# OPERATING AND SERVICING MANUAL

# FOR

# MODEL 521A/C

# INDUSTRIAL ELECTRONIC

# COUNTERS

521A
Serial 1182 and above

521C
Serial 1182 and above



521A/C001-1

# TABLE OF SPECIFICATIONS

## FOR

## MODELS 521A/C ELECTRONIC COUNTERS

| | |
|---|---|
| COUNTING RATE: | 1 to 120,000 events per second. (May be increased to 220,000 evenfs per second by replacing units AC-4A with an AC-4B.) |
| REGISTRATION: | 521A - 4 places. Total count capacity 9,999; resets to 0000 on the 10,000th count.<br>521C - 5 places. Total count capacity 99,999; resets to 00000 on the 100,000th count. |
| RESOLUTION: | 8.3 microseconds. (4.5 μs with an AC-4B installed |
| ACCURACY: | ±1 count, ±accuracy of timing frequency signal. (Approximately ±.1% when power line is used.) (±.01% when crystal controlled electronic time base is used.) |
| INPUT VOLTAGE: | 0.2V rms minimum to 100V rms maximum. 1 volt peak positive for pulses. (1V rms minimum with AC-4B installed.) |
| INPUT WAVEFORM: | Must have a rate of rise of 0.2 volts per second or faster. |
| INPUT IMPEDANCE: | 1 megohm shunted by 50 μμf. 0.5 megohm at phototube jack. |
| GATE TIMES: | 521A - 1/10 and 1 second. (10 second standard gate time available on special order.)<br>521C - 1/10, 1, and 10 second. |
| DISPLAY TIME: | Continuously adjustable from 1/10 second to 15 seconds or can be held indefinately. |
| POWER REQUIREMENTS: | 115/230 volts, 50 or 60 cycles, 185 watts. |
| SIZE: | Cabinet Mount: 9-3/4" wide, 15-1/4" high, 14-1/2" deep.<br>Rack Mount: 19" wide, 8-3/4" high, 14-1/2" deep. |
| WEIGHT: | Cabinet Mount: 28 lbs net, shipping weight 41 lbs.<br>Rack Mount: 26 lbs net, shipping weight 43 lbs. |

## SPECIFICATIONS FOR MODELS 521A/C ELECTRONIC COUNTERS (CONT'D.)

**MEASUREMENT RANGES:**

Frequency: 1 cps to 120 kc. (220 kc with AC-4B.)

Time Interval: Depends upon standard frequency that is counted.

521A - 1/60 sec. to 167 sec. using 60 cps. 1/10,000 sec. to 1 sec. using 10 kc timing signal.

521C - 1/60 sec. to 1667 sec. using 60 cps. 1/10,000 sec. to 10 sec. using 10 kc timing signal.

Total Events:

521A - Up to 10,000 electrical events.
521C - Up to 100,000 electrical events.

### FEATURES

**INPUT ATTENUATOR:** Adjusts SENSITIVITY from 0.2 volt to 100 volts rms to overcome noise effects.

**SELF CHECK:** Internal counting of Time Base frequency provides check of proper operation of the unit.

**CRYSTAL CONTROLLED TIME BASE PLUG-IN:** 521A - Optional and available at extra cost, the hp Model 521A-59B Plug-In Crystal Controlled Electronic Time Base can be ordered with the instrument or procured later and installed in the instrument. The unit permits error to be reduced to less than 0.01% ±1 count and can drive several 521A's.

521C - The 521A-59B Plug-In Crystal Controlled Electric Time Base is furnished with the instrument.

**EXTERNAL TIME STANDARD:** Any multiple of 10 cps between 10 cps and 100 cps may be employed. If sine wave driving voltage is used, its amplitude must be between 5 volts rms minimum and 50 volts rms maximum.

**ACCESSORY SOCKET:** Cannon connector on rear chassis supplies 6.3V ac at 0.6 amp, +300V dc at 10ma, and -150V dc at 5 ma.

**PHOTOTUBE INPUT:** Standard phone jack on rear chassis supplies bias voltage for type 1P41 (or equal) phototube and is signal input connector for phototube.

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# FOR

# MODELS 521A/C ELECTRONIC COUNTERS

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# SECTION I

# GENERAL INFORMATION

## 1-1 GENERAL

This manual, written primarily for the hp Model 521A, is also applicable, in general, to the hp Model 521C. The Model 521C features are discussed in paragraph 1-6.

## 1-2 MODEL 521A, GENERAL DESCRIPTION

The Model 521A is a portable, direct-reading instrument that counts periodic and random events and automatically displays the answer in digital form. When coupled to the proper transducers this instrument may be used for a wide range of measurements formerly possible only with much more elaborate equipment. In addition to straightforward frequency and time measurements it measures speed, RPM, RPS, weight, pressure, temperature, acceleration, or any quantity that can be converted into electrical impulses by means of appropriate mechanical and photo-electric transducers. The 521A counts total random events within a selected time interval or it may be used to measure the time between two events from a fraction of a second to over one hundred seconds. An internal self-checking feature is provided to confirm the accuracy of operation.

## 1-3 ACCURACY

The accuracy of the displayed answer on the 521A, when using the power line frequency as a standard timing signal (normal operation condition) is nominally ±0.1%, the accuracy of the line frequency, plus the possible ±1 count variation inherent with a digital counting system. The ±1 count variation is in general, significant only at frequencies below 500 cycles, for example: at 50 cycles the percent error is ±2% using the 1 SEC. automatic gate time. If greater accuracy is required for measurement of frequencies above 500 cps, an externally generated signal of 10 cycles, or any multiple thereof up to 100 cycles, may be used instead of the power line frequency. The 521A then assumes the accuracy of the applied signal unless the ±1 count is of greater significance. An accessory plug-in unit, the hp Model 521A-59B Crystal Controlled Time Base, is available which can be quickly

installed in any 521A Electronic Counter to increase the accuracy of measurement to better than 0.01%. Installation is fully described in Section II.

## 1-4 PHYSICAL CHARACTERISTICS

The 521A is a very compact counter, weighing only 28 lbs. It can be obtained either for rack mounting in a standard 19 inch wide relay rack, or in the cabinet model. The cabinet model is designed for table top use and with its convenient carrying handle and rigid construction is very suitable for field use. Both models are ventilated by a fan and air filter located in the bottom of the instrument, and louvered in the sides and top. Do not obstruct the ventilating louvers.

## 1-5 PRINCIPAL OF OPERATION

For frequency measurements, the unknown signal applied to the INPUT jacks is fed through a Signal Gate to four Counter Units. The Signal Gate is opened and closed by the Time Base for an accurately controlled period of time, such as 1 second. The Counter Units count and display the number of events which occurred during the one second period and the answer is read across the front panel directly in cycles per second. When the 1/10 second gate time is used, the answer is read directly in cycles per 1/10 second. The maximum counting rate of the 521A is 120,000 events per second. However, the maximum counting rate can be increased to 220,000 events per second by replacing the units AC-4A Decade Counter with an AC-4B Decade Counter. The only operational difference is that the minimum input signal with the AC-4B installed is 1 volt rms.

For time interval measurement, either the power line frequency or 10 KC supplied by the accessory Crystal Controlled Time Base when this unit is installed, is applied through the Signal Gate to the Counter Units. The electrical or mechanical events that mark the beginning and ending of the time interval to be measured are then applied to the 521A to open and close the Signal Gate. The Counter Units count and display the number of cycles that occurred while the gate was open. To convert the displayed number to seconds, multiply the displayed number by 1/60 for a 60 cycle line, 1/50 for a 50 cycle line, etc.

## 1-6 THE 521C FEATURES

The Model 521C is a modified ℎ𝑝 Model 521A and is equal in every respect to the 521A. The 521C incorporates the following added features:

1. Added Decade Scaler - In order to display a total registration of 5 significant figures in the number columns across the front panel of the instrument, an extra decade scaler has been added to the 521C. The 521C will display a total count of 99,999 events per second before the counters return to zero. The maximum counting rate of the 521C is the same as that of the 521A, i.e., 1 to 120,000 events per second. The maximum counting rate of the 521C can be increased to 1 to 220,000 events per second by replacing the units AC-4A Decade Counter with an AC-4B Decade Counter. The only operational difference is that the minimum input signal with the AC-4B installed is 1 volt rms.

2. Added Gate Time - An extra phantastron frequency divider has been incorporated in the instrument to give a 10 second gate time in addition to the 1/10 second and 1 second gate times. When the GATE SELECTOR switch is in the 10 SEC position, the frequency of the signal is displayed in cycles per 10 seconds.

3. Reset Amplifier - In order to reduce the minimum display time of 10 seconds to approximately 1 second when the GATE SELECTOR switch is in the 10 SEC position, reset amplifier V17 has been added between display time phantastron V15 and phantastron frequency divider V16. The operation of the reset amplifier is as follows:

   The trailing edge of the display time pulse from V15 cuts off conduction in V17A making its plate voltage return to +200 volts. This positive signal feeds to the grid of V17B making this half of the tube conduct and thereby send a large negative signal (approximately -50 volts) to the second control grid (pin 7) of V16. This signal cuts off V16 and restores it to its original state to receive the next trigger pulse from phantastron frequency divider V4.

   The reset action takes place within 10 microseconds after the display time pulse so that the counters can begin a recount in approximately 1 second after a count has been displayed on the front panel.

   The reset amplifier will also reset the 10 second phantastron frequency divider when the manual reset button is actuated. When the reset button is pushed, C218 is charged up to -105 volts through R264 and R262. When the reset button is released, the negative discharge feeds to the grid of the reset amplifier V17A and appears at the plate of V17B as a large negative pulse which resets the 10 second phantastron divider V16.

   The GATE SELECTOR switch has been changed to a four position switch to accommodate the use of the 10 SEC gate position.

4. Crystal Controlled Time Base - The Model 521A-59B Plug-In Crystal Controlled Time Base is furnished with the Model 521C and is included in the price. Operation and adjustment of the unit is discussed in paragraphs 2-13 and 5-9 of this manual.

The 521C Schematic Diagrams and Supplementary Parts List will be found at the end of this manual.

## 1-7 POWER LINE VOLTAGE

Unless specially ordered from for 230 volt service, the 521A Electronic Counter is wired for 115 volt operation. Conversion to 230 volt service is simple and involves only changing wire jumpers on the power transformer primary winding terminal strip.

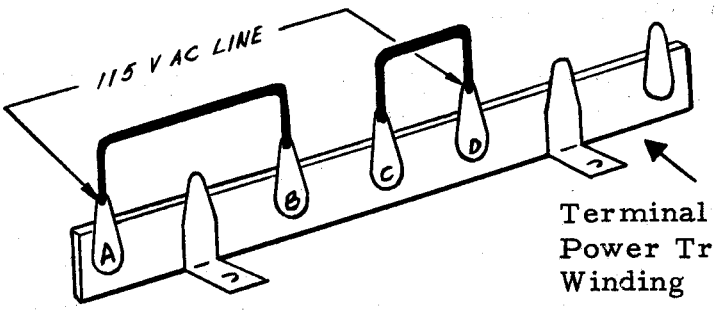
To connect the instrument for 230 volt service, remove any jumpers between AB and between CD as in Figure 2. Install a jumper between BC. To convert to 115 volt operation remove any jumpers between BC and connect two jumpers - one between AB and one between CD. For 230 volt operation the power fuse must be changed from 2 ampere Slow-Blow to 1 ampere Slow-Blow.

## 1-8 SHIPPING DAMAGE

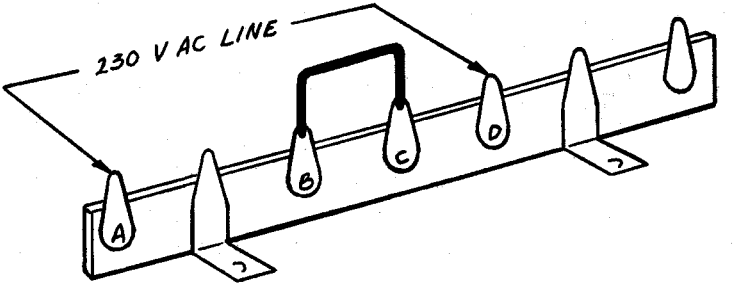
After unpacking the instrument, turn it on and self-check it as described in the operating instructions. Should any shipping damage be discovered, follow the procedure described in the "Claim for Damage" section on the last page of this manual.

## 1-9 DIGITAL RECORDER KIT

The Model 521A and 521C Industrial Counters can be adapted for use with the Model 560A Digital Recorder by adding the Digital Recorder Kit #521A-95A. The kit may be installed either at the factory or in the field. Details are given at the rear of Section V for a counter equipped with this modification kit. If no kit is installed, the information should be disregarded.

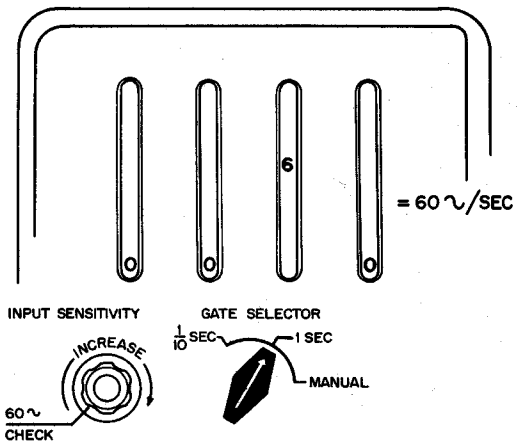



A. Connections for 115 V Operation

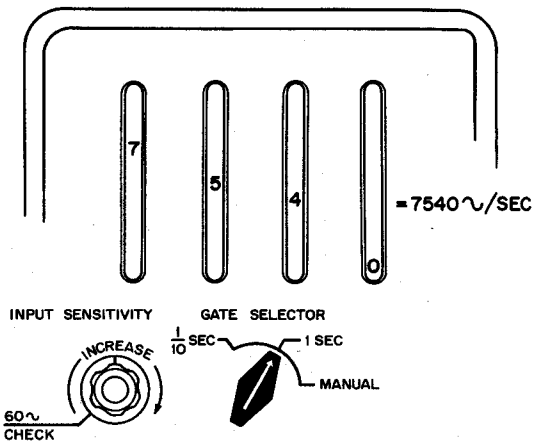



B. Connections for 230 V Operation

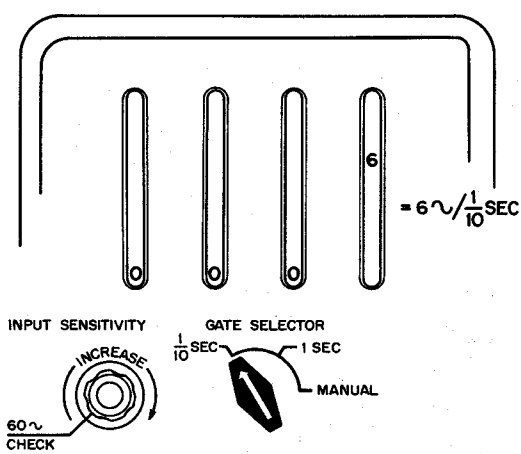
Fig. 2. Connecting the 521A for use on 115 volt or 230 volt a-c power lines.



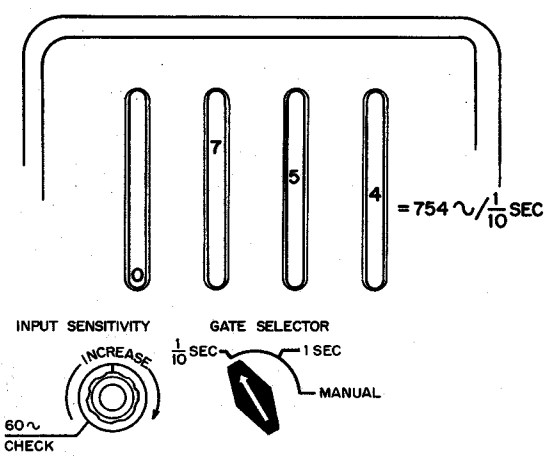

(A)




(C)




(B)




(D)

READING THE ANSWER DURING SELF CHECK WITH: (A) 1 SEC GATE TIME (B) $\frac{1}{10}$ SEC GATE TIME.

