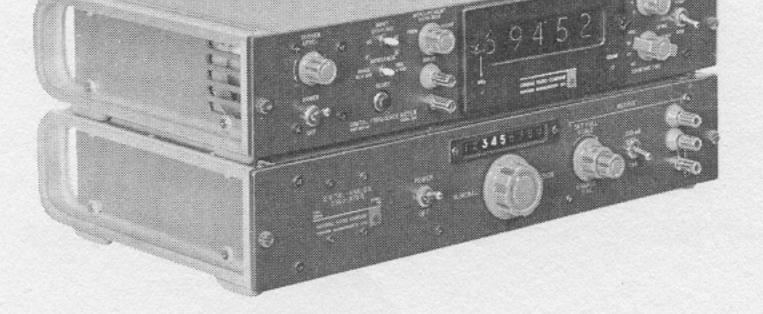


1.6.4 ANALOG RECORDING

The Type 1153 Digital Frequency Meter, the Type 1144 100-Mc Digital Frequency Meter, or the Type 1143 Frequency Measuring Assembly can be used with the Type 1510 Digital-to-Graphic Recording Assembly to record data permanently in analog form. The Type 1510 consists of a Type 1136 Digital-to-Analog Converter and a Type 1521 Graphic Level Recorder.



The Type 1153 Digital Frequency Meter, the Type 1144 100-Mc Digital Frequency Meter, or the Type 1143 Frequency Measuring Assembly can be used with the Type 1136 Digital-to-Analog Converter to convert data to analog form.





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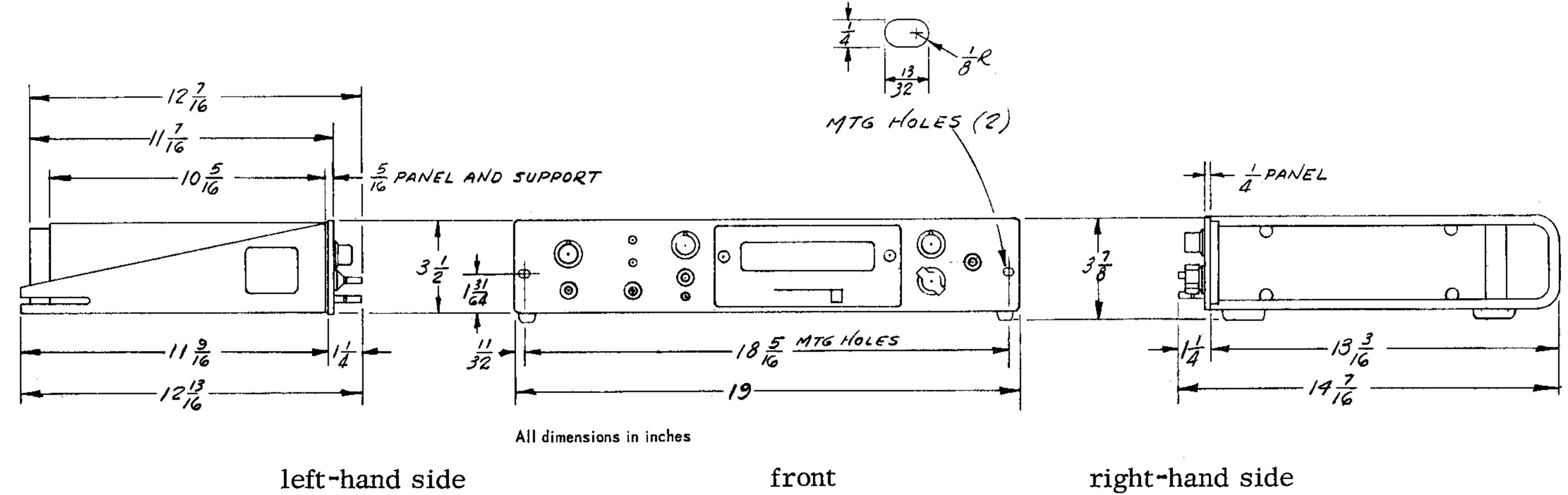
INSTALLATION

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• 2.1 DIMENSIONS



(rack mount)

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(bench mount)

• 2.2 VENTILATION

.

To cool the internal components, air is vented through an air filter at the rear of the instrument to an exhaust fan on the left-hand side. Mount the instrument so that the air flow is not blocked at either the filter or the exhaust port.

INSTALLATION 5

•

• 2.3 MOUNTING

CONVERSION SETS

2.3.1 BENCH/RACK CONVERSION

The Type 1153 Digital Frequency Meters are supplied in two models, bench mount and rack mount. Either model may be converted to the other by the installation of a simple conversion set.

Model	Use	Conversion Set
Bench	For bench mounting and stack mounting	7860-9602 rack support set, converts bench model to rack model
Rack	For rack mounting in standard 19-inch	5310-9822 end frame set,

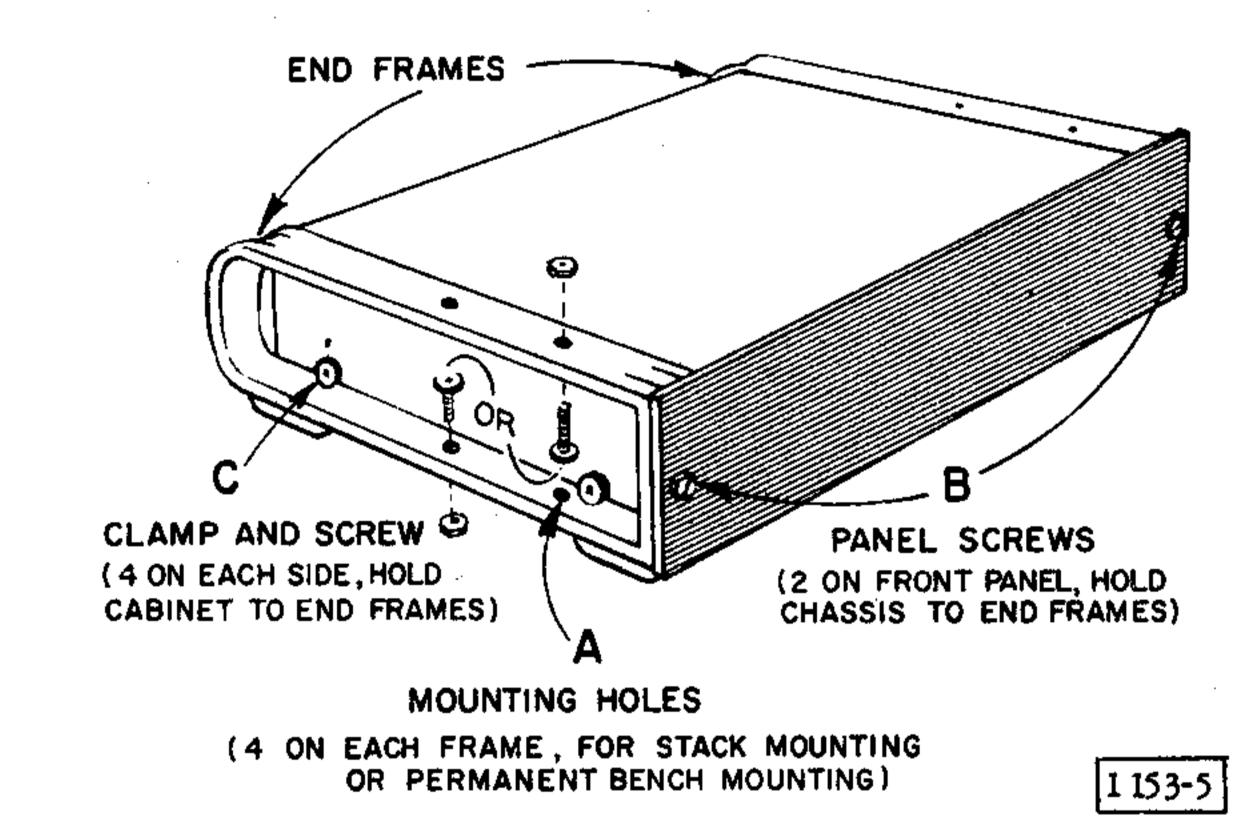
relay rack

bench model

2.3.2 BENCH MOUNTING (bench model)

The frequency meter normally rests on four rubber feet on top of a bench or shelf. However, holes (A) are provided in each end frame to allow it to be permanently mounted on top or under a bench or shelf.

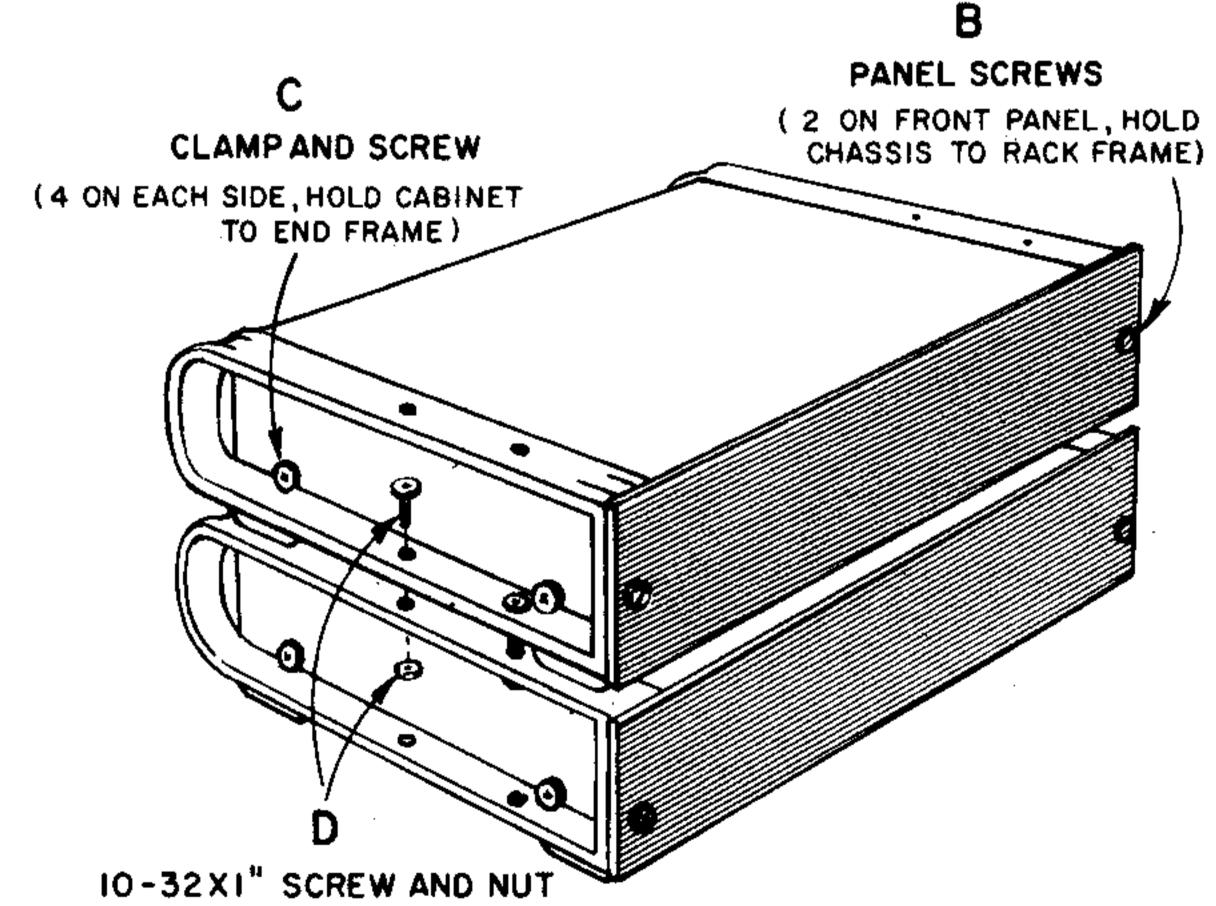
This type of mounting permits either the chassis or the cabinet to be withdrawn independently. To remove the chassis and leave the cabinet mounted, loosen the two panel screws (B) and slide the instrument forward out of the cabinet. To remove the cabinet and leave the chassis mounted, remove the eight clamps and screws (C) and pull the cabinet back off the chassis from the rear of the instrument.



2.3.3 STACK MOUNTING (bench model)

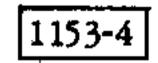
The frequency meter can be permanently assembled with another rack-bench instrument, such as the Type 1156 Decade Scaler or the Type 1133 Frequency Converter, by bolting the end frames together with four 10-32 x 1-inch screws and four 10-32 nuts.

This type of mounting permits the chassis of each instrument to be withdrawn independently. To remove the chassis, loosen the four panel screws (B) and slide the instrument forward out of the cabinet.



6 TYPE 1153-A DIGITAL FREQUENCY METER

(2 ON EACH END FRAME, HOLD END FRAMES TOGETHER)

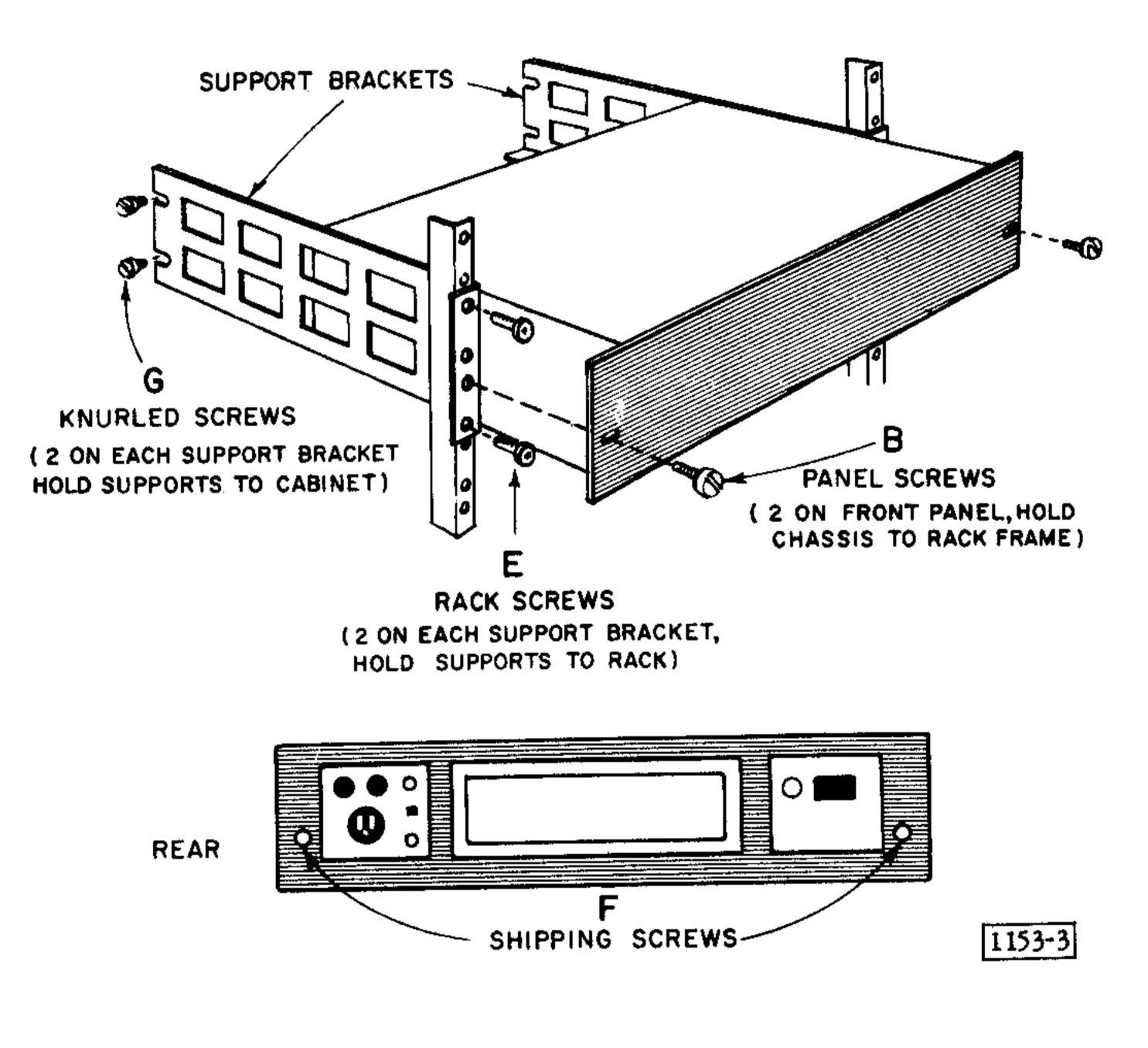


2.3.4 RACK MOUNTING (rack model)

To install the frequency meter in a relay rack, proceed as follows:

a. Attach each support bracket to the rack with two 10-24 binder-head rack screws (E). Use the inside holes on the brackets. Face the bracket lips in.

b. Slide the instrument into the brackets as far as it will go.



c. Insert the two panel screws with attached washers (B) through the front panel and support brackets and screw them into the rack. The washers are provided to protect the face of the instrument.

d. At the rear of the instrument, remove the two 10-32 binder-head shipping screws that hold the cabinet to the chassis. These are used only for shipment and can be discarded. Two of the four 10-32 knurled screws (G) can be used to secure the cabinet to the chassis, if necessary, for subsequent reshipments.

e. Insert the four knurled screws (G) through the slots in the rear of the support brackets and screw them into the cabinet.

This type of mounting permits either the cabinet or the chassis to be withdrawn independently. To remove the chassis and leave the cabinet mounted, loosen the four panel screws (B) and slide the instrument forward out of the rack. To remove the cabinet and leave the chassis mounted, remove the four knurled screws (G) and pull the cabinet back off the chassis from the rear of the rack.

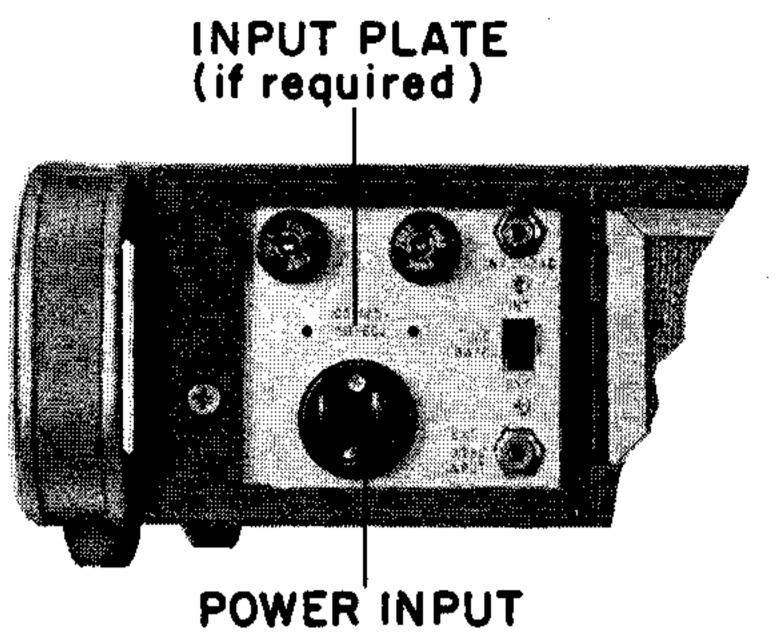
INSTALLATION 7

• 2.4 POWER CONNECTION

Use the Type CAP-22 Three-Wire Power Cord, provided, to connect the frequency meter to a source of power as indicated on the chassis over the power input connector. The long cylindrical pin (ground) is connected directly to the metal case of the instrument, and hence to the INPUT ground connector on the front panel.

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The power transformer is normally wired for 115volt operation but can be rewired for either 215-volt or 230-volt operation.



2.4.1 115-VOLT LINE

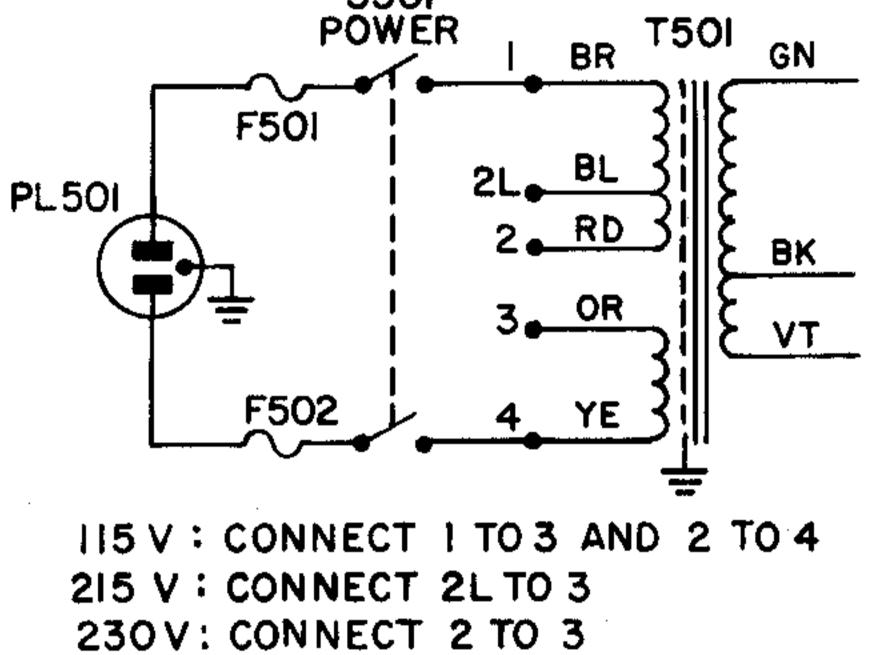
Power required is 105 to 125 V, 50 to 60 c/s, 70 W. No input plate is used, as the input-line voltage data is silkscreened on the rear of the instrument above the power input connector. On the power supply and oscillator etched board, terminal 1 is connected to terminal 3 and terminal 2 to terminal 4. Fuses for F501 and F502 are 1A, part number 5330-1400 each.

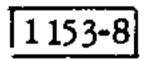
2.4.2 215-VOLT LINE

Power required is 195 to 235 V, 50 to 60 c/s, 70W. An input plate for 215-V operation is used, part number 5590-1668. It attaches to the rear of the instrument, above the power input connector, by means of two 4-40 x 3/16'' screws with attached lockwashers, part number 7090-4030, each. On the power supply and oscillator etched board, terminal 2L is connected to terminal 3. Fuses for F501 and F502 are 0.5A, part number 5330-1000 each.

CONNECTOR PL50

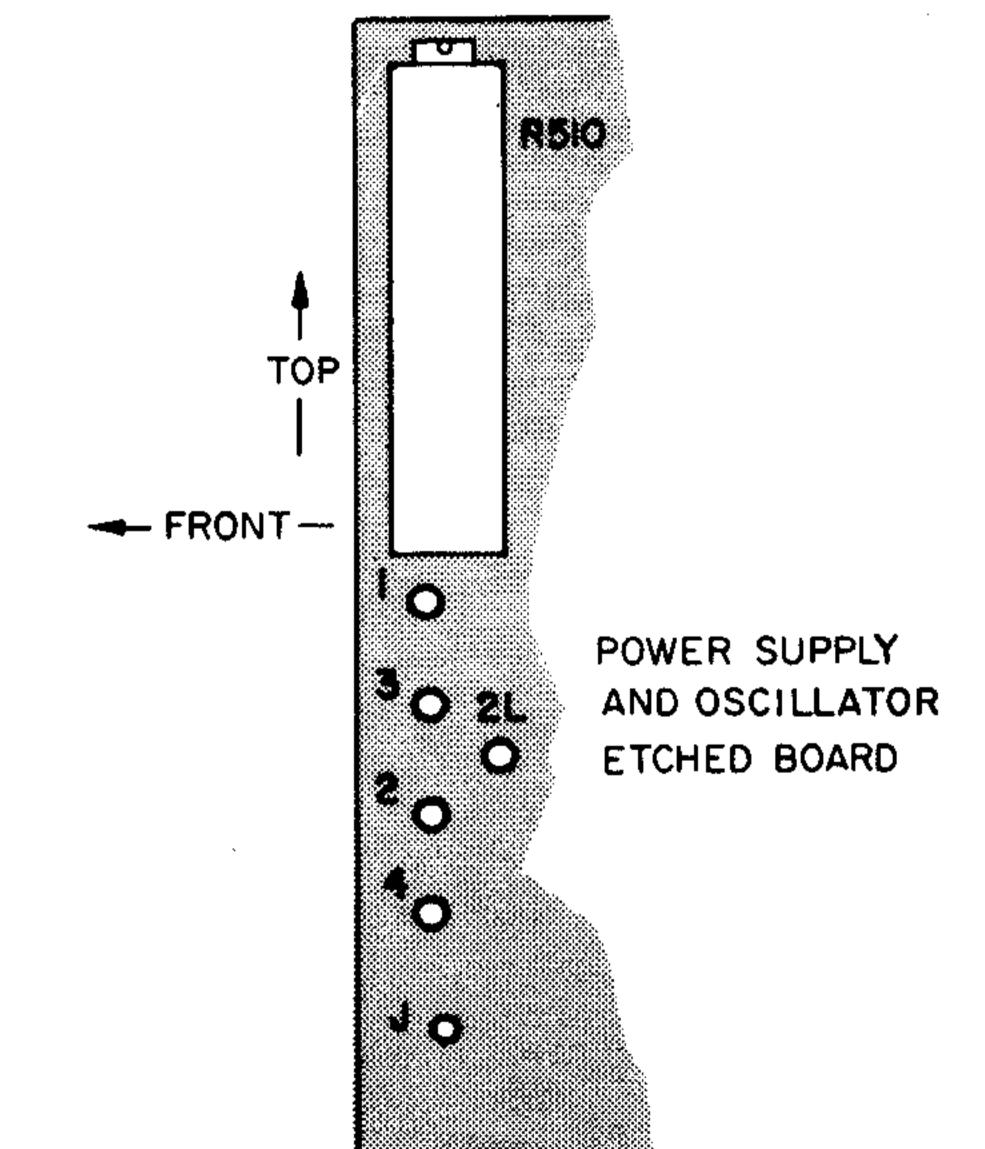
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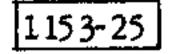


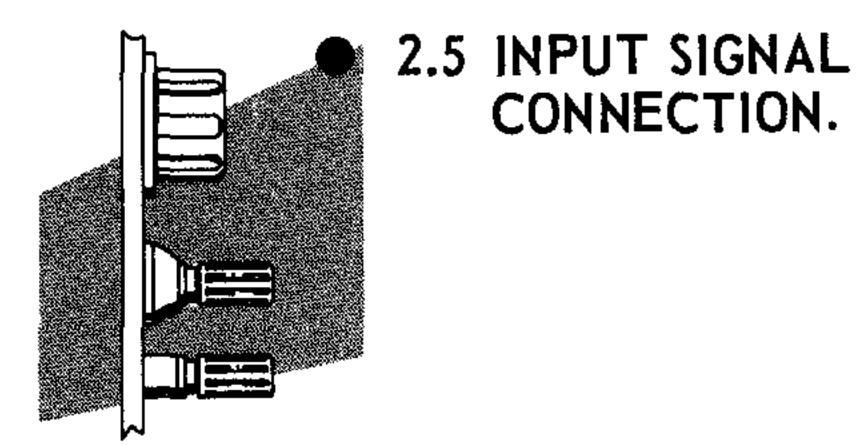
2.4.3 230-VOLT LINE

Power required is 210 to 250 V, 50 to 60 c/s, 70 W. An input plate for 230-V operation is used, part number 5590-1664. It attaches to the rear of the instrument, above the power input connector, by means of two 4-40 x 3/16'' screws with attached lockwashers, part number 7090-4030 each. On the power supply and oscillator etched board, connect terminal 2 to terminal 3. Fuses for F501 and F502 are 0.5A, part number 5330-1000



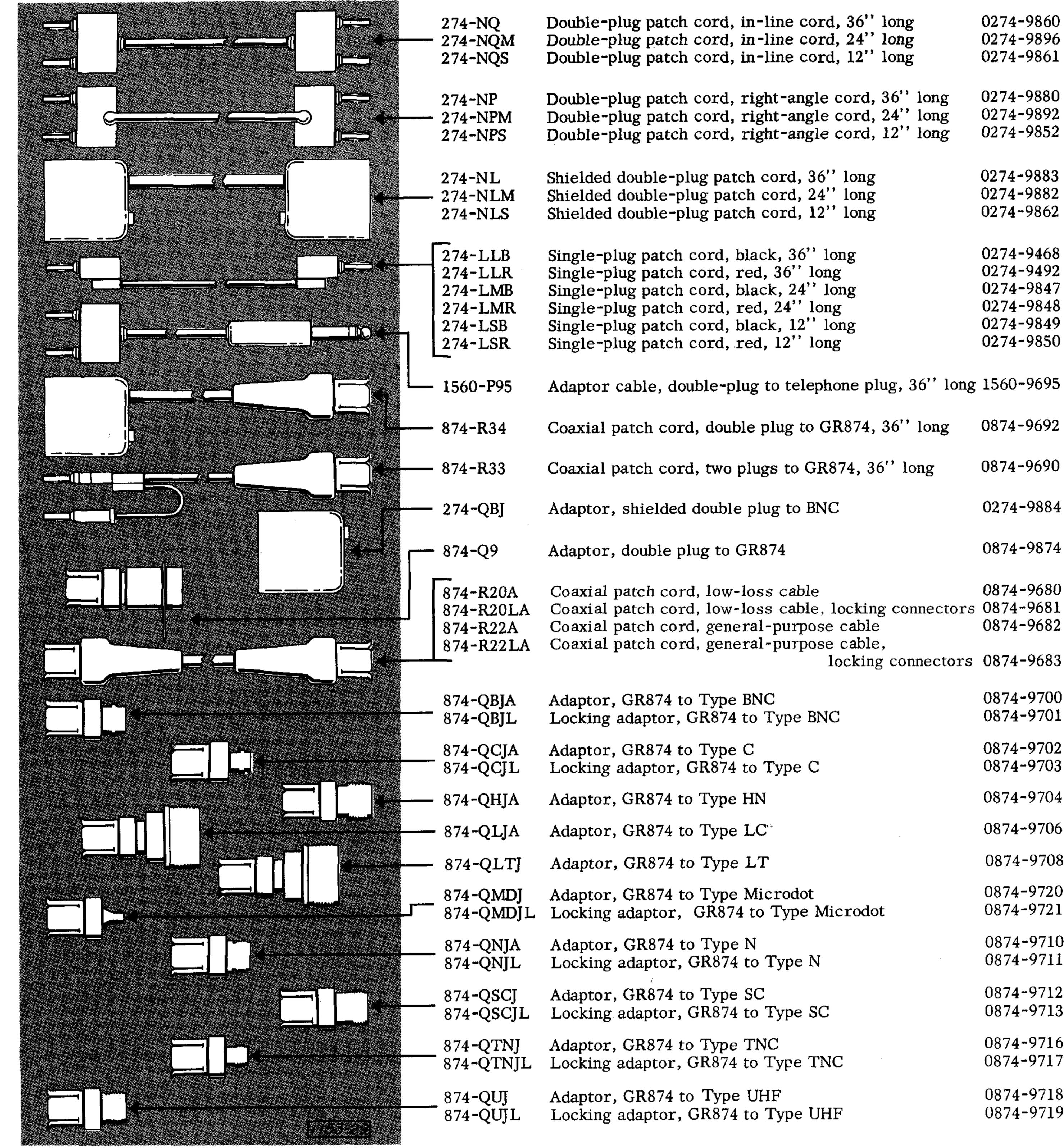
each.





The INPUT connectors are standard, ³/₄-inch-spaced binding posts which accept banana plugs, standard telephone tips, alligator clips, crocodile clips, spade terminals, and all wire sizes up to number 10. A wide variety of GR patch cords is also available, as well as a full line of adaptors to convert the INPUT terminals for use with most commercial and military coaxial connectors:

> NOTE: GR874 connectors are 50 Ω and are mechanically sexless, i.e., any two although identical, can be plugged together.



0274-9860 0274-9896 0274-9861

0274-9880 0274-9892

NPS	Double-plug patch cord, right-angle cord, 12'' long	0274-9852
IL ILM ILS	Shielded double-plug patch cord, 36'' long Shielded double-plug patch cord, 24'' long Shielded double-plug patch cord, 12'' long	0274-9883 0274-9882 0274-9862
LLR LMB LMR LSB LSR	Single-plug patch cord, black, 36'' long Single-plug patch cord, red, 36'' long Single-plug patch cord, black, 24'' long Single-plug patch cord, red, 24'' long Single-plug patch cord, black, 12'' long Single-plug patch cord, red, 12'' long	0274-9468 0274-9492 0274-9847 0274-9848 0274-9849 0274-9850
·P95	Adaptor cable, double-plug to telephone plug, 36'' long	; 1560 - 9695
R 34	Coaxial patch cord, double plug to GR874, 36'' long	0874-9692
\ 33	Coaxial patch cord, two plugs to GR874, 36'' long	0874-9690
QBJ	Adaptor, shielded double plug to BNC	0274-9884
29	Adaptor, double plug to GR874	0874-9874

0874-9712 0874-9713

0874-9680

0874-9681

0874-9682

0874-9700

0874-9701

0874-9702

0874-9703

0874-9704

0874-9706

0874-9708

0874-9720

0874-9721

0874-9710

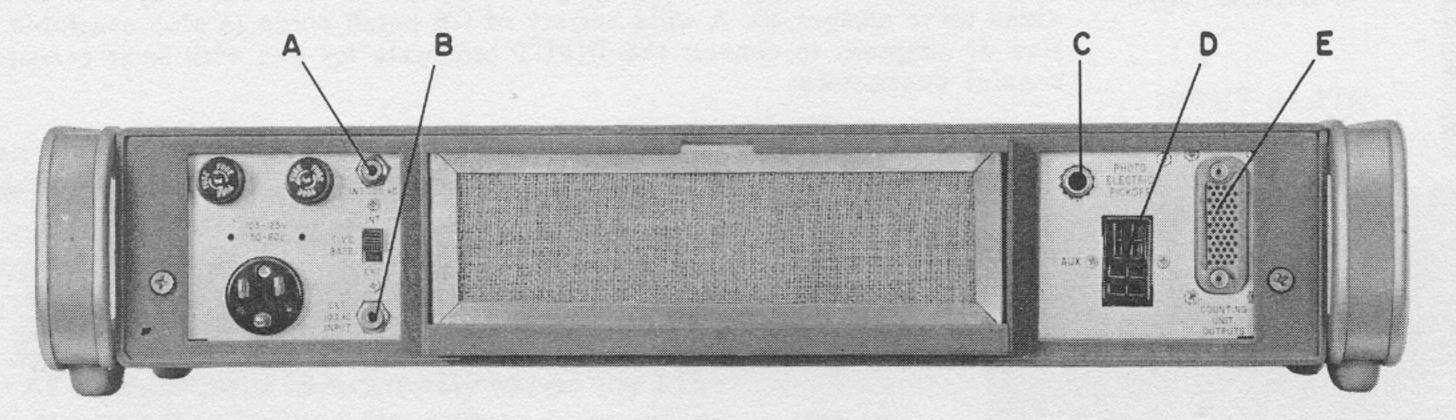
0874-9711

0874-9716 0874-9717

0874-9718 0874-9719

INSTALLATION 9

2.6 SUPPLEMENTARY CONNECTIONS



- Time-Base Output At the INT 100-kc phono jack on the rear of the instrument, 100 kc/s, 4V, p-to-p, be-A hind 2 kΩ, is available from the internal 100-kc oscillator for driving accessory equip-
- An external 100-kc or 200-kc signal can be used as a reference source in place of External Time-Base B the 100-kc signal from the crystal oscillator of the Type 1153. Apply the signal to Input the EXT 100 kc INPUT phono jack at the rear of the instrument and set the TIME BASE switch to EXT. The external 100-kc source should be capable of providing 1V, p-to-p, into $1 k\Omega$ (slightly higher voltage required at 200 kc/s).

ment.

C

D

E

only)

Printer/Converter

Pin

1

2

Signal

Ground

Photoelectric Pickoff The PHOTOELECTRIC connector is a 3-terminal telephone jack. One terminal is connected to +20V dc from the instrument's power supply and the other two terminals Input are connected in parallel with the INPUT terminals.

This jack is provided for direct connection to a General Radio Type 1536 Photoelectric Transducer. The transducer has a light source and a photoconductor which convert changes in reflection of the light source into electrical input signals. For instance, when the transducer is placed in the path of a piece of reflecting tape on a rotating object, with the COUNTING TIME switch set to 1 SEC, the frequency meter indicates revolutions per second. Since the photoelectric pickoff signal is in parallel with the INPUT terminals, no signal should be connected to the INPUT terminals.

An eight-contact, Jones-type socket (AUX) on the rear of the instrument is provided Connection (Type 1153 for connection to auxiliary equipment. It has the following characteristics:

Characteristic/Purpose

To ground of the external system.

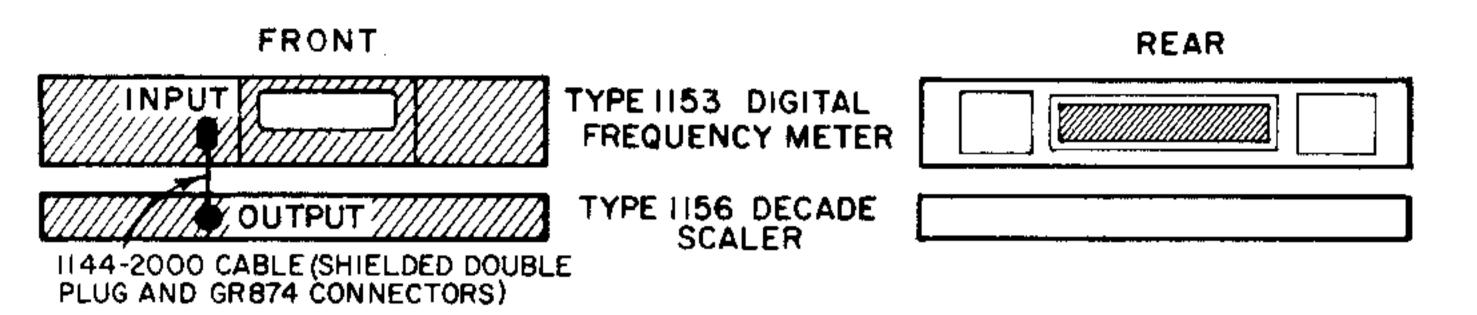
- To feed a reset signal from an external system into the Type 1153. The reset sig-Reset nal can be achieved by applying a negative-going pulse from a pulse generator or by momentarily grounding pin 2 through a switch.
- A negative 14-V pulse which represents the 9-to-0 transition in the last decade. 3 Carry It should be capacitively coupled, if used, as an overload can cause errors in the instrument operation and a direct short can cause permanent damage.
- A negative 20-V pulse which occurs when the counting gate closes. It will drive Print 4 Command a printer or a Type 1136 Digital-to-Analog Converter.
- A negative 20-V, 500-µs pulse which indicates the main gate will open in the next 5 Zero-Set 10 ms. It can be used to start auxiliary equipment and should be capacitively cou-Pulse pled.
- Electrically simulates COUNT/MULT INT switch operation. Set the COUNT/ Gate 6 MULT INT switch to STOP. Apply a positive, 20 to 30-V signal to pin 6 to open the gate (simulate START position of COUNT/MULT INT switch).
- 20 V Positive, regulated 20V; 100mA maximum. 7
- $100 \, \text{kc/s}$ 8

7-V, p-to-p, 100-kc square waves.

The 52-pin connector, labeled COUNTING UNIT OUTPUTS, on the rear of Type 1153-AP Auxiliary Equipment models, provides voltages necessary to drive a printer, converter, or other accessory equipment. The output consists of 10-line decimal information for each digit (one wire binary

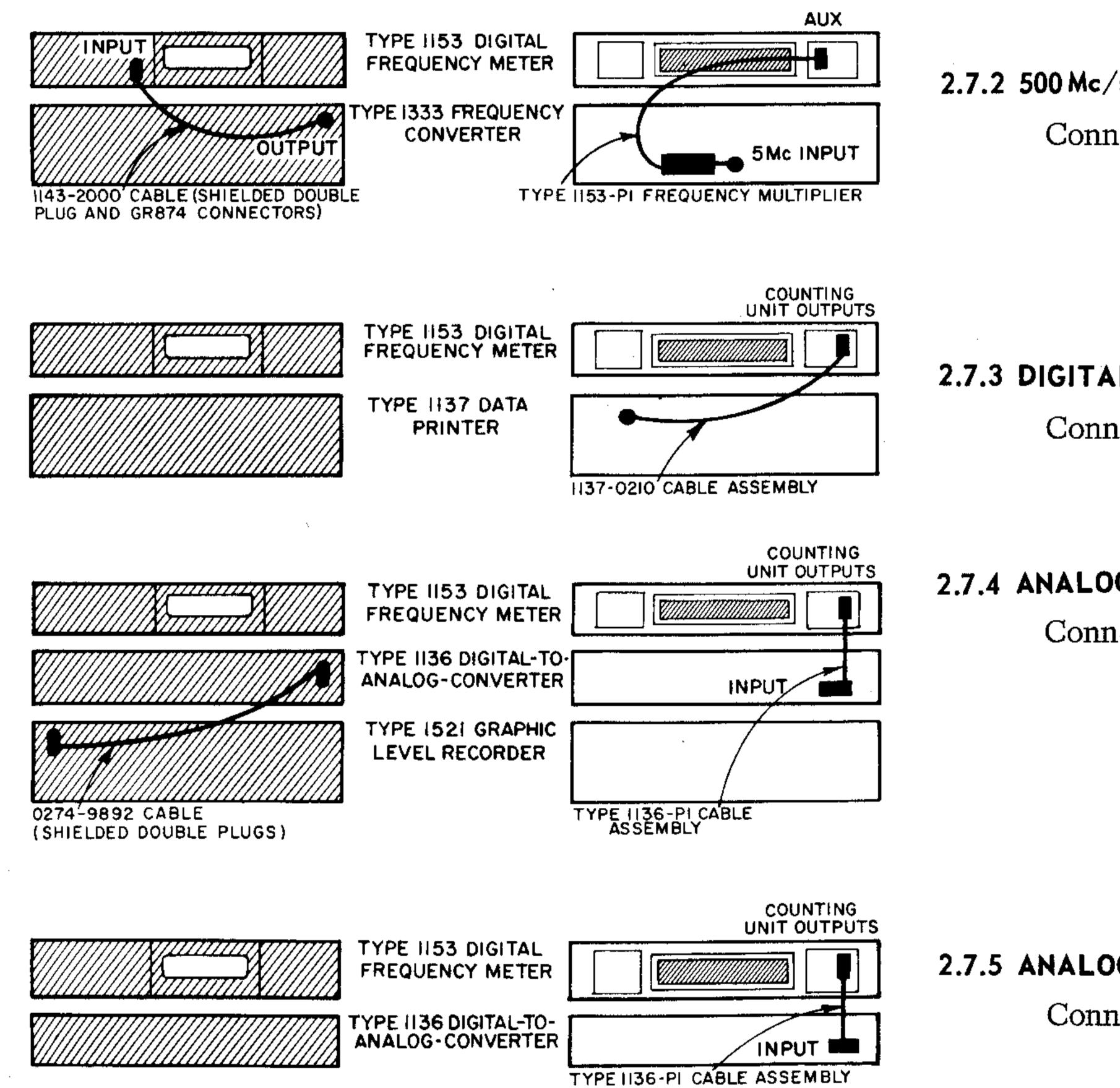
1 at a +14-V level and 9 wires binary 0 at a 0 to + 4-V level, each behind 2.4 k Ω), +20-V power, ground, and a print command pulse.

• 2.7 INTER-UNIT CONNECTIONS



2.7.1 100 Mc/s FREQUENCY RANGE

Connections to Type 1156 Decade Scaler



.

2.7.2 500 Mc/s FREQUENCY RANGE

Connections to Type 1133 Frequency Converter

2.7.3 DIGITAL RECORDING

Connections to Type 1137 Data Printer

2.7.4 ANALOG RECORDING

Connections to Type 1510 Digital-to-Graphic Recording Assembly or Type 1136 Digital-to-Analog Converter and Type 1521 Graphic Level Recorder

2.7.5 ANALOG OUTPUT

Connections to Type 1136 Digital-to-Analog Converter

.

.

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INSTALLATION 11

OPERATING PROCEDURE



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	Multiple Interval Technique					
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3.1 PRELIMINARY

Connect the instrument to a source of power and turn the POWER switch on. If the internal time-base is to be used, set the rear TIME BASE switch to INT. If an external time base is to be used, connect an external 100kc source to the rear EXT 100 kc INPUT connector and set the rear TIME BASE switch to EXT.

12 TYPE 1153-A DIGITAL FREQUENCY METER

SECTION 3

• 3.2 CHECK

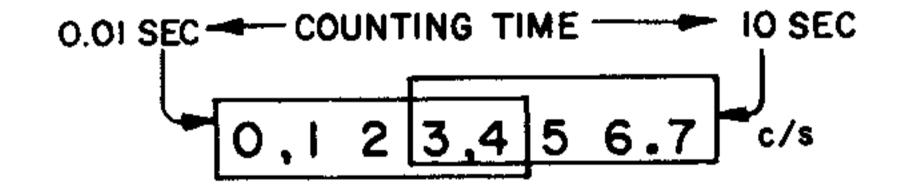
Set controls as follows

TRIGGER LEVEL. . . centered INPUT COUPLING. . AC IMPEDANCE . . . $100 \text{ k}\Omega$ MEASUREMENT . . 100 kc TEST DISPLAY TIME . . . 6 or 7COUNTING TIME . . . 0.1 SEC The instrument is now counting its own 100-kc time base for a tenth of a second and the display should read 100.00. With the COUNTING TIME switch set to 0.01 SEC the display should read 0.1000 and with it set to 1 SEC or 10 SEC the display should read 00000 and the SPILL lamp should be lit.

• 3.3 FREQUENCY MEASUREMENT

Set controls as follows:

TRIGGER LEVEL INPUT COUPLING . as required, see pages 15, 16. IMPEDANCE . . FREQUENCY



DISPLAY	TIME	0	٠	•	as	required
---------	------	---	---	---	----	----------

	-
Setting	Display Time
4	0.16 second
5	0.32
6	0.64
7	1.28
8	2.56
9	5.12
10	10.24
∞	Indefinitely or until
	RESET button is pushed.

COUNTING TIME. . .01 SEC

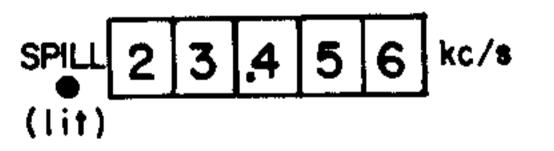
The self-check signal is removed from the IN-PUT terminals and the instrument is ready for frequency measurements of an external signal.

When the DISPLAY TIME switch is set to one of the numbered positions and the TRIGGER LEVEL control is properly set, the instrument will automatically measure the frequency, alternately counting (COUNT lamp lit) and displaying (indicators lit). The COUNTING TIME switch has the effect of windowing the display from the five most significant figures to the five least significant figures: For example: Assume the frequency of the input signal is 123,456.7 cycles per second.

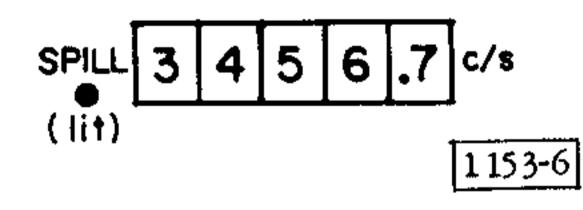
SPILL 0 1 2 3 4 Mc/s (out)

.01 SEC COUNTING TIME. Frequency is measured to a precision of 100 c/s.

SPILL 1 2 3 4 5 kc/s o (out) 0.1 SEC COUNTING TIME. Frequency is measured to a precision of 10 c/s.



1 SEC COUNTING TIME, Frequency is measured to a precision of 1 c/s.



10 SEC COUNTING TIME. Frequency is measured to a precision of .1 c/s.

Thus, the frequency of any input signal from dc to 10 Mc/s can be measured to a precision of 0.1 c/s.

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• 3.4 CUMULATIVE-COUNT MEASUREMENT (operation as a totalizer)

.

Set controls as follows:

TRIGGER LEVEL INPUT COUPLING IMPEDANCE MEASUREMENT . . COUNT DISPLAY TIME . . any position, 0 through ∞ COUNT/MULT INT . . START

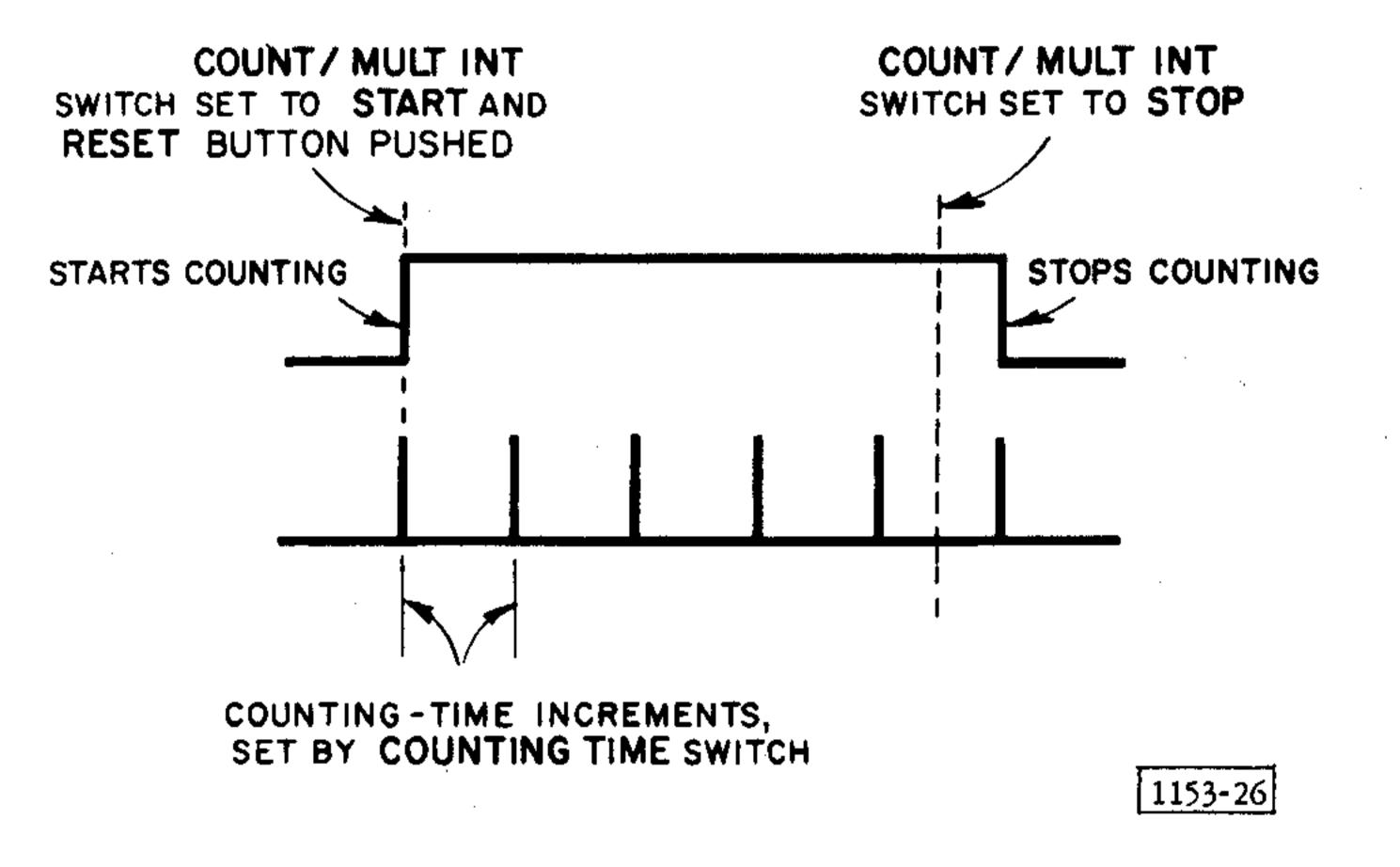
The COUNT/MULT INT switch now controls the counting time; in the START position the instrument counts and in the STOP position it does not count. The count, accumulated during the time the COUNT/MULT INT switch is in the START position, remains on the visual register until the RESET button is pushed.

The function of the COUNT/MULT INT switch can be remote-controlled through the auxiliary connector (AUX, SO801 pin 6) on the rear panel. Refer to page 10 for further details.

