INSTRUCTION MANUAL

MODELS 7350 & 7360

UNIVERSAL EPUT® & TIMER

Serial ________

NOTE

If model number is followed by one or more letters, the instrument covered by this manual has been modified. See section on modifications.

Beckman

Berkeley Division

2200 Wright Avenue, Richmond 3, California

a division of Beckman Instruments, Inc

1959

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

INSTRUCTION MANUAL REVISION

Some of the DCU model numbers referred to in this manual may not correspond to those found in the instrument. Equivalent model numbers for the DCU's are given below. Differences between corresponding units are in construction only.

Craigmount Type		Stacked Board Type
705AH, 705B	- -	775
705AHJ	- -	775J
705AHP	- -	775P
705AHP/1	- -	775P/1
705AZ	- -	775Z
705AJ	- -	775AJ
705AK	- -	775K
705AL	- -	775L
705ALJ	- -	775LJ
705BR	- -	775R
785	- -	785A
795	- -	795A

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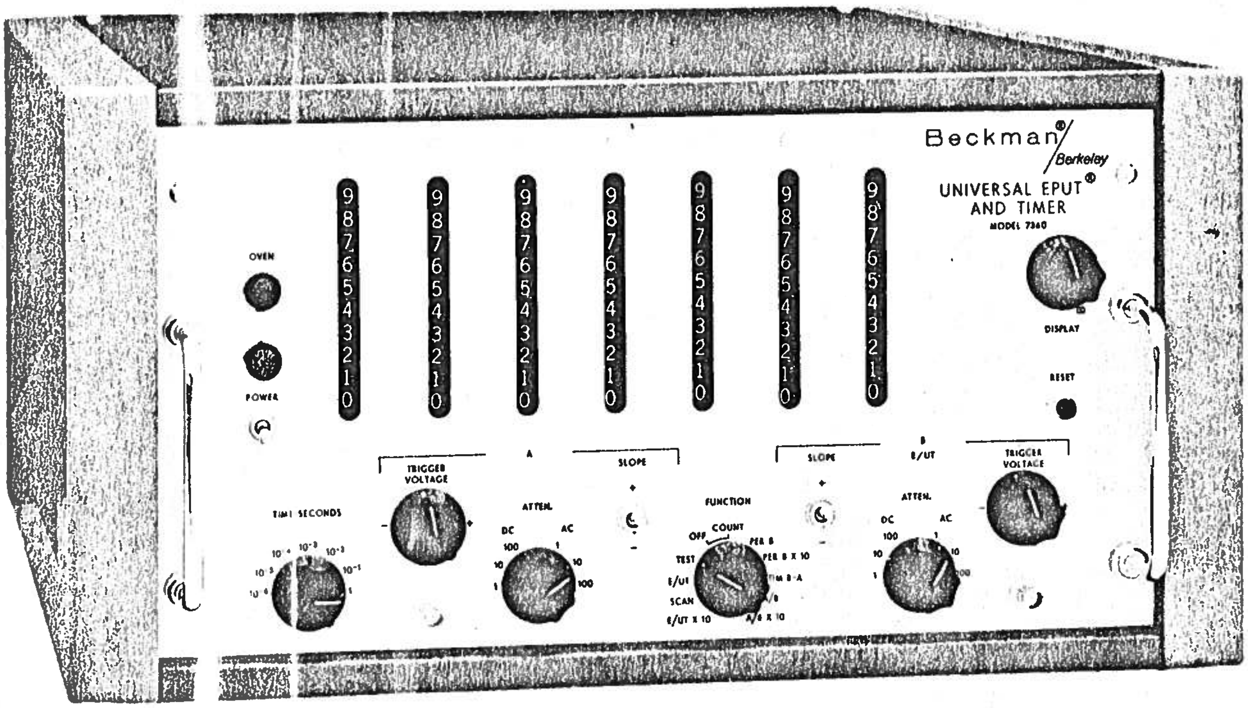


Figure 1 Front View of Model 7360

1 Introduction

DESCRIPTION

The Universal EPUT® and Timer (Models 7360 and 7350) is an electronic counter which will perform a wide variety of frequency and time measurements. These various functions are described below under "SPECIFICATIONS". The instrument consists of a precision clock-pulse generator, two input pulse-forming (trigger) channels, an electronic gate and a chain of decimal counting units (DCU's). When measuring frequency, each input signal cycle triggers a sharp voltage pulse on one of the input channels. These pulses pass through the gate and are counted by the DCU's during a precise time interval established by the clock-pulse generator. When measuring time, clock pulses are let through the gate and counted during an interval controlled by input signals.

The Model 7360 differs from the Model 7350 primarily in the highest frequency which may be measured and in the smallest unit of time measurement available. The Model 7360 will measure frequencies as high as 1 MC, whereas the Model 7350 is limited to 100 KC. The Model 7360 will make time measurements in one-μsecond units while the smallest unit of time measurement on the Model 7350 is 10 μseconds.

SPECIFICATIONS

FUNCTIONS

1. Measures frequency or counts events-per-unit-time over a maximum automatic time interval of 10 seconds with a manual extension beyond 10 seconds for extreme accuracy.

2. Measures period of a wave or the width of a pulse. Measures ten periods when greater accuracy is desired.

3. Measures the time interval between two events represented by pulses on separate input channels. When a signal is applied to one channel and the same signal is a different phase to the other channel, the result of this measurement is the phase difference.

4. Counts the number of events occuring between two events represented on the same input channel. If the events to be counted are cycles of a signal of one frequency and the two events which begin and end the counting period are successive cycles of a lower frequency, the result of this measurement is the ratio of the frequencies.

5. Counts events over a manually controled time interval.

6. Makes self-check on functioning of clock signals and Decimal Counting Units.

7. Performs any of the above functions with an appropriate external frequency substituted for the internal oscillator frequency.

PERFORMANCE CHARACTERISTICS

Input Trigger Channels

Input frequency range
d-c to 1 MC

Input impedance
10 megohms in parallel with 40 $\mu\mu f$

Input sensitivity
100 millivolts rms, 0.3 volts peak-to-peak from d-c to 1 MC

Input voltage attenuation
1, 10 or 100 a-c and d-c

Overload limits
Input impedance drops below 10 megohms when input voltage rises above +1 volt d-c after attenuation.

Trigger voltage level
Adjustable from -1 to +1 volt at the attenuated signal

Trigger slope
Plus or minus

Clock-pulse Generator

Output frequency
Selectable in decade steps from 1 cps to 1 MC on the Model 7360 and from 1 cps to 100 KC on the Model 7350

Output signal
0.25 microseconds pulse 2 volts high out of 330 ohms, available for external use.

Oscillator stability
Model 7360: 2 parts in 10^7 per day
Model 7350: 1 part in 10^6 per day

Gate, Control Circuits and DCU's

Resolution
Model 7360: 0.8 microseconds
Model 7350: 5 microseconds

Capacity
Model 7360: 10^7 counts
Model 7350: 10^6 counts

Display
Continuously variable from 0.1 to 10 seconds.

4-line code from DCU's to external connector.

APPLICATIONS

The Universal Eput & Timer can be used to make a wide variety of frequency and time measurements both in the laboratory and on the production line. It is useful in designing transmitters, receivers, tuned circuits, crystals, oscillators and other equipment which must have definite frequency characteristics. On the production line the instrument is ideal for making stability checks on transmitting and receiving equipment and on crystals during heat cycling. It may also be used to calibrate less accurate frequency monitoring equipment.

Various transducers such as photocells, magnetic pickups and switches may be used to produce voltage changes representing physical events. So equipped, the instrument will measure the characteristics of such events relative to time. Some of the known applications of the instrument are:

- Frequency measurements
- Frequency ratio measurements
- Relay and switch timing
- Phase measurements
- Viscosity and ballistic measurements
- Elasticity measurements
- Tachometry
- Telemetery
- Pulse height analysis
- Oscilloscope time base calibration
- Use as a secondary frequency standard

The versatility of the instrument can be fully utilized only when it is equipped with the proper accessories. Numerous transducers such as the Model 441 Reflecting Tachometer, as well as several data recording and data reduction instruments are available at Berkeley. The Model 1452 Digital Recorder, designed for use with this instrument, converts count information into a printed record. The unit prints the count accumulated by the counter during each counting period. The printed count appears sequentially in Arabic numerals on a standard adding machine tape. This recorder is ideal for making long term stability checks, recording transients, monitoring, or for making a permanent printed record in control or measuring systems.

The Beckman/Berkeley, Data Reduction Converters, convert digital information from the counter to a form suitable for actuating an IBM summary punch or an electric typewriter. These converters have uses similar to those of the Digital Recorder.

Berkeley Digital to Analog Converters convert the count accumulated during each counting period to a representative voltage level. This voltage is held until a new count is completed when it changes to conform with the new count. The unit may be used with a self-balancing potentiometer to provide an analog record, or the changing voltage level may be used to control the operation being monitored.

All accessory units described are available as standard models. In addition, special or modified versions can be ordered for specific applications.

2 Operation

OVER-ALL DESIGN

The counter will make three types of measurements aside from simple counting.

1. It will count the number of events occuring during a precise time interval. This is known as Events-Per-Unit Time or E/UT Operation. Frequency measurements are made in this way. The SCAN function is a variation of this operation.
2. It will measure the time interval between two events. If the two events are represented by voltage changes on separate input channels, it is called Time-Interval-Measurement or TIM Operation. If the two events are represented on the same input channel this is known as PERIOD Operation.
3. It will count the number of events occuring between two other events. This is Ratio or A/B Operation.

If the events mentioned above are not initially voltage changes, appropriate transducers are used to produce voltage changes representing the events at the counter INPUTS. Two input trigger channels within the counter convert the voltage changes they receive into sharp pulses. A clock-pulse generator in the instrument produces similar pulses separated by a precise time interval. Besides these three pulse sources the counter contains an electronic gate and a chain of decimal counting units. (DCU's). The DCU's count and indicate the number of pulses which pass through the gate between a start pulse which opens it and a stop pulse which closes it.

The FUNCTION switch determines the type of measurement made by selecting the pulse source which provides each of the three signals -- pulses to be counted, the start pulse and the stop pulse.

1. Under E/UT Operation one of the input channels provides pulses which are counted over the known time interval between start and stop pulses from clock-pulse generator. With the proper placement of a decimal point the lighted DCU's indicate events or cycles per second.
2. Under PERIOD or TIM Operation pulses of known frequency from the clock-pulse generator are counted over an unknown interval between start and stop pulses from one or both of the input channels. Since the clock-pulse frequency is equal to the 1MC or 100KC oscillator frequency divided by a power of 10, the time measurement appears directly in decimal fractions of a second.
3. Under A/B Operation pulses from one of the input channels are counted between start and stop pulses from the other channel. If the events represented by the pulses are cycles of input signal waves, the DCU's indicate the number of cycles at one input which occur during one cycle at the other INPUT or, in other words, a frequency ratio.

During all "times ten" (x 10) operations the start-stop pulse frequency is divided by 10 so that the counting period is multiplied by 10 and the reading is 10 times as large. Figures 4a thru f show the selection of pulse sources for each operation.

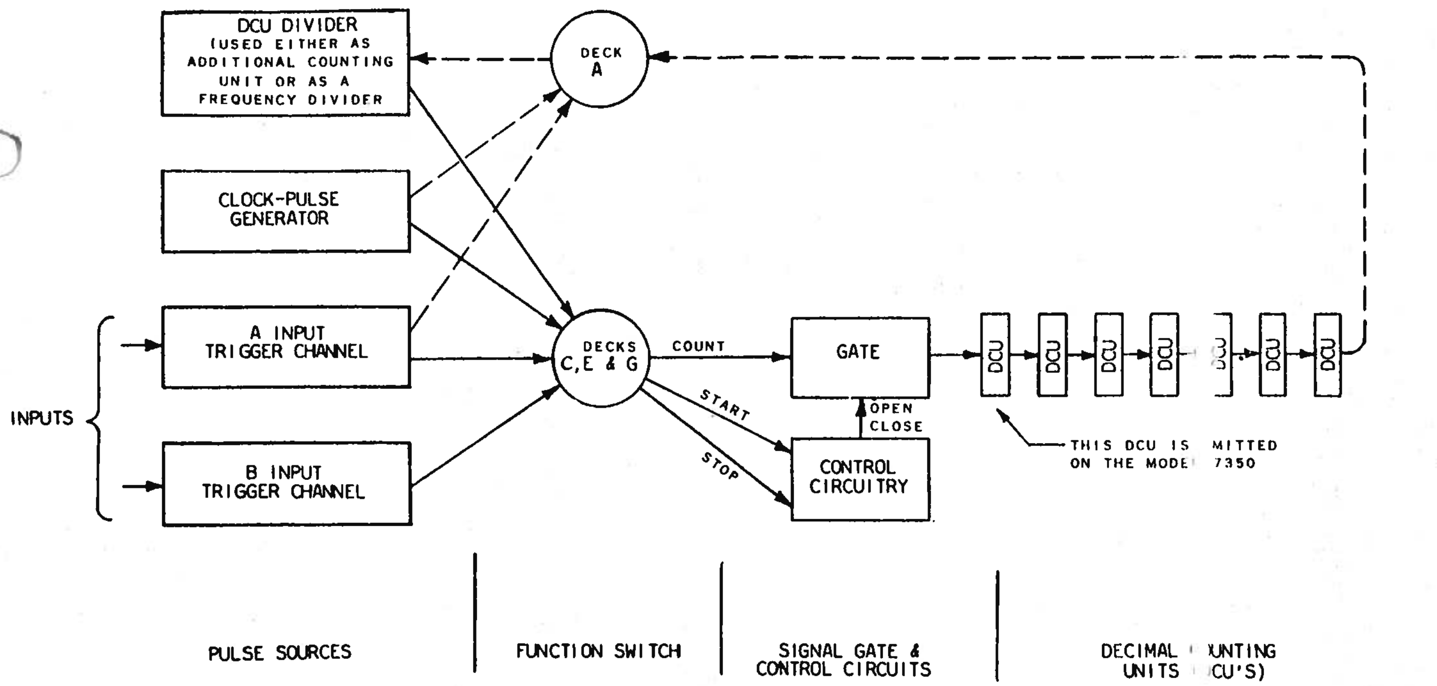


Figure 2 Signal Paths between Major Components

OPERATING CONTROL & CONNECTOR FUNCTIC NS

CONTROLS

POWER switch

Turns power on and off.

FUNCTION switch

1. Interconnects major components to perform the measurement indicated by the pointer.
2. Used to manually control COUNT and SCAN operations.

TIME-SECONDS switch

Selects time interval for events-per-unit-time & TEST measurements and unit of time measurement for PERIOD and TIM measurements.

ATTENUATION controls

Attenuates the signal at the adjacent INPUT jack by the voltage factor to which the pointer is set. When turned to the AC side only the a-c component of the input signal reaches the input trigger channel.

TRIGGER VOLTAGE Controls

Selects the instantaneous voltage at which the attenuated signal triggers the adjacent input channel.

SLOPE switches

Selects the slope of the input voltage waveform which triggers the input channel pulse used to operate the gate and control circuitry. The input channel which each SLOPE Switch affects varies with the position of the FUNCTION switch. See "PERFORMING SPECIFIC OPERATIONS" to determine the function of the SLOPE switches at a particular position of the FUNCTION switch.

DISPLAY Time Control

Determines how long the instrument holds a reading before resetting and beginning another count. When this control is turned to the extreme clockwise position, the instrument will hold a reading until the manual RESET button is depressed.

Manual RESET Button

Removes the previous reading and readies the instrument to begin another counting period.

INPUT Trigger Channel Jacks

Inputs to the two Input Trigger Channels

FREQUENCY Jack (Chassis Rear)

When the EXT-INT switch is at INTernal, the 1MC oscillator signal is available here. When the switch is at EXTernal, the external reference frequency must be connected to this jack.

COUNTER INPUT ADJUSTMENTS

INPUT ADJUSTMENTS WHEN COUNTING CYCLES OF A SINE-WAVE SIGNAL

In the common case in which the input approximates a sine-wave signal having a frequency between 10 cps and 1.15 MC, and when the object is merely to generate one pulse for each cycle without regard for the precise time at which a pulse occurs, the ATTENUATION and TRIGGER VOLTAGE controls may be set as follows:

1. Couple the input signal to the B INPUT jack. Input sensitivity is 100 mv rms (0.3 volts peak-to-peak). Input impedance is 10 megohms.
2. Place FUNCTION switch at COUNT and press manual reset button. (SLOPE switches may be in any position.)
3. Rotate the TRIGGER VOLTAGE control slowly from one extreme to the other while the ATTENUATION control is at each of the three positions on the AC side (1, 10 & 100). Notice that the instrument will count steadily over a certain arc of TRIGGER VOLTAGE positions for each ATTENUATION setting. Choose the highest ATTENUATION position at which counting will continue over an arc of at least 45 degrees rotation of the TRIGGER VOLTAGE control.
4. Position the TRIGGER VOLTAGE control at the center of the arc over which counting occurs.

EFFECT OF INPUT CONTROLS

Figure 3a is a block diagram of an input trigger channel.

The impedance at the INPUT jack is 10 megohms in parallel with 40 micromicrofarads. This impedance may be reduced to match the source or to avoid capacitive pickup by attaching a "T" connector to the jack and adding resistors or capacitors in parallel. The input sensitivity is equal to 0.3 volts peak-to-peak times the factor to which the ATTENUATION control is set. The input circuitry will withstand a signal as strong as 500 volts peak-to-ground without damage.

The attenuator divides the voltage introduced at the INPUT jack by the factor indicated by the ATTENUATION control. When the control points to a factor on the side labelled "DC", the total INPUT signal is attenuated and passed on. When the control points to a factor on the side labelled "AC", the d-c component is removed and only the a-c component is attenuated and passed on. Frequencies as low as 1 cps will be passed in the "AC" positions.

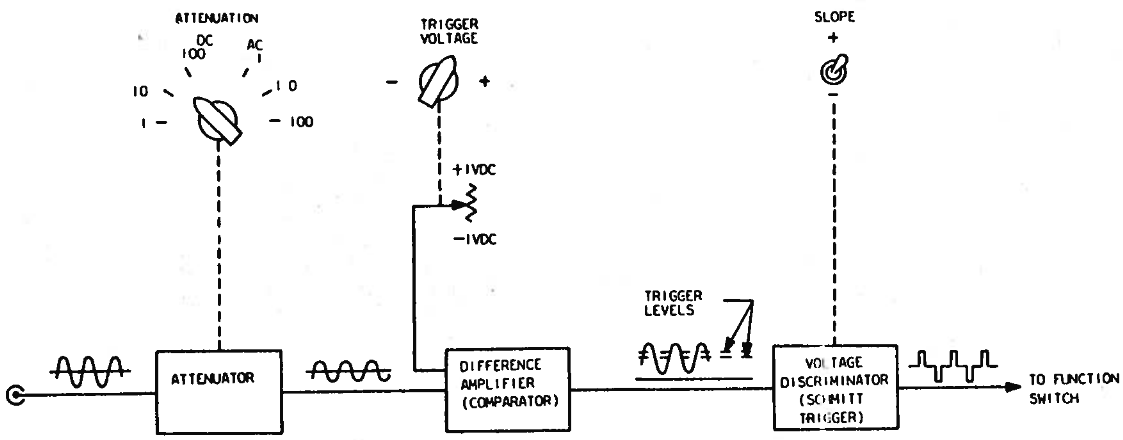


Figure 3a

Figure 3b shows how the varying voltage of the attenuated signal triggers channel output pulses. A pulse is produced each time the instantaneous voltage of the attenuated signal passes through the "positive-going trigger voltage" starting from a value more negative than the "negative-going trigger voltage". Another pulse is produced each time the instantaneous attenuated voltage passes through the "negative-going trigger voltage" starting from a value more positive than the "positive-going trigger voltage". When the SLOPE switch is at "+", only pulses triggered by positive-going voltage excursions affect the succeeding circuitry. With the SLOPE switch at "-", only pulses triggered by negative-going excursions are effective.

The two trigger voltage levels (positive-going and negative-going) are always separated by 0.3 volts, the effective hysteresis. Because a voltage excursion must travel through both levels to trigger a pulse, the sensitivity of the channel to the attenuated signal is 0.3 volts peak-to-peak.

The trigger voltage levels of either input channel may be raised or lowered simultaneously (maintaining 0.3-volt separation) when the TRIGGER VOLTAGE control for that channel is varied. This control will vary the levels from roughly -1 volt to +1 volt. Referring to figure 3, notice that the TRIGGER VOLTAGE control actually raises or lowers the d-c level of the input to the voltage discriminator. However, this action has the effect of raising or lowering the trigger voltage levels at the input to the difference amplifier.

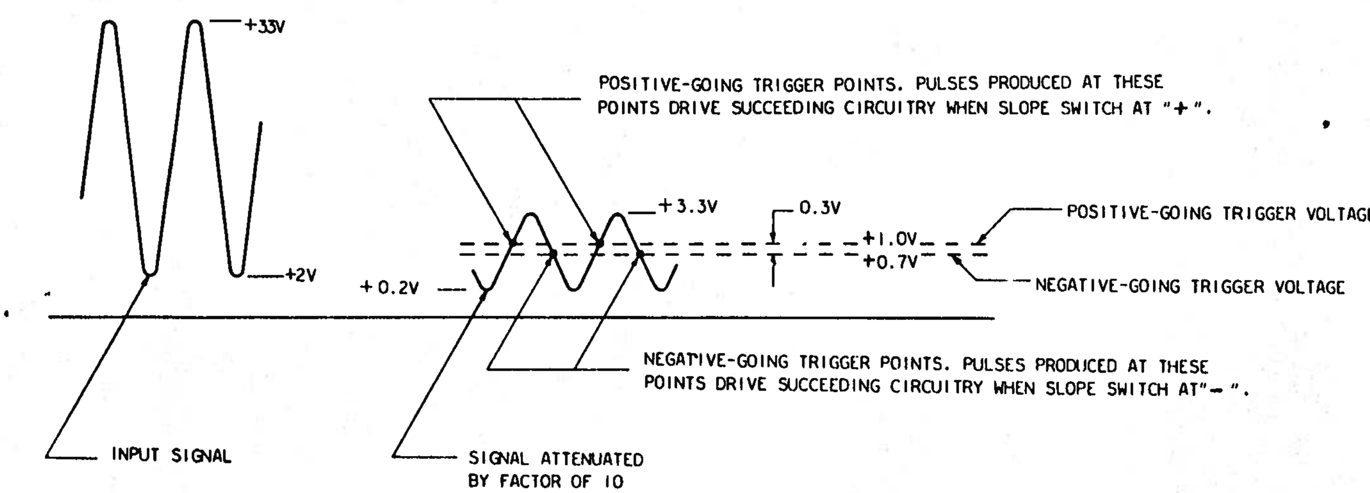


Figure 3b

The purpose of the input trigger channel is to produce a reliable pulse output representing that part of the input signal in which the operator is interested. This is achieved only when the ATTENUATION and TRIGGER VOLTAGE controls are properly adjusted. Before attempting to adjust the controls, it is best to visualize the input waveform, noting the shape, a-c amplitude and d-c level. The effect of various control settings is then relatively easy to calculate. Referring to figure 3, notice that:

1. If the attenuated signal is small peak-to-peak, the trigger voltage levels may be set so high or so low that no pulses are produced. In figure 3, for example, if the "positive-going trigger voltage" were set at -0.5 volts (thus placing the "negative-going trigger voltage" at -0.8 volts), the attenuated signal with peaks at +0.2 and +3.3 volts would not intersect either trigger voltage level.
2. If the attenuated voltage variations ride on a d-c level, they may not come within the trigger voltage range. In figure 3, again, if the input signal were not attenuated (or a-c coupled) the negative peak at +2 volts would not intersect any possible trigger voltage level.
3. Modulation or variations in the d-c level of the attenuated signal are least likely to subtract pulses if the trigger voltages are set about halfway between the peaks of the signal.
4. Extraneous signals (noise, hum, modulation, drift, etc.) have the least effect on the time at which a pulse occurs when the channel triggers on a steep slope of the waveform.
5. Noise below 0.3 volts peak-to-peak will not trigger extraneous pulses. Consequently, attenuating a signal carrying a given percentage of noise may eliminate the effect of the noise. For example, 1 volt peak-to-peak noise on a 6 volt peak-to-peak signal will trigger extraneous pulses. If the signal is attenuated by a factor of 10, the resulting 0.6 volt p-p signal will still trigger desired pulses dependably, while the resulting 0.1 volt p-p noise is well below the sensitivity of the channel.
6. Attenuating the input signal
   (a) Reduces the slope at all points
   (b) Shifts the a-c component nearer ground if it rides on a d-c level.
   (c) Increases the minimum peak-to-peak variations necessary to trigger pulses (measured at the INPUT jack) from 0.3 volts to 3 or 30 volts
   (d) Increases the range of possible trigger voltage setting on the <u>input</u> signal from ±1 volt to ± 10 volts or ± 100 volts.

Adjustment of ATTENUATION and TRIGGER VOLTAGE controls should be made keeping the above characteristics in mind. When using any regular periodic input signal, consistent E/UT or PERIOD readings are a good indication that the controls are properly adjusted.

The point on an input waveform where the input channel triggers may be seen on an oscilloscope. Observe the input of the voltage discriminator in the input channel used (V303, Pin 2). The waveform which appears is the amplified input signal together with small "notches" created on each slope as the channel triggers. Rotating the TRIGGER VOLTAGE control will cause these notches to move up and down the waveform. See "Typical Waveforms" for a sample display.

The trigger voltage may be set at a precise value by applying a d-c voltage of that value at the INPUT jack, setting the ATTENUATION control at an appropriate factor on the DC side and rotating the TRIGGER VOLTAGE control to the point where an output pulse is produced. With no input voltage the INPUT jack lies at ground and a pulse will be produced at ground level. Output pulses from the B channel may be seen being counted when the FUNCTION switch is at E/UT. Pulses from the A channel are counted on the A/B position.

Some information about the position of the trigger voltage relative to the signal may be extracted from the instrument itself. The trigger voltage may be varied between the positive and negative peaks of an attenuated signal whose peaks lie within the range -1 to +1 volts. As the trigger voltage pass beyond the signal peaks the pulse output of the channel will cease and these positions of the control may be noted.

PERFORMING SPECIFIC OPERATIONS

MEASURING FREQUENCY

The frequency of a regular sine-wave signal can be measured either directly under E/UT or E/UT x 10 Operation or indirectly by measuring the period of the signal and calculating the frequency. The direct method is simpler and will ordinarily be used except when measuring a low frequency signal with extreme accuracy. See the "ACCURACY" section of this manual for the accuracy limitations of events-per-unit-time operation.

> NOTE: At "X10" positions of the function switch, the DCU at the far left does not function in the counting chain; therefore, disregard its indication.

TEST Operation

To put the instrument in operation connect the power cord and place the POWER switch in the position which lights the green indicator above it. After a two minute warm-up, test the instrument for proper operation:

1. Turn DISPLAY Time to a point near the extreme counter -clockwise position to obtain a short display time and automatic operation.
2. Turn FUNCTION switch to TEST.
3. Rotate TIME switch to each position starting with the 10-5 seconds setting on the Model 7360 or the 10^{-4} seconds setting on the Model 7350. In either case this should give a reading of 10. As the switch is turned clockwise, other settings should read successively 100, 1000 or 999, 10, 000 or 9, 999, 100, 000 or 99, 999 and (on the Model 7360 only) 1, 000, 000 or 999, 999.

Note that the DISPLAY time is infinite at the extreme clockwise position of the control. In this position, the instrument must be reset manually.

E/UT (Events-Per-Unit-Time) Operation

At the E/UT position of the FUNCTION switch the unit counts the input to the B Channel between start and stop signals separated by a precise time interval. This setting may be used to measure the frequency of a signal or the number of events occuring within a selected time interval. The major components are connected as diagramed in Figure 4a.

To make a measurement proceed as follows:

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to the E/UT position. In this position the SLOPE

switch on the B-START-E/UT-PERIOD side of panel determines the polarity of the voltage excursion which triggers count pulses. It may be at either position.

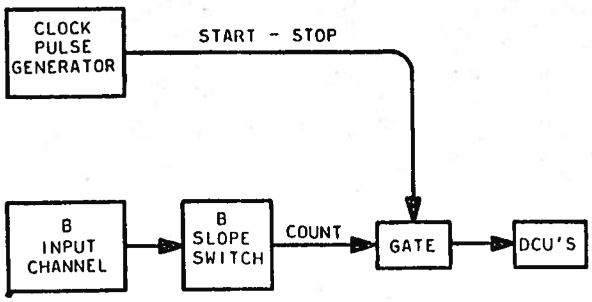


Figure 4a

3. Set the TIME switch at the time interval over which events are to be counted.
4. Adjust the DISPLAY time control to a position at which the count on the lighted DCU's may be read conveniently.
5. To obtain a reading in events per second, divide the reading on the lighted DCU's by the number to which the TIME switch is set.

E/UT x 10 Operation

At the E/UT x 10 position of the FUNCTION switch the unit counts every cycle of the input to the B channel between stop and start signals separated by 10 times the interval indicated by the TIME switch. This setting may be used to obtain a 10-second time interval. Counting over the 10-second period produces more accurate frequency measurements than may be made using shorter time intervals. The major components are connected as diagramed in Figure 4a except that the output of the Clock-Pulse Generator is fed through the DCU Divider before reaching the Gate. To make a measurement proceed as follows:

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate FUNCTION switch to the E/UT x 10 position.
3. Set the TIME switch. At this position of the FUNCTION switch the interval during which events are counted is 10 times that indicated by the TIME switch.
4. Adjust the DISPLAY TIME control for a convenient reading.
5. To obtain a reading in events per second divide the reading on the DCU's by 10 times the factor indicated by the TIME switch.

SCAN Operation

The interval during which events are counted may be extended to any multiple of the 1 or 10-second counting periods. Consider the total counting interval desired as N counting periods. Then proceed as follows:

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Turn DISPLAY TIME control fully clockwise.
3. Place FUNCTION switch at E/UT or E/UT x 10.
4. Select a one or ten-second counting period. If the FUNCTION switch is at E/UT x 10 turn the TIME switch to 1 to obtain a 10-second period and to 10^{-1} to obtain a one-second period.
5. Press the RESET button. Within 1 second the instrument will begin a normal counting period.
6. Before the end of this period (one or 10 seconds as the case may be) turn the FUNCTION switch to the SCAN position and begin timing N minus 1 counting periods with a stopwatch.
7. At the end of N minus 1 periods turn the FUNCTION switch back to E/UT or E/UT X 10.
8. When the instrument stops counting, read the count. Ignore the digit (if any) appearing on the DCU farthest to the left. This DCU has not been counting continuously during the extended interval.

A/B Operation

At the A/B position of the FUNCTION switch the unit counts the signal at the A INPUT between consecutive voltage excursions through a selected level at the B INPUT. This setting may be used to measure the ratio of two frequencies or to count the number of events occurring while the B INPUT is above or below a given voltage level. The major components are connected as diagrammed in Figure 4b.

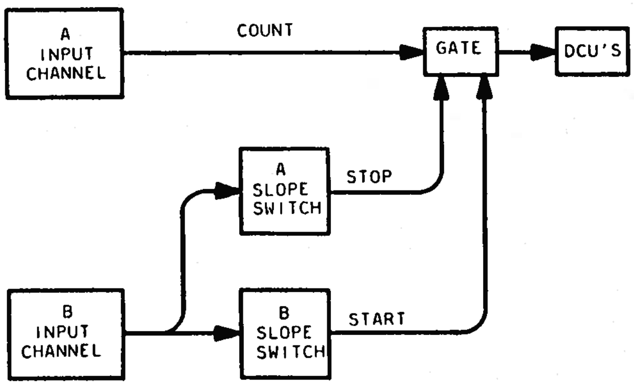


Figure 4b

To make a measurement proceed as follows:

1. Connect the higher frequency to the A INPUT jack and the lower frequency to the B INPUT jack. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to A/B. In this position the SLOPE switch on the B side of the panel determines the polarity of the voltage excursion which begins count of the A input. The other SLOPE switch sets the polarity of that which ends the counting period.
3. Therefore,
   (a) When measuring the ratio of two frequencies set both SLOPE switches "+" or both to "-".
   (b) When counting the A input during the period the B input voltage remains above a certain level, set the SLOPE switch on the B side to "+" and the other to "-".
   (c) When counting the A input during the period the B input voltage remains below a certain level, set the SLOPE switch on the B side to "-" and the other to "+".
4. Adjust the DISPLAY TIME control to a position at which the count on the lighted DCU's may be read conveniently.
5. Take a reading. When measuring a frequency ratio the DCU's indicate the ratio of the A input frequency to the B input frequency.

A/B x 10 Operation

At the A/B x 10 position of the FUNCTION switch the unit counts the signal at the A INPUT between a voltage excursion through a selected level at the B INPUT and the tenth following excursion. This setting will measure a frequency ratio more accurately than the A/B operation. The major components are connected as diagrammed in Figure 4c.

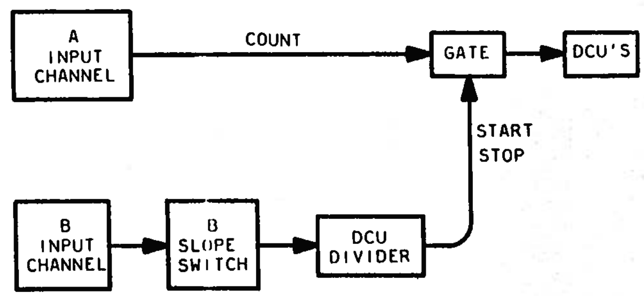


Figure 4c

To make a measurement proceed as follows:

1. Connect the higher frequency to the A INPUT jack and the lower frequency to the B INPUT jack. (See "COUNTER INPUT ADJUSTMENT" above).
2. Rotate the FUNCTION switch to A/B x '10. In this position the B SLOPE switch determines the polarity of the voltage excursion which begins and ends counting.
3. For greatest accuracy set this SLOPE switch on the steeper slope of the B input
4. Adjust the DISPLAY TIME control to a position at which the count on the lighted DCU's may be read conveniently.

5. Divide the reading by 10 to obtain the ratio of the A INPUT frequency to the B INPUT frequency.

TIM (Time-Interval-Meter) Operation

At TIM position of the FUNCTION switch the unit measures the time between a voltage excursion through a selected level at the B (START) INPUT and a voltage excursion through an independently chosen level at the A (STOP) INPUT. The major components are connected as diagramed in Figure 4d.

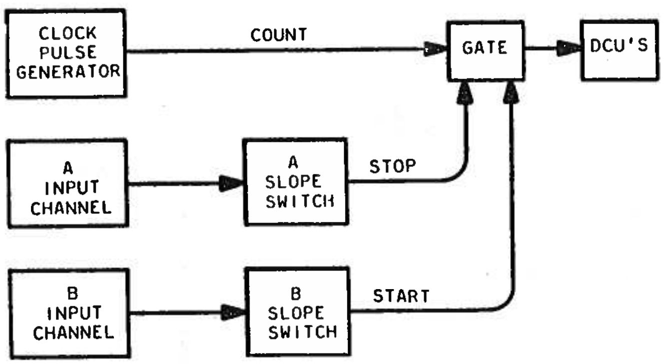


Figure 4d

To make a measurement proceed as follows:

1. Connect the start signal to the START INPUT and the stop signal to the STOP INPUT. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to TIM. In this position the B SLOPE selects the polarity of the voltage excursion which begins the timing period. The A SLOPE switch selects the polarity of that which ends the timing period.
3. Rotate the TIME switch to the desired unit of time measurement. For example, at the 10^{-4} position the time measurement appears in ten-thousandths of a second. The smaller the time unit chosen, the more accurate the reading.
4. Adjust the DISPLAY time control to a position at which the count on the lighted DCU's may be read conveniently.
5. To obtain a reading in seconds, multiply the count on the DCU's by the factor to which the TIME switch is set.

PERIOD Operation

At the PER position of the FUNCTION switch the unit measures the time interval between consecutive voltage excursions through a selected level at the B INPUT. This setting may be used to measure the period of a wave or the width of a pulse. The major components are connected as in Figure 4e.

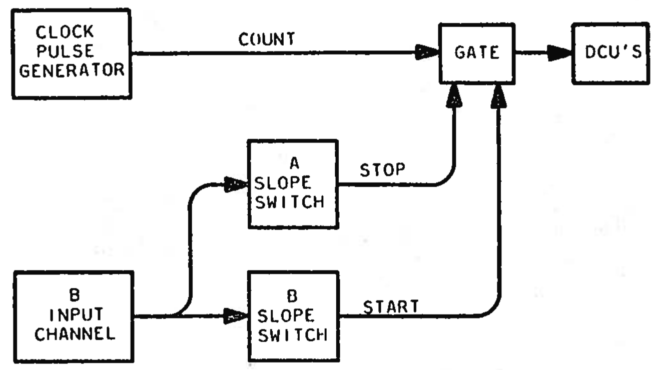


Figure 4e

To make a measurement proceed as follows:

1. Connect the wave or pulse source to the B (PERIOD) INPUT. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to PERIOD. At this position the B SLOPE switch selects the polarity of the voltage excursion which begins the timing period. The A SLOPE switch selects the polarity of that which ends the timing period.
3. Therefore,
   (a) When measuring the period of a wave, set both SLOPE switches to "+" or both to "-".
   (b) When measuring the width of a positive pulse, set the B SLOPE switch to "+" and the A SLOPE switch to "-".
   (c) When measuring a negative pulse, set the B SLOPE switch to "-" and the A SLOPE switch to "+",
4. Follow steps 3, 4 & 5 under "TIM Operation".

PERIOD x 10 Operation

The unit measures the time interval between a voltage excursion through a selected level at the B INPUT and the tenth following excursion. This setting will measure the period of a wave more accurately than the PERIOD operation. The major components are connected as diagramed in Figure 4f.

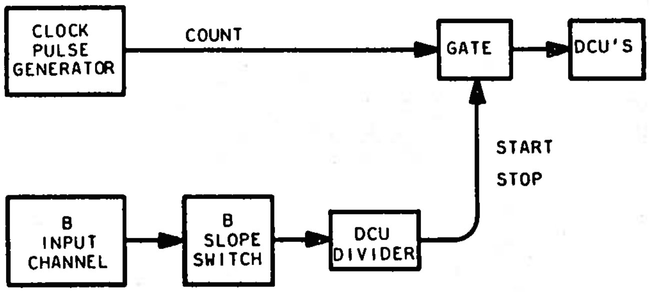


Figure 4f

To make a measurement proceed as follows:

1. Connect the wave source to the B (PERIOD) INPUT. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to PERIOD x 10. The B SLOPE switch selects the polarity of both start and stop voltage excursions.
3., 4 & 5. Follow steps 3, 4 & 5 under "TIM Operation".
6. Divide the reading by 10 to obtain the length of one period.

COUNT Operation

The unit counts the input to the B channel during the period the FUNCTION switch is in the COUNT Position.

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Turn FUNCTION switch to OFF.
3. Depress manual RESET button.
4. Twist FUNCTION switch to COUNT to begin counting.
5. Twist FUNCTION switch to OFF to stop counting.

