INSTRUCTION MANUAL

type 1395-A

MODULAR PULSE GENERATOR

(MAIN FRAME)

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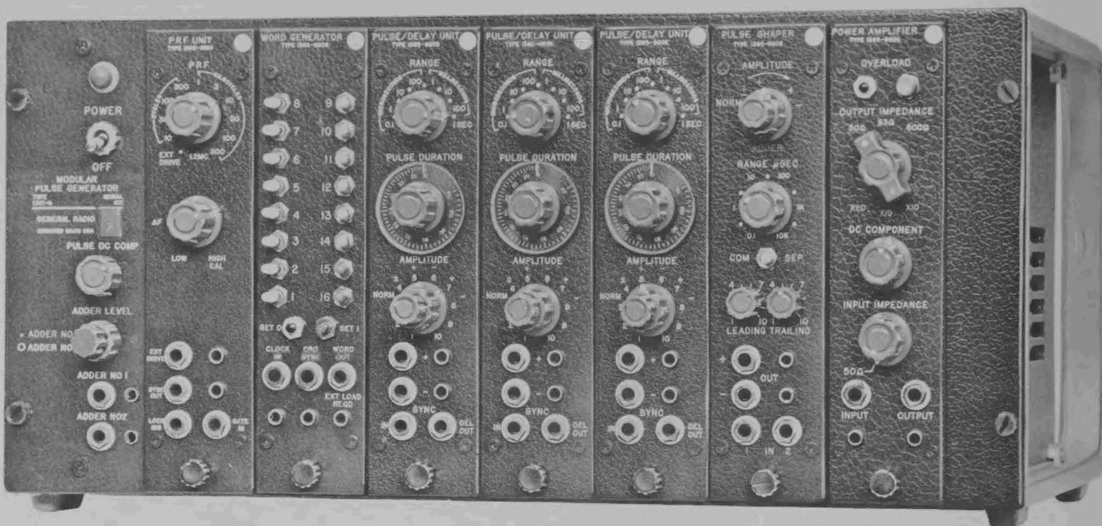
Form 1395-0100-A ID 1009 January, 1966

GENERAL RADIO COMPANY

West Concord, Massachusetts



The Type 1395-A Modular Pulse Generator main frame shown with various modules inserted. These modules do not come with the main frame, but are available as separate instruments.

SPECIFICATIONS

MAIN FRAME

ADDER Output Level: 0 to 1 V or more, depending on number of modules used (continuously adjustable).

ADDER Output Impedance: 100 Ω or less (100-Ω pot).

PULSE DC COMPONENT Range: 0 to +20 V (continuously adjustable).

Power Required: 105 to 125 V, 195 to 235 V, or 210 to 250 V, 50 to 60 c/s; approximately 250 W, depending on quantity and type of plug-ins.

Accessories Supplied: Type CAP-22 Power Cord; spare fuses; six patch cords — one each Types 274-LMB and 274-LMR, two each Types 274-LSB and 274-LSR; four blank cover panels; one 14-conductor module extension cable.

Accessories Available: All modules in the Type 1395 series, Type 1217-P2 Single-Pulse Trigger (see page 164).

Mechanical Data: Rack-Bench Cabinet (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Wt**		*Ship Wt**	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	9⅛	230	14½	370	29	13.2	42	19.5
Rack	19	485	8¾	220	13¼†	340	27	12.3	42	19.5

* Without modules. † Behind panel.

SECTION 1

INTRODUCTION

1.1 THE TYPE 1395-A MODULAR PULSE GENERATOR SYSTEM.

The General Radio Type 1395-A Modular Pulse Generator is a customized pulse generator made up of a main frame, which includes power supplies and adder circuits, and various plug-in modules. As requirements change, the plug-in modules can be rearranged in a few minutes to create exactly the pulse generator for the new application.

Several modules are available:. Some determine the shape of a pulse; others determine pulse amplitude and duration; still others are amplifiers, pattern generators, or clocks. Wise interconnection of these modules is the key to success. A number of examples are given in these instructions and in the instructions for individual modules, but practice and ingenuity will take the user far beyond the limits of any instruction book.

1.2 DESCRIPTION OF THE MODULAR PULSE GENERATOR, TYPE 1395-A.

The Type 1395-A Modular Pulse Generator, shown in Figures 1-1 and 1-2, consists of a largely empty frame containing only power supplies and adder circuits. Various plug-in modules in the 1395 Series can be inserted in the large cavity in the front panel. Interconnections between the plug-in modules determine the type of pulse generator that results. Thus, the Type 1395 is not a single instrument, but a very large number of pulse generators.

The Type 1395-A frame (in these instructions, frame denotes the empty Type 1395-A Modular Pulse Generator without plug-in modules) supplies the following voltages: +150 volts dc; -150 volts dc; 0 to +20 volts dc, variable; 6.3 volts ac, offset from ground by +50 volts; and 6.3 volts ac, offset from ground by -75 volts. These voltages meet the requirements of all modules that employ vacuum-tube circuitry and of some hybrid modules. Modules that employ transistors exclusively have self-contained power supplies that use one of the 6.3-volt ac sources as the primary voltage for a miniature power transformer.

The Type 1395-A frame also contains two adder busses that connect to each of the seven sockets for the plug-in modules. Panel controls on modules such as the Type 1395-P2 Pulse/Delay Unit or the Type 1395-P3 Pulse Shaper permit output power from these modules to flow into an adder bus. Thus, outputs from several modules can be combined to produce pulses of extraordinary shapes. Back-panel connectors allow external signal sources to be injected into the adder circuits.

The back connectors give limited provision for interconnection between modules. This feature is useful with the Type 1395-P6 Word Generator when a binary word longer than 16 bits is required.

1.3 CONTROLS AND CONNECTORS.

Controls and connection points of the Type 1395-A frame are shown in Figures 1-1 and 1-2 and identified in Table 1-1. Remember, however, that the frame without plug-in modules is not very useful.

TABLE 1-1
CONTROLS AND CONNECTORS

Reference	*Name*	*Type*	*Function*
1	Pilot light	Red neon lamp	Lights when power is on.
2	POWER	Toggle switch	Turns power on and off.
3	PULSE DC COMPONENT	Continuous rotary control	Determines voltage level at the baseline of pulses.
4	ADDER LEVEL NO. 1	Continuous rotary control	Adjusts amplitude of the sum signal at the output of Adder No. 1.
5	ADDER LEVEL NO. 2	Continuous rotary control	Adjusts amplitude of the sum signal at the output of Adder No. 2.
6	ADDER NO. 1	Jack	Output terminal for Adder No. 1.
7	none	Jack	Ground terminal for Adder No. 1 output.
8	ADDER NO. 2	Jack	Output terminal for Adder No. 2.
9	none	Jack	Ground terminal for Adder No. 2 output.
10 through 16	none	Multipin sockets	Power connectors for plug-in modules.
17	none	Cord	Cheater cord for operating modules outside of frame.
18	none	3-wire plug	Mates with power cord supplied.
19	CURRENT LIMIT	Continuous rotary control	Prevents current from the 0-to-20-volt supply from exceeding safe value.
20	ADDER INPUT NO. 1	Jack	Provides external access to Adder No. 1 bus.
21	none	Jack	Ground terminal for external connection to Adder No. 1 bus.
22	ADDER INPUT NO. 2	Jack	Provides external access to Adder No. 2 bus.
23	none	Jack	Ground terminal for external connection to Adder No. 2 bus.
24, 25	LINE	Fuses	Fuses for power line.
26, 27, 28	FILAMENTS	Fuses	Fuses for 6.3-V filament windings.

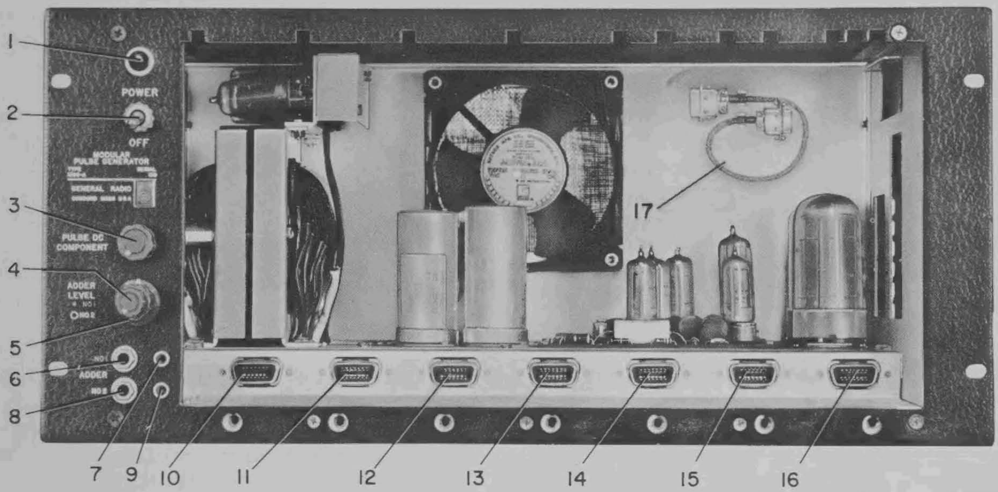


Figure 1-1. Panel view of the main frame of the Type 1395-A Modular Pulse Generator. (For legend, refer to paragraph 1.3.)

