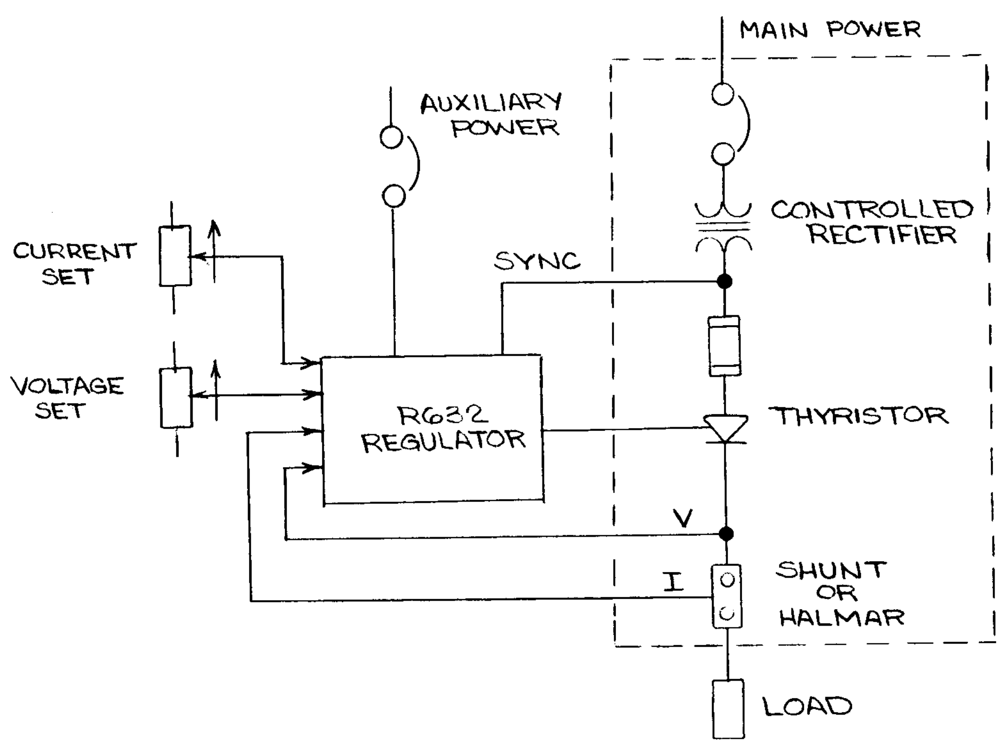
I.L. 16-800-352

R632

BASIC REGULATING SYSTEM

INTRODUCTION

The R632 Regulator is a general purpose regulator which is designed for use with thyristor controlled rectifiers. The rectifier system can be controlled by regulating for either output voltage with current limit or output current with voltage limit. Rectifier output voltages are presently restricted to approximately 1000 volts DC. Rectifier output currents are basically limited by the equipment. Figure 1 is a typical single line diagram of the controlled rectifier.

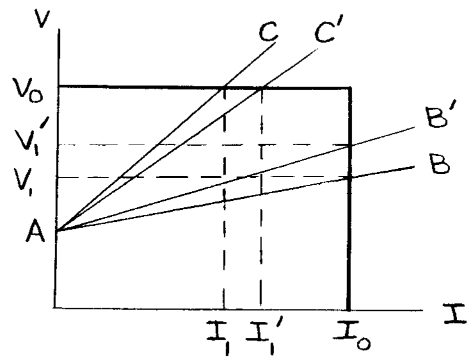


CONTROLLED RECTIFIER SINGLE LINE DIAGRAM

FIGURE 1

EFFECTIVE DATE: DEC. 1977

Figure 2 depicts the load characteristics for different load lines. For load lines AB or AB' the system will regulate for output current I_0 with voltages V_1 and V_1' respectively. For these two curves the system is regulating for current and the output current I_0 would be determined by the setting of the current set potentiometer. For load lines AC or AC' the system will regulate for output voltage V_0 with currents I_1 and I_1' respectively. For these two curves the system is regulating for voltage and the output voltage V_0 would be determined by setting of the voltage set potentiometer.



LOAD LINES

FIGURE 2

As the load requirements change which correspond to different load lines, the output from the controlled rectifier must be along the horizontal line corresponding to V_0 or along the vertical line corresponding to I_0.

When the R632 Regulator is applied to a thyristor rectifier system, the regulator must be properly interfaced with the rectifier equipment. This interfacing requires the selection of the correct components that are needed for the particular system being designed. The regulator has a minimum set of components which are always used to control a thyristor rectifier. In addition, there are optional components which can be used with the regulator and these options would be selected per the job specifications.

BASIC SYSTEM

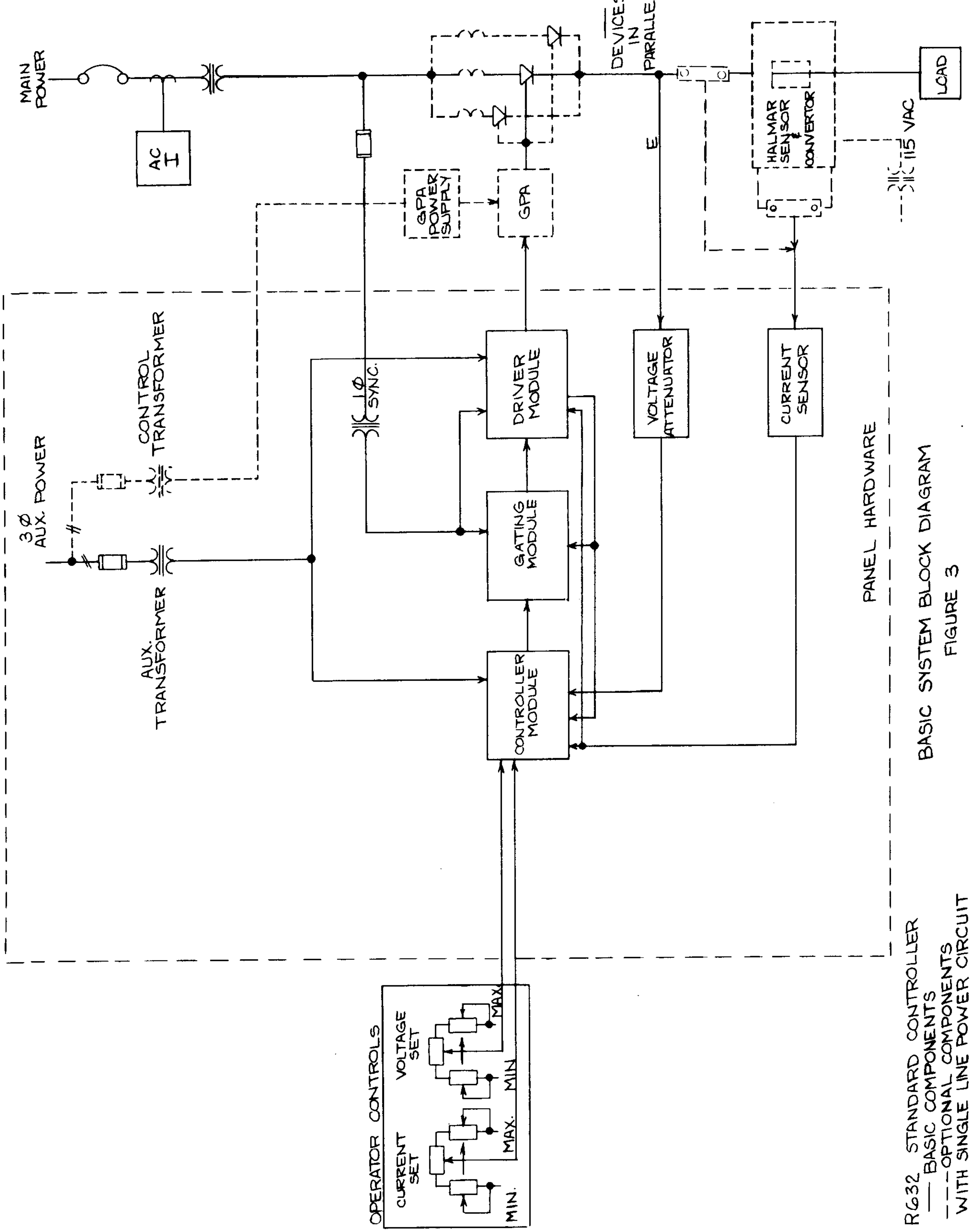
Figure 3 shows the basic R632 Regulator with some optional components shown dotted. These optional components are primarily associated with the thyristor power equipment and they may or may not exist in a particular system.

The options shown in Figure 3 involve thyristor paralleling to increase the output current capability and an option on the type of current sensing: shunt or Halmar. The ac current sensing option is not shown.

When the thyristors are paralleled in quantities greater than two, GPA's (gate pulse amplifiers), a GPA power supply, a control transformer and its input fusing are required in order to power the GPA's. Of this hardware mentioned, only the control transformer and its input fuses are a part of the R632 Regulator hardware. The GPA's and the associated power supply are normally mounted with the thyristors in the power structure. Normally there are six (6) GPA's required in the power structure and they will be similar to S#1710A36G01. The GPA Power Supply will be similar to S#1560A56G02.

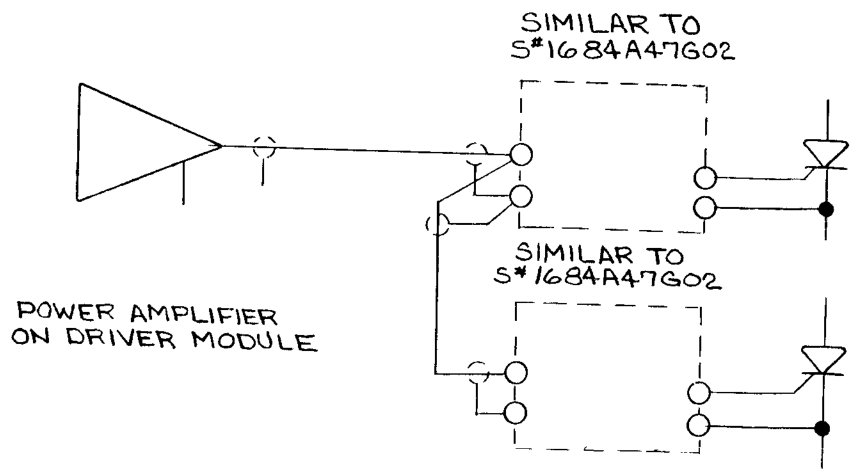
The output Power Amplifier on the Driver Module is capable of firing either one (1) or two (2) thyristors directly, properly interfaced through a pulse transformer assembly similar to S#1684A47G02. The wiring of the pulse transformer(s) is (are) shown in Figure 4. When paralleling two thyristors, the second pulse transformer assembly is wired from the first as shown. The pulse transformer assembly provides isolation between the regulator electronics and the voltage in the power circuit.

Current sensing in the rectifier can be either from ac CT's, a shunt or a Halmar system depending upon the current level and the design requirements. When a Halmar system is used, 115V AC through an isolating transformer is required. The control transformer required for this function is not a part of the R632 hardware. The 115V AC cannot be supplied from the control transformer mounted with the R632 hardware.