READING THE ANSWER TO TYPICAL FREQUENCY MEASUREMENT WITH: (C) 1 SEC GATE TIME (D) $\frac{1}{10}$ SEC GATE TIME.

Fig. 3. Reading the Displayed Answer from the Model 521A Electronic Counter

# SECTION II

# OPERATING INSTRUCTIONS

## 2-1 INTRODUCTION

This section gives instructions for reading the answer from the front panel and for making three basic types of measurements and describes the functions of the various front panel controls and terminals on the 521A Electronic Counter.

## 2-2 READING THE ANSWER FROM THE FRONT PANEL OF THE 521A

The answer to a measurement made with the 521A is automatically displayed in a number across the front panel by a lighted figure in each of the number columns (see Figure 3). The units' digit appears at the observer's right, the thousandths digit at the extreme left. The number displayed on the panel is the total number of events sensed by the instrument during the time the measurement was made.

When the GATE SELECTOR switch is in the 1 SEC position, the 521A counts the number of electrical events occurring during an accurate 1 second interval and all answers are displayed directly in cycles per second, revolutions per second, etc. When the GATE SELECTOR switch is in the 0.1 SEC position, the 521A counts the number of electrical events occurring during an accurate 0.1 second interval and all answers are indicated directly in cycles per .1 second. In both cases the answer will have four significant figures, however, if the total numberical count is greater than a four figure number, only the last four numbers of the figure will be shown in the displayed answer, for example; if counting a frequency of 14500 only the 4500 will be displayed.

Frequencies up to 9,999 cps are read directly from the displayed answer across the front panel to an accuracy of ±1 cycle with the GATE SELECTOR switch in the 1 SEC position. With the GATE SELECTOR switch in the 0.1 SEC position frequencies up to 99,999 cps are read directly to an accuracy of ±1 cycles, however, the units digit of the number is not included and must be assumed to be zero. Frequencies up to 99,999 cps can be read directly to five significant figures by first using the GATE SELECTOR switch on the 0.1 SEC GATE to read the first four significant figures of the number then switch to the 1 SEC position and read only the Units and Tens Digits. Replace the Units Digit in the 0.1 SEC answer with the Units and Tens Digits from the 1 SEC answer.

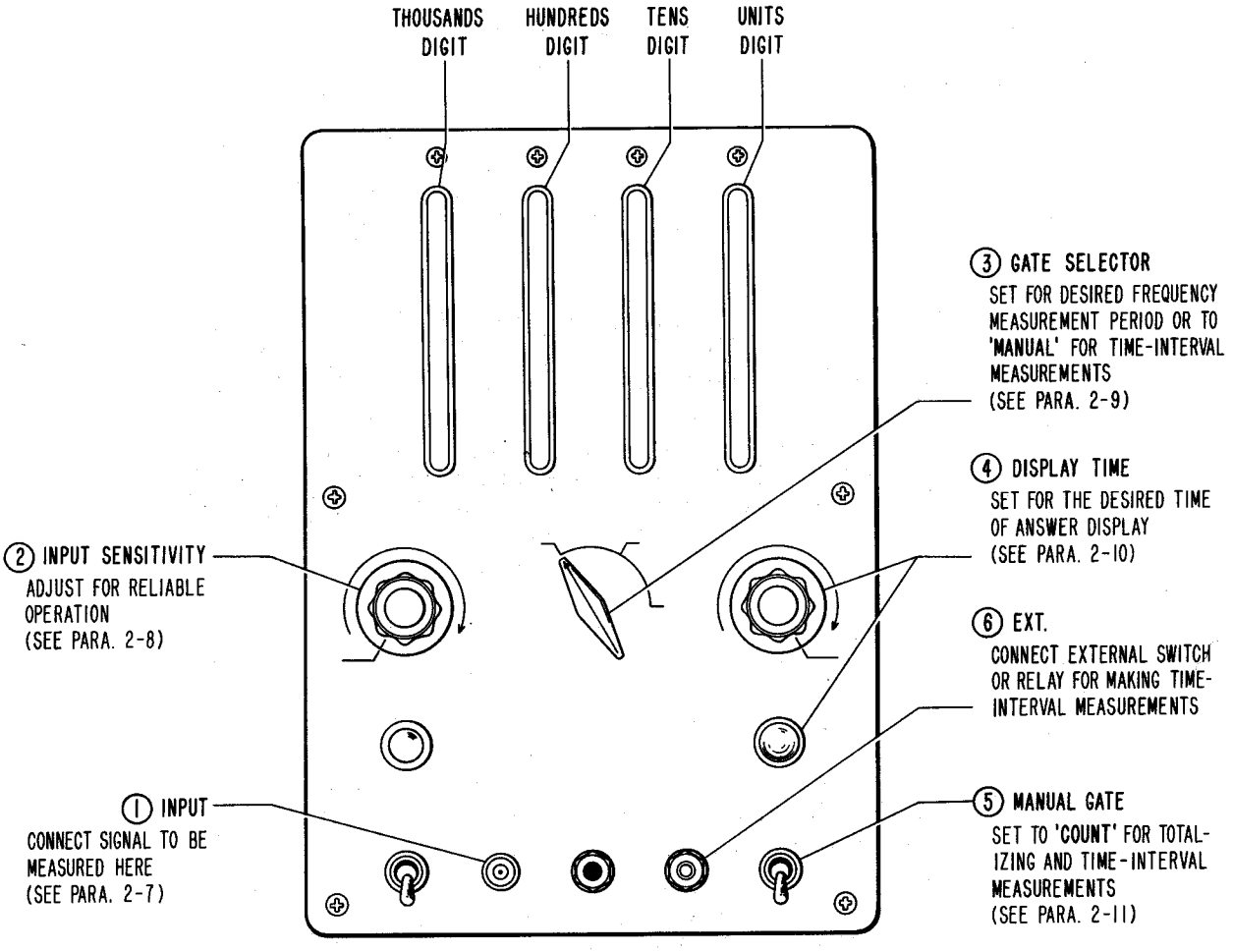



Fig. 4. Controls and Terminals

## 2-3 HOW TO SELF-CHECK THE MODEL 521A

The operator can, in one simple procedure, check the overall operation of the 521A Electronic Counter as follows:

a. Turn on the 521A and allow to warm up.

b. Set the INPUT SENSITIVITY control to CHECK, set the GATE SELECTOR switch to 1/10 SEC. and adjust the DISPLAY TIME control as desired.

c. The 521A should count and display the number 0006 for a 60∿ power line frequency.

d. Set the GATE SELECTOR switch to 1 SEC. The 521A should count and display 0060. For 50∿ power line frequency the displayed numbers will be 0005 and 0050 in steps d and e.

e. If the accessory Crystal Controlled Time Base plug-in unit is installed and the TIME BASE toggle switch is set to CRYSTAL, the displayed answer will be 1000 for the 1/10 SEC. gate and 0000 for the 1 SEC. gate times.

## 2-4 HOW TO MEASURE FREQUENCY

The 521A measures frequency by counting the number of cycles which occur within an accurately known period of time, .1 or 1 second, as determined by the GATE SELECTOR switch. When the period is over, the total is displayed in terms of cycles per 0.1 second or cycles per 1.0 second. To measure frequency proceed as follows:

a. Connect the frequency to be measured to the INPUT jack.

b. Turn the INPUT SENSITIVITY control completely clockwise.

c. Set the GATE SELECTOR switch for the desired counting interval (preferably the 1 SEC. position).

d. Adjust the DISPLAY TIME control for the length of answer display time desired.

e. Adjust the INPUT SENSITIVITY control to the lowest level that gives consistent counting (see paragraph 2-8).

f. The 521A will now count the input signal and display the frequencies in cycles per second or cycles per 1/10 second, depending on the GATE SELECTOR switch.

## 2-5 HOW TO MEASURE TIME INTERVAL

The 521A measures time interval by counting the number of cycles of an accurately known frequency that occur during a time interval determined by the operator or by external equipment. The time interval may be started and stopped either by means of the MANUAL GATE toggle switch on the front panel or by a remote switching device connected to the EXT. jack. The frequency which is counted during this time interval is either the power line frequency, 10 kilocycles supplied by the accessory Crystal Controlled Time Base when this unit is installed, or any externally generated frequency applied to the INPUT jack.

Externally generated frequencies may be used instead of the line frequency for time interval measurements if desired. Higher frequencies provide greater resolution and may sometimes be known to a greater degree of accuracy. An external timing frequency is applied to the INPUT jack and the INPUT SENSITIVITY control turned up as in frequency measurement.

Mechanical switching devices connected to the EXT. jack to start and stop a time interval measurement should have a low resistance such as a relay. The operating time of such a device determines the shortest time interval that can be measured accurately. If the operating time of the mechanical device varies, the accuracy of the short time interval measurements will be affected adversely. If the operating time for starting and stopping are exactly the same, the accuracy of short time interval measurements will be improved. To measure time interval, proceed as follows:

a. If the line frequency is to be used for counting, or if the 10 kc output from the accessory Crystal Controlled Time Base plug-in unit is used, turn the INPUT SENSITIVITY control to the CHECK position.

b. If an externally generated signal is to be used for counting connect this signal to the INPUT jack and turn the INPUT SENSITIVITY control to maximum. Read this frequency exactly.

c. Turn the GATE SELECTOR switch to MANUAL.

d. Set the MANUAL GATE toggle switch to the down position.

e. The 521A is now ready to measure a time interval. Counting will begin when the external switching device closes the circuit or when the MANUAL GATE toggle switch is set to the COUNT position. Counting will stop when the external device opens the circuit, or when the MANUAL GATE toggle switch is returned to the down position. The displayed answer is the number of cycles of the line or 10 KC (or externally applied signal) frequency that was counted during the time interval.

f. To convert the displayed answer to seconds, multiply the displayed number by the period (1/f) of the frequency counted.

## 2-6 HOW TO MEASURE TOTAL NUMBER OF EVENTS

The 521A can be used to totalize any periodic or random electrical events that fall within the input signal specifications given in paragraph 2-7. To totalize electrical events proceed as follows:

a. Connect the signal to be totalized to the INPUT jack.

b. Adjust the INPUT SENSITIVITY control as described in paragraph 2-8.

c. Set the GATE SELECTOR switch to MANUAL.

d. Start the count by setting the MANUAL GATE switch in the COUNT position. End the count by returning the MANUAL GATE switch to the down position.

e. The displayed answer is the total number of events sensed by the 521A during the time the MANUAL GATE switch was in the COUNT position.

## 2-7 INPUT SIGNAL REQUIREMENTS

The INPUT connector on the front panel of the Model 521A receives the signal to be counted. This signal must be at least 0.2 volt rms in amplitude and not greater than 200 volts rms. The input wave should have a rise time of .2 volt per second or faster and should have a repetition rate not greater than 120,000 cycles per second. Two pulses separated by less than 8.3 microseconds will be recorded as a single pulse. To prevent counting unwanted signals, the input signal should have a good signal to noise ratio.

## 2-8 SENSITIVITY CONTROL

The INPUT SENSITIVITY control permits the amplitude of the signal received at the INPUT or PHOTOTUBE INPUT jacks to be adjusted to an optimum operating level for the 521A. The optimum signal voltage for any given application is a little higher than the lowest voltage that will produce a satisfactory count. If the signal level is increased much beyond this point, there is the possibility of erroneous counts if there is random noise in the input signal. If the signal voltage is free of noise, the sensitivity may be increased with safety. To make this adjustment, set the INPUT SENSITIVITY control counterclockwise until the 521A will no longer count the input signal. Increase the INPUT SENSITIVITY control until counting starts. Set the control slightly beyond this point.

If difficulty is encountered with noise (erratic counting), the input signal voltage should be examined with an oscilloscope to disclose the nature of unwanted signals that are large enough to operate the 521A. Signals generated by electro-mechanical devices in particular should be examined for effects of contact bounce or vibration.

The extreme counterclockwise position of the INPUT SENSITIVITY control (CHECK) is used to self-check the 521A and for measuring time intervals. These two functions are described under paragraphs 2-3 and 2-5. No sensitivity adjustment is required for these operations.

## 2-9 GATE SELECTOR SWITCH

This switch selects one of two time periods for counting the input signal frequency. In the 1/10 SEC. and 1 SEC. positions of the GATE SELECTOR the time is determined in the instrument to be either 0.1 second or one second, as selected. When the GATE SELECTOR switch is in the MANUAL position, the gate is opened and closed by either the MANUAL GATE switch or by a switch connected to the MANUAL GATE-EXT. jack.

For all types of operation the GATE indicator lamp on the front panel always lights, i.e., as long as the 521A is counting.

## 2-10 DISPLAY TIME CONTROL

This control determines the length of time an answer is displayed. When the GATE SELECTOR is set 1/10 SEC. the display interval is adjustable from 1/10 second to 15 seconds by means of the

DISPLAY TIME control. When the GATE SELECTOR is set to the 1 SEC. position, the display is variable from 1 to 15 seconds. If longer than 15 seconds display is required, set the DISPLAY TIME control to INF and the display will remain until the RESET button is pressed. Pressing the RESET button will return the counters to zero and releasing the RESET button will start a new count of the input signal. The DISPLAY TIME control is disconnected when the GATE SELECTOR switch is set to MANUAL.

## 2-11 MANUAL GATE

When the GATE SELECTOR is set to MANUAL, a count is started and stopped either by the MANUAL GATE switch or by an external switching device plugged into the EXT. jack. When the MANUAL GATE switch is in the COUNT position, the 521A will count an input signal continuously. When the switch is turned to the down position counting is stopped and the total count will be displayed. When an external switching device is plugged into the EXT. jack, the MANUAL GATE switch is made inoperative and the external switch will start and stop the count. The remote switching device may be any on-off switch connected to open and short the terminals of the phone jack; counting will occur only while the terminals are shorted.

## 2-12 TIME BASE SELECTOR

A TIME BASE SELECTOR switch, located behind the front panel on the chassis, selects either the line frequency or external time base, or the crystal controlled time base when this accessory plug-in unit is used. When the TIME BASE SELECTOR switch is in the LINE or EXT. position, connecting an external time base to the EXTERNAL STANDARD input jack on the rear of the Model 521A automatically disconnects the power line frequency as a timing signal and uses the external signal applied.

## 2-13 EXTERNAL TIME BASE

The Model 521A normally employs the power line frequency as a time standard (nominal frequency error of approximately ±0.1%). When greater accuracy is required an externally generated standard frequency of 10, 20, 30, 40, 50, 60, 70, 80, 90 or 100 cps and between 5 and 50 volts rms, may be applied to the EXTERNAL STANDARD jack on the rear of the instrument chassis. The accuracy of this signal then determines the accuracy of the Time Base in the 521A.