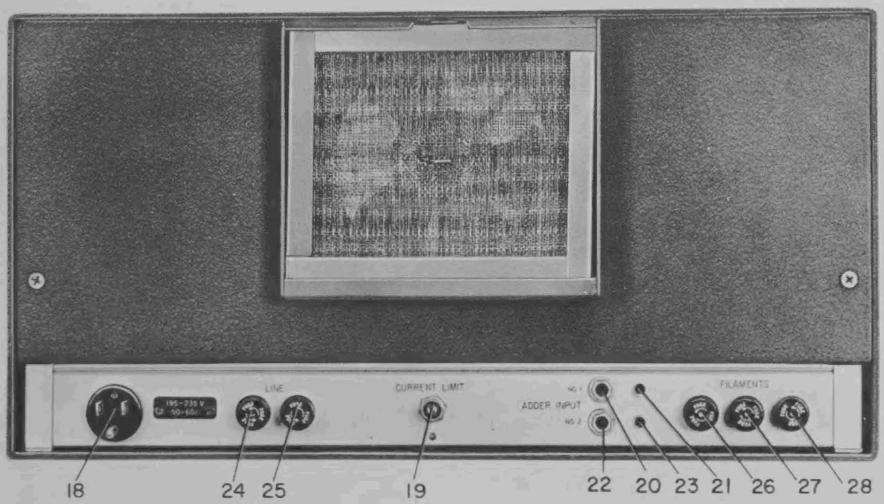


Figure 1-2. Rear view of the Type 1395-A Modular Pulse Generator. (For legend, refer to paragraph 1.3.)

SECTION 2

OPERATING PROCEDURE

Turn off the power before you insert or remove any module!

2.1 CONNECTION TO POWER SUPPLY.

Connect the Type 1395-A to a source of power as indicated by the legend at the input socket at the rear of the instrument, using the power cord provided. While instruments are normally supplied for 115-volt operation, the power transformer can be reconnected for either 220-volt or 230-volt service (see schematic diagram, Figure 4-3). When changing connections, be sure to replace line fuses with those of current rating for the new input voltage (1.6 amperes for 220 or 230 volts, 3.2 amperes for 115 volts). Appropriate measures should be taken so that the legend indicates the correct input voltage. On instruments changed from 230 to 115 volts, this simply means removal of the 230-V nameplate; a 115-V legend is marked beneath. For instruments changed to 230 volts, a nameplate (Type LAP-166E2) may be ordered from General Radio; for change to 220 volts, order a Type LAP-166E5 nameplate.

The main frame has power supplies designed to deliver the following maximum currents:

+150 volts, 250 mA
-150 volts, 250 mA
two 6.3 volts ac sources, each 7 amperes
+15 volts, 20 mA
0 to 20 volts, variable, 150 mA

If all these supplies are simultaneously loaded to the maximum of their rated currents, the line voltage should be at least 107 volts, or 214 volts in the case of instruments connected for 230-volt service.

2.2 INTERCONNECTION OF 1395 SERIES MODULES.

2.2.1 GENERAL.

Inasmuch as the Type 1395-A Modular Pulse Generator is designed for maximum versatility in the assembly of pulse-generating equipment, this book cannot possibly cover all interconnections, or even a generous assortment of them. However, some samples are described in the following paragraphs.

Most modules can be plugged into any of the seven positions (10 through 16 in Figure 1-1). The Type 1395-P4 Power Amplifier will fit only the extreme right-hand slot (connector 16). The Type 1395-P3 Pulse Shaper will fit only the three right-hand positions (connectors 14, 15, and 16). The number of Pulse Shapers and Power Amplifiers is thus limited to ensure that no combination of plug-in modules will exceed the current ratings of the Type 1395-A power supplies.

For proper circulation of cooling air, the front panel should be filled completely. If you do not require seven operating modules, cover unused slots with blank panels (four are supplied with the instrument) or insert a Type 1395-P7 Skeleton Frame in each unused slot.

2.2.2 KEEPING TRACK OF THE MODULES.

Each module has an aluminum-foil tab in its upper right-hand corner. These tabs have a slightly roughened surface to take marks from an ordinary lead pencil. When many modules are used in a Type 1395 system, it is handy to number the individual modules both on an interconnection sketch and on these aluminum tabs. In the following examples, this practice is very helpful.

2.2.3 EXAMPLE 1: A DESCENDING STAIRCASE.

Suppose we wish to obtain the waveform of Figure 2-1. Each step is 10 microseconds long and 4 volts high. The entire pattern is to be repeated at a 3-kc rate.

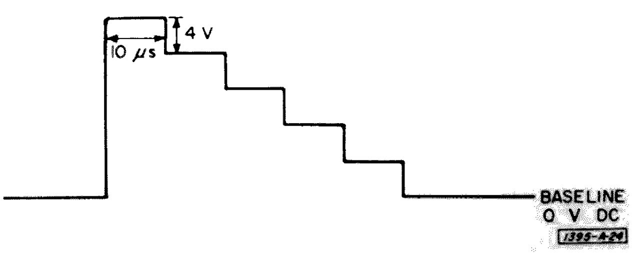


Figure 2-1. A descending staircase waveform.

In general, it is best to form a complex pulse by adding as many simple, rectangular pulses as necessary. An alternative method is to generate each part of the complex pulse separately. Thus, the steps in the staircase may each be generated by a separate Pulse/Delay Unit and each set to the proper moment of time by another Pulse/Delay Unit. This method, however, is wasteful of Pulse/Delay Units.

Another method is to have the DEL OUT pulse formed at the end of the first step trigger the next Pulse/Delay Unit to start the second step, etc. This method works well, except that switching transients are more evident in the final pulse than when simple rectangular pulses are added to form the complex pulse. This problem is discussed in more detail in the Operating Instructions for the Type 1395-P2 Pulse/Delay Unit, paragraph 2.2.5.

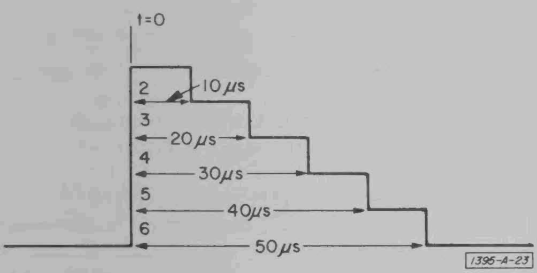


Figure 2-2. Planning sketch for the staircase waveform shown in Figure 2-1.

To make our staircase by adding simple pulses, we need an advance plan such as the sketch in Figure 2-2. Let Pulse/Delay Units produce pulses all starting at the same time, but ending at different times. Then, for example, from t = 0 to t = 10 µs, the sum of the pulses will be five steps high. From t = 10 µs to t = 20 µs, the sum is four steps, etc. The actual ADDER voltages depend on the settings of the ADDER LEVEL control and the AMPLITUDE controls on the individual Pulse/Delay Units. The ADDER output signal is then amplified as needed to achieve the specified voltages, in this example, 4 volts per step. The Type 1395-P4 Power Amplifier is recommended for this purpose.

Since the pulses in Figure 2-2 all start at the same time, they are triggered simultaneously from the same signal source, a Type 1395-P1 PRF Unit operating at 3 kc/s. The complete set-up is shown in Figure 2-3. Note that the numbers written on the tabs in the upper right-hand corners of the modules correspond to the numbers on the planning sketch of Figure 2-2.

Next, the ADDER switch on each Type 1395-P2 Pulse/Delay Unit is set to the clockwise + sign. This connects the output of the Unit to the No. 2 ADDER. Either ADDER NO. 1 or ADDER NO. 2 may be used. There may be times when it is necessary to have the adder waveforms in both polarities simultaneously. For this reason, two ADDERS are provided. When the ADDER switches on individual modules are set to the red + and the white -, ADDER NO. 1 gives the sum with positive polarity, and ADDER NO. 2 gives the sum with negative polarity.

When the adder is used, it should be at as high a level as possible for best signal-to-noise ratio. At a high level, the wanted signal will swamp out any little transients and ripples on the adder bus more effectively than at a low level. Therefore, the AMPLITUDE controls in Figure 2-3 are all shown fully clockwise. The ADDER LEVEL control is used to obtain the desired level from the adder output jack.

The adders also introduce a drop of about 26 dB compared with the voltage that would be available from the front-panel output terminals of a Type 1395-P2 Pulse/Delay Unit or a Type 1395-P3 Pulse Shaper. In the example of our staircase, the level from the adder is not adequate to give the 4-volt steps for the final output. Therefore, the adder output is connected to the input of a Type 1395-P4 Power Amplifier. A coaxial patch cord is used for minimum noise pickup from adjacent cords.

