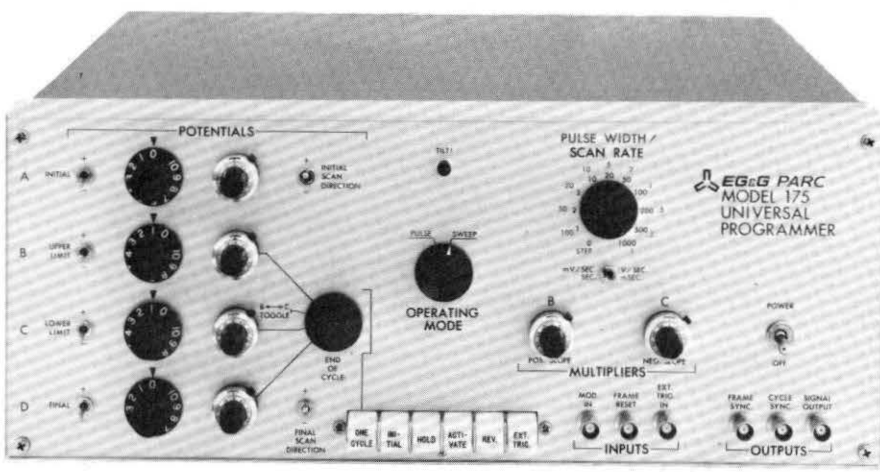
MODEL 175 UNIVERSAL PROGRAMMER

**READ SAFETY NOTICE
PRECEDING SECTION I
BEFORE OPERATING INSTRUMENT**



OPERATING AND SERVICE MANUAL

EG&G
PRINCETON APPLIED RESEARCH

MODEL 175
UNIVERSAL PROGRAMMER

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EG&G PRINCETON APPLIED RESEARCH

MDL 175; 2/81-MG

Printed in U.S.A.

SHOULD YOUR EQUIPMENT REQUIRE SERVICE

A. Contact the factory (609/452-2111) or your local factory representative to discuss the problem. In many cases it will be possible to expedite servicing by localizing the problem to a particular plug-in circuit board.

B. If it is necessary to send any equipment back to the factory, we need the following information.

(1) Model number and serial number.

(2) Your name (instrument user).

(3) Your address.

(4) Address to which instrument should be returned.

(5) Your telephone number and extension.

(6) Symptoms (in detail, including control settings).

(7) Your purchase order number for repair charges (does not apply to repairs in warranty).

(8) Shipping instructions (if you wish to authorize shipment by any method other than normal surface transportation).

C. U.S. CUSTOMERS—Ship the equipment being returned to:

EG&G PRINCETON APPLIED RESEARCH
7 Roszel Road
(Off Alexander Road, East of Route 1)
Princeton, New Jersey

D. CUSTOMERS OUTSIDE OF U.S.A.—To avoid delay in customs clearance of equipment being returned, please contact the factory or the nearest factory distributor for complete shipping information.

E. Address correspondence to:

EG&G PRINCETON APPLIED RESEARCH
P. O. Box 2565
Princeton, NJ 08540

Phone: 609/452-2111
TELEX: 84 3409

WARRANTY

EG&G PRINCETON APPLIED RESEARCH warrants each instrument of its manufacture to be free from defects in material and workmanship. Obligations under this Warranty shall be limited to replacing, repairing or giving credit for the purchase price, at our option, of any instrument returned, freight prepaid, to our factory within ONE year of delivery to the original purchaser, provided prior authorization for such return has been given by our authorized representative.

This Warranty shall not apply to any instrument which our inspection shall disclose to our satisfaction, has become defective or unworkable due to abuse, mishandling, misuse, accident, alteration, negligence, improper installation or other causes beyond our control. Instruments manufactured by others, and included in or supplied with our equipment, are not covered by this Warranty but carry the original manufacturer's warranty which is extended to our customers and may be more restrictive. Certain subassemblies, accessories or components may be specifically excluded from this Warranty, in which case such exclusions are listed in the Instruction Manual supplied with each instrument.

We reserve the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION HEREIN. THIS WARRANTY IS IN LIEU OF, AND EXCLUDES ANY AND ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESSED, IMPLIED OR STATUTORY, INCLUDING MERCHANTABILITY AND FITNESS, AS WELL AS ANY AND ALL OTHER OBLIGATIONS OR LIABILITIES OF EG&G PRINCETON APPLIED RESEARCH, INCLUDING, BUT NOT LIMITED TO, SPECIAL OR CONSEQUENTIAL DAMAGES. NO PERSON, FIRM OR CORPORATION IS AUTHORIZED TO ASSUME FOR EG&G PRINCETON APPLIED RESEARCH ANY ADDITIONAL OBLIGATION OR LIABILITY NOT EXPRESSLY PROVIDED FOR HEREIN EXCEPT IN WRITING DULY EXECUTED BY AN OFFICER OF EG&G PRINCETON APPLIED RESEARCH.

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SAFETY CONSIDERATIONS

A. INTRODUCTION

The apparatus to which this instruction manual applies has been supplied in a safe condition. This manual contains some information and warnings that have to be followed by the user to ensure safe operation and to retain the apparatus in a safe condition. The described apparatus has been designed for indoor use.

B. INSPECTION

Newly received apparatus should be inspected for shipping damage. If any is noted, immediately notify EG&G PARC and file a claim with the carrier. The shipping container should be saved for possible inspection by the carrier.

WARNING!

THE PROTECTIVE GROUNDING COULD BE RENDERED INEFFECTIVE IN DAMAGED APPARATUS. DAMAGED APPARATUS SHOULD NOT BE OPERATED UNTIL ITS SAFETY HAS BEEN VERIFIED BY QUALIFIED SERVICE PERSONNEL. DAMAGED APPARATUS WAITING FOR SAFETY VERIFICATION SHOULD BE TAGGED TO INDICATE TO A POTENTIAL USER THAT IT MAY BE UNSAFE AND THAT IT SHOULD NOT BE OPERATED.

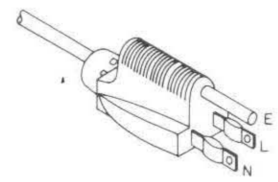
C. SAFETY MECHANISM

As defined in IEC Publication 348 (*Safety Requirements for Electronic Measuring Apparatus*), the Model 175 is Class I apparatus, that is, apparatus that depends on connection to a protective conductor to earth ground for equipment and operator safety. Before any other connection is made to the apparatus, the protective earth terminal shall be connected to a protective conductor. The protective connection is made via the earth ground prong of the M175's power cord plug. This plug shall only be inserted into a socket outlet provided with the required earth ground contact. The protective action must not be negated by the use of an extension cord without a protective conductor, or by use of an "adapter" that doesn't maintain earth ground continuity, or by any other means.

The power cord plug provided is of the type illustrated in Figure 1. If this plug is not compatible with the available power sockets, the plug or power cord should be replaced with an approved type of compatible design.

WARNING!

IF IT IS NECESSARY TO REPLACE THE POWER CORD OR THE POWER CORD PLUG, THE REPLACEMENT CORD OR PLUG MUST HAVE THE SAME POLARITY AS THE ORIGINAL. OTHERWISE A SAFETY HAZARD FROM ELECTRICAL SHOCK, WHICH COULD RESULT IN PERSONAL INJURY OR DEATH, MIGHT RESULT.



L = LINE OR ACTIVE CONDUCTOR (ALSO CALLED "LIVE" OR "HOT")
N = NEUTRAL OR IDENTIFIED CONDUCTOR
E = EARTH OR SAFETY GROUND

Figure 1. POWER CORD PLUG WITH POLARITY INDICATIONS

D. POWER VOLTAGE SELECTION AND LINE FUSES

Before plugging in the power cord, make sure that the equipment is set to the voltage of the ac power supply.

CAUTION!

THE APPARATUS DESCRIBED IN THIS MANUAL MAY BE DAMAGED IF IT IS SET FOR OPERATION FROM 110 V AC AND TURNED ON WITH 220 V AC APPLIED TO THE POWER INPUT CONNECTOR.

A detailed discussion of how to check and, if necessary, change the power-voltage setting follows.

The line voltage is selected by means of a rear-panel switch. FOR SAFETY, UNPLUG THE POWER CORD WHEN CHECKING THE LINE VOLTAGE SETTING OR WHEN CHECKING THE FUSES. FUSES SHOULD ONLY BE CHANGED BY QUALIFIED SERVICE PERSONNEL WHO ARE AWARE OF THE HAZARDS INVOLVED. Depending on the switch position, either "115" or "230" (both are printed on the switch) will be visible to the viewer. For operation from a line voltage from 100 V ac to 130 V ac, 50-60 Hz, "115" should show. For operation from a line voltage from 200 V to 260 V ac, 50-60 Hz, "230" should show.

The line fuse holder is located at the rear panel as well. For operation from 115 V or 230 V, use a slow-blow fuse rated at 3/4 A (voltage rating 250 V or higher).

WARNING!

TO AVOID THE POSSIBILITY OF A SAFETY HAZARD FROM ELECTRICAL SHOCK, WHICH COULD RESULT IN PERSONAL INJURY OR DEATH, DISCONNECT THE POWER CORD BEFORE REMOVING OR INSTALLING A FUSE.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders are prohibited.

E. VENTILATION

The Model 175 does not incorporate forced air ventilation. With a power consumption of less than 100 watts, this instrument can be operated on any laboratory bench. Alternatively, it can be rack mounted, if desired. The only requirement is that the ambient temperature be restricted to the range of 15°C to 45°C.

F. DEFECTS AND ABNORMAL STRESSES

Whenever it is likely that the protection provided by the connection to earth ground has been impaired, the apparatus shall be made inoperative and secured against any unintended operation. The protection is likely to be impaired if, for example, the apparatus:

(1) Shows visible damage,

(2) Fails to perform the intended measurement,

(3) Has been subjected to prolonged storage under unfavorable conditions,

(4) Has been subjected to severe transport stresses.

Such apparatus should not be used until its safety has been verified by qualified service personnel.

SECTION I
CHARACTERISTICS

1.1 INTRODUCTION

The Model 175 Universal Programmer is a programmable waveform generator of exceptional versatility and precision. There are two operating modes, SWEEP and PULSE. In both modes, precisely controlled single-cycle or continuous-cycle outputs are obtainable. Four sets of Potential controls allow as many as four inflection points to be set for a single output waveform, whether operating in the Pulse or Sweep mode. In sweep operation, the amplitude and ramping rate of the waveform slopes are independently and precisely adjustable. The same controls govern the amplitude and duration of the waveform segments in pulse operation. Additionally, there is provision for synchronizing, starting, stopping, and reversing a programmed waveform. Some of these functions can be controlled both manually and by means of externally derived control signals.

Featuring versatility, accuracy, and ease of control, the Model 175 is well suited to those applications where it is critical that the slope, interval, and inflection point of a programming waveform be precisely and independently controlled. Specific applications include programming electro-chemical systems, evaluation of the frequency-dependent characteristics of a system, programming voltage-controlled instruments, and testing system responses. With scan rates adjustable from 1 mV/s to 10^4 V/s, and pulse widths adjustable from 100 μs to 10^3 s, the Model 175 should see use in many general purpose laboratory applications as well.

1.2 SPECIFICATIONS

(1) MODES

(a) PULSE: Complex pulse waveforms having as many as four different levels (pretrigger level, two different segment levels while waveform is in progress, and final level) can be provided. Each of the four levels is independently adjustable over a range of ±10 V. Segment durations adjustable over range of 100 μs to 1100 s. Ratio of segment durations adjustable from 1:11 to 11:1. Rise time no slower than 1 V/μs. For examples of some possible Pulse Mode output waveforms, see Subsection 3.3H (page III-6).

(b) SWEEP: Complex triangular waveforms can be provided having as many as four different potential set points (pretrigger level, potential of first scan direction reversal, potential of second scan direction reversal, and final level). Each of the

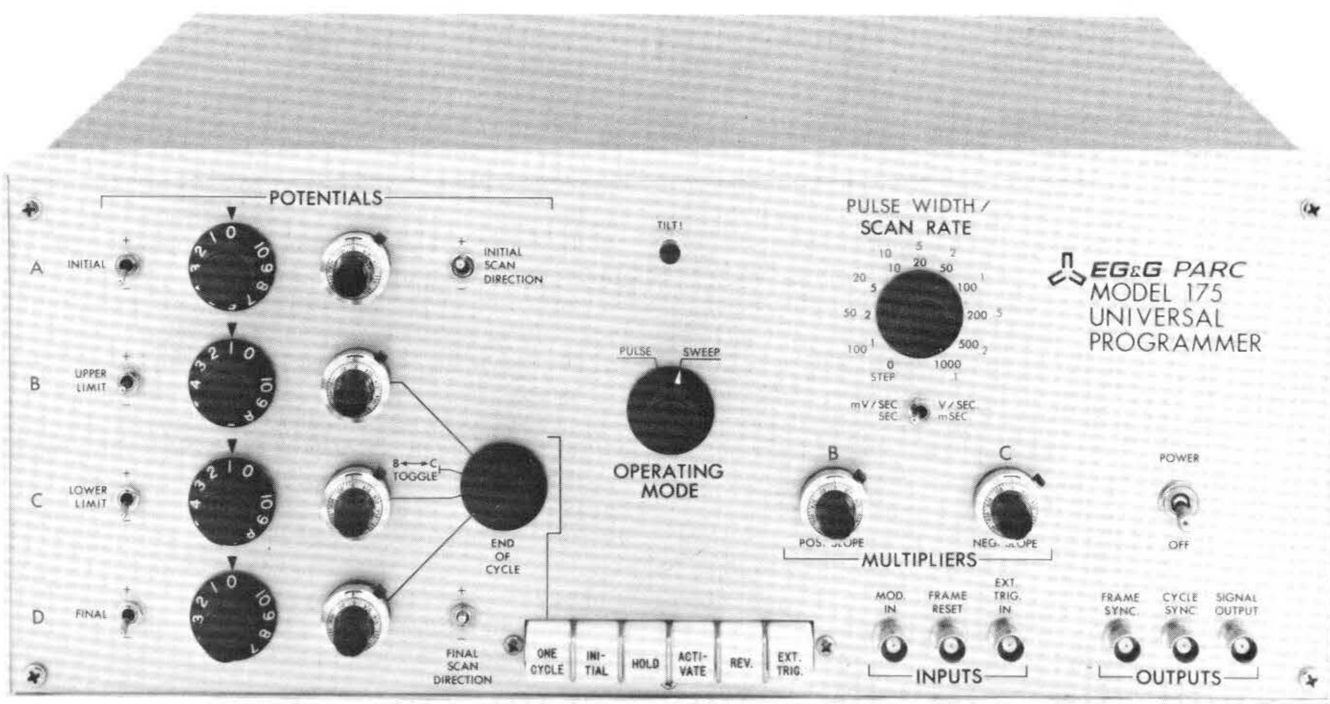


Figure I-1. MODEL 175 UNIVERSAL PROGRAMMER potential set points is independently adjustable over a range of ±10 V. Scan rates adjustable from 1 mV/s to 11000 V/s. Ratio of positive slope scan rate to negative slope scan rate adjustable from 1:11 to 11:1. For examples of some of the possible Sweep Mode output waveforms, see Subsection 3.41 (page III-11).

(2) MINIMUM RECOMMENDED OUTPUT AMPLITUDE: 100 mV. Where it is desired to operate with a lower amplitude output, the operator is advised to program a relatively high level signal and follow the Model 175 with an attenuator. This action will assure that drift and switching spikes will not degrade the programmed waveform.

(3) POTENTIAL SETTING ACCURACY: Accuracy of the four independent sets of Potential controls is 1 mV ±.25% of setting.

(4) PULSE WIDTH/SCAN RATE ACCURACY: 5 μs ±2% of width (multiplier fully counterclockwise) to 5 μs ±3% of width (multiplier fully clockwise).

(5) INPUTS

(a) MOD. IN: Allows programmed waveform to be modulated in Sweep Mode operation. Input is dc coupled and has input impedance of 10 kΩ. Modulation is inverted and then added to programmed waveform. Modulation is not amplified.

(b) FRAME RESET: Allows externally derived positive edge to reset output to selected Initial potential. Input is ac coupled (1 nF into 100 ohms and semiconductor junction to be forward biased by applied pulse). Applied edge should have rise time of at least 3 μs and an amplitude in the range of 3 V to 10 V.

(c) EXT. TRIG. IN: Allows unit to be triggered by externally derived negative edge. Input is ac coupled (1 nF into 1000 ohms followed by semiconductor junction to be forward biased by applied pulse). Source should have impedance of 3 kΩ or less and amplitude of applied edge should be in the range of 5 V to 10 V. Rise time of applied edge should be 3 μs or faster.

(6) OUTPUTS

(a) FRAME SYNC: Differentiated rectangular wave output giving positive spike to mark beginning of programmed waveform and negative spike to mark end of programmed waveform. Amplitude is nominally 2.5 V. Differentiating network is 1 kΩ and 1 nF. Frame Sync is best suited to synchronizing external equipment in One Cycle operation.

(b) CYCLE SYNC: Alternating positive and negative "spike" outputs (differentiated rectangular wave). In Pulse operation these outputs mark transitions to B potential and to C potential. In Sweep operation, these outputs mark scan direction reversals. Amplitude is nominally 2.5 V. Differentiating network is 1 kΩ and 1 nF. Cycle Sync particularly well suited to synchronizing peripheral equipment in continuous operation.

(c) SIGNAL OUTPUT: ±10 V at up to 20 mA. Output is dc coupled.

(7) POWER REQUIREMENTS: 100-130 or 200-260 V ac, 50-60 Hz; <100 W.

(8) WEIGHT: Approximately 25 lb. (11.4 kg).

(9) SIZE: 17-1/8" W x 6-3/4" H x 14" D (43.5 cm x 17 cm x 35.6 cm).

(10) MODEL 175/99 – .1 mV/s SCAN RATE: The .1 mV/s Scan Rate Modification extends the slope rate of the Model 175 Universal Programmer below its normal minimum rate of 1 mV/s. The new minimum rate of .1 mV/s is obtained by means of a special switch located at the rear panel. Setting this switch to the .1 mV/s position connects an additional bank of capacitors into the timing circuitry with the result that the slow range scan rates are reduced by a factor of ten. Similarly, the low range pulse widths are increased by a factor of ten as well. Note that the modification is only effective when the front-panel Pulse Width/Scan Rate toggle switch is in the left-hand (slow range) position. With this switch set to the right (fast range), the scan rates and pulse widths obtained are exactly those selected at the front panel, regardless of the position of the rear-panel switch. With the rear-panel switch set to the "normal" or mV/SEC position, the resulting scan rates and pulse widths are exactly as selected at the front panel for both the fast and slow ranges.

(11) MODEL 175/96 – REMOTE PROGRAMMING MODIFICATION: See supplement at end of manual.

SECTION II
INITIAL CHECKS

2.1 INTRODUCTION

The following procedure is provided to facilitate initial performance checking of the Model 175. In general, the procedure should be performed after inspecting the instrument for shipping damage (any noted to be reported to the carrier and to Princeton Applied Research Corporation), but before using it experimentally. Should any difficulty be encountered in carrying out these checks, contact the factory or one of its representatives. Note that this procedure is not intended to demonstrate that the instrument "meets specs". Each instrument receives a painstaking alignment before leaving the factory. As a result, users of the instrument can have a high degree of confidence that the Model 175 will meet or exceed all specifications if it has not sustained damage in shipping. Any such damage will usually be revealed in carrying out these checks.

2.2 EQUIPMENT REQUIRED

General purpose oscilloscope which will be used to monitor Model 175 Outputs. Also, the appropriate cables and/or probes.

2.3 PROCEDURE (do in indicated sequence)

(1) Check the rear-panel 115/230 switch. Be sure the number showing in the window corresponds to the line voltage to be used.

(2) Plug in the line cord.

(3) Set the Model 175 controls as follows.

Initial Potential controls: +1.000 V
Initial Scan Direction switch: +
Upper Limit Potential controls: +5.000 V
Lower Limit Potential controls: −5.000 V
Final Potential controls: −1.000 V
Final Scan Direction: +
End of Cycle switch: FINAL (fully counterclockwise)
Operating Mode: SWEEP
One Cycle pushbutton: Depressed (in) position. Should be illuminated.
Pulse Width/Scan Rate
    Multiposition switch: 10 (black)
    Toggle switch: V/SEC (right)
Pos. Slope Multiplier dial: 1.00 (fully counterclockwise)
Neg. Slope Multiplier dial: 1.00 (fully counterclockwise)

(4) Check the pushbuttons. Only ONE CYCLE should be depressed. If any other pushbutton is in the depressed position, release it.

(5) Depress INITIAL (pushbutton). It should become illuminated but spring back to the "out" position immediately. Then press ACTIVATE. The Activate pushbutton will become illuminated and the Initial pushbutton will go dark. After about two seconds, the Activate pushbutton will go dark. Note that, like INITIAL, ACTIVATE is a momentary pushbutton as well, that is, it does not "lock" in the down position when depressed.

(6) Connect the SIGNAL OUTPUT connector of the Model 175 to the input of the oscilloscope. The oscilloscope should be free running with a sweep time of about .5 s/cm. A suitable vertical sensitivity might be 2 V/cm. BE SURE THAT THE OSCILLOSCOPE IS DC COUPLED.

(7) Check that the oscilloscope is properly zeroed, that is, with no input (cable disconnected) the baseline is at the center of the screen.

(8) Press INITIAL. The output should immediately go to +1 V, as indicated at the oscilloscope.

(9) Press ACTIVATE. The output potential should ramp positively at 10 V/s. When the output reaches +5 V, the ramping will reverse and continue to −5 V. When it reaches −5 V, it will reverse again. When it reaches −1 V, the output will hold at that level. The ramping rate, both negative and positive, should be 10 V/s. Repeat (first depress INITIAL, then ACTIVATE) as often as is required to confirm that the unit is functioning as indicated.

(10) Set the Operating Mode switch to PULSE (red panel engraving denotes Pulse functions).

(11) Set the Pulse Width/Scan Rate to 1 SEC. (multi-position switch to red "1" and toggle to left).

(12) Press INITIAL. The output will again go to +1 V.

(13) Press ACTIVATE. The output will immediately step to +5 V, where it will remain for one second. It will then step to −5 V, and remain at that potential for a second. It will then step to −1 V to terminate the waveform.

(14) Repeat (first depress INITIAL and then ACTIVATE) as often as is required to confirm that the unit is functioning as indicated.

This completes the initial checks. If the indicated results were obtained, one can be reasonably sure that the instrument is working properly.

SECTION III
OPERATING INSTRUCTIONS

3.1 INTRODUCTION

Although operation of the Model 175 is straightforward, one must nevertheless take some care in programming the desired waveform because of the large number of parameters being controlled. The behavior of the individual controls varies according to the Operating Mode selected and the combination of control parameters desired. This section begins with a description of the individual controls and their functions, followed by separate treatments of pulse and sweep operation.

3.2 CONTROLS (descriptions keyed to Figure III-1)

A. POTENTIAL CONTROLS: Four sets of controls are provided, each consisting of a polarity switch, an integer voltage selector switch, and a vernier. In Pulse operation, these controls set the output level prior to triggering, the level of the two pulse segments, and the final "post waveform" level. In Sweep operation, they set the output level prior to triggering, the two potentials at which slope reversal is to occur, and the final post-waveform level. For both pulse and sweep operation the range of the Potential controls is ±10 V.

B. INITIAL SCAN DIRECTION: Functional in Sweep mode operation only. Determines whether slope will be "+" or "−" when unit is triggered providing output has been preset to Initial potential. If output has not been preset to Initial potential, Initial Scan Direction switch has no effect.

C. END OF CYCLE: Functional in ONE CYCLE operation only. This switch selects at which potential a given programmed waveform will terminate. A given waveform can be made to terminate at the Upper Limit potential, the Lower Limit potential, or the Final potential. B-C Toggle is a special case discussed later on.

D. FINAL SCAN DIRECTION: Functional in One Cycle operation only, and only if End of Cycle switch is set to FINAL. If set to "+", the programmed waveform ends the first time the output reaches the selected Final potential while scanning positively. If set to "−", the waveform ends the first time the Final potential is reached while scanning negatively.

E. OPERATING MODE: Allows Pulse mode or Sweep mode operation to be selected.

F. PULSE WIDTH/SCAN RATE: Two controls, a multi-position switch and a toggle switch. In Sweep mode operation, they, together with the two Multiplier controls, determine the dV/dt. In Pulse mode operation, they, together with the two Multiplier controls, determine duration of the segments (intervals between level changes).

G. MULTIPLIERS: Two independent, continuously variable, ten-turn precision controls multiply the selected Pulse Width or Sweep Rate by factors adjustable from X1 to X11. In Sweep mode operation, they allow separate adjustment of the positive and negative slope (maximum ratio 11:1, minimum 1:11). In Pulse mode operation, they allow separate adjustment of the duration of the B Potential and C Potential segments. As in Sweep mode operation, the maximum ratio is 11:1 and the minimum 1:11.

H. PUSHBUTTONS: Six illuminated pushbutton switches control the instrument's main functions, permitting the generated waveform to be started, stopped, reversed, or reset, and providing a choice of single or continuous operation. The function of each pushbutton is as follows.

(1) ONE CYCLE (locking, illuminated): Gives choice of One Cycle (pushbutton depressed) or Continuous operation (pushbutton not depressed). In one cycle operation, each applied trigger initiates a single programmed waveform. In continuous operation, a trigger causes the instrument to cycle indefinitely. A continuous wave train can be terminated by depressing either the ONE CYCLE or INITIAL pushbuttons.

(2) INITIAL (momentary, illuminated): Depressing this pushbutton (or applying a positive edge to the Frame Reset Input connector) immediately sets the output to the selected Initial potential. This is ordinarily done prior to triggering, although it can be done at any time to terminate a wavetrain in progress.

(3) HOLD (locking, illuminated): Allows operator to force a programmed waveform to "hold" at the point reached when the pushbutton is depressed. When depressed the second time, the waveform continues as programmed. (Hold function not recommended for fast ranges.)

(4) ACTIVATE (momentary, illuminated): Acts as a manual trigger. Remains illuminated for duration of instrument-active time. While the ACTIVATE pushbutton is illuminated, the instrument cannot be triggered again.

(5) REVERSE (momentary, non-illuminated): In sweep operation, each time the REVERSE pushbutton is depressed, the slope reverses polarity. Note that the programmed limits still apply. In Pulse operation, depressing the REVERSE pushbutton when the output is at the B potential immediately resets the output to the C potential. Depressing this pushbutton when the output is at the C potential has no effect.

