OPERATING MANUAL

FAST RESPONSE SOLAR ARRAY SIMULATOR

prepared for

NASA AERONAUTICS AND SPACE ADMINISTRATION

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I. INTRODUCTION

A. General Description

The Fast Response Solar Array Simulator (FRSAS) is a universal solar array simulator which features an AC response identical to that of a real array over a large range of DC operating points. In addition, short circuit current (I_{SC}) and open circuit voltage (V_{OC}) are digitally programmable over a wide range for use not only in simulating a wide range of array sizes, but also to simulate I_{SC} and V_{OC} variations with illumination and temperature. A means for simulation of current variations due to spinning is available. Provisions for remote control and monitoring, automatic failure sensing and warning, and a load simulator are also included.

B. Specification

1.0 Range

1.1 Current

1.1.1 I_{SC} shall be adjustable from 0.1 to 20 amps.

1.1.2 Variation of I as a function of temperature, sun angle and illumination shall be accomplished by variation of digitally programmed resistors (see paragraph 2.3).

1.1.3 Variation of I due to spinning shall be sine, triangular and square wave with an amplitude of no greater than $\pm 20\%$ of I and not to exceed I_{SC} setting and a frequency range of 0.01 Hz to 100 Hz. The frequency and wave shape will be set manually and the amplitude will be varied by digitally programmable resistors.

1.2 Voltage

1.2.1 V_{OC} shall be adjustable from 10 to 100 volts.

1.2.2 An initial main power supply setting shall be made manually to set the nominal V_{OC} for the simulation. This setting shall be 10 volts above the maximum V_{OC} of the simulation programmed voltage set.

1.2.3 Variation of V as a function of temperature shall be accomplished by variation of a digitally programmable resistor (see paragraph 2.3).

1.2.4 The unit shall contain all necessary considerations (wiring, connectors, documentation, console layouts, etc.) to simulate up to a 5 kw (cold temperature) with the addition of appropriate modules and consoles.

1.3 Power

1.3.1 Maximum power output shall be 750 watts with V_{OC} = 100 volts, I_{SC} = 10 amps at one extreme and with V_{OC} = 50 volts, I_{SC} = 20 amps at the other.

1.3.2 Minimum power at the maximum power point shall be 7.2 watts.

1.3.3 The locus of points shall be within the curve of Figure 1.

1.4 Impedance. The output impedance, a function of operating point and defined as the impedance seen on the simulator side of the compensation capacitance, shall be the reflected cell impedance, $(N_S/n_p)\ Z_d$, with the acceptable error limits as specified in Table 1.

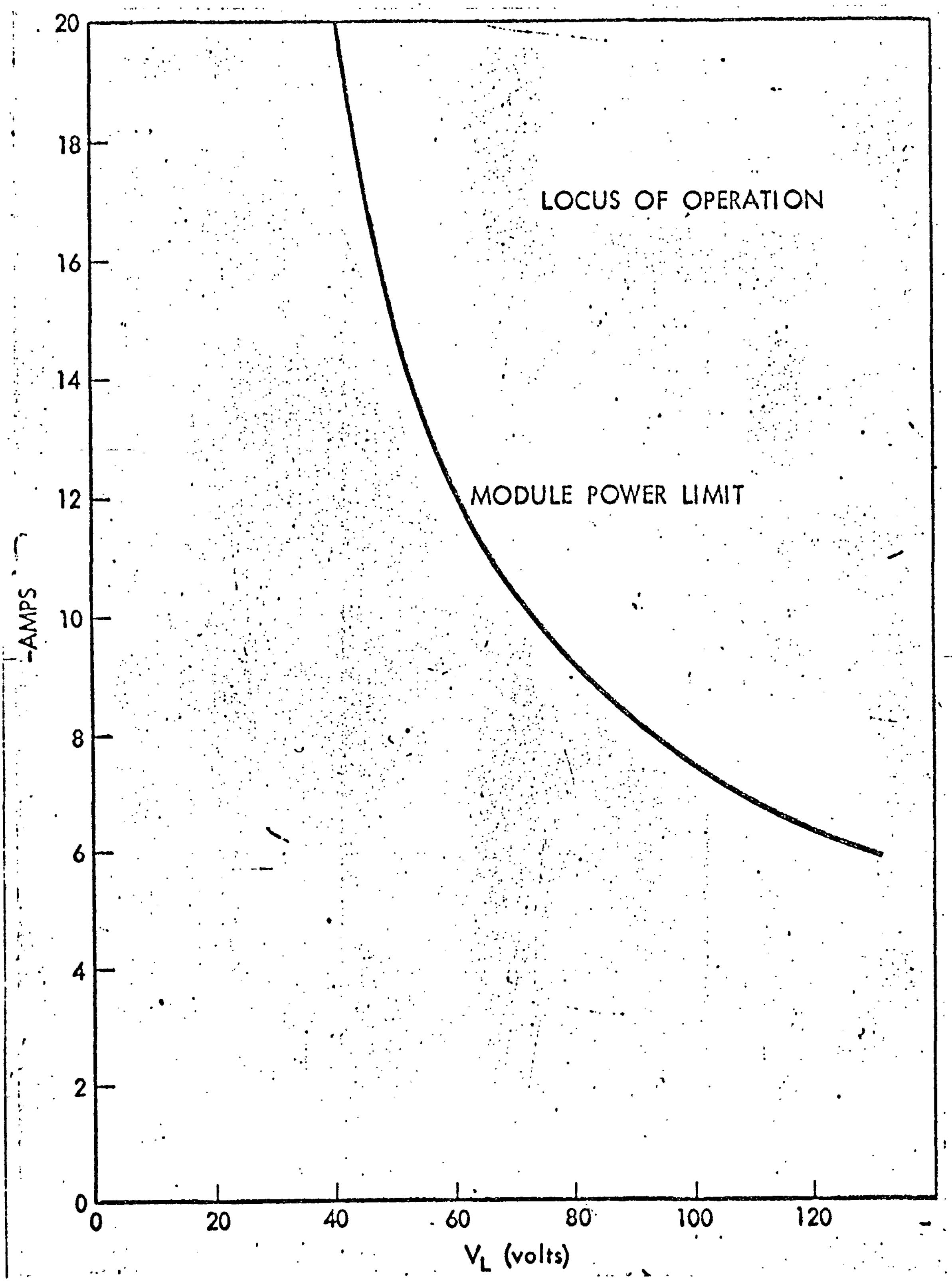

LOCUS OF OPERATION
MODULE POWER LIMIT
-AMPS
20
18
16
14
12
10
8
6
4
2
0
0
20
40
60
80
100
120
V_L (volts)

FIGURE 1

TABLE 1

V_o/V_{oc}	Frequency	db Error Limits	$Z_{os}/(n_s/n_p)Z_d$
>0.6	DC to 200kHz	+3 -3	1.4 0.7
0.25→0.6	3kHz to 200kHz	0 -12	1 0.25
	DC to 3kHz	0 -16	1 0.17
<0.25	3kHz to 200kHz	0 -16	1 0.17
	DC to 3kHz	—	0.17

NOTE: a) When on internal load the compensation capacitance is included automatically.

b). When on external load the compensation capacitance shall be requried as part of the load and it should have a value of not less than $(n_p/3)$ 0.05mf. It is further required that this capacitance be physically located within the FRSAS console.

1.5 Environmental

1.5.1 The FRSAS should operate in a room envoronment of 60 to 80°F. Internal blowers should be provided where necessary to maintain semiconductors within their ratings.

1.5.2 The FRSAS should operate in a room environment of 0% to 90% humidity.

2.0 INPUT

2.1 Power

2.1.1 208 volts ± 10 volts 60 Hz three phase

2.2 Connections

2.2.1 AC input will be on rear panel of cabinet. The panel should also contain breakers and ac routing connections to allequipment. The front panel can be utilized for breakers if AC access is deemed a safety condideration.

2.2.2 All connections from other cabinets and inputs from devices controlling the FRSAS should be through the panels on the rear of the cabinets

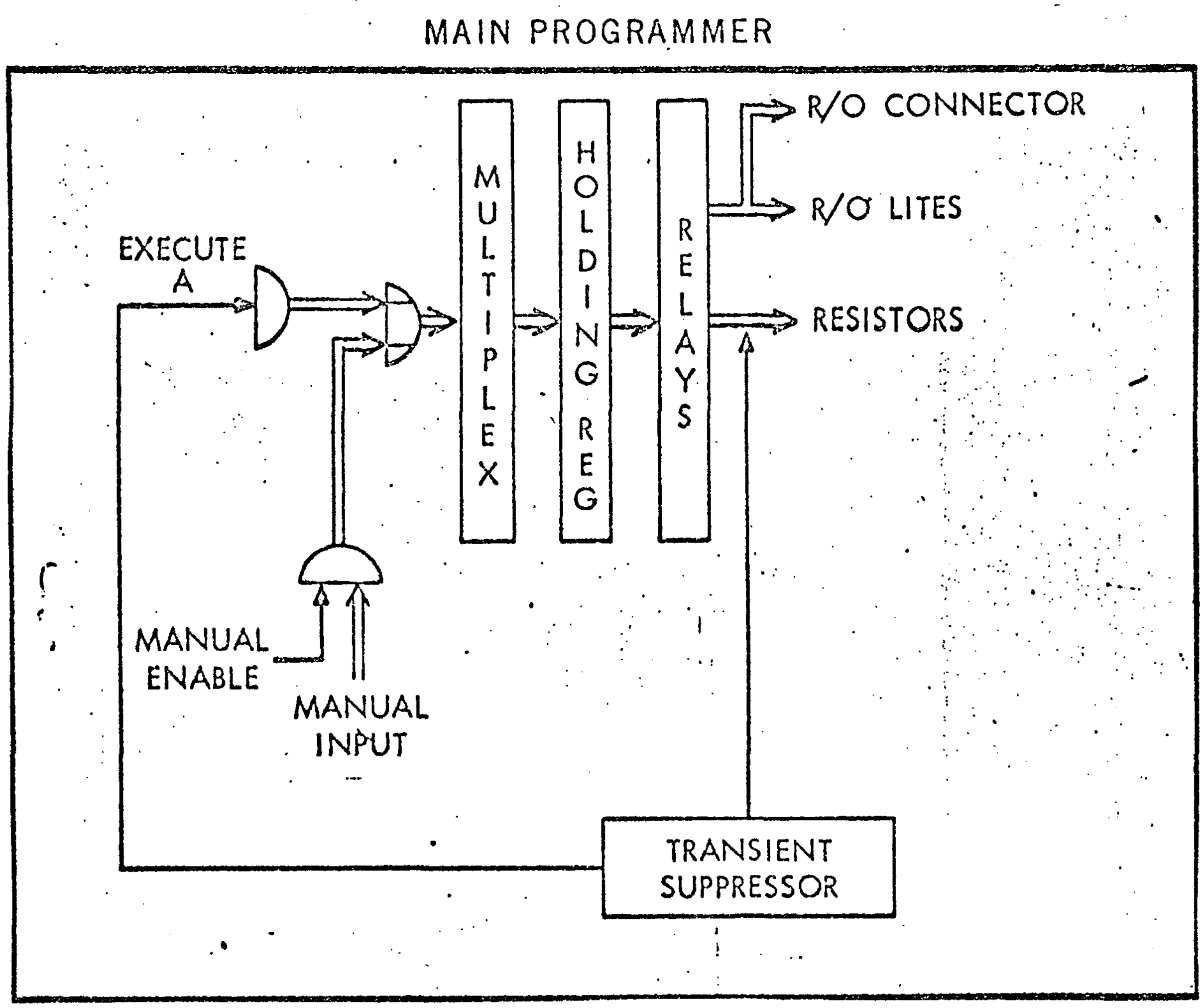


FIGURE 2. Typical Programmer and Main Controller

2.2.3 All grounding should be documented and consideration should be given to ac input ground, dc output ground and control system ground.

2.3 Internal Control

2.3.1 Initial settings shall be made manually at a control panel on the console.

2.3.2 See Figure 2 for a typical internal control block diagram. The following items should be given consideration:

(a) Execute commands

(b) Control logic for internal programming sources

(c) Transient suppression during change over from one setting to another.

3.0 OUTPUT

3.1 Accuracy. The voltage corresponding to a given V_{OC} control setting shall be within $\pm$ 1% of the voltage given in Table 2 for that setting. The current corresponding to a given I_{SC} control setting shall be within $\pm$ 1% of the current given in Table 3 for that setting. An initial 20 minute warmup period is required with the Controller at or near max-power point. A three minute settling time shall be allowed between readings.

Calibration of the V_{OC} and I_{SC} control settings is required every three months.

Tables 2 and 3 are provided in another section.

3.2 V_O and I_O Short-Term Stability. V_O and I_O drift for a fixed load line shall not exceed $\pm 1\%$, respectively, of their initial settings in a 24-hour period after a 15 minute warm-up.

3.3 Static VI Curve Repeatability. For any given array size, after V_{OC} and I_{SC} have been set, a VI baseline curve shall be generated using the internal Load Simulator. The operating point given by a particular load shall be repeatable within $\pm 1\%$ of the current and $\pm 1\%$ of the voltage established by the baseline curve and that load line, provided the percent error attributable to setting accuracy is excluded. A three minute settling time shall be allowed between readings. The baseline curve shall be rerun every three months.

3.4 Ripple. The steady state ripple shall be less than 0.05% of V_{OC} or 50 mv, whichever is less, measured peak to peak.

3.5 Curve Shape. The FRSAS shall exhibit a V-I characteristic which obeys the following relationship.

$$I_L = \frac{I_R}{H} - \frac{I_O}{H}\left(e^{V_L/nV_t} - 1\right) - \frac{V_L}{nHR_p}$$

where I_R, I_O, V_t and R_p are fixed constants to be determined by a final design (see Figure 3).

3.6 Readouts

3.6.1 The unit should have a front panel readout of V_{OC} and I_{SC}. These should also go to a connector for routing to an external process controller.

3.6.2 Trouble lights should be considered for over temperature, error in data or malfunction in any cooling device. These should go to a connector for routing to an external process controller.

3.7 Load

3.7.1 Output shall be floating.

3.7.2 Either terminal + or - may be tied to ground.

4.0 PROTECTION

4.1 The main ac circuits should have circuit breakers (see Paragraph 2.2).

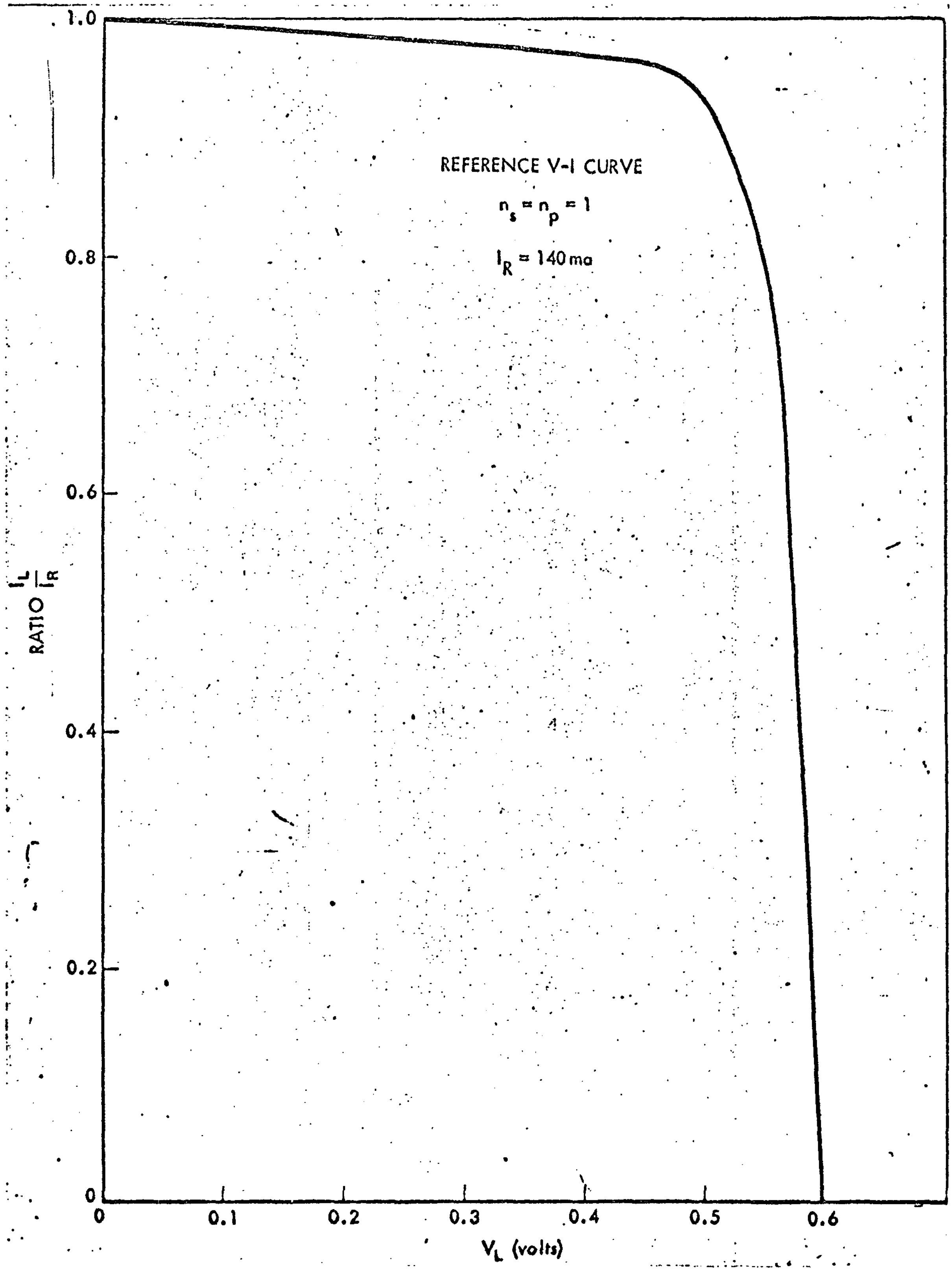
4.2 All blowers should have warning indicators when not in operation (see Paragraph 3.6.2).

4.3 Consideration should be given for protecting FRSAS from capacitive and inductive transients reflected back at the simulator from power systems that it will be connected to.

4.4 Thermal limits that are exceeded on the power transistors should give an electronic cutoff isgnal for protection of power stages.

5.0 MISCELLANEOUS

5.1 The FRSAS shall have a built-in load which can sweep the entire V-I characteristic at any intermediate time for purposes of checking. Design of this load should include the full specification range up to 5 kw. It shall be controlled manually and the output shall be available to external recording devices.



REFERENCE V-I CURVE
$n_s = n_p = 1$
$I_R = 140$ ma
1.0
0.8
0.6
0.4
0.2
0
RATIO $\frac{I_L}{I_R}$
0
0.1
0.2
0.3
0.4
0.5
0.6
V_L (volts)

FIGURE 3

5.2 The FRSAS shall be mounted in individual cabinets which will contain all the modules, logic circuits, controls, and blowers necessary for its operation. The cabinets should be made by Vent-Rak, Model VR 9051AB. Cooling requirements will change the model number, therefore consult technical monitor for approval. All logic drawers and modules should be mounted with heavy duty Chassis-Trak Slides. Consult technical monitor for approval. Nameplates to identify cabinets will be supplied by the Government.

5.3 All logic within the programmer and main controller should utilize SDS series "T" logic cards.

5.4 The basic power unit shall be modular in design and be mounted behind and on a standard 3/16 inch rack panel complete with all heat sinking and blowers as required and connectors for interconnection to additional units, loads, and programmers (see Paragraphs 2.2 and 5.7).

5.5 Consideration should be given to wire size in external connection to a system under test. Remotely controlled at connector only.

5.6 The code to be used by the internal controller and the associated logic to the programmable resistors shall be approved by the technical monitor.

5.7 Provisions shall be made in the electrical and mechanical design for the addition of identical power modules in either parallel or series mode to enable the unit to obtain a 5 kw capability.

5.8 Consideration in the design should be given to ways of simulating split array, and simulating arrays with a bump in the V-I characteristic near the V_{OC}.

II THEORY OF OPERATION

A. Basic Concept

The basic solar array simulator block diagram is shown in Figure 1. The controller utilizes a single solar cell operated as a forward biased diode as a reference to derive not only the DC curve shape but also the dynamic impedance of the illuminated solar cell. The Controller controls the Power Stage which amplifies the single cell characteristic to that of a full array. The output of the Power Stage is fed back to the Controller to force the reference diode to operate at the desired DC operating point.

The circuit of Figure 2, which is a simplified solar cell equivalent circuit, can be used to obtain the DC VI characteristic of an illuminated cell. In this case the constant current source, I_R, is a power supply and the diode is non-illuminated solar cell. Studies under Phase I of this contract have demonstrated that a solar cell operated as a forward biased diode exhibits the same dynamic impedance characteristics as an illuminated cell. Therefore, and ideal solar array simulator would be one that simply scaled the DC characteristic and this dynamic impedance up by the ratio of the number of series cells to the number of parallel cells in the array being simulated. Further, the effect of temperature on V_{oc} can be simulated by adjusting the effective number of series cells, and the effect of illumination variations and radiation degradation on I_{sc} can be simulated by adjusting the effective number of parallel cells. This, then, is the basic concept with both V_{oc} and I_{sc} being continuously adjustable.

In order to implement the above concept one must ideally build an amplifier system whose output impedance remains flat to at least a decade above the corner frequency of the reference cell. It can be shown that

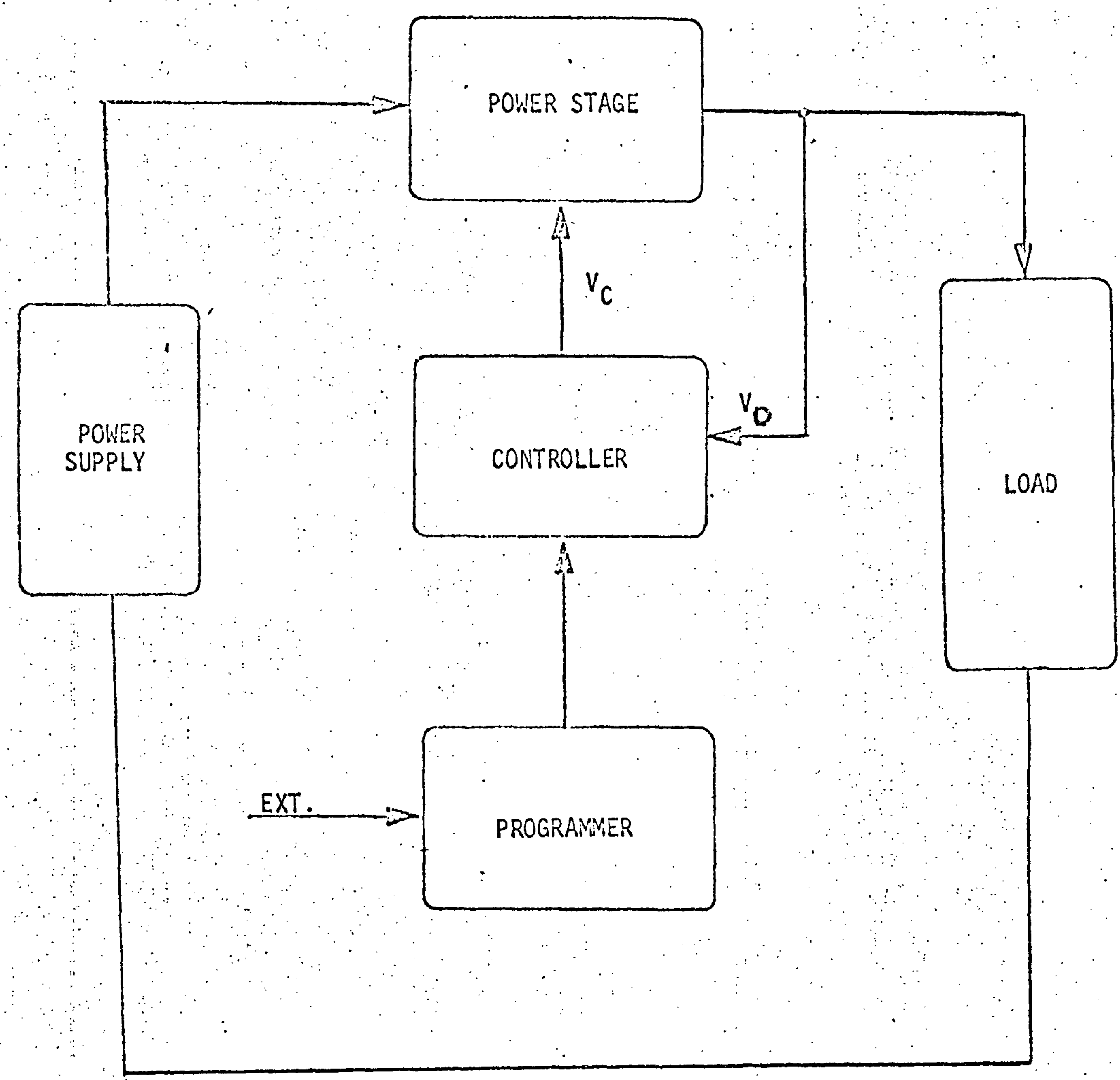


FIGURE 1
SOLAR ARRAY SIMULATOR BLOCK DIAGRAM

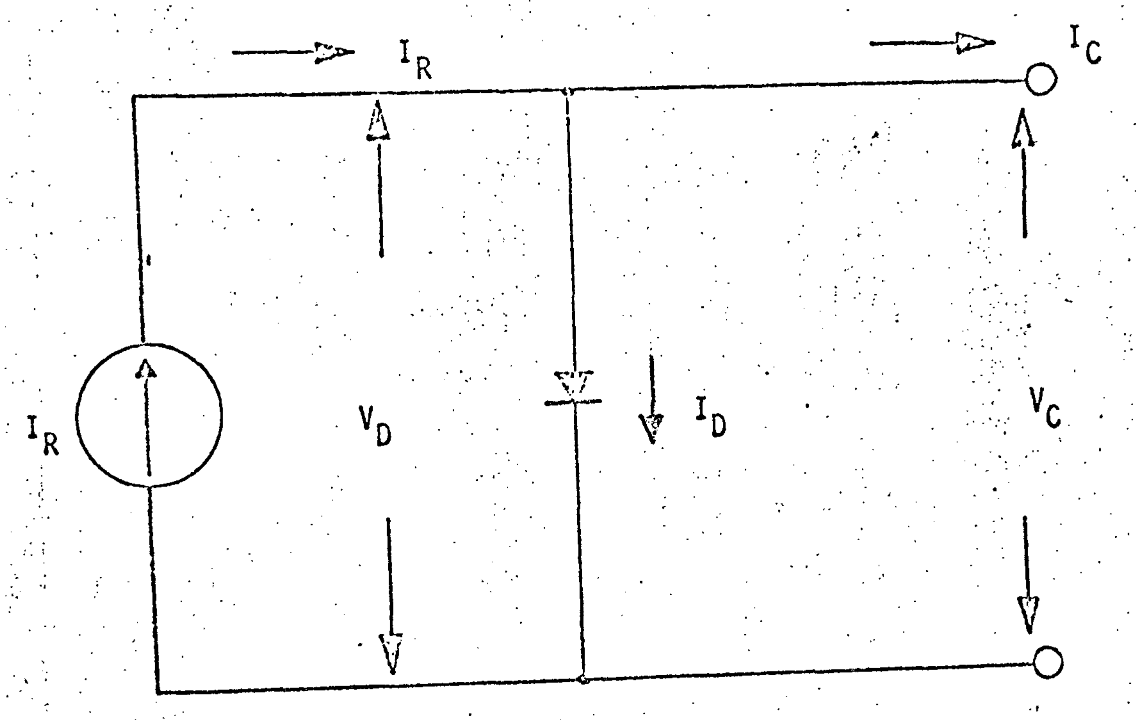


FIGURE 2
SIMPLIFIED EQUIVALENT CIRCUIT OF A SOLAR CELL

for this system

$$Z_o = \frac{n_s}{n_p} Z_d \,||\, Z_A$$

where

Z_o = the simulator output impedance.

Z_d = the reference diode impedance.

n_s = the effective number of series cells which is a function of the actual number of series cells as modified by temperature.

n_p = the effective number of parallel cells which is a function of the actual number of parallel cells as modified by illumination, cell parameters, and degradation.

Z_A = the equivalent impedance of the amplifier.

From this it is seen that Z_A should be made large in comparison to ns/np Z_d in order for the desired Z_o to be obtained.

A set of typical curves of diode impedance versus frequency as a function of diode current is shown in Figure 3. These curves may also be interpreted in terms of cell current and cell impedance by noting the following relationships as derived from Figure 2:

$$I_D = I_R - I_C$$

but since

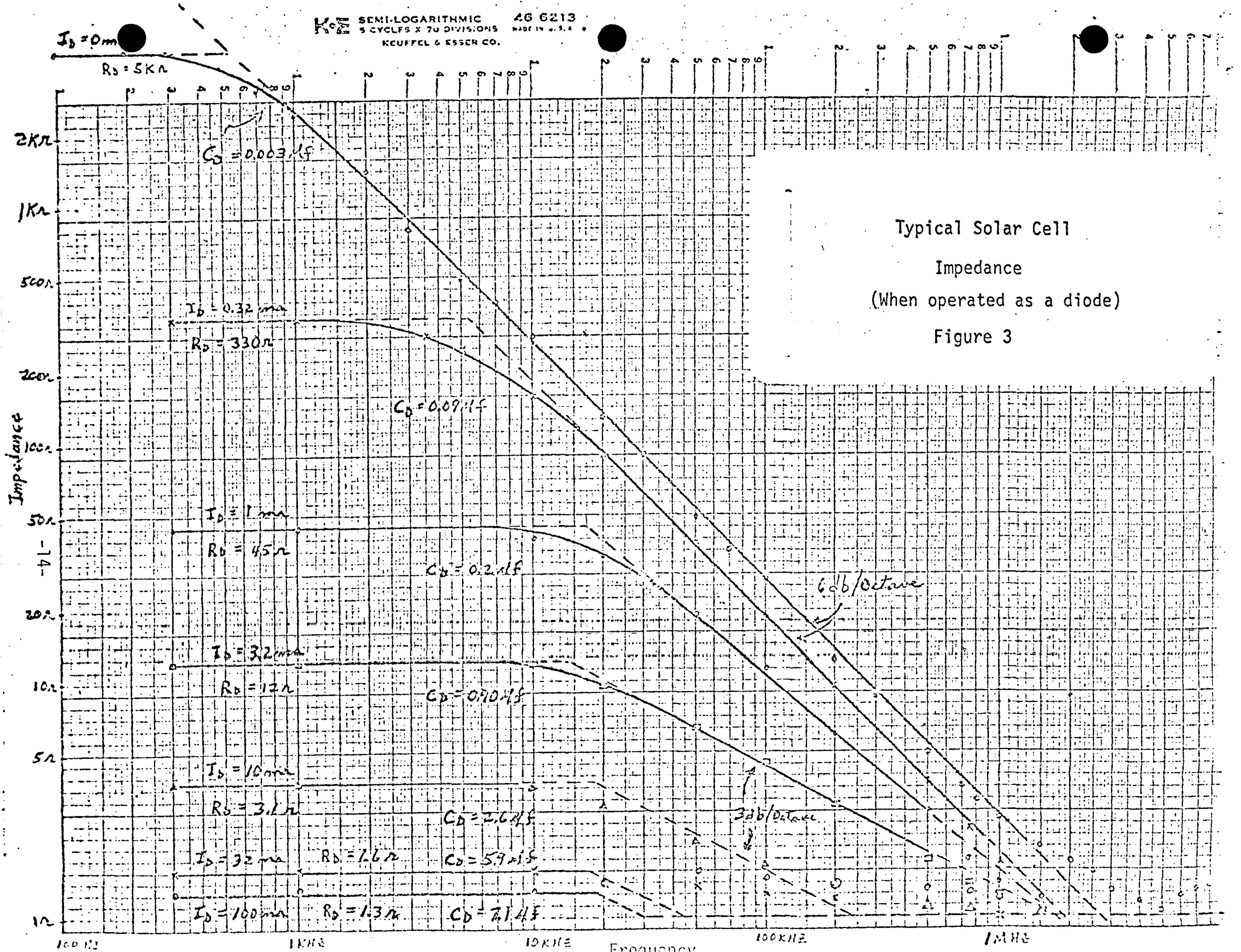
$$I_R = I_{sc} = 140 \text{ ma}$$

$$\Delta I_D = \Delta I_C$$

Also

$$V_D = V_C$$

$$\Delta V_D = \Delta V_C$$



Typical Solar Cell

Impedance

(When operated as a diode)

Figure 3

Therefore

$$\left|Z_D\right| = \left|Z_C\right|$$

Note that impedance varies as a function of frequency as well as DC operating point.

An equivalent circuit of the amplifier necessary to convert this single reference diode's voltage and current into a full array output is shown in Figure 4. (For comparison with the block diagram of Figure 1 this amplifier and the reference are divided between the Controller and the Power Stage; the reference, the comparator and voltage divider, and part of the n_p amplifier being in the Controller and the main power portion of the n_p amplifier being the Power Stage.) The simulator output voltage V_o is divided by n_s and fed back to the comparator to force the diode to operate at a current I_D which will give a cell current, I_C, which when amplified by n_p will result in the desired output current, I_0. The amplifier impedance, Z_A, as previously defined is a combination of the voltage divider impedance, the reflected current reference output impedance, the comparator impedances, the power stage impedance, and a stabilizing capacitance on the simulator output. This latter capacitance is required in order to stabilize the system for all possible combinations of gains and loads.

Based on the above discussion of Z_A and considering the impedance data of Figure 3, it can be shown that for all possible gains (i.e. ns/np) and all possible operating points from I_{sc} to V_{oc} (which determines Z_D), the desired inequality

$$Z_A \gg \frac{n_s}{n_p} Z_D$$

cannot be satisfied. This is particularly true near I_{sc} (i.e. $I_D = 0$)

where Z_D is large and when n_s is large. This is reflected in less than ideal performance near I_{sc} where impedance is dominated by Z_A.

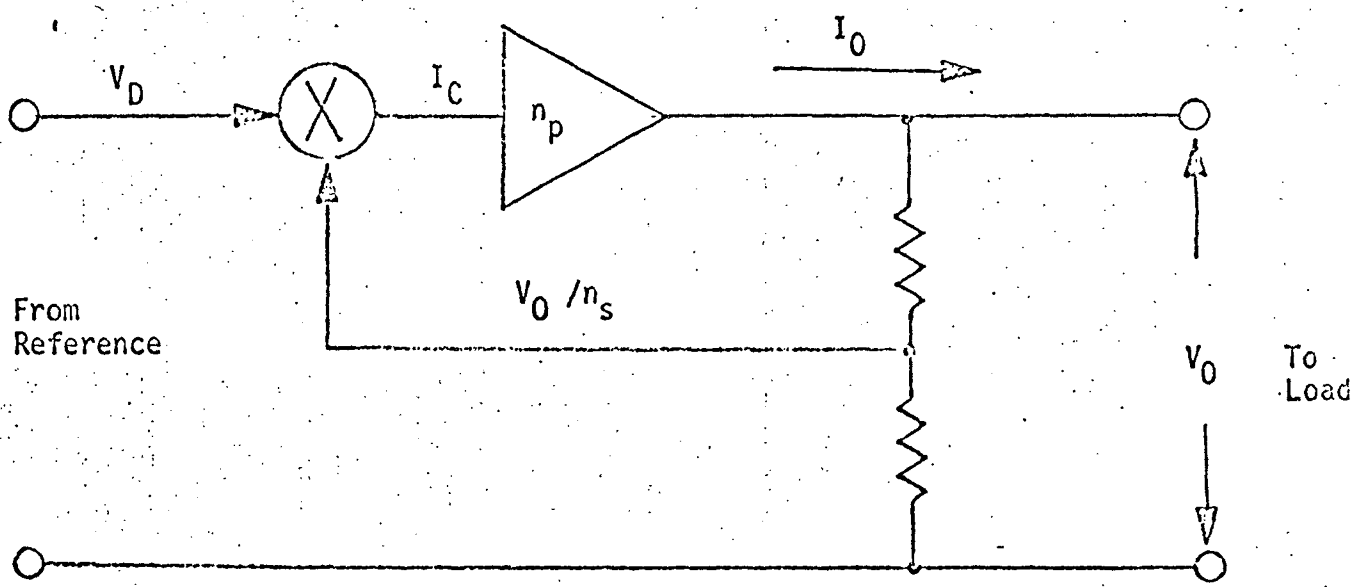


FIGURE 4
EQUIVALENT CIRCUIT OF AMPLIFIER

II. THEORY OF OPERATION (cont'd)

B. Detailed Description

1. Primary Power - The 103 drawer (reference drawing X312626) is the Primary Power control which provides the means to control the AC and DC voltages to the console. AC power is applied through a 40 amp, 3 phase main circuit breaker. When this circuit breaker is "ON", power is applied to 2 plug-mold strips and to Power Supply No. 3. A red neon indicates 3 phase power "ON". Power Supply No. 3 is the DC control source for the associated drawers, including relays, controls, lights and electronics. Its voltage is set at 26 $\pm$ .5 VDC and the current limit is set to maximum. A "START-STOP" push-button station, either local or remote, controls the 2 main DC power supplies, No. 1 and No. 2. A white "DC ON" light indicates when the main DC power is energized. A "LOCAL-REMOTE" toggle switch puts the "START-STOP" circuitry at the console or at a remote "START-STOP" station by virtue of added remote switching. This "LOCAL-REMOTE" switch is directly between the 2 LOCAL-REMOTE indicator lights and has a center "OFF" position. This "OFF" position is a safety feature, preventing the 2 main DC power supplies from being accidently turned ON. In the remote position, the main DC power can be turned "ON" and turned "OFF" at the console or at the remote station.

A circuit to put the 2 main DC power supplies in series or in dual is controlled by a push-button located between the 2 white indicators - "Series" - "Dual". The 2 main DC supplies can only be put in "Dual" when they are in the de-energized state.

II. THEORY OF OPERATION (cont'd)

B. Detailed Description

1. Primary Power (cont'd)

Once they are put in "Dual" operation, they can only be put back into "Series" operation by shutting down the console, i.e., turning off the 3 phase AC power by virtue of the main circuit breakers. When the main DC supplies (No. 1 and No. 2) are in series, they are connected in Master-Slave operation; No. 1 is the master, see reference Trygon instruction manual. When the main DC supplies are in dual operation, each supply is independent and separately controlled. However, only No. 1 provides dc power to the simulator in this mode.

A control switch is included to inhibit the audio signal emanating from Panel 110 (reference drawing X312630). This signal can be controlled locally or remotely.

There are two "safety-hooded" switches, one each for Power Supply No. 1 and No. 2. These toggle switches are to set the current limit of their respective power supply. Putting them in the "up" position energizes a heavy duty HG relay, short-circuiting the output of each supply.

Two rotary selector switches, one for current and one for voltage, are connected to the DPM's (Digital Panel Meters in drawer 109). The DPM's indicate their respective current or voltage, multiplied by a factor engraved on the 103 panel. Adjacent to each rotary selector are test points. These are paralleled with the respective DPM and can be used when greater measurement accuracy is desired by using an external 5 place DVM (Digital Voltmeter).

II. THEORY OF OPERATION (cont'd)

B. Detailed Description

2. Controller - The 113 Controller Drawer (reference drawing X312632) contains the amplifier circuitry reference solar cell, with its constant temperature oven, V_{OC}, I_R and Spin control P. C. cards and the +6, -6 and Constant Current power supplies. The electronics of this drawer are controlled by the programmer and its digiswitch settings. The TO-5 relays (transistor driven DPDT relays) on the P.C. cards are also controlled by the programmer drawer (reference drawing X312627), which in turn controls the amplifier circuit and solar-cell voltage and current. The solar cell operating temperature is kept at 45° C. The power to operate the solar-cell oven is from the No. 3 Power Supply. The Constant Current supply is energized when the main circuit breaker is "ON". The (+)6 and (-)6 power supplies are wired directly to the 201 drawer (reference drawing X312633) and, therefore, will only be energized when the 2 main DC supplies are energized.

This is a preventive measure, protecting the controller and power stage relays from being switched in or out of the circuit by accident.

In the Controller there is also a relay K30 that is activated by a signal from the Primary Power. The purpose of this relay is to reduce the base resistance R12 of Q9 so that when the FRSAS is in "SERIES" operation, the maximum current each power stage can draw is approximately 210 ma. This allows an adequate secondary breakdown margin for the power transistor Q4 in the Power Stage drawers.

II. THEORY OF OPERATION (cont'd)

B. Detailed Description (cont'd)

3. Power Stages - The Power Stages Drawers 112 and 114 (reference drawing X312631) are identical in operation and design. The drawers are also referred to as Power Stage A or Power Stage B. Each drawer has 24 identical power stages that can provide 15 watts of power apiece. These 24 individual stages are equally divided between two large fan-cooled Wakefield heatsinks. The drawers have a power stage rotary selector so any number of stages may be enabled. Each stage has a short circuit current capability of 210 milliamps in the "SERIES" mode and 420 milliamps in the "DUAL" mode. At no time can a power stage be enabled or disabled when the "Power-ON" indicator is illuminated. This is a protective feature which is accomplished by a safety hold-in circuit. De-energizing the main DC power supplies No. 1 and No. 2 (reference drawing X312626) of the 103 Primary Power Control drawer removes the power and in a few seconds, the stages can be enabled or disabled. The power stage selector has 24 positions for 24 power stages. The selected number of stages will be indicated by the illuminated lights on the front panel once the "Enable" push-button is depressed. If too many power stages are energized, depress the "Disable" push-button and all stages will drop out: NOTE: Whenever power stages are reduced, all will drop out and it is necessary to reselect. To add more stages to the ones previously selected, turn the selector to the amount and depress the "Enable" button, but only after the 2 main DC power supplies are de-energized and the "Enable" "Disable" lights are on.