BASIC SYSTEM BLOCK DIAGRAM

FIGURE 3



WIRING OF PULSE TRANSFORMER ASSEMBLIES

FIGURE 4

OPERATION OF BASIC SYSTEM

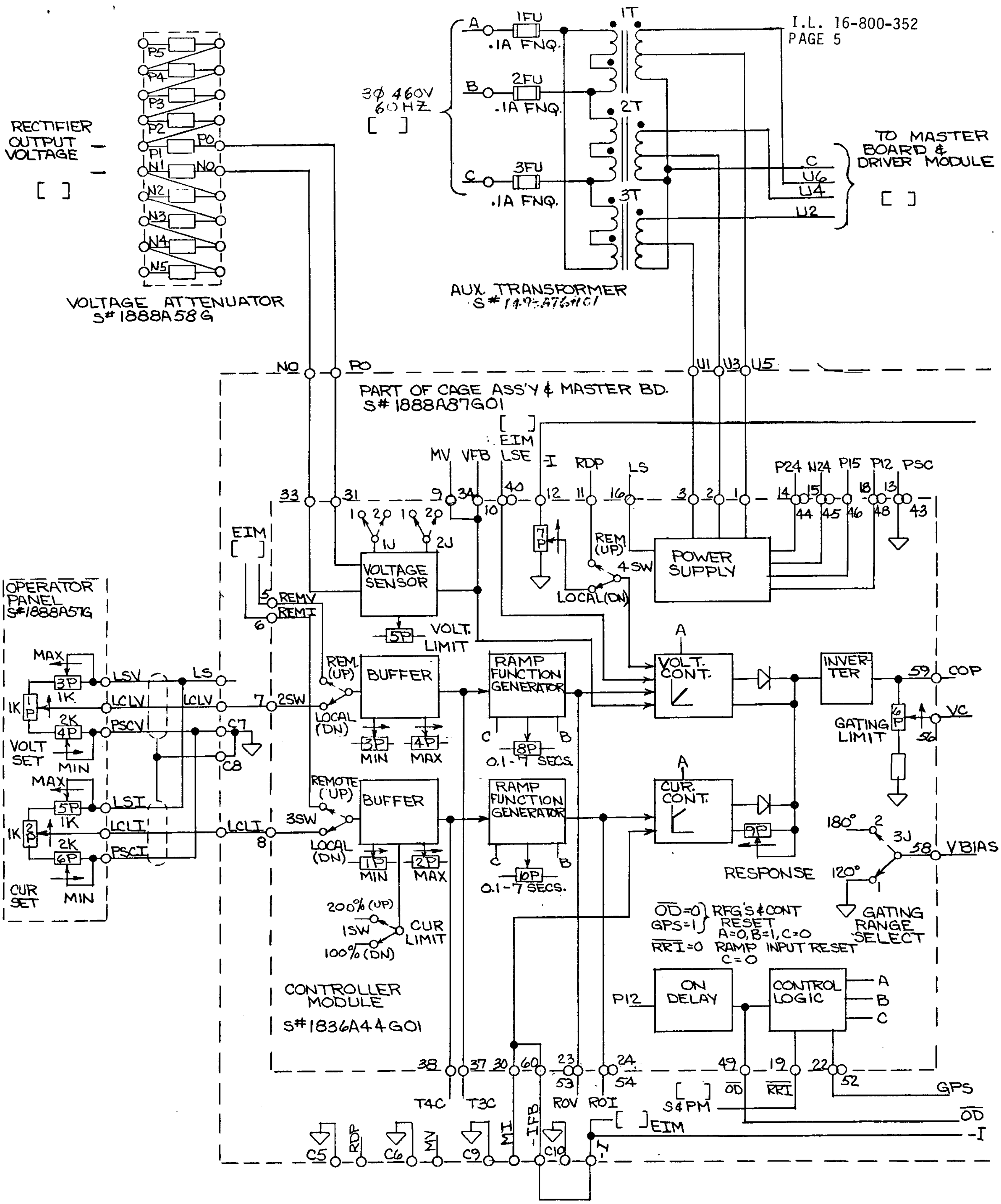
On the basic system shown in Figure 3, it is assumed that an initial set of adjustments and switch positioning has already been accomplished in the regulator startup.

For the system shown, the controlled rectifier will operate when power is applied: auxiliary and main power. If auxiliary power is applied first, the regulator will wait until main power is applied following which the regulator will soft start the rectifier. The only control on the rectifier is the externally mounted operator potentiometers. These potentiometers provide adjustment levels for either the output voltage or current. As the system uses the technique of parallel control the system will regulate for either voltage or current depending upon the load requirements. For example, if the external adjustment potentiometers are set for 100% voltage and 100% current and if 100% load current is obtained at 90% voltage, the system will regulate for 100% load current. Similarly for the same 100% setting of the potentiometers, if 100% load voltage is obtained with 80% load current the system will regulate for 100% load voltage. This type of regulating system can be described as a current regulating system with voltage limit or as a voltage regulating system with current limit. Although there are two external set potentiometers only one of the parameters (voltage or current) will be regulated at any one time, and the parameter being regulated will depend upon the setting of the potentiometers and the status of the load.

For the basic system, the sequence of application of power (auxiliary and main) is immaterial as the regulator will automatically wait for a fixed time period before starting to regulate. In general, auxiliary power is applied either before or at the same time as main power.

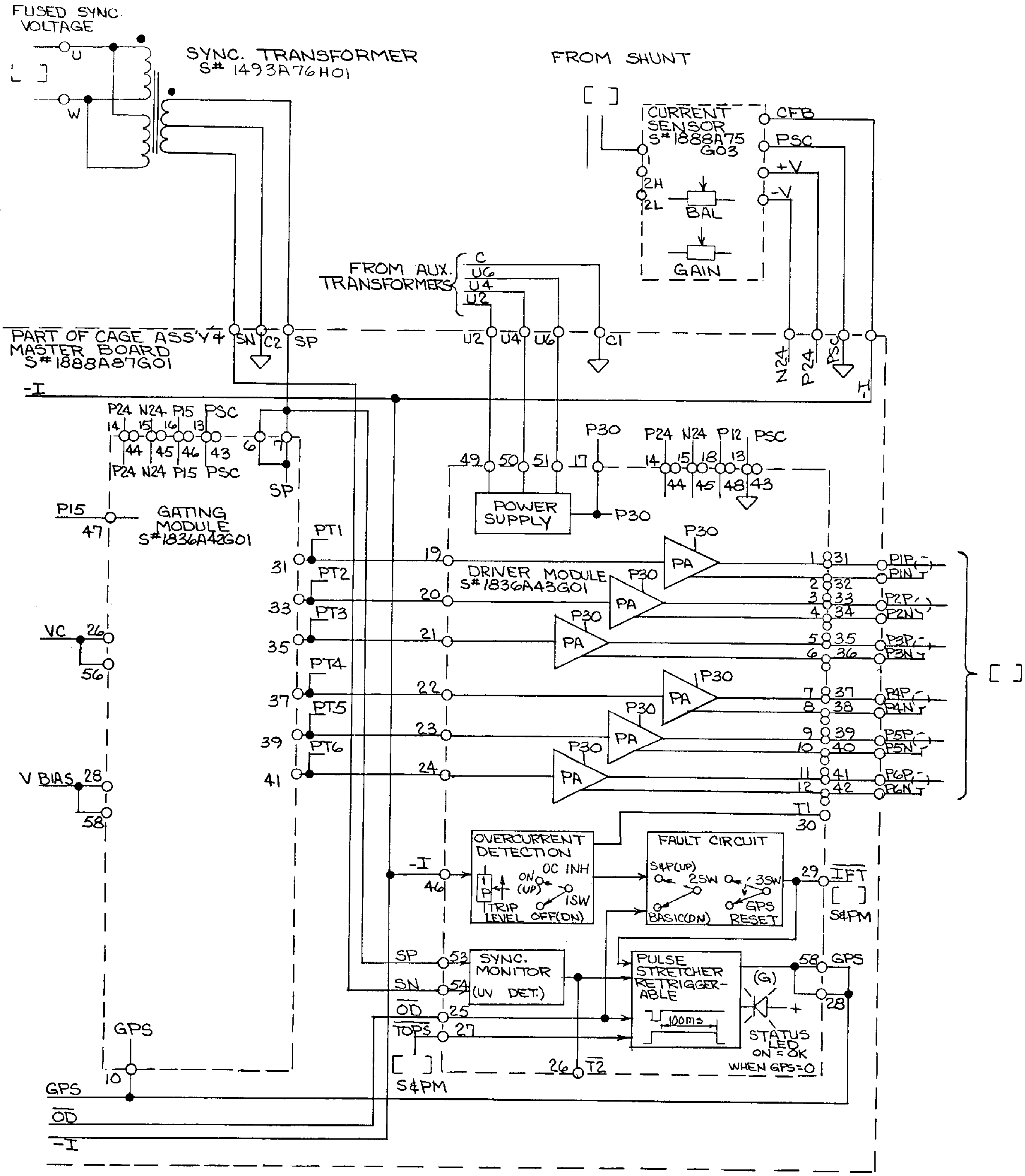
When the system is running, the only control is through the external set potentiometers. As shown in Figure 3, the set pots also have maximum and minimum adjustments which can be used to provide range limits on the adjustment range. For example, the external current potentiometer could have a range from 0 to 100%. Alternately, the voltage potentiometer could have a range from 60 to 105%. The operator potentiometers have dial indicators with 0 to 100 readings which correspond to a minimum to a maximum as established by the limit potentiometers.

To shut the system down, the main power breaker should be opened followed by the auxiliary power breaker or they could be opened at the same time. In general, the auxiliary breaker should not be opened before the main power breaker in order to prevent transient problems from occurring.