(6) EXTERNAL TRIGGER (locking, illuminated): When depressed, negative edge applied to EXT. TRIG.

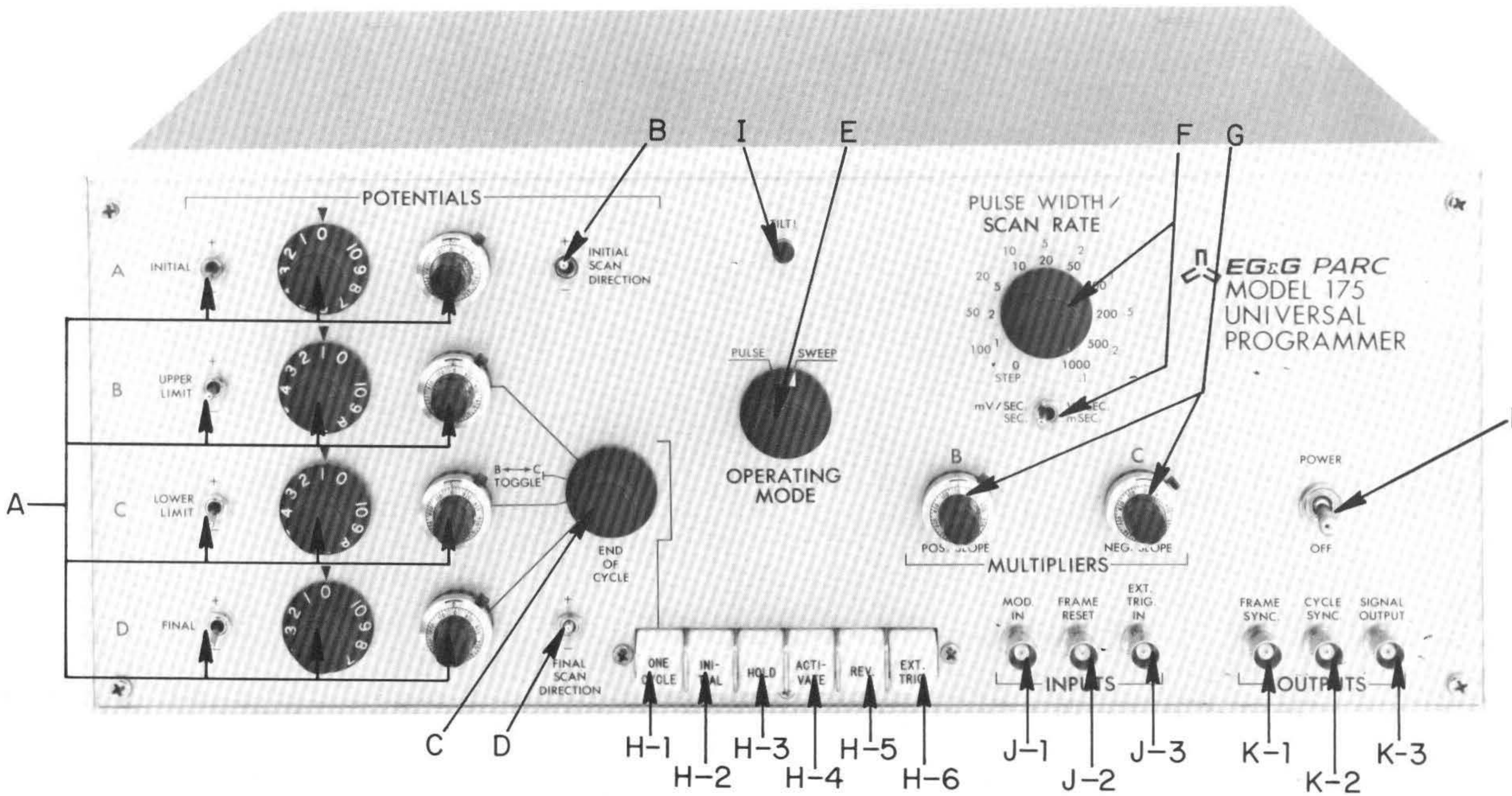


Figure III-1. MODEL 175 UNIVERSAL PROGRAMMER

INPUT connector triggers unit in same manner as ACTIVATE pushbutton.

I. TILT LIGHT: Provides a visual indication that one or more of the controls has been improperly set. When a tilt condition exists, the output remains at the Initial potential until the tilt condition is corrected. Only then can a new waveform be triggered.

J. INPUTS

(1) MODULATION IN: Allows programmed waveform to be modulated in sweep operation. After being inverted (but not amplified), modulation is added to programmed signal. Modulation amplitude must be considered in setting limit potentials (modulation ordinarily is small relative to programmed signal). Not used in Pulse operation.

(2) FRAME RESET: Positive edge applied to this input at any time resets output to selected Initial potential. Same action as depressing INITIAL pushbutton.

(3) EXT. TRIG. IN: Negative edge applied to this input (EXT TRIG pushbutton depressed and ACTIVATE pushbutton not illuminated) triggers unit in same manner as depressing ACTIVATE pushbutton.

K. OUTPUTS

(1) FRAME SYNC: Provides positive pulse coincident with triggering and negative pulse coincident with end of instrument-active time.

(2) CYCLE SYNC: In sweep operation, provides positive pulse out to mark positive-to-negative slope reversal, and negative pulse out to mark negative-to-positive slope reversal. In Pulse operation, provides a positive pulse output each time there is a transition to the B potential, and a negative positive pulse output each time there is a transition to the C potential. Additional Cycle Sync outputs can be obtained under certain circumstances as explained later in the manual.

(3) SIGNAL OUTPUT: ±10 V at up to 20 mA.

L. POWER SWITCH: Turns ac power to instrument on or off.

3.3 PULSE MODE OPERATION

3.3A INTRODUCTION

Of the two modes, pulse operation is perhaps the simpler and so is discussed first. Observing the front panel (or Figure III-1), note that the four sets of Potential controls each have two names, "letter" names, A, B, C and D, which are used in pulse mode operation, and "functional" names, INITIAL, UPPER LIMIT, LOWER LIMIT, and FINAL, which are used to describe their action in sweep mode operation. The basic sequence for each pulse cycle is for the output potential to step from potential A, to potential B, to potential C, and last, to potential D, giving great versatility as to the possible output waveforms obtainable. However, the utility of the A and D controls is constrained by other operating parameters, as explained in the following paragraphs. Questions to consider in programming the instrument for pulse operation include:

(1) Is the trigger to initiate a single cycle or a continuous pulse train?

(2) At what potential is the output waveform to begin?

(3) What potential sequence is each cycle to consist of?

(4) What will the width of each segment be?

(5) At what potential will the waveform terminate?

(6) What special considerations apply if the unit is to be externally triggered or otherwise controlled, or if the Sync. Outputs are to be used for triggering peripheral instrumentation.

3.3B SINGLE CYCLE OR CONTINUOUS

The full versatility of the instrument is achieved in single cycle operation, in which the output, each time the instrument is triggered, can be made to go through the full series of four potentials. In continuous operation, which results any time the SINGLE CYCLE pushbutton is NOT depressed, the output, once the instrument is triggered, continuously steps between the B and C potentials until the pulse train is terminated. The first and last cycles of the pulse train, however, are subject to A and D control, if desired. Two switches, INITIAL SCAN DIRECTION, and FINAL SCAN DIRECTION, have no effect on pulse operation, whether single cycle or continuous.

3.3C POTENTIAL SELECTION AND SEQUENCING

Note that each set of potential controls consists of a toggle switch, an eleven-position selector switch, and a ten-turn dial. All three work together to determine the programmed voltage. For example, to set the A potential to +4.428 V, the toggle switch would be set to "+", the eleven-position switch would be set to "4", and the dial would be set for "4" in the "window" and "28" on the dial. Note that the toggle switches, in addition to the two polarity selection positions, have a center position as well, in which the programmed voltage is 0 V regardless of the setting of the other two controls.

A complete cycle in pulse operation begins with the output at the selected A potential. When the unit is triggered, the output steps to the B potential, where it remains for the time determined by the PULSE WIDTH/SCAN RATE switch and the B MULTIPLIER. It then steps to the C potential, where it remains for the time determined by the PULSE WIDTH/SCAN RATE switch and the C MULTIPLIER. It then steps to the D potential where it remains until the unit is triggered again. However, this complete sequence is not necessarily obtained, and depends on the setting of the ONE CYCLE and INITIAL pushbuttons, as well as on the setting of the END OF CYCLE switch.

(1) ONE CYCLE OPERATION: To obtain one cycle only when the instrument is triggered, either by depressing the ACTIVATE pushbutton or by applying a negative edge to the EXT TRIG IN connector, the ONE CYCLE pushbutton must be depressed. (Once depressed, it remains down and illuminated until it is depressed again.) The potential at the output prior to triggering the instrument depends on the history of the unit and on the INITIAL pushbutton. When the unit is first turned on and the controls programmed for the desired waveform, one should depress the INITIAL pushbutton and then the ACTIVATE pushbutton to run the unit through one cycle. This "clearing" cycle assures that all the logic circuits will be in the correct state. Thus, the output potential prior to triggering will be either the C or D potential, according to the position of the END OF CYCLE switch (B is a forbidden position for this switch in pulse operation). If the operator desires that the output potential, prior to triggering, should be the A potential, he will have to depress the INITIAL pushbutton (or effect the same action by applying a positive edge to the Frame Reset connector). Note that when the INITIAL pushbutton is depressed (or a positive edge is applied to the Frame Reset connector), the pushbutton becomes illuminated. Once the unit is subsequently triggered, the button goes "dark", indicating that the A potential is no longer programmed. Thus, if it is desired to program the A potential into subsequent cycles, the INITIAL pushbutton must be separately depressed prior to each cycle (or the equivalent Frame Reset applied).

When the trigger is applied, either by depressing the ACTIVATE pushbutton or by applying a negative edge to the EXT TRIG IN connector (providing EXT. TRIG. pushbutton is depressed), the ACTIVATE pushbutton will become illuminated and the output voltage will make its first transition. The first voltage transition will be to the B potential, whether the output potential prior to triggering was the A potential (INITIAL depressed) or if it was the C or D potential. The output potential remains at the B potential for the time selected by the PULSE WIDTH/SCAN RATE switch and the B MULTIPLIER. At the end of that time, the output potential steps to the C potential. If the END OF CYCLE switch is set to C, this ends the cycle. If the END OF CYCLE switch is set to D, the output remains at the C potential for the time determined by the PULSE WIDTH/SCAN RATE switch and the C MULTIPLIER. At the end of that time, the output potential steps to the D potential to end the cycle. The A potential can only be restored by depressing the INITIAL pushbutton or by applying a positive edge to the Frame Reset connector.

Note that, if the END OF CYCLE switch is set to C, the B-to-C transition completes the cycle and the C MULTIPLIER has no significance in determining the shape of the output waveform. However, the instrument remains active internally beyond the B-to-C transition as indicated by the ACTIVATE pushbutton remaining illuminated. As long as the light remains on, the instrument cannot be triggered again. The C MULTIPLIER does directly affect the instrument active time, and, in cases where the final potential is the C potential, the C MULTIPLIER can be used to set the time the instrument remains immune to triggering. By setting the C MULTIPLIER fully counterclockwise, the "extra" trigger-immune time will be minimum and equal to the setting of the PULSE WIDTH/SCAN RATE switch.

If the END OF CYCLE switch is set to D, the ACTIVATE pushbutton goes dark coincident with the C-to-D transition and there is no extra trigger-immune time.

(2) CONTINUOUS OPERATION (ONE CYCLE PUSHBUTTON NOT DEPRESSED): Most of the same considerations apply for continuous operation as apply to one cycle operation. When the instrument is turned on and the controls set, one should depress the ONE CYCLE pushbutton and run through a cycle to "set the logic", the same as in one cycle operation. This done, the output potential, prior to triggering, will be at the C or D potential. If the operator desires to begin from the A potential, he will have to depress the INITIAL pushbutton (or use the Frame Reset input). Before triggering the unit again, be sure to release the ONE CYCLE pushbutton so that the subsequent trigger will initiate a continuous pulse train as opposed to a single cycle.

When the unit is triggered, the output potential advances to the B potential (from C, D, or A), where it remains for the time determined by the PULSE WIDTH/SCAN RATE and B MULTIPLIER controls. At the end of that time, the output potential steps to the C potential, where it remains for the time determined by the PULSE WIDTH/SCAN RATE and C MULTIPLIER controls. At the end of that time the output steps back to the B potential. It does not go to the D potential, regardless of the setting of the END OF CYCLE switch. The output continuously alternates between the B and C potentials, remaining at each for the time determined by the PULSE WIDTH/SCAN RATE and MULTIPLIER controls. This action continues until the pulse train is terminated, which can be done in either of two ways. If the pulse train is terminated by depressing the ONE CYCLE pushbutton, the cycle in progress continues to completion, ending at C or D as determined by the setting of the END OF CYCLE switch. If the pulse train is terminated by depressing the INITIAL pushbutton, the output potential immediately goes to the A potential, where it remains until the instrument is triggered again.

(3) B-C TOGGLE: This position of the END OF CYCLE switch places the instrument in a special variation of one cycle operation. If the output is at B prior to a given trigger, that trigger will cause the output to step to C. If the output is at C prior to a given trigger, that trigger will cause the output to step to B. There is only

one transition after each trigger. Note that the same first cycle considerations apply as for normal one cycle operation, that is, if the INITIAL pushbutton is depressed, the first transition will be from A-to-B. All subsequent transitions will be either B-to-C or C-to-B as described. Note that the A-to-B, B-to-C sequence allows one to generate a two-step "staircase" function manually. Also note that, once the ACTIVATE pushbutton becomes illuminated in B-C Toggle operation, it remains lighted for as long as the END OF CYCLE switch is left in the B-C TOGGLE position.

3.3D INPUTS

(1) MODULATION IN: This input is not used in pulse operation.

(2) FRAME RESET: A positive edge applied to this input has identically the same effect as depressing the INITIAL pushbutton. The INITIAL pushbutton becomes lighted and the output immediately switches to the selected A potential. As soon as the unit is triggered, the INITIAL pushbutton goes dark. ANY TIME a positive edge is applied to the Frame Reset input (or the INITIAL pushbutton is depressed), the output immediately goes to the A potential, even if a cycle is in progress. Frame Reset (Initial) is thus a master over-ride, taking precedence over all other programmed actions.

(3) EXT TRIG IN: A negative edge applied to the EXT. TRIG. IN connector has the same effect as depressing the ACTIVATE pushbutton, *providing* the EXT. TRIG. pushbutton is depressed. When this button is depressed, it becomes illuminated, indicating that the unit is receptive to external triggering. Depressing the button a second time causes the illumination to end and makes the instrument insensitive to triggers applied to the EXT TRIG IN connector.

One convenient result of having the Frame Reset respond to a positive edge and the Ext. Trig. Input respond to a negative edge is that it allows a single externally derived positive pulse applied to both the EXT. TRIG. and FRAME RESET inputs to program the A potential and trigger the unit. Reset to A takes place coincident with the leading (positive) edge of the applied pulse. Triggering takes place coincident with the trailing (negative) edge. Thus, repetitive waveforms having the maximum possible complexity can be generated when triggering externally.

3.3E OUTPUTS

(1) FRAME SYNC (Pulse Operation): Provides a positive pulse (actually the leading edge of a differentiated rectangular pulse) coincident with triggering (ACTIVATE pushbutton or external triggering) and a negative pulse (trailing edge of differentiated rectangular pulse) coincident with end of instrument activate time. Note that this is not necessarily the same as the end of the output waveform. For example, in the case of a simple pulse output which terminates with the B-to-C transition, the instrument remains active for the selected C MULTIPLIER time as well, as indicated by the ACTIVATE pushbutton remaining lighted. The negative Frame Sync output is not generated until the ACTIVATE pushbutton light goes out. The Frame Sync output is particularly useful for synchronizing peripheral equipment when the Model 175 is being used in one cycle operation. It is less useful for continuous operation because outputs are available only at the beginning and end of the pulse train.

NOTE: In B-C TOGGLE operation there are no Frame Sync outputs unless the INITIAL pushbutton is depressed. If the INITIAL pushbutton is depressed, there is a coincident positive Frame Sync output, and the subsequent trigger (first transfer to "B") gives a negative Frame Sync output. No triggers after this first one give a Frame Sync output as long as the unit remains in B-C TOGGLE operation (or unless the INITIAL pushbutton is depressed again to repeat the sequence.

(2) CYCLE SYNC (Pulse Operation): Provides a negative pulse out (leading edge of differentiated rectangular negative pulse) each time there is a transition to the B potential and a positive pulse out (trailing edge of differentiated rectangular negative pulse) each time there is a transition to the C potential. This output is most useful for synchronizing external instruments with the Model 175 when it is being operated in the continuous mode. Note that transitions to the A potential and D potential are not accompanied by Cycle Sync outputs. **EXCEPTION**: END OF CYCLE switch set to B-C TOGGLE, in which there is a positive Cycle Sync output if the INITIAL pushbutton is depressed, and a negative Cycle Sync output on the subsequent trigger which initiates the transfer to B. However, all triggers after the first, each of which initiates a B-to-C or C-to-B transition in B-C TOGGLE operation, are not accompanied by a Cycle Sync output. If the INITIAL pushbutton is not depressed, there are no Cycle Sync outputs at any time in B-C TOGGLE operation.

(3) SIGNAL OUTPUT: Programmed output is provided at ±10 V. Current capability is ±20 mA.

3.3F REVERSE PUSHBUTTON (Pulse Operation)

The sole effect of this pushbutton in Pulse Operation is to initiate an immediate transfer to the C potential when the output is at the B potential. There is no effect if the output is at the A, C, or D potential. Where the unit is programmed to provide a very long B potential pulse out, this feature may be useful for ending the pulse quickly. However, terminating the pulse in this manner has no effect on the instrument active time as determined by the PULSE WIDTH/SCAN RATE and MULTIPLIER controls, and this active time must end before the instrument can be triggered again and before the negative Frame Sync output is generated.

3.3G PULSE WIDTH/SCAN RATE SWITCH TO STEP POSITION

When this switch is set to the STEP position, a trigger will cause the output to step from whatever potential it is at (A, C, or D, as determined by the previous cycle) directly to B. A positive Frame Sync output and a negative Cycle Sync output accompany this transition. Once the unit is triggered, the ACTIVATE pushbutton remains illuminated for as long as the PULSE WIDTH/SCAN RATE switch remains set to STEP.

3.3H EXAMPLES

The following reproductions of actual oscilloscope photographs are provided to show possible outputs in Pulse Mode operation. Full indication as to the required control settings are given in each case.

Pulse Output Example #1

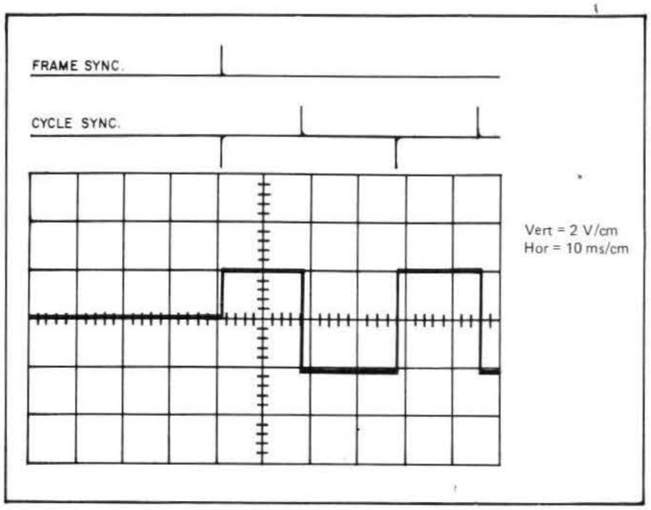


Figure III-2. PULSE OUTPUT EXAMPLE #1

Control Settings for Pulse Example #1

- A POTENTIAL: 0 V (toggle switch to center position)
- B POTENTIAL: +2.000 V
- C POTENTIAL: −2.200 V
- D POTENTIAL: Setting irrelevant since output is to be continuous
- END OF CYCLE: C or D; which is selected does not matter because output is to be continuous
- OPERATING MODE: PULSE
- ONE CYCLE pushbutton: Not depressed so as to obtain continuous operation
- INITIAL pushbutton: Depressed so that output is at A potential (0 V) prior to triggering
- PULSE WIDTH/SCAN RATE switch: 10 ms
- B MULTIPLIER: 1.70 (gives B duration of 17 ms)
- C MULTIPLIER: 1.80 (gives C duration of 18 ms)

Sequence

When unit is triggered (assume ACTIVATE pushbutton triggering), there is an immediate transition to the B potential. The output remains at the B potential for 17 ms, when it steps to the C potential, where it remains for 18 ms to complete the first cycle. Subsequent cycles follow one another uninterrupted, with each B potential portion lasting 17 ms and each C potential portion lasting 18 ms. Note that each transition to B is marked by a negative Cycle Sync output and that each transition to C is marked by a positive Cycle Sync output. A positive Frame Sync output is generated on the first transition to B. No other Frame Sync outputs are provided while the pulse train is in progress. Presumably at some future time the pulse train will be terminated either by depressing the ONE CYCLE pushbutton or by depressing the INITIAL pushbutton. If ONE CYCLE is depressed, the cycle in progress will go to completion, and a negative Frame Sync output will be provided coincident with the end of the instrument active time (marked by the ACTIVATE pushbutton light going out). If INITIAL is depressed, the output immediately goes to the A potential, and this transition will be marked by a negative Frame Sync output. If INITIAL was depressed when the output was at the B potential, there will be a positive Cycle Sync output as well. If the output was at the C potential, no Cycle Sync output occurs when INITIAL is depressed.

Pulse Output Example #2

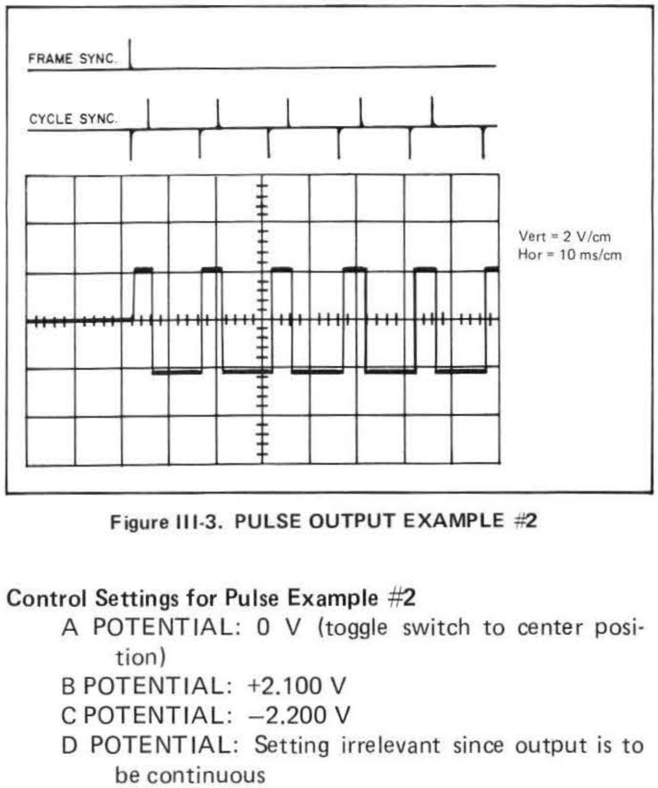


Figure III-3. PULSE OUTPUT EXAMPLE #2

Control Settings for Pulse Example #2

- A POTENTIAL: 0 V (toggle switch to center position)
- B POTENTIAL: +2.100 V
- C POTENTIAL: −2.200 V
- D POTENTIAL: Setting irrelevant since output is to be continuous
- END OF CYCLE: C or D; doesn't matter which since output is to be continuous
- OPERATING MODE: PULSE
- ONE CYCLE pushbutton: Not depressed to obtain continuous operation
- INITIAL pushbutton: Depressed. Note that output potential is at A potential (0 V) prior to triggering
- PULSE WIDTH/SCAN RATE switch: 1 ms
- B MULTIPLIER: 4.00 (gives B duration of 4 ms)
- C MULTIPLIER: 11.00 (gives C duration of 11 ms)

Sequence

The sequence for the second example is the same as for the first. Only the amplitude and durations are different. The output is initially at the A potential. When the unit is triggered, the output goes to the B potential, where it remains for 4 ms. It then steps to the C potential, where it remains for 11 ms to complete the first cycle. All of the subsequent cycles consist of 4 ms at the B potential followed by 11 ms at the C potential. Cycles follow one another automatically until either the INITIAL or ONE CYCLE pushbutton is depressed. With reference to the Frame Sync and Cycle Sync outputs, the same considerations apply as for the previous example.

Pulse Output Example #3

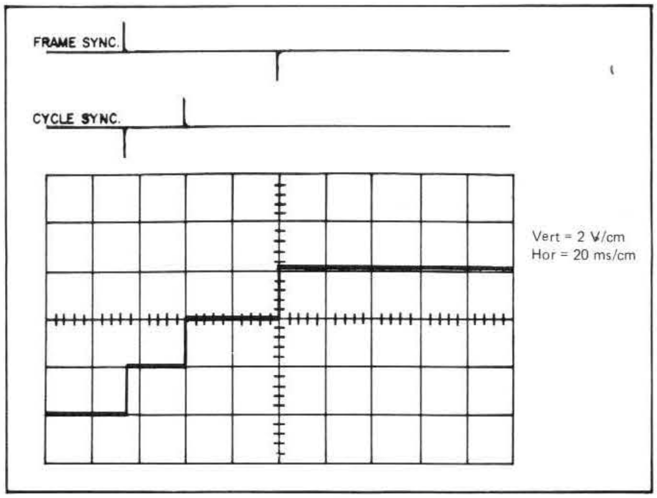


Figure III-4. PULSE OUTPUT EXAMPLE #3

Control Settings for Pulse Example #3

A POTENTIAL: –4.000 V
B POTENTIAL: –2.000 V
C POTENTIAL: 0 V (toggle switch to center position)
D POTENTIAL: +2.200 V
END OF CYCLE: D (fully counterclockwise)
OPERATING MODE: PULSE
ONE CYCLE pushbutton: depressed (illuminated)
INITIAL pushbutton: depressed - note that output is at A potential (–4 V) prior to triggering
PULSE WIDTH/SCAN RATE switch: 10 ms
B MULTIPLIER: 1.30 (gives B duration of 13 ms)
C MULTIPLIER: 2.00 (gives C duration of 20 ms)

Sequence

Prior to triggering, output is at A potential (INITIAL pushbutton depressed). When the unit is triggered, the output steps to the B potential, where it remains for 13 ms. At that time, it steps to the C potential, where it remains for 20 ms. At the end of the 20 ms, it steps to the D potential (END OF CYCLE switch set to D) to end the cycle. As shown in the figure, the Frame Sync output marks the trigger time and the end of the instrument-active time (identically the end of the programmed waveform in the example). The Cycle Sync output marks the transitions to B and C.