II. THEORY OF OPERATION (cont'd)

B. Detailed Description (cont'd)

3. Power Stages (cont'd)

All power stages have remote indicators available at the 202 remote panel (reference drawing X312634).

At the rear of the drawer are two switches. One of the switches, S5, controls number one power stage. A power stage has to be energized at all times. It can be in power stage A or power stage B. This is necessary to complete the feed-back loop to the controller. Note CAUTION notice on drawing.

The second switch, S4, is to switch the compensation capacitance bank from "Internal" to "Internal-External". When in the "Internal" position, each capacitor is connected to the common bus, and when in the "Internal-External" position, each capacitor is connected to either internal or external load, depending upon what is required.

Each string of 12 power stages is mounted on a heat-sink and forced air-cooled. A thermostat, set at 65° C, is down-stream from the blower and will shut down the console if the temperature exceeds the (+) 65° C temperature (reference drawing X213630).

4. Programmer - The 107 drawer (reference drawing X312627) contains the programmer electronics, with space P.C. card connectors and card-cage for future add-on. The associated relays and resistors for programming are mounted in the Controller Drawer (113). The front panel has three sets of digiswitches, one group for V_{OC} (open circuit voltage), I_{SC}(short circuit current) and I_{SPIN}(Spin Rate).

II. THEORY OF OPERATION (cont'd)

B. Detailed Description (cont.)

4. Programmer (cont.)

Associated with each digiswitch are binary indicator lights, i.e., 8, 4, 2 and 1. The digiswitch command setting is controlled either manually or automatically by virtue of a front panel switch. When this switch is in the manual position, the digiswitch setting is executed by depressing a momentary-make push-button switch on the front panel. Depressing this manual execute push-button creates a pulse, commanding the multiplexer and latch-register to activate relay controlled resistive dividers. As each digiswitch setting is executed, the front panel indicator lights illuminate the respective digiswitch settings. The digiswitch setting is such that an increase in numerical value is an increase in V_{oc}, I_{sc} or I_{spin}.

Contained in the drawer is the (+) 4, (+) 8 DC power supply. The control switch and protective fuses are mounted on the power supply and the cover has to be removed for access to the supply. The power "ON" switch can be left in the "ON" position, with no problems encountered.

The binary lights are "push-to-test" and have removable T-1 3/4 type 28 volt bulbs. A BNC floating type connector is mounted on the rear of the chassis and connected to the 202 remote panel to another BNC floating connector.

Setting the "Manual-Automatic" panel switch to "Automatic" connects the BNC on the 202 panel for manual or automatic executing.

II. THEORY OF OPERATION (cont.)

B. Detailed Description (cont.)

5. Load Simulator - The 104 drawer (reference drawing X312628) is the built-in load which the FRSAS has for sweeping the entire I-V characteristic. The maximum dissipation that this load can withstand is 1500 watts.

This load consists of wire-wound non-inductive resistors with means to select any parallel possible with 14 resistors.

The highest resistance combination prior to an open is 1000 ohms, whereas the lowest prior to a short is 0.015 ohms. This is accomplished by 14 "push-on, push-off" switches, front panel mounted, lettered R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14. The range of resistive values were selected so that all IV curves obtainable with the solar array simulator can be well defined. When each switch (S1 through S14) is activated to the "ON" position, its own internal lamp is energized to illuminate the push-button.

The load current is carried by heavy duty mercury relays rated at 20 amps, at 120 volts DC. The load current is measured by a 40 amp, 400 millivolt-drop shunt. The current and voltage can be displayed on the DPM's through the Primary Power drawer 103 and remote means are available through the 202 drawer, (load console status).

The "LOCAL-REMOTE" switch S17 is the master selector for all the switches and controls on the panel. When this switch S17 is in "LOCAL" position, all loads can be energized at the console, with

II. THEORY OF OPERATION (cont.)

B. Detailed Description (cont.)

5. Load Simulator (cont.)

panel and/or remote indicators. With S16 placed in the "REMOTE" position, all internal loads can be energized from a remote station and switched from internal to external load.

The "SHORT-CIRCUIT" switch S15, located on the panel, activates a relay to short the output of the power stages, which in turn gives short circuit current I_{sc}.

I_{sc} can only be executed when the Solar Array Simulator output is switched to the internal load. This can be done either at the console or from a remote station by virtue of the "LOCAL-REMOTE" switch. A white illuminated light indicates when I_{sc} has been executed. I_{sc} current is monitored by means of the current selector (Load Amp) on the 103 panel and displayed on the DPM (amps), using the same 40 amp shunt that is also used for the load current.

When the "LOCAL-REMOTE" switch is switched to "REMOTE", all load relays become de-energized and can only be energized by remote control.

A BNC connector on the front panel is connected to a current-transformer. This is the means to measure impedance of the system when the ancilliary equipment is inserted in the system by virtue of the connectors J08 and J09 at rear of the chassis. A copper bus bar jumper connects J08 to J09, and has to be removed for impedance tests connecting a high current, low impedance secondary of an isolation transformer (DC to Audio) at this point allows the means for inserting an AC signal between the FRSAS and the internal Load Simulator.

II. THEORY OF OPERATION (cont.)

B. Detailed Description (cont.)

6. Protective Circuitry - The protective circuitry is comprised of a group of series-connected micro-switches and thermostats. Two of the switches are activated by the rear left and right doors. The remaining two switches are controlled by the air-flow from the left and right blowers at the bottom of the console. The remaining five elements are thermostats located in the Power Stage drawers and in the controller drawer. Each of the four in the Power Stage drawer is mounted on a Wakefield heat-sink assembly, at the end farthest from the fan. The one in the controller is located in the reference cell temperature oven. The warning-panel (reference drawing X312630) is where all the switches and thermostats meet and shows the interconnection of additional circuitry including an audio signal device and 9 warning lights. The audio signal will sound and an indicating light will illuminate, indicating the trouble-area, whenever the console is shut down. The warning lights are in a series "hold-in" circuit that is in the "start-loop" circuits of the Primary Power. The series hold-in warning circuit can be disabled (reference drawing X312626) by depressing the "Override" red push-button on the Primary Power panel. The push-button switch should illuminate when the safety circuit is disabled. The audio signal can be disabled by placing the audio switch on the Primary Power panel into Audio-OFF (reference drawing X312626).
The drawings have self-explanatory notes so that the flow of interconnections (reference drawing X321634) makes troubleshooting an easy task.

II. THEORY OF OPERATION (cont.)

B. Detailed Description (cont.)

7. Displays - The Digital Panel Meters and Timer drawer (reference drawing X312629) contains two voltmeters. Model 343-3 has a 19.99V range while model 340A-1 has a range of 199.9 mv. The input leads (+input, -input) of the meters are connected to two double-pole multi-position rotary switches in the Primary Power. The six-position and the twelve-position switches select inputs for the 340A-1 and the 343-3, respectively. To take advantage of meter range, resistive dividers are used in approximately half of the switch positions. The 340A-1 is a voltmeter but will be reading across current shunts except when in the "OFF" position. The engraved metal strip at the bottom of the meter was changed from one reading "VOLTS DC" to one reading "AMPS".

   The elapsed time meter registers the amount of time the FRSAS has been used as a source of DC power and not the time it is on standby.

8. Power Supplies No. 1 and No. 2 - The two supplies are identical 60V-30A Trygon type Super Mercury Series featuring extremely low RMS ripple and peak-to-peak noise, automatic adjustable current limiting and constant voltage/constant current, automatic load share paralleling, and master slave tracking modes of operation. The supplies are connected in series master-slave configuration when the FRSAS output voltage V_{oc} desired is greater than 50 volts. When the main circuit breaker at the Primary Power controlling AC power is turned "ON" the supplies are automatically placed in the "SERIES" mode. The supplies are

II. THEORY OF OPERATION (cont.)

B. Detailed Description (cont.)

8. Power Supplies No. 1 and No. 2 (cont.)

not connected to the controller-power stage combination until the "START" button is depressed. In the "SERIES" mode, No. 2 is connected as the slave and therefore, its voltage will vary as the voltage on No. 1 is adjusted. Normally, the voltages are adjusted to 60V and 50V for No. 1 and No. 2, respectively.

In the "DUAL" mode of operation, the two are placed independent of each other. This configuration is used when the simulated array I-V requirement calls for a V_{oc} equal to or less than 50 volts and an I_{sc} equal to or less than 20 amps. The DC power source for the power stages will be power supply No. 1. Power supply No. 2 will be unloaded except for the 910 ohm resistor connected to its front panel output terminals.

REMEMBER: Use "DUAL" mode of operation when requirements call for a V_{oc} range of 10 to 50 volts and an I_{sc} range of 0.1 to 20 amps.

REMEMBER: Use "SERIES" mode of operation when requirements call for a V_{oc} range of above 50 to 100 volts and an I_{sc} range of 0.1 to 10 amps.

When in either of the above modes of operation, the user does not have to concern himself with adjusting the DC power source voltage 10 volts above the desired V_{oc}.

In order to be able to meet the Module Power Limit for the voltage-current locus of operation given in Figure 1, Section I, it is

II. THEORY OF OPERATION. (cont.)

B. Detailed Description (cont.)

8. Power Supplies No. 1 and No. 2 (cont.)

necessary to go in the "SERIES-ADJUST" mode. The operator shuts down Console AC power (circuit breaker) and removes relay K30, located inside the controller back panel. The I_{sc} digiswitches are then set according to Section III-B-2-c. The V_{oc} digiswitches are set per Section III-B-2-b. The voltage control knob on power supply No. 1 is turned fully CCW. Set the voltage DPM to read PS 1. Place the console on standby, then depress the "START" button. Adjust power supply No. 1 to 10 volts higher than one-half the V_{oc} desired.

9. 201 Chassis - The 201 chassis (reference drawing X312633) contains the 208/120, 3 phase AC power distribution. AC input is by means of a 60 amp, 5 wire power receptacle, applicable only to a 3 phase Wye-connected system. The AC secondary power is distributed to each plug-mold strip, No. 3 power supply, (+4+8) power supply, console blowers, power stage cooling fans, Function Generator and Digital Panel meters by virtue of the Primary-Power circuit-breaker in drawer 103 (reference drawing X12626). Mounted in the 201 drawer is a 3 phase magnetic power contractor controlled by a local or remote "START-STOP" station, and held in by a series safety circuit or an override safety switch. When this power contactor is energized, AC power is applied to power supplies No. 1, No. 2, +6, -6 and the elapsed time-meter. Three fuses, with failure indicator lamps, are mounted on the 201 panel. The 15 amp fuses are for the left and right plug-mold

II. THEORY OF OPERATION (cont.)

B. Detailed Description (cont)

9. 201 Chassis (cont.)

strips, while the 1 amp fuse is for the running time meter. The console can be mechanically grounded through the fifth wire in the AC power input cable with a little rework. This assembly is a 3 phase Wye-connected system.

10. 202 Panel - The 202 Panel (reference drawing X312634) (cable drawings) contains the receptacles for remote controlling and/or monitoring of the following drawers: Programmer, Power Stage A, Power Stage B, Primary Power, Load Simulator, and Controller. Mounted also on this panel is a connector for interfacing the FRSAS output with an external load. A chassis box, attached to the inside of the panel, contains isolating diodes to protect the FRSAS output circuitry from being electrically damaged by secondary power sources connected with external loads.

III. INSTALLATION AND OPERATION

A. Console Preparation for Use

1. General

a. Connect the 3 phase power cord to the rear of the console and to a 3 phase 208/120, 50 ampere 60 cycle service outlet.

b. Turn ON the service outlet at its source or power distribution panel.

c. Check that the AC power cords and connectors are secured. (close rear doors)

d. Turn ON Power Supplies No. 1, No. 2, No. 3, (+)6, (-)6, Constant Current and the +8, +4.

NOTE: The (+)8, (+)4 supply is located in the programmer drawer and can be left in the "ON" position.

e. Set the current limit controls on the (+)6 and (-)6 supplies to approximately the middle of full-clockwise.

NOTE: The constant current power supply is controlled by the programmer and no setting of the front control is required.

2. Primary Power Drawer

a. SEt the Voltage Selector to P.S. #3.

b. Set the "Local-Remote" switch to "Local" (up).

c. Set the "AUDIO ON" - "AUDIO OFF" switch to "AUDIO OFF" - down.

3. Load Simulator Drawer

a. Set the I_{SC}- "NORMAL" switch to "NORMAL".

b. Set the "REMOTE-LOCAL" switch to "LOCAL".

c. Set the "Internal-External" switch to "Internal".

d. Place all push button switches R1 through R14 in the "OFF"

III. INSTALLATION AND OPERATION (cont.)

A. Console Preparation for Use (cont.)

3. d. (cont.)

position. At this point, this is done by sound. A loud snap means the switch is "OFF", a soft snap - "ON".

4. Power Stage Drawers A and B

a. Set the Rotary selector to position 1.

NOTE: On the rear of the chassis (drawer) are two toggle switches, S4 and S5. S5 is a circuit in parallel with position 1 of the front panel rotary selector. The S5 switches are in essence a safety circuit in case an operator forgets to energize one of the power stages in A or B. Either S5 in power stage A or B will energize a power stage when the console is energized to operate.

Only one should be left in the "ON" position, (up) or both can be left OFF, relying upon the operator to enable (energize) a power stage.

S4 should be left in the "UP" position, except when output impedance measurements are to be made.

5. Primary Power Drawer

a. Set the main circuit breaker to "ON" (up). Red neon light should be illuminated.

6. Power Supply No. 3

a. Set current controls approximately full ON-clockwise.

b. Set output voltage of P.S. #3 to 26 $\pm$ 0.5 VDC.

Observe voltage on DPM voltmeter. Reading should be 2.6V X 10 or 26 VDC $\pm$ 0.5V.

III. INSTALLATION AND OPERATION (cont.)

A. Console Preparation for Use (cont.)

7. Programmer Drawer

a. Set the "AUTOMATIC-MANUAL" toggle switch to "MANUAL".

b. Set the V_{oc} and I_{sp} digiswitches to 000 and 00, respectively.

c. Set the I_{sc} digiswitches at full illumination, 999.

d. With the current selector on the Primary Power drawer, set at CELL, measure the cell current. It should read approximately 152 ma.

NOTE: The V_{oc} and I_{sp} settings are to be dialed-in after console DC power is turned on.

8. Function Generator

a. Set the AC power control knob to "OFF".

9. Power Supplies - No. 1, No. 2, +6, -6.

a. Turn the DC power on by depressing the "START" button.

b. Measure the supply voltages using the digital meter marked "VOLTS DC" and the voltage selector on the Primary Power. The supplies are adjusted to approximately +60V for No.1, +50V for No.2, +6V for +6, and -6V for -6. The programmer power supply voltages +4 and +8 are not adjustable.

B. Operation

1. Function of Controls

The various controls throughout the console will be discussed. Better understanding of the descriptions can be had by referring to the section containing pictures of the front panels. Beginning in the left bay, the first drawer having controls is the Load Simulator (Chassis 104). There are 17 controls on the front panel, 14 of which switch the parallel resistors R1 through R14 in and out. Depressing push-button R1 activates relay K1 (reference drawing X312628) which inserts resistor R1 across the output of the FRSAS. The push-button control is a combination switch and indicator which lights when the resistance is in the circuit. This push-button control can be duplicated remotely.

The remaining three controls of the Load Simulator are toggle switches. The Isc/NORMAL switch S15 activates relay K15, when the FRSAS is on internal load, shorting the output. The INTERNAL/ EXTERNAL switch S16 processes the output current and voltage either to the internal resistive load or an external system load. Physical control of the Load Simulator is determined by switch S17. If it is in the "REMOTE" position, then all other controls can only be activated remotely.

The Programmer has 10 controls on the front panel. Eight of these are thumbwheel switches which provide logic inputs to the multiplexers. There are 3, 2, and 3, respectively, for V_{oc}, I_{spin}, and

III. INSTALLATION AND OPERATION (cont.)

B. Operation (cont.)

1. Function of Controls (cont.)

I_{sc} control. The AUTOMATIC/MANUAL must be in the "MANUAL" position. In the "AUTOMATIC" position, the programmer will not function because it is not wired for external inputs. The "MANUAL EXECUTE" push-button releases the logic states that have been loaded into the latch registers.

The Primary Power (Chassis 103) has 11 controls on its front panel. The 3 pole circuit breaker applies AC power to the console's 2 internal mold strips and to power supply No. 3. There are 4 push-buttons, two of which control DC power from the following power supplies - No. 1, No. 2, +6, -6. There is an "OVERRIDE" push-button that allows bypassing the protection circuitry. The circular push-button provides a means for disengaging the dc power supplies No. 1 and No. 2 from master-slave series operation. The two rotary switches are for selecting the currents and voltages to be displayed on the Digital Panel Meters and be provided at the test points next to the switches. The safety-hooded toggle switches allow for shorting power supplies No. 1 or No. 2 for the purpose of setting their current limit. The two remaining controls are toggle switches. The "LOCAL/REMOTE" switch allows start-stop control at the console or at a remote station. The "AUDIO-ON/AUDIO-OFF" switch removes power from the audio warning device on the Warning Panel (Chassis 110).

The controls on the two dc power supplies No. 3 and No. 2, right below the Primary Power, are self-explanatory.

In the rightbay, the first functional drawer having controls is Power

Stage A (Chassis 114). There are three controls on the front panel and two on the back panel. The rotary switch selects the number of power stage relays that will be energized when the "ENABLE" push-button is depressed. The "DISABLE" push-button de-energizes all the relays with the exception of perhaps one. These push-buttons are the momentary-make and momentary-break type, respectively. Two toggle switches are on the back panel. S4 places the return side of the compensation capacitance bank either at the common bus in the Power Stage A drawer or at the common bus, via the load current shunt, in the Load Simulator drawer (Chassis 104). The "INTERNAL ONLY" position selects the Power Stage A common bus. S5, in the up-position, activates power stage relay no. 1 that permanently connects power stage no. 1 to the controller. This switch should be left in the up-position.

The next drawer down is Power Stage B (Chassis 112). Its controls and their function are identical to Power Stage A.

Below Power Stage B is the controller drawer (Chassis 113). There is one push-button switch on the front panel. This is for momentarily shorting out the reference current being supplied to the controller electronics. The +6, -6, and constant current dc supplies have front panel controls. The "Power ON" switches for the three supplies should be left in the "ON" position permanently. The current limit adjustment for the +6 and -6 volt supplies should be set at midpoint. The voltage controls should be adjusted to provide +6 and -6 volts and left there. The front panel current control of the constant current supply has been disengaged and therefore has no effect on the supply's output current.

The controls on dc power supplies No. 1 and No. 2 allow for AC power turn-on, coarse and fine adjustment of both voltage and current. Power Supply No. 3 has one less control allowing for only coarse current limit adjustment. The AC power-on switches should be left on and the current limit set to maximum for all three supplies. Power Supply No. 3 should be set at 26 ± 0.5 VDC. Power Supply No. 2 should be set at 50 ± 0.5 VDC while Power Supply No. 1 should be set at 60 ± 0.5 VDC. In the Series-Adjust Mode the voltage control of Power Supply No. 1 will be the only one manually adjusted.

2. Selection of Initial Settings

a. To select the proper number of power stages to be used for simulating a given size array, determine N_p from the known maximum I_{sc} desired.

$N_p = I_{SC}/0.14$ where I_{SC} is in amps.

Divide N_p by 3 to determine the number of stages when operating in the "DUAL" mode. This number is then dialed-in with the rotary selector switch in the front panel of the power stage drawer. When more than 24 stages are required, Power Stage A is operated at full capacity and the additional stages are dialed-in with Power Stage B. The simulator will function just as well if the operator chooses to divide the number of working stages between the two drawers.

In the "SERIES" mode of operation, it is necessary to divide N_p by 1.5. This number is then dialed-in as before.

In the "SERIES-ADJUST" mode, where requirements call for an I_{SC} between 10 to 20 amps and V_{oc} between 50 to 100 volts, the number of stages are set at 48.

2. Selection of Initial Settings (cont.)

b. The desired V_{oc} is set by the V_{oc} digiswitches at the programmer front panel. The numerical setting V_{ocs} is determined from Table 2 for 19x24 (456) combinations of V_{oc} and I_{scs}. I_{scs} is defined as the short circuit current setting and must be determined first in order to select V_{ocs}. The Table 2 for V_{ocs} is used for all modes of operation, i.e., "SERIES", "DUAL" and "SERIES-ADJUST".

c. The desired I_{sc} is set by a combination of the N_p obtained in (a) above and the I_{sc} digiswitches at the Programmer front panel. The numerical setting I_{scs} is determined from either Table 3A or Table 3B. For "SERIES" operation, use Table 3A while for "DUAL" operation, use Table 3B. These tables give I_{sc} current values (amps) for various numerical I_{sc}'s when the number of power stages is 48. An I_{scs} of 999 signifies the reference cell is under full illumination. Therefore, for any condition requiring less than 48 stages at full illumination, it is necessary to multiply the I_{sc} in the first-column, first-row by the ratio P/48, where P is the number of power stages, to determine the new value of I_{sc}. Furthermore, to derive a new table for any number of power stages, just multiply all I_{sc} values in the tables by P/48.

The operator should use caution when setting I_{sc} for "SERIES-ADJUST" operation. Press the "STOP" button and turn console "OFF". Turn console "ON", which assures power supplies are in the "SERIES" mode. Set I_{scs} temporarily at 100 and execute. Press "START" button and adjust power supply No. 1 to 10V above one-half the desired V_{oc}. Remove relay K30 in the controller. For the desired I_{sc} select I_{scs} from Table 3B, set the digiswitches, and execute.

2. Selection of Initial Settings (cont.)

d. The I_{sp} digiswitches on the Programmer allow control of the variation of I due to spinning. There are only 5 numerical settings possible, 00, 05, 10, 15, 20. When the amplitude control knob of the Function Generator is set properly and the I_{sp} is 20, the short-circuit current I_{sc} will be varied $\pm$ 20%. The other I_{sp} settings will represent percent variation of I_{sc} also.

e. To set the Function Generator properly, turn the amplitude control on its front panel fully CCW. The Function Generator is located directly above the Programmer. Put the Console on standby by placing the main circuit breaker in the "ON" position. Only AC power at the mold strips is required for this setup, therefore, the "DC ON" light next to the circuit breaker in the Primary Power should not be lit. Connect a DVM to the current test points at the Primary Power and set the selector switch to read cell current. With I_{scs} = 999 the current should read approximately 152 ma. Set I_{scs} = 750 and execute. The current should read 122 ma. Turn the Function Generator on, set I_{sps} = 20, and execute. Set the square-wave function in and adjust the frequency to around 0.1 Hz/sec. Increase the amplitude control of the F.G. until the current changes states from 98 ma. to 152 ma. This represents $\pm$ 20% variation of the reference current and will result in $\pm$ 20% variation of any I_{sc}. The highest I_{scs} that should not be exceeded when $\pm$ 20% modulation is to be imposed is I_{scs} = 750.
HINT: Place a permanent mark where the dial indicator sits to avoid tedious setting again.

3. Variation of Settings with Time

a. Manual - To simulate the variation of V_{oc} and/or I_{sc} with time manual adjustment of the V_{oc} and I_{sc} digiswitches is required. Short-circuit current resolution is approximately 20 ma, while for open-circuit voltage it is approximately 100 mv. To illustrate, assume it is desired to simulate an array coming out of an eclipse. Tabulate the known real array I-V characteristic, voltage and current variations due to temperature and time. Typically, a cold array will produce a higher V_{oc} and lower I_{sc} than a hot array. These parameters are then converted via Tables 1 and 2 in Section III-B-2 to the appropriate I_{scs} and V_{ocs} values. Assuming that the proper number of power stages and load have been established, dial in the first set of I_{scs} and V_{ocs} and execute. Press the "START" button and begin adjusting I_{scs} and V_{ocs} according to the figures tabulated.

b. External - With proper mechanical and electrical modifications to the Programmer drawer and logic card housing, adjustments of the settings can be made from a remote station automatically as well as manually.

4. Load Simulator

To be able to shunt the simulator's resistors across the FRSAS output, it is necessary for the "EXTERNAL/INTERNAL" toggle switch to be in the "INTERNAL" position. The resistors, then can be inserted by depressing the R buttons if the "REMOTE/LOCAL" toggle switch is in "LOCAL" and the I_{sc}/NORMAL toggle switch is in "NORMAL".

B. Operation (Cont.)

4. Load Simulator (cont.)

To control the resistors and other switches from a remote station, set "REMOTE/LOCAL" switch to "REMOTE". It is recommended that the R switches be initially operated in a sequence such as R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14. This is to be followed, if desired, by short-circuiting the output via switch "I_{sc}/NORMAL". Any single switch from R1 to R14 can be on by itself, even under maximum I-V conditions, when the FRSAS is in the "SERIES" mode. However, in the "DUAL" and "SERIES-ADJUST" modes, it is recommended that at least two consecutive switches be on beyond R9.

Test points are provided to obtain direct readings of V_o and I_o. A BNC connector is provided also to measure and observe AC load currents of the FRSAS.

V_{oc} as a Function of V_{ocs} and I_{scs} for 48 Pwr Stages

TABLE 2

V_{OCS}	999	950	900	850	800	750	700	650	600	550	500	450
I_{SCS}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}
999	99.53	95.12	90.60	86.04	81.53	77.15	73.95	68.35	64.60	59.25	55.30	50.12
950	99.17	94.77	90.27	85.73	81.25	76.85	72.69	68.10	63.60	59.03	54.51	49.90
900	98.77	94.41	89.92	85.42	90.92	76.59	72.37	67.84	63.31	58.80	54.27	49.72
850	98.41	94.02	89.58	85.06	80.61	76.26	72.09	67.54	63.06	58.54	54.05	49.50
800	97.98	93.64	89.18	84.72	80.25	75.96	71.75	67.24	62.78	58.28	53.80	49.28
750	97.51	93.18	88.77	84.29	79.89	75.57	71.40	66.92	62.47	58.00	53.55	49.05
700	97.01	92.71	88.30	83.89	79.47	75.22	71.04	66.57	62.15	57.70	53.28	48.80
650	96.53	92.20	87.86	83.43	79.08	74.81	70.65	66.20	61.81	57.38	52.99	48.53
600	95.94	91.68	87.32	82.95	78.58	74.38	70.21	65.81	61.44	57.04	52.66	48.24
550	95.33	91.08	86.79	82.41	78.11	73.88	69.76	65.39	61.04	56.68	52.33	47.93
500	94.64	90.44	86.15	81.84	77.51	73.39	69.26	64.90	60.60	56.26	51.95	47.58
450	93,87	89.70	85.46	81.15	76.91	72.76	68.68	64.37	60.10	55.80	51.52	47.19
400	92.97	88.86	84.64	80.40	76.17	72.11	68.03	63.77	59.53	55.27	51.03	46.75
350	91.92	87.85	83.71	79.47	75.35	71.28	67.27	63.07	58.87	54.66	50.47	46.24
300	90.72	86.73	82.59	78.49	74.35	70.40	66.40	62.25	58.11	53.96	49.82	45.64
250	89.29	85.33	81.32	77.22	73.21	69.26	65.37	61.27	57.20	53.12	49.05	44.93
200	87.40	83.55	79.61	75.65	71.67	67.86	64.02	60.02	56.04	52.04	48.05	44.03
150	82,83	81.10	77.30	73.42	69.63	65.89	62.20	58.32	54.46	50.58	46.70	42.80
100	80.31	76.85	73.25	69.67	66.04	62.57	59.08	55.42	51.76	48.10	44.43	40.72

$I_{SCS} \equiv$ I_{SC} setting $\quad$ $I_{SC} \equiv$ short-circuit current

$V_{OCS} \equiv$ V_{OC} setting $\quad$ $V_{OC} \equiv$ open-circuit voltage

V_{oc} as a Function of V_{oc} and I_{scs} for 48 Pwr Stages

TABLE 2 (CON'T)

V_{OCS}	400	350	300	250	200	150	100	50	40	30	20	10
I_{SCS}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}	V_{OC}
999	46.02	41.13	36.74	31.98	27.48	22.84	18.30	13.69	12.77	11.86	10.94	10.02
950	45.39	40.96	36.44	31.85	27.33	22.76	18.22	13.63	12.72	11.81	10.90	10.00
900	45.19	40.81	36.27	31.73	27.20	22.66	18.13	13.56	12.65	11.75	10.84	9.95
850	45.01	40.63	36.14	31.58	27.08	22.56	18.05	13.50	12.60	11.70	10.80	9.90
800	44.81	40.45	35.97	31.44	26.97	22.45	17.98	13.44	12.54	11.65	10.75	9.85
750	44.60	40.25	35.80	31.29	26.83	22.35	17.88	13.38	12.48	11.60	10.70	9.80
700	44.37	40.05	35.62	31.13	26.70	22.23	17.80	13.31	12.42	11.54	10.65	9.76
650	44.13	39.83	35.43	30.96	26.55	22.11	17.70	13.24	12.35	11.47	10.59	9.70
600	43.86	39.59	35.20	30.78	26.40	21.99	17.60	13.16	12.28	11.40	12.52	9.65
550	43.58	39.34	34.99	30.58	26.23	21.85	17.48	13.08	12.20	11.34	10.46	9.60
500	43.26	39.05	34.73	30.36	26.03	21.69	17.36	12.98	12.11	11.25	10.38	9.52
450	42.91	38.73	34.45	30.11	25.83	21.51	17.22	12.88	12.02	11.16	10.29	9.44
400	42.50	38.38	34.13	29.83	25.58	21.31	17.05	12.76	11.90	11.05	10.20	9.35
350	42.03	37.96	33.75	29.51	25.30	21.07	16.87	12.62	11.77	10.94	10.09	9.25
300	41.50	37.47	33.32	29.13	24.98	20.81	16.65	12.46	11.63	10.80	9.96	9.14
250	40.86	36.89	32.81	28.68	24.60	20.49	16.40	12.27	11.45	10.64	9.81	9.00
200	40.04	36.15	32.15	28.11	24.11	20.08	16.07	12.03	11.22	10.42	9.62	8.82
150	38.93	35.15	31.26	27.34	23.44	19.53	15.64	11.70	10.92	10.14	9.36	8.58
100	37.05	33.47	29.78	26.04	22.35	18.62	14.92	11.16	10.42	9.68	9.93	8.18

$I_{SCS} \equiv I_{SC}$ setting $\qquad I_{SC} \equiv$ short-circuit current

$V_{OCS} \equiv V_{OC}$ setting $\qquad V_{OC} \equiv$ open-circuit voltage

TABLE 3A

I_{sc} as a Function of I_{scs} and V_{ocs} for 48 Power Stages in "SERIES" Operation

I_{SCS}	999	950	900	850	800	750	700	650	600	550	500	450	400	350	300	250	200	150	10[illegible]
V_{OCS}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}
999 to 010	9.93	9.52	9.13	8.75	8.34	7.90	7.46	7.01	6.54	6.06	5.55	5.04	4.50	3.94	3.36	2.76	2.14	1.52	0.[illegible]

TABLE 3B

I_{sc} as a Function of I_{scs} and V_{ocs} for 48 Power Stages in "DUAL" Operation

I_{SCS}	999	950	900	850	800	750	700	650	600	550	500	450	400	350	300	250	200	150	10[illegible]
* V_{OCS}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}	I_{SC}
450 to 010	19.86	19.04	18.26	17.50	16.68	15.80	14.92	14.02	13.08	12.12	11.10	10.08	9.00	7.88	6.72	5.52	4.28	2.04	1.[illegible]

* In "SERIES-ADJUST" operation Table 3B can be used through $010 < V_{ocs} < 999$

$I_{SCS} \equiv I_{SC}$ setting

$V_{OCS} \equiv V_{OC}$ setting

$I_{SC} \equiv$ short-circuit current

$V_{OC} \equiv$ open-circuit voltage

IV. MAINTENANCE/CALIBRATION AND TROUBLESHOOTING

A. List of Drawings

X312624	Indentured Drawing List
X312625	Block Diagram
X312626	Primary Power
X312627	Programmer
X312628	Load Simulator
X312629	Digital Panel - Meters & Timer
X312630	Warning Panel
X312631	Power Stage
X312632	Controller
X312633	AC 208/120 Power Distribution
X312634	Cables
o	I-V Load Line Curve

IV. MAINTENANCE/CALIBRATION AND TROUBLESHOOTING (cont.)

B. Recommended Test Equipment

- Oscilloscope - Tektronix, Type 545B with Pre-amplifier 1A7A or equivalent.
- Digital Voltmeter - Cimron, Model 7200A with DC Pre-amplifier or equivalent.
- Milliammeter - Hewlett-Packard, Model 428B or equivalent.
- Wave Analyzer - Hewlett-Packard, Model 302 or equivalent.
- Volt-Ohmmeter - Triplett, Model 601 or equivalent.
- Power Amplifier - McIntosh, Model 100 or equivalent.
- Isolation Trabsformer - Solar Electronics Col, Type 6220-1 or equivalent
- DC Power Supplies (2). 0 to 60 V, 0 to 10 Amp.
  0 to 10 V, 0 to 50 Amp.
- Resistive Load - Non-Inductive, 40 amp range.

IV. MAINTENANCE, CALIBRATION AND TROUBLESHOOTING (cont.)

C. Maintenance/Calibration Schedule and Procedure

1. Console - The console shall be mechanically checked every six months for any malfunction. The blower motors in each power supply (Nos. 1, 2 and 3) shall be checked for bearing wear and oiled (check Trygon Instruction Manuals). The console blower motors are lifetime oiled, but should be checked for excessive bearing wear. The filter screens shall be cleaned every three months or sooner if visual inspection indicates clogging, or at any time the blower-vane switches shut down the console due to air-flow restriction.

   The console shall be electrically checked every six months in conjunction with the calibration of the digital panel meters, shunts and voltage dividers.

2. Digital Panel Meters - The digital panel meters should be calibrated against a laboratory standard every six months. The DPM 340A is a millivolt meter, reading 19.99 millivolts DC full scale. The DPM 343A is a volt meter, reading 19.9 volts DC full scale. Refer to the schematics in the DATA TECH. instruction manual.

3. Voltage Dividers and Shunts - The voltage dividers shall be checked every six months. Refer to TRW Drawing X312626 for the 10K and 100K potentiometers. The 10K potentiometers are to set the millivolt drops for the AMP digital panel meter.

   Shunts R1, R25 and R29 are rated at 30 amps, 100 millivolt drop, $\pm$ 0.1%. To calibrate lift the wires from one end of each shunt and using an external power supply, apply current in series with a laboratory shunt standard and resistive load in equal increments to 30 amps. Read each output with a lab standard digital voltmeter in millivolts at the shunt terminals and at the current test points provided on the front panel of the primary power drawer.

The reading at the test points should be where, $V_x/3.33$ equals the voltage for the DPM. Adjust appropriate 10K pot for shunt being checked. V_x is the millivolt drop at shunt terminals. The reading at the test point is read directly in amps. The 100K potentiometers, reference drawing X312626, are to set the voltages for the VOLTS digital panel meter. Power Supplies Nos. 1, 2 and 3, Power Stage A, Power Stage B, and the load have voltage divider networks.

The outputs can be checked using the console supplies. Connect a laboratory standard digital voltmeter to check points of each power supply.

a. For Power Supply No. 1, connect positive lead at cathode side of CR8 and negative at R29.

b. For No. 2, connect positive at cathode side of CR9 and negative at R25.

c. For Power Supply No. 3, connect positive at R1 and negative at TB1-5,6.

Adjust supply in equal increments and read output at the check points and at the panel voltage test points using a laboratory standard digital volt meter.

The voltage reading at the panel test points should be $V_y/10$; where V_y is the power supply at the check points. Adjust appropriate (R), 100K pots, for voltage, $V_y/10$.

3. Voltage Dividers and Shunts (cont.)

The Power stage voltages (A&B) and load voltages can be checked under actual loading using the Internal Load. Refer to Section III discussing installation and operation.

With the console under actual operation, using the internal load and power stages, execute several V_{oc} settings, read the outputs of each power stage and load voltage at the 103J01 test point panel, (at rear of primary power drawer) reference X312626.

Adjust appropriate (R) 100K pots for voltages at the panel test points. Voltages should be $V_y/10$; where V_y is the voltage at the 103J01 test points.

The Load Current Shunt, R15, is a 40 amp, 400 millivolt drop 0.1% (reference TRW Drawing X312628).

This shunt can be calibrated by removing the wires from one end of the shunt and applying a current in increments as before. Read the millivolt drop at the front panel test points (DC amps) TP3 and TP4.

4. V_{oc} and I_{sc} Tables - Tables 2 and 3 in Section III-B should be calibrated every three months. To generate Table 2, set $R_L = \infty$ and insert 48 power stages. Then record V_{oc} as a function of V_{ocs} and I_{scs}. To generate Table 3A, put the console in "SERIES" operation, set Load Simulator to "I_{sc}" after depressing consecutively all "R" buttons, and record I_{sc} as a function of V_{ocs} and I_{scs}. For generating Table 3B, put the console in "DUAL" operation and record I_{sc} as a function of V_{ocs} and I_{scs}.

IV. MAINTENANCE/CALIBRATION AND TROUBLESHOOTING (cont.)

D. Preventive Maintenance

Exercise the power stage relays before each daily use of the console. To do this, put the FRSAS on standby by turning AC power "ON" (CB1) and set selector on each power stage drawer to position 24. Exercise the relays approximately 20 times by alternately pushing the "ENABLE" and "DISABLE" buttons to clean their contacts.

Check the output on scope, observe that the noise level is within tolerance. Excessive noise can be picked up in the controller when the "DRIVE" and "SENSE" coax cables are close to the power supplies, i.e., Nos. 1, 2 or 3.

Reduce load, if at all possible, whether internal or external, before turning off DC power.

Remember that when using the Load Simulator in "DUAL" or "SERIES-ADJUST" modes, at least two consecutive R switches must be on when going beyond R9.

Perform a visual check of front panel indicators following activating of switches.

Don't have any of the "R's" energized on the Load Simulator during standby.

Don't disconnect any cable while DC power is on.

IV. MAINTENANCE/CALIBRATION AND TROUBLESHOOTING (cont.)

E. Troubleshooting Hints

1. Programmer - If front panel indicator lights do not agree with the digiswitch settings, check the bulbs. These are push-to-test bulbs and are T-1 3/4, 28 VDC bulbs. Check the Teledyne relays in the Controller with an ohmmeter. Reference drawing X312632 has a circuit diagram of the TO-f relays as well as the resistive elements they control. The Console must be on standby during tests.

2. Controller - If problems are suspected in the Controller-Power State combination, begin with the Controller. Set Power Stage A to 1 stage. Set Load Simulator to "I_{sc}". Then pull-out the Controller drawer. Turn the DC power on and take voltage readings at the points given in Table 5. If these readings check with the typical values given in the "AT I_{sc}" column go on to the power stage. If the readings are not within ± 10% of those in the Table, it will be necessary to check connections and components near the point of measurement. Refer to sheet 1 of drawing X312632.

3. Power Stage A or B - As a continuation of (2) above, take readings in the power stage being used and compare with Table 6. If the readings taken for the controller-single power stage combination check alright, then set the operating point at V_{oc} and repeat (2) and (3).

   To trace a problem down that could be in any one of the 48 power stages, simply put the FRSAS at I_{sc} in the "DUAL" mode and insert one stage in at a time. The output current should increase by 420 ma ± 5% with every additional stage. A defective stage may be permanently removed by pulling out its 4PDT relay.

E. Troubleshooting Hints. (cont.)

4. Load Simulator - To verify that the various push-buttons, toggle switches and relays are functioning, follow this procedure.

   On the front of the panel connect a VOM between the NEGATIVE side of the "LOAD VOLTS" test point and to the copper bus bar at rear of chassis. Set VOM to (R x 10). Should read open circuit.

   Depress R1 through R14 and observe that the resistance reading of the VOM gradually decreases from 1000 ohms to approximately 0.125 ohms. (Change setting of VOM for low reading).

   NOTE: Notice that the R1 through R14 push-buttons illuminate. The resistance readings should decrease by 50 percent as each push-button is depressed (energized).

   Reset push-buttons R1 through R14 to an open-circuit resistance on VOM.

   Set the "I_{sc}-NORMAL" toggle switch to "I_{sc}" (up). Observe resistance reading - should be less than 0.125 ohms.

   NOTE: Observe that the "I_{sc}","Local" and "Internal" indicators are illuminated.

   Set the "Internal-External" toggle switch to "External" - I_{sc} should drop out and resistance should be open circuit. Observe that "External" indicator is illuminated.

   Set "Internal-External" back to Internal. The I_{sc} indicator should illuminate and the VOM reading should be less than 0.125 ohms.

   Set the "Local-Remote" toggle switch to "Remote". I_{sc} should drop out and resistance should be an open circuit.

   Set "Local-Remote" switch back to "Local". Set the I_{sc}- Normal" switch back to "Normal". Remove VOM.

