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B) LOAD CONNECTION (I). The basic interconnections between the BOP and the load are shown in FIG.'s 3-2A and 3-2B. The load wire size for the 2-wire connection shown should be as large as practicable to keep the series resistance and inductance low. In addition, the load wire pair should be tightly twisted, to reduce possible "pick-up" from stray magnetic fields. The basic 2-wire connection is useful where the voltage drop in the load wires is of minor consequence, as for example, operation into a constant load or in a constant current operating mode.

C) LOAD CONNECTION (II). The recommended load connection for all applications requiring minimum load effect across a remote load is shown in FIG. 3-3A and 3-3B. A twisted, shielded pair of wires (No. 20 AWG minimum) are connected from the BOP sensing terminals to the load. This "remote error sensing" technique will compensate for load wire voltage drops up to 0.5 volts per wire.
NOTE: *OBSERVE POLARITIES: THE COMMON SENSING WIRE MUST GO TO THE "COMMON" LOAD WIRE, THE (±) OUT SENSING WIRE MUST GO TO THE "(±) OUT" LOAD WIRE.*

D) A-C GROUND. (Refer to FIG.'s 3-2, 3-3). The metal cases of electronic equipment which is operated from the a-c power line must be kept at ground potential at all times. If the 3-wire line cord with 3-prong safety plug (supplied with this equipment) is used in combination with a properly grounded a-c power outlet, this is taken care of automatically. If an adapter for a non-grounded outlet is used, however, the case must be grounded separately. A separate "GROUND" terminal is provided for this purpose on the front panel as well as on the rear of the BOP. (See Section II, FIG. 2-2).

E) D-C (SIGNAL) GROUND. (Refer to FIG.'s 3-2, 3-3). Specified ripple and noise figures for operational power supplies are valid only with the COMMON side of the output/load circuit returned to a common ground point (refer to Section I, Table 1-2). The COMMON terminal of the BOP output is shown grounded in FIG.'s 3-2A through 3-3B, since it is "common" to both, internal reference source and any external signal source. If the application requires, the COMMON of the BOP may be floated up to 500V d-c off ground. In this case, however, the common mode current (specified in Section I, Paragraph 1-8E, will flow through the impedance of whatever circuit is placed between COMMON and ground and will give rise to a common mode voltage. The signal ground point in the BOP/load circuit must consist of a single point only, to which all input source grounds, shields and load grounds are connected. Multiple signal grounds in the BOP output/load circuit may cause "ground-loop" problems, since noise signals develop across the impedances between the multiple ground points. The exact physical location of the "best" single ground point must be carefully selected for minimum ripple/noise output.

F) EXTERNAL PROGRAMMING RESISTORS. External programming resistors should be high-quality units, with low-temperature coefficients. Resistors should be selected carefully, since in most applications, the limitations for stability and drift are due, not to the BOP, but to the programming resistors. Selection criteria for resistors are:

1) TEMPERATURE COEFFICIENT
2) LEAKAGE (IN VALUES ABOVE 100K OHM)
3) HUMIDITY EFFECTS
4) DRIFT WITH TIME
5) SELF-HEATING (POWER DISSIPATION)
6) TOLERANCE.

G) For variable resistors (potentiometers or rheostats) similar selection criteria apply. In addition, such specifications as listed below should be carefully considered if the application requires:

1) END RESISTANCE
2) LINEARITY
3) CAPACITIVE AND INDUCTIVE EFFECTS

H) ACTIVE PROGRAMMING SOURCES. External programming sources (Signal Generators, etc.,) or reference sources should have temperature coefficients and drift specifications comparable to (or better than) the BOP Power Supply. CAUTION: A-C source-operated programming sources must have their output isolated from the case.

J) EXTERNAL LEADS. Shielded (preferably twisted) lead pairs are recommended for all input connections to the BOP control channels. The shield should be connected (single-ended) to the chosen signal ground point. Shielded leads should be held as short as practicable. Output leads must be voltage rated at least for the maximum BOP output voltage.

NOTE: FRONT SENSING LINKS MUST BE REMOVED. REAR SENSING LINKS MUST BE CONNECTED AS SHOWN.

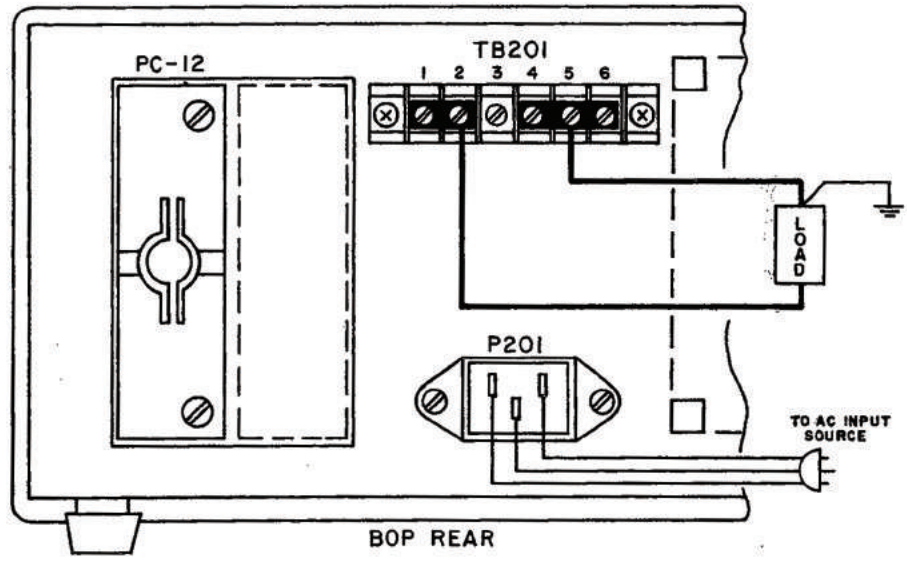


FIG. 3-2A LOAD CONNECTION AT THE REAR, WITHOUT ERROR SENSING.

NOTE: REAR SENSING LINKS MUST BE REMOVED. FRONT SENSING LINKS MUST BE CONNECTED AS SHOWN.

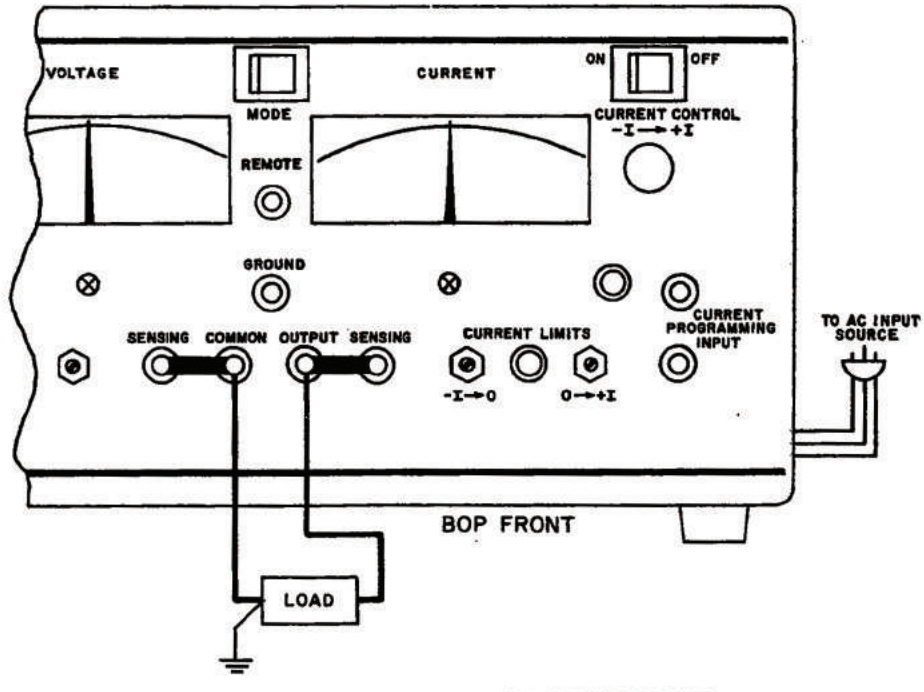


FIG. 3-2B LOAD CONNECTION AT THE FRONT, WITHOUT ERROR SENSING.

NOTE 1) FRONT AND REAR SENSING LINKS MUST BE REMOVED.

NOTE 2) FOR APPLICATIONS REQUIRING VERY LONG CONNECTIONS TO THE LOAD, ADDITIONAL EXTERNAL CAPACITORS (C_x IN FIG.'S 3-3A AND 3-3B) SHOULD BE CONNECTED AS SHOWN, TO COMPENSATE FOR THE LEAD INDUCTANCE OF THE CONNECTING WIRES.

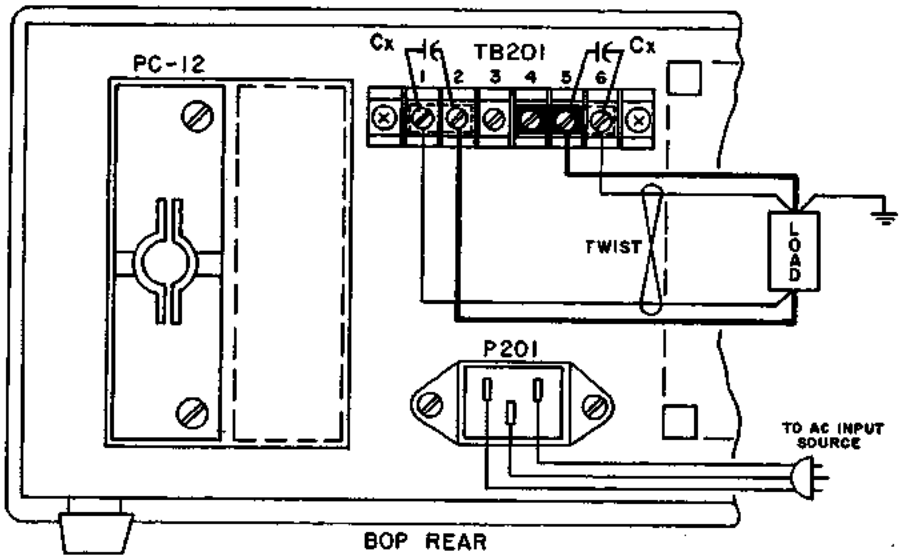
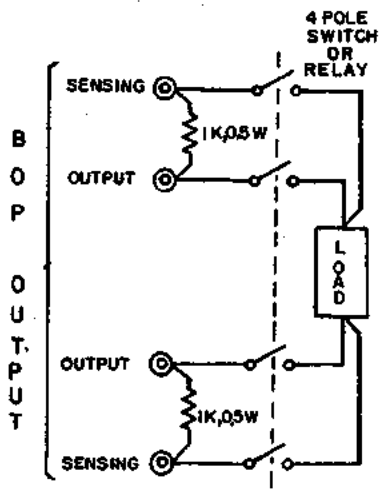


FIG. 3-3A LOAD CONNECTION AT THE REAR, WITH ERROR SENSING.

NOTE 3) FOR APPLICATIONS REQUIRING MANUALLY SWITCHED OR RELAY DRIVEN OUPUT CONNECTIONS, EXTERNAL RESISTORS MUST BE CONNECTED AS SHOWN. ALL CONNECTIONS SHOULD BE MADE AND BROKEN SIMULTANEOUSLY.



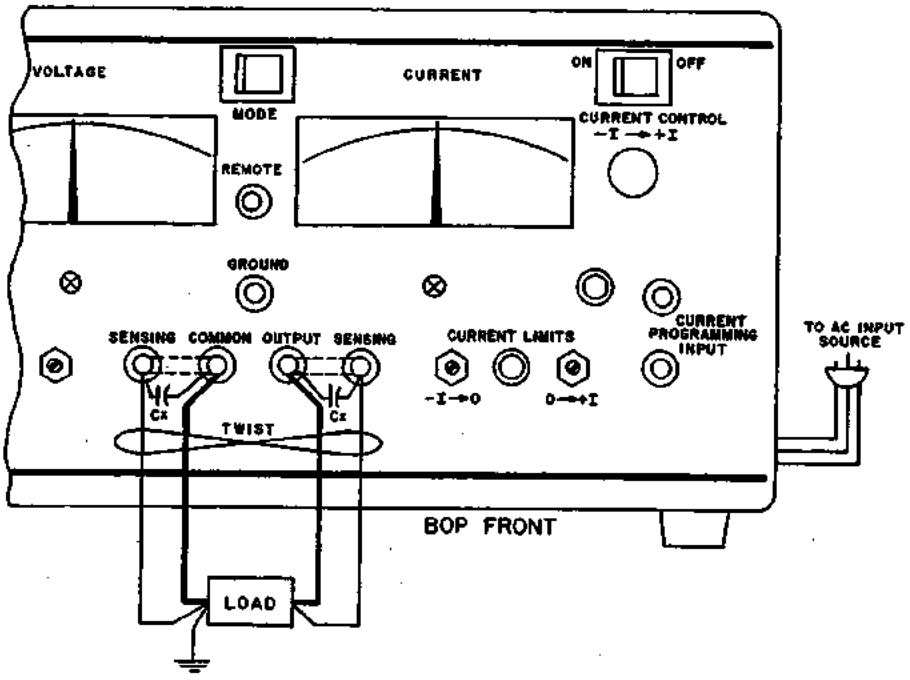


FIG. 3-3B LOAD CONNECTION AT THE FRONT, WITH ERROR SENSING.

3-4 BEFORE USING THE BOP IN ANY APPLICATION, PLEASE REFER TO SECTION II TO GET ACQUAINTED WITH THE OPERATING CONTROLS AND THE A-C POWER REQUIREMENTS. REFER TO THIS SECTION (SECTION III) FOR INFORMATION ON LOAD CONNECTIONS AND GROUNDING.

3-5 BOP OPERATION WITH LOCAL (FRONT PANEL) OUTPUT CONTROL

3-6 VOLTAGE MODE OPERATION WITH CURRENT LIMITING. The BOP may be used as a stabilized (d-c) source of positive or negative voltage with output current limiting (for either polarity) pre-selected for the application at hand.

3-7 PROCEDURE (Refer to Paragraph 3-4)

1) Determine the output voltage and current requirements of your load. Set the BOP MODE switch to the VOLTAGE position and the VOLTAGE CONTROL SWITCH to "ON".
2) With the BOP A-C CIRCUIT BREAKER/POWER SWITCH "off", connect a short circuit across the output terminals. Turn the BOP "on" again.
3) Adjust the I_o LIMIT CONTROLS for both polarities as required, monitoring the OUTPUT CURRENT METER for the correct limiting value. Proceed as follows: Turn VOLTAGE CONTROL fully counterclockwise. Adjust the "(−) I_o LIMIT CONTROL". Turn VOLTAGE CONTROL fully clockwise. Adjust the "(+) I_o LIMIT CONTROL". Turn the VOLTAGE CONTROL to the center of its range. Turn the A-C POWER switch "off" and remove the short circuit from the output and reconnect the load.
4) Turn the A-C CIRCUIT BREAKER/POWER SWITCH "on", and adjust the VOLTAGE CONTROL to the desired output voltage.

NOTE: *If the output current exceeds the pre-adjusted value at any time the VOLTAGE MODE LIGHT will go out and the (±) I_o LIMIT LIGHT will go on. After the cause of the overcurrent is eliminated, the indicator lights will return to their initial status.*

3-8 CURRENT MODE OPERATION WITH VOLTAGE LIMITING. The BOP may be used as a stabilized d-c source of positive or negative current, with output voltage limiting (for either polarity), pre-selected for the application at hand.

3-9 PROCEDURE (please refer to Paragraph 3-4)

1) Determine the output voltage and current requirement of your load. Set the BOP MODE SWITCH to the CURRENT position and the CURRENT CONTROL switch to "ON".
2) With the BOP A-C CIRCUIT BREAKER/POWER SWITCH "off", **disconnect the load.** Turn the BOP "on" again.
3) Adjust the E_o LIMIT CONTROLS for both polarities as required, monitoring the OUTPUT VOLTAGE METER for the voltage limiting value. Proceed as follows: Turn CURRENT CONTROL fully counterclockwise. Adjust the "(−) E_o LIMIT CONTROL". Turn CURRENT CONTROL fully clockwise. Adjust the "(+) E_o LIMIT CONTROL". Turn the CURRENT CONTROL to the center of its range. Turn the A-C POWER switch "off" and reconnect the load.
4) Turn the BOP "on" again, and adjust the operating current by means of the CURRENT CONTROL to the value required.

NOTE: *If the output voltage exceeds the pre-adjusted value at any time the CURRENT MODE LIGHT will go out and the (±) E_o LIMIT LIGHT will go on. After the cause of the overvoltage is eliminated, the indicator lights will return to their initial status.*

3-10 BOP OPERATION WITH REMOTE CONTROL OF THE VOLTAGE CONTROL CHANNEL.

3-11 REMOTE D-C OUTPUT VOLTAGE CONTROL BY RESISTANCE. As seen in FIG. 3-4, and as described in a previous paragraph (Paragraph 3-6) the BOP d-c output potential can be controlled within its specified range by means of the VOLTAGE CONTROL, with the VOLTAGE CONTROL SWITCH in the ON position. PREAMP "A" with the built-in feedback and input resistors, has a gain of one and the fixed gain of all BOP models is designed so that a d-c input signal of zero to (±)10 volt will control the BOP output through its specified range. In the local (front panel) control mode, the d-c control potential is applied via the VOLTAGE CONTROL. In the remote control mode, a similar control circuit, located external to the BOP is substituted for the internal control elements.