Since the rise time from the Power Amplifier is fastest at low impedances, a 50-ohm load is chosen, and the OUTPUT IMPEDANCE switch is set to 50 ohms. The INPUT IMPEDANCE control is set fully clockwise (about 1050 ohms) because the output impedance from the ADDER is about 100 ohms or less, and not much improvement in rise time will result from shunting down an impedance that is already this low. (We are

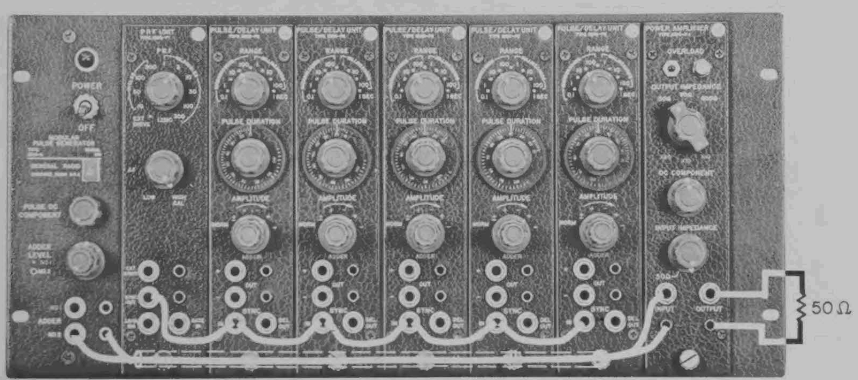


Figure 2-3. Interconnections for the five-step waveform shown in Figure 2-1.

not worried about reflections in this case. There are times to match impedances and times when it doesn't matter.)

The AMPLITUDE controls on the individual modules are adjusted to set the exact ratios of the steps. The over-all amplitude is set by adjustment of the input signal to the Power Amplifier with the ADDER LEVEL NO. 2 control. The baseline voltage is set by adjustment of the DC COMPONENT control on the Power Amplifier. The PULSE DC COMPONENT control on the frame is not useful in this application because the Power Amplifier has a dc blocking capacitor at its input. A cathode-ray oscilloscope is almost essential for these final settings. The result is shown in the oscillogram of Figure 2-4.

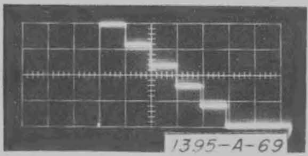


Figure 2-4. The output waveform (descending staircase) generated by the configuration shown in Figure 2-3. Vertical scale is 5 volts per major division; horizontal scale is 10 μs per major division.

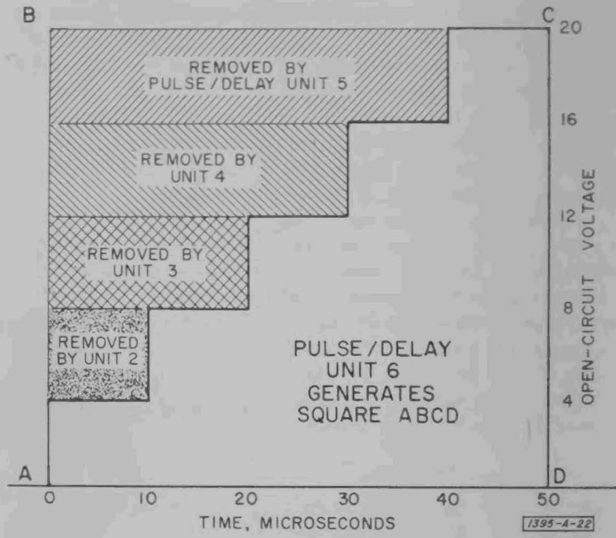


Figure 2-6. Planning sketch for sculpturing the staircase waveform shown in Figure 2-5.

2.2.4 EXAMPLE 2: AN ASCENDING STAIRCASE.

A complex pulse may be formed either by the addition of contributions from various sources (the additive method) or by the removal of unwanted parts from pulses already existing (the sculpture or subtractive method). The descending staircase described in paragraph 2.2.3 is an example of the additive method.

With the subtractive approach, we can create the staircase waveform shown in Figure 2-5 with the same system set-up as in Figure 2-3. The planning sketch of Figure 2-6 shows how this is done.

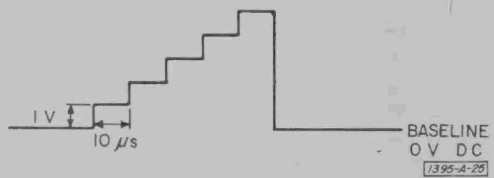


Figure 2-5. An ascending staircase waveform.

We let Pulse/Delay Unit 6 produce a pulse 50 microseconds long and 5 units high (say 20 volts, open-circuit). The ADDER switch of this Unit is set to the white + as before and the AMPLITUDE control is set fully clockwise. Now, to create the top step, we sculpture away from this pulse a chunk 40 microseconds long and 4 volts in open-circuit amplitude by setting the ADDER switch of Pulse/Delay Unit 5 to the white - and the AMPLITUDE control about 20% of the way clockwise. Next we sculpture away 4 volts and 30 microseconds, removed by Unit 4 in Figure 2-6, etc. Note the numbers in the planning sketch correspond to the tabs on the modules. The final voltage level is obtained by adjustment of the input signal to the Power Amplifier with the ADDER LEVEL NO. 2 control. The resulting waveform is shown in Figure 2-7.

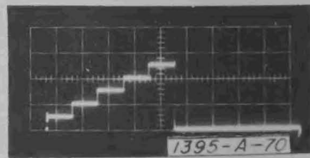


Figure 2-7. An ascending staircase produced by subtracting unwanted voltage levels. Vertical scale is 10 volts per major division; horizontal scale is 10 μs per major division.

2.2.5 EXAMPLE 3: TESTING A DATA-SENSING CIRCUIT.

Suppose we have designed a circuit to determine, in response to interrogating pulses, whether 1's or 0's are present on a data-input line (see Figure 2-8). Data and interrogations may both occur at random times. We wish to test how well the decision-making circuit works.

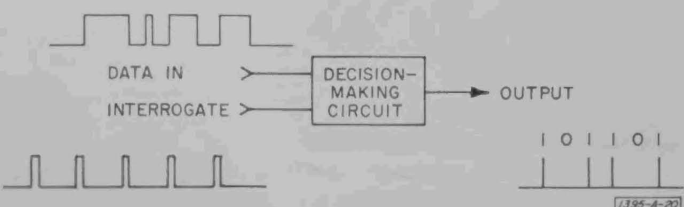


Figure 2-8. A sensing circuit to distinguish between 1's and 0's on a data input line.

It is difficult to make initial tests under entirely random conditions, so to simulate the problem we let data pulses of adjustable duration represent the varying moments of transition from 1 to 0. The interrogating pulses give the illusion of randomness when the time of their occurrence is varied relative to the start of the data pulse. Likewise, the duration of the interrogating pulses can vary. Figure 2-9 shows the possibilities, where T's represent times of pulse

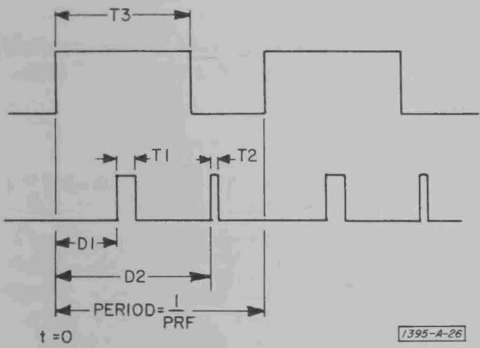


Figure 2-9. The DATA IN signal (top) and the INTERROGATE signal (bottom) shown in Figure 2-8. Duration times (T's), delay times (D's), and amplitudes are all variable.

duration and D's represent times of pulse delay. The upper waveform is the DATA IN signal of Figure 2-8, and the lower waveform is the INTERROGATE signal. All T's, D's, and amplitudes are variable.

The system configuration to produce these pulses is shown in Figure 2-10. The delays all start at t = 0, as does pulse T3. Therefore, the T3, D1, and D2 modules are all connected to the SYNC OUT terminal of the Type 1395-P1 PRF Unit. T1 and T2 are connected to the ADDER (in this case, ADDER NO. 2). The adder applies a composite of the two interrogating

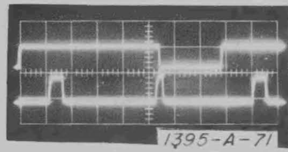


Figure 2-11. Output waveforms generated by the configuration shown in Figure 2-10.

pulses to the INTERROGATE terminal. Note that modules that provide only delay are never connected to the adder.

For a concrete example, let us choose a pulse repetition frequency (PRF) of 100 kc/s and all delay times in the 1-μs to 10-μs range. Interrogating pulses may have from 0.1- to 1-μs duration. Figure 2-11 shows an oscillogram of the data and interrogating waveforms, the latter selected so that D2 puts the second interrogating pulse in a dubious and intriguing situation.

2.2.6 EXAMPLE 4: PULSE SHAPING.

In the design of electronic musical instruments, a question often arises as to what waveform will sound best in its own right or will best imitate some other instrument. The Type 1395-P3 Pulse Shaper is extremely handy for this study. The Pulse Shaper is connected as shown in Figure 2-12 with a Type 1395-P1 PRF Unit to determine pitch and a Type 1395-P2 Pulse/Delay Unit to adjust the ratio of durations of the upper and lower parts of the waveform, thus varying the amount of the second harmonic.