TABLE 4

CONTROLLER VOLTAGE READINGS

FROM	TO	AT I_{SC}	AT V_{OC}
R1 input	Common	+2.226	+2.226
Q1-E	"	+2.206	+2.206
Q1-B	"	+1.418	+1.419
+ 6 Bus	"	+6.048	+6.048
Q1-C	"	+0.002	+0.542
Q2-E	"	-0.959	+0.517
Q2-B	"	-1.708	-0.130
Q2-C	"	-3.142	-5.375
Q3-B	"	-2.363	-0.710
Q3-C	"	-6.020	-6.020
Q4-B	"	-3.409	-3.409
Q4-E	"	-4.075	-4.075
Q5A-E	"	+0.643	+1.186
Q5B-E	"	+0.643	+1.186
Q5B-B	"	+0.002	+0.550
Q5B-C	"	-6.020	-6.020
Q7-B	"	-3.142	-5.375
Q7-E	"	-3.853	-5.970
Q8-E	"	-3.836	-5.961
Q7-C	"	-1.989	-1.871
Q6-B	"	-1.395	-1.362
Q6-C	"	+55.31	+59.78
+60 supply	"	+60.00	+60.00
Q9-E	"	+54.63	+59.08
Q10-C	"	+54.34	+58.80
Q10-B	"	0	0
Q10-E	"	-0.543	-0.543

CONDITIONS

Single Stage	I_{SC} = 453ma	I_{SCS} = 999
Dual Mode	V_{OC} = 50.36	V_{OCS} = 450

TABLE 5

POWER STAGE VOLTAGE READINGS

FROM	TO	I_{SC} OPERATION	V_{OC} OPERATION
Q1-C	Common	+0.522	+50.08
Q1-B	"	-2.755	-2.664
Q1-E	"	-3.305	-3.225
TSTP-1	"	+6.015	+6.025
TSTP-2	"	-6.031	-6.017
TSTP-3	"	+54.41	+59.10
TSTP-4	"	+0.527	+50.11
TSTP-5	"	0	0
TSTP-6	"	0	0
TSTP-7	"	+60.02	+60.13
TSTP-8	"	+54.33	+59.04
TB3-1	"	+60.15	+60.24
TB3-2	"	+60.31	+60.21
TB3-3	"	0	0
TB3-4	"	0	0
TB3-5	"	+0.080	+50.09
TB3-8	"	+60.02	+60.13
TB3-9	"	0	0
Q2-B	"	+54.42	+59.10
Q2-E	"	+55.07	+59.75
Q2-C	"	+52.71	+52.96
Q3-E	"	+52.71	+52.96
Q3-B	"	+52.10	+52.32
Q3-C	"	+2.522	+50.72
Q4-B	"	+2.522	+50.72
Q4-E	"	+0.542	+50.16
Q4-C	"	+55.17	+59.87

CONDITIONS

Single Stage	I_{SC} = 453ma	I_{SCS} = 999
Dual Mode	V_{OC} = 50.36	V_{OCS} = 450

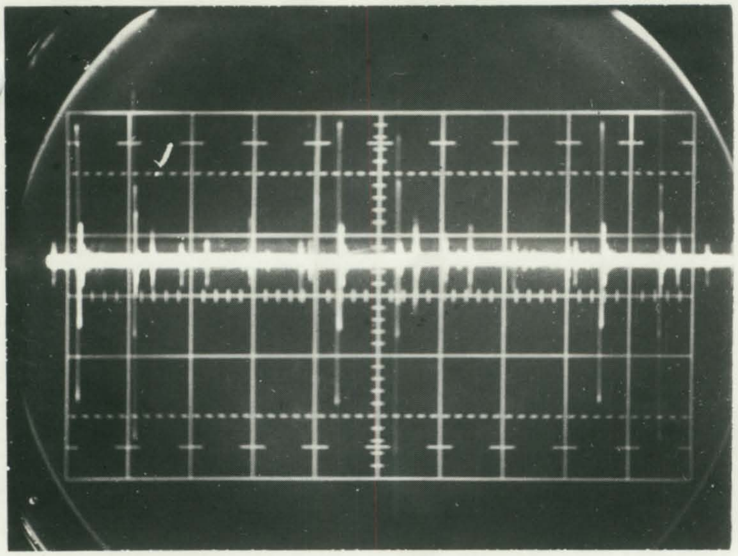
V. OUTPUT RIPPLE AND TRANSIENT RESPONSE PHOTOGRAPHS

A. Output Ripple

B. Transient Response

Output Ripple Near I_{SC}

Conditions



A.

48 Stages - Dual

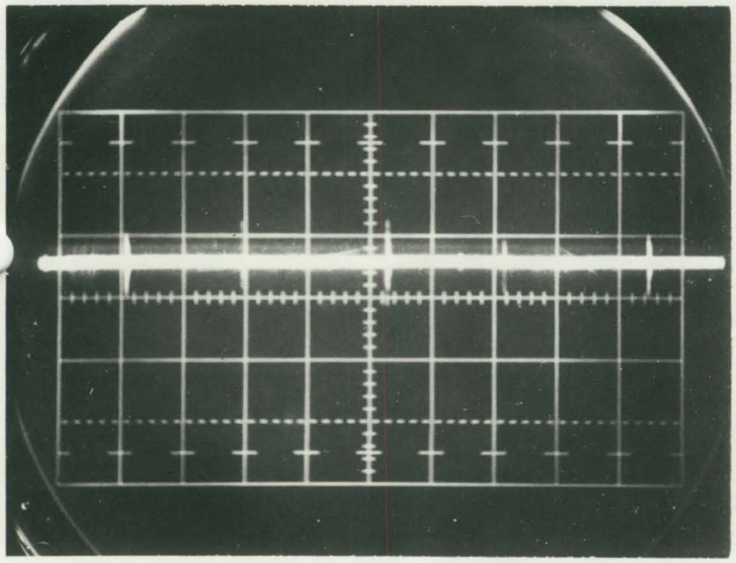
R_L = R1 → R14

V_0 = 3.19V I_0 = 19.70a

V_{OCS} = 450 I_{SCS} = 999

VERT. = 50mv/cm HORZ. = 2ms/cm

System common floating



B

48 Stages - Dual

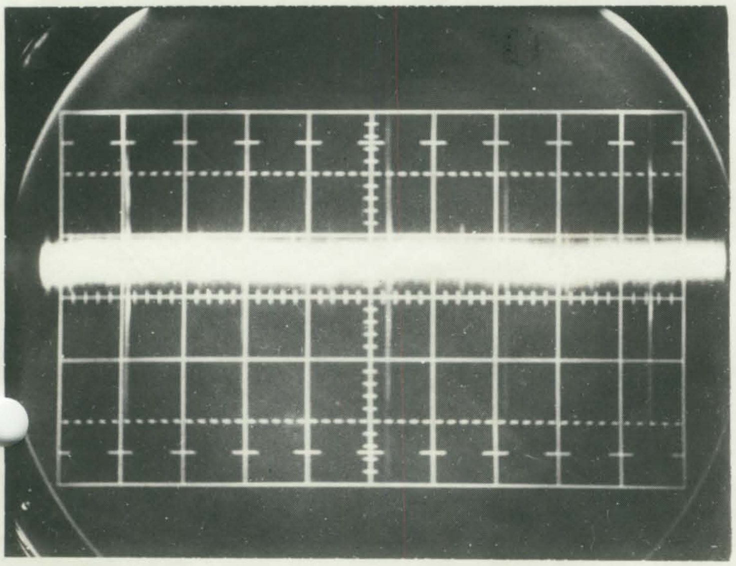
R_L = R1 → R14

V_0 = 3.19V I_0 = 19.70a

V_{OCS} = 450 I_{SCS} = 999

VERT. = 50mv/cm HORZ. = 2ms/cm

System common grounded to chassis



C

48 Stages - Dual

R_L = R1 → R14

V_0 = 3.19 I_0 = 19.70a

V_{OCS} = 450 I_{SCS} = 999

VERT. = 10mv/cm HORZ. 2ms/cm

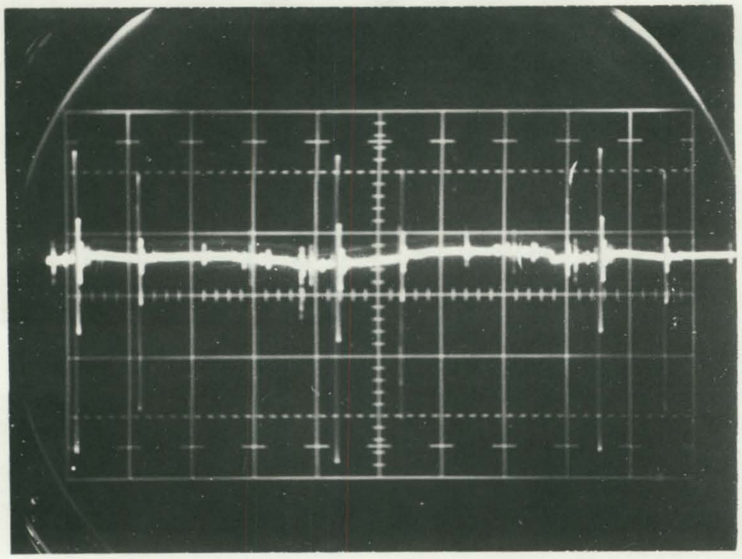
System common grounded to chassis

2 ⊕

FIGURE 1

Output Ripple

Near Max. Power Point



A.

48 Stages Dual

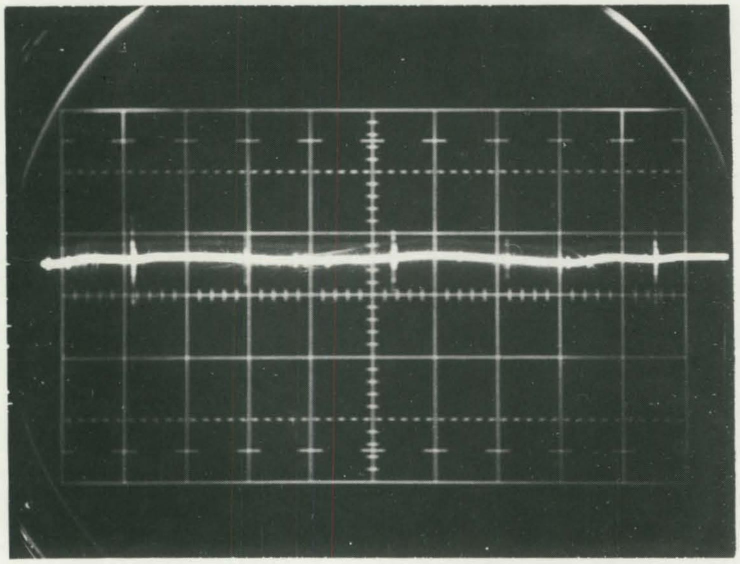
$R_L = R8 \| R9 \| R10$

$V_0 = 40.6V$ $I_0 = 17.8a$

$V_{OCS} = 450$ $I_{SCS} = 999$

VERT. = 50mv/cm HORZ. = 2ms/cm

System common floating



B.

48 Stages - Dual

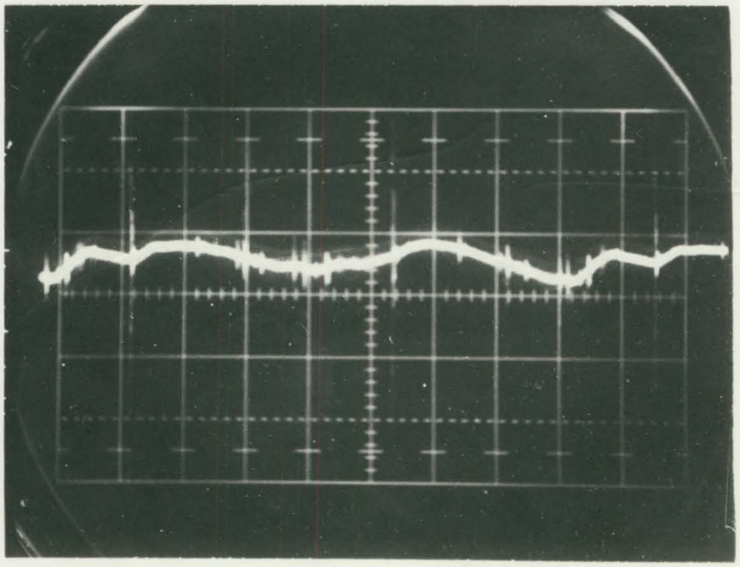
$R_L = R8 \| R9 \| R10$

$V_0 = 40.6$ $I_0 = 17.8a$

$V_{OCS} = 450$ $I_{SCS} = 999$

VERT. = 50mv/cm HORZ. = 2ms/cm

System common grounded to chassis



C

48 Stages - Dual

$R_L = R8 \| R9 \| R10$

$V_0 = 40.6V$ $I_0 = 17.8a$

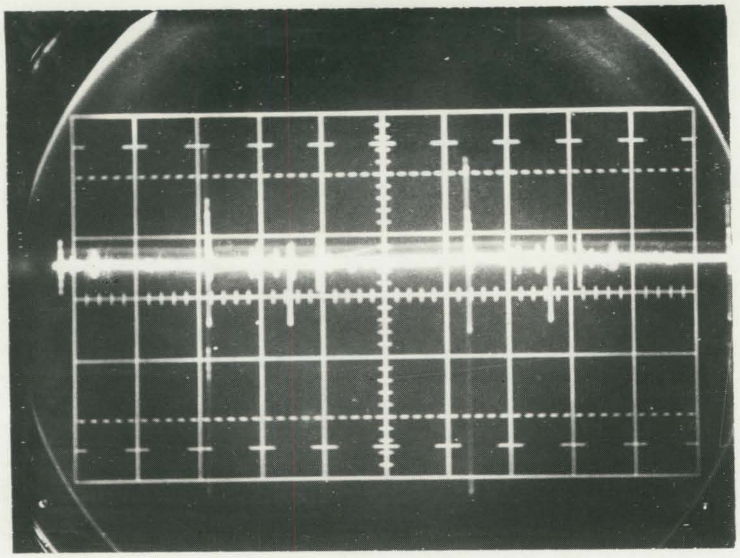
$V_{OCS} = 450$ $I_{SCS} = 999$

VERT. = 10mv/cm HORZ. = 2ms/cm

System common grounded to chassis

FIGURE 2

Ripple at V_{OC}



A

48 Stages - Dual

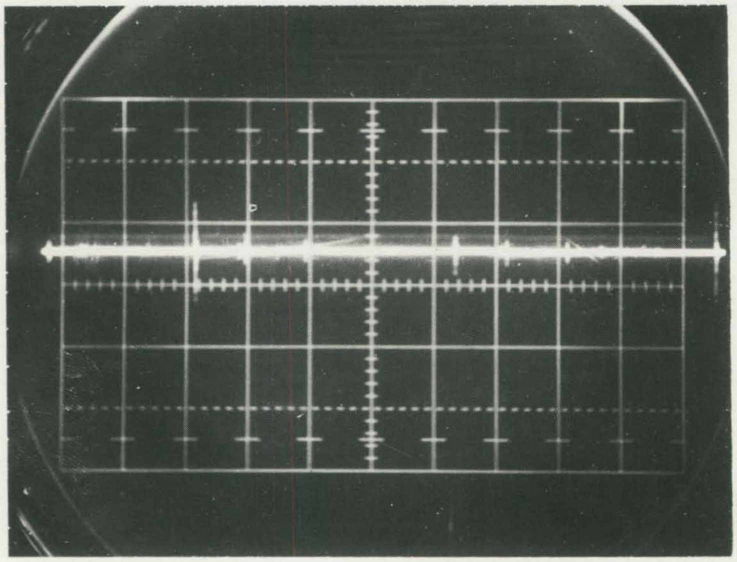
$R_L = \infty$

$V_0 = 50.04$ $I_0 = 0$

$V_{OCS} = 450$ $I_{SCS} = 999$

VERT. = 50mv/cm HORZ. = 2ms/cm

System common floating



B

48 Stages - Dual

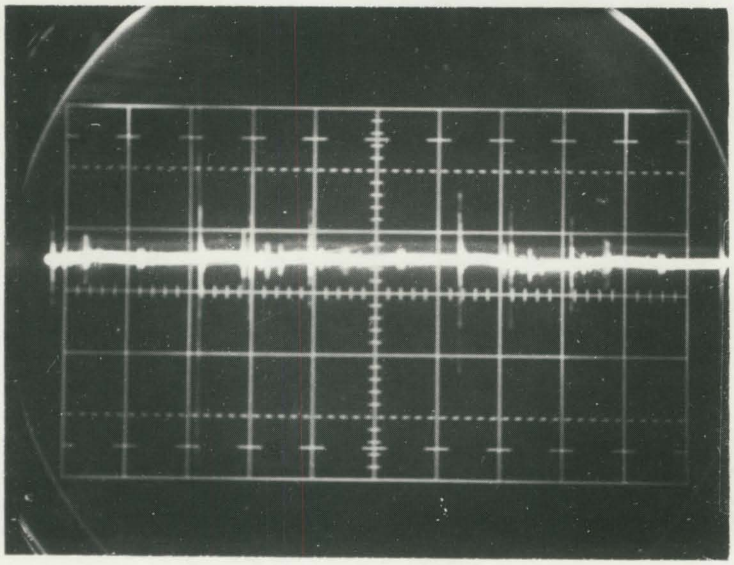
$R_L = \infty$

$V_0 = 50.04$ $I_0 = 0$

$V_{OCS} = 450$ $I_{SCS} = 999$

VERT. = 50mv/cm HORZ. = 2 ms/cm

System common grounded to chassis



C

48 Stages - Dual

$R_L = \infty$

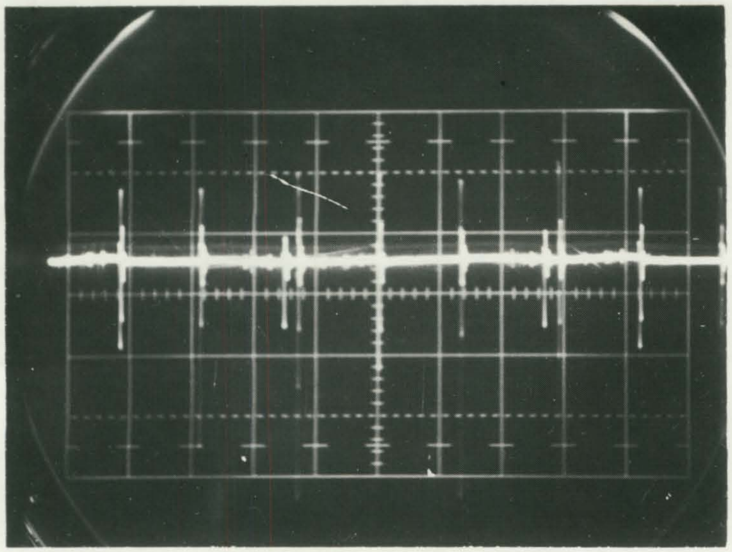
$V_0 = 50.04$ $I_0 = 0$

$V_{OCS} = 450$ $I_{SCS} = 999$

VERT. = 10mv/cm HORZ. = 2ms/cm

System common grounded to chassis

FIGURE 3



A

48 Stages - Series

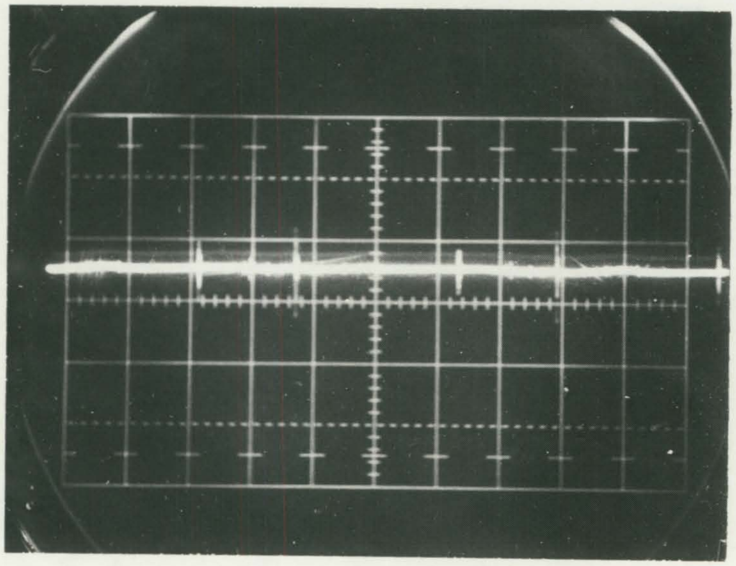
$R_L = \infty$

$V_0 = 99.69V$ $I_0 = 0$

$V_{OCS} = 999$ $I_{SCS} = 999$

VERT. = 50vm/cm HORZ. = 2ms/cm

System common floating



B.

48 Stages - Series

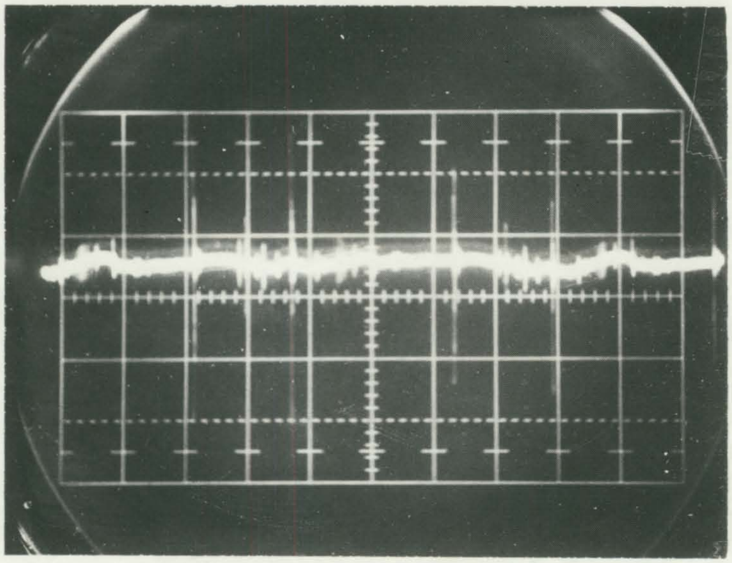
$R_L = \infty$

$V_0 = 99.69V$ $I_0 = 0$

$V_{OCS} = 999$ $I_{SCS} = 999$

VERT. = 50mv/cm HORZ. = 2ms/cm

System common grounded to chassis



C.

48 Stages - Series

$R_L = \infty$

$V_0 = 99.69V$ $I_0 = 0$

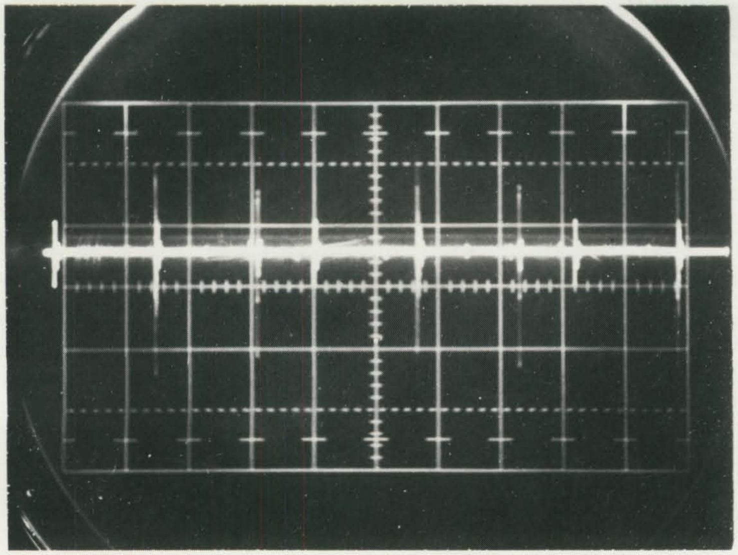
$V_{OCS} = 999$ $I_{SCS} = 999$

VERT. = 10mv/cm HORZ. = 2ms/cm

System common grounded to chassis

FIGURE 4

Output Ripple Near I_{SC}



A

48 Stages - Series

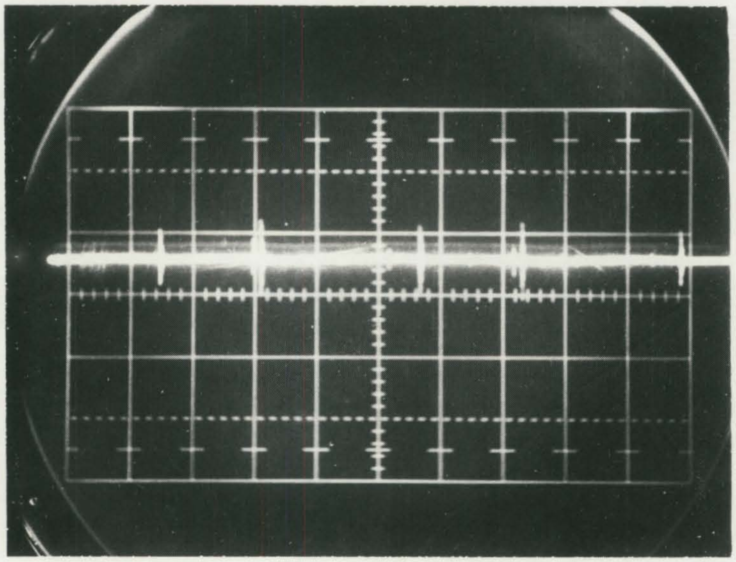
R_L = R1—▷R13

V_0 = 2.81V I_0 = 9.93a

V_{OCS} = 999 I_{SCS} = 999

VERT. = 0.1V/cm HORZ. = 2ms/cm

System common floating



B

48 Stages - Series

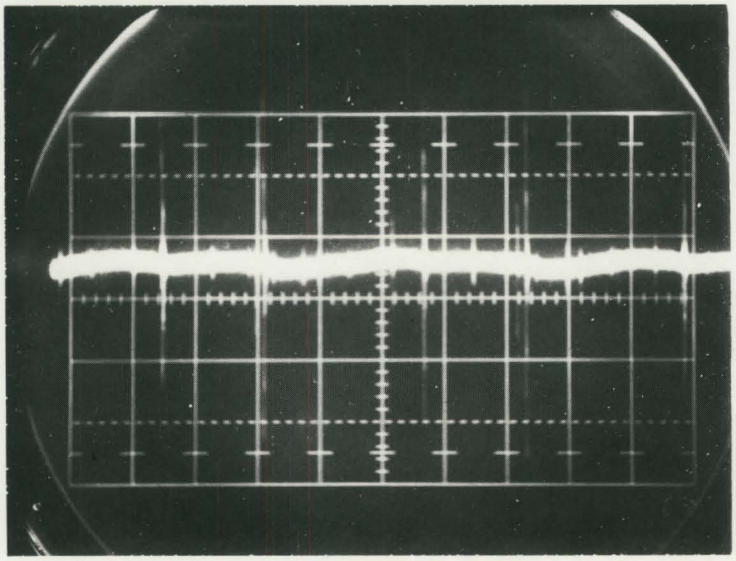
R_L = R1—▷R13

V_0 = 2.81V I_0 = 9.93a

V_{OCS} = 999 I_{SCS} = 999

VERT. = 50mv/cm HORZ. = 2ms/cm

System common grounded to chassis



C

48 Stages - Series

R_L = R1—▷R13

V_0 = 2.81V I_0 = 9.93a

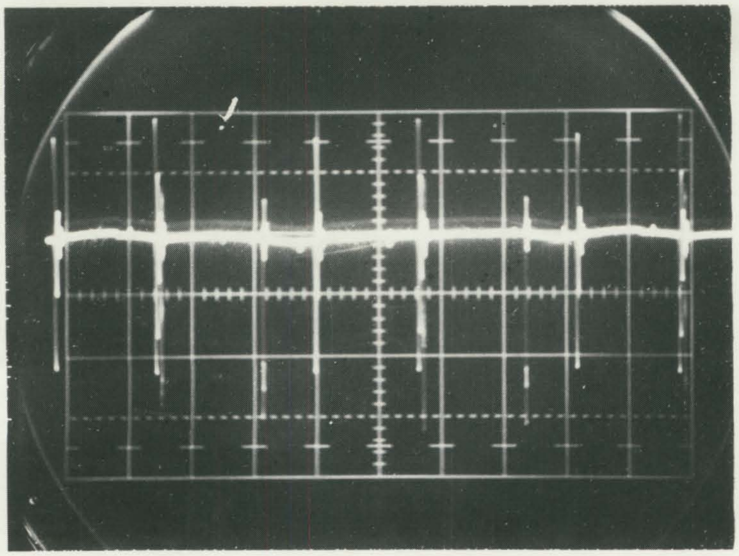
V_{OCS} = 999 I_{SCS} = 999

VERT. = 10mv/cm HORZ. = 2ms/cm

System common grounded to chassis

FIGURE 5

Output Ripple
Near Max. Power Point



A

48 Stages - Series

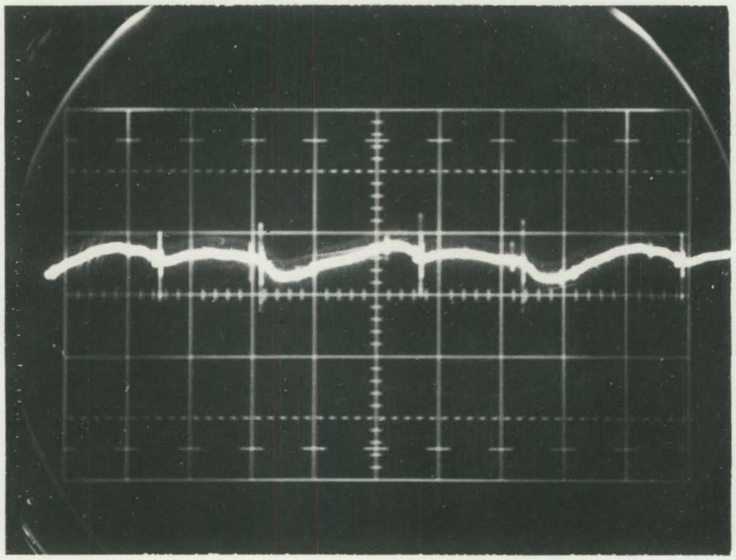
R_L = R1—▷R8

V_0 = 79.2V I_0 = 8.79a

V_{OCS} = 999 I_{SCS} = 999

VERT. = 0.2V/cm HORZ. = 2ms/cm

System common floating



B

48 Stages - Series

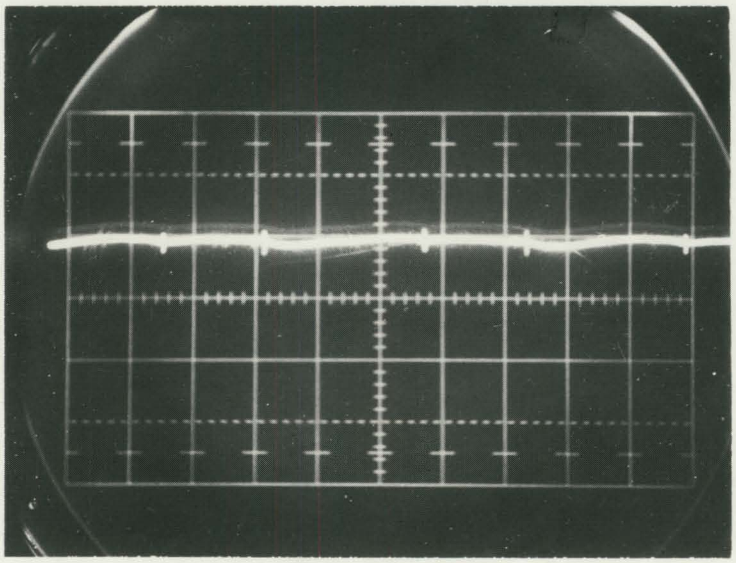
R_L = R1—▷R8

V_0 = 79.2V I_0 = 8.79a

V_{OCS} = 999 I_{SCS} = 999

VERT. = 50mv/cm HORZ. = 2ms/cm

System common grounded to chassis



C

48 Stages - Series

R_L = R1—▷R8

V_0 = 79.2V I_0 = 8.79a

V_{OCS} = 999 I_{SCS} = 999

VERT. = 0.2V/cm HORZ. = 2ms/cm

System common grounded to chassis

FIGURE 6

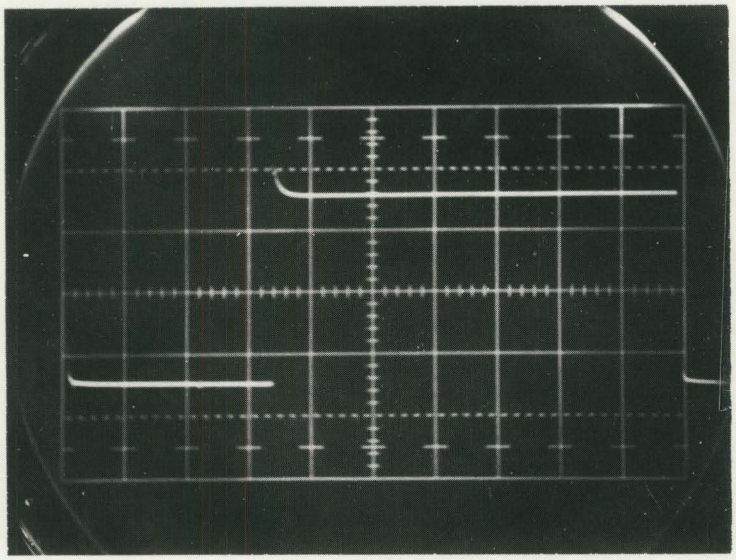
V. OUTPUT RIPPLE AND TRANSIENT RESPONSE (cont.)

B. Transient Response - The transient response of the FRSAS was measured by using an external load comprised of a resistance of approximately 4 ohms in series with contacts of a mercury-wetted relay (Potter and Brumfield Model MJL111081). The relay coil was driven with the Function Generator directly. Figures 7 and 8 show the typical response of the FRSAS to a switching load when it is operating in the "SERIES" mode with three power stages.

V. OUTPUT RIPPLE AND TRANSIENT RESPONSE (cont.)

B. Transient Response (cont.)

CONDITIONS



3 stages - Series

f = 100 hz/sec

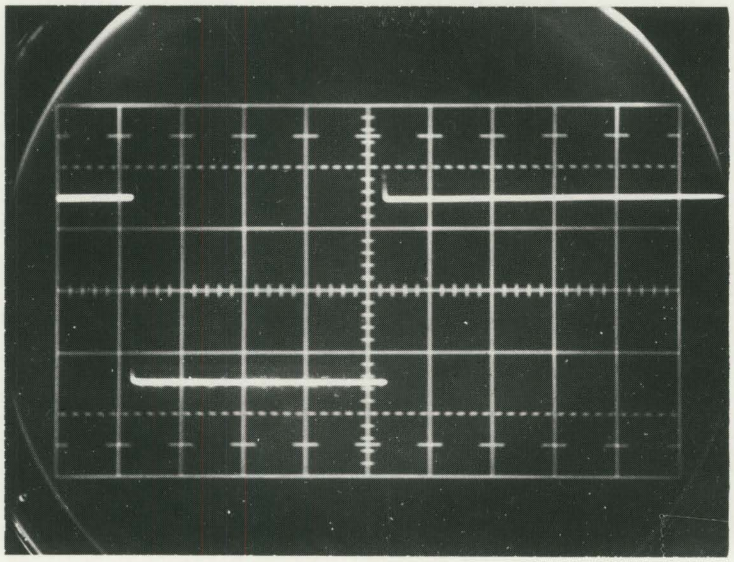
ΔV_o: 100 to 64V

ΔI_o: 0 to 0.57a

ΔR_L: ∞ to 100 ohms

Vert. = 10V/cm Hor.=1 ms/cm

A



3 stages - Series

f = 10 hz/sec

ΔV_o: 100 to 64V

ΔI_o: 0 to 0.57a

ΔR_L: ∞ to 100 ohms

Vert. = 10V/cm Hor.=10 ms/sec

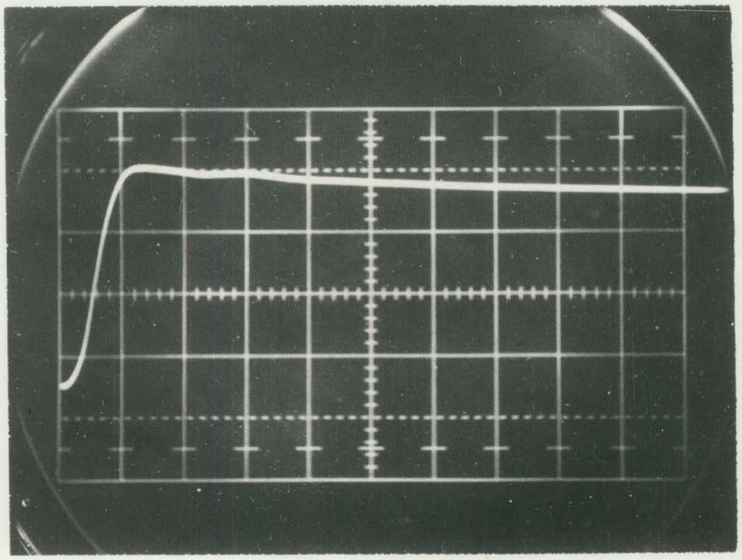
B

FIGURE 7

V. OUTPUT RIPPLE AND TRANSIENT RESPONSE (cont.)

B. Transient Response (cont.)

CONDITIONS



Risetime

3 stages - Series

f = 100 hz/sec

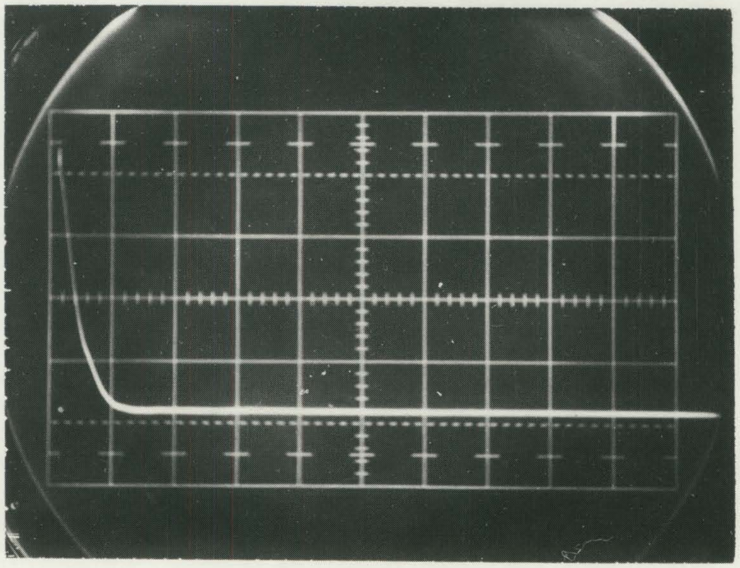
ΔV_o: 100 to 64V

ΔI_o: 0 to 0.57a

ΔR_L; ∞ to 100 ohms

Vert. = 10V/cm Hor.= 20μs/cm

A



Falltime

3 stages - Series

f = 100 hz/sec

ΔV_o: 100 to 64V

ΔI_o: 0 to 0.57a

ΔR_L: ∞ to 100 ohms

Vert.= 10V/cm Hor.= 20μs/cm

B

FIGURE 8

VI. OPTIONS

A. Provision for Expansion

1. Dual Controller/Programmer - The basic system has growth capability to 1500 watts. Space is provided for the addition of: a separate controller drawer; Programmer Logic cards; two Power Stage drawers; a Load Simulator if desired; another Function Generator (two units can mount on one panel); a drawer for interfacing the add-ons to the basic unit. With the addition of this independent system, simulation of a tapped array would be possible, as well as parallel arrays with different characteristics.

2. Additional Power Stages - The basic unit's power could be increased to 1500 watts also by just adding two more Power Stage drawers and the interface drawer.

   The Controller circuitry can drive another 1500 watt power stage. Minor component changes are required to go beyond a total of 3000 watts. All additional 1500 W units would have to be in separate bays consisting of power supplies, Power Stage drawers, Load Simulators, and protection circuitry.

VI. OPTIONS (Cont.)

B. Automatic Programming - Two P.C. card cages have been mounted inside the Programmer drawer. At present, only one is utilized and contains a dual voltage power supply, three multiplexer cards, and two latch register cards. There is still room for additional cards in this cage and with the other totally empty, the remaining space should be adequate enough to accommodate another subprogrammer and control logic for decoding, error-checking, and subprogrammer steering signals coming from an external process control unit or tape reader.