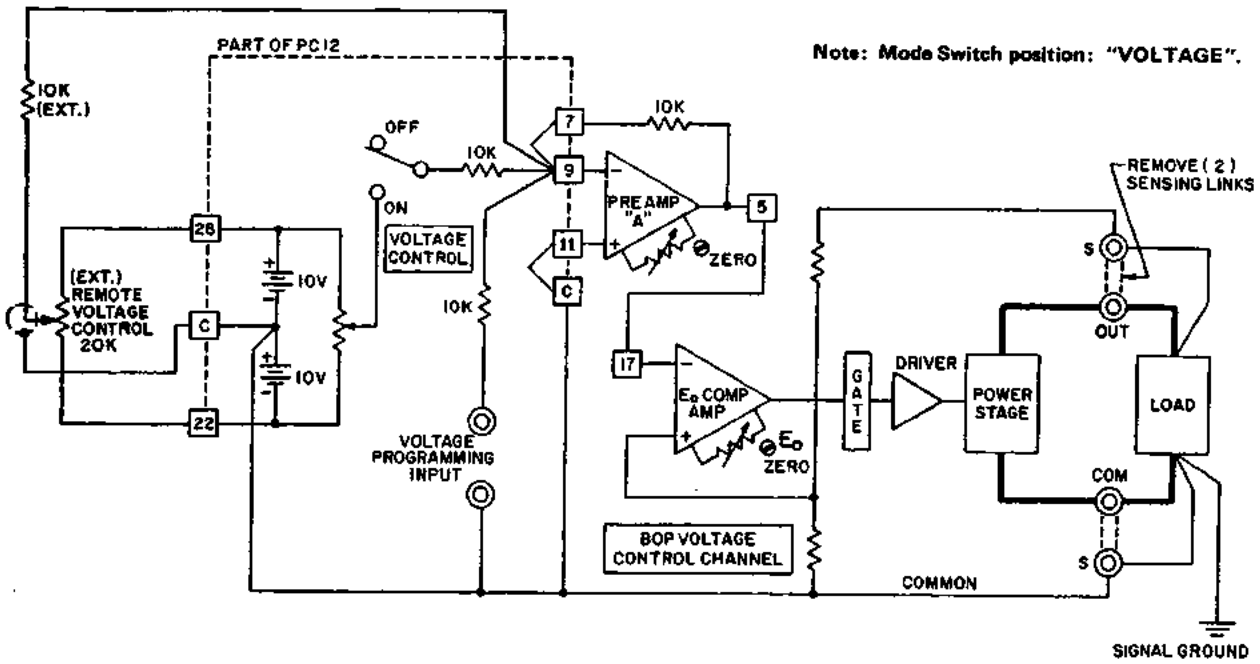


FIG. 3-4 REMOTE POTENTIOMETER CONTROL OF THE BOP D-C OUTPUT VOLTAGE

3-12 As shown in FIG. 3-4, this control method can readily be performed remotely, by setting the VOLTAGE CONTROL SWITCH to the OFF position and connecting an external REMOTE VOLTAGE CONTROL as indicated in FIG. 3-4.

3-13 Two-terminal resistance control of the d-c voltage (for example, by means of a Decade Box) can be exercised as shown in FIG. 3-5.

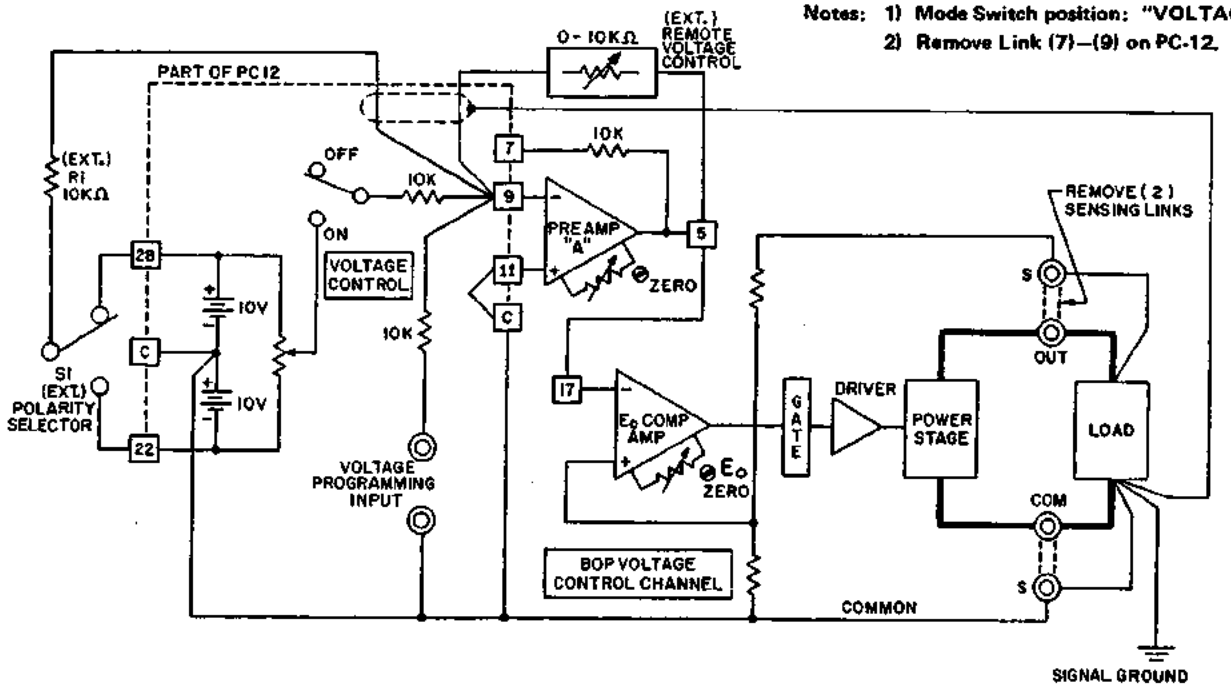


FIG. 3-5 REMOTE D-C OUTPUT VOLTAGE CONTROL BY MEANS OF A TWO-TERMINAL RESISTANCE (DECADE).

3-14 The external switch (S1), connected across the (±) reference voltage is used to pre-select either positive or negative output, by setting it to the applicable reference voltage polarity.

3-15 PREAMP "A" functions here as an inverter. Its output can be expressed by the equation:

$$E_{o\,(PREAMP\ "A")} = -E_{ref}\,(R_f/R_i).$$

R_f = Decade Resistor.
R_i = Ext. Input Resistor

Since E_{ref} = (±)10 volts and the gain ratio R_f/R_i is variable from zero to one, its output ($E_{o\,PREAMP\ "A"}$) will vary linearly from zero to (±)10 volts with the change in the decade resistance (R_f). As a consequence, the BOP output voltage will also vary linearly with the change in decade resistance.

3-16 This programming system can be calibrated very accurately by setting the REMOTE VOLTAGE CONTROL (Decade) to zero and adjusting zero output volts at the BOP E_o ZERO control, monitoring at the BOP output with a digital voltmeter. The maximum output voltage is calibrated by making all or part of R_i a rheostat and adjusting it, with the REMOTE VOLTAGE CONTROL at maximum resistance, to the maximum BOP output voltage.

3-17 REMOTE OUTPUT VOLTAGE CONTROL BY MEANS OF D-C SIGNAL VOLTAGE. The BOP d-c output voltage can be controlled directly by a (±)10V d-c signal, applied to the front panel VOLTAGE PROGRAMMING INPUT terminals. An interesting example of this application is the BOP output voltage control with a Kepco SN Digital Programmer for example. The digital input to the SN programmer can be provided by a computer, or manually by means of a keyboard. The analog output from the SN is from zero to ±10 volts and constitutes the input program for the BOP.

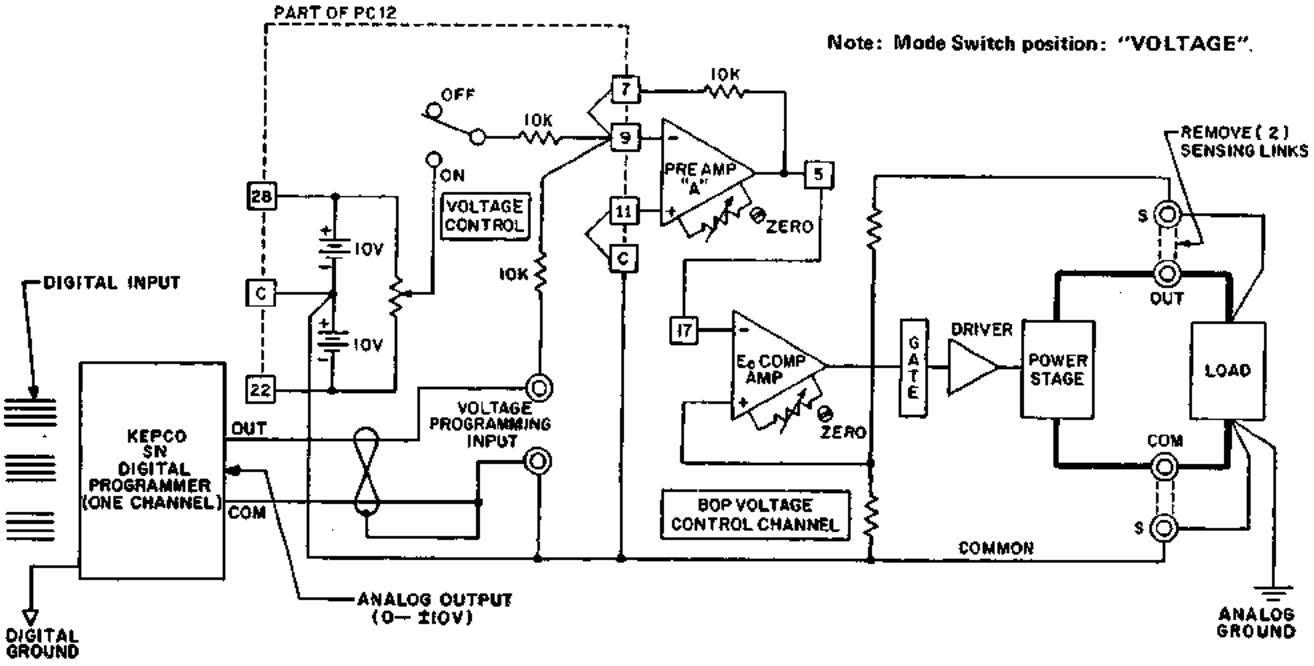


FIG. 3-6 DIGITAL CONTROL OF THE BOP D-C OUTPUT VOLTAGE.

3-18 The connections between the SN Programmer and the BOP are illustrated in FIG. 3-6. This programming system provides a resolution of 12-bits with a linearity of (±)½ LSB (0.0122%). The digital and the power supply grounds are isolated (optical isolation) to 1000 volts. Calibration of the system is performed with the provided controls on the SN Programmer. See paragraphs 3-46 through 3-82 for a description of available Kepco Digital Programming devices suitable for use with the BOP.

3-19 Since all terminals of PREAMP "A" are available at the REAR PROGRAMMING CONNECTOR, d-c output voltage control can be exercised in many other ways. PREAMP "A" can be treated as an uncommitted operational amplifier, with its applicable transfer-functions. Its ***initial*** offsets can be zeroed with the provided control, while the offset ***variations*** are specified in Section I of this manual (refer to Table 1-2). The basic principle of d-c output voltage control of the BOP is that a control voltage of (±)10 volts at 1 mA at the VOLTAGE PROGRAMMING INPUT (with the built-in feedback/input resistors) will produce the full d-c output voltage swing of the BOP. If the selected control signal does not have the required amplitude or if the required control current cannot be supplied, the PREAMP "A" configuration can be altered to provide the proper interface for the application.

3-20 If, for example, the BOP d-c output is to be controlled by means of a bipolar, 1 volt, high impedance source, it can be connected to the BOP as shown in FIG. 3-7.

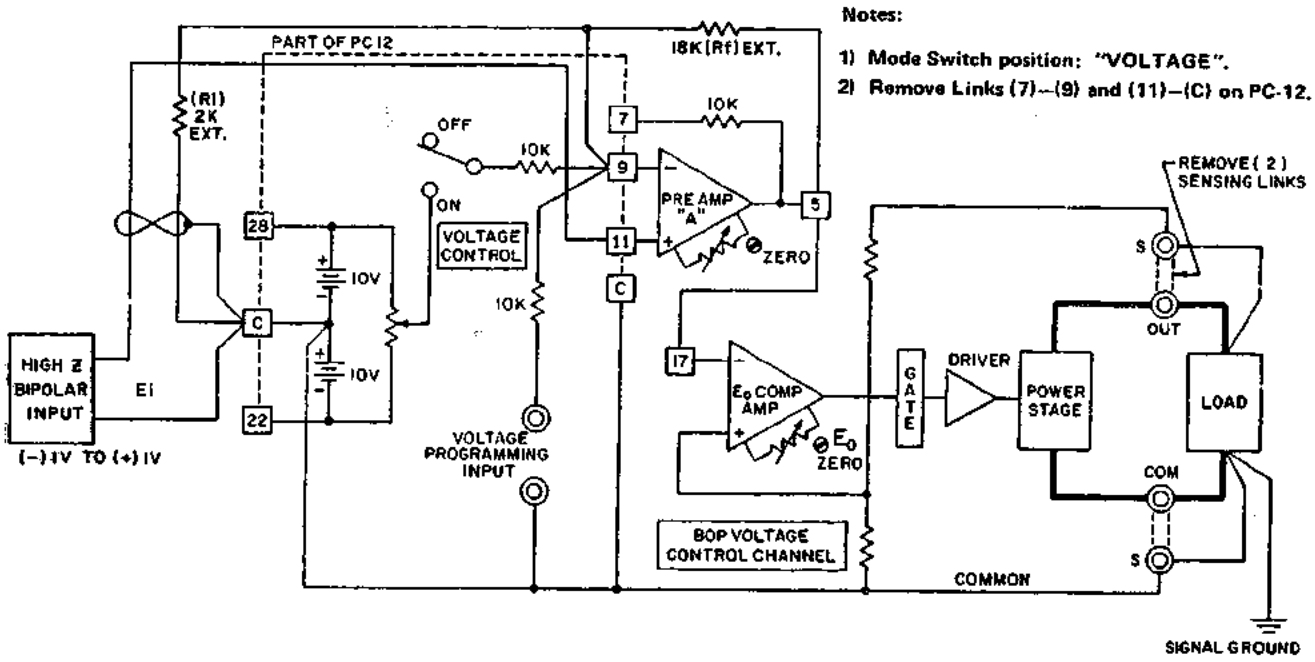


FIG. 3-7 BOP D-C OUTPUT VOLTAGE CONTROL WITH A HIGH IMPEDANCE. (±) 1V SIGNAL SOURCE.

3-21 As seen in FIG. 3-7, the original input feedback components of PREAMP "A" have been bypassed and are replaced by external resistors (small, metal film or wire-wound type resistors may be used and connected directly to the REAR PROGRAMMING CONNECTOR terminals as shown). PREAMP "A" is used in the non-inverting configuration. Its output voltage (the necessary BOP control voltage) is given by:

$$E_{o\,(\text{PREAMP "A"})} = E_i \frac{R_f + R_i}{R_i} \qquad \text{or } E_{o\,(\text{PREAMP "A"})} = \frac{18\text{K ohm} + 2\text{K ohm}}{2\text{K ohm}} = (\pm)\,10\text{V}$$

Consequently, as the BIPOLAR INPUT VOLTAGE (E_i) is controlled from (–) 1V over zero to (+) 1V, the BOP output voltage will follow over its specified range. Calibration of the system can be performed at the programming source, or the PREAMP "A" ZERO control can be used for the low end, while the feedback resistor (R_f = 18K ohm) can be trimmed to calibrate the high end of the range.

3-22 THE BOP AS AN AMPLIFIER

3-23 If, instead of the previously used d-c control signal, an a-c signal voltage is applied to the E_o PROGRAM INPUT, the BOP functions as a bipolar amplifier. As an amplifier, the BOP voltage gain is set on each BOP model so that (as before with the d-c control signal) a bipolar a-c input signal with an amplitude of 0V to 20V (peak-to-peak) will drive the BOP output through its specified (±) output voltage range. All other dynamic specifications are given in Section I, Table 1-3.

3-24 The BOP can be used to amplify, sum or scale a variety of waveshapes, some of which are illustrated in FIG. 3-8. All input signals are shown 180° out of phase with their corresponding output waveshapes. The latter can be readily produced in phase (i.e. with the output wave taking the same direction as the input signal) by addressing the non-inverting input of PREAMP "A" instead of the front panel E_o PROGRAM INPUT (Inverting).

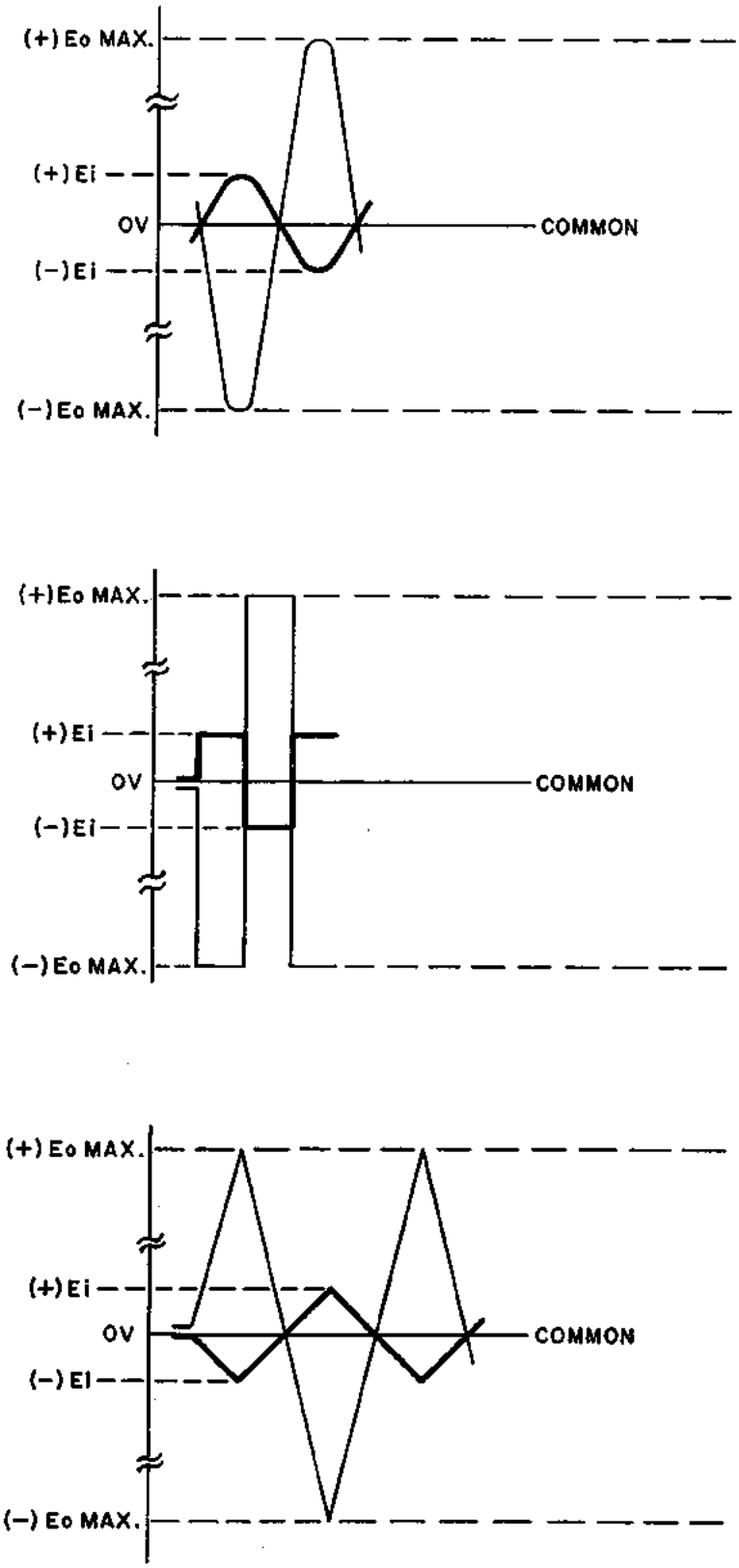


FIG. 3-8 GRAPHS OF POSSIBLE BOP INPUT/OUTPUT WAVE-SHAPES

3-25 The basic programming circuit with which the wave forms shown in FIG. 3-8 can be produced is shown in FIG. 3-9. Since all input signals in FIG. 3-8 are shown with a ±10 volts amplitude, the basic programming circuit in FIG. 3-9 must be modified if the external signal source cannot produce 10 volts and if the full BOP output voltage swing is required.