• 3.5 MULTIPLE-INTERVAL TECHNIQUE (increases measurement precision)

Frequency measurements and cumulative-count measurements can be made by use of the multiple-interval technique which provides greater measurement precisions than are possible with the longest, normal counting time of 10 seconds. This technique allows the counting time to be set for any duration desired, in increments determined by the COUNTING TIME switch. The counting time can be set for 100 seconds, for instance, which would yield a precision of 0.01 c/s, an order of magnitude better than the normal 0.1 c/s.

For example, a 10-second measurement of a particular frequency is not sufficiently accurate and a 50second measurement is desired. Set all controls as they would be in a normal frequency measurement. Then set the DISPLAY TIME control to MULT INT, the COUNTING TIME control to 10 SEC and the COUNT/MULT INT switch to START. Push the RESET button to start the count, wait a little over 40 seconds, and then set the COUNT/MULT INT switch to STOP, the count will stop



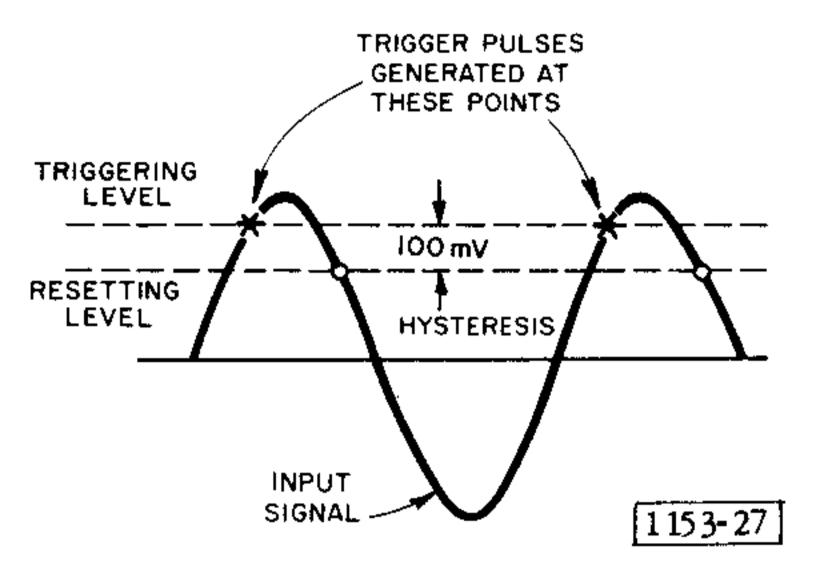
In principle, the counting-time increments can be 0.01, 0.1, 1, or 10 seconds. In practice, since the technique involves manual operation of the COUNT/MULT INT switch, the shortest possible increment is one second and the most practical increment is 10 seconds.

at a counting time of 50 seconds and will be displayed on the visual register indefinitely or until the RESET button is pushed.

• 3.6 NOISE AND WAVEFORM CONSIDERATIONS

3.6.1 TRIGGER CIRCUIT

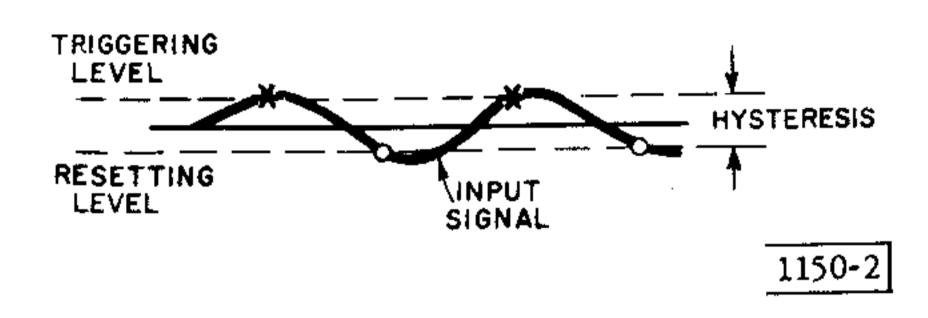
The trigger circuit consists of two, dc-coupled, differential amplifiers cascaded to a tunnel diode. This circuit is very similar to the well-known Schmitt circuit and exhibits the hysteresis effect. That is, after the circuit has triggered to form a counted pulse on a positive-going transition of the input signal, the input signal must then swing to a less positive level to reset the circuit. The hysteresis in the Type 1153 is approximately 100 mV.



3.6.2 TRIGGER SENSITIVITY

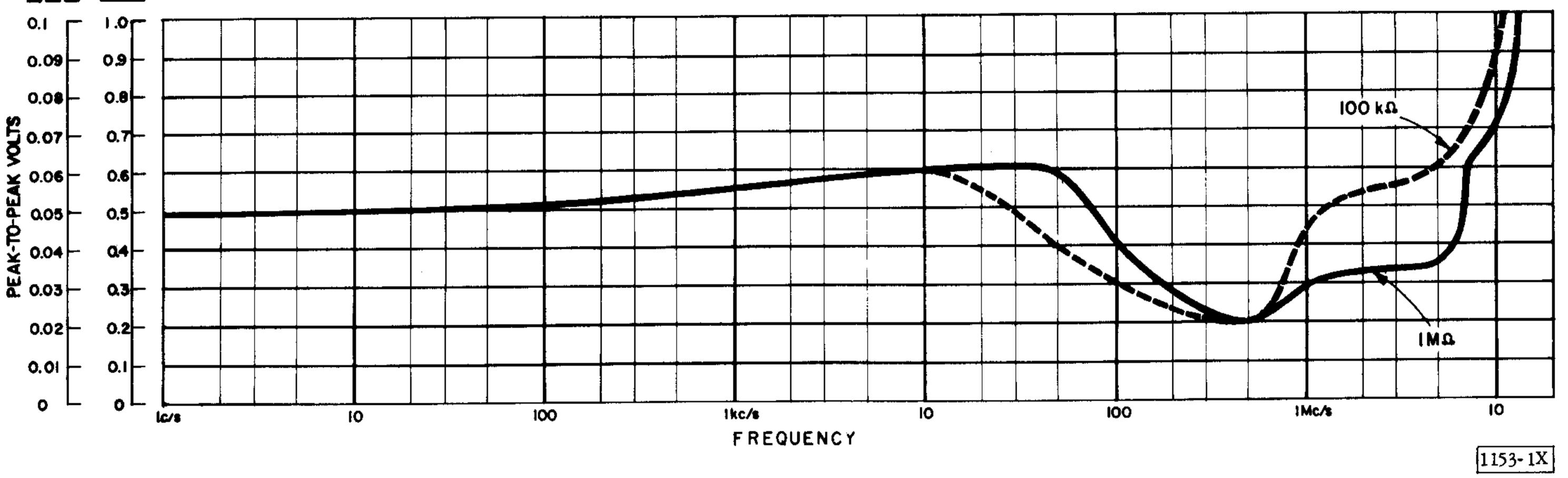
100 kΩ IMΩ

The input sensitivity of the instrument is determined by the trigger circuit's hysteresis voltage. This voltage varies to some extent with frequency and varies directly with input attenuation (IMPEDANCE switch setting).



Minimum input signal required to drive counter.

Hysteresis voltage variation with frequency and input attenuation.



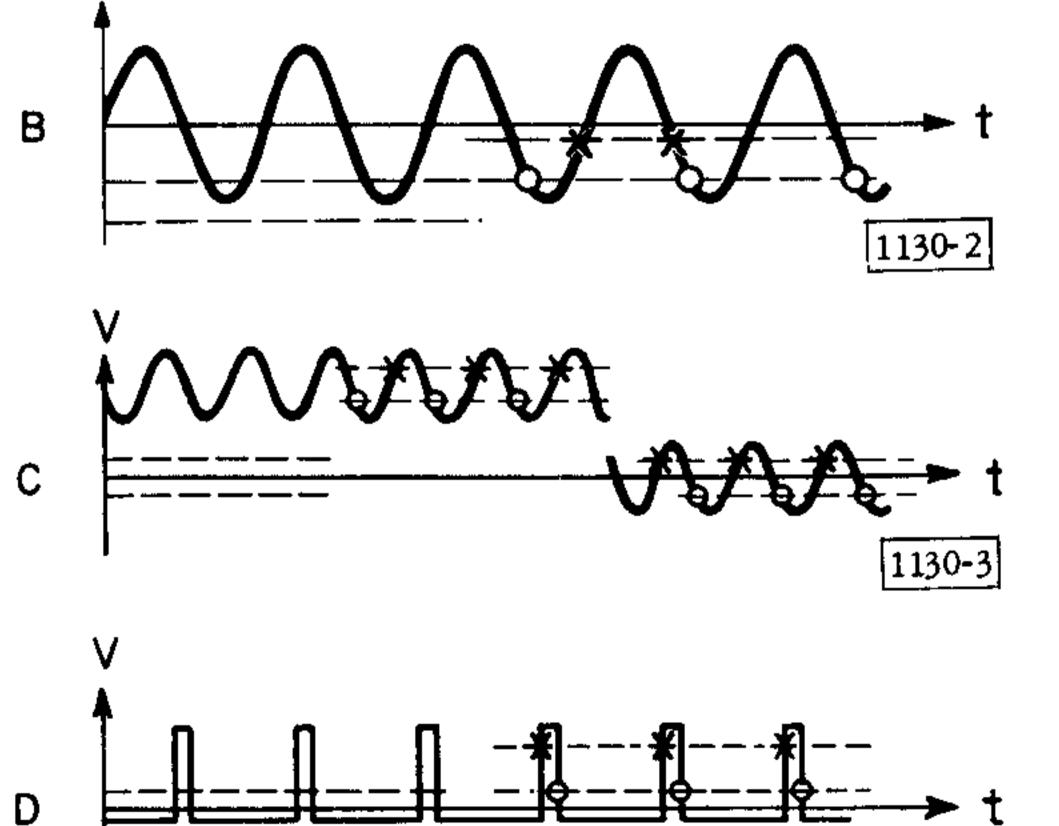
Ε

3.6.3 INPUT CONTROLS

Low-duty-ratio, ac-coupled signals or non sym- B metrical (about 0 volts) dc-coupled signals require a trigger level that is offset from 0 volts. The TRIGGER LEVEL control provides this offset and allows adjustment of the trigger level from +10 to -10 volts with a $1-M\Omega$ input impedance and from +1 to -1 volt with a 100k Ω input impedance.

Some of the characteristic input-signal problems and their solutions by correct use of the input controls are shown in the adjacent figures.

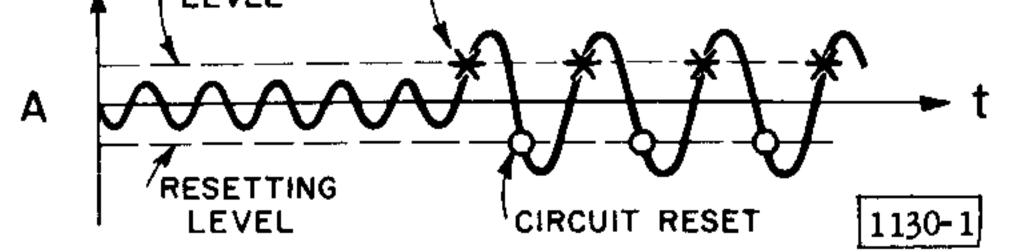
V TRIGGER TRIGGER PULSE GENERATED



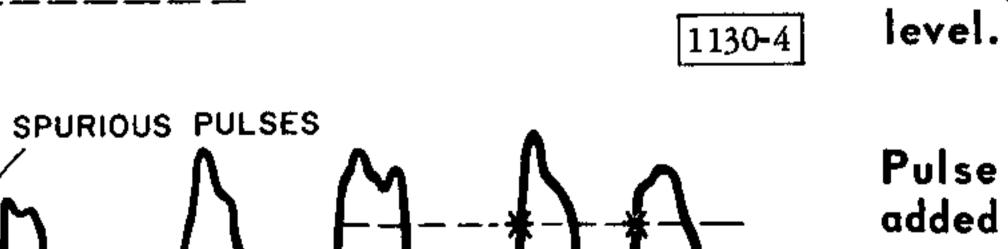
Too large a negative offset of the TRIGGER LEVEL control. Corrected by reducing offset.

DC component of signal lifts ac component out of triggering region. Corrected either by raising triggering level or by setting SLOPE control to AC.

Low duty-ratio pulse signal. Corrected by raising triggering



Signal too small; must be increased



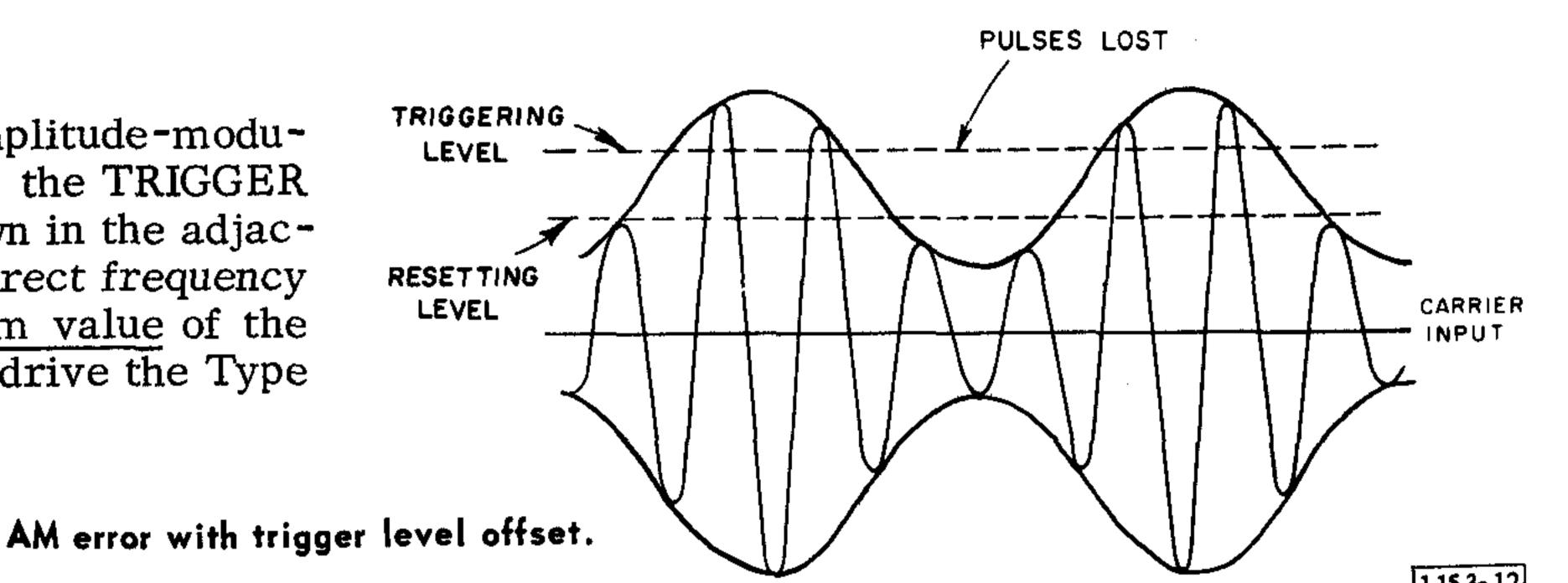
Pulse signal with added noise. Corrected by setting triggering level to region of steepest slope.

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3.6.4 AMPLITUDE MODULATION ERRORS

If the signal to be measured is amplitude-modulated, measurement errors may occur if the TRIGGER LEVEL control is offset from 0 as shown in the adjacent figure. With the control at 0, the correct frequency will be measured as long as the minimum value of the signal is greater than that necessary to drive the Type 1153.



3.6.5 EXCESSIVE INPUT-FREQUENCY ERRORS

The Digital Time and Frequency Meter measures the average value of an unknown frequency during the chosen counting interval, as long as the frequency remains within the resolution capability of the instrument. If the unknown frequency exceeds 10 Mc/s, counts may be missed and the measurement may be in error.

Conditions for measuring a signal in the presence

3.6.6 SPURIOUS SIGNAL AND NOISE ERRORS

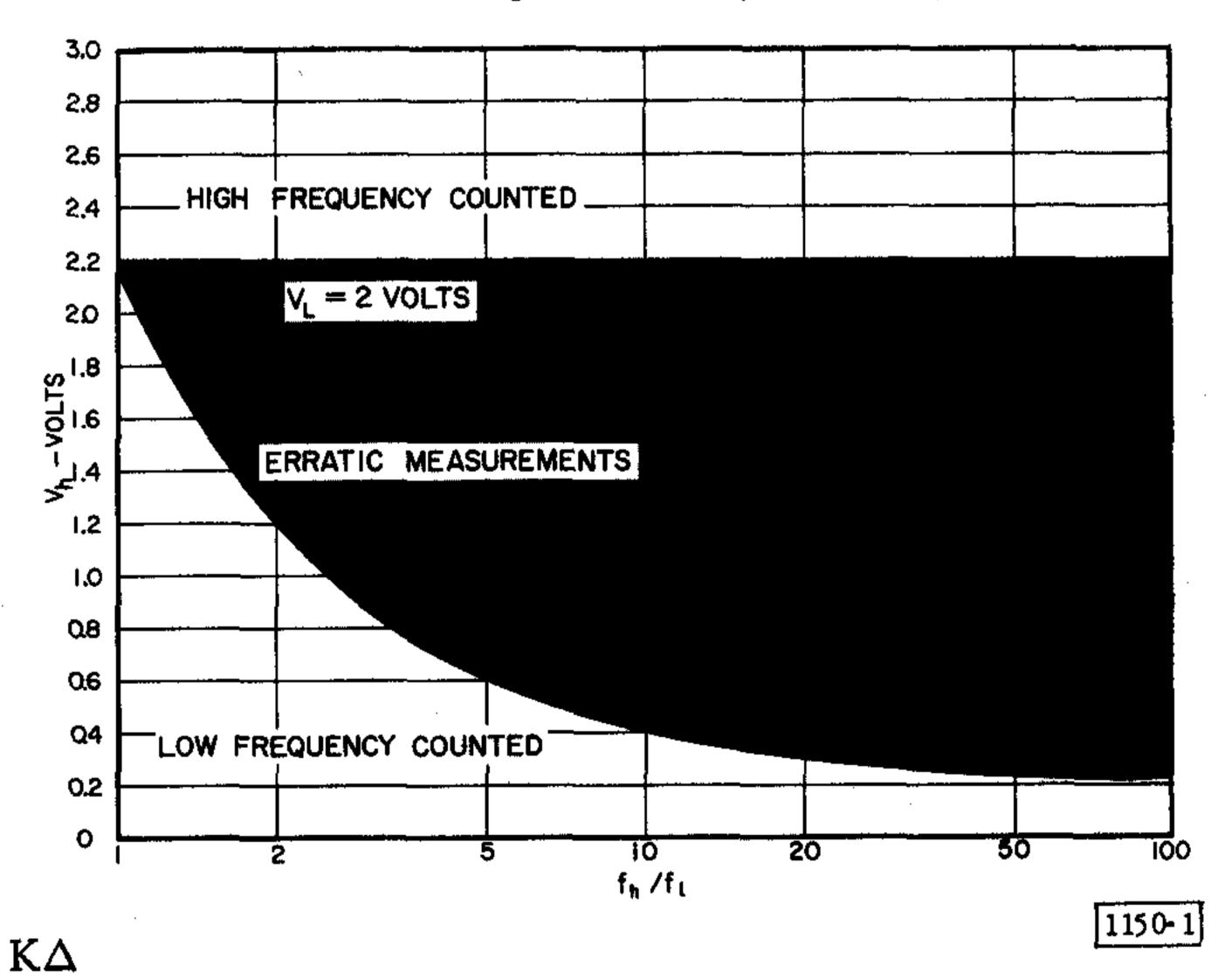
If the desired signal is accompanied by enough noise to cause extra transitions of the hysteresis region, false counts will be registered. To combat this error, adjust the TRIGGER LEVEL control to the region of steepest slope or attenuate both the signal and noise.

Occasionally it is necessary to measure the frequency of a signal in the presence of another signal of nearly equal amplitude. A capture effect exists in the Type 1153, similar to that encountered in frequencymodulation receivers. If the two signals, are nearly equal in frequency, the instrument measures the signal with the larger amplitude if its peak-to-peak amplitude exceeds that of the other signal by the hysteresis voltage of the Type 1153. If the signals differ in frequency the following relationships apply:

Type 1153 measures the higher frequency if $V_h > V_{\rho} + \Delta$

Type 1153 measures the lower frequency if $V_h < \frac{f_l}{f_1} + K\Delta$





Where V_h = peak-to-peak amplitude of higher frequency signal

V = peak-to-peak amplitude of lower frequency signal

-h

 $f_h = higher frequency$

- f_l = lower frequency
- Δ = hysteresis voltage of counter

K = a factor varying between 1 and 2

If neither condition is satisfied, the instrument will give erroneous readings. These conditions are illustrated in the adjacent figure.



3.7.1 GENERAL

There are two fundamental sources of error:

NOISE: Noise may be caused by drift, hum pickup, the input signal itself, or the triggering level. Its effects are discussed in the preceeding paragraphs (Spurious

Signal and Noise Errors).

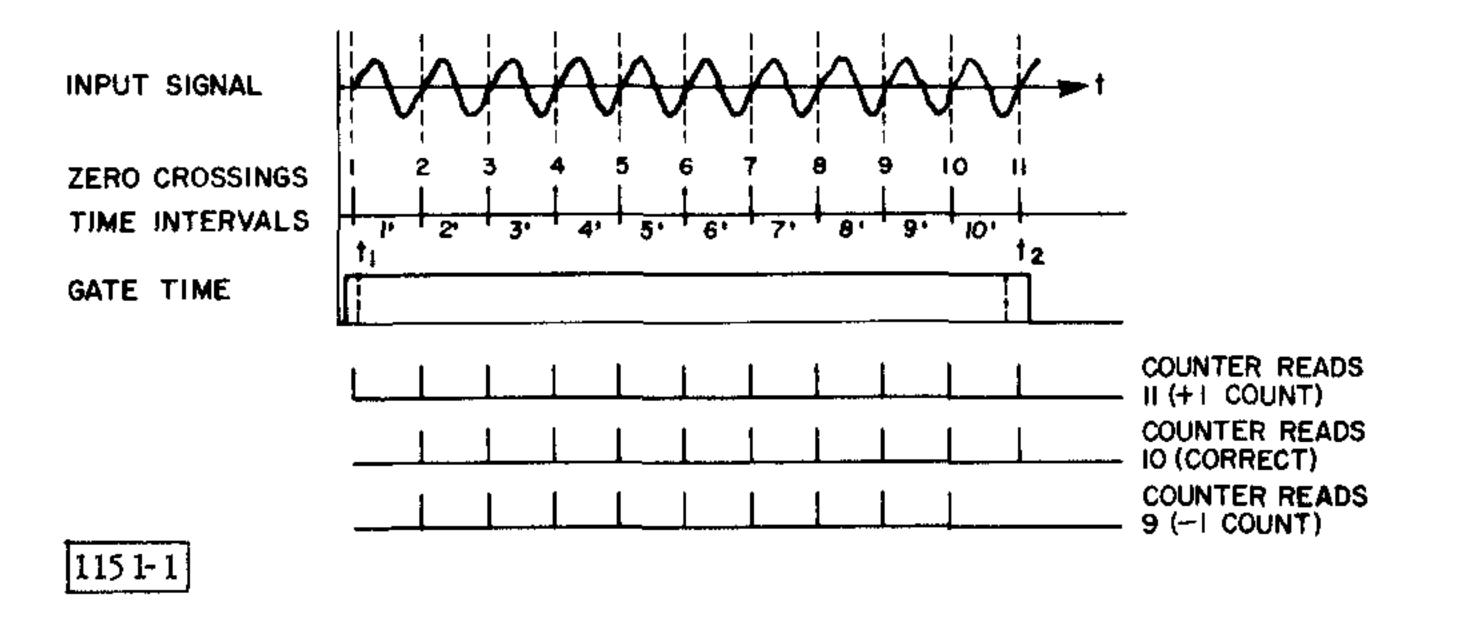
±1COUNT UNCERTAINTY: This uncertainty occurs through the gating process and is explained below.

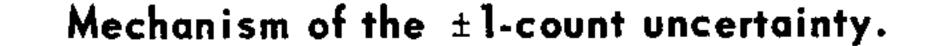
3.7.2 ±1 COUNT UNCERTAINTY

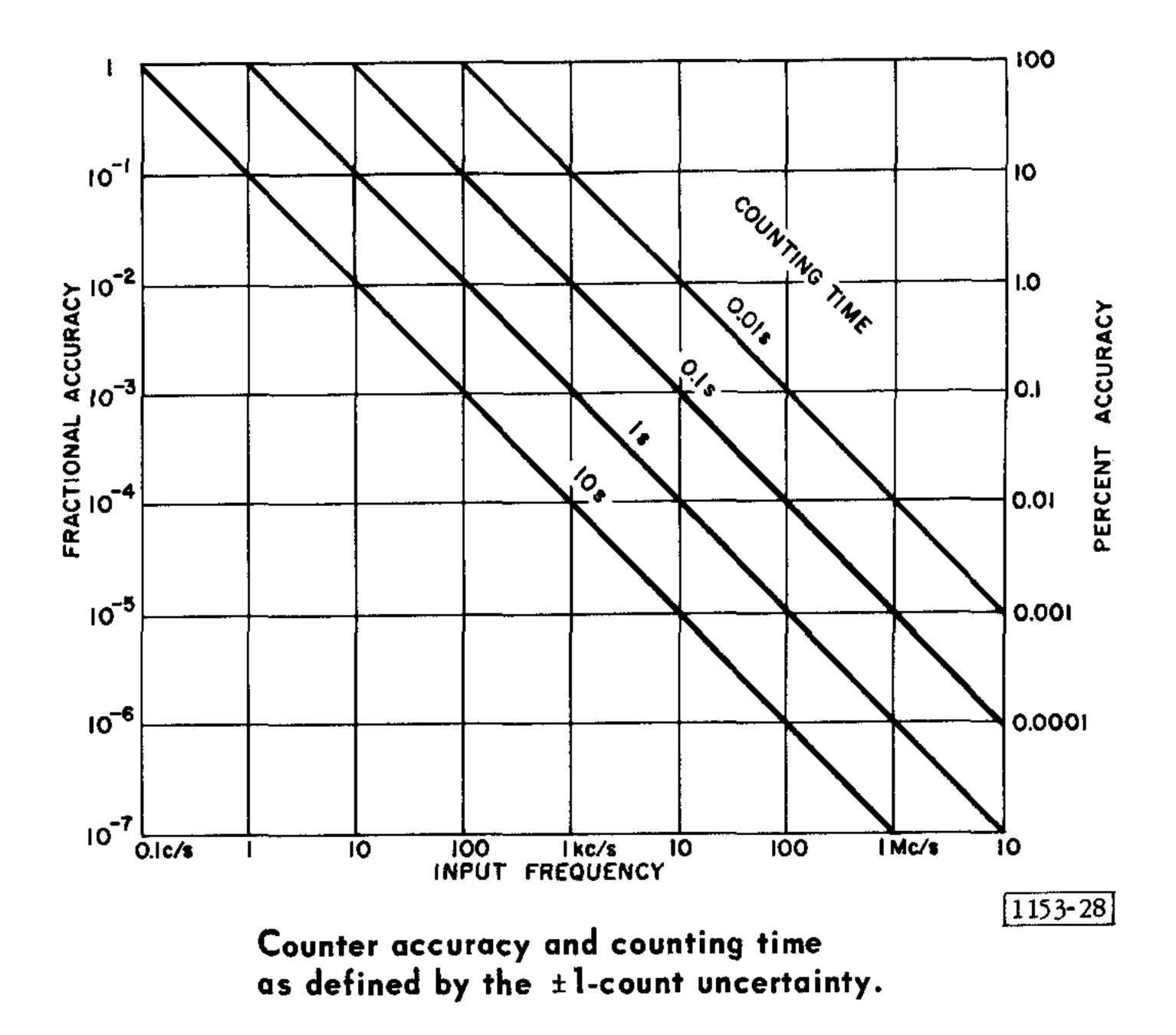
In all digital counters, frequency is measured in terms of <u>pulses</u> representing the signal zero crossings within an accurately established time interval. What we would <u>like</u> to measure to define the frequency would be the precise number of <u>time intervals</u> representative of the unknown frequency that occur within an accurate interval, but this is not possible. The conditions for a +1 count, an accurate measurement, and a -1 count are shown in the upper figure. Note that we assume that the pulses representative of the input signal are infinitely brief and that the gate is infinitely fast. Pulse duration and gating time <u>do not cause</u> the \pm 1-count error.

In the upper figure an input signal of 10 units of frequency with respect to the gate is used. The important quantity in the measurement is the 10 time intervals. 1' through 10'. Suppose that the gate opens just before pulse number 1. The counter's register accumulates a count and indicates 1, but no time interval has elapsed. If the gate then closes just after the llth pulse the register reads 11, representative of only 10 units. If the gate opens a very small amount of time (t_1) later, the first pulse is not counted and the register indicates the nearly correct value of 10. If the duration of the gate is shortened again by a very small time increment, t₂, the 11th pulse is not counted and the register reads only 9. The ±1-count error is, therefore, an inescapable result of trying to measure time intervals with pulses representing their beginnings and ends. The lower figure shows how the ±1-count error affects measurement accuracy. The longer one counts, the more accurate the measurement will be, since more and more pulses are accumulated, with the ± 1 -count error constant. Thus at 1 kc/s, for instance, the error will be 10% for a 0.01-second gate and only 0.01% for a 10-second gate.

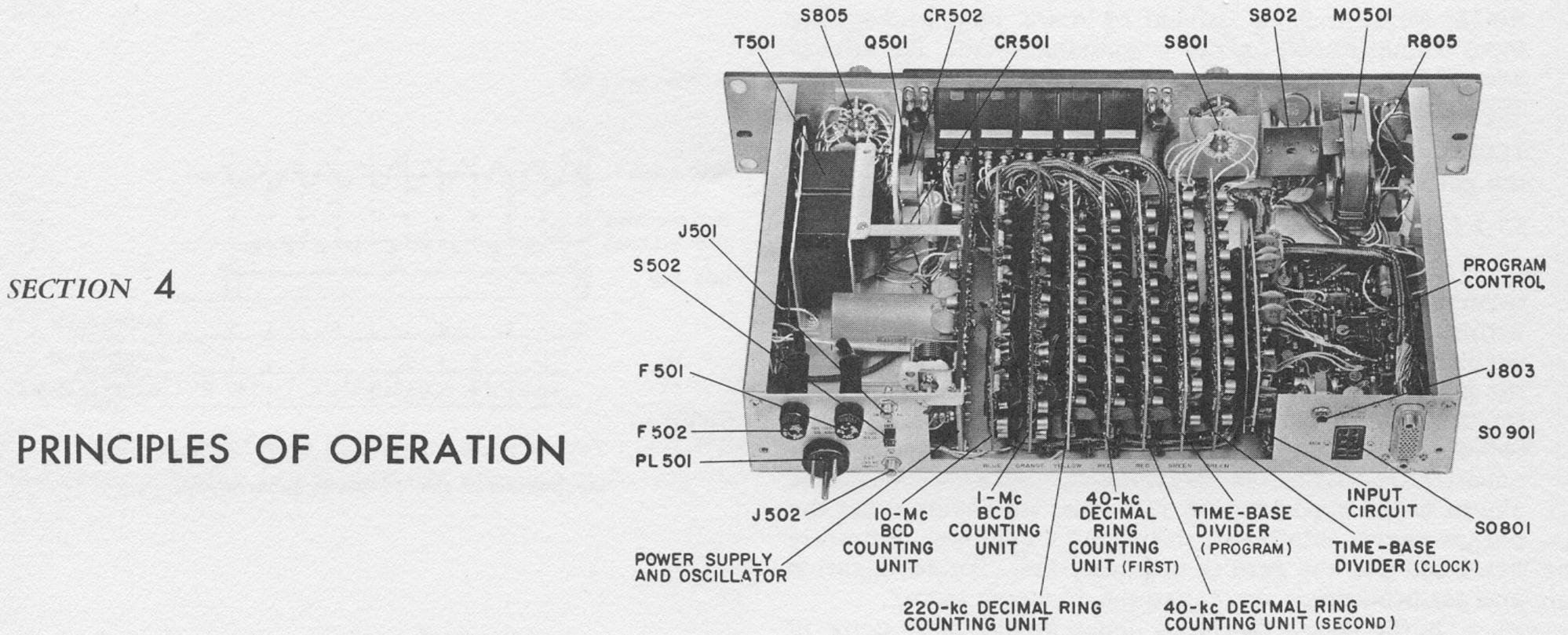
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PRINCIPLES OF OPERATION

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	Program Control									
	Power Supply									

Information on the input triggering circuit is contained in Section 3, page 15.

4.1 GENERAL 0

The Type 1153 consists of four main circuit groups:

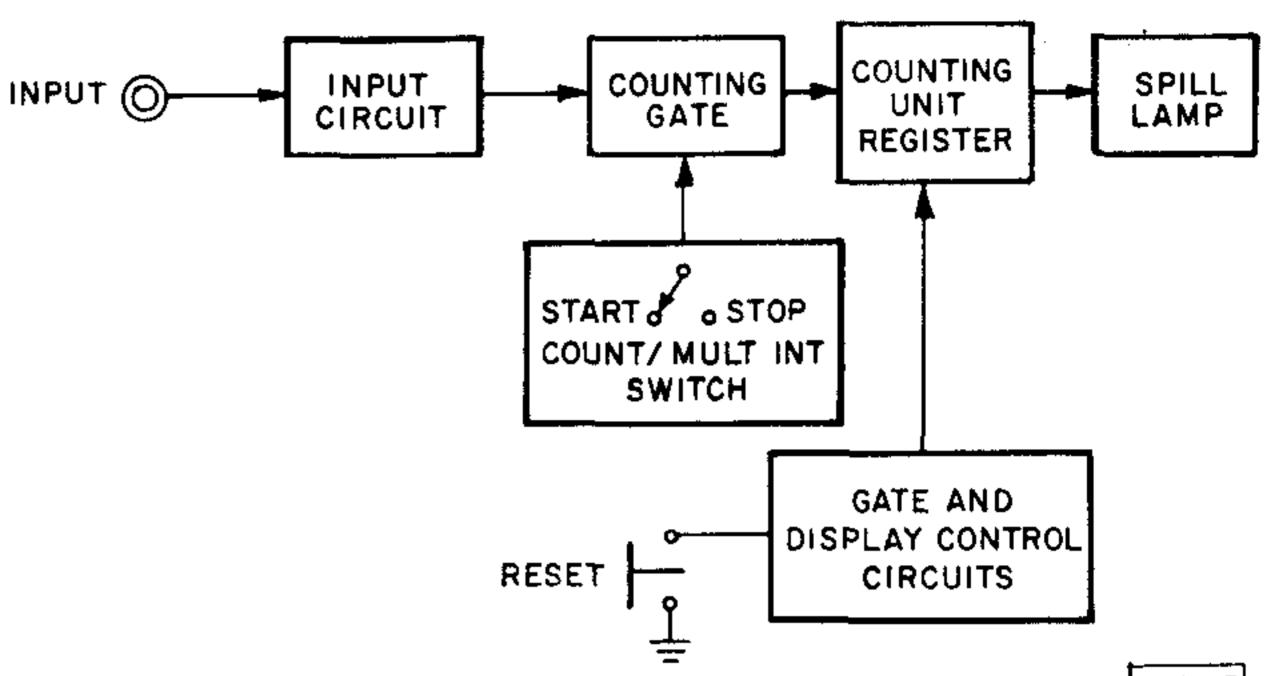
Oscillator circuit and its associated time-base divider (clock scaler). (1.)(2)Input circuit.

(3.)Counting circuits (one 10-Mc and one 1-Mc Decimal Counting Unit and two 220-kc and two 40-kc Decimal Ring Counting Units).

Display control and its associated time-base divider (program scaler). (4.)

4.2 COUNT MEASUREMENT

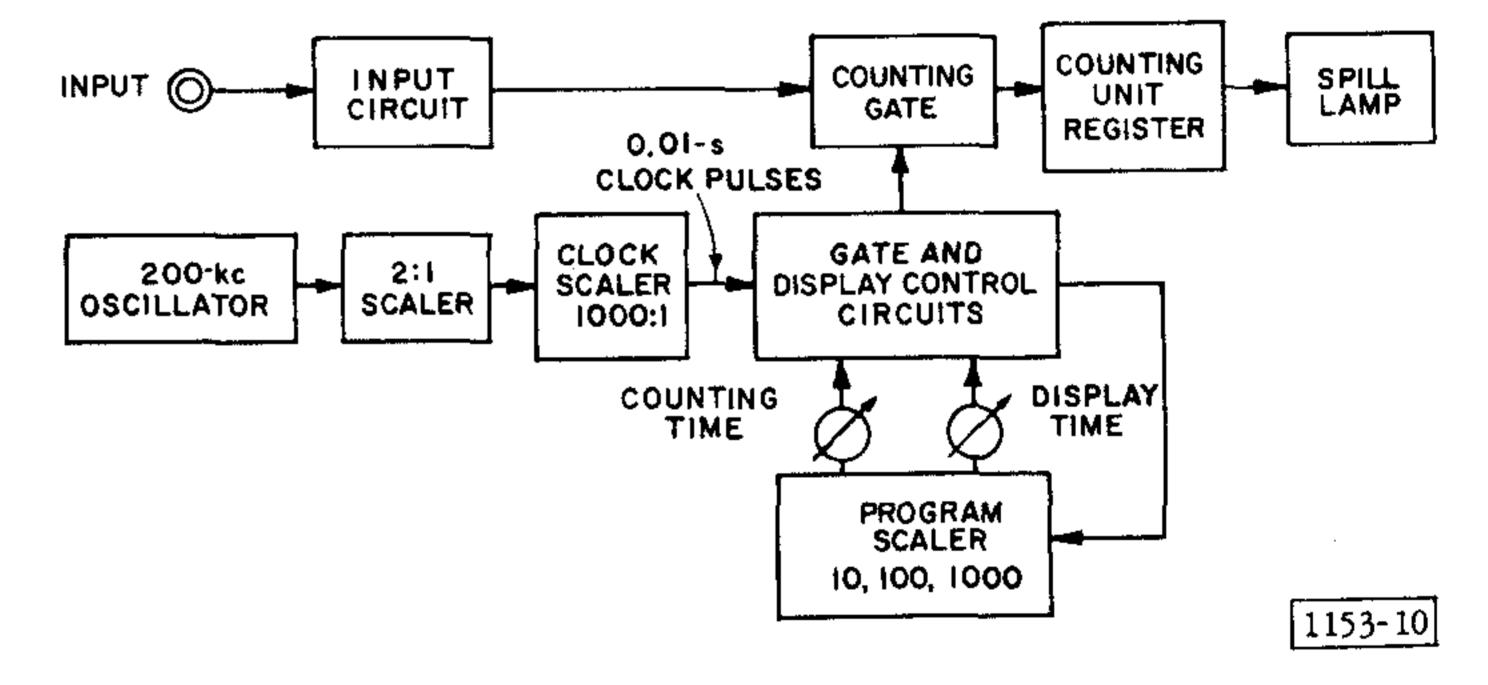
In the COUNT position of the MEASUREMENT switch, a single pulse per cycle of the input waveform is formed by the input circuits and is either passed or blocked by the counting gate. The counting gate is controlled by dc signals from the COUNT/MULT INT switch. When the gate is closed, the displayed count in the register is simply equal to the number of pulses accumulated during the gate-open time. The counting register is cleared to zero when the RESET button is pushed, and the only function of the gate and display-time logic is to



Circuit logic for count measurements

• 4.3 FREQUENCY MEASUREMENT

In the FREQUENCY position of the MEASUREMENT switch, the function of the input circuits is the same as for COUNT measurement. The counting gate, however, is now controlled by the gate and display control circuits. For accurate measurement of frequency, the counting gate must be open for an accurately controlled time interval. The result is displayed (for a period to suit the operator's convenience), and then the counting register is set to zero so that a new measurement can be made. In the Type 1153 counters all three intervals, counting, display, and reset, are under full control of the quartz-crystal oscillator. The 200-kc oscillator output is fed to a 2:1 scaler. The 100-kc output of this scaler is fed through the clock scaler which divides by a factor of 1000. The resulting 100-cycle signal from this scale-of-1000 divider (clock scaler) forms the master "clock" for the counting process. Let us assume that the instrument has just been reset to zero. The next 100-cycle clock pulse opens the main gate and pulses corresponding to the period of the input signal are admitted to the counting register. Simultaneously, the second scale-of-1000 divider (program scaler) begins to accumulate clock pulses. If a onesecond gate time has been set with the COUNTING TIME switch, the program scaler will accept 100 clock pulses. The 100th clock pulse will close the main gate, set the program scaler to zero, and start the display interval. This interval is also determined by the program scaler. The clock pulses are counted by the program scaler in a purely binary sequence. For instance, if 16 pulses are counted (DISPLAY TIME switch set to 4) the display interval will last for 0.16 second; 32 pulses counted (DIS-PLAY TIME switch set to 5) will establish a 0.32-second display, and so on, up to 1024 pulses (DISPLAY TIME switch set to 10), which establishes a 10.24-second display time. The last clock pulse during the display time



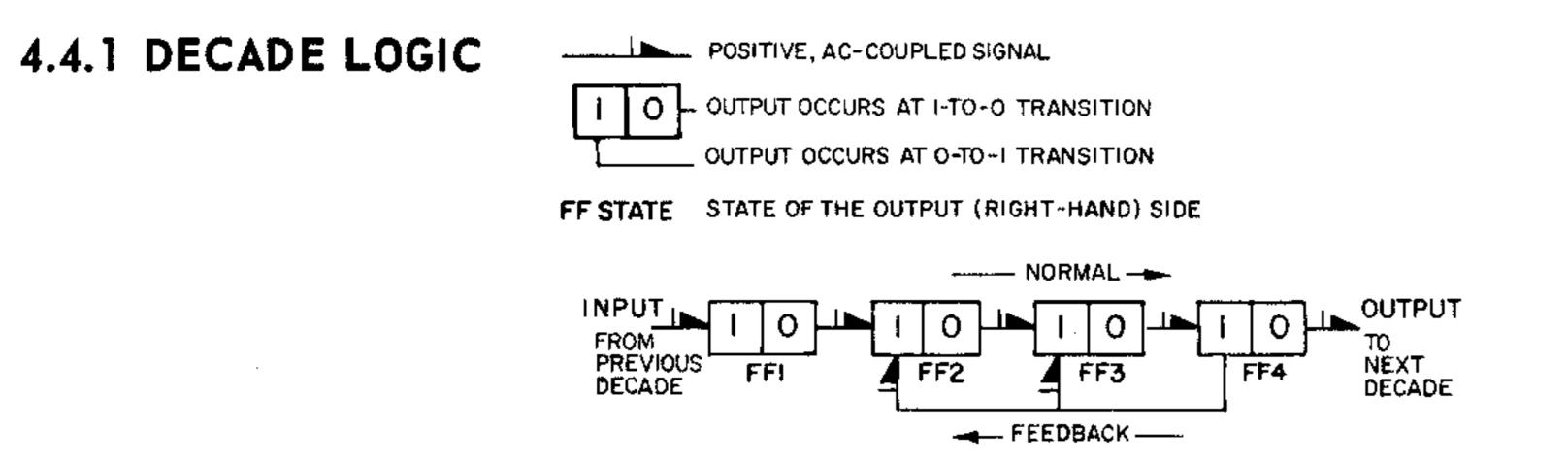
Circuit logic for frequency measurements

is fed back from the program scaler to the control circuits through the DISPLAY TIME switch. The signal from this switch terminates the display interval, generates the reset pulse, and the measurement cycle then repeats. Note that all phases of the measurement are under complete control of the clock so that this program could be termed completely synchronous.

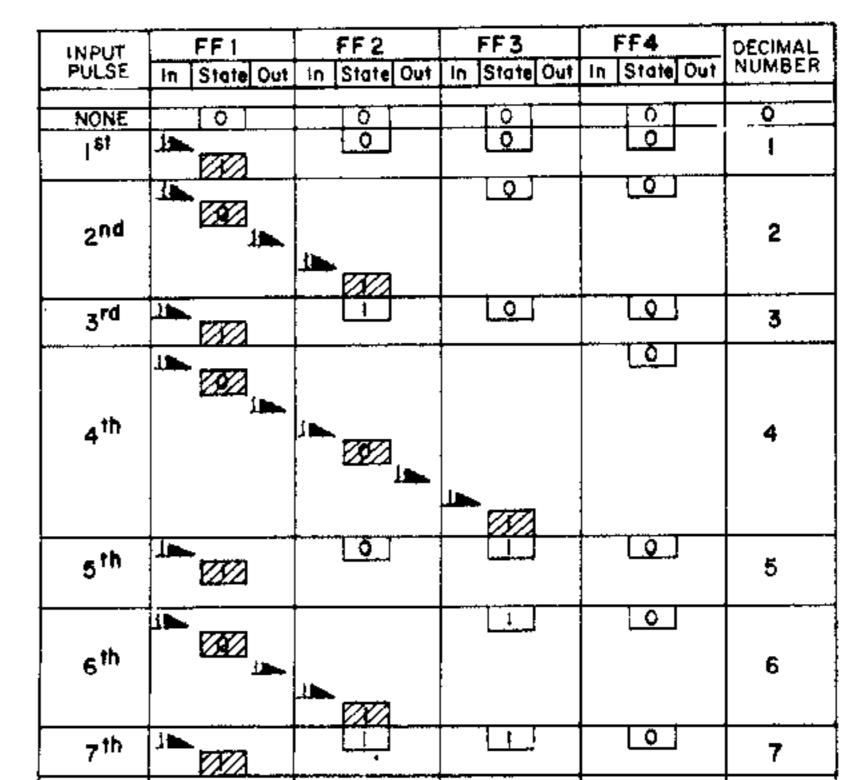
To obtain infinite display time, the display path from the program scaler can be opened (DISPLAY TIME switch set to**co**). The display will be retained until the instrument is manually reset. Multiple-interval measurement is also controlled by the DISPLAY TIME switch. With the switch in this position, the COUNT/MULT INT switch is placed in the gate time circuit. When the COUNT/MULT INT switch is set to START, the pulse from the program scaler that normally closes the counting gate is interrupted. The gate will close at the end of the time interval after the COUNT/MULT INT switch has been set to STOP. Thus gate intervals of 1, 2, 3 ...n seconds, or 10, 20, 30n tens seconds can be manually established.

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• 4.4 1-Mc AND 10-Mc BCD COUNTING UNITS



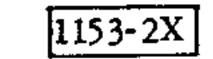
The 1-Mc and 10-Mc counting units are binary decades composed of four cascaded flip-flops. Each flipflop is in either a binary 0 or a binary 1 state and the state changes upon receipt of an input pulse. To achieve division by 10 (decade counting), the output of the fourth flip-flop is fed back to the input of the second and third. The counting action is shown in the adjacent diagram; the highlights are described below:

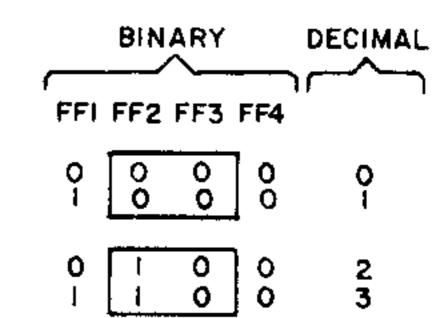


Normal pulses occur when a flip-flop changes from the 1 to the 0 state and feedback pulses occur when the flip-flop changes from the 0 to the 1 state.

The eighth input pulse to the decade causes the fourth flip-flop to send a feedback pulse to the second and third flip-flops. Therefore, the eighth pulse sets the last three flip-flops to 1, the ninth pulse sets all flipflops to 1, and the tenth pulse sets all flip-flops to 0 and causes an output pulse. Note that it takes 10 input pulses to produce one output pulse.

31 8th 8 N 1 gth . 1 L. 9 1 A A 10th 0 0 <u></u> <u>_</u>___ lith |**⊥**⊷





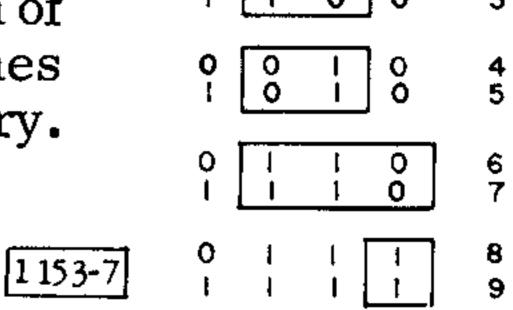
4.4.2 DECIMAL MATRIX

Binary information from the flip-flops is applied to a biquinary matrix where it is converted to decimal information and used to drive the indicator lamps. Five decimal pairs are contained in the numbers 0 through 9 and a unique combination of states from the flip-flops exist for each pair The state of flip-flop 1 determines whether the even or odd number of the pair is selected, hence the term biquinary.

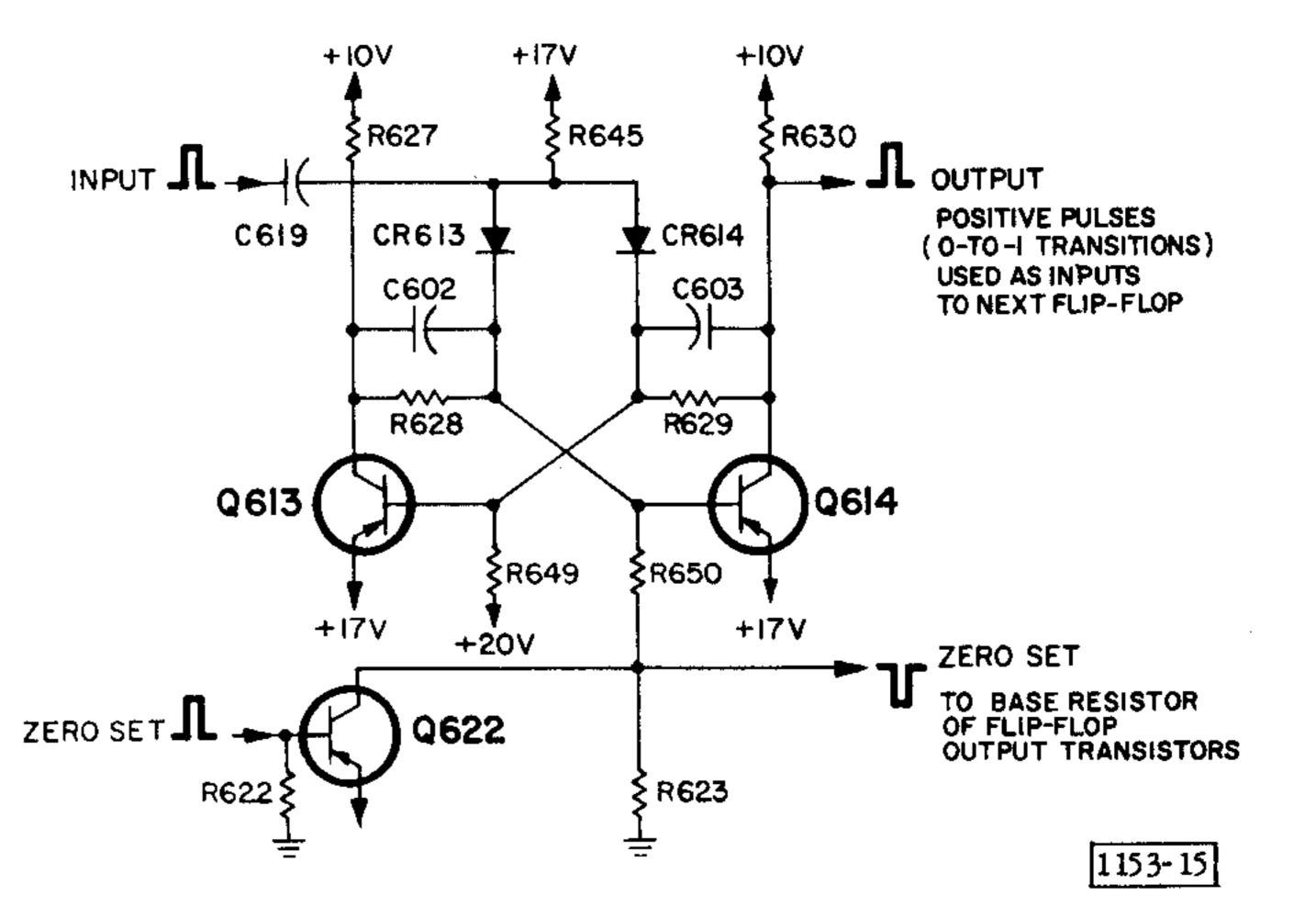
4.4.3 FLIP-FLOP CIRCUIT

QUIESCENT: Each flip-flop is comprised of two pnp transistors, which require a negative base (to emitter) voltages for conduction. The zero-set transistor, Q622, is normally conducting, and its collector rests at about +20 volts so that the base resistors, R649 and R650, of the flip-flop transistors are returned to the same potential. Assume the flip-flop is in the 0 state; i.e., its output transistor, Q614, is in the 0 state (conducting).