GATE Operation

This operation is a variation of TIM operation. Pulses generated by an external signal are substituted for internal clock pulses. The instrument counts cycles of the substituted signal between a voltage excursion through a selected level as the B (START) INPUT and a voltage excursion through an independently chosen level at the A (STOP) INPUT.

The substituted signal must have an amplitude of 5 volts rms into a 7K load. Its frequency may be as high as 100KC in the case of the Model 7350 or as high as 1MC in the case of the Model 7360. Couple the signal to the FREQ. jack at the rear of the counter and place the EXT-INT switch at EXT.

NOTE: The .01 μf capacitor (C401) connected between the FREQ. jack and the input circuit used for this operation is not large enough to pass frequencies lower than 1 KC. If the external signal frequency is lower than 1 KC, jumper this capacitor and connect a larger capacitor between the signal source and the FREQ. jack.

Rotate the TIME switch to 10^{-5} on the Model 7350 or to 10^{-6} on the Model 7360. Place the FUNCTION switch at TIM. Adjust the START and STOP input channels as described under "INPUT ADJUSTMENTS". See "TIM Operation" to learn how the SLOPE switches operate on these channels. The shaper stage of the clock pulse generator is used as the input trigger channel for the signal introduced at the FREQ. jack. Adjust the input trigger voltage of this channel with the SHAPER LEVEL control located on the top side of the counter chassis. Rotate this control to find the limits of the range in which the instruments counts. Set the control at the center of this range.

USING AN EXTERNAL REFERENCE FREQUENCY

An external reference frequency may be substituted for the internal oscillator signal. Introduce the external signal as described under "GATE Operation," but place the TIME switch at a position which produces a clock pulse frequency equal to the reference frequency divided by the desired power of 10.

REMOTE CONTROL OF OPERATING CYCLE

The counter can be controlled from a remote location so that it will not reset and begin another count until desired. Set the DISPLAY time control at a minimum and string a lead from the remote location to Pin 40 of the DIGITAL RECORDER socket. As long as this lead is grounded the counter will not reset. If a count is complete, then within 40 milliseconds after the lead is ungrounded the counter will have reset and be ready to start counting when a start pulse appears. As soon as the counter has reset, the lead may be grounded again or left ungrounded. It will not affect the operating cycle until the time arrives for the next automatic reset. At that time it must be grounded again to prevent reset.

ACCURACY

Measurements are subject to four important sources of error.

1. Counts missed or added as the Gate opens and closes.
2. Clock signal inaccuracy.
3. Errors in the time a start or stop pulse is triggered.
4. Counts missed because they occur during the resolution time of the counting circuits.

1.

Pulses which occur simultaneously with the opening or closing of the Gate may or may not be counted. This causes all measurements to vary plus or minus one count. The following equation defines the possible error introduced.

$$(1)\ \text{Max. \% error} = \frac{1}{\text{Count Indication}} \times 100.$$

Notice that measurements set up to yield the highest count indication will be most accurate.

The frequency of a sine wave signal can be measured directly by counting events-per-unit-time or indirectly by measuring the length of one period and calculating the frequency. Higher frequencies yield the highest count indication when measured directly, that is, using the E/UT or E/UT x 10 function. Lower frequencies produce the highest indication when rapid time signals are counted over one or ten periods - that is, using the PERIOD or PERIOD x 10 function.

On the Model 7360 frequencies above 1KC produce the highest count indication when measured using the E/UT x 10 function and a 10-second time interval; frequencies below 1KC yield the highest count when measured with the PERIOD x 10 function and a 1 μsecond unit of time measurement. The accuracy achieved using alternative functions at various frequencies is graphically illustrated in Figure 6. Note that the curves for E/PUT x 10 (10-second interval) and PERIOD x 10 (1 μsec time unit) cross at 1KC. This frequency cannot be measured with a possible error less than .01%. Frequencies above and below may be measured with greater accuracy.

The smallest unit of time available on the Model 7350 is 10 μseconds. Lower frequencies are most accurately measured using the PERIOD X 10 function and this time unit. Notice on Figure 6 that this curve crosses the EPUT X 10 curve at 316 cps. Therefore on the Model 7350 frequencies above 316 cps are most accurately measured using EPUT x 10 and a 10-second time interval whereas frequencies below 316 cps are best measured using the PERIOD x 10 function and the 10 μsecond unit of time. 316 cps cannot be measured with a possible error less the .03%, but lower and higher frequencies may be measured more accurately.

2. All measurements requiring a time signal (i.e. all measurements except A/B, A/B x 10 and COUNT) are subject to an additional error introduced by variations in the oscillator frequency. The oscillator frequency in the Model 7360 is stable to 2 parts in 10^7 per week, so it can cause a maximum error of only .00002%. The oscillator in the Model 7350 is stable to 1 part in 10^6 per day. It causes a maximum error of .0001%.

3. Measurements using a external signal to trigger start and stop pulses (i.e. PERIOD, PERIOD x 10, TIM, A/B and A/B x 10) may be subject to a further error caused by pulses which are triggered too soon or too late. Refer to Figure 5 which illustrates what occurs during a simple period measurement.

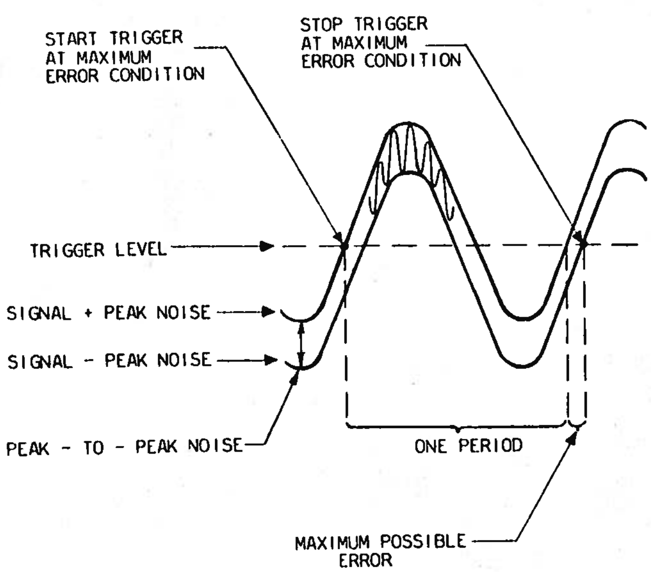


Figure 5 Effect of Noise on Accuracy of Period Measurements

Consider the total signal as an ideal signal intended to trigger the input channel plus a noise signal. The noise voltages added or subtracted from the ideal signal may trigger a pulse before or after the instant at which counting should begin or end. The maximum error in the time of triggering will be proportional to the noise amplitude and inversely proportional to the slope of the ideal signal at the trigger level. Expressed mathematically,

$$(2)\quad t\ (\text{secs}) = \frac{V_n\ (\text{volts})}{S\ (\text{volts/sec})}$$

where t = Max. error in trigger time

V_n = peak-to-peak noise

S = slope of ideal signal at trigger level

The total noise (V_n) is equal to that carried by the input signal after attenuation plus that internally generated by the input channel. The internal noise (which takes the form of amplifier drift, trigger level jitter, line frequency pick-up, etc) is not more than 300 microvolts. Note that as the amplitude of of the input signal is increased, S in equation (2) becomes larger and the internal noise causes less error.

The percentage error may be calculated by dividing the error in trigger time by the counting period and multiplying by 100. In the common case of a period measurement of a sine wave triggering at its zero cross-over value:

$$(3)\quad \text{Max. \% error} = \frac{V_n\ (\text{volts})}{V_s\ (\text{volts}) \times \pi} \times 100$$

where V_n = peak-to-peak noise

V_s = peak-to-peak signal

The maximum percent error of a PERIOD x 10 measurement is one-tenth the value given in equation (3).

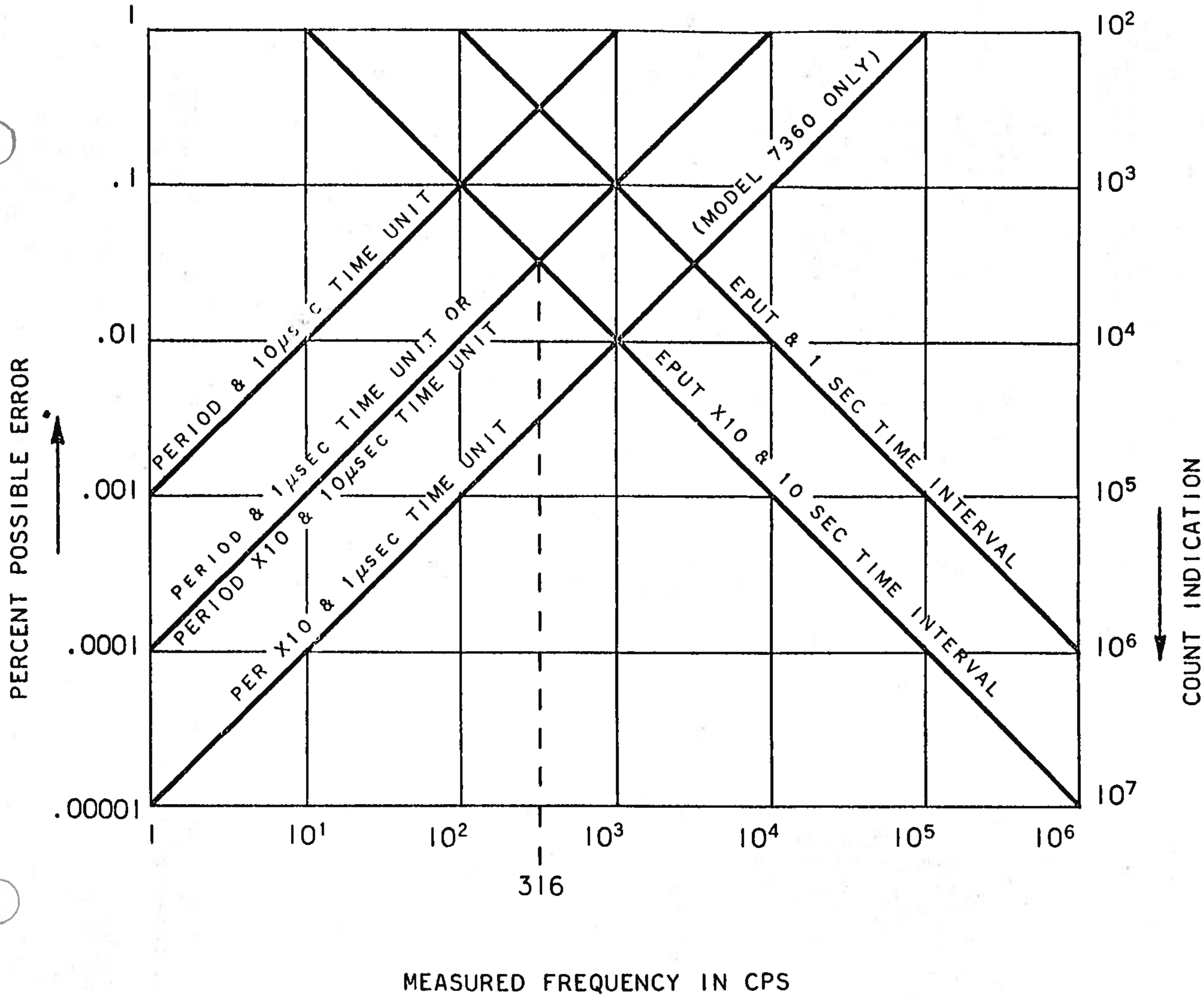
The total error due to the three causes mentioned above is equal to the sum of the separate errors.

Total Max. percent error equals:

$$\frac{100}{\text{Count Indication}} + \begin{matrix}.00002\ (7360)\\ \text{or}\\ .0001\ (7350)\end{matrix} + \text{Percent error due to noise}$$

(.00002 (7360) or .0001 (7350) ↓) If E/UT, E/UT x 10, PERIOD, PERIOD x 10

(Percent error due to noise ↓) If PERIOD, PERIOD x 10, TIM, A/B or A/B x 10



NOTE: THE 1µSECOND TIME UNIT IS NOT AVAILABLE ON THE MODEL 7350

Figure 6 Error due to ± 1 Count Limitation

4. Another source of error becomes important when random events are counted. One such event may occur immediately after another, before the counting circuits are fully recovered and prepared to register it. The second event will not only fail to cause a count but its effect on the circuitry may cause a third event to fail to register also. Formulae for calculating the counting error due to this effect may be found in "Application of Probability Theory to Nuclear Particle Detection", L. J. Rainwater and C. S. Wu, Nucleonics, October 1947. The minimum time which must elapse between events if both are to be counted is called resolution time of the instrument. The Model 7360 has a resolution time of .8 µseconds. The Model 7350 has a resolution time of 5 µseconds.

AUXILIARY CONNECTORS

DIGITAL RECORDER Jack. This multi-terminal socket, wired to the readout lines of each DCU, makes available 1-2-2-4 binary-coded signals for use with such auxiliary equipment as printers, in-line display units, and data converters. One of the tables below gives the binary code generated by the DCU's for each decimal digit registered. "0" means an output level of about -15 volts with respect to ground; "1", a level at ground or slightly positive with respect to ground. The other table lists the pin connections to each DCU.

DECIMAL DIGIT REGISTERED	FOUR - LINE BINARY CODE			
	1st Binary Stage	2nd Binary Stage	3rd Binary Stage	4th Binary Stage
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1
No Digit	0	0	1	0

	PIN NO. ON DIGITAL RECORDER SOCKET			
	1st Binary Stage	2nd Binary Stage	3rd Binary Stage	4th Binary Stage
Highest order digit read*	Pin 4	Pin 3	Pin 2	Pin 1
2nd highest order digit	8	7	6	5
3rd highest order digit	12	11	10	9
4th highest order digit	16	15	14	13
5th highest order digit	20	19	18	17
6th highest order digit**	24	23	22	21

* On instruments featuring "times ten" positions of the FUNCTION switch no read-out pins are provided for the left-most DCU, which displays the highest order digit during some measurements. On these instruments the highest order digit represented by a 4-line code is in the front-panel column second from left.

** On instruments containing only five read-out DCU's pins 21 thru 24 are permanently wired to produce the "no digit" code which is "0010".

Pin 39 carries a control signal from the counter. This pin is negative during the display period and positive from reset until the end of the next counting period. Source impedance at pin 39 is nominally 250 K shunted by 100 $\mu\mu$f.

Pin 40 is the "inhibit reset" line. When this pin is grounded the counter cannot reset.

Pins 26, 30, (7350 only), 31, 32 and 38 are grounded. Pins 25, 27 and 28 are connected to the -35 volt supply. Pin 29 and pins 33 through 37 are not used.

TIME Jack. The output signal of the clock-pulse generator is available at this jack. The signal consists of positive pulses 2.0 volts in amplitude. The positive transients are accurately spaced at the interval indicated by TIME-SECONDS switch. These transients are recommended for external use as a clock signal. The negative transients occur at the same frequency but are not so accurately spaced. The output impedance is 330 ohms.

FREQ Jack. A sine-wave signal at the oscillator frequency is available at this jack when the EXT-INT switch is at INT. The signal is 10 volts peak-to-peak out of 3000 ohms. When the EXT-INT switch is at EXT., an external signal can be introduced at this jack to substitute for the oscillator signal as described under "Using an External Reference Frequency".

SCOPE Jack. This jack is connected thru 220 K to the suppressor grid circuit of the gate tube. The voltage at the jack is about -10 volts with respect to ground when the gate is open and about -40 volts when the gate is closed. If the waveform of a signal which generates start-stop pulses is displayed on an oscilloscope, the signal at the SCOPE jack (after suitable conversion) may be used to blank the scope during the period the gate is closed. The scope will then display the portion of the wave form whose duration is being measured.

3 Circuit description

NOTE:
It is intended that the reader refer frequently to relevant schematic diagrams while reading the material in this section. The Decimal counting Units are described in an appendix.

GATE & CONTROL CIRCUITRY

The Gate and control Circuitry receive three pulse inputs from the FUNCTION switch (S201): pulses to be counted, start pulses and stop pulses. Pulses to be counted go from Deck G to the signal grid of the Gate tube (V204). The plate of this tube is coupled to the first of the cascaded DCU's. During the period its suppressor grid is at ground the tube amplifies the grid signal and drives the DCU's. In this state the Gate is "open". When the suppressor grid is below -10 volts, the tube is cut off and the Gate may be considered "closed".

The "open-close" voltages on the Gate tube suppressor grid are generated at the right plate of the Control Binary (V203). V203 is a conventional "flip-flop" circuit. Such a circuit has two stable states: left half conducting, right half cut off; and right half conducting, left half cut off. Input pulses or transients applied at various points on the circuit will trigger it back and forth between the two states. When the right half of V203 is conducting, the right plate is 30 volts negative. A negative start transient from the Start Binary, applied at the left plate of V203 and coupled through C210 to the right grid, triggers V203 to its other stable state. In this state the right half is cut off and the right plate rises above ground permitting the Gate tube to conduct. When a negative stop pulse from Deck E of the FUNCTION switch reaches the left grid of V203 through the diode CR212, V203 is triggered back to the state which holds the Gate closed.

The Start Binary is also a "flip-flop" circuit. It produces a negative start transient at its right plate each time that half begins to conduct. Its left grid is coupled to Deck C of the FUNCTION switch through the diode CR211 and C201. When the left half is conducting a negative start pulse at the grid triggers a change to the other stable state producing the output transient. Further negative pulses at the left grid have no effect since that half is already cut off.

When the instrument is ready to begin a counting period the right half of the Control Binary and the left half of the Start Binary are conducting and the Gate is closed. Negative stop pulses received at the left grid of the Control Binary have no effect since this half is cut off. The following sequence occurs. (Refer to Figures 7 & 8).

Time (1) A start pulse passes through the injection diode CR211 and triggers the Start Binary which in turn triggers the Control Binary to a state which opens the Gate. The DCU's then count and indicate the number of pulses reaching the Gate.

Time (2) A stop pulse triggers the Control Binary to a state which closes the Gate.

At this point, if the instrument is set to operate automatically, the reset circuitry begins to function. The reset control voltage appears at the junction of CR201 and CR203. Its value is determined by the combined effect of the voltage on the right plate of the Start Binary and that on the right plate of the Gate Control Binary. At the close of a counting period (and only then) both these plates are negative. The resulting negative voltage at the junction is applied to the input grid of the Reset Control through R237 and R239.

This negative voltage biases the left-hand section of theReset Control tube (V205) to cut off, and the resultant rise in plate potential is coupled to the right-hand grid. Since the right-hand section of V205 operates as a cathode follower, the rise in potential at the grid produces a voltage rise at the cathode. This voltage rise, applied at the junction of resistor R248 and the DISPLAY potentiometer (R247), causes capacitor C216 to discharge through R247. As the capacitor discharges, the potential at the input grid (pin 7) of the Reset Generator (V206) rises.

The Reset Generator is a monostable multivibrator. In its stable state, the right-hand triode section is conducting while the left-hand section is cut off. When the potential on the left-hand grid becomes sufficiently positive, it triggers the Reset Generator to its quasi-stable state (i.e., left side conducting, right side cut off). This occurs at time (3), with the interval between time (2) and time (3) depending on the setting of the DISPLAY control (R247).

At time (3) then, the potential at the left-hand plate of the Reset Generator drops, while that at the right-hand plate goes up. The drop in voltage at the left-hand plate, coupled through capacitors C214 and C215 to the DCU reset lines, produces a negative pulse which resets the DCU's. This same reset pulse also triggers the Start Binary to its initial (left side on) state and makes sure the Control Binary is triggered to its "right side on" state. The rise in voltage at the right-hand plate of the Reset Generator is fed back to the input grid of the Reset Control tube and triggers it to its orignial state (i.e., left side on, right side off). This same voltage rise also puts a reverse bias on diode CR211 so that start pulses can not pass through to trigger the Start Binary.

The Reset Generator remains in its quasi-stable state for 15 milliseconds. At the end of that period, time (4), the Reset Generator jumps back to its stable state (right side on, left side off), and the voltage on the right-hand plate drops. This removes the reverse bias from diode CR211. The Reset Control, however, is not triggered at this time because when the Start Binary is reset, the potential on its right-hand plate goes up and the reset control line is clamped to this higher potential by diode CR201. Thus, the 15 millisecond delay provided by the Reset Generator keeps any start pulses from triggering the Start Binary, to initiate counting, until all reset transients have decayed.

The next start pulse triggers the Start Binary to its "right side on" state which, in turn, triggers the Control Binary to its "left side on" state. To prevent reset action at this time, diode CR203 clamps the reset control line to the relatively high positive potential at the right-hand plate of the Control Binary. The next stop pulse triggers the Control Binary to its "right side on" state, the potential at the right-hand plate drops, and the entire reset process is repeated.

NOTE: When the counter operates with a Berkeley Digital Recorder, the operating cycle is briefly delayed at the end of the counting period (time (2)) until the recorder has received all of the count information from the DCU's (see Figure 9). This delay is produced by a relay in the recorder which grounds the input to the DISPLAY potentiometer (R247) through pin 40 of J202 for the required interval.

When the DISPLAY control is turned fully clockwise into its infinity position, the input connection to R247 is broken by switch S204 and automatic reset will not occur. Consequently, the DCU's will hold the registered count until the RESET button is pressed. When this is done, the contacts of switch S205 are shorted, and a positive pulse is applied to the left-hand grid of the Reset Generator. This positive pulse triggers theReset Generator, and causes it to produce a reset signal just as in automatic operation.

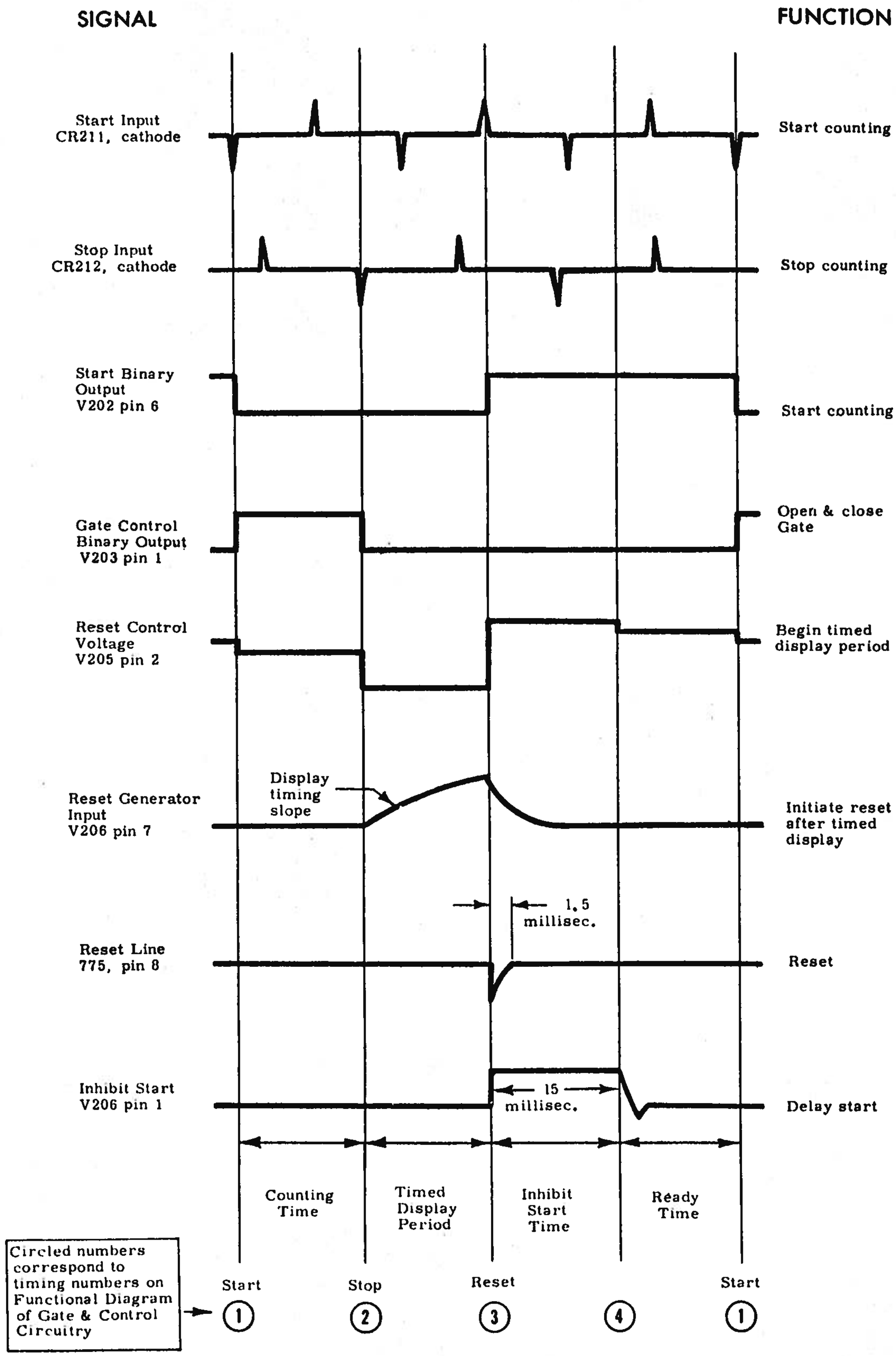
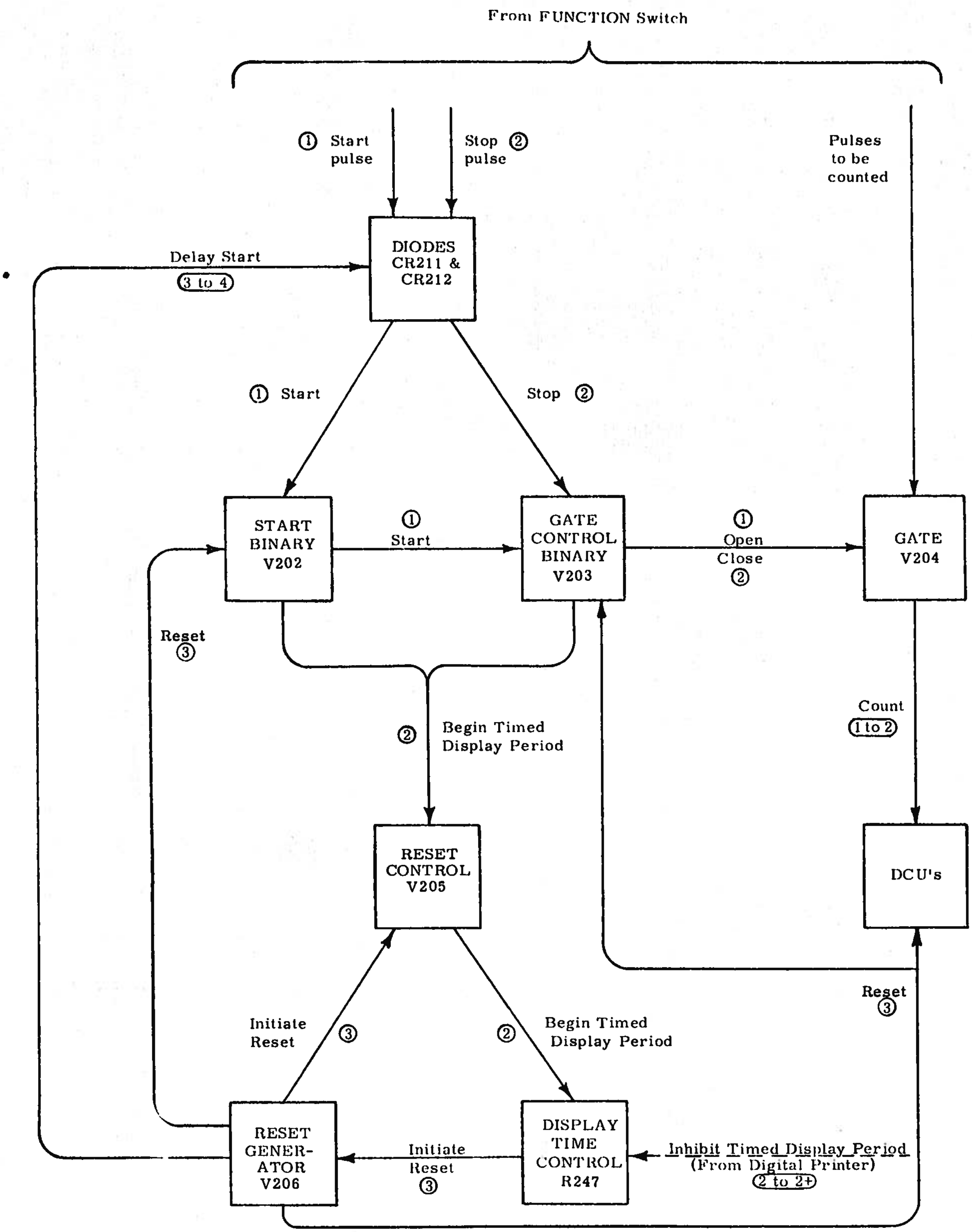


Figure 7 Control Circuit Timing Diagram

WHEN COUNTER IS NOT EQUIPPED WITH DIGITAL PRINTER



NOTE: Circled numbers indicate time of operation as labeled on the Timing Diagrams.

Figure 8 Functional Diagram of Gate and Control Circuitry

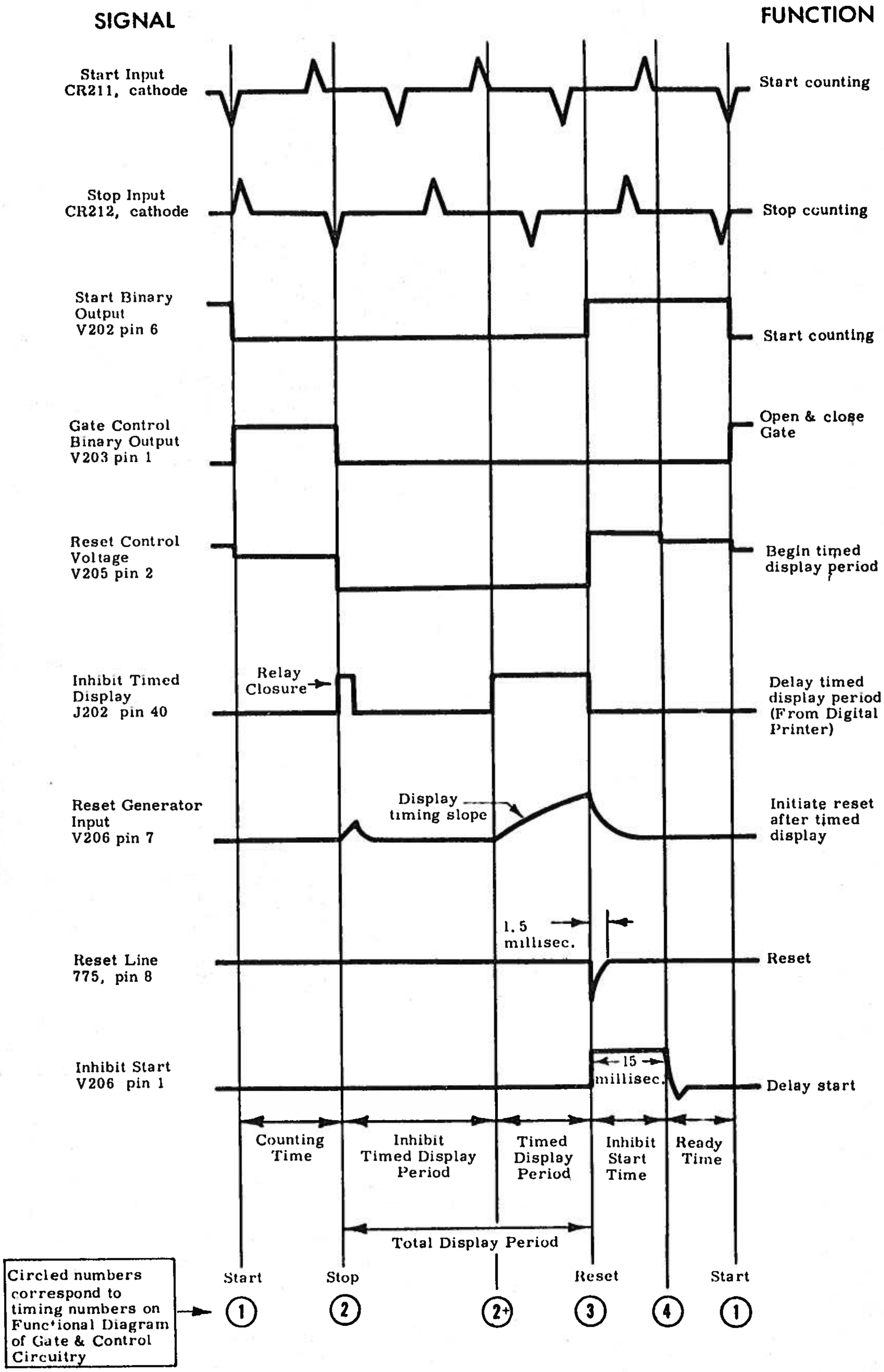


Figure 9 Control Circuit Timing Diagram

WHEN COUNTER IS EQUIPPED WITH DIGITAL PRINTER

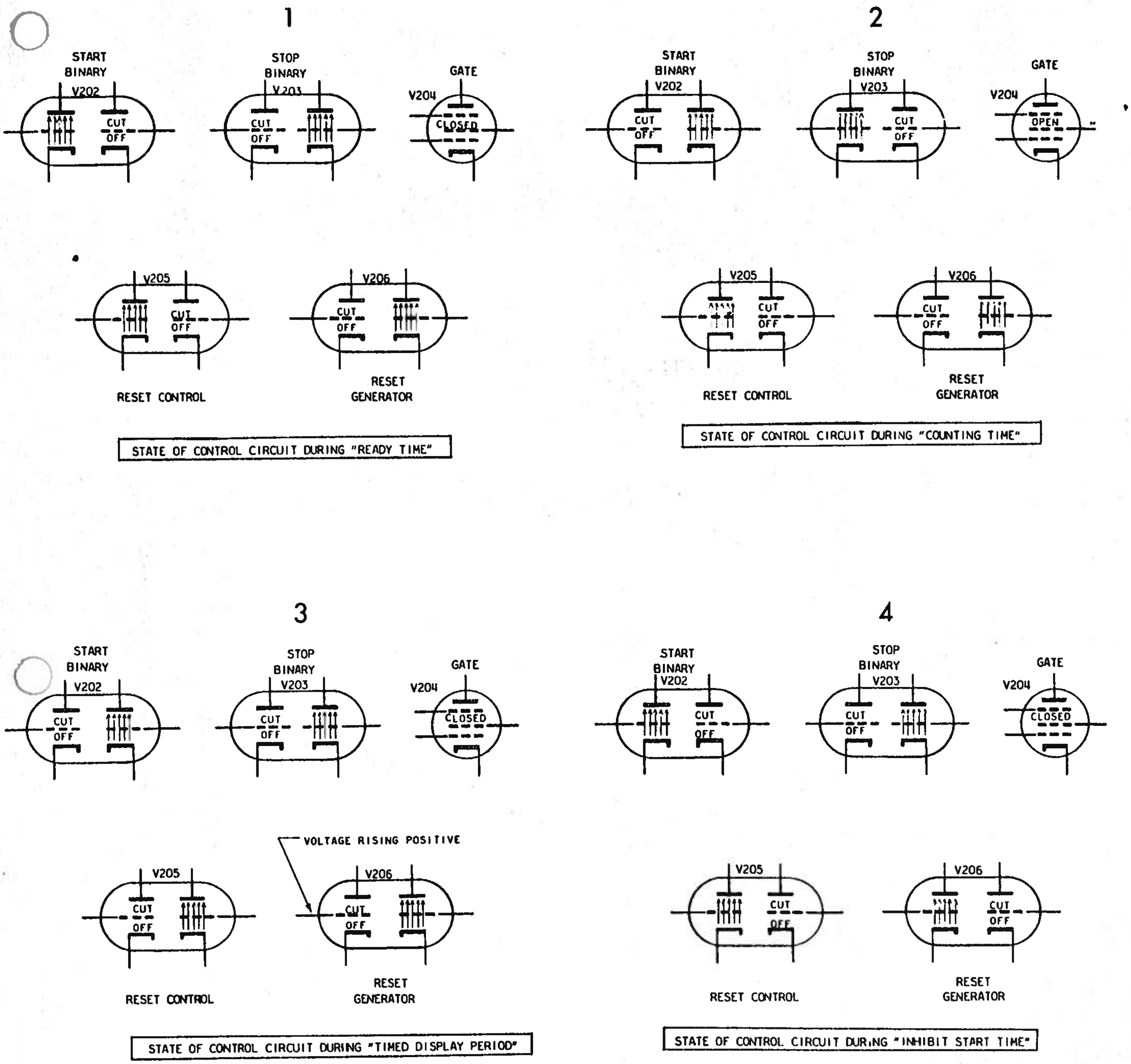


Figure 10 Tube States During the Operating Cycle

INPUT TRIGGER CHANNEL

The input trigger channel produces an output pulse each time the attenuated input signal passes a selected voltage level. The output is independent of input waveform. The channel consists of a Schmitt trigger voltage discriminator preceded by a two stage comparator amplifier. The input channel is preceded by an attenuator, which divides the input voltage by 1, 10 or 100 according to the position of the ATTENUATION control. The input impedance at all positions is about 10 megohms in parallel with 40 μμf. When the ATTENUATION control is at an AC position a .01 μf capacitor (C301) is inserted in series between the INPUT jack and the attenuator. The comparator amplifier has two stages. The first is a difference amplifier whose output is proportional to the input voltage on the grid of V301A minus a selected constant voltage on the grid of V301B. The TRIGGER VOLTAGE potentiometer (R318) varies the voltage on the grid of V301B between -1 and +1 volts. The second stage (V302) amplifies the double-ended signal received from V301 and converts it to a single-ended low impedance output at the left hand plate. This plate is connected to the input grid of the discriminator. The voltage discriminator (V303) produces an output pulse each time the input voltage on its left-hand grid passes through a fixed voltage level (about +60 volts). Consider the input to this circuit as an a-c triggering signal superimposed on a d-c level. The a-c signal is an amplified reproduction of the voltage variations on the grid of V301A, that is, the attenuated input. The d-c level is determined by the voltage on the grid of V301B, a voltage set by the TRIGGER VOLTAGE potentiometer. As the TRIGGER VOLTAGE control is rotated toward "+", the d-c level is lowered and the discriminator triggers at a higher instantaneous voltage of the a-c signal and at a higher attenuated input voltage to the channel. When the TRIGGER VOLTAGE control is turned toward "-", the channel triggers at a lower attenuated input voltage.

The discriminator (V303) is a two stage positive feedback amplifier. Feedback from the output stage occurs through the cathode coupling. The loop gain is slightly greater than one so that the circuit is regenerative and tends to assume one of two stable states. The output stage draws a steady current as long as the input grid remains below a certain triggering voltage. When the input exceeds this voltage the output tube is suddenly cut off. When the input voltage returns to a value slightly below the initial triggering voltage the output stage builds rapidly to its original steady current.