VII. PARTS LIST

ELECTRICAL, ELECTO-MECHANICAL AND MECHANICAL HARDWARE

TABLE OF CONTENTS

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			1	77M1P8		Octal Relay Socket	AMPHENOL		
			7	PTL-B2-9-387		DISPLAY INDICATORS HOT STAMPED #1	Tec-Lite	↑	
			7	"		" #2	"	DS1 →	
			7	"		" #4	"	DS28	
			7	"		" #8	"	↓	
			1	JML-1151		MERCURY RELAY	Potter-Brumfield	K1	
			1	8-T-67		DIGISWITCH	DIGITRAN		
			1	8-T-68		"	"		
			1	8-T-69		"	"		
			2	FT-20		8 Bit Buffered Latch Register	SDS		
			3	BT-33		Dual input 12 Bit Digital Multiplexer	"		
			2	MT-12		Fixed mount 32 module case wire wrap	"		
			1	PT-10		Power Supply, +4, +8V	"		
			3	8001-A-2		TERMINAL BOARD	USECO	TB 1, 2, 3	
			1	2201		PUSH BUTTON N.O. CONTACT	GRAYHILL	S2	

TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	Programmer	
		SHEET 1 of 3	

SYSTEMS 2444 REV. 2-67

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			1	1N540		200mw 400v 1N540	G.E.	CR2	
			2	2N2222		TRANSISTOR SILICON NPN	FCHD	Q2, 3	
			1	2N2907A		" " PNP	"	Q1	
			1	1N746A		ZENER DIODE 3.2V	T.I.	CR1	
			1	150D225X0035B2		2.2 ufd cap 35v	SPRAGUE	C1	
			1	7615K2		TOGGLE SWITCH 3PDT	CUTTLER-HAMMER	S1	
			200	123879		Female CONNECTOR	SDS		
			2	BJ-27		BNC COAX RECEP.	TROMPETER ELEC. INC.	J6	

TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	PROGRAMMER	
		SHEET 2 of 3	

SYSTEMS 2444 REV. 2-67

CONFIGURATION				RESISTORS	LIST OF MATERIALS OR PARTS LIST				
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			5	mf 1/8 - 1Kohm		mf Res 1/8w .1% T-9	Dale	R30-34	
			29	RCR 32G682JS		CARBON RES. 6.8K 1w 5%	ALLEN-BRADLEY	R1-29	
			28	RN 60C5110F		MF Res 511 ohm 1/8w 1%	MEPCO	R35-62	
			1	RN60C7151F		MF Res 7.15Kohm 1/8W 1%	"	R63	
			1	DM9606-27P-W		MALE RECEP.	DEUTSCH	J1	
			1	-27P-X		" "	"	J2	
			1	-19P		" "	"	J3	
			1	-197P		" "	"	J5	
			1	-197S		FEMALE "	"	J4	
			1	DM9728-27S-W		FEMALE PLUG	"	P1	
			1	-27S-X		" "	"	P2	
			1	-19S		" "	"	P3	
			1	-197S		" "	"	P5	
			1	-197P		MALE "	"	P4	

TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	PROGRAMMER	

SHEET 3 of 3

SYSTEMS 2444 REV. 2-67

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			1	BJ-27		BNC COAX Recep	Trompeter Elect.	J13	
			2	8497K5		Switch Guard	Cutler Hammer		
			2	77MIP11		Relay Socket 11 prong	Amphenol		
			2	Cat. No. B-1		Mercury Relay 24VDC SP NO	Ebert	K5,6	
			2	ST42A		Toggle SPST	Cutler Hammer	S7,8	
			2	W88HPX-51		Relay DPDT 24VDC	Magne Craft	K1,3	
			1	PM17DY		Relay 4PDT 24VDC	Potter Brumfield	K4	
			1	9PM12		Dust Cover	" "		
			1	220-240-101		Circuit Breaker 3P 40 Amp.	Wood Elect.	CB1	
			1	2J50A 12-2		Rotary Switch 12P2P2D	Shallcross	S9	
			1	2J56AC-1		" " 6P2P1D	"	S10	
			1	7693K2		Toggle 4PDT C.O.	Cutler Hammer	S3	
			4	MS-10-142		Terminal Block	Cinch Jones	TB1,2,3,4	
			4	MS 10-142		Marker Strip for 10-142	" "		
			1	2201		Push Button N.O.	Gray Hill	S6	
			2	MR 1213SB		Diode 80 Amp 200V	Motorola	CR8,9	
			1	1N2974		Zener Diode 10V, 10W	Motorola	CR1	

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	PRIMARY POWER	
		SHEET 1 of 4	

SYSTEMS 2444 REV. 2-67

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			2	108-903		JACK, BANANA	Johnson	TP1,3	
			2	108-902		JACK, BANANA	"	TP2,4	
			1	MS25257-4		LAMP, NEON, Red, PANEL MOUNT,	G.E.	DS11	
			3	PR0030A		Shunt 30Amp 100mV	MeteRMASTER	R1,25,29	
			7	67Z-210-W-D		LAMP INDICATOR	Electro Mech	DS1,4,5, 6,7,9,10	
			2	67Z-150-R-D		Lamp Switch	" "	S1,DS2, S5,DS8	
			1	67Z-150-G-D		LAMP SWITCH	" "	S4,DS3	
			6	RN65C9092F		mf 90.9K 1/4W 1%		R7,10,13, 16,19,22	
			6	RN65C1212F		mf 12.1K 1/4W 1%		R8,11,14 17,20,23	
			3	RN60C2001F		mf 2.0K 1/8W 1%		R2,26,30	
			3	RN60C1001F		MF 1.0K 1/8W 1%		R3,27,31	
			3	TYPE 48M-9		POT. 10K, .3W, CC	CLAROSTAT	R4,28,32	
			6	1N547		DIODE	MOTOROLA	CR2,3,4, 5,6,7	
			4	RC42GF512J		5.1K, 2W, 5%		R33,34, 35,36	
			6	TYPE 48M-9		POT. 100K, .2W, CC	CLAROSTAT	R9,12,15, 18,21,24	
			2	RH-15-100		100 ohm, 15W, 5%	DALE	R5	
			1	RS-2B-500		500 ohm, 3W, 1%	DALE	R6	
			1	22RJCC-1000-G-SIL		Relay Sigma 2PDT		K2	

TRW SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	PRIMARY POWER	

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			2	MS-20-140		Terminal Block	Cinch Jones	TB5,7	✓
			1	8001-A-2		Terminal Board	USECO	TB6	✓
			2	3440-24A		INDICATING FUSE POST	LITTLE FUSE	F1,2	✓
			1	ST52N		SWITCH, DPDT	CUTLER-HAMMER	S2	✓
			1	DM9606-37S		Receptacle	Deutsch	J1	
			1	" -1912S		"	"	J2	
			1	" -19S		"	"	J3	
			1	" -37-3P		"	"	J4	
			1	" -37-3S		"	"	J5	
			1	" -37-3P-X		"	"	J6	
			1	" -37-3P-W		"	"	J7	
			1	MS-3102E-24-10P		"	BENDIX	J8	
			1	" -10S		"	"	J9	
			1	DM9606-37S-C		"	DEUTSCH	J10	
			1	" -37S-2S-N		"	"	J11	
			1	" -19S-W		"	"	J12	

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	PRIMARY POWER	
		SHEET 3 of 4	

SYSTEMS 2444 REV. 2-67

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			1	DM 9728-37P		PLUG	DEUTSCH	P1	
			1	" -1912P		"	"	P2	
			1	" -19P		"	"	P3	
			1	" -37-3S		"	"	P4	
			1	" -37-3P		"	"	P5	
			1	" -37-3S-X		"	"	P6	
			1	" -37-3S-W		"	"	P7	
			1	MS-3106E-24-10S		"	BENDIX	P8*	
			1	" -10P		"	"	P9*	
			1	DM9728-37-C		"	DEUTSCH	P10	
			1	" -37-2P		"	"	P11	
			1	" -19P-W		"	"	P12	

* P8 and P9 are also indicated in the AC Distribution Panel parts list.

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	PRIMARY POWER	
		SHEET 4 of 4	

SYSTEMS 2444 REV. 2-67

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			1	5678		Male Base Recep.	Hubbell	J1	
			1	4586		Male Base Twistlock Recep	"	J3	
			1	Type 236402AAAA		Elapsed time meter	General Elect.		
			1	model 343-3		Digital Panel Meter. 19.99 V Range	Data tech Corp		
			1	model 340A-1		" " " 199.9 mV	" " "		
				with options		B1, B2, - BCD outputs	B3 - Bezel		
			2	344125A		Indicator fuse Post	Little fuse	F1,2	
			1	DM9606-197P		Receptacle	Deutsch	J2	
			1	DM9728-197S		PLUG	"	P2	

TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	DIGITAL PANEL METERS AND TIMER	
		SHEET 1 of 1	

SYSTEMS 2444 REV. 2-67

CONFIGURATION				Resistors	LIST OF MATERIALS OR PARTS LIST				
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			6	RCR07G911JS		1K 1/4w 5%	MEPCO	R 2, 5, 8 11, 47, 48	
			1	RN60C1331F		1.33K 1/8w 1%	"	R 7	
			1	RCR32G6R2JS		6.2 ohm 1w 5%	"	R 3	
			1	RN55C2671F		2.67K 1/10w 1%	"	R 6	
			1	RN55C3481F		3.48K 1/10w 1%	"	R 9	
			1	RN 65C1502F		15K 1/4w 1%	"	R 4	
			2	GN5C-200 ohm		20 ohm 5w 1% Resistor, Non-inductive	DALE	R12A R12B	
			1	GN5 - 15 ohm		15 ohm 4w 1% Resistor Non-inductive	DALE	R 13	
			1	GN5 - 10 ohm		10 ohm 4w 1% Resistor Non-inductive	DALE	R 14A	
			1	RCR07G150JS		15 ohm 1/4w 5%	MEPCO	R 15	
			1	RN60C2940F		294 ohm 1/8W 1%	"	R 16	
			1	RN 65C2430F		243 ohm 1/4w 1%	"	R10A	
			3	MF - 1/8 - 30.1 ohm		MF Res .1% 1/8w T-9	DALE	R41A, B, C	
			4	" " 40.2 ohm		" "	"	R26 R39 R40A, B	
			2	" " 80 ohm		" "	"	R27 R38	
			1	" " 100 ohm		" "	"	R37	
			1	" " 200 ohm		" "	"	R36	
			2	" " 402 ohm		" "	"	R24 R35	

TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	Controller	

CONFIGURATION				Resistors	LIST OF MATERIALS OR PARTS LIST				
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			2	Mf 1/8 - 800 ohm		Mf Res .1% 1/8w T-9	DAle	R23 R34	
			1	" " 1 K ohm		" " "	"	R33	
			1	" " 2K ohm		" " "	"	R32	
			2	" " 4.02 K ohm		" " "	"	R31 R20	
			1	" " 8K ohm		" " 1/2w "	"	R30	
			1	" " 45.3K ohm		" " 1/8w "	"	R43	
			1	" " 90.9K ohm		" " " "	"	R44	
			1	" " 182K ohm		" " " "	"	R42	
			1	" " 1.6K ohm		" " " "	"	R22	
			1	" " 160 ohm		" " " "	"	R26	
			1	" " 320 ohm		" " " "	"	R25	
			1	" " 3.2K ohm		" " " "	"	R21	
			3	" " 16K ohm		" " " "	"	R17 A, B R18	
			1	" " 100K ohm		" " 1/4 "	"	R46	
			1	" " 2.43 K ohm		" " " "	"	R45	
			1	" " 8.06K ohm		" " " "	"	R19	
			1	RN65C 7501F		" 1% 1/4W	MEPCO	R29A, 29B	
			1	MF, 1/4W, 88.2 ohm		Select-in-Test (measured value)		R14B	

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	Controller	
		SHEET 2 of 5	

CONFIGURATION				Misc.	LIST OF MATERIALS OR PARTS LIST				
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			4	1N647		DIODE, SILICON	TEXAS INST.	CR1,2,3,4	
			1	3147-1		Temp CAVITY +60°C 28 VDC	OVEN Industries		
			2	FC501-A		HEAT SINK	WAKEFIELD		
			2	NC 301-M		" "	"		
			5	2606SH5B		" "	"		
			3	2606SH18B		" "	"		
			1	Solar Cell (MANUFACTURED TO TRW SPECS PT3-1028 AND PT7-19)		N on P, 10 ohm-cm, 2x2 cm, 10 MIL	CENTRALAB	SC1	
			1	PR0001A		Shunt 1 Amp 100mV 1%	Meter Master	R1	
			1	67Z-150-R-D		Lamp Switch	Electro-Mech	S1/DS1	
			2	MS10-142		Terminal Block 10-142	CINCH JONES	TB1,2	
			1	MS10-142		MARKER STRIP for 10-142	Cinch Jones		
			2	1N547		DIODE, SILICON	G.E.	CR5,6	
			1	1N753A		ZENER, 6.2V	T.I.	CR7	
			1	AZ421-70-1L		RELAY, 4PDT, 24V	AMERICAN Zettler	K30	
			1	ST141-A1		Socket	" "		
			1	2101-K2		VE-2 Series Thermostat	G.V. Controls	S2	
			1	M747		MUFFIN FAN	ROTRON		

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	Controller	

SHEET 3 of 5

SYSTEMS 2444 REV. 2-67

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			5	TGP10		CERAMIC CAP. .1 ufd 100V 20%	SPRAGUE	C1,3,4 5,6	
			4	29F490		TANTALUM FOIL CAP. 20 ufd 25V NP	G.E.	C7,8, 9,10	
			1	BR4-450		ELECTROLYTIC CAP 4 ufd 450V	CORNELL-DUBILER	C11	
			3	5HKP10		CERAMIC CAP .1uf, 500V, 20%	SPRAGUE	C13,14, 15	
			2	DM15820J		82 PF 500V	ARCO	C2,12	
			1	RN65C3922F		39.2K ohm 1/4W 1%	MEPCO	R10B	
			1	XMOD-103		0→10V, 0→2A POWER SUPPLY	Precision Standards	+6V	
			1	XMOD-104		0→10V, 0→10A POWER SUPPLY	" "	-6V	
			1	CC100-0.2M		0→100V, 0→200mA POWER SUPPLY	KEPCO	CURRENT SOURCE	
			1	CA-3		SINGLE SLOT HOUSING FOR CC100-0.2M	"		
			1	RN60C2432F		RES, MF, 1%, 1/8 W	MEPCO	R49	
			6	BJ-27		BNC COAX RECEP.	TRUMPETER ELECTRONICS INC	J1,14A,14B 15A,15B,8	
			3	00-7001-041-163-002X		FEMALE CONN.	ELCO	P10,11,12	
			3	2309-C		41 PIN PC PLUG BOARD	VECTOR	J10,11,12	
			1	DM9728-27S		FEMALE PLUG	DEUTSCH	P1	
			1	-7P-W		MALE "	"	P3	
			1	-197S		FEMALE "	"	P4	

TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	CONTROLLER	
		SHEET 4 of 5	

SYSTEMS 2444 REV. 2-67

CONFIGURATION				TRANSISTORS		LIST OF MATERIALS OR PARTS LIST			
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			2	2N3467		TRANS., PNP, SILICON	MOTOROLA	Q1, 2	
			1	2N2905		" " "	"	Q3	
			1	2N2484		" NPN "	Fairchild	Q4	
			1	2N 3727 (DUAL)		" PNP "	"	Q5A, B	
			2	SDT 1050		" NPN "	Solitron	Q6, 10	
			2	2N 2880		" " "	"	Q7, 8	
			29	712T-26		DPDT Relay To-5 case	Teledyne	K1-29	
			1	2N 2219		TRANS., NPN, SILICON	motorola	Q9	
			29	MERC-101		10 PIN To-5 Socket	Barnes Corp		
			1	DM9728-37P		MALE PLUG	DEUTSCH	P5	
			1	DM9606-27P		MALE RECEPTACLE	DEUTSCH	J1	
			1	" -7S-W		FEMALE "	"	J3	
			1	" -37S-B		" "	"	J6	
			1	" -12S		" "	"	J7	
			1	" -19P		MALE "	"	J4	
			1	" -37S		FEMALE "	"	J5	
			1	DM9728 -37P-B		MALE PLUG	"	P6	
			1	" -12P		" "	"	P7	

TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	Controller	
			SHEET 5 of 5

SYSTEMS 2444 REV. 2-67

CONFIGURATION | Diodes & TRANSISTORS | LIST OF MATERIALS OR PARTS LIST

QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			56	1N540		Diode, SILICON	G.E.	CR1→28	
			96	SDT 1050		TRANS., NPN, SILICON TO-41 CASE	Solitron	Q1,4	
			48	2N2905		TRANS., PNP, SILICON	fairchild	Q2	
			48	2N5415		" " "	RCA	Q3	
			48	1N756A		Diode, zener, SILICON	T.I.	CR1	
			2	1N1200		Diode, SILICON	BENDIX	CR30	
			44	68Z210-W-D		Light Indicator SINGLE Bezel	Electro Mech	DS1→11 13→23	
			6	67Z210-W-D		" "	" "	DS12,24,25	
			2	67Z150-R-D		LAMP switch	" "	DS27/S3	
			2	67Z150-G-D		" "	" "	DS26/S2	
			6	10-140		TERMINAL Block	CINCH-JONES	TB1,2,3	
			6	MS-10-140		marker strip for 10-140	" "		
			2	344024A		Indicating fuse Post 16-32V	Little fuse	F1	
			2	344125A		" " " 100-125V	"	F2	
			2	ST42A		SPST Toggle switch	CUTLER-HAMMER	S5	
			2	ST42D		SPDT " "	" "	S4	
			4	BJ-27		BNC COAX CONNECTOR	TROMPETER ELECTRONICS INC.	J1,11	

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	Power Stage	

SHEET 1 of 5

SYSTEMS 2444 REV. 2-67

CONFIGURATION				Resistors	LIST OF MATERIALS OR PARTS LIST				
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			48	RCR07G150JS		15 ohm 1/4w 5%	ALLEN BRADLEY	R5	
			48	RN65C6812F		68.1K 1/4w 1%	MEPCO	R4	
			48	RCR32G223JS		22K 1w 5%	ALLEN BRADLEY	R9	
			48	RN65C1620F		162 ohm 1/4w 1%	MEPCO	R3	
			48	RN65C4021F		4.02K 1/4w 1%	"	R1	
			48	RN65C2001F		2K 1/4w 1%	"	R2	
			48	RCR07G151JS		150 ohm 1/4w 5%	ALLEN BRADLEY	R8	
			48	RCR32G2R7JS		2.7 ohm 1W 5%	"	R7	
			48	EN12-10 ohm		Non-inductive 10 ohm 10w 1%	Dale	R6	
			48	RCR32G202J		2K, 1W, 5%	ALLEN BRADLEY	R10	

TRW SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	Power Stage	

SHEET 2 of 5

SYSTEMS 2444 REV. 2-67

CONFIGURATION				Capacitors	LIST OF MATERIALS OR PARTS LIST				
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			48	5HKS50		CERAMIC CAP. 0.05Mfd 500V 20%	SPRAGUE	C1	
			48	5HKP10		CERAMIC CAP. 0.1Mfd 500V 20%	"	C3	
			2	HC5020A		ELECTROLYTIC CAP. 2000Mfd 50V 10%	Mallory	C25	
			2	MS-10-142		TERMINAL BLOCK	CINCH JONES	TB4	
			48	DM15-511J		MICA CAP. 510 Pfd 300V 5%	ARCO	C2	
			4	CAPACITORS USED ON WAKEFIELD HEAT SINKS		NON POL. CAP. 6Mfd 220VAC 60HZ	SUPPLIED WITH PAM MOTORS	C26,27	
			4	2101-K4		VE-2 SERIES N.C. THERMOSTAT	G-V CONTROLS	S6,7	
			4	FCA 820		HEATSINK MODULE CONSISTING OF 4 QUADS EACH CONTAINING	WAKEFIELD		
						3 FCA 823A-K 's AND			
						PAMOTOR INC FAN			
						MOD. 1000A			

TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	Power Stage	
		SHEET 3 of 5	

SYSTEMS 2444 REV. 2-67

CONFIGURATION				MISC		LIST OF MATERIALS OR PARTS LIST			
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			48	815.650		C-Breaker	Littlefuse	CB1→24	
			48	AZ 421-70-1L		4PDT 24V coil Relay	American Zettler	K1→24	
			48	ST141-A1		Socket	"		
			48	ST141-1		Retainer	"		
			[illegible]	PK-1100M		TO-3 Transistor Mounting Kit	DELBERT BLINN CO.		
			2	77MIP8		8 Prong Relay Socket	Amphenol		
			2	W88HPX-34		DPDT 24V DC coil Relay	Magne Craft	K25	
			2	W88HPX-32		DPDT 6VDC coil Relay	" "	K26	
			2	HE50H24-1		NON-SHORT Rotary Switch 24Pos	Shallcross	S1	
			2	8001-B-2		Term Board	USECO	TB5	
			775			INSULATED STAND-OFF TERMINAL (440 STUD)			

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	Power Stage	

SHEET 4 of 5

SYSTEMS 2444 REV. 2-67

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			2	DM9606-7P-B		MALE RECEPTACLE	DEUTSCH	J2	
			2	-197P		" "	"	J3	
			2	-197P-C		" "	"	J4	
			2	-3P-W		" "	"	J5	
			2	-7P-Y		" "	"	J7	
			2	-197P-Y		" "	"	J10	
			2	-37S-Y		FEMALE "	"	J6	
			2	-197S-Y		" "	"	J8	
			2	5678		MALE BASE "	HUBBELL	J9	
			2	DM9728-7S-B		FEMALE PLUG	DEUTSCH	P2	
			2	-197S		" "	"	P3	
			2	-197S-C		" "	"	P4	
			2	-3S-W		" "	"	P5	
			2	-7S-Y		" "	"	P7	
			2	-197S-Y		" "	"	P10	
			2	-37P-Y		MALE "	"	P6	
			2	-197P-Y		" "	"	P8	

TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	POWER STAGE	
		SHEET 5 of 5	

SYSTEMS 2444 REV. 2-67

CONFIGURATION				Resistors	LIST OF MATERIALS OR PARTS LIST				
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			1	PR0040-400		Shunt 40 amp 100 mV	Meter Master	R15	
			2	NHL-25-1K		25 W 1K 5%	Dale	R1+2	
			1	NHL-50-500		50 w 500 ohm "		R3	
			4	NHL-50-1		50 w 1 ohm "		R14	
			2	NHL-100-500		100 w 500 ohm "		R4	
			2	NHL-100-1		100 w 1 ohm "		R13	
			3	NHL-225-125		225 w 125 ohm "		R5,6	
			9	NHL-225-93.75		225 w 93.75 ohm "		R7,8	
			8	NHL-225-62.4		225 W 62.4 ohm "		R9	
			4	NHL-225-15.6		225 W 15.6 ohm "		R10	
			3	NHL-225-6		225 W 6 ohm "		R11	
			2	NHL-225-2		225 W 2 ohm "		R12	
			4	RCR32G110J		11K 1W 5%	ALLEN-BRADLEY	R16-19	
			4	7269634		SPACERS	DELCO		
			2	7270606		HEAT SINK	DELCO		
			2	1N1186A		DIODE, SILICON	WESTINGHOUSE	CR41,42	

TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	Load Simulator	
		SHEET 1 of 3	

SYSTEMS 2444 REV. 2-67

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			2	1N1200		Diode, SILICON	BENDIX	CR 35,36	
			34	1N540		Diode, "	G.E.	CR1-34	
			4	1N547		Diode, "	"	CR37,38 39,40	
			1	W88HPX-34		Relay DPDT 24VDC	MAGNECRAFT	K18	
			14	A-1		Mercury Relay 24VDC	Ebert Elect	K1→14	
			5	67Z210-W-D		LAMP indicator	Electro Mech.	DS15→19	
			12	58Z250-R-D		" switch	" "	DS1→6 8→13	
			2	67Z150-R-D		" "	" "	DS7,14	
			2	10-142		TERMINAL	CINCH-JONES	TB3,4	
			2	MS-10-142		MARKER STRIP FOR 10-142	"		
			1	344024A		Indicator fuse Post 16-32V	Little Fuse	F1	
			1	DF30BC		Binding Post 5WAY Blk	Superior	J8	
			1	DF30RC		" " Red	"	J9	
			2	108-903		JACK BANANA BLK	E.F. JOHNSON	TP2,4	
			2	108-902		JACK BANANA RED	"	TP1,3	
			1	CAT. NO. B1		MERCURY Relay 24VDC N.O.	Ebert Elect CORP	K15	
			1	" B11		" " N.O.	"	K17	
			1	" B222		N.C.	"	K16	

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	Load Simulator	

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			1	7615K2		Toggle Switch 3PDT	CUTLER HAMMER	S17	
			2	ST42A		Toggle Switch SPST	CUTLER HAMMER	S15,16	
			1	8001-B-2		TERMINAL BOARD	USECO	TB1	
			1	8001-A-2		" "	"	TB2	
			1	Model 411		CURRENT TRANSFORMER	PEARSON ELECT.	CT1	
			1	BJ-27		BNC CONNECTOR	TROMPETER ELECT.	J7	
			1	DM9728-61P		MALE PLUG	DEUTSCH	P6	
			1	DM9606-197P		MALE RECEPTACLE	DEUTSCH	J1	
			1	-197P-B		" "	"	J2	
			1	-7S		FEMALE "	"	J3	
			1	-197S		" "	"	J4	
			1	-197P-Y		MALE "	"	J5	
			1	-61S		FEMALE "	"	J6	
			1	DM9728-197S		" PLUG	"	P1	
			1	-197S-B		" "	"	P2	
			1	-7P		MALE "	"	P3	
			1	-197P		" "	"	P4	
			1	-197S-Y		FEMALE "	"	P5	

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	LOAD SIMULATOR	

SHEET 3 of 3

SYSTEMS 2444 REV. 2-67

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			1	SC628P		SONAlert 6-28VDC	Mallory		
			8	687210 W-D		Light	Electro mech	DS 1,2,3, 4,6,7,8,9	
			9	1N540		Diode	G.E.	CR1,2,3,4, 5,6,7,8,9	
			1	677210 W-D		Light	Electro mech	DS5	
			1	8001-A-2		TERMINAL STRIP	USECO	TB1	
			1	DM9606-37P		RECEPTACLE	DEUTSCH	J1	
			1	DM9728-37S		PLUG	"	P1	
			1	WK-3-22C TYPE K		PLUG	CANNON	P1	
			1	WK-3-31S "		SOCKET	"	J1	
			1	WK-5-21C "		PLUG	"	P2	
			1	WK-5-32S "		SOCKET Interface	"	J2	
			1	WK-6-21C "		PLUG Panel 205	"	P3	
			1	WK-6-31S "		SOCKET	"	J3	
			1	WK-12-21C "		PLUG	"	P4	
			1	WK-12-32S "		SOCKET	"	J4	
			1	GK-12-21C "		PLUG	"	P5	
			1	GK-12-32S "		SOCKET	"	J5	

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	WARNING PANEL	
		SHEET 1 of 1	

SYSTEMS 2444 REV. 2-67

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			2	Cat. No. 2277		90° Connector Strain Relief	THOMAS + BETTS		
			1	602-4-4PO		Power Relay 4P N.O.D.B. 24VDC Coil	Struthers-Dunn	K1	
			3	344125A		indicating fuse post	Little fuse	F1,2,3	
			1	3765		CABLE Male Cap 50 Amp, 4 Wire	Hubbell		
			1	26519		" " 60 Amp, 5 Wire	"	CABLE	
			1	26516		Connector Body 60 Amp, 5 Wire	"		
			1	26515A		MALE RECEP. (FLANGED) 60 Amp, 5 Wire	ARROW-HART	J1	
			1	7310-BG		TWIST LOCK OUTLET 20 Amp, 3 Wire	HUBBELL	J2	
			2	3330G		TWIST LOCK OUTLET 30 AMP, 3 WIRE	"	J6,7	
			2	3331G		MALE ARMORED CAP. 30 AMP, 3 WIRE	"	P6,7	
			30 ft			Power Cord 600V, 5 Cond #8 gauge		CABLE	
			2	8-150		Terminal Block 150-8 cond	Cinch Jones	TB1,2	
			2	7311-GK		MALE ARMORED CAP, 20 AMP, 3 WIRE	Hubbell	P2	
			2	5279		Female Recep. FLANGED INLET	"	J3,4	
			2	WK-3-22C		CONNECTOR, PLUG	CANNON	P9,10	
			2	WK-3-31S		CONNECTOR, SOCKET	CANNON	J9,10	
			1	1N547		DIODE	MOTOROLA	CR1	

TRW SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	AC Distrubution Panel	
		SHEET 1 of 2	

SYSTEMS 2444 REV. 2-67

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			1	WK-5-21C		CONNECTOR, PLUG	CANNON	P8	
			1	WK-5-32S		CONNECTOR, SOCKET	CANNON	J8	
			1	MS3106E-24-10S		FEMALE PLUG	BENDIX	P8*	
			1	MS3106E-24-10P		MALE PLUG	BENDIX	P9*	
			1	DM9606-3P		CONNECTOR	DEUTSCH	J5	
			1	DM9728-3S		CONNECTOR	DEUTSCH	P5	

*mates to J8 and J9 in Primary Power Drawer

TRW® SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	AC Distribution Panel	
		SHEET 2 of 2	

SYSTEMS 2444 REV. 2-67

CONFIGURATION				LIST OF MATERIALS OR PARTS LIST					
QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NO.	CODE IDENT	NOMENCLATURE OR DESCRIPTION	SPECIFICATION OR MANUFACTURER	CKT REF	ITEM NO.
			2	M7C60-30		POWER SUPPLY - DC 0-60 V., 0-30 AMP 208 1φ INPUT	TRYGON	No 1, 2	
			1	L5R24-30		POWER SUPPLY - DC 18.5-27.5 V., 0-30 A. 208 1φ INPUT	TRYGON	No 3	
			1	110R		FUNCTION GENERATOR	WAVETEK		
			1	D-9117		ASSEM. 2-BAY CABINET	VENT-RAK INC		

TRW
SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SIZE	CODE IDENT NO.		REV
A	11982	ADDITIONAL PARTS	
		SHEET 1 of 1	

SYSTEMS 2444 REV. 2-67

VIII. ASSEMBLY PHOTOGRAPHS

A. Overall Console

Figure 1 - - Front view

Figure 2 - - Back view

FIGURE 1

NOT REPRODUCIBLE

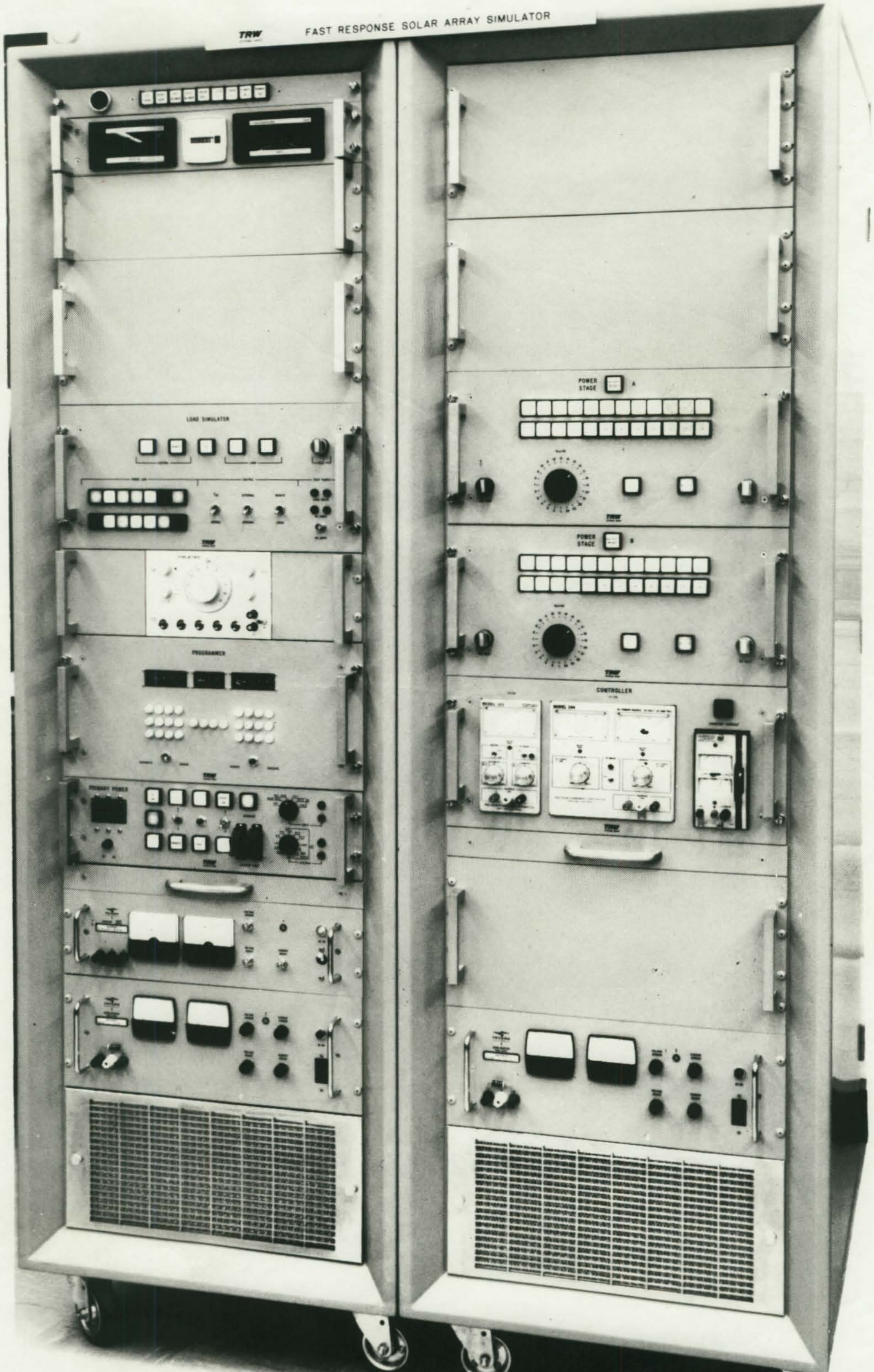
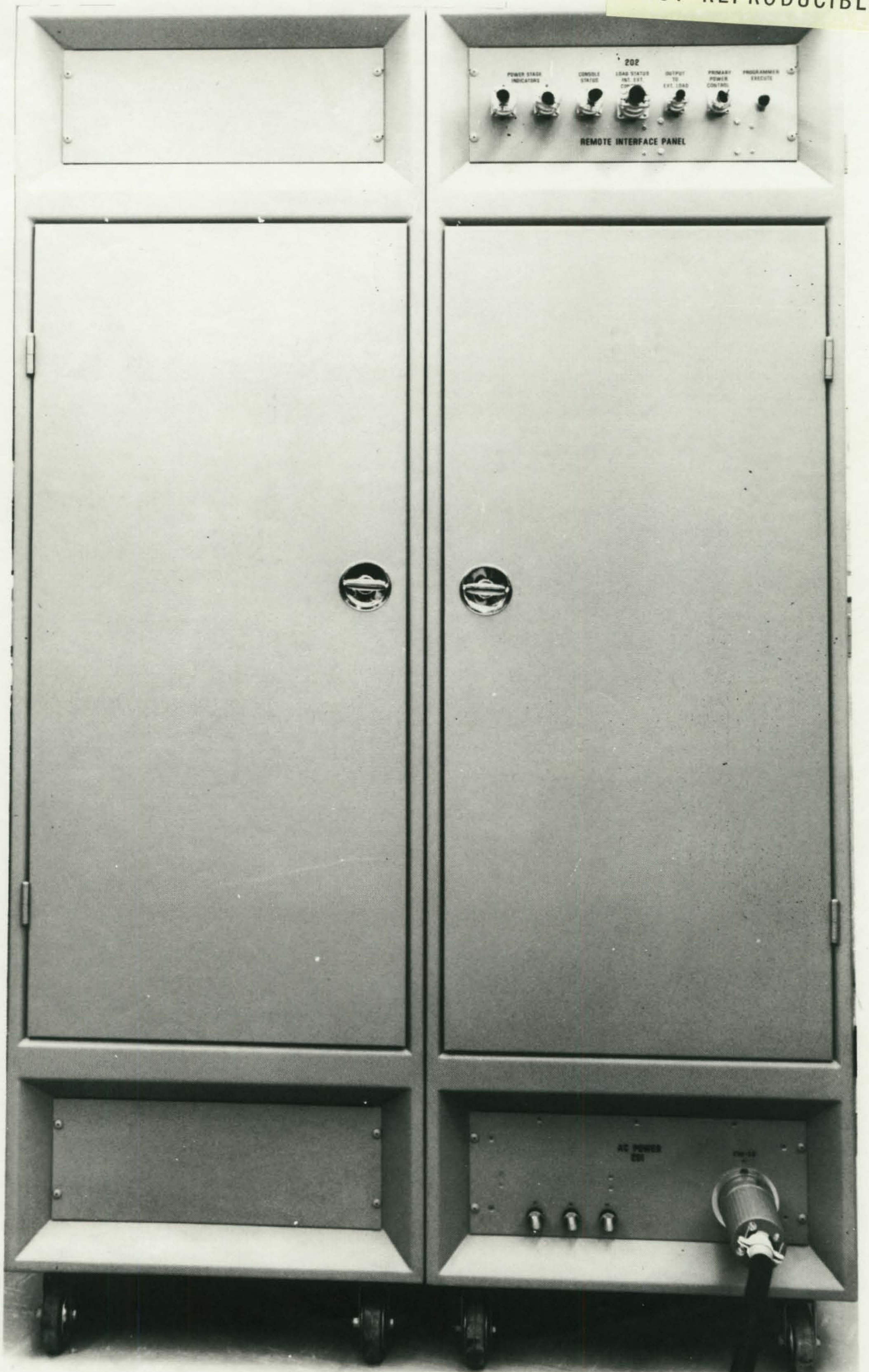


FIGURE 2

NOT REPRODUCIBLE



VIII. ASSEMBLY PHOTOGRAPHS (CONT'D)

B. Individual Drawers and Panels

NOTE: Power Stage A is identical with Power Stage B.

FIGURE 3

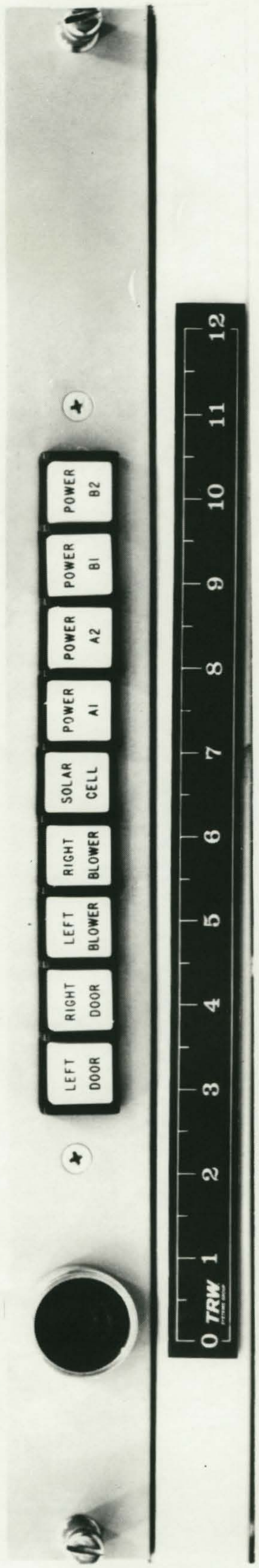

LEFT DOOR
RIGHT DOOR
LEFT BLOWER
RIGHT BLOWER
SOLAR CELL
POWER A1
POWER A2
POWER B1
POWER B2
0 TRW 1 2 3 4 5 6 7 8 9 10 11 12