SWITCHING: A positive input pulse is applied to CR613 and CR614, which starts the normal multivibrator regenerative action as follows: the positive pulse is fed through CR614 at the base of Q614 and turns Q614 off. As Q614 turns off, its collector voltage drops from +17 volts to +10 volts. This negative transition is coupled through C603 to the base of Q613 and turns Q613 on. As Q613 turns on, its collector voltage increases from +10 volts to +17 volts, this positive transition is coupled through C602 to the base of Q614 and further turns Q614 off. The flip-flop has changed states from 0 to 1. The next input pulse will change the state from 1 to 0.



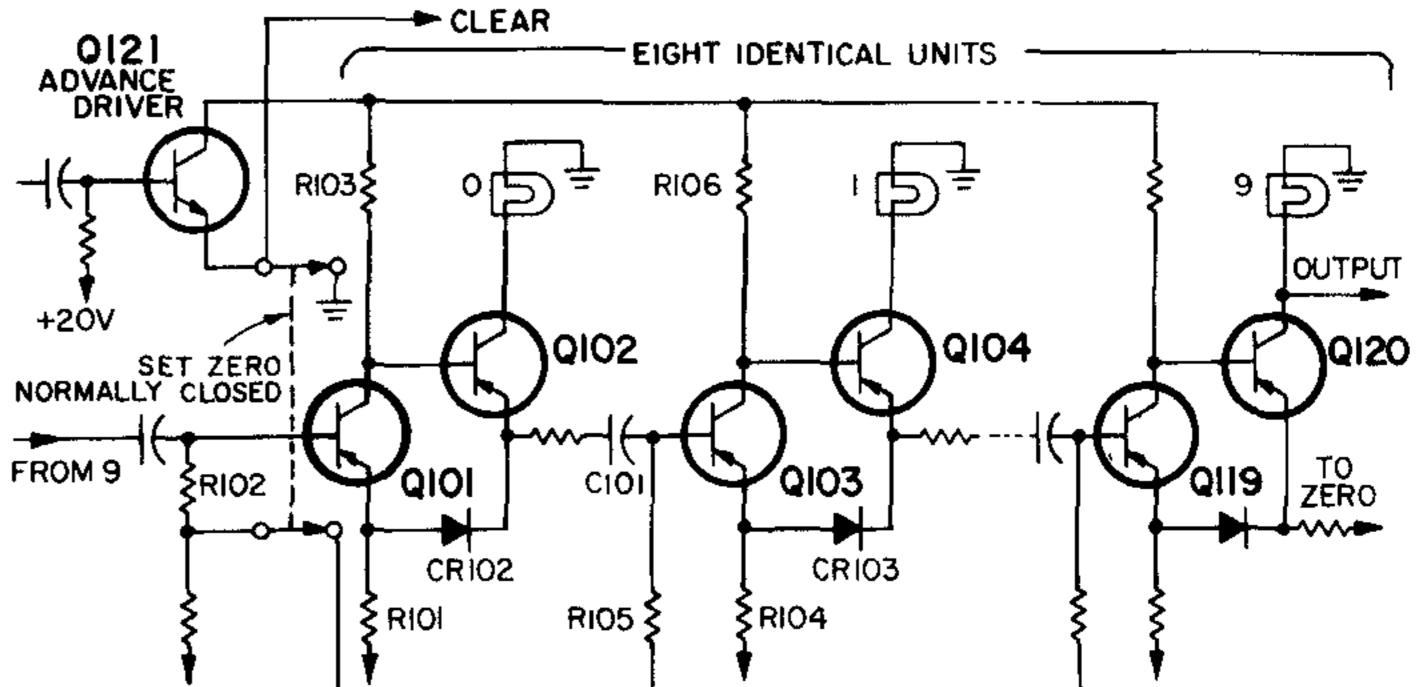
ZERO SET: A positive pulse applied to the base of Q622 (zero-set pulse) is inverted and applied to the base of the output transistors in the flip-flops. This negative pulse turns the output transistors on and thus sets all flip-flops to the 0 state.

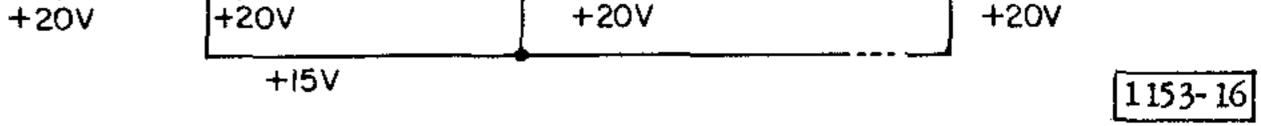


• 4.5 220-kc AND 40-kc DECIMAL RING COUNTING UNITS

Each unit contains a ring of 10 bistable circuits. Each bistable circuit has one "high-current" transistor capable of driving the associated incandescent lamp for that decades indicator.

Assume the counting unit has been set to its zero state. Q101 is off and Q102 is on. Q102, with base forward bias current provided by R103, is kept saturated and passes 80 mA to light the zero lamp in the indicator. This 80-mA current produces a voltage drop of 5.5 volts across R101. The base of Q101 is returned via R102 to the set-zero buss voltage of about 15 volts. The base of Q101 is, therefore, reverse-biased with respect to the emitter and Q101 remains off. The circuit is stable in this state. All other pairs in the ring have the opposite stable state. The left-hand transistors (Q103, etc) are on, and all right hand transistors (Q104, etc) are off. Q103, for example, is on and has nearly 1 mA of forward drive. Since the drop across the 68-ohm resistor (R104) on the common emitter is only 0.07 volt, the full 20-volt collector-supply voltage appears across R106. The very small drop in emitter-to-collector voltage of Q103 will normally be below the conduction kneevoltage of Q104 and will keep it off. Complete cutoff of Q104 for all possible transistor combinations at elevated temperature is ensured by the silicon diode (CR103 in series with the emitter of Q104).



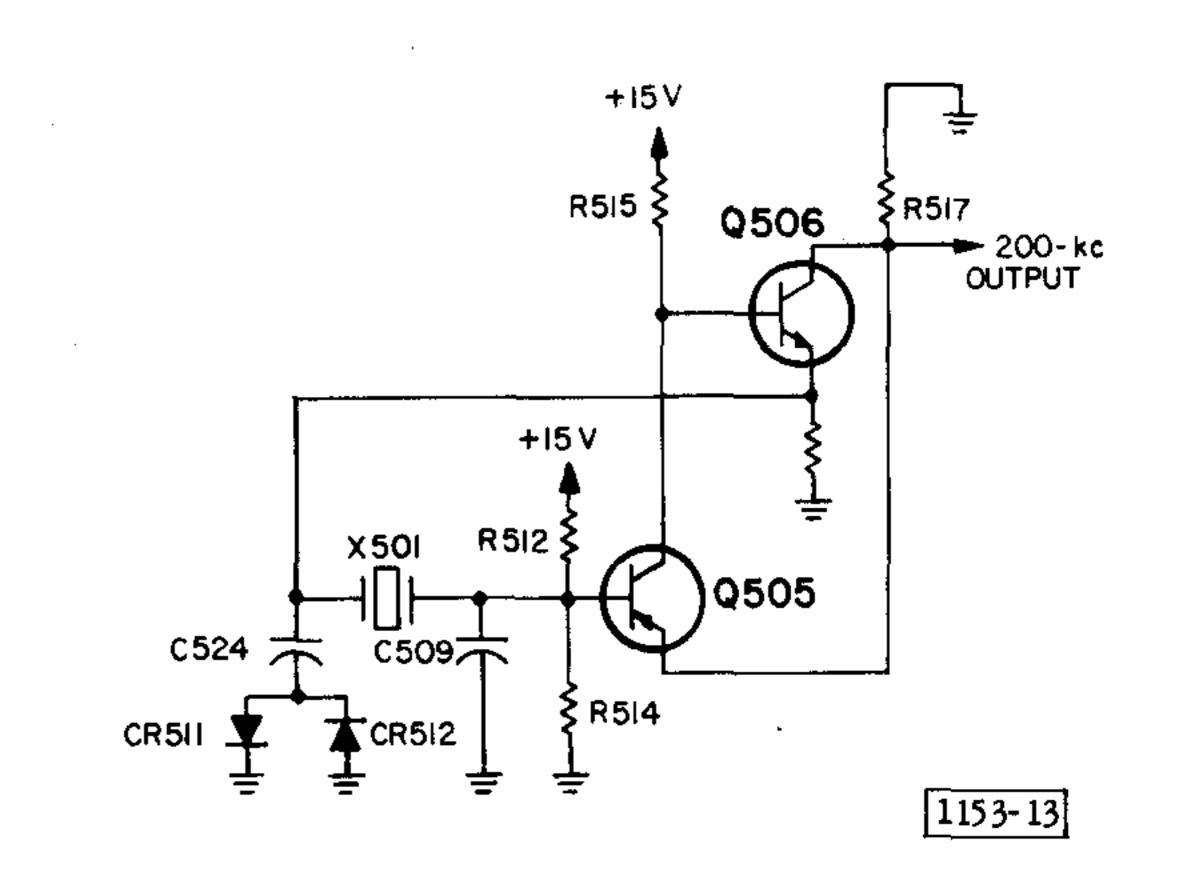


The input signal advances the state of the decade by one stage per pulse. A negative pulse is applied to the base of the advance driver, Q121, turning it off. Q102 loses base forward drive and goes off. The commonemitter voltage rises from +15 to +20 volts and Q101 goes on. The positive pulse at the common emitter is fed through C101, turning Q103 off and Q104 (the 1 driver) on. Each succeeding pulse applied to Q101 will advance the count by one digit. At the count of 10 the zero pair is switched to the initial conditions, and the negative pulse generated as the 9 lamp extinguished is fed from this ring counting unit as a carry pulse to the advance driver of the succeeding unit.

• 4.6 TIME-BASE OSCILLATOR

The time-base oscillator consists of Q505 and Q506 arranged as a modified Pierce crystal oscillator with an output frequency of 200 kc/s. Q505 and Q506 set the output impedance and provide 60 dB of negative feedback to achieve a circuit largely independent of transistor parameters and changes in voltage and temperature. A roomtemperature, GT-cut crystal is used which, together with the large amount of negative feedback, results in an oscillator with a very stable frequency characteristic.

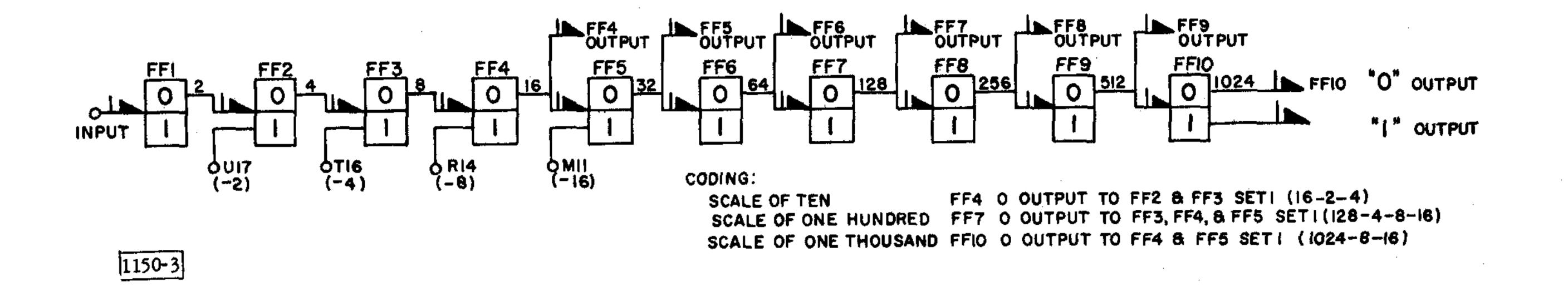
The output is fed through an amplifier, Q507, to a 2:1 scaler. The scaler consists of Q508 and Q509 connected as a multivibrator that divides, by 2, any input frequency over 150 kc/s. The scaler's 100-kc output is applied to the rear-mounted INT 100 kc output connector, to the time-base dividers in the FREQUENCY position of the MEASUREMENT switch, and to the time-base dividers and INPUT terminals in the 100 KC TEST position of the MEASUREMENT switch.





4.7 TIME-BASE DIVIDERS

· · ·



There are two identical scale-of-1000 time-base dividers used in the Type 1153, the clock scaler and the program scaler. Each divider consists of 10 identical, serially connected flip-flips. The resolution of each scale-of-1000 divider permits counting up to 200 kc/s.

There is no internal coding in these dividers. In the absence of a set-1 signal on any of the second through fifth flip-flops, the system counts in a binary fashion (aggregation of $2^{10} = 1024$).

flop (which is in the "0" state) is set to 1, which subtracts 8 from the total, and the fifth flip-flop (which is also in the "0" state) is set to 1, which subtracts 16 from the total. Thus the feedback "converts" the binary 1024-to-1 divider to a 1000-to-1 divider (1024 - 8 -16 = 1000).

The second scale-of-1000 divider (program scaler) provides the gate and display times. To provide accurate gate times, the program scaler can be used as a scale-of-10, scale-of-100, or scale-of-1000 divider. When used as a scale-of-10 divider, the output of the fourth flip-flop is connected through the COUNTING TIME switch to the program control and feedbacks are provided to the set-1 terminals of the second and third flip-flops (16 - 2 - 4 =10). When used as a scale-of-100 divider, the output of the seventh flip-flop is fed through the COUNTING TIME switch to the program control and feedbacks are provided to the set-1 terminals of the third, fourth, and fifth flip-flops (128 - 4 - 8 - 16=100). All 10 flip-flops are used for the scale-of-1000 divider. Feedback is provided from the tenth flip-flop to the set-1 terminals of the fourth and fifth flip-flops (1024 - 8 -16 = 1000), as in the clock scaler.

Outputs from the fourth through the tenth flip-flops connect to the COUNTING TIME and DISPLAY TIME switches. Inputs for feedback are provided for the second through the fifth flip-flops. Only a single feedback path is necessary to code the first scale-of-1000 divider (clock scaler), which produces the 100-cycle clock from the quartz-crystal oscillator.

The feedback coding for the clock scaler is permanently wired on the socket into which the scaler card plugs. The coding connects from the "1" output of the tenth flip-flop to the set-l input of the fourth and fifth flip-flops. With this feedback connection, when the tenth flip-flop is triggered to the "1" state, the fourth flip-

22 TYPE 1153-A DIGITAL FREQUENCY METER

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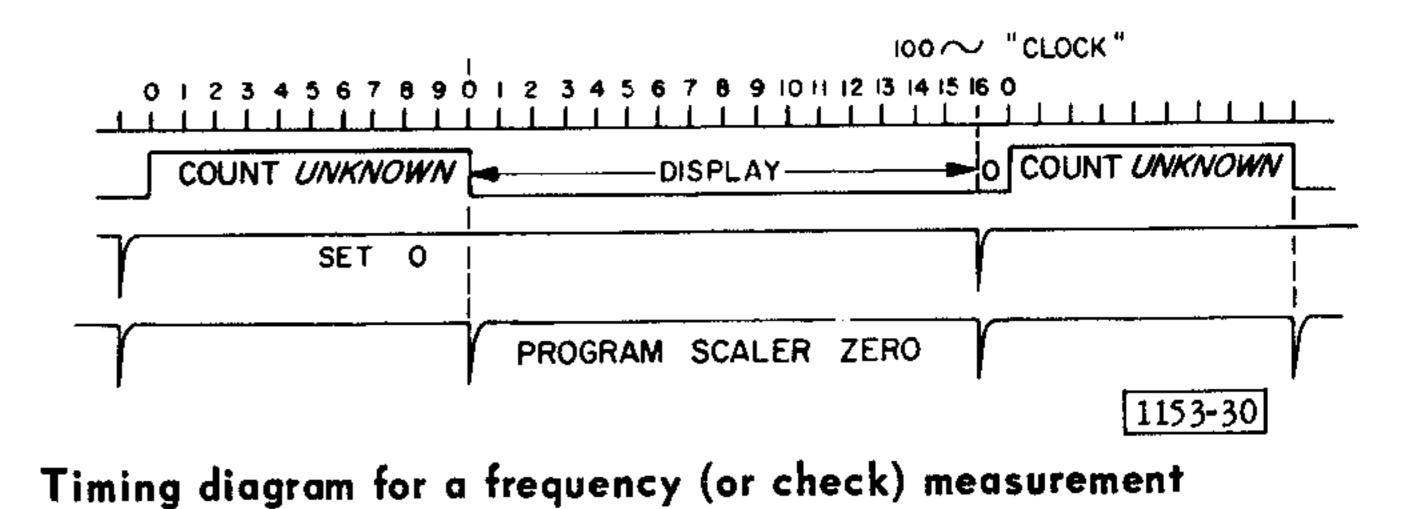
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Refer to the logic diagram on page 43. Assume that the measurement switch is at FREQ, the COUNTING TIME switch at 0.1 SEC, and the DIS-PLAY TIME switch at 4 (for a 0.16-second display).

a. Assume that a reset pulse has just been produced; thus:

(1) Flip-flop (FF1) is in the 0 state, so gate 1 (G1) is closed, (2) FF2 is in the 0 state, so G3 and G5 are closed and G4 is open.



4.8 PROGRAM CONTROL

(3) The program scaler is set to 0.

b. The first 100-cycle clock pulse from the clock scaler passes through G2 and sets FF1 to 1, opening G1. The count begins and the program scaler is advanced from 0 to 1.

c. The third clock pulse advances the program scaler from 1 to 2, the fourth clock pulse advances the scaler from 2 to 3, etc.

d. At the count of 8 in the program scaler, feedback is sent through G4 for binary-to-decimal conversion.

e. The tenth pulse of the program scaler passes through the COUNTING TIME switch to set FF2 to 1, closing G2 and G4 opening G3 and G5 and generating a zero-set pulse for the program scaler through G6.

f. The next clock pulse passes through G3 and sets FF1 to 0, closing G1 and stopping the count. Note that the gate time has been 10 counts.

g. The next clock pulse advances the program scaler from 0 to 1, the following clock pulse advances the scaler from 1 to 2, etc; until the sixteenth clock pulse passes through the DISPLAY TIME switch and G5, generating the reset pulse.

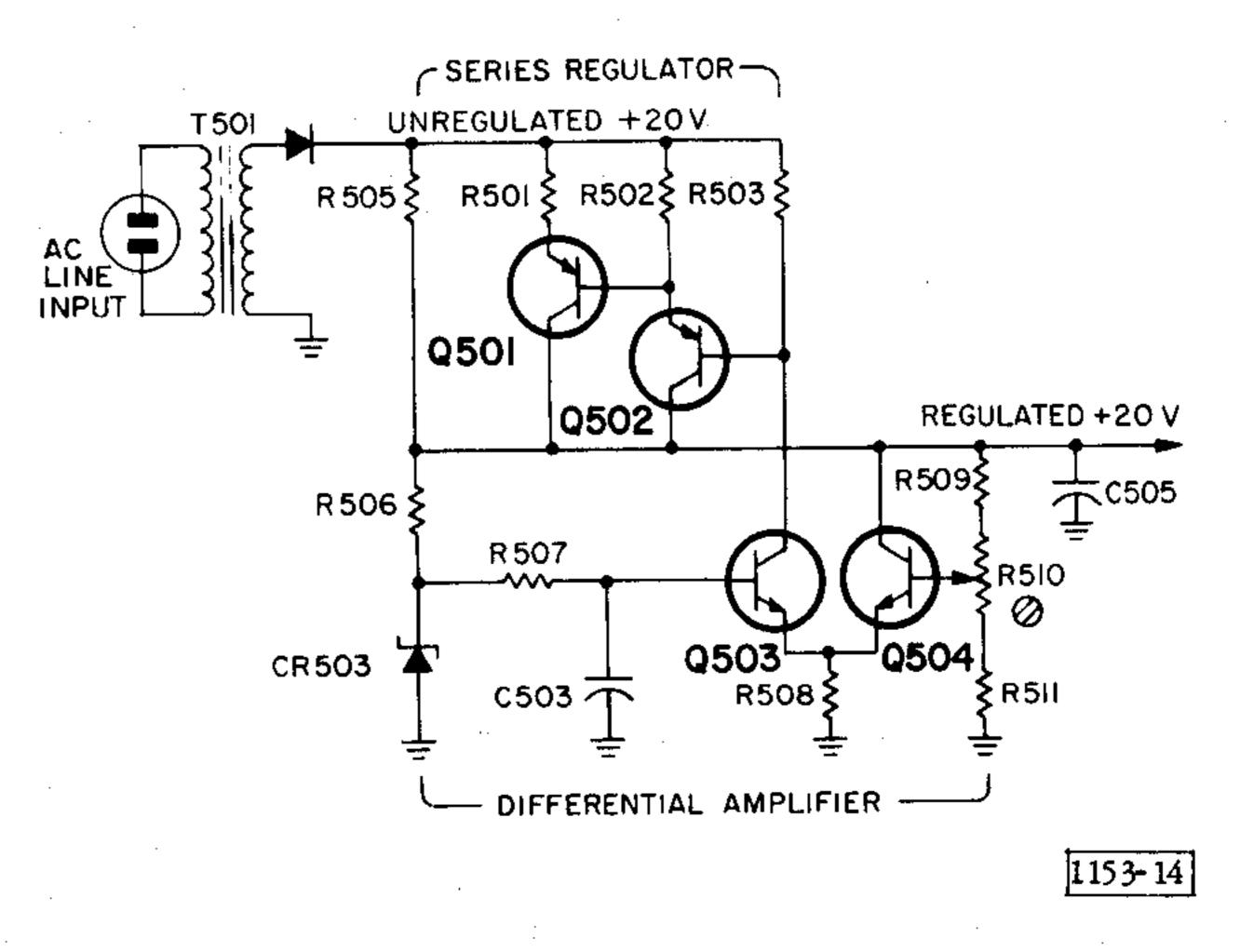
h. The cycle repeats for the next measurement.

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4.9 POWER SUPPLY

A single regulated dc source of +20 volts, with respect to chassis ground, is used for all circuits in the Type 1153 counters. A series-type electronic regulator is used for both dc voltage control and for ripple reduction. A portion of the output voltage (determined by the voltage divider, R509, R510, and R511) is compared with a fixed reference voltage (determined by Zener diode CR503) in a differential amplifier (Q503 and Q504). If the output voltage increases, the current in Q504 also increases, decreasing the current in Q503. In turn, Q503 reduces the base current in the emitter-follower (Q502) and in the series transistor (Q501), reducing the output voltage.

When power is first applied, base forward drive for Q503 is supplied via a 15-ohm resistor, R505, which will allow the regulator to start. In normal operation this resistor supplies a portion of the load current.



PRINCIPLES OF OPERATION 23

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SECTION 5

AND MAINTENANCE SERVICE

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CONTENTS

5.1	Warrant	v.	•	•	• •	•	•	•	•	•	•	•	•	24
	Service	-												_
	Routine													
5.4	General	Trou	bles	shoc	oting	•	•	•	•	•	•	•	•	26
5.5	Program	Trou	ıble	sho	oting	g.	•	•	•	•	•	•	•	27
5.6	Calibrati	ion Pi	coce	edur	е.	•	•	•	•	•	•	•	•	28

Additional information, such as schematics, waveforms, dc voltages, and etchedboard layouts, is contained in Section 6, Parts Lists and Schematics.

• 5.1 WARRANTY

We warrant that each new instrument 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, sales engineering 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 Sales Engineering 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 GENERAL

Clean the air filter, oil the motor, and, in case of trouble, check the indicator lamps first.

The Type 1153 Series Digital Frequency Meters feature a modular construction that greatly simplifies repair. Transistors are on etched boards which, except for the program-control and power-supply boards, are

easily removable from the main structure. To keep "down time" to a minimum, the user can replace a defective board immediately, thus keeping the counter in use while the defective board is being repaired. Components not mounted on etched boards include frontpanel controls and switches, indicators, plugs, sockets, power-supply regulating transistor and rectifier diodes, and the power transformer.

5.3.2 AIR FILTER

5.3.3 FAN MOTOR

To maintain proper cooling efficiency, the air filter should be cleaned periodically. Local air conditions determine how often this is necessary. To clean, release the air filter from its holder, rap gently to remove excess dirt, flush from the dirty side with hot soapy water, rinse, and let dry. Commercially available preparations to increase the filtering efficiency may be applied but are not necessary.

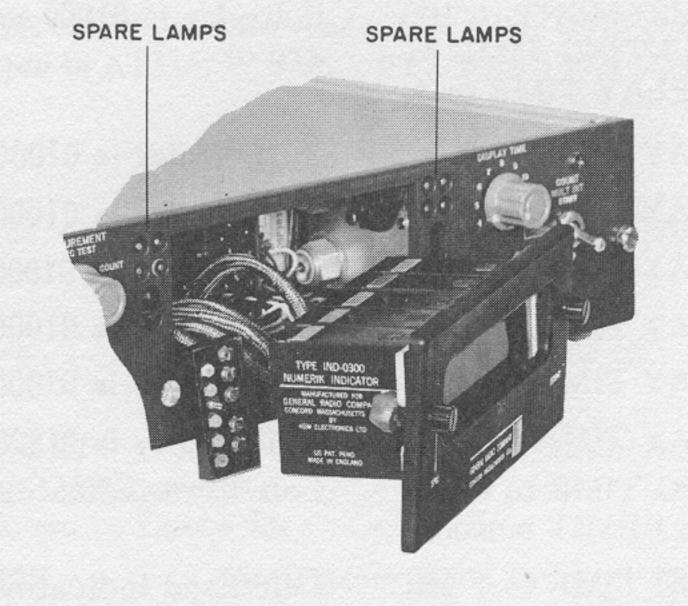
5.3.4 INDICATOR LAMPS

Most troubles can be traced to defective indicator lamps. To determine the lamp at fault, perform Check 4b, page 26.

Burned-out (open-circuited) lamps will cause the 220-kc and 40-kc Decimal Ring Counting Units to fail. To gain access to the lamps, turn off the power to avoid shorting the connecting terminals to the chassis, turn the two knurled panel screws on either side of the indicator bank a quarter turn counterclockwise, and pull the indicator bank from the instrument. Eight spare indicator bulbs are provided in the front panel and are accessible when the indicator bank is removed. To remove a burned-out bulb, remove the two screws at the rear of the faulty indicator.

The probability of failure for incandescent bulbs is a function of their operating time. Very few bulbs will have to be replaced until the instrument has accumulated several thousand hours of use, and then the rate of replacement will increase rapidly. We recommend that all bulbs be replaced when increase in failure rate is noted (typically after 5000 hours of use). You will notice that used bulbs have darkened due to condensation of filament material on the inside of the glass envelope and may not provide sufficient illumination if continued in use.

For long, trouble-free operation, lubricate the fan motor at least once a year with SAE 20 or 30 premiumquality oil. There are two lubricating holes, one in each of the brass brackets on either side of the motor laminations.



SERVICE AND MAINTENANCE 25

The lamps supplied in the Type 1153 counters are 14-V, 80-mA General Electric Type 330 or equivalent.

5.4 GENERAL TROUBLESHOOTING

These checks should localize 90% of all troubles to a small group of components. The checks are fast, simple, and performed without external test equipment or removal of the cabinet. More detailed checks are given on page 27.

Preliminary measurement conditions:

IMPEDANCE	•	•	. 100 kΩ
MEASUREMENT	•	•	. COUNT
DISPLAY TIME	٠	٠	. 10
COUNTING TIME .	•	٠	01 SEC
COUNT/MULT INT	•	•	. START

Check

- 1 Connect to power line and turn POWER on.
- 2 Momentarily push RESET button.
- 3 Turn TRIGGER LEVEL back and forth 10 complete cycles.
- 4 a. Set MEASUREMENT to 100kc TEST, DISPLAY TIME to 10, COUNTING TIME to .01 SEC.

b. Set COUNTING TIME to 1 SEC.

If blower starts Power line and fuses ok. If COUNT lamp glows B+ present.

If display is 00000 Set "0" (Q307 through Q310) ok, register cleared and counting units set to zero, zero lamps ok. If display is at normal brilliance . . . Regualted B+ (Q501 through Q504) ok.

- If display advances one count per cycle and final display is 00010 . . . Input circuit (Q401 through Q409) ok, main gate (G1) open and passing pulses to be counted, 10-Mc counting unit and its indicators ok. If check fails, check waveforms and dc voltages of input circuit (page 53) and 10-Mc counting unit (page 55).
- ... Oscillator (Q505 If display is 01000 and blinks every 10 seconds through Q509) ok, 100-kc to 100-cycle counting units ok, and program control ok. If check fails, proceed to b.
 - If instrument counts for one second then display 00000 Lamps ok. If one of the two right-hand indicators is blank, proceed to next step. If one of the three left-hand indicators is blank, check lamps in blank indicator for resistance to ground of 30 to 50 Ω ; infinite resistance indicates lamp is burned out.

Set MEASUREMENT to COUNT, set COUNT/MULT INT to START, and turn TRIGGER LEVEL back and forth several cycles.

c. Set MEASUREMENT to 100kc TEST, COUNTING TIME to .01 SEC, DISPLAY TIME to 4.

Set DISPLAY TIME to 5. Set DISPLAY TIME to 6. Set DISPLAY TIME to 7. Set DISPLAY TIME to 8. Set DISPLAY TIME to 9. Set DISPLAY TIME to 10.

5 Set COUNTING TIME to 0.1 SEC and push RESET button.

Set COUNTING TIME to 1 SEC and push RESET button.

If display advances one count per cycle up to 00099 Lamps ok. If a number on one of the two right-hand indicators fails to light, the lamp for that number is burned out.

If display is 01000 and blinks every 0.16 second Q201 through Q208 are ok.

If display is 01000 and blinks every 2.56 seconds Q215 and Q216 are ok. If display is 01000 and blinks every 10.24 seconds Q219 and Q220 are ok. Left-hand indicator should read 1.

Left-hand indicator should count to 9 and cycle to 0, then SPILL lamp should glow and instrument should stop counting. If SPILL lamp operates, Q319 and Q320 are ok. If instrument counts properly, all counting units are ok, G4 (Q316 through Q318) is ok, G6 (Q314 and Q315) is ok, and the program scaler is ok.

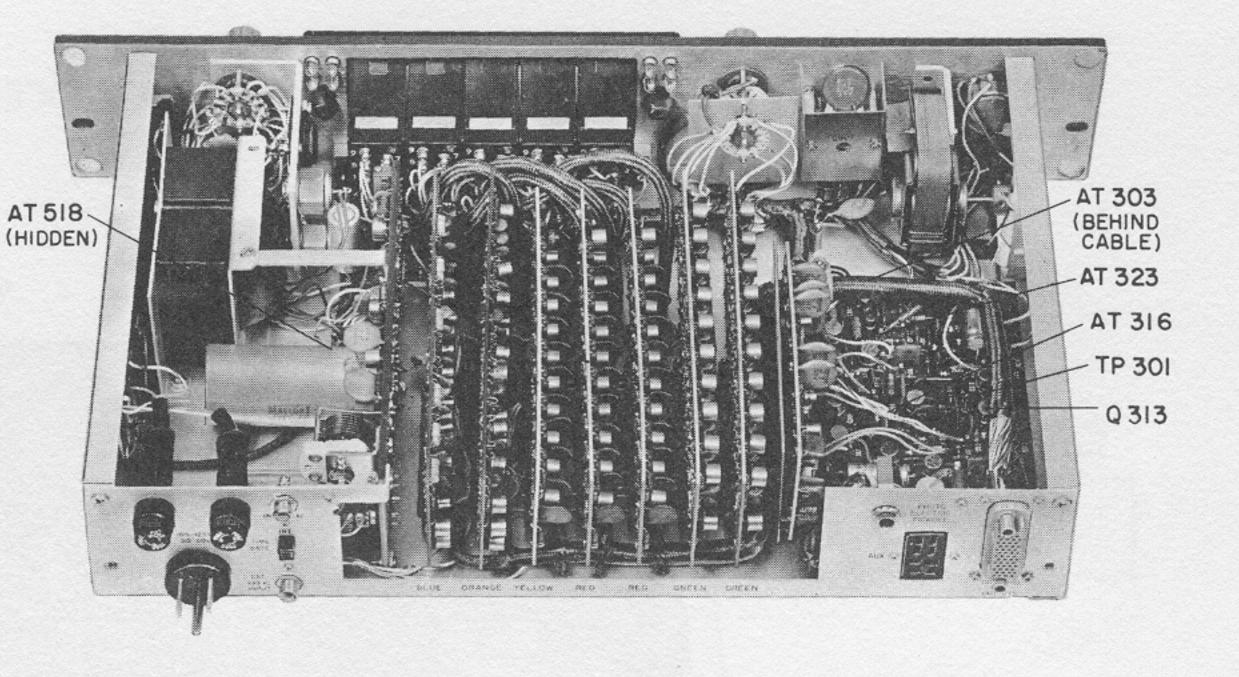
Set COUNTING TIME to 10 SEC and push RESET button.

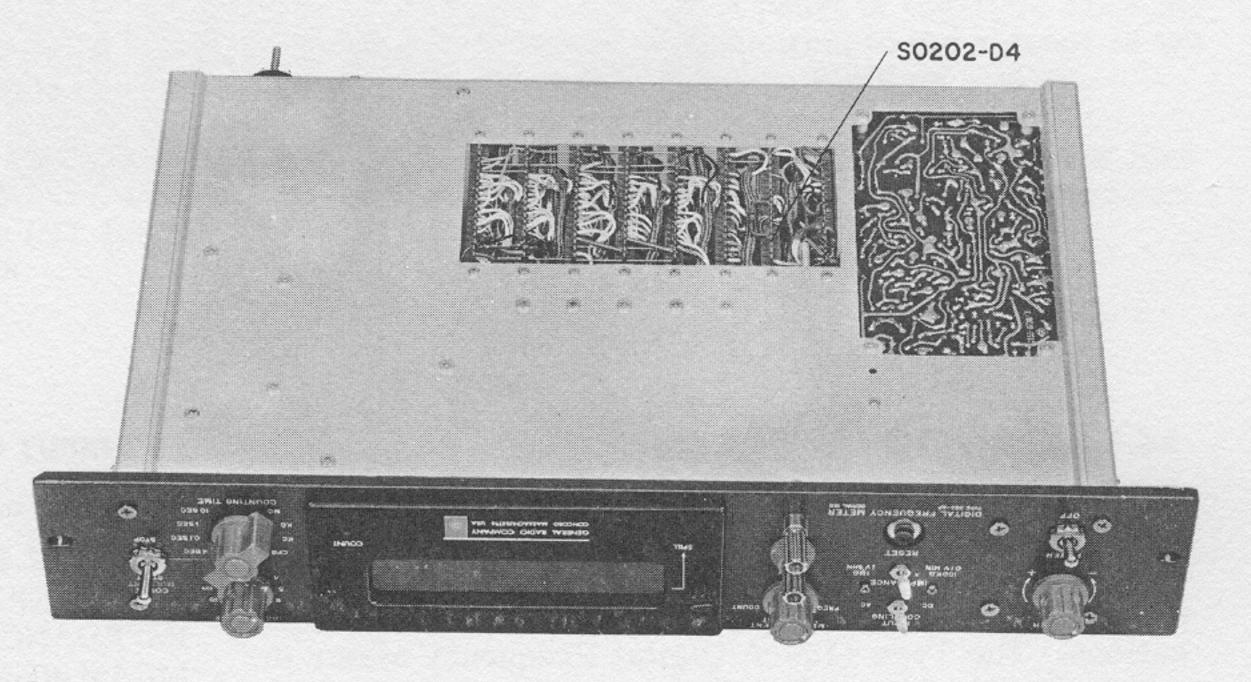
Left-hand indicator should count to 9 and cycle to 0, then SPILL lamp should glow and instrument should count to 9 and cycle to 0 nine more times (ten in all) before it stops. If the check fail, check waveforms and dc voltages of program control (page 47 and 49).

5.5 PROGRAM TROUBLESHOOTING

If a general troubleshooting check indicated a program failure, perform the following checks:

Preliminary measurement conditions: TIME BASE (rear). . . . EXT Cabinet removed.





Check Procedure

Observation

- A Connect voltmeter to TP301, push RESET button, and note reading. Momentarily connect case of Q313 to AT316 and note reading.
- B Set MEASUREMENT to 100 kc TEST, connect voltmeter to AT323, push RESET button, and note reading. Momentarily ground AT303.
- C Set TIME BASE (rear) to INT connect voltmeter SO202-D4.
- D Connect voltmeter to AT518.

If voltmeter first reads +19V and then reads +5V (after Q313 case is momentarily connected to AT316) FF2 (Q312 and Q313) ok.

If voltmeter first reads +17V and then reads +13.5V (after AT303 is momentarily grounded) FF1 (Q303 and Q304) ok.

If COUNT lamp glows . . . COUNT lamp and Q305 are ok.

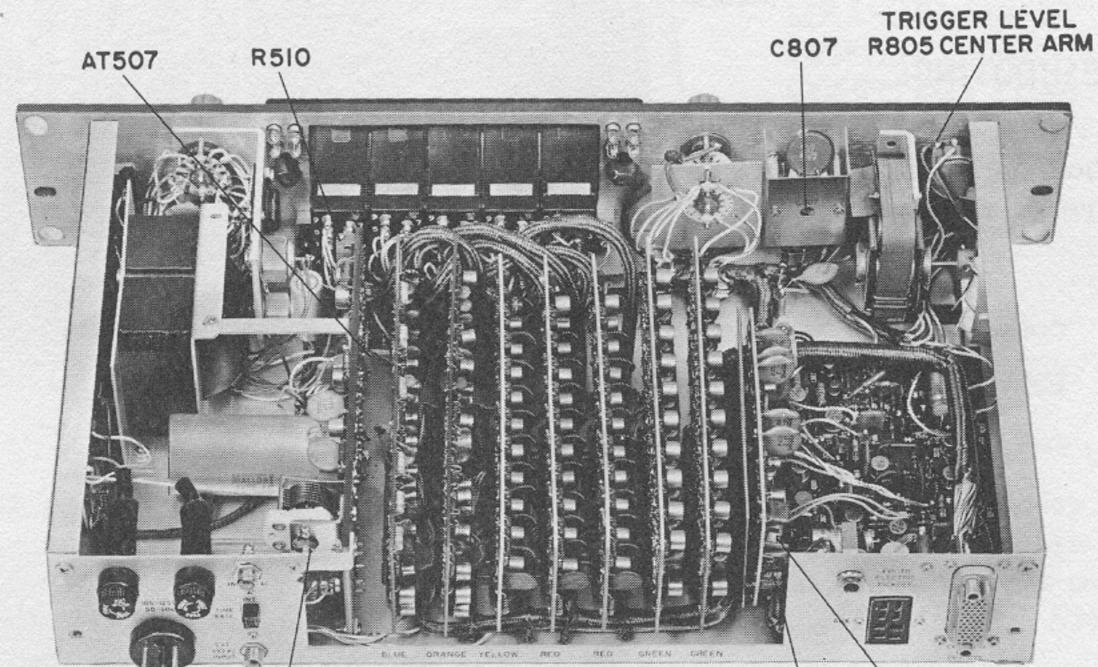
If voltmeter reads +12.5V 1000:1 time-base divider and oscillator (Q505 through Q509) are ok. If check fails, proceed to Check D.

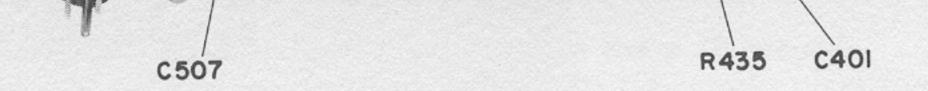
If voltmeter reads -10V Oscillator (Q505 through Q509) is ok.

- (Check C failure due to 1000:1 time-base divider.) If check fails, proceed to Check E.
- E Set TIME BASE (rear) to EXT, apply 1-V p-to-p, 100-kc signal to EXT 100 kc INPUT connector (rear), and connect voltmeter to AT518.
 If voltmeter reads -10V Oscillator amplifier (Q508 and Q509) is ok. (Check D failure due to Q505, Q506, or Q507.) If check fails, Q508 or Q509 is faulty.

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5.6 CALIBRATION PROCEDURE





5.6.1 INTRODUCTION

Each step in the calibration procedure should be performed in sequence since one step serves as a foundation for the next. A complete calibration insures that all circuits are operating properly and within specifications. The Type 1153-A Digital Frequency Meter incorporates the high reliability one expects of conservatively designed, semiconductor circuits and routine calibrations are unnecessary.

5.6.2 EQUIPMENT REQUIRED

Dc Voltmeter

Range: 0 to 25 V, ±3% accuracy. Impedance: At lease 20,000 ohms per volt.

Sinewave Oscillator

Frequency: 1 kc/s to 9.9 Mc/s Output: 100 mV to 10 V, p-to-p.

Radio Receiver

Capable of receiving WWV on 5 Mc/s.

100-pF Capacitor

5.6.4 INPUT CIRCUIT

Set controls as follows:

TRIGGER LEVEL.			•		Centered
INPUT COUPLING.		•			AC
IMPEDANCE				•	1 MΩ
MEASUREMENT .					FREQUENCY
DISPLAY TIME .					4
COUNTING TIME .	•				0.1 SEC

TRIGGER LEVEL mechanical zero: Connect a voltmeter to the center arm of the TRIGGER LEVEL potentiometer, R805, and set the potentiometer for -0.435 volt, Loosen the set screw in the knob and slip the knob on the shaft so that the white dot points straight up. Retighten the set screw.

Sensitivity: Connect a 10-volt, p-to-p, 1-kc sine-wave signal to the INPUT terminals; the display should read 001.00. Reduce the amplitude of the input signal to 1 volt, p-to-p, and adjust R435 for a display of 001.00.

100-k Ω high-frequency adjustment: Set the COUNT-ING TIME switch to .01 SEC and the IMPEDANCE switch to 100 k Ω . Change the input signal to 100 C401 millivolts, p-to-p, of 9.9 Mc/s and adjust C401 for

5.6.3 POWER SUPPLY

Turn POWER on, connect a voltmeter to AT507 or R510 the collector of Q501, and adjust R510 for +20 volts.

a display of 9.9000.

 1-MΩ high-frequency adjustment: Set the IMPED-ANCE switch to 1 MΩ. Change the input signal
 to 1 volt, p-to-p, of 9.9 Mc/s and adjust C807 for a display of 9.9000.

5.6.5 TIME-BASE OSCILLATOR

WWV is a convenient and accurate reference frequency with which to compare the oscillator frequency of the Type 1153. The two frequencies are mixed and the oscillator of the counter is adjusted for a zero beat.

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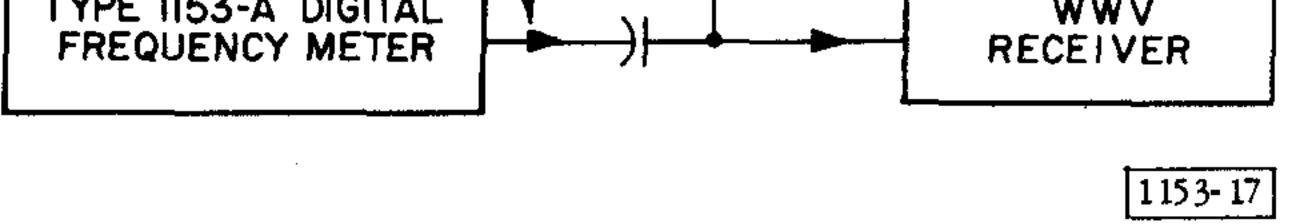
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CONNECT TO INT IOO KC CONNECTOR ON REAR PANEL WITH SHIELDED LEAD OR COAXIAL CABLE	Y	RECEIVER TUNED TO WWV ON 5 Mc/s
TYPE US3-A DIGITAL	100pF	

If the receiver has an "S" meter, the meter can be used as the zero-beat detector and the oscillator in the counter is adjusted for very slow excursions of the meter needle.

If the receiver has no "S" meter, the speaker can be used as the zero-beat detector. The receiver's beatfrequency oscillator is turned on and the oscillator in the counter is adjusted for a very low frequency audio tone.

Set the MEASUREMENT switch to COUNT. Connect a shielded lead or coaxial cable to the INT 100 kc



output connector on the rear panel of the Type 1153 and connect it, via a 100-pF capacitor, to the antenna of the receiver. Tune the receiver to WWV on 5 Mc/s.

Adjust C507 for a zero beat. A zero beat of less than 0.5 c/s indicates a precision of adjustment of better than 1 part in 10^7 .