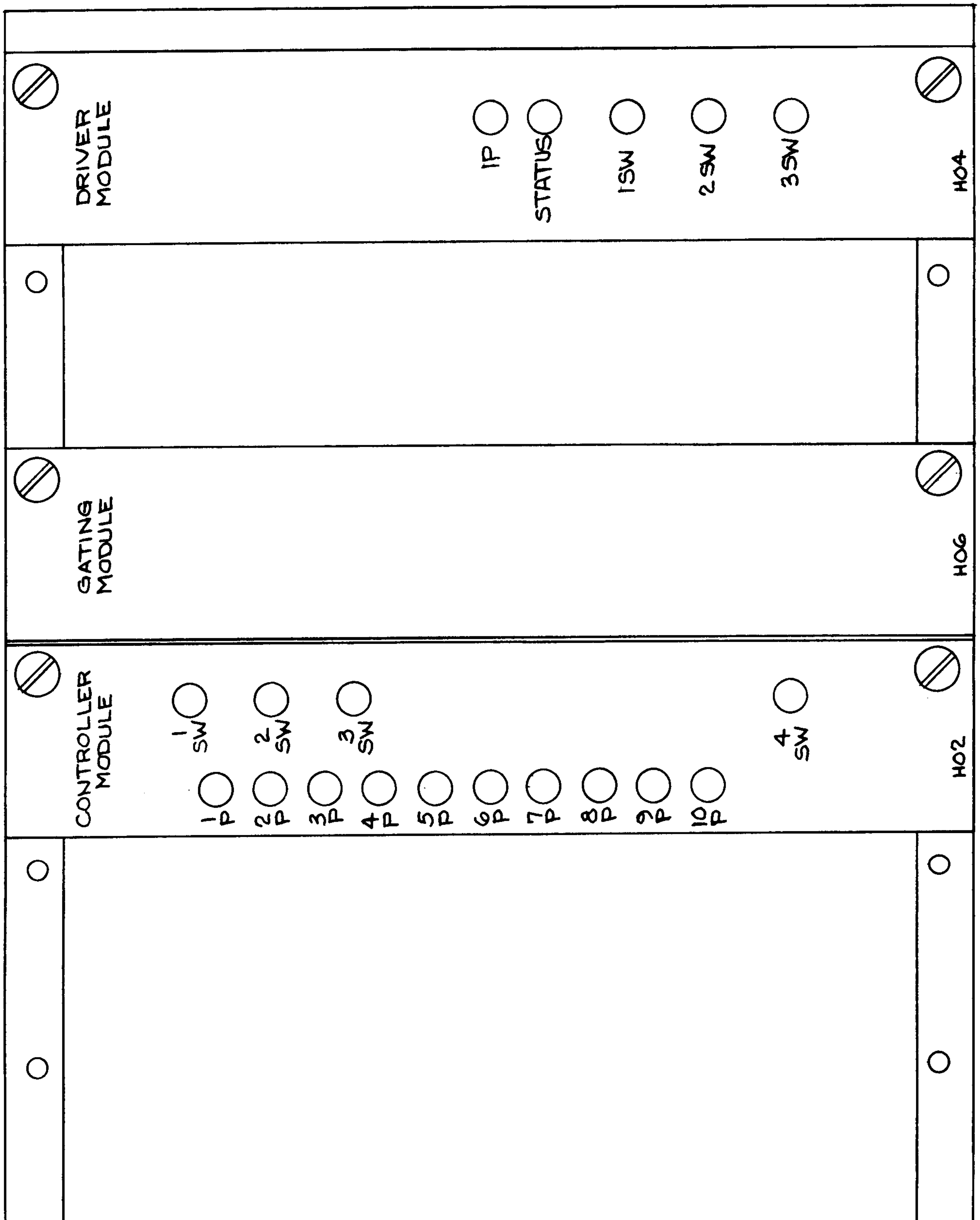
CONTROL SYSTEM

FIGURE 5



GATING SYSTEM

FIGURE 6



FRONT VIEW OF REGULATOR CAGE

FIGURE 7

The following discussion pertains to operation of the regulator electronics as shown in Figures 5 and 6. Assume that auxiliary power is applied before main power. With auxiliary power only applied, all of the power supply voltages in the regulator should be stabilized at their correct levels. The regulator will be in an Inhibit/Reset mode which means that no thyristor gate pulses are being generated and that the current and voltage regulators and their appropriate reference ramps, which are used for soft starting of the equipment, are reset. The only indication of this mode of operation in the regulator is the STATUS LED (Light Emitting Diode) on the Driver Module. See Figure 7 which shows a front view of the plug-in modules. When the LED is off, the system is in the Inhibit/Reset mode. When this LED is on, the system is operating. With main power not applied and hence no synchronizing voltage available, the STATUS LED will be off.

When main power is applied, synchronizing voltage is detected and after a time delay of 100ms to allow power stabilization, the system is automatically released from the Inhibit/Reset mode. The STATUS LED will come on. The system will soft start and will regulate for either voltage or current depending upon the setting of the externally mounted operator potentiometers and depending upon the slope of the load line.

When the system is running, the external operator potentiometers will change the rectifier output. On the system shown in Figure 3 (the Basic System) there are two additional operating conditions that will change the status of the system. This discussion will assume that auxiliary power is supplied separately from main power. If the voltage level of main power drops below the trip level of the undervoltage detection circuit on the Driver Module, the system will be put into the Inhibit/Reset mode and will remain in this mode until the input voltage recovers. When the input voltage rises above the trip level, the pulse stretcher circuit on the Driver Module is allowed to time out and following this time delay (100ms), the system is allowed to restart in a soft start fashion. The dip in the main power line could be transitory due to the starting of other equipment or it could be a complete loss of main power. The system will automatically be controlled by the presence (above trip level) or absence (below trip level) of main power. Again, the only indication of no gating is the Status LED on the Driver Module being out. The second condition that will change the regulator status is an overcurrent condition. The Driver Module has an overcurrent detection circuit and if the rectifier current exceeds the trip level of this circuit, the regulator will be put into a permanent Inhibit/Reset mode. This condition would again cause the Status LED to extinguish but it will remain in this state until some operator action is taken. The lockout condition caused by the overcurrent trip can be disabled by removing and re-applying main and auxiliary power. Alternatively, switch 3SW (spring return toggle switch) on the Driver Module can be raised momentarily to clear the fault circuitry. When the toggle switch is raised, the fault circuitry is reset and when the switch is released, the pulse stretcher is allowed to time out following which the system will automatically soft start.

There is an option on the basic system which eliminates the overcurrent detection circuit. In this instance, the system would normally be protected by fuses, breakers and overcurrent protection associated with the main power transformer. This type of arrangement would be used when it is expected that load feeder breakers should clear on an overcurrent condition without shutting down the entire system.

REGULATOR ELECTRONICS

Figures 5 and 6 depict the basic regulator in block diagram form along with the associated peripheral equipment. Figure 5 is the control system block diagram. Figure 6 is the gating system block diagram. At the end of this IL are the detailed schematics for the Controller Module S#1836A44G01, the Gating Module S#1836A42G01, the Driver Module S#1836A43G01, the Current Sensor S#1888A75G03 and the Master Board S#1900A70G01.

Refer to Figure 5 for the following discussion

The system reference signals are supplied by the externally mounted Operator Panel S#1888A57 G--. Notice that there are maximum and minimum limit potentiometers associated with the two operator set potentiometers. The limit pots are set as required during startup.

The two set point voltages LCLV and LCLI are applied through two switches 2SW and 3SW to buffers. 2SW and 3SW are normally in the down position to accept the associated voltages. When the External Interface Module S#1836A45G01 is used to provide a set point signal from remote equipment, the associated switch would be repositioned as required. When this happens, the associated set potentiometer is disconnected. During startup the local set potentiometers could be used and then the system could be transferred to the remote reference when the startup is completed.

The buffer blocks buffer the input signals and provide redundant limit functions, if required, in the system. On the basic system these limit potentiometers (3P and 4P for the voltage reference and 1P and 2P for the current reference) are normally set during system start up so that their limit functions are inoperative. If the External Interface Module is used to provide a remote reference signal the associated limit potentiometers on the buffers can be used if required to establish limits for this signal.

Toggle switch 1SW is used to change the current reference signal from a 5V level (100%) to a 10V level (200%). Normally 1SW will be set for 100%. In voltage regulating systems with current limit where the required current limit is 200% the switch would be set up. Switch 1SW should be set during start up.

The output signals from the buffers are applied to two duplicate ramp function generators which provide a soft start function for the system. The ramp times are independently adjustable by potentiometers 8P and 10P and will be set during start up. The ramps are bidirectional in the sense that when the associated rate potentiometer is preset, the starting and stopping rates will be the same. All reference changes are rate controlled by the ramps.

The ramps are controlled logically by signals C and B. Logic signal C is used only when the Sequence and Protection Module option S#1836A46G01 is used. Logic signal C applies (C = 1) or removes (C = 0) the input reference signals to the ramps so that starting and stopping of the system with the external operator station occurs in a rate controlled manner. Logic signal B resets the ramps. On the basic system this is controlled by the GPS signal from the Driver Module. In the course of applying power to the system, the GPS signal changing from a "1" to a "0" causes a corresponding change in logic signal B and with the ramps released the system soft starts under the ramp control. On the basic system the ramps are immediately reset under a fault condition as indicated by the Driver Module. When the S & P option is used the ramps are reset under a fault or stop (after the system has ramped to zero) command by the GPS line which is indirectly controlled by the S & P module.

The output from the ramps are applied to the appropriate controllers. The controllers are reset when the ramps are reset and are operative when the ramps are operative. This is done with logic signal A which statically is the opposite of logic signal B.

The voltage controller is an integratal type controller and the normal inputs are the reference signal from the ramp and the feedback signal from the voltage sensor.

The voltage sensor is a differential input amplifier which is indirectly connected to the TPM output voltage through the external voltage attenuator which is selected during design for the application. Associated with the voltage sensor are two gain range jumpers (1J and 2J) which are set depending upon the TPM voltage and a voltage limit potentiometer 5P which is set during startup so that the output signal VFB is -5 volts when the TPM is producing rated output voltage.

Additional inputs to the voltage controller are droop and load share error. Droop can be from the local current signal or from a remote current signal. Toggle switch 4SW down selects local droop which is adjustable with 7P. Toggle switch 4SW up selects the remote droop signal. Whether or not droop is used depends upon the system application. On the basic system if droop is not used, 4SW should be placed up to insure that no droop is inadvertently injected in the event 7P is not set correctly. The load share error signal LSE is used only when the EIM module option is used and systems are paralleled in a voltage regulating mode.

The current controller is a proportional plus integral type controller with an adjustable lead time constant (9P) which is used to compensate for different load time constants. The normal inputs are the reference signal from the ramp and the current feedback signal from the externally mounted current sensor S#1888A75G03. Note that this signal is obtained by a jumper on the master board terminal blocks -IFB to -I. In cases where the current feedback is from other than the local current sensor, the external current feedback signal is connected to input point -IFB. The local current sensor which provides magnetic isolation between the power circuit and the electronics is connected to either a shunt or to a Halmar converter or to a burden resistor on the ac CT's depending upon the system design.

The outputs from the two controllers are diode auctioneered to allow the system to operate as a parallel type controller. This signal is inverted and then attenuated by 6P before being applied to the Gating System. 6P is used to adjust the output signal level to correspond to the setting of the Gating Range Select jumper 3J. 3J sets the maximum gating angle of the system to either 120° or 180° depending upon the system requirement. 3J and 6P should be set during startup.

The power supply block takes input voltages from the auxiliary transformer, rectifies and filters it and creates the various voltages required to operate the system.

Refer to Figure 6 for the following discussion.

The Gating Module receives two signals from the control system: the control voltage VC which determines the gating angle in conjunction with the VBIAS voltage which sets the maximum phase delay (α). The gain of the Gating Module is approximately 30°/V. The Gating Module is a digital gating system which utilizes a phase locked loop and multiplexing to create the six output pulse trains which are ultimately used to fire thyristors. The system time coordination is provided by the synchronizing signal SP which is obtained from the Sync Transformer. The input to this transformer should be connected to the U and W input ac terminals on the TPM assembly.

The functions provided by the Driver Module are as follows:

1. Power amplification for picket fence pulse train.
2. Overcurrent detection circuit with an adjustment potentiometer (1P) for setting the trip point level of instantaneous overcurrent (if selected by 1SW).
3. Switch (2SW) to select the basic fault condition or the fault condition associated with the Sequence & Protection (S&P) Module option.
4. GPS (Gate Pulse Suppression) reset by 3SW when switch 2SW is in the BASIC position.
5. Sync. Monitor circuit
6. Pulse Stretcher
7. Status LED indication
8. Power supply (P30) for output power stage.

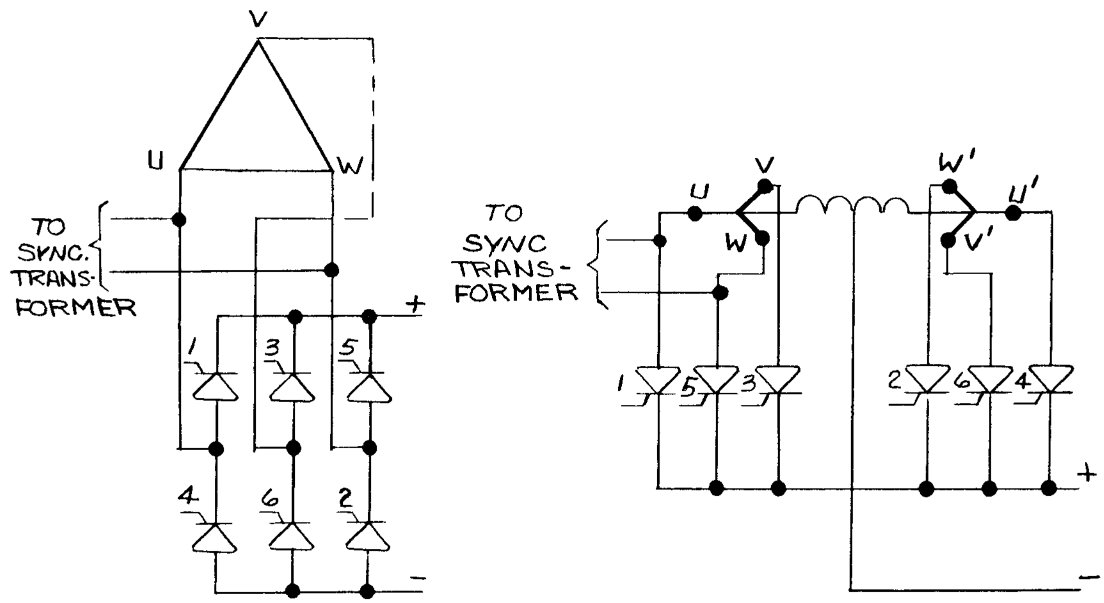
Figure 6 shows the simplified diagram of this module. On the simplified diagram and the schematic diagram (DN) and (UP) refer to down and up: the physical orientation of the switch.