Pulse Output Example #4

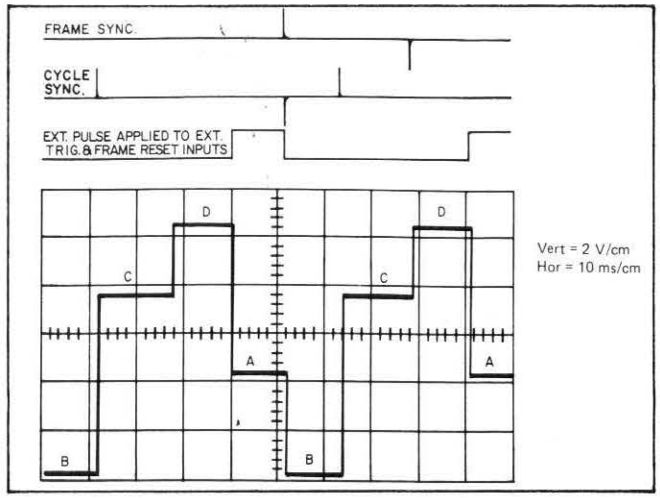


Figure III-5. PULSE OUTPUT EXAMPLE #4

Control Settings for Pulse Example #4

A POTENTIAL: –1.600 V
B POTENTIAL: –5.800 V
C POTENTIAL: +1.600 V
D POTENTIAL: +4.400 V
END OF CYCLE: D
OPERATING MODE: PULSE
ONE CYCLE puuhbutton: depressed (lighted)
INITIAL pushbutton: No need to depress to obtain A potential because positive edge is applied to Frame Reset Input
EXT. TRIG. pushbutton: Depressed because unit is to be triggered externally
PULSE WIDTH/SCAN RATE switch: 10 ms
B MULTIPLIER: 1.200 (gives B duration of 12 ms)
C MULTIPLIER: 1.500 (gives C duration of 13 ms)

Sequence

The interesting point to be brought out concerning Example #4 is that a positive external pulse is being used to both trigger and reset the Model 175. This same pulse is applied to both the Frame Reset and Ext Trig Inputs. The Frame Reset Input responds to the positive going edge to reset the output to the A potential. The Ext. Trig. Input responds to the negative going edge to trigger the instrument (initiate the A-to-B transition). A repetitive four-level programmed output is thus obtained, with the repetition rate being that of the externally derived reset/trigger pulse. The Frame Sync positive transition is coincident with the trigger (transition from A-to-B) and the Frame Sync negative transition is coincident with the transition from C-to-D. The Cycle Sync negative output marks the transition to B, and the Cycle Sync positive output marks the transition to C. Only the leading edge of the external reset/trigger pulse marks the transition from D-to-A. **NOTE:** In operating the Model 175 in this manner, one must take care not to apply the reset-trigger pulse before the programmed cycle is completed. Even though the instrument is immune to triggering when a cycle is in progress, it is not immune to being reset to the A potential by a positive edge applied to the Frame Reset connector. Each positive going edge applied to this input will instantly drive the output to the A potential, regardless of any other programming considerations.

3.4 SWEEP MODE OPERATION

3.4A INTRODUCTION

Most of the same operation considerations that apply to pulse operation apply to sweep mode operation too. In addition, there are a few other factors which must be taken into account. For example, in pulse operation the Initial Scan Direction and Final Scan Direction switches have no significance. In sweep operation their effect must be considered. Also, there are constraints on the setting of the Potential controls that do not apply in pulse operation. Note that the functional names, INITIAL, UPPER LIMIT, LOWER LIMIT, and FINAL, are used in referring to the Potential controls for sweep operation (as opposed to the A, B, C, and D designations used when discussing pulse operation). Questions to consider in programming the instrument for sweep operation include:

(1) Is the trigger to initiate a single cycle or a continuous wavetrain?

(2) At what potential is the sweep to begin and what should the initial direction of the scan be?

(3) At what potentials should the inflection points be established?

(4) What should the scan rate be for each portion of the programmed waveform?

(5) At what potential should a scan terminate, and what should the direction of scan be when it terminates?

(6) What special considerations apply if the unit is to be externally triggered or otherwise controlled, or if the Sync Outputs are to be used for triggering peripheral equipment.

3.4B SINGLE SWEEP OR CONTINUOUS

As with pulse operation, the choice of one cycle or continuous operation is dictated primarily by the application. In one cycle operation, the operator has full four-level control over each cycle. In continuous operation, all cycles but the first and last are limited to two levels as determined by the setting of the Upper and Lower Limit potentials. In the case of the first cycle, the INITIAL potential can be included as well. In the case of the last cycle, the FINAL potential can be included, if desired.

3.4C POTENTIAL SELECTION AND SEQUENCING

A complete cycle in sweep operation begins with the output at the selected Initial potential. When the unit is triggered, the output voltage begins to linearly ramp, either positively or negatively, as determined by the setting of the INITIAL SCAN DIRECTION switch. **NOTE:** If the selected Initial potential is outside the zone bounded by the Limit controls, the selected Initial Scan direction must be that which will carry the scan into the zone. The ramping rate is set by the PULSE WIDTH/SCAN RATE and MULTIPLIER controls. Note that one Multiplier governs the positive ramping rate and the other the negative ramping rate. If the initial slope is positive, the output voltage continues until it reaches the Upper Limit potential. If negative, it continues until the Lower Limit potential is reached. In either case, when the limit is reached, the slope polarity reverses, and the output voltage ramps towards the other Limit potential. When the second limit is reached, the slope reverses polarity again, and the output ramps again at the first rate, this time towards the selected Final potential. When the output voltage reaches the Final potential, it holds at that voltage to terminate the cycle.

In many applications, it is desirable to operate with less than a "complete" cycle. As will be shown, many variations are possible by appropriately setting the END OF CYCLE and FINAL SCAN DIRECTION switches, and by selecting different pushbutton combinations.

(1) SINGLE CYCLE OPERATION: To obtain one cycle only when the instrument is triggered, the ONE CYCLE pushbutton must be depressed. The potential at the output prior to triggering the instrument depends on the history of the unit. When the instrument is first turned on and the controls programmed for the desired waveform, one should depress the INITIAL pushbutton and then the ACTIVATE pushbutton to run the unit through one "clearing" cycle. This action assures that all the logic circuits will be in the correct state. Thus, prior to triggering, the output will be at the potential reached at the end of the clearing cycle (Upper Limit potential, Lower Limit potential, or Final potential, according to position of End of Cycle switch). If the output is to be at the Initial potential prior to triggering, it will be necessary to depress the INITIAL pushbutton (or effect equivalent action by applying a positive edge to the Frame Reset input).

When the trigger is applied, the output voltage commences to ramp, with the direction depending on control settings and on the output potential prior to triggering. If the output, prior to triggering, was set to the INITIAL potential, then the slope will be as indicated by the position of the INITIAL SCAN DIRECTION switch. **NOTE:** If the selected Initial potential is outside the zone bounded by Limit control settings, then the Initial Scan Direction selected *must* be that which will carry the scan into the zone. If the output, prior to triggering, was at the Upper Limit potential (End of Cycle switch set to UPPER LIMIT for clearing cycle), the slope will be negative. If the output, prior to triggering, was at the Lower Limit potential (End of Cycle switch set to LOWER LIMIT for clearing cycle), the slope will be positive. If the output, prior to triggering, was at the Final potential (End of Cycle switch set to FINAL for clearing cycle), the slope will be that selected by the FINAL SCAN DIRECTION switch, that is, the scan merely continues in the same direction it was headed when the previous cycle terminated.

There are two constraints on the setting of the Potential controls during sweep operation. The Upper Limit potential must be positive with respect to the Lower Limit potential, and the Final Potential must be between the selected Upper and Lower Limit potentials.

Once triggered, a sweep continues as programmed. When the output reaches either the Upper or Lower limit, the slope changes sign, with two such direction reverses being possible in a given cycle. A reversal upon reaching the Upper Limit only occurs if the approach was from a more negative potential. (Note that it is possible for the Upper Limit to be approached from a more positive potential if the Initial potential selected is positive with respect to Upper Limit.) A reversal on reaching the lower limit only occurs if the approach was from a more positive potential. The cycle continues until the selected End of Cycle conditions are satisfied, whereupon the cycle immediately stops with the output holding at the last potential reached.

Three different cycle-end conditions can be selected. If the End of Cycle switch is set to UPPER LIMIT, the cycle will end the *first time* the output potential reaches the Upper Limit potential while approaching from a more negative potential. If the End of Cycle switch is set to LOWER LIMIT, the cycle will end the *first time* the output potential reaches the lower limit potential while approaching from a more positive potential. If the End of Cycle switch is set to FINAL, the cycle will end the *first time* the output potential reaches the selected Final Potential while scanning in the direction selected by the FINAL SCAN DIRECTION switch. **NOTE:** The B-C TOGGLE position of the End of Cycle switch is a special case and is discussed later.

The ramping rate throughout each cycle is determined by the PULSE WIDTH/SCAN RATE and MULTIPLIER controls. The POS. SLOPE MULTIPLIER (left-hand dial) governs the ramping rate when the output is sweeping positively. The NEG. SLOPE MULTIPLIER (right-hand dial) governs the ramping rate when the output is sweeping negatively.

For the duration that the instrument is active each time it is triggered, the ACTIVATE pushbutton remains lighted and the instrument is immune to being triggered. However, the instrument is always subject to reset to the Initial potential by depressing the INITIAL pushbutton or by applying a positive edge to the Frame Reset Input, and, if reset, the output does not move off the Initial potential until the unit is triggered again.

(2) CONTINUOUS OPERATION (One Cycle Pushbutton *Not* Depressed)

Most of the same considerations apply for continuous operation as apply to One Cycle operation. When the instrument is turned on and the controls set, one should depress the ONE CYCLE pushbutton and run through a clearing cycle, the same as in one cycle operation. Then release the One Cycle pushbutton so that the next trigger will initiate continuous operation. This done, the output potential will be either at the Upper Limit, Lower Limit, or Final potential, according to the position of the End of Cycle switch during the clearing cycle. If the wavetrain is to begin at the Initial potential, it will be necessary to depress the INITIAL pushbutton (or apply a positive edge to the Frame Reset input).

The wavetrain begins when the instrument is triggered, with the direction of the first ramp determined in the same manner as for one cycle operation. The scan slope direction reverses direction each time either the Upper Limit or Lower Limit potential is reached, and the output potential cycles between these two limits until the wavetrain is terminated by the operator. As with pulse operation, a continuous wavetrain is terminated either by depressing the ONE CYCLE pushbutton, or by depressing the INITIAL pushbutton. INITIAL immediately returns the output to the selected Initial potential. ONE CYCLE allows the cycle in progress to be completed as programmed by the End of Cycle switch.

Note that Final Potential and Final Scan Direction controls have no significance while the continuous cycling is in progress. However, they will affect the last cycle if the End of Cycle switch is set to FINAL, and if the wavetrain is ended by depressing the ONE CYCLE pushbutton.

(3) B-C TOGGLE

This position of the END OF CYCLE switch places the instrument in a special variation of one cycle operation. (ONE CYCLE must be depressed. Otherwise continuous operation is obtained.) If the output is at the Upper Limit potential prior to applying a given trigger, that trigger will cause the output to scan to the Lower Limit potential at a programmed rate. If the output is at the Lower Limit potential prior to applying a given trigger, that trigger will cause the output to scan to the Upper Limit potential at the programmed rate. The INITIAL pushbutton retains its control in B-C Toggle operation. If INITIAL is depressed prior to triggering, the output will immediately go to the selected Initial potential. The ramping direction when the subsequent trigger is applied will be that selected by the Initial Scan Direction switch. Note that if the selected Initial potential is outside the voltage bounds set by the Upper and Lower Limit controls, the selected scan direction must be that which will carry the output potential within the bounds. If not, a "tilt" condition will exist and the output will simply be held at the Initial potential. If the correct direction is selected, the output, upon triggering, will ramp through the first limit reached and continue to the second, where it will stop. Frame Sync Output pulses mark the beginning and end of each sweep in B-C Toggle operation.

3.4D INPUTS

(1) MODULATION IN: This input allows the operator to superimpose externally derived programming on the waveform generated by the Model 175. The applied signal is inverted and added. There is no amplification. Note that the limit reverses are triggered by the modulation input in the same manner as they are triggered by the internally generated waveform. Thus, in most instances, it will prove desirable to keep the amplitude of the modulation small relative to that of the internally generated signal.

(2) FRAME RESET: This input has the same effect in sweep operation as it does in pulse operation. A positive edge applied to this input resets the output to the Initial potential and lights the INITIAL pushbutton the same as if the pushbutton had been depressed. The output remains at the Initial potential and the pushbutton remains lighted until the instrument is triggered again.

(3) EXT TRIG IN: If the EXT TRIG IN pushbutton is depressed, a negative edge applied to this input triggers the instrument in the same manner as if the ACTIVATE pushbutton had been depressed. Thus, its function in sweep mode operation is the same as in pulse mode operation.

As in pulse operation, an externally derived positive pulse applied to both the Frame Reset and Ext. Trig. Inputs will both reset and trigger the unit. The reset to the Initial potential is coincident with the positive edge of the applied pulse, and the trigger is coincident with the negative edge. In operating the instrument in this manner, one must take care not to have the repetition rate of the externally derived pulse faster than fastest possible rate for the programmed waveform. Even though the unit is immune to triggering while a cycle is in progress, it is not immune to reset. Thus, any positive edge applied to the Frame Reset input will immediately reset the instrument to the Initial potential, even if a cycle is in progress when the positive edge is applied.

3.4E OUTPUTS

(1) FRAME SYNC: Provides a positive pulse (actually the leading edge of a differentiated rectangular positive pulse) coincident with triggering (ACTIVATE pushbutton or external pulse) and a negative pulse (trailing edge of differentiated rectangular positive pulse) coincident with end of programmed waveform. Normal Frame Sync outputs are obtained in B-C Toggle operation in the sweep mode. (See subsection 3.3 to compare with B-C Toggle Frame Sync output action in pulse mode.) The Frame Sync output is particularly useful for synchronizing peripheral equipment in one cycle operation. It is less useful for continuous operation because outputs are available only at the beginning and end of the wavetrain.

(2) CYCLE SYNC: Provides a positive pulse out (leading edge of differentiated rectangular positive pulse) each time the waveform reverses on reaching the Upper Limit potential and a negative pulse out each time the waveform reverses on reaching the Lower Limit potential. Thus the Cycle Sync output is best suited to synchronizing associated equipment in continuous operation where the instrument simply cycles between the two limits.

Under certain specific conditions, Cycle Sync outputs can be obtained at other points on a programmed waveform as well. Triggering is accompanied by a negative Frame Sync output if the scan direction following triggering is positive. If negative, there is no Cycle Sync output coincident with triggering. Similarly, a positive Cycle Sync output accompanies the end of the programmed waveform, providing the output potential is scanning positively at the end of the sweep. If scanning negatively, there is no Cycle Sync output coincident with the end of the sweep.

In B-C Toggle operation, Cycle Sync outputs mark the beginning and end of a scan from the Lower Limit potential to the Upper Limit potential (negative Cycle Sync output at beginning, positive at end). If the sweep is from the Upper Limit to the Lower Limit, no Cycle Sync outputs are generated.

(3) SIGNAL OUTPUT: Programmed output is provided at ±10 V. Current capability is ±20 mA.

3.4F REVERSE PUSHBUTTON

Each time the Reverse pushbutton is pressed, the direction of the scan in progress reverses. This pushbutton need not be held down to maintain its effect. When it is depressed the first time, the scan direction reverses and will continue in the reversed direction even after the button is released. If it is depressed a second time, the original scan direction is restored. Any number of reverses can be made. Note, however, that the scan will end the moment the selected End of Cycle conditions are fulfilled, at which time the Reverse pushbutton will have no further effect.

No Frame Sync outputs are generated when the REVERSE pushbutton is depressed. However, Cycle Sync outputs are provided. If the sweep is ramping positively when reversal occurs, a positive Cycle Sync output is generated. If the sweep is ramping negatively, a negative Cycle Sync output is generated.

3.4G PULSE WIDTH/SCAN RATE SWITCH TO "0" POSITION

No meaningful output is obtained in sweep mode operation with this switch set to "0".

3.4H SAWTOOTH GENERATOR OPERATION

In addition to being able to generate triangular waves having the rise and fall times independently adjustable over an 11:1 range, the Model 175 can also generate real sawtooth waveforms, that is, waveforms having an adjustable rate ramp followed by a high speed reset. Either polarity outputs are possible.

To see how this can be done, recall that whenever a "tilt" condition occurs, the instrument resets instantly to the selected Initial Potential. If the instrument can be made to ramp linearly until a "tilt" condition is obtained, sawtooth waves can be made to occur. To generate a positive sawtooth, one must be concerned with the Initial, Upper, and Lower Limit potentials. The Initial Potential sets the baseline. The Upper Limit potential marks the desired amplitude, and the Lower Limit is set positive with respect to the Upper Limit (normally a forbidden condition). With the controls set in this manner (End of Cycle switch *not* set to FINAL) and with the INITIAL pushbutton depressed, the output potential will be at the Initial potential prior to triggering. When the trigger is applied, the output ramps positively towards the selected Upper Limit (providing the Initial Scan Direction switch is set to "+"). As soon as the Upper Limit potential is reached, the "tilt" condition (Lower Limit more positive than Upper Limit) is sensed and the output immediately resets to the Initial Potential, completing the sawtooth.

Negative sawteeth are produced in a similar manner. The Initial Potential sets the baseline. The Lower Limit sets the amplitude, and the Upper Limit is set negative (normally a forbidden condition) with respect to the Lower Limit. The Initial Scan Direction switch must be set to "–".

3.41 EXAMPLES

Sweep Output Example #1

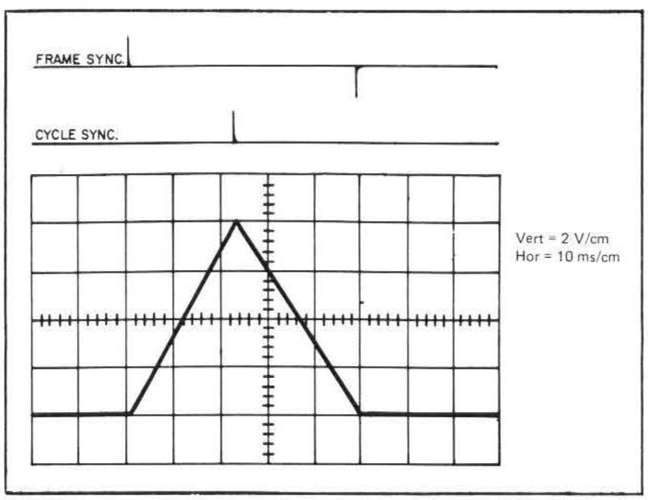


Figure III-6. SWEEP OUTPUT EXAMPLE #1

Control Settings for Sweep Example #1

- INITIAL POTENTIAL: Setting irrelevant. Initial pushbutton not depressed.
- INITIAL SCAN DIRECTION switch: Setting irrelevant
- UPPER LIMIT POTENTIAL: +4.000 V
- LOWER LIMIT POTENTIAL: –4.000 V
- FINAL POTENTIAL: Setting irrelevant. End of Cycle switch set to LOWER LIMIT.
- END OF CYCLE: LOWER LIMIT
- FINAL SCAN DIRECTION switch: Setting irrelevant
- OPERATING MODE: SWEEP
- ONE CYCLE pushbutton: Depressed to establish One Cycle operation
- INITIAL pushbutton: Not depressed. Initial potential not to be programmed into cycle.
- PULSE WIDTH/SCAN RATE switch: 200 V/s
- POSITIVE SLOPE MULTIPLIER: 1.82 (gives positive slope of 364 V/s)
- NEGATIVE SLOPE MULTIPLIER: 1.54 (gives negative slope of 308 V/s)

Sequence

Prior to triggering, the output is at the selected Lower Limit potential, the voltage reached at the end of the clearing cycle. When triggered, ramping towards the upper limit commences, with the rate being that determined by the PULSE WIDTH/SCAN RATE switch and POSITIVE SLOPE MULTIPLIER. When the upper limit is reached, the direction of the scan reverses, and the new ramping rate is that determined by the PULSE WIDTH/SCAN RATE switch and NEGATIVE SLOPE MULTIPLIER. The scan continues until the End of Cycle conditions are satisfied. In this case, the END OF CYCLE switch is set to LOWER LIMIT. Consequently, when the output voltage reaches the selected Lower Limit potential, approaching from a more positive potential, the scan ends.

Sweep Output Example #2

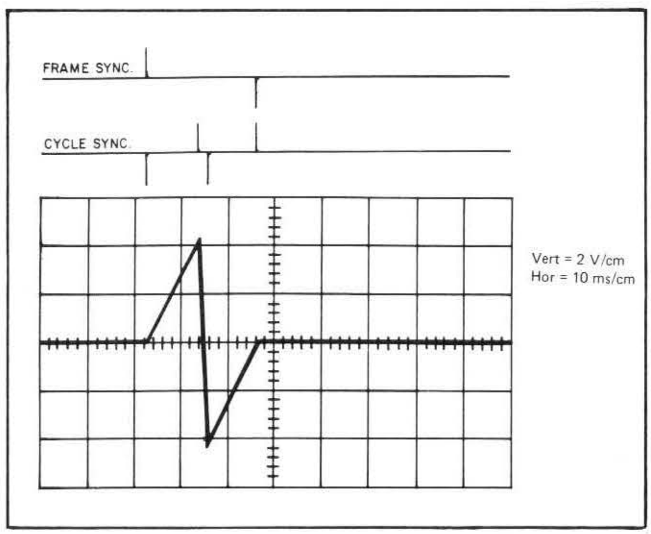


Figure III-7. SWEEP OUTPUT EXAMPLE #2

Control Settings for Sweep Example #2

- INITIAL POTENTIAL: Toggle switch to center (OFF) position to obtain 0 V Initial potential
- INITIAL SCAN DIRECTION switch: "+"
- UPPER LIMIT POTENTIAL: +4.400 V
- LOWER LIMIT POTENTIAL: –4.400 V
- FINAL POTENTIAL: Toggle switch to center (OFF) position to obtain 0 V Final potential
- END OF CYCLE switch: FINAL
- FINAL SCAN DIRECTION switch: "+"

OPERATING MODE: SWEEP
ONE CYCLE pushbutton: Depressed to establish One Cycle operation
INITIAL pushbutton: Depressed to program 0 V Initial potential
PULSE WIDTH/SCAN RATE switch: 200 V/s
POSITIVE SLOPE MULTIPLIER: 1.00 (gives positive slope of 200 V/s)
NEGATIVE SLOPE MULTIPLIER: 11.00 (gives negative slope of 2200 V/s)

Sequence

Prior to triggering, the output is at the selected Initial potential (0 V; toggle switch to center position). When triggered, ramping towards the upper limit commences, with the ramping rate being that determined by the PULSE WIDTH/SCAN RATE switch and POSITIVE SLOPE MULTIPLIER. When the Upper Limit is reached, the direction of the scan reverses. The negative slope is determined by the PULSE WIDTH/SCAN RATE switch and NEGATIVE SLOPE MULTIPLIER. When the negative limit is reached, the ramp direction reverses again. When the selected Final Potential is reached (0 V; toggle switch to center position), the selected End of Cycle conditions are satisfied and the ramp ends. Note that the Frame Sync output marks the beginning and end of the waveform and that the Cycle Sync output marks the two inflection points or reversals. Because the initial slope is positive, an "extra" Cycle Sync output marks the beginning of the waveform as well. Similarly, the positive ramping at the end of the waveform causes an "extra" Cycle Sync output there too.

Sweep Output Example #3

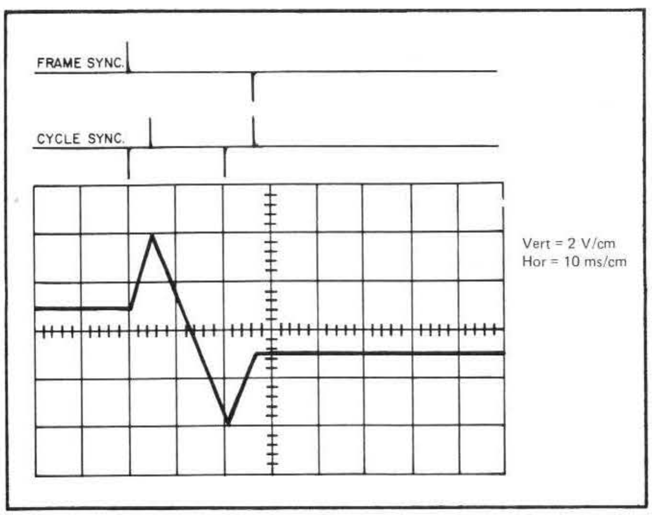


Figure III-8. SWEEP OUTPUT EXAMPLE #3

Control Settings for Sweep Example #3

INITIAL POTENTIAL: +1.000 V
INITIAL SCAN DIRECTION switch: +
UPPER LIMIT POTENTIAL: +4.000 V
LOWER LIMIT POTENTIAL: −4.000 V
FINAL SCAN POTENTIAL: −1.000 V
FINAL SCAN DIRECTION switch: +
END OF CYCLE switch: FINAL
OPERATING MODE: SWEEP
ONE CYCLE pushbutton: Depressed to establish One Cycle operation
INITIAL pushbutton: Depressed to program in selected Initial potential
PULSE WIDTH/SCAN RATE switch: 500 V/s
POSITIVE SLOPE MULTIPLIER: 1.20 (gives positive slope of 600 V/s)
NEGATIVE SLOPE MULTIPLIER: 1.00 (gives negative slope of 500 V/s)

Sequence

Except that the Initial and Final potentials are set to non-zero values, Example #3 is essentially the same as Example #2.