The difference between the level at which a positive-going voltage change triggers the circuit and the lower level at which a negative-going voltage change re-triggers it is called the hysteresis of the circuit. At the input to the comparator amplifier the hysteresis is about 0.3 volts. The hysteresis determines the input sensitivity. An attenuated input signal weaker than 0.3 volts peak-to-peak or about 0.1 volts rms will not trigger a series of pulses. This means that any noise at the attenuated input below this level will not trigger extraneous pulses, although it may affect the time at which a pulse occurs.

The primary winding of T301, differentiates the rapid current changes in the output stage to produce a positive pulse at the plate when the circuit is triggered by a positive-going voltage and a negative pulse when triggered by a negative-going voltage. The secondary of T301 produces inverted pulses -- a negative pulse when the circuit is triggered on a positive slope and a positive pulse when triggered on a negative slope.

DCU DIVIDER

Deck A of the FUNCTION switch (S201A) selects the signal which is divided by the DCU Divider (A201). During all operations other than "times ten" (x10) operations the output of DCU A202 is coupled to the input of this divider and it functions as the last in the chain, raising the maximum count indication to 9, 999, 999 on the Model 7360 or to 999, 999 on the Model 7350. During "times ten" operations the source of "start-stop" pulses is coupled to this divider through a two stage amplifier (V207), and the output of the divider becomes the "start-stop" input to the Control Circuitry. Since it produces an output pulse at every tenth input pulse, the time interval during which pulses are counted is ten times as large as it would be if the source of "start-stop" pulses drove the Control Circuitry directly. This DCU will not divide a frequency above 100 KC because its pulse resolution time is about 10 μseconds.

When the divider is part of the counting chain, Deck B of the FUNCTION switch (S201B) couples the reset pulse to pin 8 of the DCU Plug so that it resets to zero. During "times ten" operations Deck F of the FUNCTION switch connects pin 10 to -15 volts to extinguish the DCU indicator lamps and Deck D couples the reset pulse to pin 3 causing the divider to reset to nine. This is done so that the counting period will begin with the first input pulse rather than the tenth, thus eliminating an unnecessary delay.

CLOCK-PULSE GENERATOR

The Clock Pulse Generator provides:

1. Pulses of a known frequency which are counted between start and stop pulses to make time measurements.
2. Start and stop pulses separated by a known time interval over which events are counted to make events-per-unit-time measurements.

The circuitry consists of an oscillator, a pulse shaping circuit, a series of multivibrator frequency dividers, and an output trigger circuit. The shaper stage transforms the sinusoidal output of the oscillator into appropriate pulses. Each of the dividers divides the preceding frequency by ten. Decade frequencies from the shaper and the various dividers are selected by the TIME switch, shaped by the output trigger circuit (the Time Pulse Trigger) and applied to the FUNCTION switch, where they are available for start, stop or [pul]ses to be counted.

OSCILLATOR

The oscillator circuit consists of two sections: a crystal controlled oscillator stage (V401A), followed by a buffer amplifier (V401B). The oscillator stage uses either a 1 megacycle or 100 kc, oven-controlled crystal (for Model 8360 or 8350 respectively). It is adjusted with the temperature stable capacitor, C410, which can shift the frequency of oscillation by a few cycles per second. Capacitor C404 has the nominal value given on the schematic diagram, but is selected at the factory to allow capacitor C410 to adjust the oscillator to the correct frequency.

The output of the oscillator stage drives the buffer amplifier, a pentode with a tuned circuit plate load. A portion of the output from the buffer amplifier is fed back to the oscillator stage to increase the amplitude stability of the signal.

SHAPER

The shaper stage (V402) amplifies and shapes the oscillator output for use as an input to the control circuitry and the dividers. The circuit is a voltage discriminator which operates in the same way as that discussed under "Input Trigger Channels". The trigger voltage level is set by adjusting R414. L402 differentiates the rapid current changes at the output plate to produce fast positive and negative pulses. The negative transients drive the first divider and the pulse output goes to the TIME SECONDS switch (where it may be selected to drive the Time Pulse Trigger). The output also goes directly to the FUNCTION switch where it provides pulses to be counted during TEST operation and the start pulse for COUNT operation.

DIVIDERS

The divider chain is a series of cascaded monostable multivibrators. Each produces one output pulse for every ten input pulses. The Model 7350 has five dividers which scale its 100 kc oscillator frequency down to 1 cps. The Model 7360 has an additional divider preceding the last five which scales its 1 mc oscillator frequency down to 100 kc. Although the 1 mc divider (V608) has additional circuitry to provide for high speed operation, it functions in essentially the same way as the others. The circuit operation will therefore be described with reference to V603.

With no input the circuit is stable; the right-hand side is conducting because its grid is connected to +120 VDC and the left-hand side is cut off. A negative transient reaching the input capacitor (C605) is coupled through R617 and R618 to each of the two plates. The negative pulse produced on the left plate is coupled by C609 to the right grid. It appears as an amplified positive pulse at the right plate, which is coupled to the left grid through C607. The left-hand side of the tube conducts, driving the left plate and the right grid even further negative. This regenerative action produces a quasi-stable state in which the right side is cut-off and the left side is conducting. In this state the voltage on the right grid (called the "timing grid") is rising relatively slowly as the voltage at the wiper of potentiometer R656 charges the timing capacitor (C609) through R645. At the same time negative input pulses at the right plate reach the left grid through C607 and appear as large positive pulses at the left plate. These pulses reach the timing grid through C609 and appear superimposed on the rising voltage curve there. (See Figure 11). When one of the positive pulses brings the timing grid above cut-off, the right side conducts and a reverse regenerative action returns the circuit to its original stable state. The slope of the rising grid voltage curve determines which of the successive positive pulses will rise above cutoff. The slope changes when the charging voltage at the wiper of R656 is raised or lowered. R656 is adjusted so that the ninth pulse rises above cut-off. The tenth pulse returns the circuit to the quasi-stable state.

In the interval between the ninth and tenth pulses the right side is conducting and the right plate is negative. The negative transient produced is the useful output of the divider. It drives the next divider stage and also goes to the TIME SECONDS switch where it is available as a clock signal.

The additional circuitry associated with the 1 MC divider (V608) speeds up its response. V608 is a multivibrator which operates just as V603. V607B is a cathode follower inserted between left plate of the multivibrator and the timing grid. Its function is to discharge C628, the timing capacitor, within the brief 1 microsecond output pulse period so that the capacitor will pass the next positive pulse to the grid. V607A functions as a diode clamp on the left grid of the multivibrator. It prevents this grid from going so far negative during the 1 microsecond pulse output period that it will not rise above cutoff when the next positive pulse reaches it.

TIME PULSE TRIGGER

The TIME switch selects a negative output transient from one of the divider stages and feeds it to the Time Pulse Trigger (V601). The Time Pulse Trigger is a voltage discriminator which operates in the same way as that described under "Input Trigger Channels". Output clock pulses produced at L601 are coupled to the FUNCTION switch.

POWER SUPPLY

A conventional circuit consisting of a transformer, two selenium bridge rectifiers and a filter network produces the +200 and -110 volt unregulated supply. Ripple on these supplies is about 10%.

The regulated +120 volt supply is obtained by dropping 190 volts through V102. The voltage drop across V102 is controlled by V101 in such a way as to maintain a constant voltage at the regulated output. A voltage dividing network (R106, R107 R113, R116) is connected between the regulated supply and a point held 60 volts negative of ground by a diode (CR106). The control grid of V101 is connected to a point on this network which is slightly below ground when the regulated supply is 120 volts. When the regulated supply varies from 120 volts, the voltage on the control grid varies proportionately and V101 delivers a signal to V102 which opposes the change.

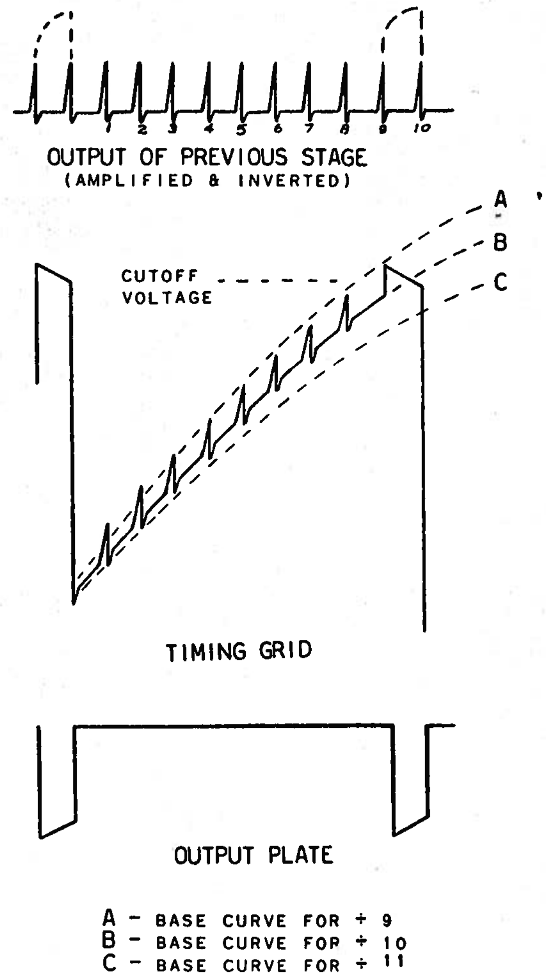
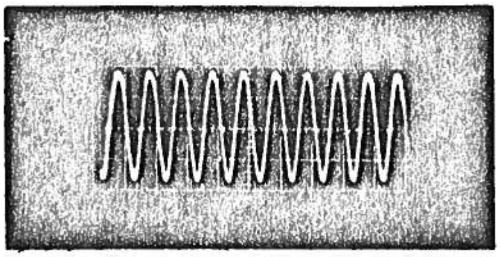
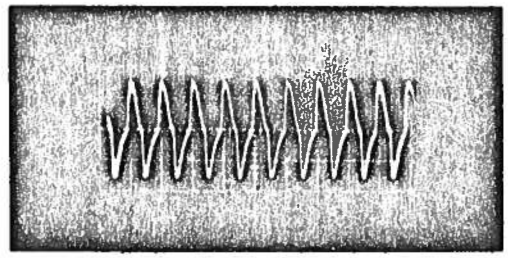


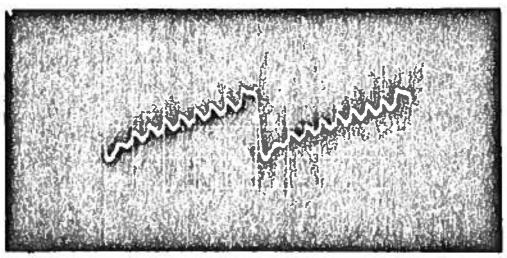
Figure 11 Divider Stage Waveforms



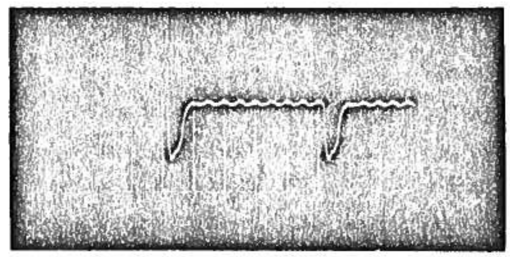
1 MC Oscillator output (V401, pin 6).
Vert. scale: 5v./div.
Horiz. scale: 1μs/div.



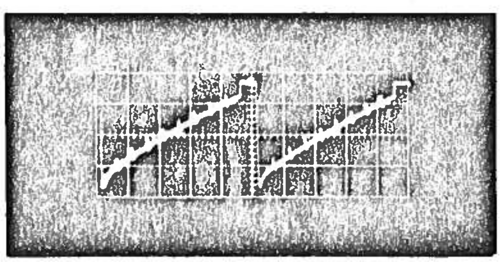
Shaper output (V402, pin 1).
Vert. scale: 5v./div.
Horiz. scale: 1μs/div.



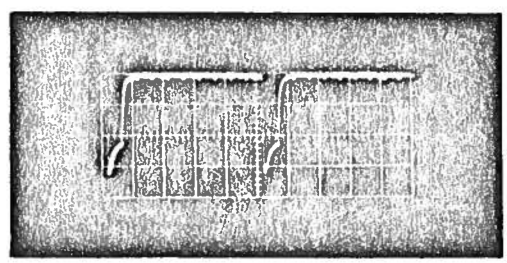
1 MC Divider, timing grid (V608, pin 2).
Vert. scale: 10v./div.
Horiz. scale: 2μs/div.



1 MC Divider output (junction of R666 and R668).
Vert. scale: 10v./div.
Horiz. scale: 2μs/div.

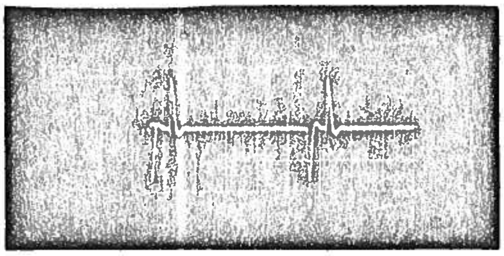


100 KC Divider, timing grid (V602, pin 7).
Vert. scale: 10v./div.
Horiz. scale: 20μs/div.

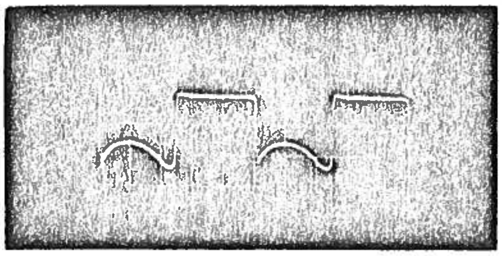


100 KC Divider output (V602, pin 6).
Vert. scale: 20v./div.
Horiz. scale: 20μs/div.

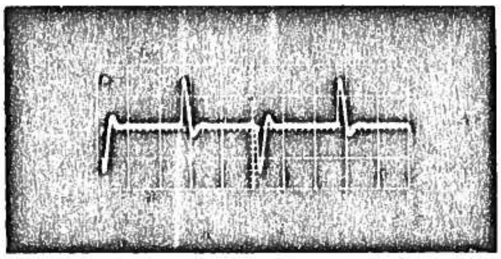
Figure 12a Typical Waveforms



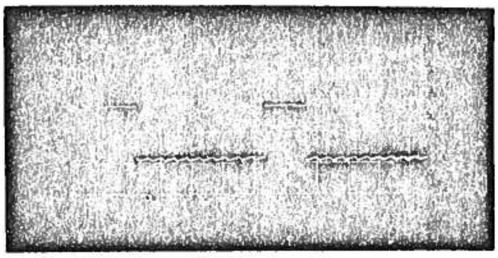
Time Pulse Trigger, 100 KC output (V601, pin 1).
Vert. scale: 5v./div.
Horiz. scale: $2\mu s$/div.



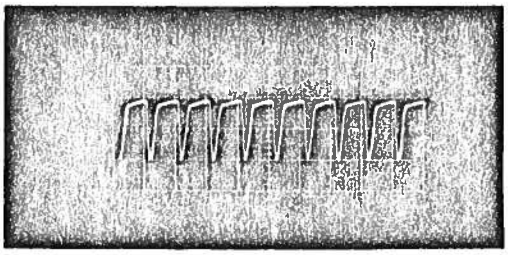
Discriminator Amplifier plate (V303, pin 6); with 100 KC input signal.
Vert. scale: 5v./div.
Horiz. scale: $2\mu s$/div.



Discriminator output (V303, pin 1); with 100 KC input signal.
Vert. scale: 5v./div.
Horiz. scale: $2\mu s$/div.

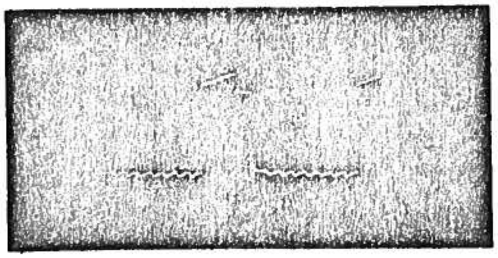


Start Binary output (V202, pin 6) with FUNCTION switch at TEST, TIME switch at "10^{-2}". (Upper level of waveform is at -11 volts).
Vert. scale: 20v./div.
Horiz. scale: 20ms/div.



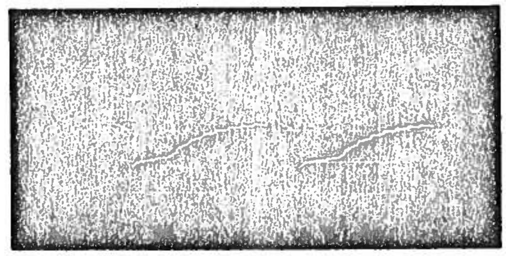
Signal Gate output (V204, pin 5); with 1 MC input signal.
Vert. scale: 5v./div.
Horiz. scale: $1\mu s$/div.

Figure 12b Typical Waveforms



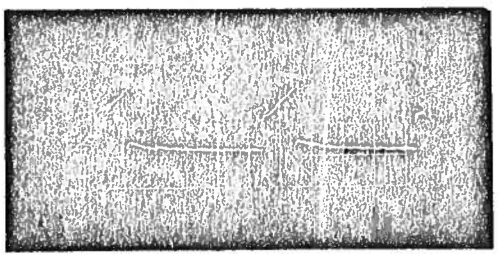
Reset Control input (junction of R236 and R239) or print command (J202, pin 39); with FUNCTION switch at TEST, TIME switch at "10^{-2}", and minimum display time.

Vert. scale: 10v./div.
Horiz. scale: 20ms/div.



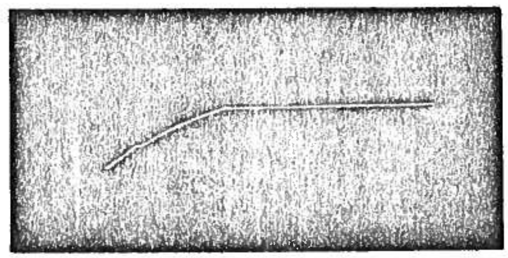
Reset Generator input (V206, pin 7); with FUNCTION switch at TEST, TIME switch at "10^{-2}", and minimum display time.

Vert. scale: 20v./div.
Horiz. scale: 20ms/div.



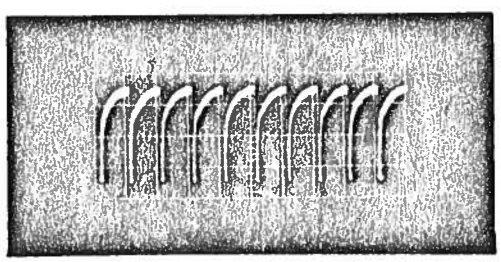
Reset Generator output (V206, pin 1); with FUNCTION switch at TEST, TIME switch at "10^{-2}", and minimum display time.

Vert. scale: 50v./div.
Horiz. scale: 20ms/div.



Reset pulse (junction of C215 and CR205); 5 μs rise time.

Vert. scale: 50v./div.
Horiz. scale: 500μs/div.



DCU Divider Drive output (V207, pin 6); with FUNCTION switch at E/UT X 10, TIME switch at "10^{-5}".

Vert. scale: 50v./div.
Horiz. scale: 10μs/div.

Figure 12c Typical Waveforms

4 Maintenance

ROUTINE ADJUSTMENTS

OSCILLATOR

The frequency of oscillation can be adjusted by a small amount with the XTAL ADJ control at the top of the chassis. To make this adjustment, rotate the control until the oscillator output signal (which appears at the FREQ jack) produces a zero beat with a signal from WWV or some other highly accurate frequency standard. The Beckman/Berkeley Model 905 Receiver, which operates at any of the six standard WWV frequencies, is especially useful for this purpose.

NOTE

Whenever the oscillator crystal is replaced, it may be necessary to change capacitor C404 so that the frequency of oscillation can be adjusted to the correct value.

SHAPER

The shaper stage in the clock-pulse generator is a voltage discriminator similar to those in the Input Trigger Channels. The SHAPER LEVEL control, located on the top side of the counter chassis, sets the trigger voltage at the input to this circuit. To adjust, set the FUNCTION switch at TEST. Find the limits of the range of adjustment in which the instrument continues to count. Set the control at the center of this range.

NOTE

On the Model 7360, this adjustment should be checked at both the 10^{-6} and 10^{-5} settings of the TIME-SECONDS selector.

DIVIDERS

If the instrument fails to indicate correctly with the FUNCTION switch at TEST, one or more dividers may be out of adjustment. Some Model 7360 instruments may read "9" with the TIME switch at 10^{-5} and "99" with the switch at 10^{-4}. These readings are correct provided the unit reads "999,999" or "1,000,000" at the 1 second position. Dividers should be adjusted using the potentiometer controls located under the cabinet lid and labeled "ADJ 1 SEC; ADJ 10^{-1} SEC;" etc. To adjust, place the FUNCTION switch at TEST, then follow the procedure for the model you are servicing.

Adjustment procedure for Model 7350.

1. Turn TIME switch to 10^{-4} and measure the d-c voltage between test point E4 and ground. Rotate the ADJ 10^{-4} SEC control to the extremes of the range in which reading of 10 appears on the DCU's, noting the test point voltage at each extreme. Then adjust the control until the test point voltage is midway between the extreme values.
2. Turn TIME switch to 10^{-3}. Measure voltage at E3. Rotate ADJ 10^{-3} SEC control to extremes of range which reads "100", noting test points voltages at extremes. Adjust control until voltage is halfway between extremes.
3. With TIME switch at 10^{-2}, set ADJ 10^{-2} SEC control similarly but to center of voltage range in which either 1000 or 999 appears.
4. Adjust the remaining controls in order to the center of the 10,000 or 9,999 range, and the 100,000 or 99,999 range.

Adjustment procedure for Model 7360.

1. Turn TIME switch to 10^{-5} and measure the d-c voltage between test point E5 and ground. Rotate the ADJ 10^{-5} SEC control to the extremes of the range in which a reading of 10 appears on the DCU's noting the test point voltage at each extreme. Then adjust the control until the test point voltage is midway between the extreme values.

With TIME switch at 10^{-4}, rotate the ADJ 10^{-4} SEC control to the center of the range in which either 99 or 100 appears.

3. With TIME switch at 10^{-3}, rotate the ADJ 10^{-3} SEC control to the center of the range in which 999 or 1000 appears.

4. If neither of these readings can be obtained, return the TIME switch to 10^{-5} and re-adjust the ADJ 10^{-5} SEC control to the center of the range in which 9 (rather than 10) appears. Then, repeat steps 2 and 3 above.

5. With TIME switch at 10^{-3}, adjust all three controls (10^{-5}, 10^{-4} & 10^{-3}) to the center of the range in which either 999 or 1000 appears.

6. Adjust the remaining controls in order to the center of the 10,000 or 9,999 range, the 100,000 or 99,999 range and the 1,000,000 or 999,999 range.

The adjustment of each divider affects the adjustment of the others slightly. Therefore, after the initial adjustment outlined above, a final adjustment should be made. With the FUNCTION switch at TEST, set the TIME switch to 10^{-1}.

On the Model 7360, a reading of 100,000 or 99,999 will appear. Adjust in turn ADJ 10^{-5} SEC thru ADJ 10^{-1} SEC to the center of the corresponding test point voltage range within which either of these readings appears. Then, set the TIME switch at 1 and rotate ADJ 1 SEC to the center of the voltage range at E0 within which either 1,000,000 or 999,999 appears.

On the Model 7350, a reading of 10,000 or 9,999 will appear. Adjust in turn ADJ 10^{-4} SEC thru ADJ 10^{-1} SEC to the center of the corresponding test point voltage range within which either of these readings appears. Then move the TIME switch to 1 and rotate ADJ 1 SEC to the center of the voltage range at E0 within which either 100,000 or 99,999 appears.

REGULATED 120 VOLT SUPPLY

With an accurate voltmeter, measure the supply voltage at the test point labeled "+120" (located at the top of the chassis). If necessary, adjust the +120V ADJUST control, located on the rear panel of the instrument, for a reading of 120 volts.

TIME PULSE TRIGGER

The Time Pulse Trigger (V601) is a Schmitt trigger circuit. The TIME TRIGGER LEVEL control varies the instantaneous voltage at which an input signal triggers the circuit from one state to another. Whenever the tube is replaced, adjust the control until, with no input signal, the potential on the input grid (Pin 2) is -1 volts with respect to the cathode (pin 7). Check TEST operation under two conditions: (1) line power reduced to 105 volts and TIME switch at 1 second (2) normal line voltage and TIME switch at 10^{-6} seconds. An incorrect adjustment will cause either a reading of 100,000 rather than 1,000,000 at the 1 second position or no reading instead of "1" on the 10^{-6} seconds position. If necessary, re-adjust the control until correct readings are obtained under both conditions.

ATTENUATOR ADJUSTMENTS

The ceramic trimmer capacitors on the attenuator assembly must be adjusted properly to prevent the attenuator from distorting the input signal. When the counter chassis is upside down and the attenuator shaft is pointing at the viewer, the capacitor on the right side of the attenuator is C303 and that on the left C302. To adjust, apply a 500 cps square wave signal to the front panel INPUT jack. Observe the corresponding amplifier output at Pin 1 of V302 with a 100KC band-width oscilloscope. Turn the attenuator to 10 on the AC side. Adjust the input signal to about 1 volt peak-to-peak. Adjust the TRIGGER VOLTAGE control to any position in which the channel triggers. Adjust C303 for a square wave output. Then, turn the attenuation control to 100 on the AC side and adjust the input signal to about 10 volts peak-to-peak. Adjust C302 for a square wave output.

The following test equipment is necessary to service the instrument effectively:

1. An oscilloscope, sensitivity 1/4 volt, bandwidth 5 MC, preferably direct coupled.

2. A signal generator, frequency range 100 cps to 1 MC, output at least 100 mv rms.

3. A vacuum tube voltmeter.

When the instrument fails to perform properly, first make sure that it is being operated correctly. Some common errors in operation are:

1. TRIGGER VOLTAGE control positioned incorrectly.

2. ATTENUATION control set incorrectly.

   (a) Wrong choice of AC or DC coupling.

   (b) Attenuated signal too strong or too weak.

3. SLOPE switches set incorrectly. (See "PERFORMING SPECIFIC OPERATIONS" for correct setting for each operation.)

4. Input signal coupled to wrong jack.

5. FUNCTION switch set at "times ten" position when original start-stop frequency is above 100 KC. For example:

   (a) FUNCTION switch at E/UT x 10 and TIME switch at 10^{-6}.

   (b) FUNCTION switch at A/B x 10 when B frequency is above 100 KC.

6. Wrong TIME switch setting.

   (a) Unit of time measurement too large to measure a brief period under PERIOD operation.

   (b) Time interval too short to measure a low frequency under events-per-unit-time operation.

7. Too much noise on input signal.

When it is certain the instrument is functioning improperly, first check the power supply voltages to see that they lie within the limits listed below.

Supply	Limits of average level	Acceptable ripple
Unreg. pos.	200V ±10%	20V peak-to-peak
Unreg. neg.	-110V ±10%	11V peak-to-peak
Reg. pos.	+120V to accuracy of adjustment	0.1V peak-to-peak
Reg. neg.	-55V to -65V	0.5V peak-to-peak

If the supply voltages are adequate, the next step is to trace the failure to one of the major components. This can be done by observing the start, stop and count pulses at Decks C, E & G respectively of the FUNCTION switch. If the signals at these points approximate the proper output waveforms of the pulse sources the trouble lies in the Gate and Control Circuitry or the indicating DCU's. Refer to the master schematic diagram to determine the source of pulses when the FUNCTION switch is in a particular position. If a deficient pulse is found, the trouble lies in that pulse source.

When the trouble has been traced to one of the major components, consult the Circuit Description section of this manual and the waveforms of Figure 12 for guidance in locating the specific fault. The Input Trigger Channels may be conveniently checked by observing whether or not a pulse is produced as the TRIGGER VOLTAGE control is rotated from one extreme to the other and back.

Tubes, chokes, germanium diodes and pulse transformers are the most common sources of trouble. A transconductance tube tester will not always detect a faulty tube and, conversely, the tester may reject a tube which is functioning properly. Although the circuits are designed for wide tube variation, avoid swapping tubes or wholesale replacement. An aged tube is generally more reliable than a new tube, because catastropic failure usually occurs early in the life of a tube if at all. An aged tube undergoes only a gradual loss of transconductance, emission, etc.

The Sylvania 6U8 tube is recommended for use in trigger circuits V402, V601 and V303. (There are two V303 stages -- one in each input trigger channel.)

PREVENTIVE MAINTENANCE

Since a tube tester will not detect tubes which are likely to cause trouble and it is undesirable to replace tubes wholesale as they grow old, other methods must be used to forestall failures. The most effective method is "marginal checking". In its simplest form this consists in causing intermittent or latent failures to manifest themselves by operating the instrument at exceptionally high or low line voltages. A variable auto-transformer may be used to manipulate the line voltage.

Supplementary Service Notes, SSN7000

Introduction. These notes cover recommended methods of servicing any instrument in the BECKMAN/Berkeley 7000 Series. This includes Models 7050, 7060, 7150, 7160, 7250, 7360, and the counter portion of Model 5571. Some of these instruments do not contain all the major components treated below (for example, Models 7250 and 7260 do not contain a frequency dividing chain); therefore, ignore inapplicable references.

Training and Experience Required. Any person who knows basic electronics and has used a scope and vacuum-tube voltmeter should not hesitate to undertake the repair of a Beckman counting instrument. Short of actual factory training, reading the instruction manual is the best way to familiarize oneself with the instrument. A detailed study of the schematics will yield additional knowledge, and, studied along with an actual instrument removed from the cabinet, will familiarize one with the layout of the components. Strive to keep the block diagram in mind, the details will fall in place as experience is gained.

Checking Instrument Upon Receipt. Occasionally, upon receipt by a customer, an instrument will fail to operate properly. This may be due to rough handling or vibration that has taken place in shipment. The cause of the trouble most often will be a loose tube or perhaps some other loose plug-in component, such as a DCU or a crystal. In some cases a time base divider may require re-alignment, but rarely is more than one divider out of adjustment. Refer to the manual for proper alignment procedure, and be sure to use an auto-transformer on the 117-volt input line in order to test the alignment over any expected line swing within the specified variation of ±10 per cent. Check to see that the switch on the cooling fan is turned on. At the same time make sure the INT-EXT switch on the oscillator sub-chassis is in the INT position. If the pilot light fails to come on when the POWER switch is thrown, there is probably a loose or broken line fuse. These fuses are located on the rear of the chassis.

Routine Care of Instrument. As time goes on, dust and grit may accumulate inside the chassis. This should be removed with an air hose and brush to prevent deterioration of components. Remove the tubes and clean the tops of the sockets with a rag. Make sure that the cooling fan rotates at normal speed.

HOW TO TRACE A FAULT TO A MAJOR COMPONENT

Examining Operating Characteristics. Refer to the schematic diagram of the gate and control circuitry. You will notice that the complete instrument, excluding the power supply, is shown on this page either in detailed schematic form or block diagram. It is your best overall look at the instrument and with reference to this diagram you can trace the signal and pulse paths through the function switch to their destinations. Understanding this diagram is the key to the isolation of troubles in the entire instrument. Notice that the input trigger channels, the oscillator and the frequency dividing chain all feed pulses to the FUNCTION switch, but that at some positions of the FUNCTION switch not all the pulse sources are coupled to succeeding circuits. Since some major components are not used while performing certain operations, a fault may often be localized by observing which functions fail. For example, no pulses from an input trigger channel are used during the TEST operation; therefore, one may reasonably suppose an input channel is at fault if the instrument operates all right at TEST, but does not operate with an input signal. To take another example, the frequency dividing chain has no part in the COUNT operation, so if the instrument performs this function successfully when other functions fail, one may suspect the dividing chain.

Signal Substitution Using Another 7000 Series Instrument. Another 7000 Series instrument in good operating condition is a great help in localizing trouble. Make up a couple of patchcords, three or four feet in length, and having the BNC type connectors on both ends. These will serve to conduct pulses from one unit to another. On the rear lip of the chassis you will find two connectors, one labeled TIME and the other FREQ. The clock pulses from the frequency dividers are available at the TIME jack, and the oscillator frequency is present at the FREQ jack.

If you suspect incorrectly timed clock pulses in a faulty instrument, their accuracy can be checked by introducing the clock pulses from a good instrument into the B channel of the defective instrument and obtaining a readout in the PER function. Make this test with several combinations of the TIME-SECONDS switch on both instruments. Have both SLOPE switches the same polarity. Be sure that the oscillator of the good instrument has been carefully set to the correct frequency before attempting this type of test.

Another test is to patch the oscillator output from the good unit into the FREQ jack of the faulty one and throw the INT-EXT switch, located on the oscillator sub-chassis, to the EXT position, thus bypassing the oscillator of the defective instrument. Don't overlook the possibility of counting the clock pulses from a good instrument as a check on the accuracy of the E/UT function of a suspected instrument.

Observing Pulses at the FUNCTION Switch. The FUNCTION switch consists of four wafers. With one exception, there are contacts on both sides of each wafer. The contacts on each side make up one section, and each section is identified on the schematic diagram of the gate and control circuitry by a letter from A to G. Section A is the rear side of the wafer nearest the front panel (the forward side of this wafer is not used). The forward side of the second wafer is section B; the rear side, section C, and so on. A scope probe may be conveniently placed on the wiper contacts of sections C, E and G in order to observe "start", "stop" and "count" pulses respectively. These pulses originate in one or another of the major components depending upon the position of the FUNCTION switch. By rotating the switch to various positions, one may observe the output of an input channel, the oscillator-shaper, and (in conjunction with the TIME switch) the output of any frequency divider.

INPUT TRIGGER CHANNELS

Referring to the schematic, notice that the internal test signal does not pass through an input trigger channel, so, given a correct reading at TEST, it is a good bet that the trouble lies here. There are only three tubes in an input channel and the entire channel is contained on one sub-chassis. Thus troubleshooting is confined to a small amplifier-shaper section of the circuitry.

No one can state as a general rule where the trouble will be found in an input channel. The most likely cause of trouble is a defective tube and substitution should be tried. Then, of course, find out if the correct supply voltages are present. It is always wise to check supply voltages before doing any trouble-shooting, but remember if we found a correct TEST reading, we can assume that the supply voltages are correct for most of the circuitry. Ordinary signal tracing, using the scope, may be employed on an input channel and typical voltages listed on the diagram may be verified with a vacuum-tube voltmeter. Don't overlook comparison of waveforms with those of a similar instrument that you may have in your possession, but remember that the attenuator and trigger voltage controls should be in identical positions on both instruments. Turn off the power to the faulty instrument and take resistance measurements, perhaps the defective component will show up by this method. At any rate one of the above methods should yield results and the time required for the repair will depend on the skill of the technician and his familiarity with the instrument.

OSCILLATOR-SHAPER

The oscillator is the heartbeat of a 7000 series instrument; without it, operation ceases, except for the A/B function which is independent of the oscillator. Therefore, one of the first things to investigate, after noting a complete failure to count in the TEST position, is the oscillator.

Look at the oscillator sub-chassis to be sure that the INT-EXT switch has not been accidentally thrown to the EXT position. Put the scope probe on pin 2 of V402, (or on the FREQ jack on the rear of the instrument): the oscillator output waveform should appear, a distorted sine wave in the range of 10 to 16 volts peak-to-peak. A value of about 12 volts is normal, but the instruments will operate correctly over at least the range noted above. If this waveform is not present, adjust C410, marked "XTAL ADJ" on the chassis. (Upon completion of the repair, don't forget to reset this control so that the oscillator frequency will be precise.) If a spare crystal is available it should be tried as a substitute but with a new crystal the value of C404 may need to be changed as suggested in the manual. Remaining components and wiring can be checked with an ohmmeter.

Located on the same sub-chassis as the oscillator is the shaper circuitry. This section amplifies and shapes the signal generated by the oscillator. If the proper oscillator signal was found to be present when checked with a scope at pin 2 of V402, the oscillator is not at fault and trouble may be found in the shaper. Place the scope probe on pin 1 of V402; a waveform should appear, with a peak-to-peak value of from 12 to 20 volts. The appearance of this waveform will differ in the 100kc and 1mc models, and will also depend on the setting of the SHAPER LEVEL control, R414, located in the pin 2 grid circuit of V402.

After repairing the trouble be sure that the SHAPER LEVEL control is reset properly as described in the manual, but, before doing this, rotate it back and forth, noting whether operation is restored with the FUNCTION switch at TEST. You will find that there is a range of settings within which the instrument will perform correctly, but a setting well to the side of this range may cause entire lack of amplification through the shaper tube. Other points to check are the B supply voltage, the tube and the small choke coil, L402. Other components may be checked in the usual manner. Most component values in the oscillator-shaper circuit are not critical.

TIME BASE DIVIDERS

Be sure to make use of the circuit description and waveforms published in the instruction manual when shooting troubles in the dividers. The amplitudes listed on the waveform photographs are approximate: there is appreciable variation among instruments. It is advisable to become familiar with the adjustment of the dividers before trouble occurs. Practice on an instrument that is known to be in good operation. Put the unit in the TEST function and take note of the readings obtained as the first divider is misadjusted, then the second, the third and so on. An actual trouble will probably occur in a single divider only, so the complication of more than one divider being out of adjustment is rare.

Make certain that the supply voltage of +120 volts is present and well-regulated. Make sure that the input pulses from the oscillator-shaper are entering the divider chain. Use the TIME-SECONDS switch and the readout on the DCU's to pin down the defective stage. Check division ratios with a scope at the points suggested in the manual. A slight adjustment of one divider may bring a unit back to normal, or perhaps the replacement of one tube may have the same result. Do not overlook the possibility that the TIME TRIGGER LEVEL control (R606) is set incorrectly. Aged tubes should be used as replacements in the divider chain in order that the original adjustment will hold for several months or more. Replacements for the 6U8 (V601) should be Sylvania brand for best performance. The adjustment procedure for the dividers and the TIME TRIGGER LEVEL control is well covered in the instruction manual; no further mention will be made here.

The voltages shown in the table on page 6 will be of real help in servicing the dividers. Notice that all the dividers, except V608 (contained in Models 7160 and 7360 only), are identical, so voltages and resistances in one stage may be compared with those in another. A convenient point to monitor the clock pulses is at the TIME jack, located on the rear lip of the chassis.

GATE AND CONTROL CIRCUITRY

<u>Learning How the Circuits Operate</u>. No one can hope to be successful in troubleshooting the control circuitry unless he understands the operating cycle. First, study the circuit description and the cyclic timing diagrams reproduced in the manual. Second, if possible, study the circuitry in a well-functioning instrument while it rests in each of its three stable states: "ready time", "counting time" and "display time". (The fourth state of the operating cycle, the "inhibit start time", is a transient condition lasting only a few milliseconds.) Use the following procedure:

Rotate the DISPLAY control clockwise until a switch clicks. This prevents the instrument from resetting automatically.

(b) Place the FUNCTION switch at some position at which an input trigger channel supplies "start" and "stop" pulses, but do not couple an input signal to the channel.

(c) Press the RESET button. After a brief "inhibit start" period, the circuitry should switch to the "ready time" state. This state may then be studied deliberately with a VTVM.

(d) Introduce a "start" pulse by rotating the trigger voltage control on the input channel back and forth. The circuitry should then assume the "counting time" state.

(e) Introduce a "stop" pulse by moving the trigger voltage control back and forth again. This should place the circuitry in the "display time" state.