Figure 2-13 shows three waveforms obtained with different settings of the Pulse Shaper. The pitch is C-sharp above middle C. The top waveform is approximately symmetrical, the Pulse/Delay Unit is set for 1.8 milliseconds (each major division is 0.5 millisecond). The rise time of the Pulse Shaper is equal to the fall time, both about 1 millisecond. This

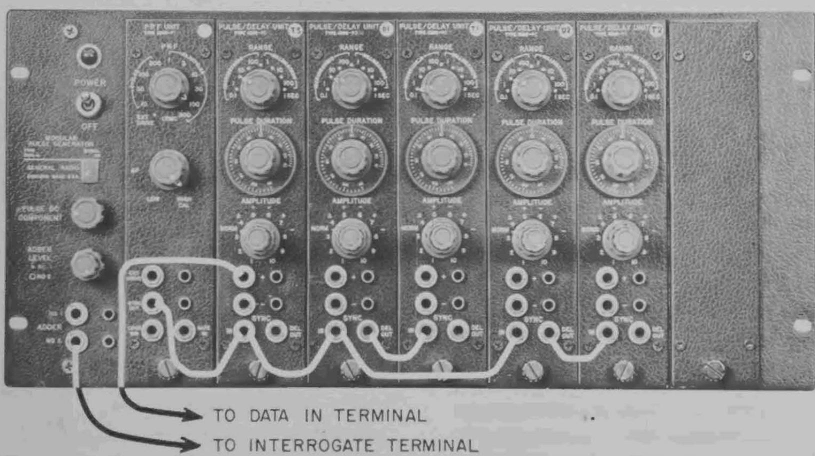


Figure 2-10. Type 1395-A Modular Pulse Generator set up to test the decision-making circuit shown in Figure 2-8.

Figure 2-12. Type 1395 Series modules connected to test musical tones.

tone is rather bland. In the middle waveform, the 1-millisecond rise and fall times are retained, but the Pulse/Delay Unit is set to 2.6 milliseconds. The waveform is now quite asymmetrical, has a pronounced second harmonic, and is a pleasing tone. In the bottom waveform, the 2.6-millisecond duration is retained, but the rise and fall times are much shorter (about 0.1 millisecond). This tone has quite a "bite" to it; any shorter rise time sounds definitely unpleasant.

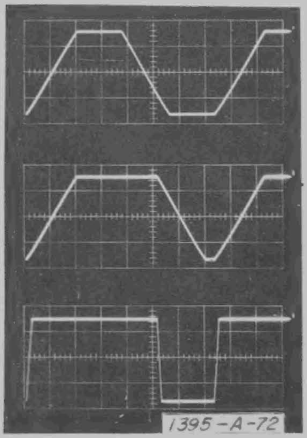


Figure 2-13. Three musical-tone waveforms synthesized by simple adjustments of the Modular Pulse Generator shown in Figure 2-12.

Work with musical tones, data transmission, and many other applications requires precise control of frequency. For such applications, we recommend either the General Radio Type 1161 or Type 1162 Coherent Decade Frequency Synthesizer, as an external driver for the Type 1395-P1 PRF Unit. When extraordinary precision is required, the synthesizer may in turn be controlled by a General Radio Type 1115-B Standard-Frequency Oscillator.

2.3 OPERATING TECHNIQUES.

2.3.1 PLUG-IN MODULES.

A few operating features of the plug-in modules are mentioned in the interconnection examples of paragraph 2.2. For fuller discussion of operating techniques of an individual module, refer to the instruction book for that module.

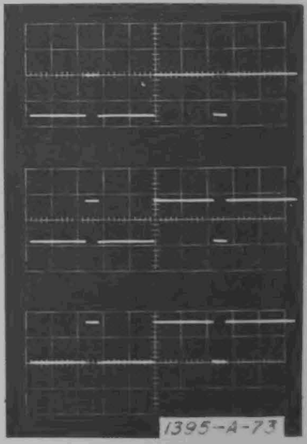
2.3.2 ADJUSTING THE PULSE DC COMPONENT.

The output pulses from the Type 1395-P2 Pulse/Delay Unit and the Type 1395-P3 Pulse Shaper are generated from an adjustable baseline. The positive pulses start from a voltage below the baseline and rise to the baseline; the negative pulses start from the baseline and drop down below it.

Most applications involve pulses referred to ground. To obtain a negative pulse referred to ground, set the PULSE DC COMPONENT control very nearly counterclockwise. (Fully counterclockwise position puts the baseline at about -2 or -3 volts.) To obtain a positive pulse referred to ground, turn the PULSE DC COMPONENT control clockwise until the dc level is shifted positive by an amount equal to the voltage amplitude of the pulse. Then the potential from which the positive pulse starts its rise is 0 volts dc, and the pulse rises up to the true baseline.

Figure 2-14 shows several examples of pulse levels. The top waveform shows a positive pulse starting at about -15 volts and rising to ground, while the negative pulse starts at ground and drops to -15 volts. For the center waveform, ground potential is about at the center of the pulses. The bottom waveform shows a positive pulse starting at 0 volts and rising to +15 volts, while the negative pulse starts at +15 volts and drops to ground.

Figure 2-14. Effect of the PULSE DC COMPONENT control. Each waveform shows a positive pulse on the left and a negative p, lse on the right. Vertical scale is 10 volts per major division; horizontal scale is 100 μs per major division.



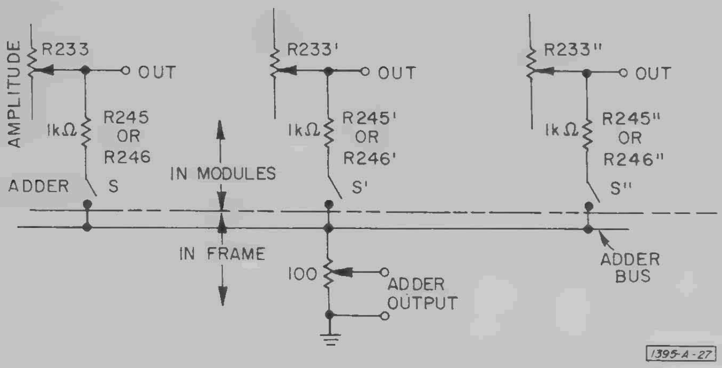


Figure 2-15. The outputs of three Type 1395-P2 Pulse/Delay Units connected to an adder bus in the Type 1395-A main frame.

2.3.3 USE OF THE ADDERS.

2.3.3.1 Normal Operation. The Type 1395-A Modular Pulse Generator frame contains two adder bus bars. The ADDER switch on the front panel of a Type 1395-P2 Pulse/Delay Unit or a Type 1395-P3 Pulse Shaper selects which output (+ OUT or - OUT) will be connected to which adder bus. Red plus and minus symbols represent connection to ADDER NO. 1 and white symbols represent connection to ADDER NO. 2. The ADDER switch position marked with both a red + and a white - simultaneously sends a portion of the + OUT to ADDER NO. 1 and a portion of the - OUT to ADDER NO. 2.

Figure 2-15 shows the outputs of three Type 1395-P2 Pulse/Delay Units connected to an adder bus. Components above the section line are in the modules, those below the line are in the frame. The adder circuits of the Type 1395-P3 Pulse Shaper are identical to those of the Pulse/Delay Unit except for component part numbers.

To begin with, imagine that the prime (') and double-prime ('') units are not plugged in. The tap of R233 (AMPLITUDE control) connects to the OUT terminal and to a 1-kilohm resistor. If S (ADDER switch) is closed, the 1-kΩ resistor is connected to an adder bus. With R233 set for maximum amplitude, the total load resistance is R233 shunted by the sum of R245 and the 100-ohm adder potentiometer (1000 ohms in parallel with 1100 ohms). This resistance is about 525 ohms, and the maximum open-circuit output voltage is 10.5 volts, compared with 20 volts with the adder disconnected. One eleventh (100 ohms ÷ 1100 ohms) of this open-circuit voltage appears at the top of the adder potentiometer (about 0.95 volt). This is an attenuation of about 26.5 dB compared with the open-circuit voltage at the OUT jack when the adder is not connected. To obtain lower voltages at the adder output terminals, turn the ADDER LEVEL controls on the main frame counterclockwise.

When several Pulse/Delay Units are connected to the adder bus (switches S' and S'' in Figure 2-15 are closed, for example), a certain amount of crosstalk is present among the output terminals. Therefore, when the adders are in use, connections should not be made simultaneously to the regular OUT jacks. No harm is done, but the results may be confusing.

2.3.3.2 Adding Externally Produced Signals. If a waveform that is not available from any plug-in module (such as a sine wave or noise) is desired as part of a finished signal, it can be injected into the adder busses from the rear panel (reference numbers 20 through 23 in Figure 1-2).

Between the input jacks and the adder busses are 1000-ohm, 2-watt resistors, corresponding to resistors R245, R246, etc, in Figure 2-15. To avoid overheating these resistors, any voltages injected into the external adder jacks should not be over 40 volts rms. The external adder inputs are direct-coupled to the adder busses. Low frequencies, even down to dc, may be inserted.