The power amplifier stage amplifies the picket fence pulse train to a power level capable of driving either pulse transformer assembly S#1684A47G02 or a gate pulse amplifier module similar to S#1710A36G01. The basic design of this module is for a 6 pulse system. If the external power equipment requires only 3 pulse sets then external wiring is left off. The output power stage can drive either 1 or 2 pulse transformer assemblies S#1684A47G02 in parallel. Wiring for the pulse transformers is shown in Figure 4.

Figure 8 shows a typical pulse train supplied to two parallel pulse transformer assemblies. With a single pulse transformer or with a gate pulse amplifier the amplitude decay of the trailing pulses will not be as pronounced. The six output pulse trains will be spaced at 60° increments in numerical order 1 through 6. The six output pulse trains are time coordinated to provide full control over either of the arrangements shown in Figure 9 provided that the system synchronizing transformer is energized from the appropriate points as shown.

TYPICAL PULSE TRAIN TO THYRISTORS

FIGURE 8



a) Bridge Circuit

b) Double-wye Circuit

TYPICAL RECTIFIER TRANSFORMER SECONDARIES

FIGURE 9

The instantaneous overcurrent gate pulse suppression trip level is adjusted by potentiometer 1P. The available trip range is 125% to 225%. The percentage levels listed are approximate values as the type of system and the ripple content of the output current will influence the trip level. Switch 1SW in the OFF position (DN) allows the overcurrent detection circuitry to function. Switch 1SW is the ON position (UP) inhibits the overcurrent circuitry.

A toggle switch 2SW with positions BASIC (DN) and S&P (UP) is to be oriented depending upon the system hardware configuration. For the basic system, the switch should be placed in the BASIC (DN) position. If the S&P Module option is used, the switch should be placed in the S&P (UP) position. In the BASIC position, this switch allows a memory circuit to seal in on an overcurrent fault. In the S&P position, the memory circuit on this module is disabled; and the appropriate memory circuit on the S&P Module is used.

When the prior switch is in the BASIC position, the GPS Reset switch 3SW is used to clear the fault circuitry to allow system restarting. On the basic system there are no controls to clear the fault circuit. 3SW can be used to clear the fault in the event of an overcurrent condition.

The sync monitor circuit is primarily used to detect the presence of synchronizing voltages. If the synchronizing voltage drops below 50% of rated synchronizing transformer secondary voltage, an output signal is generated. As it is expected that applications will require operation of the synchronizing transformer at less than rated voltage, the system trip levels for this circuit will vary from 50% to 80%.

The pulse stretcher circuit is equivalent to an on delay function. When an input is low, the output is high and will remain in this state until all inputs have recovered to the one (high) state. The pulse stretcher is retriggerable and has a recovery delay of 100ms.

The status LED (green) is lit when all required operating conditions are satisfied. When the LED is on, the system will regulate.

The P30 power supply rectifies, filters and regulates the secondary voltages of the auxiliary transformers to provide the required operating voltage for the power amplifiers. (P30 supply is actually +28.6 volts).

When the system is powered up it it is assumed that auxiliary power will be first applied. This will allow the system power supplies to come to a stable operating level. On the Driver Module, the absence of synchronizing voltage will generate a high GPS signal and the Status LED will be off. The high GPS signal will inhibit the generation of any pulses from the Gating Module and will completely reset the Controller Module. When main transformer power is applied and hence power to the synchronizing transformer, the Pulse Stretcher is allowed to time out and when the GPS line goes low the system is allowed to operate. The Status LED will be on.

Normal inputs to the Pulse Stretcher are from the Instantaneous Overcurrent circuit, the Sync Monitor circuit and the $\overline{OD}$ (on delay inhibit) signal from the Controller Module. If any of these signals goes low, the system will go into an Inhibit/Reset mode for the duration of the input low signal plus 100ms. If an instantaneous overcurrent fault occurs, the system will be permanently reset until the GPS Reset switch 3SW on the Driver Module is toggled. The toggle switch 2SW in the BASIC position causes a memory circuit to be established.

If the S&P Module option is used, an additional input ($\overline{TOPS}$) is applied to the Pulse Stretcher circuit from the S&P Module. The toggle switch 2SW should then be placed in the S&P position. When an overcurrent occurs, the Pulse Stretcher is triggered and a signal is applied to the S&P Module. Fault memory is available on the S&P Module and not on the Driver Module. When the S&P Module option is used, the Status LED will be out if the system is in the stop or the fault mode. The Status LED will come on after the faults have been cleared and/or a start command has been generated.

The following brush recordings were taken on an R632 basic system with auxiliary and main power being applied simultaneously.

Figure 10 shows the system voltage and current from breaker closing to breaker opening with the reference ramps set for the slowest ramp. Brush time is 5mm/sec.

Figure 11 shows the system voltage and current from breaker closing to breaker opening with the reference ramps set at their midrange point. Brush time is 5mm/sec.

Figure 12 shows the system voltage and current from breaker closing to breaker opening with reference ramps set for the fastest ramp. Brush time is 5mm/sec.

Figure 13 is the same as Figure 12 except the brush time is 25mm/sec.

Figure 14 shows the system voltage and current with the reference ramps set for the slowest ramp. The recording also shows what happens when the reference potentiometers are changed.

In Figures 10, 11, 12 and 13 note that when the breaker is closed, the reference signals come up rapidly to a steady level but no voltage or current is generated by the power rectifier until various delays in the system are timed out. When the breaker is opened, the undervoltage detection immediately notices the loss of power and the system is put into the Inhibit/Reset mode. All thyristor gating would be stopped.

In Figure 14 the system is started under soft start control. In addition, all reference changes must pass through the reference ramp so that any changes in the system operational level as determined by the operator potentiometer are soft. Note in Figure 14 the voltage reference change at point G. There is a slight delay before the voltage feedback signal starts to change which indicates that the system was operating in a current regulating mode. As the voltage reference ramps down to a point corresponding to the new potentiometer setting, the system switches into the voltage regulating mode and the output voltage reduces to the required operating level. At points H, I and J the current reference potentiometer setting is changed but as no changes are seen in the current feedback, this indicates that the system is still in the voltage regulating mode. The current reference level is still above the current being produced in the system. At point K, the current reference was turned to 0. Following a time delay allowing the current reference ramp to reduce, the system transfers into the current regulating mode; and the output current follows the reference down to the zero level. Note that all changes in the output voltage and current as indicated by the voltage feedback and current feedback signals are smooth.

In the mode of operation where the overcurrent detection is inhibited, the basic system will operate similar to a diode rectifier with the exception being the Inhibit/Reset condition which occurs on transient undervoltage conditions. In a diode system, the output voltage/current would show a transient condition; but in the R632 basic system, the output is held at zero until the input line recovers.

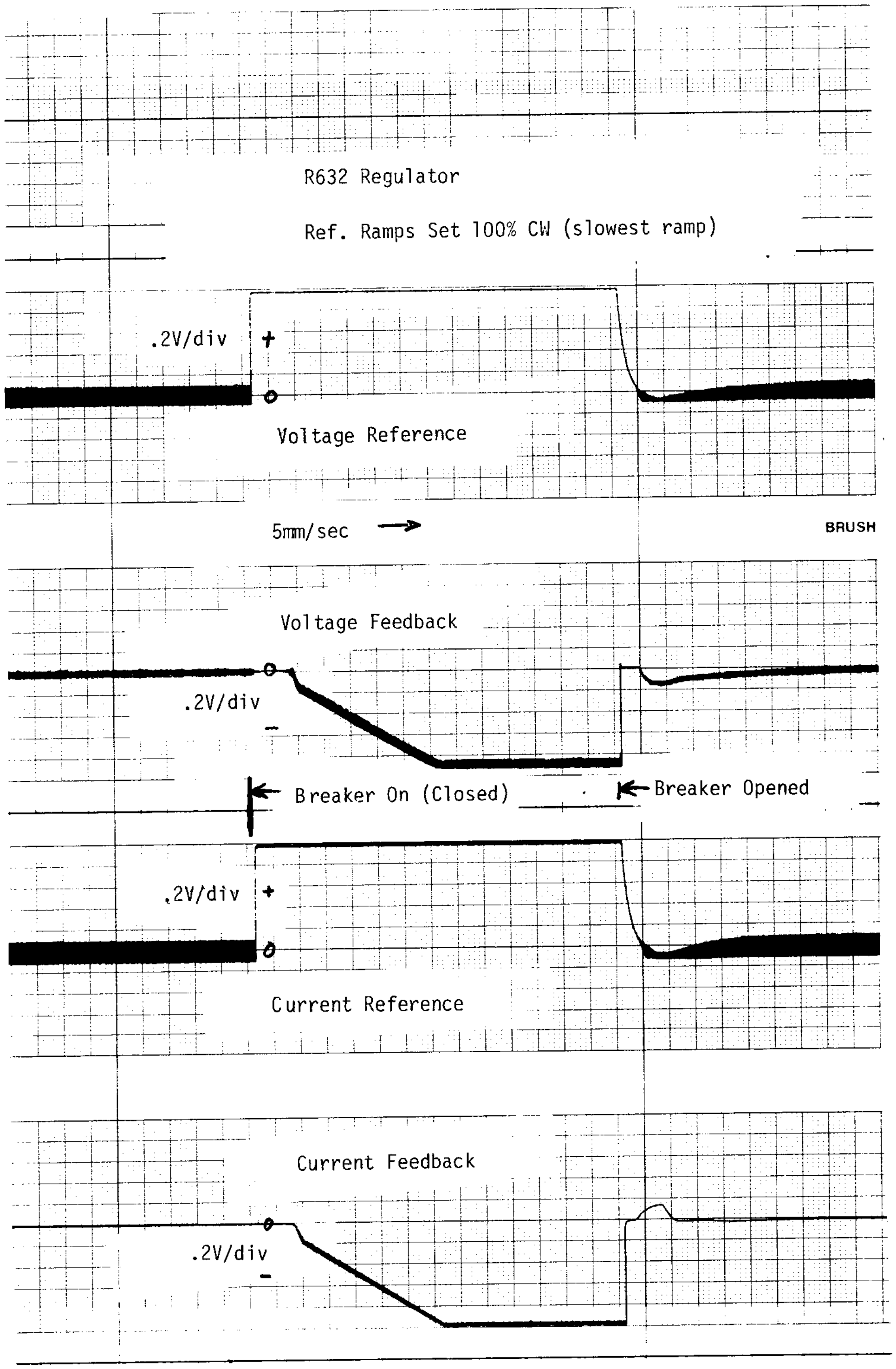

R632 Regulator
Ref. Ramps Set 100% CW (slowest ramp)
.2V/div
+
0
Voltage Reference
5mm/sec
BRUSH
Voltage Feedback
0
.2V/div
−
Breaker On (Closed)
Breaker Opened
.2V/div
+
0
Current Reference
Current Feedback
0
.2V/div
−