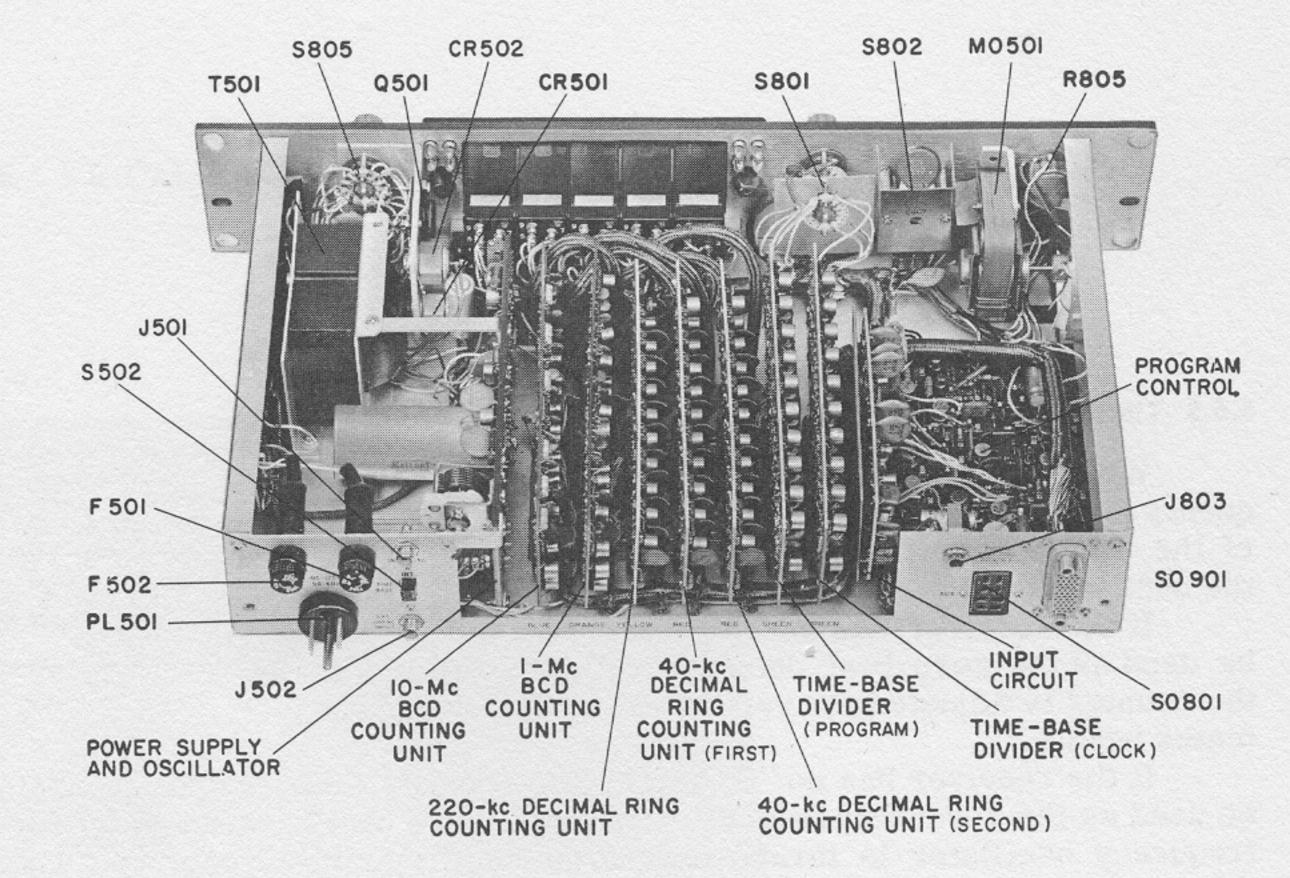
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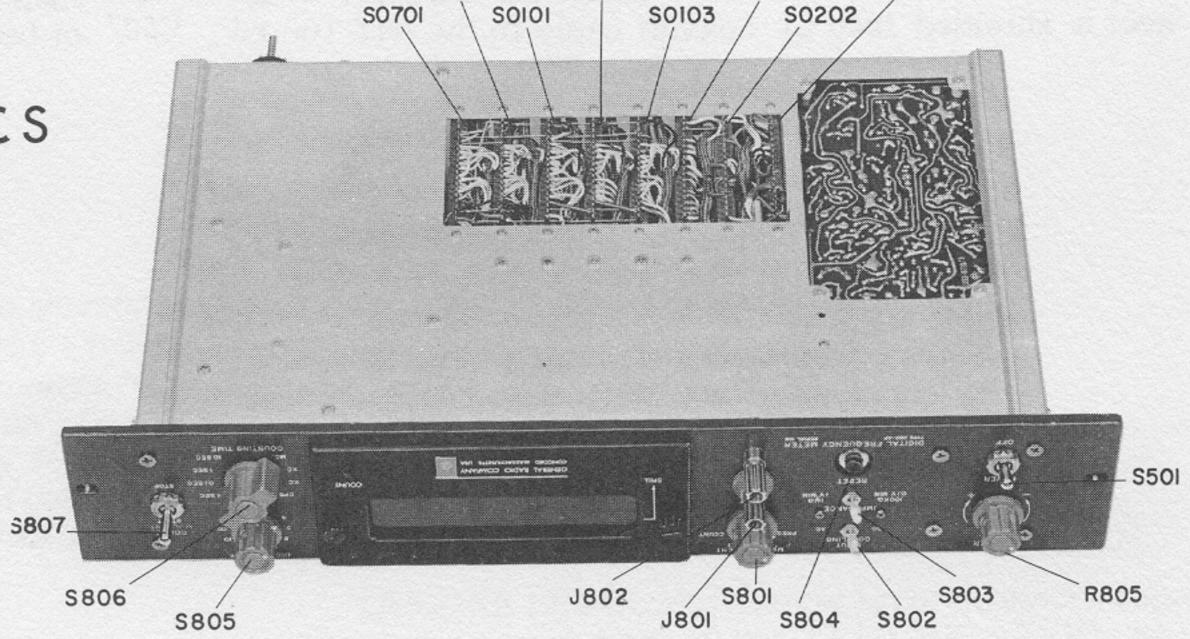
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S0601 S0401 S0102 S0201

SECTION 6



PARTS LIST AND SCHEMATICS



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Parts List

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Schematics (Includes waveforms, dc voltages and etched-board layouts):

	Etched-Circuit boan Assembly Number	rd Reference Number Series		
	Assembly Number	Series		
Logic Diagram			43	
Interconnections		800 and 900 to 950	44,45	
Program Control	1153-2730	300	47,49	
Input Circuit	1153-4740	400	51	
10-Mc BCD Counting Unit	1153-4770	700	53,55	
1-Mc BCD Counting Unit	1153-4760	600	57	
220-kc Decimal Ring Counting Unit	1150-4000	100	59	
40-kc Decimal Ring Counting Unit (2 used)	1150-4010	100	61	
Time-Base Divider (2 used)	1151-4720	200	63	
Power Supply and Oscillator	1153-2751	500	65	
Type 1153-P1 Frequency Multiplier	1153-3100	960 up	67	

PARTS LIST

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REF NO	DESCRIPTION	PART NO.
CAPACITO	RS	
C101 thru C110	*Ceramic, 0.001 μF ±10% 500V **Ceramic, 0.0022 μF +10% 500V	4406-2108 4406-2228
C111	*Ceramic, 0.001 μF ±10% 500V **Ceramic, 0.0033 μF ±10% 500V	4406-2108 4406-2338
C201 thru	Ceramic, 0.001 µF ±5% 500V	4405-2105

C220

C221

thru

C230

Ceramic, 330 pF ±10% 500V

C301 Ceramic, 220 pF $\pm 5\%$ 500V C302 Ceramic, 68 pF $\pm 5\%$ 500V C305 Ceramic, 0.1 µF $\pm 80-20\%$ 50V C306 Ceramic, 0.1 µF $\pm 20\%$ 25V C307 Ceramic, 0.01 µF $\pm 80-20\%$ 50V

C308Ceramic, $0.01 \ \mu F + 80 - 20\%$ 500VC309Electrolytic, $100 \ \mu F + 100 - 10\%$ 15VC312Ceramic, $0.001 \ \mu F \pm 10\%$ 500VC313Ceramic, $1 \ \mu F \pm 20\%$ 25VC314Ceramic, $330 \ pF \pm 10\%$ 500V

C315Ceramic, 330 pF $\pm 10\%$ 500VC316Ceramic, 330 pF $\pm 10\%$ 500VC317Ceramic, 0.001 μ F $\pm 10\%$ 500VC318Ceramic, 0.001 μ F $\pm 10\%$ 500VC319Ceramic, 0.47 μ F $\pm 20\%$ 25V

4404-1225 4404-0685 4403-4100 4400-2050 4401-3100 4406-3109 4450-2800 4405-2105 4400-2070

4404-1338

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4405-2105 4405-2105 4400-2054

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C320	Ceramic, 0.001 μ F ±10% 500V
C321	Ceramic, 0.01 μ F +80-20% 500V
C322	Electrolytic, 100 μ F +100-10% 15V
C323	Ceramic, 0.01 μ F +80-20% 500V
C324	Ceramic, 0.1 μ F ±20% 25V
C325	Ceramic, $0.022 \ \mu\text{F} +80-20\% 500V$
C326	Electrolytic, $100 \ \mu\text{F} +100-10\% 15V$
C327	Ceramic, $0.001 \ \mu\text{F} \pm 10\% 500V$
C328	Ceramic, $0.01 \ \mu\text{F} +80-20\% 500V$
C401	Variable, 8 to 50 pF
C402	Ceramic, 33 pF $\pm 5\%$ 500V
C403	Ceramic, 0.47 μ F $\pm 20\%$ 25V
C404	Ceramic, 1 μ F $\pm 20\%$ 25V
C405	Ceramic, 0.47 μ F $\pm 20\%$ 25V
C406	Ceramic, 0.1 µF +80-20% 50V
C407	Ceramic, 62 pF ±10% 500V
C408	Ceramic, 0.1 µF +80-20% 12V
C409	Ceramic, 33 pF ±5% 500V
C410	Ceramic, 0.1 µF +80-20% 50V

4405-2105 4406-3100 4450-2800 4406-3109 4400-2050 4407-3229 4450-2800 4405-2105 4406-3109 4910-1170 4404-0335 4400-2054 4400-2070 4400-2054 4403-4100 4404-0628 4403-4100 4404-0335 4403-4100

C411Ceramic, $0.1 \ \mu F$ $\pm 80-20\%$ 12VC412Ceramic, $0.1 \ \mu F$ $\pm 80-20\%$ 12VC413Ceramic, $330 \ pF$ $\pm 5\%$ 500VC414Ceramic, $330 \ pF$ $\pm 5\%$ 500VC415Ceramic, $330 \ pF$ $\pm 10\%$ 500V

C416 Ceramic, $0.1 \ \mu F +80-20\% 50V$ C417 Ceramic, $2.2 \ \mu F \pm 20\% 25V$

*Value for 220-kc Decimal Ring Counting Unit **Value for 40-kc Decimal Ring Counting Unit 4403-4100 4403-4100 4404-1335 4404-1335 4404-1338 4403-4100

4400-2080

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REF NO.	DESCRIPTION	PART NO.	
C501	Electrolytic, $6.8 \ \mu F \pm 20\% 35V$	4450-5000	
C502	Electrolytic, $2400 \ \mu F \pm 20\% 35V$	4450-5610	
C503	Ceramic, $0.01 \ \mu F \pm 80-20\% 50V$	4401-3100	
C504	Ceramic, $0.01 \ \mu F \pm 80-20\% 50V$	4401-3100	
C505	Electrolytic, $6.8 \ \mu F \pm 20\% 34V$	4450-5000	
C506	Mica, 0.001 μF ±2% 500V	4590-0690	
C507	Variable air, 4 to 50 pF	4380-0300	
C508	Ceramic, 47 pF ±5% 300V	4391-0475	
C509	Mica, 0.001 μF ±2% 500V	4590-0690	
C510	Ceramic, 0.1 μF ±80-20% 50V	4403-4100	
C511	Ceramic, 0.1 μ F +80-20% 50V	4403-4100	
C512	Ceramic, 0.1 μ F +80-20% 50V	4403-4100	
C513	Ceramic, 0.01 μ F +80-20% 500V	4406-3109	
C514	Ceramic, 0.1 μ F ±10% 500V	4403-4100	
C515	Ceramic, 0.1 μ F ±10% 500V	4403-4100	
C516	Ceramic, 0.1 µF +80-20% 50V	4403-4100	·
C517	Ceramic, 1 µF ±20% 25V	4400-2070	
C518	Ceramic, 820 pF ±5% 500V	4405-1825	
C519	Ceramic, 220 pF ±10% 500V	4404-1228	
C520	Ceramic, 0.01 µF +80-20% 50V	4401-3100	
C521	Ceramic, 470 pF $\pm 10\%$ 500V	4404-1478	· -
C522	Ceramic, 0.1 µF $\pm 80-20\%$ 50V	44C3-4100	
C523	Ceramic, 0.01 µF $\pm 80-20\%$ 50V	4401-3100	
C524	Ceramic, 0.1 µF $\pm 80-20\%$ 50V	4403-4100	
C525	Ceramic, 0.01 µF $\pm 80-20\%$ 50V	4406-3109	
C526	Ceramic, 0.0047 µF ±10% 500V	4407-2478	
C601	Ceramic, 0.1 µF +80-20% 50V	4403-4100	
C602	Ceramic, 150 pF ±5% 500V	4404-1155	
C603	Ceramic, 150 pF ±5% 500V	4404-1155	
C604	Ceramic, 0.01 µF +80-20% 50V	4401-3100	
C605	Ceramic, 82 pF ±5% 500V	4404-0825	
C606	Ceramic, 220 pF $\pm 5\%$ 500V	4404-1225	
C607	Ceramic, 220 pF $\pm 5\%$ 500V	4404-1225	
C608	Ceramic, 0.01 µF $\pm 80-20\%$ 50V	4401-3100	
C609	Ceramic, 0.01 µF $\pm 80-20\%$ 50V	4401-3100	
C610	Ceramic, 82 pF $\pm 5\%$ 500V	4404-0825	
C611	Ceramic, 330 pF ±5% 500V	4404-1335	
C612	Ceramic, 330 pF ±5% 500V	4404-1335	
C613	Ceramic, 0.01µF +80-20% 50V	4401-3100	
C614	Ceramic, 82 pF ±5% 500V	4404-0825	
C615	Ceramic, 330 pF ±5% 500V	4404-1335	
C616	Ceramic, 330 pF $\pm 5\%$ 500V	4404-1335	
C617	Ceramic, 0.01 µF $\pm 80-20\%$ 50V	4401-3100	
C618	Ceramic, 0.001 µF $\pm 10\%$ 500V	4405-2108	
C619	Ceramic, 220 pF $\pm 10\%$ 500V	4404-1228	
C620	Ceramic, 330 pF $\pm 5\%$ 500V	4404-1335	
C701	Ceramic, 0.1 µF ±80-20% 50V	4403-4100	
C702	Ceramic, 47 pF ±5% 500V	4404-0475	
C703	Ceramic, 47 pF ±5% 500V	4404-0475	
C704	Ceramic, 0.01 µF +80-20% 50V	4401-3100	
C705	Ceramic, 120 pF ±5% 500V	4404-1125	
070/			

4404-0825 4404-0825 4401-3100 4401-3100 4404-1125 4404-0825 4404-0825

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C706	Ceramic, 82 pF ±5% 500V
C707	Ceramic, 82 pF ±5% 500V
C708	Ceramic, 0.01 µF +80-20% 50V
C709	Ceramic, 0.01 µF +80-20% 50V
C710	Ceramic, 120 pF ±5% 500V
C711	Ceramic, 82 pF ±5% 500V
C712	Ceramic, 82 pF ±5% 500V

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REF NO. DESCRIPTION C713 Ceramic, $0.01 \ \mu F + 80-20\% 50V$ Ceramic, 120 pF ±5% 500V C714 Ceramic, 150 pF ±5% 500V C715 Ceramic, 150 pF ±5% 500V C716 Ceramic, 0.01 µF +80-20% 50V C717 Ceramic, $0.001 \ \mu F \ \pm 10\% \ 500V$ C718 C719 Ceramic, $0.001 \ \mu F \ \pm 10\% \ 500V$ Ceramic, 120 pF ±5% 500V C720 Ceramic, 0.01 µF +80-20% 50V C721Ceramic, 0.01 µF +80-20% 50V C722 Electrolytic, $33 \ \mu F \pm 20\% 20V$ C801 Ceramic, 0.1 µF +80-20% 50V C802 Ceramic, 0.1 µF +80-20% 50V C803

PART NO.4401 - 31004404 - 11254404 - 11554404 - 11554401 - 31004405 - 21084405 - 21084405 - 21084404 - 11254401 - 31004401 - 31004401 - 31004401 - 31004403 - 41004403 - 4100

$ \begin{array}{ccccc} C806 & Ceramic, 0.047 \ \mu F \ +80\ -20\% \ 500V & 4409\ -3479 \\ C807 & Variable, 1.5 to 7 \ pF & 4910\ -0300 \\ C808 & Ceramic, 4.7 \ pF \ +5\% \ 500V & 4403\ -4100 \\ C809 & Ceramic, 0.1 \ \mu F \ +80\ -20\% \ 50V & 4403\ -4100 \\ C810 & Electrolytic, 10 \ \mu F \ \pm 20\% \ 20V & 4450\ -5100 \\ \end{array} \right) \\ \textbf{DIODES CR101 } Type \ 1N18A & 6082\ -1006 \\ \hline CR102 & thru & Type \ 1N645 & 6082\ -1016 \\ \hline CR201 & thru & Type \ 1N625 & 6082\ -1012 \\ \hline CR301 & Type \ 1N625 & 6082\ -1012 \\ \hline CR302 & Type \ 1N645 & 6082\ -1016 \\ \hline CR303 & Type \ 1N645 & 6082\ -1016 \\ \hline CR304 & Type \ 1N645 & 6082\ -1016 \\ \hline CR305 & Type \ 1N645 & 6082\ -1016 \\ \hline CR306 & Type \ 1N645 & 6082\ -1016 \\ \hline CR307 & Type \ 1N645 & 6082\ -1016 \\ \hline CR308 & Type \ 1N645 & 6082\ -1016 \\ \hline CR309 & Type \ 1N645 & 6082\ -1016 \\ \hline CR309 & Type \ 1N645 & 6082\ -1016 \\ \hline CR309 & Type \ 1N645 & 6082\ -1016 \\ \hline CR300 & Type \ 1N645 & 6082\ -1016 \\ \hline CR301 & Type \ 1N645 & 6082\ -1016 \\ \hline CR301 & Type \ 1N645 & 6082\ -1016 \\ \hline CR302 & Type \ 1N645 & 6082\ -1016 \\ \hline CR301 & Type \ 1N645 & 6082\ -1016 \\ \hline CR311 & thru & Type \ 1N645 & 6082\ -1016 \\ \hline CR311 & thru & Type \ 1N645 & 6082\ -1016 \\ \hline CR312 & Type \ 1N645 & 6082\ -1016 \\ \hline CR311 & thru & Type \ 1N645 & 6082\ -1016 \\ \hline CR311 & thru & Type \ 1N645 & 6082\ -1016 \\ \hline CR312 & Type \ 1N645 & 6082\ -1016 \\ \hline CR311 & thru & Type \ 1N645 & 6082\ -1016 \\ \hline CR311 & thru & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline CR321 & Type \ 1N645 & 6082\ -1016 \\ \hline C$		C804 C805	Ceramic, 0.01 μ F ±20% 500V Ceramic, 0.001 μ F ±10% 500V	4406-3100 4405-2108
CR102 thru Type 1N645 6082-1016 CR111 CR201 thru Type 1N625 6082-1012 CR201 thru Type 1N625 6082-1012 CR301 Type 1N625 6082-1012 CR302 Type 1N625 6082-1012 CR303 Type 1N645 6082-1012 CR304 Type 1N645 6082-1016 CR305 Type 1N645 6082-1016 CR306 Type 1N645 6082-1016 CR307 Type 1N645 6082-1016 CR308 Type 1N645 6082-1016 CR309 Type 1N645 6082-1016 CR310 Type 1N645 6082-1016 CR311 thru Type 1N645 6082-1016 CR311 thru Type 1N645 6082-1016 CR317 Type 1N645 6082-1012 CR320 Type 1N645 6082-1012 CR321 Type 1N645 6082-1012 CR321 Type 1N645 6082-1012 CR401 Type TD-1 6085-1003 CR402 Type 1N645 6082-1016 CR403		C807 C808 C809	Variable, 1.5 to 7 pF Ceramic, 47 pF ±5% 500V Ceramic, 0.1 µF +80-20% 50V	4910-0300 4404-0475 4403-4100
thru Type 1N645 6082-1016 CR201 Type 1N625 6082-1012 CR224 CR301 Type 1N625 6082-1012 CR301 Type 1N625 6082-1012 6082-1012 CR302 Type 1N625 6082-1012 6082-1012 CR303 Type 1N645 6082-1016 6082-1016 CR304 Type 1N645 6082-1016 6082-1016 CR305 Type 1N645 6082-1010 6082-1010 CR306 Type 1N645 6082-1010 6082-1010 CR307 Type 1N645 6082-1016 6082-1016 CR308 Type 1N645 6082-1016 6082-1016 CR310 Type 1N645 6082-1016 6082-1016 CR311 thru Type 1N625 6082-1012 6082-1012 CR316 CR317 Type 1N625 6082-1012 6082-1012 CR320 Type 1N625 6082-1012 6082-1012 CR317 Type 1N625 6082-1012 6082-1012 CR317 Type 1N625 6082-1012 6082-1012 CR321 Type 1N625 6082-1012<	DIODES	CR101	Type 1N118A	6082-1006
thru CR224 Type 1N625 6082-1012 CR301 Type 1N625 6082-1012 CR302 Type 1N625 6082-1012 CR303 Type 1N645 6082-1016 CR304 Type 1N645 6082-1016 CR305 Type 1N645 6082-1016 CR306 Type 1N645 6082-1016 CR307 Type 1N645 6082-1010 CR308 Type 1N645 6082-1010 CR307 Type 1N645 6082-1016 CR308 Type 1N645 6082-1016 CR309 Type 1N645 6082-1016 CR310 Type 1N645 6082-1016 CR311 thru Type 1N625 6082-1012 CR316 Type 1N645 6082-1012 CR317 Type 1N645 6082-1012 CR320 Type 1N645 6082-1012 CR321 Type 1N625 6082-1012 CR322 Type 1N625 6082-1012 CR321 Type 1N625 6082-1012 CR401 Type TD-1 6085-1003 CR402 Type 1N645 6082-1015		thru	Type 1N645	6082-1016
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		thru	Type 1N625	6082 - 1012
CR307 Type 1N455 6082-1010 CR308 Type 1N645 6082-1016 CR309 Type 1N645 6082-1016 CR310 Type 1N645 6082-1016 CR311 thru Type 1N625 6082-1012 CR316 CR317 6082-1016 6082-1012 CR320 CR321 Type 1N625 6082-1012 CR321 Type 1N625 6082-1012 CR322 Type 1N625 6082-1012 CR401 Type TD-1 6085-1003 CR402 Type 1N645 6082-1015 CR404 Type 1N645 6082-1016		CR302 CR303 CR304	Type 1N625 Type 1N645 Type 1N645	6082-1012 6082-1016 6082-1016
thru Type 1N625 6082-1012 CR316 CR317 6082-1016 CR320 Type 1N645 6082-1016 CR321 Type 1N625 6082-1012 CR322 Type 1N625 6082-1012 CR401 Type TD-1 6085-1003 CR402 Type 1N965B 6083-1015 CR404 Type 1N645 6082-1016 CR405 Type 1N645 6082-1016		CR307 CR308 CR309	Type 1N455 Type 1N645 Type 1N645	6082-1010 6082-1016 6082-1016
thru CR320Type 1N6456082-1016CR321 CR322Type 1N6256082-1012CR322 CR322Type 1N6256082-1012CR401 CR402Type TD-16085-1003CR402 CR402Type 1N965B6083-1015CR404 CR404Type 1N6456082-1016CR405 Type 1N6455082-1016		thru	Type 1N625	6082 - 1012
CR322 Type 1N625 6082-1012 CR401 Type TD-1 6085-1003 CR402 Type 1N965B 6083-1015 CR404 Type 1N645 6082-1016 CR405 Type 1N645 6082-1016		thru	Type 1N645	6082-1016
CR402Type 1N965B6083-1015CR404Type 1N6456082-1016CR405Type 1N6456082-1016				
		CR402 CR404 CR405	Type 1N965B Type 1N645 Type 1N645	6083-1015 6082-1016 6082-1016

CR408 Type 1N746 CR409 Type 1N957B CR410 Type 1N3604 CR501 Type 1N3493 CR502 Type 1N3493 CR503 Type 1N941

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6083-1005 6083-1009 6082-1001 6081-1007 6081-1007 6083-1013

REF NO.		DESCRIPTION	PART NO.
CR504 CR505	Type 1N645 Type 1N645		6082 - 1016 6082 - 1016
CR506 CR507 CR508 CR509 CR510	Type 1N625 Type 1N625 Type 1N625 Type 1N645 Type 1N645		6082-1012 6082-1012 6082-1012 6082-1016 6082-1016
CR511 CR512 CR513	Type 1N625 Type 1N625 Type 1N629		6082-1012 6082-1012 6083-1015
CR601 thru	Type 1N118A		6082 - 1006

CR612

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	CR613 thru CR622	Type 1N3604	6082 - 1001
	CR623	Type 1N3828A	6083-1056
	CR701 thru CR712	Type 1N995	6082-1002
	CR713 thru CR723	Type 1N3604	6082 - 1001
	CR726	Type 1N3828A	6083-1056
	CR801	Type 1N645	6082-1016
FUSES	F501	For 115-V operation, 1A 3AG slo-blo For 230-V operation, 0.5A 3AG slo-blo	5330-1400 5330-1000
	F502	For 115-V operation, 1A 3AG slo-blo For 230-V operation, 0.5A 3AG slo-blo	5330-1400 5330-1000
INDICATORS	II thru I6	Type IND-300 Indicator Assemblies, incandescent- lamp operated, each includes 10 lamps	5437 - 0300
	lamps	No. 330, 14V, 80 mA, size T-1 3/4	5600-0309
	spare lamps	Eight spare lamps are included with the instrument, see page	·
JACKS	J501 J502	Phono jack, Switchcraft No. 3505F INT 100 kc Phono jack, Switchcraft No. 3505F EXT 100 kc INPUT	4260-1280 4260-1280
	J801	Binding-post assembly, consists of: INPUT One binding post, metal top Two insulators, gray plastic	4060-0100 4130-0200
	J802	Binding-post assembly, consists of: ground One binding post, metal top One spacer, metal	4060-0100 7800-0600
	J803	Telephone jack, Switchcraft No.12B PHOTOELECTRIC PICKOFF	4260-1200

INDUCTORS	L301 L302	2.2 μH 2.2 μH	• •
	L702 L703 L704 L706 L707	5.6 μH 4.7 μH 5.6 μH 5.6 μH 4.7 μH	±10% ±10% ±10%

4300-1200 4300-1200 4300-1800 4300-1600 4300-1800 4300-1800 4300-1600

	<i>REF NO.</i> L708	DESCRIPTION 5.6 µH ±10%		<i>PART NO.</i> 4300-1800
	L801	10,000 μH ±10%		4300-6200
MOTOR	MO501	Blower motor Fan blade		5760-1200 5180-4251
LAMPS	For lamps	s used in indicators, see INDICATORS, pag	e	
	P801 P802	Number 344, 10V,15MA, size T-13/4	SPILL COUNT	5600-0314 5600-0314
	P803 thru P806	Number 330, 14V, 80 mA, size T-1 3/4 de	ecimal points	5600-0309

PLUG PL501	3-terminal power plug, consists of: 2-terminal power plug Ground pin	4240-0600 4240-0800
TRANSISTORS Q101 thru Q120	Type 2N1303	8210-1019
Q121	*Type MM-487	8210-1028
	**Type 2N1302	8210-1018
Q201 thru Q220	Type 2N1303	8210-1019
Q301 Q302 Q303 Q304 Q305	Type 2N1499B Type 2N1499B Type 2N779A Type 2N779A Type 2N1131	8210-1068 8210-1068 8210-7791 8210-7791 8210-1025
Q306 Q307 Q308 Q309 Q310	Type 2N1303 Type 2N1303 Type 2N1302 Type TI412 Type 2N2714	8210-1019 8210-1019 8210-1018 8210-1102 8210-1047
Q311 Q312 Q313 Q314	Type 2N1303 Type 2N1303 Type 2N1303 Type 2N1302	8210-1019 8210-1019 8210-1019 8210-1018
Q315 thru Q319	Type 2N1303	8210-1019
Q320	Type 2N1302	8210-1018
Q401 Q403 Q404	Type 2N708 Type 4JX 12G1162 Type 2N708	8210-3089 8210-1101 8210-3089
Q405 thru Q410	Type 2N779A	8210-7791
Q501	Type 2N1544	8210-1014

	for 220-kc Decimal Ring Counting Unit for 40-kc Decimal Ring Counting Unit
Q507	Type 2N1305
Q506	Type 2N708
Q505	Type 2N779A
Q504	Type 2N1304
Q503	Type 2N1304
Q502	Type 2N1131
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0210-1014 8210-1025 8210-1304 8210-1304 8210-7791 8210-3089 8210-1305

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	REF NO.	DESCRIPTION	PART NO.
	Q508	Type 2N1305	8210-1305
	Q509	Type 2N1305	8210-1305
	Q601 thru Q612	Type 2N3638	8210-1096
	Q613 thru Q620	Type 2N1499A	8210-1499
	Q621	Type 2N3638	8210-1096
	Q622	Type 2N3638	8210-1096
	Q701 thru Q710	Type 2N1305	8210-1305
	Q711	Type 2N1374	8210-1374
	Q712	Type 2N1305	8210-1305
	Q713	Type 2N976	8210-1057
	Q714	Type 2N976	8210-1057
	Q715 thru Q720	Type 2N779A	8210-7791
	Q721	Type 2N1305	8210-1305
	Q722	Type 2N1305	8210-1305
RESISTORS	R101	Composition, $68\Omega \pm 5\% 1/2w$	6100-0685
	R102	Composition, $4.3 k\Omega \pm 5\% 1/2w$	6100-2435
	R103	*Composition, $2.7 k\Omega \pm 5\% 1/2w$	6100-2275
	R103	**Composition, $3.3 k\Omega \pm 5\% 1/2w$	6100-2335
	R104	Composition, $68 \Omega \pm 5\% 1/2w$	6100-0685
	R105	Composition, $4.3 k\Omega \pm 5\% 1/2w$	6100-2435
	R106	*Composition, 2.7 k Ω ±5% 1/2w	6100-2275
	R106	**Composition, 3.3 k Ω ±5% 1/2w	6100-2335
	R107	Composition, 68 Ω ±5% 1/2w	6100-0685
	R108	Composition, 4.3 k Ω ±5% 1/2w	6100-2435
	R109	*Composition, 2.7 k Ω ±5% 1/2w	6100-2275
	R109	**Composition, 3.3 k Ω ±5% 1/2w	6100-2335
	R110	Composition, 68 Ω ±5% 1/2w	6100-0685
	R111	Composition, $4.3 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2435
	R112	*Composition, $2.7 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2275
	R112	**Composition, $3.3 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2335
	R113	Composition, $68 \Omega \pm 5\% 1/2\text{w}$	6100-0685
	R114	Composition, $4.3 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2435
	R115	*Composition, $2.7 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2275
	R115	*Composition, $3.3 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2335
	R116	Composition, 68 $\Omega \pm 5\% 1/2w$	6100-0685
	R117	Composition, 4.3 k $\Omega \pm 5\% 1/2w$	6100-2435
	R118	*Composition, 2.7 k $\Omega \pm 5\% 1/2w$	6100-2275
	R118	**Composition, 3.3 k $\Omega \pm 5\% 1/2w$	6100-2335
	R119	Composition, 68 $\Omega \pm 5\% 1/2w$	6100-0685
	R120	Composition, 4.3 k $\Omega \pm 5\% 1/2w$	6100-2435
	R121	*Composition, 2.7 k Ω ±5% 1/2w	6100-2275
	R121	**Composition, 3.3 k Ω ±5% 1/2w	6100-2335
	R122	Composition, 68 Ω ±5% 1/2w	6100-0685
	R123	Composition, 4.3 k Ω ±5% 1/2w	6100-2435
	R124	*Composition, 2.7 k Ω ±5% 1/2w	6100-2275
	R124	**Composition, 3.3 k Ω ±5% 1/2w	6100-2335
	R125	Composition, 68 Ω ±5% 1/2w	6100-0685

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Composition, 4.3 k Ω ±5% 1/2w *Composition, 2.7 k Ω ±5% 1/2w R126 R127

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*Value for 220-kc Decimal Ring Counting Unit **Value for 40-kc Decimal Ring Counting Unit

6100-2435 6100-2275

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	DEE NO	ΝΕΚΟΡΙΡΤΙΟΝ	DADT NO
	<i>REF NO.</i> R127	DESCRIPTION **Composition, 3.3 k Ω ±5% 1/2w	<i>PART NO</i> . 6100-2335
	R128	Composition, 82 Ω ±5% 1/2w	6100-0825
	R129	Composition, 4.3 k Ω ±5% 1/2w	6100-2435
	R130	*Composition, 2.7 k Ω ±5% 1/2w	6100-2275
	R130	**Composition, 3.3 k Ω ±5% 1/2w	6100-2335
	R131	Composition, 5.1 k Ω ±5% 1/2w	6100-2515
	R132	Composition, 560 Ω ±10% 1w	6110-1569
	R133		6000 .1000
	thru	Composition, 330 Ω ±10% 1/2w	6099-1339
	R142	a = 141 = 0.71	6099-2279
	R201	Composition, 2.7 k Ω ±10% 1/4w	6099-2279
	R202	Composition, 6.8 k Ω ±10% 1/4w	6099-2089
	R203	Composition, 2.7 k Ω ±10% 1/4w	6099-2689
	R204	Composition, 6.8 k Ω ±10% 1/4w Composition, 2.7 k Ω ±10% 1/4w	6099-2279
	R205		6099-2689
	R206	Composition, 6.8 k Ω ±10% 1/4w Composition, 2.7 k Ω ±10% 1/4w	6099-2089
	R207	Composition, 2.7 KM $\pm 10\%$ 1/4w Composition, 6.8 k Ω $\pm 10\%$ 1/4w	6099-2689
	R208	Composition, 0.6 k 10 10 174w Composition, 2.7 k Ω $\pm 10\%$ $1/4w$	6099-2279
`	R209 R210	Composition, 2.7 KM $\pm 10\%$ 1/4w Composition, 6.8 k Ω $\pm 10\%$ 1/4w	6099-2689
	R211	Composition, 2.7 k Ω ±10% 1/4w	6099-2279
	R212	Composition, 6.8 k Ω ±10% 1/4w	6099-2689
	R213	Composition, 2.7 k Ω ±10% 1/4w	6099-2279
	R214	Composition, 6.8 k Ω ±10% 1/4w	6099-2689
	R215	Composition, 2.7 k Ω ±10% 1/4 w	6099 - 2279
	R216	Composition, 6.8 k Ω ±10% 1/4w	6099-2689
	R217	Composition, 2.7 k Ω ±10% 1/4w	6099-2279
	R218	Composition, 6.8 k Ω ±10% 1/4w	6099-2689
	R219	Composition, 2.7 k Ω ±10% 1/4w	6099-2279
	R220	Composition, 6.8 k Ω ±10% 1/4w	6099 - 2689
	R221	Composition, 2.7 k Ω ±10% 1/4w	6099 - 2279
	R222	Composition, 6.8 k Ω ±10% 1/4w	6099-2689
	R223	Composition, 2.7 k Ω ±10% 1/4w	6099 - 2279
	R224	Composition, 6.8 k Ω ±10% 1/4w	6099-2689
	R225	Composition, 2.7 k Ω ±10% 1/4w	6099-2279
	R226	Composition, 6.8 k Ω ±10% 1/4w	6099-2689
	R227	Composition, 2.7 k Ω ±10% 1/4w	6099-2279
	R228	Composition, 6.8 k Ω ±10% 1/4w	6099-2689
	R229	Composition, 2.7 k Ω ±10% 1/4w	6099-2279
	R230	Composition, 6.8 k Ω ±10% 1/4w	6099-2689
	R231	Composition, 2.7 k Ω ±10% 1/4w	6099-2279
	R232	Composition, 6.8 k Ω ±10% 1/4w	6099-2689
	R233	Composition, 2.7 k Ω ±10% 1/4w	6099-2279
	R234	Composition, 6.8 k Ω ±10% 1/4w	6099-2689
	R235	Composition, 2.7 k Ω ±10% 1/4w	6099-2279
	R236	Composition, 6.8 k Ω ±10% 1/4w	6099-2689 6099-2279
	R237	Composition, 2.7 k Ω ±10% 1/4w	6099-2279
	R238	Composition, 6.8 k Ω ±10% 1/4w	6099-2009
	R239	Composition, 2.7 k Ω ±10% 1/4w	6099-2689
	R240	Composition, 6.8 k Ω ±10% 1/4w	0077 2007
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6099-2279

Composition, 2.7 k Ω ±10% 1/4w thru R270

R271 Composition, 100 Ω ±10% 1/4w thru R280A

Composition, 220 Ω ±10% 1/4w R281 *Value for 220-kc Decimal Ring Counting Unit **Value for 40-kc Decimal Ring Counting Unit

6099-1109

6099-1229

REF NO.	DESCRIPTION	PART NO.
R282	Composition, 220 Ω ±10% 1/4w	6099 - 1229
R283	Composition, 220 Ω ±10% 1/4w	6099-1229
R284	Composition, 220 Ω ±10% 1/4w	6099 - 1229
R302	Composition, 13 k Ω ±5% 1/4w	6099-3135
R303	Composition, 1.5 k Ω ±5% 1/2w	6100-2155
R304	Composition, 6.8 k Ω ±5% 1/4w	6099-2685
R305	Composition, 82 Ω ±5% 1/4w	6099-0825
R306	Composition, $10 \text{ k}\Omega \pm 5\% \text{ 1/4w}$	6099-3105
R307	Composition, $1 k\Omega \pm 5\% 1/2w$	6100 - 2105
R308	Composition, 560 Ω ±5% 1/2w	6100-1565
R309	Composition, 300 Ω ±5% 1/4w	6099-1305
R310	Composition, 300 Ω ±5% 1/4w	6099-1305
R311	Composition, 2.7 k Ω ±5% 1/4w	6099 - 2275
R312	Composition, 3.9 k Ω ±5% 1/4w	6099-2395
R313	Composition, 2.7 k Ω ±5% 1/4w	6099-2275
R314	Composition, $1 k\Omega \pm 5\% 1/4w$	6099-2105
R315	Composition, 4.7 k Ω ±5% 1/4w	6099-2475
R316	Composition, 4.7 k Ω ±5% 1/4w	6099-2475
R317	Composition, 2.7 k Ω ±5% 1/4w	6099-2275 6099-2275
R318	Composition, 2.7 k Ω ±5% 1/4w	6099-2275 6099-3225
R319	Composition, 22 k Ω ±5% 1/4w	6099-3223
R320 R321	Composition, 750 Ω ±5% 1/4w Composition, 22 k Ω ±5% 1/4w	6099-1733
R323	Composition, 2.7 k Ω ±5% 1/4w	6099-2275 6099-3105
R325	Composition, $10 k\Omega \pm 5\% 1/4w$	6099-3275
R326	Composition, 47 k Ω ±5% 1/4w	6099-3273
R327 R328	Composition, 2.7 k Ω ±5% 1/4w Composition, 4.7 k Ω ±5% 1/4w	6099-2475
		· · · ·
R329	Composition, 560 k Ω ±5% 1/4w	6099-4565
R330	Composition, 3.3 k Ω ±5% 1/4w	6099-2335
R331	Composition, 15 k Ω ±5% 1/4w	6099-3155 6099-2275
R332	Composition, 2.7 k Ω ±5% 1/4w	6099-2273
R333	Composition, 200 Ω ±5% 1/4w	
R334	Composition, 510 Ω ±5% 1/4w	6099-1515
R335	Composition, 1.3 k $\Omega \pm 5\% 1/4w$	6099-2135
R336	Composition, 5.6 k Ω ±5% 1/4w	6099-2565 6000-2205
R337	Composition, $3 k\Omega \pm 5\% 1/4w$	6099-2305 6099-2205
R338	Composition, $2 k\Omega \pm 5\% 1/4w$	-
R339	Composition, 7.5 k Ω ±5% 1/4w	6099-2755
R340	Composition, 10 k Ω ±5% 1/4w	6099-3105
R341	Composition, 12 k Ω ±5% 1/4w	6099-3125
R342	Composition, 2.7 k Ω ±5% 1/4w	6099-2275 6099-2275
R343	Composition, 2.7 k Ω ±5% 1/4w	
R344	Composition, $10 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-3105
R345	Composition, $10 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-3105
R346	Composition, $10 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-3105
R347	Composition, 4.7 k Ω ±5% 1/4w	6099-2475
R348	Composition, 4.7 k $\Omega \pm 5\% 1/4w$	6099-2475
R349	Composition, 8.2 k Ω ±5% 1/4w	6099-2825
R350	Composition, 68 k Ω ±5% 1/4w	6099-3685
R351	Composition, 2.7 k Ω ±5% 1/4w	6099-2275
R352	Composition, 4.7 k Ω ±5% 1/4w	6099-2475
R353	Composition, 4.7 k Ω ±5% 1/4w	6099-2475
R354	Composition, 2.7 k Ω ±5% 1/4w	6099-2275
R355	Composition, $1 k\Omega \pm 5\% 1/4w$	6099-2105
R356	Composition, 510 Ω ±5% 1/4w	6099-1515
R357	Composition, $10 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-3105
R358	Composition, 120 Ω ±5% 2w	6120-1125

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REF NO.	DESCRIPTION	PART NO.
R359	Composition, $4.7 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2475
R360	Composition, $2.7 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2275
R361	Composition, $4.7 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2475
R362	Composition, $4.7 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2475
R363	Composition, $820 \Omega \pm 5\% 1/4\text{w}$	6099-1825
R364	Composition, $10 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-3105
R365	Composition, $6.8 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2685
R366	Composition, $680 \Omega \pm 5\% 1/4\text{w}$	6099-1685
R367	Composition, $2 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2205
R368	Composition, $620 \Omega \pm 5\% 1/4\text{w}$	6099-1625
R369	Composition, $10 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-3105
R370	Composition, $360 \Omega \pm 5\% 1\text{w}$	6110-1365
R371	Composition, $10 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-3105
R372	Composition, $10 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-3105
R373	Composition, $5.1 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2515
R374	Composition, 2.4 k Ω ±5% 1/4w	6099-2245
R375	Composition, 10 k Ω ±5% 1/4w	6099-3105
R376	Composition, 2 k Ω ±5% 1/4w	6099-2205
R401	Composition, 75 k Ω ±5% 1/4w	6099-3755
R402	Composition, 39 k Ω ±5% 1/4w	6099-3395
R403	Composition, 620 k Ω ±5% 1/4w	6099-4625
R404	Composition, 47 Ω ±5% 1/4w	6099-0475
R405	Composition, 47 Ω ±5% 1/4w	6099-0475
R406	Composition, $3.9 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2395
R407	Composition, $47 \Omega \pm 5\% 1/4\text{w}$	6099-0475
R408	Composition, $47 \Omega \pm 5\% 1/4\text{w}$	6099-0475
R409	Composition, $5.6 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2565
R410	Composition, $560 \Omega \pm 5\% 1/4\text{w}$	6099-1565
R411	Composition, $5.6 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2565
R412	Composition, $39 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-3395
R413	Composition, $18 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-3185
R414	Composition, $5.6 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2565
R415	Composition, $1 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2105
R416	Composition, $20 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-3205
R417	Composition, $2.7 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2275
R418	Composition, $2.2 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2225
R419	Composition, $560 \Omega \pm 5\% 1/4\text{w}$	6099-1565
R420	Composition, $56 \Omega \pm 5\% 1/4\text{w}$	6099-0565
R421	Composition, 560 $\Omega \pm 5\% 1/4w$	6099-1565
R422	Composition, 560 $\Omega \pm 5\% 1/4w$	6099-1565
R423	Composition, 3.9 k $\Omega \pm 5\% 1/4w$	6099-2395
R424	Composition, 820 $\Omega \pm 5\% 1/4w$	6099-1825
R425	Composition, 1.2 k $\Omega \pm 5\% 1/4w$	6099-2125
R426	Composition, $100 \Omega \pm 5\% 1/4w$	6099-1105
R427	Composition, $390 \Omega \pm 5\% 1/4w$	6099-1395
R428	Composition, $2.7 k\Omega \pm 5\% 1/4w$	6099-2275
R429	Composition, $360 \Omega \pm 5\% 1/4w$	6099-1365
R430	Composition, $200 \Omega \pm 5\% 1/4w$	6110-1205
R431	Composition, $150 \Omega \pm 5\% 1/4w$	6099-1155
R432	Composition, $220 \Omega \pm 5\% 1/4w$	6099-1225
R433	Composition, $820 \Omega \pm 5\% 1/4w$	6099-1825
R434	Composition, $330 \Omega \pm 5\% 1/4w$	6099-1335

- R434 Composition, $350^{-1}-5\%$ 174w R435 Potentiometer, composition, 1 M Ω ±20%
- R436 Composition, 2.2 k Ω ±5% 1/4w
- R501Wire-wound, $0.47 \ \Omega \pm 10\% 2w$ R502Composition, $200 \ \Omega \pm 5\% 1/2w$ R503Composition, $1 \ k\Omega \pm 5\% 1/2w$ R504Thyrector diode, $90 \ V$

6040-1500 6099-2225 6760-8479 6100-1205 6100-2105 6741-1002

REF NO.	DESCRIPTION	<i>PART NO.</i> 6630-0155
R505 R506 R507 R508 R509 R510	Wire-wound, $15 \Omega \pm 5\% 30w$ Composition, $1.2 k\Omega \pm 5\% 1/2w$ Composition, $1 k\Omega \pm 5\% 1/2w$ Composition, $3.9 k\Omega \pm 5\% 1/2w$ Precision wire-wound, $1 k\Omega \pm 1\% 3$ Potentiometer, wire-wound $2 k\Omega \pm 1\%$	6100-2125 6100-2105 6100-2395 6100-2395 6730-1100
R511	Precision wire-wound, $1.5 \text{ k}\Omega \pm 1\%$	3/10w 6730-2150
R512	Composition, $2.7 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2275
R513	Composition, $3.3 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2335
R514	Composition, $7.5 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2755
R515	Composition, $24 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-3245
R516	Composition, $2.2 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2225
R517	Composition, $3.3 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2335
R518	Composition, $24 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-3245
R519	Composition, $1 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2105
R520	Composition, $24 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-3245
R521	Composition, $10 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-3105
R522	Composition, $1 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2105
R523	Composition, $30 \Omega \pm 5\% 1/2\text{w}$	6100-0305
R524	Composition, $2 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2205
R525	Composition, $3.9 \text{ k}\Omega \pm 5\% 1/2\text{w}$	6100-2395
R526	Composition, $820 \ \Omega \pm 5\% \ 1/2w$	6100-1825
R527	Composition, $13 \ k\Omega \pm 5\% \ 1/2w$	6100-3135
R528	Composition, $150 \ \Omega \pm 5\% \ 1/2w$	6100-1155
R529	Composition, $470 \ \Omega \pm 5\% \ 1/2w$	6100-1475
R530	Composition, $9.1 \ k\Omega \ \pm 5\% \ 1/2w$	6100-2915
R531 R532 R533 R534 R601	Composition, $330 \ \Omega \pm 5\%$ 1w Composition, $2 \ k\Omega \pm 5\%$ 1/2w Composition, $2 \ k\Omega \pm 5\%$ 1/2w Composition, $470 \ \Omega \pm 5\%$ 1/2w	6110-1335 6100-2205 6100-2205 6100-1475
thru	Composition, $4.7 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2475

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Composition, $4.7 \text{ K}_{32} = 5\% = 1/4\text{ w}$ R606

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R607 R608		68 Ω ±5% 2w 4.7 kΩ ±5% 1/4w	6120-0685 6099-2475
R609 thru R618	Composition,	390 Ω ±5% 1/4w	6099 -1395
R619 R620 R621 R622 R623	Composition, Composition, Composition,	43 Ω ±5% 1w 5.1 k Ω ±5% 1/4w 1 k Ω ±5% 1/4w 5.1 k Ω ±5% 1/4w 1 k Ω ±5% 1/4w	6110-0435 6099-2515 6099-1105 6099-2515 6099-1105
R624 R625 R626 R627 R628	Composition, Composition, Composition,	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	6099-1515 6120-1155 6099-1395 6099-1565 6099-2335
R629 R630		3.3 k Ω ±5% 1/4w 560 Ω ±5% 1/4w	6099-2335 6099-1565 6000-1205

6099-1395 Composition, 390 Ω ±5% 1/4w R631 R632 6099-1565 Composition, 560 Ω ±5% 1/4w thru R635 6099-2475 Composition, 4.7 k Ω ±5% 1/4w R636 6099-1565 Composition, 560 k Ω ±5% 1/4w R637 6099-1565 Composition, 560 k Ω ±5% 1/4w R638

REF NO.	DESCRIPTION	PART NO.
R639 thru R644	Composition, $3.3 \text{ k}\Omega \pm 5\% \text{ 1/4w}$	6099 -2335
R645 thru R648	Composition, 820 Ω ±5% 1/4w	6099 - 1825
R649 thru R656	Composition, $6.2 \text{ k}\Omega \pm 5\% \text{ 1/4w}$	6099 - 2625
R701 thru R706	Composition, 4.7 k Ω ±5% 1/4w	6099-2475

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R707 R708	Composition, Composition,	1.5 k Ω ±5% 1/4w 4.7 k Ω ±5% 1/4w	6099-2155 6099-2475
R709 thru R718		390 Ω ±5% 1/4w	6099-1395
R719 R720 R721 R722 R723	Composition, Composition, Composition,	27 $\Omega \pm 5\%$ 1w 5.1 k $\Omega \pm 5\%$ 1/4w 1 k $\Omega \pm 5\%$ 1/4w 5.1 k $\Omega \pm 5\%$ 1/4w 1 k $\Omega \pm 5\%$ 1/4w 1 k $\Omega \pm 5\%$ 1/4w	6110-0275 6099-2515 6099-2105 6099-2515 6099-2105
R724 R725 R726 R727 R728	Composition, Composition, Composition,	510 Ω ±5% 1 '4w 120 Ω ±5% 2w 390 Ω ±5% 1 '4w 300 Ω ±5% 1 '4w 2.2 k Ω ±5% 1 '4w	6099-1515 6120-1125 6099-1395 6099-1305 6099-2225
R729	Composition,	$2.2 \text{ k}\Omega \pm 5\% 1/4 \text{w}$	6099-2225
R730 thru R735	Composition,	$300 \ \Omega \ \pm 5\% \ 1/4w$	6099 - 1305
R736 R737 R738	Composition,	1 kΩ ±5% 1/4w 300 Ω ±5% 1/4w 300 Ω ±5% 1/4w	6099-2105 6099-1305 6099-1305
R739 thru R744	Composition,	2.2 k Ω ±5% 1/4w	6099-2225
R745 R746 R747 R748	Composition, Composition,	270 Ω ±5% 1/4w 820 Ω ±5% 1/4w 820 Ω ±5% 1/4w 820 Ω ±5% 1/4w 820 Ω ±5% 1/4w	6099-1275 6099-1825 6099-1825 6099-1825
R749 thru R756	Composition,	4.7 kΩ ±5% 1/4w	6099-2475
R757	Composition,	$200 \Omega \pm 5\% 1/4w$	6099-1205
R801 R802 R803 R804	Composition, Composition, Composition,	24 $\Omega \pm 5\% 1/4w$ 47 k $\Omega \pm 5\% 1/2w$ 5.6 k $\Omega \pm 5\% 1/2w$ 470 $\Omega \pm 5\% 1w$ TDICCED	6100-0245 6100-3475 6100-2565 6110-1475
DOOF		$f = \frac{1}{2} + $	6045-1060

R804 TRIGGER 6045-1060 Potentiometer, composition, $5 k\Omega \pm 10\%$; R805 LEVEL uses 5530-0400 gray knob

Composition, 910 k Ω ±5% 1/2w R806 Composition, 75 Ω ±5% 1w R807 Composition, $510 \text{ k}\Omega \pm 5\% 1/2\text{w}$ R808 Composition, $1 k\Omega \pm 5\% 1/4w$ R809 Composition, $10 \ k\Omega \ \pm 5\% \ 1/4w$ R810

6100-4915 6110-0755 6100-4515 6099-2105 6099-3105

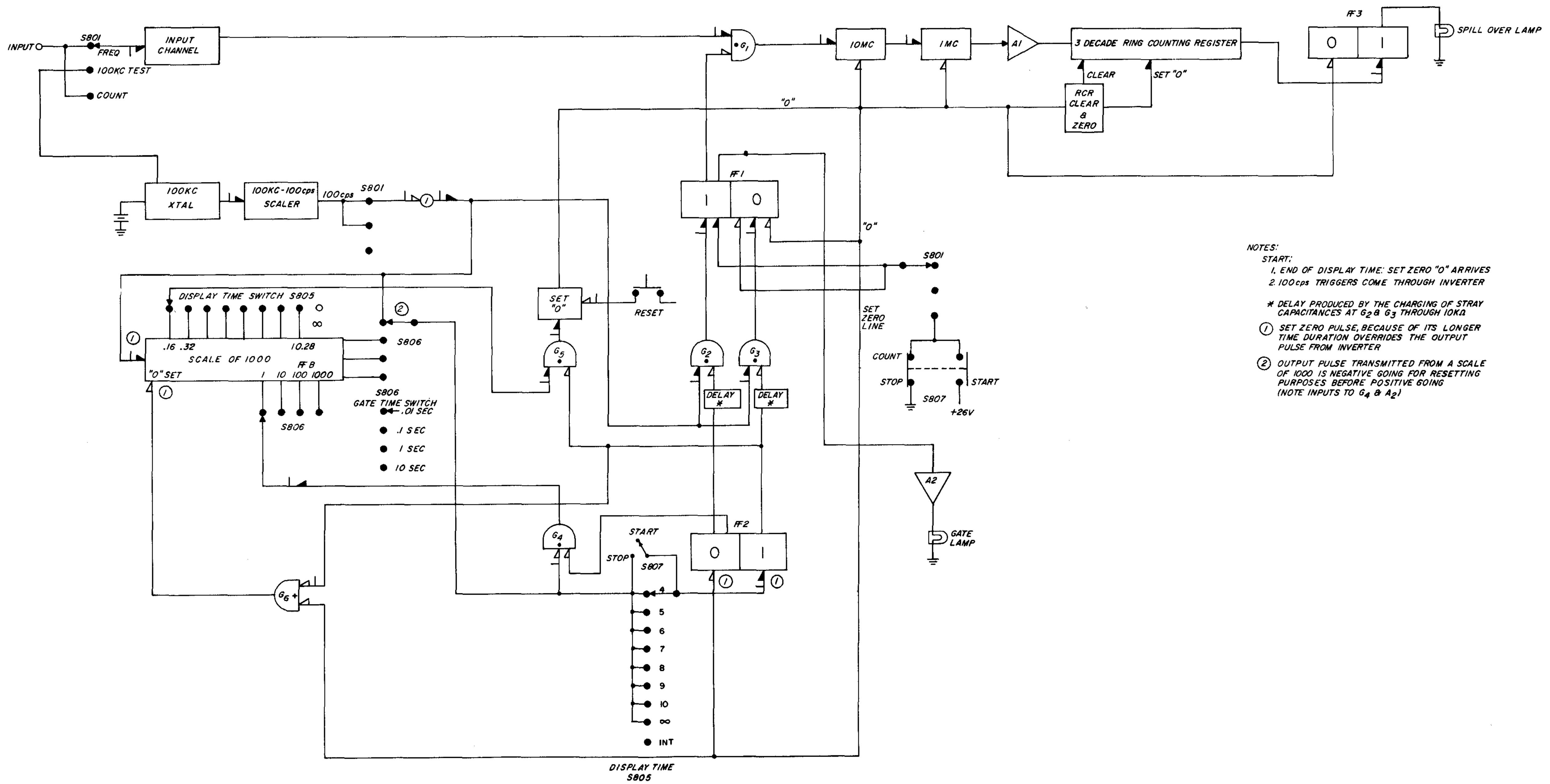
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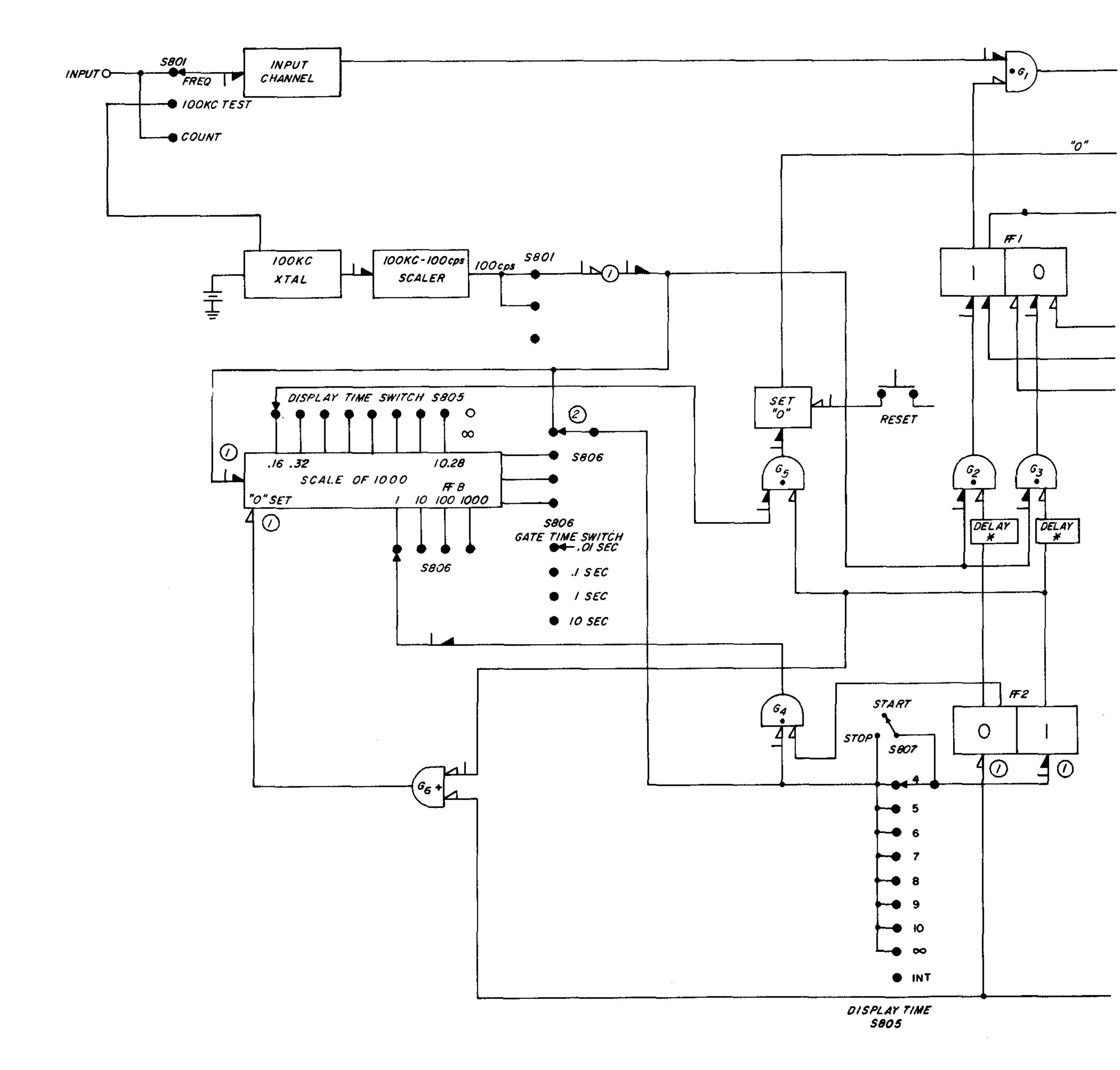
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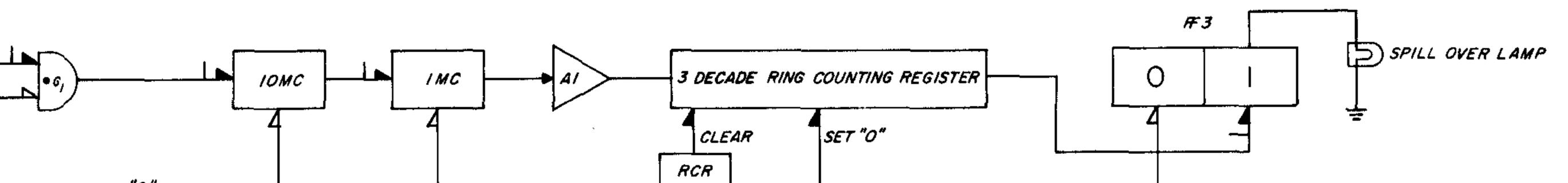
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	REF NO.	DESCRIPTION		PART NO.
	R811 R812	Composition, 10 Ω ±5% 1/2w Composition, 10 k Ω ±5% 1/4w		6100-0105 6099 - 3105
	R901 thru R950	Composition, 2.4 k Ω ±5% 1/4w		6099 - 2245
SWITCHES	S501 S502 S801	Toggle, dpst Slide, dpst Rotary, 3-position, 2-section, non- shorting; uses 5530-0400 gray knob	POWER TIME BASE MEASUREMENT	
	S802 S803	Toggle, spdt Toggle, spdt	INPUT COUPLING IMPEDANCE	7910-0792 7910-0792
	S804 S805	Push-button, spdt, Microswitch Rotary, 9-position, 1-section, non-	RESET DISPLAY TIME	7870-1123 7890-3920
	S80 6	shorting; uses 5530-0400 gray knob Rotary, 4-position, 2-section, non- shorting; uses 5500-1700 gray knob	COUNTING TIME	7890-3930
	S807		COUNT/MULT INT	7910-1500
SOCKETS	SO101 thru SO701	18-contact, Methode No. CDG18S		4230-2699
	SO801 SO901	8-contact, Jones,No. S-308-AB 52-contact, Amphenol No. 220-698-0	AUX COUNTING UNIT OUTPUT	4230-5000
TRANSFORMERS	T401 T402 T403 T501	Pulse transformer Pulse transformer Pulse transformer Power transformer		5000-6010 5000-6010 5000-6010 0485-4024
CRYSTAL	X501	Crystal, 200-kc, GT-cut		1153-0420