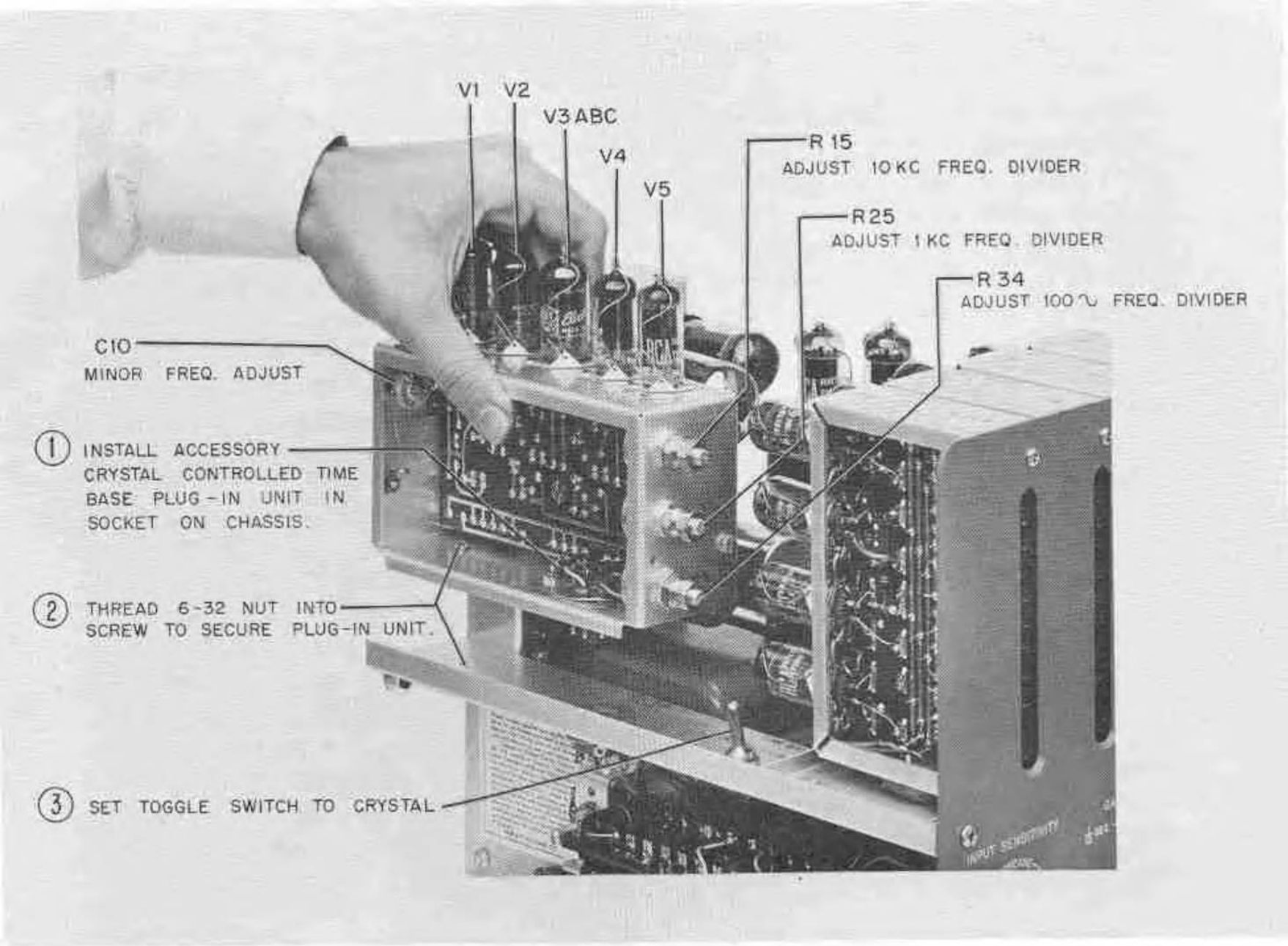



Fig. 5. Installing the accessory Crystal Controlled Time Base plug-in unit

The EXTERNAL STANDARD jack is a three circuit type. The external timing signal is introduced between the tip and body of the plug. The "ring" connection on the plug is a standard frequency output terminal which provides a very accurate 100 cycle signal when the accessory Crystal Controlled Time Base plug-in unit is installed. When the Crystal Controlled Time Base is installed in the 521A measurement accuracy of better than ±0.01% is possible. The "ring" connection on the EXTERNAL STANDARD jack may be used as the standard signal source to drive a number of other 521A Electronic counters that may be used near by.

## 2-14 PHOTOCELL INPUT

The PHOTOTUBE INPUT on the rear of the instrument is a three circuit phone jack designed to simultaneously supply bias to and to receive a signal from a phototube such as the 1P41. The PHOTOTUBE INPUT jack is connected in parallel with and has the same input signal requirements as the INPUT jack. To adjust the phototube system for optimum performance, connect a vacuum tube voltmeter to the INPUT jack and adjust the optical system for the highest signal reading on the voltmeter.

## 2-15 CRYSTAL CONTROLLED TIME BASE ACCESSORY PLUG-IN UNIT

The Crystal Controlled Time Base plug-in unit is an accessory which can be conveniently plugged into a socket inside the 521A Electronic Counter to increase the accuracy of frequency measurement to better than 0.01%. The use of the Crystal Controlled Time Base is desirable in areas where the power line frequency is not closely regulated, or whenever an assurance of higher accuracy is required.

The Crystal Controlled Time Base is installed by removing the 521A cabinet and plugging the unit into the socket as shown in Figure 5. Secure the retaining nut and set the toggle switch on the Time Base Section to CRYSTAL. All connections are automatically made and the unit is ready for operation. The adjustments on the Crystal Controlled Time Base have been set at the factory and require no further adjustment upon installation. Instructions for making the adjustments when servicing on the plug-in unit are given in Section V.

# SECTION III

# APPLICATIONS AND ACCESSORY-TRANSDUCERS

## 3-1 GENERAL

The Model 521A has a wide range of applications and when coupled with proper transducers can perform many specific industrial measurements heretofore possible only with much more elaborate equipment. A single Model 521A may be employed to monitor many transducers of various type which may be remotely located. For example: Shaft speeds at a number of different locations throughout a plant or system may be accurately measured from one central point employing one 521A Counter. The installation requires only that the proper transducers be attached to each shaft to be measured and that the transducers be wired to a selector switch connected to a Model 521A. The speed of any shaft in the system may be measured in turn as selected by the switch. About 30 seconds is required to make such a measurement. When making the original hook-up, use cables which do not attenuate the signals below the input requirements of the 521A. Check also for stray electric or magnetic fields that can induce noise in the input cables. Low capacity coaxial cables are recommended. The selector switch should also be shielded to prevent pickup from electric fields.

## 3-2 RPM MEASUREMENTS WITH TACHOMETER GENERATORS

The Model 521A measures RPM and RPS by counting an electrical frequency that is proportional to the speed of a rotating shaft. Generation of this frequency may be accomplished by several types of transducers which allow considerable latitude in measurement technique.

A simple and direct way to measure RPM is through the use of a tachometer generator that produces a frequency that is proportional to the speed of its own shaft. The hp Models 508A and 508B are examples of this type transducer, and are recommended for use with the 521A Electronic Counter. Both are of the variable reluctance type and have no brushes or slip rings to cause noise or random irregularities that result in inaccurate readings. Other types of generators may be used if they have an output frequency proportional to their shaft speeds and are free of electrical noise and transients. To assure accurate counts, the use of an oscilloscope to check the signal from other types of tachometer generators is recommended.

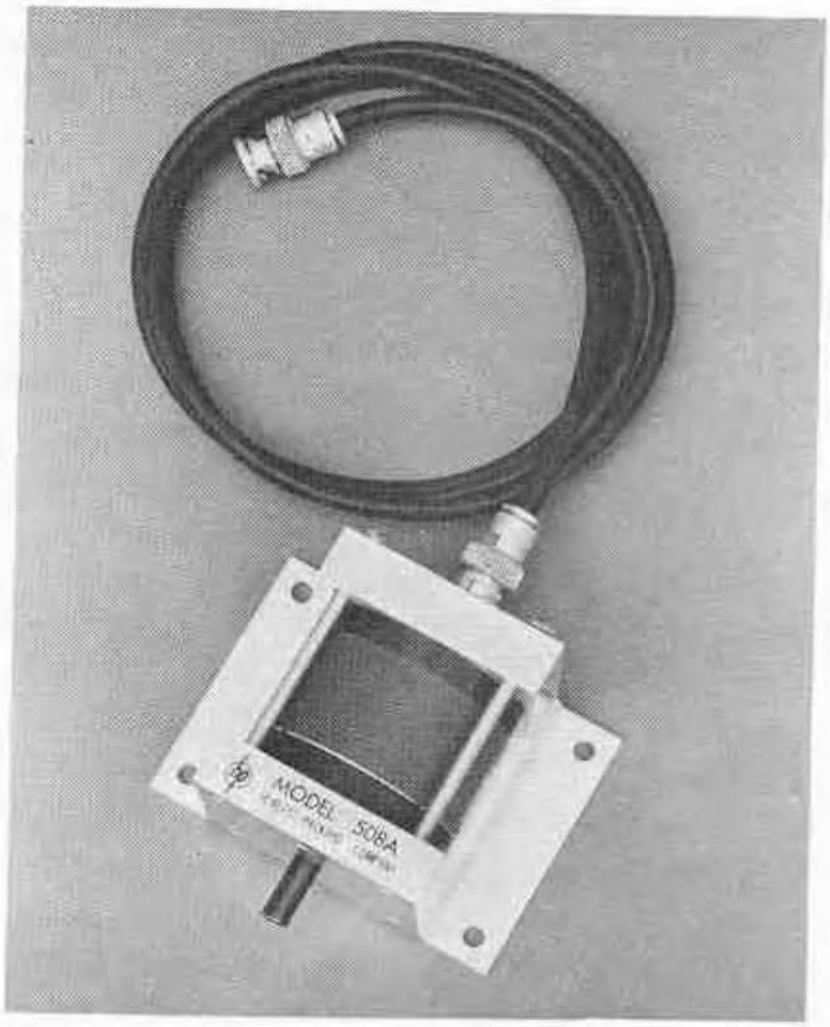



Fig. 6. ℌ Model 508A, B, C Tachometer Generators

## 3-3 ACCESSORY TACHOMETER GENERATORS ℌ MODELS 508A, B, C

The ℌ Models 508A, 508B and 508C are compact low-torque tachometer generators. The Model 508A produces 60∿ for each revolution of its drive shaft, Model 508B produces 100∿, and the 508C produces 120∿. When using the 508A, the 521A Counter indicates shaft speed directly in RPM. When using the 508B, the displayed answer is divided by 100 to obtain RPS.

The useful shaft speed range for Model 508A Tachometer Generator is from approximately 15 RPM to 40,000 RPM. Consequently, this tachometer generator is entirely suitable for all shaft speeds normally encountered. The output voltage from these transducers increases almost linearly from 15 RPM and 5000 RPM from a minimum of about 0.1 volt RMS to a maximum of almost 10 volts. At shaft speeds above 5000 RPM, the output voltage decreases gradually to a value of about 1 volt at 40,000 RPM. The linear relationship between output voltage and shaft RPM to about 5000 RPM provides a very useful auxiliary function for the tachometer generator. The speed-voltage relationship makes it possible to present on an oscilloscope screen a curve describing the instantaneous rate of rotation of a shaft as a function of time. This allows analysis of the instantaneous effect on rotating equipment from the action of clutches, brakes, or other mechanical components.

For this application, connect the output of the tachometer generator to the vertical deflection plates of an oscilloscope, while the horizontal deflection is controlled by the internal time base in the 521A Counter, or by some other appropriate means. Since the data presented on the oscilloscope screen is usually non-repetitive in nature, a photographic record is normally made. Torsional vibration, harmonic-ringing and the action of intermittent motions are shown as a function of time by variations in the height of the oscilloscope trace.

## 3-4 RPM MEASUREMENTS USING ACCESSORY PHOTOELECTRIC PICKUPS

Photoelectric tachometry pickups have three particular advantages: they are effective over a wide range of speeds; they are easily adaptable to a wide range of situations; they do not load a system under measurement. The Model 521A is designed for use with photoelectric transducers and a special connector (PHOTOCELL INPUT) located on the rear of the instrument supplies the necessary bias voltage to a photocell of type 1P41 or equal. This jack serves also as the signal input jack for this application.

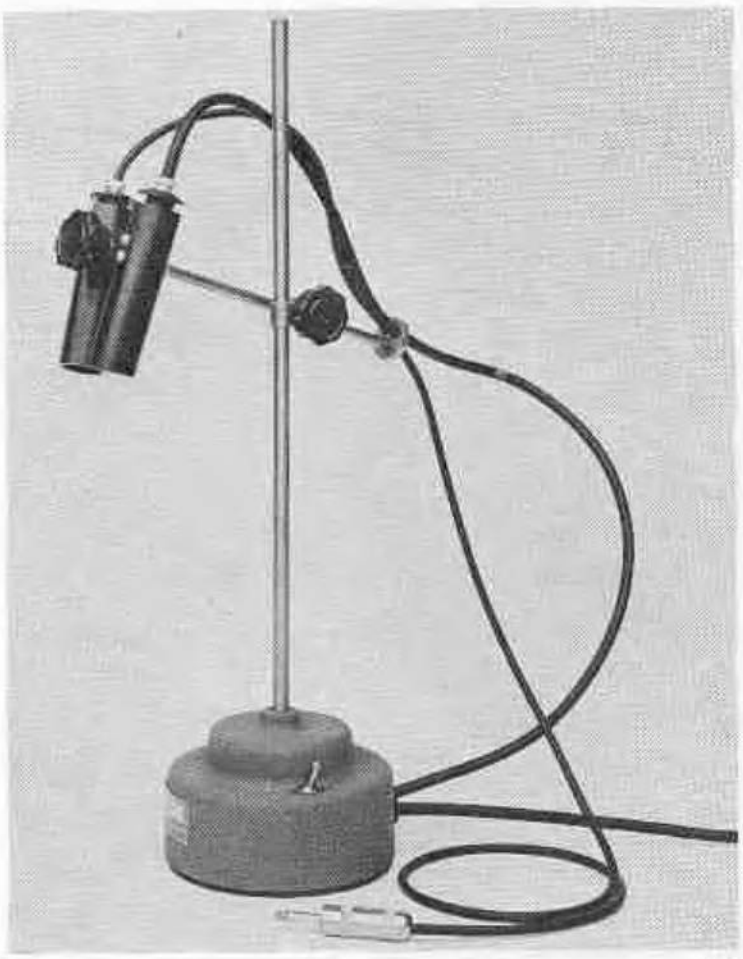


Fig. 7. Model 506A Optical Tachometer Pickup

## 3-5 PHOTOTUBE OPTICAL TACHOMETER PICKUP -hp- MODEL 506A

The Model 506A Tachometer provides for counting speeds or revolutions over a wide range from about 300 RPM (5 RPS) to 300,000 RPM (5,000 RPS). The light source in the Model 506A Tachometer Pickup illuminates a moving part which is prepared with alternate reflecting and absorbing surfaces. The interrupted reflected light is picked up by the phototube and the electrical impulses generated are transmitted to the 521A Electronic Counter. This system is positive in action and the danger of fractional or multiple errors inherent in other measuring methods is eliminated.

For best results, the size of the reflecting and absorbing surfaces should be approximately 3/4" square. This means that the shaft whose speed is to be measured should have a diameter of at least 1/2". The speeds of smaller diameter shafts may be measured by installing a sleeve of larger diameter, or by providing a rotating, reflecting, and absorbing surface at right angles to the plane of the shaft. Surfaces such as these are also used for increasing resolution in measurement of low RPM where the multiple absorbing and reflecting surfaces provide a large number of impulses per revolution. When this is done, a division factor is applied to the reading obtained on the Model 521A.

The ⓗ Model 506A consists of a pair of shielded tubes, one of which contains an incandescent light source, while the other houses a Type 1P41 Phototube. These are equipped with condensing lenses and are so oriented that proper focus is obtained at a distance between 3 and 6 inches from the reflecting surface. The light source and phototube assembly is mounted on an adjustable stand for optimum positioning of both light source and phototube. The base of this stand contains a transformer which provides the proper voltage for operating the incandescent lamp. The phototube requires a bias voltage from +70 to +90 volts. This voltage is automatically supplied by the PHOTOTUBE INPUT jack on the back of the ⓗ Model 521A.

## 3-6 RPM MEASUREMENT USING A MAGNETIC PICKUP

Model 521A may be used to count the electrical pulses generated by a magnetic pickup device activated by a gear or keyway or magnetic material (steel) that is affixed to a rotating shaft. Magnetic pickups of this type consist of a permanent magnet core around which is wound a coil of wire. Magnetic material passing near the pickup causes an alternating electrical voltage to be induced in the coil. The frequency of this voltage, which is proportional to the RPM, can be measured by the Model 521A. To obtain R PS, a division factor is applied to the displayed count. Transducers of this type are normally small in dimension and adequately sensitive, especially at high speeds and are useful in circumstances that do not lend themselves to the use of tachometer generators or photo-electric pickups.