FIGURE 10

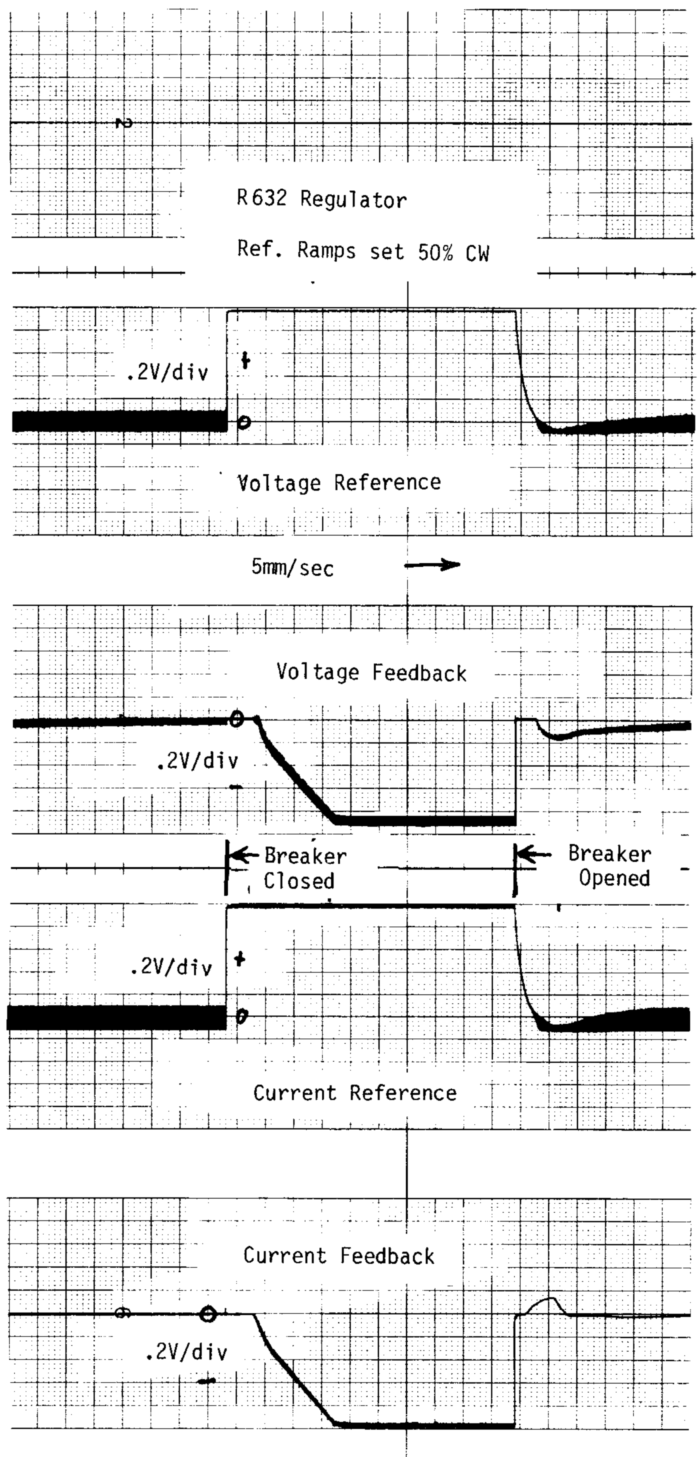

R632 Regulator
Ref. Ramps set 50% CW
.2V/div
Voltage Reference
5mm/sec
Voltage Feedback
.2V/div
Breaker Closed
Breaker Opened
.2V/div
Current Reference
Current Feedback
.2V/div

FIGURE 11

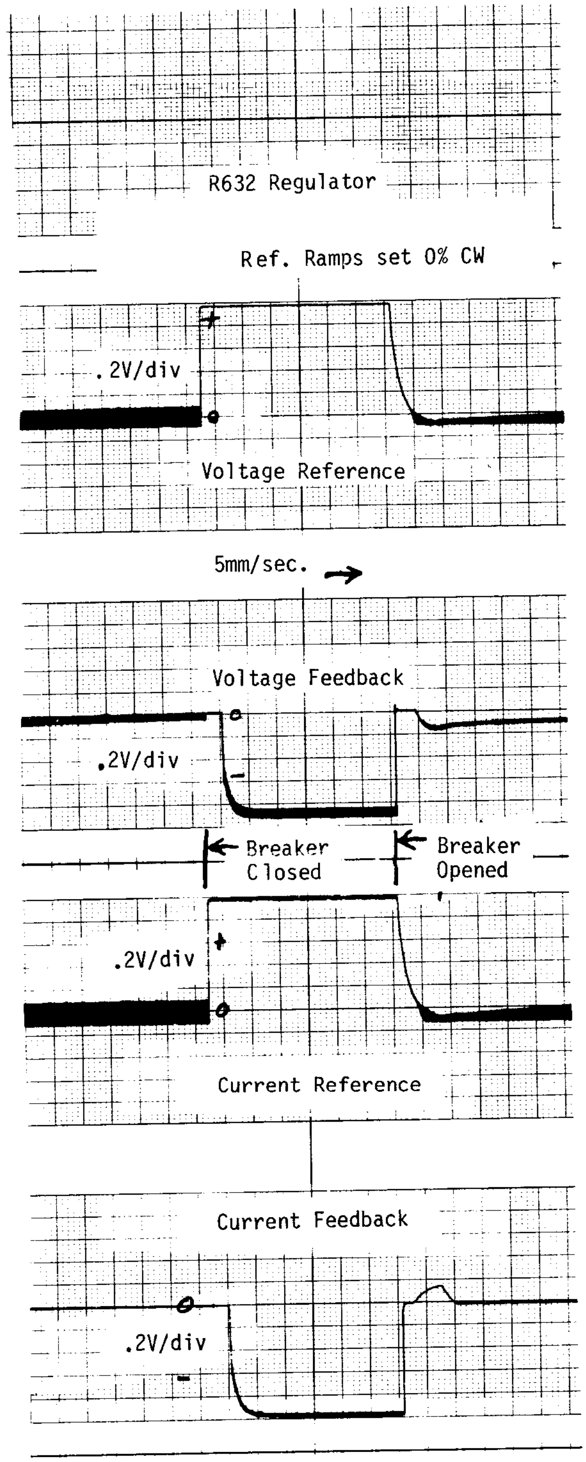

R632 Regulator
Ref. Ramps set 0% CW
.2V/div
Voltage Reference
5mm/sec.
Voltage Feedback
.2V/div
Breaker
Closed
Breaker
Opened
.2V/div
Current Reference
Current Feedback
.2V/div

FIGURE 12

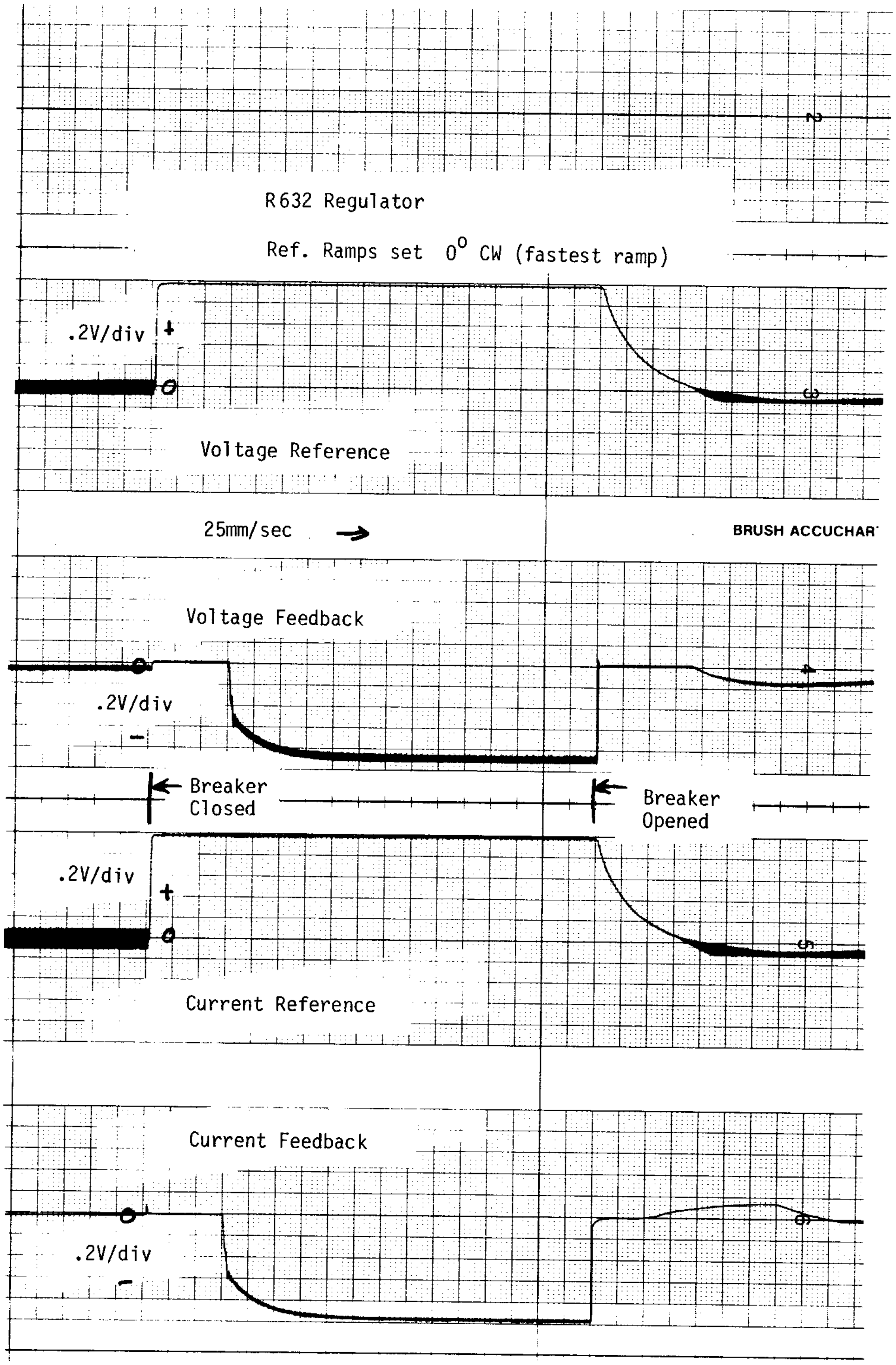

R632 Regulator
Ref. Ramps set 0° CW (fastest ramp)
.2V/div
+
0
Voltage Reference
25mm/sec
BRUSH ACCUCHART
Voltage Feedback
.2V/div
-
Breaker
Closed
Breaker
Opened
.2V/div
+
0
Current Reference
Current Feedback
.2V/div
-