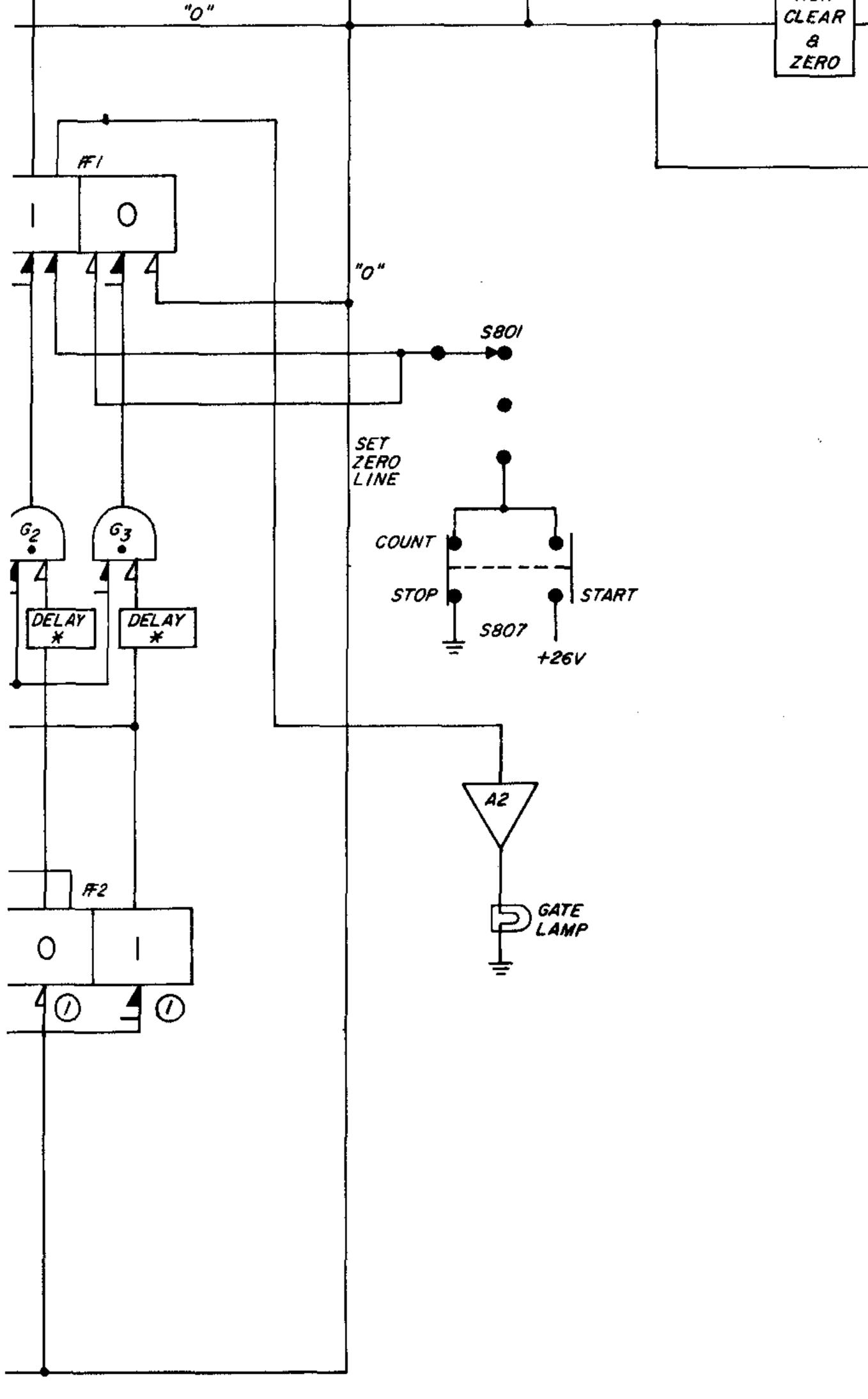
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NOTES:

START:

I, END OF DISPLAY TIME: SET ZERO "O" ARRIVES 2. 100 cps TRIGGERS COME THROUGH INVERTER

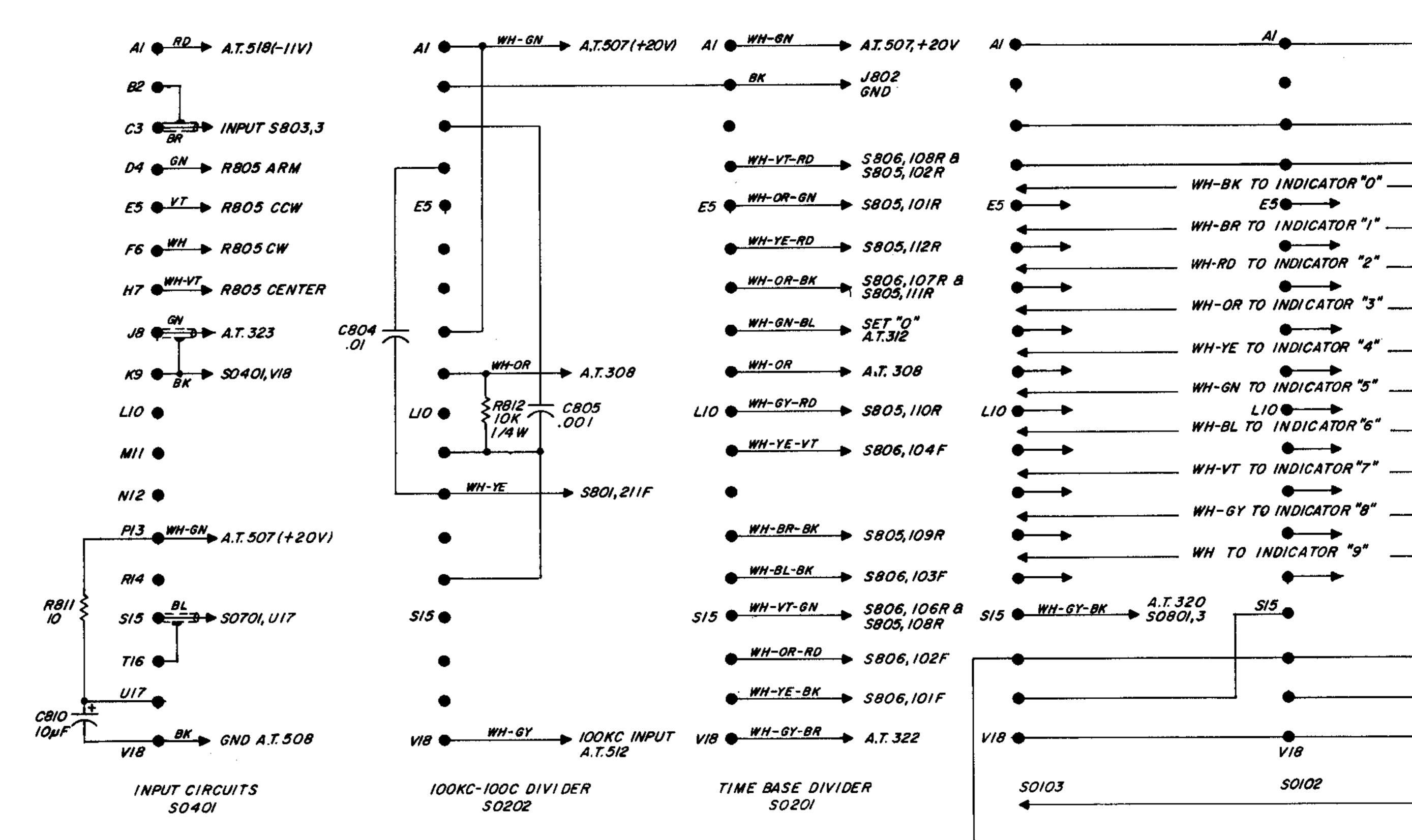
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- * DELAY PRODUCED BY THE CHARGING OF STRAY CAPACITANCES AT G28 G3 THROUGH IOKA
- () SET ZERO PULSE, BECAUSE OF ITS LONGER TIME DURATION OVERRIDES THE OUTPUT PULSE FROM INVERTER
- 2 OUTPUT PULSE TRANSMITTED FROM A SCALE OF 1000 IS NEGATIVE GOING FOR RESETTING PURPOSES BEFORE POSITIVE GOING (NOTE INPUTS TO 64 & A2)

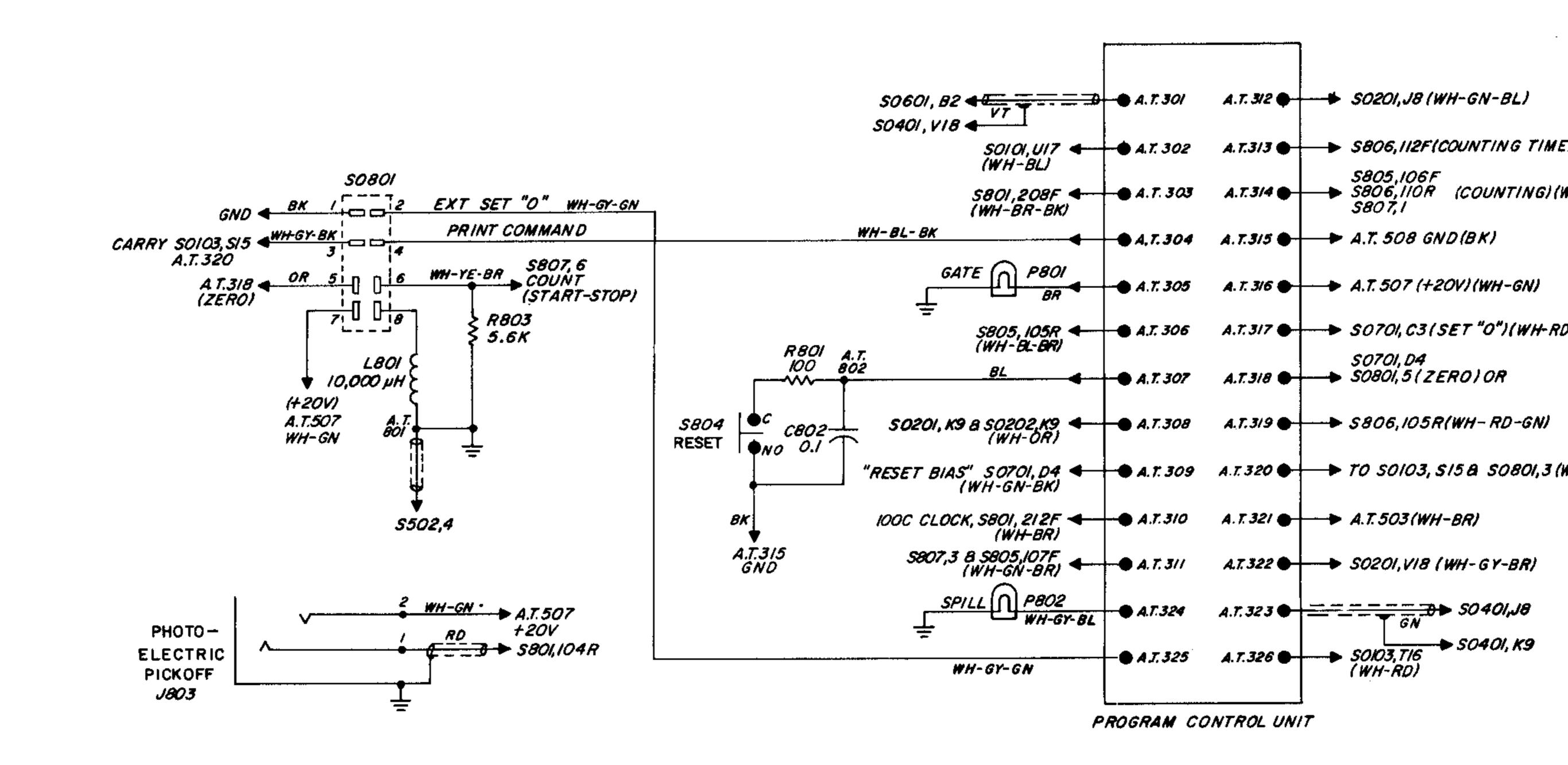
LOGIC DIAGRAM 43

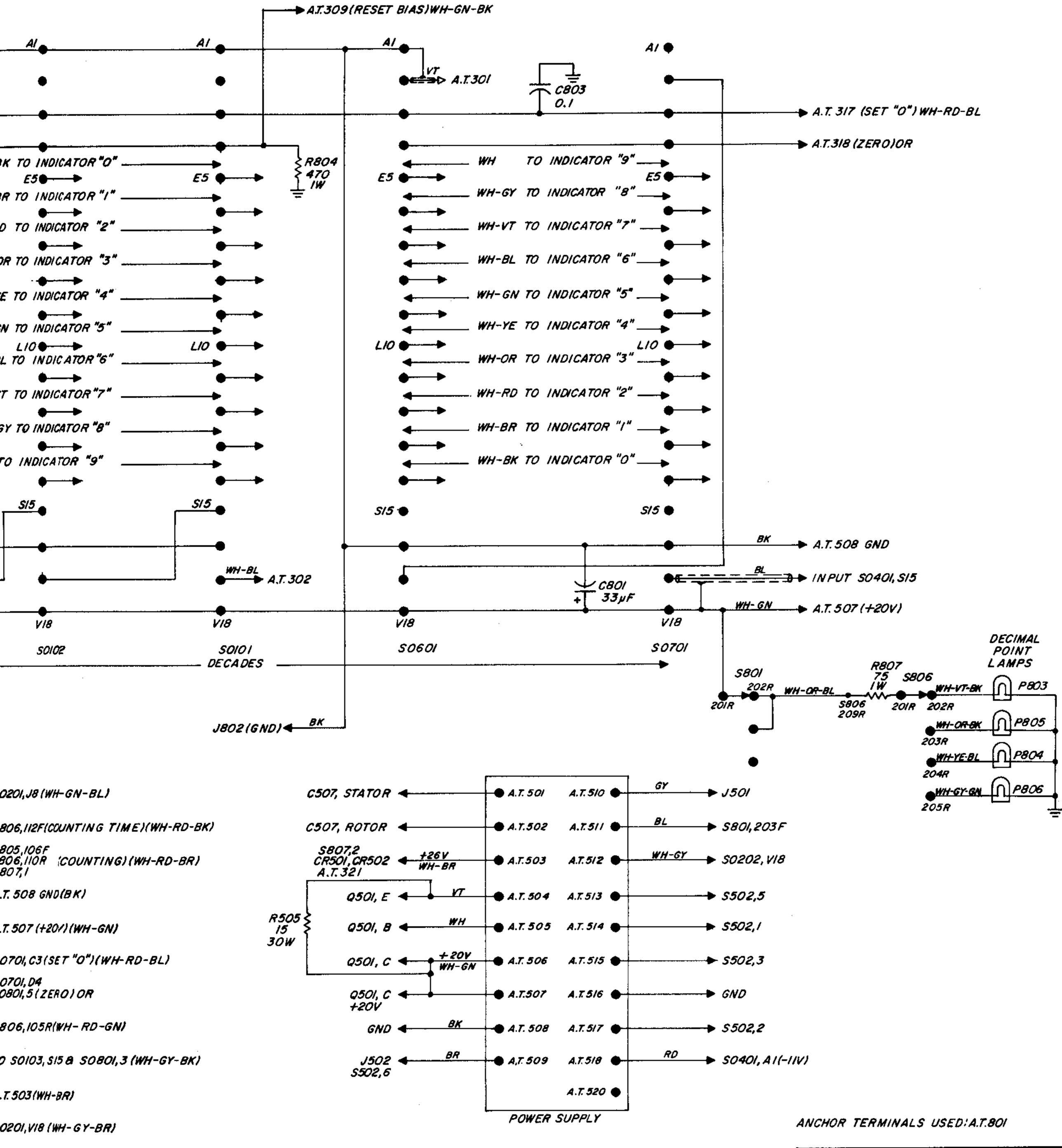
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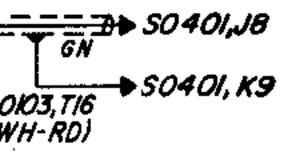








NOTE UNLESS SPECIFIED



 POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK. 	 RESISTANCE IN OHMS K = 1000 OHMS M 1 MEGOHM CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
3. REFER TO SERVICE NOTES IN INSTR- UCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.	7. O KNOB CONTROL 8. SCREWDRIVER CONTROL 9. AT - ANCHOR TERMINAL
4. RESISTORS 1/2 WATT.	10. TP - TEST POINT

INTERCONNECTIONS 45

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NOTE UNLESS SPECIFIED

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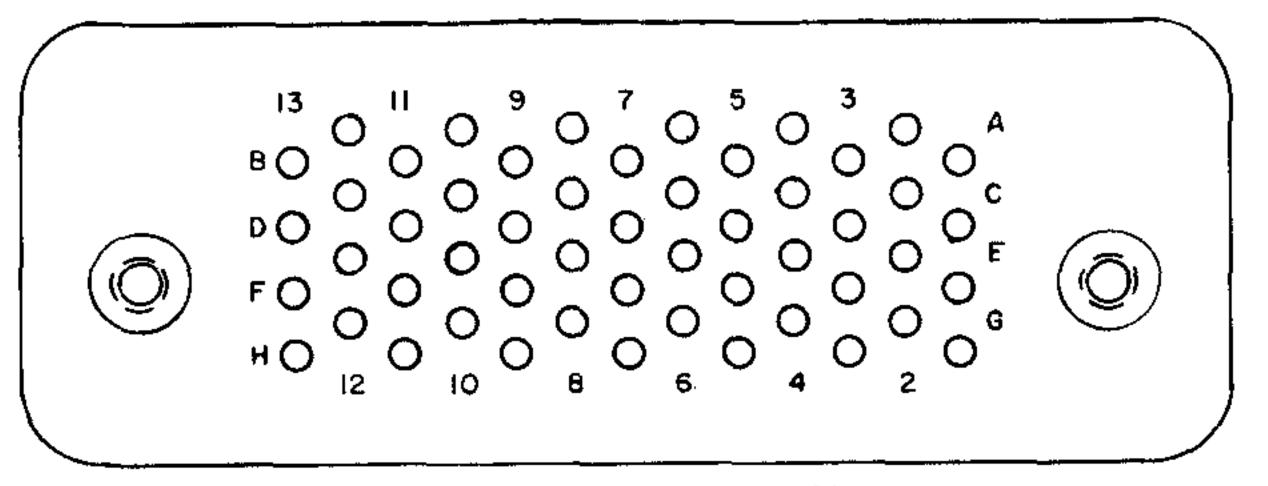
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ALL RESISTORS ARE REC-9BF, 2.4KQ±5%

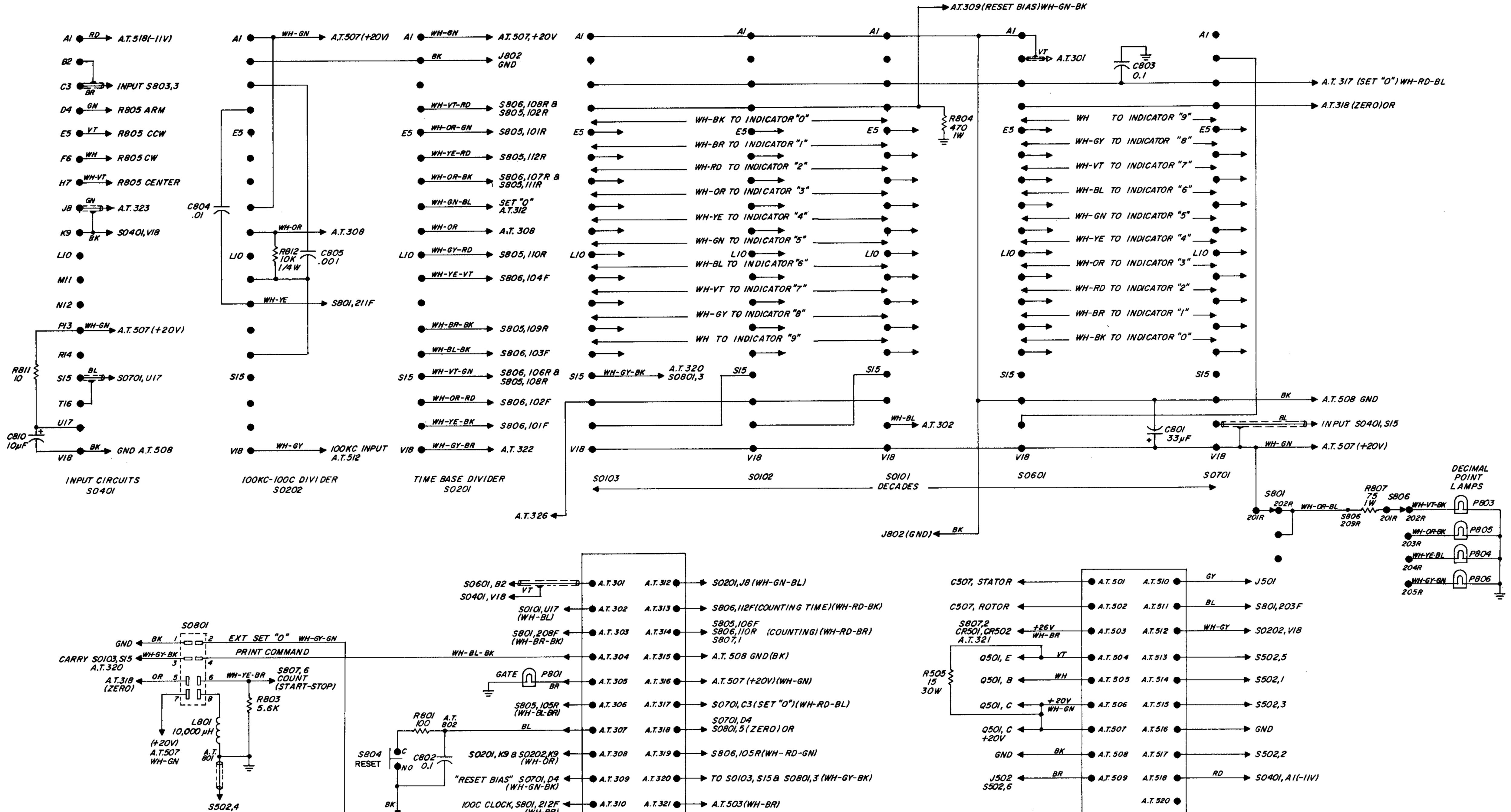
INDICATOR	BROWN FERRULES	RED FERRULES	BLUE FERRULES	YELLOW FERRULES	GREEN FERRULES	
 	то то 50901 5070, R 901	TO TO I SO901 SO 601 R 9 11	TO TO 50901 SOIOI R921	TO TO SO901 SO102 R 931	TO TO 50901 S0103 R 94 1	
0	A2	89 🖝	D3	EIO	G4 ●> E5 (WH-BK)	
	R902 A4 ● ^ F6	R9/2 8// ●₩► F6	R922 D5 ●^// F6	R932 E12 ●-^^/► F6	R942 G 6 ●^^/~> F6(WH-BR)	
2	R903 A6 €	R9/3 BI3 ●^//► H7	R923 D7 ●^//> H7	R933 FI •	R943 G8 ●^//→ H7(WH-RD)	
3	R904 A8 •	R9/4 C2 ●	R924 D9 €^^/-► J8	R934 F3 ●-^^/→ J8	R944 GIO ●-^^/~-► J8 (WH-OR)	HII WH-GN-BR
4	R905 AIO●_^^^_► K9	R915 C4 ●₩	R 9 25 D/I ●∿√√► K9	R935 F5 ●-₩	R945 GI2 ●\\/> K9 (WH-YE)	
- i					R946 HI ●-^^/-► LIO(WH-GN)	
6	R907 BI ●> MII	R917 C8 ●> MII	R927 E2 ●^//→ M//	R937 F9 ●-^///► MII	R947 H3 ●-^\\ -> MII (WH-BL)	
7	R908 83 ● ^^- NI2	R.918 CIO ●VV► NI2	R 9 28 E4 ●∿∿> NI2	R938 FII ●-^^/ ► NI2	R 94 8 H5	
8	R909 85 €-₩-> PI3	R 9 I9 CI2 €^//→ PI3	R929 E6 ● -₩-> P13	R939 FI3 ●₩	R949 H7 ●^\\\v> PI3 (W I-GY)	
9	R 91 0 B7 ●	R920 DI ●> RI4	R93 0 E8 €₩> RI4	R940 G2	. 79 50 H9 ●-^^/ ► RI4(WH)	1
L	UNITS	TENS	HUNDREDS	THOUSANDS	TEN THOUSANDS	

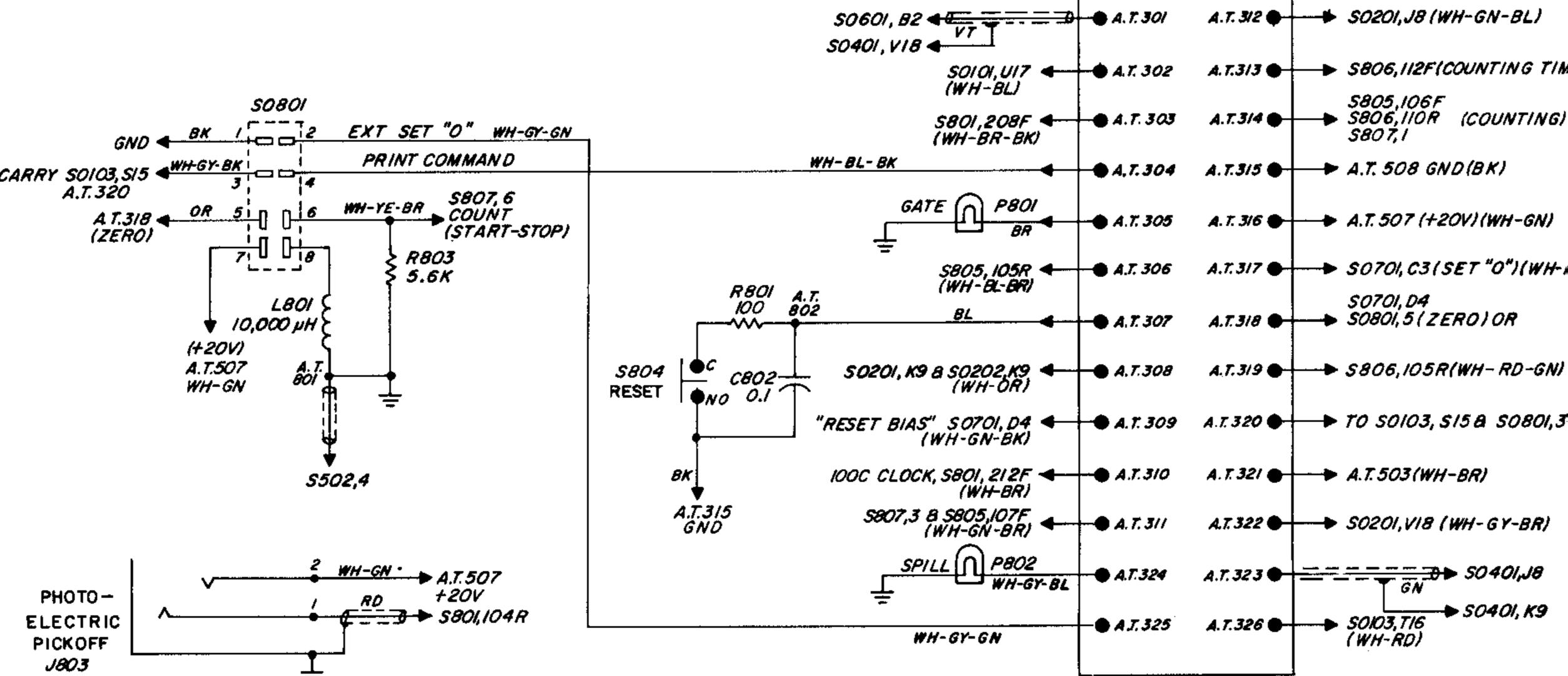
SO90I EXTERNAL ACCESSORY SOCKET



REAR VIEW OF SO901

NOTE: FOR SCHEMATIC DIAGRAMS SEE 10-Mc BCD COUNTING UNIT, PAGE 55; 1-Mc BCD COUNTING UNIT, PAGE 57; 220-kc DECIMAL RING COUNTING UNIT, PAGE 59; AND 40-kc DECIMAL RING COUNTING UNIT, PAGE 61.





PROGRAM CONTROL UNIT

POWER SUPPLY

ANCHOR TERMINALS USED: A.T.801

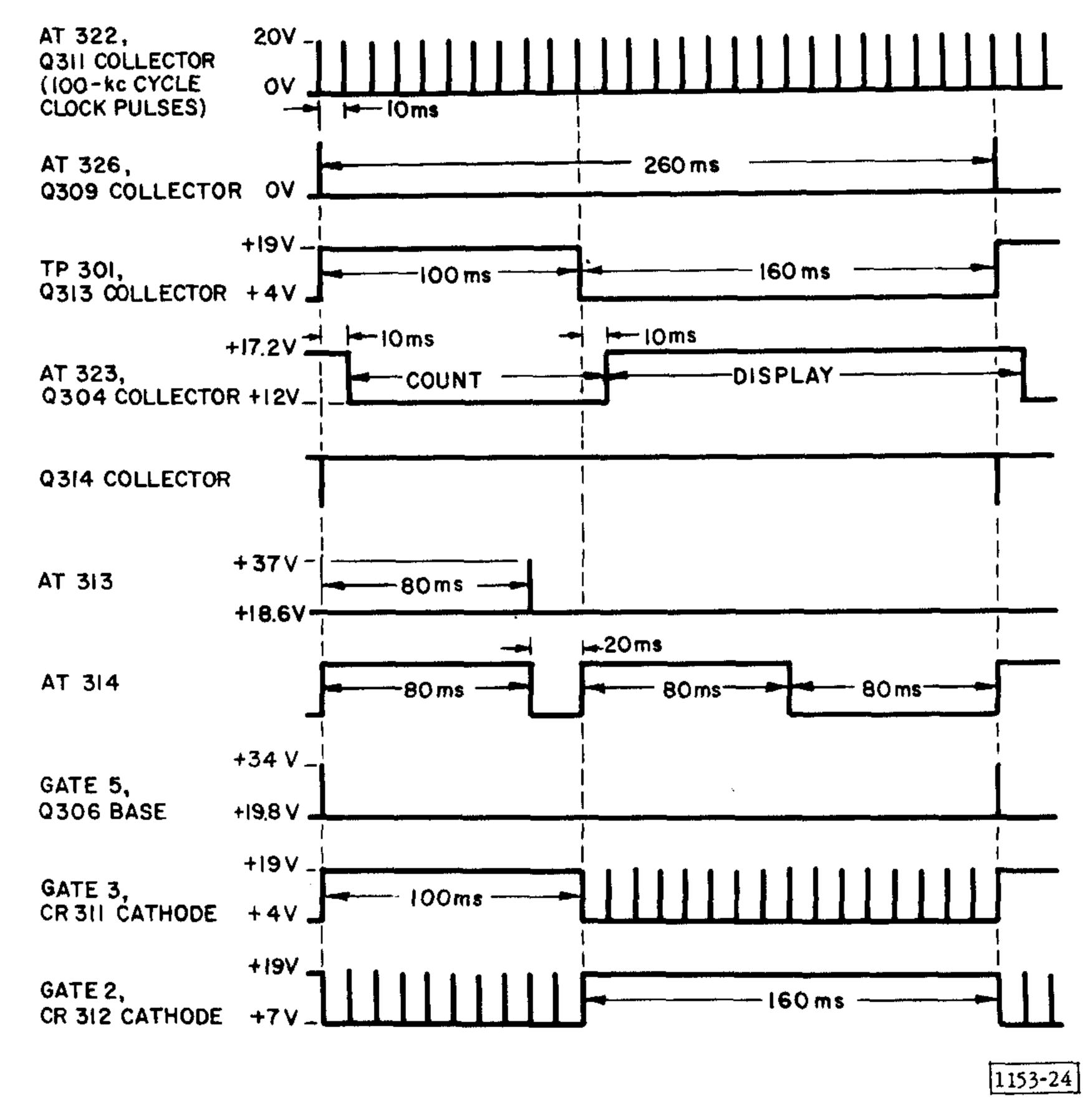
NOTE UNLESS	SPECIFIED
1. POSITION OF ROTARY SWITCHES	5. RESISTANCE IN OHMS
SHOWN COUNTERCLOCKWISE.	K = 1000 OHMS M 1 MEGOHM
2. CONTACT NUMBERING OF SWITCHES	6. CAPACITANCE VALUES ONE AND
EXPLAINED ON SEPARATE SHEET	OVER IN PICOFARADS, LESS
SUPPLIED IN INSTRUCTION BOOK.	THAN ONE IN MICROFARADS.
3. REFER TO SERVICE NOTES IN INSTR-	7. O KNOB CONTROL
UCTION BOOK FOR VOLTAGES	8. O SCREWDRIVER CONTROL
APPEARING ON DIAGRAM.	9. AT - ANCHOR TERMINAL
4. RESISTORS 1/2 WATT.	10. TP - TEST POINT

PROGRAM CONTROL



.





Transistor	DC Voltage to Ground Terminal			
TTANSISTOL	e	b	с	
Q301	+19.0	+18.5	+18.8	
Q302	+19.0	+19.3	0	
Q303	+17.1	+23.2	+12.0	
Q304	+17.1	+16.7	+17.0	
Q305	+19.0	+19.5	+ 2.7	
Q306	+20.0	+19.8	+19.9	
Q307	+19.2	+19.9	0	
Q308	0	0	+20.7	
Q309	0	+ 0.8	+ 0.5	
Q310	+14.9	+15.5	+20.0	
Q311	+19.3	+20.0	0	
Q312	+19.3	+19.8	+ 6.5	
Q313	+19.3	+19.0	+19.2	
Q314	0	0	+20.7	
Q315	+19.2	+20.5	0	
Q316	+19.2	+20.0	0	
Q317	+19.3	+19.0	+19.2	
Q318	+19.2	+19.2	0	

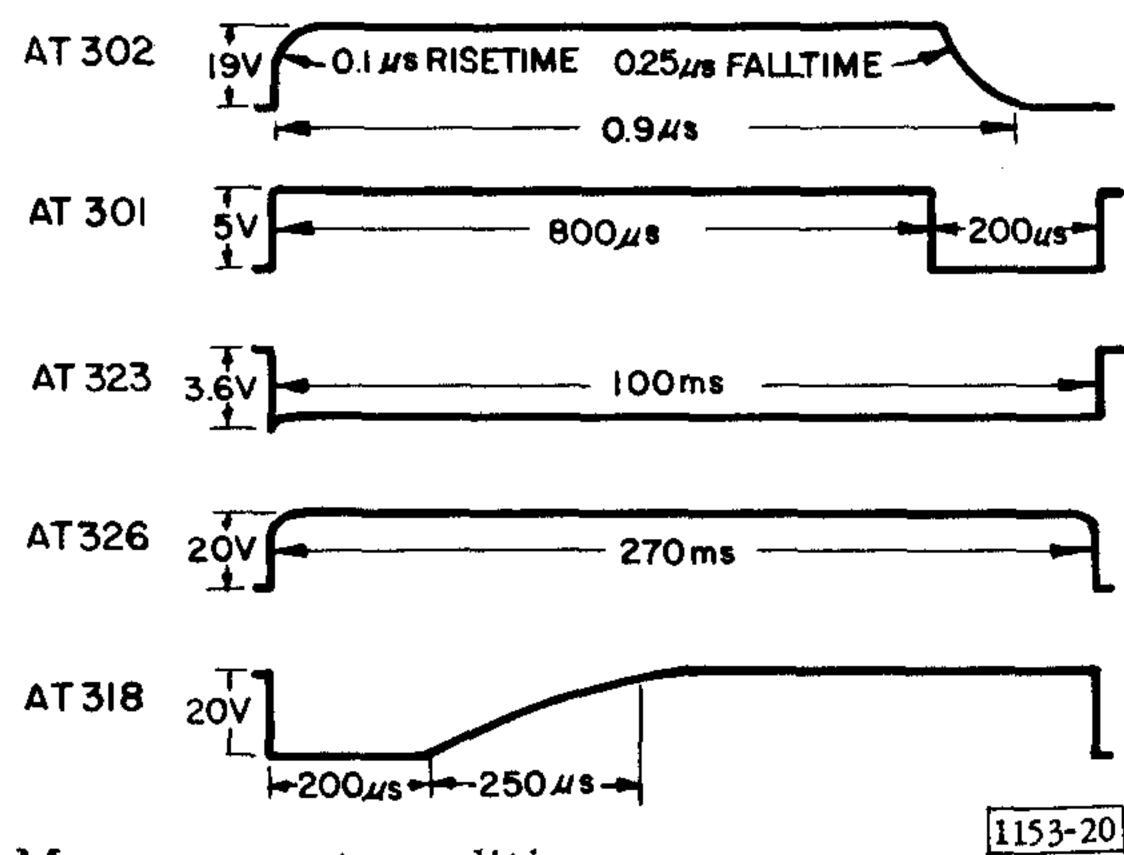
Measurement conditions:

TRIGGER LEVEL...centered MEASUREMENT....COUNT COUNTING TIME... MULT INT COUNT/MULT INT. . . STOP

No input signal applied. Voltmeter

impedance at least 20,000 ohms per volt. Push RESET button each time a voltmeter connection is made.

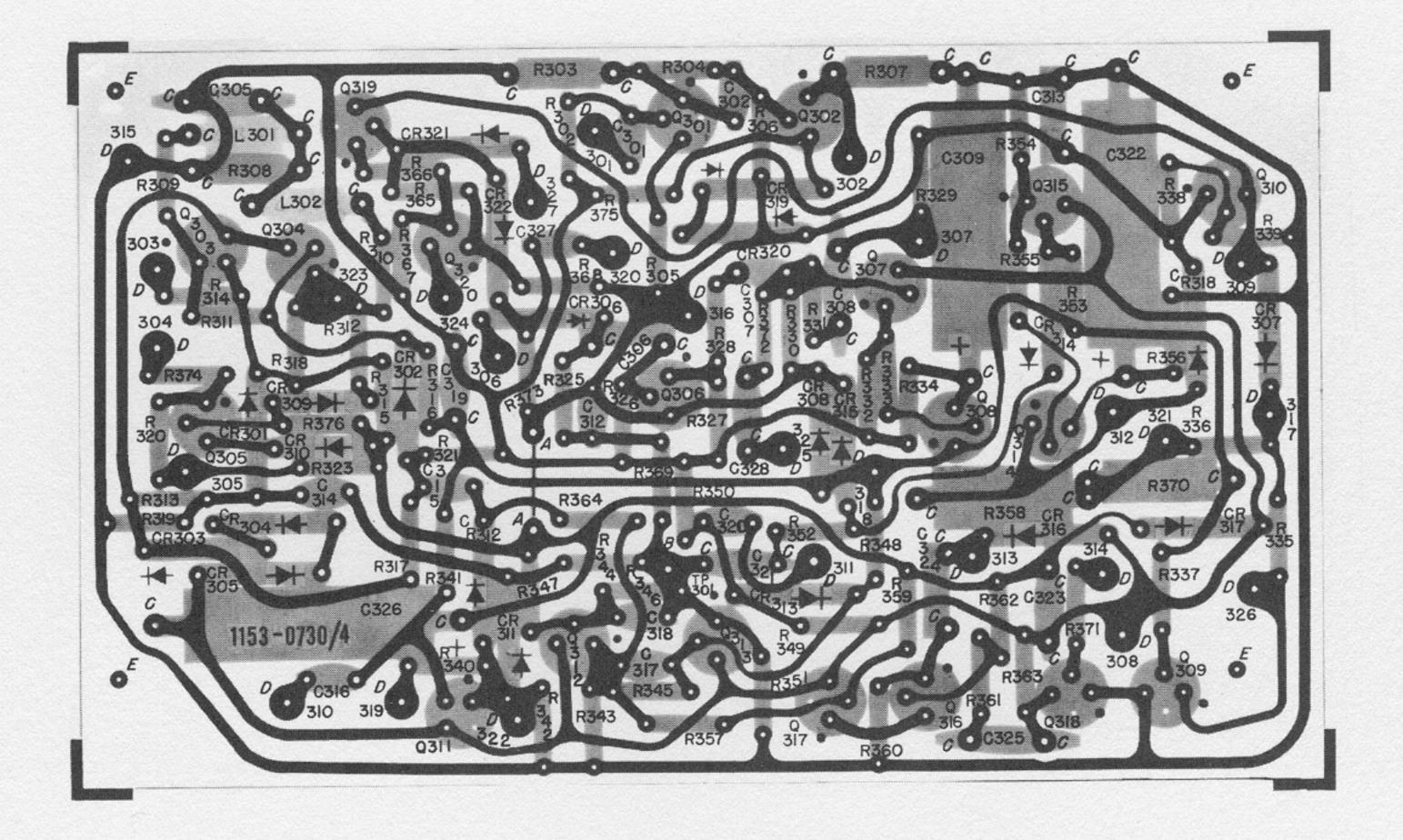
WAVEFORMS



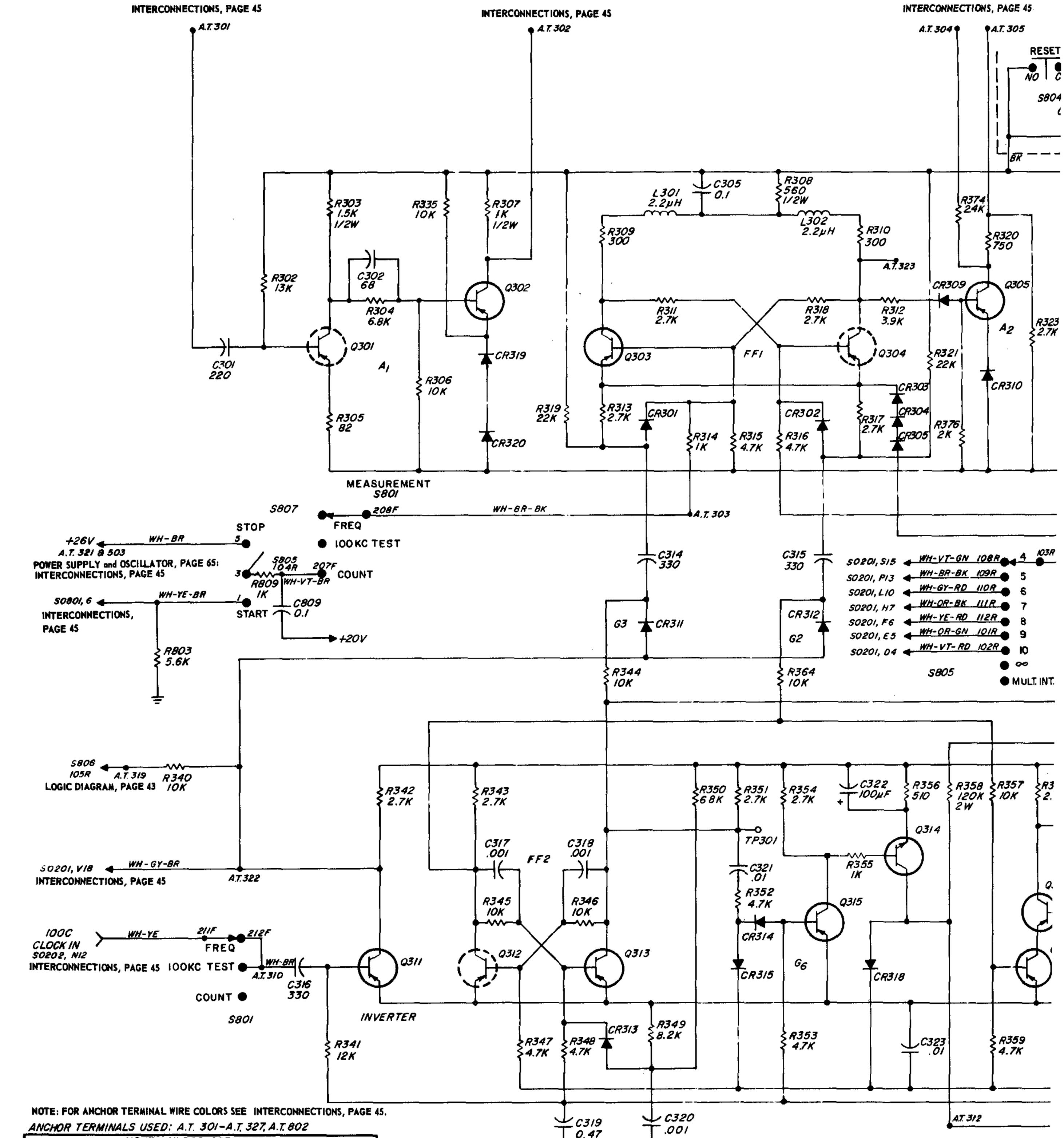
Measurement conditions:

MEASUREMENT....100 kc TEST DISPLAY TIME 4 COUNTING TIME . . . 0.1 SEC

Trigger oscilloscope from zero-set pulse (AUX socket on rear panel, pin 5)



PROGRAM CONTROL 47

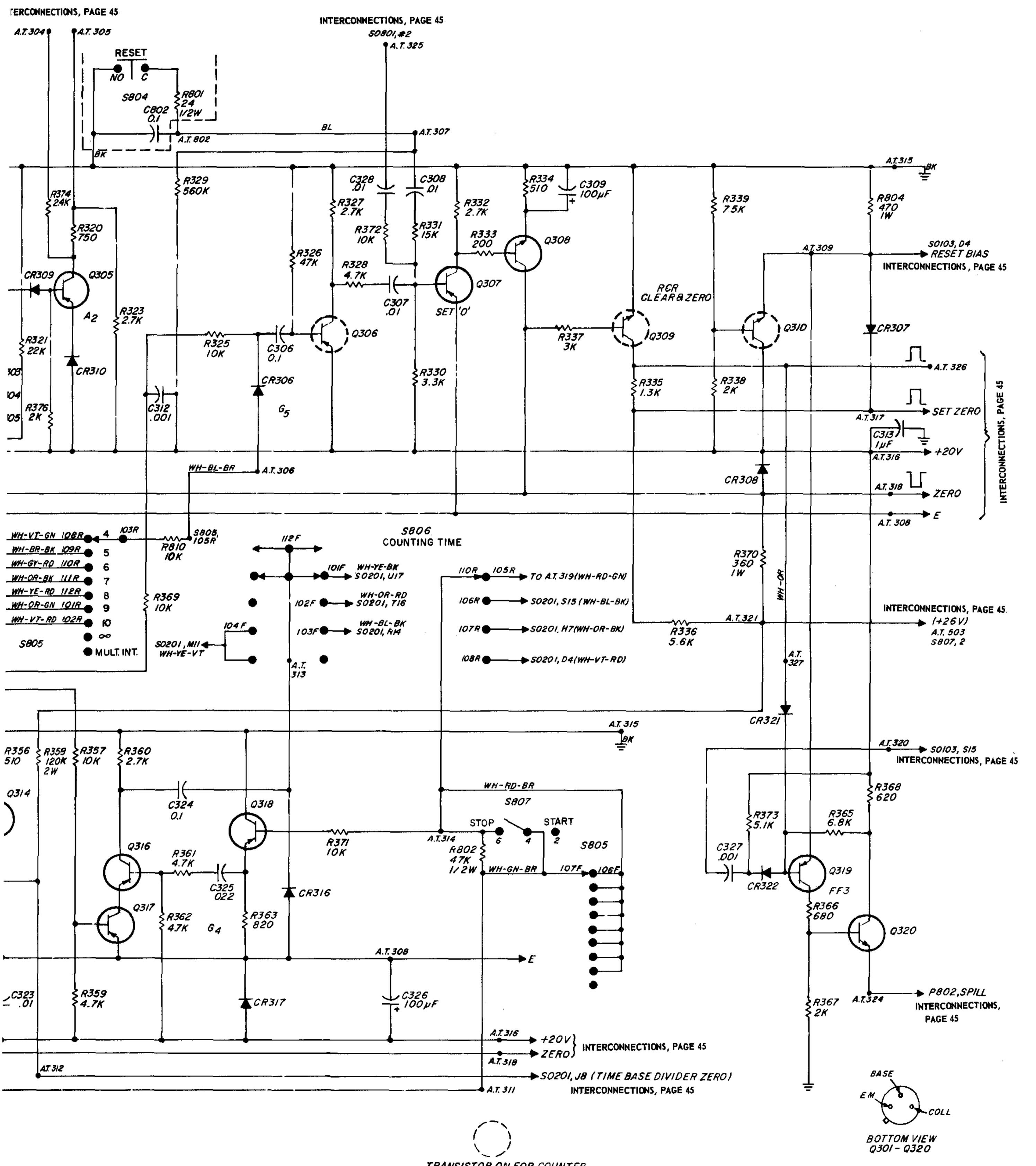


NOTE UNLESS	SPECIFIED
1. POSITION OF ROTARY SWITCHES	5. RESISTANCE IN OHMS
SHOWN COUNTERCLOCKWISE.	K 1000 OHMS M 1 MEGOHM
2. CONTACT NUMBERING OF SWITCHES	6. CAPACITANCE VALUES ONE AND
EXPLAINED ON SEPARATE SHEET	OVER IN PICOFARADS, LESS
SUPPLIED IN INSTRUCTION BOOK.	THAN ONE IN MICROFARADS.
3. REFER TO SERVICE NOTES IN INSTRUC-	7. O KNOB CONTROL
TION BOOK FOR VOLTAGES	8. O SCREWDRIVER CONTROL
APPEARING ON DIAGRAM.	9. AT ANCHOR TERMINAL
4. RESISTORS 1/4 WATT.	10. TP TEST POINT