FIGURE 4

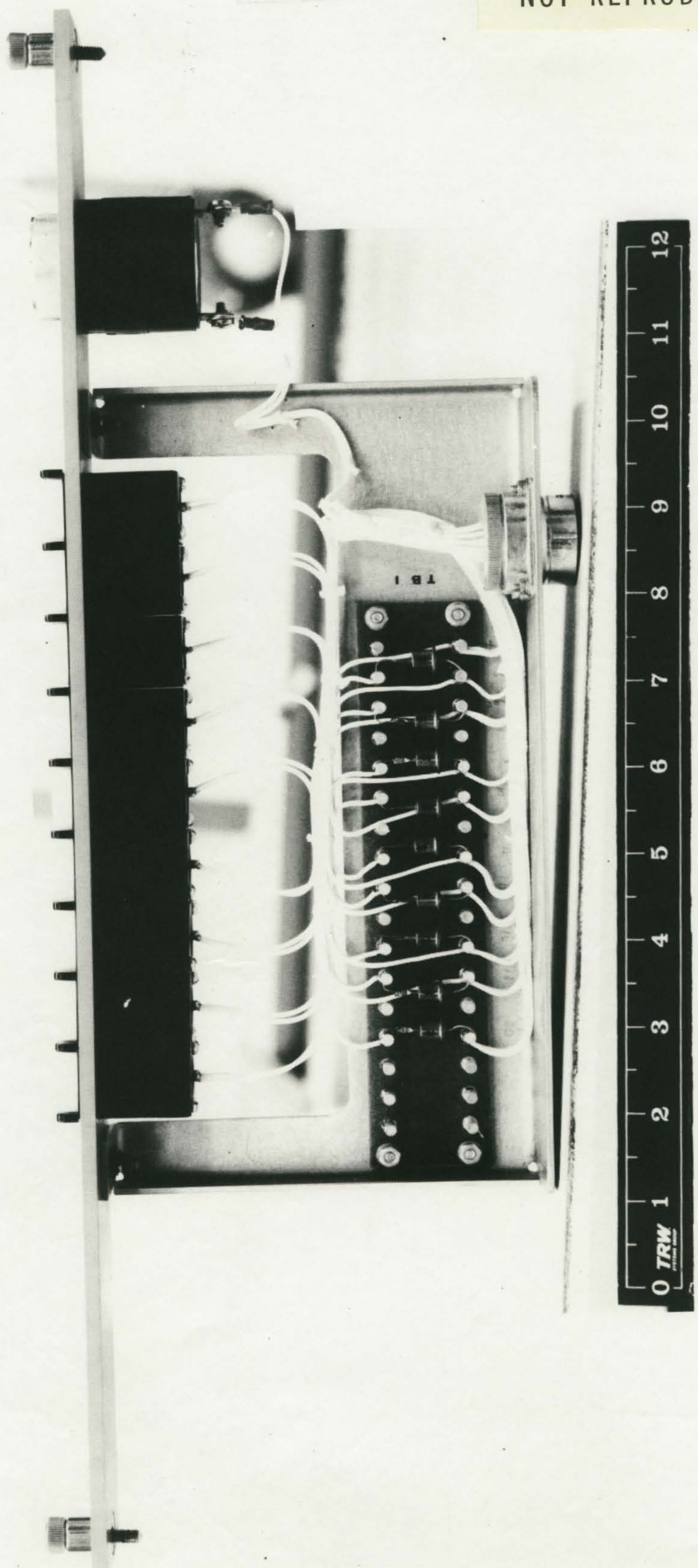


FIGURE 5

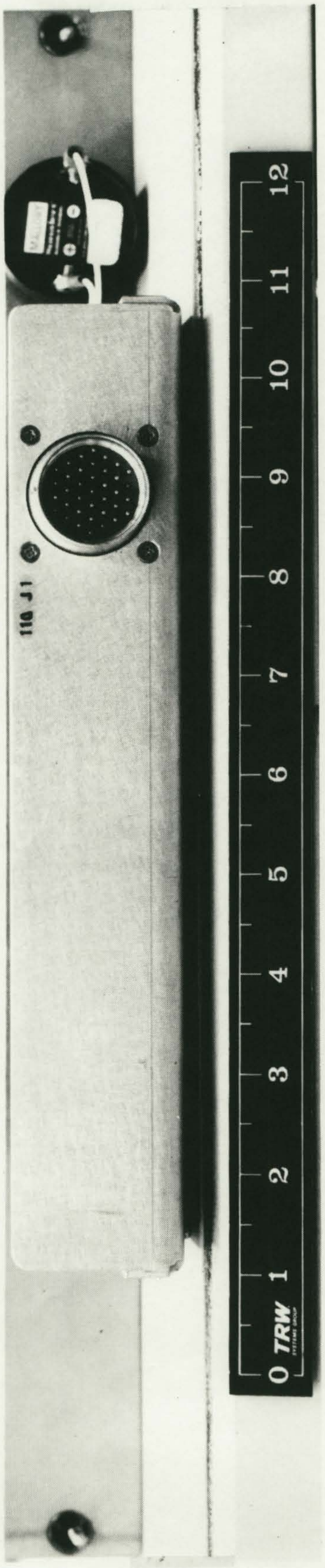


FIGURE 6

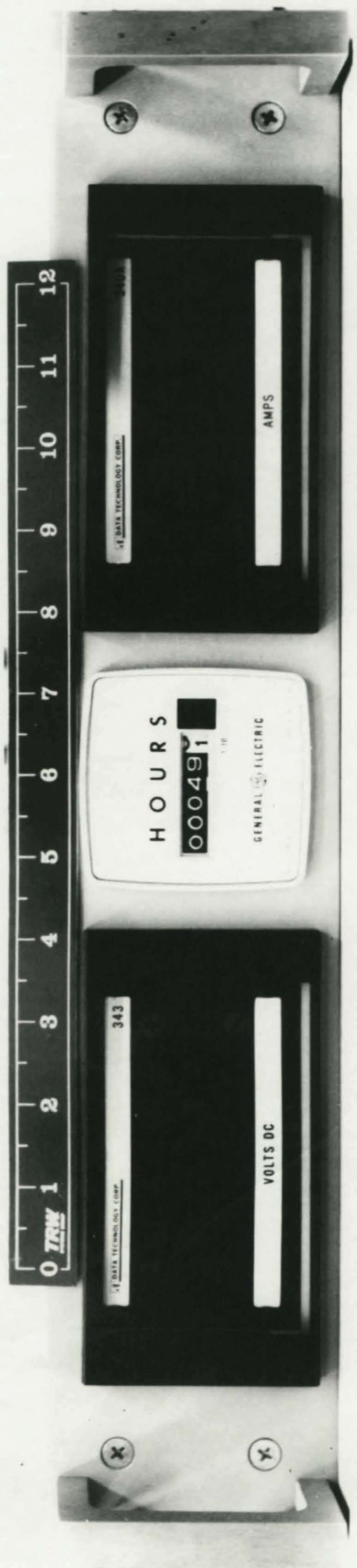

AMPS
DATA TECHNOLOGY CORP
HOURS
GENERAL ELECTRIC
343
DATA TECHNOLOGY CORP
VOLTS DC
TRW

FIGURE 7

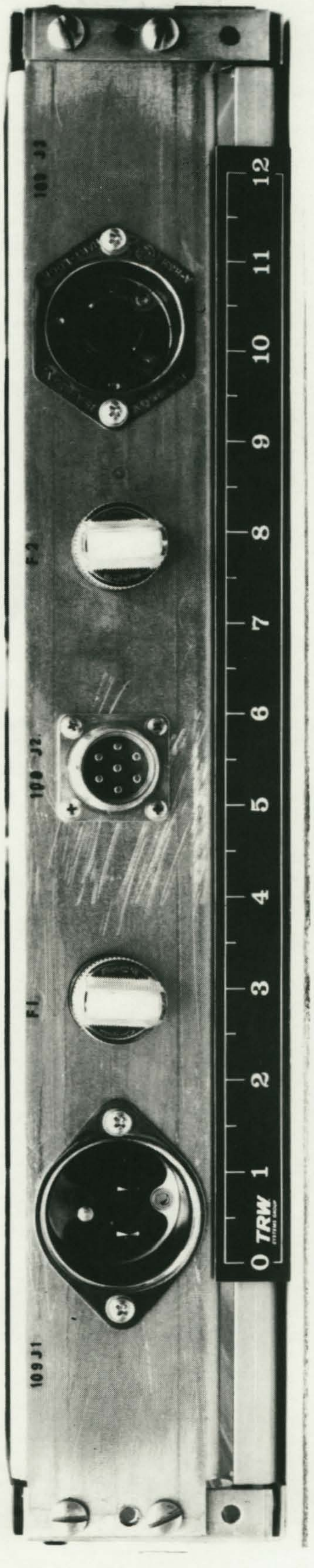


FIGURE 8

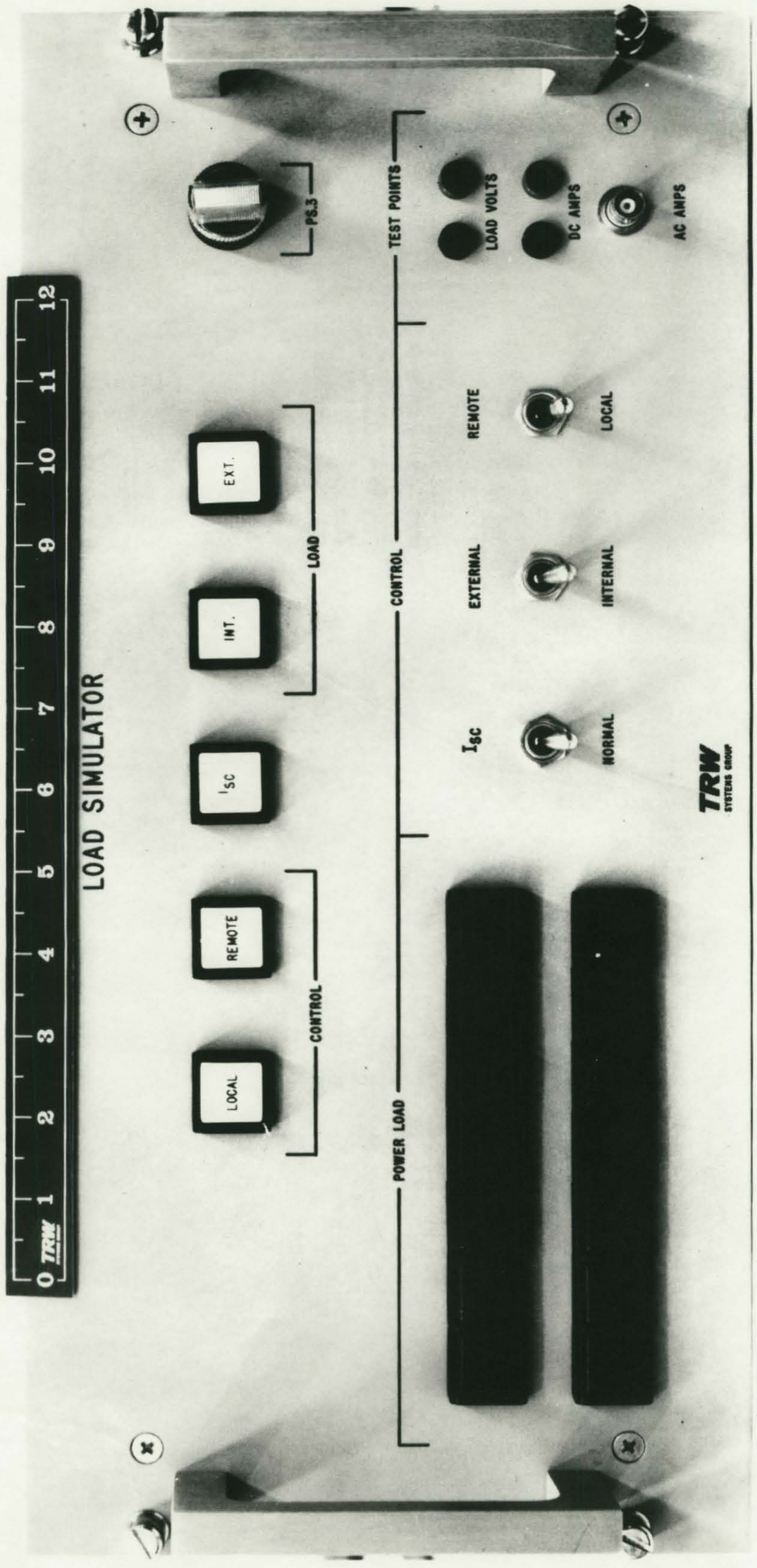

LOAD SIMULATOR
LOCAL
REMOTE
I SC
INT.
EXT.
CONTROL
LOAD
POWER LOAD
CONTROL
TEST POINTS
PS.3
LOAD VOLTS
DC AMPS
AC AMPS
REMOTE
LOCAL
EXTERNAL
INTERNAL
Isc
NORMAL
TRW
SYSTEMS GROUP

FIGURE 9

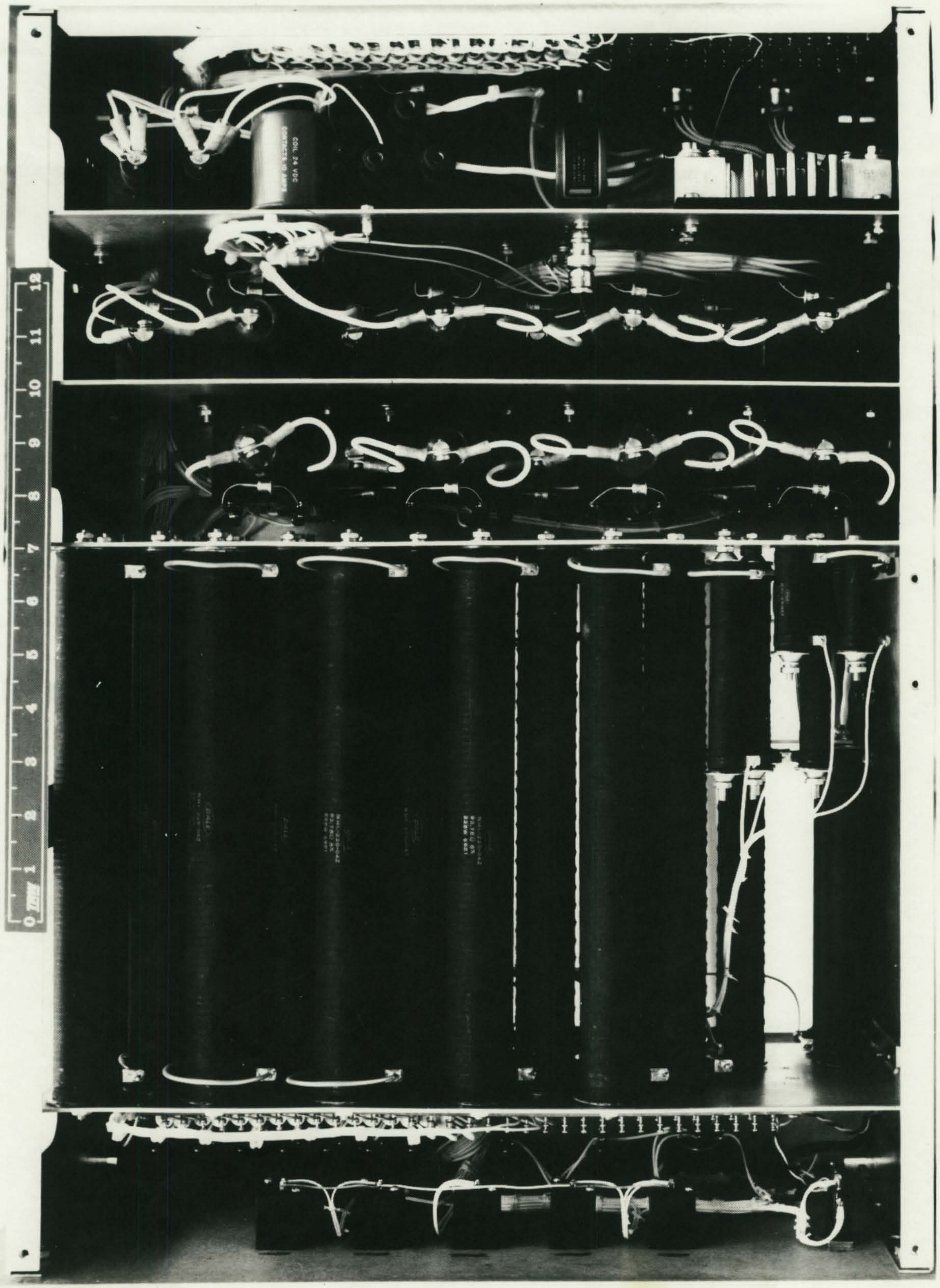


FIGURE 10

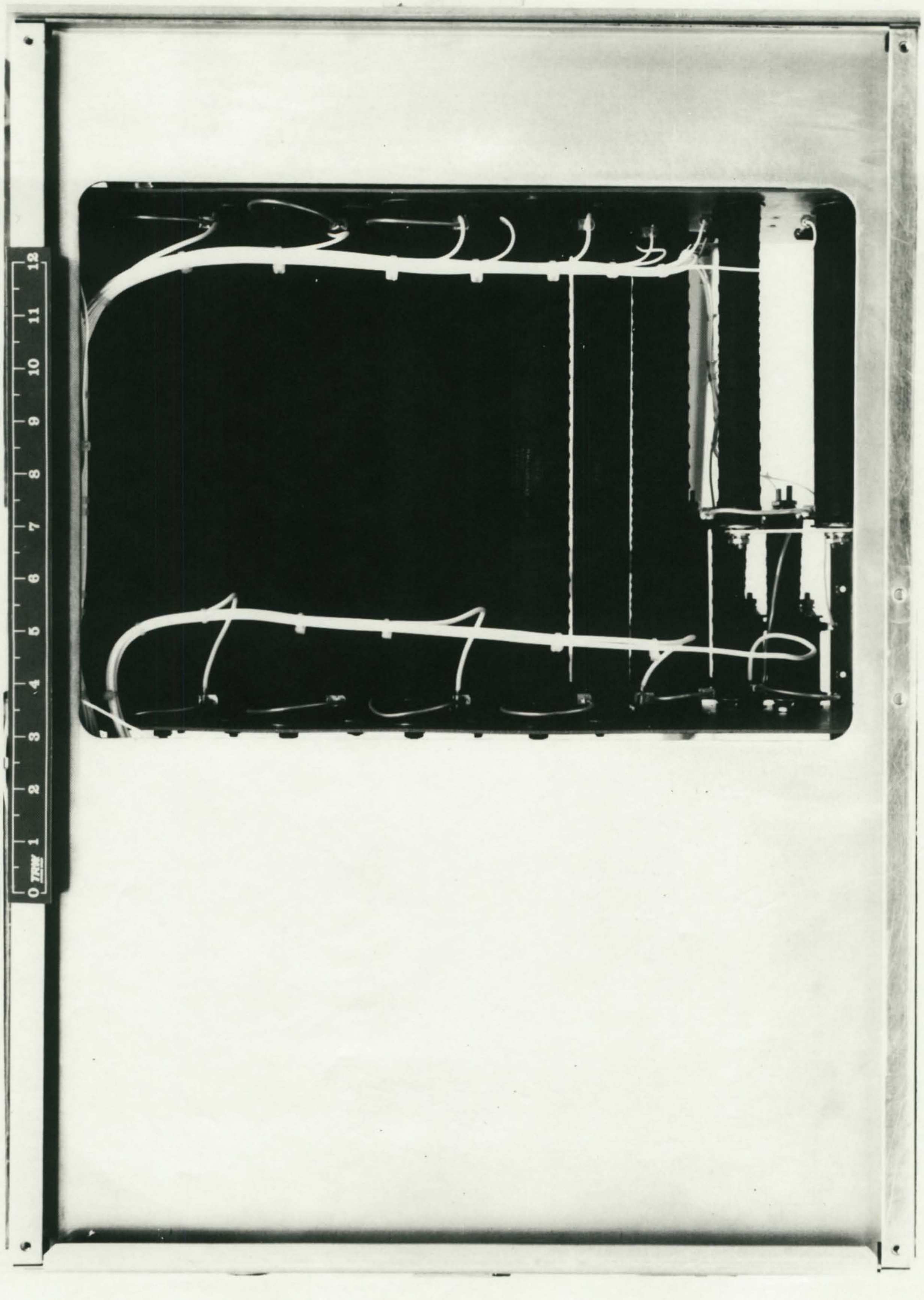


FIGURE 11

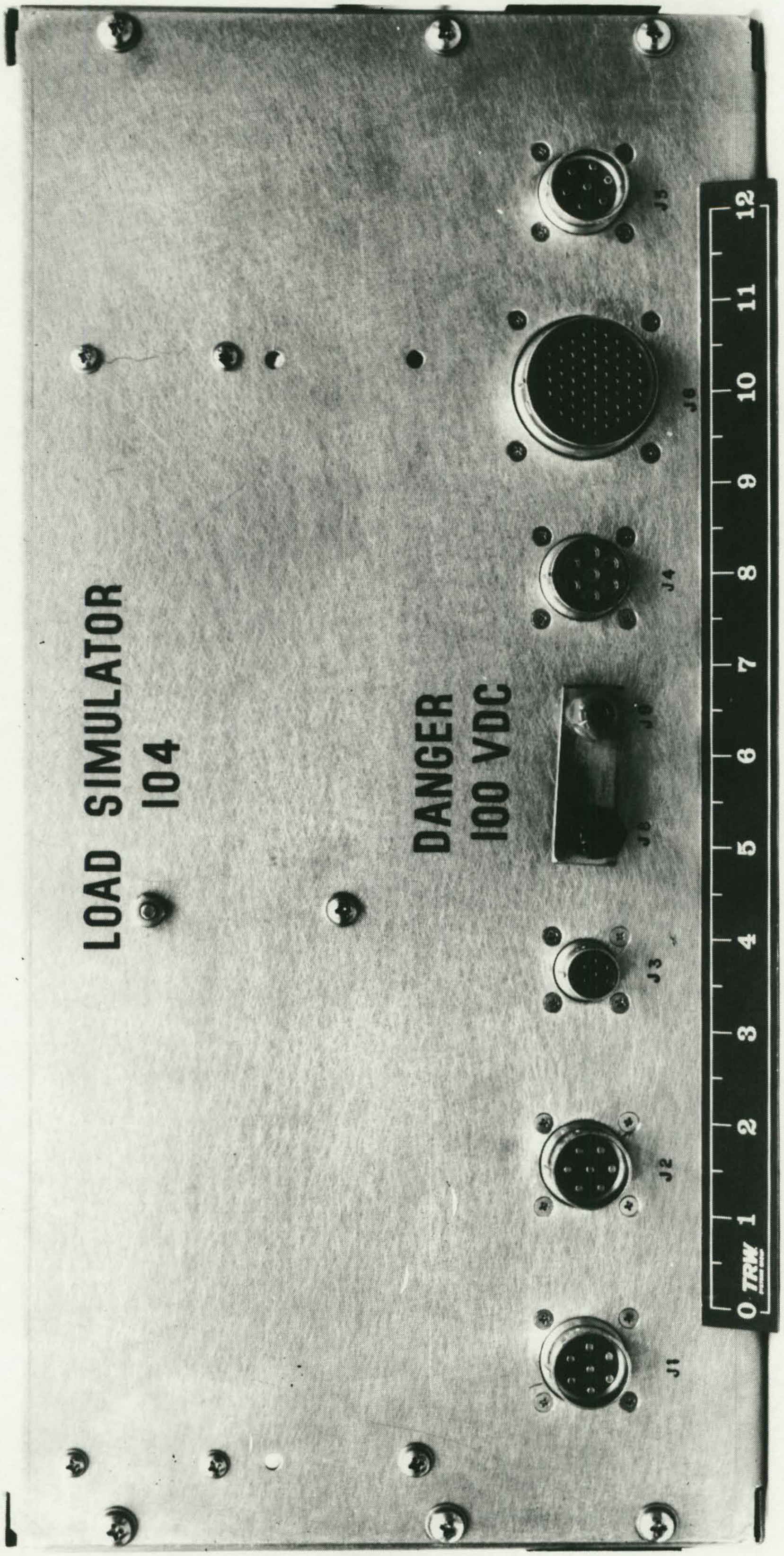


FIGURE 12

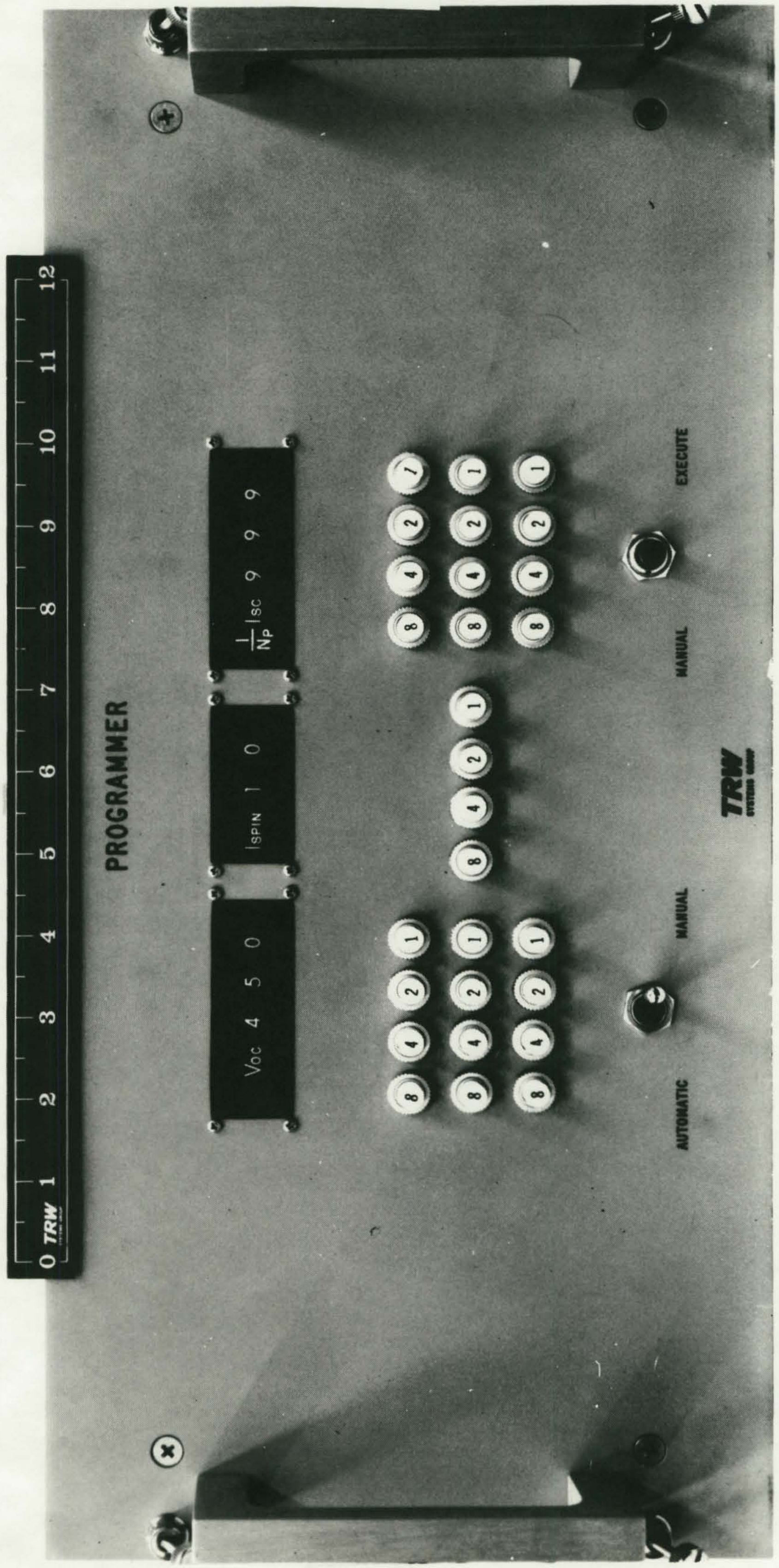

PROGRAMMER
Voc 4 5 0
ISPIN 1 0
1/Np Isc 9 9 9
AUTOMATIC
MANUAL
MANUAL
EXECUTE
TRW

FIGURE 13

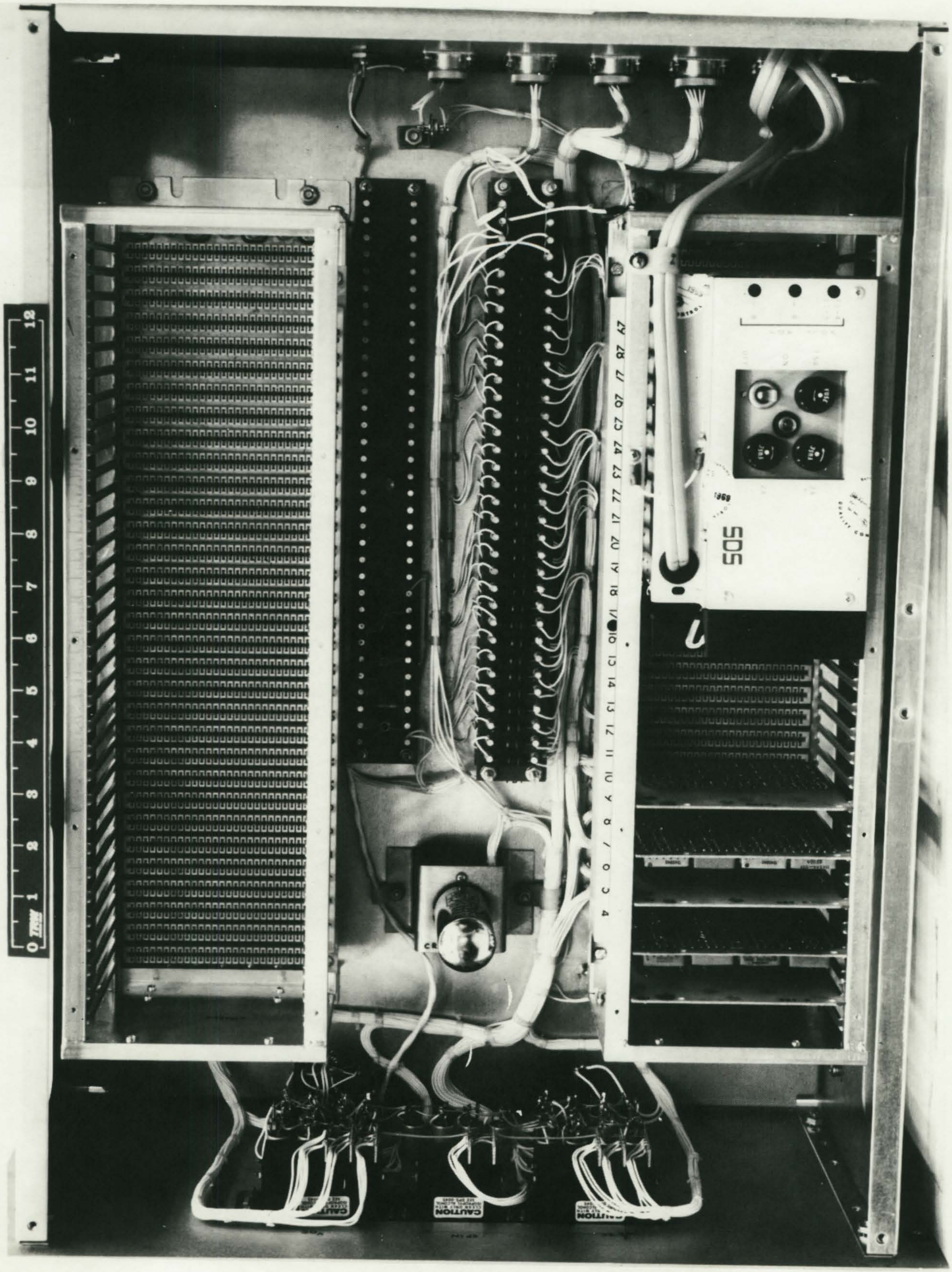


FIGURE 14

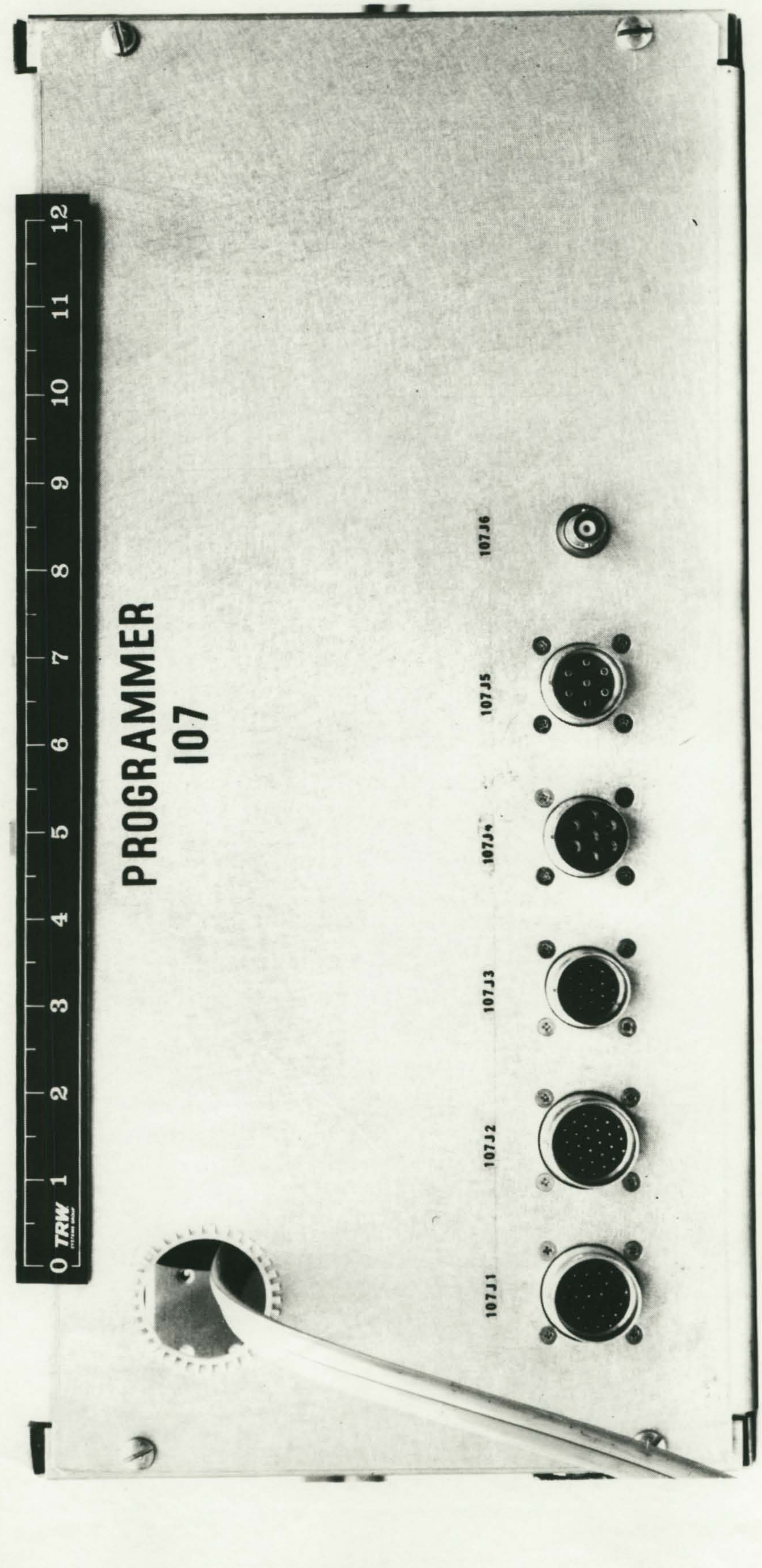


FIGURE 15

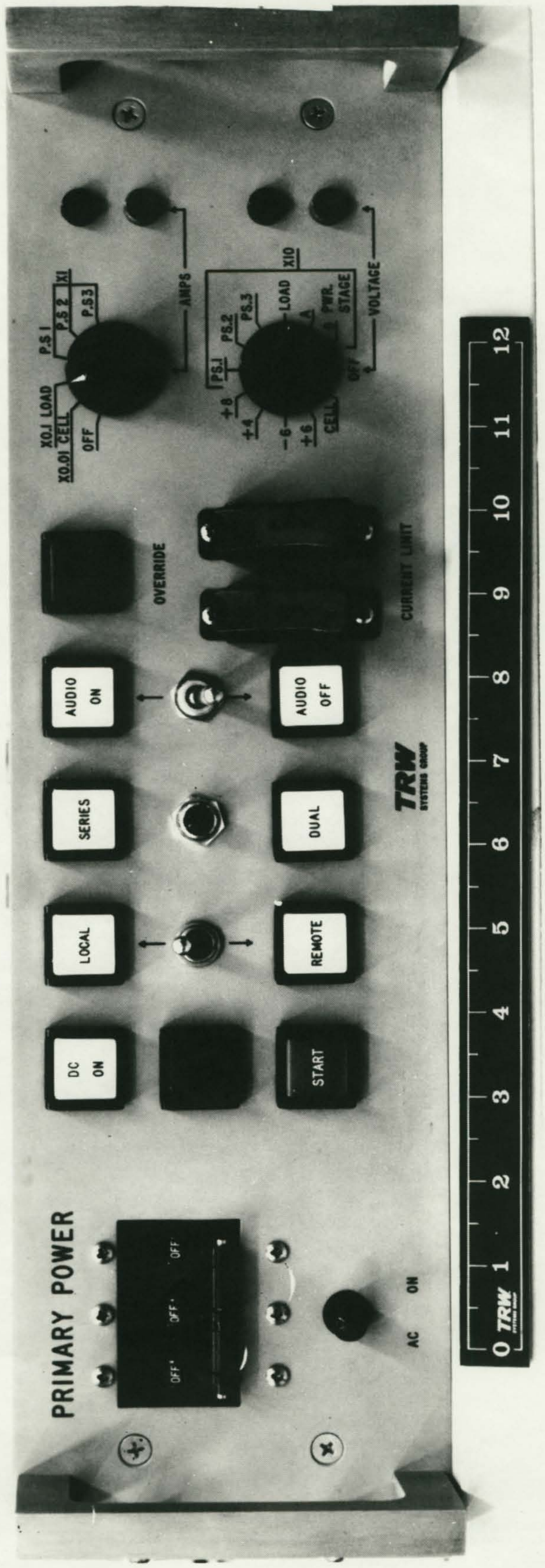

PRIMARY POWER
OFF
AC
ON
DC ON
START
LOCAL
REMOTE
SERIES
DUAL
AUDIO ON
AUDIO OFF
TRW SYSTEMS GROUP
OVERRIDE
CURRENT LIMIT
X0.1 LOAD
X0.01 CELL
OFF
P.S.1
P.S.2
P.S.3
X1
AMPS
P.S.1
P.S.2
P.S.3
LOAD
X10
PWR. STAGE
CELL
VOLTAGE
0 1 2 3 4 5 6 7 8 9 10 11 12
TRW