## 3-7 PRESSURE MEASUREMENT

Pressure, or any other variable which can be made to change the tension on a specially mounted wire, can be measured by using Model 521A in conjunction with the Byron Jackson Vibrotron. The Vibrotron is fundamentally a fine wire under tension vibrating at its natural frequency. One end of the wire is attached to a pressure diaphragm. Motion of the diaphragm, caused by a pressure change, changes the natural frequency of the wire to a new value corresponding to the new pressure. The total motion of the diaphragm is limited to a few ten-thousandths of an inch. Small permanent magnets provide a magnetic field in which the wire vibrates, causing an a-c voltage of the wire frequency to be generated across the wire. This voltage is amplified by an amplifier and a portion of the voltage is returned to the wire to maintain continuous vibration. The Vibrotron is manufactured by the Byron Jackson Company, Los Angeles, California.

The output frequency of the Vibrotron, which is proportional to the pressure being measured, can be counted by the Model 521A and the displayed count is adjusted by a suitable calibration factor for the system. Power to drive the Vibrotron circuits can be taken from the accessory socket on the 521A chassis.

## 3-8 FLOW MEASUREMENTS

Accurate measurement of either total flow or rate of flow of fluids is greatly simplified by the use of an "in the line" transducer that generates an electrical frequency which is proportional to the rate of flow. To measure total flow, the Model 521A is used as a totalizer (see paragraph 2-6) and counts the total number of cycles generated by a suitable transducer. To measure rate of flow, the Model 521A measures the frequency of the alternating voltage generated by the transducer. In either case the number displayed on the Model 521A must be modified by a calibration factor suitable for the system. A transducer for flow measurements is manufactured by the Potter Aeronautical Corp. and is available in a number of different sizes and materials. It consists of a housing containing a turbine-type rotor. Within the body of the rotor is a small permanent magnet. Rotation of the magnet sets up an alternating current in a coil of wire mounted on the housing within the field of the magnet. The transducer housing is so designed that it may be inserted directly into the pipe in which flow is to be measured.

## 3-9 ENGINE EFFICIENCY MEASUREMENT

When coupled with a tachometer pickup and a fuel metering device, the Model 521A measures engine efficiency by determining the number of RPM produced by a known quantity of fuel. In this system, the fuel metering device is connected to operate the external gate of the 521A and holds this gate open during the time that a known amount of fuel is consumed by the engine. While the gate is held open, the Model 521A counts the output of the tachometer generator to determine the number of revolutions produced by the predetermined amount of fuel. The resultant ratio (revolutions per unit fuel) is used in calculating the engine efficiency.

# SECTION IV

# PRINCIPLES OF OPERATION

## 4-1 GENERAL

The Model 521A Electronic Counter consists of the basic circuits shown in the block diagram in Figure 8. The block diagram shows the major circuits as they are used for frequency measurement. The purpose of each major circuit is discussed below.

a. The signal applied to the INPUT jack is fed through the INPUT SENSITIVITY control to the Amplitude Discriminator. The essential part of the input signal, the frequency, goes through the amplitude discriminator unchanged; however, the output wave from the discriminator is a constant-amplitude high-speed pulse which is required for accurate, consistent operation of the counters.

b. The signal to be counted passes through a "gate tube", V9, to the counters. The Signal Gate acts as a valve to the input signal; it either passes the input signal on to the counters or it blocks their path completely.

c. The counters consist of four identical plug-in decade counters. The output of each counter is fed to the next counter, the units counter first, tens counter second, etc. Following an applied signal, each counter will display one number in its column, the number of the cycle at which the count was stopped. To return the count to zero, a separate signal is applied to the counter's reset circuit either automatically or by the RESET push button.

d. The Time Base Section generates the accurately controlled signals which open and close the Signal Gate, V9, during frequency measurement. It provides two lengths of signals, 0.1 second and 1.0 second. Both time intervals are obtained either from the power line frequency or by an external signal applied by the operator.

e. The Time Base Gate V10A prevents timing signals from the Time Base from operating the gate control circuits while an answer is being displayed on the counters. When the display time is over, the gate is opened and the timing signals from the Time Base again operate the gate control circuits.

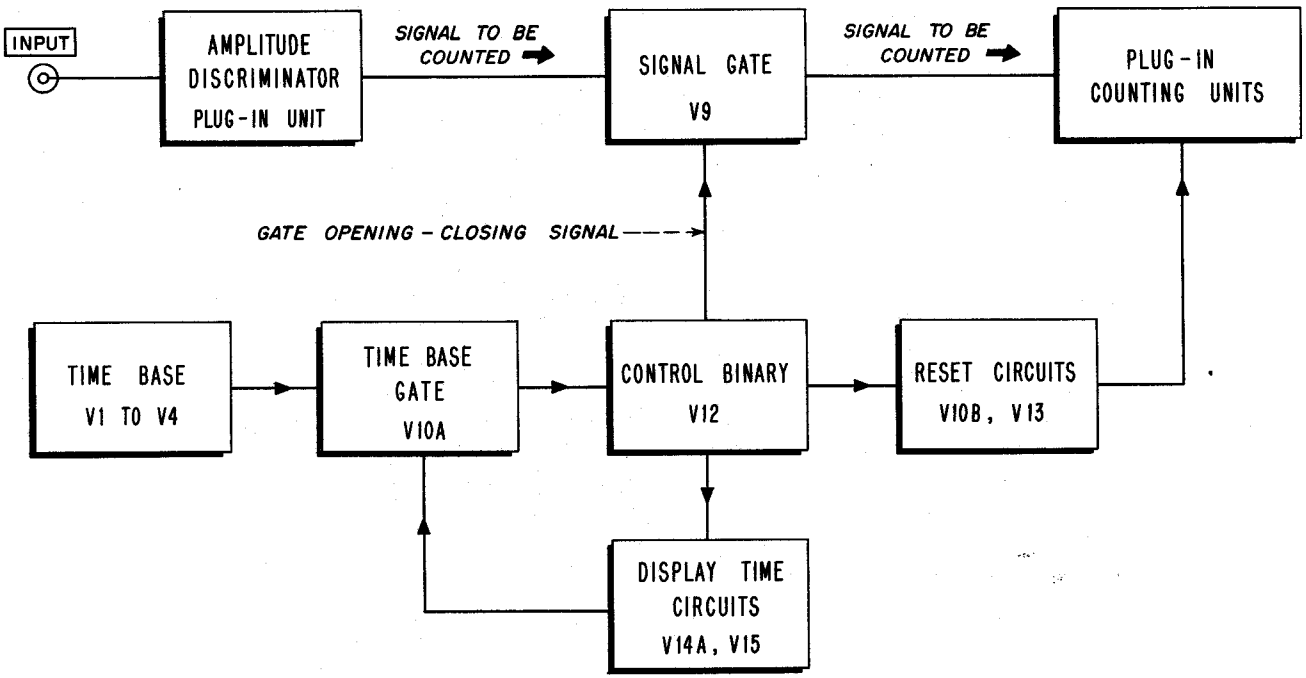



Fig. 8. Simplified Block Diagram of the 521A Electronic Counter

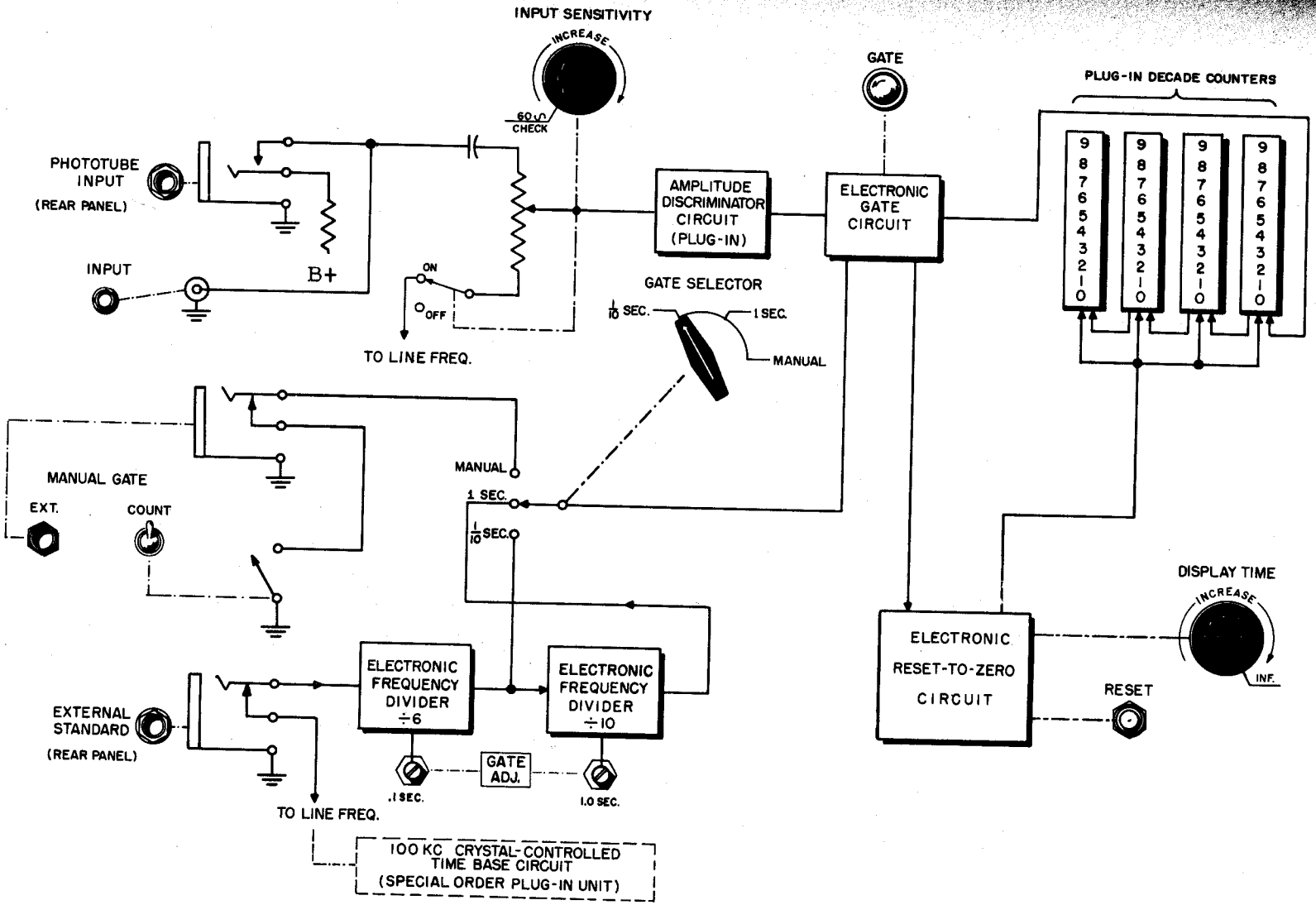



Fig. 9. Operational Block Diagram of the 521A Electronic Counter

f. The Control Binary, V12, generates the signal that opens and closes the Signal Gate. When the Control Binary receives the start signal it applies a positive voltage to the Signal Gate to open it. The positive voltage remains until the Control Binary receives the stop signal, at which time it applies a negative voltage to the Signal Gate and closes it.

g. The Display Time Circuits determine the length of time an answer will be displayed on the counters. This is done by preventing passage of subsequent Time Base signals for a period of time set by the DISPLAY TIME control. So long as Time Base signals are blocked, the counters will continue to display the last count they received.

h. The Reset Circuits automatically apply a signal to each counter unit to bring its count back to 0 just before a new count is to be started.

## 4-2 OPERATION

Assume that the 521A is ready to start a new count; the first timing signal from the time base passes through the open Time Base Gate and triggers the one-shot Delay Multivibrator and produces a positive output pulse about 45 microseconds wide. This pulse is differentiated to form a positive pulse followed in 45 microseconds by a negative pulse. The positive pulse passes through the open Reset Gate and triggers the Reset Thyratron resetting the decade counters to zero. Forty-five microseconds later, time for reset transients to die down, the negative pulse triggers the Control Binary. Triggering of the Control Binary opens the Signal Gate, lights the neon gate lamp and closes the Reset Gate. The count is started.

The next timing signal from the Time-Base passes through the Time Base Gate and again fires the one-shot multivibrator. The positive portion of the differentiated multivibrator pulse passes through the open Reset Gate and is lost. The negative position of the pulse triggers the Gate Binary which closes the Signal Gate to end the count and extinguishes the neon gate lamp. The negative pulse also opens the Reset Gate and triggers the Display Time Phantastron. Triggering the display time phantastron closes the Time Base Gate and blocks the passage of the timing signals until the display time is finished. At the end of the display time, the Time Base Gate is opened and the system is ready to repeat the operation. The individual circuit groups are discussed in the following paragraphs.

## 4-3 AMPLITUDE DISCRIMINATOR (Plug-In Unit)

The Amplitude Discriminator Unit consists of a differential amplifier followed by a bistable multivibrator. This unit is used as a wave shaper to provide fast, constant amplitude pulses to operate the decade counters. A positive going input signal is amplified and triggers the bistable multivibrator causing it to flip to its other stable state. When the input wave returns toward negative it again triggers the multivibrator and causes it to flop back to its original state. Only positive pulses from the multivibrator will affect the counter units; the negative pulses represent the return to an original state and cause no further circuit action.

The bistable multivibrator is designed to flip when the input signal waveform passes +.2 volt going in a positive direction, and will flop when the voltage passes approximately +.2 volt going in a negative direction. It will again flip when the +.2 volt point on the following cycle appears. Thus a strong positive pulse is sent to the counters each time the input waveform rises past the +.2 volt level, or higher, as set by the INPUT SENSITIVITY control.

## 4-4 SIGNAL GATE

The Signal Gate, V9, is a type 5915 tube which is specially designed and constructed for gating purposes. The suppressor grid is rather closely wound and is used as a second control grid. By lowering the suppressor grid voltage, plate current is cut off. When this grid is driven beyond cut-off, any signal impressed on the main control grid, pin 1, does not appear in the plate circuit and the gate is closed. When the voltage on the suppressor grid approaches zero, with respect to cathode, the tube functions as an ordinary amplifier, the control grid signal appears in the plate circuit and the gate is open.

## 4-5 CONTROL BINARY

The Gate Binary, V12, opens and closes the Signal Gate by raising and lowering the potential on the suppressor grid, V9, through cathode follower V14B. In addition, the Gate Binary starts the counter reset signal and the display time. The binary is a bistable multivibrator designed to be triggered by negative pulses. One half of the twin triode is cut off while the other is conducting. The half employing pins 6, 7, and 8 is cut off during the display time and conducts during the time that the Signal Gate is open. The Signal Gate is controlled by the rise and fall of potential at the plate (pin 1) of V12. When the voltage at the plate (pin 1) of the control binary is low (conducting) the grid, (pin 7) of the Signal

Gate tube is negative with respect to its cathode. This closes the Signal Gate and the input signals cannot pass through the Signal Gate to the counters. The electrical signal that causes the Gate Binary to switch from one stable state to the other is supplied from either the manual gate circuits or by the 45 μsec Delay Multivibrator.

## 4-6 DELAY MULTIVIBRATOR AND TIME BASE GATE

In order to allow time for the Reset Circuits to reset the counters, the triggering of the Gate Binary is delayed some 45 microseconds with respect to the timing signals from the time base. This delay is provided by the Delay Multivibrator which is a non-stable multivibrator with a free-running time of approximately 45 microseconds. The circuit operates in the following manner:

To start a count a signal from the Time Base passes through the open Time Base Gate, V10A, and triggers the Delay Multivibrator, V11, causing a 150V positive pulse of approximately 45 microseconds width at the plate (pin 6) of V11. Differentiation of this pulse (C209 and C210) provides a sharp, positive pulse followed in 45 microseconds by a sharp, negative pulse. The positive pulse has no effect on the Control Binary but does fire the Reset Thyratron, resetting the decade counters to zero. The negative pulse has no effect on the Reset Thyratron but triggers the Control Binary which opens the Signal Gate and starts the count. This delay allows time for all transients due to the reset operation to completely die down. The next timing signal from the Time Base passes through the open Time Base Gate and triggers the Delay Multivibrator causing the Control Binary to retrigger. This change of state of the Control Binary closes the Signal Gate, ends the count, and triggers the Display Time Phantastron and closes the Time Base Gate. The action of the Reset Gate prevents the firing of the Reset Thyratron at this time.