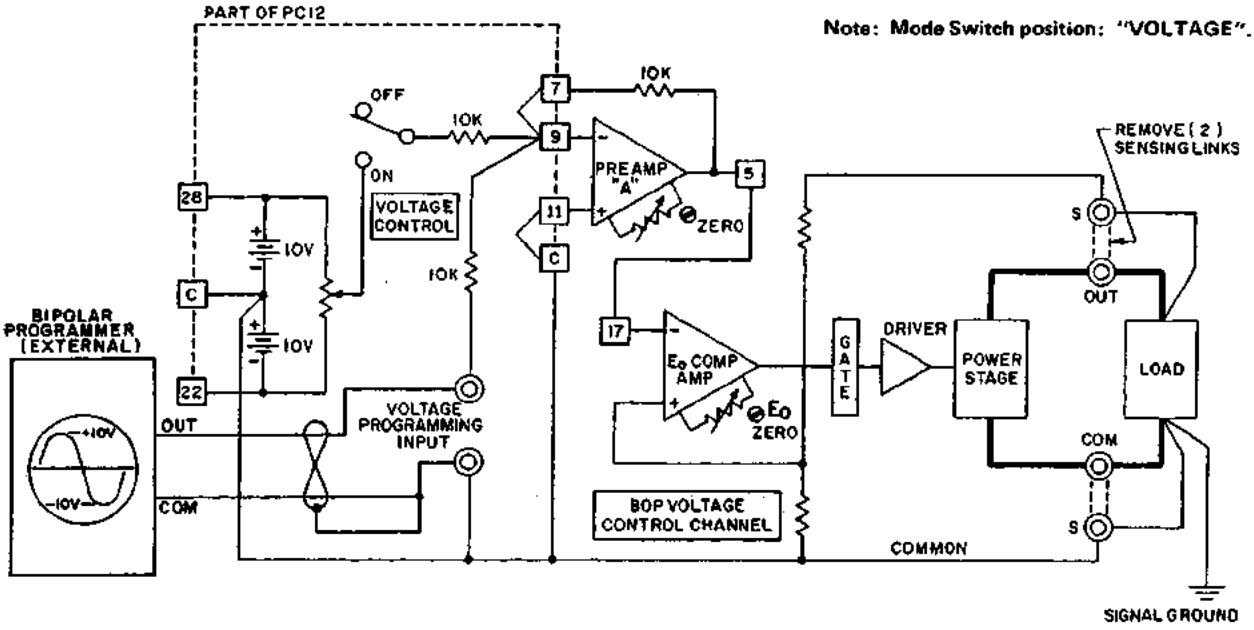


FIG. 3-9 BASIC PROGRAMMING CIRCUIT FOR USE OF THE BOP AS A BIPOLAR AMPLIFIER (VOLTAGE MODE)

3-26 If the EXT. PROGRAMMING SOURCE does not have sufficient amplitude to drive the BOP over its full output range, the gain of PREAMP "A" must be changed from the built-in value (one) to suit the application. To calculate the required components for the new gain requirement, the output equation for PREAMP "A" in the inverting configuration is used:

$$E_{o(\text{PREAMP "A"})} = -E_i\,(R_f/R_i)$$

where E_o (PREAMP "A") = ±10V, and the values of R_f and R_i depend on the available amplitude of the programming source. If, for example, a ±1 volt source is available, the ratio R_f/R_i must be 10, and the two resistor values can be 10K and 100K respectively. The built-in resistor (R_i = 10K) can be retained, and only R_f must be replaced with a 100K metal film (½ watt) unit. The necessary connections are illustrated in FIG. 3-10. Gain control (1 to 10) can be exercised by making R_f a rheostat instead of a fixed resistor.

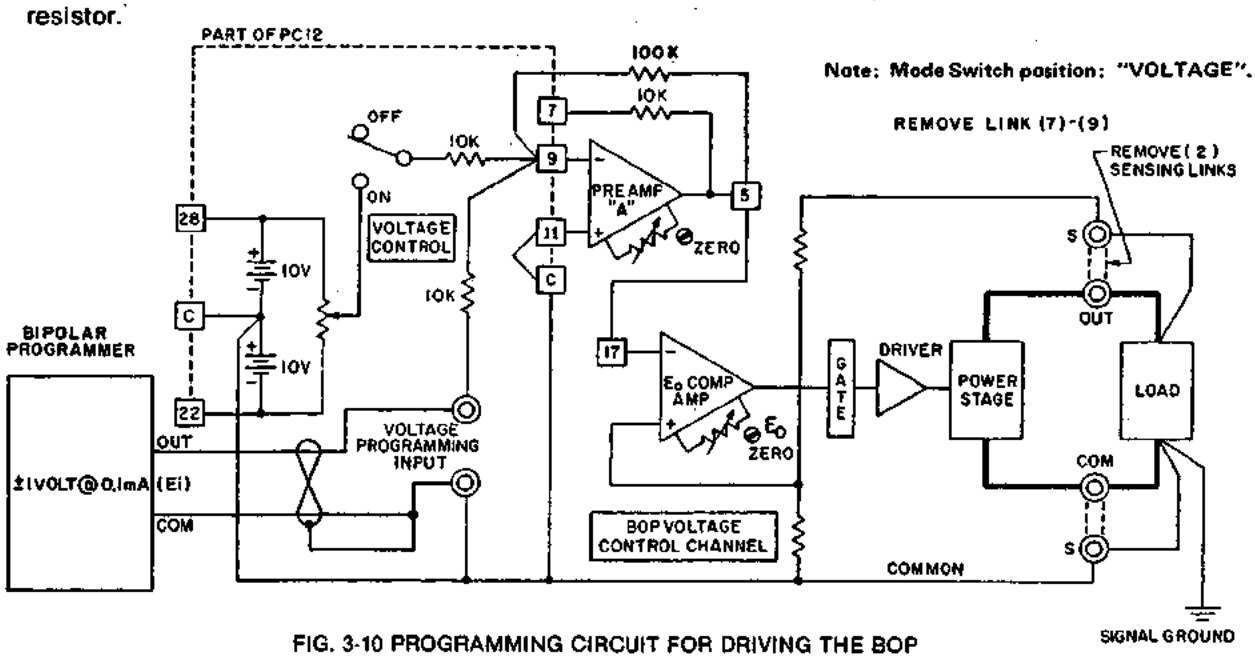


FIG. 3-10 PROGRAMMING CIRCUIT FOR DRIVING THE BOP OUTPUT VOLTAGE WITH A BIPOLAR (±1V) SIGNAL

3-27 The non-inverting input of PREAMP "A" is used for applications where the external programming source has a high impedance and/or cannot supply the necessary drive current, or where a positive going output swing is desired for a positive going input signal. The necessary connections are illustrated in FIG. 3-11 for a PREAMP "A" gain of unity (with the built-in value for R_i retained and a short across R_f), although other gain configurations can be chosen, according to the output equation for the non-inverting configuration:

$$E_{o\ (PREAMP\ "A")} = \frac{R_f + R_i}{R_i}$$

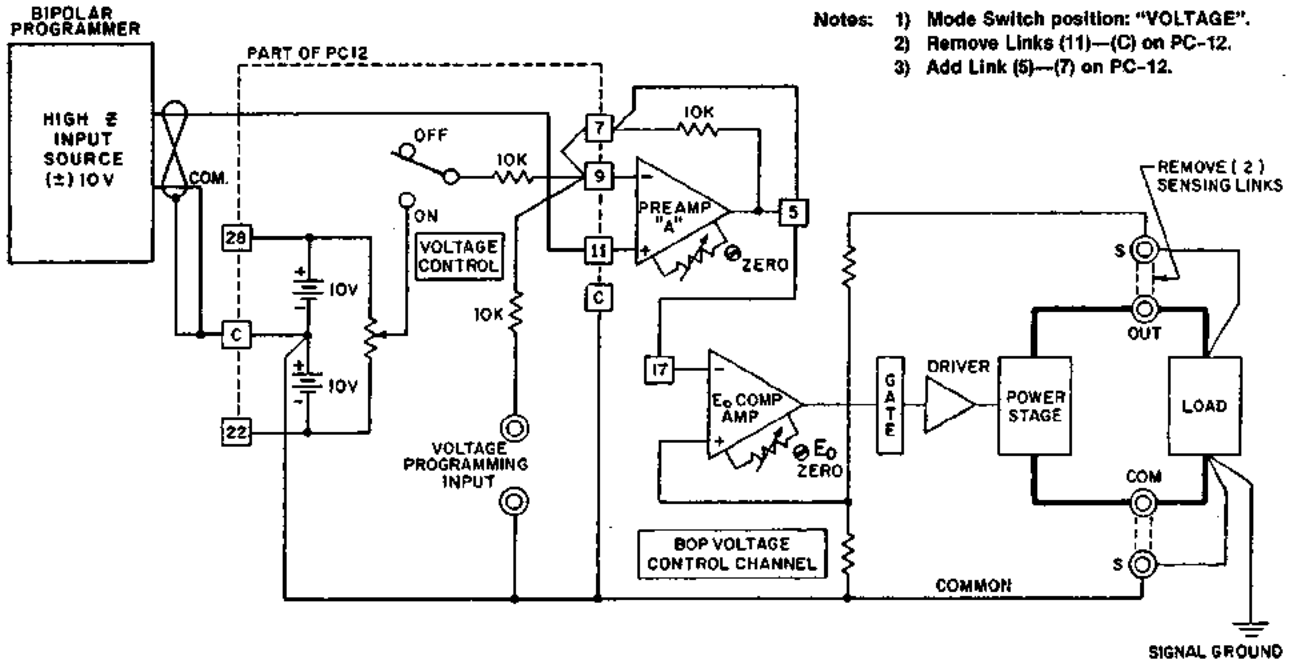


FIG. 3-11 PROGRAMMING CIRCUIT FOR DRIVING THE BOP OUTPUT VOLTAGE WITH A HIGH-IMPEDANCE SOURCE, USING THE NON-INVERTING INPUT OF PREAMP "A".

3-28 BOP OPERATION WITH REMOTE CONTROL OF THE CURRENT CONTROL CHANNEL

3-29 GENERAL: In the local (front panel) control mode, the BOP output current can be controlled by means of the CURRENT CONTROL, with the CURRENT CONTROL SWITCH closed, and the MODE SWITCH in the "CURRENT" position, over the full output range. The control potential (zero to (±)10V) is applied via PREAMP "B", operating with unity gain, to the I_o COMP. AMP which drives the POWER STAGE with a fixed gain as listed in Section I, Table 1-1. A d-c control signal from zero to (±)10 volts will, therefore, control the BOP output current through its specified range (refer to FIG. 3-12).

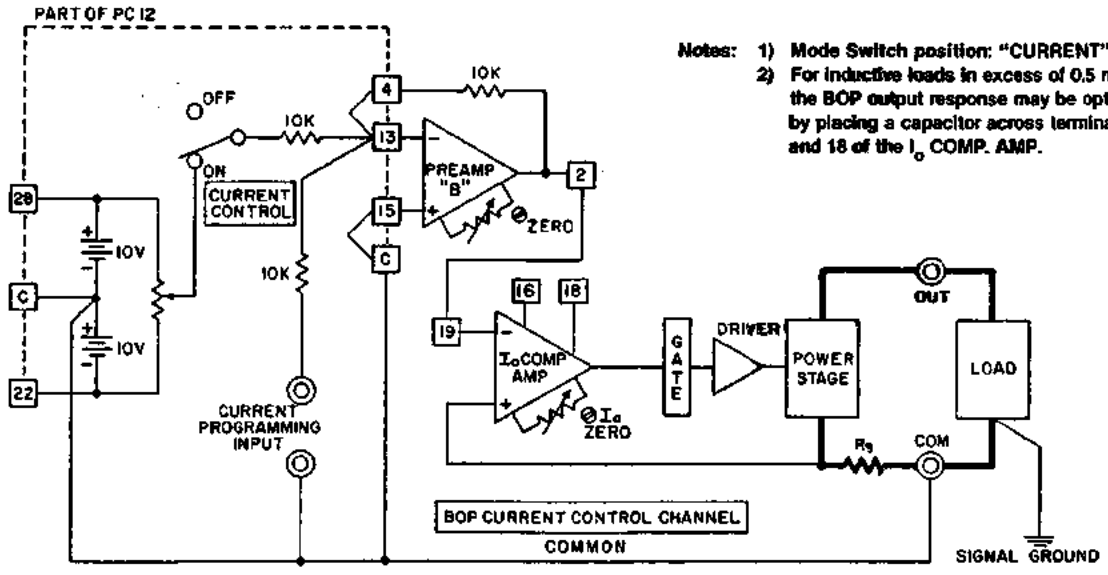


FIG. 3-12 LOCAL (FRONT PANEL) CONTROL OF THE BOP OUTPUT CURRENT WITH THE BIPOLAR CURRENT CONTROL

3-30 REMOTE CONTROL OF THE BOP CURRENT CHANNEL. Since the input signal requirements for the control of the BOP output current are the same as for programming the output voltage, and since the control circuitry of the current channel is almost identical to that of the voltage channel, all programming circuit descriptions for programming the output voltage of the BOP can be applied to current programming. The current programming circuits are illustrated in the following diagrams. Any comments, specifically applicable to current channel programming are noted on the diagrams. ***NOTE:*** *Adjust the "zero" output current point by means of the built-in ZERO control of PREAMP "B" or that of the I_0 COMP. AMP.*

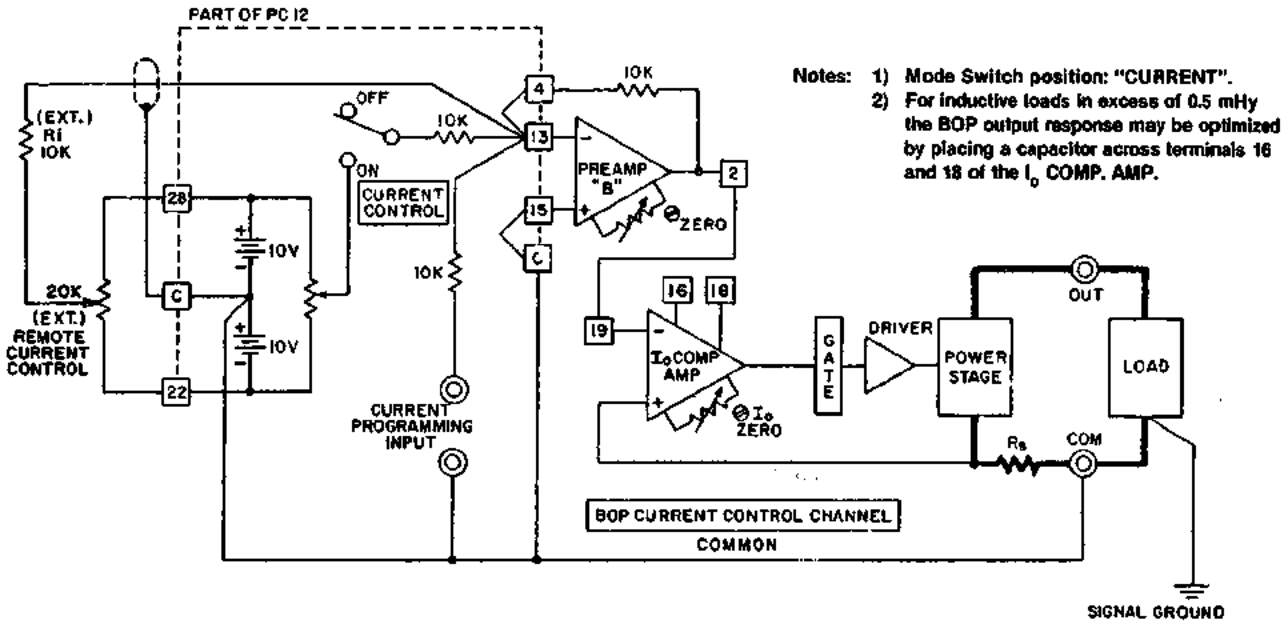


FIG. 3-13 REMOTE POTENTIOMETER CONTROL OF THE BOP OUTPUT CURRENT

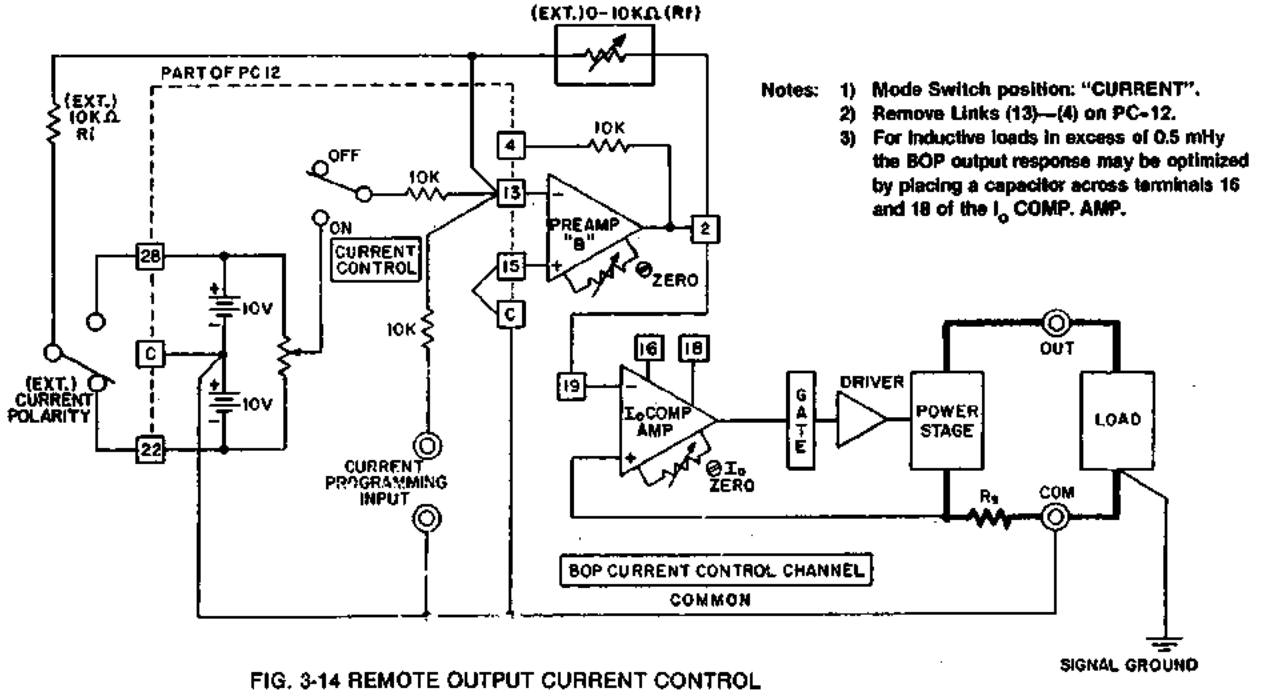


FIG. 3-14 REMOTE OUTPUT CURRENT CONTROL BY MEANS OF A TWO-TERMINAL RESISTANCE.