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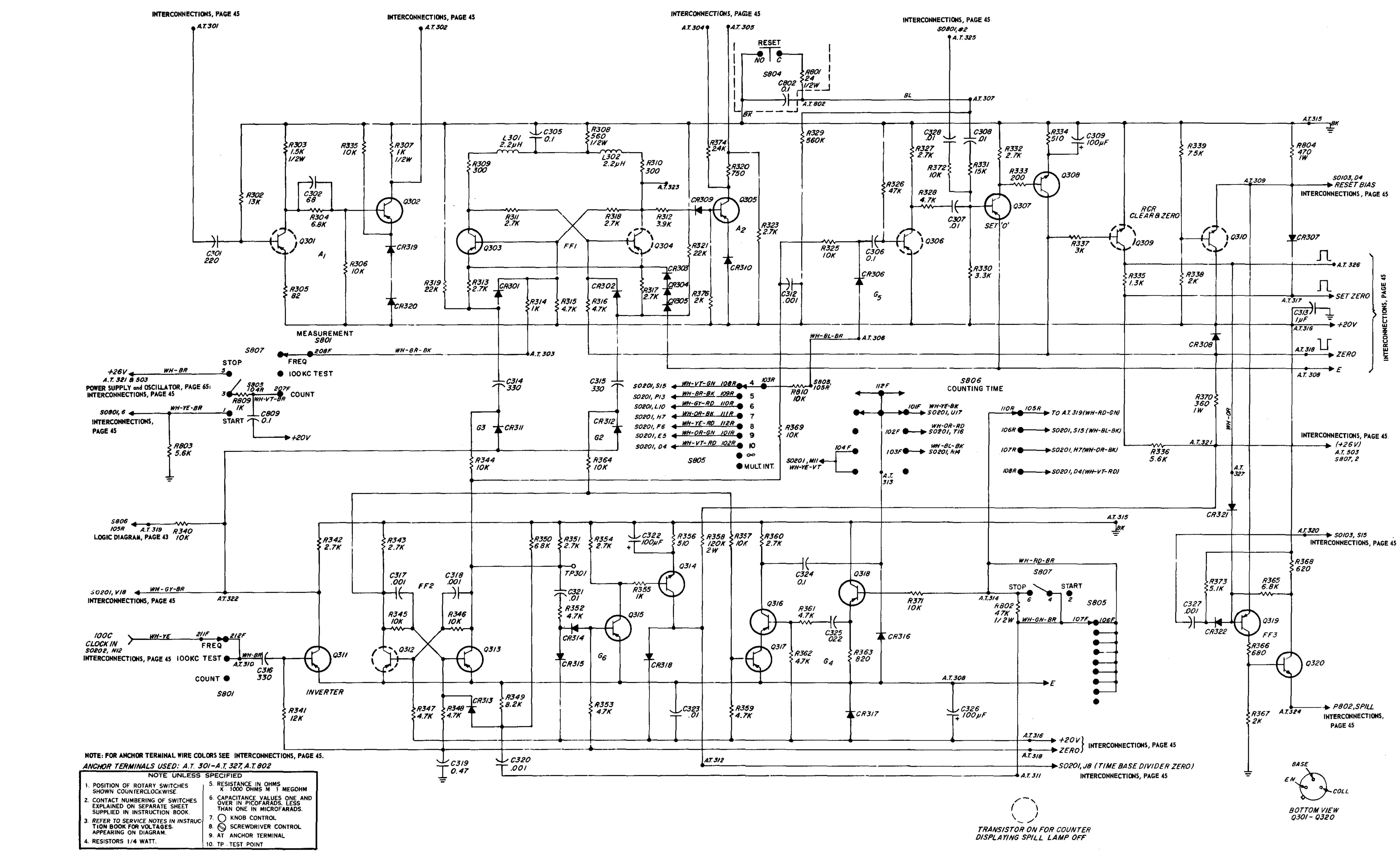
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TRANSISTOR ON FOR COUNTER DISPLAYING SPILL LAMP OFF

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PROGRAM CONTROL 49



PROGRAM CONTROL 49

INPUT CIRCUIT

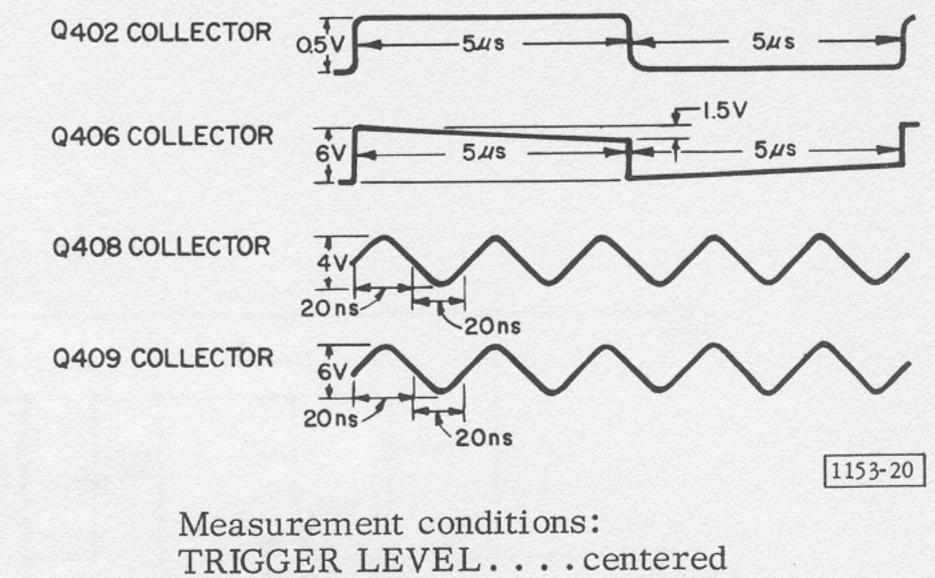
VOLTAGES

Transistor	DC Voltage to Ground Terminal e b c			
Q401	+ 9.7	+10.4	+14.8	
Q402	+ 9.7	+10.4	+15.0	
Q403A	68	- 0.06	+10.4	
Q403B	68	- 0.06	+10.4	
Q405	+15.5	+15.0	+ 8.5	
Q406	+ 3.4	+ 3.6	+ 2.0	
Q407	+ 3.4	+ 3.1	0	
Q408	+16.5	+16.5	+ 9.5	
Q409	+16.5	+16.8	+ 9.5	
Q410	+16.5	+17.0	+16.5	

Measurement conditions:

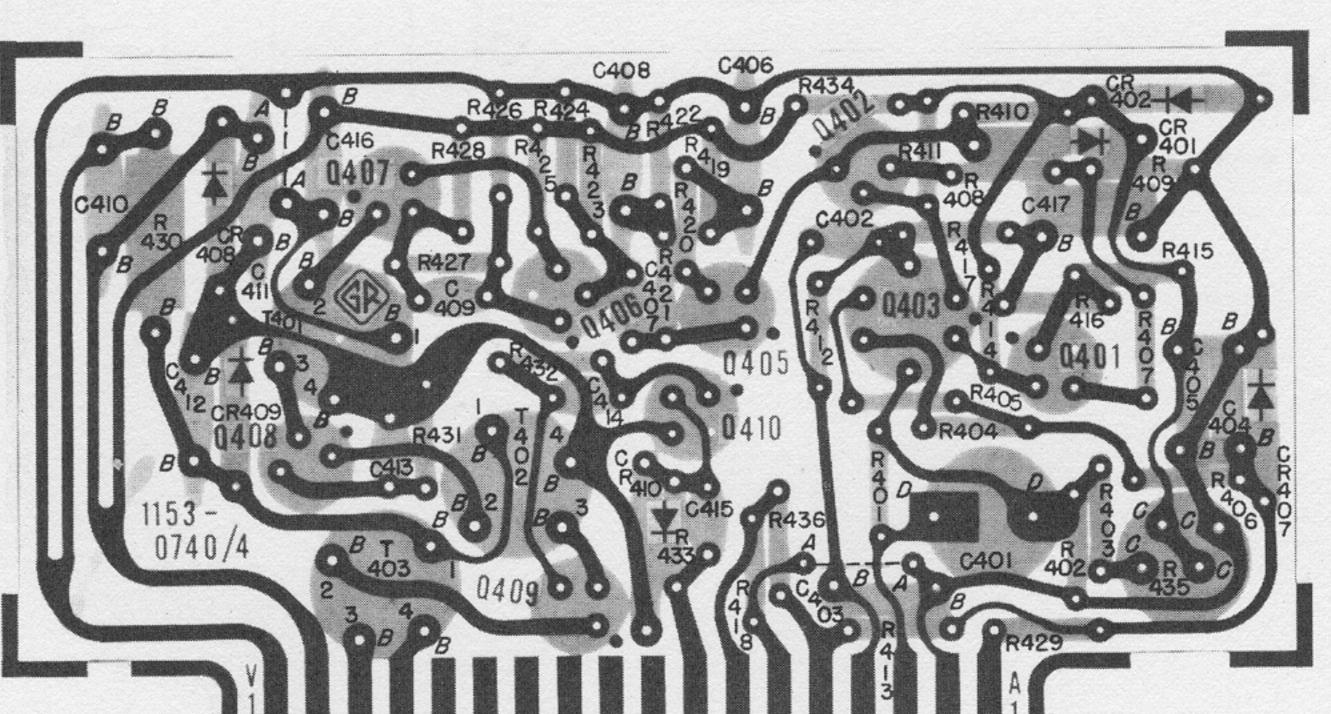
	and and and and and and and and	aantorod
mpraanp	TTITTI	

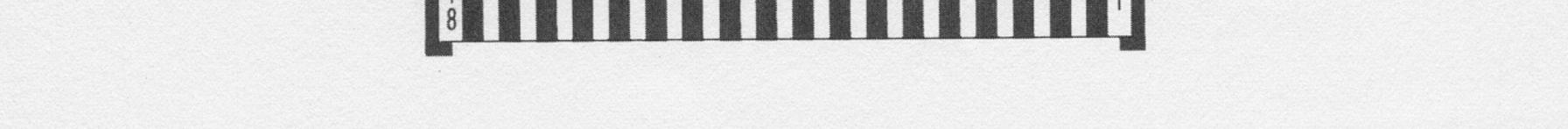
WAVEFORMS



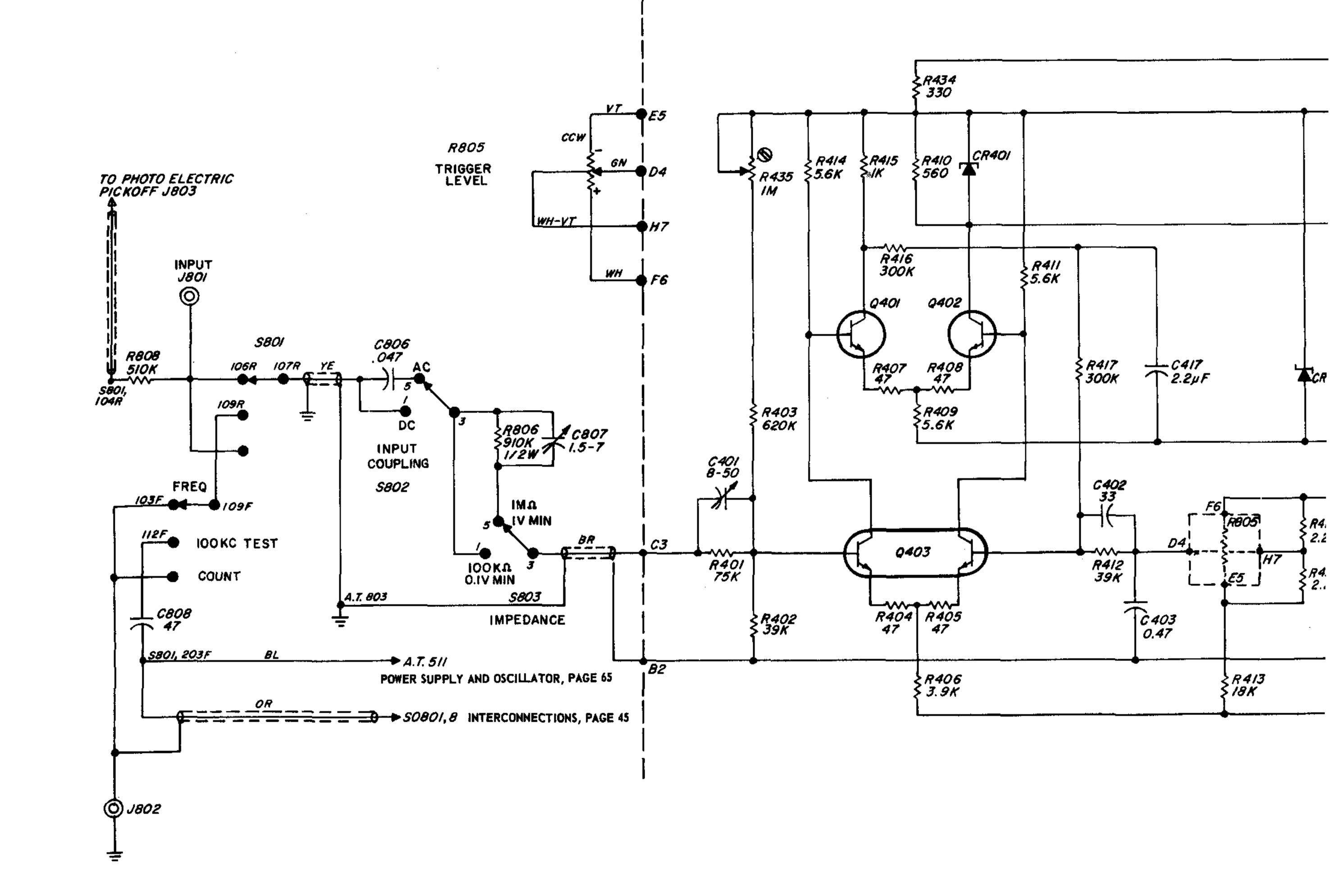
INPUT COUPLING. . . . AC IMPEDANCE 100 k Ω MEASUREMENT. . . . 100 kc TEST

TRIGGER LEVEL...centered MEASUREMENT.... COUNT No input signal applied





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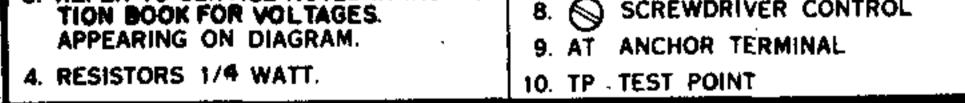
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NOTE: FOR SO401 SOCKET CONNECTIONS SEE INTERCONNECTIONS, PAGE 45. ANCHOR TERMINAL USED: A.T.803

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NOTE UNLESS	SPECIFIED
NOTE UNLESS	
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.	5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET	6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
SUPPLIED IN INSTRUCTION BOOK. 3. REFER TO SERVICE NOTES IN INSTRUC	7. O KNOB CONTROL

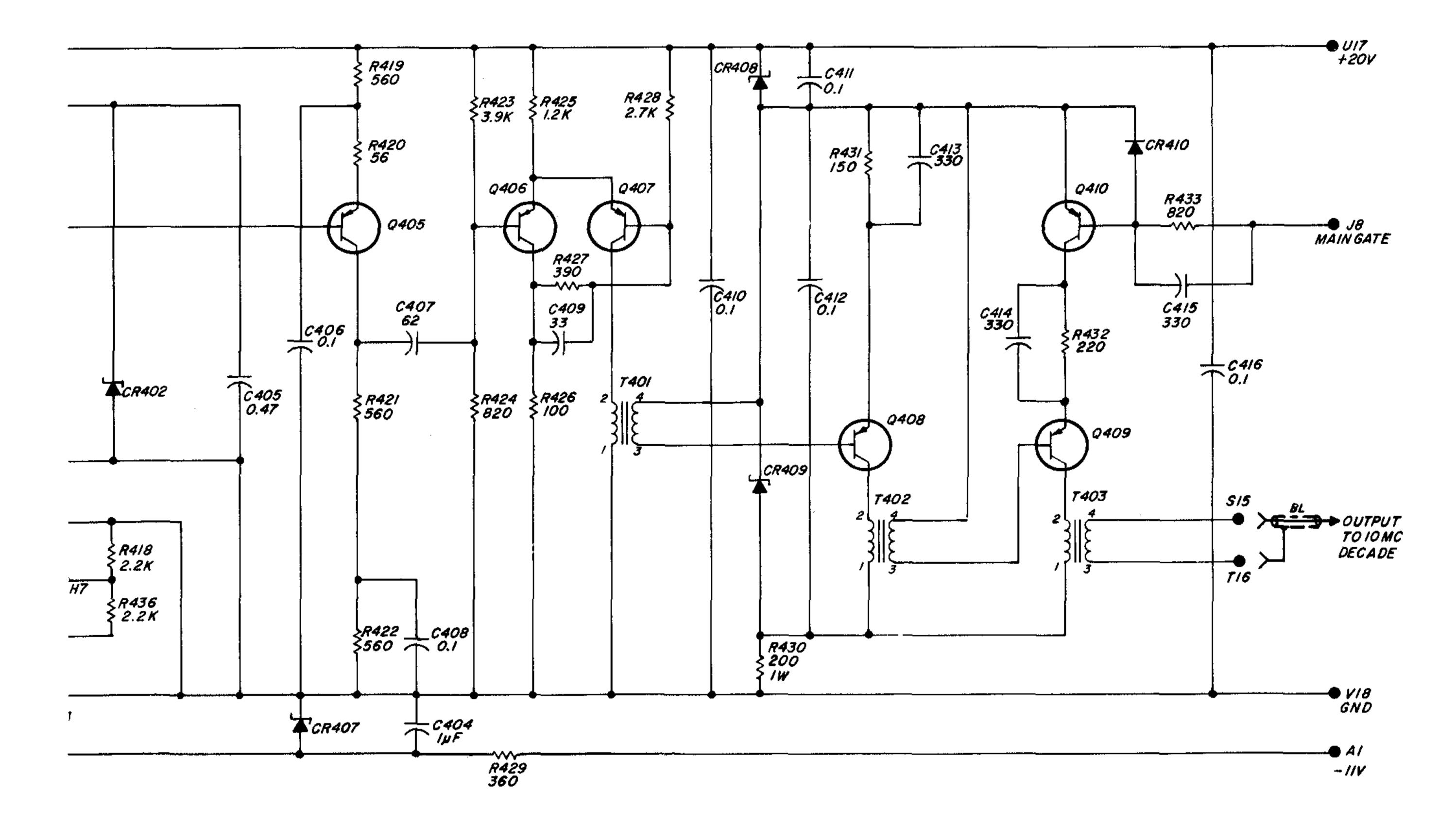


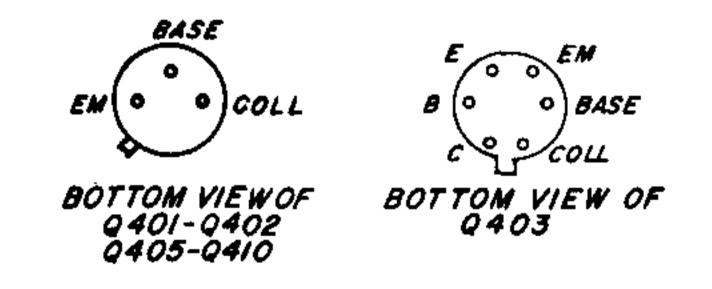
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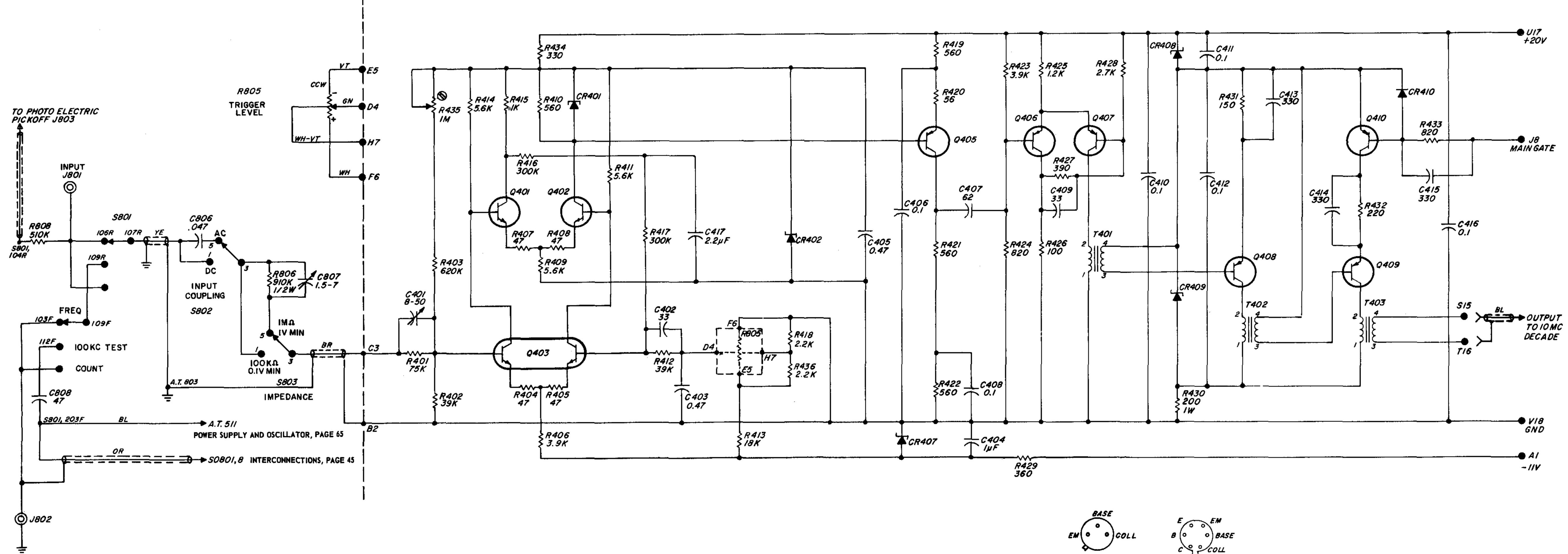


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INPUT CIRCUIT 51

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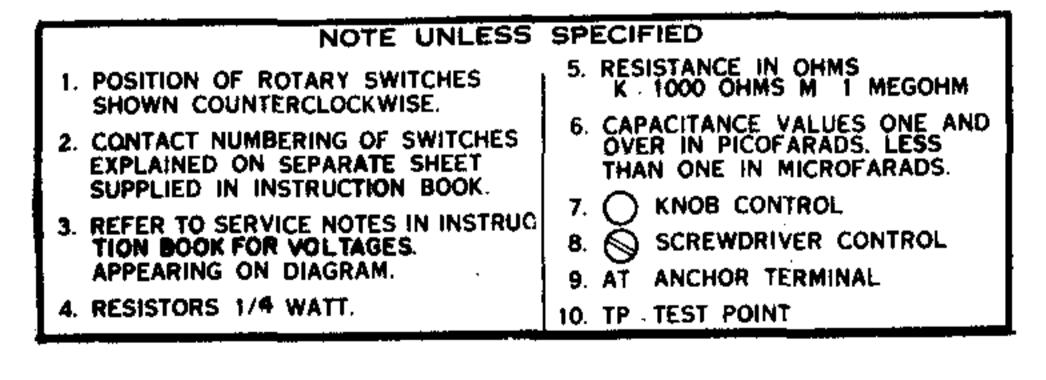
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NOTE: FOR SO401 SOCKET CONNECTIONS SEE INTERCONNECTIONS, PAGE 45. ANCHOR TERMINAL USED: A.T.803

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BOTTOM VIEWOF Q401-Q402 Q405-Q410

COLL BOTTOM VIEW OF Q403

10-Mc/s COUNTER

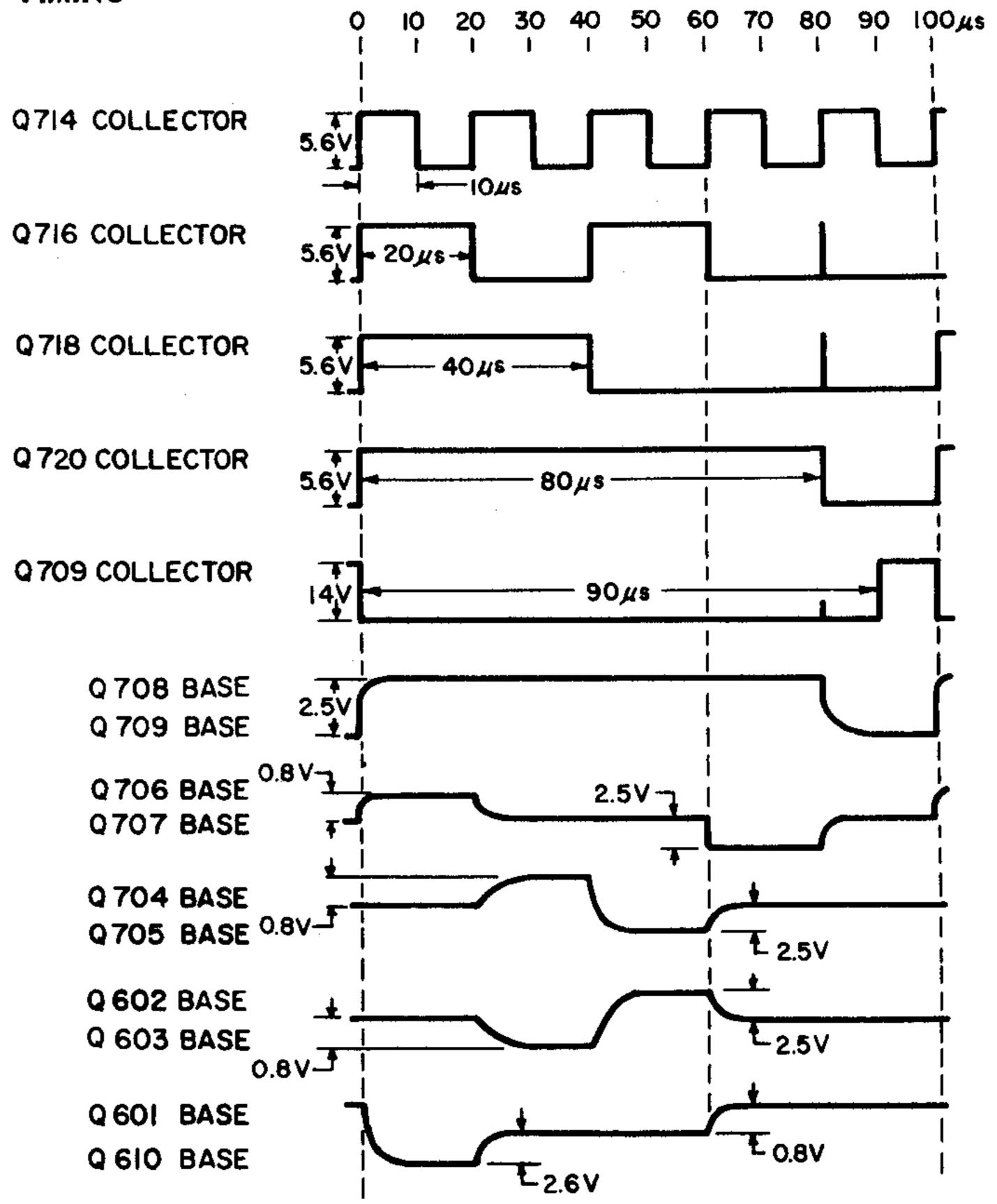
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VOLTAGES	DC Vo	oltage to G	Fround
Transistor		Terminal	
	е	b	С
Q701	+13.0	+13.0	0
Q702	+13.5	+15.5	0
Q703	+13.0	+15.5	0
Q704	+13.5	+15.5	0
Q705	+13.0	+15.5	0
Q706	±13.5	+16.0	0
Q707	+13.0	+16.0	0
Q708	+13.5	+15.4	0
Q709	+13.0	+15.4	0
Q710	+13.5	+13.0	+13.4
Q711	+13.6	+13.1	+13.5
Q712	+13.6	+15.6	+13.0
Q713	+17.0	+17.6	+11.5
Q714	+17.0	+16.5	+16.9
Q715	+17.0	+17.6	+11.5
Q716	+17.0	+16.5	+16.9
Q717	+17.0	+17.6	+11.5
Q718	+17.0	+16.5	+16.9
Q719	+17.0	+17.6	+11.5
Q720	+17.0	+16.5	+16.9

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TIMING



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Measurement conditions:

MEASUREMENT....COUNT DISPLAY TIME....10 COUNT/MULT INT. . . STOP

1153-22

Measurement conditions: TRIGGER LEVEL....centered INPUT COUPLING . . . AC MEASUREMENT... 100 kc TEST DISPLAY TIME....4 COUNTING TIME... 10 SEC

DECADE CODE

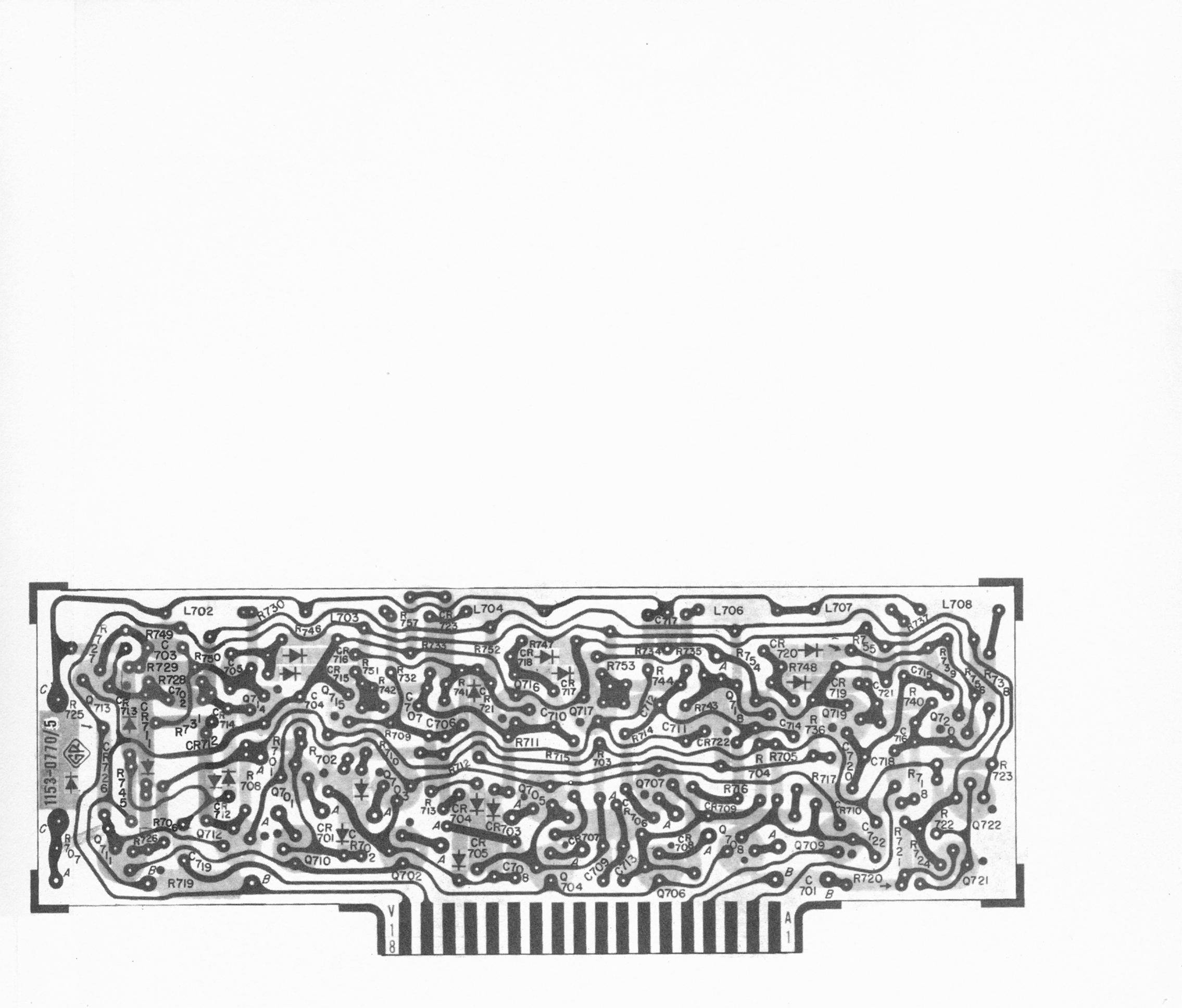
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DECIMAL	BINARY				
	FF1	FF2	FF3	FF4	
0	0	0	0	0	
1	1	0	0	0	
2	0	1	0	0	
3	1	1	0	0	
4	0	0	1	0	
5	1	0	1	0	

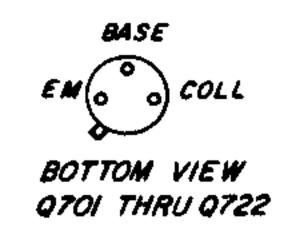
0 8 1 1 9 0 0 0 0

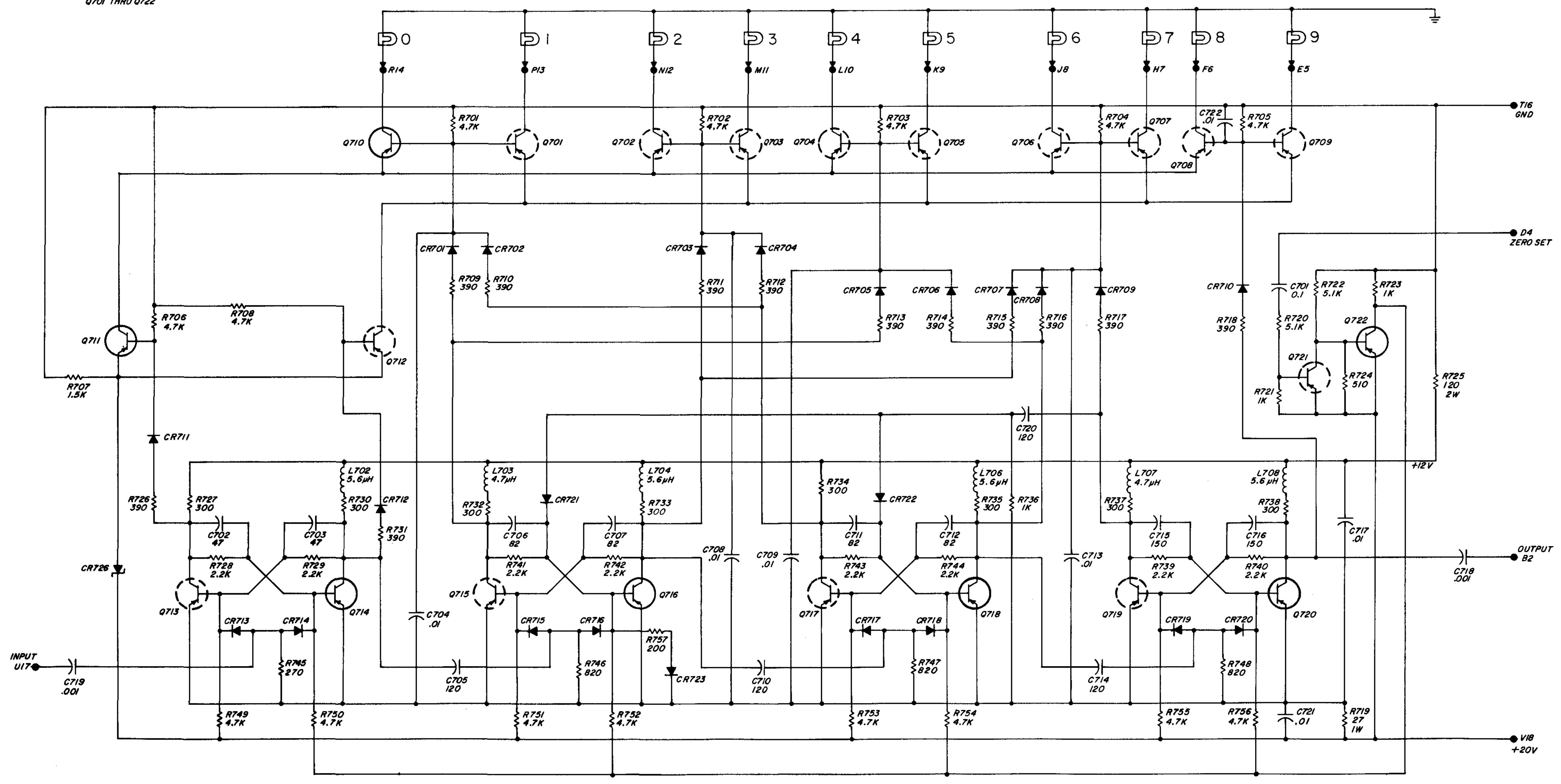
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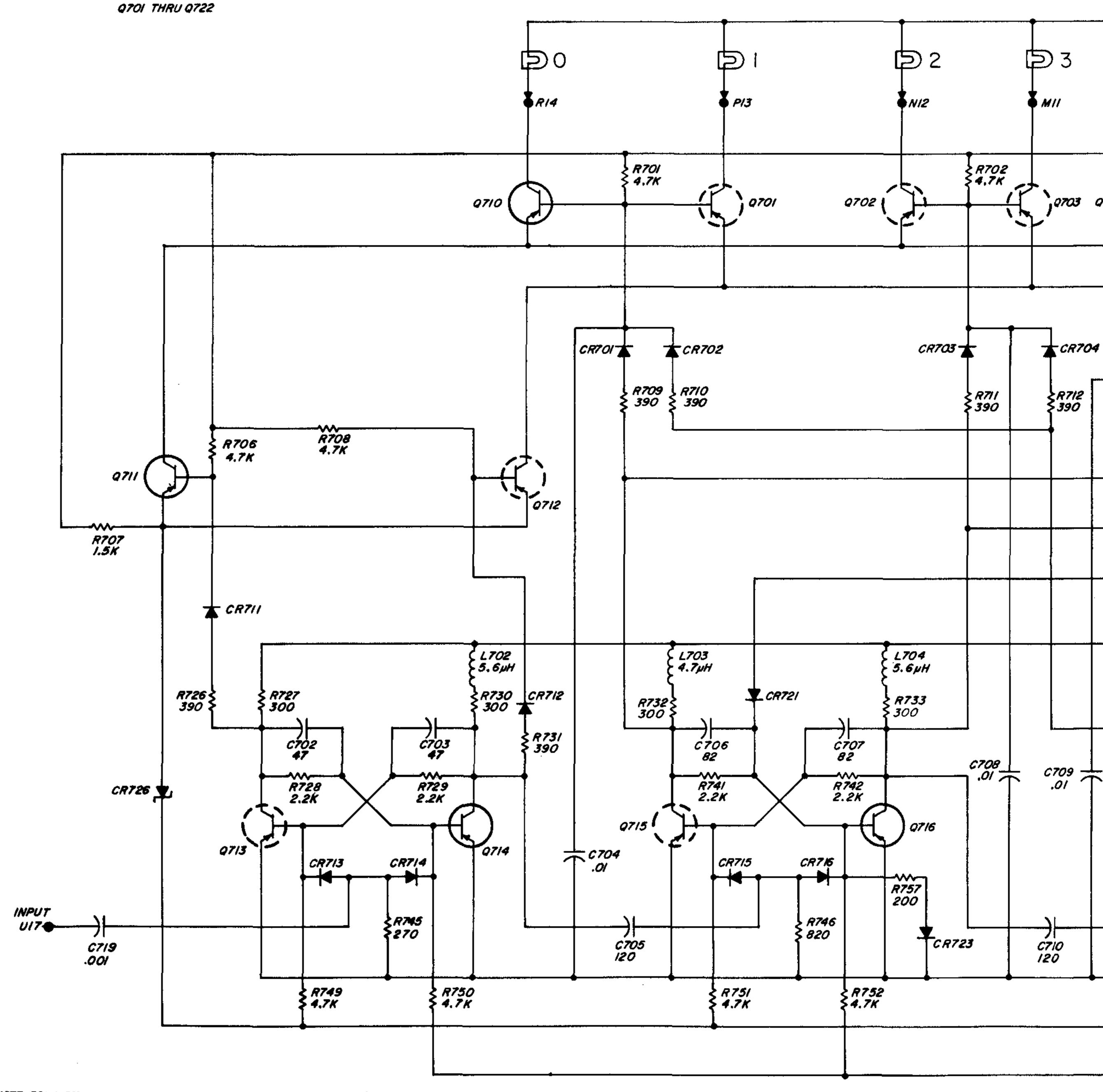
10-Mc BCD COUNTING UNIT 53





NOTE: FOR SO701 SOCKET CONNECTIONS SEE INTERCONNECTIONS, PAGE 45

NOTE UNLESS	SPECIFIED
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.	5. RESISTANCE IN OHMS K = 1000 OHMS M 1 MEGOHM
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK. 3. REFER TO SERVICE NOTES IN INSTRUC- TION BOOK FOR VOLTAGES	 6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS. 7. KNOB CONTROL 8. SCREWDRIVER CONTROL
APPEARING ON DIAGRAM. 4. RESISTORS 1/4 WATT.	9. AT - ANCHOR TERMINAL 10. TP - TEST POINT



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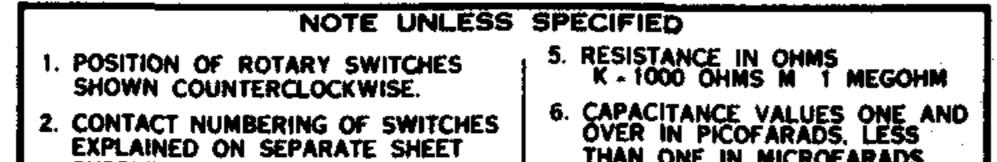
BASE

EN (00) COLL

BOTTOM VIEW

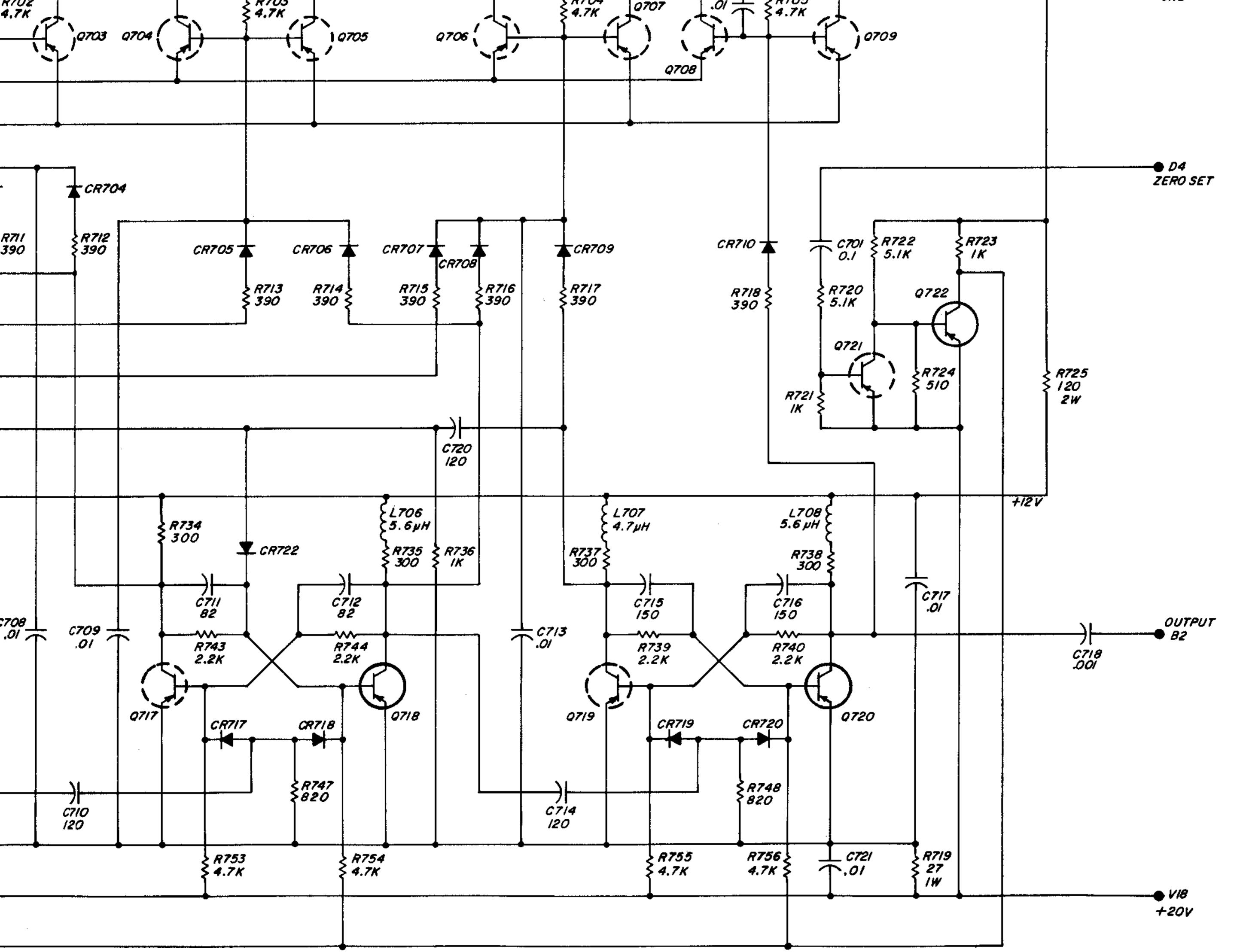
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NOTE: FOR SO701 SOCKET CONNECTIONS SEE INTERCONNECTIONS, PAGE 45



SUPPLIED IN INSTRUCTION BOOK.	7. O KNOB CONTROL
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES	8. O SCREWDRIVER CONTROL
APPEARING ON DIAGRAM.	9. AT - ANCHOR TERMINAL
4. RESISTORS 1/4 WATT.	10. TP - TEST POINT

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	MU	L10		K9	J8	2	H7	F6		E5		
R702		ţ	R703			R704	0707	C722	R705			TIG GND



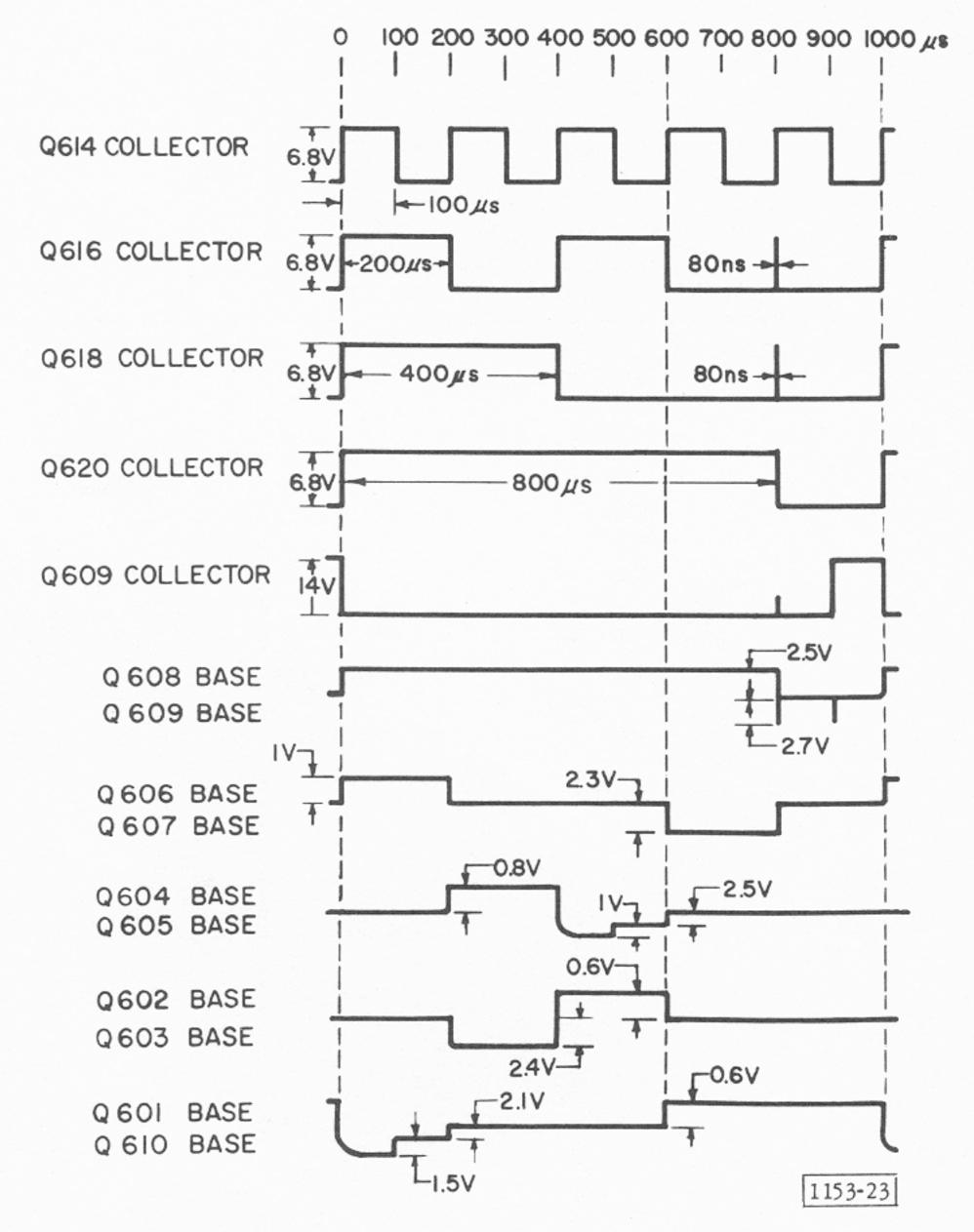
10-Mc BCD COUNTING UNIT 55

1-Mc/s COUNTER

VOLTAGES

Т	I	M	1	N	G
	-		-		-

Transistor	DC Voltage to Ground Terminal				
	е	b	C .		
Q601	+13.1	+13.1	0		
Q602	+13.6	+15.0	0		
Q603	+13.1	+15.0	0		
Q604	+13.6	+14.9	0		
Q605	+13.1	+14.9	0		
Q606	+13.6	+15.6	0		
Q607	+13.1	+15.6	0		
Q608	+13.6	+15.0	0		
Q609	+13.1	+15.0	0		
Q610	+13.6	+13.1	+13.4		
Q611	+13.8	+13.5	+13.6		
Q612	+13.8	+15.0	+13.1		
Q613	+16.7	+17.8	+10.2		
Q614	+16.7	+16.4	+16.6		
Q615	+16.7	+17.8	+10.2		
Q616	+16.7	+16.4	+16.6		
Q617	+16.7	+17.8	+10.2		
Q618	+16.7	+16.4	+16.6		
Q619	+16.7	+17.8	+10.2		
Q620	+16.7	+16.4	+16.6		