FIGURE 16

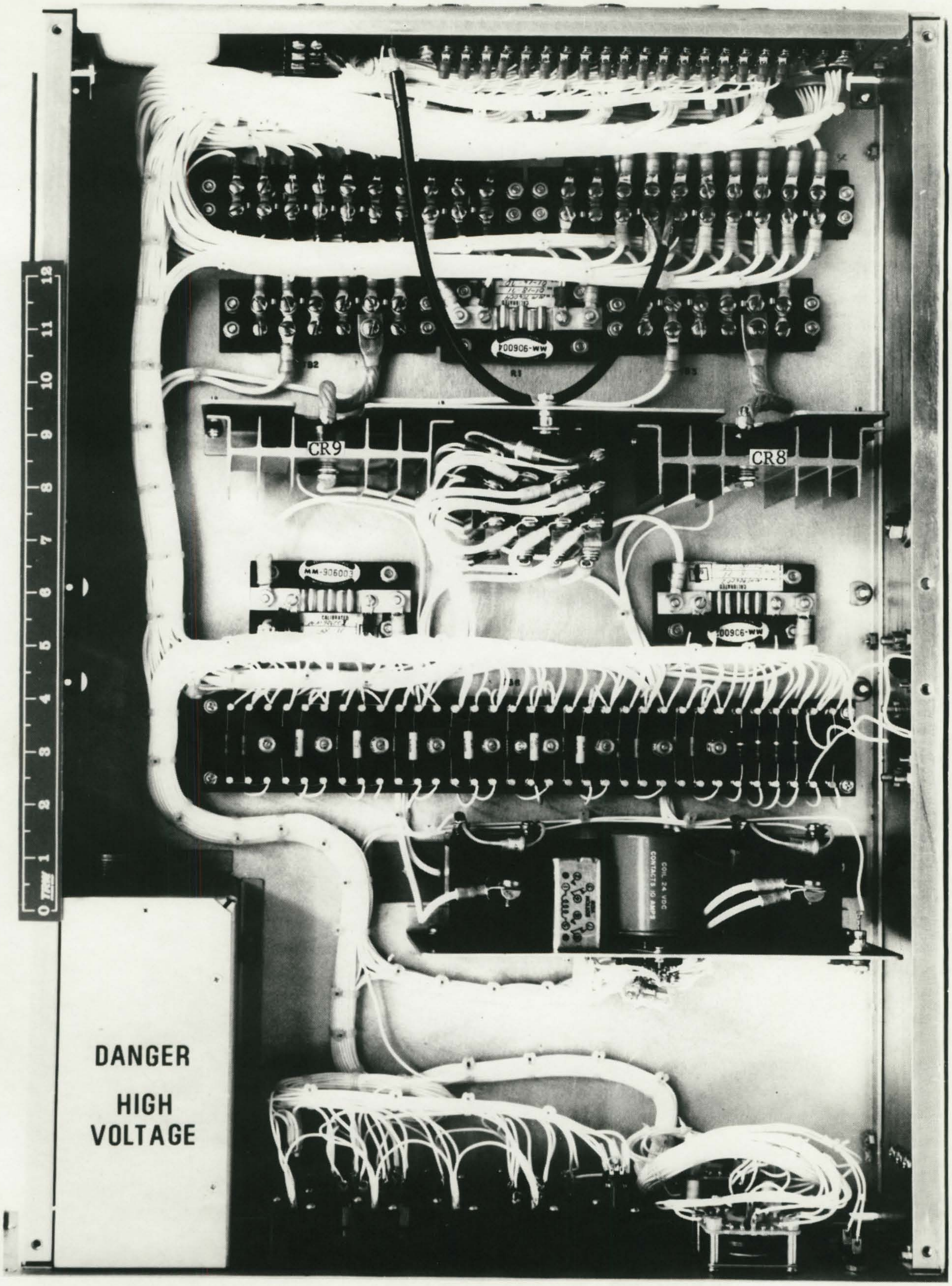


FIGURE 17

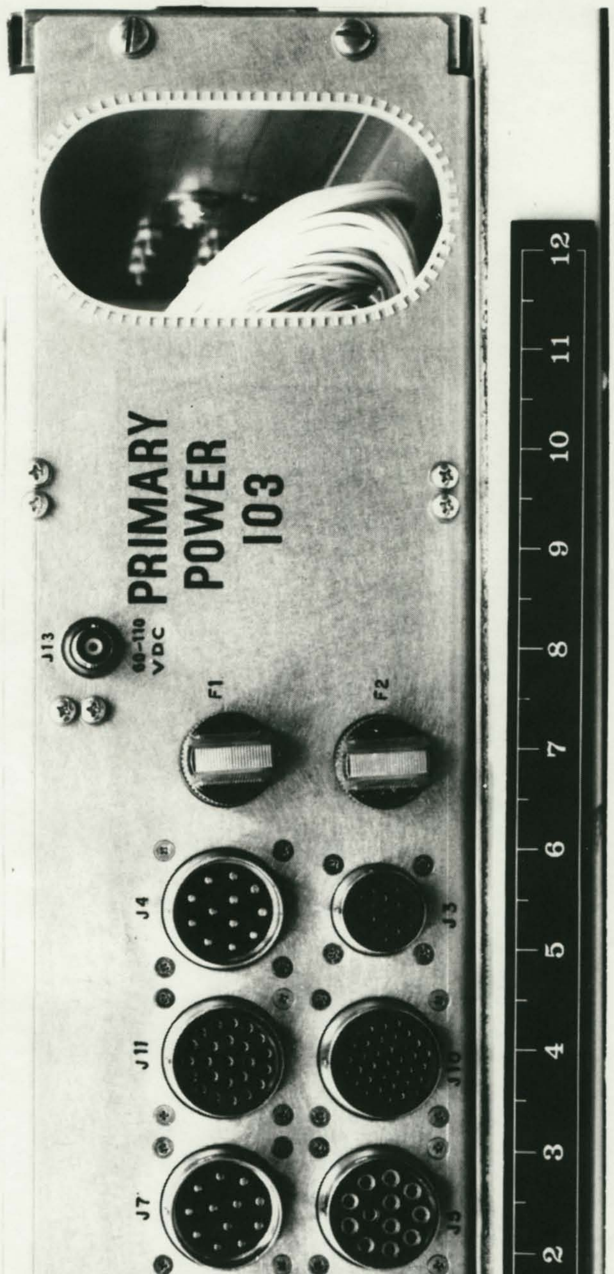


FIGURE 18

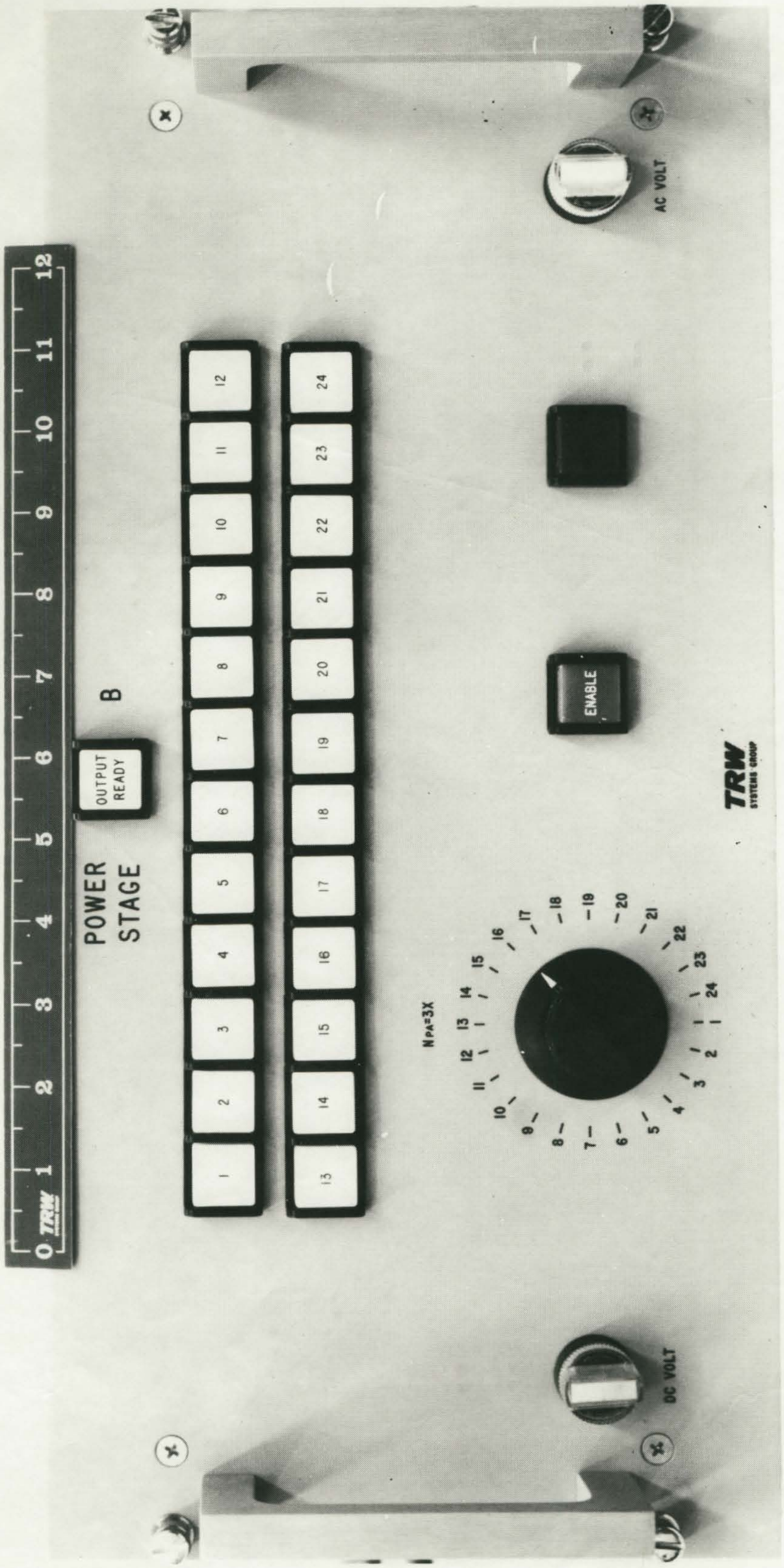

POWER STAGE
B
OUTPUT READY
ENABLE
AC VOLT
DC VOLT
TRW SYSTEMS GROUP
NPA=3X

FIGURE 19

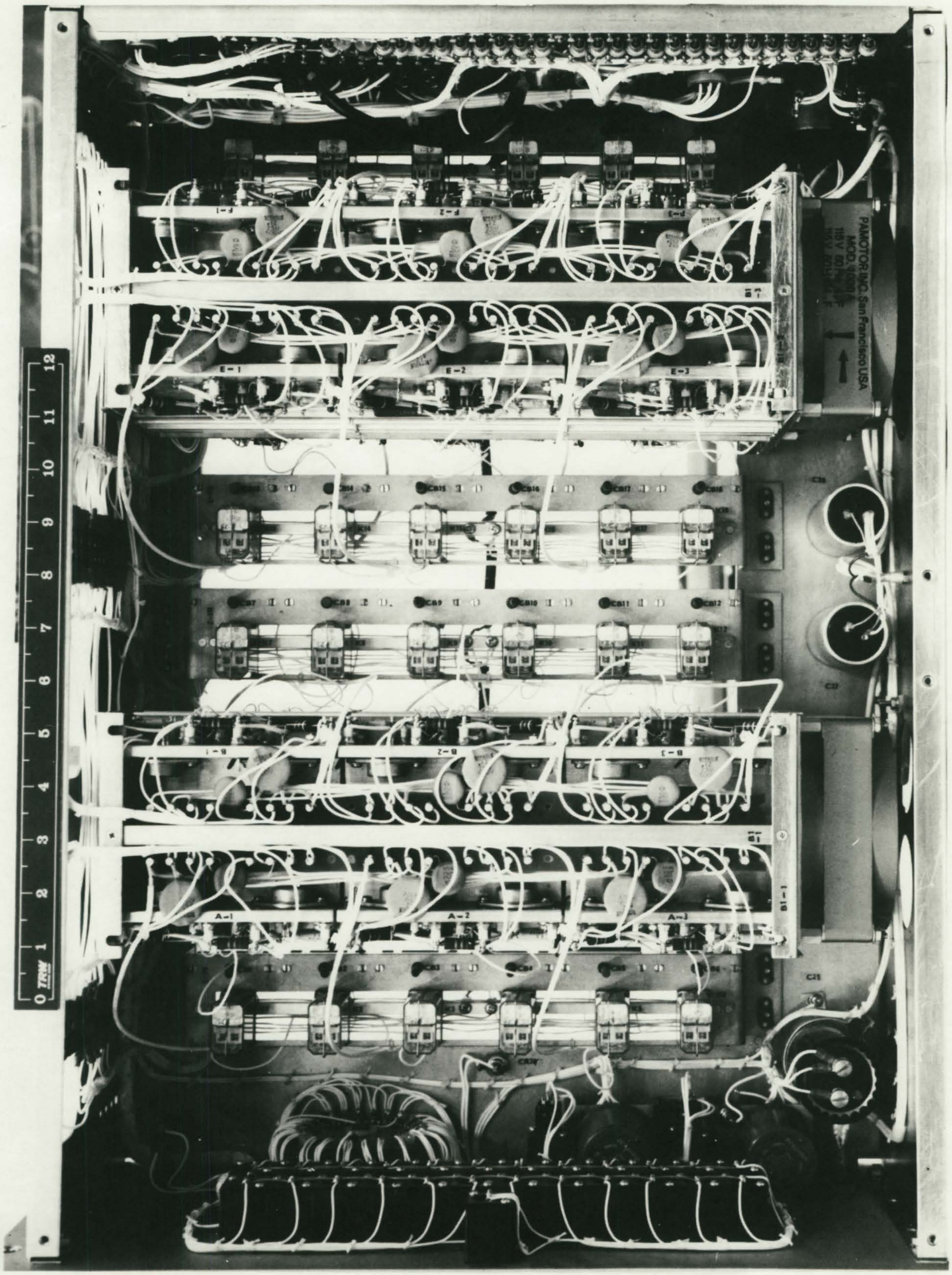


FIGURE 20

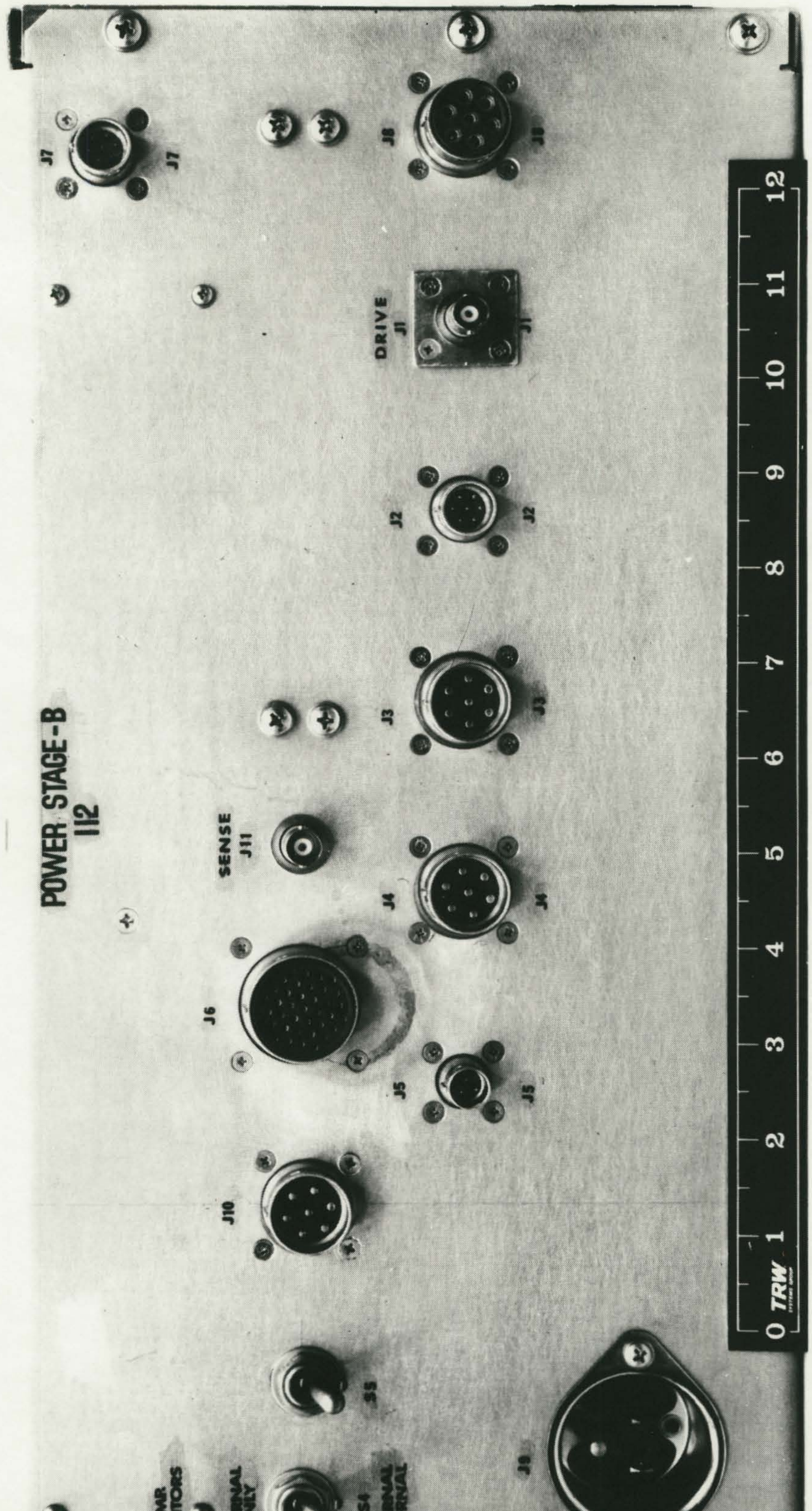

POWER STAGE-B
112
SENSE
J11
DRIVE
J1
J2
J3
J4
J5
J6
J7
J8
J9
J10
COMMR. CAPACITORS
INTERNAL ONLY
S4
INTERNAL EXTERNAL
S5
TRW

FIGURE 21

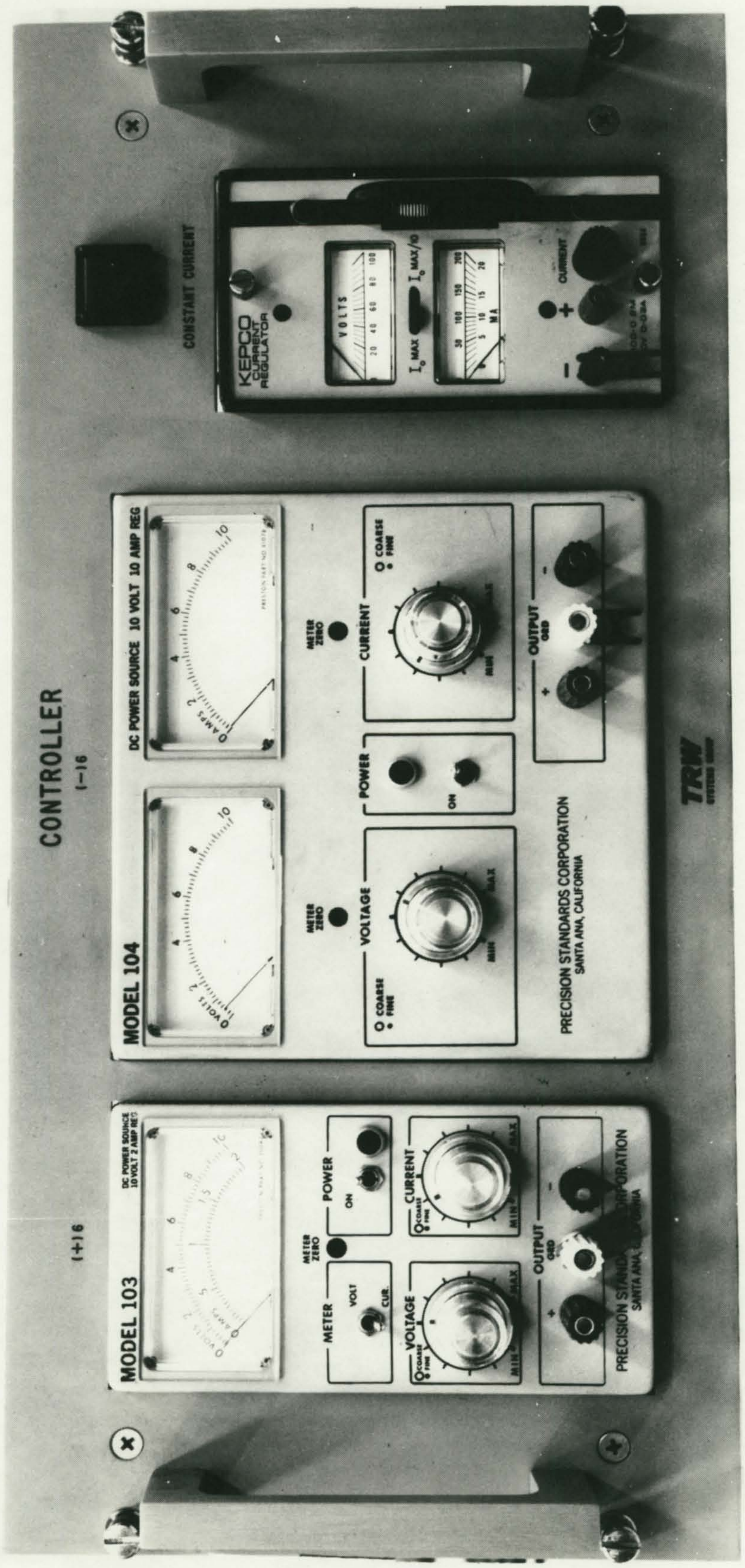

CONSTANT CURRENT
KEPCO CURRENT REGULATOR
VOLTS
MA
CURRENT
CONTROLLER
I-16
I+16
MODEL 104
DC POWER SOURCE 10 VOLT 10 AMP REG
METER ZERO
VOLTAGE
CURRENT
POWER
ON
COARSE
FINE
MIN
MAX
OUTPUT
GND
PRECISION STANDARDS CORPORATION
SANTA ANA, CALIFORNIA
TRW
MODEL 103
DC POWER SOURCE 10 VOLT 2 AMP REG
METER
VOLT
CUR.

FIGURE 22

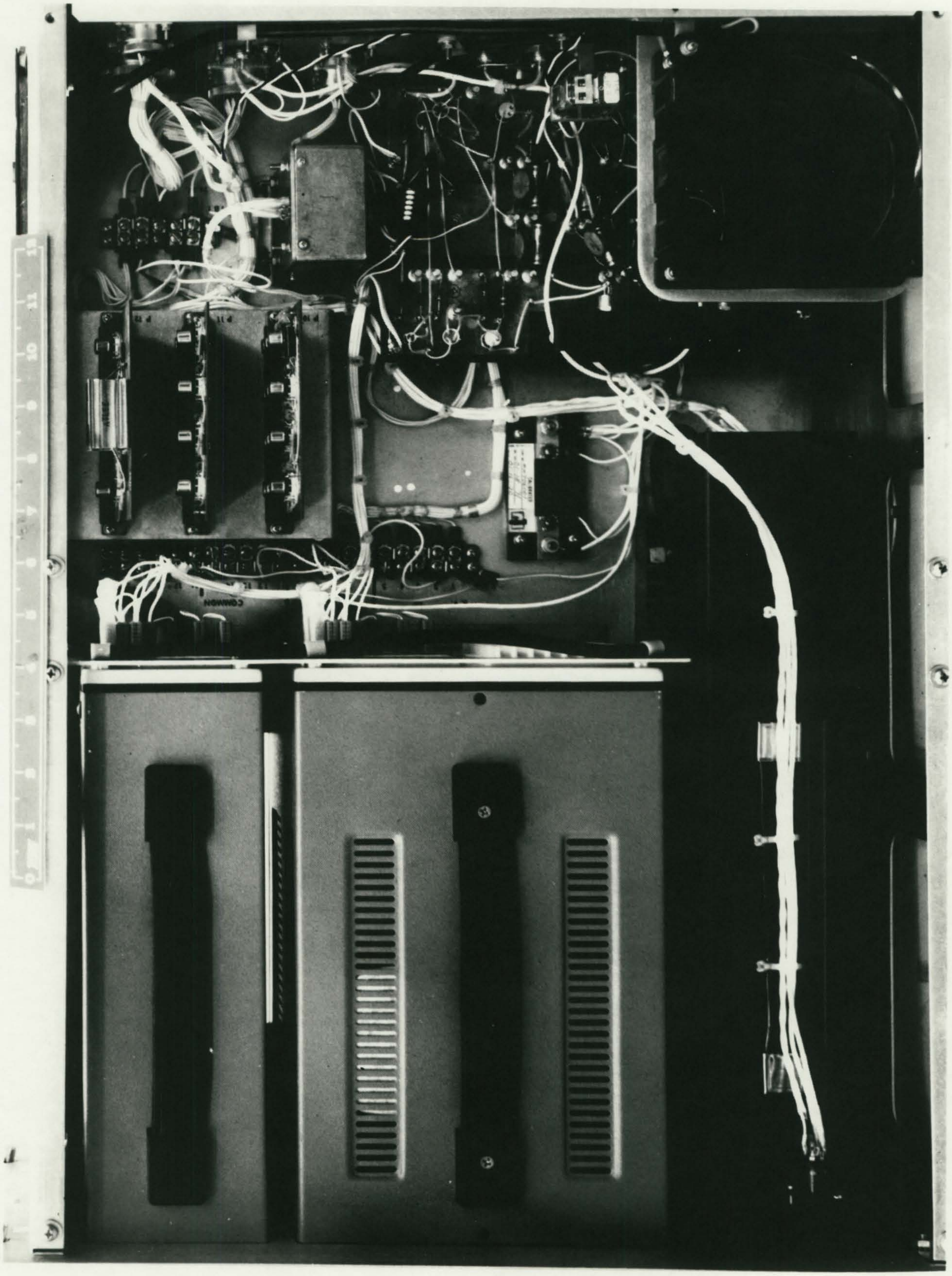
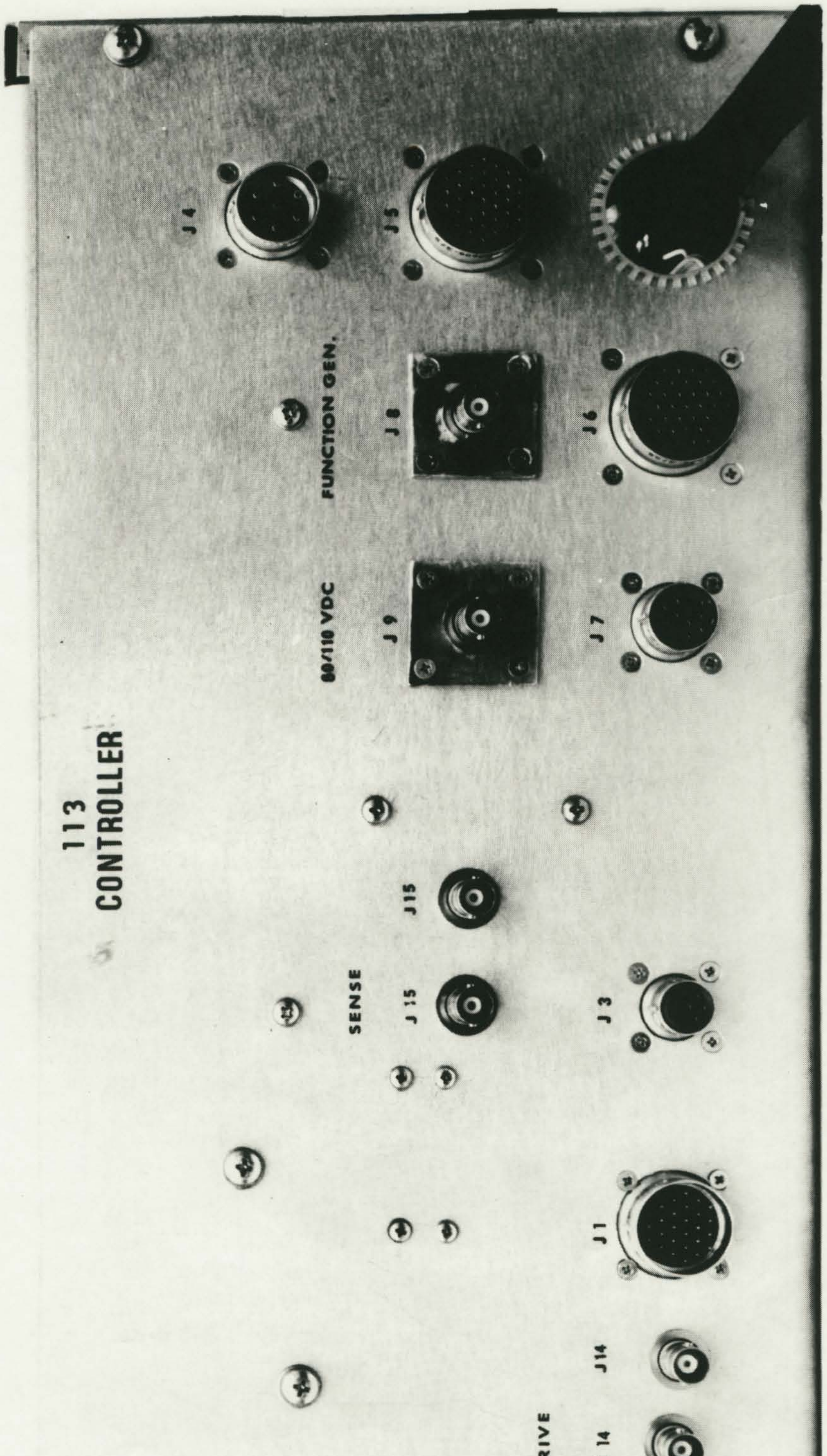


FIGURE 23


113
CONTROLLER
J 4
J 5
FUNCTION GEN.
J 8
J 6
80/110 VDC
J 9
J 7
SENSE
J 15
J15
J 3
J 1
DRIVE
J 14
J14

IX DRAWINGS

TABLE OF CONTENTS

INDENTURED DRAWING LIST

IDL X312624 | REV | DATA CUTOFF DATE

TRW SYSTEMS
TRW INC.
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SHEET 1 OF 1

CONFIGURED ITEM NAME Fast Response Solar Array Simulator | CI NO.

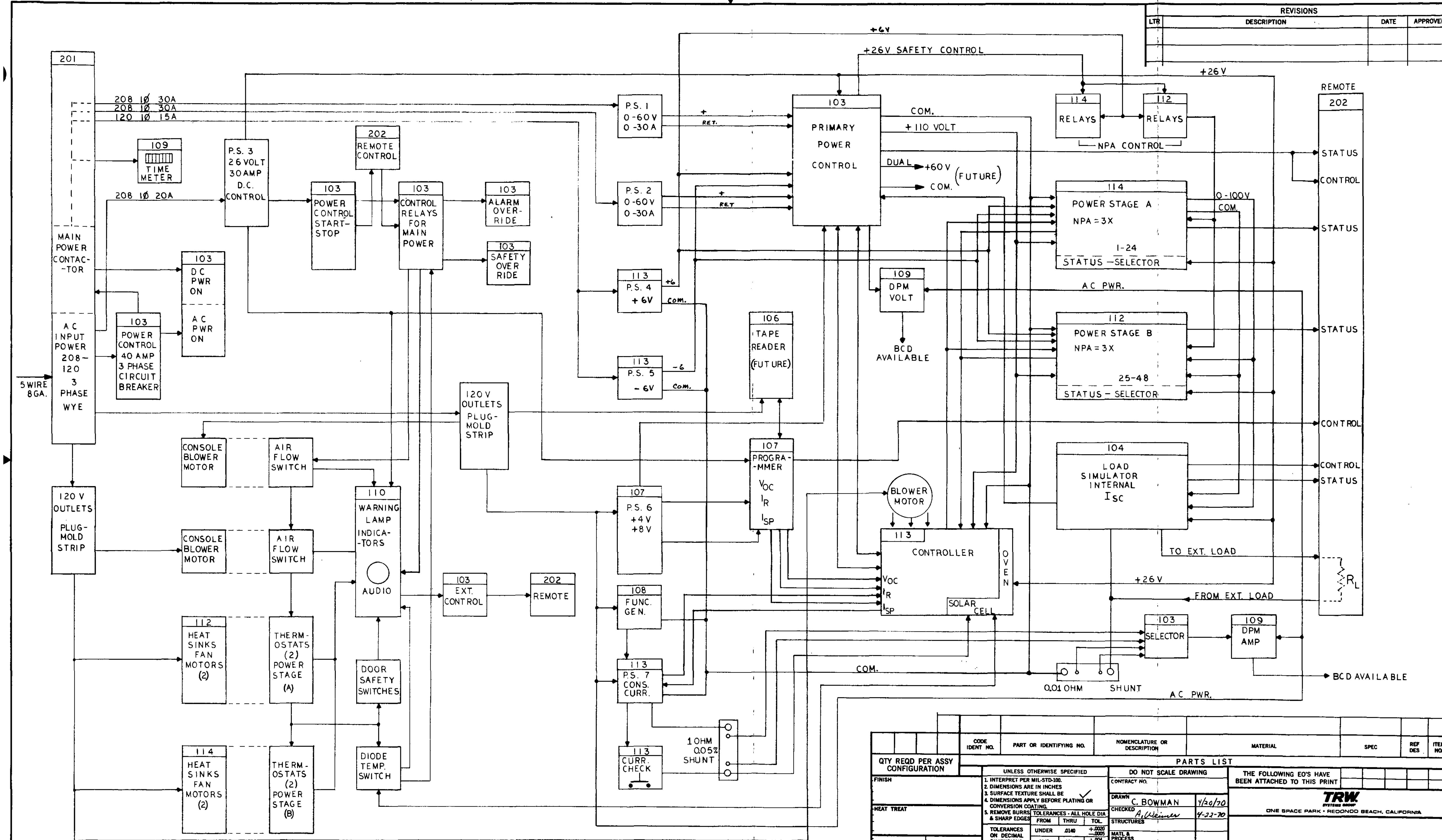
PROGRAM FRSAS | NEXT HIGHER ASSY N/A | NHA CI NO.

PROJ DESIGNER R. Von Hatten | PROD ENGINEER RC Weimer

ITEM NO.	REP DWG	INDENT LVL	PART OR IDENT NUMBER	APL		TITLE	QTY NHA	RELEASE DATE (M-D-Y)	IDL REV
1			X312625			Block Diagram	1		
2			X312626			Primary Power	1		
3			X312627			Programmer	1		
4			X213628			Load Simulator	1		
5			X312629			Digital Panel - Meters & Timer	1		
6			X312630			Warning Panel	1		
7			X312631			Power Stage	2		
8			X312632			Controller	1		
9			X312633			AC 208/120 Power Distribution	1		
10			X312634			Cables	1		
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									

FOLDOUT FRAME 1

FOLDOUT FRAME 2



1. IDENTIFICATION MARKING PER PR 12-1
TYPE_____CLASS_____PART NUMBER_____

NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD PER ASSY CONFIGURATION	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPEC	REF DES	ITEM NO.

PARTS LIST

FINISH

HEAT TREAT

UNLESS OTHERWISE SPECIFIED
1. INTERPRET PER MIL-STD-100.
2. DIMENSIONS ARE IN INCHES
3. SURFACE TEXTURE SHALL BE ✓
4. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
5. REMOVE BURRS & SHARP EDGES

TOLERANCES ON DECIMAL DIMENSIONS: .XXX ± .010, .XX ± .03, .X ± .1

TOLERANCES ON ANGULAR DIMENSIONS: MACHINED & LOCATING ± 0°30', FORMED ± 2°, CHAMFERS ± 5°

TOLERANCES - ALL HOLE DIA FROM	THRU	TOL.
UNDER	.0140	+.0020 −.0005
.0145	.125	+.004 −.001
.126	.250	+.005 −.001
.251	.500	+.006 −.001
.501	.750	+.008 −.001
.751	1.000	+.010 −.001
1.001	2.000	+.012 −.001
OVER	2.000	+.015 −.005

DO NOT SCALE DRAWING
CONTRACT NO.
DRAWN C. BOWMAN 4/20/70
CHECKED A. Weiner 4-22-70
STRUCTURES
MATL & PROCESS
ENGR R. Von Hatten 4/22/70
SUPERVISOR
OTHER APPROVALS

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

BLOCK DIAGRAM

SIZE D | CODE IDENT NO. 11982 | X312625
SCALE | SHEET 1 OF 2

FRSAS | PR 12-1
USED ON | NEXT ASSY | NEXT ASSY QTY REQD
APPLICATION
APPLICABLE SPECIFICATIONS
THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

X312625

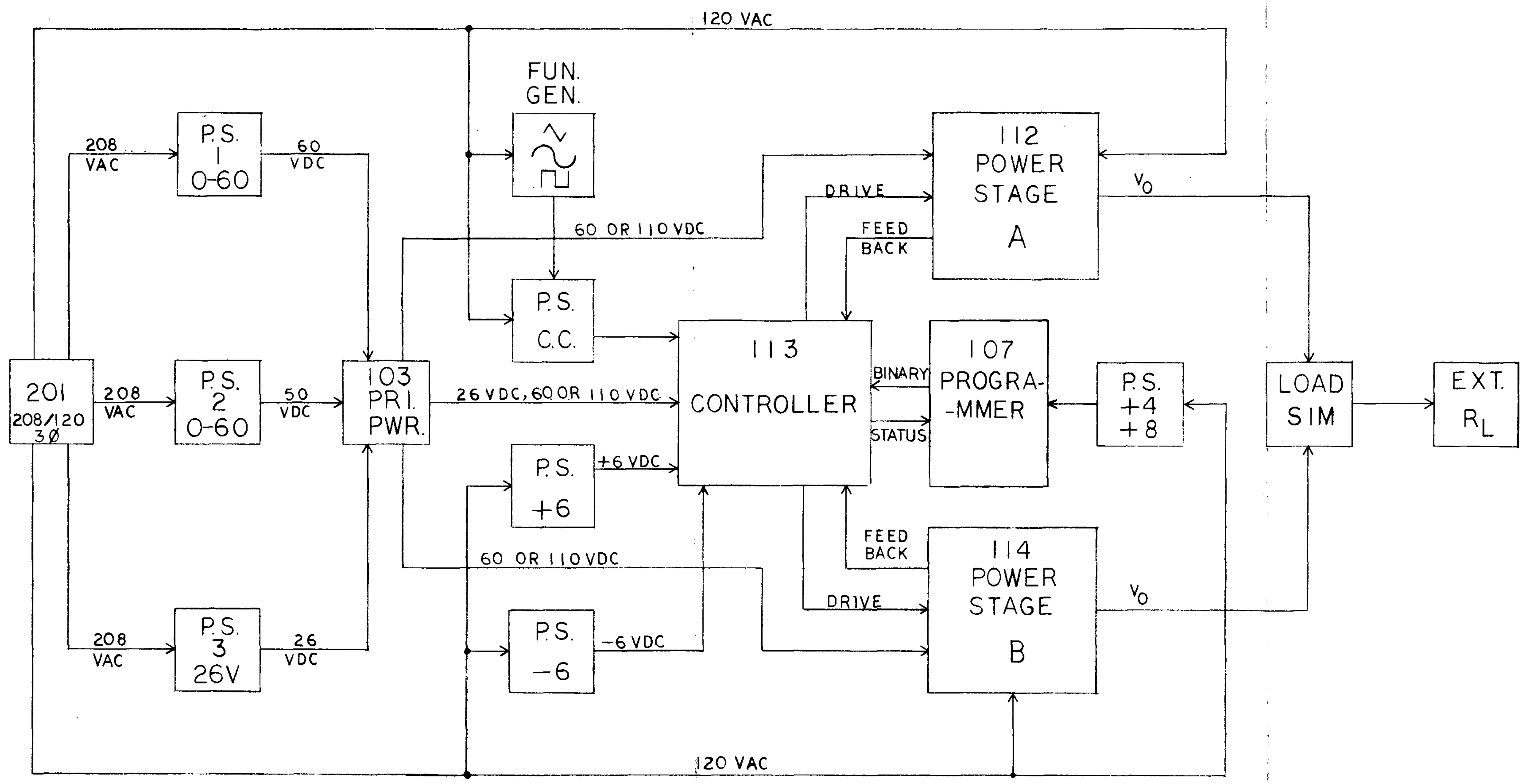
SYSTEMS 3407 REV. 4-69

7/69 DIETZGEN-POST CLEARPRINT 1020

FOLDOUT FRAME 1

FOLDOUT FRAME 2

X312625 CHG LTR



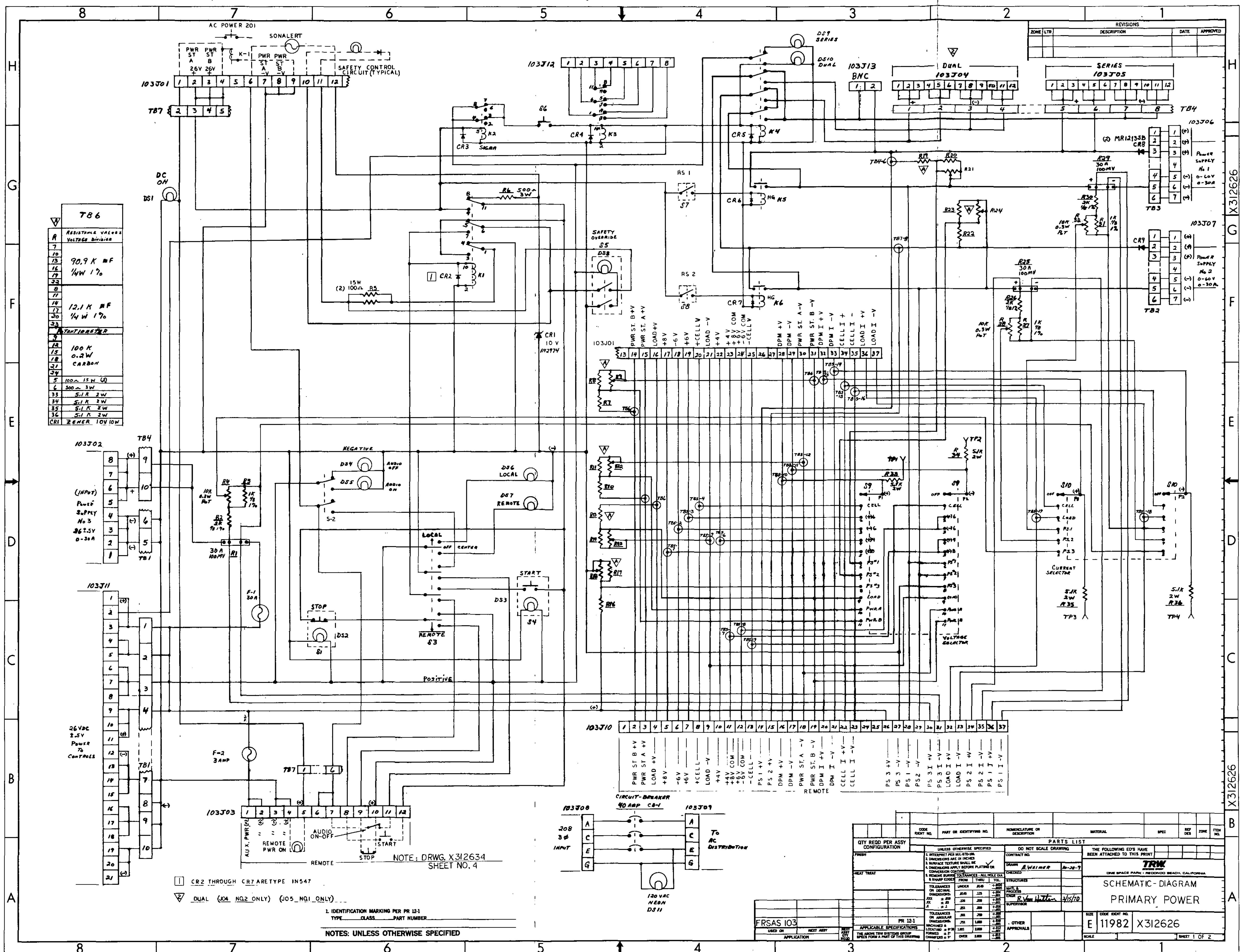
ORIGINATOR	DATE	TITLE	
A. WEIMER	4/29/70	FRSAS BLOCK DIAGRAM (SIMPLIFIED)	ENGINEERING SKETCH TRW SYSTEMS GROUP ONE SPACE PARK • REDONDO BEACH • CALIFORNIA
C. Bowman	4/29/70		X312625
R. Von Hatten	4/29/70		SHEET 2 OF 2

SYSTEMS 3956

FOLDOUT FRAME 1

FOLDOUT FRAME 2

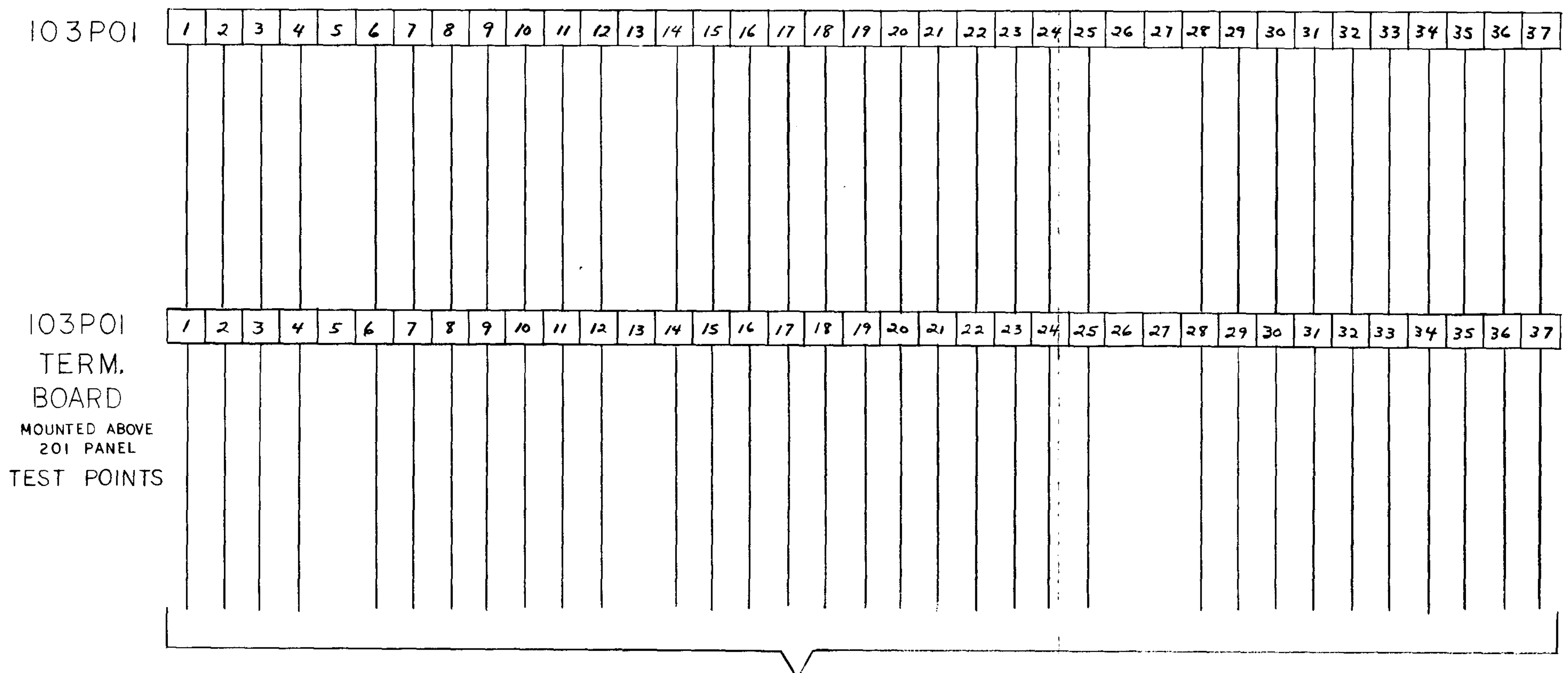
PRIMARY POWER X312626 SHEET 1 of 5



FOLDOUT FRAME 1

FOLDOUT FRAME 2

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



CABLE INTERCONNECTION
SHEET NO.2 X312634

NOTE: DRWG. X312626 FOR TEST POINT VOLTAGES

X312626

1. IDENTIFICATION MARKING PER PR 12-1
TYPE_____CLASS_____PART NUMBER_____

NOTES: UNLESS OTHERWISE SPECIFIED

CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPEC	REF DES	ITEM NO.