## 4-7 RESET CIRCUIT

Just before each new count is begun the decade counter units are reset to zero by a positive pulse from the cathode of the Reset Thyratron, V13. V13 is fired by the positive portion of the Delay Multivibrator pulse. To prevent firing the Reset Thyratron and resetting the counter at the end of the counting period, Reset Gate V10B is connected to the grid of V13 to cut off the positive triggering pulse that occurs at this time. The cathode of the reset gate is connected to the plate (pin 6) of the Control Binary V12. During the counting period, the plate (pin 6) of V12 is at a low potential and the resulting bias on the cathode of V10B allows

it to absorb the positive thyratron triggering pulse.

The decade counters may be reset at any time, except while the instrument is counting, by pressing the RESET button on the front panel. When the RESET button is pressed, C213 and C218 discharge through R236, and apply a positive voltage to the grid of the reset thyratron. Due to the action of the Reset Gate just described, the positive voltage resulting from pressing the RESET button can trigger the reset thyratron only during the display time.

## 4-8 DISPLAY TIME CIRCUITS

These circuits control the length of time that a count is displayed by holding the Time Base Gate closed for a length of time selected by the operator. The action of the group is initiated at the time that the Control Binary closes the Signal Gate. The operation may be automatic, in that at the end of the display time a new count automatically is started, or the operation may be manual with the display time continuing until the operator presses the RESET button. The Display Time circuits are disconnected by the GATE SELECTOR when in the MANUAL position.

The automatic display time may be as long as 15 seconds but not less than the gate time employed, 1/10 second for 1/10 SEC. gate and one second for the 1 SEC. gate. The circuit employs a regular phantastron, V15, in which the swing of the plate potential is limited by the variable control of V14A.

In its quiescent state, the plate of Display Time Phantastron is cut off and the screen conducts. The suppressor, (pin 7), is connected to the plate, (pin 6), of the Control Binary through C217 and R256. At the end of the counting period the potential at the plate of V12 rises. This rise, differentiated by C217, triggers the Display Time Phantastron, causing the plate voltage of V15 and the cathode voltage of V14 to drop at a rate determined by the r-c time constant of C216 and R252.

The potential continues to drop until V14A conducts and causes the phantastron to return to its quiescent state. The DISPLAY TIME control R247 adjusts the grid voltage of V14A which determines the point on the phantastron plate voltage curve where V14A conducts, and in this manner selects the length of the display time.

The screen grid of V15 is connected through R244 and R245 to the cathode of the Time Base Gate, V10A. During the time that the Display Time Phantastron is in its quiescent state, the screen grid voltage is low and no blocking bias is applied to the Time

Base Gate. At the end of the counting period, the Control Binary closes the Signal Gate and triggers the Display Time Phantastron to begin the display time. Triggering the Display Time Phantastron drops the plate voltage as described, causing the screen grid voltage to rise sharply. The increased potential of the screen, applied to the Time Base Gate forms sufficient back bias to block the timing signals from the Time Base and prevent them from triggering the delay multivibrator until the delay time is over.

When the DISPLAY TIME control is set to the INF position the automatic operation is discontinued and the display is held until the RESET button is pressed. In this position switch S203 is closed, thus preventing V15 from operating as a phantastron. The tube operates as a bistable multivibrator to apply back bias to the Time Base Gate during the display time and to remove it when the RESET button is pressed. Pressing the RESET button resets the counters to zero and places a negative charge on C218. Releasing the RESET button applies a negative voltage to the grid of V15 and retriggers the tube. This action removes the back bias from the Time Base Gate and the instrument is ready to start a new count.

## 4-9 TIME BASE SECTION

The Time Base of the Model 521A is composed of four tubes and their related circuitry. V1 is a Schmitt Trigger circuit that serves to sharpen incoming timing signals so they accurately drive the first phantastron frequency divider. V2, a dual diode, serves as coupling diode for V3 and V4. V3 and V4 are identical phantastron frequency divider circuits differing only in their operating time constant. The repetition rates are, 1/10 of a second for the first phantastron and one second for the second phantastron. The output of both phantastrons is connected to the GATE SELECTOR switch, S102A, which connects the output of the first phantastron when a 1/10 SEC. gate time is selected, the output of the second phantastron when a 1 SEC. gate time is selected, and disconnects both phantastrons when the MANUAL GATE is used and the timing signals are not required.

## 4-10 DECADE COUNTER UNITS

Operation and servicing of the decade counter units is discussed in the instruction manual for the Model AC-4A, which is attached to this booklet.

## 4-11 THE PHANTASTRON FREQUENCY DIVIDER

Two phantastron frequency dividers are used in the Time Base Section of the 521A to obtain 10 cycle and 1 cycle per second output frequencies from the 60 cycle line frequency. The first divider divides by six, the second one by 10. There are also three phantastron frequency dividers in the Crystal Controlled Time Base accessory plug-in unit, each dividing by 10. All of the phantastron circuits are alike, except for component values, to obtain appropriate time constants at the different working frequencies. The action of a typical 10:1 phantastron circuit is explained in the following paragraphs.

Each complete divider consists of a coupling diode which acts as a gate to the incoming signal and a type 5915 pentagrid amplifier acting as a one shot multivibrator. The operating time of the multivibrator is adjusted to be almost equal to the "period" of the desired output frequency. The gate, upon receiving a pulse of the incoming signal, passes the signal and starts the multivibrator in its one cycle of operation. During the cycle of operation the diode gate is biased so that it blocks the incoming signal for this period of time. When the multivibrator has completed its cycle of operation the gate will again be opened to receive another pulse of the incoming signal, and so on.

The cycle of operation of the multivibrator is timed by the coupling capacitor, series resistor, and voltage applied, to last just one period of the desired output frequency. It will thus divide any multiple of the desired frequency down to the desired frequency. During its cycle of operation the plate of the 5915 swings in a negative direction and closes the diode gate. After the cycle of operation, the plate voltage returns approximately to the supply voltage, thus opening the diode gate to incoming negative pulses of high enough amplitude to overcome the bias normally on the diode.

In the case of the 10:1 frequency divider every time the tenth cycle of the input frequency comes along the multivibrator produces one large pulse. If the frequency of the input signal is changed, the time constant of the multivibrator must also be changed so that its cycle of operation is made to last only as long as nine cycles of the new input frequency, or, if the phantastron is to divide by another number, such as 6, the time constant of the multivibrator need only be adjusted to last for five cycles of the input frequency. The divider will then produce one large pulse for every six cycles of the input frequency.

The action of the 5915 is similar to a one shot multivibrator, as follows: In the stable state the plate is not conducting and the voltage is at B+ potential. The screen grid is conducting and the screen

voltage is at a low potential. This state is maintained by a constant negative bias applied to the second control grid. When the first negative part of the incoming signal comes through the diode gate it charges the coupling capacitor and applies a negative voltage to the first control grid of the 5915. The cathode voltage follows this negative voltage to a point where the second control grid is positive relative to the cathode. This starts the switching action of the multivibrator; current through the screen grid stops and current through the plate begins; screen voltage goes up, plate voltage down. The process continues until the charge leaks off the coupling capacitor at which time switching again occurs, the tube current turns from the plate to the screen grid and the plate voltage rises to open the diode gate.

The time constant of coupling capacitor C1 and its 2.2 megohm series resistor and the voltage applied by potentiometer R1, determines the length of the cycle of operation. Figure 10 shows a typical phantastron circuit with a graph of the tube voltages during one cycle of operation.

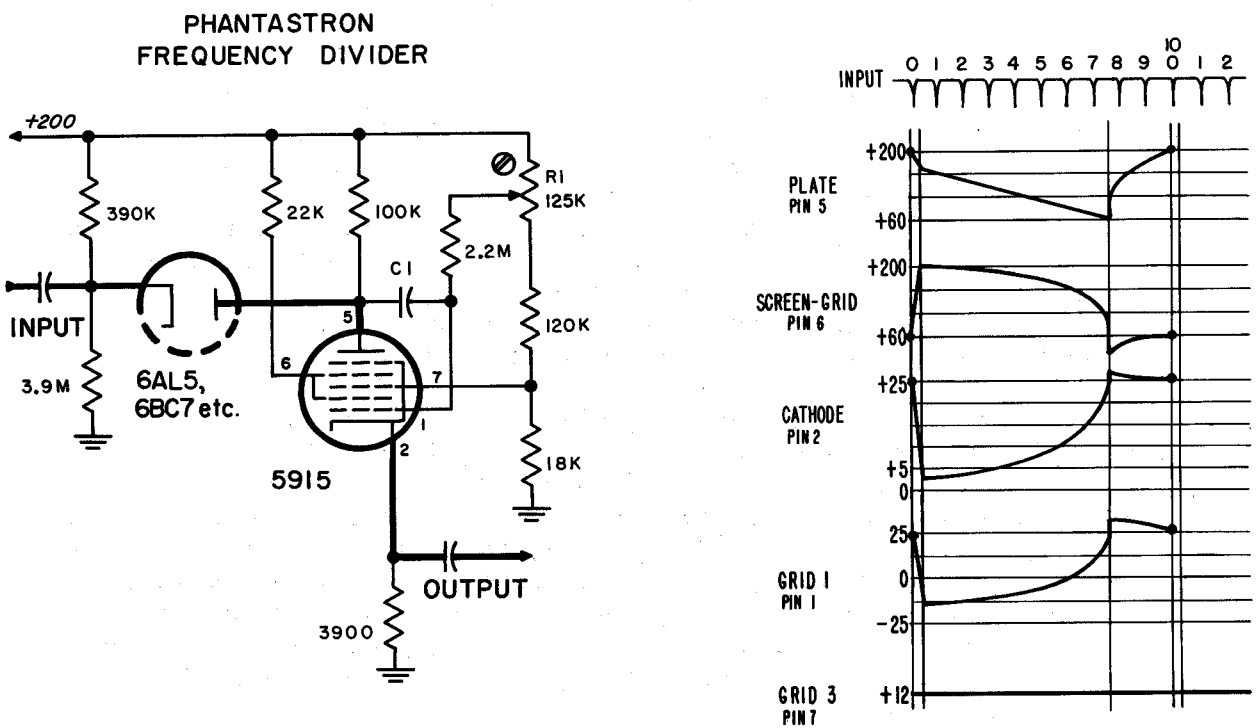



Fig. 10. Typical Circuit of Phantastron Frequency Divider with Graph Showing Tube Voltages During One Cycle of Operation

# SECTION V

# SERVICE INSTRUCTIONS

## 5-1 INTRODUCTION

This section contains instructions for replacing tubes, making circuit adjustments and trouble shooting the 521A Electronic Counter. At the rear of the manual are location diagrams, tube socket voltage-resistance diagrams and the schematic diagrams for complete equipment. All maintenance data for the Counter Units is contained in the complete manual for AC-4A at the end of this manual. A diagram and information on the accessory Crystal Controlled Time Base plug-in unit is also supplied in this manual.

The material in this section is as follows:



## 5-2 AIR FILTER SERVICE

The air filter element used in the 521A is a renewable type. To clean the filter element proceed as follows:

a. Remove the filter element from the instrument cabinet by snapping it out of the recess in the cabinet bottom.

b. Clean the filter element by washing in warm water and detergent.

c. Re-coat the filter with a light film of the filter oil that is supplied with the instrument.

## 5-3 CABINET REMOVAL

To remove the instrument chassis from the cabinet:

a. Remove the two retaining screws at the rear of the cabinet.

b. Slide the instrument panel and chassis forward out of the cabinet. The bezel ring remains on the cabinet.

## 5-4 TUBE REPLACEMENT

The following chart lists the tubes in the 521A with their functions and adjustments required following replacement. The chart is in three parts, the main instrument, the amplitude discriminator plug-in unit and the accessory Crystal Controlled Time Base plug-in unit.

521A Electronic Counter

| Symbol | Type | Function | Adjustment |
|---|---|---|---|
| V1 | 5963 twin diode | Schmitt Trigger | Trigger Bias (See para. 5-8) |
| V2 | 6AL5 twin diode | Coupling Diodes | Phantastron Frequency Divider adj. (See para. 5-6) |
| V3 | 5915 pentode | Phantastron Frequency Divider | Phantastron adj. (See para. 5-6) |
| V4 | 5915 pentode | Phantastron Frequency Divider | Phantastron adj. (See para. 5-6) |
| V5 | 5U4G dual diode | Rectifier Full Wave | None |
| V6 | 6AV5 power pentode | Series Regulator | +200 volts dc (See para. 5-5) |
| V7 | 6CB6 pentode | Control tube | +200 volts dc (See para. 5-5) |
| V8 | OB2 Gaseous Regulator | Voltage Reference | +200 volts dc (See para. 5-5) |

521A Electronic Counter (Con't.)

| Symbol | Type | Function | Adjustment |
|---|---|---|---|
| V9 | 5915 hexode | Signal Gate | None |
| V10 | 6AL5 dual diode | Diode Gates | None |
| V11 | 5963 dual triode | Multivibrator | None |
| V12 | 5963 dual triode | Gate Gontrol Binary | None |
| V13 | 5696 thyratron | Reset Pulse Shaper | None |
| V14 | 5963 dual triode | A. Clamp<br>B. Cathode Follower | None |

Amplitude Discriminator Plug-In Unit

| Symbol | Type | Function | Adjustment |
|---|---|---|---|
| V1 | 5963 dual triode | Differential Amplifier | Ampl. Disc. Adj. (See para. 5-7) |
| V2 | 5963 dual triode | | Ampl. Disc. Adj. (See para. 5-7) |

Crystal Controlled Time Base Plug-In Unit

| Symbol | Type | Function | Adjustment |
|---|---|---|---|
| V1 | dual triode | Oscillator | Osc. Freq. Adj. (See para. 5-9) |
| V2 | triple diode | Coupling diodes | Phantastron Frequency Divider Adj. (See para. 5-7) |

Crystal Controlled Time Base Plug-In Unit (Cont'd.)

| Symbol | Type | Function | Adjustment |
|---|---|---|---|
| V3 | hexode | 10 KC Phantastron Frequency Divider | Phantastron Frequency Divider Adj. (See para. 5-7) |
| V4 | hexode | 1 KC Phantastron Frequency Divider | Phantastron Frequency Divider Adj. (See para. 5-7) |
| V5 | hexode | 100 cps Phantastron Frequency Divider | Phantastron Frequency Divider Adj. (See para 5-7) |

## 5-5 REGULATED POWER SUPPLY VOLTAGE ADJUSTMENT

The regulated power supply voltage should be checked prior to making any other adjustments in the instrument and whenever tubes in the power supply are replaced; proceed as follows:

a. Connect an accurate voltmeter to pin 3 of V6.

b. If necessary adjust R134, 200 volt adj., until the meter reads +200 volts, and check for regulation with ±10% line voltage change.

c. If this adjustment cannot be made or if regulation is poor, check V6, V7 and V8.

## 5-6 PHANTASTRON FREQUENCY DIVIDER ADJUSTMENTS

Failure of the 521A/C to self-check properly indicates the phantastrons need adjustment. The adjustment potentiometers for these circuits are located on the rear chassis. To gain access, remove cabinet screws and slide chassis forward. Set the TIME BASE switch (located behind the front panel) to LINE-EXT. Set the instrument controls for self-check as described in paragraph 2-3, using the 0.1 sec gate time. Adjust the 0.1 gate adjustment (on rear of the instrument) until the displayed count is consistently 0006 (see note on following page). Reset the GATE SELECTOR switch to the 1 SEC position and adjust the 1 SEC gate adjustment until the displayed count is consistently 0060 (see note on following page). This completes adjustment on the 521A. On the 521C, switch GATE SELECTOR to 10 SEC and adjust the 10 SEC gate adjustment until the display count is consistently 0600 (see note).