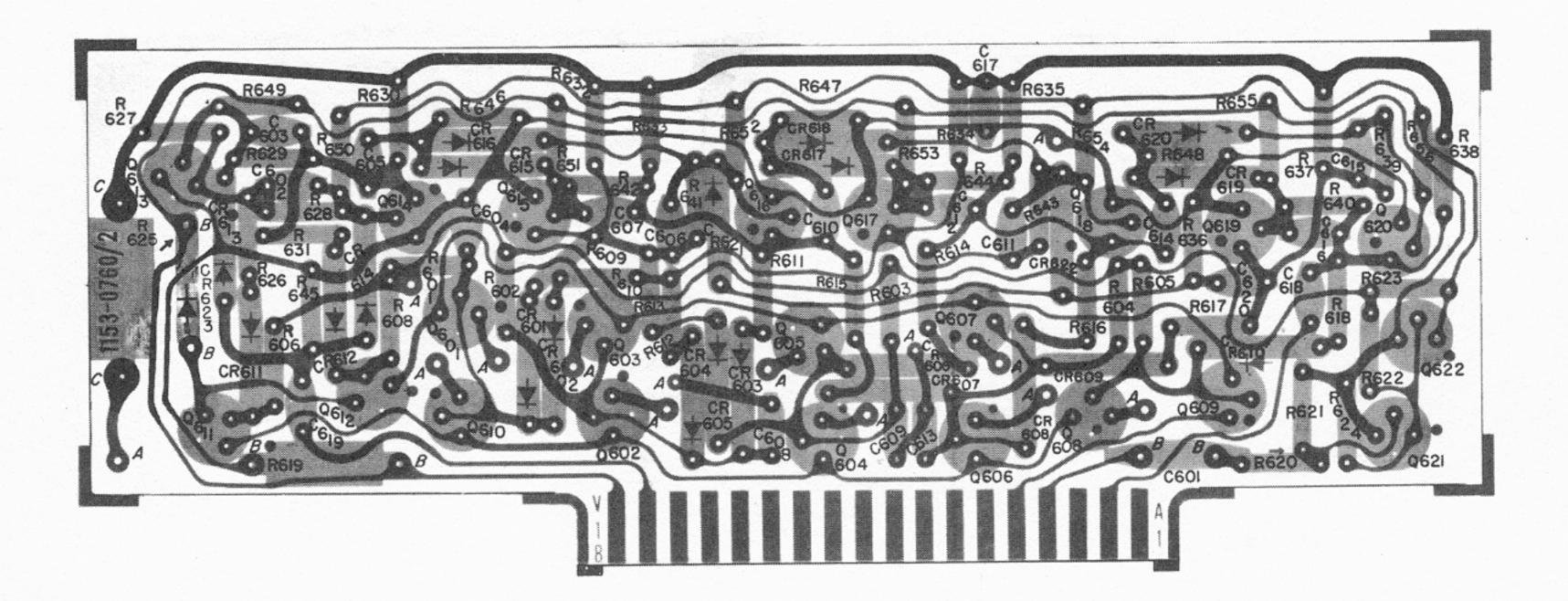


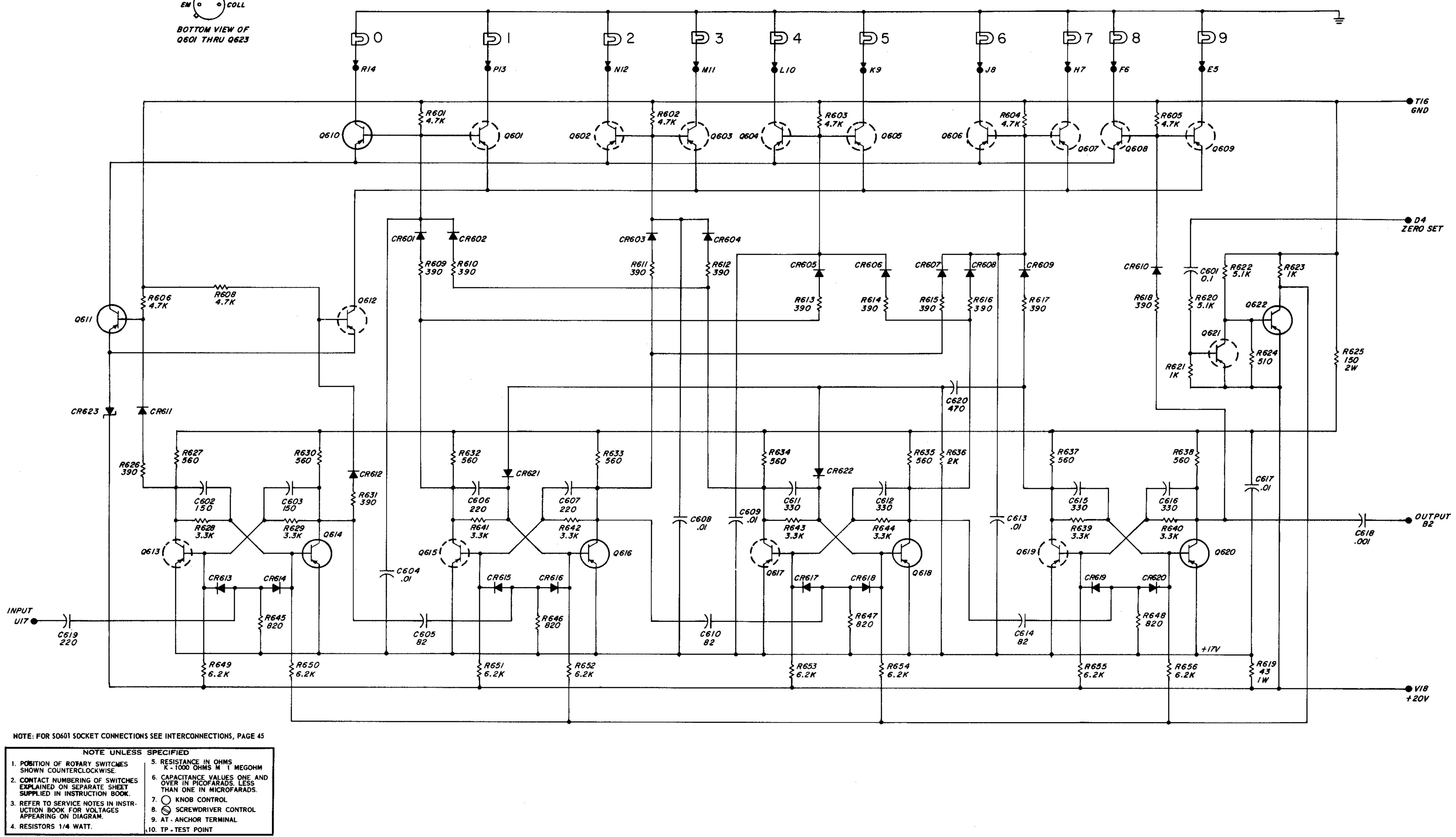
Measurement conditions:

MEASUREMENT....COUNT DISPLAY TIME....10 COUNT/MULT INT...STOP

Measurement conditions:

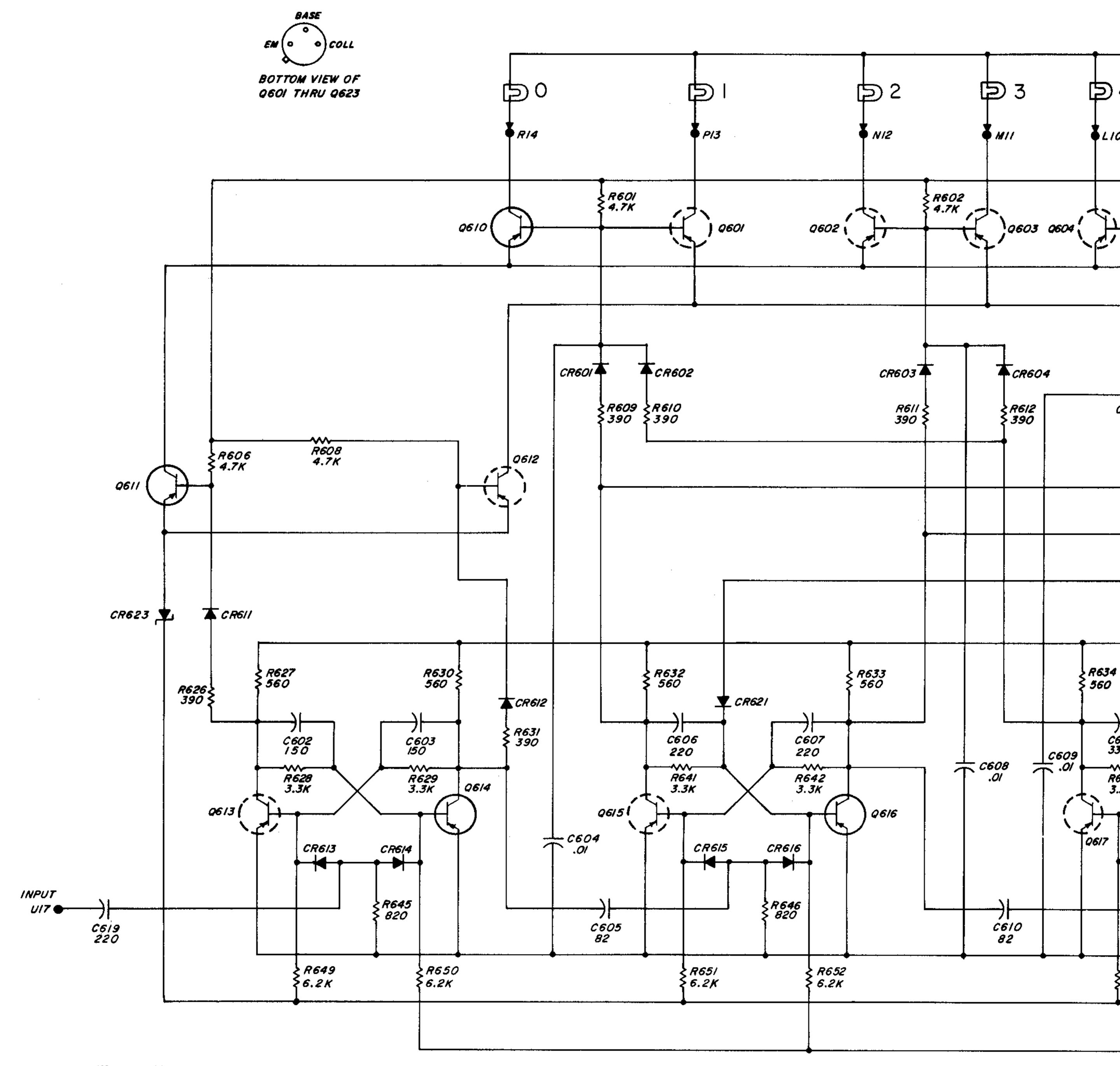
TRIGGER LEVEL . . . centered INPUT COUPLING AC IMPEDANCE 100 kΩ MEASUREMENT 100 kc TEST DISPLAY TIME 4 COUNTING TIME 10 SEC





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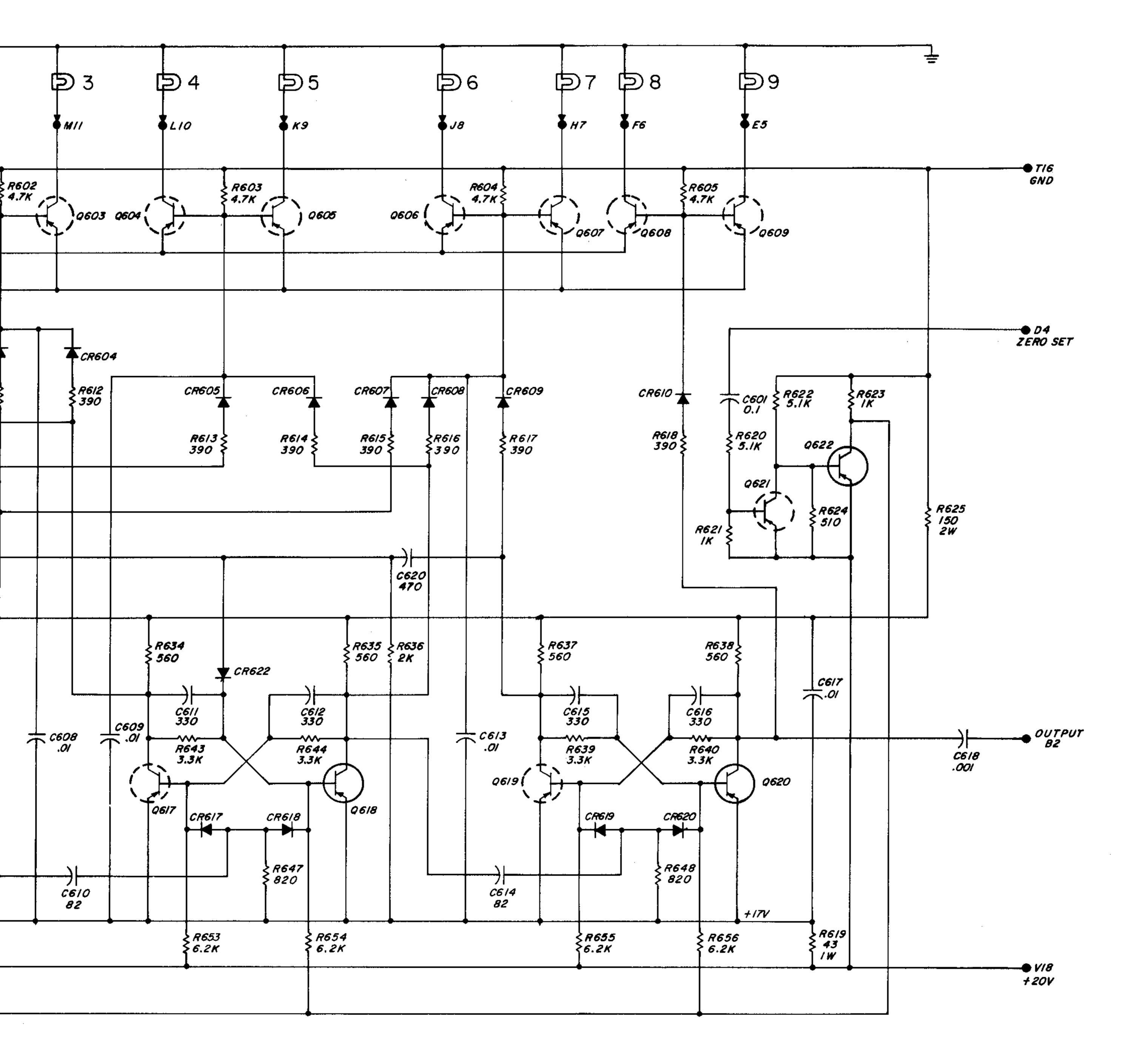
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NOTE: FOR \$0603 SOCKET CONNECTIONS SEE INTERCONNECTIONS, PAGE 45

	NOTE UNLESS	SPECIFIED
	1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.	5. RESISTANCE IN OHMS K = 1000 OHMS M 1 MEGOHM
	2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.	6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
·	3. REFER TO SERVICE NOTES IN INSTR- UCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.	7. O KNOB CONTROL 8. O SCREWDRIVER CONTROL 9. AT - ANCHOR TERMINAL
	4. RESISTORS 1/4 WATT.	10. TP - TEST POINT

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1-Mc BCD COUNTING UNIT 57

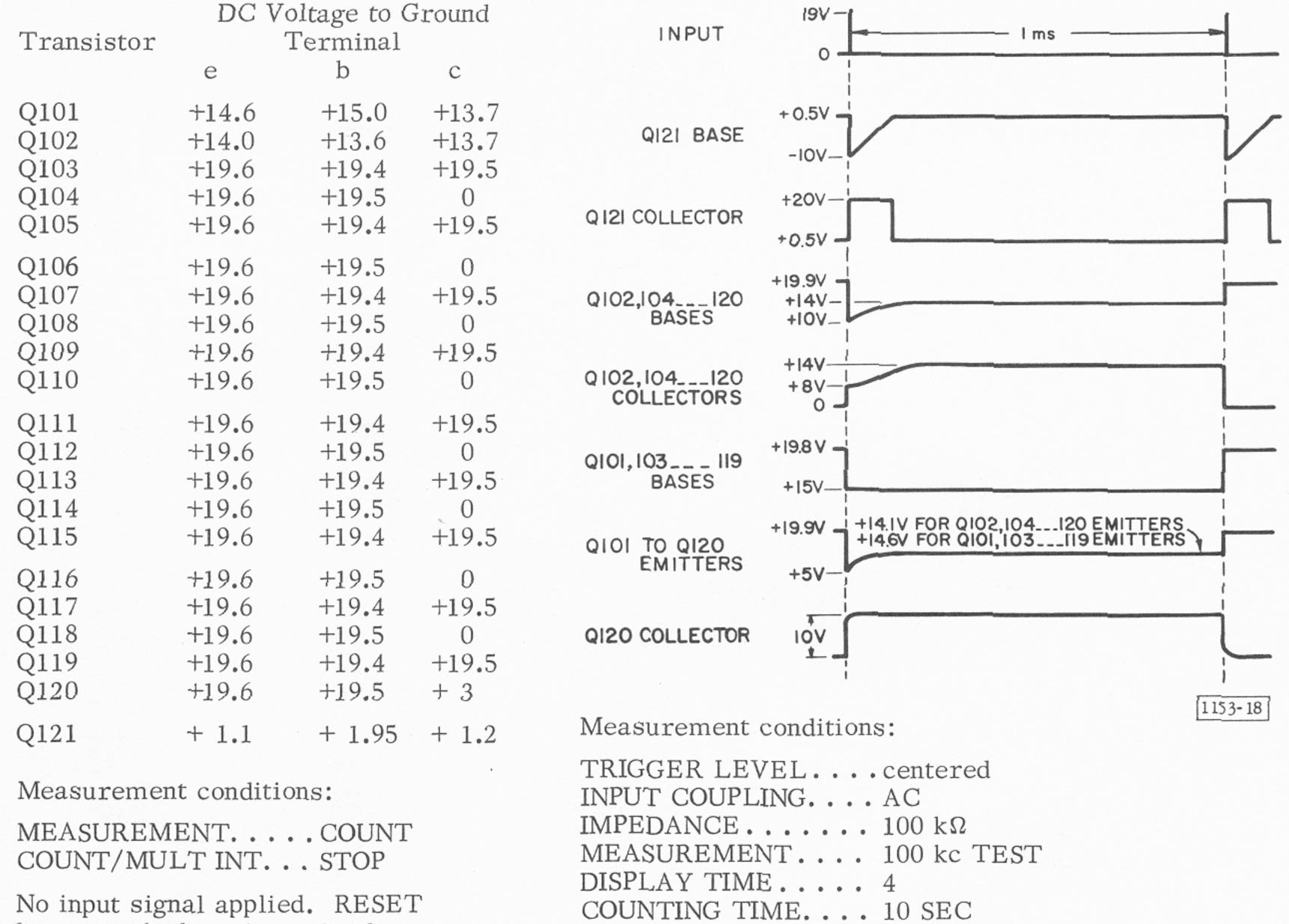
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220-kc/s DIVIDER

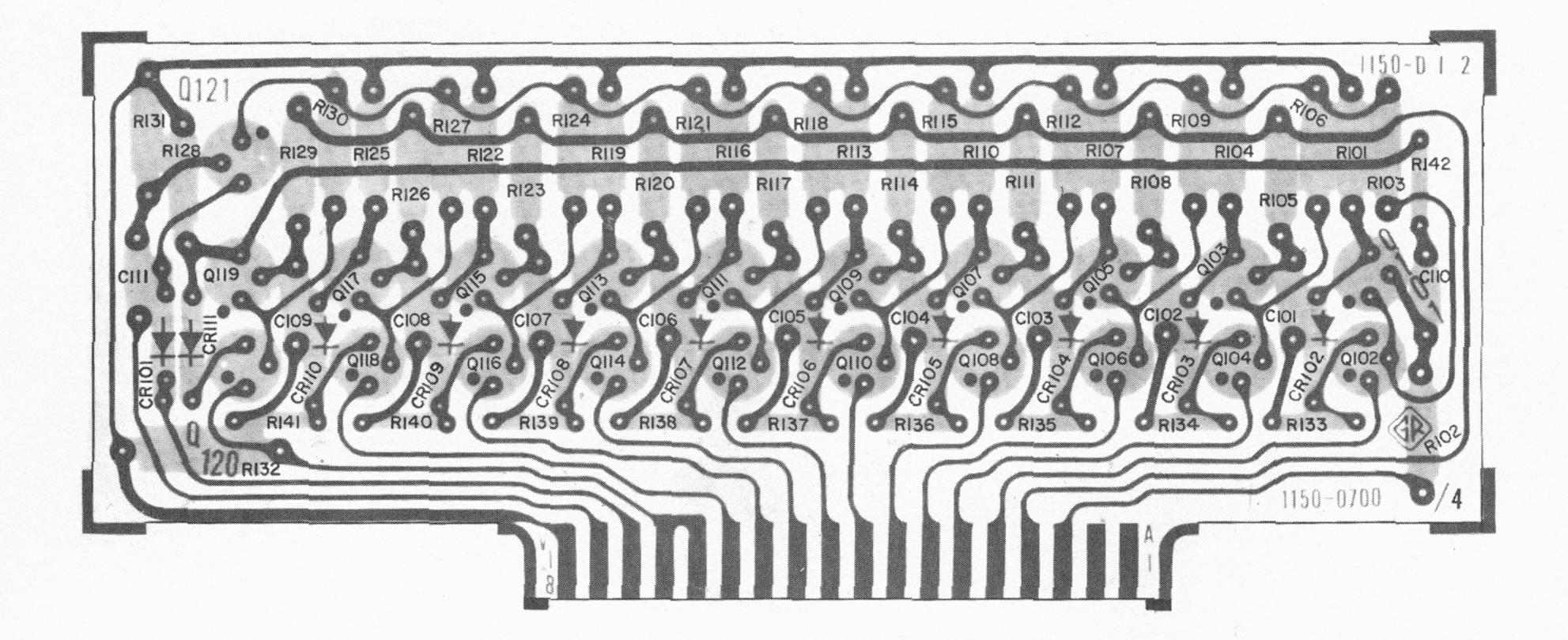
VOLTAGES

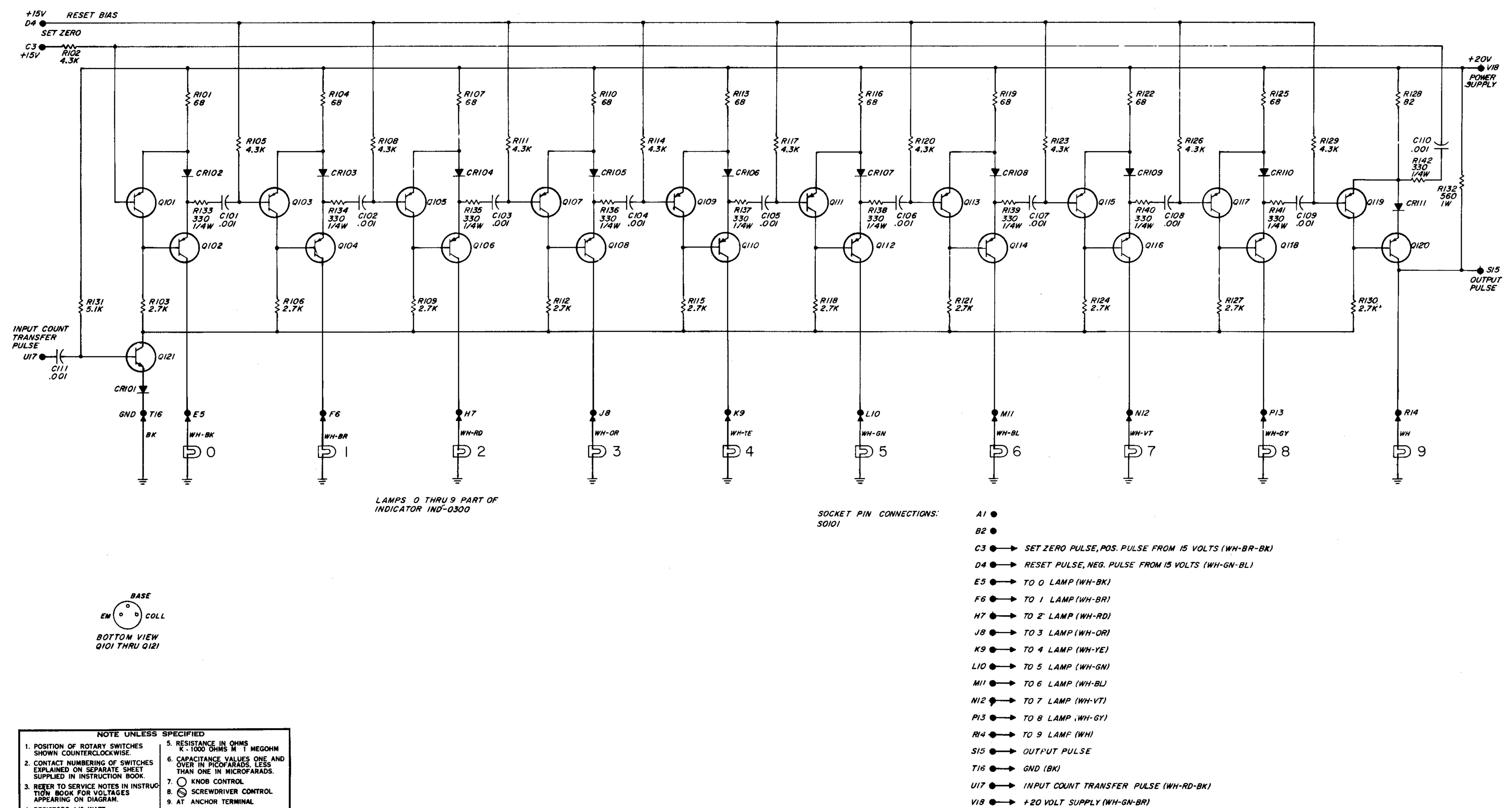
TIMING



Q114	+19.6	+19.5	0
Q115	+19.6	+19.4	+19.5
Q116	+19.6	+19.5	$0 \\ +19.5 \\ 0 \\ +19.5 \\ + 3$
Q117	+19.6	+19.4	
Q118	+19.6	+19.5	
Q119	+19.6	+19.4	
Q120	+19.6	+19.5	
Q121	+ 1.1	+ 1.95	+ 1.2

button pushed to give a display of 00000.

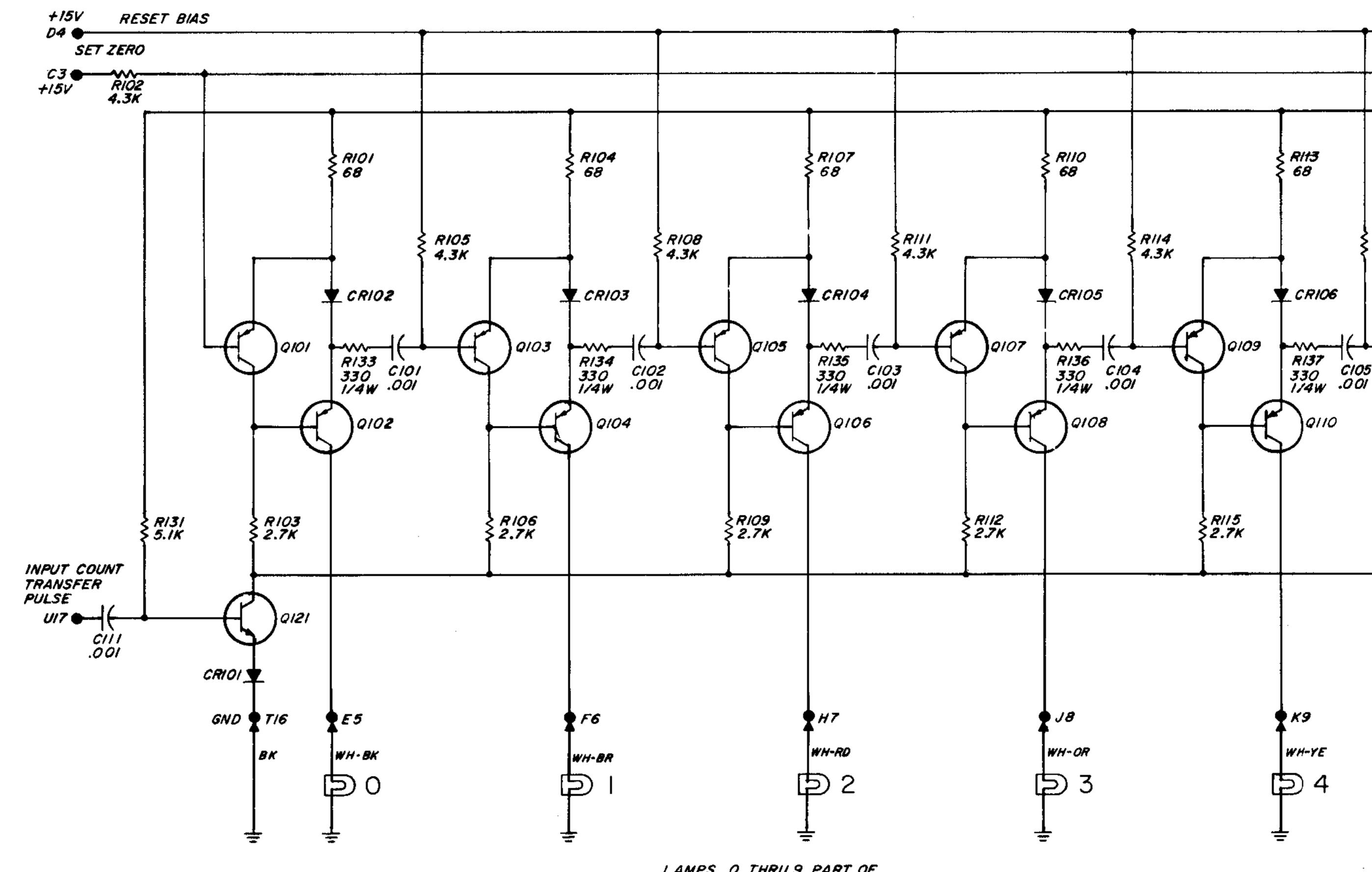




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- 4. RESISTORS 1/2 WATT.
- 10. TP . TEST POINT

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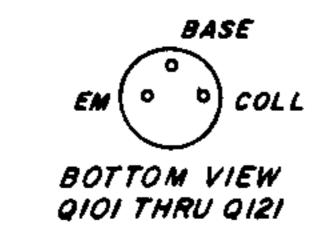


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LAMPS O THRU9 PART OF INDICATOR IND-0300

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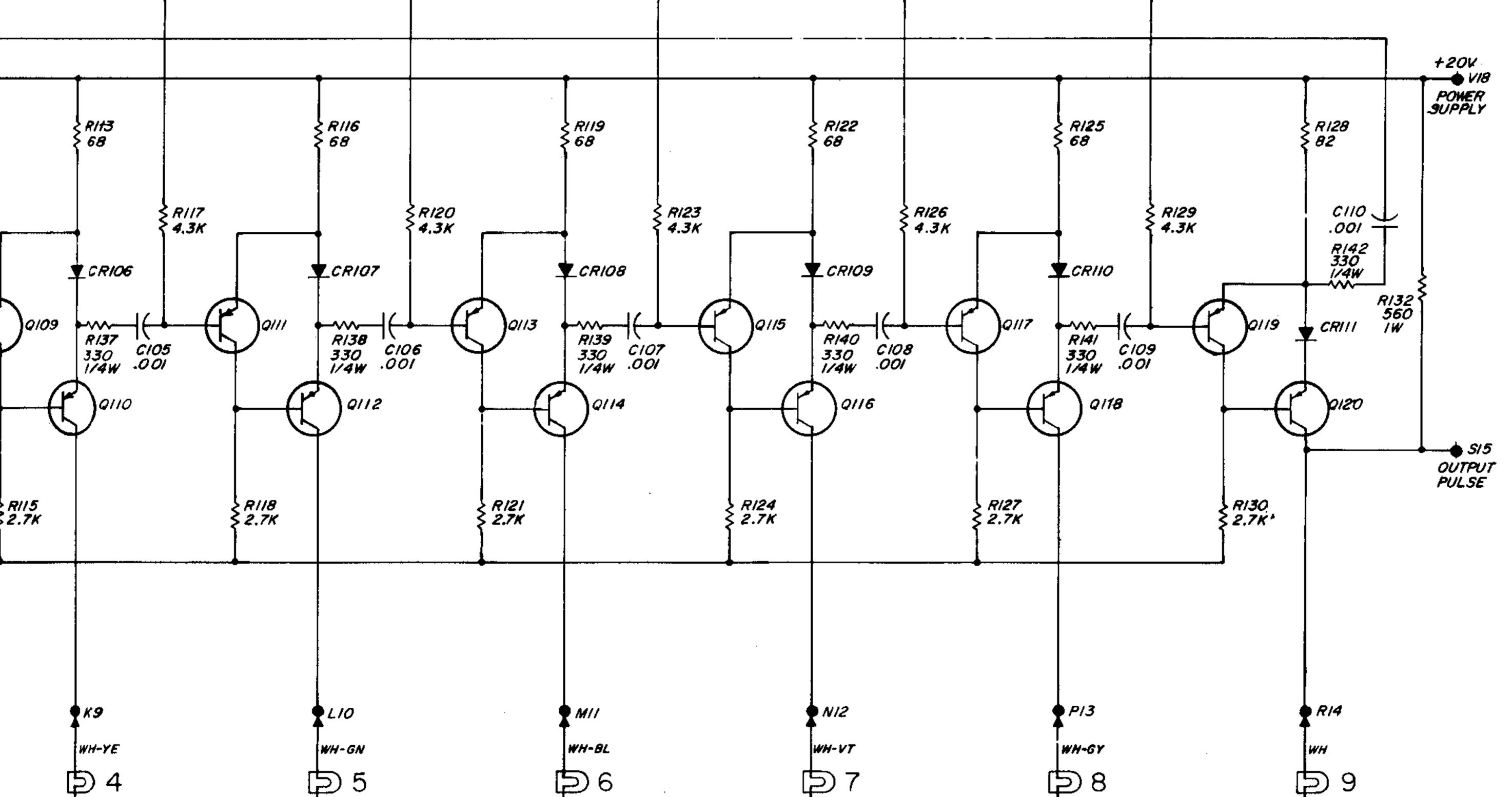
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NOTE UNLESS	SPECIFIED
1. POSITION OF ROTARY SWITCHES	5. RESISTANCE IN OHMS
SHOWN COUNTERCLOCKWISE.	K + 1000 OHMS M 1 MEGOHM
2. CONTACT NUMBERING OF SWITCHES	6. CAPACITANCE VALUES ONE AND
EXPLAINED ON SEPARATE SHEET	OVER IN PICOFARADS, LESS
SUPPLIED IN INSTRUCTION BOOK	THAN ONE IN MICROFARADS.
3. REFER TO SERVICE NOTES IN INSTRUC-	7. O KNOB CONTROL
TION BOOK FOR VOLTAGES	B. O SCREWDRIVER CONTROL
APPEARING ON DIAGRAM.	9. AT ANCHOR TERMINAL
4. RESISTORS 1/2 WATT.	10. TP . TEST POINT

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WH-GN	WH-BL	WH-VT	WH-GY	WH
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				_
SOCKET PIN CONNECTI SOIOI	IONS: AI 🗢			
50707	B2 单			
	C3 🗣 SET ZERO	PULSE, POS. PULSE FROM 15 VO	OLTS (WH-BR-BK)	
	D4 🔶 🕨 RESET PUL	LSE, NEG. PULSE FROM I <mark>S</mark> VOLTS	(WH-GN-BL)	
	ES 🕳 TO O LAMI	P (WH-BK)		
	F6 🔶 TO I LAMI	P(WH-BR)		
	H7 🔶 — TO 2° LAMI	P (WH-RD)		
	J8 🖝 TO 3 LAMP	P (WH-OR)		
	K9 🖝 TO 4 LAMP	P (WH-YE)		
	LIO 🔶 TO 5 LAMP	P (WH-GN)		
	MII G TO 6 LAMP	P (WH-BL)		
	NI2 🌩 TO 7 LAMP	P (WH-VT)		
	PI3 🖝 TO 8 LAMP	P (WH-GY)		
	RI4 - TO 9 LAMP	° (WH)		
	SIS 🛶 OUTPUT PL	ULSE		

T16 ---- GND (BK)

UIT - INPUT COUNT TRANSFER PULSE (WH-RD-BK)

VIS + 20 VOLT SUPPLY (WH-GN-BR)

220-kc DECIMAL RING COUNTING UNIT 59

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40-kc/s COUNTER

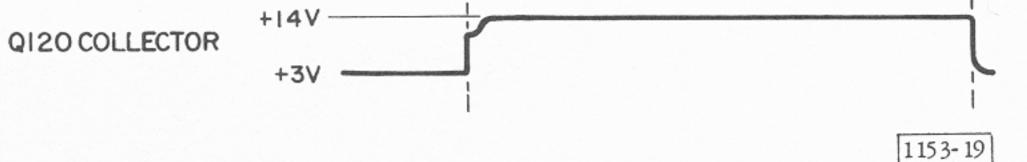
TIMING VOLTAGES DC Voltage to Ground +14V-Transistor Terminal INPUT b С е +3V +1.5V_ +0.5V +13.5Q101 +14.5+15.0Q12I BASE +13.5+13.7Q102 +13.9 +6.5V-+19.6 +19.4+19.5Q103 +19.5Q104 +19.6 0 +20V Q121 COLLECTOR +19.4 +19.5 Q105 +19.6 +0.5V +19.5 0 +19.6 Q106 +1.99V Q107 +19.4+19.5+19.6 Q102,104 ____ 120 +14V-BASES +10V-Q108 +19.6 +19.50 +19.5Q109 +19.6 +19.4+14V -QI02,I04___ I20 COLLECTORS +19.5 0 Q110 +19.6 +5V 0V +19.5Q111 +19.6 +19.4+19.8V +19.5 Q112 +19.6 0 QI01,103___120 +19.6 +19.4 +19.5Q113 BASES +15V +19.6 +19.5 0 Q114 +14.1 FOR Q102,104...120 EMITTERS, +14.6 FOR Q101, 103...119 EMITTERS +19.9V +19.5+19.6 +19.4 Q115 QIOI TO QI20 EMITTERS +5V-+19.6 +19.50 Q116 +195+10 6 +19 1 0117

QII/	+19.0	719.4	T19.5	
Q118	+19.6	+19.5	0	
Q119	+19.6	+19.4	+19.5	
Q120	+19.6	+19.5	+ 3.0	
Q121	+ .45	+ .85	+ .65	

Measurement conditions:

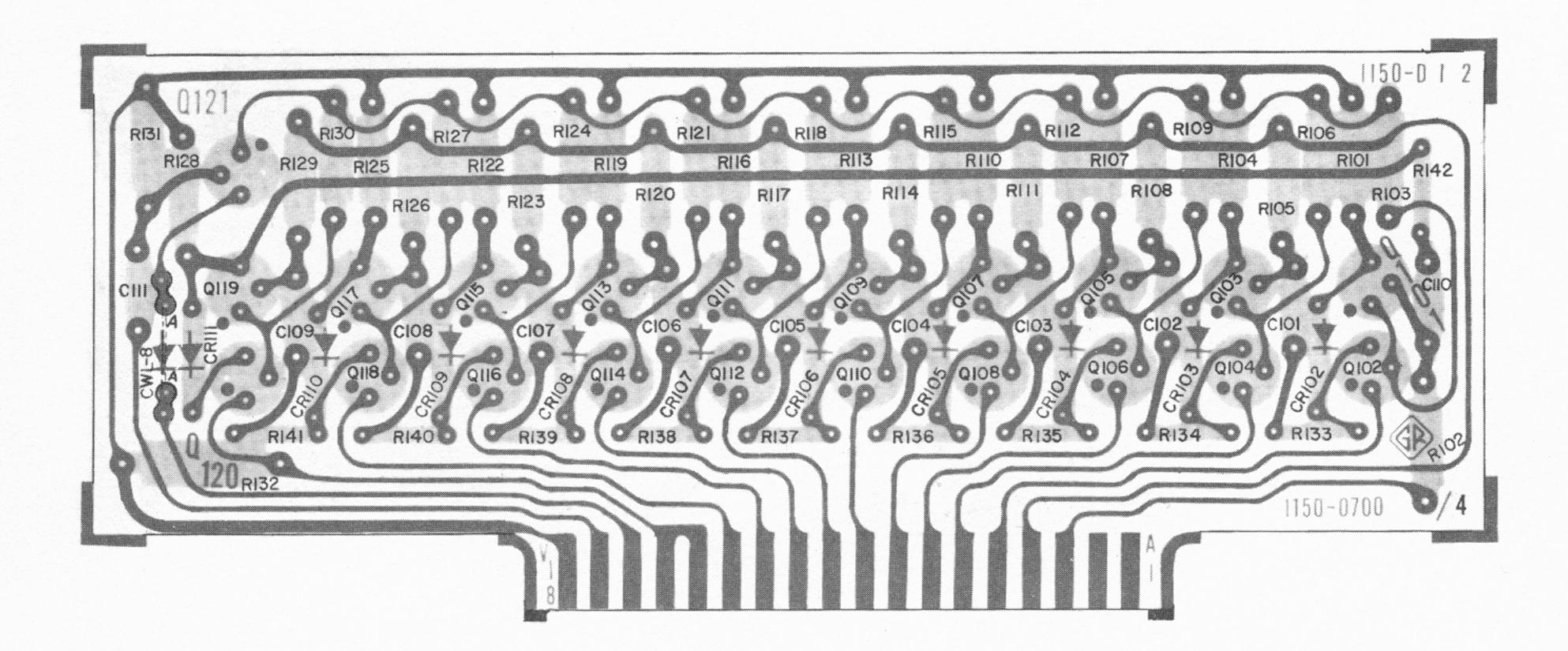
MEASUREMENT....COUNT COUNT/MULT INT...STOP

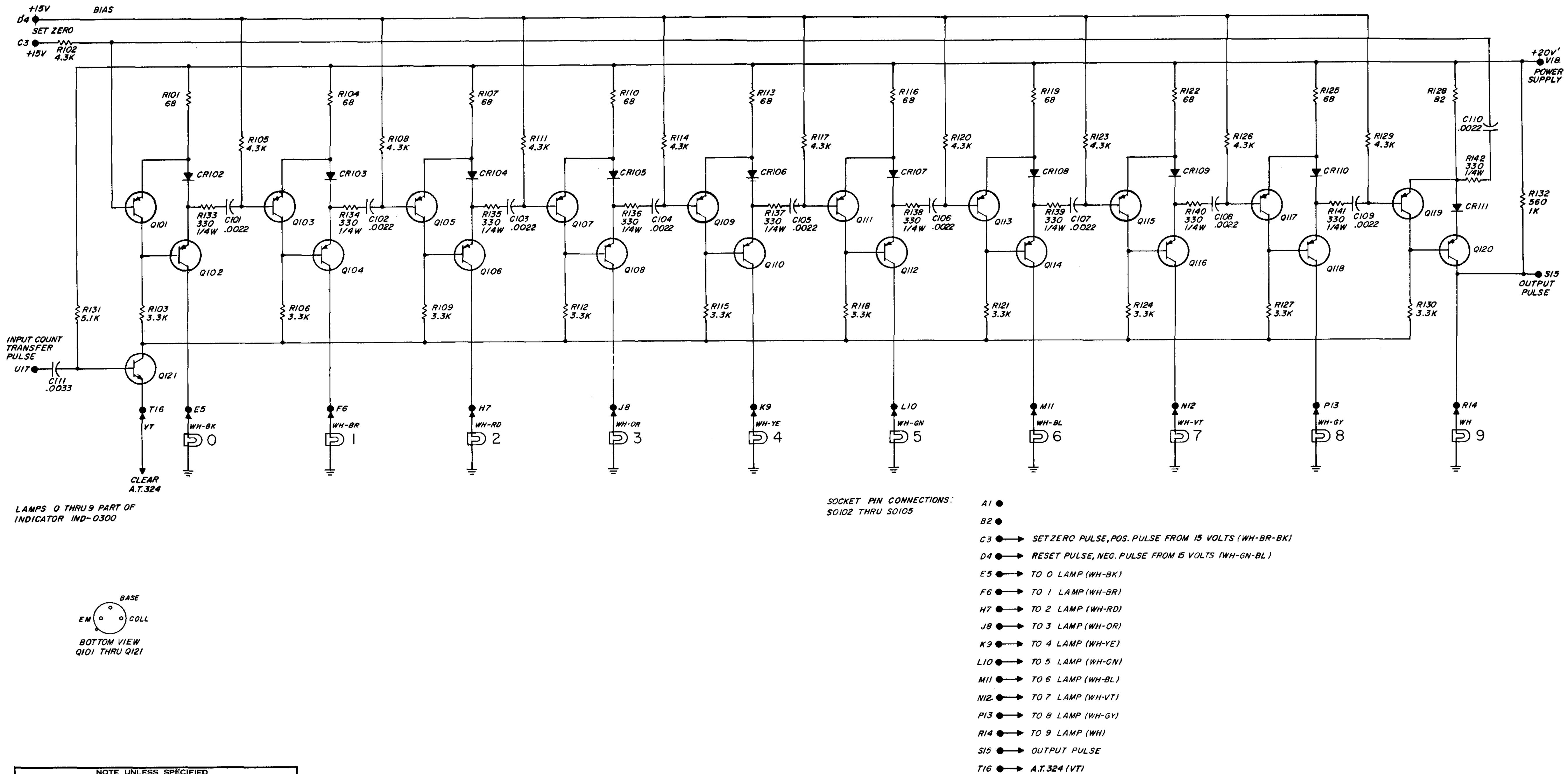
No input signal applied, RESET button pushed to give a display of 00000.



Measurement conditions:

TRIGGER LEVEL... centered INPUT COUPLING ... AC IMPEDANCE ... 100 kΩ MEASUREMENT ... 100 kc TEST DISPLAY TIME ... 4 COUNTING TIME ... 10 SEC

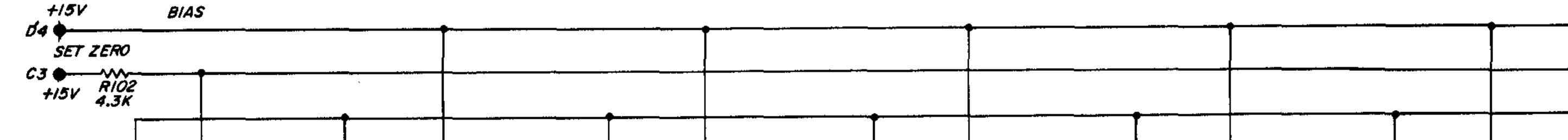


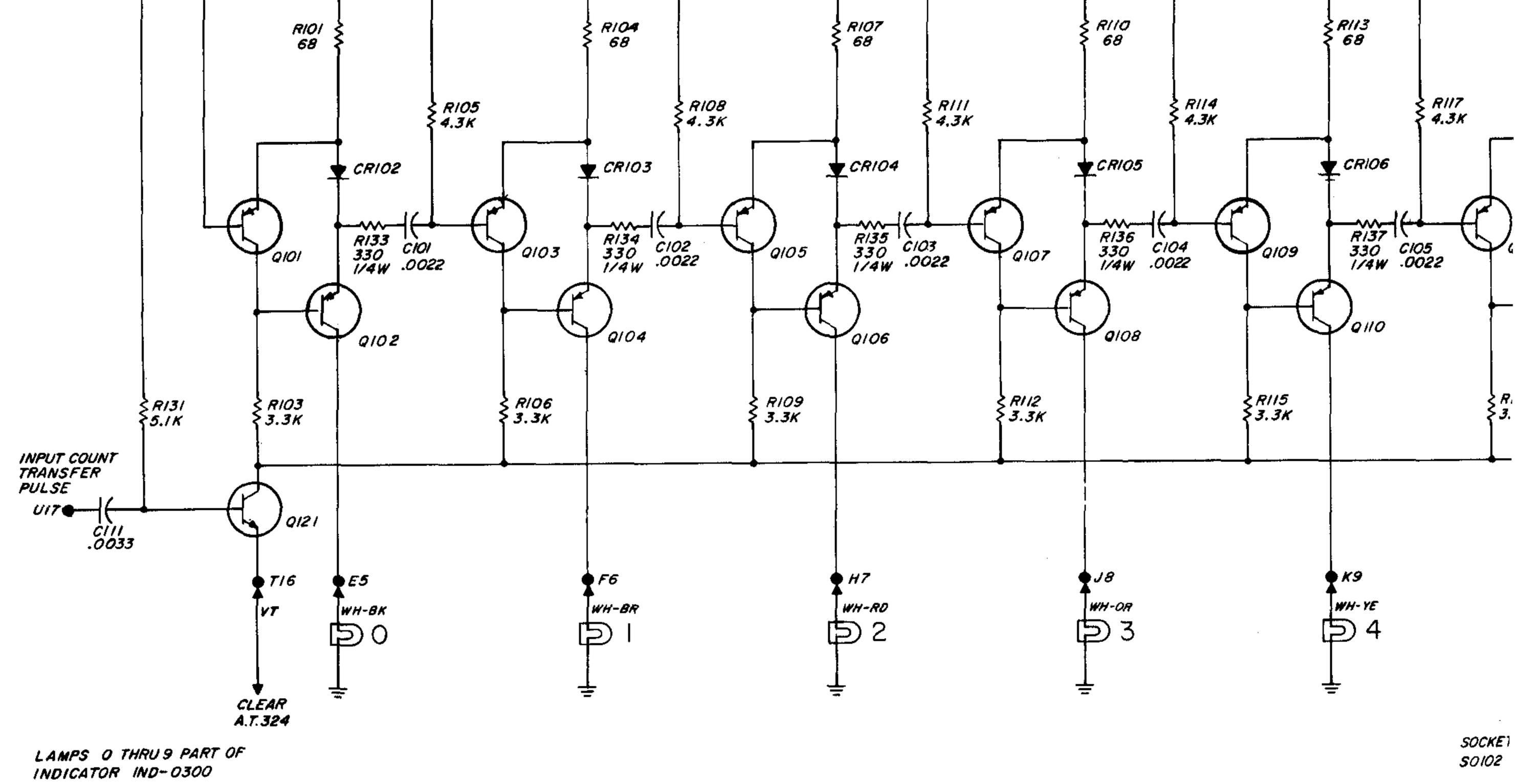


NOTE UNLESS	SPECIFIED
 POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM. RESISTORS 1/2 WATT. 	 5. RESISTANCE IN OHMS K = 1000 OHMS M 1 MEGOHM 6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS. 7. KNOB CONTROL 8. SCREWDRIVER CONTROL 9. AT = ANCHOR TERMINAL 10. TP = TEST POINT

UIT ---- INPUT COUNT TRANSFER PULSE (WHIRD-BK)

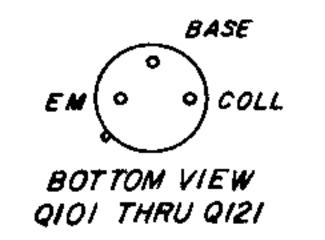
VI8 🗣 🔶 + 20 VOLT SUPPLY (WH-GN-BR)





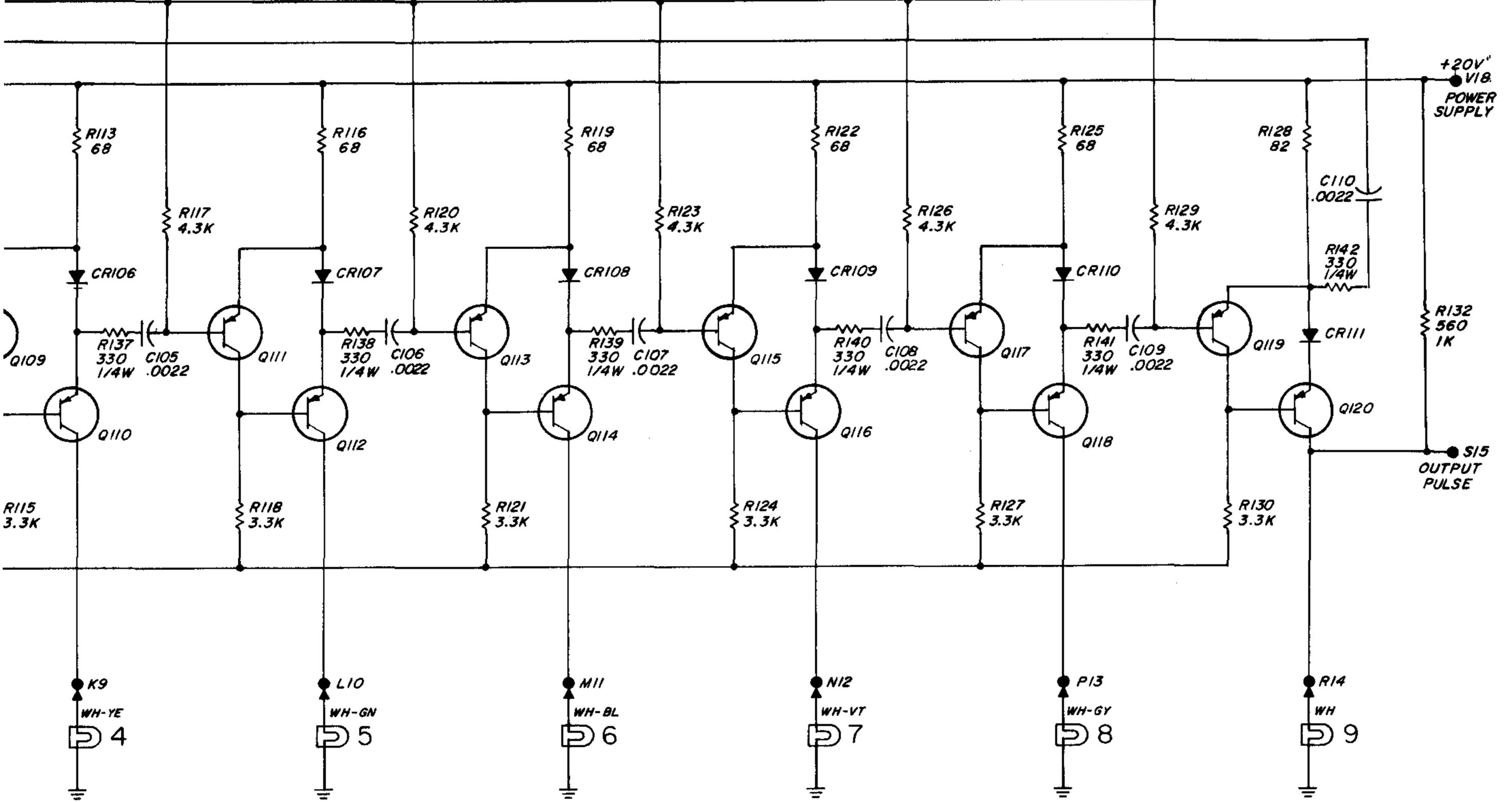
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NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES	5. RESISTANCE IN OHMS
SHOWN COUNTERCLOCKWISE.	K = 1000 OHMS M 1 MEGOHM
2. CONTACT NUMBERING OF SWITCHES	6. CAPACITANCE VALUES ONE AND
EXPLAINED ON SEPARATE SHEET	OVER IN PICOFARADS, LESS
SUPPLIED IN INSTRUCTION BOOK.	THAN ONE IN MICROFARADS.
3. REFER TO SERVICE NOTES IN INSTRUC	7. O KNOB CONTROL
TION BOOK FOR VOLTAGES	8. O SCREWDRIVER CONTROL
APPEARING ON DIAGRAM.	9. AT - ANCHOR TERMINAL
4. RESISTORS 1/2 WATT.	10, TP - TEST POINT