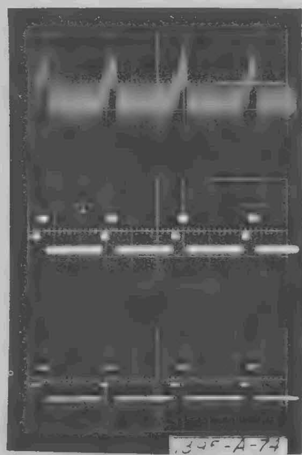


Figure 2-16. A set of noisy pulses produced by injecting random noise into an external ADDER INPUT jack. The noise is attenuated 20 dB in the middle waveform, 40 dB in the bottom waveform.

Figure 2-16 shows the sum of noise plus pulses. This waveform was used to test the ability of a level-sensing circuit to operate in the presence of noise. The noise source was a General Radio Type 1390-B Random-Noise Generator. The first two steps of an ascending staircase were generated by the subtractive method described in paragraph 2.2.4, and the noise signal was injected at ADDER INPUT NO. 2 on the rear panel (reference numbers 22 and 23 in Figure 1-2). In the middle waveform the noise was attenuated 20 dB; in the bottom waveform, 40 dB.

SECTION 3

PRINCIPLES OF OPERATION

3.1 THE MAIN (150-VOLT) POWER SUPPLIES.

The -150-volt supply is the dominant supply in the Type 1395-A because it also serves as the reference voltage source for the positive supplies. Figure 3-1 is a simplified circuit diagram of the -150-volt power supply. The complete circuit diagram of the instrument, Figure 4-3, shows this circuit with the time-delay relay, fuses, etc. There are basically four parts in this power supply:

1) voltage reference, regulator tube V507
2) amplifiers, tubes V506 and V505
3) series tube, V502
4) rectifiers and filters, CR505, CR506, CR507, CR508, C502, and C512.

The main current path is as follows: from anchor terminal AT512 through series tube V502 to ground; up from ground through any loads connected to the -150-volt supply, and into AT518; from AT518 back through the rectifier-filter area, ending at AT512.

The regulator action can best be explained in terms of what happens if the output voltage changes. Suppose a module is unplugged and the load on the -150-volt supply decreases. We assume the voltage then increases, say to -160 volts. Pin 7 of V506 is held at -87 volts by the reference tube V507, so the added voltage (10 volts) must be accounted for by an increased IR drop in R529. Otherwise, pin 8 would change from -86 volts to -96 volts, and the right-hand half of V506 would have a positive bias of 9 volts.

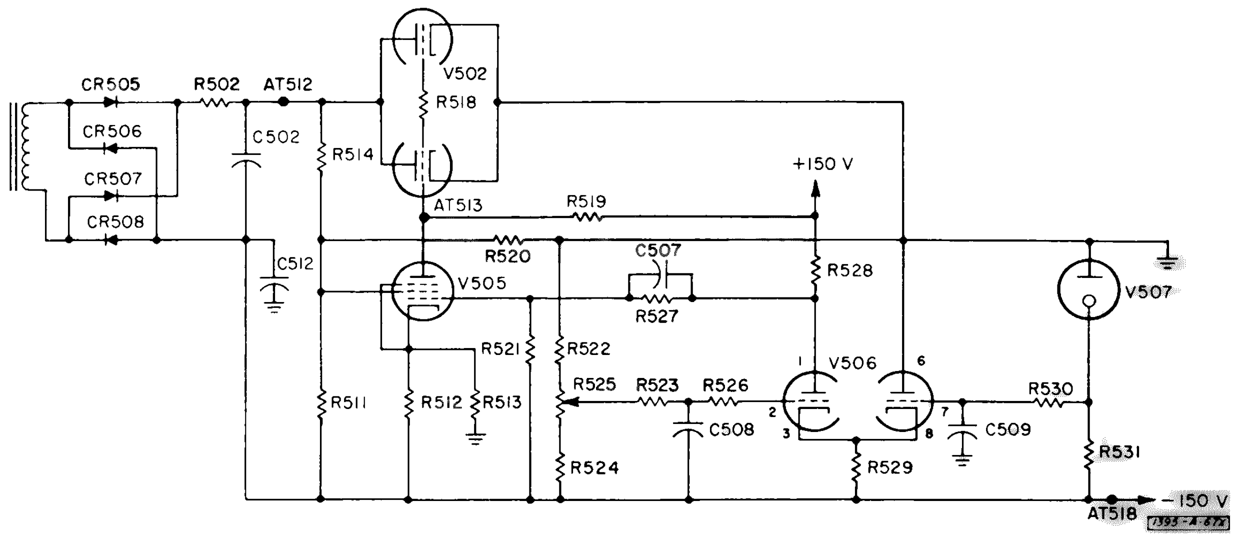


Figure 3-1. Schematic diagram of the -150-volt power supply.

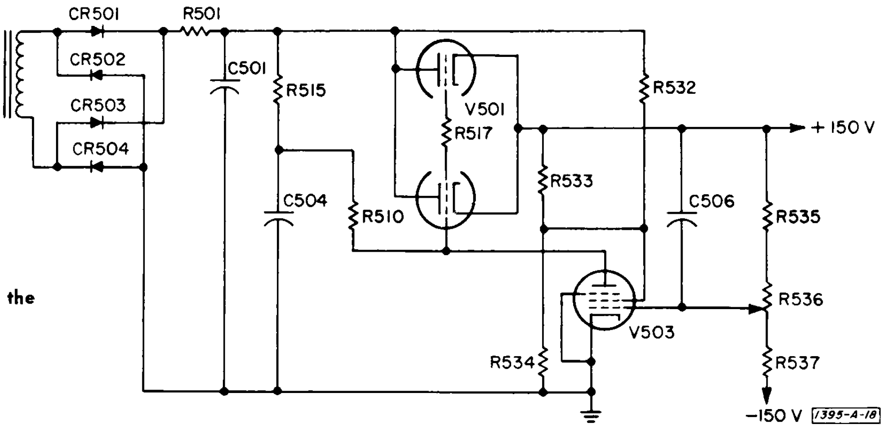


Figure 3-2. Schematic diagram of the +150-volt power supply.

Actually, the increased current from the right-hand triode provides added IR drop in R529 and the potential at pins 3 and 8 stays close to -86 volts.

In the meantime, the voltage at pin 2 of V506 has changed. Normally this pin has 87/150's of the output (-87 volts). When the output voltage changes to -160 volts, this voltage becomes about -93 volts. As a result, the left-hand side of V506 is biased much closer to cutoff than before, and so the voltage on its plate becomes more positive. This causes V505 to conduct harder, and the voltage on the plate of V505 (AT513) decreases. The voltage on the grids of V502 is identical to the plate voltage of V505. V502 now has a more negative bias, so V502 conducts less well. V502 may be thought of as a resistor that has suddenly increased in value. Then AT512 rises in potential.

The rectifier assembly floats between AT512 and AT518, so when AT512 rises in potential, AT518 also rises. AT518 is the output point, and when it rises in potential, it will no longer be at -160 volts but restored towards -150 volts where it belongs.

Figure 3-2 shows the +150-volt power supply. It is substantially the same as the -150-volt supply, except that it has no voltage reference tube. The reference voltage is the -150 volts that appears at the bottom of R537, which depends on the accuracy and stability of the -150-volt supply.

The two power supplies are mutually dependent. Note that in Figure 3-1, resistors R519 and R528 are referred to the +150-volt supply. This dependence is built in so that a small perturbation in one supply is accompanied by a similar change in the other. For example, in Figure 3-2, if the -150-volt reference at R537 goes more negative, the grid of V503 responds as if the +150-volt output were less positive. Therefore, the control action increases the +150-volt potential. Any devices connected between the +150-volt and the -150-volt supplies are affected nearly symmetrically. The benefit of this feature to the variable dc supply is described in paragraph 3.3.

3.2 THE +15-VOLT POWER SUPPLY.

The +15-volt power supply furnishes an average current of only a few milliamperes. This supply is the voltage source for the synchronizing pulse generators that deliver pulses of about 0.1-microsecond duration. This application ensures a low duty cycle and therefore a relatively light current drain.

As shown in Figure 3-3, the +15-volt supply is simply a cathode follower. Since the cathode-follower circuit presents a low output impedance, the voltage at AT8 stays a few volts positive relative to the potential on the grid, pin 7.

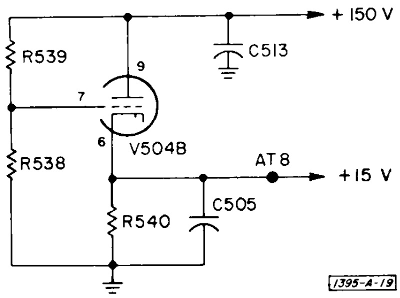


Figure 3-3. Schematic diagram of the +15-volt power supply.

3.3 THE VARIABLE DC SUPPLY, 0 TO 20 VOLTS.

The variable dc supply is the source of baseline voltage from which pulses are generated in the Type 1395-P2 Pulse/Delay Unit and the Type 1395-P3 Pulse Shaper. The schematic diagram is shown in Figure 3-4. This supply is, in a sense, a double cathode follower in which the output of cathode follower V504A is the reference voltage for emitter follower Q501.