NOTE: When adjusting phantastrons, turn the control clockwise until the counter miscounts. Continue slightly past this point and then rotate the control counterclockwise until the counter just begins to give a correct count. This is the range limit in the clockwise direction. Note the shaft position. Do the same in the counterclockwise direction and note the shaft position. Set the potentiometer midway between these two points. Check the phantastron for correct count with the line voltage at 102 volts and 128 volts. Allow the counter to operate at each extreme for at least 1 minute. Failure to operate properly indicates improper setting of the control, or a weak tube.

## 5-7 AMPLITUDE DISCRIMINATOR SENSITIVITY (BIAS ADJ.) ADJUSTMENT

The amplitude discriminator bias should be adjusted when either of the tubes in the amplitude discriminator are replaced or whenever the maximum sensitivity of the instrument does not meet the 0.2 volt specification. Proceed as follows:

a. Set the GATE SELECTOR switch to 1 SEC GATE and INPUT SENSITIVITY control on maximum.

b. Apply a 1 KC input signal of about 3 volts rms amplitude to the INPUT jack. Consistent operation of the counter should now be obtained, if not, rotate R205 (BIAS ADJ.) to its maximum counterclockwise position.

c. Adjust R2 (located on top of the Discriminator plug-in) using a small screwdriver that will not short the shaft to ground, to the center of the range that produces a stable indication. Watch the flashing gate lamp to make certain the instrument is operating properly.

d. Decrease the input voltage amplitude to .6 volts rms and rotate R205 (BIAS ADJ.) clockwise until a stable count just begins. Again watch the neon lamp.

e. Repeat steps c and d with reduced input voltage of .1 volt.

## 5-8 TIME BASE SCHMITT TRIGGER BIAS ADJUSTMENT

The trigger bias should be adjusted whenever V1 is replaced. To adjust, set the instrument for self check. Set the TIME BASE selector switch (behind the panel) to the LINE or EXT. position. Connect an external signal (frequency any multiple of 10~ to 100~) of several volts magnitude to the EXTERNAL STANDARD jack at the rear of the instrument. Adjust Trigger Bias potentiometer until the counter indicates correctly. Reduce the magnitude of the standard voltage in small steps, readjusting the Trigger Bias after each step so that consistent operation is obtained. Continue this process until further reduction in the voltage is not possible. Minimum operating voltage should be approximately 1 volt.

## 5-9 CRYSTAL CONTROLLED TIME BASE PLUG-IN ADJUSTMENT

Need of adjustment of the frequency dividers in the Crystal Controlled Time Base plug-in unit will be evident by the displayed number shown when self-checking the 521A.

On 1/10 SEC. gate the count should be 1000.
On 1 SEC. gate the count should be 0000.

Improper adjustment will produce counts such as 990, 9900, 8900, 0100, etc. To adjust the frequency dividers in the plug-in time base, proceed as follows:

a. Set the TIME BASE selector switch to LINE or EXT. position.

b. Self-check the 521A as shown in paragraph 2-3 and if necessary, adjust the phantastron frequency dividers at the rear of the 521A chassis as shown in paragraph 5-6.

c. Connect a jumper lead from the 10 KC output, pin 6, on the 521A-59B socket to the INPUT jack.

d. Turn the INPUT SENSITIVITY control to maximum clockwise.

e. Turn the GATE SELECTOR switch to 1/10 SEC. gate and adjust the DISPLAY TIME as desired.

f. The displayed count should be 1000, if not, loosen the potentiometer lock nut on the 10 KC divider (R15) and adjust the potentiometer until the proper count is obtained.

g. Move the jumper lead to the next lower output frequency, 1 KC, pin 7, on the 521A-59B socket. The displayed count should be 0100 on the 1/10 SEC. gate or 1000 on the 1 SEC. gate. If it is not, adjust the 1 KC potentiometer, R25.

h. Move the jumper lead to the 100 cps output, pin 8. The displayed count should be 0100 on the 1 SEC. gate. If it is not, adjust the 100$\Omega$ potentiometer R34. Remove the jumper lead.

i. This completes the adjustment of the frequency dividers in the TIME BASE plug-in unit.

j. Set the TIME BASE selector switch to the CRYSTAL position. Turn the INPUT SENSITIVITY control to CHECK. The 521A should now count 10 KC and display 1000 on the 1/10 SEC. gate.

A trimmer capacitor C10 is provided in the TIME BASE plug-in unit to set the 100 KC frequency "on". This adjustment has been made at the factory, and should not be readjusted unless a standard frequency of 100 KC is available, and a comparison indicates that adjustment is necessary. The simplest procedure is to connect the 100 KC standard frequency to the INPUT jack, read its frequency with the 521A, and then adjust trimmer C10 until the displayed frequency is 0000 (100, 000 cps).

## 5-10 TROUBLE LOCALIZATION

a. Turn on the counter and set the controls as follows:

SENSITIVITY - CHECK
GATE SELECTOR - MANUAL
MANUAL GATE - COUNT

b. The Gate indicator lamp should light and the counters should count continuously. Counting should progress until each number in each column will have been lighted. If one number fails to light the Counter Unit containing that light has a faulty circuit or tube. Tubes in the counters may be replaced without need for readjustment.

c. If the pilot light does not light, check the power cord connections, fuse, pilot lamp, etc.

d. If all decade counter units fail to count, check the power supply voltages shown on the schematic diagram, the Amplitude Discriminator tubes, V9, V12, V14 and Decade Counter Unit Z-205.

e. Set the GATE SELECTOR switch to the 1 SEC. position. The counter should count to 60 repeatedly, when the TIME BASE selector switch is on LINE or EXT.

f. If the neon gate lamp fails to function, check the gate and time base circuits.

g. If the neon gate lamp operates correctly, but the displayed count is wrong, check the Time Base circuit adjustments described in this section.

h. If the neon gate lamp operates correctly and no count is obtained, check the input connections, Amplitude Discriminator, Signal Gate, and the UNITS Decade Counter Unit.

i. Set the controls for frequency measurement. Set the INPUT SENSITIVITY control to max. position. With a 1 KC signal input, reduce the magnitude of the input signal to 0.2 volts to test the instrument's sensitivity. If the instrument lacks sensitivity, the Amplitude Discriminator requires adjustment (See paragraph 5-7).

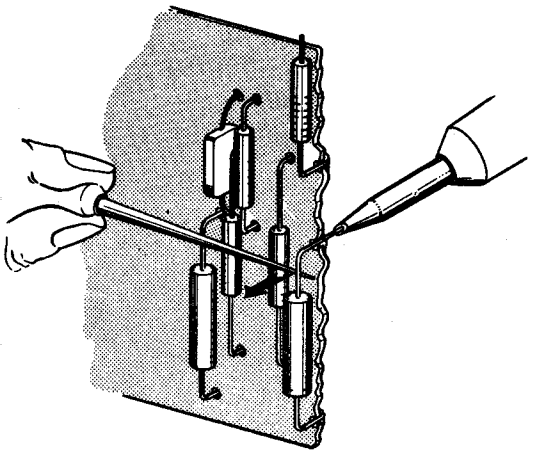
j. Check operation with frequencies from 1 cycle to 120 KC. Do not readjust disc. bias at any of these frequencies.

**CAUTION**

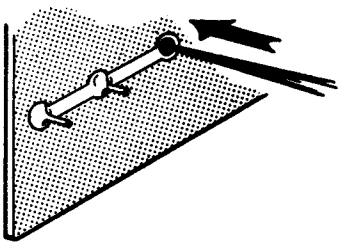
When servicing printed circuits DO NOT push or pull wires in such a way as to raise the printed wiring from the board.

When soldering leads, use 50 watt iron or smaller. Apply heat sparingly to the leads on the part to be replaced, not to the printed wiring on the board.

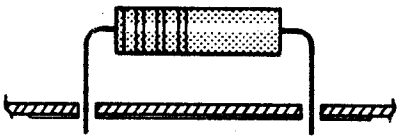
Before installing new parts, clean holes to receive new part without forcing. Have new leads tinned and if necessary fluxed to receive solder quickly with a minimum of heat and without residue.



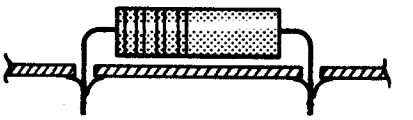
Apply heat sparingly to lead of part to be replaced. Remove part from card as iron heats the lead.



2. Using a small awl, carefully clean inside of hole left by old part.



Bend clean leads on new part and carefully insert through holes on board.



4. Hold part against board and solder leads.

Figure 11. Diagram Showing how to Replace Parts Mounted on Etched Circuit Boards

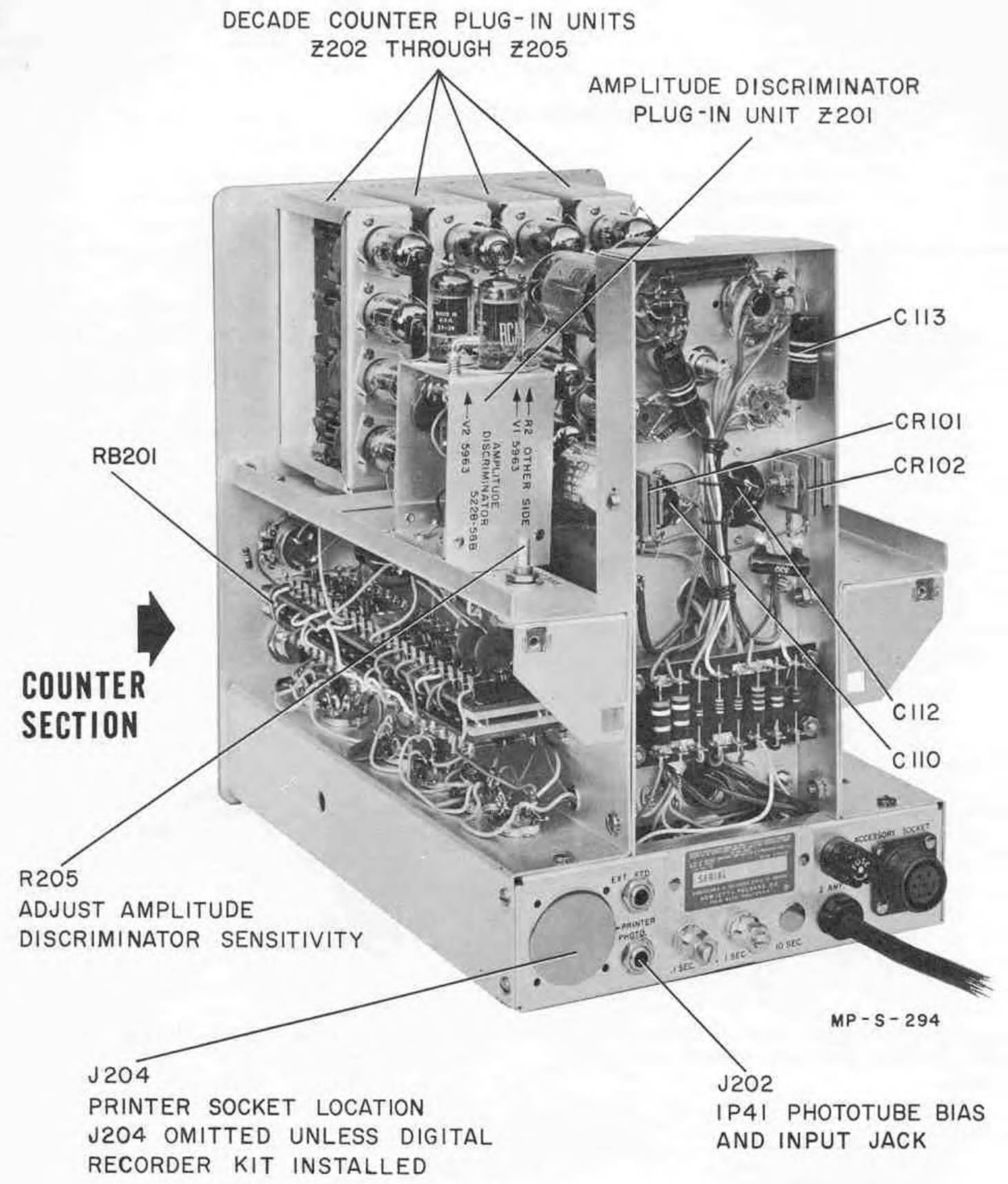



Fig. 12. Model 521A Electronic Counter, right oblique view, cabinet removed to locate adjustments and components

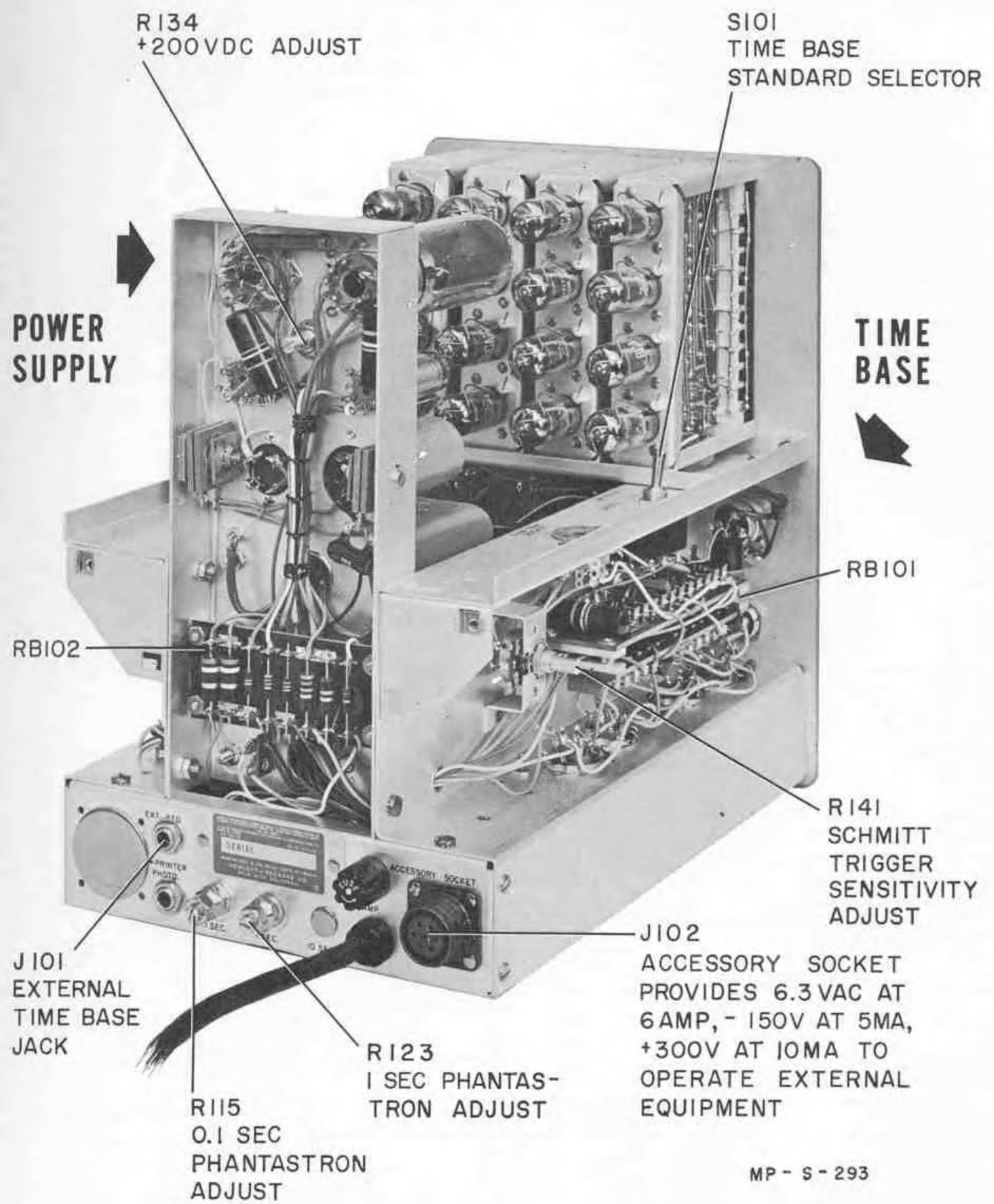



Fig. 13. Model 521A, left oblique view, cabinet removed to locate adjustments and components