Troubleshooting. The control circuitry is the most difficult part of the instrument to service; therefore, be sure it is receiving adequate input signals ("start", "stop" and "count" pulses) before beginning to search for trouble. The following troubleshooting procedure is recommended.

Step 1. Observe signal at control grid of gate tube (V204, pin 1). Pulses to be counted should appear here. If not the DCU's will not count even though the control circuitry is functioning perfectly.

Step 2. Observe the d-c voltage change at the gating grid (V204, pin 7) while the control circuitry is receiving start and stop pulses separated by one second or more and is adjusted to reset automatically. If the d-c voltage switches back and forth from -15v or more negative to ground level or more positive, the control circuitry is operating all right. In this case inspect the gate tube and associated components for defects. If a sufficient voltage change fails to appear, proceed to step 3.

Step 3. Attempt to place the control circuitry in the "ready time" state by following steps (a) thru (c) above. If the DCU's do not reset, search for trouble in the reset circuitry (V205 & V206). In particular, inspect diodes CR205 and CR209. If the reset line has been accidentally shorted to ground these diodes may burn out. If the DCU's reset correctly proceed to step 4.

Step 4. See whether the reset pulse has switched the control circuit binaries to the "ready time" state. The d-c voltage at pin 1 of both V202 and V203 should be about -47v. If voltages approximating these fail to appear, check the tubes and associated circuitry. If adequate voltages appear, proceed to step 5.

Step 5. Try to switch the binaries to the "counting time" state by introducing a start pulse as described under (d) above. Both binaries should change state, causing the d-c voltage at pin 1 of both V202 and V203 to change to approximately -10v. If either binary fails to "flip", the tube or associated components may be at fault. The cause may also be one of the injection diodes (CR211 or CR212). Check voltages and components using ordinary techniques, but do not attempt to measure grid voltages on either binary because touching a grid pin with a probe may in itself "flip" the binary. If both binaries have changed state proceed to step 6.

Step 6. Attempt to place the circuitry in the "display time" state by injecting a stop pulse as described in (e) above. The control binary should change state, causing the voltage at pin 1 of V203 to return to approximately -47v. The automatic reset action begins when a stop pulse occurs. If you adjust the counter for an automatic display period of 4 or 5 seconds, you may check this action by observing the gradually rising voltage at pin 7 of V206. The voltage there should change from about -1v to +20v.

TYPICAL VOLTAGES AND RESISTANCES

The following voltages and resistances appear in a Model 7360. The table is valid for all other 7000 Series instruments (Models 7050, 7060, 7150, 7160, 7250, 7260, 7350 and 7360) except that some of the tubes or other plug-in components listed will not be installed in the instrument. The resulting lower load on the power supply may cause unregulated voltages to rise 5%. Ordinarily, readings may vary ±10% from the typical value without causing trouble. Special conditions of measurement are indicated by letter superscripts ("a", "b", "c", etc.) which refer to notes at the end of the table. Otherwise conditions are as follows:

1. Voltages measured with a VTVM having an input impedance of 11 megohms.
2. Line voltage 117 volts.
3. FUNCTION switch at OFF.
4. TIME switch at 10^{-6}.
5. ATTENUATION controls at "DC1".
6. DISPLAY control turned clockwise until switch clicks.
7. Instrument in "ready time" state; that is, after reset but before a start pulse occurs.
8. No input signals coupled to the instrument.

D-C Supplies	DC Volts with respect to ground	Resistance to ground in Ohms
Unreg. B+	+200	7.4K
Reg. B+	+120	4.5K
Unreg. B-	-116	7.8K
Reg. B-	-54 to -66	8.1K

Plug-in DCU	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
A202	Same as A205		
A203	Same as A205		
A204	Same as A205		

Plug-in DCU	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
A201	1	Fil -116	7.3K
	2	-116	7.5K
	3	-116	8.9K
	4	-60	68K
	5	+210	7.5K
	6	N.C.	
	7	210	30K
	8	-114	7.3K
	9	N.C.	
	10	+21	∞
	11	Fil -116	7.6K

Plug-in DCU	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
A205	1	Fil -116	7.5K
	2	-38	1.5M
	3	-116	7.5K
	4	-54	66K
	5	+210	7.5K
	6	-51	1.42M
	7	-54	63K
	8	-116	7.4K
	9	-49	1.46M
	10	-48	1.46M
	11	Fil -116	7.5K

Plug-in DCU	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
A206	1	Fil -116	7.5K
	2	-39	1.5M
	3	-116	7.5K
	4	-54	63K
	5	+210	7.5K
	6	-51	1.42M
	7	+89	16.8K
	8	-116	7.4K
	9	-50	1.42M
	10	-48	1.44M
	11	Fil -116	7.5K
A207	1	Fil	
	2	-20	580K
	3	0	0
	4	+89	16.8K
	5	+210	7.5K
	6	+13.5	660K
	7	+119	5.5K
	8	+0.55	300[b]
	9	-29	570K
	10	-18	650K
	11	Fil	
Tube			
V101	1	-2.1	470K
	2	0	0
	3	Fil	
	4	Fil	
	5	+90	110K
	6	+92	28K
	7	0	0
V102	1	+87	110K
	2	+210	7.5K
	3	+120	4.8K
	4	+85	110K
	5	+210	7.5K
	6	+120	4.8K
	7	Fil	
	8	Fil	

Tube	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
V202	1	-47/-9/-3[cd]	11K
	2	-82/-92/-92	34K
	3	-80	18K
	4	Fil	
	5	Fil	
	6	-11/-48/-48	11K
	7	-91/-81/-81	42K
	8	-80	18K
	9	Fil	
V203	1	-47/-10/-47	5.8K
	2	-92/-101/-91[cd]	21K
	3	-91/-92/-91[cd]	12K
	4	Fil	
	5	Fil	
	6	-11/-54/-11[cd]	7.2K
	7	-99/-91/-99[cd]	42K
	8	-91/-92/-91[c]	12K
	9	Fil	
V204	1	-5.3/-6.4/-6.4[c]	22K
	2	0	0
	3	Fil	
	4	Fil	
	5	+120	5.8K
	6	+120/+118/+116[c]	5.9K
	7	-18/+0.3/-18[c]	200[b]
V205	1	+40/+37.5/+200[c]	82K
	2	-0.5/-0.5/-28[c]	320K
	3	0	0
	4	Fil	
	5	Fil	
	6	+210	7.5K
	7	-37.5/-37.5/+40[c]	605K
	8	-32	25K
	9	Fil	

Tube	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
V206	1	+61	25K
	2	+32	4.4M
	3	+32	3.3K
	4	Fil	
	5	Fil	
	6	+210	61K
	7	-1/-1/+20[ce]	8.5M
	8	+32	3.3K
	9	0	
V207	1	+93	18.5K
	2	+13	530K
	3	+13	1.0K
	4	Fil	
	5	Fil	
	6	+210	32K
	7	0	24K
	8	+13	1.0K
	9	Fil	
V301	1	+79/+82[f]	14.5K
	2	+2.1/-1.7[f]	varies w/ setting of trigger voltage potentiometer
	3	+5.3/+2.9[f]	28K
	4	Fil	
	5	Fil	
	6	+88/+87[f]	14.5K
	7	-99	10M
	8	+5.3/+2.9[f]	28K
	9	Fil	
V302	1	+50/+52[f]	17K
	2	-3.5/-3.9[f]	69K
	3	+1.75/+2.10[f]	18K
	4	Fil	
	5	Fil	
	6	+69/+68.5[f]	12K
	7	-2.9/-1.9[f]	69K
	8	+1.75/+210[f]	18K
	9	Fil	
V303	1	+119/+119[f]	5.1K
	2	+50/+52[f]	17K
	3	+110	5.1K
	4	Fil	
	5	Fil	
	6	+92/+91[f]	7.5K
	7	+61/+62[f]	
	8	+61/+62[f]	6.8K
	9	+59/+58[f]	10.0K
V401	1	+88	63K
	2	0	115K
	3	+116	5.1K
	4	Fil	
	5	Fil	
	6	+116	5.2K
	7	+3.1	680K
	8	0	0
	9	-3.6	2.7M
XY401 (crystal)	1	117 AC	
	2	N.C.	
	3	N.C.	
	4	N.C.	
	5	0	0
	6	117 AC	0
	7	+89	63K
	8	0	∞
V402	1	+116	5K
	2	+58	47K
	3	+116	5K
	4	Fil	
	5	Fil	
	6	+92	7.5K
	7	+62	6.8K
	8	+62	6.8K
	9	+58	9.5K

Tube	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
V601	1	+120	4. 2K
	2	+58	45K
	3	+115	5. 0K
	4	Fil	
	5	Fil	
	6	+83	7. 2K
	7	+59	7. 1K
	8	+59	7. 1K
	9	+50	8. 8K
V602	1	+67	25K
	2	+22. 5	120K
	3	+24	8. 2K
	4	Fil	
	5	Fil	
	6	+104	25K
	7	+5. 2	4. 1M
	8	+24	8. 2K
	9	Fil	
V603	1	+106	26K
	2	+2. 0	4. 1M
	3	+24	8. 2K
	4	Fil	
	5	Fil	
	6	+105 +66	25K
	7	+22. 5	120K
	8	+24	8. 2K
	9	Fil	
V604	1	+66	26K
	2	+21. 5	120K
	3	+24	8. 2K
	4	Fil	
	5	Fil	
	6	+106	26K
	7	+0. 8	4. 1M
	8	+24	8. 2K
	9	Fil	

Tube	Pin No.	DC Volts with respect to ground	Resistance to ground in Ohms
V605	1	+65	26K
	2	+22	118K
	3	+24	8. 2K
	4	Fil	
	5	Fil	
	6	+105	25K
	7	-1. 7	4. 0M
	8	+24	8. 2K
	9	Fil	
V606	1	+66 ±10[g]	26K
	2	+22 ±2[g]	118K
	3	+25 ±1[g]	8. 2K
	4	Fil	
	5	Fil	
	6	+105 ±11[g]	26K
	7	-4 ±16[g]	4. 0M
	8	+25 ±1[g]	8. 2K
	9	Fil	
V607	1	+120	4. 6K
	2	+54	58K
	3	+54	15K
	4	Fil	
	5	Fil	
	6	+23. 5	4. 0K
	7	+23. 5	4. 0K
	8	+29	30K
	9	Fil	
V608	1	+109	7. 3K
	2	+19	11. 5K
	3	+24	5. 0K
	4	Fil	
	5	Fil	
	6	+85	7. 6K
	7	+29	30K
	8	+24	5. 0K
	9	Fil	

Notes

a. This DCU is installed only on instruments which feature "X10" positions of the FUNCTION switch.

b. Resistance reading here will vary with amplitude and polarity of the voltage applied by the measuring device. This reading was obtained using an RCA type WV-98A Volt-Ohmyst on the RX 100 range, negative terminal grounded.

c. Three voltage reading taken: the first with the instrument in "ready time" state; the second, in "counting time" state, the third, in "display time" state.

d. This pin is connected to a binary grid or plate. If you touch the pin with a probe, the binary may "flip", thus producing a wrong reading. Therefore, when measuring the voltage here attach the probe first, then cause the instrument to pass through the three stable states in the operating cycle.

e. To obtain the third reading place the instrument in the "display time" state with display control in ∞ position, then rotate the DISPLAY control CCW just far enough to cause the switch to click. The voltage should begin rising from ground level, reaching about +20v in approximately ten seconds.

f. Two voltage readings taken: the first with the associated TRIGGER VOLTAGE control fully clockwise; the second, with the control fully CCW.

g. This divider stage cycles so slowly that the needle of a voltmeter will wobble visibly within the range noted.

NOTE

Modified instruments are identified by one or more letters after the model number, each letter standing for one of the modifications described below. For example, Model 7150DR is a standard 7150 that has been modified to incorporate an oven-controlled crystal instead of an unheated crystal (Modification D) and is fitted for rack mounting (Modification R). Some modifications in this section may not appear in alphabetical order.

MODIFICATION B

Modification B extends the count capacity by a factor of 10 or divides the frequency of the start and stop pulses by 10.

Models 7151, 7351, 8151, and 8351

A Model 775Z DCU, A705, is placed between the Divider Input Gate, V701, and DCU A704. When switch S206 is in the "N X 10" position, A705 divides the digital divider drive pulses by 10, raising the maximum input frequency from 10 kc to 100 kc. In the "N X 1" position, the instrument works as if unmodified. The circuit changes are shown in Figure B.

Other Models

The schematic diagrams of the other instruments for which modification B is available show the modified circuitry.

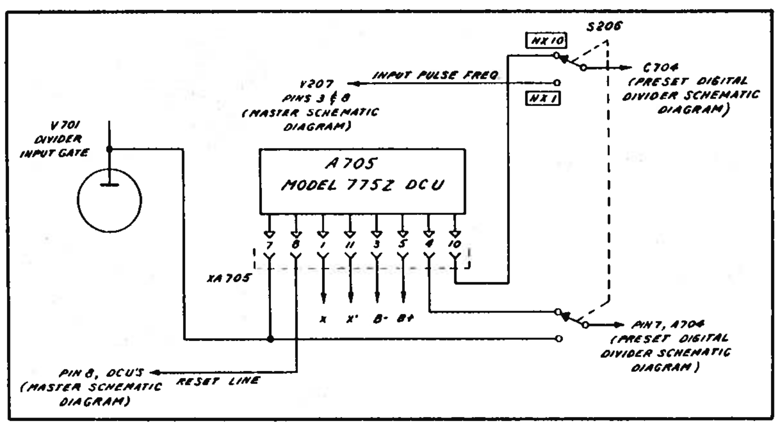


FIGURE B CIRCUIT CHANGES FOR MODIFICATION B IN MODELS 7151, 7351, 8151 AND 8351

MODIFICATION C

An instrument with modification C has a mechanical register that extends the count capacity by three extra digits. The register coil is the plate load of a one-shot multivibrator, V21, driven by the output signal of DCU A202; thus, the register records one count for every output pulse of the DCU.

The register is reset manually by a small lever on the front panel just below the register dials and is not affected by the electronic signal that resets the DCU's.

In C-modified instruments with "X 10" modes of operation, the count-indicating panel of the DCU Divider, A201, is not exposed to view, and the digit normally displayed by A201 appears as the right-hand digit of the register.

When A202 resets, it may give an output pulse. To stop this from registering, the reset line is connected to the control grid, pin 2, of V21 so that the inverted reset pulse appearing at the plate, pin 1, supresses the false count.

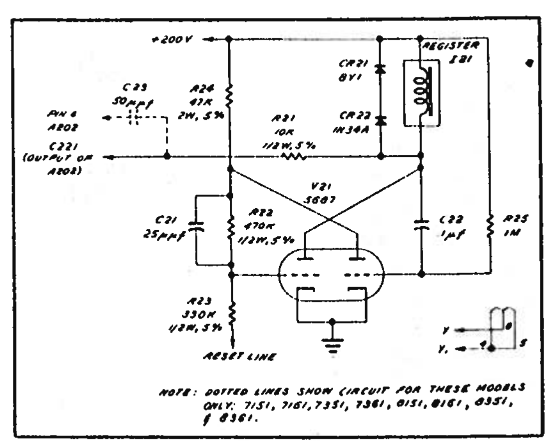


FIGURE C CIRCUIT OF MODIFICATION C

MODIFICATION D

The frequency stability of the clock pulse generator instruments using an unheated crystal is 1 part in 10^5 per day. Modification D substitutes a temperature-controlled crystal for the unheated type and improves the oscillator stability to 1 part in 10^6 per day.

Power for the heating element in the crystal oven is taken from one of the filament circuits in the instrument (the circuit that has one side grounded).

The circuitry is shown on the crystal oscillator schematic diagrams of the instruments concerned.

MODIFICATION H

Instruments with this modification have a power transformer with a 222-volt primary instead of the standard 117-volt, the primary being two windings in series, a 117-volt and a 105-volt. The line fuses, F101 and F102, have one-half the current rating of those in the standard instruments. Figure H-1 shows the modified circuitry. Note that in instruments with a 1 mc heated crystal in the oscillator, the crystal oven no longer begins heating as soon as the line cord is plugged into a power receptacle, but heats only when the POWER switch is on.

If operation on 210 volts or 231 volts is desired, take the wire off terminal 2 of the transformer and connect this wire to terminal 14 or 11 respectively.

To convert to 117-volt operation, rewire the transformer connections as shown in Figure H-2 and replace F101 and F102 with fuses of twice the current rating. The correct current rating is listed on the power supply schematic diagrams of the instruments.

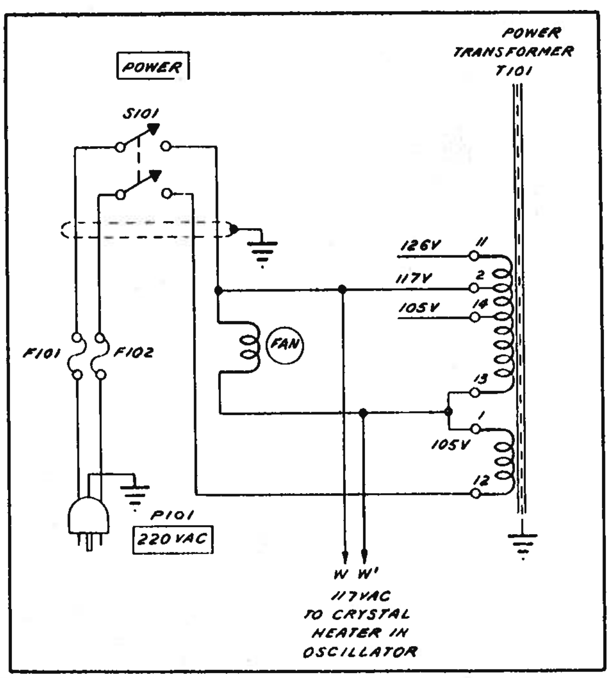


FIGURE H-1 CIRCUIT CHANGES IN POWER SUPPLY FOR MODIFICATION H

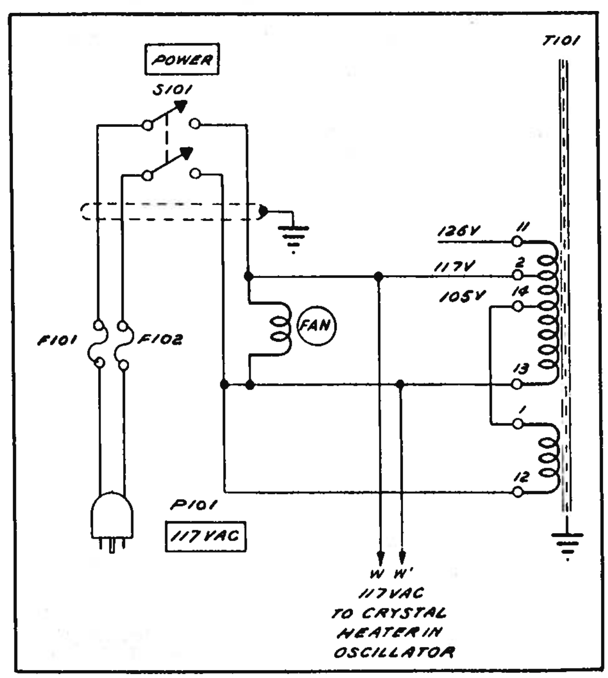


FIGURE H-2 REWIRING MODIFICATION H TO OPERATE ON 117 VOLTS AC

MODIFICATION J

Modification J raises the maximum counting rate of 100 kc instruments to 220 kc, and 1 mc instruments to 2.1 mc.

100 kc Instruments

DCU A206 is replaced by a 220 kc DCU, Model 713AH, and the circuitry of the instrument is modified to suit the new unit as shown in Figure J-1.

1 mc Instruments

a) DCU A207 is replaced by a 711AH, and A206 by a 713AH. Each of these DCU's has about double the counting speed of the unit it replaces. The plate load of the Gate Control tube in the instrument is changed and the circuitry immediately associated with the new DCU's is modified as shown in Figure J-2.

b) In addition, any input channels required to operate between 1 mc and 2 mc in count modes are supplanted by faster channels with a cathode-follower between the comparator amplifier and the voltage discriminator. These 2 mc input channels are shown in Figure J-3 (A or B channels, where appropriate) and Figure J-4 (C channel only).

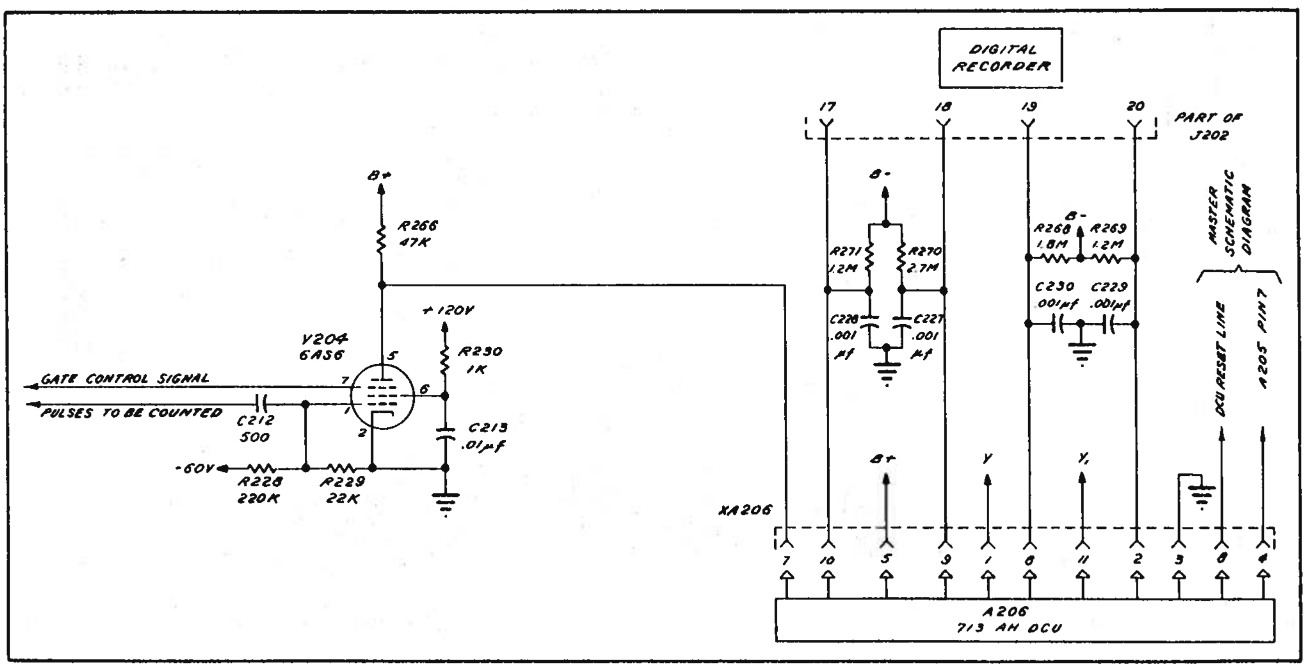


FIGURE J-1 100 KC INSTRUMENT MODIFIED FOR 200 KC OPERATION

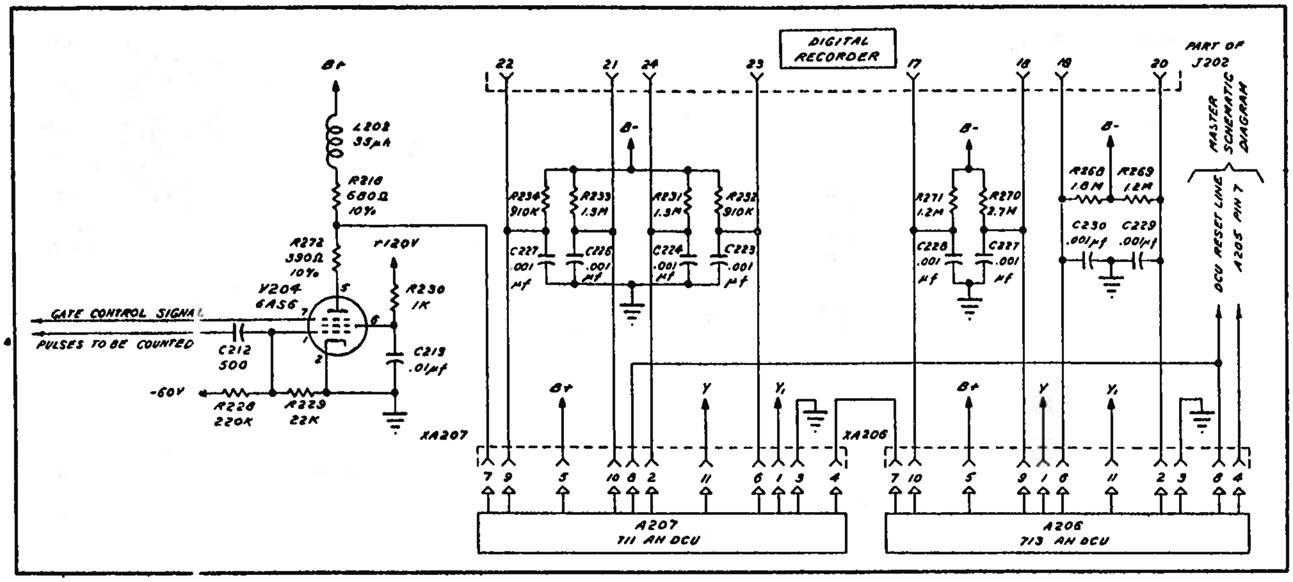


FIGURE J-2 1 MC INSTRUMENT MODIFIED FOR 2 MC OPERATION

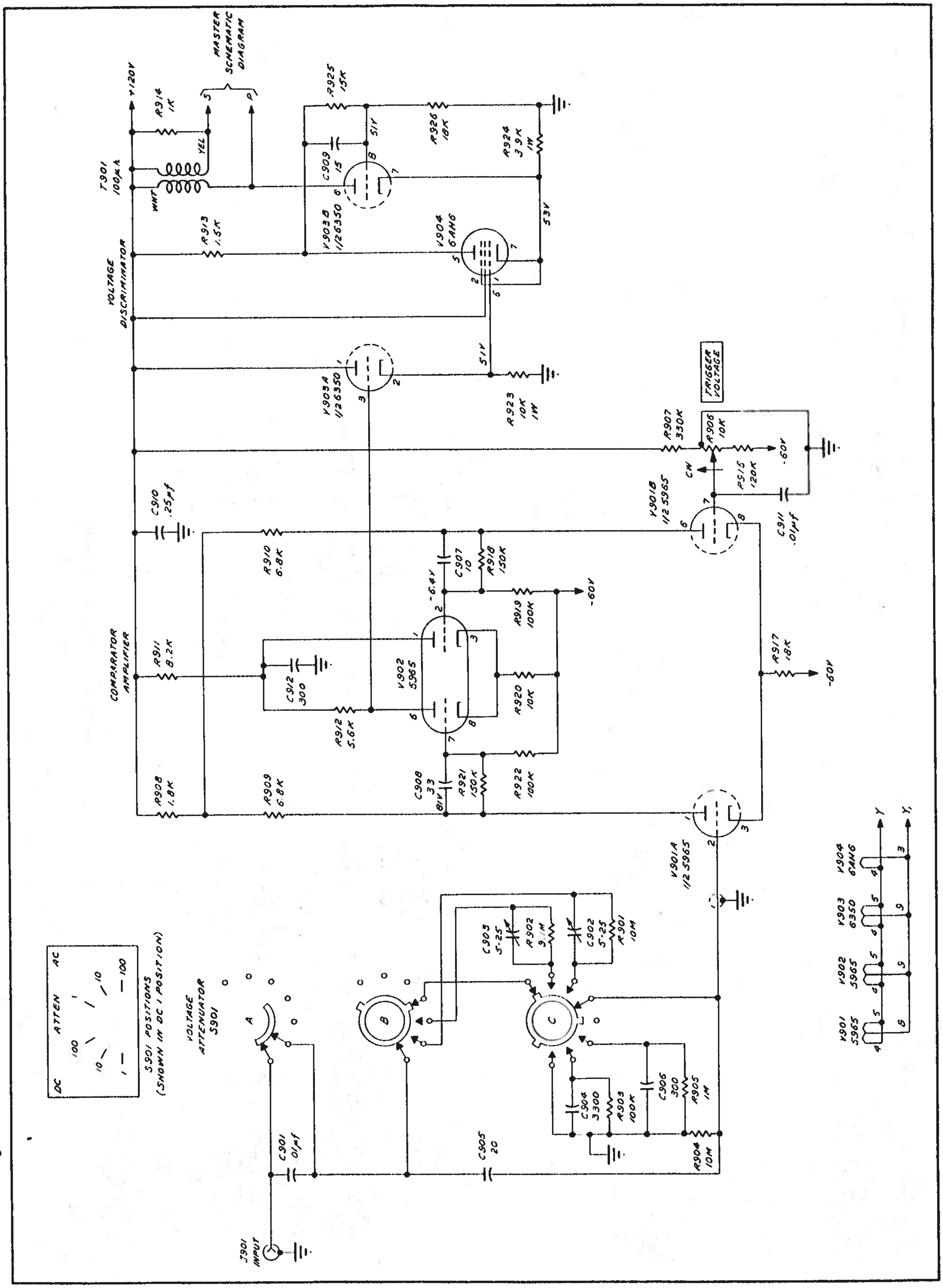


FIGURE J-3 A OR B INPUT CHANNEL IN 2 MC J MODIFICATION

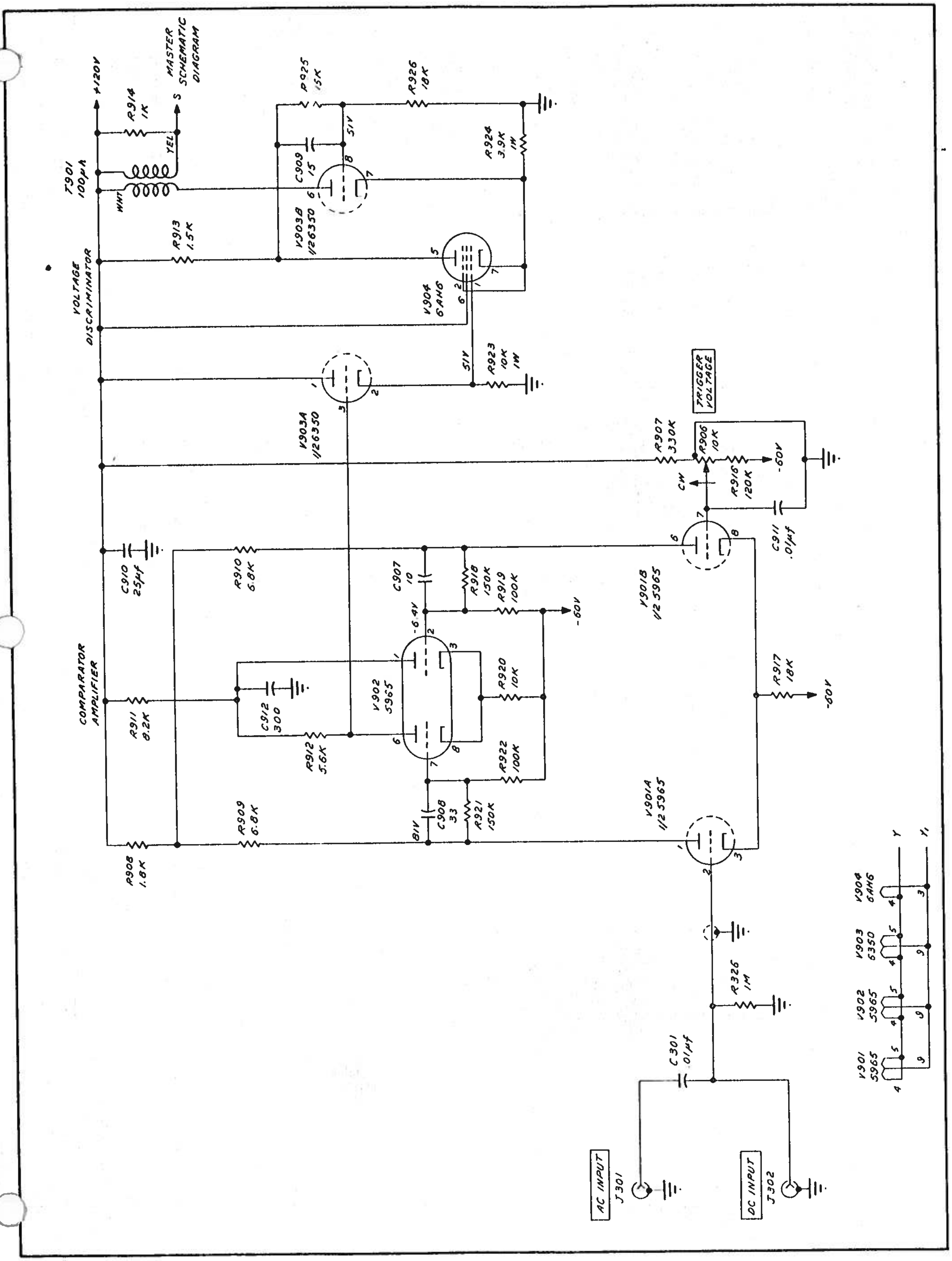


FIGURE J-4 C INPUT CHANNEL IN 2 MC J MODIFICATION

MODIFICATION K

To increase the input sensitivity of a counter from 100 mv rms to 5 mv rms, a step-up transformer is inserted between the attenuator and the first grid of any input channel used in count modes. The transformer is put in or out of circuit by a front panel switch (S350) marked HIGH (transformer in) and NORM (transformer out and attenuator connected straight through to the first grid). It should be switched in only if the input signal is below the sensitivity of the counter.

With the transformer connected, the ATTENUATION control should be at DC-1. Under these conditions the input impedance will vary with frequency, rising from at least 300 ohms at 5 cps to about 25K ohms at 10 kc. Sensitivity is at least 5 mv over this range.

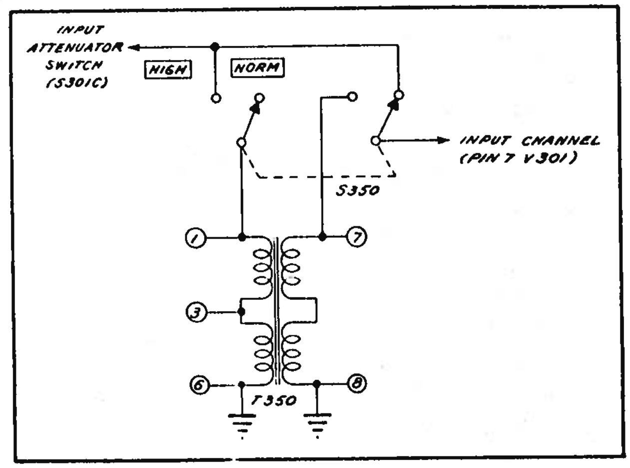


FIGURE K CIRCUIT DIAGRAM FOR MODIFICATION K

MODIFICATION L

Applicable to Preset EPUT® Meters or Preset Universal EPUT® and Timers, this modification permits remote control of the digital divider setting, as well as normal control from the front panel.

The sockets of the digital divider DCU's are wired to a female connector (J 801) on the rear chassis lip. One matching plug, on a flexible lead coming out of the rear lip, is wired to the internal preset switches; another is provided for wiring to remote preset switches. Front panel control or remote control is obtained by inserting the appropriate plug into J801.

Figure L shows the internal connections to J801 and gives the recommended wiring of a manually-operated external preset switch. In this application the voltages at pins 21, 22, and 23 of J801 are not used.

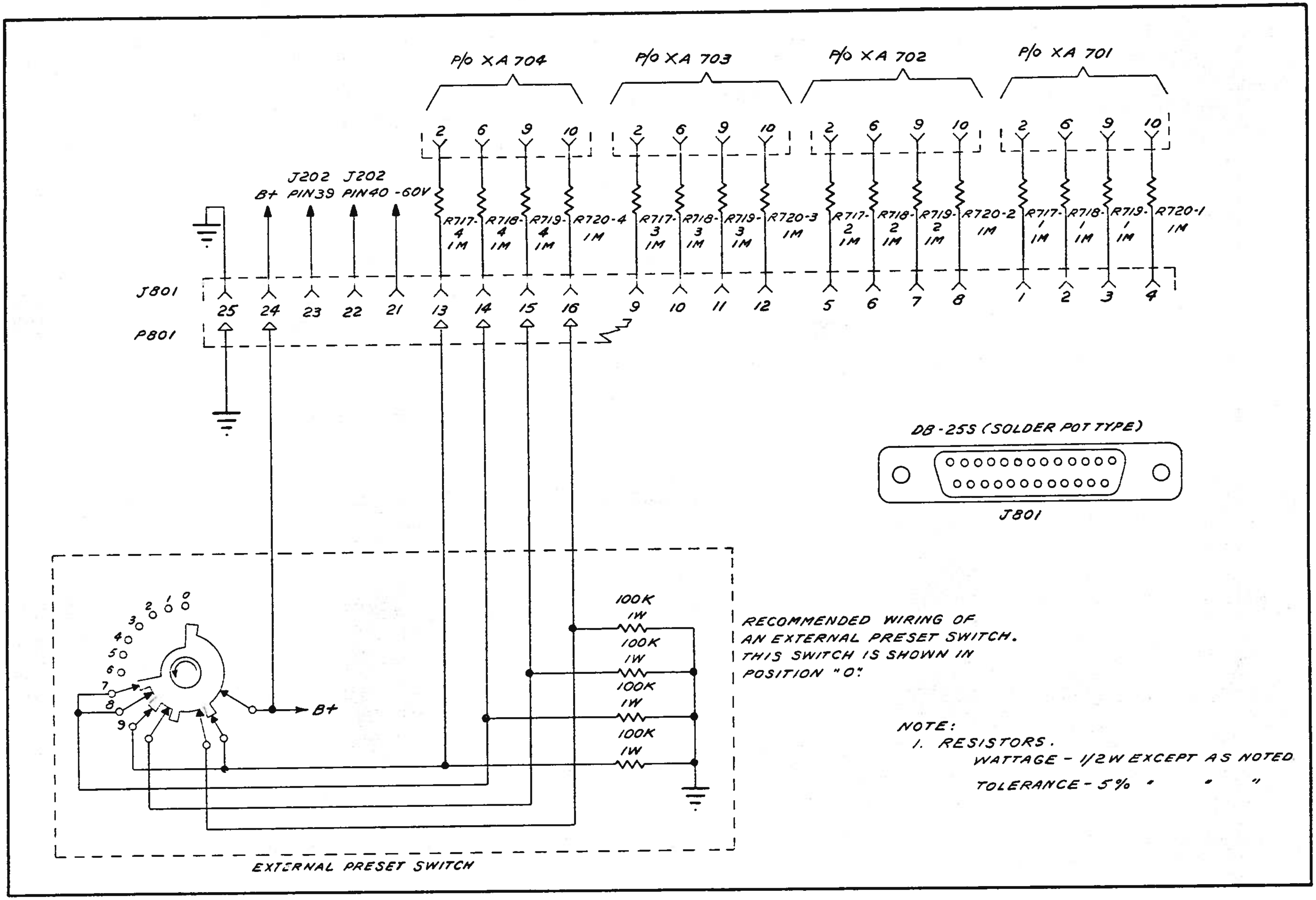


FIGURE L WIRING DIAGRAM FOR MODIFICATION L

MODIFICATION R

Instruments with this modification are intended for mounting in a standard relay rack and are supplied without a cabinet but with a top dust cover. Mounting dimensions are given in Figure R.