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SOCKET PIN CONNECTIONS! SO102 THRU SO105

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B2 🔴

AI 🔴

- C3 SETZERC PULSE, POS. PULSE FROM IS VOLTS (WH-BR-BK)
- D4 RESET PULSE, NEG. PULSE FROM 15 VOLTS (WH-GN-BL)
- E5 ---- TO O LAMP (WH-BK)
- F6 --- TO I LAMP (WH-BR)
- H7 TO 2 LAMP (WH-RD)
- J8 TO 3 LAMP (WH-OR)
- K9 TO 4 LAMP (WH-YE)
- LIO TO 5 LAMP (WH-GN)
- MII ---- TO 6 LAMP (WH-BL)
- NI2 TO 7 LAMP (WH-VT)
- PI3 TO 8 LAMP (WH-GY)
- RI4 ---- TO 9 LAMP (WH)
- SIS OUTPUT PULSE
- TI6 ---- A.T. 324 (VT)

--- INPUT COUNT TRANSFER PULSE (WHIRD-BK) UI7 🖝

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VI8 + 20 VOLT SUPPLY (WH-GN-BR)

40-kc DECIMAL RING COUNTING UNIT (2 used) 61

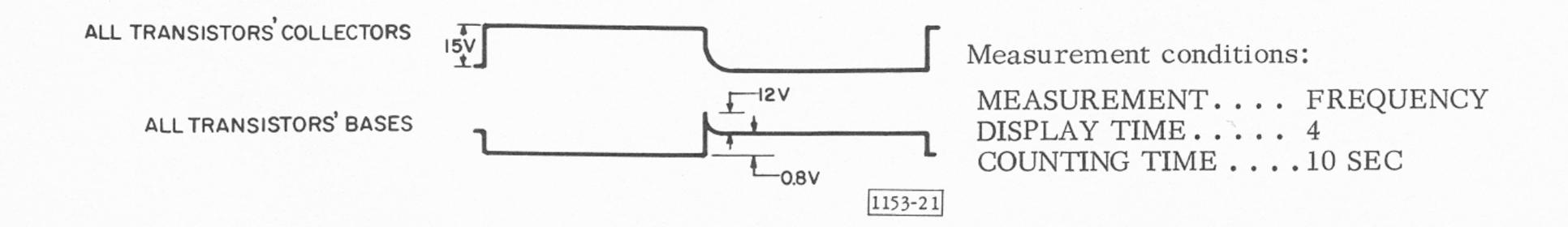
TIME BASE DIVIDER

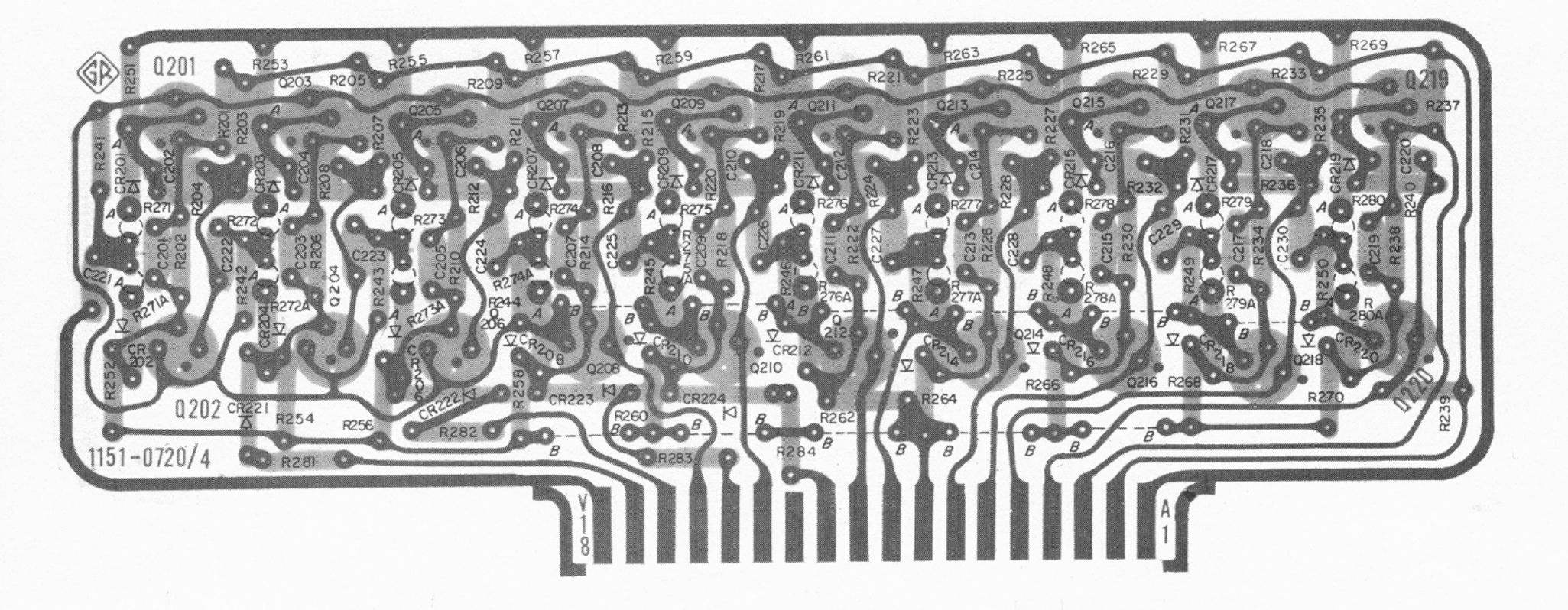
WHEN PLUGGED INTO SO201				WHEN PLUG	GED INTO					
		ltage to G	round			oltage to (Ground			
Transistor		Terminal	*	Transistor		erminal	*с			
	е	b	*с		е	b	C			
Q201	+19.4	+19.0	+ 5.5	Q201	+19.2	+19.0	+19.2			
Q202	+19.4	+19.0	+19.2	Q202	+19.2	+19.9	+ 5.5			
Q203	+19.4	+19.0	+ 5.5	Q203	+19.2	+19.0	+19.2			
Q204	+19.4	+19.0	+19.2	Q204	+19.2	+19.9	+ 5.5			
Q205	+19.4	+19.0	+ 5.5	Q205	+19.2	+19.0	+19.2			
Q206	+19.4	+19.0	+19.2	Q206	+19.2	+19.9	+ 5.5			
Q207	+19.4	+19.0	+ 5.5	Q207	+19.2	+19.0	+19.2			
Q208	+19.4	+19.0	+19.2	Q208	+19.2	+19.9	+ 5.5			
Q209	+19.4	+19.0	+ 5.5	Q209	+19.2	+19.0	+19.2			
Q210	+19.4	+19.0	+19.2	Q210	+19.2	+19.9	+ 5.5			
Q211	+19.4	+19.0	+ 5.5	Q211	+19.2	+19.0	+19.2			
Q212	+19.4	+19.0	+19.2	Q212	+19.2	+19.9	+ 5.5			
Q213	+19.4	+19.0	+ 5.5	Q213	+19.2	+19.0	+19.2			
Q214	+19.4	+19.0	+19.2	Q214	+19.2	+19.9	+ 5.5			
Q215	+19.4	+19.0	+ 5.5	Q215	+19.2	+19.0	+19.2			
Q216	+19.4	+19.0	+19.2	Q216	+19.2	+19.9	+ 5.5			
Q217	+19.4	+19.0	+ 5.5	Q217	+19.2	+19.0	+19.2			
Q218	+19.4	+19.0	+19.2	Q218	+19.2	+19.9	+ 5.5			
Q219	+19.4	+19.0	+ 5.5	Q219	+19.2	+19.0	+19.2			
Q220	+19.4	+19.0	+19.2	Q220	+19.2	+19.9	+ 5.5			

Measurement conditions:

TIME BASE (rear). . .EXT

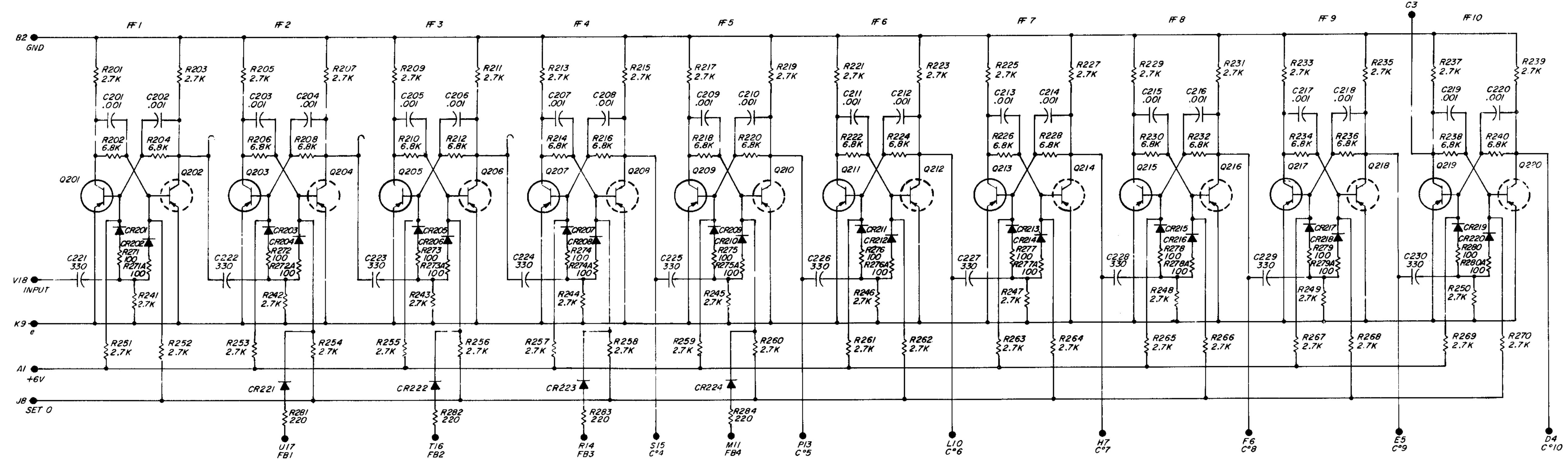
*Collector voltages may be reversed depending on how far the divider has counted before the TIME BASE switch was set to EXT. For instance, the voltages may be as shown through Q208 but the odd transistor may be 19.2 V and the even transistor may be 5.5 V from Q209 through Q220

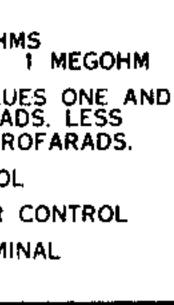




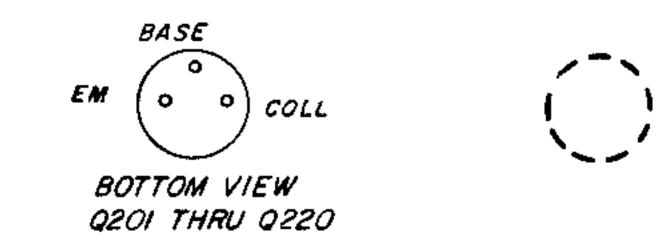
. .

NOTE UNLESS	SPECIFIED
1. POSITION OF ROTARY SWITCHES	5. RESISTANCE IN OHM
SHOWN COUNTERCLOCKWISE.	K 1000 OHMS M
2. CONTACT NUMBERING OF SWITCHES	6. CAPACITANCE VALUE
EXPLAINED ON SEPARATE SHEET	OVER IN PICOFARAD
SUPPLIED IN INSTRUCTION BOOK.	THAN ONE IN MICRO
3. REFER TO SERVICE NOTES IN INSTRUC-	7. O KNOB CONTROL
TION BOOK FOR VOLTAGES	8. O SCREWDRIVER C
APPEARING ON DIAGRAM.	9. AT ANCHOR TERMIN
4. RESISTORS 1/4 WATT.	10. TP TEST POINT





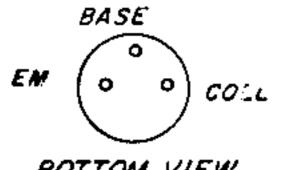
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TRANSISTORS "ON" FOR BINARY ZERO

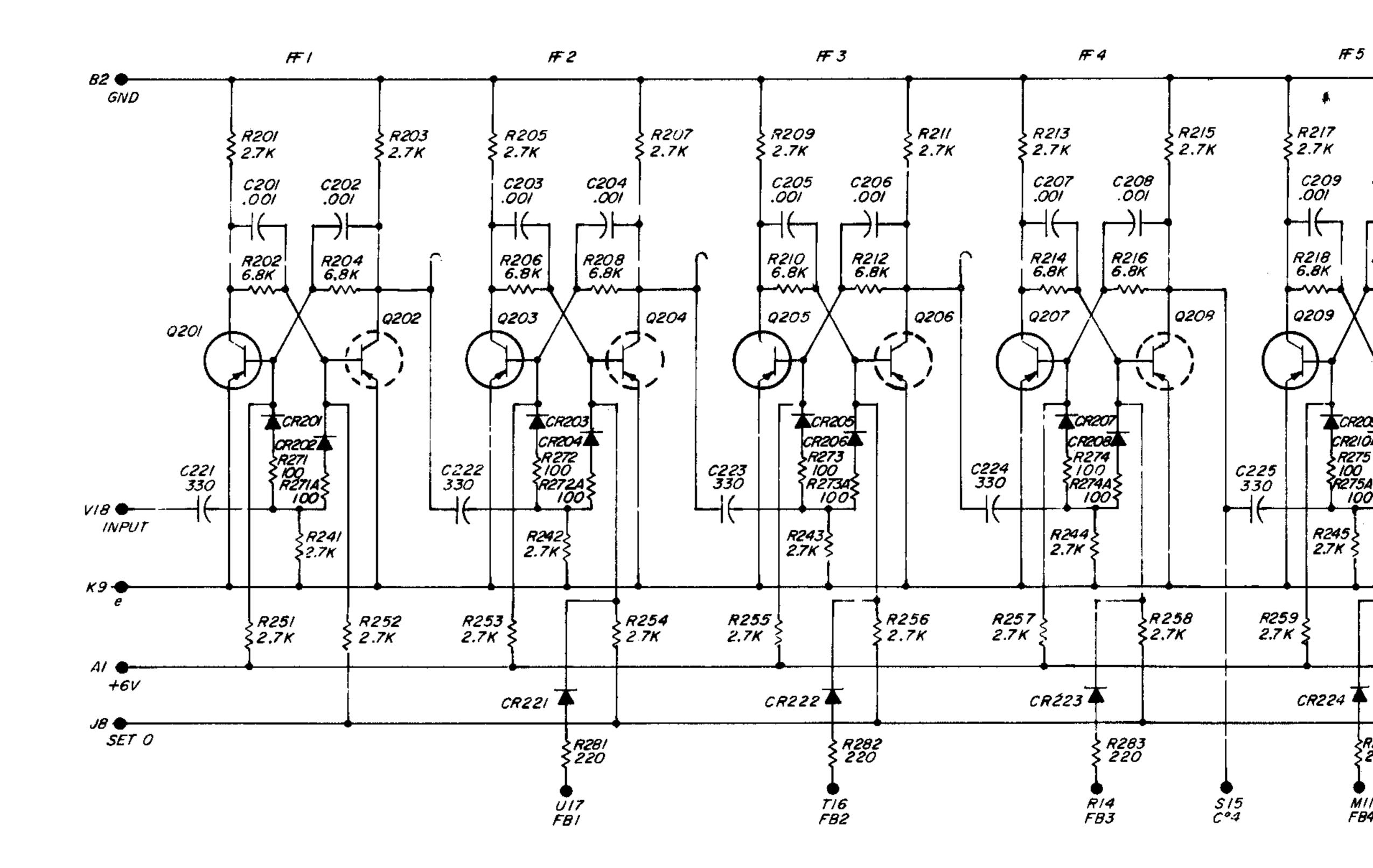
NOTE UNLESS	SPECIFIED
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.	5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.	 CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS. KNOB CONTROL
3. REFER TO SERVICE NOTES IN INSTRUC- TION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.	8. SCREWDRIVER CONTROL 9. AT ANCHOR TERMINAL
4. RESISTORS 1/4 WATT.	10. TP TEST POINT

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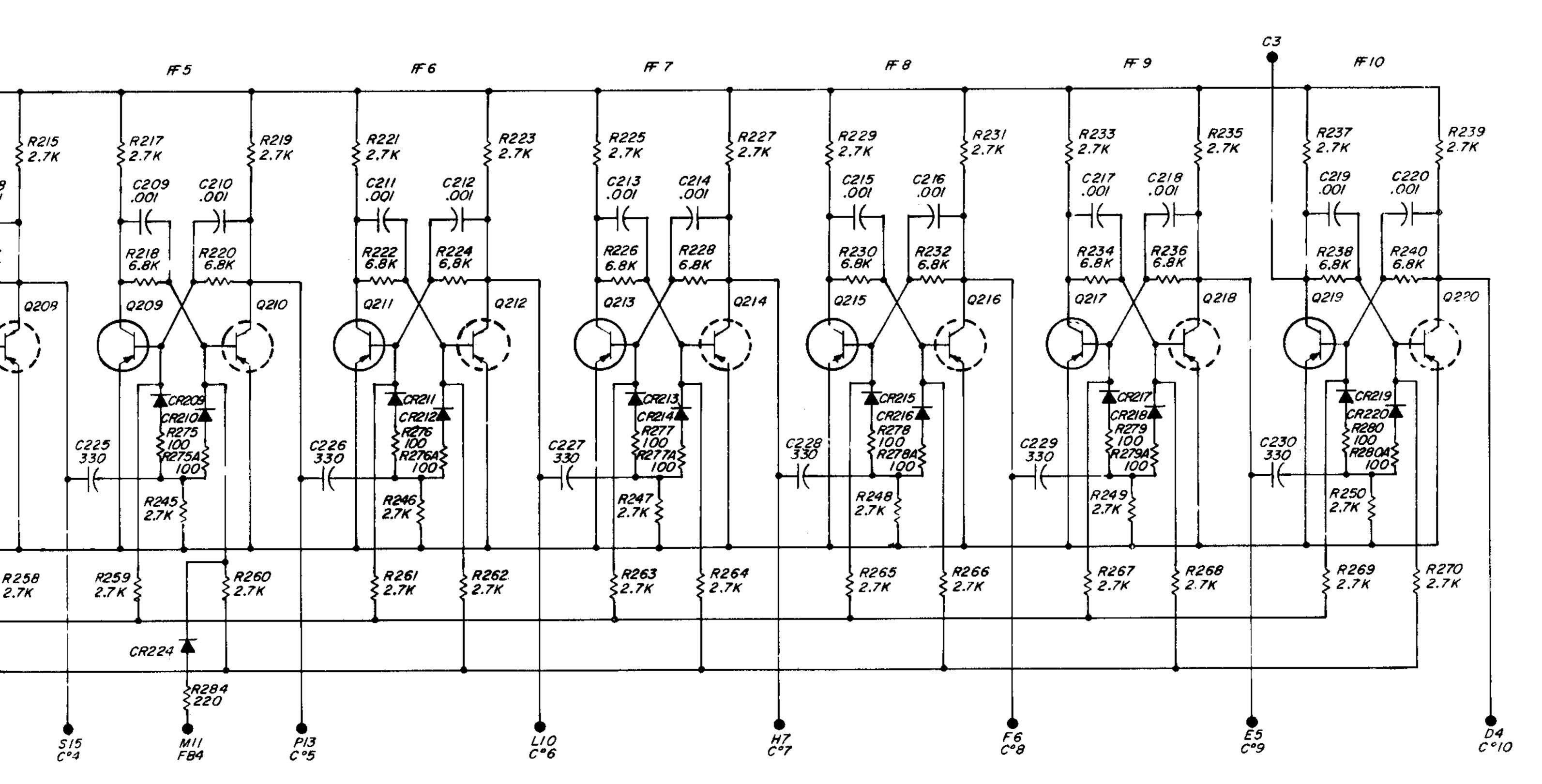
BOTTOM VIEW Q201 THRU Q220



<u>/</u>_\ TRANSISTORS "ON" FOR BINARY ZERO

EW Q220

COIL



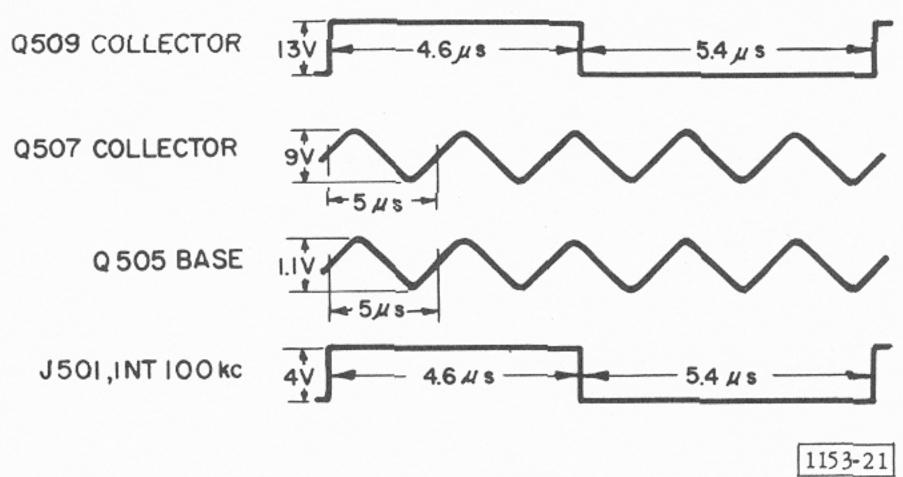
TIME-BASE DIVIDER (2 used) 63

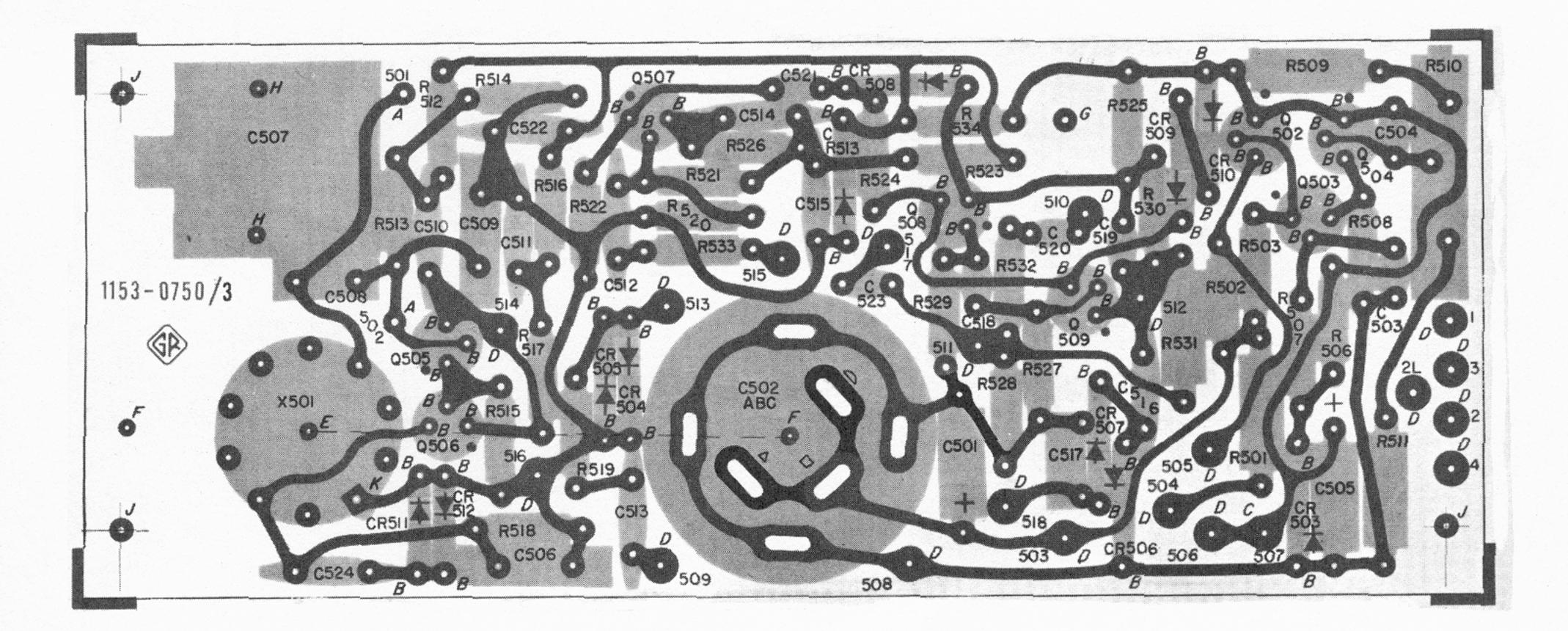
POWER SUPPLY & OSCILLATOR

VOLTAGES

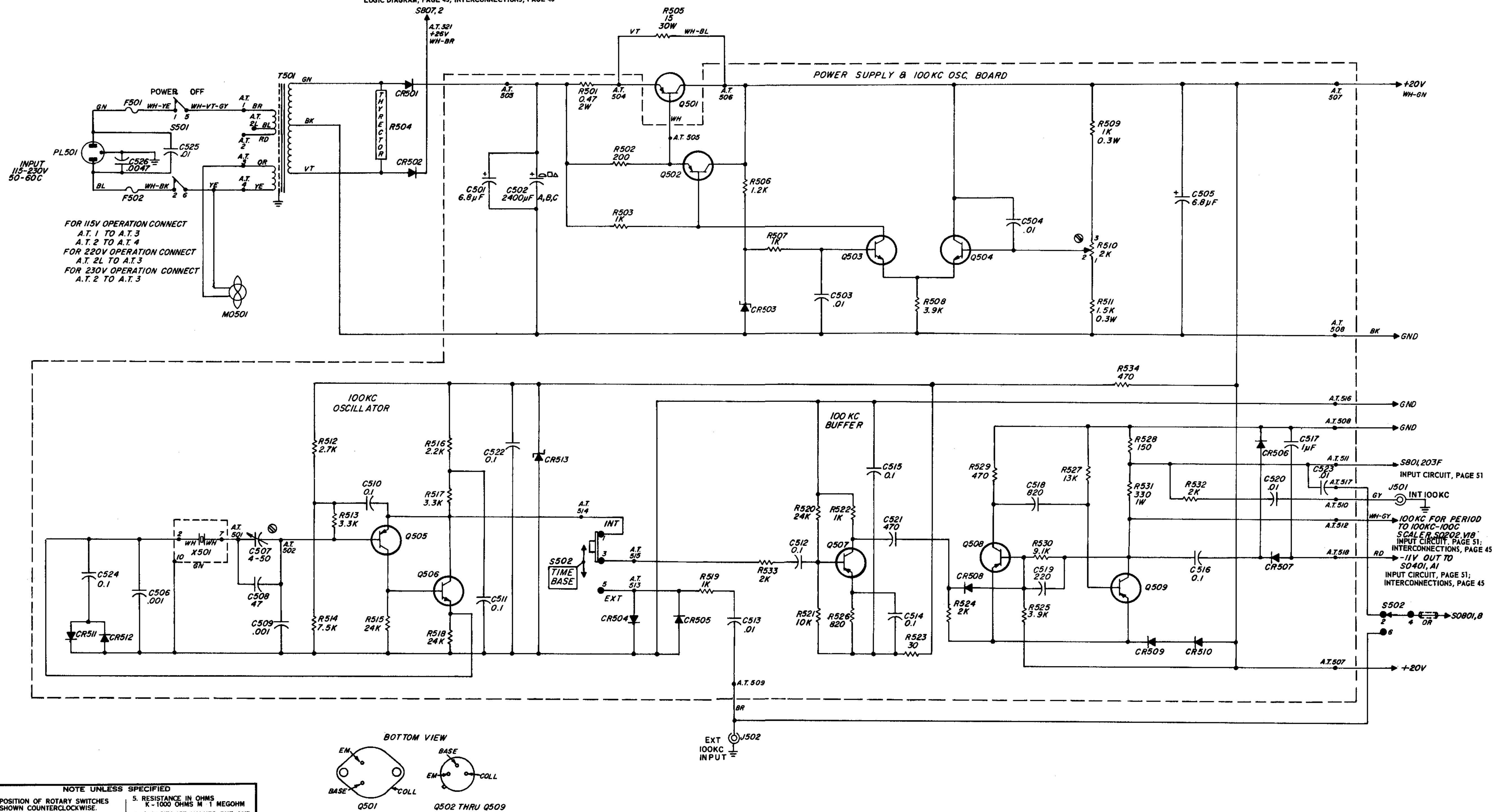
Transistor		oltage to C T <i>ermina</i> l	Ground
	е	b	с
Q501 Q502 Q503 Q504 Q505	+32.2 +32.0 +11.5 +20.0 +11.1	+32.0 +31.5 +11.8 +11.7 +10.9	+20.0 +20.0 +31.0 +20.0 + 7.5
Q506 Q507 Q508 Q509	+ 8.7 +10.6 +18.8 +18.8	+ 7.5 +10.9 +18.8 +21.8	+11.1 + 4.7 +11.0 +12.0
AT518	-1	0.0	

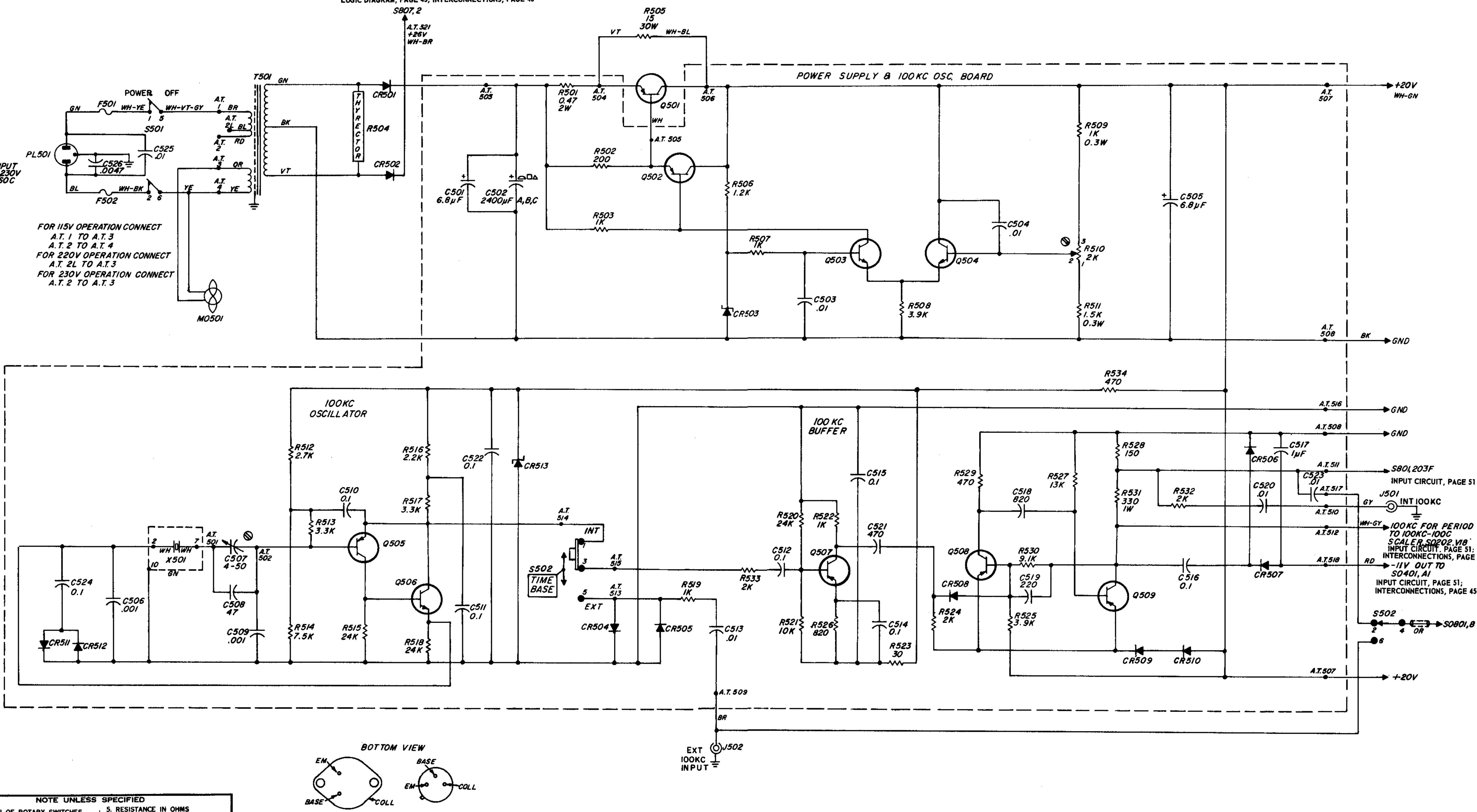
WAVEFORMS







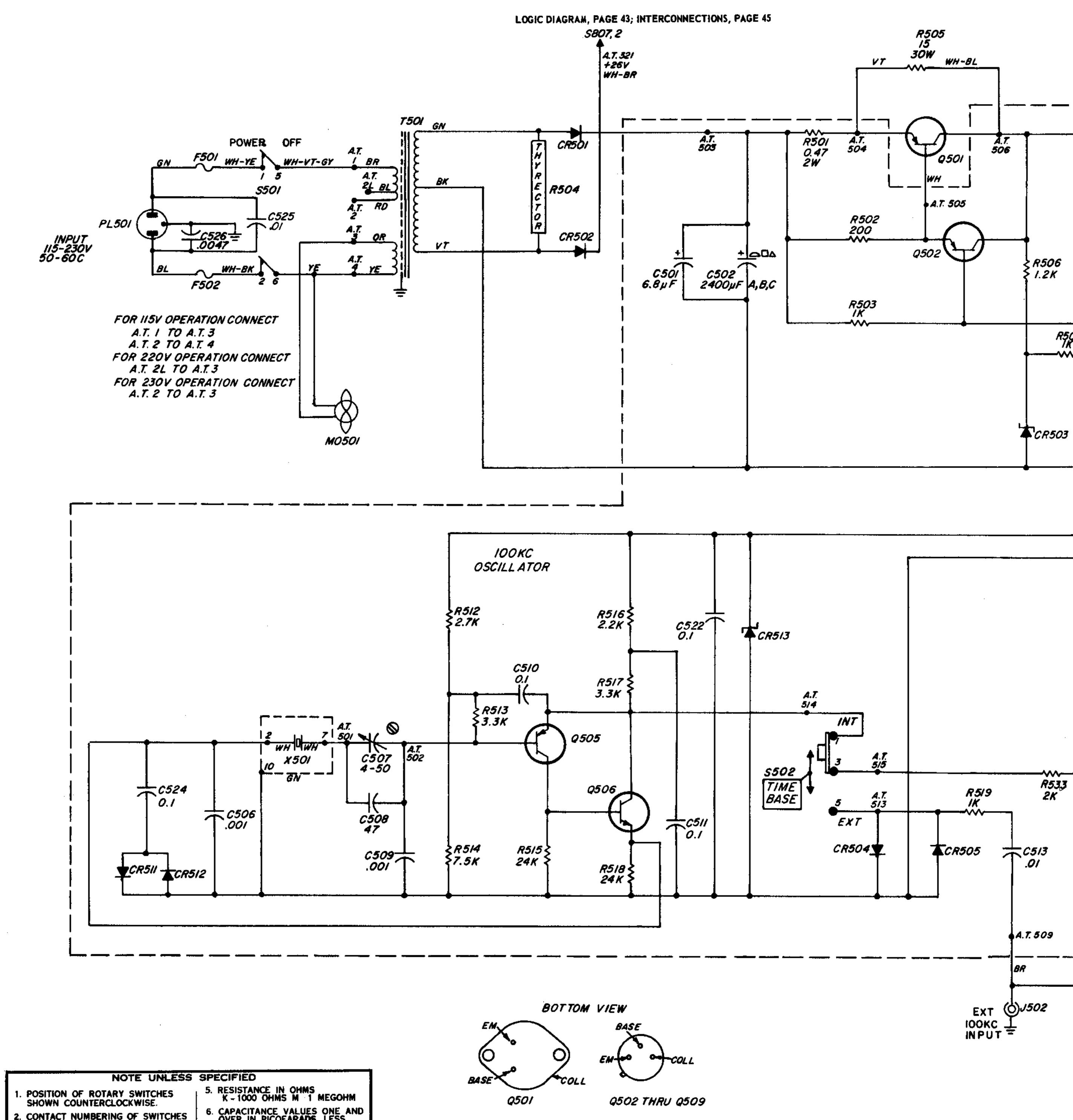




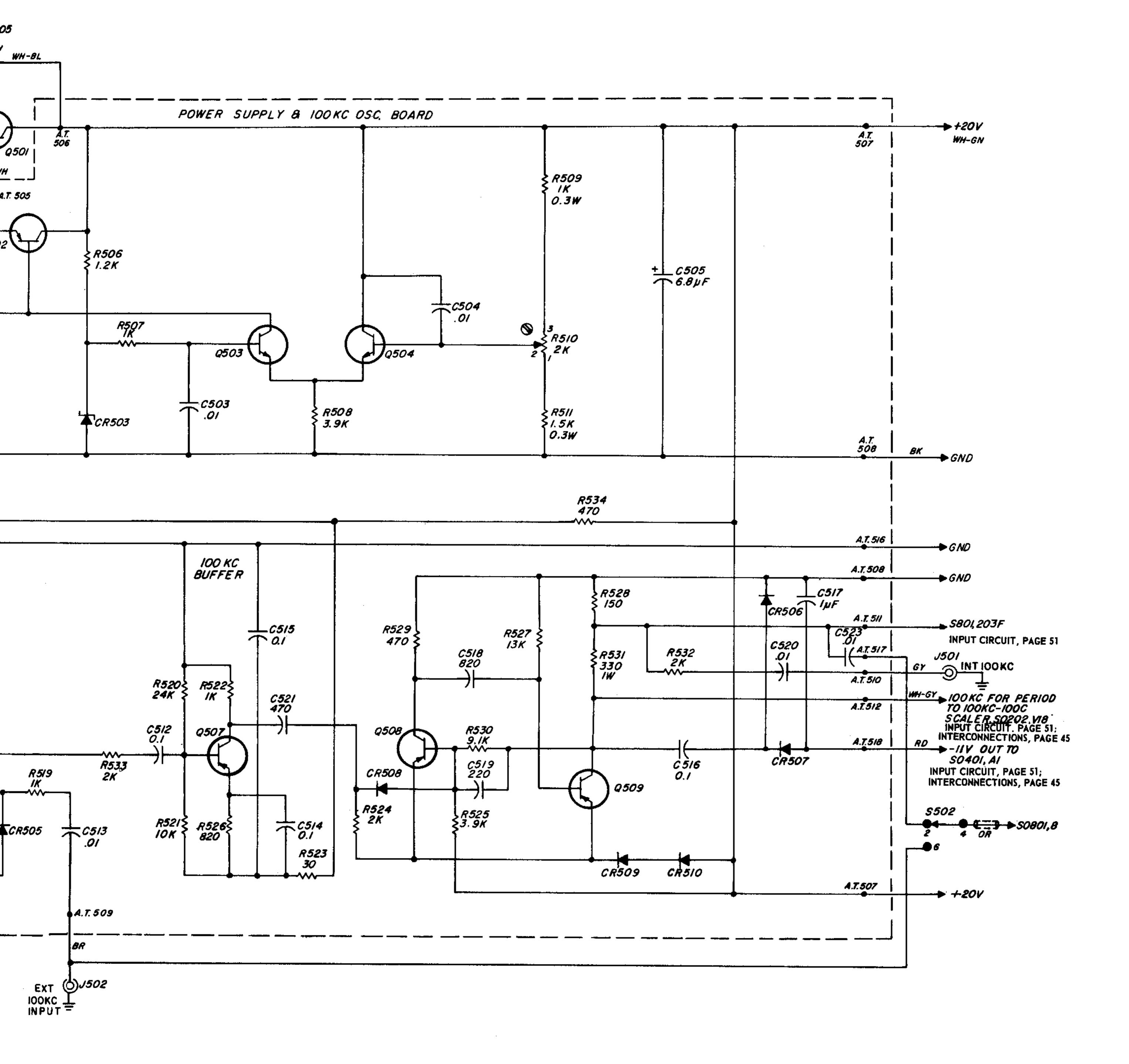
NOTE UNLESS	SPECIFIED	
 POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK. REFER TO SERVICE NOTES IN INSTRUC- TION BOOK FOR VOLTAGES. APPEARING ON DIAGRAM. RESISTORS 1/2 WATT. 	 5. RESISTANCE IN OHMS K - 1000 OHMS M 1 MEGOHM 6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS. 7. KNOB CONTROL 8. SCREWDRIVER CONTROL 9. AT - ANCHOR TERMINAL 10. TP - TEST POINT 	AN

CHOR TERMIALS USED: A.T. 1, 2, 2L, 3, 4, 501 - 518

LOGIC DIAGRAM, PAGE 43; INTERCONNECTIONS, PAGE 45



EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.	THAN ONE IN MICROFARADS.	
3. REFER TO SERVICE NOTES IN INSTRUC-		
TION BOOK FOR VOLTAGES. APPEARING ON DIAGRAM.	8. SCREWDRIVER CONTROL 9. AT - ANCHOR TERMINAL	
4. RESISTORS 1/2 WATT.	10. TP - TEST POINT	ANCHOR TERMIALS USED: A.T. 1,2, 2L, 3,4, 501 - 518



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POWER SUPPLY and OSCILLATOR 65

TYPE 1153-P1 FREQUENCY MULTIPLIER

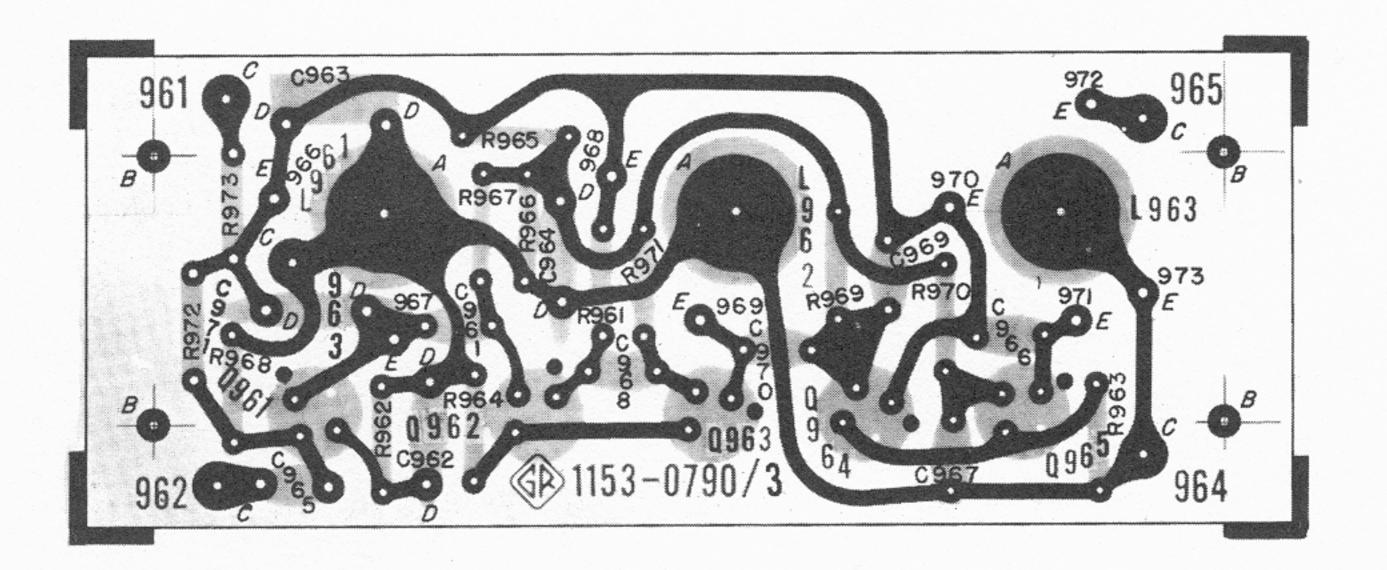
PARTS LIST

REF NO.

DESCRIPTION

PART NO.

Capacitors C961	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C962	Ceramic, 0.1 µF +80-20% 50V	4403-4100
C963	Ceramic, $1 \mu F \pm 20\% 25V$	4400-2070
C964 C965	Ceramic, 0.1 μF +80-20% 50V Ceramic, 100 pF ±5% 500V	4403-4100 4404-1105
C966	Ceramic, 150 pF ±5% 500V	4404-1155
C967	Ceramic, $0.001 \mu\text{F} + 80-20\% 500V$	4404-2109
C968 C969	Ceramic, 0.001 μF ±5% 500V Ceramic, 0.001 μF ±5% 500V	4405-2105 4405-2105
C909 C970	Ceramic, $0.001 \mu\text{F} \pm 5\%$ 500V Ceramic, $0.001 \mu\text{F} \pm 5\%$ 500V	4405-2105
C971	Ceramic, 0.0047 µF ±5% 500V	4407-2475
Inductors	Variable 110 to 186 ull	4290-4265
L961 L962	Variable, 110 to 186 μH Variable, 29 to 55.5 μH	4290-4203
L963	Variable, 4.5 to 8.6μ H	4290-4050
Plug	Variable, 1.0 to 0.0 pm	12/0 1000
PL961	8 contact, Jones No. 261-31-08-030	4220-5000
Transistors		
Q961		
thru	Type 2N2714	8210-1047
Q965 Resistors		
R961	Composition, 470 Ω ±5% 1/4w	6099-1475
R961	Composition, $1 k\Omega \pm 5\% 1/4w$	6099-2105
R963	Composition, $2.4 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2245
R964	Composition, 2.4 k Ω ±5% 1/4w	6099-2245
R965	Composition, $10 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-3105
R966	Composition, $10 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-3105
R967	Composition, $12 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-3125
R968	Composition, $5.1 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2515
R969	Composition, $5.1 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2515
R970	Composition, $5.1 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2515
R971	Composition, $5.1 \text{ k}\Omega \pm 5\% 1/4\text{w}$	6099-2515
R971	Composition, 120 k Ω ±5% 1/4w	6099-4125
R973	Composition, $1 k\Omega \pm 5\% 1/4w$	6099-2105



NOTE UNLESS	SPECIFIED
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE. 2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK. 3. REFER TO SERVICE NOTES IN INSTRUC- TION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.	 5. RESISTANCE IN OHMS 6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS. 7. OKNOB CONTROL 8. SCREWDRIVER CONTROL
4. RESISTORS 1/4 WATT.	9. AT ANCHOR TERMINAL 10. TP TEST POINT

ANCHOR TERMINALS USED: A.T. 961-A.T. 973

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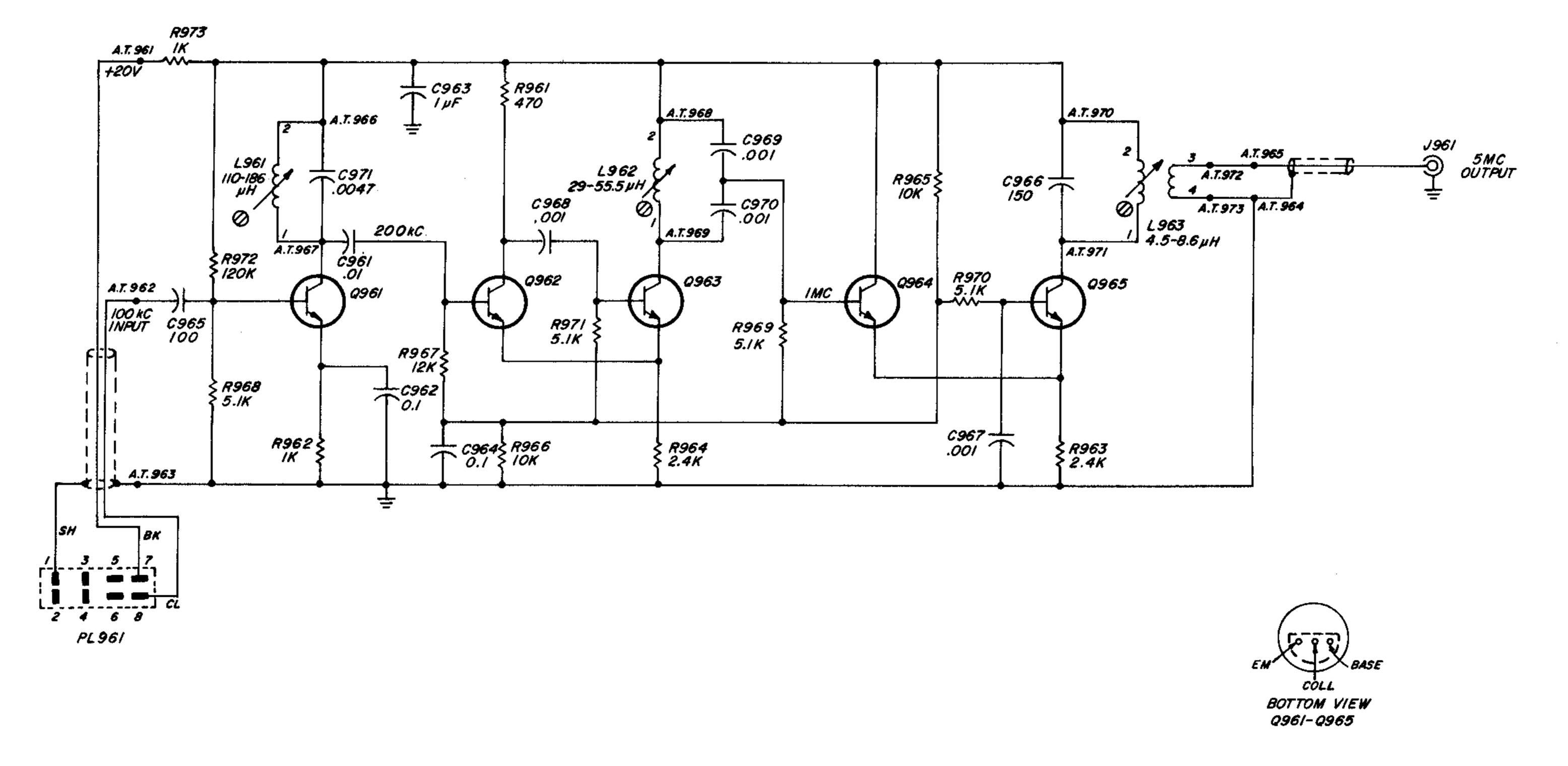
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X2 MULT

X5 MULT





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TYPE 1153-P1 FREQUENCY MULTIPLIER 67

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