Sweep Output Example #4

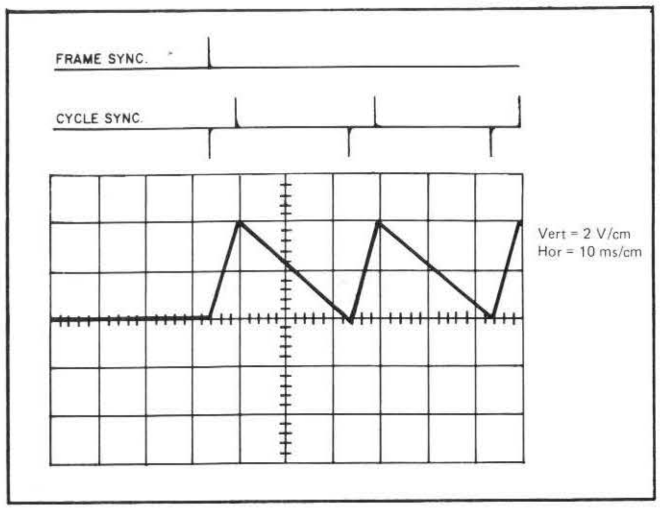


Figure III-9. SWEEP OUTPUT EXAMPLE #4

Control Settings for Sweep Example #4

INITIAL POTENTIAL: 0 V (toggle switch to center position)
INITIAL SCAN DIRECTION switch: +
UPPER LIMIT POTENTIAL: +4.000 V
LOWER LIMIT POTENTIAL: −0.200 V
FINAL SCAN POTENTIAL: Setting irrelevant (operation to be continuous)
FINAL SCAN DIRECTION switch: Setting irrelevant
END OF CYCLE switch: Setting irrelevant
OPERATING MODE: SWEEP
ONE CYCLE pushbutton: Not depressed (operation to be continuous)
INITIAL pushbutton: Depressed to program in selected Initial potential (0 V)
PULSE WIDTH/SCAN RATE switch: 100 V/s
POSITIVE SLOPE MULTIPLIER: 6.66 (gives positive slope of 666 V/s)
NEGATIVE SLOPE MULTIPLIER: 1.75 (gives negative slope of 175 V/s)

Sequence

Prior to triggering, the output is at the selected Initial potential, 0 V. When the unit is triggered, the output commences to ramp positively. It continues until the selected Upper Limit potential is reached, at which point the output reverses direction, ramping negatively towards the Lower Limit potential. Each time a limit is reached, the scan reverses direction. The positive and negative rates differ as determined by the setting of the PULSE WIDTH/ SCAN RATE and MULTIPLIER controls. This cycling continues until the wavetrain is terminated. Note that a Frame Sync output marks the beginning of the wavetrain, and that each reversal is marked by a Cycle Sync output. Because the initial slope is positive, an extra Cycle Sync output is provided at the beginning. Depending on how the wavetrain is terminated, there may or may not be Frame Sync output when the wavetrain is terminated.

3.5 USING THE MODEL 175 WITH OTHER EQUIPMENT

3.5A MODEL 170 AND 171 ELECTROCHEMICAL SYSTEMS

Because the External Inputs of both of these systems is capacitively coupled, they cannot be used with the Model 175 unless the coupling capacitor is shorted out. In both cases, the coupling capacitor C323, a 10 μF capacitor located on the Summing Amplifier Circuit Board, can be easily shorted as required. This is probably most conveniently done by "solder-tacking" a short jumper on the underside of the circuit board. Once this modification is made, the Models 170 and 171 have dc coupled inputs with an input resistance of 10 kΩ.

The Model 175 output can be combined with the Model 170 programming signal to produce programs neither can generate singly. For example, if a pulse-ramp sequence were desired, the Model 170 could be set to PULSE and the Model 175 to SWEEP. The Pulse program would be initiated at the Model 170, with the trailing edge of the pulse used to trigger the Model 175 Sweep program. There are undoubtedly many uses for the combined instruments once their full combined capabilities are appreciated.

3.5B MODEL 371 AND MODEL 373 POTENTIOSTATS

The Model 175 Signal Output can be connected directly to the External Signal Input of either the Model 371 or 373. No modifications are required. For most applications, it is recommended that the Applied Potential controls at the Model 371 (373) be switched off, leaving the Model 175 alone to provide the desired program potentials and waveforms.

3.5C MODEL 173 POTENTIOSTAT

As with the Models 371 and 373, there are no interface problems. The output of the Model 175 is connected directly to the External Signal Input connector of the Model 173. The combination offers the possibility of combining the Sweep/Pulse capabilities of the Model 175 with the Pulse/Step capabilities of the Model 173. Triggering is required, but two dc levels and switching are available in the Model 173 to combine with the Model 175 Output. Complete control by the Model 175 only can be achieved by setting the Model 173 Applied Potential controls to OFF.

3.5D MODEL 174 POLAROGRAPHIC ANALYZER

The Model 175 output can be directly connected to the Model 174 External Input at J36 (Accessory Ext. Pwr. connector at rear of Model 174). A special cable to accomplish this is available (Princeton Applied Research Corporation #6020-0091-03) for interconnecting these two instruments. This cable is terminated at one end in a 14-pin connector that mates with J36 of the Model 174. The other end is terminated in a BNC connector to mate with the Model 175 Signal Output connector.

The Model 174 has a limited current capability and frequency response. Consequently one should take care to only select programs at the Model 175 that the Model 174 can follow. In particular, sweeps faster than 10 V/s should not be used. However, all other Model 175 programming capabilities can be used. It may be possible to increase the Model 174 frequency response for a specific application. The factory should be consulted for advice in each case.

3.6 POTENTIAL AND CONTROL AMBIGUITIES

It may occasionally happen that an operator will program a waveform, press ACTIVATE, and find that the instrument doesn't respond. Should this occur, a close investigation will usually reveal that the instrument has indeed responded and generated the programmed waveform, but that the program was not what the operator thought it to be due to potential ambiguities. When two potentials are set within 10 mV of each other, it is always possible, as a result of dc drift, that the polarity relationship between the potentials may not be as indicated by the controls. For example, suppose one wished to program a sweep waveform that was to start at 0 V, ramp positively to +5 V, ramp negatively to −5 V, and then ramp positively to end at 0 V. There are two possible approaches to programming the waveform. One "obvious" approach, the one that can cause difficulties, would be to set INITIAL to 0.000 (Initial Scan Direction to "+"), UPPER LIMIT to +5.000 V, LOWER LIMIT to −5.000 V, and FINAL to 0.000 V (Final Scan Direction to "+"). To operate with this program, after the clearing cycle, one would press INITIAL and then ACTIVATE. The problem lies with having both INITIAL and FINAL set to the same potential and both "in" the program. Suppose, due to drift effects, that FINAL was actually a few millivolts negative with respect to INITIAL. There would be no problem. The expected waveform would appear at the output. Now suppose that the situation was reversed, in other words, that FINAL was actually a few millivolts positive with respect to INITIAL. When ACTIVATE was depressed, the ramp would begin to move positively. However, after only a few millivolts, the final conditions would be fulfilled, namely that the selected FINAL potential was reached while ramping positively, and the ramp would stop right there. Chances are the operator would assume that the instrument had mistriggered, when, in fact, it had done exactly as commanded, namely to ramp until the FINAL conditions were satisfied, and then to stop.

The alternative way to generate this waveform is simply NOT to include INITIAL. If the Initial pushbutton is not depressed prior to pressing ACTIVATE, the Output will be at the FINAL potential (0.000 V) prior to triggering (it got there via the clearing cycle). When the unit is triggered, there will be no ambiguities because the entire program contains but three potentials (UPPER LIMIT, LOWER LIMIT, FINAL), all separated by more than 10 mV, and the expected output will be obtained without fail.

Consider another example. Suppose one had a program similar to that described above, but where INITIAL and FINAL were in fact substantially different potentials. Instead of starting from 0 V, the operator wanted to start at +4.995 V, ramp positively to +5.000 V, negatively to −5.000 V, and positively to 0 V to end the program. The problem in this example doesn't lie with the use of INITIAL (it must be used to obtain a four-level program) but rather with the closeness of the INITIAL and UPPER LIMIT potentials. The five millivolt difference is so small, that drift could easily generate a situation where the INITIAL potential was positive with respect to the UPPER LIMIT. Should this occur, when the unit is triggered, it could not possibly follow the first command, namely, to ramp positively towards a potential that is negative with respect to the INITIAL potential. The result would be a TILT.

Problems of this sort should be relatively rare. By observing the following two guidelines, they should never occur at all.

(1) Never program in more sets of Potential controls than there are *different* potential levels in the desired waveform. Be especially mindful of this situation wherever the potential at the end of the waveform is the same as at the beginning, because there is frequently an all too "obvious" way of programming the waveform using different controls for the pre-trigger and end-of-waveform levels.

(2) Never set any two "programmed in" sets of Potential Controls within 10 mV of each other.

SECTION IV SAFETY NOTICE

WARNING! POTENTIALLY LETHAL VOLTAGES ARE PRESENT INSIDE THIS APPARATUS. THESE SERVICE INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO TO SO. Any adjustment, maintenance and repair of the opened apparatus under voltage shall be avoided as far as possible and, if unavoidable, shall be carried out only by a skilled person who is aware of the hazard involved. When the apparatus is connected to a power source, terminals may be live, and the opening of covers or removal of parts is likely to expose live parts. The apparatus shall be disconnected from all voltage sources before it is opened for any adjustment, maintenance, or repair. Note that capacitors inside the apparatus may still be charged even if the apparatus has been disconnected from all voltage sources. Service personnel are thus advised to wait several minutes after unplugging the instrument before assuming that all capacitors are discharged. If any fuses are replaced, be sure to replace them with fuses of the same current and voltage rating and of the same type. The use of makeshift fuses and the short-circuiting of fuse holders are prohibited.

SECTION IV
ALIGNMENT

4.1 INTRODUCTION

The Model 175 Universal Programmer is a reliable, conservatively designed instrument. High quality stable components are used throughout the unit and one can reasonably expect a long period of troublefree operation without need to realign the instrument. However, to be assured of continued high confidence in measurement data obtained with the Model 175, it is advisable to run through the following alignment procedure at one year intervals. Also, should the unit have to be repaired, realignment after proper operation has been restored is advised. Note that these checks and adjustments are NOT intended to be used as a troubleshooting procedure. The basic assumption underlying this section is that the instrument is functioning normally. Appropriate information on isolating malfunctions is contained in Section V.

Because there is considerable interaction between many of the adjustments, it is important that these procedures be carried out in the indicated order. Any decision to make a partial alignment should be reserved to someone having sufficient knowledge of the circuitry to fully understand all possible interactions.

A special convention is used throughout this section to aid in physically identifying the adjustments. When the component number of an adjustment is mentioned, that number is followed by another number in parentheses. The number in parentheses indicates which of the adjustments on that particular circuit board is being called out. Number (1) represents the adjustment closest to the front of the instrument on the circuit board in question. Number (2) represents the next adjustment, moving towards the rear. Number (3) is the third, and so forth, up to as high a number as is required. Thus, for example, R106(7) represents the seventh adjustment from the front on the Amplifier board. Figure IV-1, in addition to identifying the boards, gives a secondary means of identifying the adjustments. Note that all "100 series" components are located on the Amplifier board, all "200 series" components are located on the Logic board, and all "300 series" components are located on the Power Supply board.

The testpoints referred to are "gold-pin" type testpoints located at various spots on the circuit boards. An appropriate identification number is located next to each testpoint on the component side of the board. The Parts Location Diagrams associated with the schematics in Section VI can also be used to locate a given testpoint. Frequently, practical considerations make it quicker and easier to identify the testpoints from the Parts Location Diagrams than from the boards themselves. If the instrument is warmed up and running, it is not generally advisable to shut down and remove a board so that the testpoint can be identified. Two accessories particularly well suited to monitoring testpoints far from a board edge are the Rye Industries KLEP 30 "clip/probe" and the Pomona "grabber" plunger-action Mini-Test clip.

4.2 EQUIPMENT REQUIRED

(1) Digital Voltmeter (referred to hereafter simply as DVM). Instrument is to have five places and be accurate to ±0.05% overall. DVM will be used to make off-zero voltage measurements.

(2) Differential Voltmeter having a sensitivity of ±100 μV or better. Voltmeter will be used to make zero adjustments. HP-419A is suitable.

(3) Counter for making time interval measurements. HP-5325B is suitable.

4.3 PRELIMINARY STEPS

To be assured of a good alignment, the instrument should be warmed up for about one hour prior to beginning. Inasmuch as the cover must be off to do the alignment itself, it is advisable to have the cover off during the warmup to avoid any sudden temperature gradients which might develop if the cover were removed at the end of the warmup but immediately before proceeding. With the same considerations in mind, it is advisable that the alignment be performed in a room which has a fairly stable temperature (the early morning warming trend is given time to stabilize) and which is relatively free of drafts.

4.4 POWER SUPPLY CHECKS

(1) Connect the DVM to TP302 on the Power Supply board. The voltage should be +5 V ±0.2 V. There is no adjustment for the +5 V level.

(2) Transfer the DVM to TP303. The voltage there should be +15 V ±0.1 V. R326(1) can be used to bring the voltage within tolerance. Do not bother adjusting R326 unless the error is greater than 0.1 V because the +15 V level is critically adjusted further on in the procedure to different criteria.

(3) Transfer the DVM to TP304. The voltage there should be −15 V ±0.1 V. R343(2) can be used to bring the voltage within tolerance. Do not bother adjusting R343 unless the error is greater than 0.1 V because the −15 V level is critically adjusted to different criteria further on in the procedure.

4.5 POTENTIAL ADJUSTMENTS

(1) Set the front panel controls as follows (settings don't matter for controls not mentioned).

Four sets of POTENTIAL controls: 0.000 V (toggles to center position; dials fully counterclockwise)
Operating Mode: SWEEP
Power: ON
Initial pushbutton: Depress this pushbutton. It will become illuminated and remain so after release.

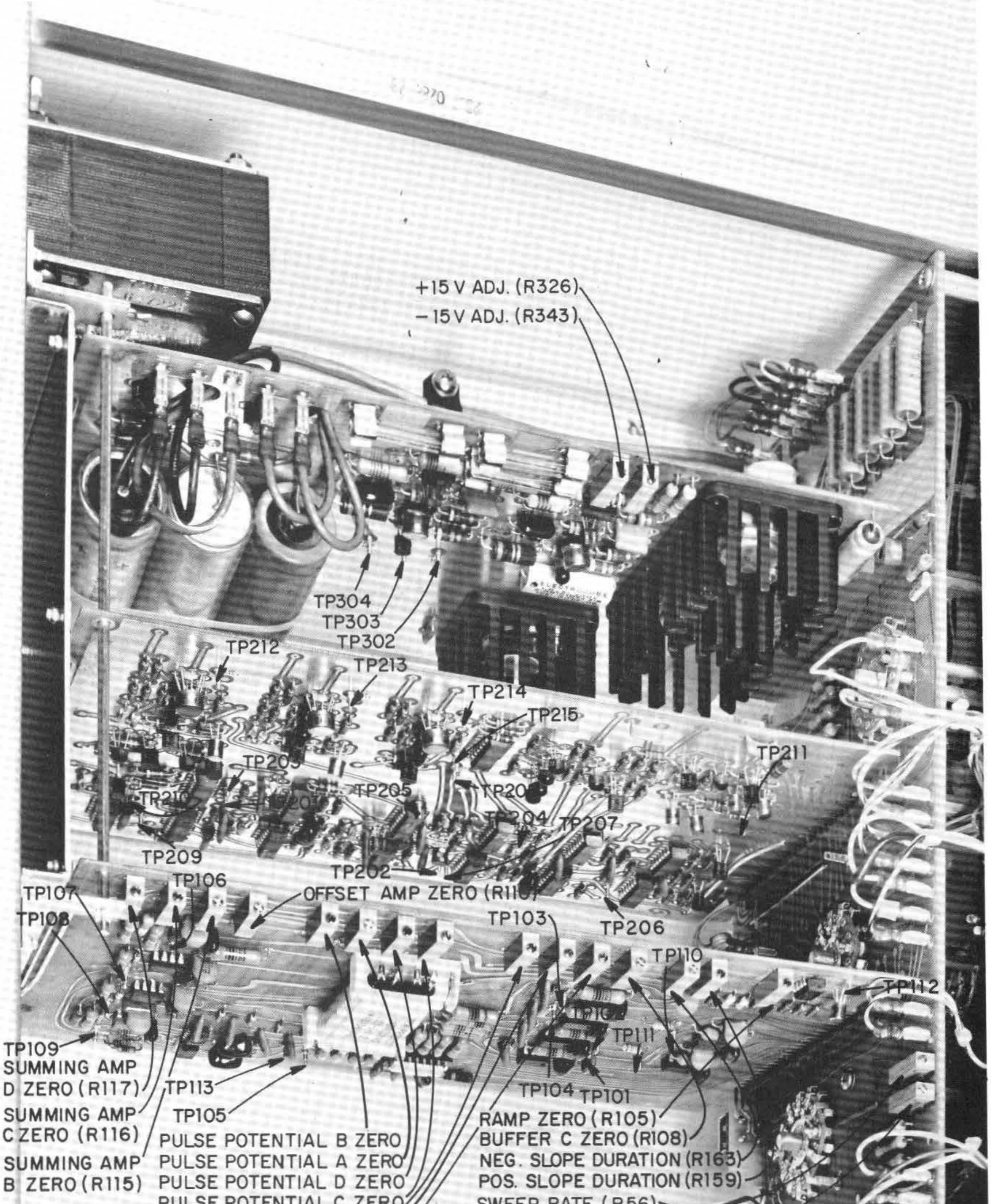


Figure IV-1. MODEL 175 ADJUSTMENTS AND TESTPOINTS

NOTE: With this combination of control settings, the TILT light will glow. This is normal and not a malfunction indication.

(2) Buffer Amplifier A Zero ------ R106(7)

(a) Connect the dc voltmeter (HP-419A) to TP101 on the Amplifier board. The ground should be picked up at quick-disconnect pin 20 on the Mother board. Observing the instrument from the front, note that there is a column of eight quick-disconnect pins mounted on the reverse side of the Mother board along the right-hand edge. Pin 20 is the third one down.

(b) Adjust R106(7) for a meter reading of 0 V ±50 μV.

(3) Initial Potential Calibration

(a) Remove the dc voltmeter from TP101 and connect the DVM in its place. Again the ground should be taken from quick-disconnect pin 20 of the Mother board.

(b) Set the INITIAL Potential controls to +1.000 V. Note and record the DVM indication.

(c) Set the INITIAL Potential controls to −1.000 V. The DVM reading should be equal but opposite to that obtained in (a). If it is not, it will be necessary to alternate the Initial Potential toggle switch between "+" and "−" while adjusting R343(2) on the Power Supply board as required to make the two readings equal. Note that R343(2), which sets the −15 V level, affects the "+" potential output only.

(d) Set the Initial Potential toggle switch to the center (off) position. Then recheck the potential at TP101 with the dc voltmeter. If the zero has shifted, rezero, and after so doing, go back and repeat steps (a) through (c).

(e) With the INITIAL Potential controls set to +1.000 V and the DVM monitoring TP101, adjust R326(1) on the Power Supply board as required to obtain a DVM indication of +1.000 V.

(f) Increase the selected Initial Potential to +5.000 V. The DVM indication should be in the range of +4.990 V to +5.010 V. Then reverse the polarity of the Initial Potential. The DVM indication should then be in the range of −4.990 V to −5.010 V. If either of these indications are out of tolerance, further trimming of the R326(1) and R343(2) will be required. The tolerance spread is ±0.2% at 5 V (both polarities) and at 1 V (both polarities). If necessary, alternate between 1.000 V (both polarities) and 5.000 V (both polarities) while making further adjustments of R343 and R326 until the Initial Potential calibration criteria are satisfied.

(g) With the Initial Potential toggle switch in the center position, again check the zero at TP101 with the dc voltmeter. It should still be within the ±50 μV specified tolerance range. If it is out of tolerance, readjust R106(7) on the Amplifier board.

(h) Be sure all Potential toggle switches are set to center (off) position before proceeding. INITIAL should remain illuminated.

DO NOT TOUCH THE POWER SUPPLY BOARD ADJUSTMENTS AGAIN THROUGHOUT THE REMAINDER OF THIS PROCEDURE.

4.6 AMPLIFIER BOARD ZERO ADJUSTMENTS (continue ground connection to pin 20 of Mother board)

(1) Buffer Amplifier A ------ R106(7)

This adjustment has already been set in subsection 4.5 and need not be disturbed again.

(2) Buffer Amplifier B ------ R107(6)

(a) Connect the voltmeter to TP102.

(b) Adjust R107(6) for a meter indication of 0 V ±100 μV.

(3) Buffer Amplifier C ------ R108(4)

(a) Connect the voltmeter to TP103.

(b) Adjust R108(4) for a meter indication of 0 V ±100 μV.

(4) Buffer Amplifier D ------ R109(5)

(a) Connect the voltmeter to TP104.

(b) Adjust R109(5) for a meter indication of 0 V ±100 μV.

(5) Ramp Generator ------ R105(1)

(a) Connect the voltmeter to TP112.

(b) Adjust R105(1) for a meter indication of 0 V ±100 μV.

(6) Offset Amplifier ------ R110(12)

(a) Connect the dc voltmeter to TP106.

(b) Adjust R110(12) for a meter indication of 0 V ±200 μV.

(7) Summing Amplifier B ------ R115(13)

(a) Connect the voltmeter to TP107.

(b) Adjust R115(13) for a meter indication of 0 V ±500 μV.

(8) Summing Amplifier C ------ R116(14)

(a) Connect the voltmeter to TP108.

(b) Adjust R116(14) for a meter indication of 0 V ±500 μV.

(9) Summing Amplifier D ------ R117(15)

(a) Connect the voltmeter to TP109.

(b) Adjust R117(15) for a meter indication of 0 V ±500 μV.

(10) Remove the dc voltmeter.

4.7 AMPLIFIER BOARD PULSE ADJUSTMENTS (continue ground connection to pin 20 of Mother board)

(1) Change the operating mode switch position from SWEEP to PULSE. Then depress the ONE CYCLE pushbutton.

(2) Transfer the dc voltmeter input from TP109 to TP105.

(3) Pulse, Potential A ------ R111(10)

(a) Verify that the voltmeter is connected to TP105 and that INITIAL is illuminated as a result of having been depressed in an earlier step.

(b) Adjust R111(10) for a meter indication of 0 V ±100 μV.

(4) Pulse, Potential B ------ R112(11)

(a) Set the Pulse Width/Scan Rate switch to STEP.

(b) Press the ACTIVATE pushbutton.

(c) Adjust R112(11) for a meter indication of 0 V ±100 μV.

(5) Pulse, Potential C ------ R113(8)

(a) Set the End of Cycle switch to C, LOWER LIMIT. Then set the Pulse Width/Scan Rate switch to .1 (fully clockwise; red symbolization). The associated toggle switch should be to the left and the Multipliers should be fully counterclockwise, giving a .1 s pulse width.

(b) Press the ACTIVATE pushbutton.

(c) Adjust R113(8) for a meter indication of 0 V ±100 μV.

(6) Pulse, Potential D ------ R114(9)

(a) Set the End of Cycle switch to D, FINAL.

(b) Press the ACTIVATE pushbutton.

(c) Adjust R114(9) for a meter indication of 0 V ±100 μV.

4.8 PULSE WIDTH/SCAN RATE ADJUSTMENTS

(1) Set the controls as follows.

A Potential: 0 V (toggle switch to center [off] position)
B Potential: +1.000 V
C Potential: −1.000 V
D Potential: −0.500 V
One Cycle pushbutton: Release pushbutton to "out" position (not illuminated)
Pulse Width/Scan Rate: 10 (red symbolization); toggle to mSEC (right)

(2) Connect the time interval counter to the Signal Out jack. Set the counter controls to start counting on a negative transition and to stop on a positive transition with a common trigger.

(3) Pulse Duration ------ R163(3)

(a) Press the ACTIVATE pushbutton. The Model 175 will commence to pulse continuously and the counter should indicate the pulse duration (nominally 10 ms). To be sure the correct interval is being measured (the pulse as opposed to the duration between the pulses), adjust the C Multiplier. If the indicated duration changes, the correct interval is being measured. Leave the Multiplier set to 1.000 (fully counterclockwise).

(b) Adjust R163(3) on the Amplifier board for an indicated duration of 10.00 ms.

(4) Pulse Duration ------ R159(2)

(a) Reverse the counter trigger polarity settings, that is, set the counter controls to start on a "+" and stop on a "−". This time, the B Multiplier should affect the indicated reading. Leave the B Multiplier set to 1.000 (fully counterclockwise).

(b) Adjust R159(2) on the Amplifier Board for an indicated duration of 10.00 ms.

(5) Sweep Rate ------ R56 (located on Mother board; see Figure IV-1)

(a) Set the Operating Mode switch to SWEEP. The selected scan rate should be 10 V/SEC. (With respect to the control settings, 10 V/SEC in sweep operation is the same as 10 mSEC in pulse operation.)

(b) Transfer the counter input from the Signal Out jack to the Cycle Sync jack of the Model 175. Set the counter controls to start counting on "–" and to stop on "+".

(c) Adjust the B (Pos. Slope) Multiplier to verify correct triggering. If the indicated duration (nominally 200 ms) varies with the B Slope Multiplier setting, the triggering is correct. Leave the Multiplier fully counterclockwise (1.00).

(d) Adjust R56 on the Mother board for an indicated duration of 200 ms.

(6) Sweep Rate ------ R55 (Mother board)

(a) Reverse the counter trigger polarity, that is, set the controls so that the counter starts on "+" and stops on "–".

(b) Adjust R55 for an indicated duration of 200 ms.

This completes the alignment. The test equipment can be removed and the top cover returned.

SECTION V SAFETY NOTICE

WARNING! POTENTIALLY LETHAL VOLTAGES ARE PRESENT INSIDE THIS APPARATUS. THESE SERVICE INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO TO SO. Any adjustment, maintenance and repair of the opened apparatus under voltage shall be avoided as far as possible and, if unavoidable, shall be carried out only by a skilled person who is aware of the hazard involved. When the apparatus is connected to a power source, terminals may be live, and the opening of covers or removal of parts is likely to expose live parts. The apparatus shall be disconnected from all voltage sources before it is opened for any adjustment, maintenance, or repair. Note that capacitors inside the apparatus may still be charged even if the apparatus has been disconnected from all voltage sources. Service personnel are thus advised to wait several minutes after unplugging the instrument before assuming that all capacitors are discharged. If any fuses are replaced, be sure to replace them with fuses of the same current and voltage rating and of the same type. The use of makeshift fuses and the short-circuiting of fuse holders are prohibited.