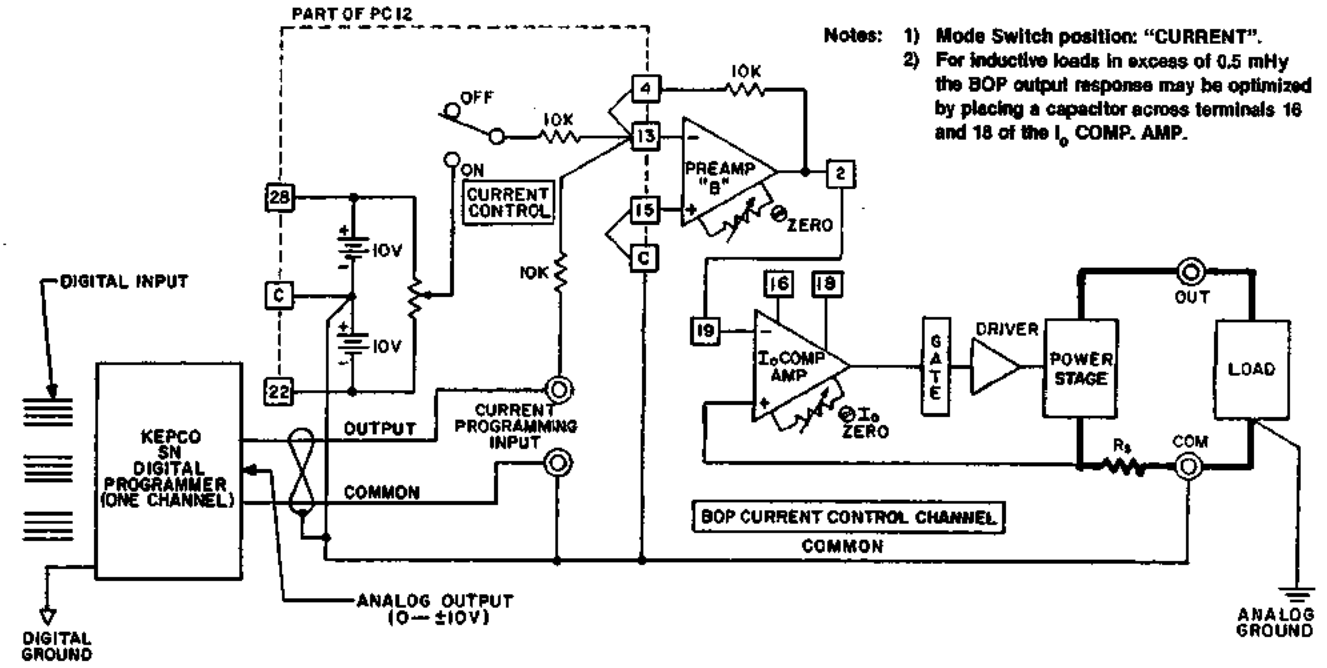


FIG. 3-15 DIGITAL CONTROL OF THE BOP OUTPUT CURRENT

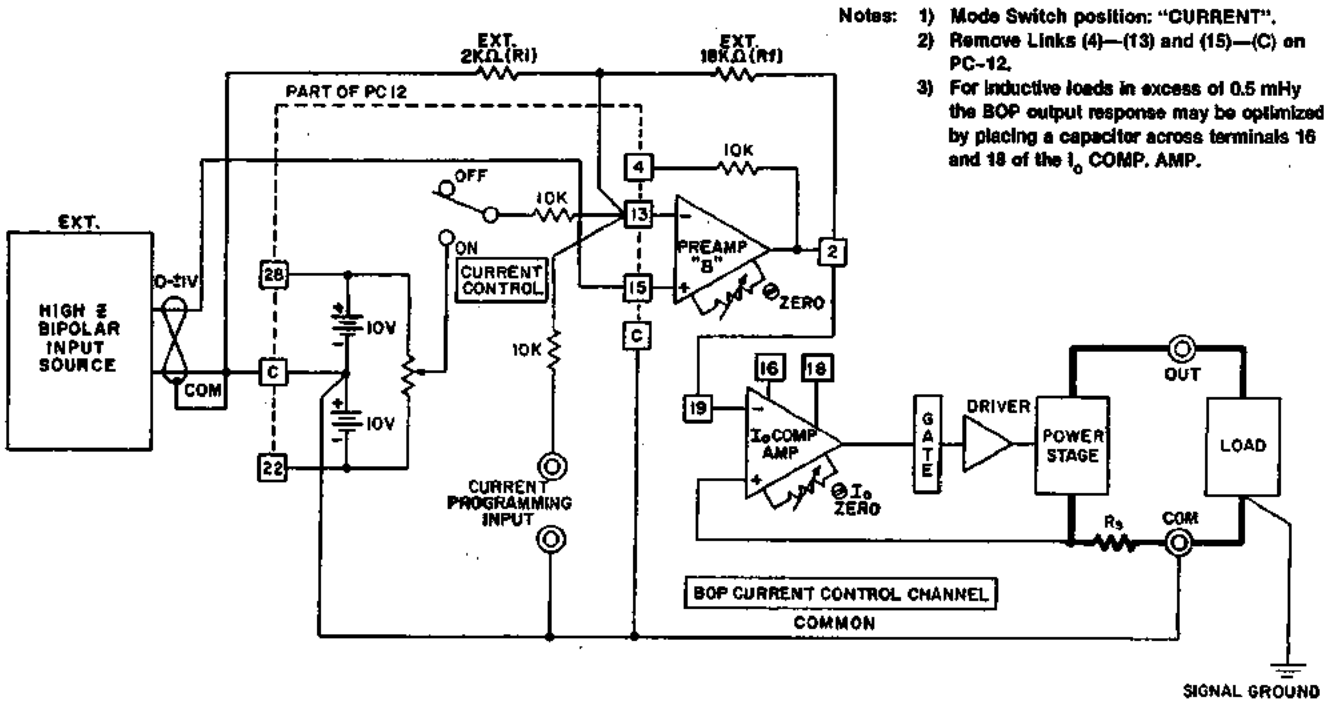


FIG. 3-16 BOP OUTPUT CURRENT CONTROL WITH A HIGH IMPEDANCE (±)1 VOLT SIGNAL SOURCE

NOTE: The non-inverting input of the Pre-amplifier is used to prevent loading of the input source.

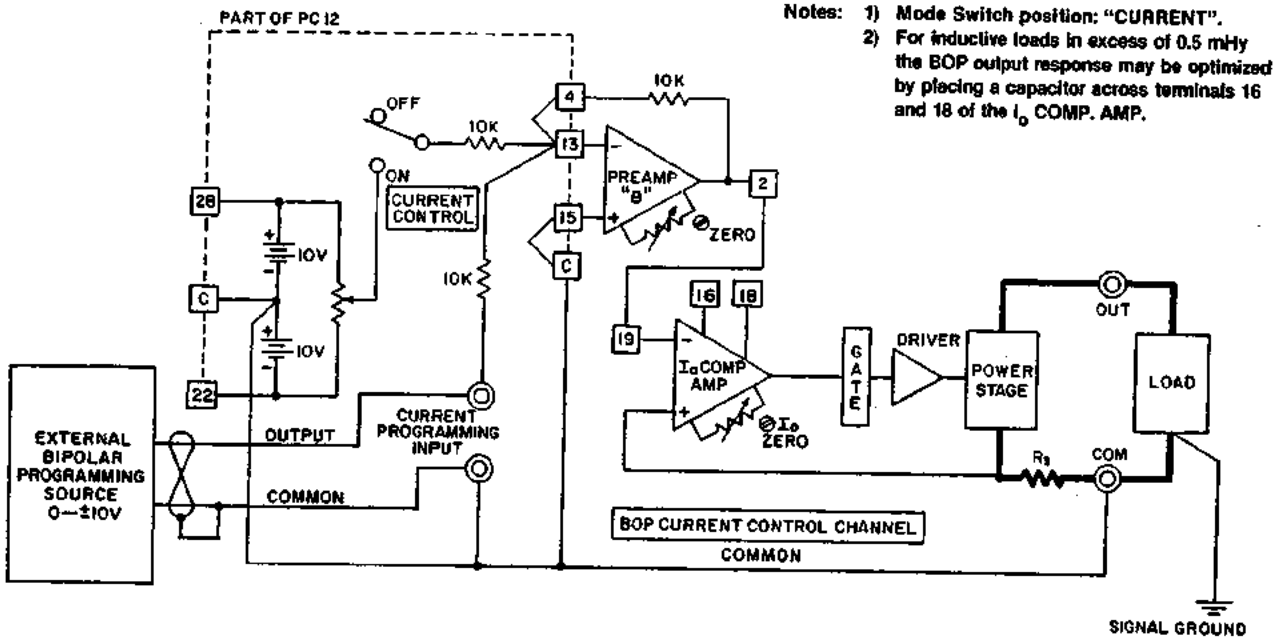


FIG. 3-17 BASIC PROGRAMMING CIRCUIT FOR USE OF THE BOP AS A BIPOLAR CURRENT-STABILIZED AMPLIFIER.

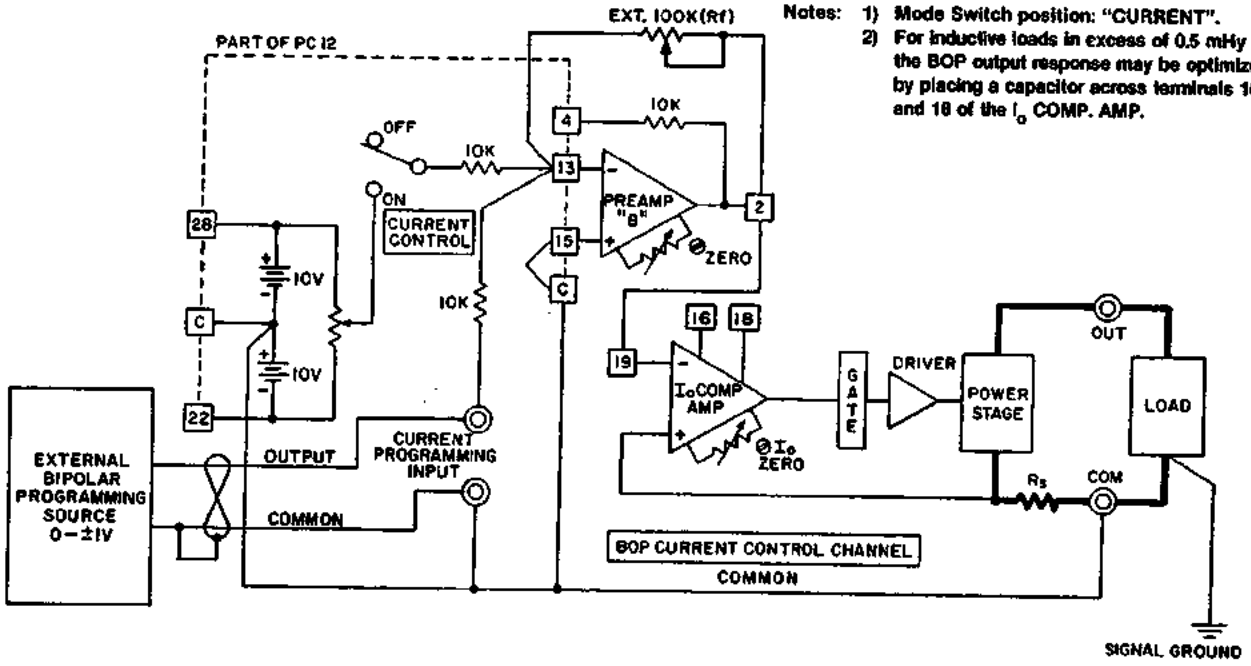


FIG. 3-18 PROGRAMMING CIRCUIT FOR DRIVING THE BOP OUTPUT CURRENT WITH A BIPOLAR SIGNAL LESS THAN ±10V (EXAMPLE SHOWN: ± 1V SOURCE)

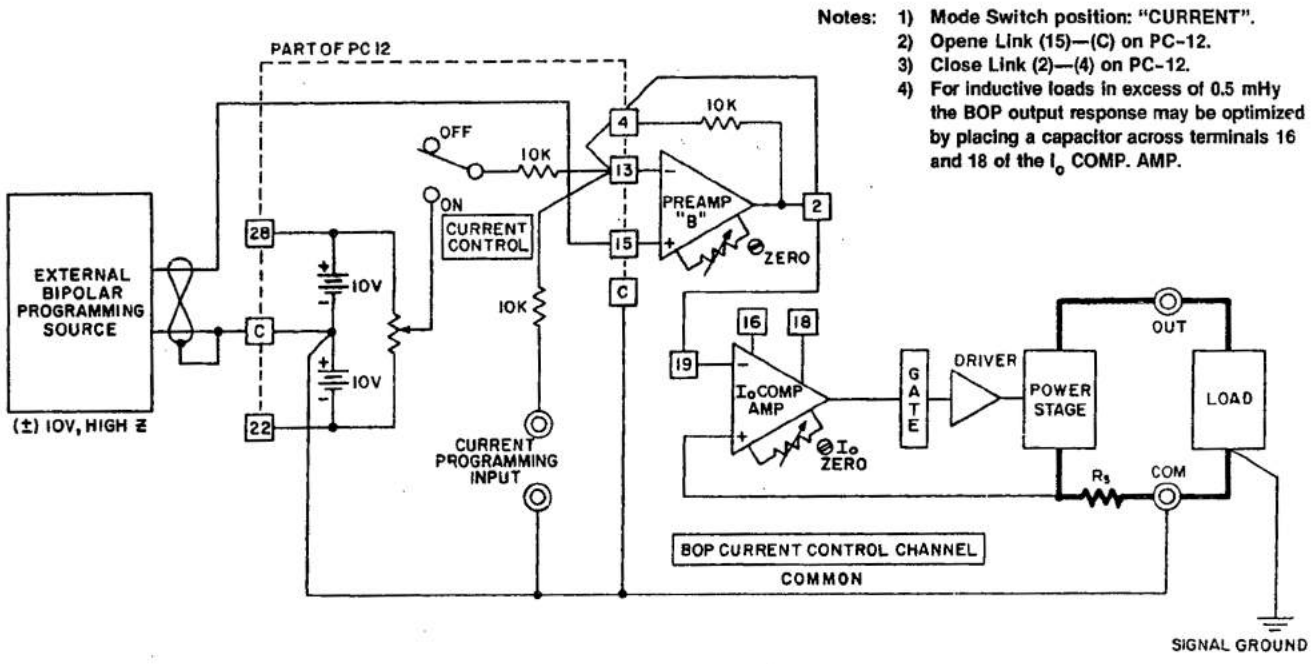


FIG. 3-19 PROGRAMMING CIRCUIT FOR DRIVING THE BOP OUTPUT CURRENT WITH A HIGH IMPEDANCE SOURCE

3-31 REMOTE CONTROL OF THE BOP CURRENT LIMIT (Refer to FIG. 3-35.)

3-32 The output current is sensed by the current sensing resistor (R_s). The voltage drop across R_s is proportional to the output current value, and is amplified by a current sensing amplifier (not shown in FIG. 3-20) and is applied at the input to the (−) I_o LIMIT COMPARISON AMPLIFIER and to the (+) I_o LIMIT COMPARISON AMPLIFIER. In the local (front panel) control mode, as well as in the external control mode, a 0 to 10 volt signal, applied at the inverting inputs of the ± I_o LIMIT COMPARISON AMPLIFIERS, will control the current limit point over the entire output current range of each BOP model. For the internal (front panel) control mode, the control signal is derived across both 10 volt reference sources, applied by means of the ± I_o LIMIT controls to the internal ± I_o LIMIT AMPLIFIERS (both connected as 1:1 voltage followers) and directed to the respective inputs of the ± I_o LIMIT COMPARISON AMPLIFIERS. In the internal control mode, both ± I_o LIMIT AMPLIFIERS (EXT) are biased "off" by means of the 15V BIAS source.