This circuit shows well the advantages of symmetrical variations in the +150-volt and -150-volt power supplies. Suppose the tap on R508 is set so that AT525 is at ground potential. Now let the +150-volt supply increase in value but allow no change in the -150-volt supply. AT525 will rise above ground, and the variable dc voltage will change in value. On the other hand, if the -150-volt supply drops in potential about as much as the +150-volt supply rises, the voltage at AT525 remains essentially constant, and so does the variable dc voltage.

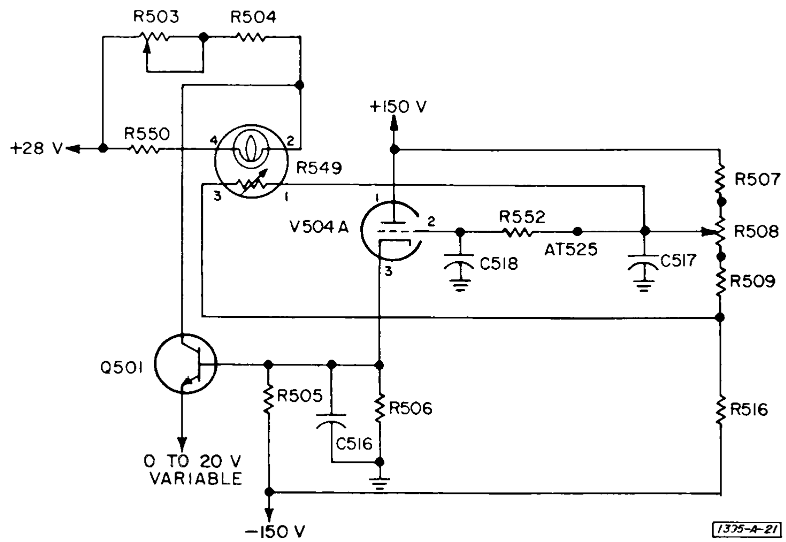


Figure 3-4. Schematic diagram of the 0-to-20 volt variable power supply.

If the variable supply is set for any value other than 0 and a heavy load is connected to the supply (for example, accidental grounding of an output terminal of a Type 1395-P2 Pulse/Delay Unit or Type 1395-P3 Pulse Shaper), damaging currents presumably would flow. This difficulty is prevented by the current-limiting system. If heavy current flows in the collector of Q501, part of this current will be enough to cause the filament between terminals 2 and 4 of the photo-resistor R549 to glow. This causes the value of R549 to drop, effectively connecting AT525 to the junction between R509 and R516. This junction point is sufficiently negative to cut off tube V504A, so the base of Q501 is left at about -4.7 volts and Q501 turns off, ending the flow of current.

The preceding explantion is oversimplified, since if the current ceases entirely, R549 will return to a high resistance, and the current flow will resume. Actually, a limiting action takes place. The limiting current is determined by how heavily R503 and R504 shunt R550 and the filament of R549. During factory adjustment, the value of R503 is set to limit the current available from Q501 to 150 mA.

SECTION 4

SERVICE AND MAINTENANCE

4.1 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.

4.2 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 the 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.

4.3 TROUBLE-SHOOTING.

4.3.1 GENERAL.

If the Type 1395-A Modular Pulse Generator fails to operate properly, be sure that the modules are in good working order. Replace any suspected module with another of the same type known to be in good repair.

Be sure the fuses in the frame (rear panel) are of the proper value and not burned out. Be sure that the power-line voltage and frequency are correct.

If the filaments in the tubes glow, but no dc power is available at the connectors, check the two relays mounted above the power transformer in the left rear portion of the instrument.

Table 4-1 gives the voltages or resistances that should appear on the various pins of the module connectors (10 through 16 in Figure 1-1). When using Table 4-1, refer as necessary to the circuit diagram of Figure 4-3 and to the etched-board layouts in Figures 4-1 and 4-2.

4.3.2 THE 150-VOLT SUPPLIES.

First, remove all the plug-in modules from the main frame. The +150-volt and -150-volt supplies are interdependent, and a serious malfunction in either one will cause both to misbehave. The most probable trouble is a defective tube. Remove all tubes and test them. If the tubes are operating properly, leave them out of their sockets for the moment and proceed as follows:

Turn on the power and wait for the time-delay relay to click. With a dc voltmeter, measure the voltage across C501. This voltage should be between 240 and 275 volts, depending on the exact value of line voltage. If it is appreciably less than 240 volts, check for a shorted C501, an open (probably charred or cracked) R501, or one or more damaged rectifiers CR501, CR502, CR503, or CR504. If the voltage is right, connect a load that will draw about 100 milliamperes across C501. Remember that this represents about 25 watts of power, so use an adequate resistor. A couple of 15-watt, 120-volt light bulbs connected in series will suffice if an adequate resistor is not available. Again measure the voltage across C501. It should be 10 or 15 volts less than the first measurement. If the voltage drop is much more than 15 volts, the diodes CR501 through CR504 are providing only half-wave rectification and two of the diodes are open-circuited. If the voltage drop is only a little more than 10 to 15 volts, there may be one defective diode. On an oscilloscope, look at the voltage across C501. If the ripple frequency is 60 c/s, a defective diode exists. If the ripple is 120 c/s, the diodes, R501, and C501 are operating properly.

Repeat the tests just described, measuring the voltage across C502.

WARNING

Capacitor C502 is not grounded. The voltmeter must float across it. Be careful to avoid injury from electrical shock.

Measure the resistance across capacitor C512 with an ohmmeter (positive lead grounded). The ohmmeter indication will be very low initially, but should build up to 11,400 ohms ±5%. If the resistance is less, C512 is almost surely defective. This measurement also checks the following resistors: R505, R506, R511, R512, R513, R520, R522, R524, R525, R545, and R546. Resistance higher than 11,400 ohms indicates that one or more of these resistors is open-circuited.

Measure the resistance from pin 3 or pin 6 of V501 to ground, with the negative side of the ohmmeter grounded. This resistance should be 31,000 ohms ±5%. The following resistors are checked by this measurement: R507, R508, R509, R516, R521, R527, R528, R533, R534, R535, R536, R537, R538, R539, R541, R542, R543, and R544.

If nothing has been found wrong this far, replace tubes V502, V505, V506, and V507 in their sockets. Connect +150 volts to pin 6 of V501 from an external power supply. Turn on the Type 1395-A Modular Pulse Generator and see if the -150-volt supply is now all right. If the -150-volt supply is correct, the trouble is in the +150-volt supply. If the -150-volt supply is not correct, check through the circuit of the -150-volt supply for the voltages shown in Figure 4-1.

If the trouble is localized in the +150-volt supply, proceed as follows: Remove tubes V502, V505, V506, and V507 from their sockets. Remove the external +150-volt supply. Insert tubes V501 and V503 into their sockets, and connect an external source of -150 volts to anchor terminal AT518. Turn on the Modular Pulse Generator and check through the circuit of the +150-volt supply for the voltages shown in Figure 4-1.

When both 150-volt supplies are operating properly, replace all the tubes.

4.3.3 THE +15-VOLT SUPPLY.

Remove all modules. Remove tube V504 from its socket and test it. If the tube is all right, continue as follows: With an ohmmeter, measure the resistance from AT510 to ground (positive ohmmeter lead on AT510). This resistance should be 10,000 ohms ±5%. If the resistance is low, the defective component is probably C505; if the resistance is high, the defective component is probably R540.

Turn on the power (V504 still out of its socket) and measure the voltage at pin 7 of V504. This voltage should be 11.7 volts ±5%. If the voltage is low, the value of R538 is too low or the value of R539 is too high; if the voltage is high, the value of R538 is too high or the value of R539 is too low.

4.3.4 THE VARIABLE DC SUPPLY.

Most troubles in the 0-to-20-volt variable dc supply arise from a heavy overload that occurs when the CURRENT LIMIT control R503 is misadjusted. In this case, R504 will be charred and probably cracked. Usually the photoresistor assembly R549 is destroyed simultaneously, but damage to this component is not detectable by its appearance.

Test Q501. If you remove Q501 to test it, be very careful to replace the mica washer and insulating shoulder washers so that the case of Q501 cannot touch the chassis. If the case is grounded even momentarily, the filament in R549 is almost sure to burn out, regardless of the setting of R503.

If the variable dc supply voltage does not respond to the PULSE DC COMPONENT control on the front panel, test V504. With V504 out of the socket, check the voltage at AT516 or AT527. This voltage should be -4.7 volts ±5%. If the voltage is somewhat more negative, R506 is too large or R505 is too small; if the voltage is much more negative, R506 is open or R505 is shorted; if the voltage is between -4.7 volts and 0, R505 is too large or R506 is too small; if the voltage is 0, R506 or C516 is shorted; if the voltage is positive, Q501 has broken down between the collector and base.

NOTE

The voltage delivered by the variable dc supply will drop very slowly as the PULSE DC COMPONENT control is turned counterclockwise unless there is a load on the supply. A load of about 1 kΩ to 2 kΩ connected between pin 10 on any module socket and ground is sufficient.

4.4 NORMAL ADJUSTMENTS AND CALIBRATION.

4.4.1 THE 150-VOLT SUPPLIES.

First set the -150-volt supply. Connect a voltmeter to pin 2 on any of the module connectors or, if the instrument is out of its cabinet, to AT518. Adjust R525 until the voltmeter indicates -150 volts. Then connect the voltmeter to pin 1 on any of the sockets or to AT509. Adjust R536 until the voltage is +150 volts. Because the two supplies are interdependent, recheck and trim up these voltages two or three times, setting first one and then the other.