FIGURE 13

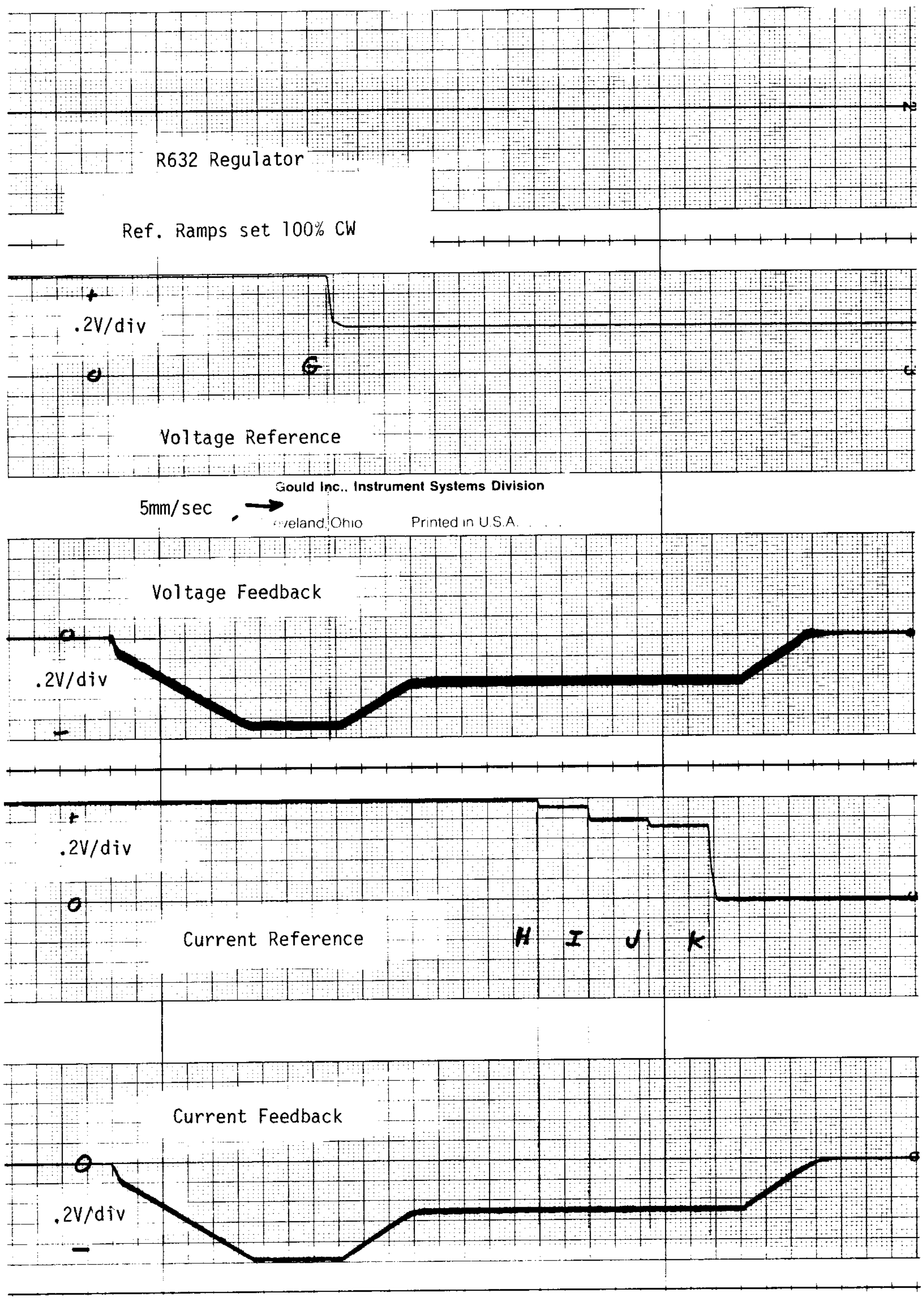

R632 Regulator
Ref. Ramps set 100% CW
+
.2V/div
0
G
Voltage Reference
Gould Inc., Instrument Systems Division
5mm/sec
Cleveland Ohio
Printed in U.S.A.
Voltage Feedback
0
.2V/div
-
+
.2V/div
0
Current Reference
H
I
J
K
Current Feedback
0
.2V/div
-

FIGURE 14

BASIC HARDWARE & ASSOCIATED OPTIONS

The hardware used in the basic R632 regulator is shown in Figures 5 and 6. This hardware, except for the Operator Panel, contains a cage assembly and associated peripheral hardware which is mounted on a panel. The cage assembly always contains the Controller Module S#1836A44G01, the Gating Module S#1836A42G01 and the Driver Module S#1836A43G01.

The associated peripheral equipment is selected to meet the requirements of the particular rectifier.

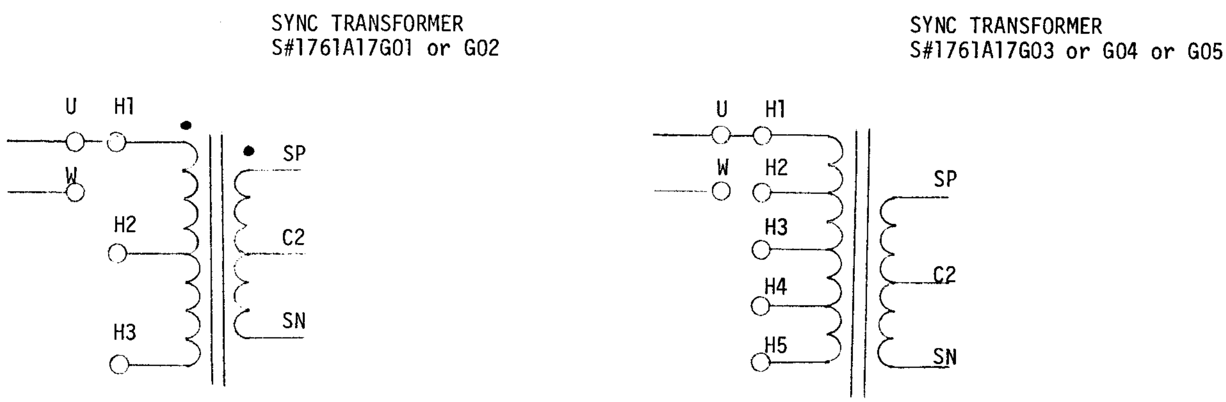
The Operator Panel can have a single turn or a 10 turn current set potentiometer and when used with the Sequence and Protection Module option these potentiometers would be part of an assembly which contains operator pushbuttons and indicator lights.

The voltage attenuator is selected for the particular rectifier voltage from a group which will have several different voltage taps.

The auxiliary transformers are normally operated from 3Ø, 460V, 60 hz but they could be operated from 3Ø, 380V, 50 hz in which case there would be wiring changes associated with these transformers. These transformers would then be connected with the primary windings on each transformer connected in parallel with the three transformers connected in a wye configuration on the primary side.

System current feedback as shown in Figure 5 is supplied by the current sensor shown in Figure 6. This signal is supplied by a wire jumper between -I and -IFB as shown in Figure 5. In systems where the current feedback is to be supplied by an external device, the feedback signal could be brought directly into the terminal block point -IFB.

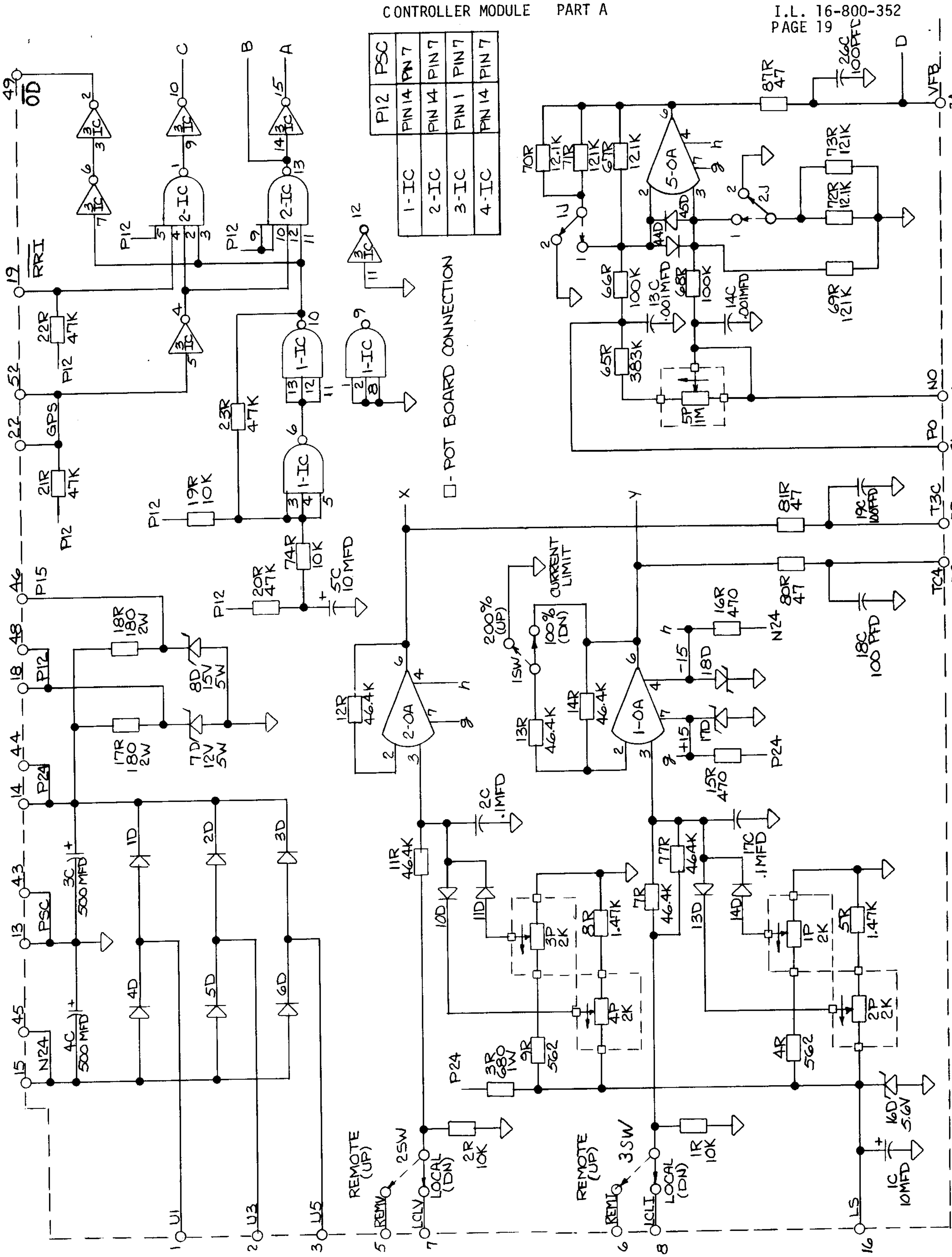
The synchronizing transformer shown would be used on an industrial rectifier (250V dc). In other rectifier systems where the rectifier output voltage is different, the synchronizing transformer would be selected for the appropriate rectifier input voltage. The transformer used would be similar to those shown in Figure 15 and would be selected from a pre-designed set of transformers with multiple primary taps.