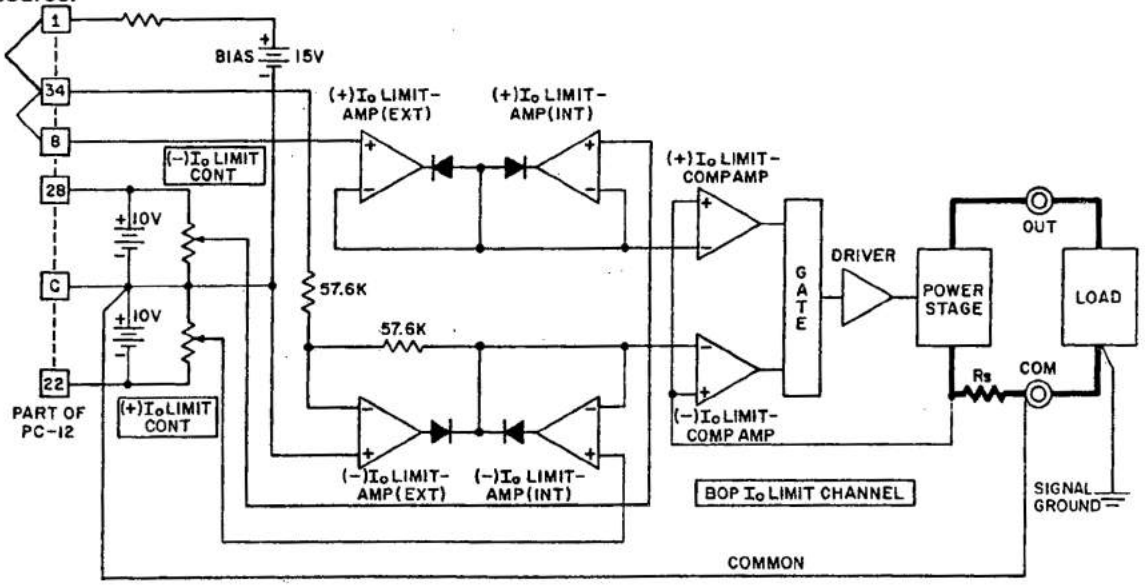


FIG. 3-20 LOCAL (FRONT PANEL) CONTROL OF THE BOP CURRENT LIMIT CIRCUIT

3-33 In the external control mode, the ± I_o LIMIT AMPLIFIERS (EXT) are disconnected from the 15V BIAS source (jumper 1-8 removed) and external 0-10V control signal is applied to terminals 8 and 34, with reference to COMMON. This control signal will program both, the negative as well as the positive current limit simultaneously and symmetrically over the BOP output current range (See FIG. 3-21). If individual control of the ± current limits is desired, the jumper 8-34 must be removed and separate control sources must be connected, 0-10 volts to pin 8 for the (+) I_o limit, and 0-10 volts to pin 34 for the (−) I_o limit, both with reference to COMMON (See Fig. 3-22).

NOTE: *The front panel ± I_o LIMIT controls serve as a back-up when external current limit programming is used. The controls should be set to a value slightly larger than the external current limits that are to be programmed.*

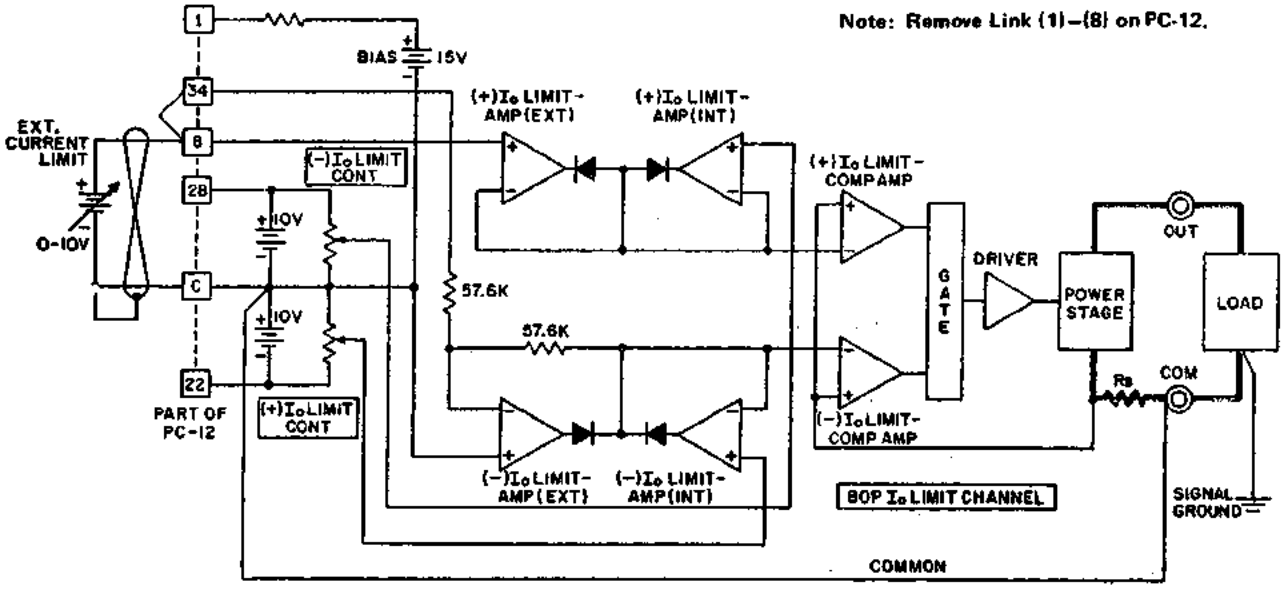


FIG. 3-21 SYMMETRICAL REMOTE CONTROL OF THE BOP CURRENT LIMITS

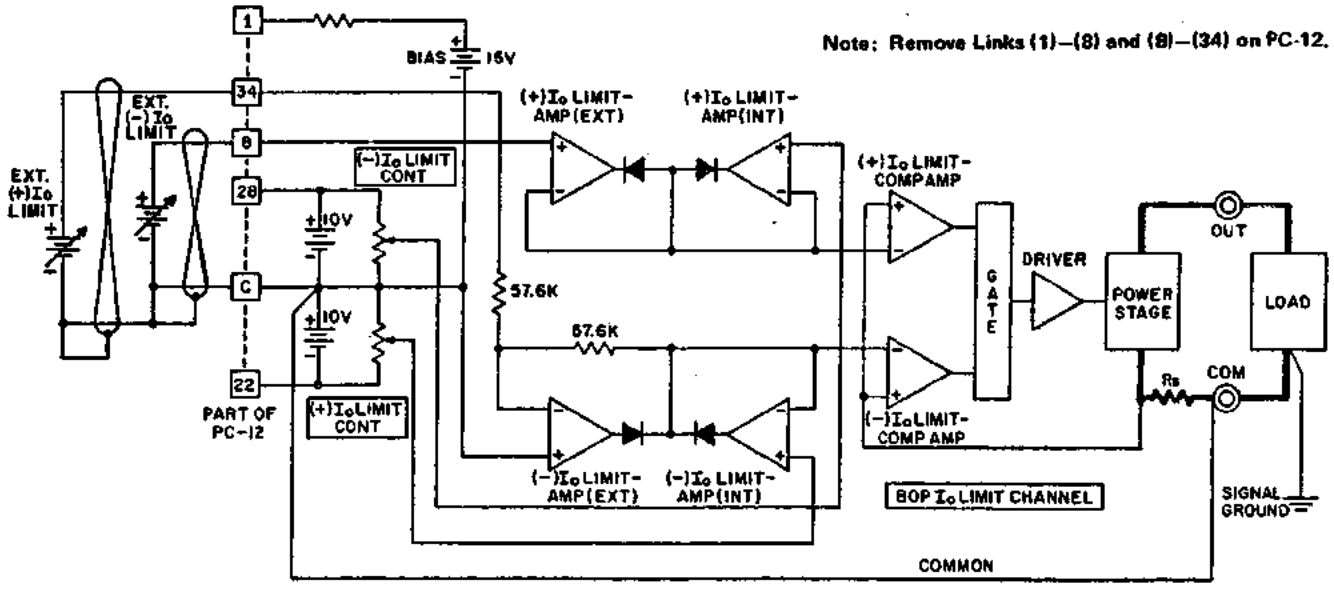


FIG. 3-22 INDEPENDENT REMOTE CONTROL OF THE BOP (+) I_o AND (−) I_o LIMITS

3-34 REMOTE CONTROL OF THE BOP VOLTAGE LIMIT

3-35 The BOP E_o LIMIT CIRCUIT in the local (front panel) control mode is shown in FIG. 3-23. The circuit functions in a similar manner as the I_o LIMIT CIRCUIT described previously (refer to Paragraph 3-31), except that the voltage limit feedback is derived by means of a voltage divider across the BOP output. The ± voltage limit can be remotely controlled symmetrically with a 0 to 10V d-c source, or the (+) and (−) voltage limit can be controlled independently by individual 0 to 10V d-c sources, The necessary circuit connections are illustrated in FIG.'s 3-24 and 3-25.

***NOTE:** The front panel VOLTAGE LIMIT CONTROLS serve as a "back-up" when remote controlling the voltage limits on the BOP. The front panel VOLTAGE LIMIT CONTROLS should be set to their maximum positions if full range remote control of the BOP voltage limit is desired.*

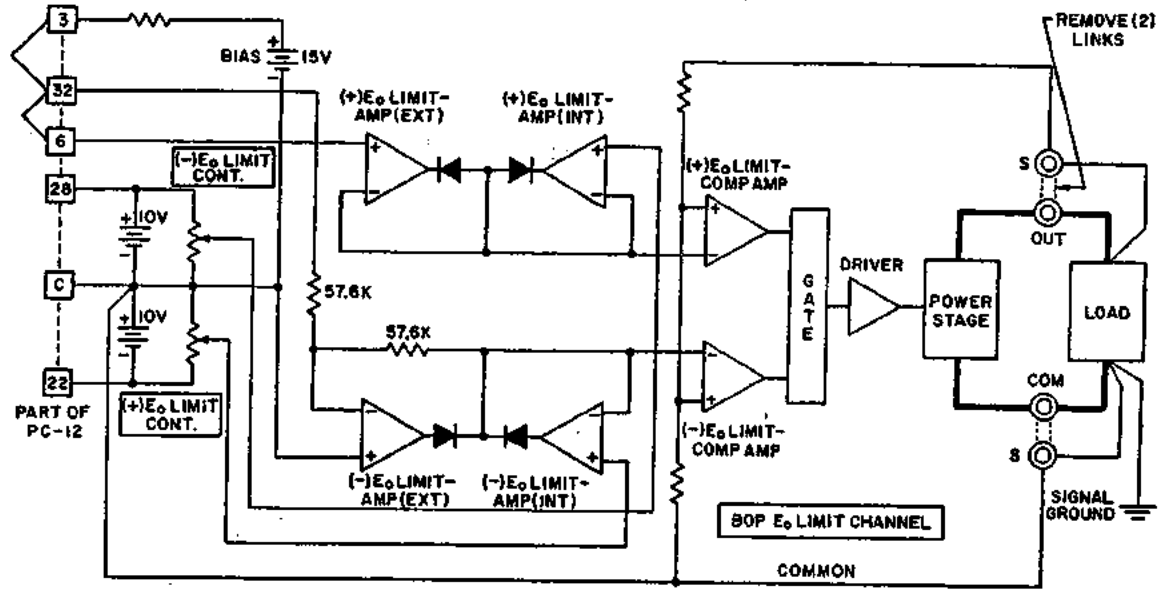


FIG. 3-23 LOCAL (FRONT PANEL) CONTROL OF THE BOP VOLTAGE LIMIT CIRCUITS

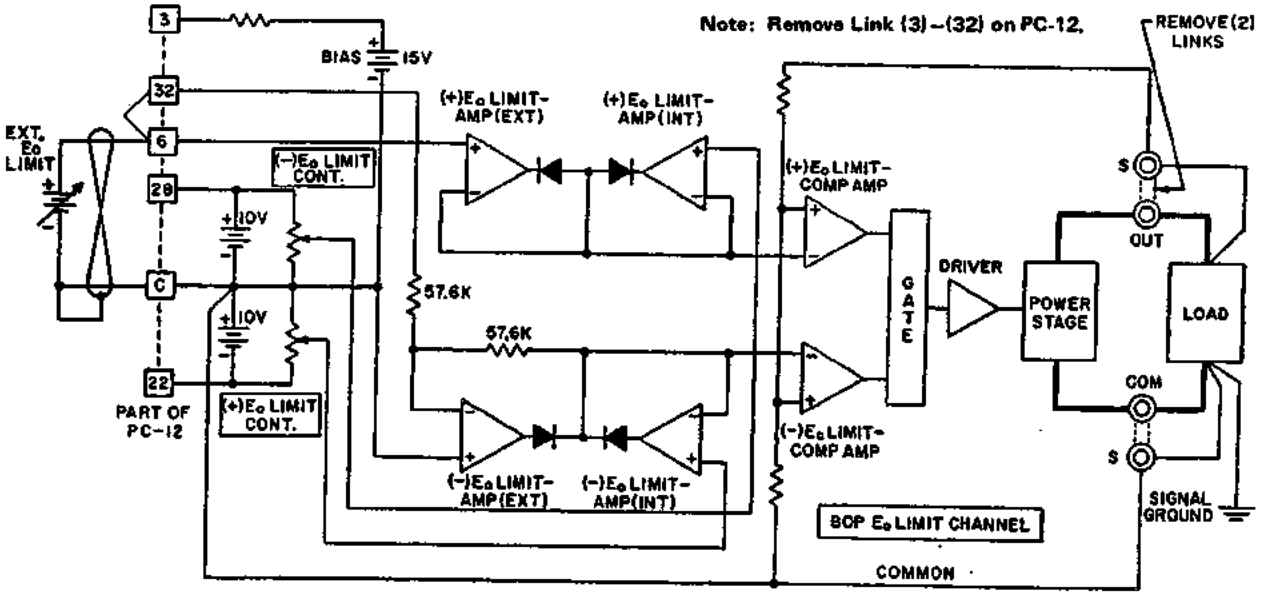


FIG. 3-24 SYMMETRICAL REMOTE CONTROL OF THE BOP VOLTAGE LIMIT CIRCUITS

Note: Remove Links (3)–(32) and (6)–(32) on PC-12.

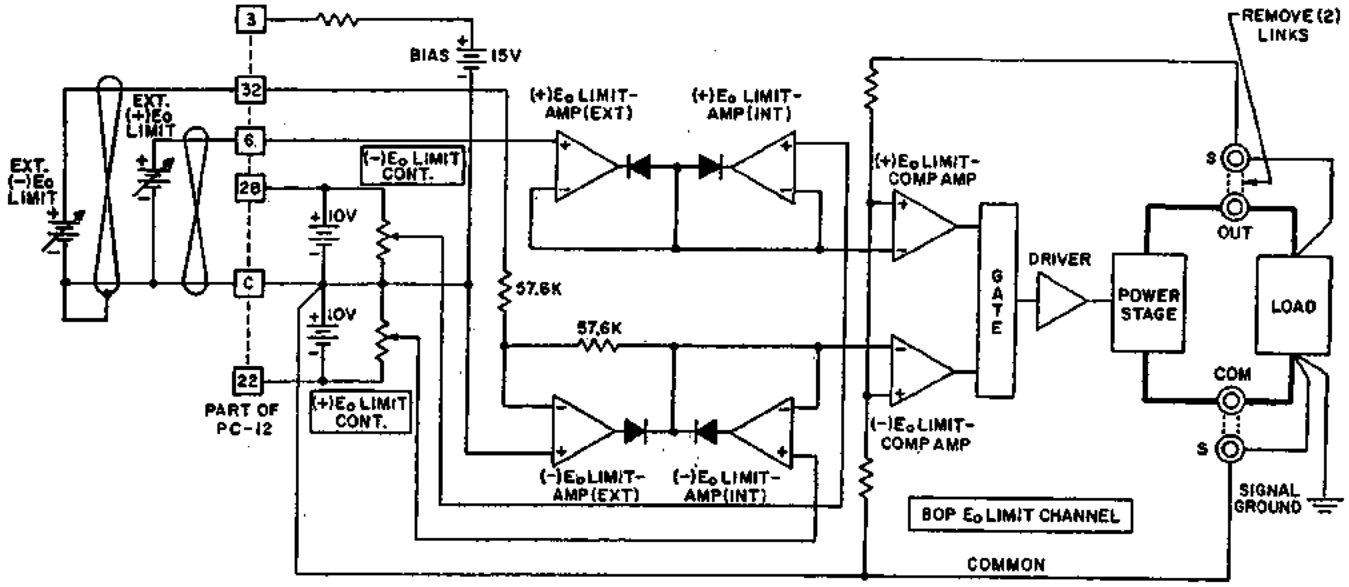


FIG. 3-25 INDEPENDENT REMOTE CONTROL OF THE BOP
(+) E_o AND (−) E_o VOLTAGE LIMIT CIRCUITS

3-36 SERIES AND PARALLEL CONNECTION OF BOP POWER SUPPLIES.

3-37 GENERAL. Voltage sources, such as batteries, cells or stabilized d-c power supplies can be readily series-connected, but normally, they can not be paralleled. Even minute differences in their terminal potential would cause large, damaging circulating currents. By complementary reasoning, current sources can easily be paralleled, but not series-connected. Fortunately, with practical stabilized power supplies these difficulties can be overcome in various ways.

3-38 There are two basic methods which are commonly used for the series or parallel connection of stabilized d-c power supplies. The first method is the "AUTOMATIC" series or parallel connection by which the power supply outputs are simply connected together, in series or parallel, as required. The individual supplies can now be adjusted to the load requirements. The "AUTOMATIC" method presents no problems as long as it is confined to SERIES connection with voltage sources, or to PARALLEL connection with current sources. As far as the BOP is concerned, the only thing to remember is to place the MODE switch into its proper position:

AUTO-SERIES CONNECTION: All BOP MODE SWITCHES TO "VOLTAGE"

AUTO-PARALLEL CONNECTION: All BOP MODE SWITCHES TO "CURRENT".

3-39 The second method for series or parallel connection of two or more units is the "MASTER/SLAVE" configuration, by which a designated MASTER supply controls the output of one or more SLAVE units. This control method permits control of the common output by a single unit - the MASTER. Since this method presents the least problems for either series or parallel connections and since it is readily implemented with BOP power supplies, it is the recommended method for this kind of operation and will be fully described below.