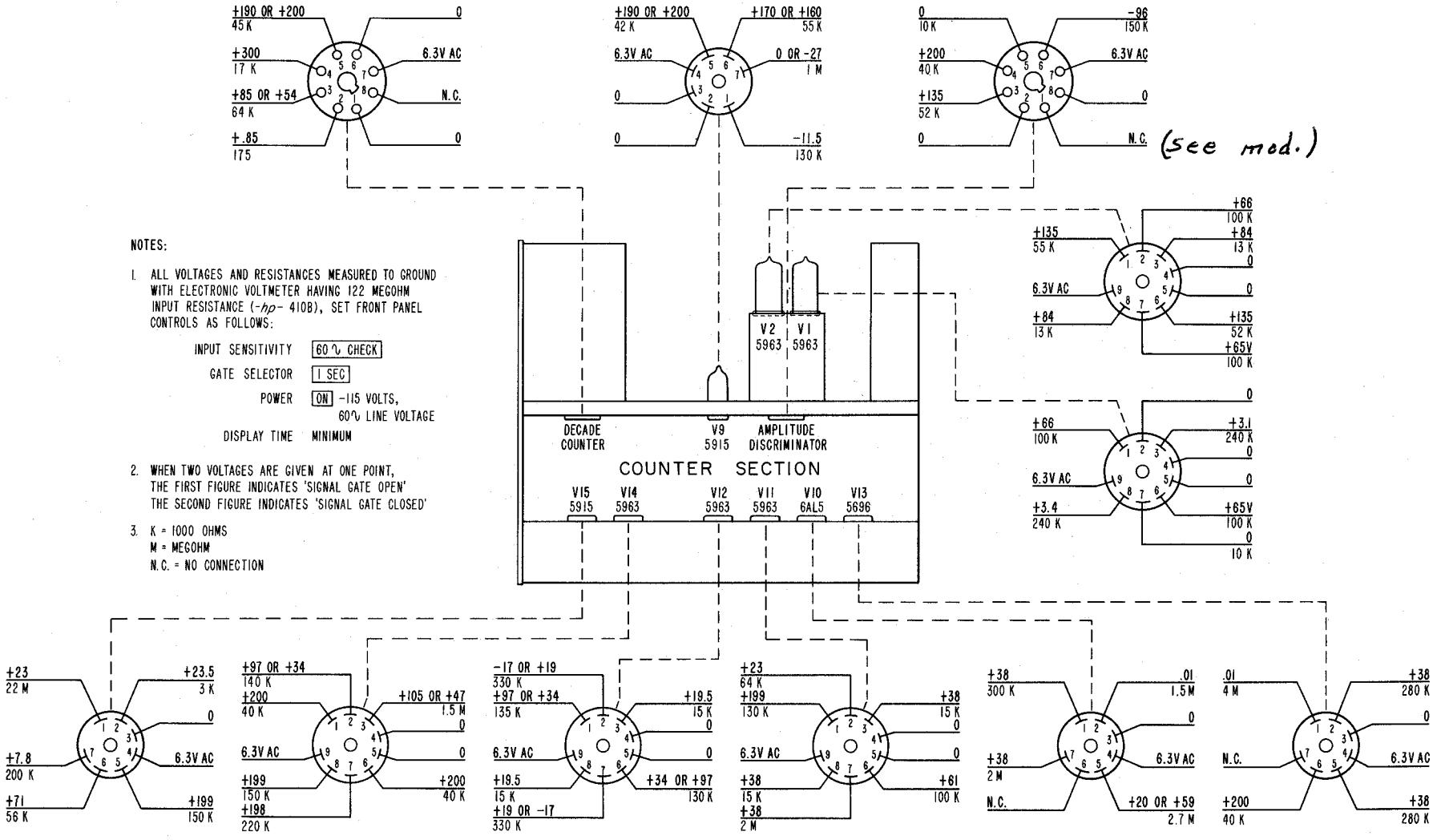
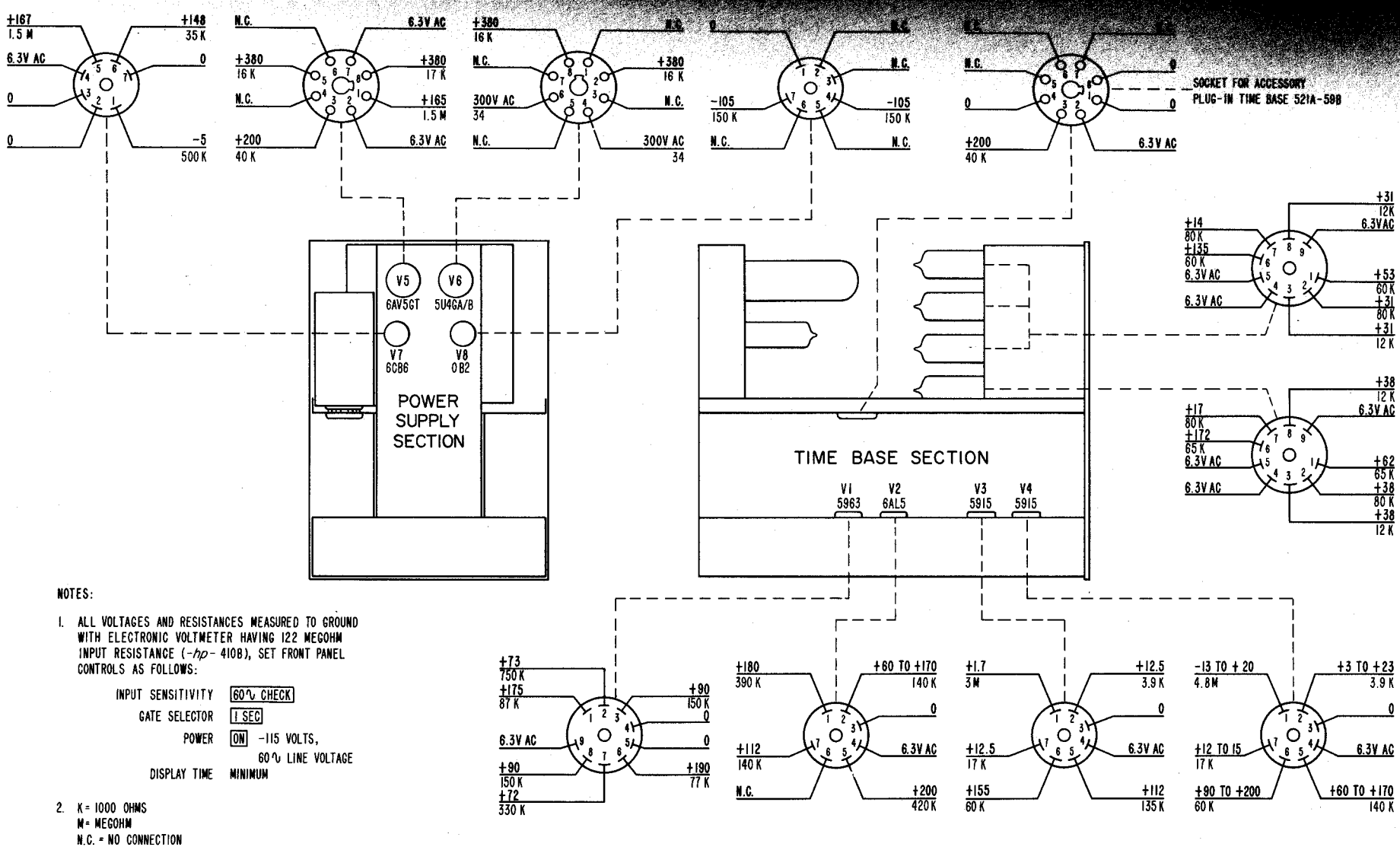



Fig. 14. Tube Socket Voltage-Resistance Diagram for the Counter Section (Signal Gate Circuits)



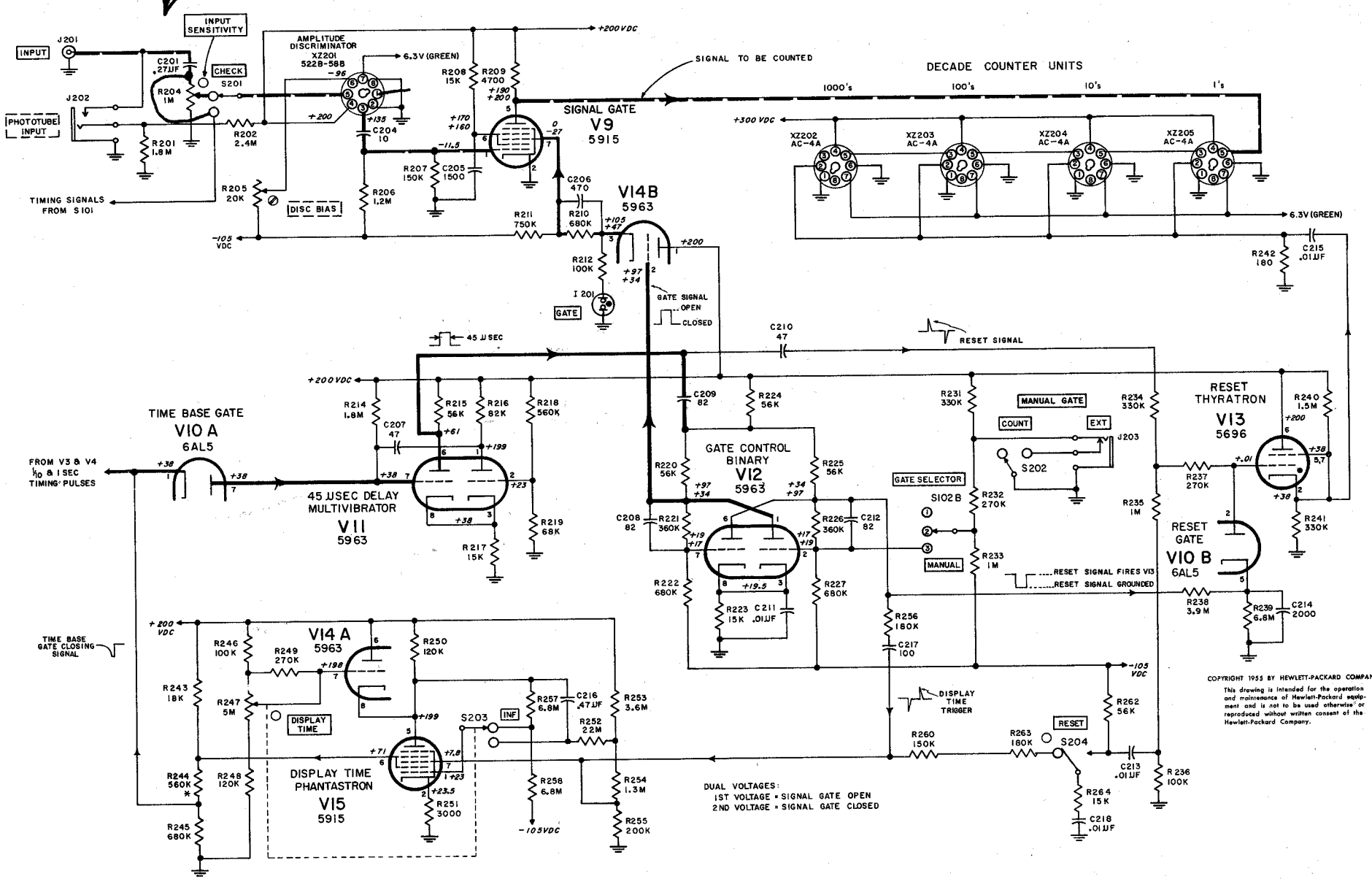

NOTES:

1. ALL VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH ELECTRONIC VOLTMETER HAVING 122 MEGOHM INPUT RESISTANCE (*-hp-* 410B), SET FRONT PANEL CONTROLS AS FOLLOWS:

| | |
|---|---|
| INPUT SENSITIVITY | 60∿ CHECK |
| GATE SELECTOR | 1 SEC |
| POWER | ON -115 VOLTS, 60∿ LINE VOLTAGE |
| DISPLAY TIME | MINIMUM |