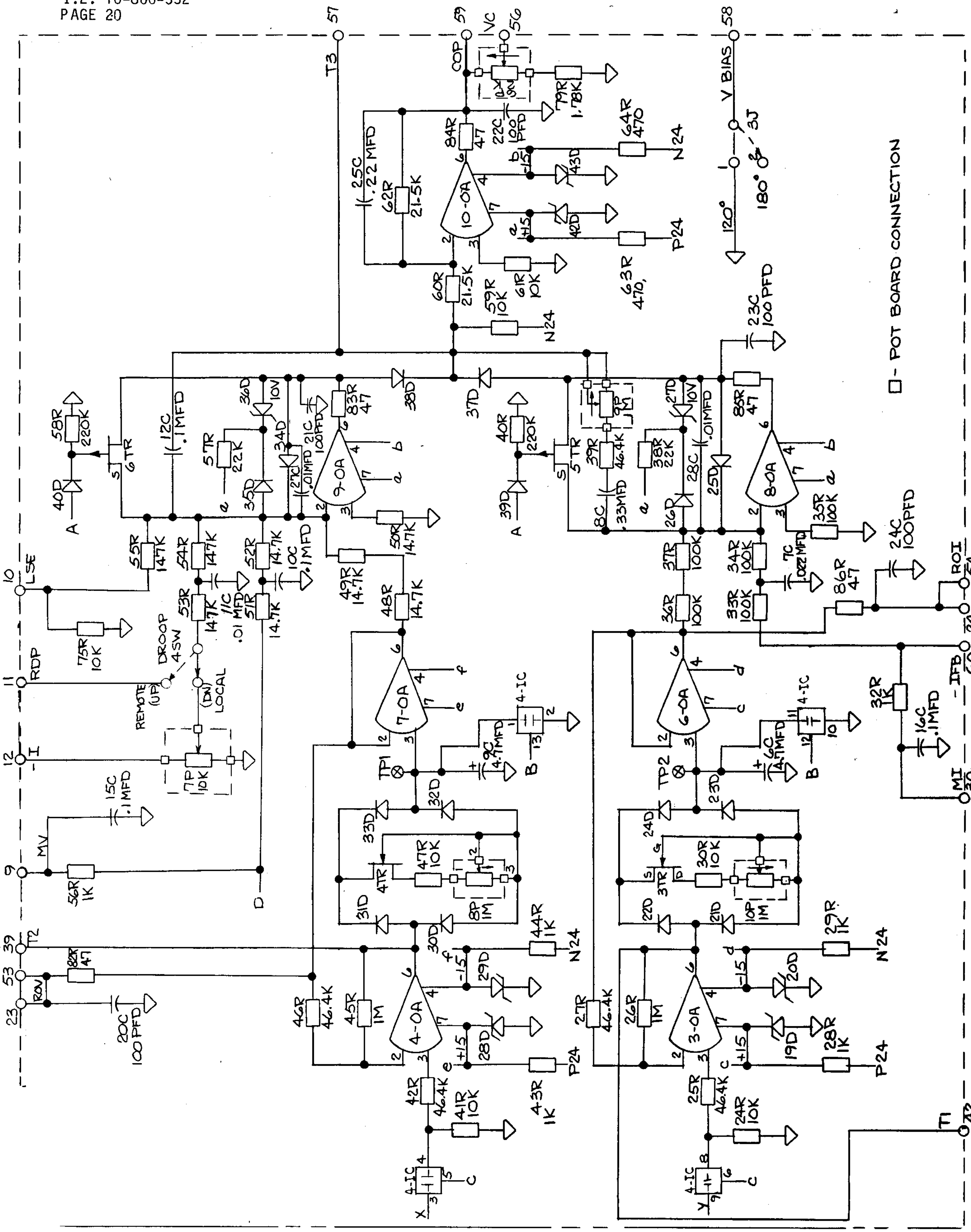
ALTERNATE SYNCHRONIZING TRANSFORMERS

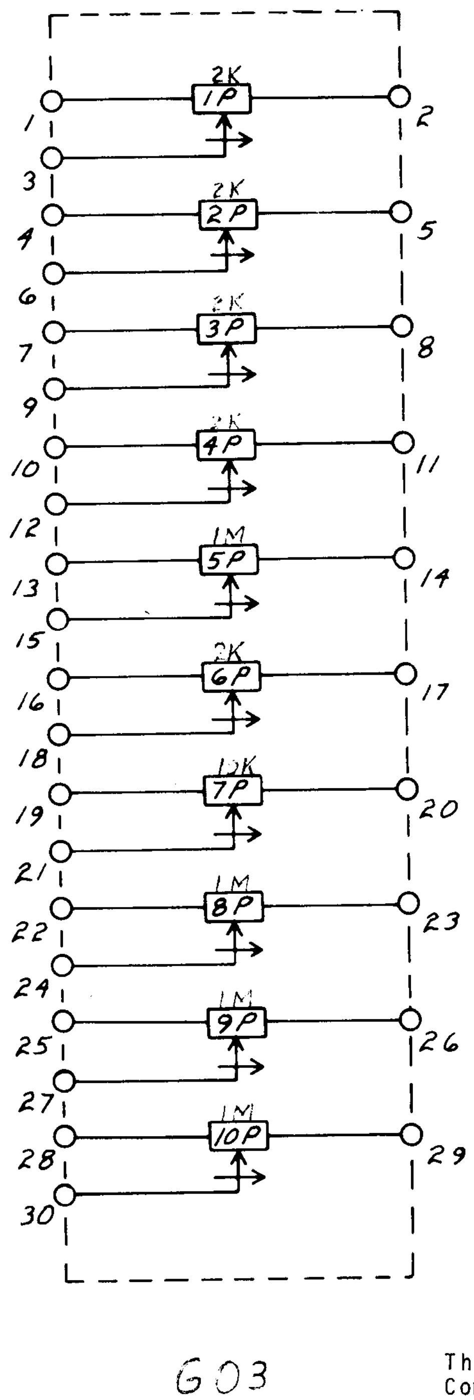
FIGURE 15

	P12	PSC
1-IC	PIN 14	PIN 7
2-IC	PIN 14	PIN 7
3-IC	PIN 1	PIN 7
4-IC	PIN 14	PIN 7



CONTROLLER MODULE PART B

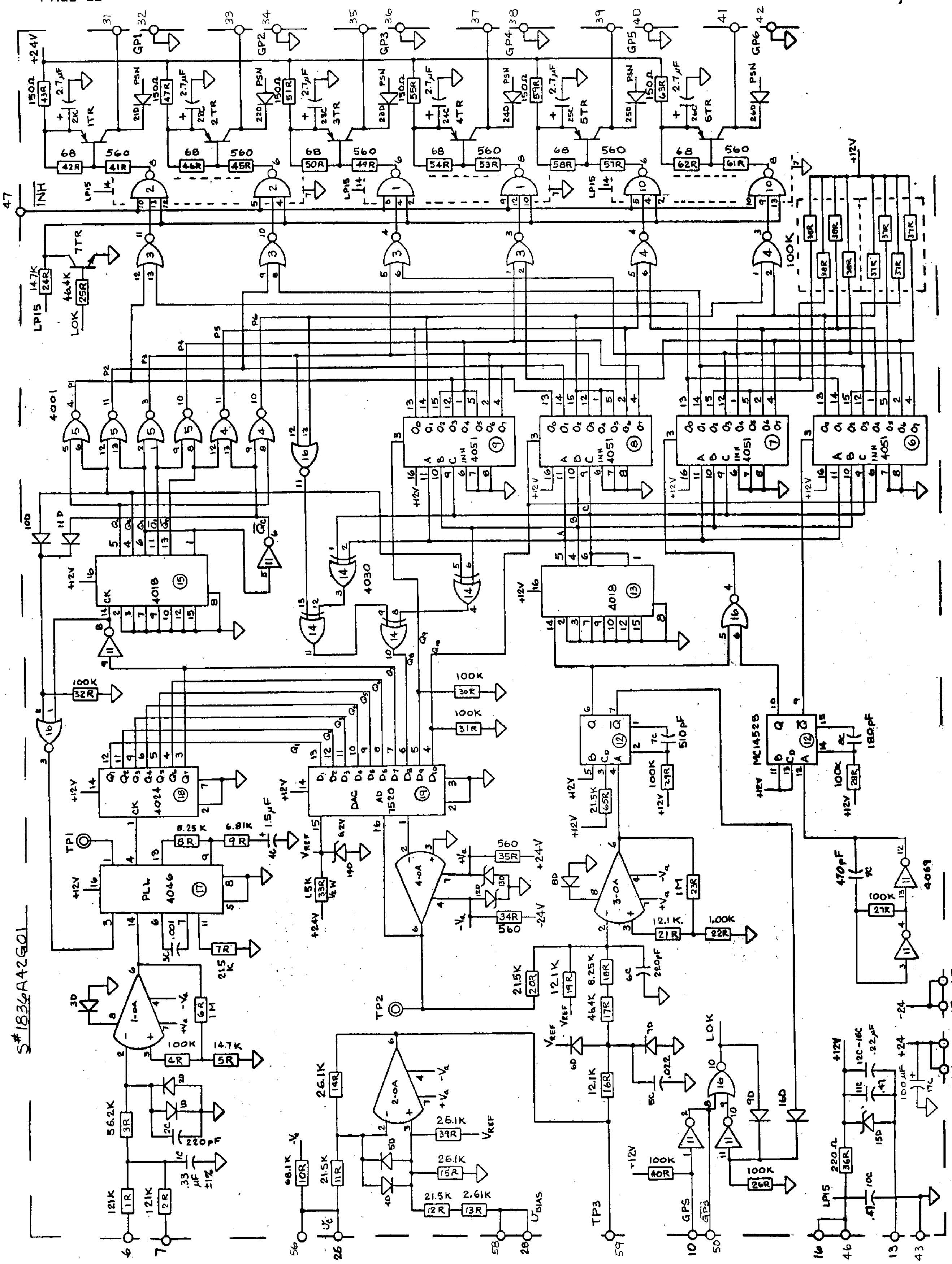




This board is an integral part of Controller Module S#1836A44G01

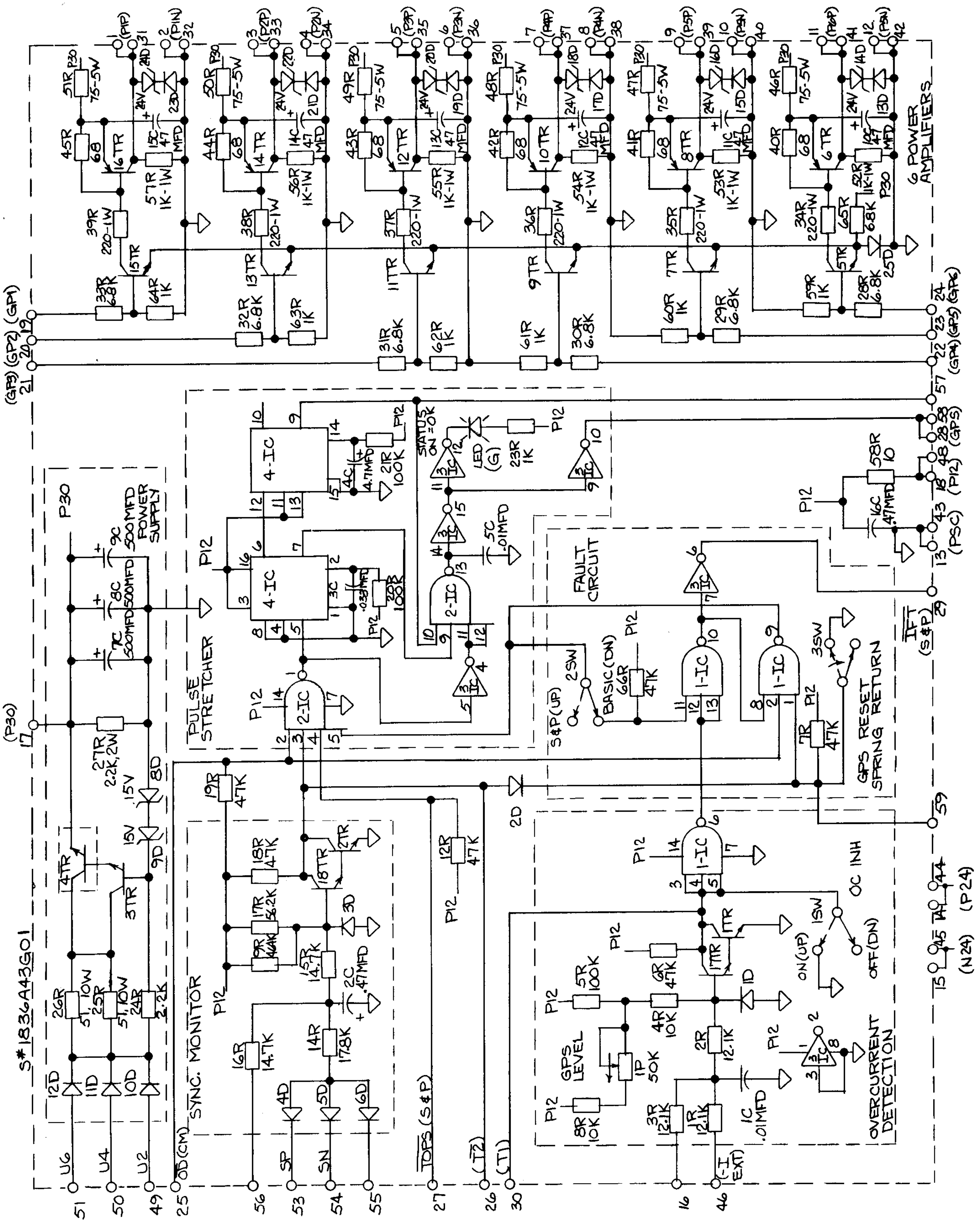
S630/C600 POT BOARD