The air intake ports in the sides of the chassis and the exhaust opening at the back should be kept free from obstruction so that the forced-draft cooling system can work efficiently. For the same reason, the dust cover must be kept in place when the instrument is in operation, as overheating can cause serious damage to components.

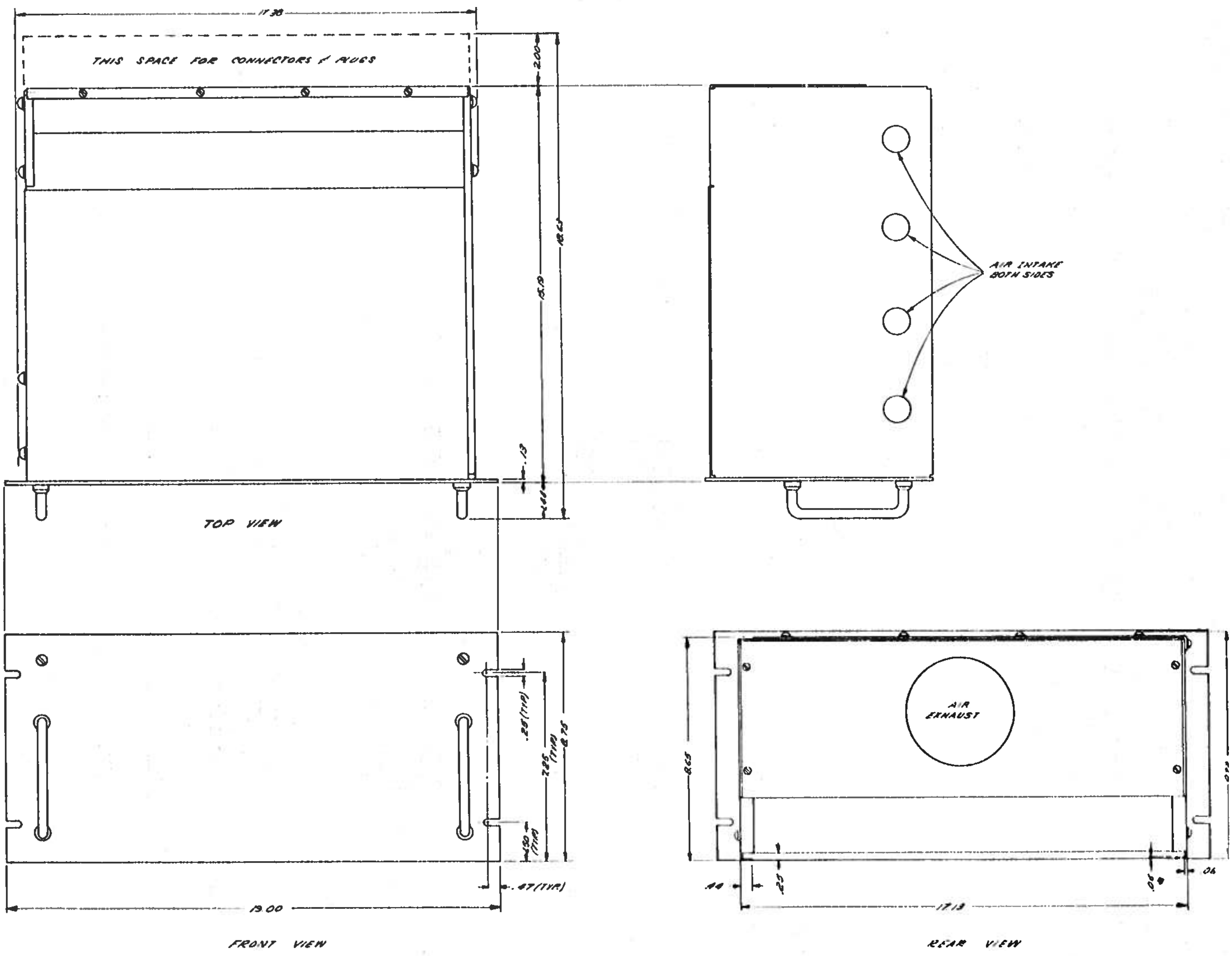


FIGURE R RACK MOUNTING DIMENSIONS FOR 7000 AND 8000 MODEL SERIES INSTRUMENTS

MODIFICATION T

In contrast to the standard Beckman/Berkeley 1-2-2-4 readout code, instruments with the T modification furnish a 1-2-4-8 readout. The modified code is supplied by special DCU's substituted for the standard units. These DCU's are designated by the letter "R" following the model number.

The only modification to the wiring of the instrument is that pin 35 of the DIGITAL RECORDER connector, J202, is grounded.

MODIFICATION U

Modification U supplies power for auxiliary equipment through an ACCESSORY socket, J101, mounted on the rear chassis lip of the instrument.

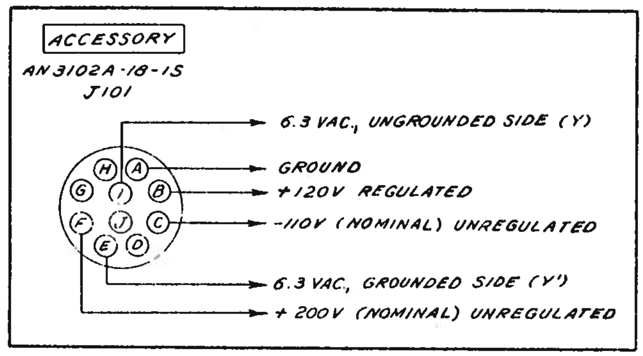


FIGURE U CONNECTIONS TO ACCESSORY SOCKET, J101, IN MODIFICATION U

MODIFICATION W

This modification adds a circuit that provides strobe pulses of variable width for external use (see Figure W).

The circuit consists of two identical one-shots (V901 and V902) driven by the "start" and "stop" pulses coming from the FUNCTION switch. One-shot V901 is triggered by "start" pulses, and V902 by "stop" pulses. When one of these negative pulses appears at the input grid (pin 7), the one-shot flips to the quasi-stable state and then back to its stable state. In so doing, it generates a negative output pulse of about 25 volts at one of the plates (pin 1). The duration of the quasi-stable state, and hence the width of the output pulse, depends on the capacitance put into the circuit by the STROBE PULSE WIDTH switch (S901).

The negative output pulses from the one-shots appear at the STROBES jacks (START, J901, and STOP, J902) on the rear panel of the instrument. Capacitors C201 and C206 are replaced by C919 and C920 respectively. The pulses can be applied to the Z axis of an oscilloscope to intensify the input waveform at the points where the input channel of a counter is being triggered.

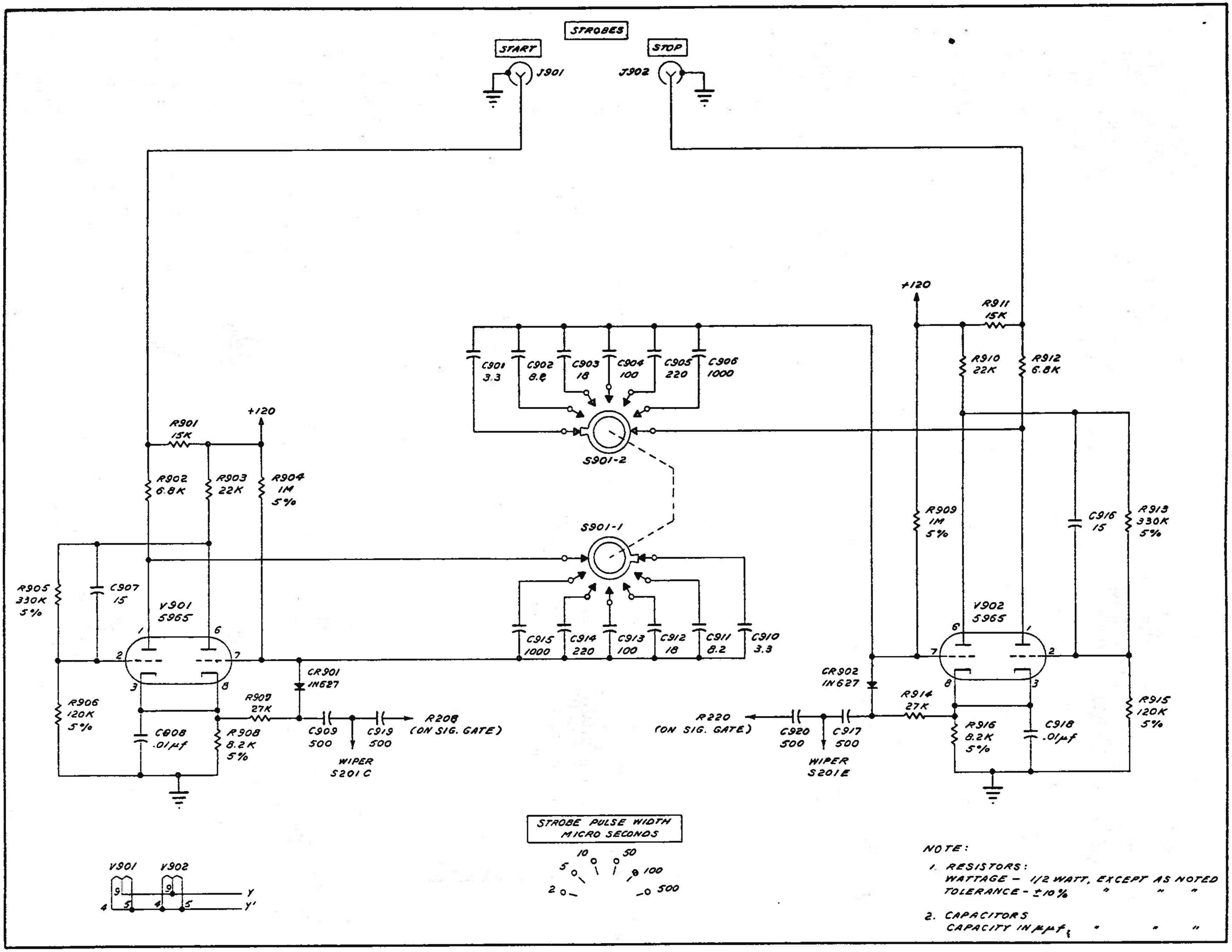


FIGURE W CIRCUIT DIAGRAM FOR MODIFICATION W

PARTS LIST, MASTER SCHEMATIC DIAGRAM

Refer to Dwg. No. 7350 D 9

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

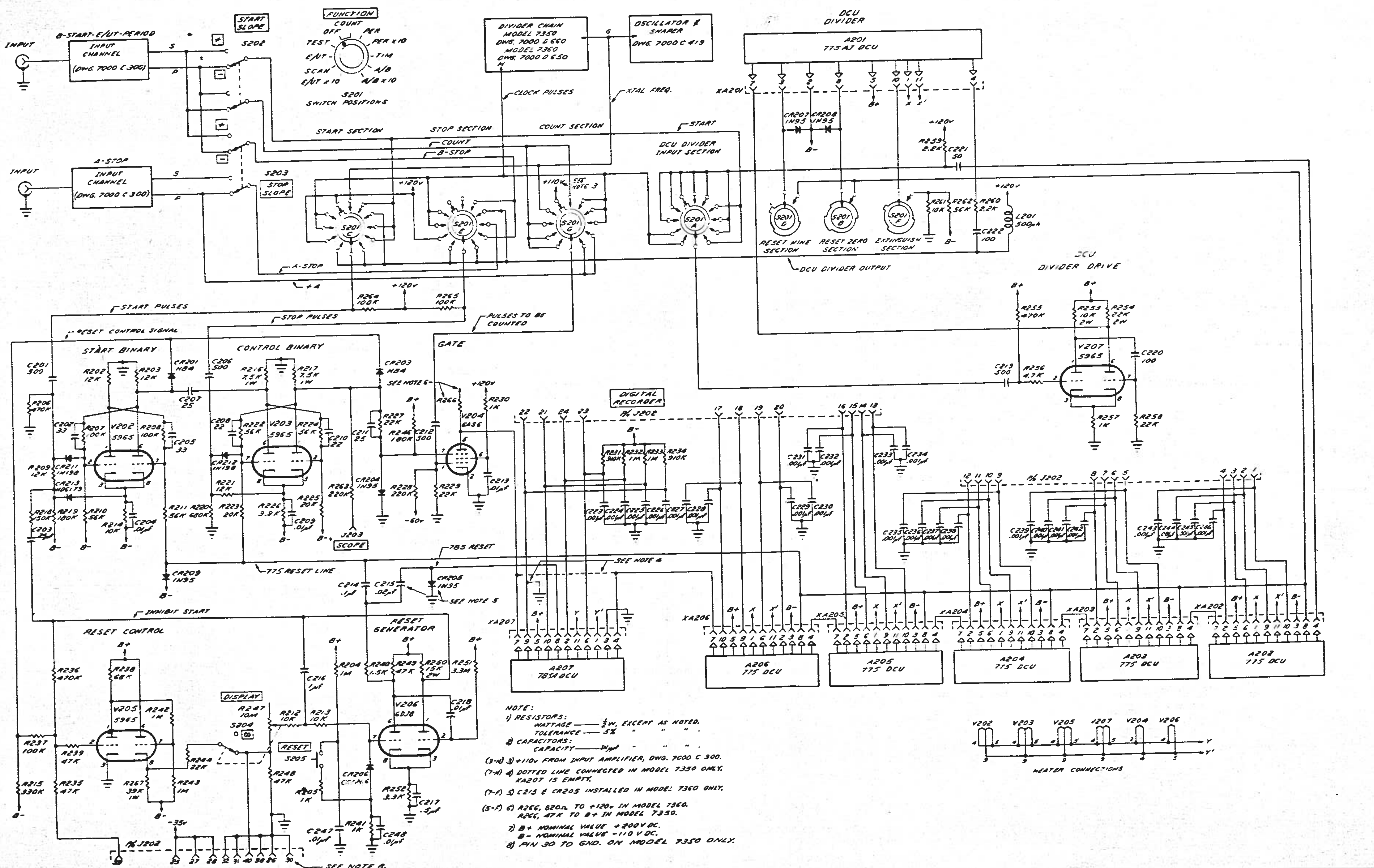
ABBREVIATIONS

B/B	Beckman/Berkeley Division, Richmond, California
CH	Cutler-Hammer Co., Milwaukee, Wisconsin
GMV	Guaranteed Minimum Value
WW	Wirewound

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
C201	2-2137	Capacitor, mica, 500μμf, 300V, 5%	Sangamo RR1350
C202	2-2607	Capacitor, mica, 33μμf, 500V, 5%	Sangamo RR1433
C203	2-2760	Capacitor, paper, 0.25μf, 400V, 20%	Sangamo 3304025
C204	2-4388	Capacitor, ceramic, .01μf, 500V, +80% -20%	Sprague 29C9
C205		Same as C202	
C206		Same as C201	
C207	2-2138	Capacitor, mica, 25μμf, 500V, 5%	Sangamo RR1425
C208	2-5015	Capacitor, mica, 22μμf, 500V, 5%	Sangamo RR1422
C209		Same as C204	
C210		Same as C208	
C211		Same as C207	
C212		Same as C201	
C213		Same as C204	
C214	2-5691	Capacitor, paper, 0.1μf, 400V, 20%	Hopkins P14D
C215	2-6492	Capacitor, ceramic, .02μf, 600V, GMV	Erie 817-.02
C216	2-6122	Capacitor, paper, 1μf, 200V	Sprague 2TM-M1
C217	2-7272	Capacitor, paper, 0.5μf, 200V, 20%	Hopkins P52DS
C218	2-2230	Capacitor, ceramic, .01μf, 450V	Erie 811-.01
C219		Same as C201	
C220	2-2136	Capacitor, mica, 100μμf, 500V, 5%	Sangamo RR1310
C221	2-2141	Capacitor, mica, 50μμf, 500V, 5%	Sangamo RR1450
C222		Same as C220	
C223 thru C246	2-5793	Capacitor, ceramic, .001μf, 1000V, 20%	Centralab DD102
C247		Same as C218	
C248		Same as C218	
CR201	8-7561	Diode, HB4	Hoffman

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
CR203		Same as CR201	
CR204	8-5580	Diode, 1N95	Hughes
CR205	8-4128	Diode, 1N96	Hughes
CR206	8-7183	Diode, CD1266	Continental Devices
CR207 thru CR209		Same as CR204	
CR211	8-7274	Diode, 1N198	Hughes
CR212		Same as CR211	
CR213	8-8140	Diode	B/B
J202	17-5620	Connector, 40 pin, female	Cannon DPX-40-34S
J203	17-7712	Connector, tip jack	Whitso JNP-11
L201	3-6164	Inductor, 500μh	Wilco 1500-15
R247	1-2956	Potentiometer, WW, 10M, 1/2W, 20%, W/switch S204	Centralab BA98
S201	12-6029	Switch, rotary	B/B
S202	12-1909	Switch, toggle, DPDT	CH 8373K7
S203		Same as S202	
S204		Switch, part of R247	
S205	12-0446	Switch, pushbutton, SPDT	Switchcraft 203
V202	5-3301	Tube, 5965	
V203		Same as V202	
V204	5-0500	Tube, 6AS6	
V205		Same as V202	
V206	5-7562	Tube, 6DJ8	
V207		Same as V202	
XA201	4-1720	Socket, 11 pin	Amphenol 77M1P11
XA202 thru XA207		Same as XA201	
XV202	4-2973	Socket, 9 pin, min.	Elco 377BC
XV203		Same as XV202	
XV204	4-2972	Socket, 7 pin, min.	Elco 316BC
XV205		Same as XV202	
XV206		Same as XV202	
XV207		Same as XV202	

MASTER SCHEMATIC DIAGRAM



PARTS LIST, INPUT CHANNEL

Refer to Dwg. No. 7000C300

ABBREVIATIONS

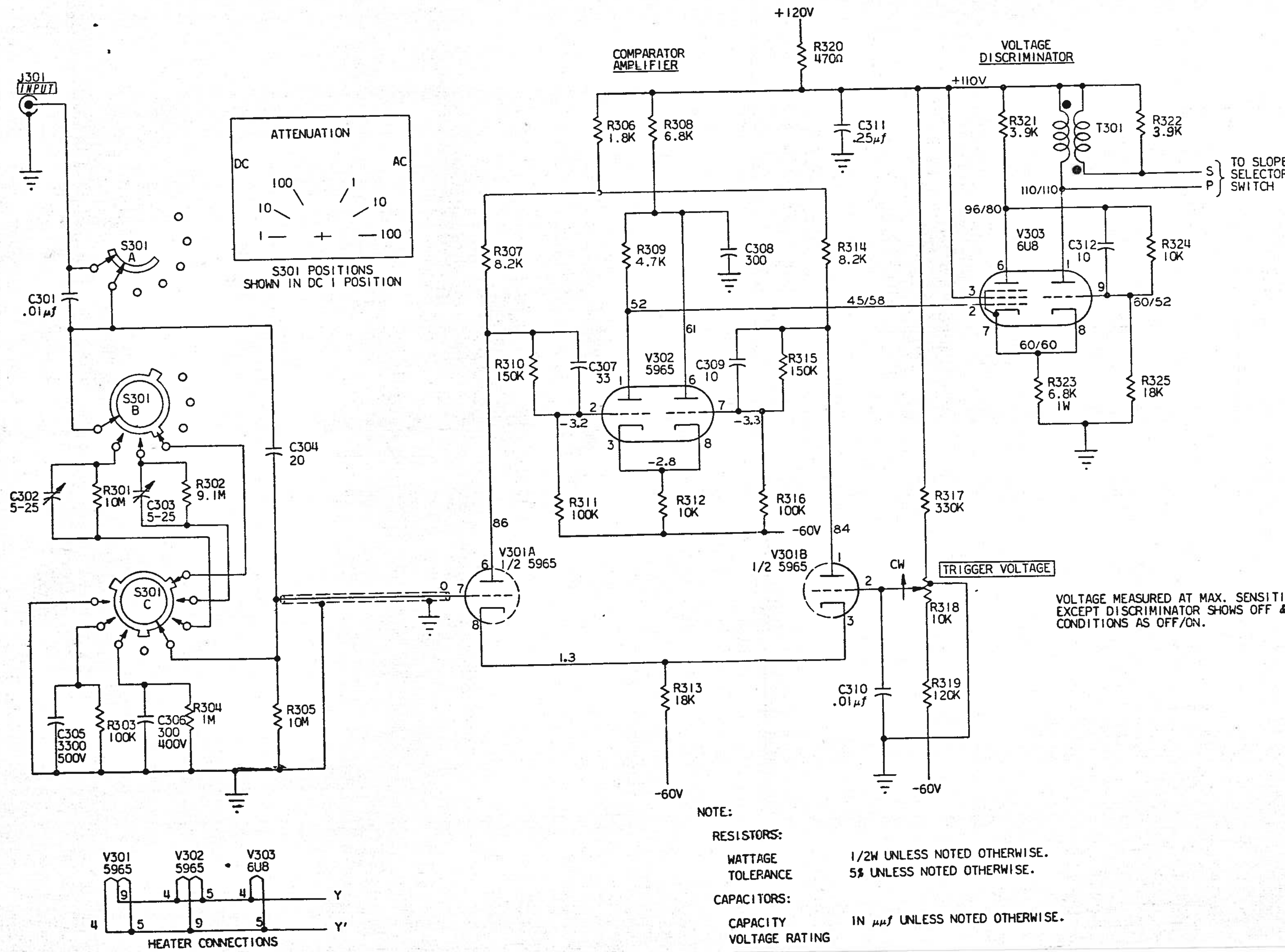
AB	Allen-Bradley Company, Milwaukee, Wisconsin
BDB	Berkeley Division Beckman, Richmond, California
GE	General Electric, Schenectady, New York
IPC	Industrial Products Co., Danbury, Connecticut
RCA	Radio Corporation of America, Harrison, New Jersey

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
C301	2-2230	Cap., .01 μfd, ceramic disc	Erie 811
C302 & C303	2-2326	Capacitor, 5-25 μμfd, Variable	Erie 557-F
C304	2-1939	Capacitor, 20 μμfd, Mica	Sangamo RR 1420
C305	2-6474	Capacitor, 3300 μμfd, Mica	Sangamo CR 1233
C306	2-2608	Capacitor, 300 μμfd, Mica	Sangamo RR 1330
C307	2-2607	Cap., 33 μμfd, Mica	Sangamo RR 1433
C308	2-2608	Cap., 300 μμfd, Mica	Sangamo RR 1330
C309	2-2082	Cap., 10 μμfd, Mica	Sangamo RR 1410
C310	2-2230	Same as C301	Erie 811
C311	2-5747	Cap., .25 Mfd, 200 V Metalized	Hopkins Eng.
C312		Same as C309	
J301 & J302	17-3179	Connector, Low Voltage	IPC MS 595
R318	1-5573	Potentiometer, 10K, 2W, 20%, 40% tap.	AB JU1032-SD3048
S301	12-5698	Switch, 2 Sec., 7 Pos.	
T301	6-5821	Transformer, Pulse 300 μ H	BDB
V301 & V302	5-3301	Tube, 5965	RCA
V303	5-2526	Tube, 6U8	GE
XV301, XV302 & XV303	4-2973	Socket, 9 Pin W/O Shield W/ Lugs	Elco 377BC

January 1960



VOLTAGE MEASURED AT MAX. SENSITIVITY, EXCEPT DISCRIMINATOR SHOWS OFF & ON CONDITIONS AS OFF/ON.

NOTE:

RESISTORS:
- WATTAGE — 1/2W UNLESS NOTED OTHERWISE.
- TOLERANCE — 5% UNLESS NOTED OTHERWISE.

CAPACITORS:
- CAPACITY — IN µµf UNLESS NOTED OTHERWISE.
- VOLTAGE RATING

PARTS LIST, OSCILLATOR & SHAPER

Refer to Dwg. No. 7000 C 419.

ABBREVIATIONS

BDB	Berkeley Division Beckman, Richmond, Calif.
CRL	Centralab, Milwaukee, Wis.
JFD	JFD Electronics, Brooklyn, N. Y.
AB	Allen-Bradley Company, Milwaukee, Wisconsin

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

Detail No.	Berkeley Stock No.	Description	Mfr. & No.
C401	2-2230	Capacitor, disc, ceramic, .01 μf	Erie 811-.01
*C402	2-2137	Capacitor, silvered mica, 500 $\mu\mu f$	Sangamo RR1350
**C402	2-3068	Capacitor, silvered mica, 180 $\mu\mu f$	Sangamo RR1318
*C403	2-7535	Capacitor, silvered mica, 1200 $\mu\mu f$	Sangamo KR1212
**C403	2-2172	Capacitor, silvered mica, 400 $\mu\mu f$	Sangamo RR1340
*C404	2-3157	Capacitor, silvered mica, 39 $\mu\mu f$	Sangamo RR1439
**C404	2-6065	Capacitor, ceramic, 56$\mu\mu f$, 600V, 5%	Erie NPO
C405		Same as C401	
C406		Same as C401	
C407	2-2135	Capacitor, silvered mica, 15 $\mu\mu f$	Sangamo RR1415
C408		Same as C401	
C409	2-5491	Capacitor, silvered mica, 150 $\mu\mu f$	Sangamo RR1315
*C410	2-5617	Capacitor, variable, 100 $\mu\mu f$	Hammarlund MAPC-101
**C410	2-5706	Capacitor, variable, 2-18 $\mu\mu f$	JFD VC-4
C411	2-4268	Capacitor, electrolytic, 5 μf, 8 v.	Barco PS8-5
C412	2-5793	Capacitor, disc, ceramic, .001 μf	CRL DD102
C413		Same as C412	
**C414	2-2136	Capacitor, silvered mica, 100 $\mu\mu f$	Sangamo DR1310
C415		Same as C401	
C416		Same as C401	
C417	2-5747	Capacitor, paper, metalized, .25 μf	Hopkins MPA .25-200
CR401	8-7274	Diode, 1N198	
J401	17-4985	Test Jack, UG 1094/U	
**L401	3-6328	Inductor, 240 μh	Wilco 3240-15
*L402	3-6397	Inductor, 400 μh	Wilco 1400-15
**L402		Same as L401	
S401	12-1643	Switch, toggle, SPST	BDB
V401	5-2526	Tube, 6U8	Sylvania
V402		Same as V401	
XV401	4-2973	Tube Socket, 9 pin, min.	Elco 377BC
XV402		Same as XV401	
XY401	4-3213	Crystal Socket, octal mica filled	Cinch 16203
*Y401	13-6325	Crystal, 100 kc, w/oven	BDB
**Y401	13-5606	Crystal, 1 mc, w/oven	BDB

ADDITIONS

I401	21-1677	Lamp	General Electric 47
R414	1-2318	Potentiometer, 50K, 2W, 20%	AB JU5032-SD3048
XI401	4-3324	Socket, lamp	Drake 101

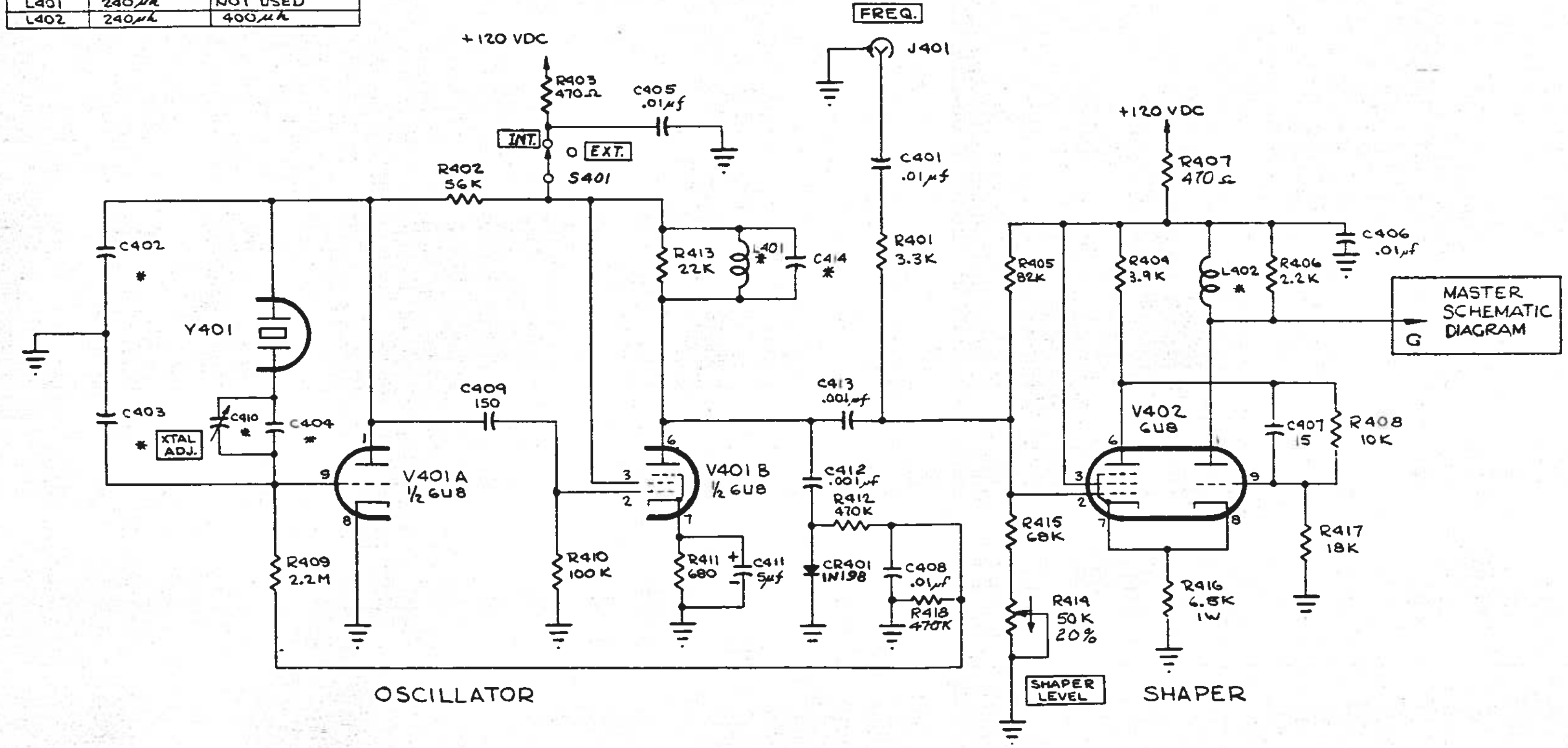
*For instruments using 100 kc crystal.
**For instruments using 1 mc crystal.

January 1960

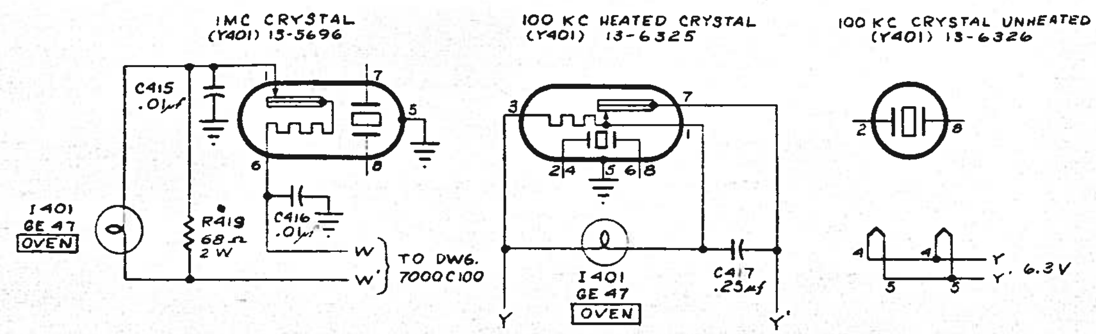
OSCILLATOR AND SHAPER SCHEMATIC DIAGRAM

*COMPONENT VALUES ARE AS LISTED BELOW

COMP.	WITH 1 MC XTAL	WITH 100 KC XTAL
C402	180 μμf	500μμf
C403	400 μμf	1200μμf
C404	56 μμf (NOM.)	39 μμf (NOM)
C410	2-18μμf	100μμf VAR.
C414	100μμf	NOT USED
L401	240μh	NOT USED
L402	240μh	400μh



NOTE:
1. RESISTORS:
WATTAGE - ½W UNLESS OTHERWISE NOTED
TOLERANCE - 10% " " "
2. CAPACITORS:
CAPACITY - IN μμf UNLESS OTHERWISE NOTED



PARTS LIST, 1 MC FREQUENCY DIVIDER

Refer to Dwg. No. 7000 D 650

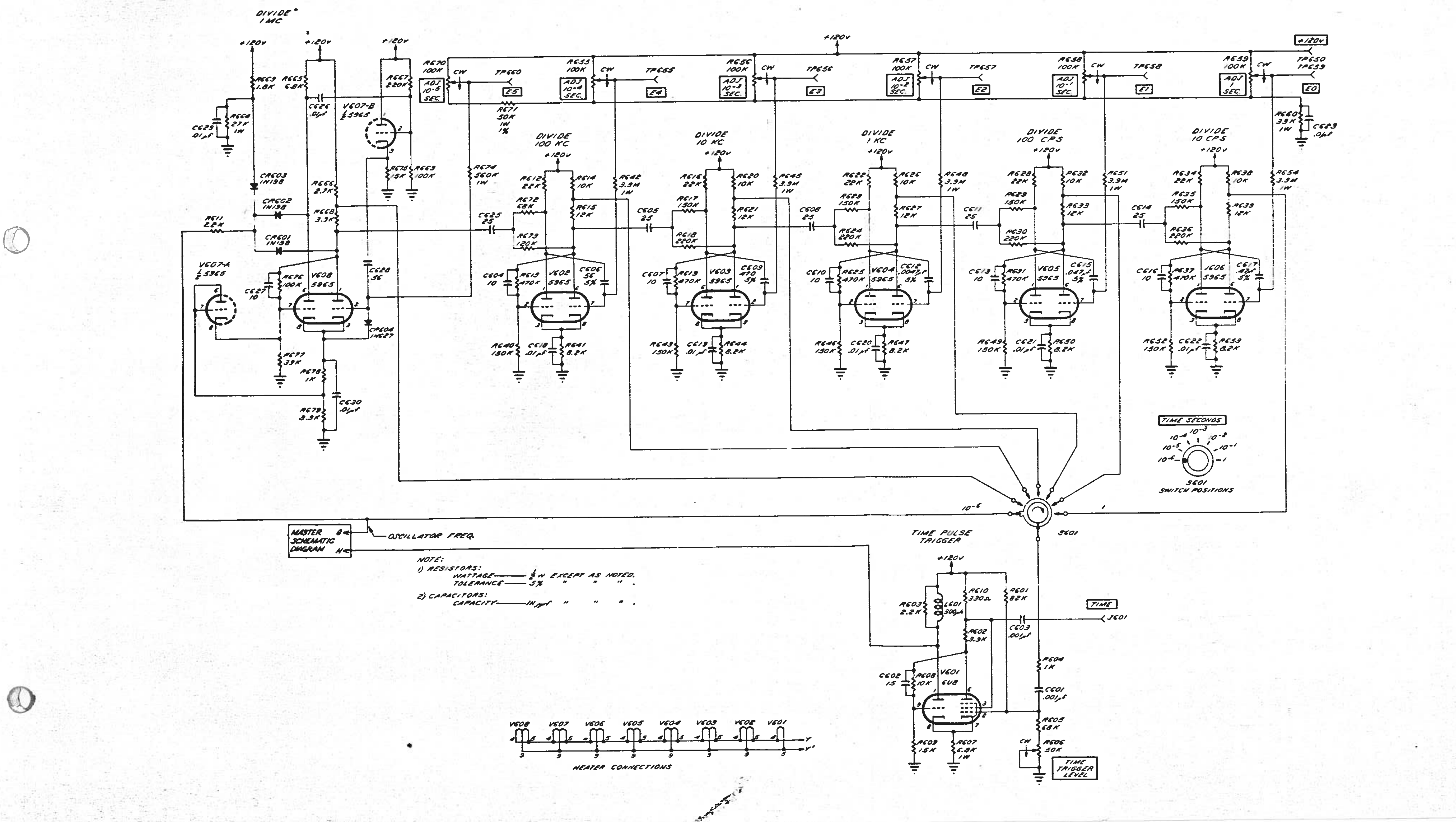
NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

ABBREVIATIONS

AB	Allen-Bradley Company, Milwaukee, Wisconsin
AE	Automatic Electric Company, Northlake, Illinois
BDB	Berkeley Division Beckman, Richmond, California
d. c.	Deposited Carbon

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
C601	2-3242	Capacitor, ceramic, .001µf, 600V, 10%	Erie GPL-1000
C602	2-2135	Capacitor, mica, 15µµf, 500V, 5%	Sangamo RR1415
C603		Same as C601	
C604	2-2082	Capacitor, mica, 10µµf, 500V, 5%	Sangamo RR1410
C605	2-2138	Capacitor, mica, 25µµf, 500V, 5%	Sangamo RR1425
C606	2-3879	Capacitor, glass, 56µµf, 500V, 5%	Vitramon CY13C470JA
C607		Same as C604	
C608		Same as C605	
C609	2-3574	Capacitor, glass, 470µµf, 500V, 5%	Vitranon CY17C471JA
C610		Same as C604	
C611		Same as C605	
C612	2-4206	Capacitor, paper, .0047µf, 300V, 5%	Sprague 186P47253S3
C613		Same as C604	
C614		Same as C605	
C615	2-5603	Capacitor, paper, .047µf, 300V, 5%	Sprague 186P47353S3
C616		Same as C604	
C617	2-5604	Capacitor, paper, 0.47µf 300V, 5%	Sprague 186P47453S3
C618	2-2230	Capacitor, ceramic, .01µf, 450V	Erie 811
C619		Same as C618	
C620		Same as C618	
C621		Same as C618	
C622		Same as C618	
C623		Same as C618	
C625		Same as C605	
C626		Same as C618	
C627		Same as C604	
C628		Same as C606	
C629		Same as C618	
C630		Same as C618	
CR601	8-7274	Diode, 1N198	Hughes
CR602 & CR603		Same as CR601	
CR604	8-7453	Diode, 1N627	BDB
J601	17-4985	Connector, coaxial	AE UG1094/U
L601	3-7317	Inductor, 300µh	Wilco 1300-15
R606	1-2318	Potentiometer, 50K, 2W, 20%	AB JU5032-SD3048
R642	1-6010	Resistor, 3.9M, 1W, 1%, d.c.	Electra DC-1
R645		Same as R642	
R648		Same as R642	
R651		Same as R642	
R654		Same as R642	
R655	1-1340	Potentiometer, 100K, 2W, 20%	AB JU1042-SD3048
R656		Same as R655	
R657		Same as R655	
R658		Same as R655	
R659		Same as R655	
R660	1-3846	Resistor, 33K, 1W, 1%, d.c.	Electra DC-1
R670		Same as R655	
R671	1-4258	Resistor, 50K, 1W, 1%, d.c.	Electra DC-1
R674	1-6012	Resistor, 560K, 1W, 1%, d.c.	Electra DC-1
S601	12-5700	Switch, rotary	BDB
TP650	17-7637	Connector, tip jack	Whitso JNP-12
TP655 thru TP659		Same as TP650	
TP660		Same as TP650	
V601	5-2526	Tube, 6U8	Sylvania
V602	5-3301	Tube, 5965	
V603 thru V608		Same as V602	
XV601 thru XV608	4-2973	Socket, 9 pin	Elco 377BC


DIVIDE 1 MC
DIVIDE 100 KC
DIVIDE 10 KC
DIVIDE 1 KC
DIVIDE 100 CPS
DIVIDE 10 CPS
+120V
V607-B ½ 5965
V607-A ½ 5965
V608 5965
V602 5965
V603 5965
V604 5965
V605 5965
V606 5965
V601 6U8
ADJ 10-5 SEC.
ADJ 10-4 SEC.
ADJ 10-3 SEC.
ADJ 10-2 SEC.
ADJ 10-1 SEC.
ADJ 1 SEC.
CW
TP660
TP655
TP656
TP657
TP658
TP650 TP659
E5
E4
E3
E2
E1
E0
TIME SECONDS
S601 SWITCH POSITIONS
S601
TIME PULSE TRIGGER
TIME
J601
TIME TRIGGER LEVEL
MASTER SCHEMATIC DIAGRAM
OSCILLATOR FREQ.
HEATER CONNECTIONS
NOTE:
1) RESISTORS:
WATTAGE — ½W EXCEPT AS NOTED.
TOLERANCE — 5% " " " .
2) CAPACITORS:
CAPACITY — IN μμf " " " .