4.4.2 THE CURRENT LIMIT CONTROL.

Remove all the modules from the chassis. Turn the CURRENT LIMIT control on the back panel fully counterclockwise.

CAUTION

For the next few steps there is no protection against overloads on the variable dc supply.

Connect a dc voltmeter between pin 10 of any one of the seven plug-in sockets and ground. Adjust the PULSE DC COMPONENT control so that the voltmeter indicates zero. Between any pin 10 and ground, connect a 120-ohm, 5-watt resistor with a milliammeter in series with the resistor. Use a milliammeter with a full-scale value from 200 to 500 milliamperes (preferably nearer 200 mA).

Watch the milliammeter closely while you gradually rotate the PULSE DC COMPONENT control clockwise. Increase the current until the meter reads 160 milliamperes. The PULSE DC COMPONENT control will be almost completely clockwise at this current indication. On the rear panel, rotate the CURRENT LIMIT control clockwise. Watch the milliammeter. When the current drops to 150 milliamperes, the CURRENT LIMIT control is calibrated. Turn off the power and remove the meter and the 120-ohm resistor.

4.5 ROUTINE MAINTENANCE.

4.5.1 PILOT LIGHT.

The pilot light in this instrument is operated at about 10% below its rated voltage and should last many thousands of hours. When replacement is necessary, remove the red plastic cap on the pilot light. Rotate the cap counterclockwise. Touch only the cap, not the silver-colored knurled nut between the cap and the front panel. To remove the bulb, rotate it counterclockwise. This bulb has a screw base, not a bayonet-type base. Three or four full turns will be necessary to get the bulb out. To get a better grip on the bulb, slip a bit of rubber or plastic tubing over it. Replace with a 7-volt, midget-screw-base, T-1 3/4 bulb, such as Drake Company No. 765.

4.5.2 FAN.

To extend the life of the fan, oil the bearing about once a year. Use an industrial hypodermic needle to pierce the label and self-sealing rubber cap and inject lubricant into the well, or order an Oil Injector for Gold Seal Muffin Fans from the Rotron Company.

4.5.3 FILTER.

The air filter on the rear cover should be cleaned between two and four times a year, depending on how dusty the environment is. Wash the filter in hot water with any household soap or detergent, rinse it well, and drain dry or blow dry with an air hose.

TABLE 4-1
CONNECTOR VOLTAGES AND RESISTANCES

Pin	*Voltage*	*Remarks*
1	+150	The +150-V level depends on the -150-V supply. First check the -150-V level at pin 2 (see below). When the -150-V level is correct, adjust the +150-V level with R536. If this does not correct the level, check tubes V501 and V503.
2	-150	Adjust R525. If this does not correct the -150-V level, check tubes V502, V505, V506, and V507.
3 4		Pins 3 and 4 are used for interconnection between Type 1395-P6 Word Generators. Resistance from any pin 3 to ground or from any pin 4 to ground must be at least 100 megohms. Resistance between pin 4 on one socket and pin 3 on the next (e.g., pin 4 of SO501 to pin 3 of SO502) and between pin 4 of SO507 to pin 3 of SO501 must be less than one ohm.
5		Turn the ADDER controls on all modules to NORM. Set ADDER LEVEL NO. 2 fully clockwise. Measure the resistance between pin 5 and the ADDER NO. 2 output terminal with an ohmmeter. If this resistance is higher than 5 ohms, check for broken wires between the plug and printed board or a defective ADDER LEVEL NO. 2 potentiometer.
6 13	6.3 V, 60 c/s, at -75 V dc	Check fuses. If the dc level differs by more than about 10% from -75 volts, suspect a cathode-filament short in V505 or V506, or one of the plug-ins.
7 14	6.3 V, 60 c/s, at +50 V dc	Check fuses. If the dc level differs by more than about 10% from +50 volts, suspect a cathode-filament short in one of the plug-ins.
8	+15	This supply is not regulated and cannot furnish much current. A voltage between 12 and 18 volts is OK. If the voltage is less than 12 volts, look for excessive current in one of the modules. If a Pulse/Delay Unit is suspected, look for a shorted CR210.
9	Ground	Check continuity with an ohmmeter. If the resistance between pin 9 and chassis is more than 1 ohm, look for broken wires or cold solder joints.
10	0 to +20 V dc, variable	Turn the PULSE DC COMPONENT control back and forth. Voltage on pin 10 must vary at least from 0 to +20 volts, and will probably vary from -2 or -3 volts to +22 volts or more. If performance falls short of a variation from 0 to +20 volts, check V504 and Q501. Refer to NOTE in paragraph 4.3.4.
11		Resistance between pin 11 on one socket and pin 11 on any other socket must not be over 1 ohm. If the resistance is higher, check the printed board (Figure 4-3) or leads from socket to board. Resistance between pin 11 on any socket and ground must be at least 100 megohms. If it is less, look for short circuits, dirty board, or solder splashes.
12		Turn the ADDER controls on all modules to NORM. Set the ADDER LEVEL NO. 1 fully clockwise. Measure the resistance between pin 12 and ADDER NO. 1 output terminal with an ohm-meter. If this resistance is greater than 5 ohms, check for broken wires between plug and printed board or defective ADDER LEVEL NO. 1 potentiometer.

TABLE 4-2
TABLE OF VOLTAGES

Tube or Transistor (Type)	*Pin*	*DC Volts to Ground*
V501 (6080)	1	+122
	2	+235
	3	+151
	4	+122
	5	+235
	6	+151
	7	+75
	8	+75
V502 (6080)	1	-29
	2	+82
	3	0
	4	-29
	5	+82
	6	0
	7	+75
	8	+75
V503 (6AU6)	1	-1.8
	2	0
	3	+75
	4	+75
	5	+122
	6	+70
	7	0
Q501 (2N2196)	E	+22
	B	+23
	C	+27
V504 (7119)	1	+151
	2	+17
	3	+23
	4	+75
	5	+75
	6	+19
	7	+12
	8	+75
	9	+151

Tube or Transistor (Type)	*Pin*	*DC Volts to Ground*
V505 (6AU6)	1	-89
	2	-87
	3	-75
	4	-75
	5	-29
	6	-11
	7	-87
V506 (5751)	1	+1
	2	-87
	3	-86
	4	-75
	5	-75
	6	0
	7	-87
	8	-86
	9	-75
V507 (5651)	1	0
	2	No Connection
	3	No Connection
	4	No Connection
	5	No Connection
	6	No Connection
	7	-87

Test Conditions: One 1395-P1 PRF Unit and four 1395-P2 Pulse/Delay Units are inserted into the instrument. The PRF Unit is set to operate at 300 kc/s. No connections are made between any of the modules. The PULSE DC COMPONENT control is fully clockwise. Voltages are measured with a dc voltmeter, 20,000 ohms per volt. The voltages listed should be considered a guide to expected values, rather than an "average" or a go-no-go check list.

PARTS LIST

REF NO.	DESCRIPTION	PART NO.
	CAPACITORS	
C501A, C501B, C501C	Electrolytic, 60 µF, 50 µF, 50 µF +100 -10% 300 V	4450-2650
C502A, C502B, C502C	Electrolytic, 60 µF, 50 µF, 50 µF +100 -10% 300 V	4450-2650
C503	Electrolytic, 3000 µF +100 -10% 30 V	1150-0440
C504	Plastic, 0.47 ±F ±10% 200 V	4860-8247
C505	Ceramic, 0.1 µF +80 -20% 50 V	4403-4100
C506	Ceramic, 0.022 µF +80 -20% 500 V	4407-3229
C507	Ceramic, 0.022 µF +80 -20% 500 V	4407-3229
C508	Ceramic, 0.022 µF +80 -20% 500 V	4407-3229
C509	Ceramic, 0.022 µF +80 -20% 500 V	4407-3229
C510	Ceramic, 0.047 µF ±20% 500 V	4409-3470
C511	Ceramic, 0.047 µF ±20% 500 V	4409-3470
C512A, C512B	Electrolytic, 25 µF, 25 µF +100 -10% 200 V	4450-3300
C513	Plastic, 0.47 µF ±10% 200 V	4860-8247
C514	Plastic, 0.47 µF ±10% 200 V	4860-8247
C515	Ceramic, 0.47 µF ±20% 25 V	4400-2054
C516	Plastic, 1 µF ±10% 100 V	4860-8274
C517	Ceramic, 1 µF ±20% 25 V	4400-2070
C518	Ceramic, 1 µF ±20% 25 V	4400-2070
	DIODES	
CR501 through CR508	Type 1N3254	6081-1002
CR509	Type 1N3253	6081-1001
CR510	Type 1N3253	6081-1001
	FUSES	
F501	115-volt, 3.2-ampere	5330-2300
	230-volt, 1.6-ampere	5330-1700
F502	115-volt, 3.2-ampere	5330-2300
	230-volt, 1.6-ampere	5330-1700
F503 through F505	8-ampere	5330-2550
	JACKS	
J501		4150-3100
J502		4150-3100
J503		5440-2727
J504		5440-2727
J505		4150-3200
J506		4150-3200
J507		5440-2727
J508		5440-2727
	MOTOR	
MO501	Fan Motor	5180-4687
	PILOT LIGHT	
P501		7510-1380