3-40 MASTER/SLAVE SERIES CONNECTION OF TWO BOP SUPPLIES, PROCEDURE:

1) Connect the BOP supplies as shown in FIG. 3-26. Set the MODE switches and the VOLTAGE CONTROL switches as directed in the set-up diagram, FIG. 3-26. Load-wire size should be as large as practicable and load-wire pairs should be twisted to keep the d-c resistance, as well as the inductance as low as possible. Use shielded cable for connecting the coupling resistor (R_T). Connect shield to common ground. Either the positive, or the negative output side of the system can be grounded.
2) Both BOP power supplies should be connected to the power line using a common circuit breaker. Alternatively, the BOP Circuit-Breaker Control Circuit, as described in Section III, paragraph 3-83 can be used to interconnect both BOP's in such a way, that if one of them should fail, the other one is automatically shut down also.
3) The coupling resistor (R_T) should be either a wire-wound or a metal film unit with a low temperature coefficient. It is calculated by:

$$R_T \text{ (Kohms)} = E_{OM} \text{ (MAX) Volts - 10 Volts,}$$

where E_{OM} (MAX.) is the rated maximum output voltage of the BOP MASTER supply. This value of R_T will be able to drive the BOP SLAVE unit to its ($\pm$) maximum output voltage, as the BOP MASTER is controlled through its range.
4) Following the set-up procedures as described above, turn BOP's "on" and commence operation. The system as shown in the set-up diagram (FIG. 3-26) operates in the Voltage Mode, since the MASTER MODE switch is in "VOLTAGE" position. For operation in the Current Mode, transfer the MASTER MODE switch to "CURRENT".

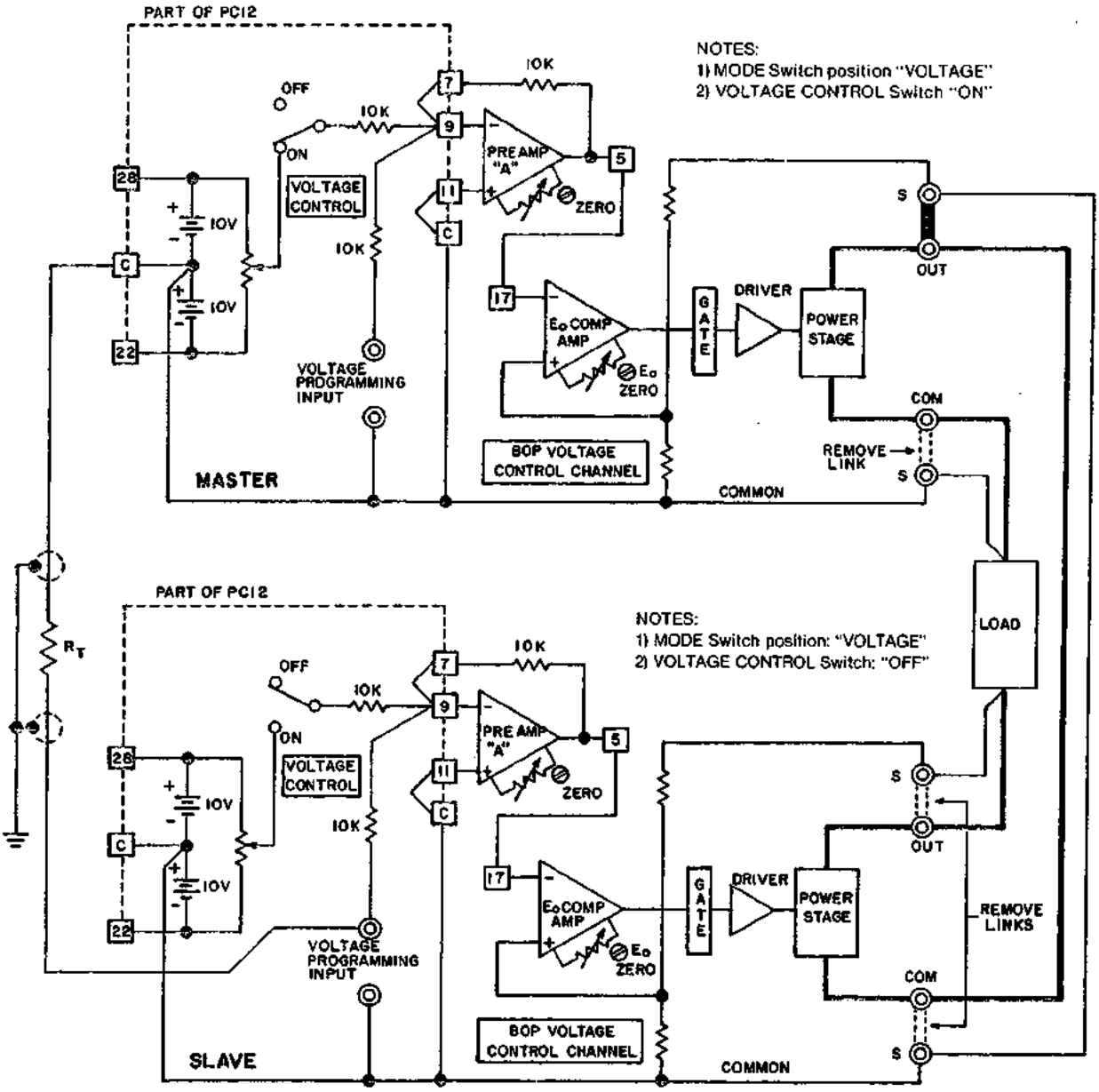


FIG. 3-26 MASTER/SLAVE SERIES CONNECTION OF TWO BOP POWER SUPPLIES, WITH ERROR SENSING AT THE COMMON LOAD.

NOTE: *Remove grounding network on SLAVE unit by opening the Link (4)-(5) on the rear barrier strip (TB201).*

3-41 MASTER/SLAVE PARALLEL CONNECTION OF TWO BOP SUPPLIES, PROCEDURE:

1) Connect the BOP supplies as shown in FIG. 3-27. Set the MODE switches and the VOLTAGE and CURRENT CONTROL switches as directed in the set-up Diagram, FIG. 3-27. Load-wire size should be as large as practicable and load-wire pairs should be twisted to keep the d-c resistance, as well as the inductance, as low as possible. Use shielded cable for the drive signal connection between the BOP's. Connect the shield to common ground. Either the positive or the negative output side of the system can be grounded.
2) Both BOP power supplies should be connected to the power line using a common circuit breaker. Alternatively, the BOP Circuit-Breaker Control Circuit, as described in Section III, paragraph 3-83 can be used to interconnect both BOP's in such a way, that if one of them should fail, the other one is automatically shut down also.
3) Following the set-up procedure as described above, turn BOP's "on" and commence operation. The system as shown in the set-up diagram (FIG. 3-27) operates in the Voltage Mode, since the MASTER MODE switch is in "VOLTAGE" position. For operation in the current mode, transfer the MASTER MODE switch to "CURRENT".

3-42 MASTER/SLAVE SERIES OR PARALLEL CONNECTIONS FOR MORE THAN TWO BOP POWER SUPPLIES.

The concept of series connecting or paralleling two BOP power supplies can be extended to include interconnection of more than two BOP units. The limitations applying to the series-connection is the isolation limit of the BOP itself (500V), while that of the parallel connection is the load-wire size required for larger and larger loads.

3-43 To extend the concept of series connection to more than two BOP units, refer to FIG. 3-26. The BOP unit now designated the SLAVE becomes the new MASTER for the next BOP unit to be added and so on, up to the desired number of BOP's in series. Simply place the BOP outputs in series and connect a further coupling resistor (R_T) from the ***present*** SLAVE, terminal [C] to the ***new*** SLAVE, front panel VOLTAGE PROGRAMMING INPUT. Place the MODE switch on the BOP added to the series combination to VOLTAGE and the VOLTAGE CONTROL switch OFF.

3-44 To add more BOP units to the parallel system shown in FIG. 3-27, simply place the output leads of the unit to be added in parallel to the load. Set its MODE switch to CURRENT and its CURRENT CONTROL switch to OFF. Now connect another shielded cable from the BOP designated MASTER in FIG. 3-27, terminal [10] on PC-12, to the new BOP to be added, PC-12 terminal [19].

3-45 All series/parallel systems of BOP power supplies should be interconnected via the BOP Circuit Breaker Control Circuit, as described in Section III, paragraph 3-83. This failure detection loop will shut down ***all*** BOP units in a series or parallel system if one of them fails.

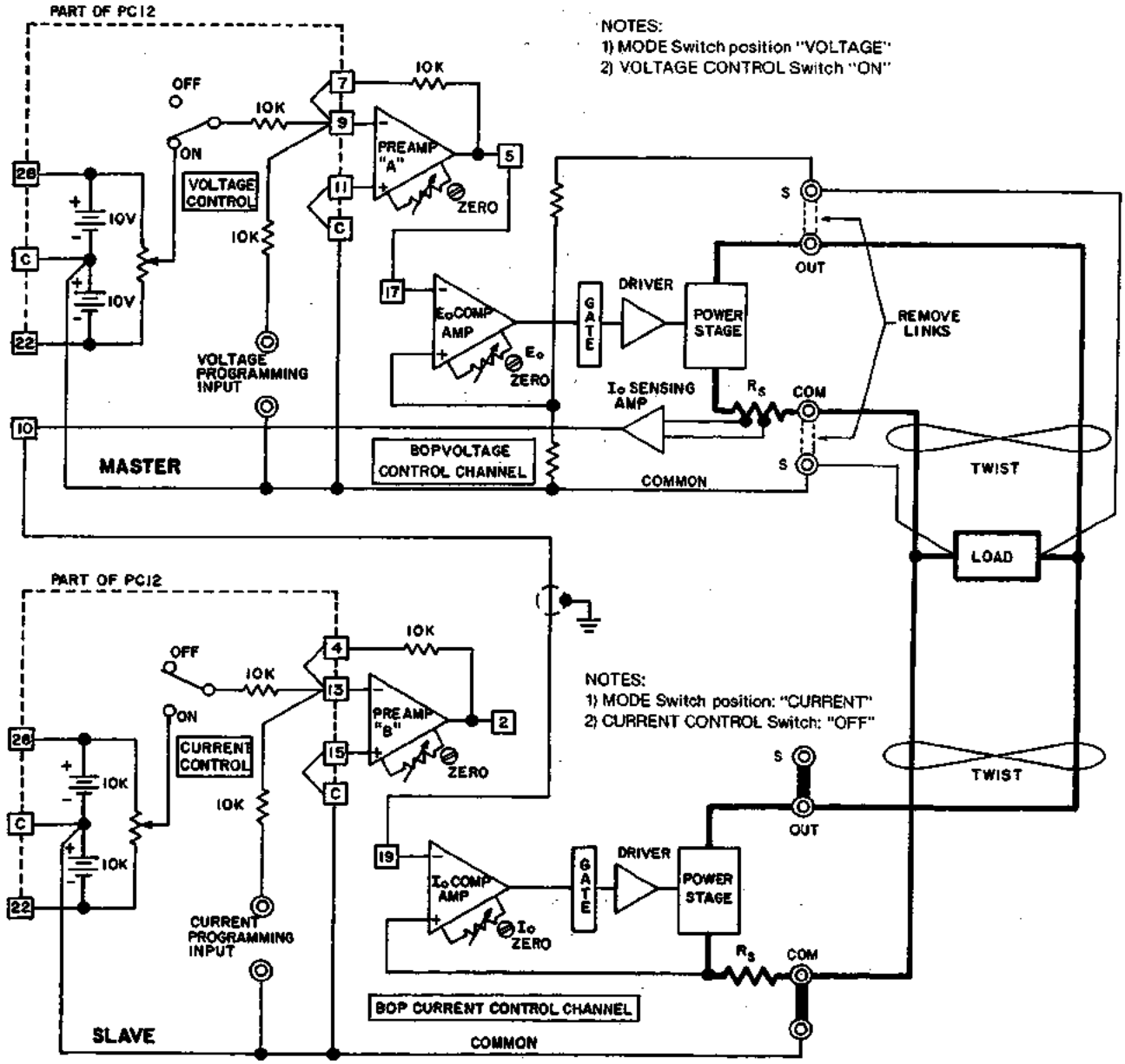


FIG. 3-27 MASTER/SLAVE PARALLEL CONNECTION OF TWO BOP POWER SUPPLIES

3-46 DIGITAL CONTROL OF BOP POWER SUPPLIES.

3-47 The output of the BOP power supply, that is, the output voltage and the output current limit, with the BOP in the Voltage Mode of operation, or the output current and the output voltage limit with the BOP in the Current Mode of operation, may be digitally controlled by means of a Kepco Digital Programmer. Kepco Digital Programmers accept data from serial or parallel data buses and convert this data to an analog output voltage which, in turn, controls the output parameters of the connected BOP power supply.

3-48 The following paragraphs present a brief overview of the available Kepco programming interfaces. Each of these devices is delivered with its own instruction manual, which provides the necessary details for operation, programming and maintenance.

3-49 Common features of all Kepco programming interfaces include optical isolation of digital input and analog output, dual, selectable output ranges of 0 to 1V or 0 to 10V, and output polarity control, making them suitable for unipolar or bipolar power supply programming.

3-50 Since the output of all Kepco Digital Programmers is a linear, analog voltage of either 0 to 1V, or 0 to 10V, depending on the range selected, all programming examples in this section (Section III) which show an external programming source may be used for digitally programming the BOP power supply. Although the given examples show single function applications only, simultaneous programming of several output functions, such as voltage control with current limit or current control with voltage limit may be performed with all digital programmers having more than one output channel.

3-51 KEPCO DIGITAL PROGRAMMERS.

3-52 The SN GROUP consits of the following models:

	MODEL SN 488-				MODEL SN 500-			
	121	122	031	032	121	122	031	032
CHANNELS	1	2	1	2	1	2	1	2
INPUT DATA CODE	ASCII/HEX		ASCII/BCD		ASCII/HEX		ASCII/BCD	
RESOLUTION	12 bit		3 DIGIT		12 bit		3 DIGIT	
OUTPUT	0-1V or 0-10V		0-1V or 0-10V		0-1V or 0-10V		0-1V or 0-10V	

3-53 SN 488 SINGLE OR DUAL CHANNEL DIGITAL PROGRAMMERS

3-54 The Kepco SN 488 Programmers were designed to operate on the GPIB (IEEE 488) bus. Once addressed by the controller with their unique, presetable address code and placed in the Data Mode, they accept a sub-set of the 7-bit ASCII code ("0" through "9", "A" through "F") having the following data format and sequence: NCVVV (ASCII)

Byte 1 — N = Channel Select, "1" or "2".

Byte 2 — C = Control Character: C = "0" Pos. Out, High Range

Byte 3 — VVV = Output Volts C = "1" Neg. Out, High Range

Byte 4 — as a percentage of full C = "2" Pos. Out, Low Range

Byte 5 — scale C = "3" Neg. Out, Low Range

3-55 Data transfer is byte-serial. The output voltage bytes (3 to 5) may be encoded in hexadecimal notation (000 to FFF) for models SN 488-121 and SN 488-122 and in BCD notation (000 to 999) for SN 488-031 and SN 488-032. The data transfer time is approximately 60μsec.

3-56 SN 500 SINGLE OR DUAL CHANNEL DIGITAL PROGRAMMERS

3-57 The Kepco SN 500 programmers were designed to operate on bit parallel data buses. The SN 500 accepts either positive or negative logic (selectable) on its input port. The SN 500 programmer is terminated with a 50-pin edge connector with pin-outs as shown below (See paragraph 3-59). The magnitude field input data may be BCD for SN 500-021 and SN 500-022 or BINARY for SN 500-121 and SN 500-122.

3-58 Data transfer is bit-parallel and is controlled by the STROBE pulse and the internally created BUSY signal following each STROBE (externally applied, 2μsec min.). Data transfer time is approximately 35μsec., although the data lines are free for other purposes, following the 2μsec. STROBE.

3-59 INPUT/OUTPUT CONNECTOR, PIN-OUT.

A) PIN 2 — $\overline{\text{SERIAL INPUT}}$
PIN 4 — $\overline{\text{SERIAL OUTPUT}}$
PIN 6 — SERIAL OUTPUT

WIRE JUMPER FOR NEGATIVE LOGIC

WIRE JUMPER FOR POSITIVE LOGIC (SUPPLIED)

Pins 2, 4 and 6 serve to select either POSITIVE LOGIC (L = 0, H = 1) by placing the jumper from pin 2 to pin 6, or NEGATIVE LOGIC (L = 1, H = 0) by placing the jumper from pin 2 to pin 4. The $\overline{\text{SERIAL INPUT}}$ may also be used for other purposes and may be syncronized by means of the $\overline{\text{SHIFT CLOCK}}$ output.

B)

PIN 8 — RANGE, CHANNEL 1	L = HIGH RANGE (0-10V)	H = LOW RANGE (0-1V)
PIN 10 — POLARITY, CHANNEL 1	L = POSITIVE OUTPUT	H = NEGATIVE OUTPUT
PIN 12 — RANGE, CHANNEL 2	L = HIGH RANGE (0-10V)	H = LOW RANGE (0-1V)
PIN 14 — POLARITY, CHANNEL 2	L = POSITIVE OUTPUT	H = NEGATIVE OUTPUT

All four RANGE and POLARITY selection terminations have been provided for manual preselection of range and polarities on both channels. If RANGE and POLARITY are machine controlled, only pins 8 and 10 are needed, since a CHANNEL SELECTOR command is required to preselect each channel. ***NOTE:*** *Pin 12 should be connected to pin 8 while pin 14 should be connected to pin 10. If, however, the application calls for fixed polarity and range, the appropriate pins can be hardwire according to the requirements.*

C) MAGNITUDE FIELD, DATA INPUT PINS:

PINS:	16	18	20	22	24	26	28	30	32	34	36	38
BITS:	12 MSB	11	10	9	8	7	6	5	4	3	2	1 LSB
DECADE	10^{-1}				10^{-2}				10^{-3}			
BCD	8	4	2	1	8	4	2	1	8	4	2	1

D) PIN 40 D-C LOGIC SUPPLY OUTPUT, 5V at 20mA maximum. May be used to connect pull-up resistors for establishing pre-wired logic states or to drive external logic within the given rating.

E) PIN 42—$\overline{\text{STROBE}}$. The negative going edge of the strobe signal (H—L) enables the loading of the Temporary Storage Registers with the data presented on the data pins. *The minimum duration of $\overline{\text{STROBE}}$ must be 2μsec.*

F) PIN 44—BUSY (H = BUSY, L = NOT BUSY). This output delivers a status signal to the bus. On the first clock transition (H—L), following the STROBE signal, the BUSY line goes high (H) and remains high until the first clock transition (H—L) following data transfer (approximately 35μsec.), indicating the SN 500 is ready to accept new data.

G) PIN 46—CHANNEL SELECT (H = CHANNEL 1, L = CHANNEL 2).