PARTS LIST, 100 KC FREQUENCY DIVIDER

Refer to Dwg. No. 7000 D 660

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

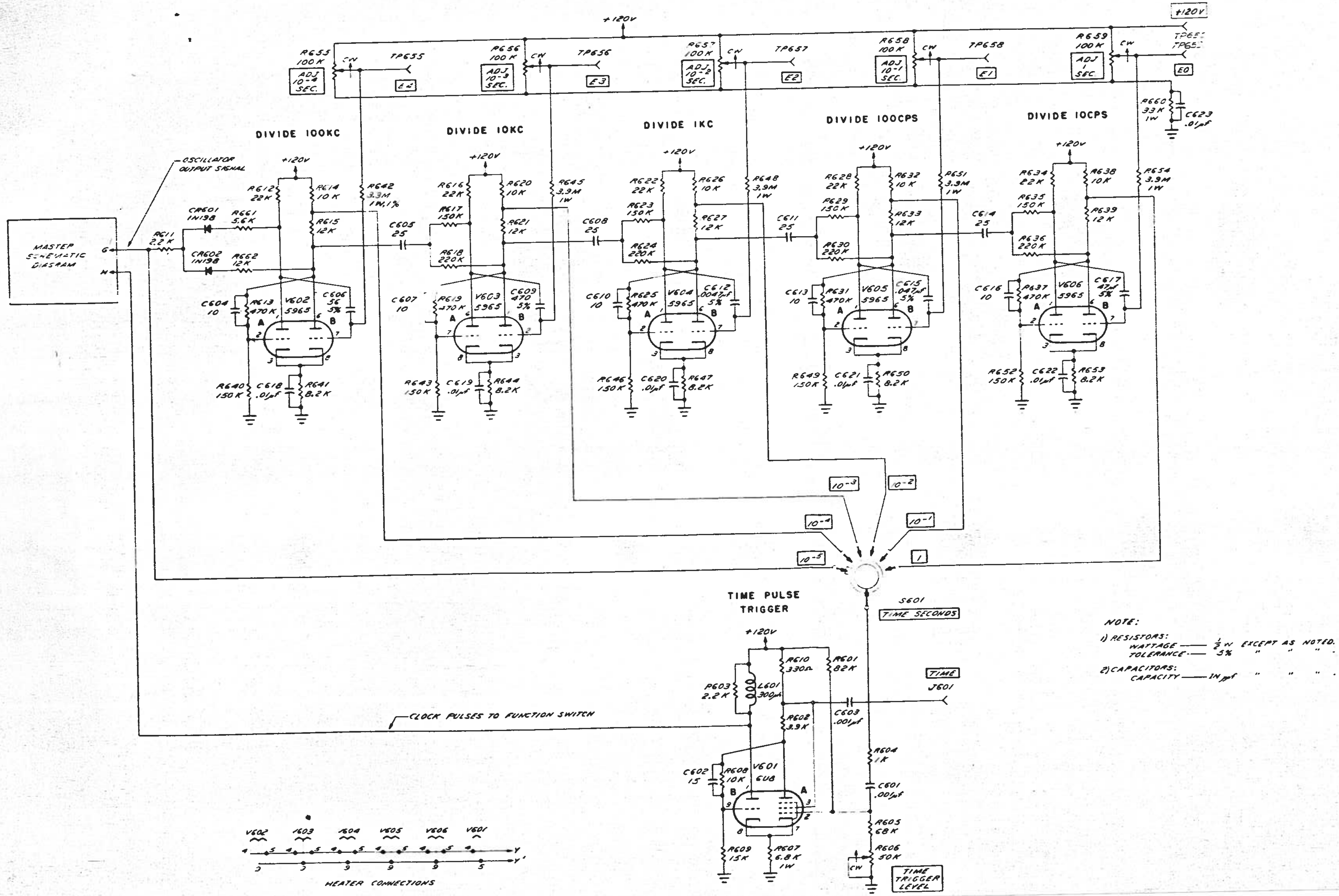
ABBREVIATIONS

AB	Allen-Bradley Company, Milwaukee, Wisconsin
AE	Automatic Electric Company, Northlake, Illinois
BDB	Berkeley Division Beckman, Richmond, California
d. c.	Deposited Carbon

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
C601	2-3242	Capacitor, ceramic, .001μf, 600V, 10%	Erie GPL-1000
C602	2-2135	Capacitor, mica, 15μμf, 500V, 5%	Sangamo RR1415
C603		Same as C601	
C604	2-2082	Capacitor, mica, 10μμf, 500V, 5%	Sangamo RR1410
C605	2-2138	Capacitor, mica, 25μμf, 500V, 5%	Sangamo RR1425
C606	2-3879	Capacitor, glass, 56μμf, 500V	Vitramon CY13C470JA
C607		Same as C604	
C608		Same as C605	
C609	2-3574	Capacitor, glass, 470μμf, 500V	Vitramon CY17C471JA
C610		Same as C604	
C611		Same as C605	
C612	2-4206	Capacitor, paper, .0047μf, 300V, 5%	Sprague 186P47253S3
C613		Same as C604	
C614		Same as C605	
C615	2-5603	Capacitor, paper, .047μf, 300V, 5%	Sprague 186P47353S3
C616		Same as C604	
C617	2-5604	Capacitor, paper, 0.47μf, 300V, 5%	Sprague 186P47453S3
C618	2-2230	Capacitor, ceramic, .01μf, 450V	Erie 811
C619 thru C623		Same as C618	

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
CR601	8-7274	Diode, 1N198	Hughes
CR602		Same as CR601	
J601	17-4985	Connector, coaxial	AE UG1094/U
L601	3-7317	Inductor, 300μh	Wilco 1300-15
R606	1-2318	Potentiometer, 50K, 2W, 20%	AB JU5032-SD3048
R642	1-7376	Resistor, 3.3M, 1W, 5%, d. c.	Electra DC-1
R645		Same as R642	
R648		Same as R642	
R651		Same as R642	
R654		Same as R642	
R655	1-1340	Potentiometer, 100K, 2W, 20%	AB JU1042-SD3048
R656 thru R659		Same as R655	
R660	1-3846	Resistor, 33K, 1W, 1%, d. c.	Electra DC-1
S601	12-5700	Switch, rotary	BDB
TP650	17-7637	Connector, tip jack	Whitso JNP-12
TP655 thru TP659		Same as TP650	
V601	5-2526	Tube, 6U8	Sylvania
V602	5-3301	Tube, 5965	
V603 thru V606		Same as V602	
XV601	4-2973	Socket, 9 pin	Elco 377BC
XV602 thru XV606		Same as XV601	

April 1961



NOTE:
1) RESISTORS:
WATTAGE — ½W EXCEPT AS NOTED.
TOLERANCE — 5% " " "
2) CAPACITORS:
CAPACITY — IN μf " " "

PARTS LIST, POWER SUPPLY

Refer to Dwg. No. 7370 C 100.

ABBREVIATIONS

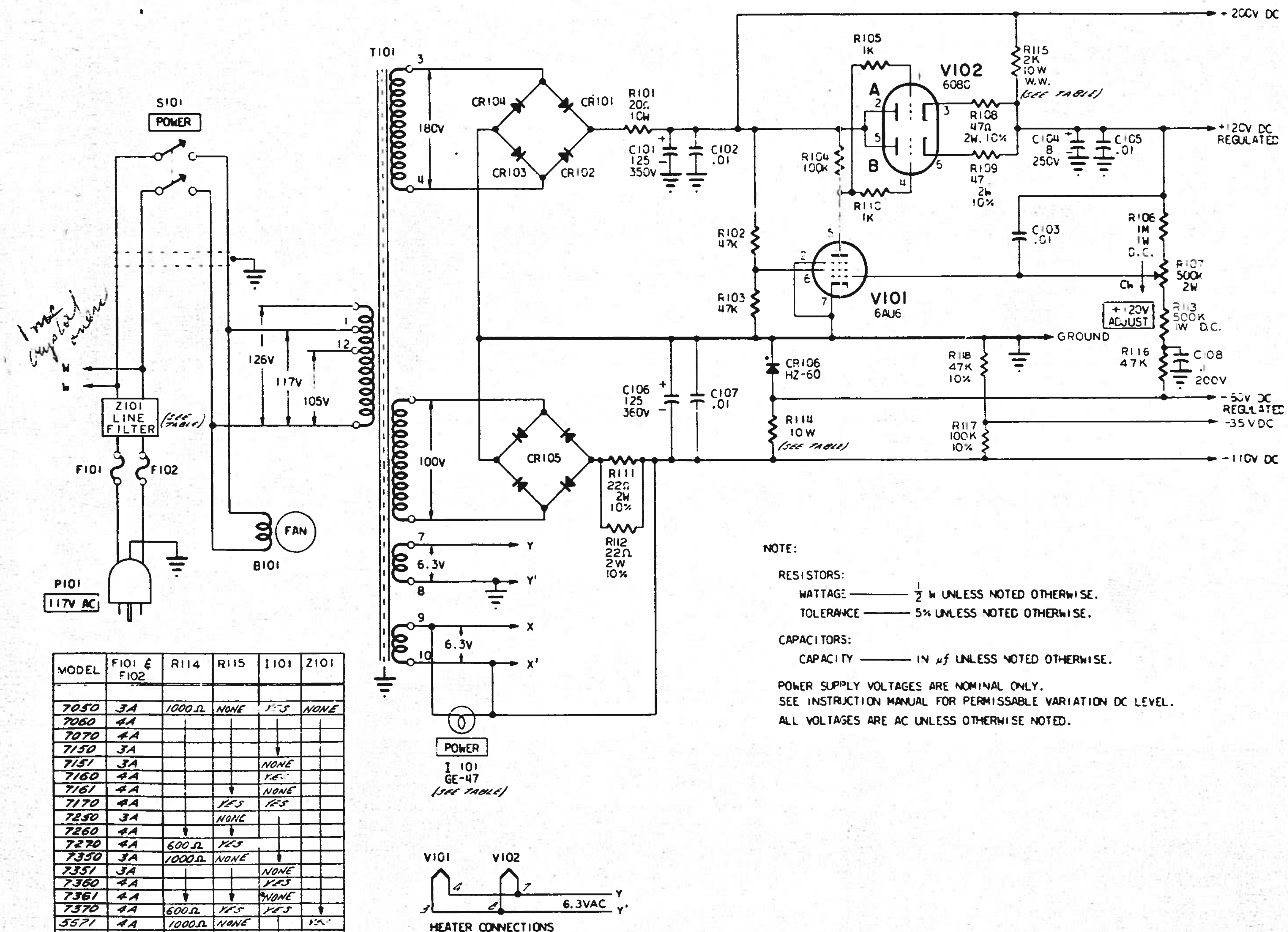
AB	Allen-Bradley Co., Milwaukee, Wis.
BDB	Berkeley Division Beckman, Richmond, Calif.
CH	Cutler-Hammer Co., Milwaukee, Wis.
DCF	Deposited carbon film
GE	General Electric, Schenectady, N.Y.
Gen. Ind.	General Industries, Elyria, Ohio
VDC	Volts direct current
WW	Wirewound

NOTE

Any resistor which does not appear in the list below is a fixed composition resistor of the value, wattage and tolerance noted on the schematic diagram. All other electrical components are listed.

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
B101	9-3390	Fan Motor	Gen. Ind. A5CW
C101	2-4254	Capacitor, 125µf, 350 v.	Mallory FP140
C102	2-2230	Capacitor, disc, .01µf	Erie Type 811-.01
C103		Same as C102	
C104	2-3982	Capacitor, electrolytic, 8µf, 250 v.	Sangamo MT 2508
C105		Same as C102	
C106		Same as C101	
C107		Same as C102	
C108	2-5937	Capacitor, 0.1µf, ±20%, 200VDC	Sangamo 330201
CR101	8-4425	Rectifier, silicon	Sarkes Tarzian M500
CR102		Same as CR101	
CR103		Same as CR101	
CR104		Same as CR101	
CR105	8-5633	Rectifier, 110 v rms, 110VDC, 130ma	GE 6R21PB3AT1
CR106	8-7228	Diode	BDB
F101	7-5824	Fuse, SloBlo, 4 amp., 125 v.	Littelfuse 313004 3 AG
F102		Same as F101	
I101	21-1677	Lamp	GE 47
R101	1-2927	Resistor, 20Ω, 10W	Tru-Ohm FRL-10
R106	1-6257	Resistor, DCF, 1 meg., 1W	Arnhold Ceramics Stemag Type A2
R107	1-2905	Potentiometer, Linear Carbon, 500K, 2W	AB JU 5041 SD 3048
R113	1-6258	Resistor, DCF, 500K, 1W	Arnhold Ceramics Stemag Type A2
R114 (All Models except 7270 & 7370)	1-0998	Resistor, WW, 1000Ω, 10W, 10%	Tru-Ohm FRL-10
R114 (Models 7270 & 7370)	1-7267	Resistor, WW, 600Ω, 10W	Tru-Ohm FRL-10
R115	1-1067	Resistor, WW, 2K, 10W	Tru-Ohm FRL-10
S101	12-1642	Switch, toggle, DPST	CH 8370 K8
T101	6-7265	Transformer, power	BDB
V101	5-0550	Tube, 6AU6	
V102	5-2625	Tube, 6080	
XCR101	24-4459	Spring Clip	Littelfuse 099062
XCR102		Same as XCR101	
XCR103		Same as XCR101	
XCR104		Same as XCR101	
XF101	4-3154	Fuse Post	Bussman HKP
XF102		Same as XF101	
XI101	4-1678	Lamp Socket Assy., green jewel	Dialco 81410-132
XV101	4-2972	Tube Socket, 7 pin	Elco 318BC
XV102	4-2377	Tube Socket, octal	Cinch 9950

POWER SUPPLY SCHEMATIC DIAGRAM



MODEL	F101 & F102	R114	R115	I101	Z101
7050	3A	1000Ω	NONE	YES	NONE
7060	4A				
7070	4A				
7150	3A				
7151	3A			NONE	
7160	4A			YES	
7161	4A			NONE	
7170	4A		YES	YES	
7250	3A		NONE		
7260	4A				
7270	4A	600Ω	YES		
7350	3A	1000Ω	NONE		
7351	3A			NONE	
7360	4A			YES	
7361	4A			NONE	
7370	4A	600Ω	YES	YES	
5571	4A	1000Ω	NONE		YES
7413 1016	4A				
7423 1026	4A				
7-3-57	4A			NONE	NONE

NOTE:

RESISTORS:
- WATTAGE — ½ W UNLESS NOTED OTHERWISE.
- TOLERANCE — 5% UNLESS NOTED OTHERWISE.

CAPACITORS:
- CAPACITY — IN μf UNLESS NOTED OTHERWISE.

POWER SUPPLY VOLTAGES ARE NOMINAL ONLY.
SEE INSTRUCTION MANUAL FOR PERMISSABLE VARIATION DC LEVEL.
ALL VOLTAGES ARE AC UNLESS OTHERWISE NOTED.

INSTRUCTION MANUAL

Models 775, 775AJ & 775K
DECIMAL COUNTING UNITS

Beckman
Berkeley Division
2500 Wright Avenue, Richmond 3, California
a division of Beckman Instruments, Inc.

1960

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

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BECKMAN INSTRUMENTS, INC.

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CONTENTS

ILLUSTRATIONS

INTRODUCTION

These decimal counting units are direct-reading, plug-in electronic counters. The number of input pulses received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. Any number of these units can be connected in cascade (the output of one unit driving the next) forming a counter whose total count capacity depends only on the number of DCU's. Thus, five units will count to 99,999 resetting to "00,000" on the 100,000th pulse.

Models 775 and 775K generate a binary coded decimal readout. This code is in the form of high or low voltages at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication

Direct reading, decimal presentation

Power Requirements

Heaters: 6.3 v. at 1.2 amps
Plates: 300 v. at 13 ma

Input Requirements

Negative pulses (see "OPERATION")

Output Characteristics

Designed to drive a Model 775 DCU or any modification except a 775LJ (i.e., 775AJ, 775K, etc.).

Resolution of Paired Pulses

5 microseconds

Reset

Will reset to either zero or nine depending on polarity of reset pulse applied.

Maximum Counting Rate

120,000 counts per second

Construction

Plug-in unit, 11-pin socket

OPERATION

Power Requirements. The heaters require 6.3 volts a-c at 1.2 amperes. The plate circuits may be operated on from 200 to 400 volts, although the design center is 300 volts at 13 ma. Plate voltage may be applied in the form of B + and B - voltages. The d-c level of all output voltages will depend upon the level of the plate supply voltages.

Input Requirements. A negative pulse at least two microseconds wide is required to drive the unit. The optimum pulse amplitude depends on the rise time. With a rise time of 0.5 microseconds (measured between ten and ninety percent values) the pulse amplitude should be between 75 and 135 volts. With a two-microsecond rise time, the amplitude should be between 120 and 165 volts. When operating the plate circuits on 300 volts, optimum performance is obtained with a rise time of one microsecond or less and a pulse amplitude of 100 volts. If the unit is powered by unregulated d-c supplies, the input pulse amplitude should vary in phase with the supply voltage. The input load presented when an input pulse occurs is 15K ohms in series with 100 picofarads ($\mu\mu$f).

Output Characteristics. The output is the rectangular waveform shown in Figure 3. As every tenth input pulse triggers the unit from count display "9" to count display "0", a negative transient occurs at pin 4 of the DCU plug. With a plate supply of 300 volts, the potential at pin 4 drops from +135 to +55 volts with respect to B-. This transient can be used to drive succeeding decimal counting units or other circuitry. The load impedance connected between the output terminal and ground must not be less than 300K or 6K in series with 100 picofarads.

Method of Resetting after a Counting Period. A DCU can be reset to a registered count of either zero or nine by the application of a voltage pulse of the proper polarity to the proper pin of the DCU plug. See the table below.

	RESET TO ZERO Pulse Polarity	Applied at Pin No.	RESET TO NINE Pulse Polarity	Applied at Pin No.
775	Neg.	8	Pos.	8
775AJ	Neg.	8	Pos.	8
	Pos.	3	Neg.	3
775K	Neg.	8	Pos.	8

The reset pin (or pins in the base of Model 775AJ) should be maintained at the B- supply voltage except when a reset pulse occurs. A 50-volt pulse at least 3μseconds wide is adequate. A 100-volt pulse need be only 1.5μseconds wide. There is no maximum pulse width; however the DCU will not begin counting again until the reset pin returns to the B- supply voltage.

Simply disconnecting a reset pin from B- with a switch or relay will have the same effect as applying a positive pulse.

Binary Code Readout. Models 775 and 775K generate a modified binary code representing the decimal digit registered. The code appears in the form of a voltage (high or low) at one plate of each of four double-triode binaries. In the table below, "0" represents a plate voltage of approximately +55 volts with respect to B-; "1" represents a plate voltage of about +135 volts with respect to B-. (These are the voltage levels which appear when using a 300-volt plate supply.) Each of the four plates is coupled to a pin of the DCU plug through a 1.2 megohm resistor except in the case of pin 4 on the 775K DCU. This pin is connected directly to a plate of the fourth binary. To obtain a readout voltage at this pin, it is necessary to add a 1.2M resistor externally.

DECIMAL DIGIT REGISTERED	FOUR - LINE BINARY CODE 1st Binary Stage	2nd Binary Stage	3rd Binary Stage	4th Binary
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1

Extinguishing the Indicating Lamps During the Counting Period. On Models 775 and 775K, it is possible to prevent the neon lamps from lighting by placing approximately +100 volts with respect to B- on pin 10 of the DCU plug. Ordinarily, the user will wish to extinguish the lamps while the DCU is actively counting, and to allow them to light, indicating the registered count, at the end of a counting period.

CIRCUIT DESCRIPTION

The Binaries. The decimal counting units contain four "flip-flop" circuits. These circuits are slightly modified versions of the Eccles-Jordan trigger circuit. They are referred to here as binaries.

Figure 1 is a schematic diagram of a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut

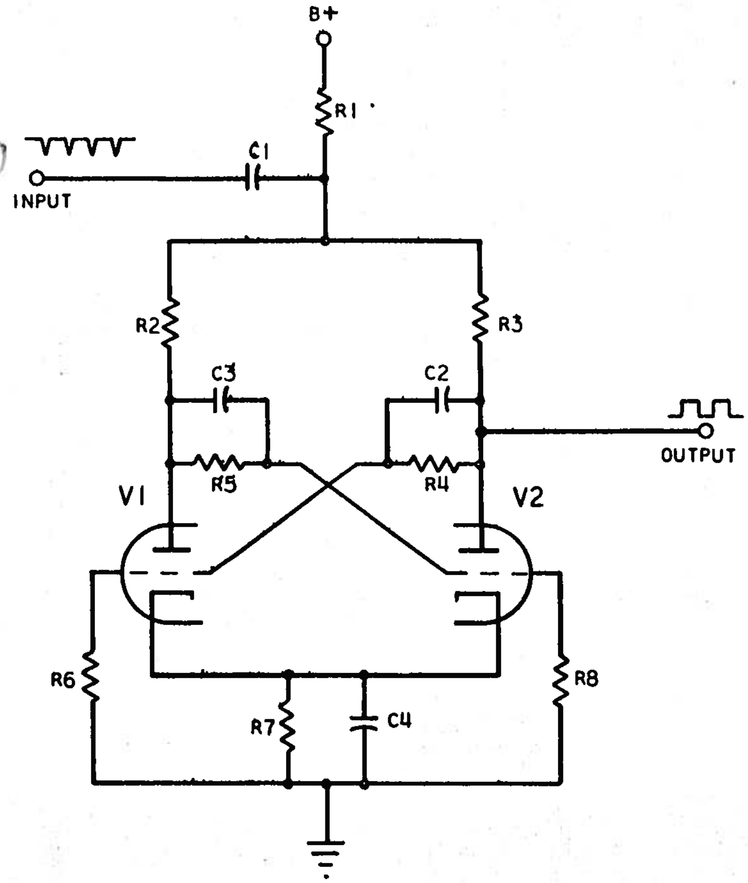


FIGURE 1. A TYPICAL BINARY.

off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B- voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R5 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R4 and R6, holds this grid several volts below cut-off. Since small changes in the potential at the grid of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

The circuit is triggered from one state to another by negative pulses applied at the input. For example, assume that V2 is conducting and V1 is cut off. If a negative pulse is applied to the input, there is a drop in the plate voltage of V1. This drop in voltage is transmitted through a crossover network (R5, R8, C3 and the grid-to-ground capacitance of V2) and applied to the grid of V2. The plate voltage of V2 then starts to rise, carrying with it the grid of V1. If the input pulse is of sufficient amplitude, V1 begins to conduct. The moment V1 conducts, the drop in voltage at its plate, coupled to the grid of V1, reinforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut off and V1 is conducting at a steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input transients applied, making it a scale-of-two. The output is the drop in voltage at one of the plates as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next) a counter having a scale of any power of two can be built.

The Scale of Ten. In the Model 775 four binaries are connected in cascade forming a scale-of-16 which is permuted to a scale-of-10 by two positive feedback paths. (See Figures 2 and 3). For the first three negative input pulses, the unit operates like a simple binary counter. At the fourth input pulse, the third binary is triggered for the first time, sending a pulse through the first feedback path which triggers the second binary. Since it requires two input pulses to trigger the second binary, this is equivalent to adding two input pulses; therefore, the state of the unit now

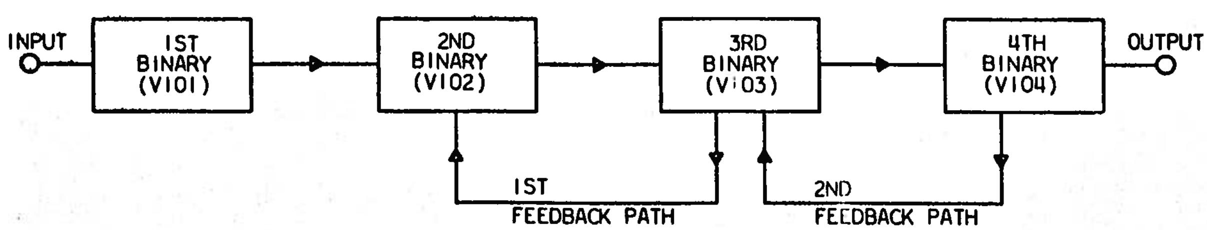


FIGURE 2. BLOCK DIAGRAM.

corresponds to a binary count of six. The sixth input pulse (equivalent to the eight in a simple binary chain) triggers the fourth binary which sends a pulse through the second feedback path, triggering the third binary. This is equivalent to adding four more input pulses so the state of the unit now corresponds to a binary count of 12. For the next four input pulses (7 thru 10) the unit operates again as a simple binary chain, producing an output pulse at the tenth input pulse. Adding the equivalent of six input pulses internally has changed the binary chain from a scale-of-16 to a scale-of-10.

When the third binary is triggered by a feedback pulse, it tends to retrigger the second binary in the same way that it did at the time of input pulse four. This tendency is offset by a simultaneous opposing signal from the fourth binary.

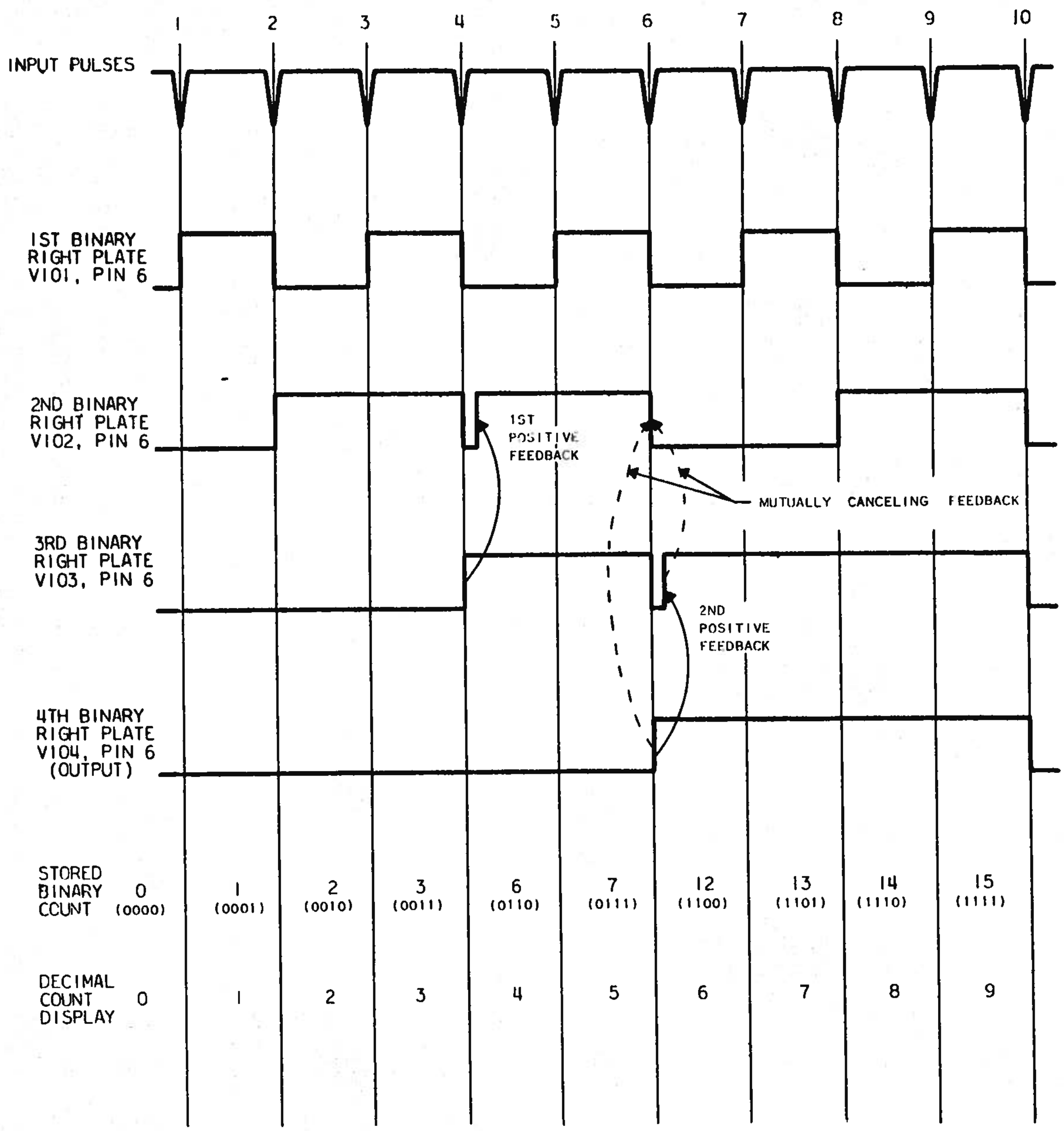


FIGURE 3. IDEALIZED WAVEFORMS. "RIGHT PLATE" REFERS TO THE PLATE APPEARING ON THE RIGHT-HAND SIDE OF THE BINARY AS DRAWN ON THE SCHEMATIC.

TROUBLESHOOTING PROCEDURES

When a decimal counting unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Because the counting unit is usually the indicating device of an instrument, it is often accused of operating incorrectly when the fault is external to it.

Two methods are recommended for locating a defect in a DCU. The first is to observe the lighting sequence while driving the unit at a slow pulse rate. The second is to study the output waveform of each binary while driving the unit fast enough to create an oscilloscope display. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. The table of common troubles lists the probable defects indicated by particular variations from the proper lighting sequence. Binary output waveforms may be compared with the idealized waveforms of Figure 3 and the photographs appearing in Figure 4 & 5.

A table of typical voltages and resistances has been provided to help the serviceman locate a defect within one of the binary stages. Values may deviate considerably from those given without causing trouble. The fact that the unit is designed to operate at plate supply voltages ranging from 200 to 400 volts is a rough indication of permissable tolerances.

TROUBLESHOOTING CHART

NOTE: **Reset unit to zero before testing for symptoms**

SYMPTOMS	POSSIBLE CAUSES
Unit Fails to Count	(a) Insufficient supply voltage. (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity. (d) First stage inoperative.
Unit Counts Spuriously	(a) Extraneous input signals. (b) Pulses received through power supply. (c) External voltages picked up by output lead.
Unit Counts Erratically	(a) Input signal too large or small, incorrect rise time. (b) Supply voltage fluctuating too much.
Unit Fails to Reset	(a) Stray counts from reset switch or associated circuitry. (b) Defective component.

Unit counts regularly but neon bulbs light in wrong sequence and the pattern of lighting is repeated consistently after a definite number of input pulses. One or more bulbs may be lit simultaneously during a cycle but the number of states per cycle remains constant.

1. Unit skips every other number
   - (a) First stage defective.
   - (b) Input circuit supplies double pulses.

2. Two stable states per cycle.
   - (a) Second stage defective(Display sequence may be 01 or 45).
   - (b) Loss of drive to second stage (01).

3. Four stable states per cycle.
   - (a) Third stage defective (Display sequence may be 0123 or 6789).
   - (b) Loss of drive to third stage (0123).

4. Six stable states per cycle.
   - (a) Output excessively loaded (Display sequence may be 012345).
   - (b) Last stage inoperative (Display sequence may be 1 012345 or $67^{89}_{23}89$.*
   - (c) Loss of drive to fourth stage (Display sequence may be 012345).

5. Eight stable states per cycle or any failure where two successive numbers are skipped.
   - (a) Second or third stage failure.

6. Ten stable states per cycle, but the lighting sequence is incorrect.
   - (a) When the wrong neon lamp lights, the trouble is usually a defect in the lamp that should have lit, but it may be a defect in the lamp that lit improperly. It's also possible that more than one lamp will light in place of the correct one.

7. Twelve stable states per cycle.
   - (a) When lighting sequence is $0123^{01}_{45}456789$* the cause may be a failure of the first feedback or lowered cathode emission in first or second binary.
   - (b) When the lighting sequence is $01234567^{23}_{89}89$ the cause may be failure of the second feedback or low cathode emission in third or fourth binary.

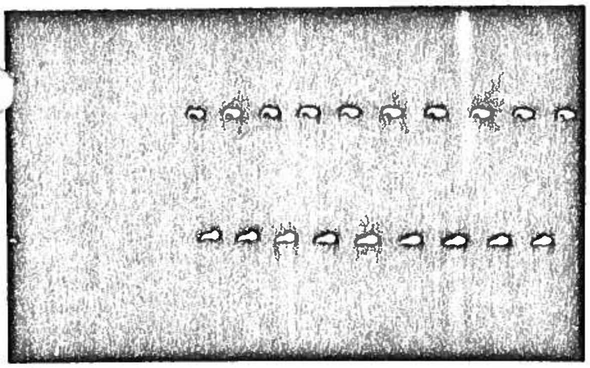
* One digit above another means both lamps are lit.

TABLE OF VOLTAGES & RESISTANCES

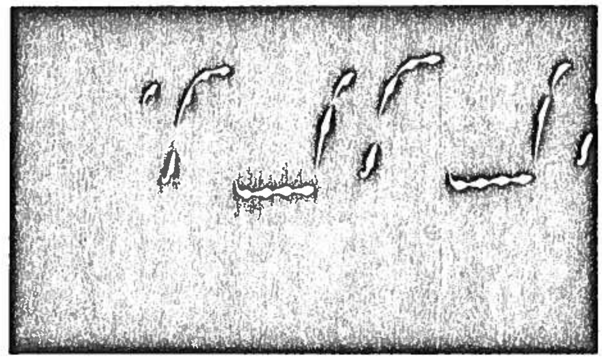
Tube	Pin No.	D-C Voltage with respect to B-.*	Resistance to B minus Terminal**
V101	1	170	105K
	2	17	85K
	3, 8	37	12K
	4, 5, 9	Filaments	
	6	60	105K
	7	37	85K
V102	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K
V103	1	135	100K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	100K
	7	30	83K
V104	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K

* Voltages measured in unit with 300-volt plate supply

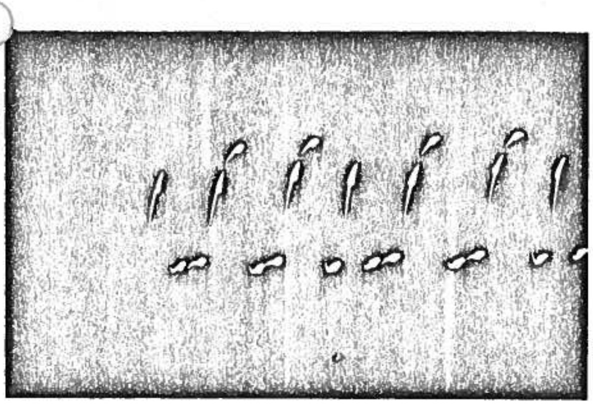
** Before making resistance measurements jumper pins 3 and 8 on the DCU plug.



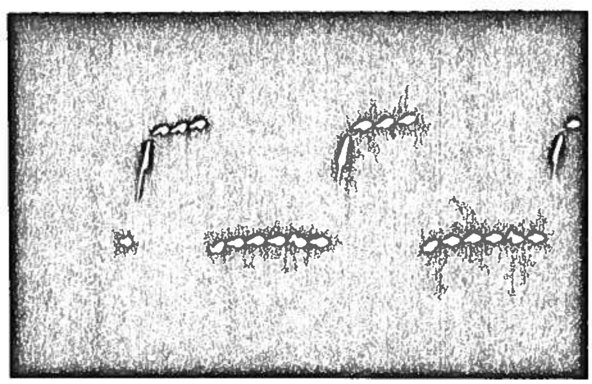
(1) First Binary Output (V101, Pin 6).
Upper voltage level is +168v
Lower voltage level is +55v



(2) Second Binary Output (V102, Pin 6)
Upper voltage level is +140v
Lower voltage level is +55v.

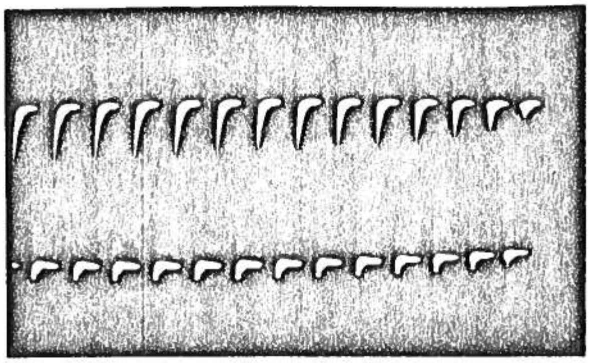


(3) Third Binary Output (V103, Pin 6)
Upper voltage level is +140v.
Lower voltage level is +55v.

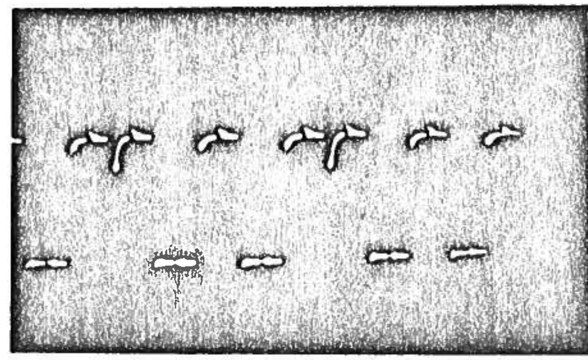


(4) Fourth Binary Output (V104, Pin 6).
Upper voltage level is +140v.
Lower voltage level is +55v.