QTY REQD PER ASSY CONFIGURATION — PARTS LIST

FINISH

HEAT TREAT

PR 12-1

APPLICABLE SPECIFICATIONS
THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

ERSAS 103 | USED ON | NEXT ASSY | NEXT ASSY QTY REQD
APPLICATION

UNLESS OTHERWISE SPECIFIED
1. INTERPRET PER MIL-STD-100.
2. DIMENSIONS ARE IN INCHES
3. SURFACE TEXTURE SHALL BE ✓
4. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
5. REMOVE BURRS & SHARP EDGES

TOLERANCES ON DECIMAL DIMENSIONS: .XXX ± .010, .XX ± .03, .X ± .1
TOLERANCES ON ANGULAR DIMENSIONS: MACHINED & LOCATING ± 0°30', FORMED ± 2°, CHAMFERS ± 5°

TOLERANCES - ALL HOLE DIA		
FROM	THRU	TOL.
UNDER	.0140	+.0020 −.0005
.0145	.125	+.004 −.001
.126	.250	+.005 −.001
.251	.500	+.006 −.001
.501	.750	+.008 −.001
.751	1.000	+.010 −.001
1.001	2.000	+.012 −.001
OVER	2.000	+.015 −.005

DO NOT SCALE DRAWING
CONTRACT NO.
DRAWN A. WEIMER 10-28-9
CHECKED
STRUCTURES
MATL & PROCESS
ENGR R. Von Hatten 11/3/69
SUPERVISOR
OTHER APPROVALS

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

CABLE-EXTENSION
PRIMARY POWER

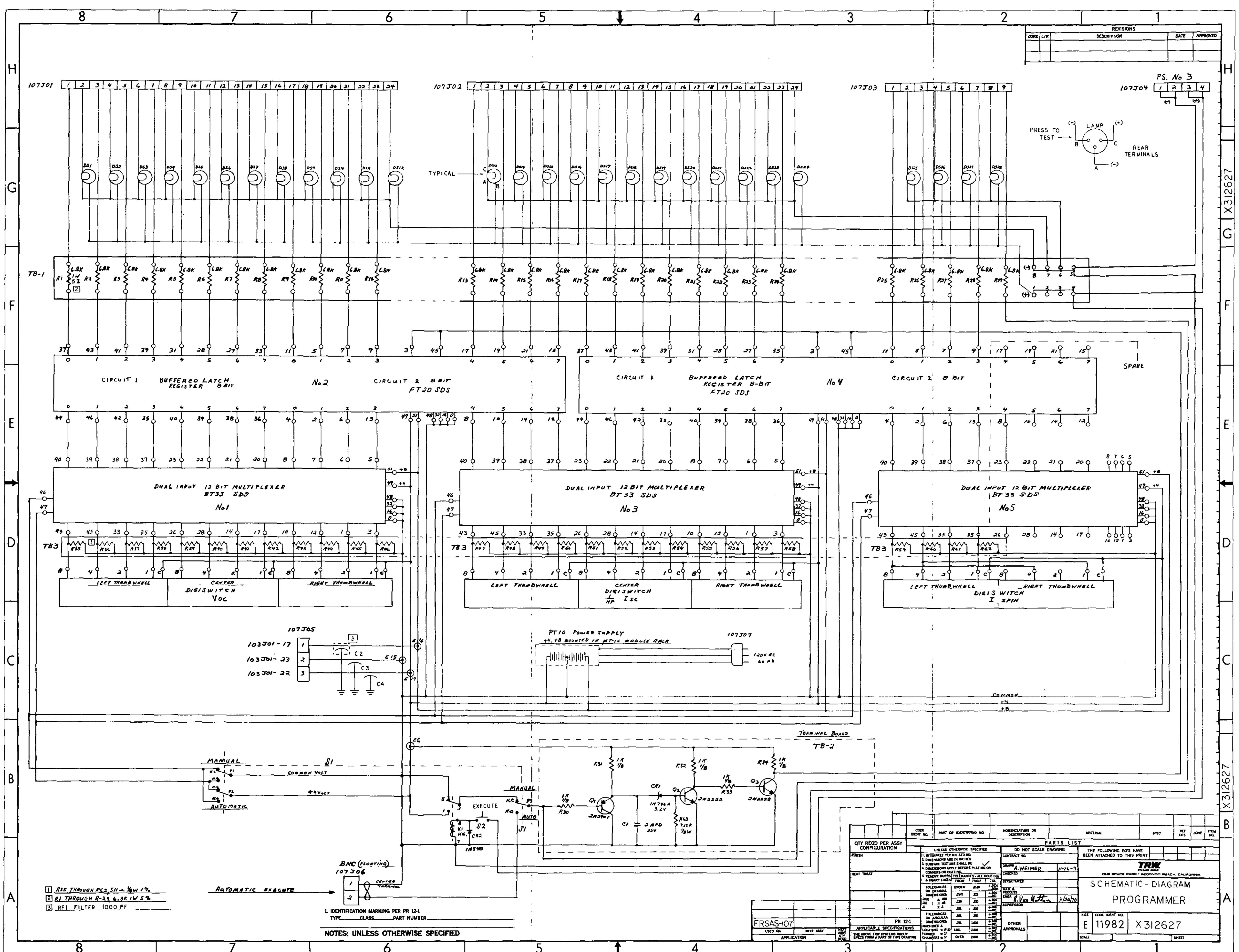
SIZE D | CODE IDENT NO. 11982 | X312626
SCALE | SHEET 2 OF 2

SYSTEMS 3467 REV. 4-68

DIETERICH-POST CLEARPRINT 1020

FOLDOUT FRAME 1

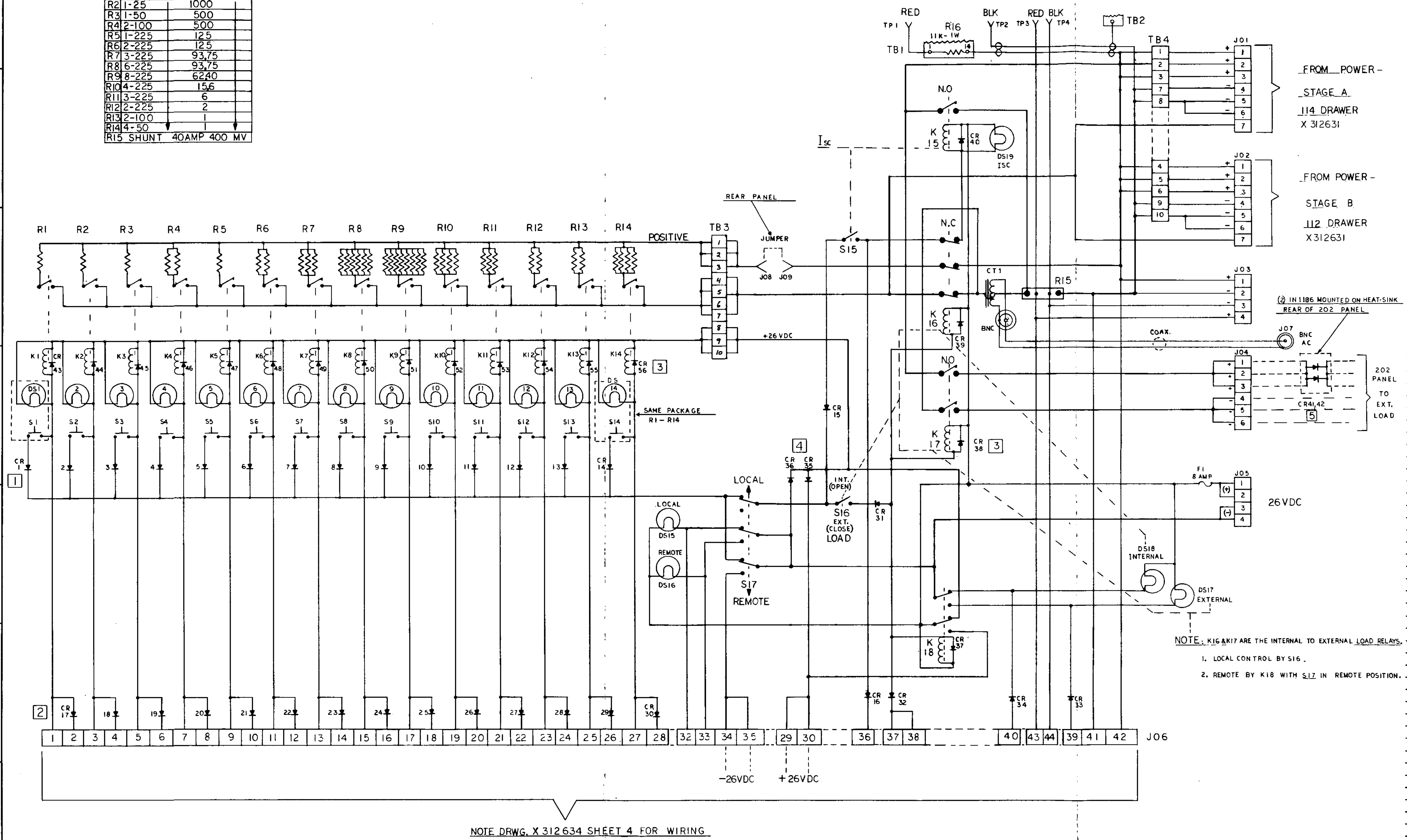
FOLDOUT FRAME 2



FOLDOUT FRAME 1

FOLDOUT FRAME 2

LOAD RESISTORS N.I 5%		
R1	1-25 WATT	1000 OHM
R2	1-25	1000
R3	1-50	500
R4	2-100	500
R5	1-225	125
R6	2-225	125
R7	3-225	93,75
R8	6-225	93,75
R9	8-225	62,40
R10	4-225	15,6
R11	3-225	6
R12	2-225	2
R13	2-100	1
R14	4-50	1
R15 SHUNT 40AMP 400 MV		



NOT REPRODUCIBLE

1 IN540 CR1-CR16 MOUNTED ON TB1 FRONT TERMINAL BD.

2 IN540 CR17-CR34 TB2 REAR TER. BD.

3 IN547 CR37-CR40, CR43-CR56

4 IN1200 CR35, CR36

5 IN1186 CR41-CR42

1. IDENTIFICATION MARKING PER PR 12-1 TYPE____CLASS____PART NUMBER____

NOTES: UNLESS OTHERWISE SPECIFIED

LOAD SIMULATOR X312628

PARTS LIST

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

LOAD SIMULATOR SCHEMATIC DIAGRAM

SIZE	CODE IDENT NO.	
E	11982	X312628

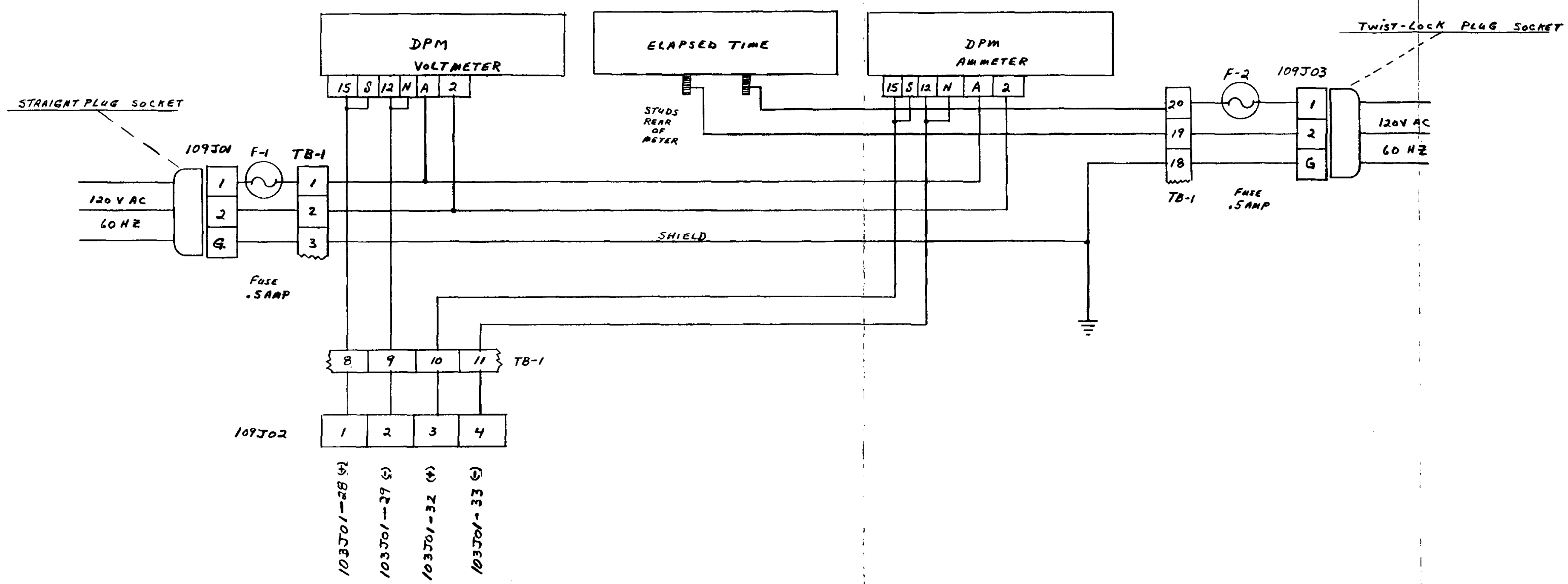
FRSAS 104

127

FOLDOUT FRAME 1

FOLDOUT FRAME 2

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



X312629

1. IDENTIFICATION MARKING PER PR 12-1
TYPE_____CLASS_____PART NUMBER_____

NOTES: UNLESS OTHERWISE SPECIFIED

CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPEC	REF DES	ITEM NO.

QTY REQD PER ASSY CONFIGURATION — PARTS LIST

FINISH

HEAT TREAT

PR 12-1

APPLICABLE SPECIFICATIONS

THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

FRSAS 109

USED ON	NEXT ASSY	NEXT ASSY QTY REQD
APPLICATION		

UNLESS OTHERWISE SPECIFIED
1. INTERPRET PER MIL-STD-100.
2. DIMENSIONS ARE IN INCHES
3. SURFACE TEXTURE SHALL BE ✓
4. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
5. REMOVE BURRS & SHARP EDGES

TOLERANCES ON DECIMAL DIMENSIONS: .XXX ± .010, .XX ± .03, .X ± .1

TOLERANCES ON ANGULAR DIMENSIONS: MACHINED & LOCATING ± 0°30', FORMED ± 2°, CHAMFERS ± 5°

TOLERANCES - ALL HOLE DIA		
FROM	THRU	TOL.
UNDER	.0140	+.0020 −.0005
.0145	.125	+.004 −.001
.126	.250	+.005 −.001
.251	.500	+.006 −.001
.501	.750	+.008 −.001
.751	1.000	+.010 −.001
1.001	2.000	+.012 −.001
OVER	2.000	+.015 −.005

DO NOT SCALE DRAWING

CONTRACT NO.		
DRAWN	A. WEIMER	12-1-9
CHECKED		
STRUCTURES		
MATL & PROCESS		
ENGR	R. Von Hatten	12-1-9
SUPERVISOR		
OTHER APPROVALS		

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SCHEMATIC-DIAGRAM
PANEL METERS

SIZE	CODE IDENT NO.	
D	11982	X312629

SCALE SHEET

7/69 DIETERICH-POST CLEARPRINT 1020

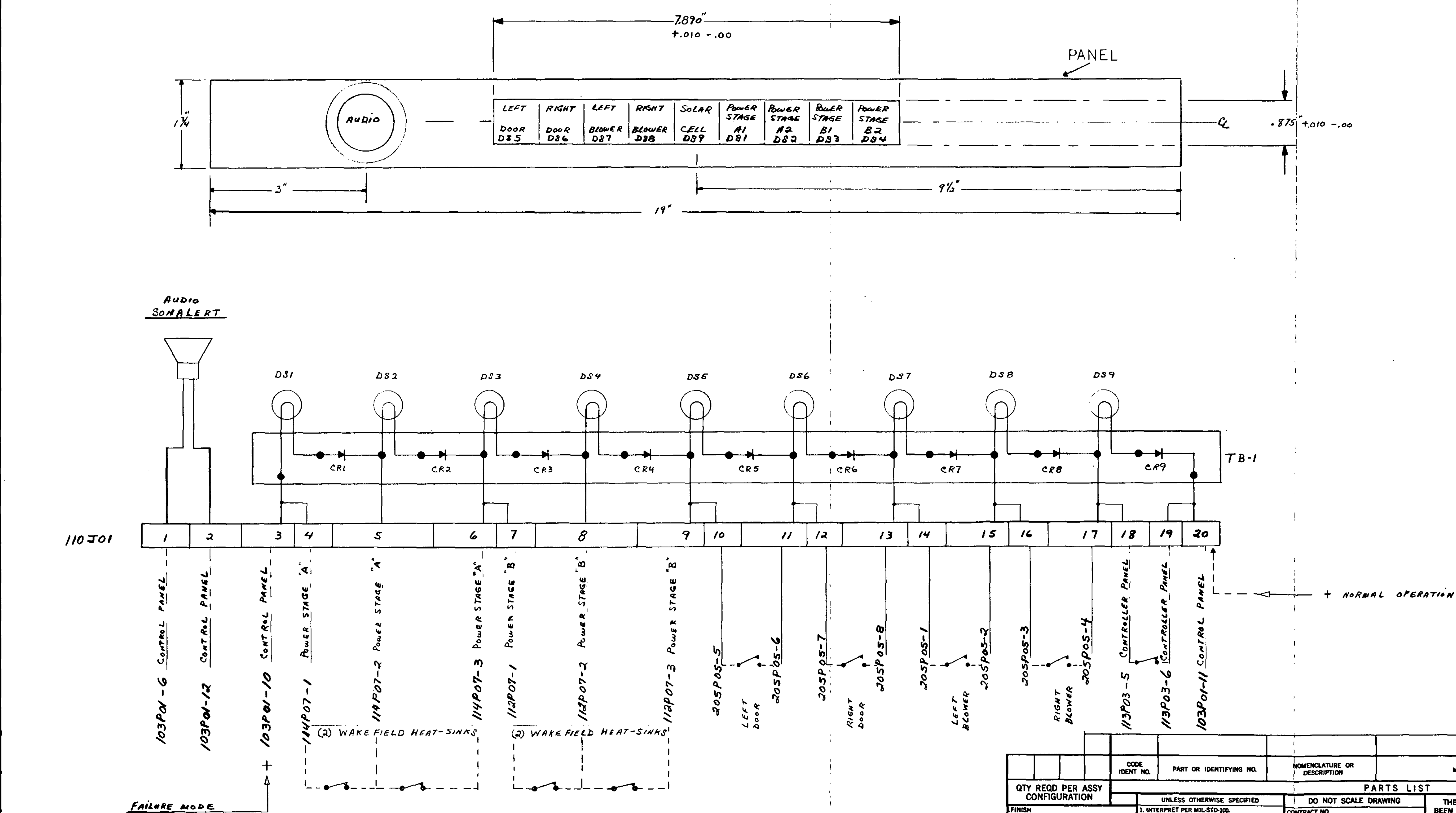
128

SYSTEMS 3487 REV. 4-69

FOLDOUT FRAME 1

FOLDOUT FRAME 2

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



1. IDENTIFICATION MARKING PER PR 12-1
TYPE_____CLASS_____PART NUMBER_____

NOTES: UNLESS OTHERWISE SPECIFIED

CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPEC	REF DES	ITEM NO.

PARTS LIST

QTY REQD PER ASSY CONFIGURATION

FINISH

HEAT TREAT

APPLICABLE SPECIFICATIONS: PR 12-1

THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

FRSAS-110

USED ON	NEXT ASSY
APPLICATION	

UNLESS OTHERWISE SPECIFIED
1. INTERPRET PER MIL-STD-100.
2. DIMENSIONS ARE IN INCHES
3. SURFACE TEXTURE SHALL BE ✓
4. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
5. REMOVE BURRS & SHARP EDGES

TOLERANCES ON DECIMAL DIMENSIONS: .XXX ± .010, .XX ± .03, .X ± .1

TOLERANCES ON ANGULAR DIMENSIONS: MACHINED & LOCATING ± 0°30', FORMED ± 2°, CHAMFERS ± 5°

TOLERANCES - ALL HOLE DIA		
FROM	THRU	TOL.
UNDER	.0140	+.0020 -.0005
.0145	.125	+.004 -.001
.126	.250	+.005 -.001
.251	.500	+.006 -.001
.501	.750	+.008 -.001
.751	1.000	+.010 -.001
1.001	2.000	+.012 -.001
OVER	2.000	+.015 -.005

DO NOT SCALE DRAWING

CONTRACT NO.

DRAWN A. WEIMER 11-4-9

CHECKED

STRUCTURES

MATL & PROCESS

ENGR R. Von Hatten 2-10-70

SUPERVISOR

OTHER APPROVALS

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SCHEMATIC - DIAGRAM AND PANEL LAYOUT
WARNING PANEL

SIZE	CODE IDENT NO.	
D	11982	X312630

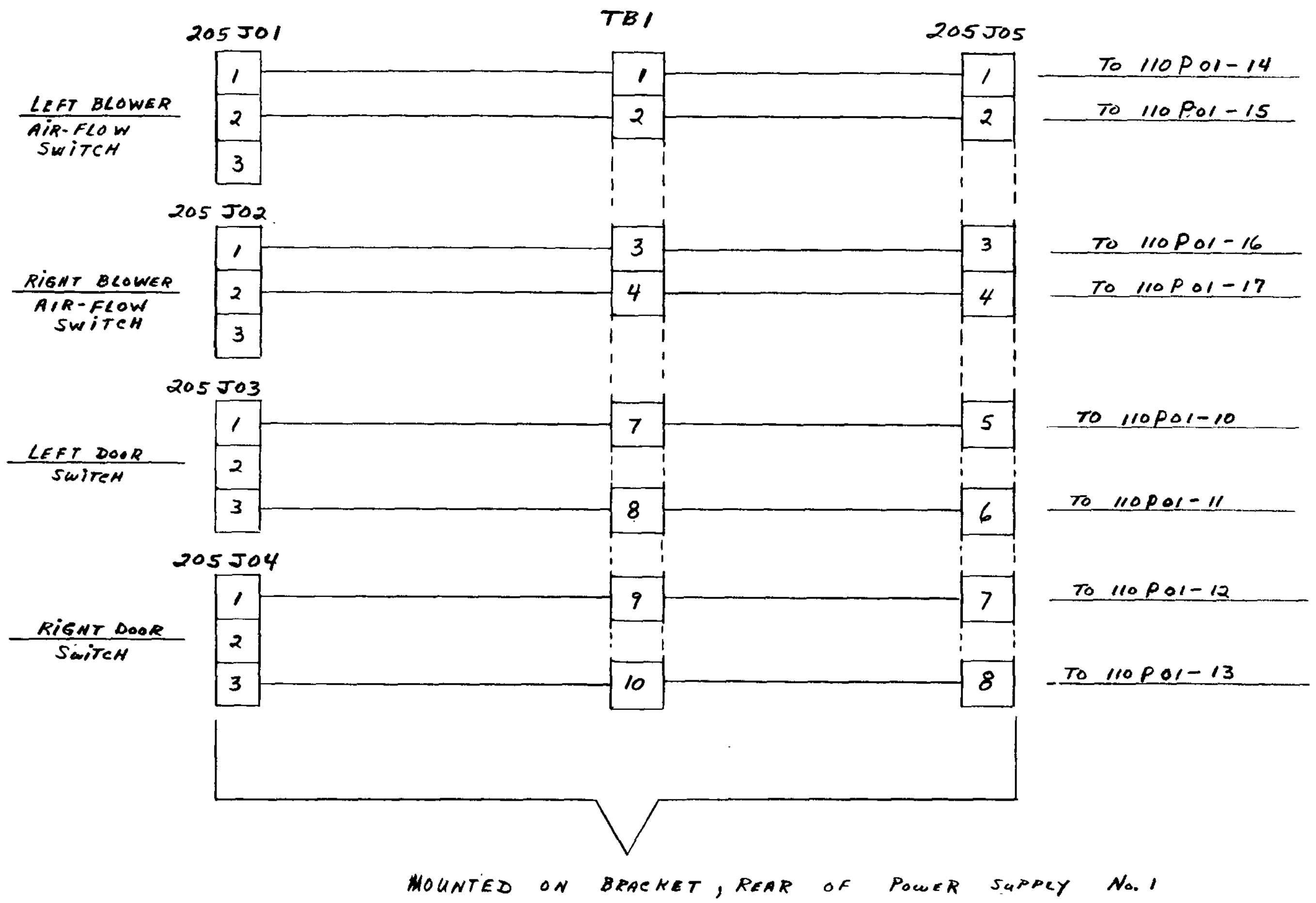
SCALE | SHEET 1 OF 2

X312630

FOLDOUT FRAME 1

FOLDOUT FRAME 2

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



1. IDENTIFICATION MARKING PER PR 12-1
TYPE______CLASS______PART NUMBER______

NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD PER ASSY CONFIGURATION	CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPEC	REF DES	ITEM NO.
			PARTS LIST				

FINISH

HEAT TREAT

PR 12-1

APPLICABLE SPECIFICATIONS

THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

FRSAS-110		
USED ON	NEXT ASSY	NEXT ASSY QTY REQD
APPLICATION		

UNLESS OTHERWISE SPECIFIED
1. INTERPRET PER MIL-STD-100.
2. DIMENSIONS ARE IN INCHES
3. SURFACE TEXTURE SHALL BE ✓
4. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
5. REMOVE BURRS & SHARP EDGES

TOLERANCES - ALL HOLE DIA		
FROM	THRU	TOL.
UNDER	.0140	+.0020 −.0005
.0145	.125	+.004 −.001
.126	.250	+.005 −.001
.251	.500	+.006 −.001
.501	.750	+.008 −.001
.751	1.000	+.010 −.001
1.001	2.000	+.012 −.001
OVER	2.000	+.015 −.005

TOLERANCES ON DECIMAL DIMENSIONS: .XXX ± .010, .XX ± .03, .X ± .1

TOLERANCES ON ANGULAR DIMENSIONS: MACHINED & LOCATING ± 0°30′, FORMED ± 2°, CHAMFERS ± 5°

DO NOT SCALE DRAWING

CONTRACT NO.		
DRAWN	A. WEIMER	11-4-9
CHECKED		
STRUCTURES		
MATL & PROCESS		
ENGR	R. Von Hatten	11/5/69
SUPERVISOR		
OTHER APPROVALS		

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

CABLE INTERFACE WARNING PANEL

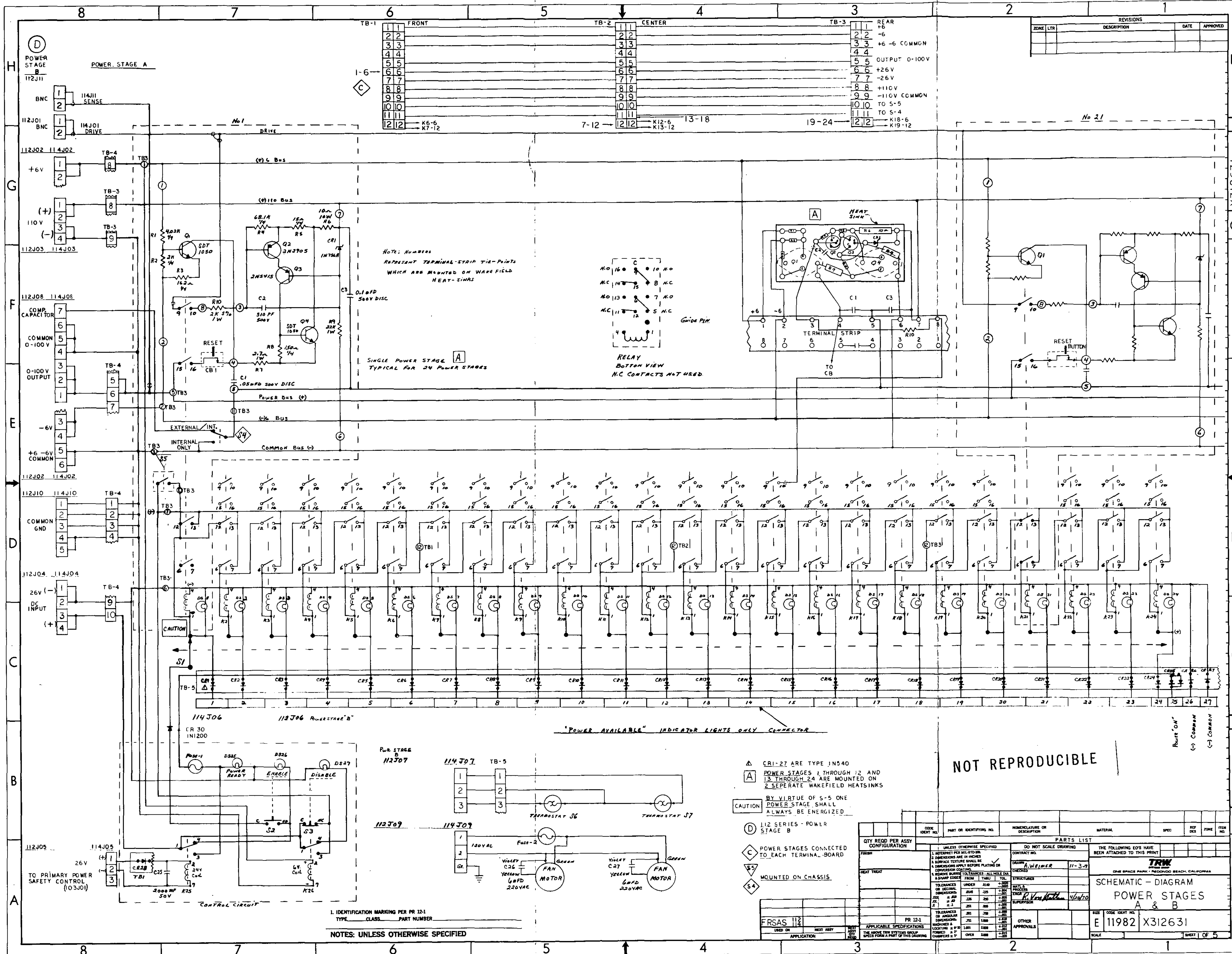
SIZE	CODE IDENT NO.	
D	11982	X312630
SCALE		SHEET 2 OF 2

SYSTEMS 3487 REV. 4-69

X312630

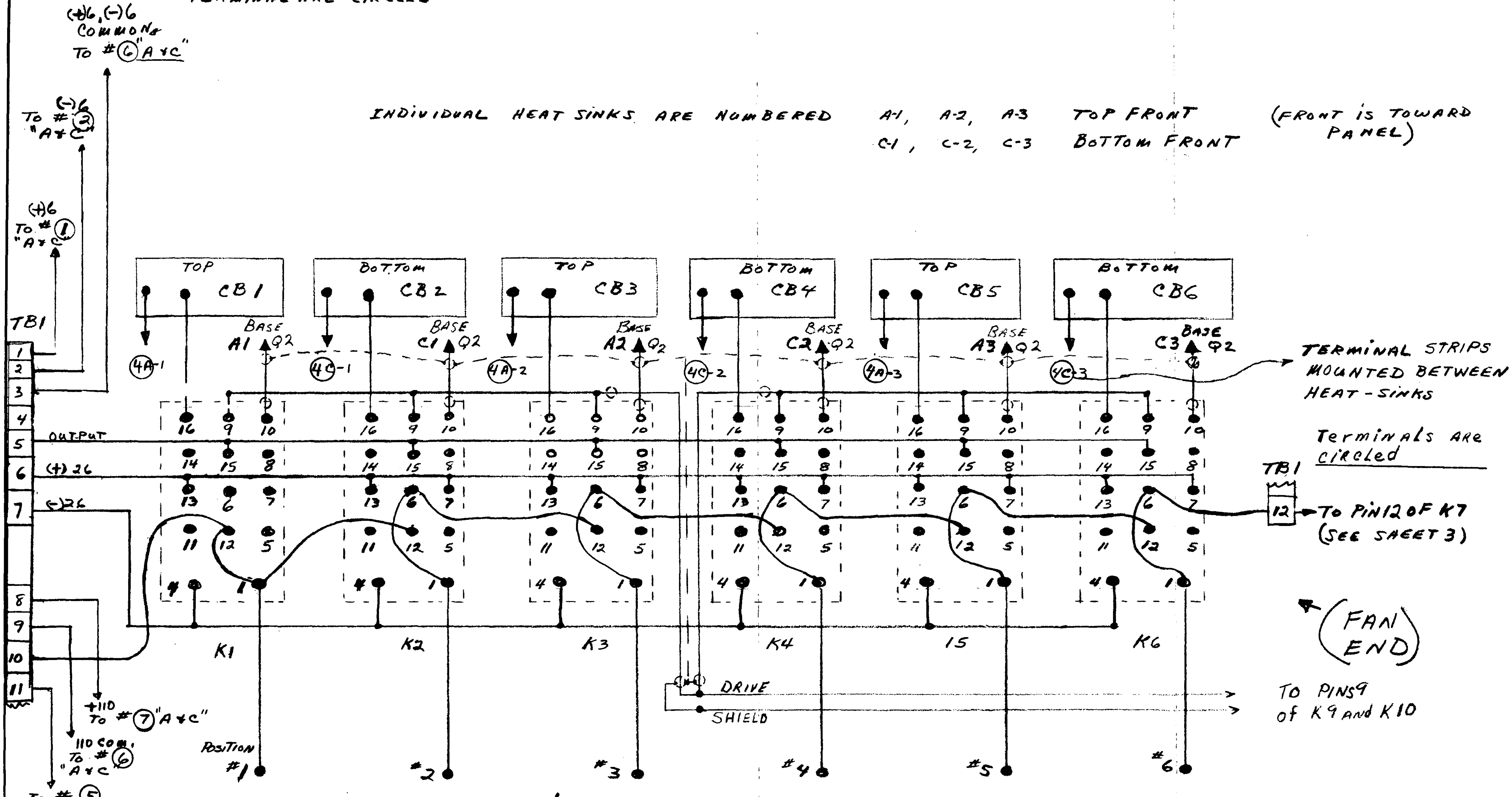
FOLDOUT FRAME 1

FOLDOUT FRAME 2



X312631 CHG LTR

TERMINAL STRIP MOUNTED BETWEEN HEAT-SINKS
TERMINAL ARE CIRCLED

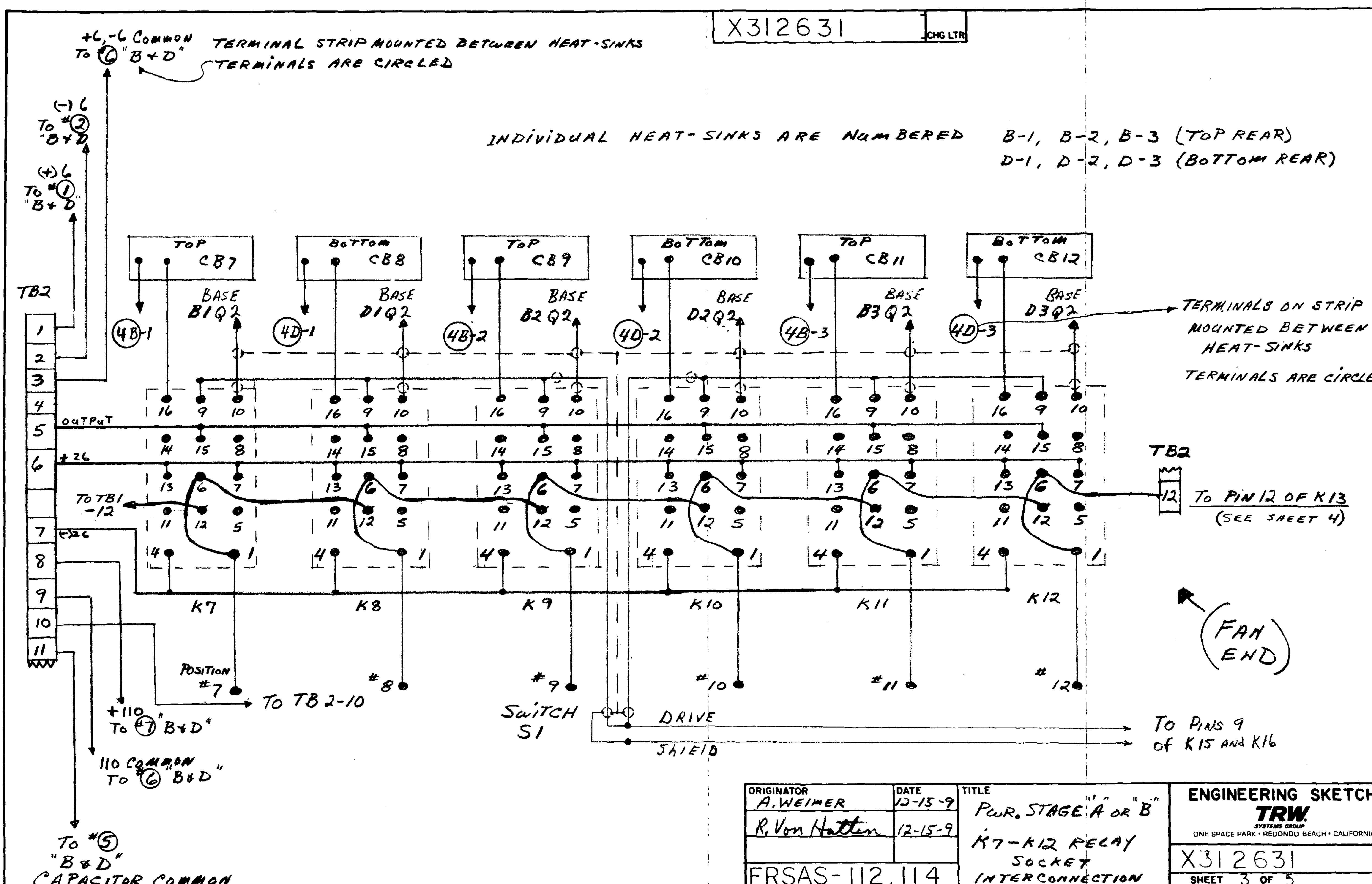


TB1 — 10 GOES TO S5

ORIGINATOR	DATE	TITLE	ENGINEERING SKETCH
A. WEIMER	12-15-9	PWR. STAGE "A" OR "B" K1 — K6 RELAY SOCKET INTER CONNECTION	TRW SYSTEMS GROUP ONE SPACE PARK • REDONDO BEACH • CALIFORNIA
R. Von Hatten	12-15-9		X312631
FRSAS-112, 114			SHEET 2 OF 5

FOLDOUT FRAME 1

FOLDOUT FRAME 2



ORIGINATOR	DATE	TITLE
A. WEIMER	12-15-9	PWR. STAGE "A" OR "B"
R. Von Hatten	12-15-9	K7-K12 RELAY SOCKET INTERCONNECTION
FRSAS-112, 114		

ENGINEERING SKETCH

TRW SYSTEMS GROUP

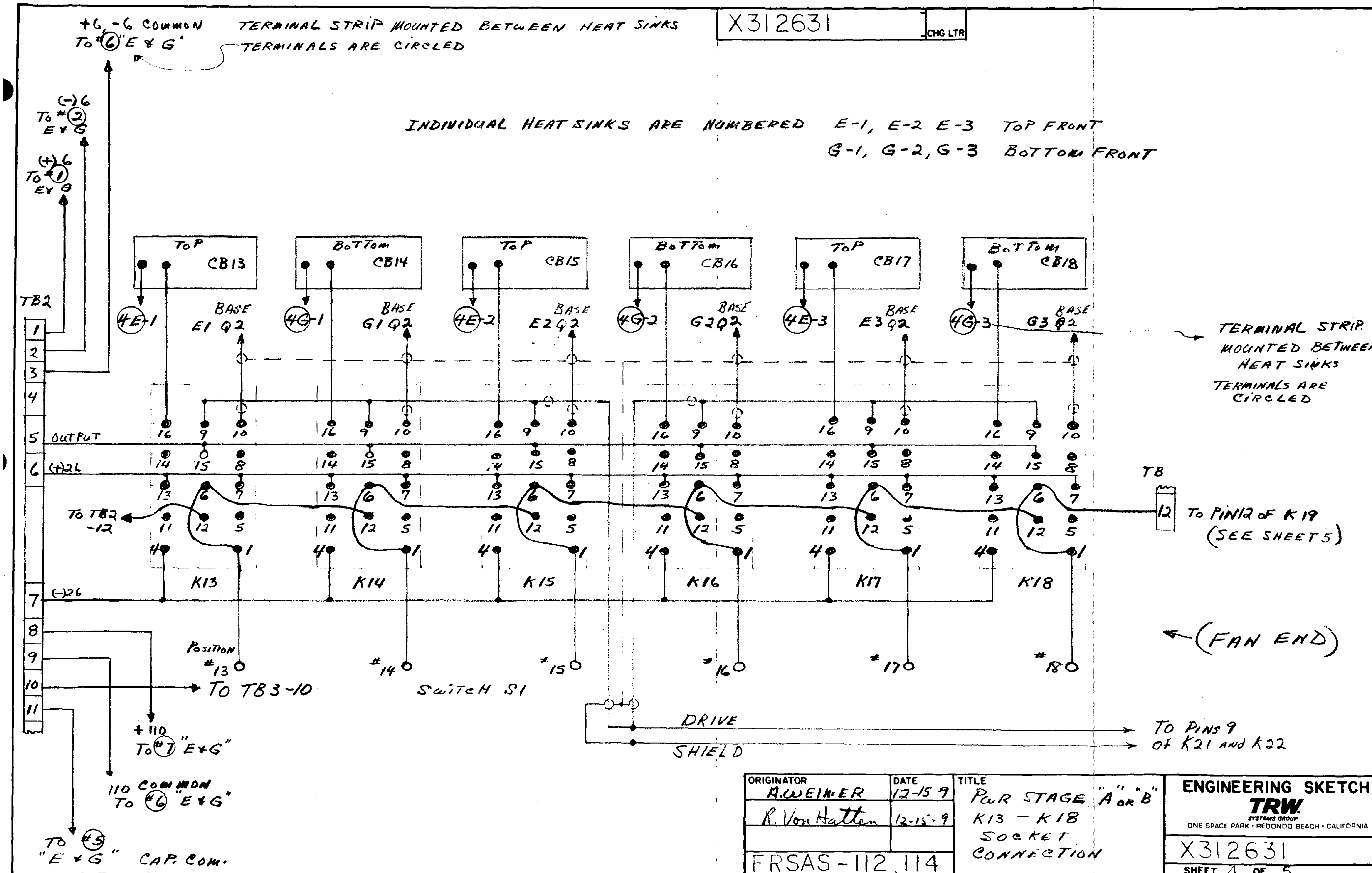
ONE SPACE PARK · REDONDO BEACH · CALIFORNIA

X312631

SHEET 3 OF 5

STEMS 3663 REV. 5-67

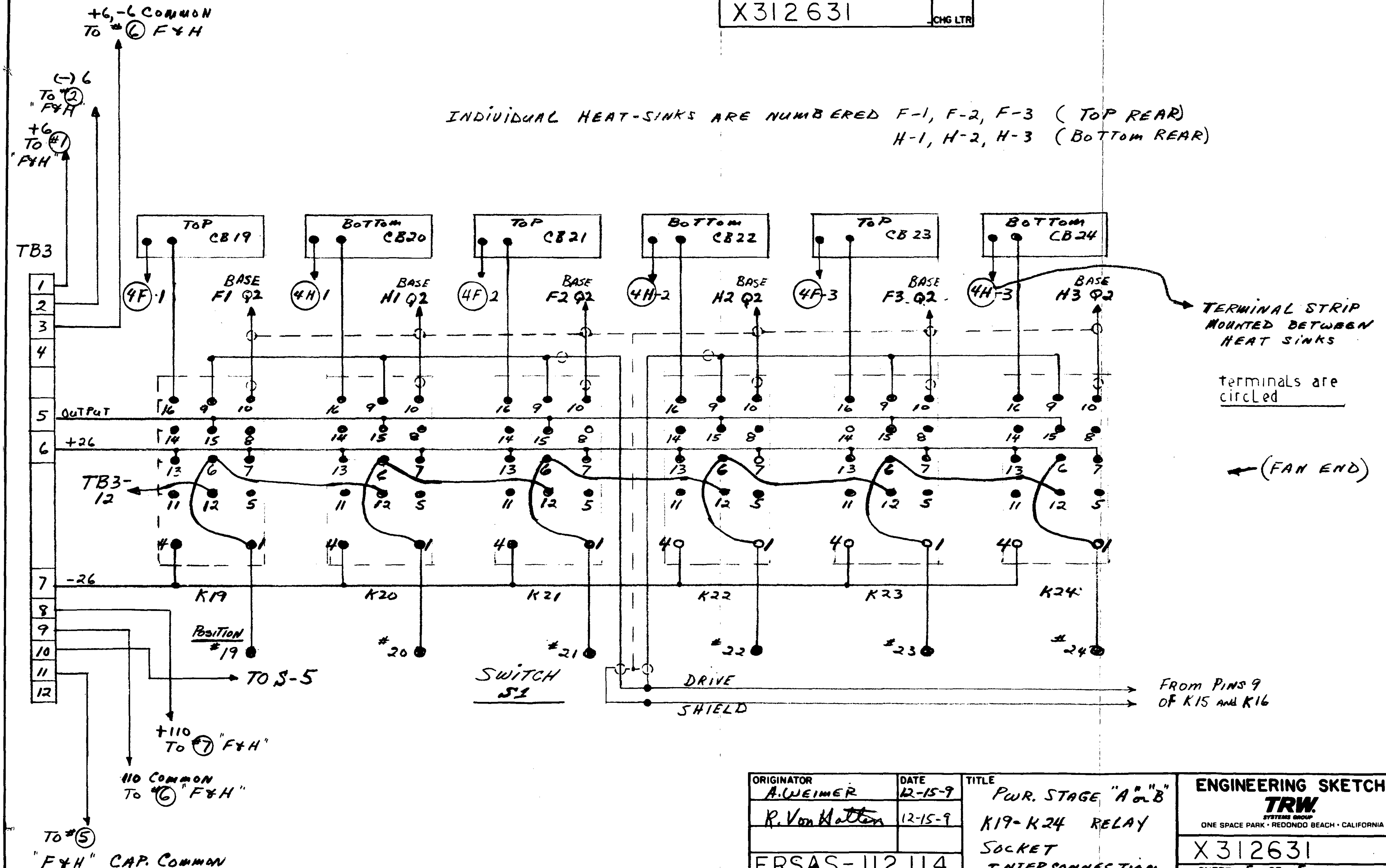
FOLDOUT FRAME 1 FOLDOUT FRAME 2



FOLDOUT FRAME 1

FOLDOUT FRAME 2

X312631 CHG LTR



ORIGINATOR	DATE	TITLE
A. WEIMER	12-15-9	PWR. STAGE "A" & "B"
R. Von Hatten	12-15-9	K19-K24 RELAY SOCKET INTERCONNECTION
FRSAS-112,114		