H) PIN 48—$\overline{\text{SHIFT CLOCK}}$. This output is used to synchronize the external SERIAL INPUT, if used.

J) PIN 50—SHIELD (CHASSIS). Chassis and Case connection of the SN 500.

K) PINS 1 thru 49 (Odd No.'s): LOGIC GROUND and LOGIC SUPPLY COMMON.

3-60 THE SNR PROGRAMMING SYSTEM

3-61 The Kepco SNR 488 Programming System consists of a full-rack housing with built-in interface card for the GPIB (IEEE 488) bus and several optional plug-in cards, each able to control 2 channels with a common connection.

3-62 The Model SNR 488-8 housing can accomodate eight (8) plug-in cards, while Model SN 488-4 seats four (4) cards and in addition has room for either two Kepco quarter-rack or one half-rack size power supply. Each housing is connected to the bus via a single cable, which serves all plug-in cards. Each SNR housing has a device address selector switch, while individual cards addresses are handled by means of the input command string to the SNR and a presetable address selector switch for each card.

3-63 SNR 488 programmers, when connected to the bus, addressed by the controller with their unique, presetable address code and placed in the data mode, accept a sub-set of the 7-bit ASCII code ("0" through "9", "A" through "F" and "="), having the following data format and sequence: N = CVVVIII, each symbol representing an ASCII character, for a total of 9 bytes:

Byte 1 — N = Address Byte, card address

Byte 2 — "Equal" sign, delimiter

Byte 3 — Control CharacterC: determines RANGE and POLARITY for both, CHANNEL A and CHANNEL B Coded with ASCII characters "0" through "F", see SNR-488 Instruction Manual

Byte 4
Byte 5 — VVV = Output Quantity, Channel A
Byte 6

Byte 7
Byte 8 — III = Output Quantity, Channel B
Byte 9

3-64 Data transfer on the GPIB (IEEE 488) is byte-serial. The output quantity bytes (VVV and III) are encoded in hexadecimal notation for Model SN 488-B cards and in BCD notation for Model SN 488-D cards. Encoding ranges are 000 to FFF and 000 to 999 respectively. Data transfer time is approximately 60μsec.

3-65 THE BIT PROGRAMMING CARDS

3-66 These cards are inserted into an existing slot in the BOP series of Kepco power supplies. They convert the BOP into a stand-alone, digitally programmable power source. The card may be field-installed by the user, or the BOP may be ordered with the BIT card factory installed.

3-67 There are four (4) BIT models available. Two (2) of them, Models BIT 488-B and BIT 488-D are for operation of the BOP on the GPIB (IEEE 488) bus. The other two (2), Models BIT 500-B and BIT 500-D are for operation of the BOP on parallel data buses. Each BIT card controls the BOP's main channel and limit channel. Depending on the BOP's operating mode selection, either Output Voltage and Current Limit (Voltage Mode) or Output Current and Voltage Limit (Current Mode) can be controlled simultaneously.

3-68 THE BIT 488 DUAL CHANNEL DIGITAL PROGRAMMING CARDS.

3-69 The BIT 488 programming cards were designed to operate on the GPIB (IEEE 488) bus. Once addressed by the bus controller with their unique, presetable address code, they are placed in the Data Mode and accept a subset of the 7-bit ASCII code ("0" through "F").

3-70 The BIT 488 card requires the following data format and sequence: CMMMLL (ASCII).

Byte 1 — Control Character: C - determines BIT output range, polarity and BOP operating mode. ASCII DIGITS "0" through "7". See BIT 488 Instruction Manual

Byte 2
Byte 3 — Main Channel Output
Byte 4

Byte 5
Byte 6 — Limit Channel Output

3-71 Data transfer is byte-serial. The Main channel field (MMM) may be encoded in hexadecimal notation (000 to FFF) for BIT 488-B models or in BCD notation (000 to 999) for BIT 488-D models. Data transfer time is approximately 60μsec.

3-72 **THE BIT 500 DUAL CHANNEL DIGITAL PROGRAMMING CARDS.** The BIT 500 programming cards were designed to operate on bit-parallel data buses. These cards expect either positive or negative logic (selectable) at their input port. Once installed in the BOP, they are terminated by a 50-pin edge connector with pin-outs as shown in paragraph 3-74. The magnitude field for the MAIN CHANNEL and for the LIMIT CHANNEL is to be binary encoded for Model BIT 500-B and BCD encoded for Model BIT 500-D.

3-73 Data transfer is bit-parallel and is controlled by the externally applied STROBE pulse (2μsec. min) and the internally created BUSY signal, following each strobe. Data transfer time is approximately 35μsec., although the data lines are free for other purposes, following the 2μsec. STROBE.

3-74 INPUT/OUTPUT CONNECTOR, PIN-OUT FOR BIT 500.

***NOTE:** All input commands are with reference to LOGIC GROUND.*

A) PIN 5 — SERIAL INPUT
PIN 1 — SERIAL OUTPUT
PIN 3 — SERIAL OUTPUT



Pins 1, 3 and 5 serve to select either POSITIVE LOGIC (L = 0, H = 1) by placing the jumper from pin 5 to pin 3, or NEGATIVE LOGIC (L = 1, H = 0), by placing the jumper from pin 5 to pin 1. The selection of POSITIVE or NEGATIVE logic applys only to DATA, POLARITY and RANGE signals.

B) Pin 17—Control (LOC/REM), H = REMOTE, L = LOCAL. Selects either local (FRONT PANEL) or remote (BUS) control of the BOP.

***NOTE:** THIS PIN MUST BE HIGH (H) FOR REMOTE, (BUS) CONTROL OF THE BOP.*

C) Pin 15—MODE (V/I), H = CURRENT Mode, L = VOLTAGE Mode. Determines BOP operating mode. Designates the Main Channel to Voltage Control, Limit Channel to Current Limit Control.

D) Pin 13—RANGE (HI/LO), H = Low Range (0-1V), L = High Range (0-10V). Selects Main Channel output range.

E) Pin 11—POLARITY (+/−), H = Negative, L = Positive, Selects Main Channel output polarity with reference to ANALOG GROUND.

F) Pin 9 d-c LOGIC SUPPLY OUTPUT, 5V at 20 mA maximum. May be used to connect pull-up resistors for establishing pre-wired logic states or to drive external logic within the given ratings.

G) Pin 7—$\overline{\text{STROBE}}$. The negative going edge signal (H—L) enables the loading of the Temporary Storage Registers with the data presented on the data pins. The minimum duration of $\overline{\text{STROBE}}$ must be 2μsec.

H) Pin 47—BUSY (H = busy, L = not busy). This output delivers a status signal to the bus. On the first clock transition (H—L), following the $\overline{\text{STROBE}}$ signal, the BUSY line goes high (H) and remains high until the first clock transition (H—L), following data transfer (approximately 50μsec.), indicating the BIT 500 is ready to accept new data.

J) Pin 49—SHIELD (CHASSIS). Chassis and Case connection of the BIT 500.

K) Pins 37,39,41,43,45 LOGIC GROUND, COMMON, 5V LOGIC SUPPLY.

L) MAGNITUDE FIELD, MAIN CHANNEL

PINS:	2	4	6	8	10	12	14	16	18	20	22	24
BITS: (BIT 500-B)	12 MSB	11	10	9	8	7	6	5	4	3	2	1 LSB
DECADE (BIT 500-D)	10^{-1}				10^{-2}				10^{-3}			
BCD	8	4	2	1	8	4	2	1	8	4	2	1

M) MAGNITUDE FIELD, LIMIT CHANNEL

PINS:	34	36	38	40	42	44	46	48
BITS: (BIT 500-B)	8 MSB	7	6	5	4	3	2	1 LSB
DECADE (BIT 500-D)	10^{-1}				10^{-2}			
BCD	8	4	2	1	8	4	2	1

3-75 THE KEPCO MODEL TLD 488-16 INTERACTIVE DIGITAL PROGRAMMER.

3-76 The Kepco Model TLD 488-16 was designed to operate on the GPIB (IEEE 488) bus as a LISTENER/TALKER. It is configures as a standard rack card-cage, containing a micro-computer with bus interface, status monitor for catastrophic error reporting via a discrete line to the controller and an on-board parallel peripheral interface for optional load isolations relays.

3-77 The Kepco TLD 488-16 accepts up to four plug-in programming boards, either the Kepco Model TL 488-4A for Kepco ATE power supplies, or the TL 488-4B for Kepco BOP power supplies, or a mixture of these two models. Each board can control up to four (4) power supplies, so that a maximum of sixteen (16) power supplies may be digitally programmed via the TLD output ports, using only a single GPIB bus connection.

3-78 When using TL 488-4B programming cards for BOP power supplies, each BOP must be equipped whith an optional Kepco interface card, Model PCA X-3, which is installed inside the BOP. When using TL 488-A programming cards for ATE power supplies, each ATE is connected to the TLD 488-16 via a unique interface connector, Model PCA X-X, model number depending on ATE model designation. These PCA devices have the function of informing the TLD about the parameters of the connected power supplies.

3-79 Communications between the TLD 488-16 and the system controller in the COMMAND mode follow the GPIB (IEEE 488) protocol, with the TLD 488-16 implementing the following functions:

GPIB FUNCTION	SUBSET SYMBOL	COMMENTS
Source handshake	SH1	—
Acceptor handshake	AH1	—
Talker	T6	Basic talker, serial poll, unaddress if MLA
Listener	L4	Basic listener unaddress if MTA
Service request	SR1	—
Device clear	DC1	—

3-80 Communications between the TLD 488-16 and the system controller in the DATA mode, use elements of the CONTROL INTERFACE INTERMEDIATE LANGUAGE (CIIL). The statement syntax and operation codes of CIIL are encoded using the 7-bit ASCII character set and are briefly described below[1].

1) FNC - function op-code

   SYNTAX: FNC DCS :CHnn

   This operator, with the operands DCS and :CHnn is used at the start of each set-up sequence. The "DCS" operand is a CIIL "noun" and describes the type of device being set-up (DCS = d-c source, power supply). The :CHnn operand is used in the set-up of all devices and indicates the port or channel number of the TLD 488-16 in our case.

2) SET - set-up code

   SYNTAX: SET VOLT (value nnn)

   The SET command string is used to specify a characteristic of the device "DCS" specified in the FNC command string. The first operand (VOLT) indicating that characteristic. Possible operands for this field when programming the TLD 488-16 are: VOLT, CURR, VLTL, CURL. The second operand (value) which may be encoded in ASCII integer, decimal or scientific notation.

3) STA - status op-code

   SYNTAX: STA

   This op-code command the device to report its current operating status. It should be sent by the system controller after each set-up command string. There are no operands associated with this op-code.

4) RST - reset op-code

   SYNTAX: RST DCS :CHnn

   The RST command string resets the device at :CHnn to zero and opens the relays if used.

[1] For more details, refer to the TLD 488-16 OPERATOR'S MANUAL.

3-81 CIIL TRANSMISSION FORMAT.

3-82 The sequence of commands which address a specific power supply at port 0, set its voltage to 10V, its current limit to 2A and its subsequent reset is illustrated below:

TRANSMISSION 1: FNC sp DCS sp :CH00 sp (set-up)
SET sp VOLT sp 10 sp
SET sp CURL sp 2 cr lf

TRANSMISSION 2: STA cr lf (STATUS CHECK)

TRANSMISSION 3: RST sp DCS sp :CH00 cr lf (shut-down)

NOTE 1: *sp = ASCII (space or blank), cr = ASCII (carriage return) lf = ASCII (line feed).*

NOTE 2: *The individual CIIL statements of transmission 1 are shown on separate lines for readability only. In actuality they are concacenated into a single ASCII string.*

3-83 **THE CIRCUIT BREAKER CONTROL CIRCUIT (REFER TO FIG. 3-28).** The BOP is protected by the dual-coil CIRCUIT BREAKER/ON-OFF SWITCH (CB101). **The current sensing coil of CB101 is connected in series with the primary winding of T201, thus detecting overcurrents reflected into the primary circuit and subsequently tripping the circuit breaker. The voltage sensing coil of CB101 is connected in series with an SCR (CR4) across the DRIVER COLLECTOR SUPPLY. If the SCR is triggered "on", the voltage sensing coil is energized and trips the circuit breaker. The SCR (CR4) can be triggered in several ways as described in paragraphs** 3-83A thru 3-83D.

A) On a-c line power loss or interruption, Q1 will loose its turn-on bias first, due to the small time-constant provided in its base circuit (not shown in simplified block diagram). As a result, Q2 is turned "on", energizing the diode in the optical isolator (LC-1) and providing a turn-on signal for the SCR (CR4).

B) In the event of an excessive heat rise on the POWER STAGE ASS'Y (A4), the thermal switch (S401) will close, energizing the diode in the optical isolator (LC-1) and providing thus the turn-on signal for the SCR (CR4).

C) In the event of an external, isolated turn-off signal (which, for example, in system applications, could originate from a companion BOP), the diode in the second optical isolator (LC-2) is energized. The resulting signal energizes in from the diode in the first optical isolator (LC-1) thus providing for SCR turn-on.

D) A manual, non-isolated turn-off is provided which, when implemented with an external switch contact as shown in FIG. 3-28, will energize the diode in the first opto coupler (LC-1), thus providing the SCR turn-on.

3-84 If it is <u>not</u> desired to trip the circuit breaker (CB101) on a-c line power loss, it can be prevented by a jumper wire or an external switch across Pins 24 and 25 on PC-12. In this manner, Q1 is inhibited from providing a turn-on signal for Q2, thus avoiding triggering the SCR and tripping the circuit breaker.

3-85 THE INDICATOR AND FLAG LOGIC CIRCUIT (SEE FIG. 3-29). Digital Logic Circuits (IC15, IC16, IC17 are used in the BOP to drive the LED front panel lamps which indicate the prevailing operating mode:

E_o LIMIT MODE	**(DS101)**
I_o LIMIT MODE	**(DS102)**
E_o MODE	**(DS103)**
I_o MODE	**(DS104)**
REMOTE	**(DS105)**

Together with these visual front panel indicators, TTL-compatible status flags are provided at the rear programming connector (PC-12) for the above BOP operating modes. All status flags available on PC-12 indicate a logic "0" if the BOP is operating in the indicated operating mode, and a logic "1" if it is not.

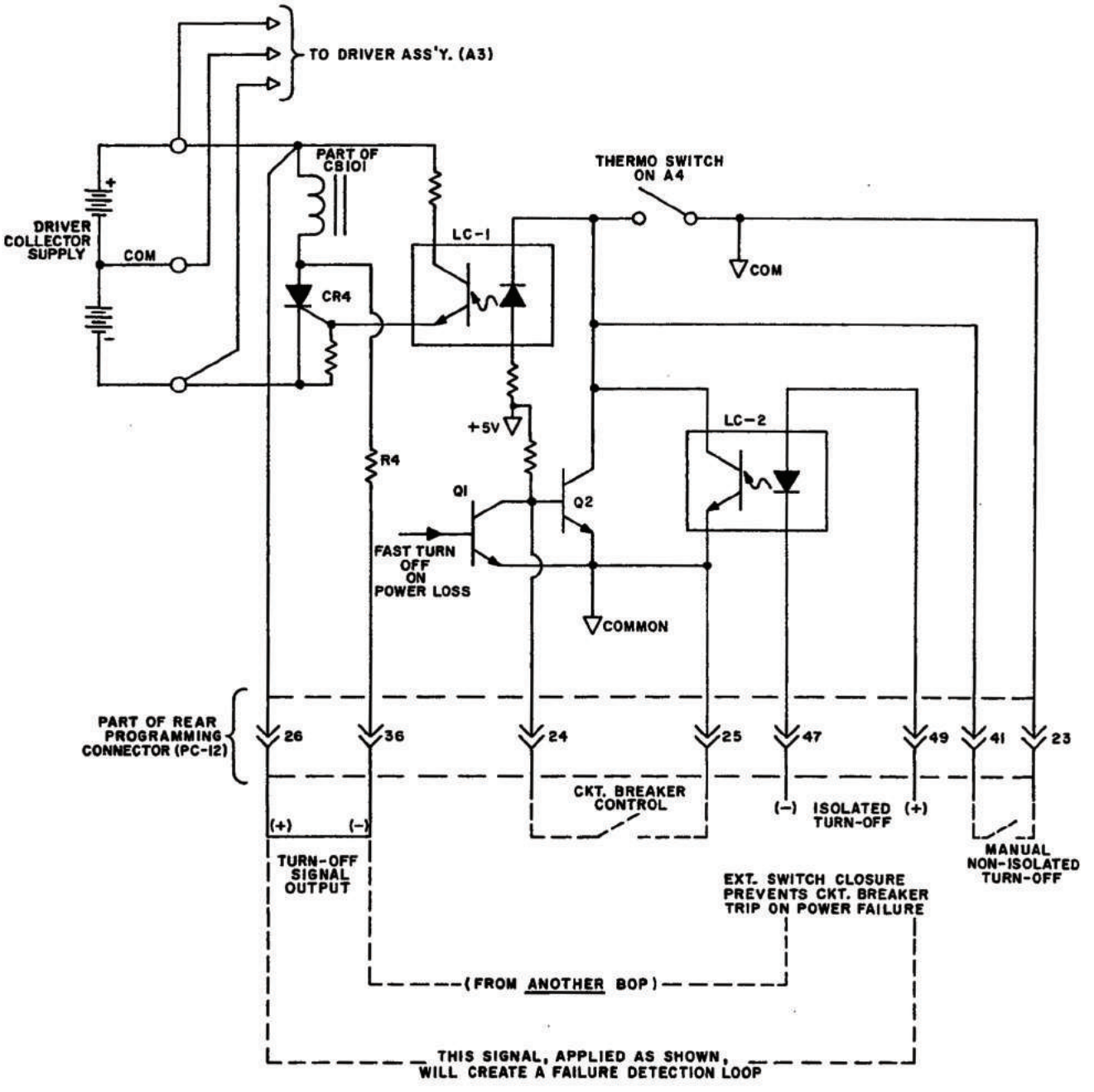


FIG. 3-28 CIRCUIT BREAKER CONTROL CIRCUIT, SIMPLIFIED DIAGRAM.

3-86 The logic status indicated in FIG. 3-29 are valid for the BOP operating in the voltage mode (E_o MODE) and not driven by the GPIB INTERFACE. If the GPIB interface is connected, control of the BOP output may be assumed by the external controller, once the "REMOTE" command is applied via J204/P5 Pin 6. At this time, the REMOTE/LOCAL FLAG (PC-12 pin 35) will go to "0", the REMOTE front panel lamp goes on and the front panel MODE SWITCH (S103) is no longer functional. All other front panel LED indicators will function as in the local control mode.