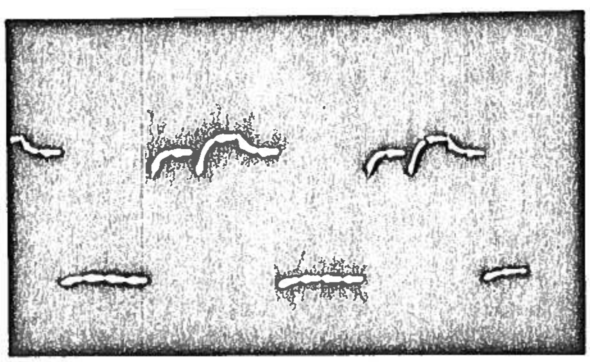
FIGURE 4. BLANKED WAVEFORMS AT INPUT FREQUENCY OF 100KC. ALL VOLTAGE LEVELS ARE MEASURED WITH RESPECT TO B MINUS.



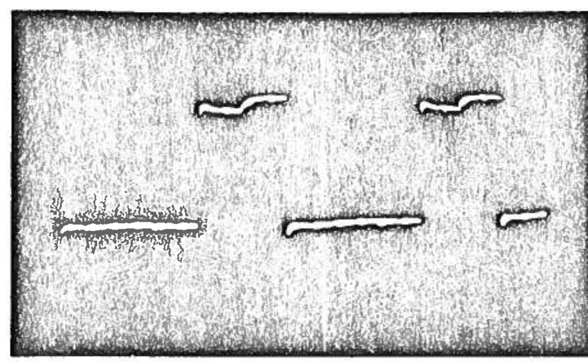
(1) First Binary Output (V101, Pin 6).
Upper Voltage level is +168V
Lower voltage level is +55v



(2) Second Binary Output (V102, Pin 6)
Upper voltage level is +140v
Lower voltage level is +55v.



(3) Third Binary Output (V103, Pin 6)
Upper voltage level is +140v.
Lower voltage level is +55v



(4) Fourth Binary Output (V104, Pin 6).
Upper voltage level is +140v.
Lower voltage level is +55v.

FIGURE 5. BLANKED WAVEFORMS AT INPUT FREQUENCY OF 20KC. ALL VOLTAGE LEVEL'S ARE MEASURED WITH RESPECT TO B MINUS.

COMPONENT LOCATION GUIDE

REFERENCE NO.	COMPONENT BOARD LOCATION		
	MODEL 775 FIG. 7	MODEL 775 AJ FIG. 9	MODEL 775 K FIG. 11
C101	B 17	B 17	B 17
C102	B 18	B 18	B 18
C103	C 12	C 12	C 12
C104	C 7	C 7	C 7
C105	A 19	A 19	A 19
C106	A 21	A 21	A 21
C107	A 13	A 13	A 13
C108	A 15	A 15	A 15
C109	A 8	A 8	A 8
C110	A 10	A 10	A 10
C111	A 3	A 3	A 3
C112	A 5	A 5	A 5
C113*	A 17	A 17	A 17
C114*	A 12	A 12	A 12
C115*	A 7	A 7	A 7
C116*	A 2	A 2	A 2
C117	B 8	B 8	B 8
C118	C 6	C 6	C 6
C119	B 12	B 12	B 12
C120	-	D 2	-
CR101	-	D 20	D 20
CR102	-	D 18	D 19
R101	D 21	D 21	D 21
R102	D 17	D 17	D 17
R103	D 16	D 16	D 16
R104	D 15	D 15	D 15
R105	D 14	D 14	D 14
R106	D 13	D 13	D 13
R107	D 11	D 11	D 11
R108	D 8	D 8	D 8
R109	D 6	D 6	D 6
R110	D 5	D 5	D 5
R111	D 4	D 4	D 4
R112	D 3	D 3	D 3
R113	C 19	C 19	C 19
R114	C 14	C 14	C 14
R115	C 9	C 9	C 9
R116	C 4	C 4	C 4
R117	C 20	C 20	C 20
R118	C 17	C 17	C 17
R119	C 21	C 21	C 21
R120	C 18	C 18	C 18
R121	C 16	C 16	C 16
R122	C 13	C 13	C 13
R123	C 11	C 11	C 11
R124	C 8	C 8	C 8
R125	C 5	C 5	C 5
R126	C 3	C 3	C 3
R127	A 18	A 18	A 18
R128	A 20	A 20	A 20
R129	A 14	A 14	A 14
R130	A 16	A 16	A 16
R131	A 9	A 9	A 9
R132	A 11	A 11	A 11
R133	A 4	A 4	A 4
R134	A 6	A 6	A 6
R135	B 19	B 19	B 19
R136	B 20	B 20	B 20
R137	B 14	B 14	B 14
R138	B 15	B 15	B 15
R139	B 9	B 9	B 9
R140	B 10	B 10	B 10
R141	B 4	B 4	B 4
R142	B 5	B 5	B 5
R143	A 17	A 17	A 17
R144	A 12	A 12	A 12
R145	A 7	A 7	A 7
R146	A 2	A 2	A 2
R147	B 13	B 13	B 13
R148	C 10	C 10	C 10
R149	D 2	-	-
R150	D 7	-	D 7
R151	D 12	-	D 12
R152	D 18	-	D 18
R162	B 6	B 6	B 6
R163	-	D 9	-
R164	-	D 19	-

*Reverse side of board

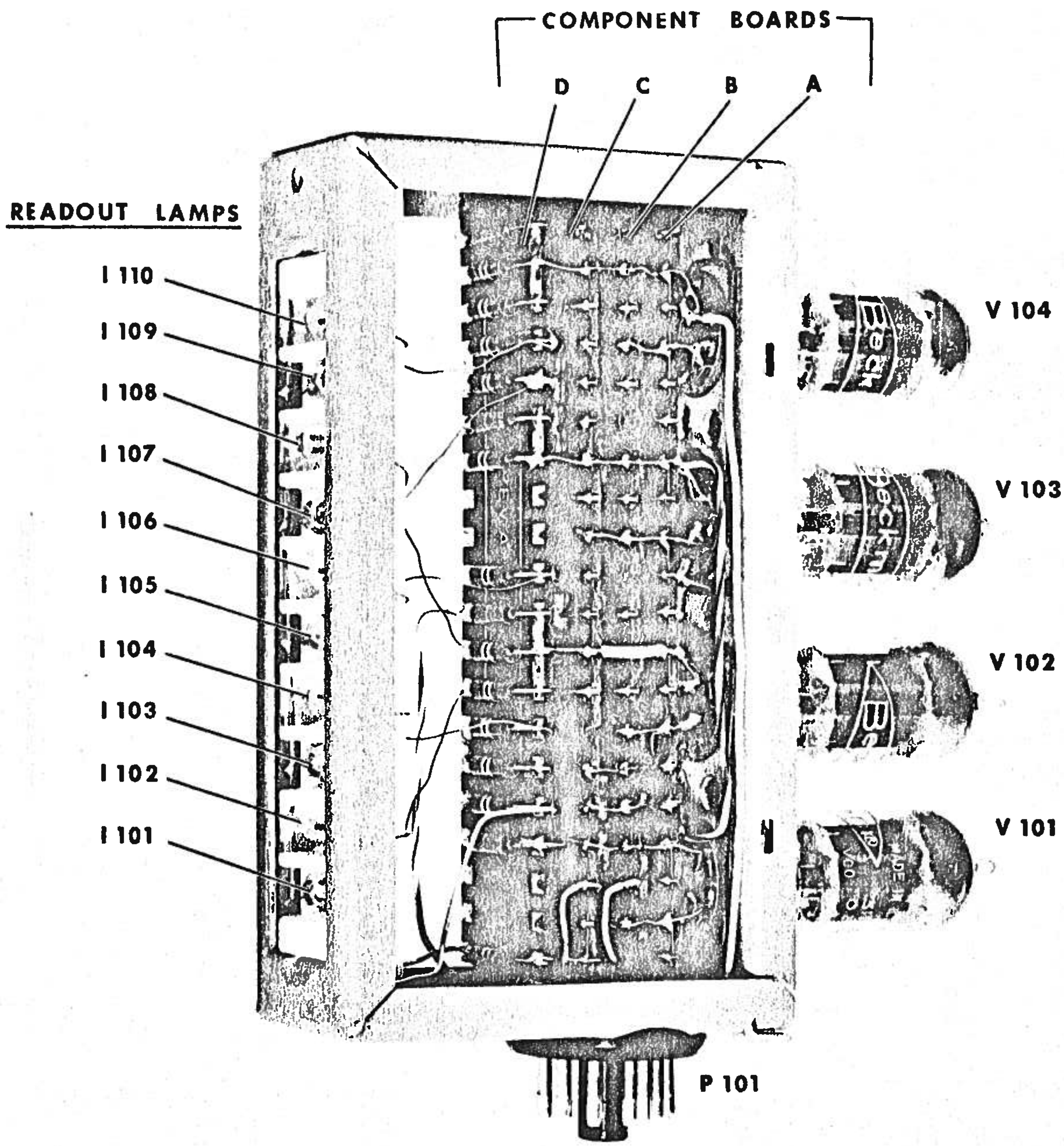


FIGURE 6. MODEL 775 DCU WITH NUMBER MASK REMOVED.

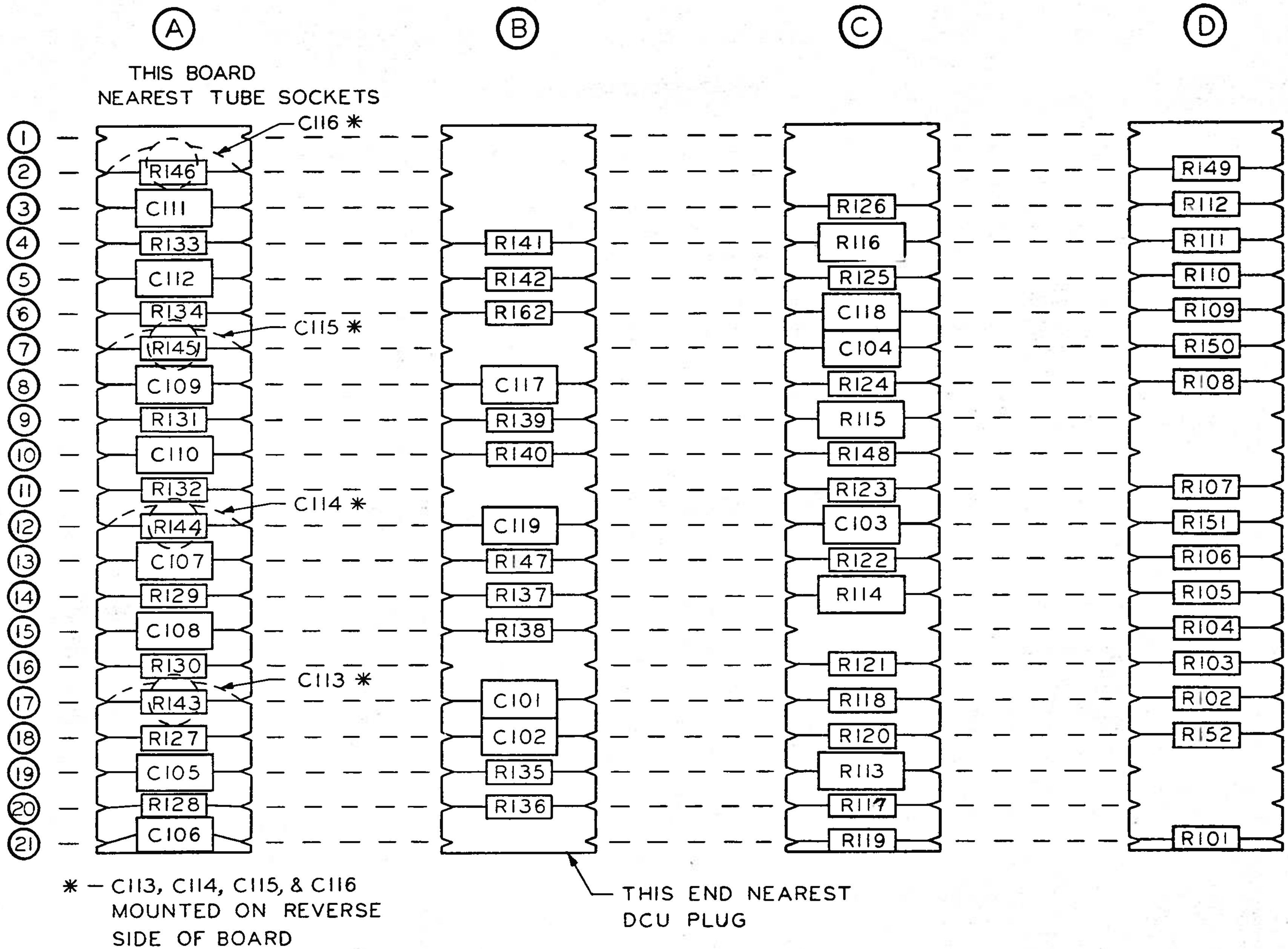


FIGURE 7. MODEL 775 COMPONENT BOARD LAYOUT.

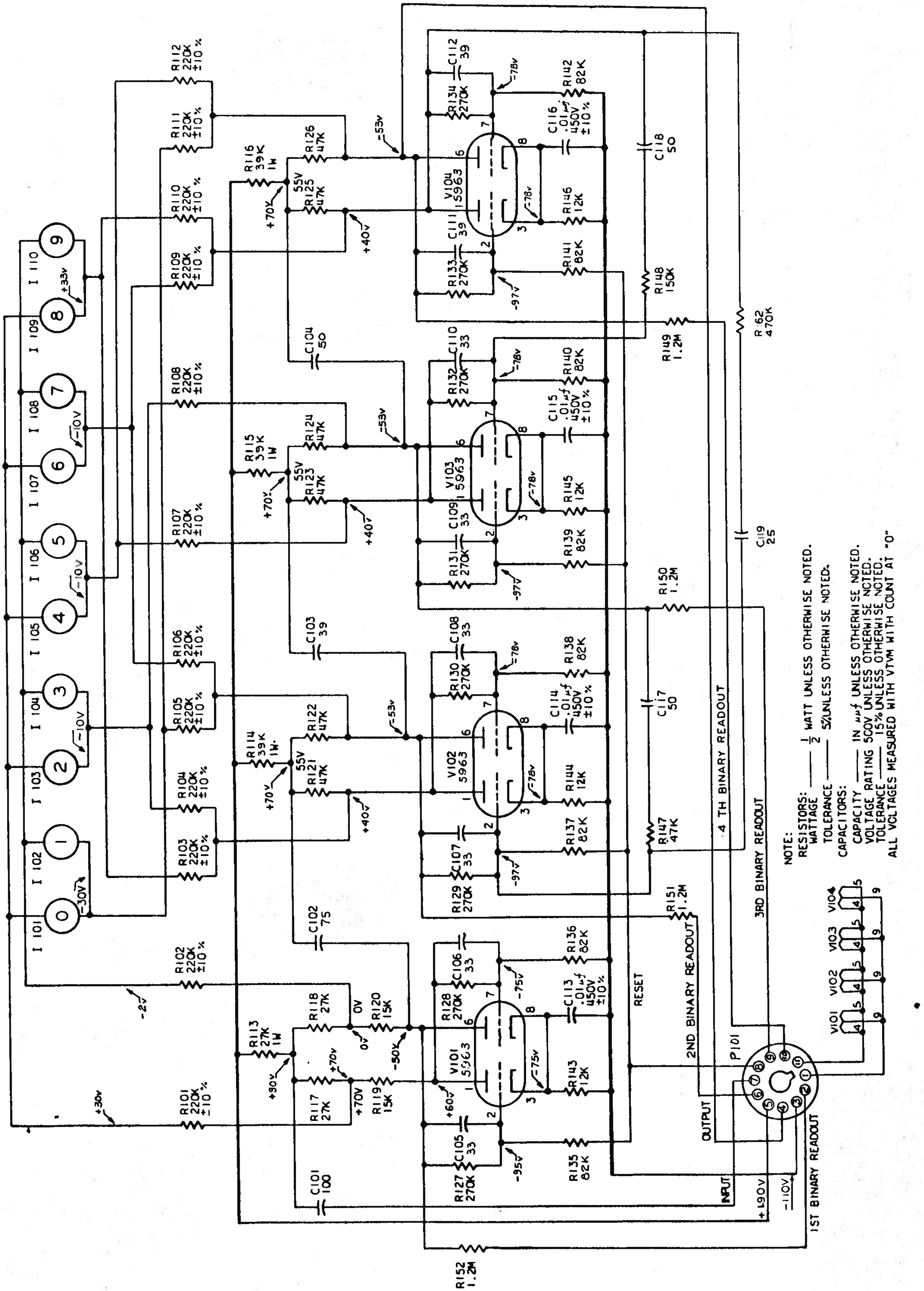


FIGURE 8. MODEL 775 SCHEMATIC DIAGRAM.

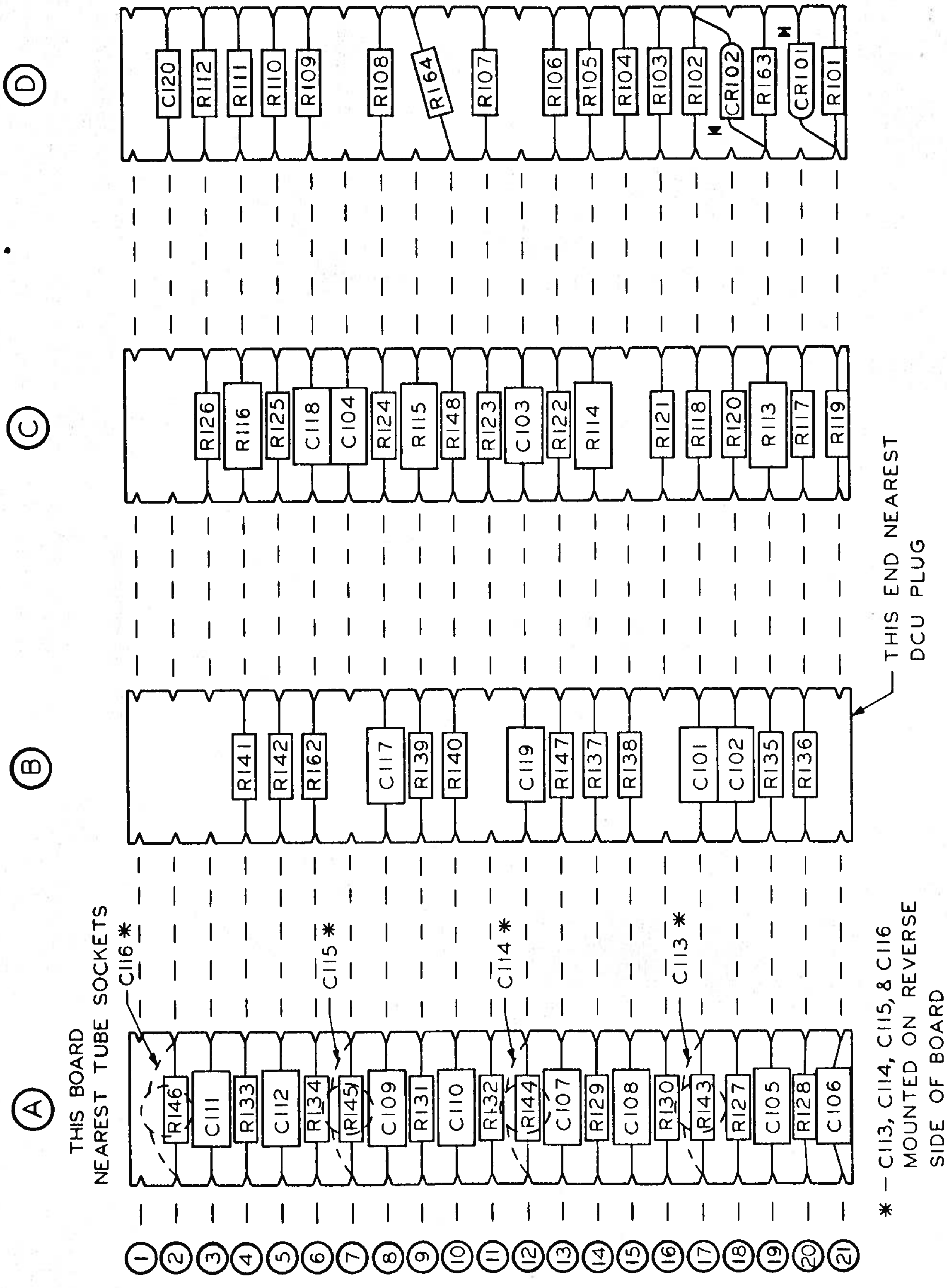


FIGURE 9. MODEL 775AJ COMPONENT BOARD LAYOUT.

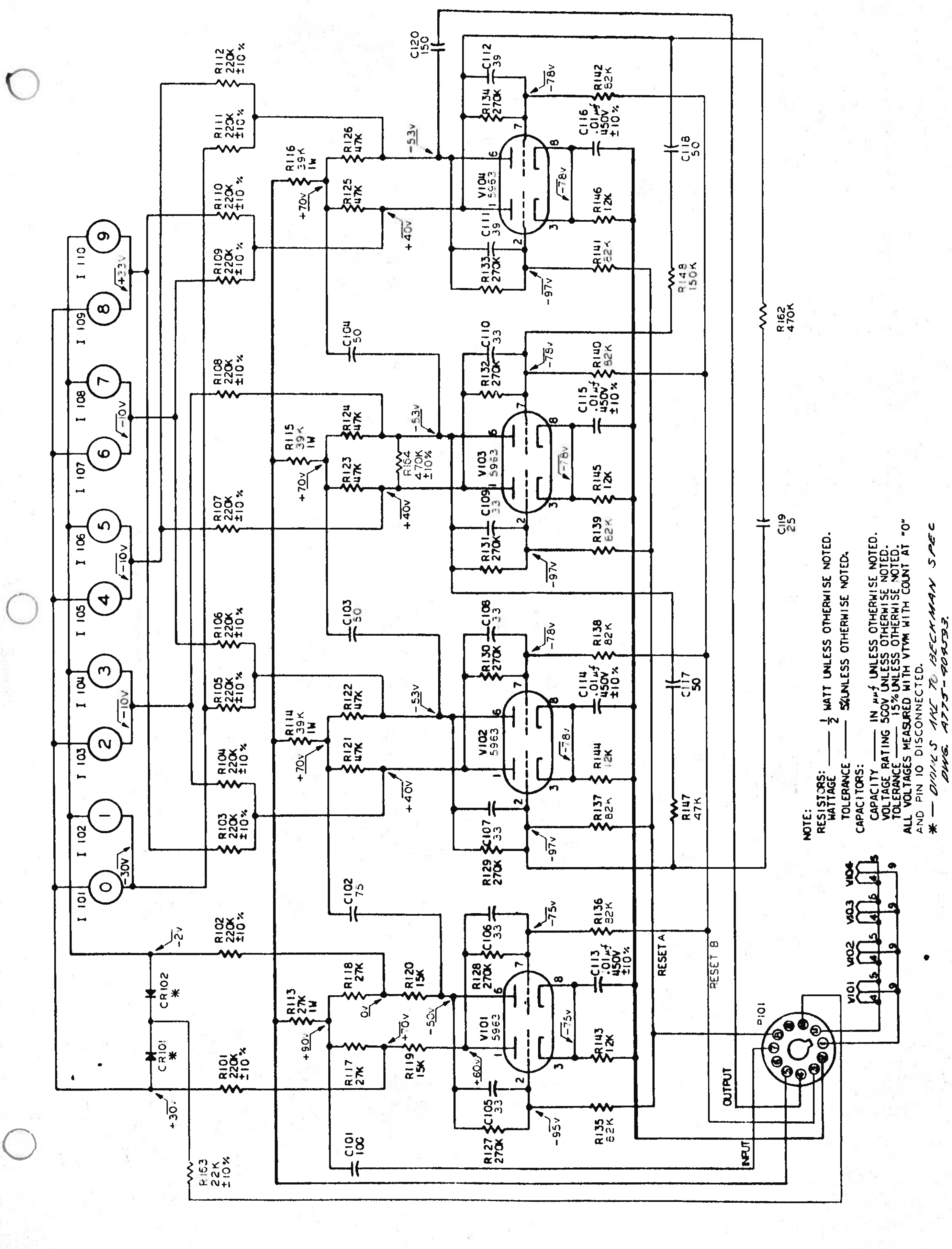


FIGURE 10. MODEL 775AJ SCHEMATIC DIAGRAM.

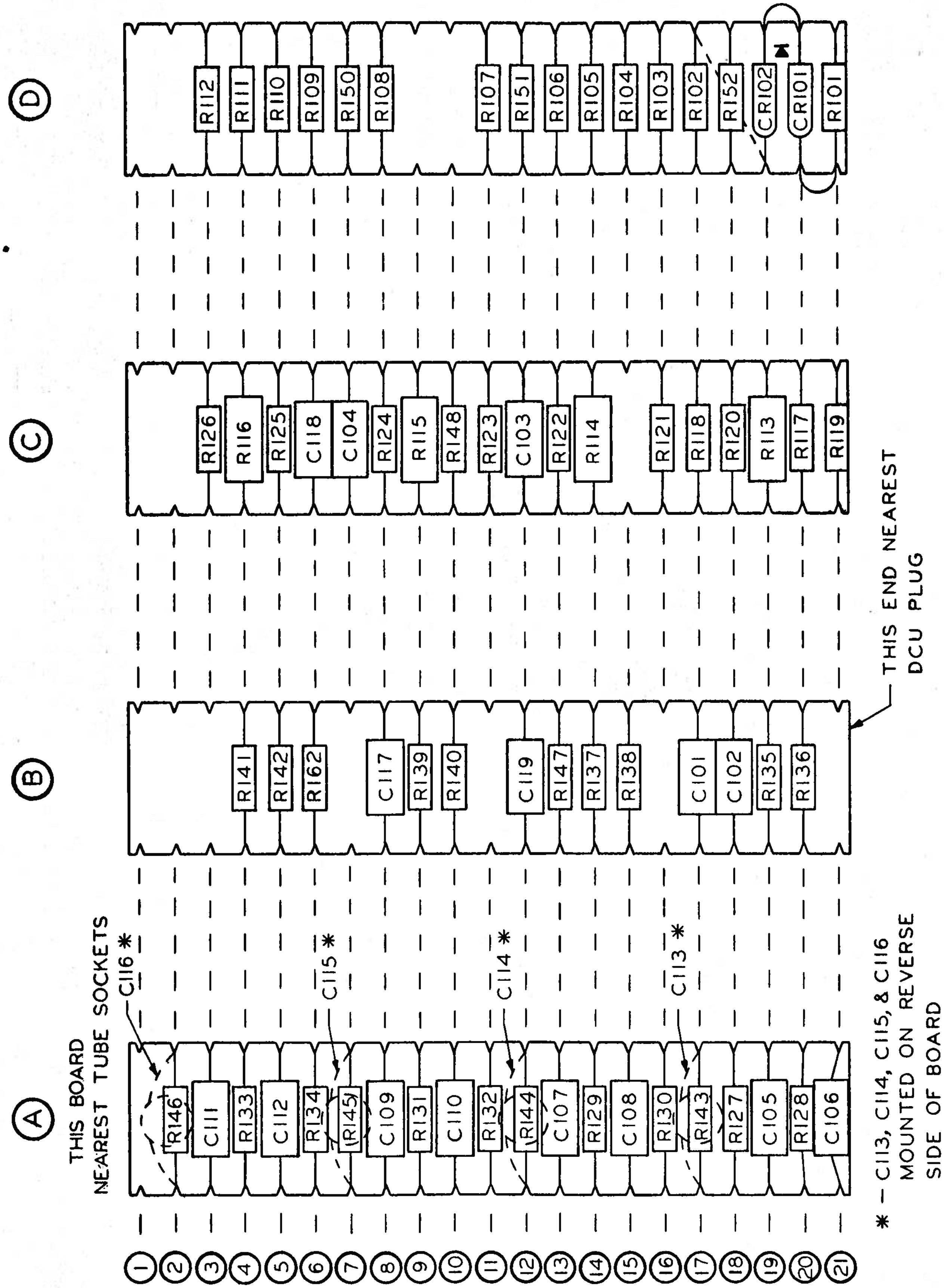


FIGURE 11. MODEL 775K COMPONENT BOARD LAYOUT.

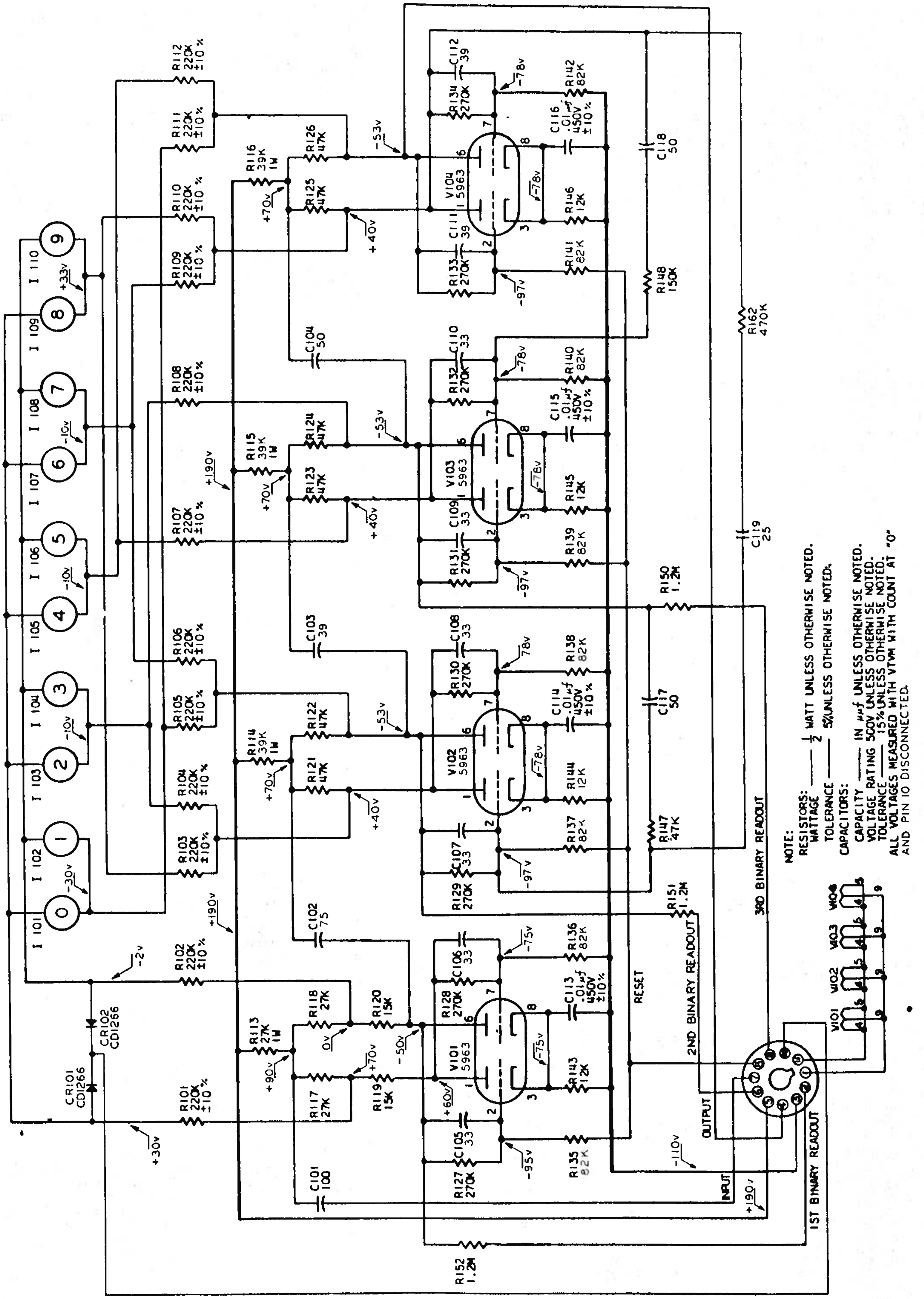
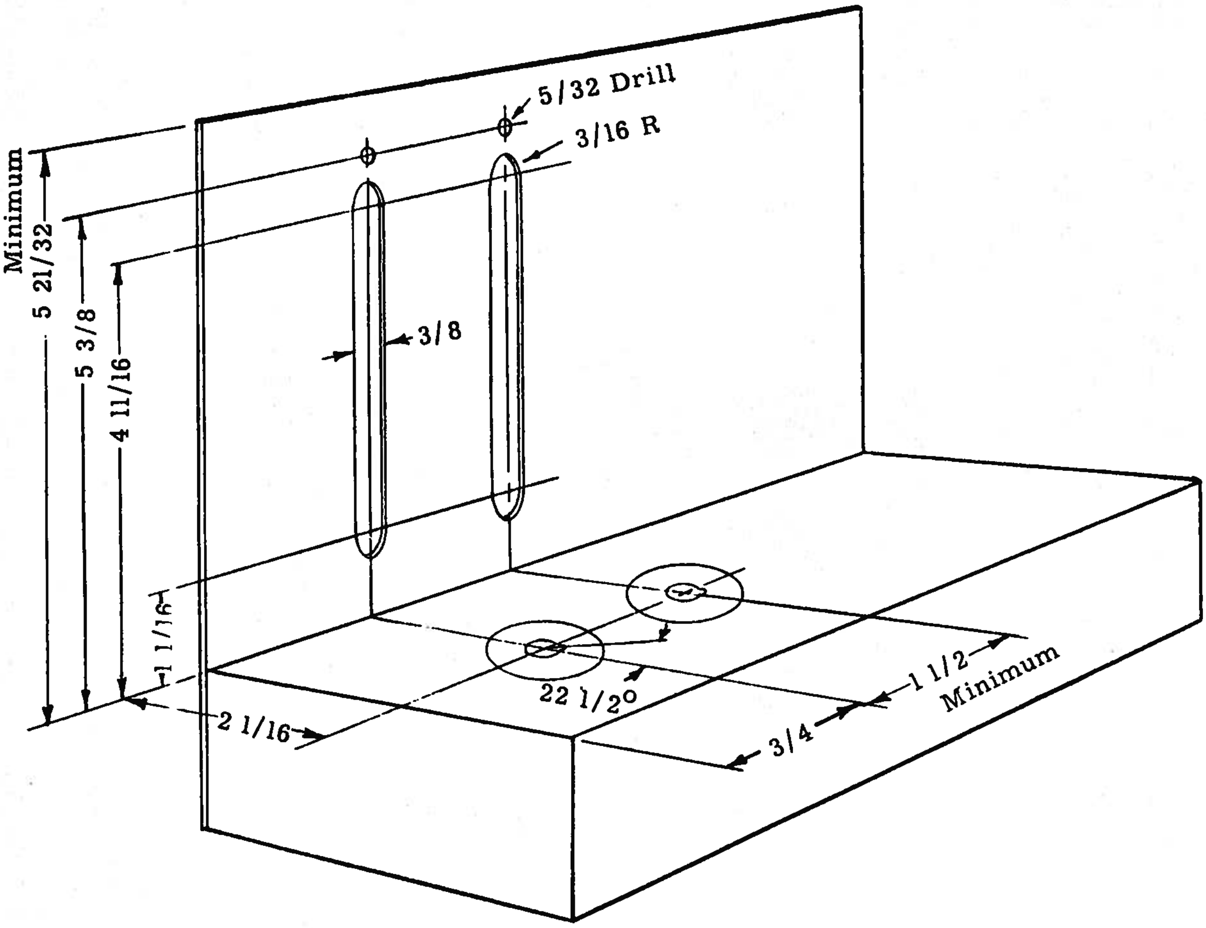


FIGURE 12. MODEL 775K SCHEMATIC DIAGRAM.



NOTE: Dimensions are based on the use of an Amphenol "MIP" 8 or 11-pin socket mounted above the chassis.

FIGURE 13. MOUNTING DIMENSIONS FOR MODEL 775, 775AJ, AND 775K.

Instruction Manual

MODEL 785A
DECIMAL COUNTING UNIT

Beckman
Berkeley Division
2200 Wright Avenue, Richmond 3, California
a division of Beckman Instruments, Inc.

1960

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

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BECKMAN INSTRUMENTS, INC.

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CONTENTS

ILLUSTRATIONS

GENERAL DESCRIPTION

The Model 785A is a direct-reading, plug-in decimal counting unit. A decimal counting unit (DCU) registers voltage pulses applied at an input. Starting from zero it counts to nine, returning to zero on the tenth pulse and simultaneously generating an output signal. The count score is indicated by the illumination of one of ten neon lights placed behind a numbered acetate panel. This unit will count at a maximum rate of 1, 100, 000 pulses per second. This output is suitable for driving a Model 775 DCU or any modification of it (775AJ, 775K, etc.) except a 775LJ. Decimal counting units may be connected in cascade (output of one to input of next), thus forming a counter whose total capacity depends only on the number of units in the chain. For example, a chain consisting of one 785A followed by five 775's will count to 999, 999, returning to "000, 000" on the 1, 000, 000th input pulse.

The unit also generates a binary-coded decimal readout in the form of high or low voltages at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication
: Illuminated decimal digits

Input Requirements
: Negative pulses. (See "OPERATION")

Resolution of Paired Pulses
: 0.8 microseconds

Maximum Counting Rate
: 1, 100, 000 counts per second

Output Characteristics
: Designed to drive a Model 775 DCU or any modification of it except a 775LJ. (See "OPERATION".)

NOTE: The 785A will also drive the 705 series DCU's since the latter are interchangeable with the 775 series.

Reset
: Reset to zero by negative pulse applied to pin 8 of plug.

Power Requirements
: Heaters: 6.3V a-c at 1.8 amps near ground potential.

Plates
: 175 to 260 volts. (Design center is 210 volts at 45 ma.)

Construction
: Plug-in unit which fits into standard 11-pin tube socket.