SECTION V
TROUBLESHOOTING

5.1 INTRODUCTION

This section of the manual is intended to serve as an aid in troubleshooting the Model 175. Basically the section is divided in two. The first portion consists of a block diagram discussion. The second comprises a suggested troubleshooting procedure. By making voltage and waveform checks at critical points, it should be possible to narrow most problems down to the malfunctioning circuit board. Once the faulty board is located, the operator is advised to contact the factory or the authorized representative in this area for advice on how to get the instrument back into operation in the shortest possible time. In the case of units still in Warranty, it is particularly important that the factory or one of its authorized representatives be contacted before doing any work on the board itself, as any damage incurred from unauthorized work could invalidate the Warranty.

Although past experience indicates that most instrument failures are caused by the failure of a plug-in board component, it is of course perfectly possible that a component other than one located on a circuit board could go bad. Where this is the case, the person troubleshooting will have to appropriately adapt the procedure to isolate the faulty component.

5.2 BLOCK DIAGRAM DISCUSSION

5.2A INTRODUCTION

Figures V-1 and V-2 are simplified block diagrams of portions of the Model 175. Figure V-1 illustrates the functioning of the basic sweep generator circuitry. Figure V-2 illustrates the functioning of the additional circuitry which is activated in pulse mode operation.

5.2B SWEEP GENERATOR

Referring to Figure V-1, note that the basic Ramp Generator consists of an operational amplifier having a feedback capacitor connected from its output to its summing junction, with the summing junction being fed from a variable current source (variable resistor between the summing junction and a potential source). For any given input current, the ramping rate in volts per second is simply i/C, where "i" is the current through the resistor in microamperes and "C" is the feedback capacitance in microfarads. Different settings of the Pulse Width/Scan Rate control result in different values for the Ramping Current Resistor, and hence in different sweep rates. The Ramping Current Resistor is returned to the junction of two separate potential sources, one positive and the other negative, only one of which is "on" at a time. Field-effect

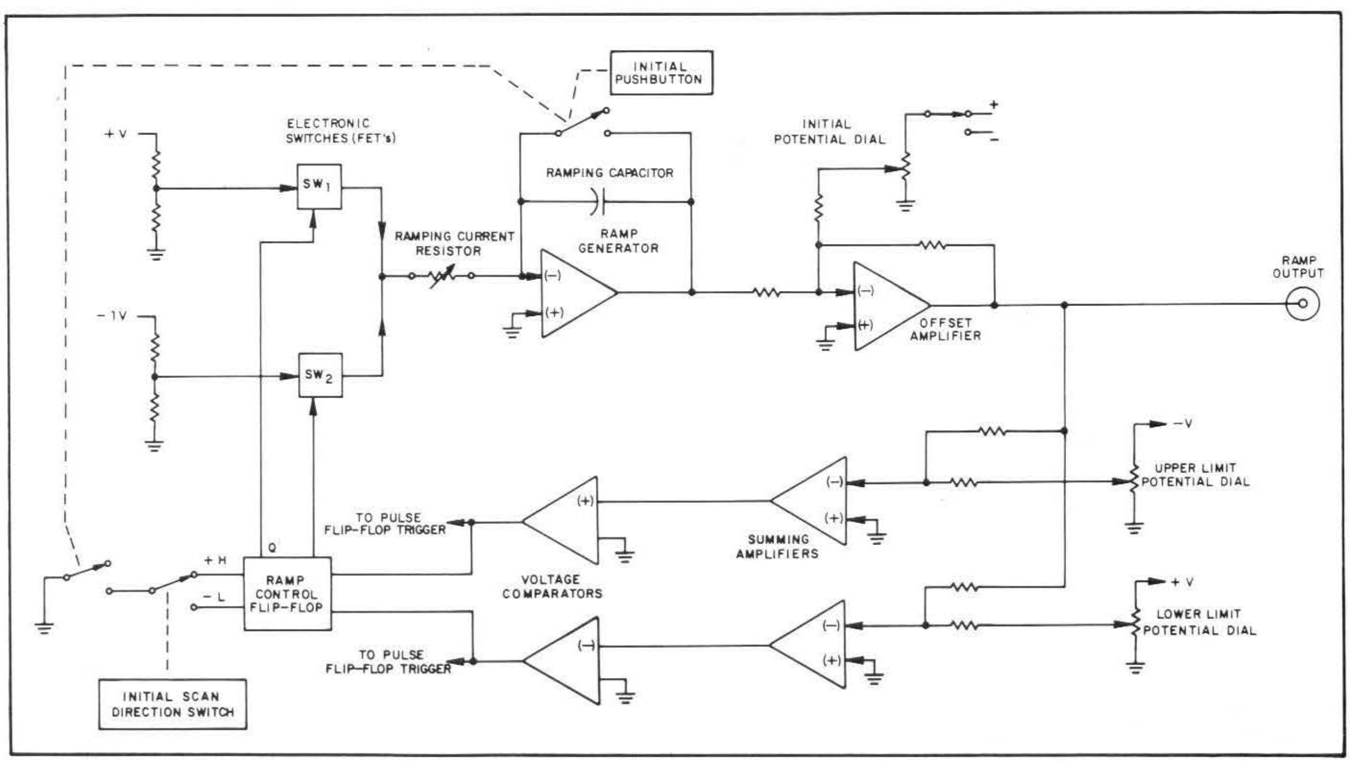


Figure V-1. SIMPLIFIED BLOCK DIAGRAM OF SWEEP GENERATOR CIRCUITS transistor switches SW_1 and SW_2 connect one potential source or the other (never both) to the Ramping Current Resistor. When the positive source is connected to the resistor, the Ramp Generator output ramps negatively. When the negative source is connected to the Ramping Current resistor, the Ramp Generator ramps positively. A Ramp Control Flip-Flop circuit determines which electronic switch is "on" at any time. This flip-flop in turn is controlled by feedback and comparison circuits, as explained in the following paragraphs.

The output of the Ramp Generator is applied to an inverting Offset Amplifier, which directly drives the Model 175 Signal Output connector. Note that this Offset Amplifier also has as an input the potential selected by the Initial Potential control (assuming Initial pushbutton is depressed). The effect of having the Initial potential summed with the Ramp Generator output is to allow the Initial Potential controls to select the potential at which a given ramp begins. When the Initial pushbutton is depressed, the Ramp Generator feedback capacitor is shorted, clamping the Ramp Generator output to ground, and leaving the selected Initial potential as the only input to the Offset Amplifier. In this manner the Output Potential is established at the Initial potential. This state persists until the instrument is triggered, at which time the clamp releases.

Note that the Initial Scan Direction switch supplies one set of inputs to the earlier mentioned Ramp Control Flip-Flop. This arrangement, which is active only when the Initial Pushbutton has been depressed, allows the Initial Scan Direction switch to act through the flip-flop to govern which way the Ramp Generator will ramp when the clamp is released.

Besides driving the instrument output, the Offset Amplifier also drives two Summing Amplifiers. One of these amplifiers also has as an input the selected Upper Limit potential. The other has the Lower Limit potential as its second input. The output of the first amplifier is the sum of the ramp and the selected Upper Limit potential. The output of the other is the sum of the ramp and the selected Lower Limit potential. Each amplifier drives a Voltage Comparator that switches when the output of the preceding amplifier crosses ground potential. With this arrangement, only one of the two comparators controls the state of the Ramp Control Flip-Flop at a time. When the output of the first comparator is "up", switch SW_1 is "on" and a positive ramp is applied to the Signal Output connector. When the output of the other comparator is "up", switch SW_2 is "on", and a negative ramp is applied to the Signal Output connector.

To better see how the Limit circuits work, assume the unit is operating continuously and that a positive ramp is in progress (positive referred to Signal Output connector; corresponds to negative at output of Ramp Generator). For a positive ramp to be in progress, SW_1 must be "on", as determined by the Ramp Control flip-flop. Initially, the net input to the upper Summing Amplifier is negative because of the potential input from the Upper Limit controls. (Note that actual potential applied to Summing Amplifier is of opposite polarity to that selected.) However, as the ramp rises, the net input will eventually become positive when the ramp voltage reaches (and exceeds by some small voltage) the Upper Limit potential. When that happens, the Summing Amplifier output switches, as does that of the Voltage Comparator, and the Ramp Control Flip-Flop is switched to the opposite state, turning SW_1 off and SW_2 on. The ramping polarity reverses and the sweep, as observed at the Signal Output connector, heads negative. It continues negative until the Lower Limit Summing Amplifier and Voltage Comparator work in an analogous manner to again reverse the ramp direction. Thus the output alternately sweeps between the upper and lower limit potentials. In One Cycle operation, other circuits, not shown, act to terminate the waveform after one cycle is completed.

5.2C PULSE GENERATOR

Referring to Figure V-2, note that the heart of the Pulse Generator circuitry is a Four-Channel Operational Amplifier (Harris Semiconductor HA2405). This is a programmable amplifier that accepts four input potentials, and, depending on the logic programming input to the amplifier, applies one of these four input potentials to the Signal Output connector. The four input potentials are those selected by the four sets of front-panel Potential controls. There are two digital control lines, D_0 and D_1. When both lines are high (logic 1), the A potential is applied to the output. When D_0 is high and D_1 low (logic 0), potential B appears at the output. When both lines are low, it is potential C. Last, when D_0 is low and D_1 is high, potential D appears at the output. The switching from one potential to the other is smooth and fast (2 V/μs) and there is little or no overshoot. All of the other Pulse Generator circuits serve to control D_0 and D_1 so that at any time the correct potential is applied to the output.

In seeing how these circuits work, it is necessary to consider both the control logic circuits and the sweep circuits discussed earlier. For the sake of completeness and simplicity, assume the Initial pushbutton has been depressed. The output is clamped to the selected Initial potential and the Ramp Generator is inactive. At the moment the Initial Pushbutton is depressed, a pulse is applied to the three flip-flops, setting them as shown. Since the output of the Initial Flip-Flop is low, the output of NAND Gates 1 and 2 is set high (independent of the states of the Pulse and Final Flip-Flops). As indicated above, with both D_0 and D_1 high, potential A is applied to the Signal Output connector.

When the unit is triggered, an Activate Pulse is generated that switches the Initial Flip-Flop, changing its output from low to high. As a result, Gate 1 has one high input (Initial Flip-Flop output) and one low input (Pulse Flip-Flop output), and its output remains high. Gate 2, on the other hand, now has both of its inputs high and so its output switches to the low state, causing potential B to be routed through the Four-Channel Operational Amplifier and applied to the Signal Output connector. Thus, triggering is immediately followed by a step from potential A to potential B.

At the same time, the clamp on the Ramp Generator is

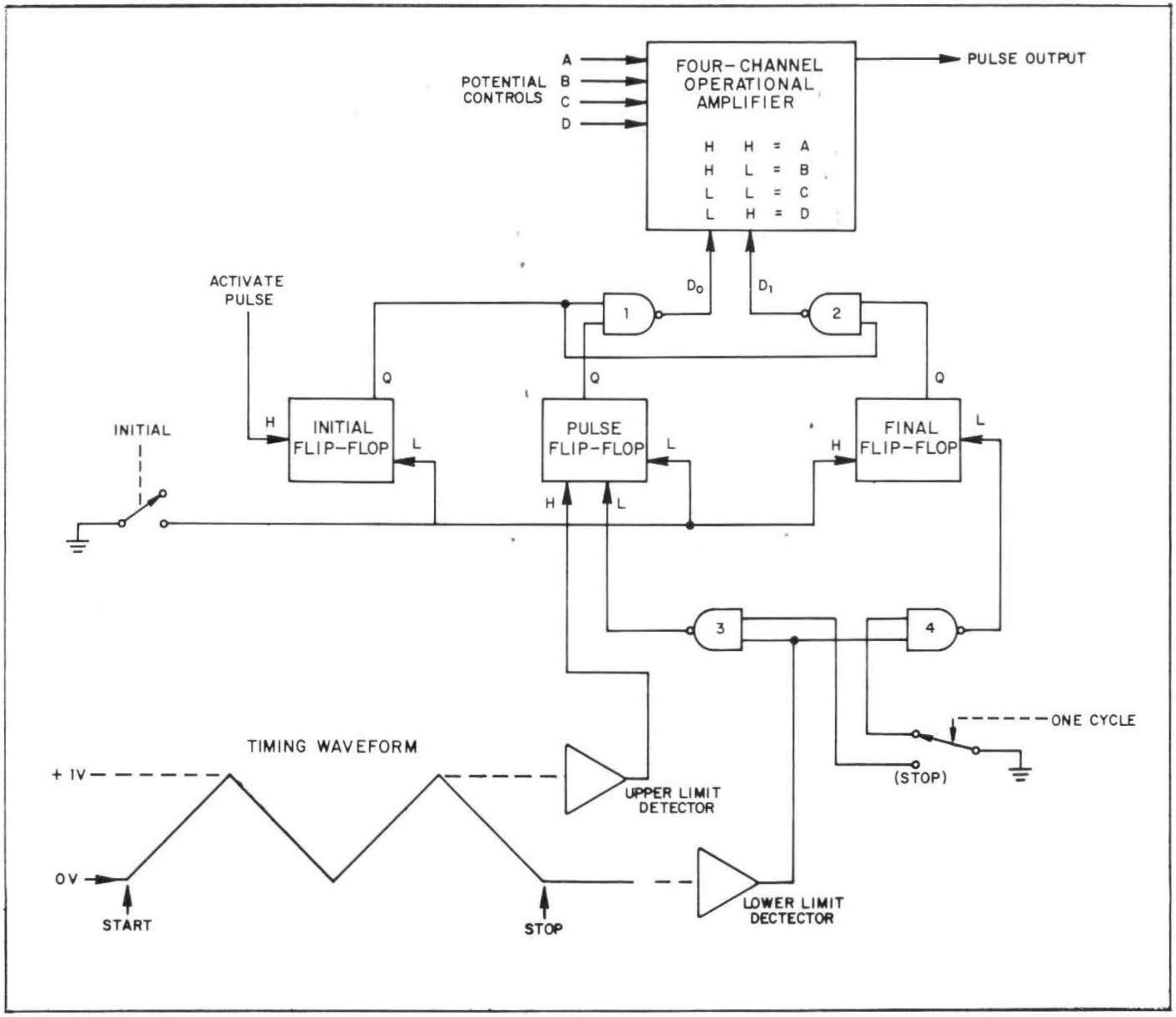


Figure V-2. SIMPLIFIED BLOCK DIAGRAM OF PULSE GENERATOR CIRCUITS

released, and the resultant ramp is applied to the Upper and Lower Limit Detector circuits as shown. No further switching occurs until a limit is reached (upper limit in the illustrated examples), at which time the Limit Detector acts to reverse the state of the Pulse Flip-Flop. With the output of the Pulse Flip-Flop switched from low to high, Gate 1 has both inputs high and its output goes low. Gate 2 is unaffected, that is, its output remains low. With both D_0 and D_1 low, the Four-Channel Operational Amplifier switches again and potential C is applied to the output.

Because of the limit detection, the ramp direction reverses. The output remains at potential C until the lower limit is detected. The Lower Limit Detector then acts through Gate 3 to again reverse the state of the Pulse Flip-Flop, which switches the output of Gate 1 back to the high state, restoring potential B at the output. The ramp direction simultaneously reverses again, heading positive. These alternate transitions from B to C and back again will continue for as long as continuous operation is maintained.

In One Cycle operation, Gate 4 becomes active (in continuous operation its output is held continuously high) after the transition to potential C. The following limit detection switches Gate 4 and hence the Final Flip-Flop, Gate 2 switches and D_1 goes high. This time, however, Gate 3 is inhibited, and D_0 remains low. With D_0 low and D_1 high, potential D appears at the output. Other circuitry, not illustrated, stops the sweep at that point and no further change occurs unless the instrument is triggered.

5.3 TROUBLESHOOTING PROCEDURE

5.3A INTRODUCTION

When the instrument is known or suspected to be malfunctioning, the first step the operator should take is to eliminate such possibilities as a defective cable, a defective fuse, or even an operator error. One reasonable way to begin is to try the Initial Checks procedure outlined in Section II of this manual. If correct results are obtained, one can be reasonably sure that the instrument is at least performing its basic functions correctly. If the indicated behavior is not observed, then the instrument is surely malfunctioning and additional troubleshooting will be required.

Note that both the top and bottom covers can be easily removed to give access to the circuitry. However, for most checks, it will prove necessary to remove the top cover only. With the cover removed, note that there are four circuit boards. Of these, one is the Mother board, on which passive components only (resistors, capacitors, and switches) are located. All of the active components (transistors and integrated circuits) are located on the three plug-in boards. More often than not, malfunctions will turn out to be associated with components on one of the plug-in boards.

Once the top cover is removed, the operator can easily check the three internal fuses mounted on top of the Power Supply Regulator board. The fuses can be identified by referring to the Parts Location Diagram on page VI-12. All three fuses should be fast-blow fuses rated at one ampere. These three fuses protect the ±21 V and +5 V unregulated levels. A fourth fuse (3/4 A fast-blow) mounted on the rear panel and accessible from outside the instrument is electrically in series with the ac line power to the instrument. If one of the fuses is found to be blown, try replacing it. If normal operation is restored, chances are the trouble lies solely with the fuse. If the replacement fuse should fail, there is a short somewhere in the instrument that will have to be repaired.

5.3B POWER SUPPLY CHECKS

Power Supply problems can manifest themselves in many different ways. Hence, whenever there is a malfunction, it is advisable to eliminate the power supply first. This is easily done by checking the voltages at testpoints TP302 (+5 V), TP303 (+15 V), and TP304 (−15 V). If all of these voltages are nominally correct (stated value ±½ V), one can reasonably assume there are no power supply problems. If any are high, chances are there is a problem with the associated regulator circuits. A low or missing indication could result from many different causes. The malfunction could be in either the unregulated supply components, or there could even be a short circuit almost anywhere in one of the other instrument circuits. The same would apply in instances where the problem is fuse failure. One possibility that should always be checked is to verify that the rear-panel Line Voltage Selector switch is properly set.

One approach to low and missing power supply potentials is to disconnect as much of the load as possible. This is done by removing the Amplifier and Logic circuit boards. To remove the boards, first remove the locking pin that slides through the boards at the rear of the instrument. With the pin removed, one can then firmly grasp the circuit-board guide assembly at the rear and pull it straight up to remove it from the instrument. The individual boards can then be easily maneuvered to the rear to free them from their sockets. If the supply voltages return to normal with the Logic and Amplifier boards removed, the short is on one of the two boards. Which one can easily be determined by returning first one board and then the other, while observing the effect on the monitored voltages. Note that it is always advisable to have the power off when a board is being removed or inserted.

If incorrect voltages are still obtained with the boards removed, then the problem is most likely on the Power Supply board itself. With the exception of the power transformer and the Line Voltage Selector switch, all of the supply components, both regulated and unregulated, are located on the Power Supply board. Correct unregulated levels (see schematics on pages VI-13 and VI-15) and incorrect regulated levels indicate that the problem is with one of the regulator circuits. Incorrect unregulated levels could be caused by problems with either the unregulated supply components or the regulators.

As can be seen from the schematic on page VI-13, regulated +15 V serves as the reference for the −15 V regulator. Hence any problem with the +15 V regulator will affect both the +15 V and −15 V levels. A problem with the −15 V regulator will generally affect the −15 V level alone.

It may prove helpful to know that the integrated circuit that accepts the +10 V unregulated level and provides the +5 V regulated level has an internal thermal overload protection circuit.

NOTE: DO NOT ATTEMPT TO SET THE ±15 V LEVELS TO EXACTLY ±15 V. THESE VOLTAGES ARE SET AS PART OF THE ALIGNMENT PROCEDURE (SECTION IV) TO MEET SPECIFIC PERFORMANCE CRITERIA, AND MAY DIFFER FROM ±15 V BY AS MUCH AS 0.2 V.

5.3C STATIC TESTS USING TESTPOINTS

If the power supplies are working correctly but the instrument still malfunctions, the best approach is to make static checks at the various instrument testpoints to try to isolate the problem. The remainder of this section indicates the test conditions and expected voltage readings. If a reading is obtained which does not agree with that indicated, the operator will have a "clue" as to the malfunctioning circuit. However, even with the information obtained with these testpoint checks, successful identification of the malfunctioning component can only reasonably be expected of someone knowledgeable in troubleshooting IC circuitry. It should be pointed out that some of the logic circuits are sufficiently sensitive that the very act of connecting a probe to the associated testpoint could initiate logic changes. These changes can only occur where the last instruction prior to monitoring the testpoint voltages is to press ACTIVATE. If an incorrect voltage is noted where this is the case, the following steps can be taken to determine whether the incorrect voltage results from a circuit malfunction or simply from an "accidental" trigger.

(1) Leave the probe connected to the testpoint having the correct voltage.

(2) Press INITIAL and then ACTIVATE. Do not disturb the probe.

(3) If the voltage reading is still incorrect, the circuit is malfunctioning. If the voltage reading is now correct, one can assume that some sort of accidental trigger occurred when the probe was first connected to the testpoint and that there is no circuit malfunction.

NOTE: In monitoring these testpoints, it will prove very convenient to use a miniature grasping type probe such as the Rye Industries KLEP 30 "clip/probe" or the Pomona "grabber" plunger-action Mini-Test Clip.

(1) Set the controls as follows.
Initial Potential controls: +1.000 V
Initial Scan Direction switch: +
Upper Limit Potential controls: +5.000 V
Lower Limit Potential controls: −5.000 V
Final Potential controls: −1.000 V
Final Scan Direction: +
End of Cycle switch: FINAL (fully counterclockwise)
Operating Mode switch: SWEEP
Power: ON
One Cycle pushbutton: Out position
Pulse Width/Scan Rate Multiposition switch: 10 (black)
Toggle switch: V/SEC (right)
Pos. Slope Multiplier dial: 1.00 (fully counterclockwise)
Neg. Slope Multiplier dial: 1.00 (fully counterclockwise)

(2) Check the pushbuttons. None should be depressed. If any pushbutton is in the depressed position, release it.

(3) Depress the INITIAL pushbutton. This is a momentary-contact type switch; that is, it will not lock. It should become illuminated when depressed.
NOTE: If the TILT light is illuminated due to a circuit fault, troubleshooting can be made difficult because the output will be continuously clamped to the Initial potential. To overcome this obstacle to setting up the desired conditions, locate and cut the small wire jumper located near testpoint TP201. With the jumper cut, the Tilt light will continue to indicate a Tilt condition, but the output will no longer be automatically and continuously clamped to the Initial potential.

(4) Check the testpoint voltages as indicated in Step A of Tables V-1 (Logic Board Testpoints) and V-2 (Amplifier Board Testpoints). Note that many of the Logic Board testpoint voltages are simply designated as H (high) or L (low). For troubleshooting purposes, assume an H to be +3.5 V ±1 V and an L to be +0.2 V ±0.2 V.

(5) Set the Pulse Width/Scan Rate switch to STEP. Then press the ACTIVATE pushbutton. The INITIAL pushbutton should become dark and the ACTIVATE pushbutton should become illuminated instead.

(6) Check the testpoint voltages as indicated in Step B of Tables V-1 and V-2.

(7) Set the Pulse Width/Scan Rate switch back to 10 (black). Then set the End of Cycle switch to UPPER LIMIT (fully clockwise position).

(8) Press the INITIAL and ONE CYCLE pushbuttons. Both will become illuminated.

(9) Press the ACTIVATE pushbutton. INITIAL will become dark and ACTIVATE will be illuminated for about half a second.

(10) Check the testpoint voltages as indicated in Step C of Tables V-1 and V-2.

(11) Set the End of Cycle switch to LOWER LIMIT. Then press the INITIAL pushbutton again.

(12) Press ACTIVATE. INITIAL should become dark and ACTIVATE should become illuminated for about 1.5 s.

(13) Check the testpoint voltages as indicated in Step D of Tables V-1 and V-2.

(14) Set the End of Cycle switch to FINAL. Press INITIAL and then ACTIVATE. The Activate pushbutton will become illuminated for about two seconds.

(15) Check the testpoint voltages as indicated in Step E of Tables V-1 and V-2.

(16) Set the Upper Limit potential controls to −5.000 V and the Lower Limit Potential controls to +5.000 V. The TILT light should turn on.

(17) Check the testpoint voltages as indicated in Step F of Tables V-1 and V-2.

(18) Set the Mode switch to PULSE, the Upper Limit to +5.000 V, and the Lower Limit to −5.000 V. Then press the INITIAL pushbutton.

(19) Check the testpoint voltages as indicated in Step G of Tables V-1 and V-2.

(20) Set the Pulse Width/Scan Rate switch to STEP and release the ONE CYCLE pushbutton. Then press the ACTIVATE pushbutton.

(21) Check the testpoint voltages as indicated in Step H of Tables V-1 and V-2.

(22) Set the Pulse Width/Scan Rate switch to 10 (red) and the associated toggle switch to SEC (left). Then set the End of Cycle switch to LOWER LIMIT and depress the INITIAL pushbutton.

(23) Press the ONE CYCLE pushbutton. Then press the ACTIVATE pushbutton, which should become illuminated for about 20 s.

(24) Check the testpoint voltages as indicated in Step I of Tables V-1 and V-2.

This completes the troubleshooting checks. If all readings are as indicated in the tables, chances are the instrument is either working normally, or has a problem which cannot be turned up with these procedures. For further advice, the operator is advised to contact the factory or the factory-authorized representative in his area.