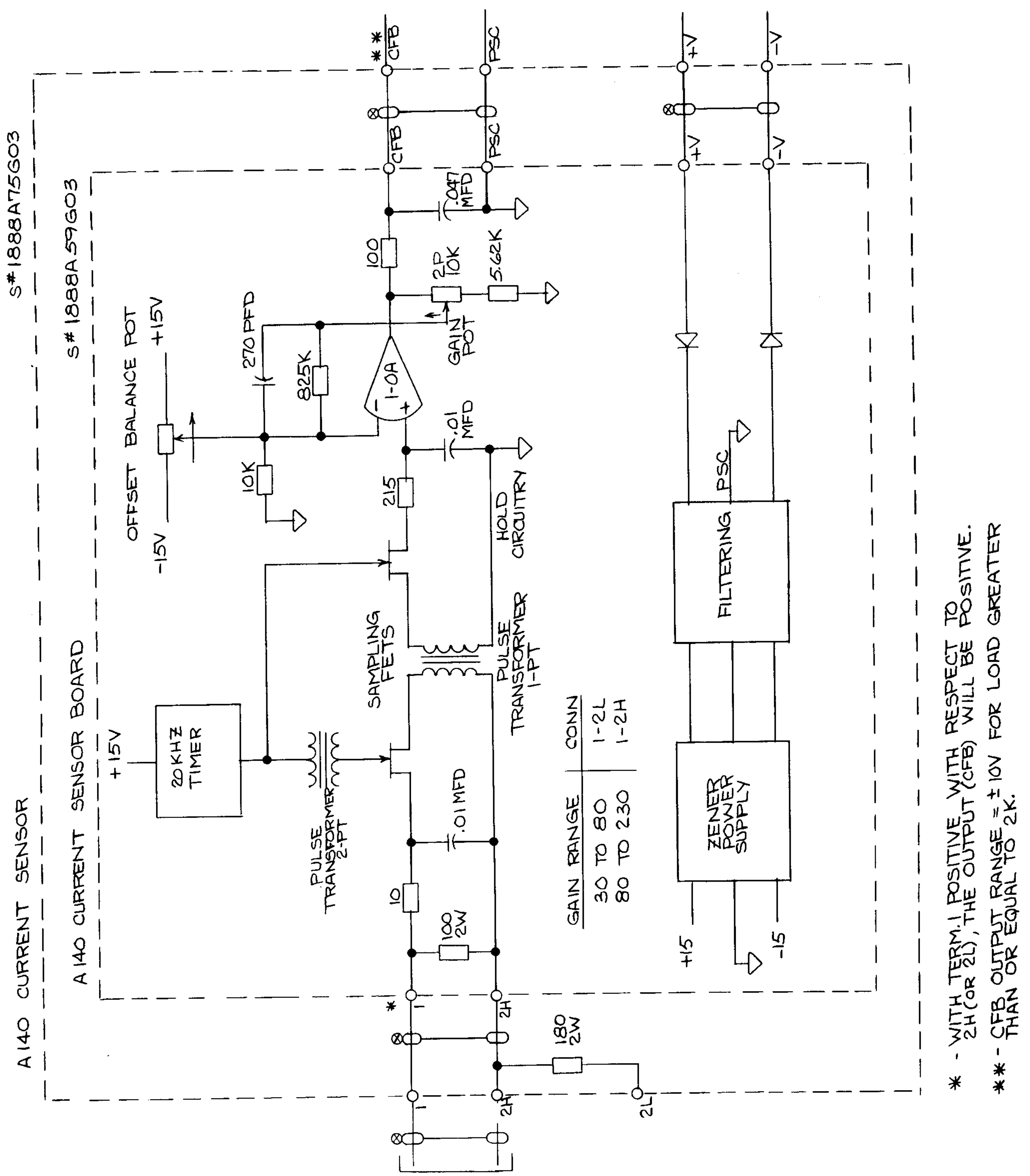
DIGITAL GATE PULSE GENERATOR



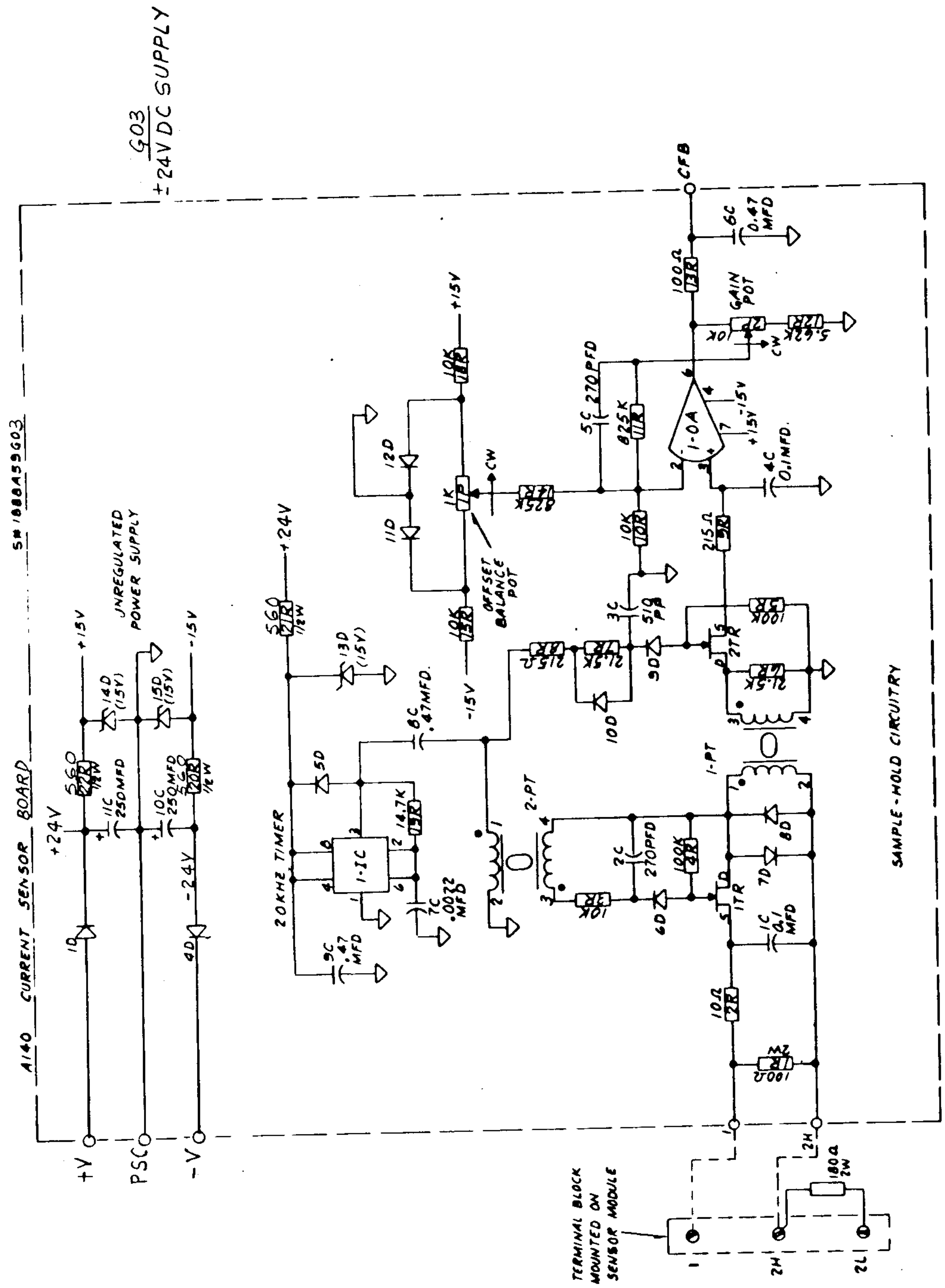
Printed in USA

DRIVER MODULE

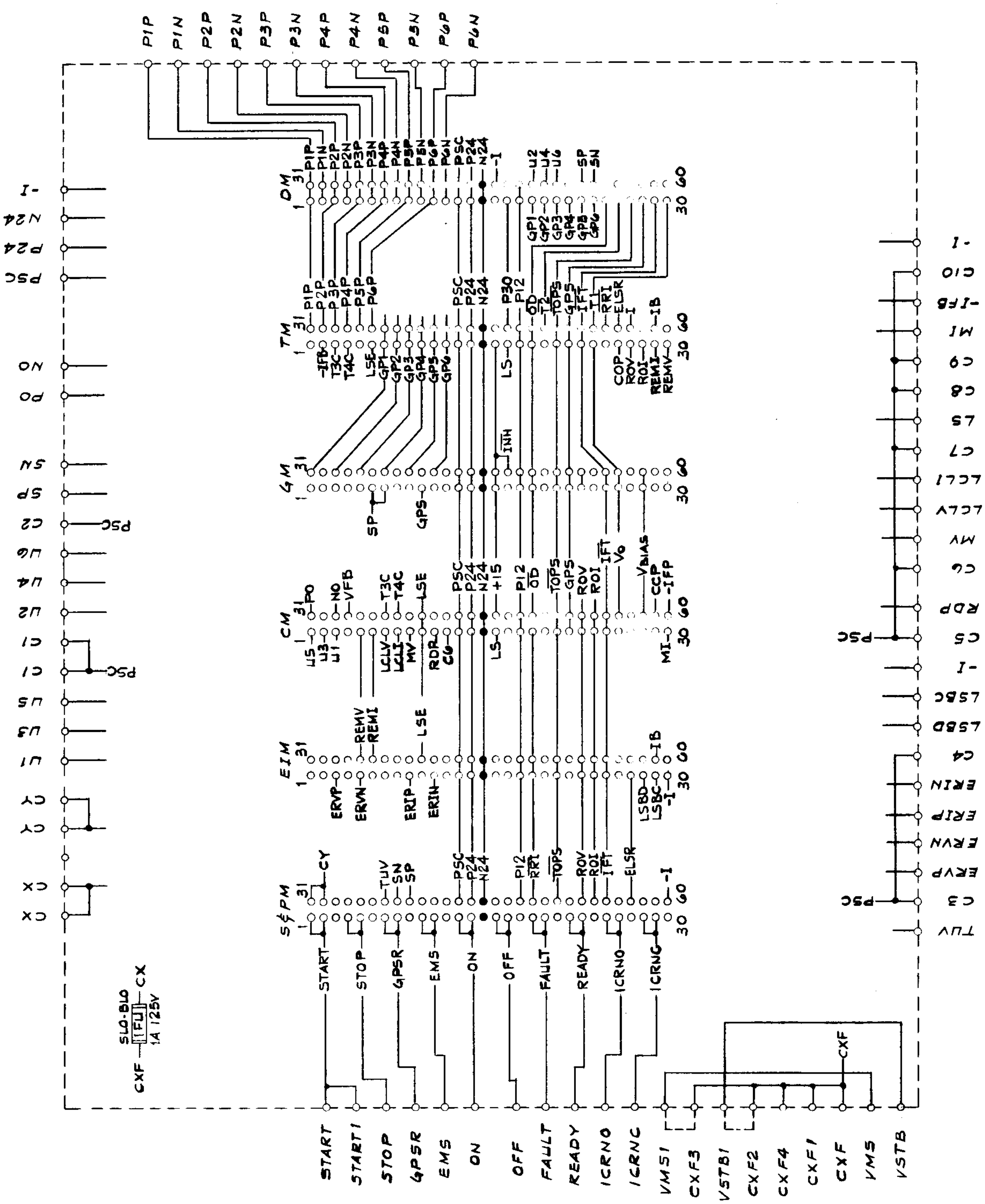




A140 CURRENT SENSOR



A140 CURRENT SENSOR BOARD


P1P
P1N
P2P
P2N
P3P
P3N
P4P
P4N
P5P
P5N
P6P
P6N
DM
TM
GM
CM
EIM
S&PM
START
START1
STOP
GPSR
EMS
ON
OFF
FAULT
READY
ICRNO
ICRNC
VMS1
CXF3
VSTB1
CXF2
CXF4
CXF1
CXF
VMS
VSTB
SLO-BLO
1A 125V