PARTS LIST (continued)

REF NO.	DESCRIPTION	PART NO.
	PLUG	
PL501	Power Plug	4240-0600
	TRANSISTOR	
Q501	Type 40250	8210-1095
	RESISTORS	
R501	Composition, 4.7 Ω ±10% 1 W	6100-9479
R502	Composition, 4.7 Ω ±10% 1 W	6100-9479
R503	POTENTIOMETER, Wire-wound 10 Ω ±10%	6050-0600
R504	Composition, 4.7 Ω ±5% 1/2 W	6100-9475
R505	Composition, 68 kΩ ±5% 1/2 W	6100-3685
R506	Composition, 2.2 kΩ ±5% 1/2 W	6100-2225
R507	Film, 178 kΩ ±1% 1/8 W	6250-3178
R508	POTENTIOMETER, Composition 50 kΩ ±10%	6040-1765
R509	Composition, 20 kΩ ±5% 1/2 W	6100-3205
R510	Composition, 220 kΩ ±5% 1/2 W	6100-4225
R511	Composition, 150 kΩ ±5% 1/2 W	6100-4155
R512	Composition, 12 kΩ ±5% 1/2 W	6100-3125
R513	Composition, 18 kΩ ±5% 1 W	6110-3185
R514	Composition, 120 kΩ ±5% 1/2 W	6100-4125
R515	Composition, 130 kΩ ±5% 1/2 W	6100-4135
R516	Film, 159 kΩ ±1% 1/8 W	6250-3159
R517	Composition, 1 kΩ ±5% 1/2 W	6100-2105
R518	Composition, 1 kΩ ±5% 1/2 W	6100-2105
R519	Composition, 2.2 MΩ ±5% 1/2 W	6100-5225
R520	Composition, 68 kΩ ±5% 1/2 W	6100-3685
R521	Composition, 2.2 MΩ ±5% 1/2 W	6100-5225
R522	Film, 68.1 kΩ ±1% 1/8 W	6250-2681
R523	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R524	Film, 51.1 kΩ ±1% 1/8 W	6250-2511
R525	POTENTIOMETER, Composition 10 kΩ ±20%	6040-0700
R526	Composition, 1 kΩ ±5% 1/2 W	6100-2105
R527	Composition, 3.3 MΩ ±5% 1/2 W	6100-5335
R528	Composition, 680 kΩ ±5% 1/2 W	6100-4685
R529	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R530	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R531	Composition, 33 kΩ ±5% 1/2 W	6100-3335
R532	Composition, 220 kΩ ±5% 1/2 W	6100-4205
R533	Composition, 68 kΩ ±5% 1/2 W	6100-3685
R534	Composition, 39 kΩ ±5% 1/2 W	6100-3395
R535	Film, 332 kΩ ±1% 1/8 W	6250-3332
R536	POTENTIOMETER, Composition 25 kΩ ±20%	6040-0800
R537	Film, 332 kΩ ±1% 1/8 W	6250-3332
R538	Composition, 11 kΩ ±5% 1/2 W	6100-3115
R539	Composition, 130 kΩ ±5% 1/2 W	6100-4135
R540	Composition, 10 kΩ ±5% 1/2 W	6100-3105
R541	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R542	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R543	Composition, 51 kΩ ±5% 1/2 W	6100-3515
R544	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R545	Composition, 24 kΩ ±5% 1/2 W	6100-3245
R546	Composition, 24 kΩ ±5% 1/2 W	6100-3245
R547	Composition, 6.8 Ω ±5% 1/2 W	6100-9685
R548A R548B	POTENTIOMETER, Composition 100 Ω / 100 Ω ±10%	6045-1000
R549	Photoresistor, Type CK1115	1395-0430
R550	Composition, 30 Ω ±5% 1/2 W	6100-0305

PARTS LIST (continued)

REF NO.	DESCRIPTION	PART NO.
	RESISTORS	
R551	Composition, 3.3 kΩ ±10% 1 W	6110-2339
R552	Composition, 33 kΩ ±5% 1/2 W	6100-3335
R553 through R556	Composition, 200 Ω ±5% 1/2 W	6100-1205
R557	Composition, 1 kΩ ±5% 2 W	6120-2105
R558	Composition, 1 kΩ ±5% 2 W	6120-2105
	RELAYS	
RE501	Time-Delay Relay	1395-0410
RE502		1130-0440
	SWITCH	
S501	Power Switch	7910-1300
	SOCKETS	
SO501 through SO507		4230-5004
	TRANSFORMER	
T501		0685-4100
	TUBES	
V501	Type 6080	8380-6080
V502	Type 6080	8380-6080
V503	Type 6AU6	8360-2100
V504	Type 7119	8380-7119
V505	Type 6AU6	8360-2100
V506	Type 5751	8380-5751
V507	Type 5651	8380-5651

NOTE

In instruments with serial numbers below 168, photoresistor R549 may be a Type CK1114. In this case, a Type T156 diode is connected across terminals 2 and 4 of R549, and R550 is a 100-ohm resistor.

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 INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4 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

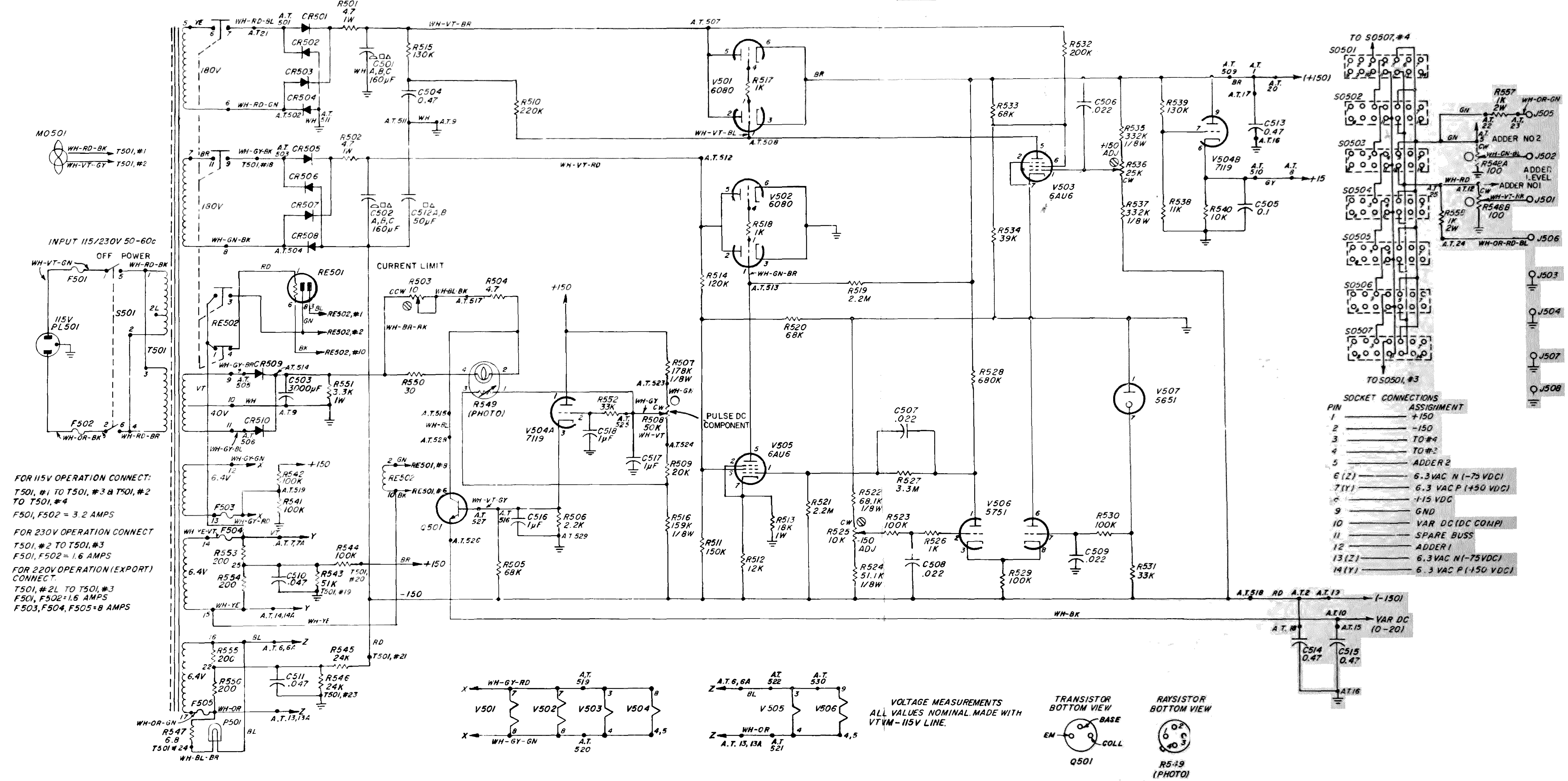


Figure 4-1. Schematic diagram of the Type 1395-A power-supply board.