2. K = 1000 OHMS
   M = MEGOHM
   N.C. = NO CONNECTION

**Fig. 15. Tube Socket Voltage-Resistance Diagram for the Time Base Section and Power Supply**





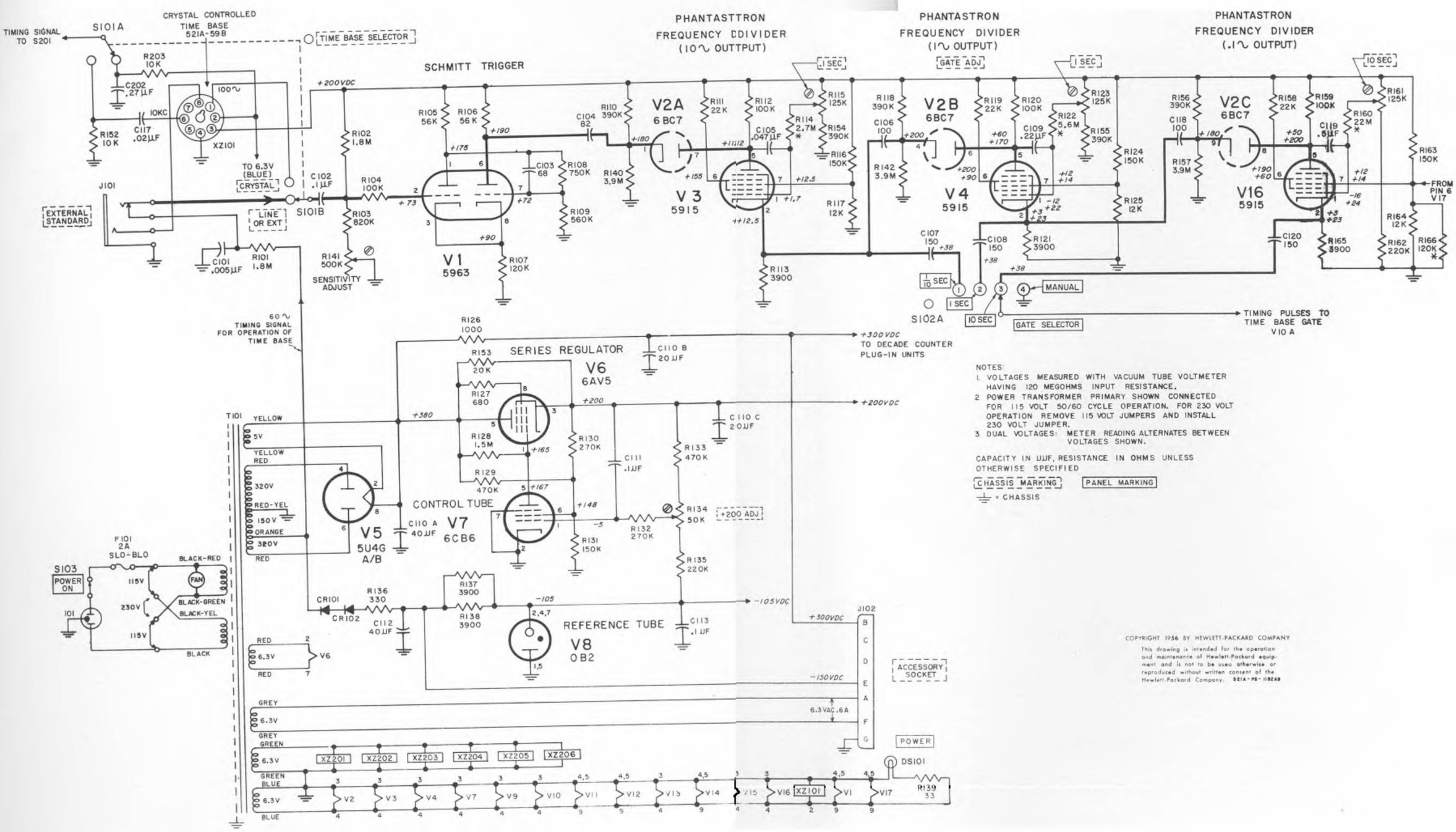



**hp MODEL 521A**

COUNTER SECTION

SERIAL 1182 & ABOVE

Fig. 16

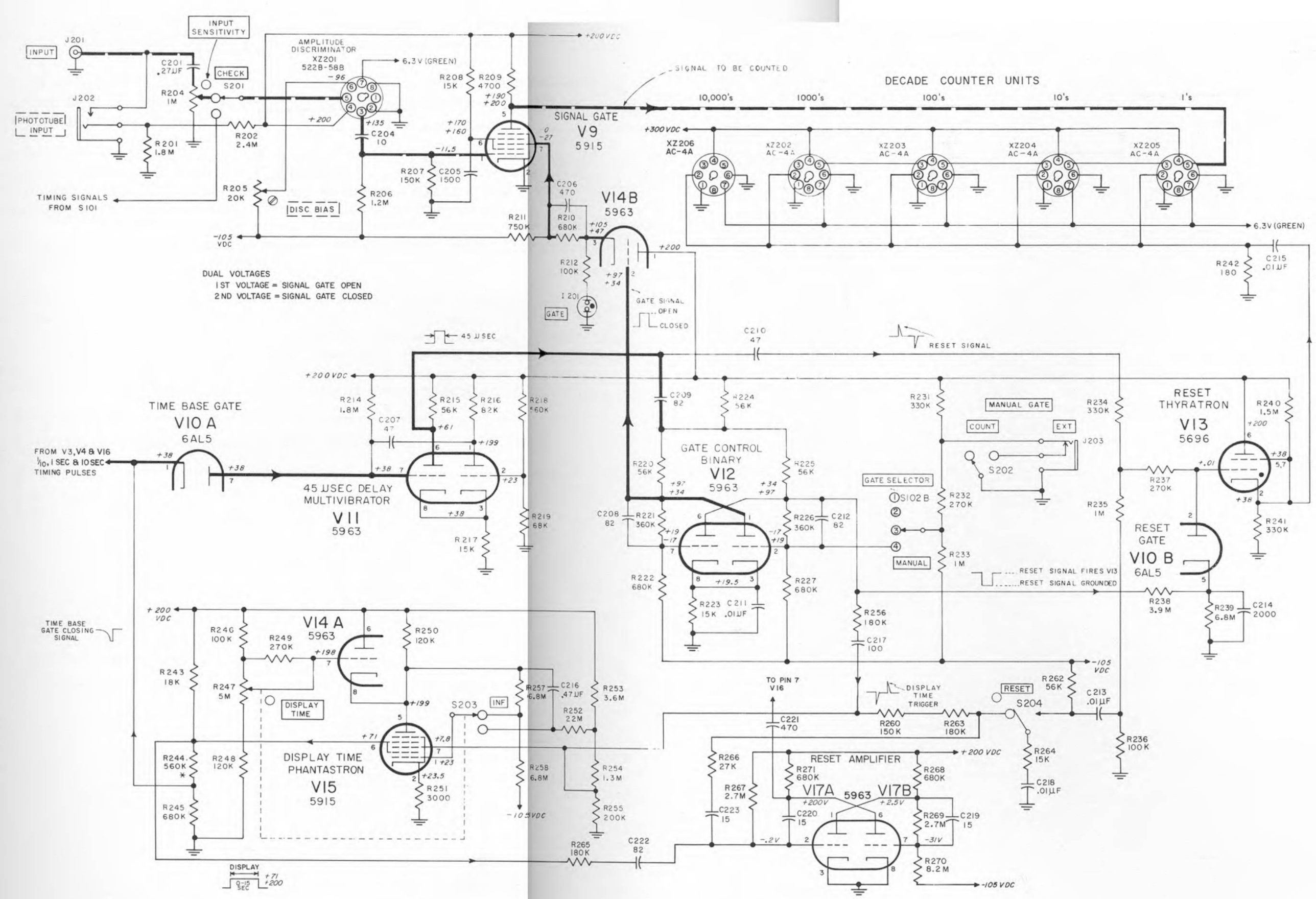



NOTES:
1. VOLTAGES MEASURED WITH VACUUM TUBE VOLTMETER HAVING 120 MEGOHMS INPUT RESISTANCE.
2. POWER TRANSFORMER PRIMARY SHOWN CONNECTED FOR 115 VOLT 50/60 CYCLE OPERATION. FOR 230 VOLT OPERATION REMOVE 115 VOLT JUMPERS AND INSTALL 230 VOLT JUMPER.
3. DUAL VOLTAGES: METER READING ALTERNATES BETWEEN VOLTAGES SHOWN.

CAPACITY IN µµF, RESISTANCE IN OHMS UNLESS OTHERWISE SPECIFIED

CHASSIS MARKING  PANEL MARKING

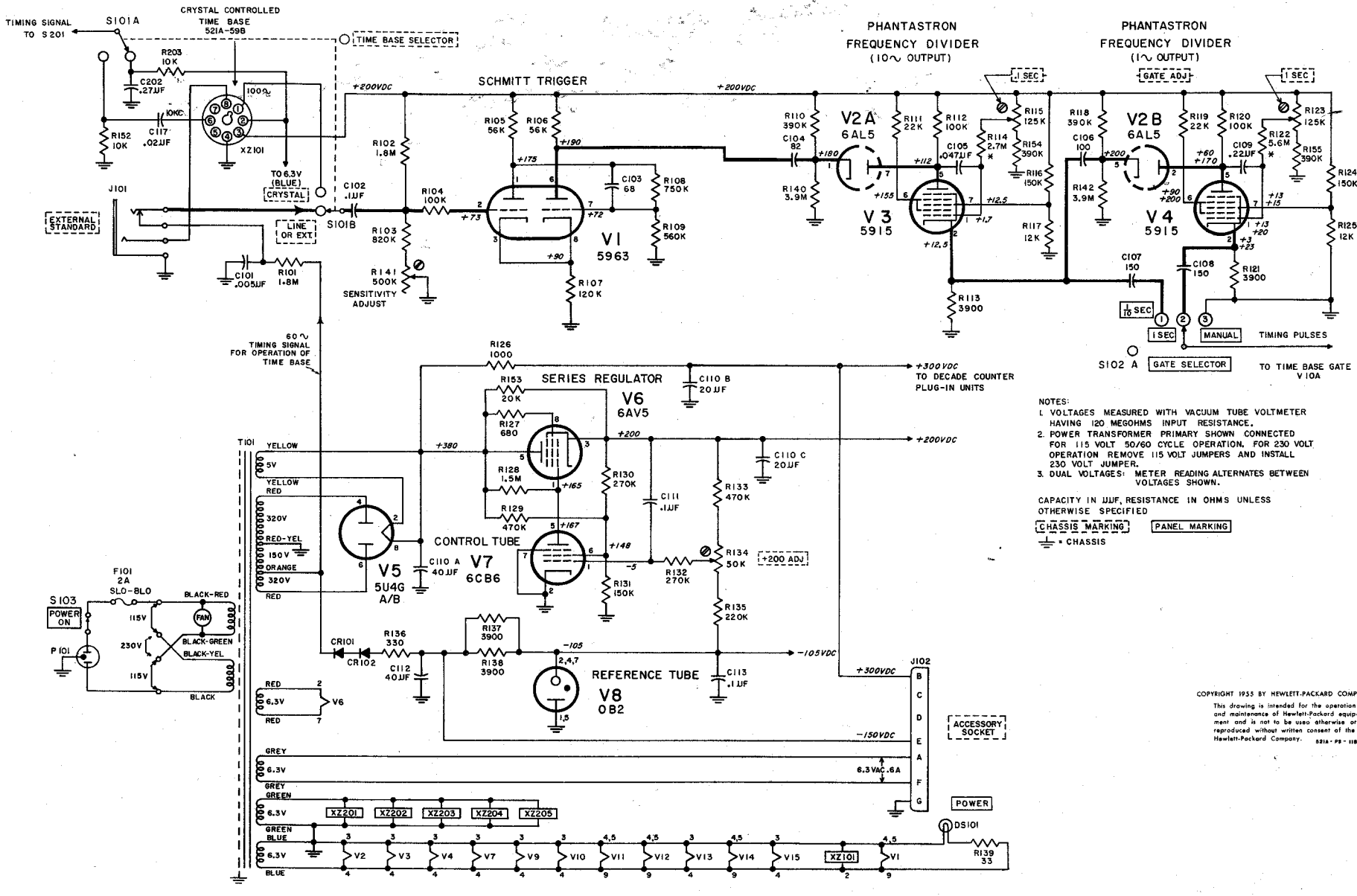
⏚ = CHASSIS




# MODEL 521C

## COUNTER SECTION

SERIAL 1182 & ABOVE

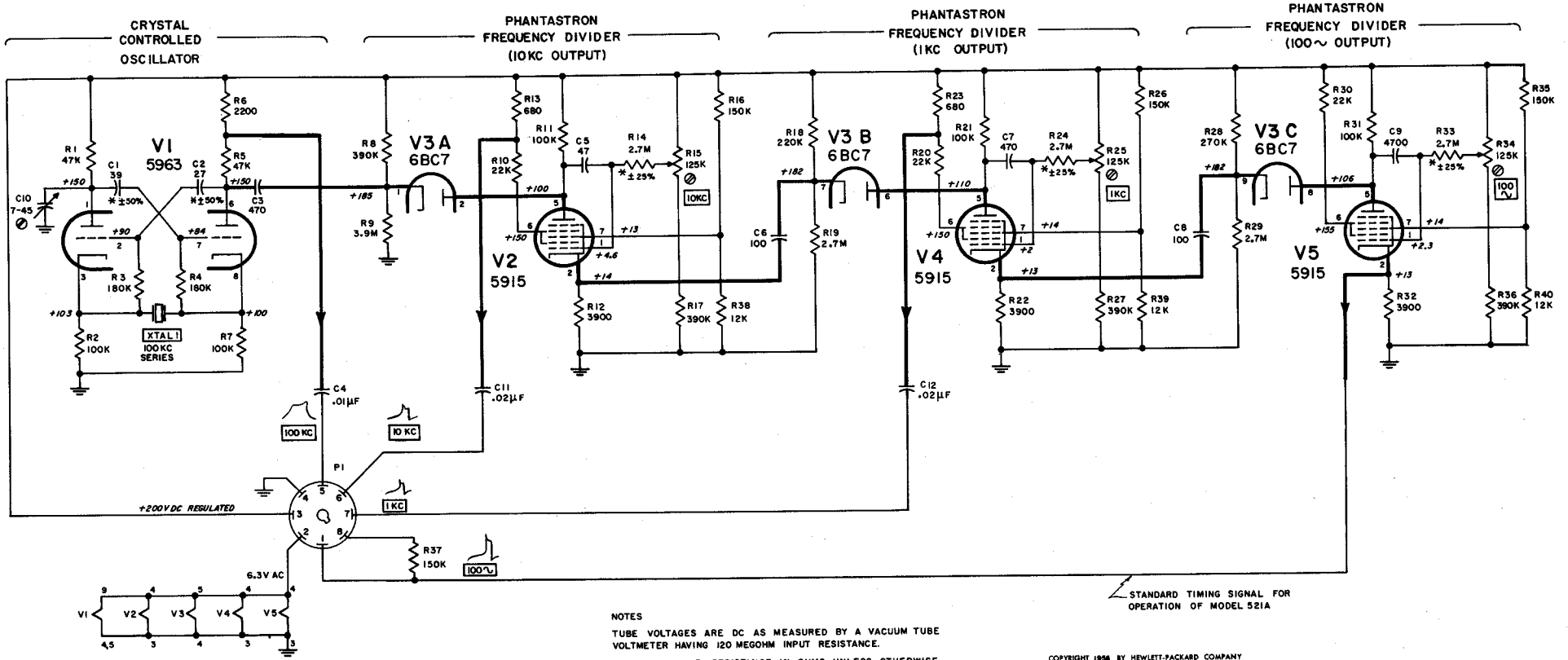



NOTES:
1. VOLTAGES MEASURED WITH VACUUM TUBE VOLTMETER HAVING 120 MEGOHMS INPUT RESISTANCE.
2. POWER TRANSFORMER PRIMARY SHOWN CONNECTED FOR 115 VOLT 50/60 CYCLE OPERATION. FOR 230 VOLT OPERATION REMOVE 115 VOLT JUMPERS AND INSTALL 230 VOLT JUMPER.
3. DUAL VOLTAGES: METER READING ALTERNATES BETWEEN VOLTAGES SHOWN.

CAPACITY IN µµF, RESISTANCE IN OHMS UNLESS OTHERWISE SPECIFIED

CHASSIS MARKING  PANEL MARKING

⏚ = CHASSIS




NOTES

TUBE VOLTAGES ARE DC AS MEASURED BY A VACUUM TUBE VOLTMETER HAVING 120 MEGOHM INPUT RESISTANCE.

CAPACITY IN µµF, RESISTANCE IN OHMS UNLESS OTHERWISE NOTED.

* INDICATES VALUE SELECTED DURING MANUFACTURE.

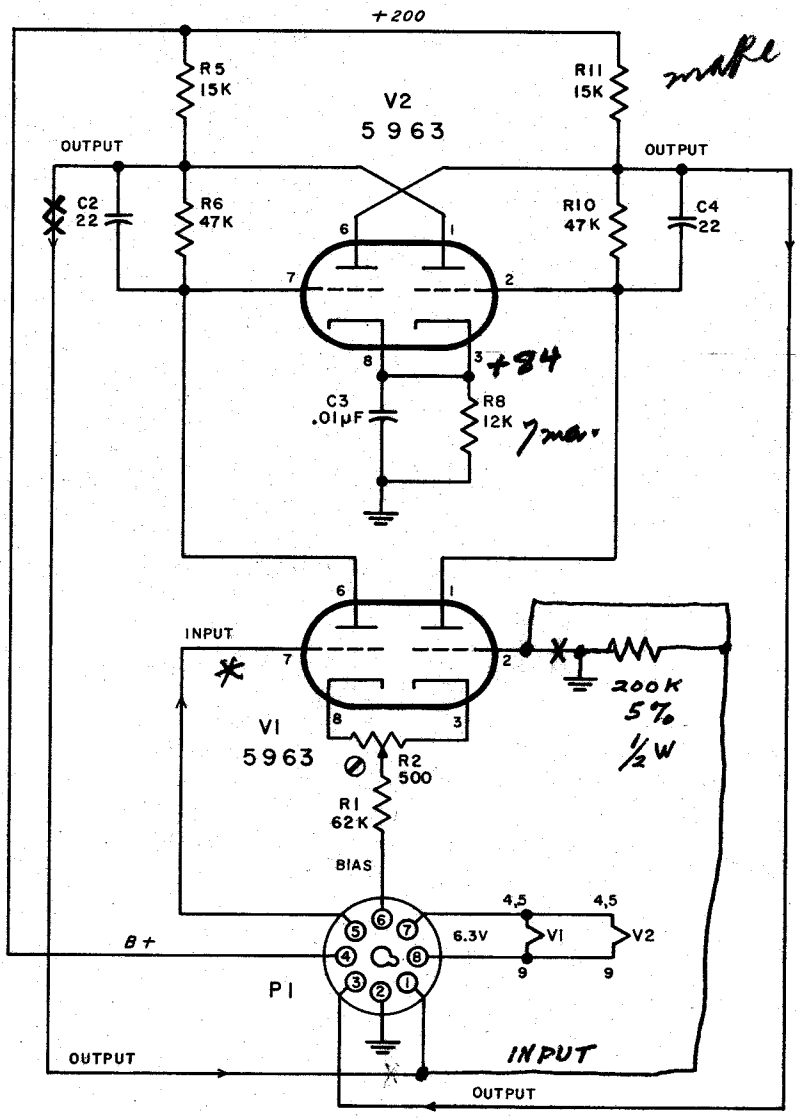


## 521A-59B

# CRYSTAL CONTROLLED TIME BASE ACCESSORY PLUG-IN UNIT Z101

ADC 1521

Fig. 18






522B-58-B

# AMPLITUDE DISCRIMINATOR ACCESSORY PLUG-IN UNIT Z201

ADC 1241

Fig. 19.

# K4XL's  BAMA

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