ENGINEERING SKETCH
TRW SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH • CALIFORNIA

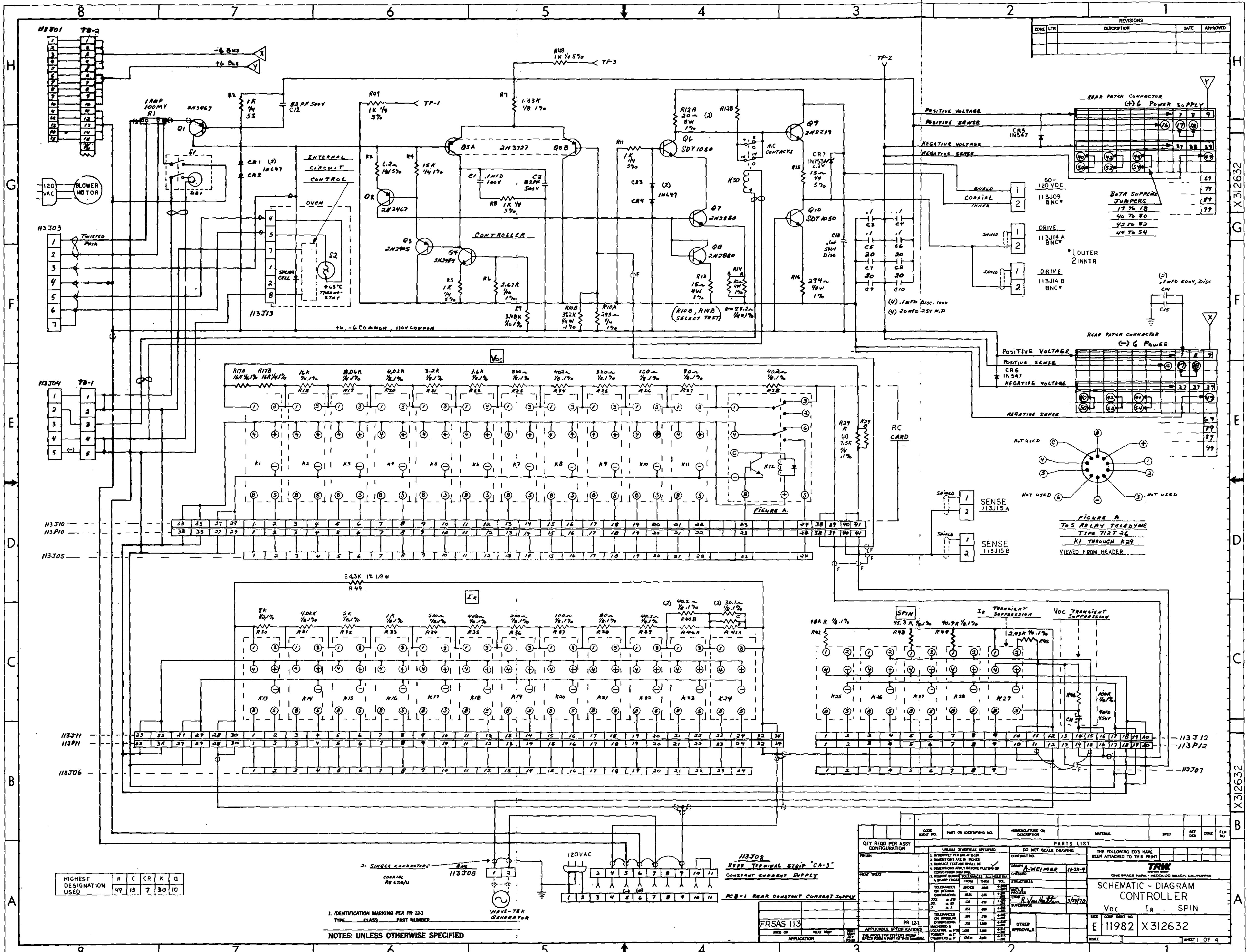
X312631

SHEET 5 OF 5

SYSTEMS 3663 REV. 5-67

FOLDOUT FRAME 1

FOLDOUT FRAME 2

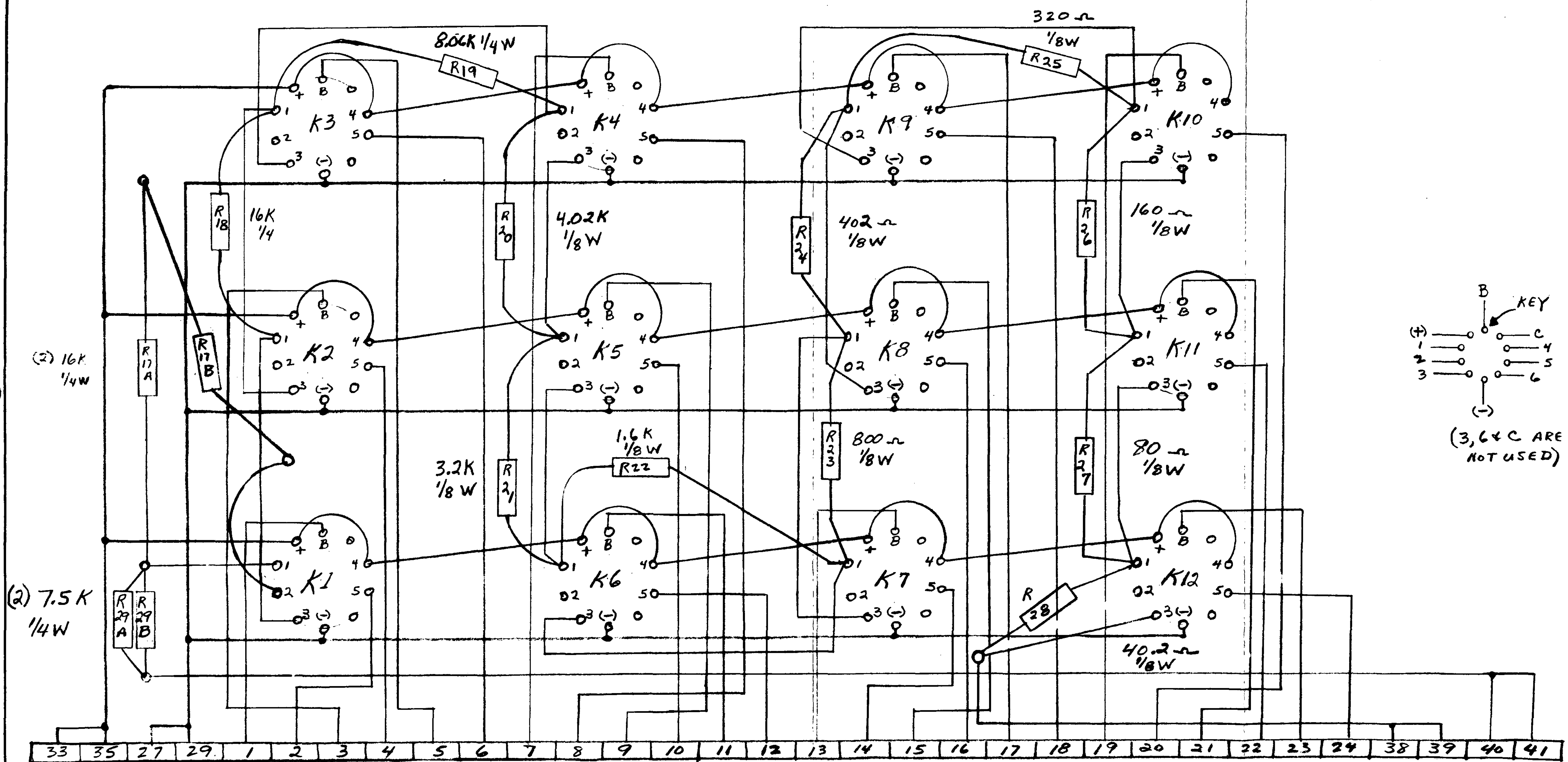


FOLDOUT FRAME 1

FOLDOUT FRAME 2

X312632 CHG LTR

SN Voc



113J10

ORIGINATOR	DATE	TITLE
A. WEIMER	11-5-69	Voc P.C CARD CONTROLLER
R. Von Hatten	4-7-70	
FRSAS 113		

ENGINEERING SKETCH

TRW SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH • CALIFORNIA

X312632

SHEET 2 OF 4

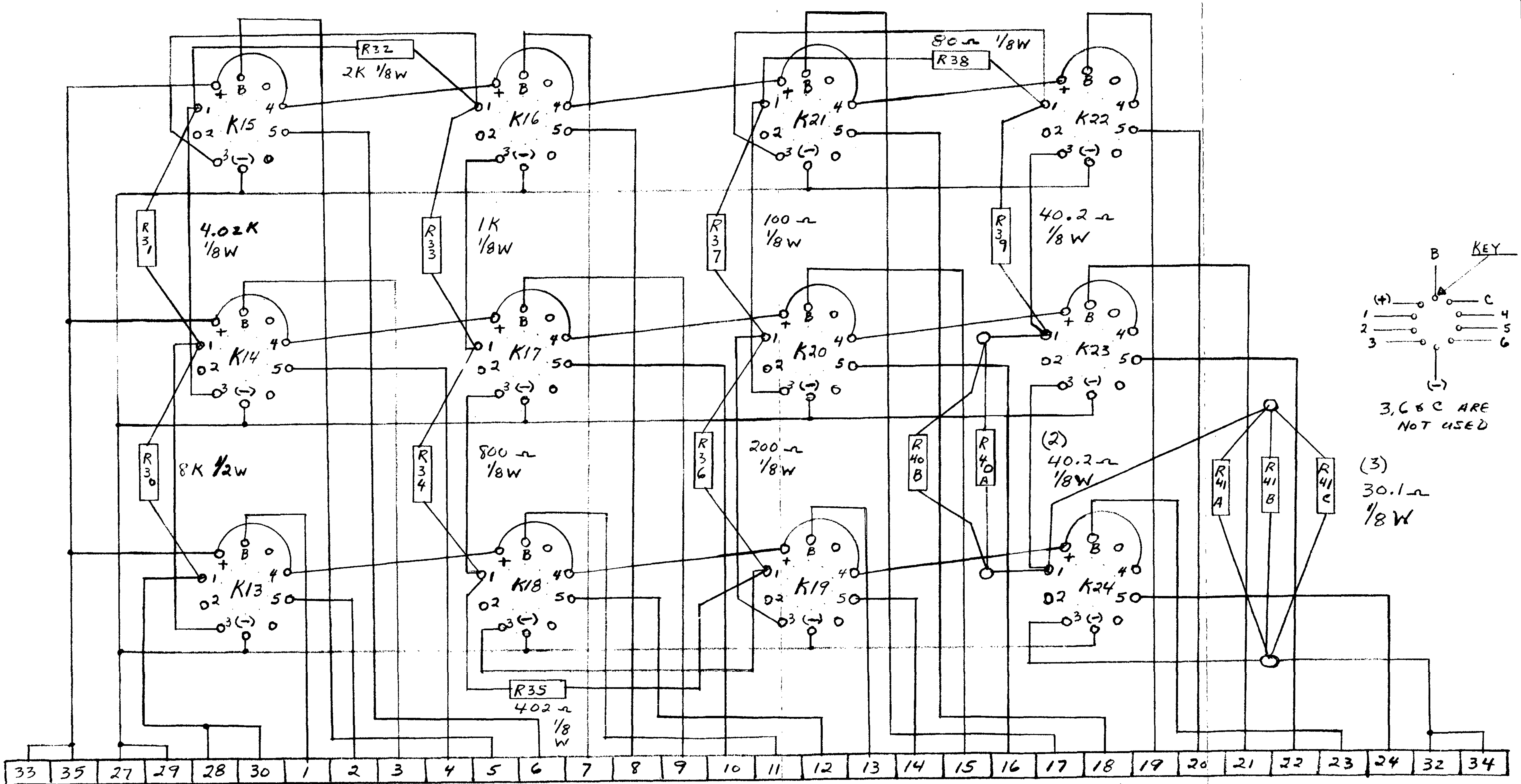
SYSTEMS 3663 REV. 5-67

FOLDOUT FRAME 1

FOLDOUT FRAME 2

X312632 CHG LTR

SN I_R



113 J11

ORIGINATOR	DATE	TITLE
A. WEIMER	11-6-69	I_R
R. VonHatten	4-7-70	P.C CARD
		CONTROLLER
FRSAS-113		

ENGINEERING SKETCH

TRW SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH • CALIFORNIA

X312632

SHEET 3 OF 4

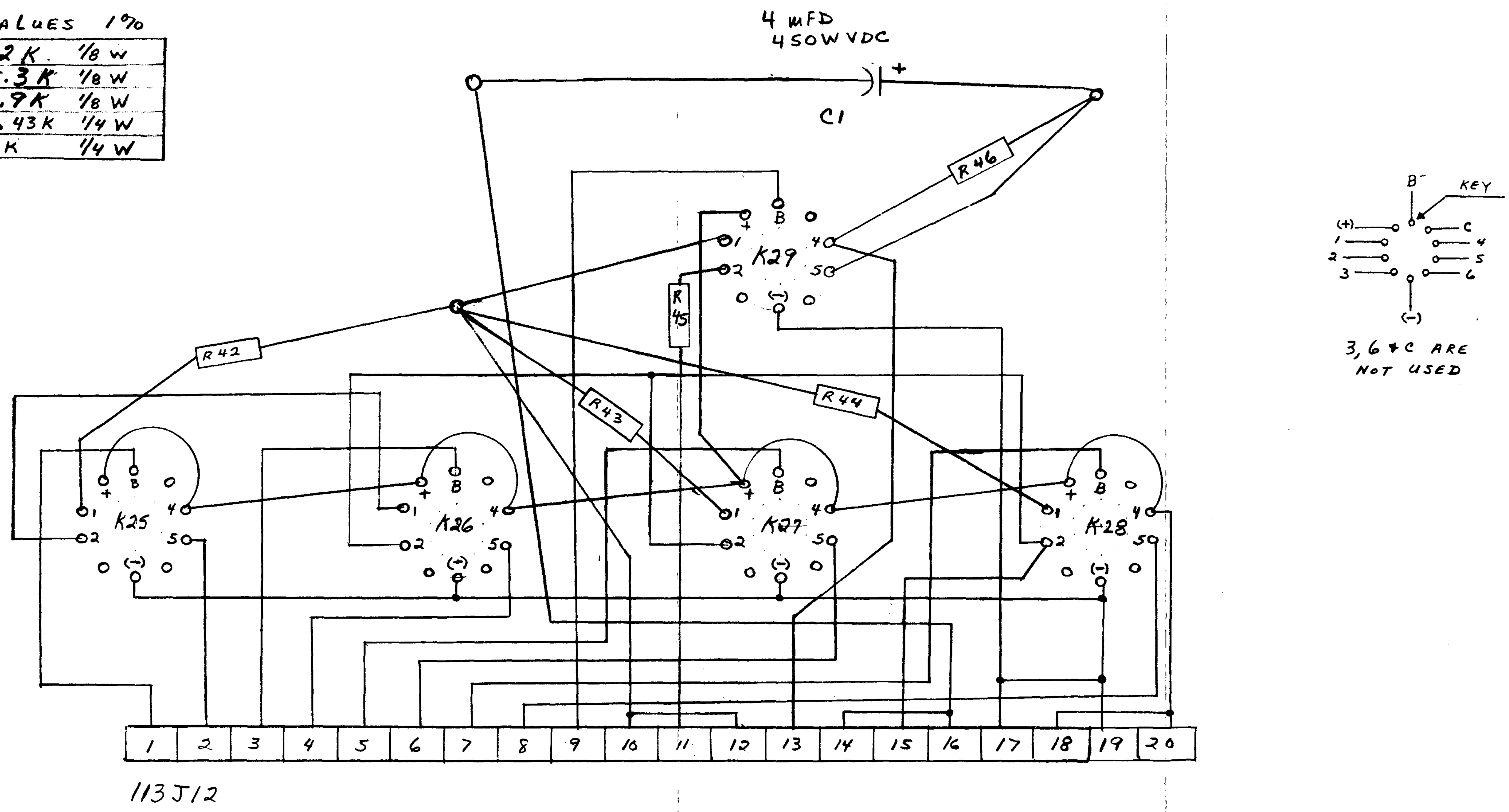
SYSTEMS 3663 REV. 5-67

X312632 CHG LTR

SN SPIN

R VALUES 1%

R42 -	182 K	1/8 W
R43 -	45.3 K	1/8 W
R44 -	90.9 K	1/8 W
R45 -	2.43 K	1/4 W
R46 -	100K	1/4 W



ORIGINATOR	DATE	TITLE
A. WEIMER	11-3-69	SPIN P.C CARD IR AND Voc TRANSIENT SUPPRESSION
R. Von Hatten	4-7-70	
FRSAS 113		

ENGINEERING SKETCH

TRW SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH • CALIFORNIA

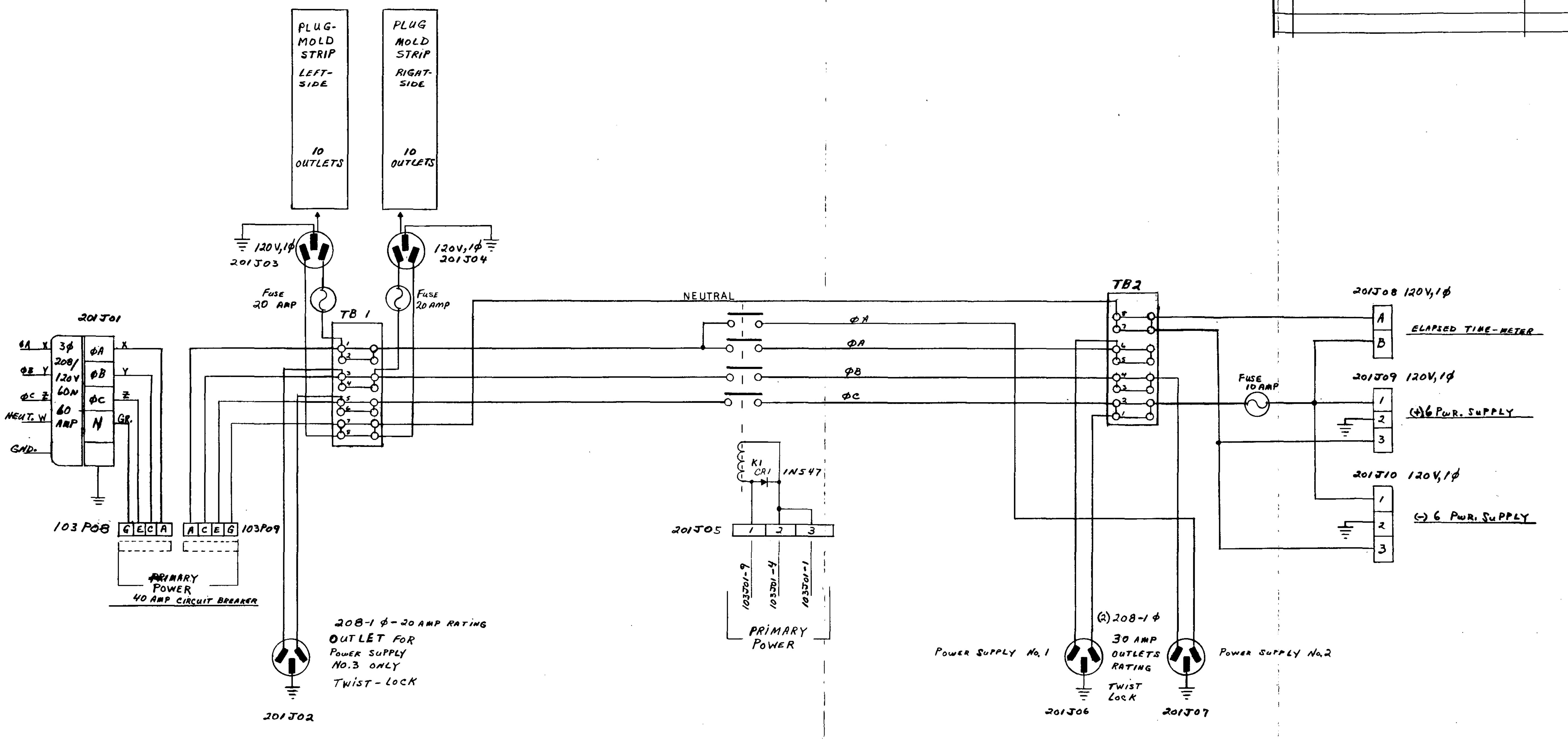
X312632

SHEET 4 OF 4

FOLDOUT FRAME 1

FOLDOUT FRAME 2

LTR	DESCRIPTION	DATE	APPROVED
	REVISIONS		



X312633

CODE IDENT NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPEC	REF DES	ITEM NO.

QTY REQD PER ASSY CONFIGURATION

PARTS LIST

FINISH

HEAT TREAT

UNLESS OTHERWISE SPECIFIED
1. INTERPRET PER MIL-STD-100.
2. DIMENSIONS ARE IN INCHES
3. SURFACE TEXTURE SHALL BE ✓
4. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
5. REMOVE BURRS & SHARP EDGES

TOLERANCES - ALL HOLE DIA

FROM	THRU	TOL.
UNDER	.0140	+.0020 −.0005
.0145	.125	+.004 −.001
.126	.250	+.005 −.001
.251	.500	+.006 −.001
.501	.750	+.008 −.001
.751	1.000	+.010 −.001
1.001	2.000	+.012 −.001
OVER	2.000	+.015 −.001

TOLERANCES ON DECIMAL DIMENSIONS: .XXX ± .010, .XX ± .03, .X ± .1

TOLERANCES ON ANGULAR DIMENSIONS: MACHINED & LOCATING ± 0°30', FORMED ± 2°, CHAMFERS ± 5°

DO NOT SCALE DRAWING

CONTRACT NO.

DRAWN A. WEIMER 11-3-9

CHECKED

STRUCTURES

MATL & PROCESS

ENGR R. Von Hatten 3/13/70

SUPERVISOR

OTHER APPROVALS

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

SCHEMATIC - DIAGRAM
AC POWER 208/120
DISTRIBUTION

SIZE D | CODE IDENT NO. 11982 | X312633

SCALE | SHEET

FRSAS-201 | PR 12-1

USED ON | NEXT ASSY | NEXT ASSY QTY REQD

APPLICATION

APPLICABLE SPECIFICATIONS

THE ABOVE TRW SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

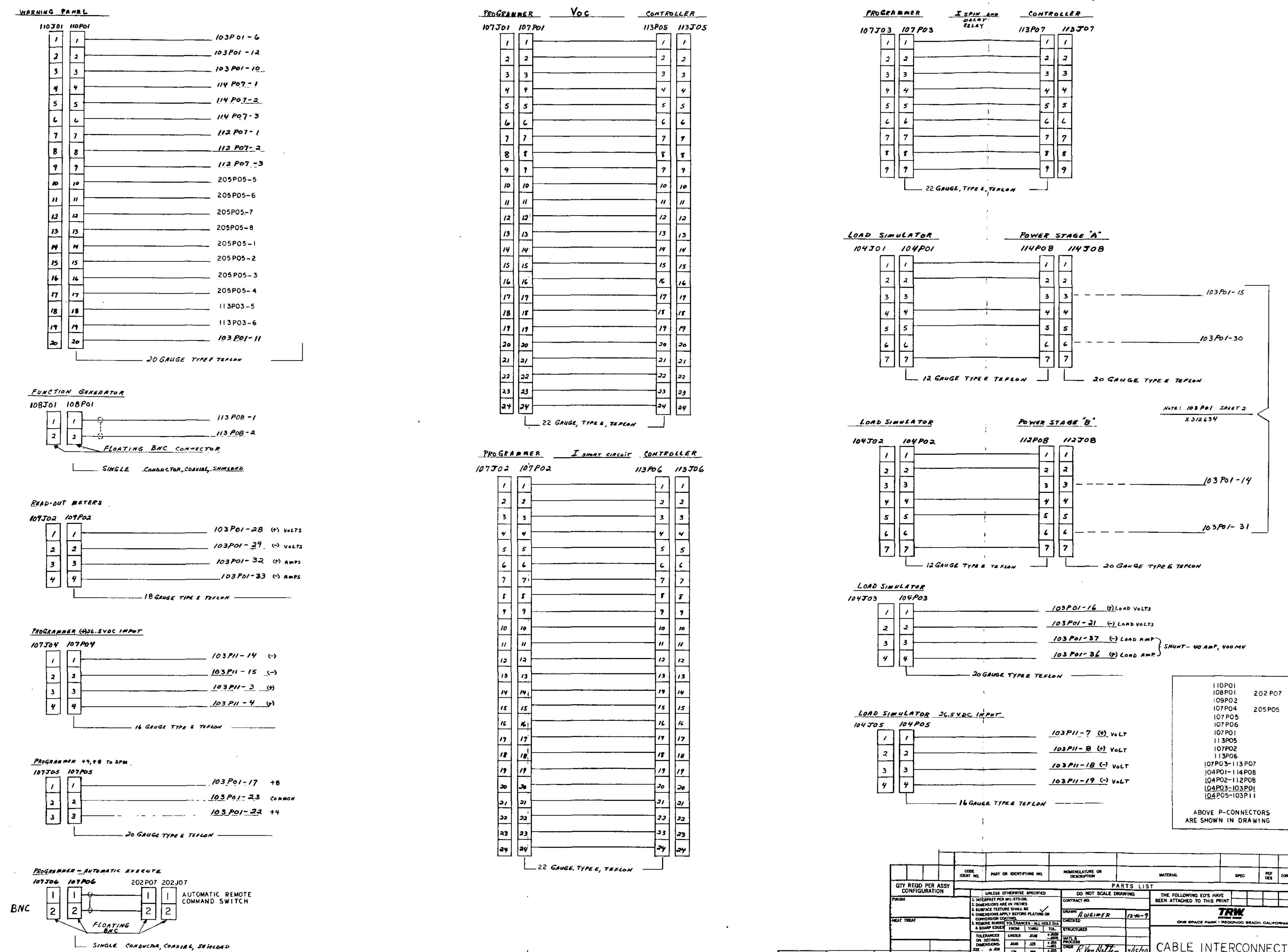
1. IDENTIFICATION MARKING PER PR 12-1
TYPE_____CLASS_____PART NUMBER_____

NOTES: UNLESS OTHERWISE SPECIFIED

X312633

FOLDOUT FRAME 1

FOLDOUT FRAME 2



1. IDENTIFICATION MARKING PER PR 12-1 TYPE____CLASS____PART NUMBER____

NOTES: UNLESS OTHERWISE SPECIFIED

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

PARTS LIST

TRW

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

CABLE INTERCONNECT

E 11982 X312634

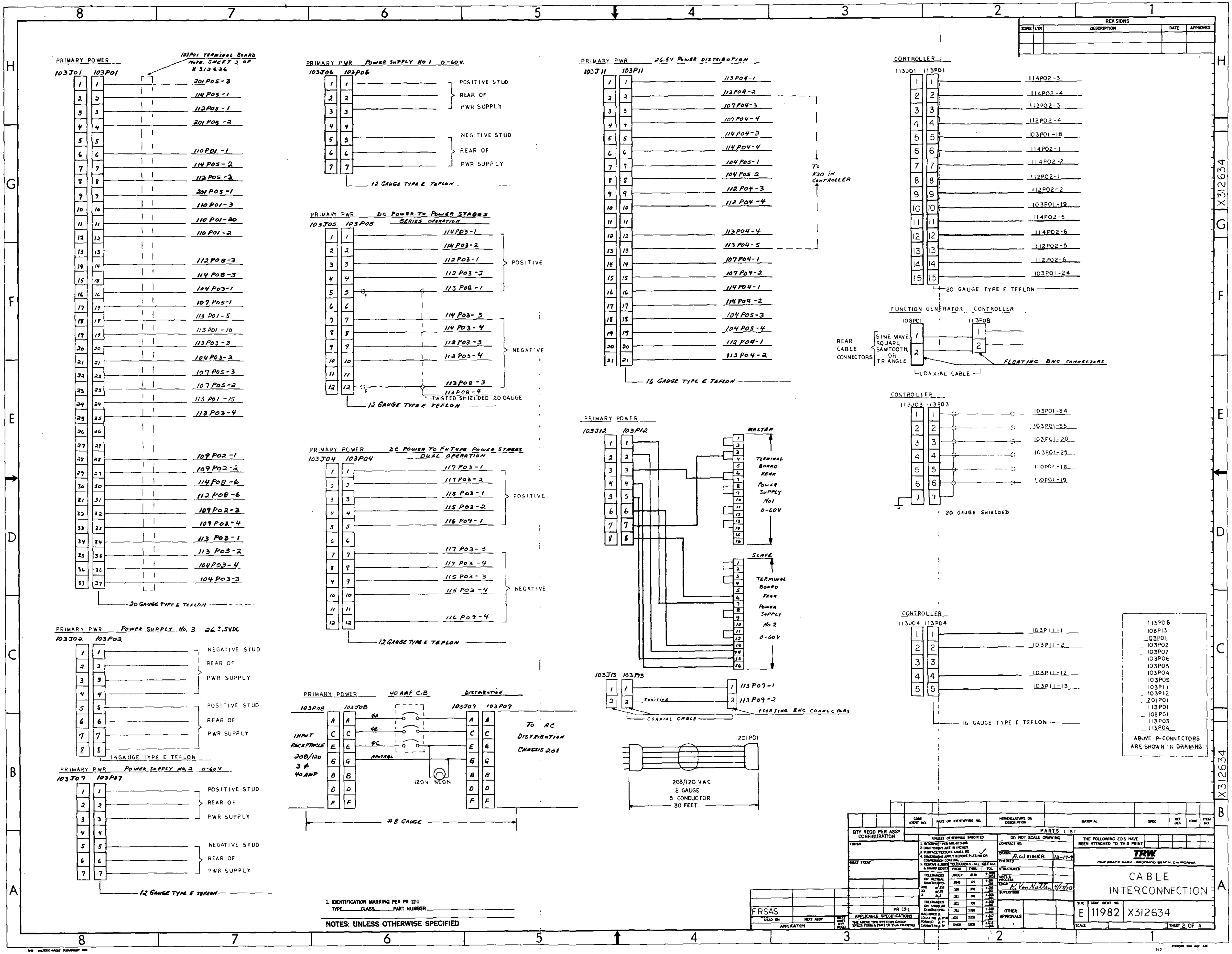
SHEET 1 OF 4

FRSAS

NOT REPRODUCIBLE

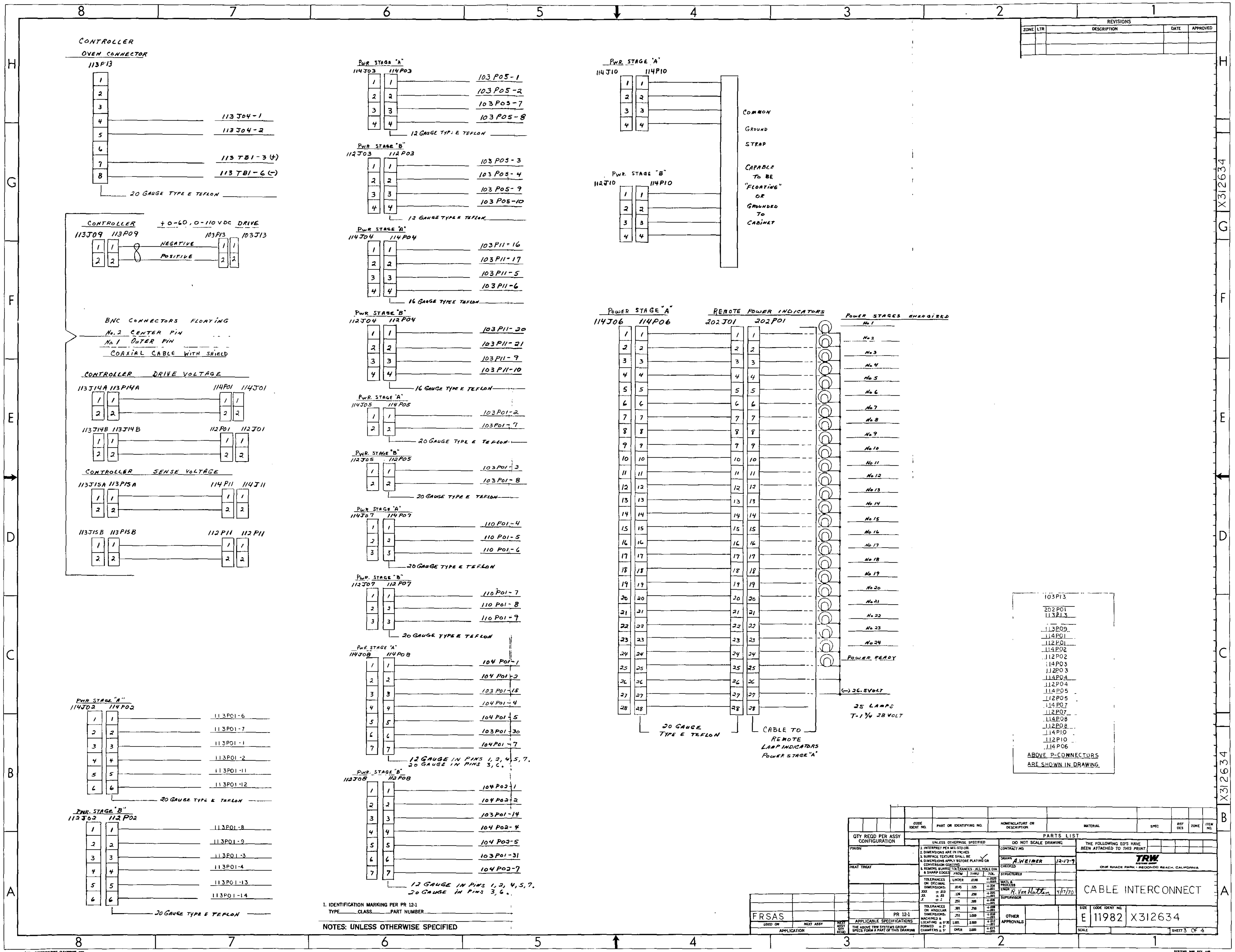
FOLDOUT FRAME 1

FOLDOUT FRAME 2



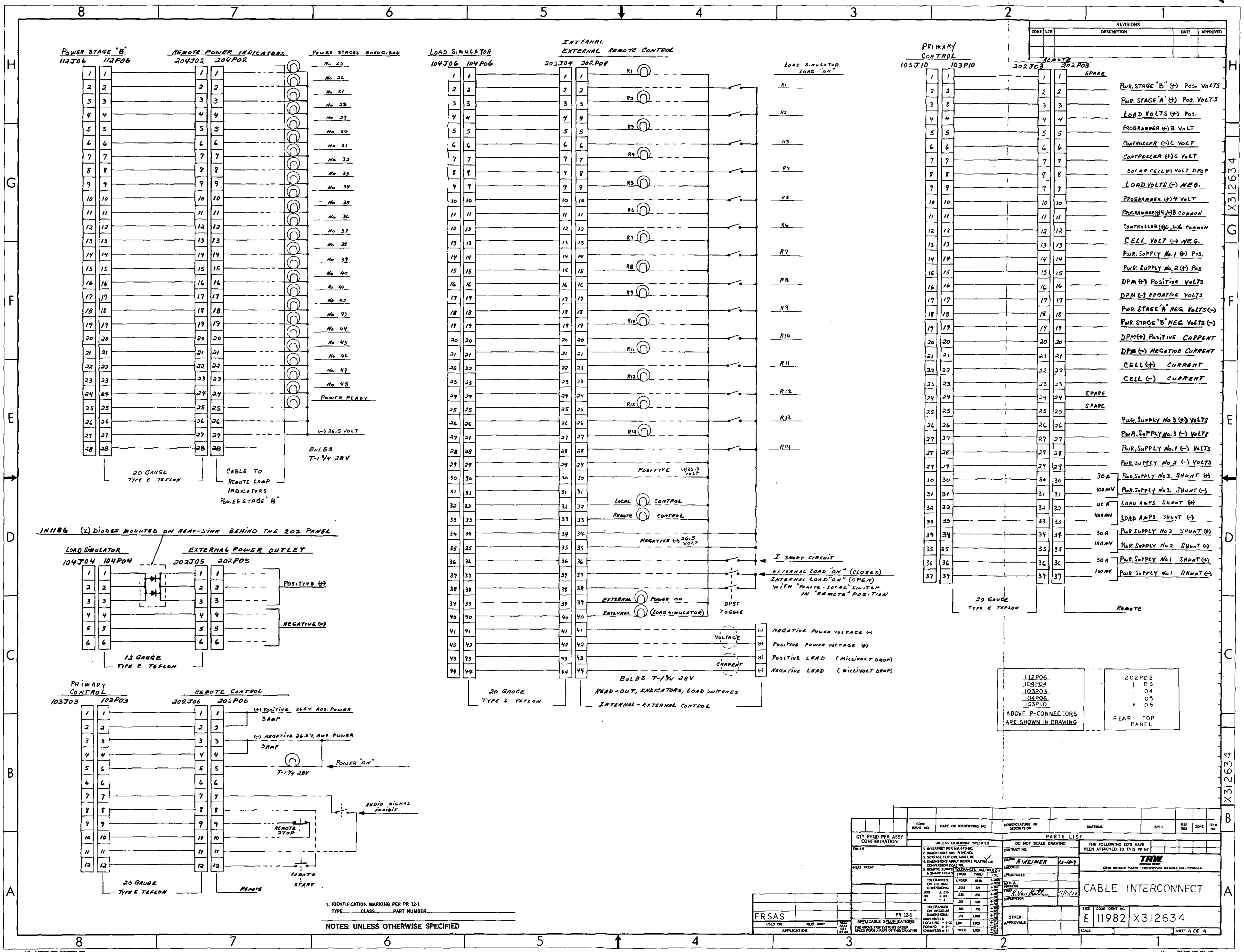
FOLDOUT FRAME 1

FOLDOUT FRAME 2



FOLDOUT FRAME 1

FOLDOUT FRAME 2



FOLDOUT FRAME 1

FOLDOUT FRAME 2