STEP	TEST CONDITIONS	TP201	TP202	TP203	TP204	TP205	TP206	TP207	TP208	TP209	TP210	TP211	TP212	TP213	TP214	TP215
A	Sweep Mode; Initial	H	L	H	H	L	H	H	H	H	L	0 V	+5 V	+5 V	L	+5 V
B	Sweep Mode; Activate; S14 to Step	H	H	H	L	L	H	L	H	H	H	+1 V	+5 V	+5 V	L	+5 V
C	Sweep Mode; Activate; Ramp to +5 V and Hold	H	H	L	L	H	L	H	H	L	H	0 V	L	+5 V	L	+5 V
D	Sweep Mode; Activate; Ramp to –5 V and Hold	H	H	L	L	H	H	H	H	L	H	0 V	+5 V	L	+5 V	+5 V
E	Sweep Mode; Activate; Ramp to Final	H	H	L	H	H	H	H	H	L	H	L	+5 V	+5 V	L	+5 V
F	Sweep Mode; Upper Limit = –5 V; Lower Limit = +5 V; Tilt	H	L	H	H	H	H	H	H	H	H	0 V	L	L	L	+5 V
G	Pulse Mode; Initial	H	L	H	H	L	H	H	H	H	L	0 V	+5 V	L	L	+5 V
H	Pulse Mode; Activate; S14 to Step	H	H	H	L	L	H	L	H	H	H	+10 V	+5 V	L	L	+5 V
I	Pulse Mode; Activate; Stop at Lower Limit	H	H	L	L	H	H	H	H	L	H	0 V	+5 V	L	L	+5 V

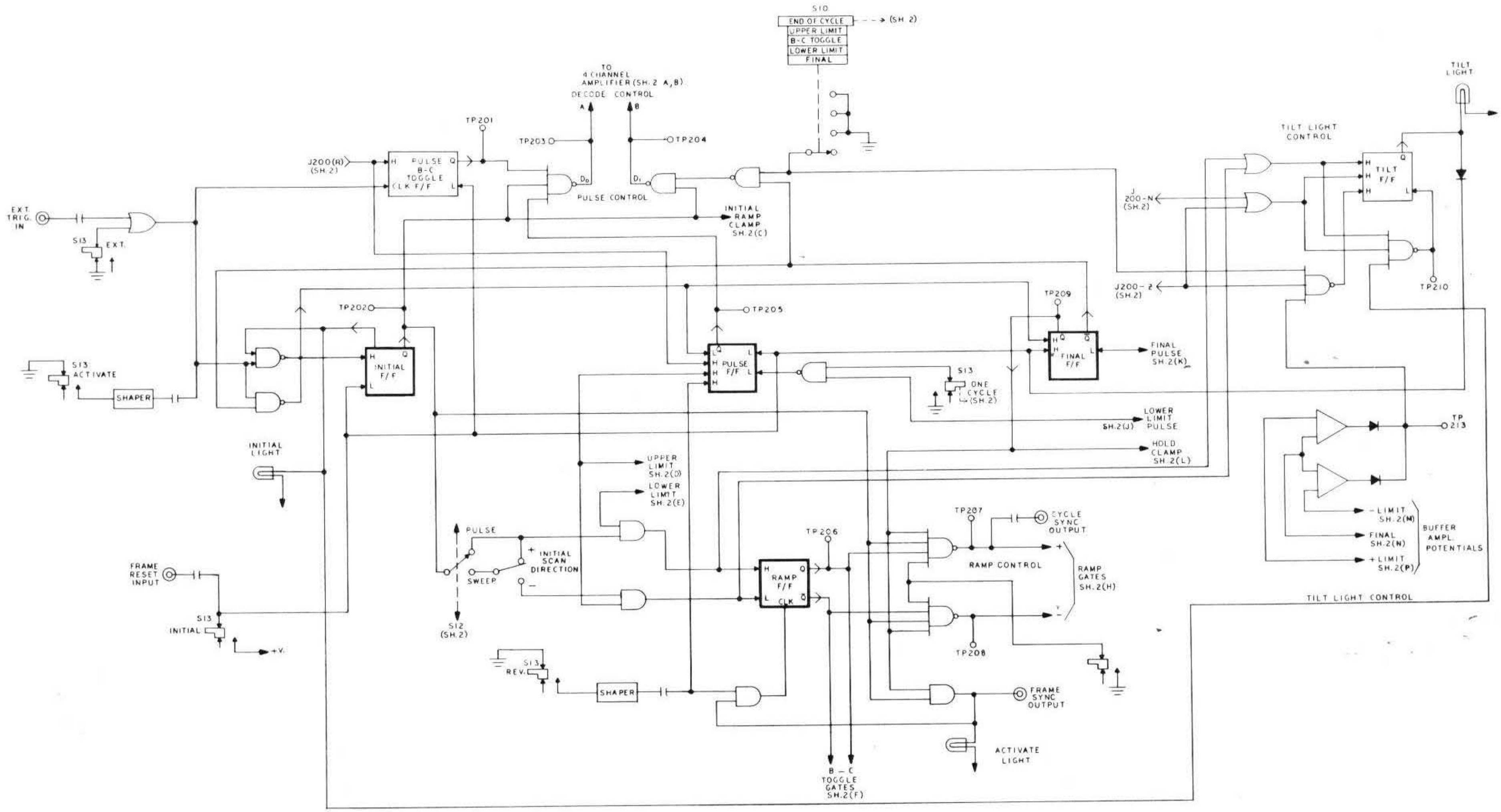
Table V-1. LOGIC BOARD NORMAL TESTPOINT VOLTAGES

STEP	TEST CONDITIONS	TP101	TP102	TP103	TP104	TP105	TP106	TP107	TP108	TP109	TP110	TP111	TP112	TP113
A	Sweep Mode; Initial	−1 V	−5 V	+5 V	+1 V	+1 V	+1 V	at least +10 V	at least −10 V	−10 V	between +9 V & +11 V	between −9 V & −11 V	0 V	−.6 V
B	Sweep Mode; Activate; S14 to Step	−1 V	−5 V	+5 V	+1 V	+5 V	+1 V	at least +10 V	at least −10 V	−10 V	″	″	0 V	−.6 V
C	Sweep Mode; Activate; Ramp to +5 V and Hold	−1 V	−5 V	+5 V	+1 V	−5 V	+5 V	0 V	at least −10 V.	at least −10 V	″	″	−2 V	−.6 V
D	Sweep Mode; Activate; Ramp to −5 V and Hold	−1 V	−5 V	+5 V	+1 V	−5 V	−5 V	at least +10 V	0 V	at least +10 V	″	″	+3 V	−.6 V
E	Sweep Mode; Activate; Ramp to Final	−1 V	−5 V	+5 V	+1 V	−1 V	−1 V	at least +10 V	at least −10 V	0 V	″	″	+1 V	−.6 V
F	Sweep Mode; Upper Limit = −5 V; Lower Limit = +5 V; Tilt	−1 V	+5 V	−5 V	+1 V	+1 V	+1 V	at least −10 V	at least +10 V	−10 V	″	″	0 V	at least +10 V
G	Pulse Mode; Initial	−1 V	−5 V	+5 V	+1 V	+1 V	0 V	+5 V	0 V	0 V	″	″	0 V	−.6 V
H	Pulse Mode; Activate; S14 to Step	−1 V	−5 V	+5 V	+1 V	+5 V	0 V	+5 V	0 V	0 V	″	″	0 V	−.6 V
I	Pulse Mode; Activate; Stop at Lower Limit	−1 V	−5 V	+5 V	+1 V	−5 V	0 V	+5 V	0 V	0 V	″	″	0 V	−.6 V

Table V-2. AMPLIFIER BOARD NORMAL TESTPOINT VOLTAGES

SECTION VI
SCHEMATICS

Page

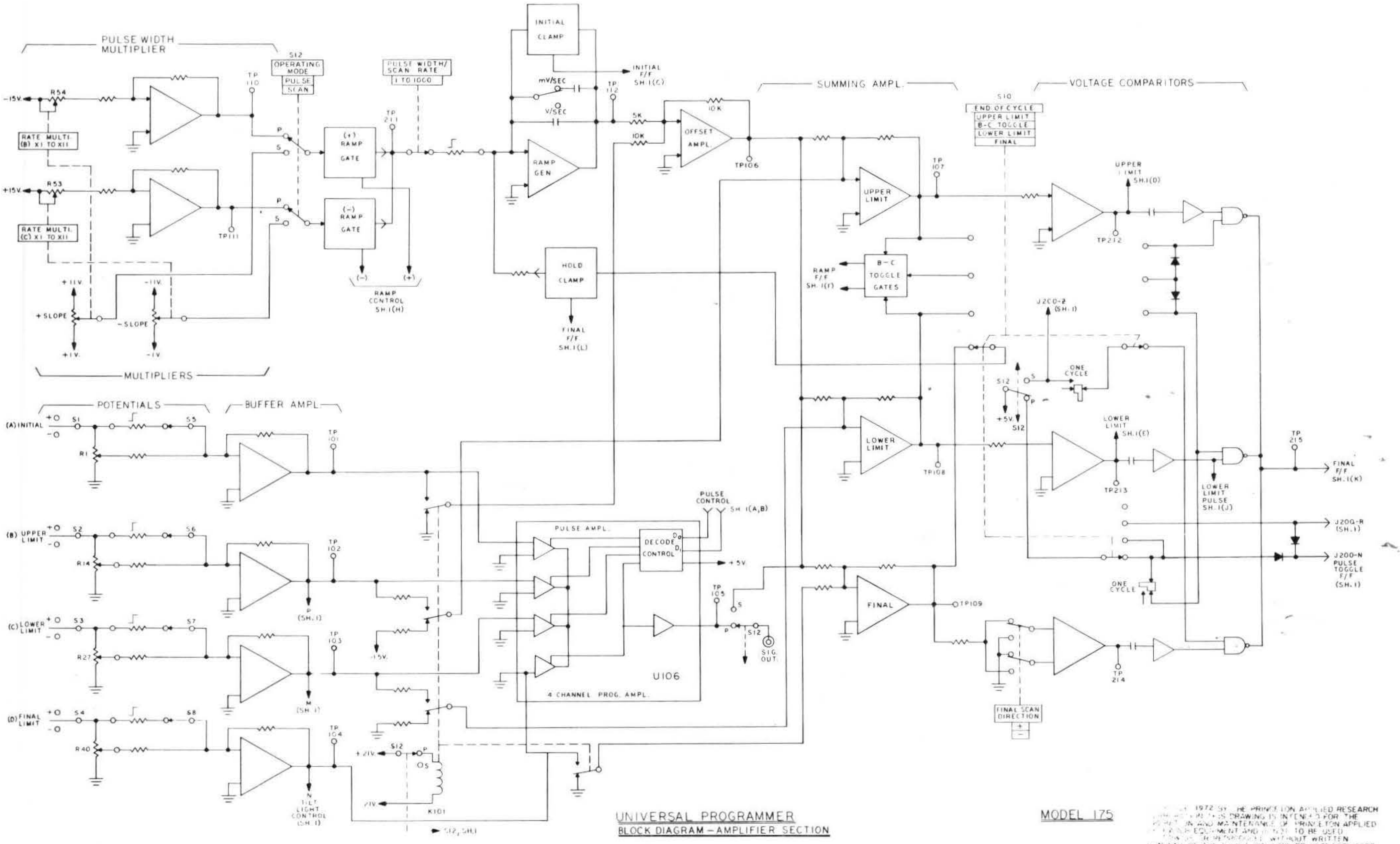


LOGIC SECTION

UNIVERSAL PROGRAMMER
BLOCK DIAGRAM
LOGIC SECTION

MODEL 175

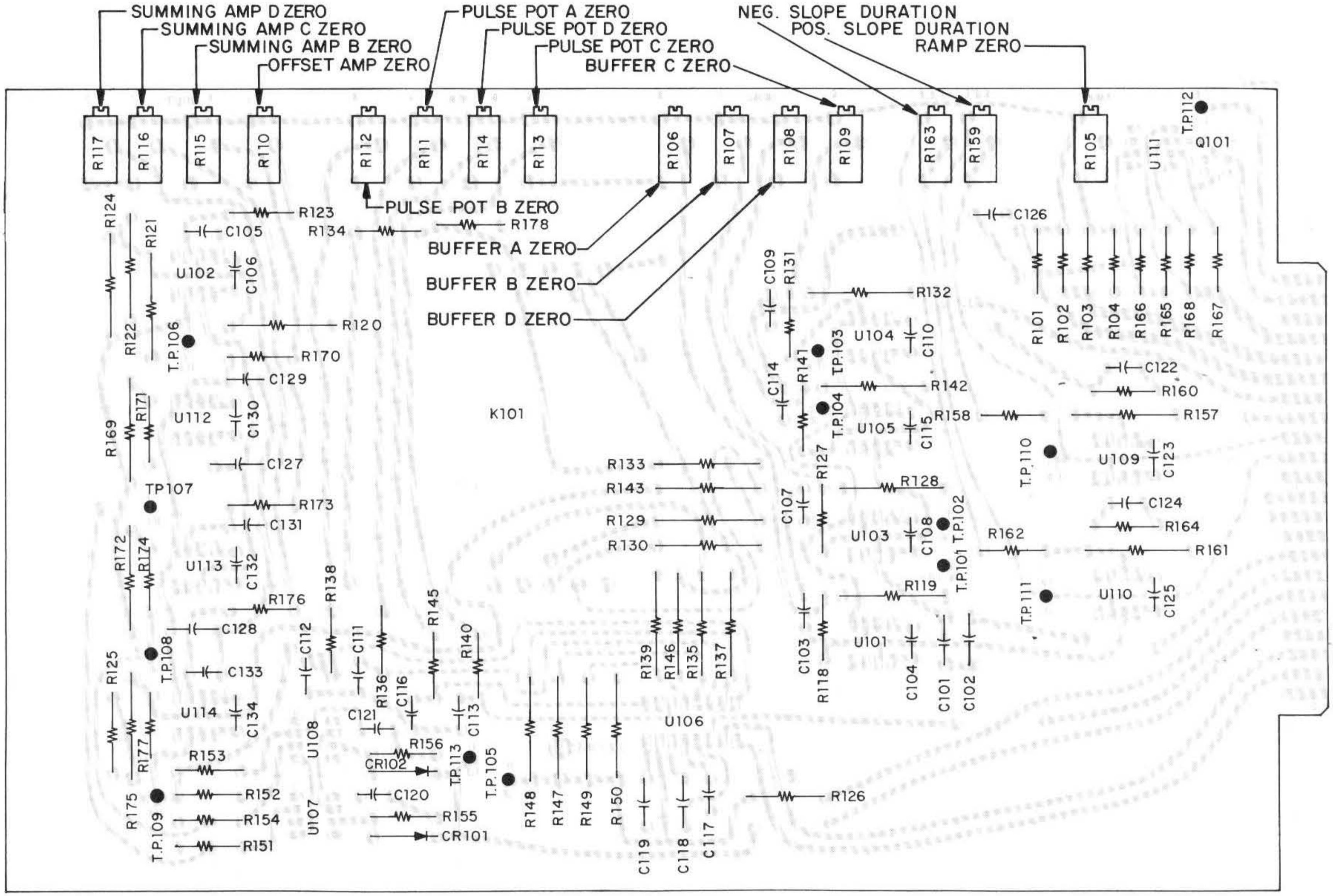
SHEET 1 OF 2 | 7729 | D | SD | A



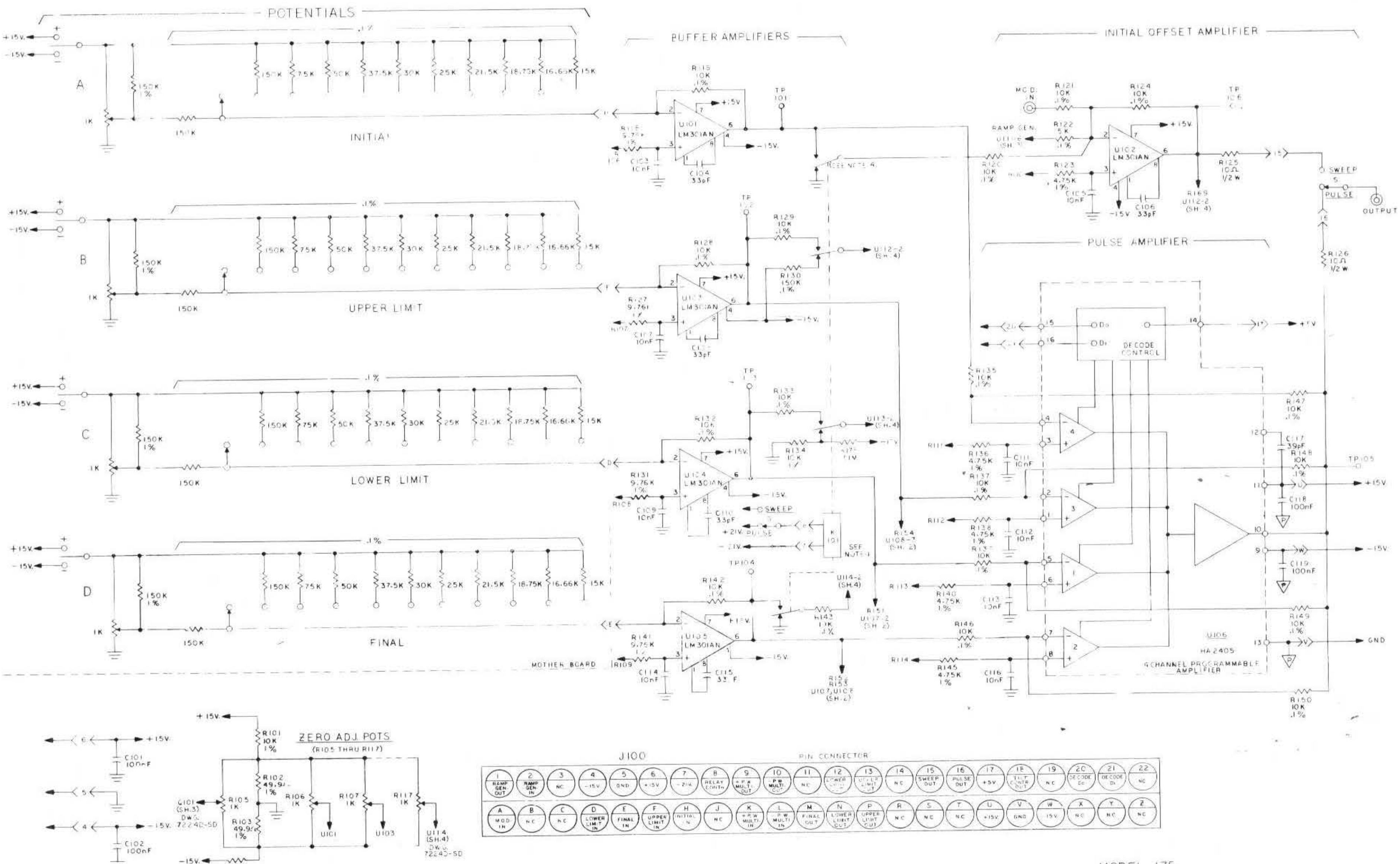
UNIVERSAL PROGRAMMER
BLOCK DIAGRAM – AMPLIFIER SECTION

MODEL 175

SHEET 2 OF 2 7729 D SD



SYMBOLIZATION
MODEL 175
AMPLIFIER BOARD
FAB # 7078-MD-A



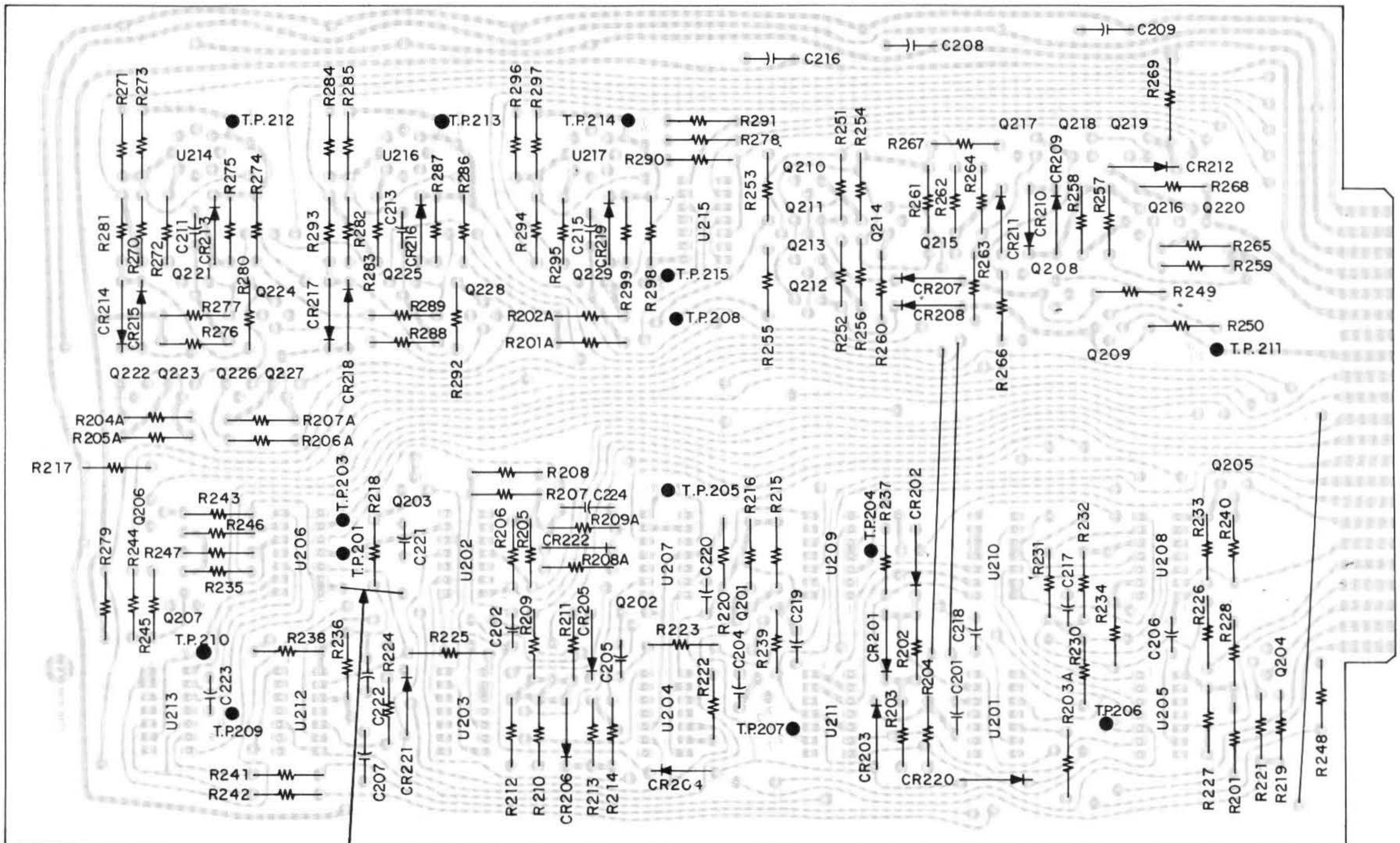
AMPLIFIER BOARD

MODEL 175

NOTES:

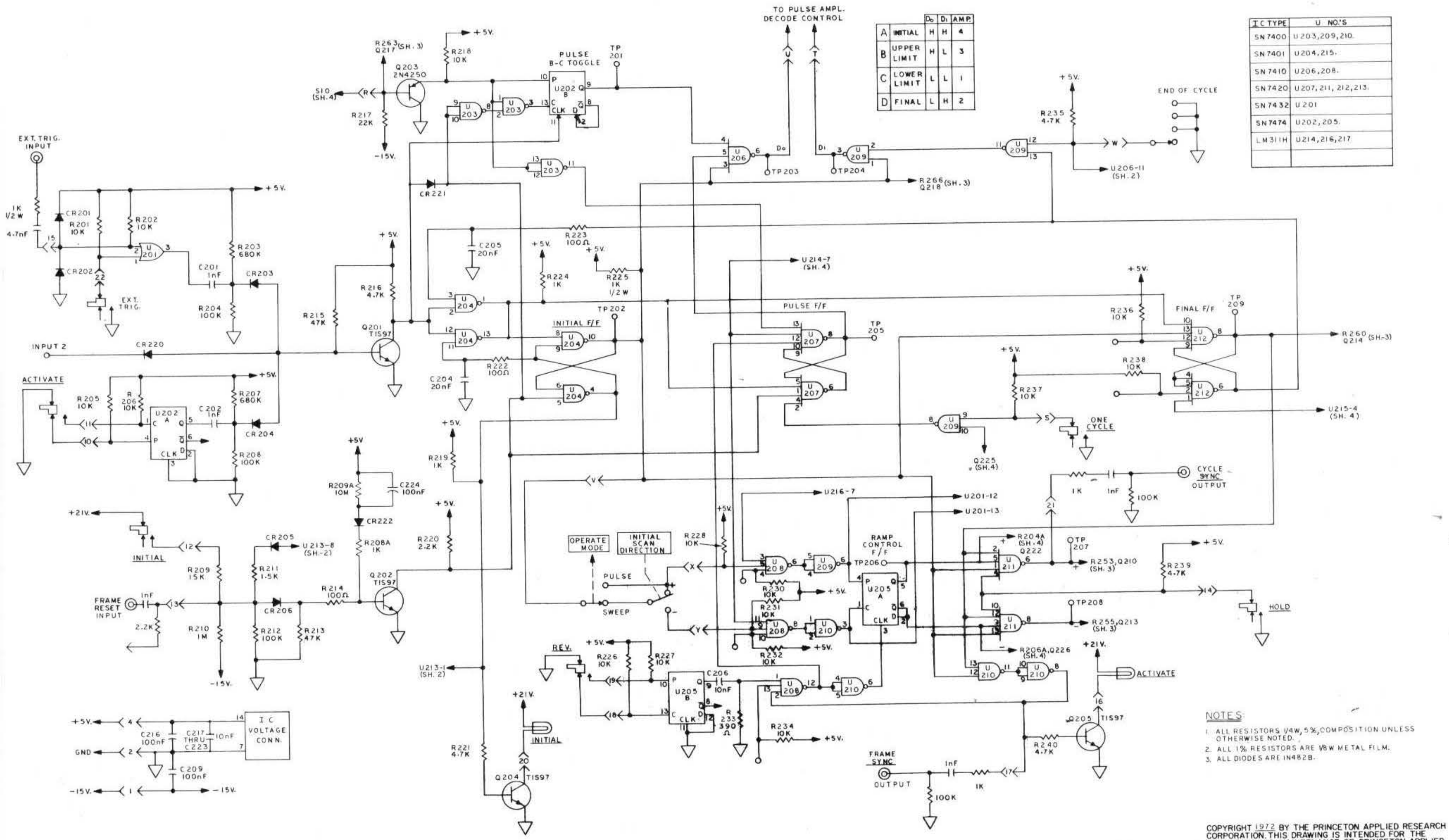
1. ALL RESISTORS 1/4W, 5%, COMPOSITION UNLESS OTHERWISE NOTED.
2. ALL .1% RESISTORS ARE 1/2 W, METAL FILM.
3. ALL 1% RESISTORS ARE 1/8W, METAL FILM.
4. RELAY SHOWN ENERGIZED.