Dimensions
: 1-3/8" by 5" by 5-3/8"

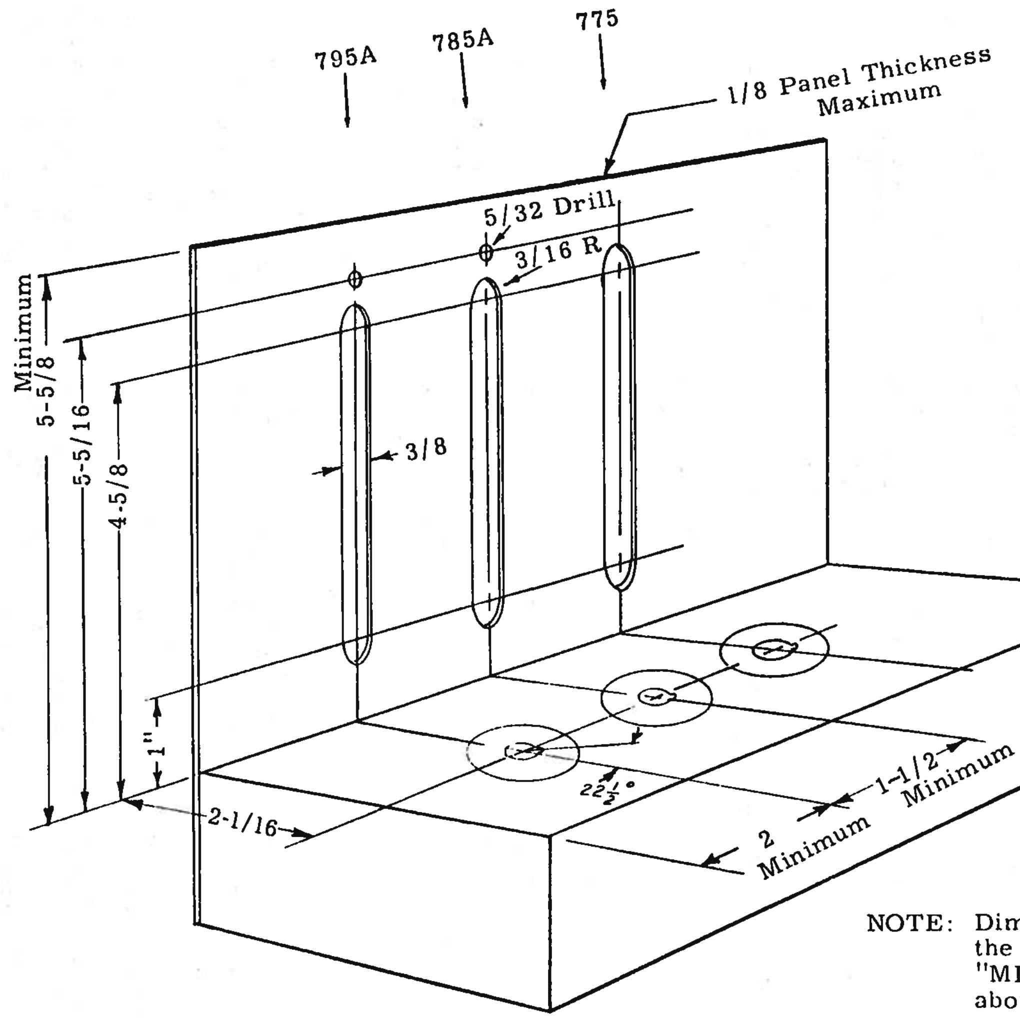
Weight
: 1 pound

Tube Complement
: Four type 12AV7.

INSTALLATION AND OPERATION

When purchased as part of another instrument, the decimal counting units are fully installed and ready to function. DCU's purchased separately should be installed and operated in accordance with the directions that follow.

Mounting. Figure 1 shows the dimensions of a chassis suitable for mounting one of these DCU's together with a Model 795A (10MC) and a Model 775 (100KC).



NOTE: Dimensions are based on the use of an Amphenol "MIP" socket mounted above the chassis.

The drawing shows the chassis dimensions for mounting Models 795A, 785A, and 775 DCU's side by side. Spacing between all units (or additional units) is identical.

FIGURE 1.

MOUNTING DIMENSIONS FOR MODEL 785A OR 795A DECIMAL COUNTING UNIT

INPUT REQUIREMENTS

A negative pulse of 7 volts peak amplitude is required to trigger the unit. The rise time should be less than 0.12 microseconds, and the duration at least 0.25 microseconds. When the unit is powered by an unregulated supply, the drive amplitude should be proportional to the actual B+ voltage.

OUTPUT CHARACTERISTICS

The output is a rectangular waveform as shown in Figure 4. It is represented at the output terminal as a change in direct current voltage level. During count display "0" thru "3" it is 115 volts; during count display "4" thru "9", 205 volts. Ordinarily, the 90-volt negative transient produced at the count of ten drives the following decimal counting unit.

The load imposed on a unit must not be more than a 27,000 ohm resistor in series with a 39 $\mu\mu f$ capacitor to ground.

METHOD OF RESET

Regardless of the number of units, all may be set back to zero by applying a negative pulse to a common line connected to pin 8 of the 11-pin socket.

BINARY CODE READOUT

The output at pins 2, 6, 9, and 10 of the DCU plug may be used to operate another binary coded readout or printing device. Refer to the Binary Readout Code table on page 6 to learn the relationship between binary digits and plug terminal pins.

CIRCUIT DESCRIPTION

THE BINARIES

The Model 785A DCU contains four "flip-flop" circuits referred to here as binaries. These circuits are modifications of the Eccles-Jordan trigger circuit.

Figure 2 shows a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut off, or V2 conducting and V1 cut off. Suppose V1 is not conducting; then its plate is near the B+ voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R4 and R8, raises this grid above cutoff and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R3 and R7, holds this grid several volts below cutoff. Since small changes in the potential at the grid

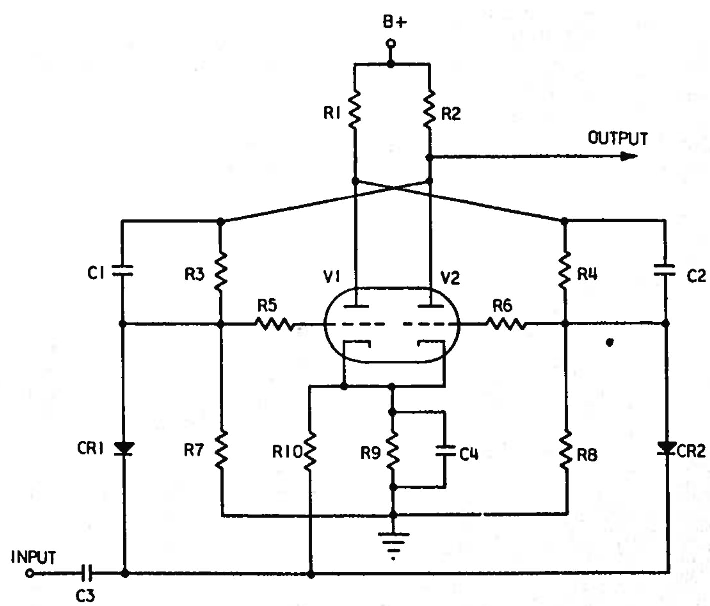


FIGURE 2.
A TYPICAL BINARY STAGE

V1 will not raise it above cutoff, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

The circuit is triggered from one state to another by negative transients applied at the input. The input diodes CR1 and CR2 form a gating system which couples the pulse formed at C3 to the grid of the conducting triode but blocks it from the grid of the other triode. Suppose, as before, that V1 is cut off and V2 is conducting. The diode side of C3 will carry a potential of about 40 volts (the same as that on the grid of V2). An applied transient will cause this potential to drop momentarily toward 30 volts. CR1 will not conduct since its plate is negative of 30 volts. However CR2 will conduct and the negative transient at the grid of V2 will lower tube current and cause an amplified rise in plate voltage. This rise will carry the grid of V1 above cutoff. The moment V1 conducts, the drop in voltage at its plate, coupled to the opposite grid, reinforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut off and V1 is conducting at a steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input transients applied, making it a scale of two. The output is the drop in voltage at one of the plates as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next), a counter having a scale of any power of two can be built. A chain of three cascaded binaries would be a scale-of-eight (2^3). If we call the input pulses driving such a chain "counts", the operation may be described as follows. The first binary will produce a negative pulse upon counts 2, 4, 6 and 8. The second binary will generate output pulses at counts 4 and 8, and the third binary will produce a pulse only at count 8. Count 8 completes a full cycle; the binaries will then be in the same state they were in before the first count.

THE SCALE OF TEN

In the Model 785A three binaries are connected in cascade to form a scale of eight. A fourth binary is arranged to block the input to the second binary during two input pulses to the counter, so that ten rather than eight pulses are required to produce a complete cycle. Figure 3 is a block diagram of the circuit.

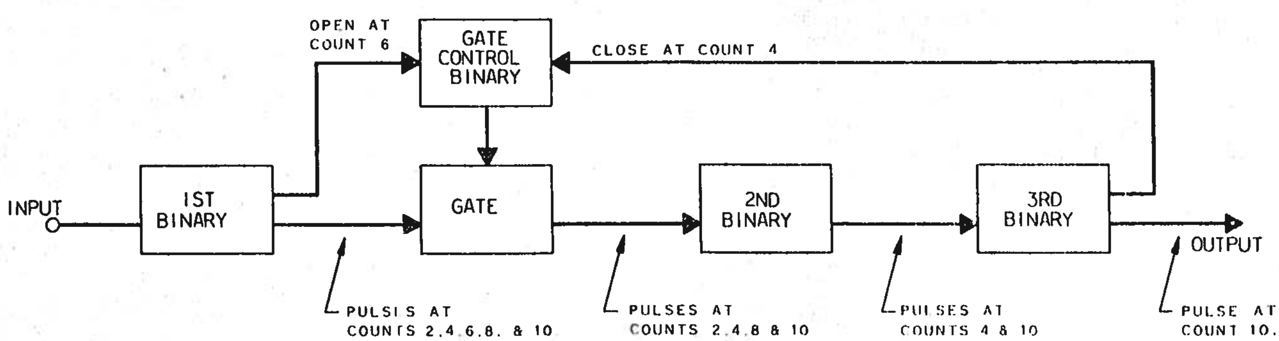


FIGURE 3.
BLOCK DIAGRAM OF MODEL 785A DCU

At the beginning of a cycle the gate control binary is in the state which holds the gate open. For the first three counts (that is, counts "1" through "3") the unit operates like a simple binary counter. At count 4 the third binary is triggered for the first time and, in turn triggers the gate control binary to its other state, closing the gate. The gate is closed during counts 5 and 6. At count 6 the first binary produces an output pulse which triggers the gate control binary back to the "open" state. During counts 7, 8, 9, and 10 the unit again operates like a simple binary chain. At count 10 the third binary produces a negative output transient which will drive another decimal counting unit.

TABLE 1

	Count Display	State of Each Binary Stage 4th	3rd	2nd	1st
	0	0	0	0	0
	1	0	0	0	1
	2	0	0	1	0
	3	0	0	1	1
	4	1	1	0	0
5	5	1	1	0	1
	6	0	1	0	0
	7	0	1	0	1
	8	0	1	1	0
	9	0	1	1	1
	0	0	0	0	0

The operating sequence of the DCU is summarized in Table 1 which shows the state of each binary for each registered count score. The state of a binary is defined by whether or not triode B is conducting. "0" means triode B is conducting; "1" means triode B is cut off.

Figure 4 shows how voltages throughout the unit change as successive input pulses are received. Voltages are identified by circled reference points located on the schematic diagram. The output voltage used to drive succeeding binaries is taken from the junction of two plate load resistors in the right-hand triode circuit rather than from the plate itself.

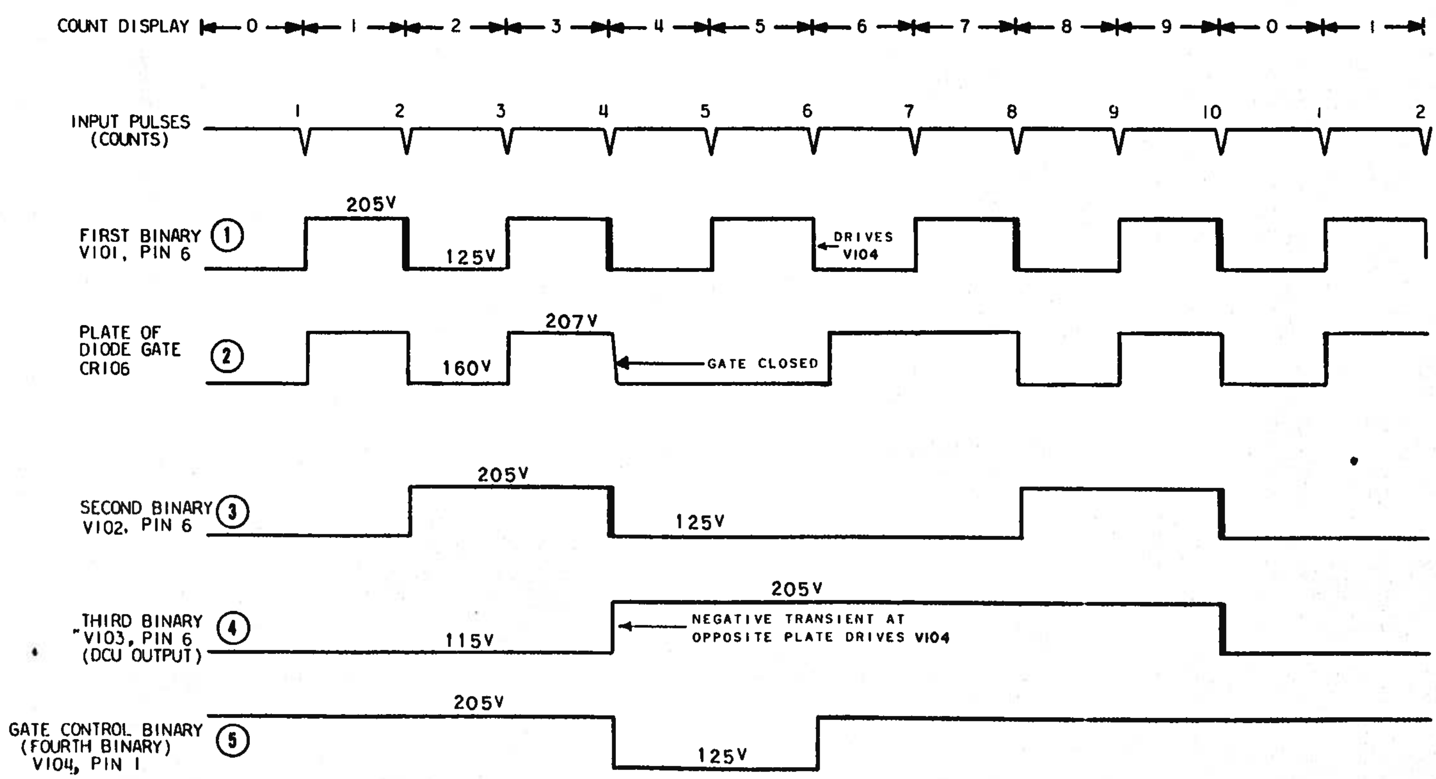


FIGURE 4.

IDEALIZED WAVEFORMS

The waveforms at this junction are identical to the plate waveforms shown in Figure 4, but of smaller amplitude. The negative transients (shown in heavy lines in Figure 4) drive succeeding binaries. The negative transient from the first binary which occurs at count 6 does not reach the second binary because of the action of the gate diode CR106 described in the paragraph "Gate Control Circuit".

Actual oscilloscope waveforms are shown in Figure 8. Each photograph has a number corresponding to the point on the schematic diagram where the waveform was observed.

BINARY CODE READOUT

The output voltages of each binary are also brought out to pins 2, 6, 9 and 10 of the DCU plug to operate auxiliary binary-coded readout devices. Observe that voltage at pin 6 combines the output of the second binary and the output of the right half of the fourth binary while the voltage at pin 10 combines the output of the third binary with that of the left half of the fourth binary. The resultant modified binary code given in Table 2 below agrees with that generated by other Beckman instruments. In the table, "0" represents a voltage of -15 volts or more negative; "1" represents a voltage at ground level or more positive.

TABLE 2. BINARY READOUT CODE

Count Display	Pin on DCU Plug 10	9	6	2
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	1	0
5	0	1	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1
0	0	0	0	0

GATE CONTROL CIRCUIT

At count 4, the voltage at the right plate of the third binary (Point (4) on the schematic) rises. At the same time, the voltage at the left plate drops. The negative transient produced at the left plate is coupled to the right grid of the gate control binary (V104), causing it to switch to the state in which the left triode conducts. (Point (5)). The resultant voltage drop across R119 causes the plate of the diode gate (CR106) to drop to +160v. (Point (2)). At this time the diode plate voltage is equal to its cathode voltage, which varies between +207v and +160v. The diode does not conduct and therefore prevents the negative output transient at count 6 from reaching the second binary. However, the negative output pulse of V101 is coupled through C104 to the left grid of the control binary which is now above cutoff. This switches the control binary back to its original stable state, opening the gate to pass a trigger pulse to the second binary at count 8.

OUTPUT CIRCUITRY

As the DCU cycles through counts "1" to "10", ten discrete combinations of binary states are produced, corresponding to the binary code given in the table on the preceding page. The output voltage of binaries #2 through #4 is at one of two levels which we shall designate "high" or "low". The outputs are connected to the neon bulbs in a matrix using diodes so that if one lamp terminal is connected to a low potential the voltage at that point will remain low regardless of the output level of another binary which may be connected to the same terminal. The output voltage of binary #1 is either "low" or "intermediate" because the voltage divider networks in the plate circuits prevent the voltage from reaching the "high" level.

At count "1" lamp No. 1 has both high and low potentials existing at its terminals. The circuit can be analyzed as in Figure 5 for each count of the cycle in order to verify that this condition will exist for only one neon bulb at each count.

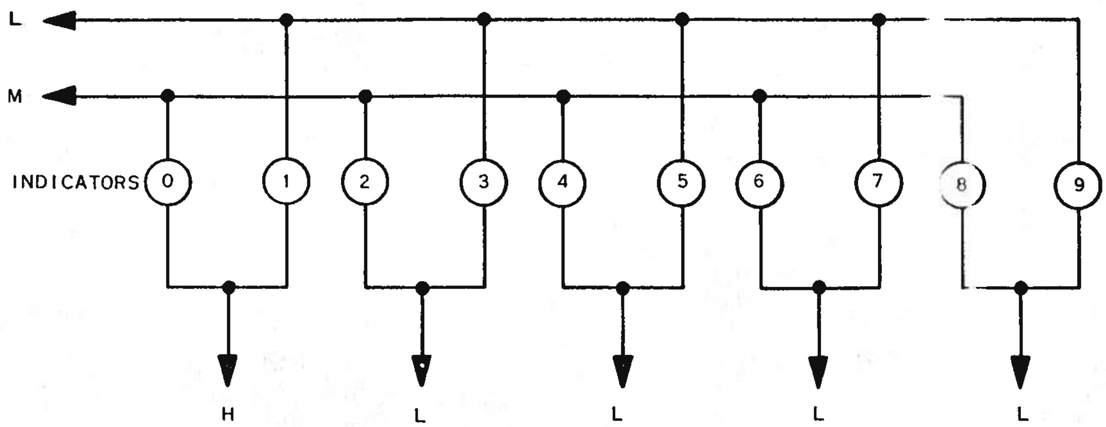


FIGURE 5.

VOLTAGE LEVELS ACROSS NEON BULBS EXISTING AT COUNT ONE
(H = HIGH, M = INTERMEDIATE, L = LOW)

SERVICING

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Since the counting unit is usually the indicating device of a larger instrument, faulty operation is often ascribed to it when the symptoms of external faults are displayed.

TROUBLESHOOTING

Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequence while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first.

The Troubleshooting Chart (Table 3) lists some common troubles which may be readily localized by observing the lighting patterns. Figure 8 shows actual oscilloscope waveforms to be used for comparison. Voltage and resistance measurements at tube pins are given in Table [illegible].

It will be found that most failures are caused by faulty tubes.

TABLE 3

TROUBLESHOOTING CHART

NOTE: Reset unit before troubleshooting

Symptom	Cause
Unit fails to count	(a) Insufficient supply voltage
	(b) Input signal of insufficient amplitude
	(c) Input signal of wrong polarity
	(d) First stage inoperative
Unit counts spuriously	(a) Stray input signal
	(b) Pulses received through power supply
	(c) External voltages picked up by output lead
Unit counts erratically	(a) Input signal too large or small, incorrect rise time
	(b) Supply voltage fluctuating too much
Unit fails to reset	(a) Stray counts from reset switch or associated circuitry
	(b) Defective component

Symptom	Cause
Unit counts in wrong sequence	
1. Skips every other number	(a) First stage defective
	(b) Input circuit supplies double pulses
2. Skips 4 and 5	(a) 4th stage not being driven by the 3rd
3. Skips 6 and 7	(a) Defective gate diode (CR106)
Repeats a pattern of numbers	
1. Two stable states per cycle (0-1 or 2-3, etc.)	(a) 2nd stage not being driven
2. Four stable states per cycle (0-1-2-3 or 6-7-8-9)	(a) 3rd stage not being driven
3. Counts up to 5, then alternates between 4-5	(a) 4th stage not being driven by the 1st
Two lamps light simultaneously	Defective diode (CR101 to CR105)

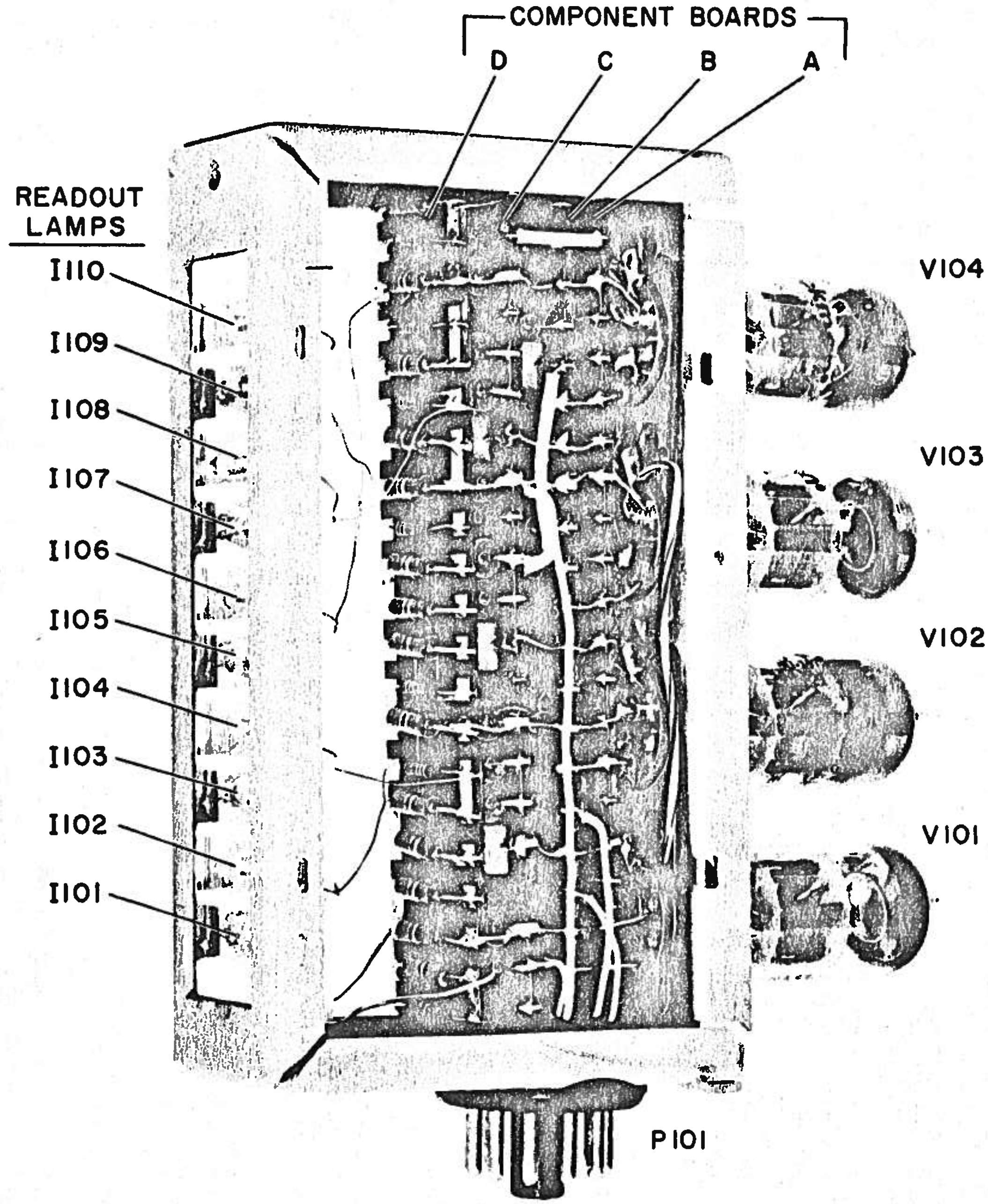


FIGURE 6.

MODEL 785A DCU WITH NUMBER MASK REMOVED

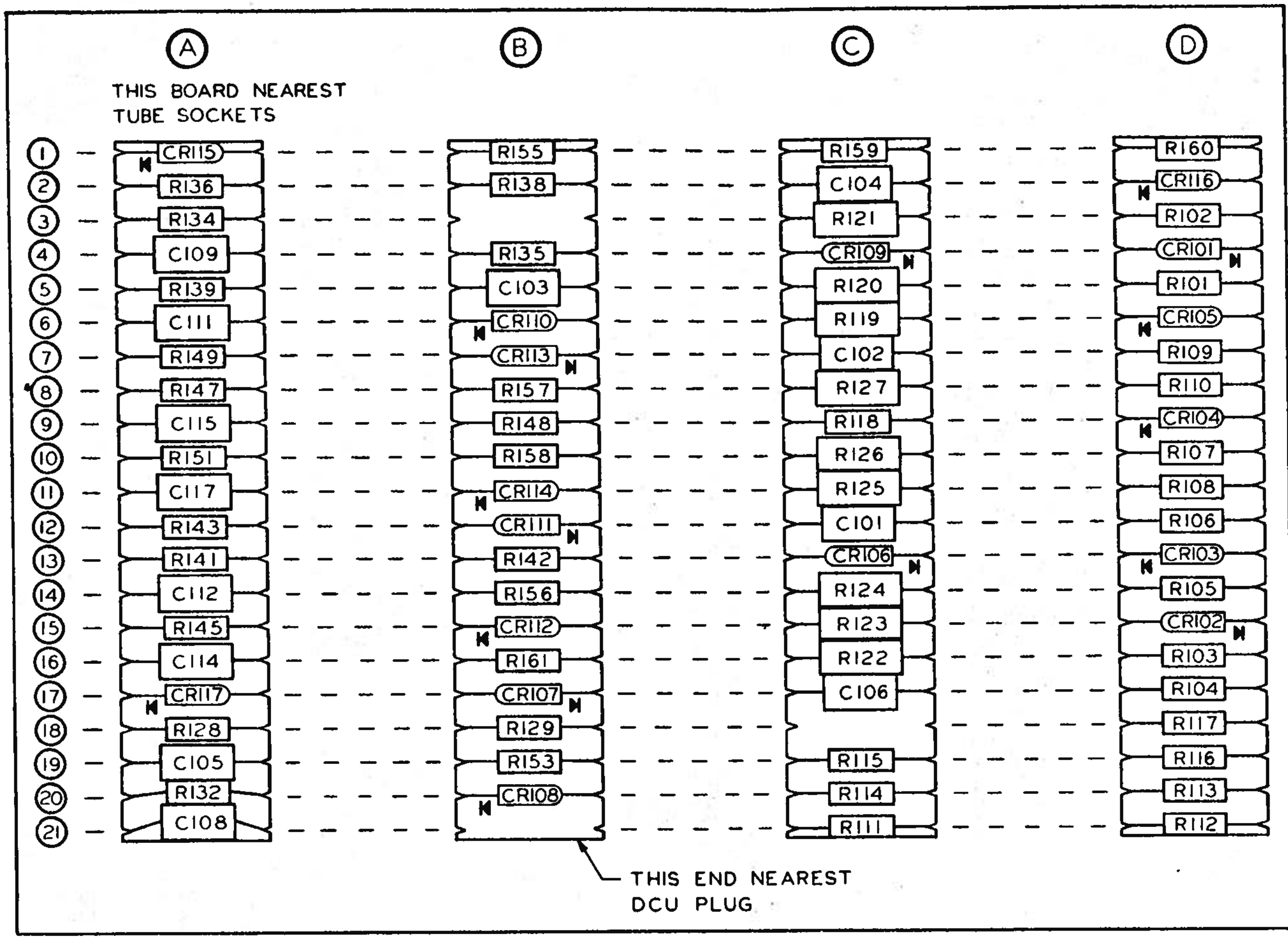


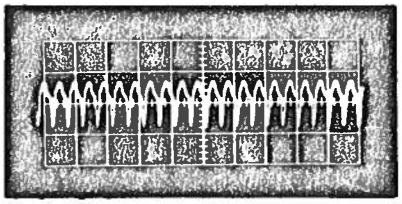
FIGURE 7.

COMPONENT BOARD LAYOUT

TABLE 4. PARTS LOCATION GUIDE*

Reference Number	Position (Fig. 7)	Reference Number	Position (Fig. 7)	Reference Number	Position (Fig. 7)
C101	C 12	CR115	A 1	R125	C 11
C102	C 7	CR116	D 2	R126	C 10
C103	B 5	CR117	A 17	R127	C 8
C104	C 2			R128	A 18
C105	A 19	R101	D 5	R129	B 18
C106	C 17	R102	D 3	R132	A 20
C108	A 21	R103	D 16	R134	A 3
C109	A 4	R104	D 17	R135	B 4
C111	A 6	R105	D 14	R136	A 2
C112	A 14	R106	D 12	R138	B 2
C114	A 16	R107	D 10	R139	A 5
C115	A 9	R108	D 11	R141	A 13
C117	A 11	R109	D 7	R142	B 13
		R110	D 8	R143	A 12
CR101	D 4	R111	C 21	R145	A 15
CR102	D 15	R112	D 21	R147	A 8
CR103	D 13	R113	D 20	R148	B 9
CR104	D 9	R114	C 20	R149	A 7
CR105	D 6	R115	C 19	R151	A 10
CR106	C 13	R116	D 19	R153	B 19
CR107	B 17	R117	D 18	R155	B 1
CR108	B 20	R118	C 9	R156	B 14
CR109	C 4	R119	C 6	R157	B 8
CR110	B 6	R120	C 5	R158	B 10
CR111	B 12	R121	C 3	R159	C 1
CR112	B 15	R122	C 16	R160	D 1
CR113	B 7	R123	C 15	R161	B 16
CR114	B 11	R124	C 14		

*Parts not listed in this table can be found at the appropriate tube socket terminals,

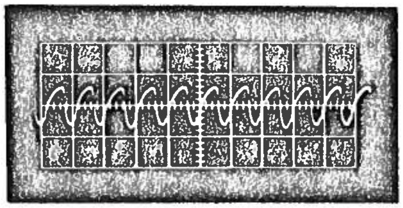


INPUT PULSES

Test Point: P101, pin 7

Vert. Scale: 5v/div

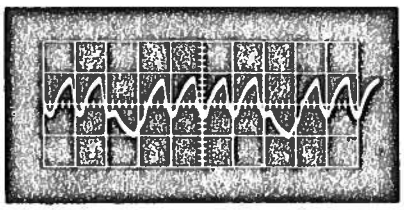
Note: The pulses shown are the output of a 10 mc DCU.



FIRST BINARY, PLATE B

Test Point: V101, pin 6

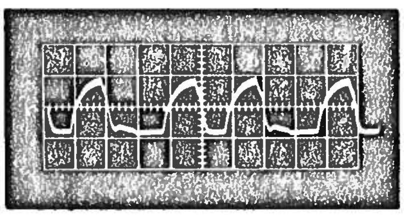
Vert. Scale: 50v/div



GATE DIODE (CR106), ANODE

Test Point: Junction CR106, C101, R118

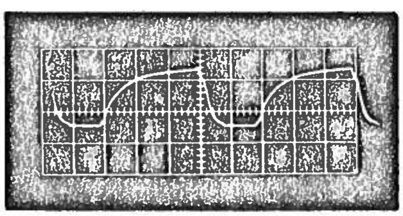
Vert. Scale: 50v/div



SECOND BINARY, PLATE B

Test Point: V102, pin 6

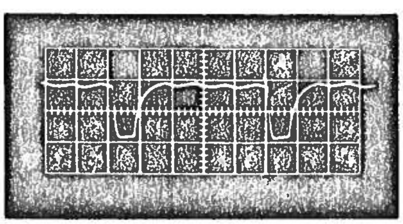
Vert. Scale: 50v/div



THIRD BINARY, PLATE B

Test Point: V103, pin 6

Vert. Scale: 50v/div



FOURTH (GATE CONTROL) BINARY, PLATE A

Test Point: V104, pin 1

Vert. Scale: 50 v/div

FIGURE 8

TYPICAL WAVEFORMS WITH INPUT FREQUENCY OF 1 MC.
TIME SCALE IS 2 μS/DIV

TABLE 5a

VOLTAGES

Note: Voltages measured to ground at count "0" with a vacuum tube voltmeter such as an RCA Volt-ohmyst Senior. B+ voltage is 200 volts.

Tube	Voltages at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	+170	+42	+56	0	0	+104	+56	+56	6.3AC
V102	+170	+38	+52	0	0	+94	+52	+52	6.3AC
V103	+170	+19	+32	0	0	+78	+33	+32	6.3AC
V104	+170	+37	+50	0	0	+92	+53	+50	6.3AC

TABLE 5b

RESISTANCES

Note: Resistances are measured to chassis ground with the DCU removed from its socket.

Tube	Resistances at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	23K	33K	7K	∞	∞	25K	26K	7K	∞
V102	26K	18K	5.8K	∞	∞	26K	15K	5.8K	∞
V103	25K	11K	3.4K	∞	∞	24K	11K	3.4K	∞
V104	26K	21K	6K	∞	∞	26K	17K	6K	∞

PARTS LIST

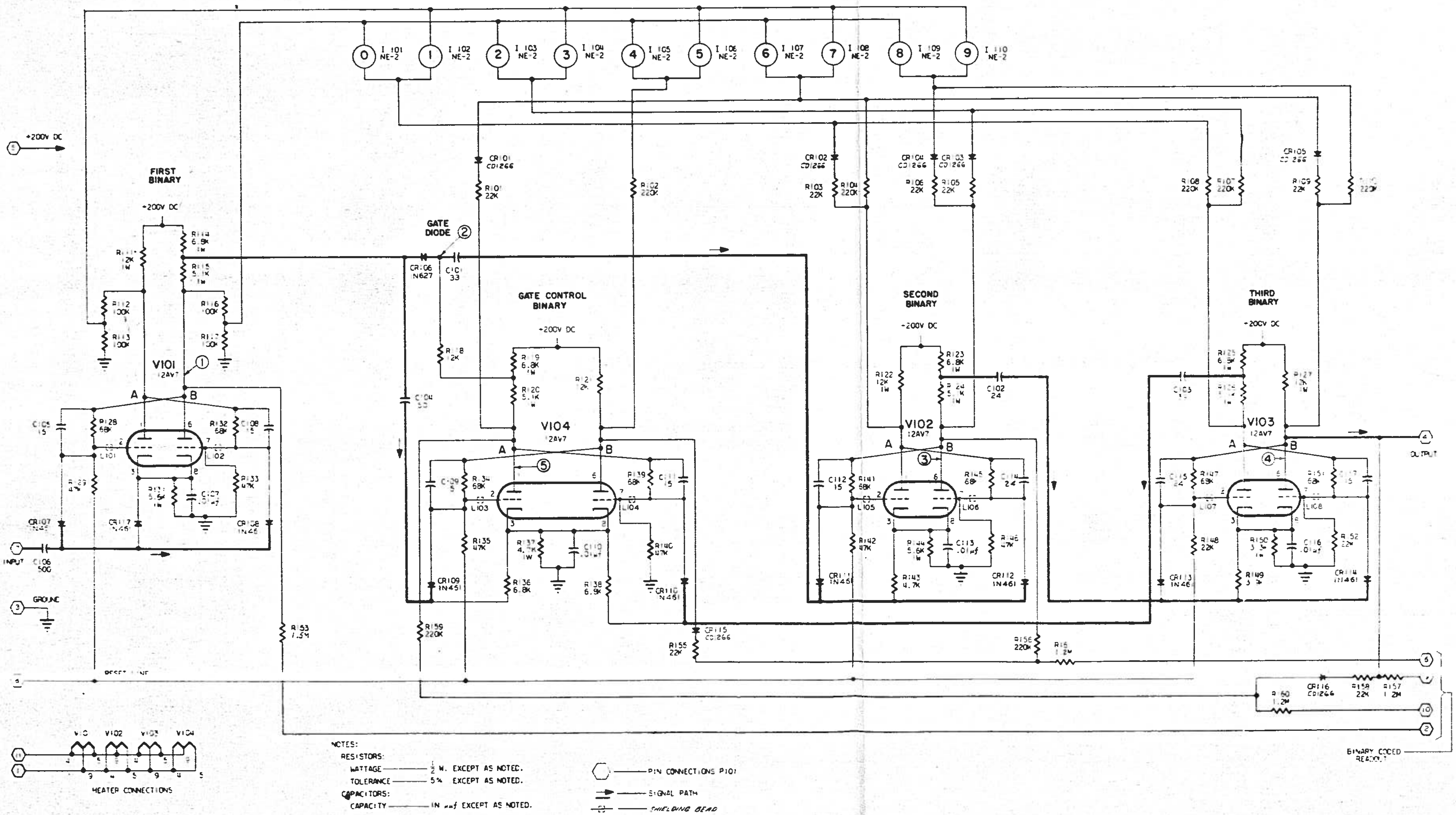
MODEL 785A DECIMAL COUNTING UNIT

Refer to Dwg. No. 785 D 300

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
C101	2-2607	Capacitor, mica, 33μμf, 500V, 5%	Sangamo RR1433
C102	2-2554	Capacitor, mica, 24μμf, 500V, 5%	Sangamo DR1424
C103	2-3157	Capacitor, mica, 39μμf, 500V, 5%	Sangamo RR1439
C104	2-2141	Capacitor, mica, 50μμf, 500V, 5%	Sangamo RR1450
C105	2-2135	Capacitor, mica, 15μμf, 500V, 5%	Sangamo RR1415
C106	2-2137	Capacitor, mica, 500μμf, 300V, 5%	Sangamo RR1350
C107	2-4388	Capacitor, ceramic, .01μf, 500V, +80 -20%	Sprague 29C9
C108 & C109		Same as C105	
C110		Same as C107	
C111 & C112		Same as C105	
C113		Same as C107	
C114		Same as C105	
C115		Same as C102	
C116		Same as C107	
C117		Same as C105	
CR101	8-4182	Diode, CD1266	Continental Devices
CR102 thru CR105		Same as CR101	
CR106	8-7453	Diode, 1N627	
CR107	8-4967	Diode, 1N461	Hughes
CR108 thru CR114		Same as CR107	
CR115 & CR116		Same as CR101	
CR117		Same as CR107	
I101	21-6180	Lamp, NE2A	General Electric
I102 thru I110		Same as I101	
L101	3-7251	Ferrite bead	Ferroxcube 255 T 118 A 205
L102 thru L108		Same as L101	
P101	17-1719	Plug, 11 pin	Amphenol 86CP11
V101	5-5977	Tube, 12AV7	
V102 thru V104		Same as V101	
XV101	4-3317	Socket, 9 pin	Elco 280BC
XV102 thru XV104		Same as XV101	



+200V DC
FIRST BINARY
GATE DIODE
GATE CONTROL BINARY
SECOND BINARY
THIRD BINARY
V101 12AV7
V104 12AV7
V102 12AV7
V103 12AV7
I 101 NE-2
I 102 NE-2
I 103 NE-2
I 104 NE-2
I 105 NE-2
I 106 NE-2
I 107 NE-2
I 108 NE-2
I 109 NE-2
I 110 NE-2
INPUT
GROUND
OUTPUT
RESET LINE
BINARY CODED READOUT
HEATER CONNECTIONS
NOTES:
RESISTORS:
WATTAGE — ½ W. EXCEPT AS NOTED.
TOLERANCE — 5% EXCEPT AS NOTED.
CAPACITORS:
CAPACITY — IN μμf EXCEPT AS NOTED.
PIN CONNECTIONS P101
SIGNAL PATH
SHIELDING BEAD