7225 | D | SD | B



CUTTING THIS JUMPER PREVENTS OUTPUT FROM LOCKING UP IN INITIAL
WHEN TILT CONDITION IS PRESENT

SYMBOLIZATION
MODEL 175
LOGIC BOARD
FAB.# 7099-MD-A



		D_0	D_1	AMP.
A	INITIAL	H	H	4
B	UPPER LIMIT	H	L	3
C	LOWER LIMIT	L	L	1
D	FINAL	L	H	2

I C TYPE	U NO.'S
SN7400	U203, 209, 210.
SN7401	U204, 215.
SN7410	U206, 208.
SN7420	U207, 211, 212, 213.
SN7432	U201
SN7474	U202, 205.
LM311H	U214, 216, 217.

NOTES:

1. ALL RESISTORS 1/4W, 5%, COMPOSITION UNLESS OTHERWISE NOTED.
2. ALL 1% RESISTORS ARE 1/8W METAL FILM.
3. ALL DIODES ARE IN482B.

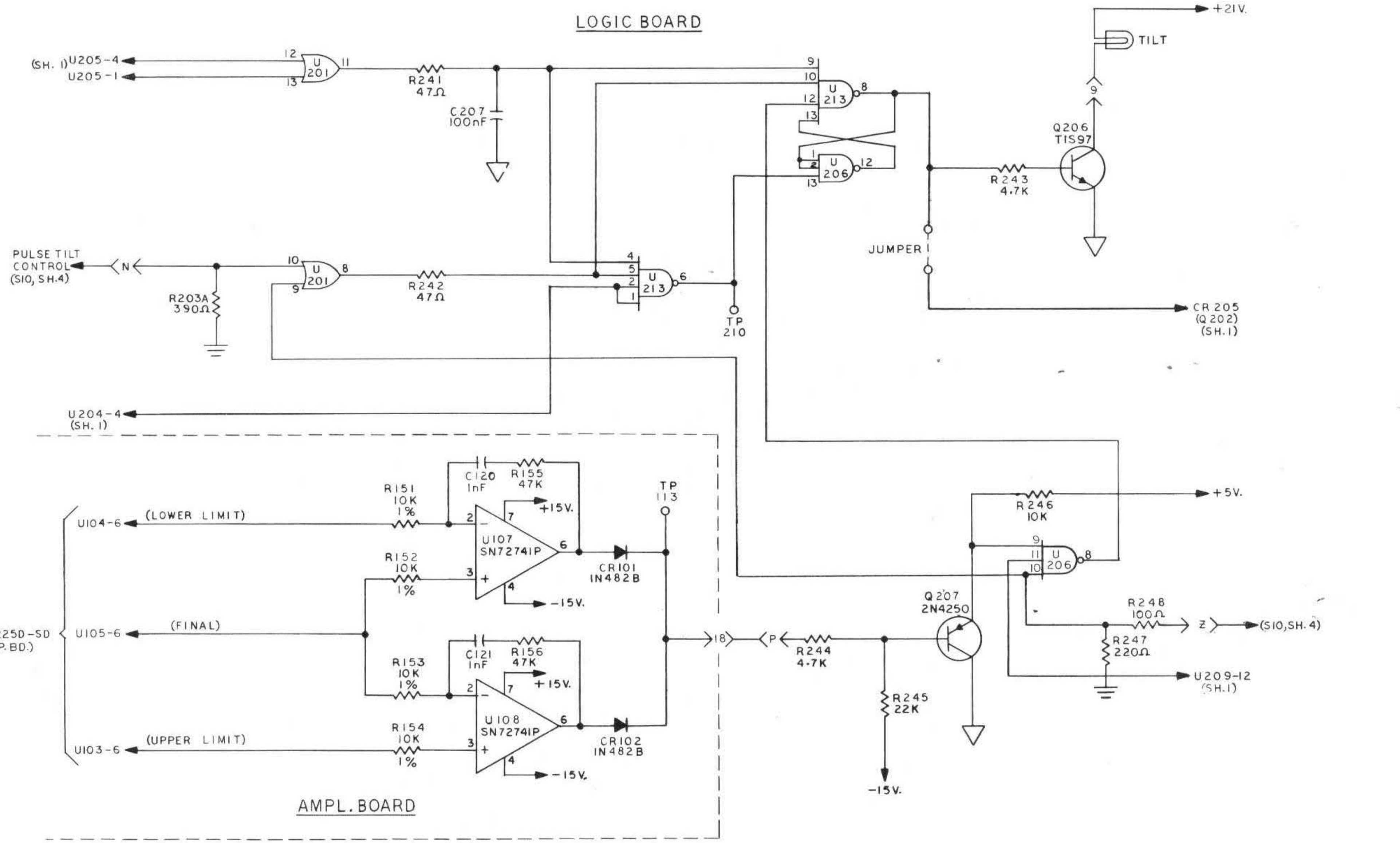
LOGIC BOARD

SUB ASSEMBLY 1750-15-0003S (PARTIAL)

MODEL 175

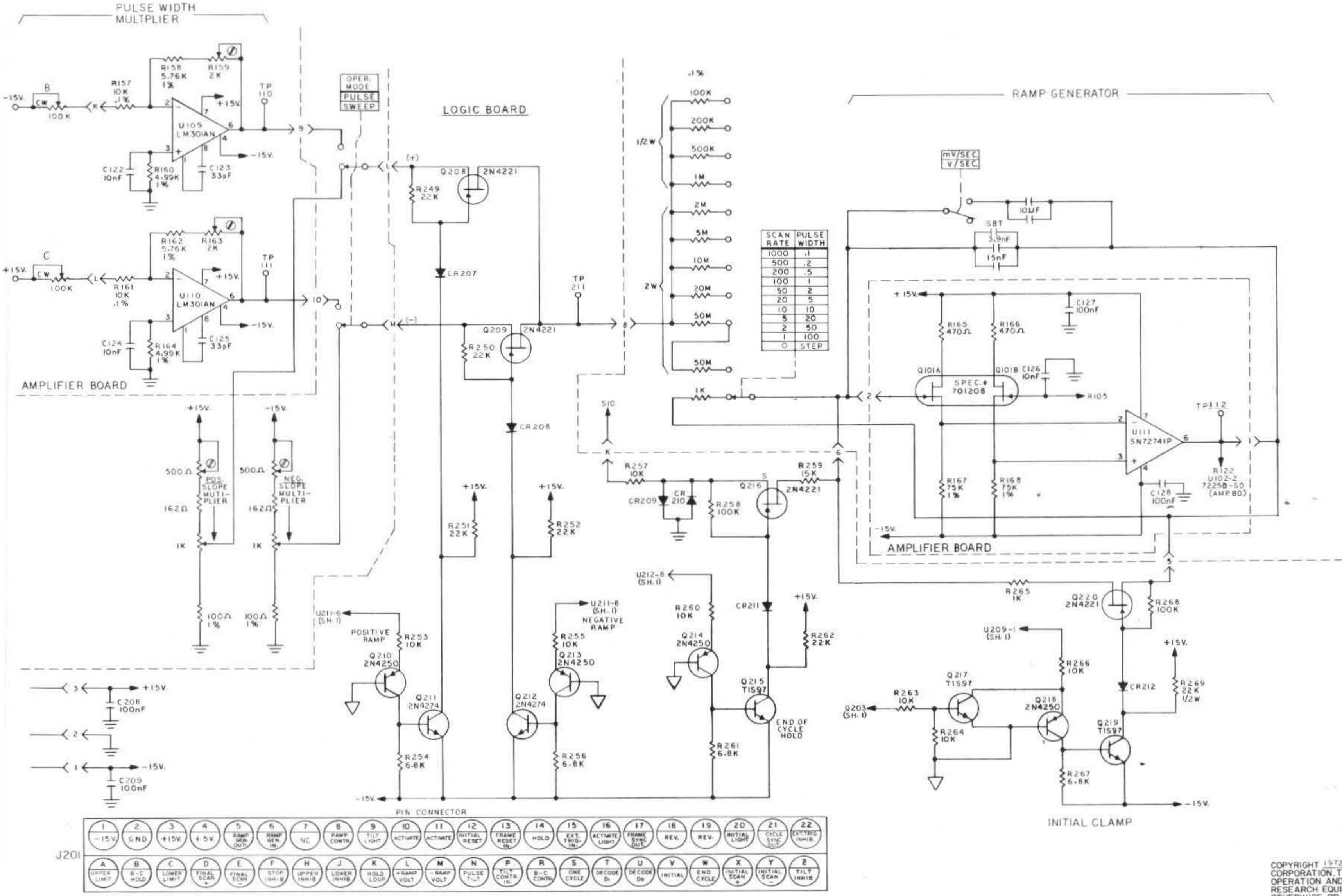
SHEET 1 OF 4 | 7224 | D | SD | F

TILT LIGHT CONTROL



LOGIC BOARD   SUB ASSEMBLY 1750-15-0003S (PARTIAL)   MODEL 175

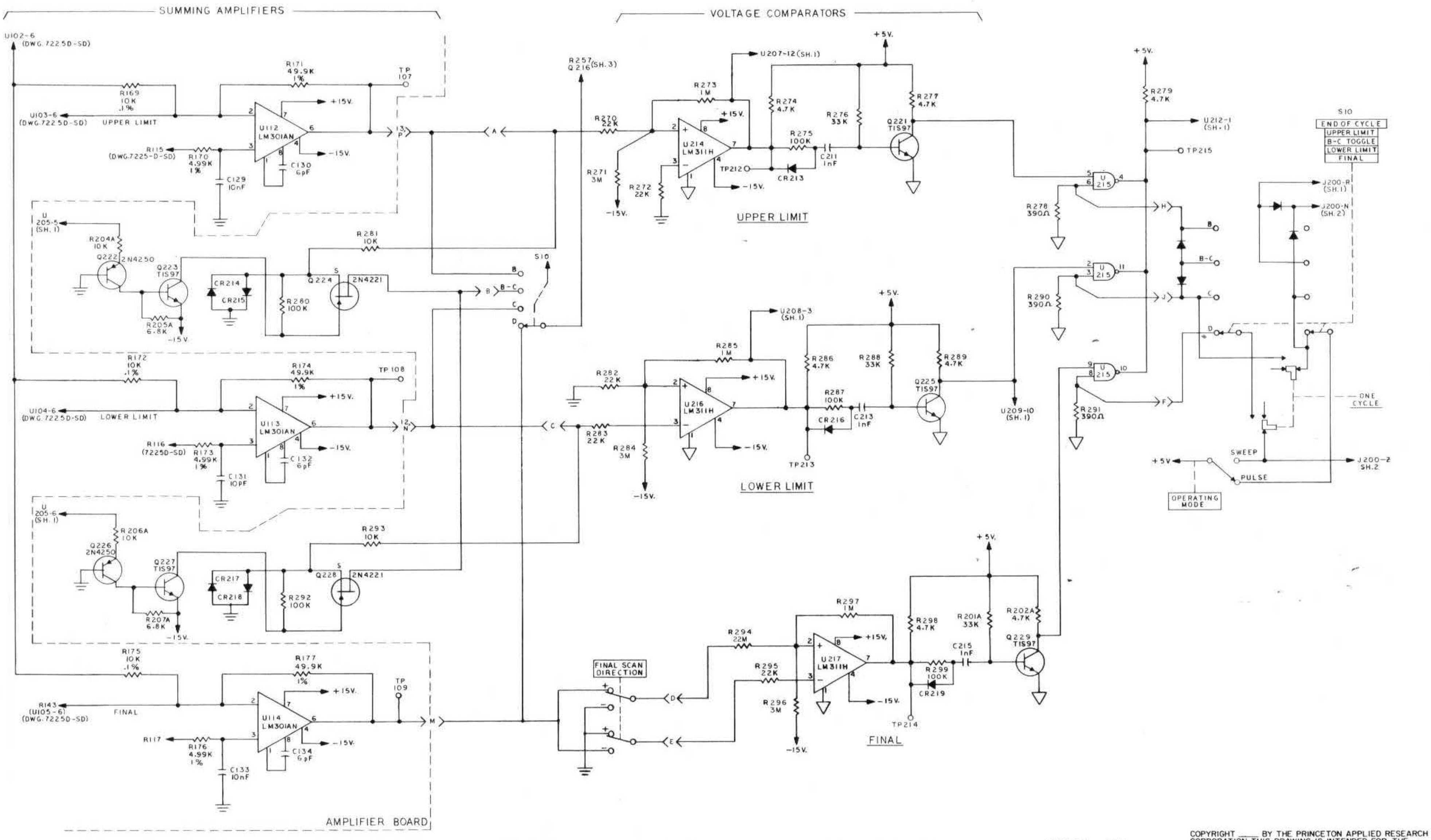
SHEET 2 OF 4 | 7224 | C | SD



LOGIC BOARD SUB ASSEMBLY 1750-15-0003S (PARTIAL)

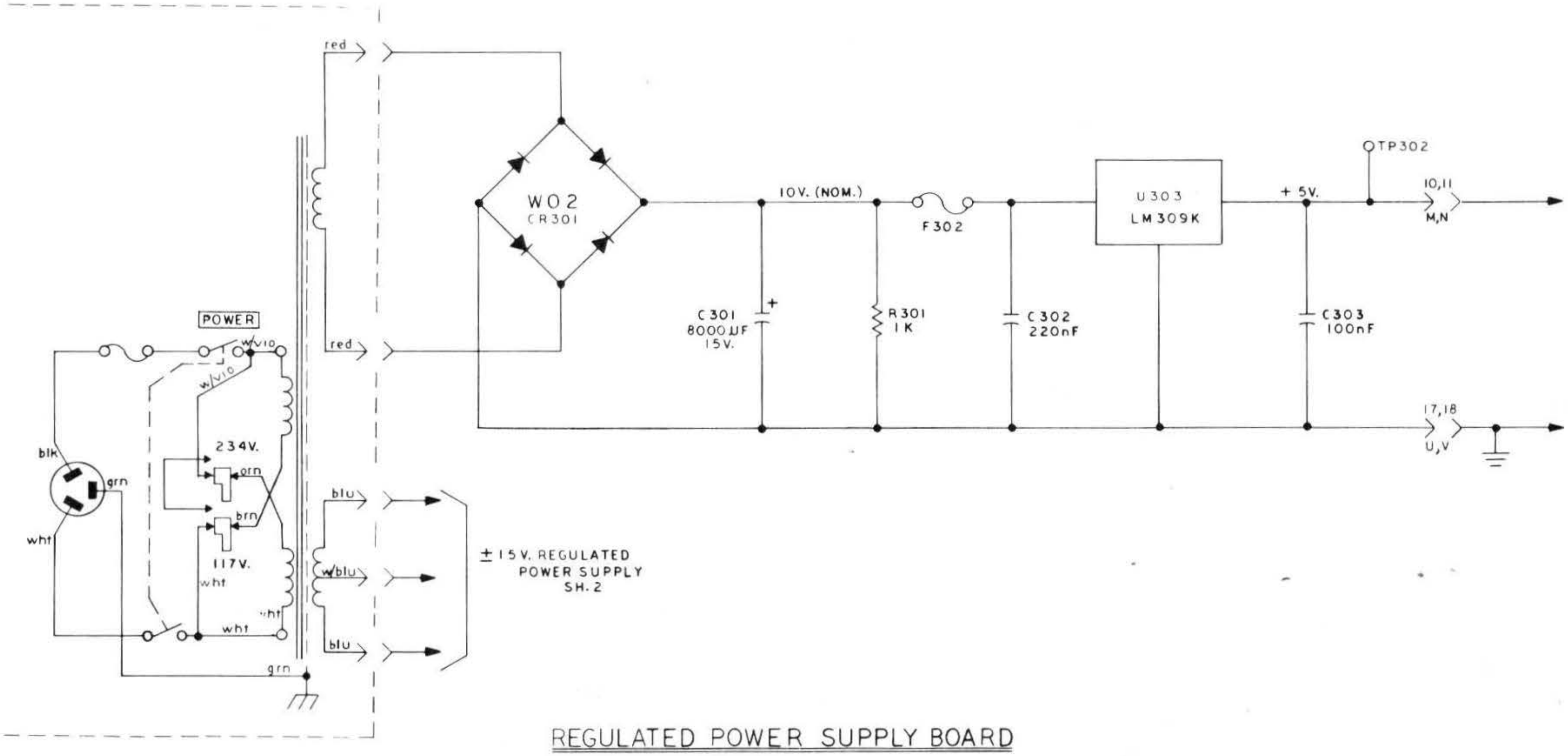
MODEL 175

SHEET 3 OF 4 | 7224 | D | SD



LOGIC BOARD   SUB ASSEMBLY 1750-15-0003S (PARTIAL)   MODEL 175

SHEET 4 OF 4 | 7224 | D | SD



REGULATED POWER SUPPLY BOARD

MODEL 175

J3

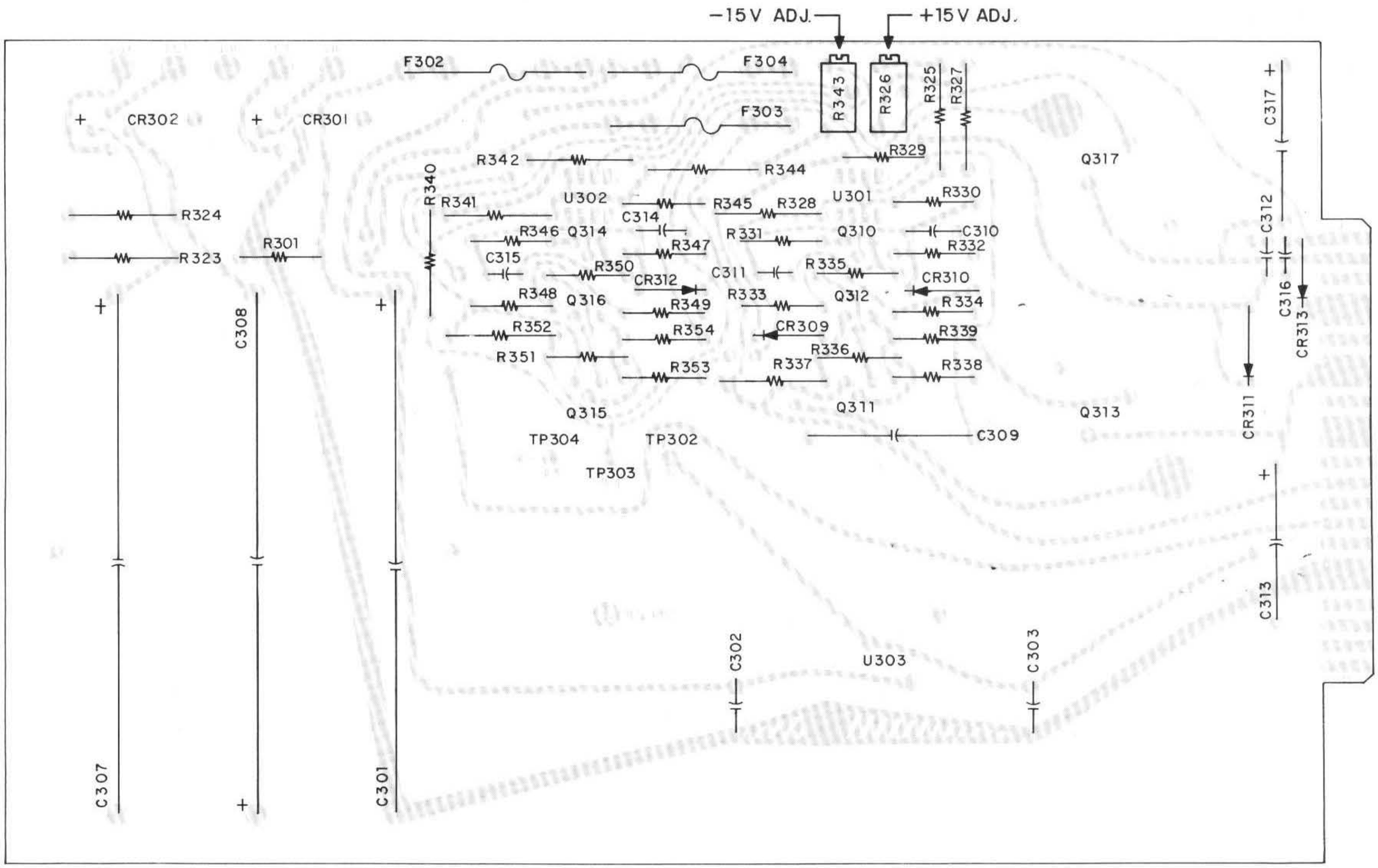
PIN CONNECTOR

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
-15V. SEN.	-15V.	NC	GND	GND	NC	+15V.	+15V.	NC	+5V.	+5V.	THRU	+21V.	NC	-21V.	NC	GND	GND	NC	NC	NC	GND
A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V	W	X	Y	Z
-15V.	-15V.	NC	GND	GND	NC	+15V.	+15V. SEN.	NC	+5V.	+5V.	THRU	+21V.	NC	-21V.	NC	GND	GND	NC	NC	NC	GND

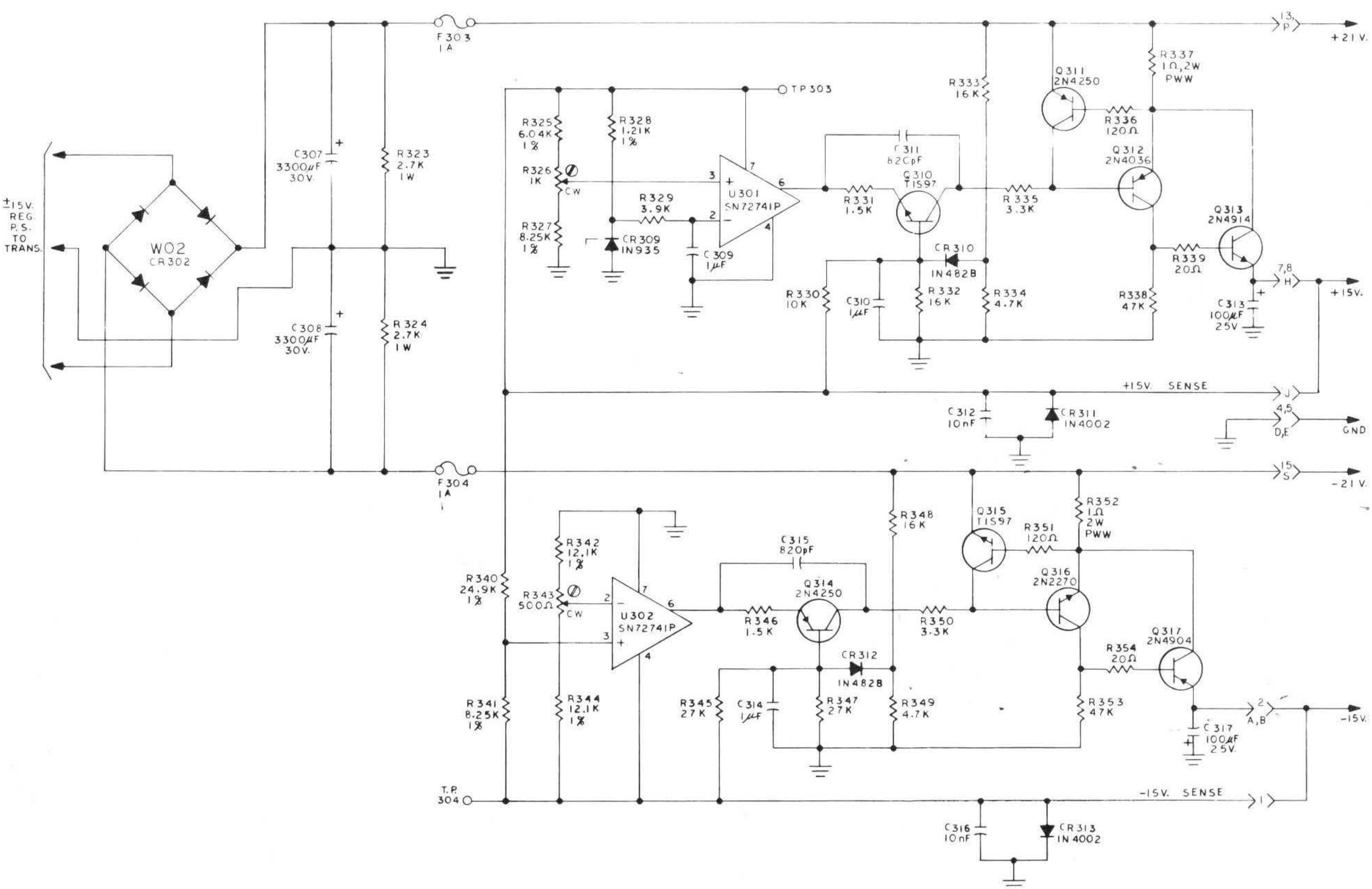
NOTES:

1. ALL RESISTORS 1/2 W, 5 %, COMPOSITION UNLESS OTHERWISE NOTED.

SHEET 1 OF 2 | 7066 | C | SD



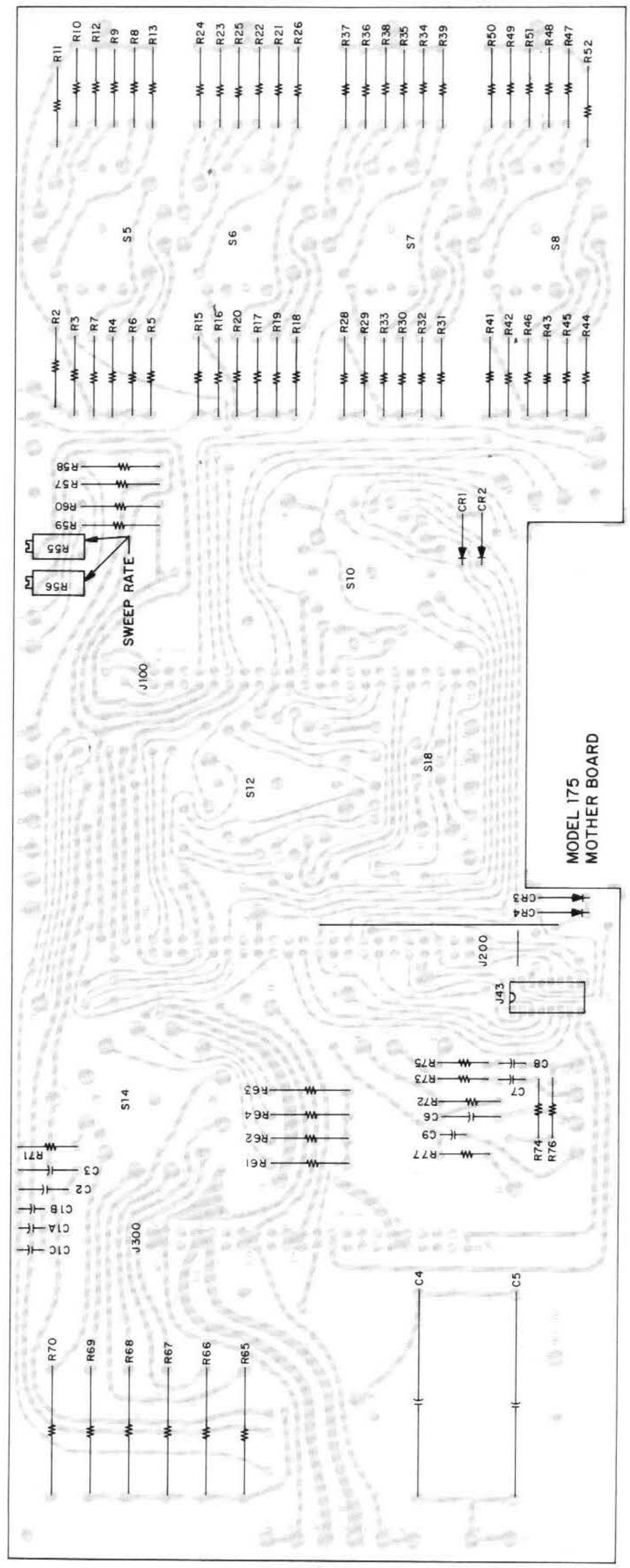
SYMBOLIZATION
MODEL 175
REGULATED POWER SUPPLY BOARD
FAB # 7081—MD—A

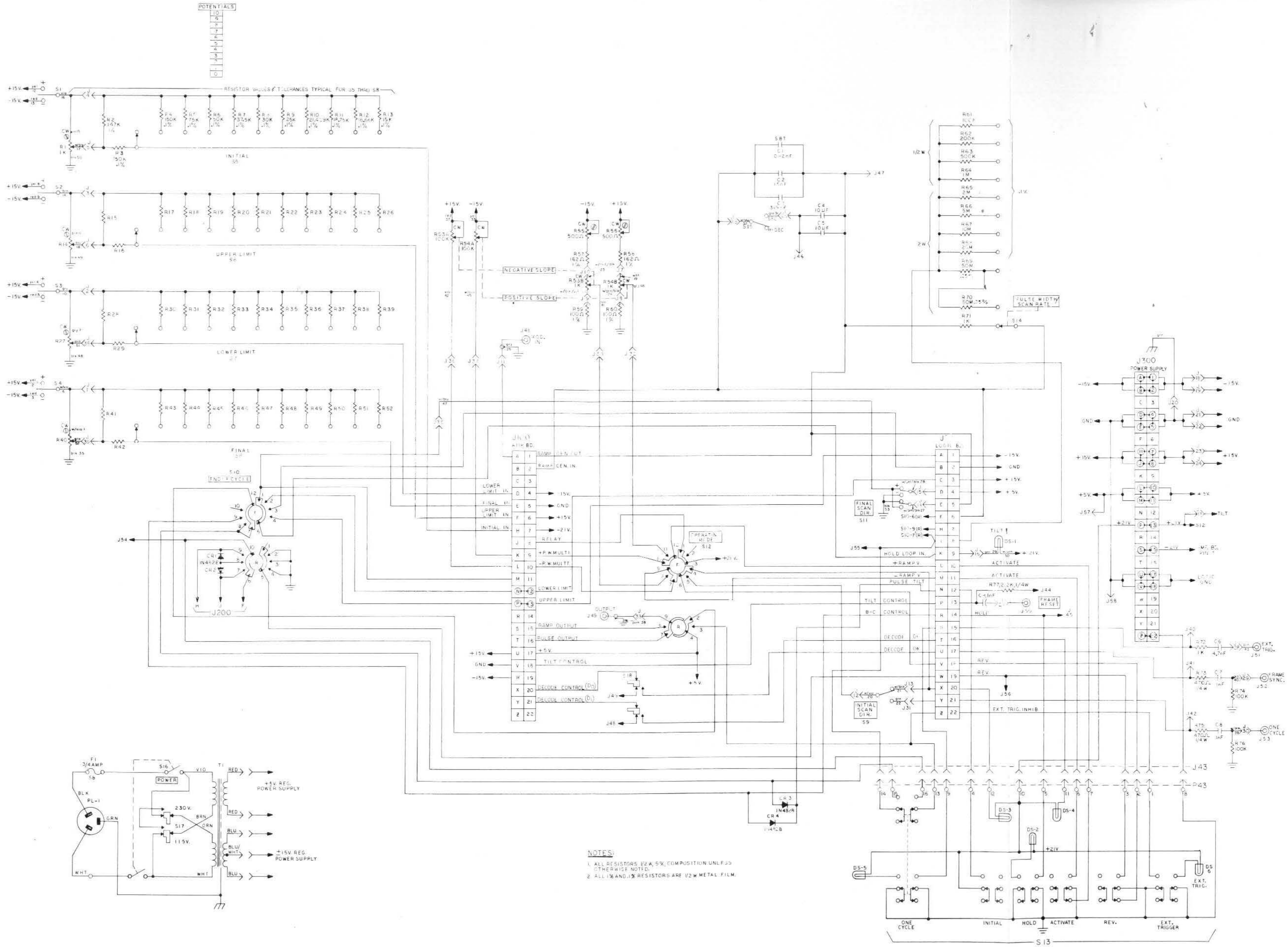


REGULATED POWER SUPPLY BOARD

MODEL 175

SHEET 2 OF 2 | 7066 | C | SD


MODEL 175
MOTHER BOARD
SWEEP RATE
S5
S6
S7
S8
S10
S12
S14
S18
J100
J200
J300
J43



NOTES:

1. ALL RESISTORS 1/2 W, 5%, COMPOSITION UNLESS OTHERWISE NOTED.
2. ALL 1% AND .1% RESISTORS ARE 1/2 W METAL FILM.

CHASSIS WIRING DIAGRAM

MODEL 175

7158 | E | SD | A

APPENDIX A
MODEL 175/96
REMOTE PROGRAMMING MODIFICATION

INTRODUCTION

This modification consists of adding a rear-panel 36 pin connector wired to provide inputs and outputs in addition to those provided in the standard unit. Some of the front-panel functions are also duplicated at this connector so that they can be controlled by externally derived signals as well as by the appropriate front-panel controls. It should be noted that, whereas ac coupling is used at the front-panel to reduce the risk of inadvertent damage, dc coupling is used at the Remote Programming connector. A list of the functions and signals available at this connector follows. Pins not mentioned are not used.

Pin

1 EXT TRIG: During One Cycle operation, a logic 0 applied to this input triggers unit if EXT TRIG pushbutton is depressed.

4 HOLD: Logic 0 applied to this pin duplicates action of front-panel HOLD pushbutton.

5 REV: Logic 0 applied to this pin duplicates function of front-panel REV pushbutton.

7 FRAME SYNC OUT: dc coupled, non-differentiated pedestal out that parallels timing of front-panel FRAME SYNC. Output.

8 CYCLE SYNC OUT: dc coupled, non-differentiated pedestal out that parallels timing of front-panel CYCLE SYNC output.

13 & 14 +5 V

15 & 16 GND.

18 External capacitance connected between this pin and pin 36 will slow selected ramping rate (increase selected pulse width). Used on slow range only. Internal capacitance is 20 μF. External capacitance parallels internal capacitance with change in rates being proportional to change in total capacitance. Although this function is compatible with M175/99 modification, it would not normally be used in a unit equipped with the M175/99 modification.

19 FRAME RESET: Logic 1 applied to this pin duplicates front-panel FRAME RESET function.

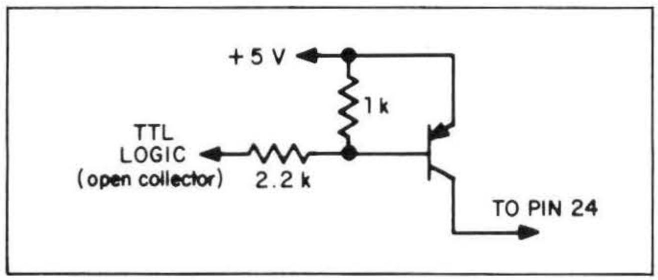
22 AMPLIFIER CONTROL, D_0

23 AMPLIFIER CONTROL, D_1

Appropriate logic signals applied to pins 22 and 23 will control the four states of Pulse Amplifier U106. To establish potential "A" at output, both pin 22 and pin 23 must be at logic 1. To establish potential "B", pin 22 should be set to logic 1 and pin 23 to logic 0. Pins 22 and 23 both at logic 0 establish potential "C". Last, potential "D" is established by setting pin 22 to logic 0 and pin 23 to logic 1.

An internal switch determines whether D_0 and D_1 will be controlled by rear-panel signals or by internal logic. For control from levels applied to pins 22 and 23, this switch (located on Mother board next to quick-disconnects J32 and J33) must be set to the left.

24 ONE CYCLE, SWEEP: With ONE CYCLE pushbutton released, logic 0 gives Continuous Sweep operation and logic 1 gives One Cycle operation. **NOTE:** Certain internal electrical considerations prohibit the connection of standard TTL circuits to this point. A sketch of a suitable interface circuit follows.



29 OUTPUT: Parallels front-panel output.

31 +15 V

32 −15 V

33 & 34 GND.

35 MOD. IN: Duplicates front-panel MOD IN function. Modulation signal not to exceed 10% of selected output.

36 RAMP OUT: Ramp signal similar to output ramp, but always starting at 0 V. Amplitude is half that of signal at OUTPUT connector and of opposite polarity. **NOTE:** In pulse operation, there is a pulse output of fixed ½ V amplitude (baseline 0 V).

INSTALLATION

The modification can be installed either at the factory (preferred) or in the field. The installation consists of installing the connector, which is supplied with the harness attached, followed by connecting the harness wires. For convenience in making the connections, quick-disconnect terminations have been pre-installed on the harness wires wherever practical. Early Model 175's do not have the required connector opening in the rear panel. A sketch of the dimensions and location of the required opening is included as a part of this appendix. Assuming the unit to be modified has the required panel opening, the following procedure can be used to complete the installation.

(1) Remove the Model 175 cover, the board retainers, and both the Logic and Amplifier circuit boards.

(2) On units having the hole precut and covered by a plate, remove the plate and discard it. Retain the hardware, however, as it will be used to secure the connector.

(3) Slip the harness-connector through the rear-panel hole from inside the unit. The narrow side of the connector should be down. Bolt the connector in place using the hardware which formerly secured the cover plate. **NOTE:** If the unit is an early one for which the customer had to punch the connector opening himself, appropriate connector-mounting hardware will have to be obtained.

(4) Dress the harness towards the Mother board, then run in leftwards (facing unit from the rear) along the lower edge of the board.

(5) Connect the various quick-disconnect harness-wire terminations to the proper terminals as indicated below. **NOTE:** In the case of a shielded wire, the "color" is that of a strip of tape wrapped around the outer insulation near the end of the wire.

Wire	Connect to Quick-Disconnect Terminal
Green	J54
Red shielded wire	J33[1]
White/Orange	J49
White/Gray	J48
Orange	J55
Yellow shielded wire	J11[2]
White shielded wire	J42
Gray	J44
Violet	J56
White/Blue	J41
White/Violet	J40
White/Green	J45
White/Black (2)	J58
White/Red (2)	J57
Gray shielded wire	J46
Brown shielded wire	J47
Red	J23[3]
Black (2)	J21
Yellow	J18[4]

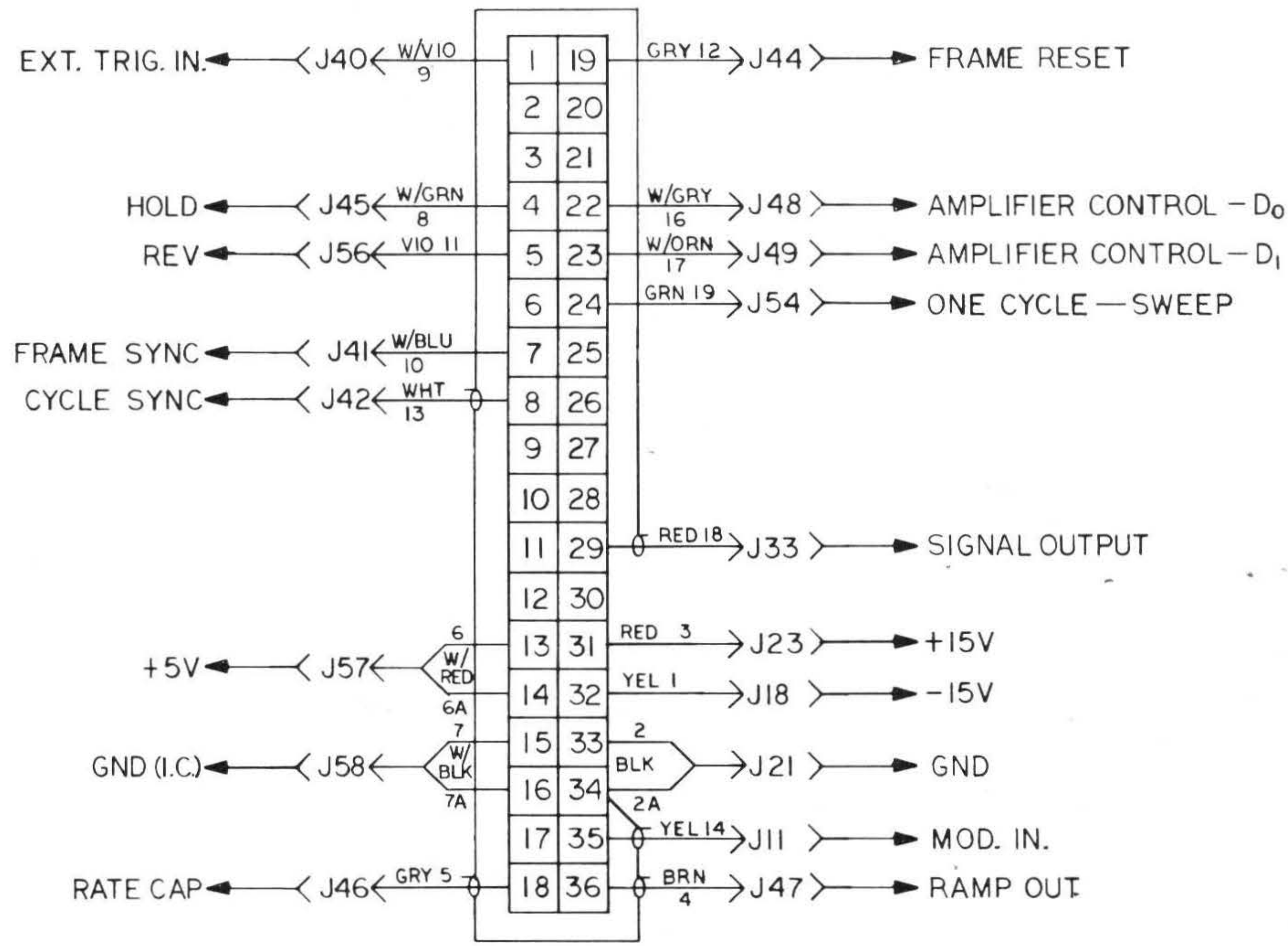
[1] The wire from the front-panel SIGNAL OUTPUT connector must be combined with this harness wire by crimping them both in a common quick-disconnect termination and connecting it in turn to J33.

[2] The wire from the front-panel MOD IN connector must be combined with this harness wire by crimping them both in a common quick-disconnect termination and connecting it in turn to J11.

[3] The original red harness wires that go to J23 and J24 should be cut and then combined by crimping them into a single quick-disconnect termination to be connected to J24. The wire from the new harness then is connected to J23.

[4] The original yellow harness wires that go to J18 and J19 should be cut and combined by crimping them into a single quick-disconnect termination to be connected to J19. The wire from the new harness then is connected to J18.

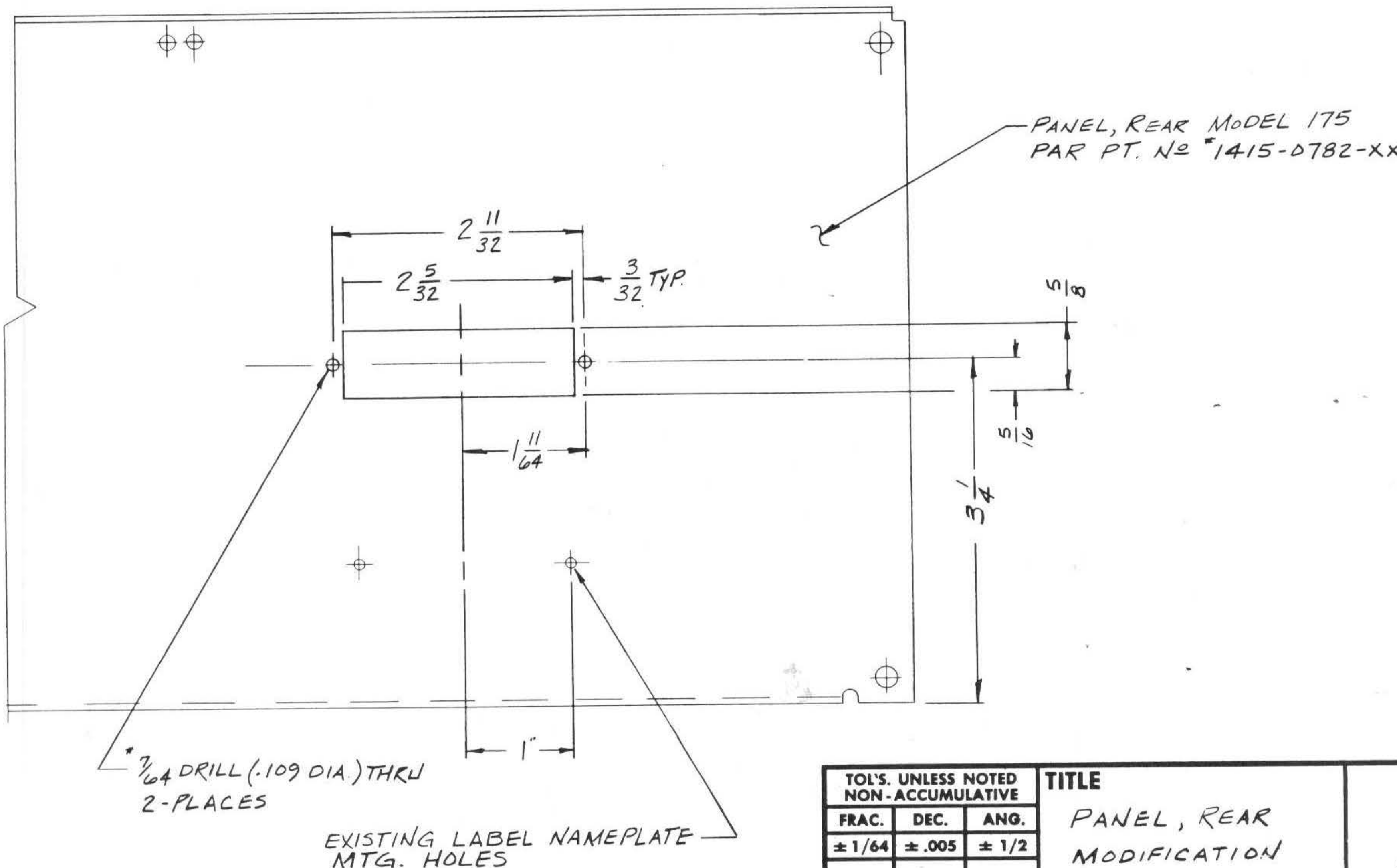
(6) Use the stick-on harness clamps supplied with the kit to hold the harness in place. This completes the installation, the circuit boards, board retainers, and top cover can be reinstalled.



REMOTE PROGRAMMING

MODEL 175/96

7893 | B | SD



TOL'S. UNLESS NOTED NON-ACCUMULATIVE			TITLE		PRINCETON APPLIED RESEARCH PRINCETON N.J.			
FRAC.	DEC.	ANG.	PANEL, REAR MODIFICATION					
± 1/64	± .005	± 1/2						
SCALE FULL			USED ON MODELS 175/96					
DRWN. DML		1/26/73			DWG. NO.	SIZE	TYPE	REV.
CHKD FAR		2-22-73	PART NO.	NEXT ASSY.	0549	B	SK	
APPD. FAR		2-22-73	SEE DWG.					

APPENDIX B
THIS APPARATUS AS A SOURCE OF RADIO FREQUENCY INTERFERENCE

In a typical application, it is unlikely that this apparatus will act as a source of noticeable radio frequency interference. However, when operated near particularly sensitive equipment, interference emanating from this apparatus could be a problem. Should this happen, steps can be taken to minimize that interference. A discussion of the recommended approach follows.

Interference below about 10 MHz is most likely to be caused by radio frequency currents flowing in the input and output cables, in the digital interface cables, or in the power line cord, if there is one. (Apparatus which depends on dc power from another piece of equipment will generally not have a line cord of its own.) The use of coaxial cables in making the analog signal input/output connections will usually prevent these lines from becoming a source of "below 10 MHz" radio frequency interference. Two approaches are suggested for reducing interference that has its source in the digital interface cables. The first is simply to shield these cables. The second is to provide a heavy ground connection between the grounds of all equipment sharing the interface bus. Practically, this is accomplished by strapping the chassis together with a metal braided or solid strap (solid strap does a better job but is more clumsy; copper, aluminum, or brass are the recommended materials). Because most EG&G PARC equipment has an internal low-pass filter connected to the power line, the ac line cord or dc lines carrying power from some other device of EG&G PARC manufacture are unlikely to be a source of radio-frequency interference. Should the device in question either not have an internal filter, or if the internal filter seems to be inadequate, try decoupling the power line with an external filter. At frequencies below 100 kHz, an isolation transformer could be helpful. If these techniques fail to do the job, and only then, try installing an internal filter using series inductances and shunt capacitors to ground.

WARNING!

TO REDUCE THE RISK OF POTENTIALLY DANGEROUS ELECTRICAL SHOCK, SUCH SERVICE SHOULD ONLY BE PERFORMED BY A QUALIFIED SERVICE TECHNICIAN, AND THEN ONLY WITH THE INSTRUMENT DISCONNECTED FROM ALL SOURCES OF POWER.

At frequencies above 10 MHz, these measures may not suffice to prevent radiation from being a problem, particularly at VHF frequencies. Additional measures will then be required. Shielding is generally effective. A suitable shield can be constructed using metal foil, wire screening, or similar materials. **NOTE:** In installing such a shield, take care that adequate ventilation is maintained. Once the apparatus is completely surrounded by the shield, the only additional requirement is to install low pass filters where lines pass through the shield (all openings through the shield should be as small as possible). A capacitor between a line and the shield can function as a suitable low-pass filter. The leads of the capacitor should be as short as possible. This requirement is optimally satisfied by using coaxial feedthrough capacitors. In the case of a signal lead, it is essential that the capacitor value be such as to attenuate the interference frequencies without unduely attenuating critical frequency components of the signal itself. The need to keep filter-capacitor leads short cannot be overemphasized. Long leads establish sizable ground loops and may additionally act as radiating rf antennae.

Coaxial cables are a special case in that the cable shield acts as an extension of the enclosure shield. This being the case, the filter can be mounted in a shielded box fitted with coaxial connectors without undue concern for keeping this box extremely close to the enclosure. If more convenient to do so, it can be located at some distance from the enclosure as long as the integrity of the coaxial shield is maintained.

The techniques described are extraordinary measures that should be required for unusual cases only. If they are applied with care, radio frequency should be reduced to an acceptably low level in all but the most critical applications. However, if these techniques are applied incorrectly, the efforts to reduce the interference could prove disappointing. Users are advised to contact the factory for advice in the case of a problem that does not yield to these measures.

APPENDIX C
TTL FRAME SYNC & CYCLE SYNC OUTPUTS

It may happen that equipment connected to the M175's FRAME SYNC or CYCLE SYNC outputs require TTL level signals instead of the ac-coupled signals normally provided at these outputs. These changes can be made in the field BY A QUALIFIED ELECTRONICS TECHNICIAN ONLY. To make the change, refer to the Chassis Wiring Diagram (7158-E-SD) on page VI-15. Observing the schematic, note that the BNC connectors for the FRAME SYNC output (J52) and CYCLE SYNC output (J53—marked ONE CYCLE on the schematic) are indicated at the far right.

To change the FRAME SYNC output to TTL, unplug the female plug J29 and move it to the male jack J41. This change directly connects the FRAME SYNC output BNC connector to J41. Similarly, to change the CYCLE SYNC output to TTL levels, move the female J30 to the male J42, thereby directly connecting the CYCLE SYNC BNC connector to J42.

APPENDIX D
TRANSIENT SENSITIVITY

Generally speaking, the design and construction techniques used in equipment manufactured by EG&G PARC are conducive to assuring normal operation in the presence of moderate transient levels. Although these provisions are sufficient for operation in most places where this equipment is used, it is certainly possible for the transient levels in particular environments to be so severe as to make reliable operation uncertain. High-level transients are of three general types.

(1) Static discharge. Transients from this source generally affect input or output circuits. Input circuits that include MOS field-effect transistors to achieve a high input impedance are particularly susceptible to damage from this source. Damage typically occurs when the charge built up on a user's body discharges into an input or output connector as a connection is being made. Among the factors determining the tendency for charges to build are the kind of clothing fabrics worn, shoe materials, and the materials in the floor or floor covering.

(2) High level transients generated internal to the place of use. Such transients almost always enter the instrument via the line cord. Possible sources include heavy-duty electric motors, rf equipment, lasers, diathermy machines, arc welders, spark chambers, etc.

(3) Lightning. Unless the equipment is connected to remote sensors, or other devices so located as to be vulnerable to lightning strikes, transients caused by lightning almost always enter the instrument via the line cord.

If a user is having problems due to transient interference, or if operation in a high-transient environment is anticipated, steps should be taken to minimize the transient problem. Static discharge problems can sometimes be avoided by judiciously selecting one's clothing and shoes, or by altering the floor covering in the work area. The simplest approach to the problem is to discharge one's body by touching a grounded metal object immediately prior to touching the instrument, particularly when making connections to it. Transients that enter the instrument via the line cord can generally be suppressed by means of external line-transient filters. Suitable devices are commercially available.

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