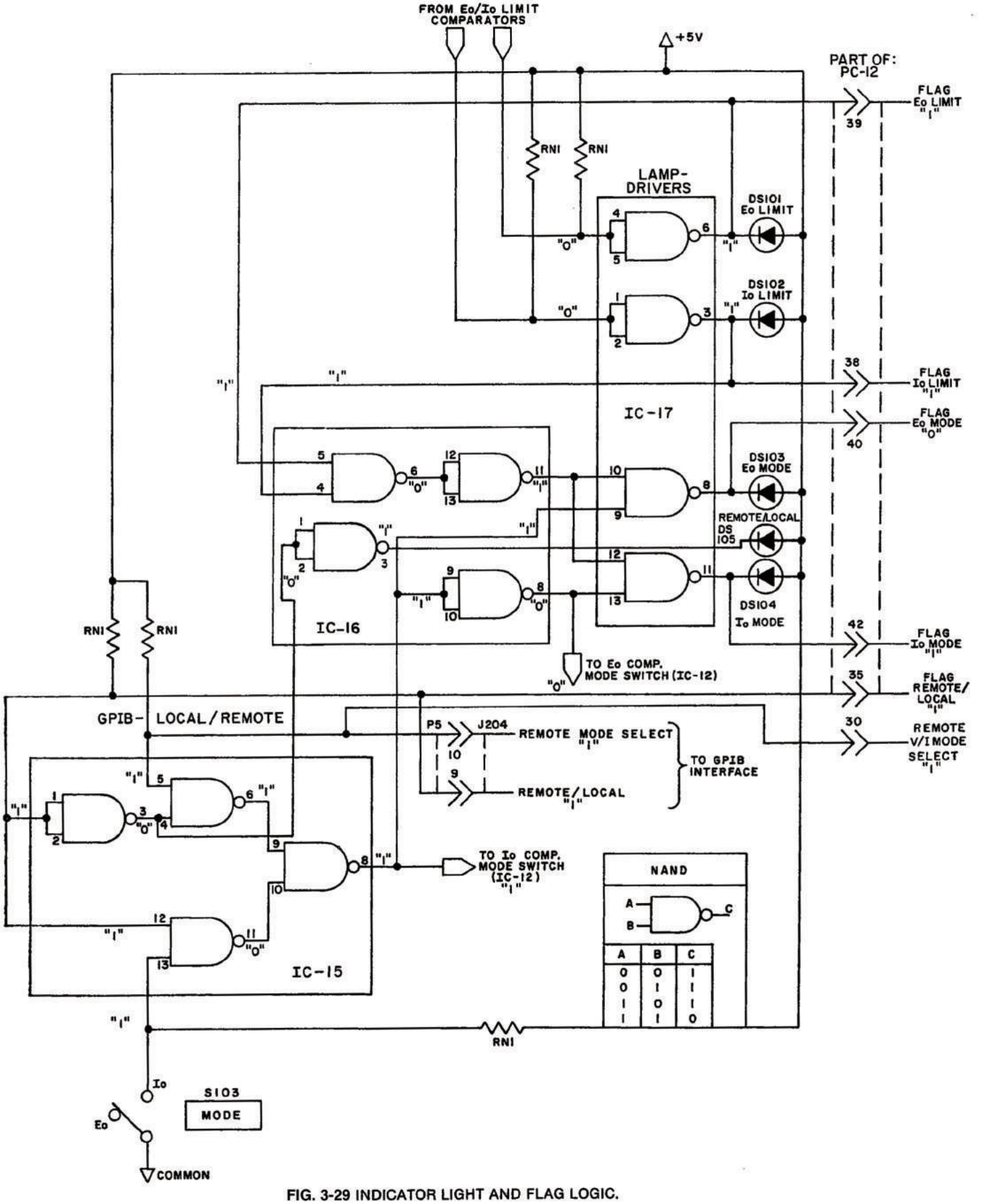


FIG. 3-29 INDICATOR LIGHT AND FLAG LOGIC.
CONDITIONS SHOWN: Eo MODE, GPIB "LOCAL".

3-87 INTERNAL ADJUSTMENTS AND CALIBRATIONS

The location of all internal controls is illustrated in Section II, FIG. 2-1. The use of the zeroing controls for the BOP output voltage and current has been described in Section III. The adjustment for the remaining controls is described **below. See FIG. 3-31 for disassembly.**

Note: *These controls are factory calibrated. Re-calibration is necessary only if components, related to the circuitry involving these controls have to be replaced.*

A) ADJUSTMENT OF THE (±) 10 VOLT CALIBRATION CONTROLS (R31,32)

1) Connect a precision digital voltmeter to the REAR PROGRAMMING CONNECTOR (PC-12) from COMMON to pin 22 (– 10 volt) and subsequently to pin 28 (+ 10 volt).
2) Turn the BOP "on" and locate the calibrating controls (see Section II, FIG. 2-1).
3) Adjust control to exactly 10 volts as read out on the digital voltmeter.

B) ADJUSTMENT OF THE AMMETER ZERO CONTROL (R50)

1) Without a load connected to the BOP output, connect a digital voltmeter to the REAR PROGRAMMING CONNECTOR (PC-12) from COMMON to pin 10.
2) Turn the BOP "on" and locate the AMMETER ZERO control (R50, see Section II, FIG. 2-1).
3) Adjust control to exactly zero volts as read out on the digital voltmeter.

C) ADJUSTMENT OF OPTOCOUPLER LINEARIZATION CONTROL (ONLY IN MODEL BOP 200-1M).

1) Remove the BOP cover.
2) Connect a resistive load to the output. Set load to produce the rated maximum output current.
3) Attach an oscilloscope probe to test point, located on A1 control board (See Section III, FIG. 3-32). (Oscilloscope common should be connected to output common of the unit. Select 1V/Division or 2V/Division sensitivity on the oscilloscope.
4) Set BOP to Voltage Mode with voltage control switch on "off" position (See Section II, FIG. 2-2).
5) Using the Voltage Programming Input terminals, program the unit by using a triangular voltage source (Function Generator) producing a 20V p-p, 250 Hz triangular wave. Observe the output signal on the scope, and adjust R15A Linearization control (See Section II, FIG. 2-1) until the nonlinearity in the ramps of the triangular wave disappears (See FIG. 3-30).

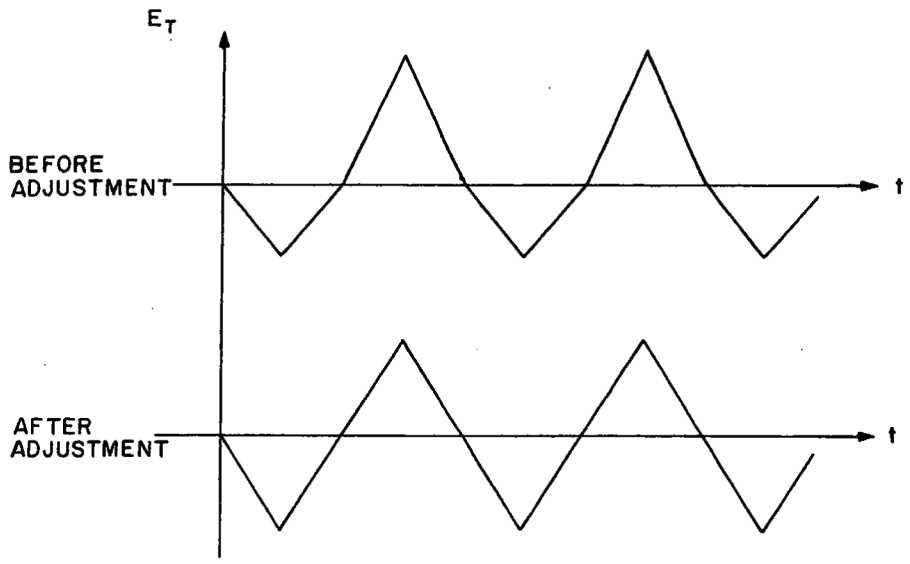
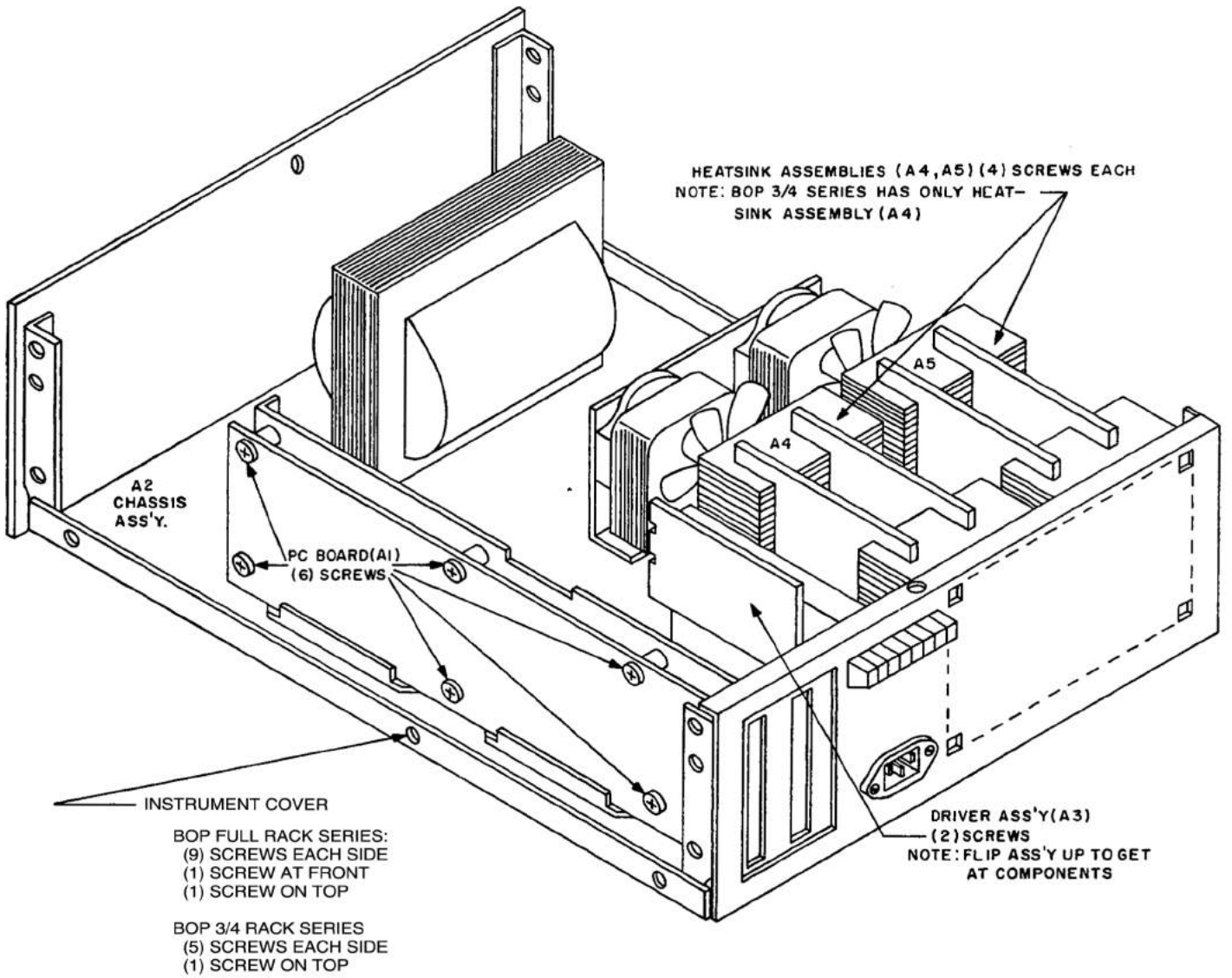


FIG. 3-30 OPTOCOUPLER LINEARIZATION IN MODEL BOP 200-1M.
*(**NOTE:** THE TRIANGULAR WAVE DOES NOT HAVE TO SHOW ZERO VOLT D-C AVERAGE).*

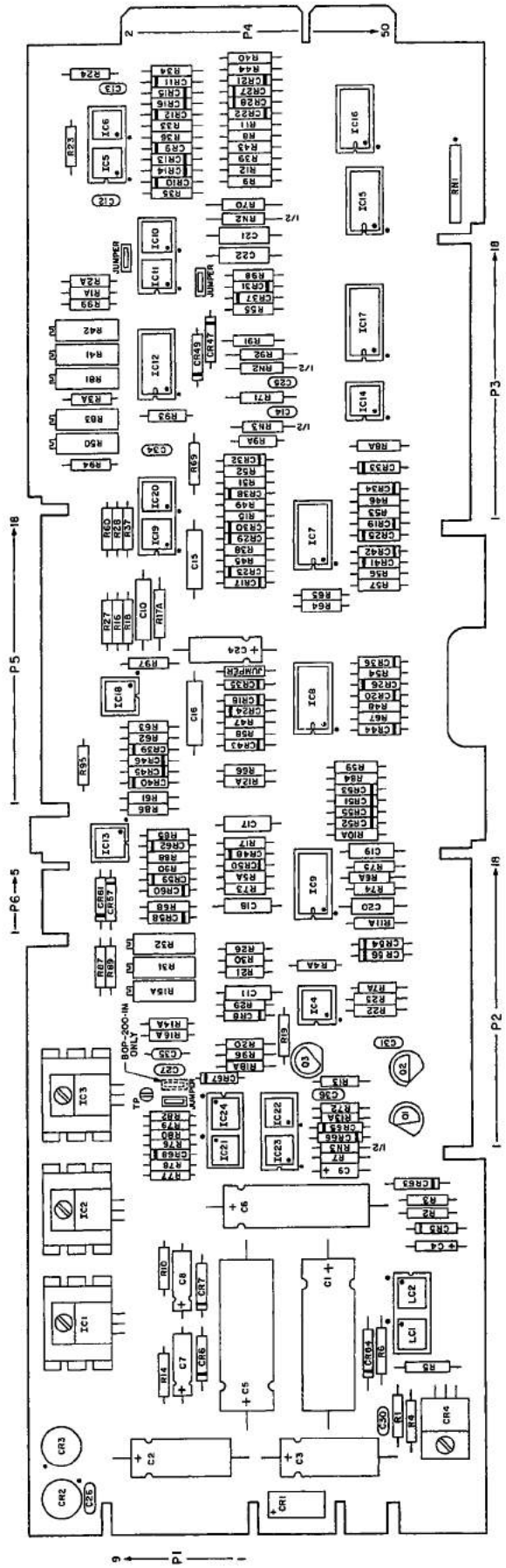
D) **ADJUSTMENT OF THE I_O OUTPUT CURRENT** (Applies only to Models specified in Table 2-1, Note 2.)

1) Remove the BOP cover.
2) Connect a precision ammeter in series with a temperature-compensated shunt resistor to the output of the power supply.
3) Set BOP MODE switch for current mode operation (see Fig. 2-2).
4) Set BOP voltage and current control switches to "OFF" position (see Fig. 2-2).
5) Using the CURRENT PROGRAMMING INPUT terminals, program the unit by using an accurate and precise DC voltage source. Set DC programming source to 10V (full scale output current.)
6) Turn BOP power supply "ON."
7) Adjust R316 (except on BOP 200-1M, adjust R314) (located on A3 assembly, see Figs. 3-31 and 3-33 for location) until current reading displayed on precision ammeter exactly matches the BOP rated output current (e.g. for a BOP 50-4M, adjust for exactly 4A.)



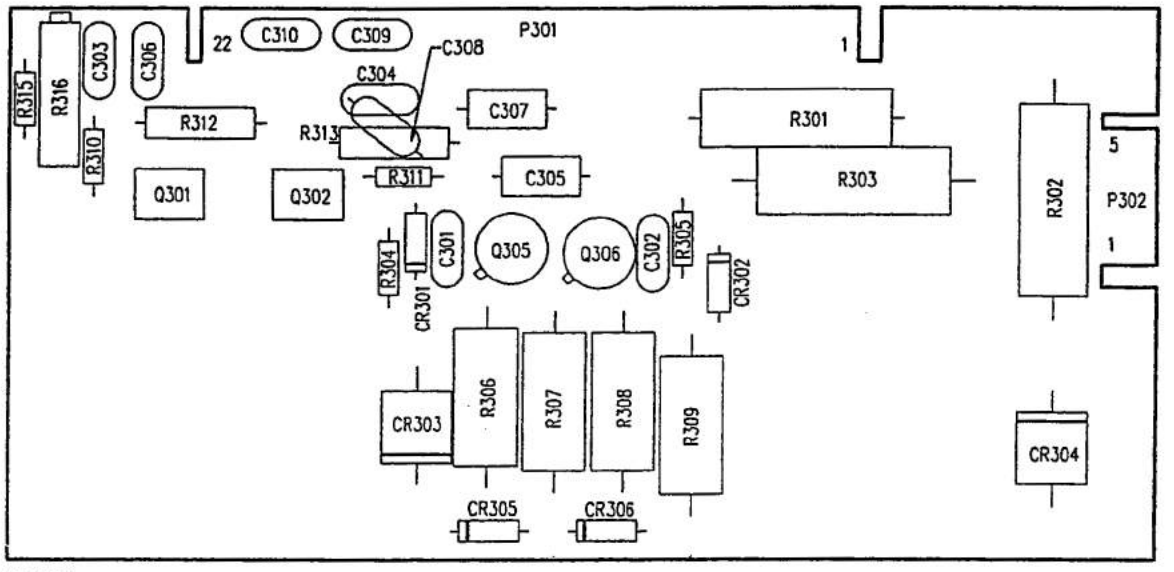
***NOTE:** BOP FULL-RACK MODEL SHOWN, FOR ¾ RACK BOP MODELS, SEE SPECIAL REFERENCES IN DISASSEMBLY NOTES ON FIG. 3-31.*

FIG 3-31 DISASSEMBLY, BOP SERIES.



NOTE: NOT ALL COMPONENTS USED IN ALL MODELS, SEE PARTS LIST.

FIG 3-32 COMPONENT LOCATION, CONTROL ASSEMBLY (A1).



NOTE: NOT ALL COMPONENTS USED IN ALL MODELS.

FIGURE 3-33 COMPONENT LOCATION, DRIVER ASS'Y (A3), ALL EXCEPT BOP 200-1M, BOP 200-1D

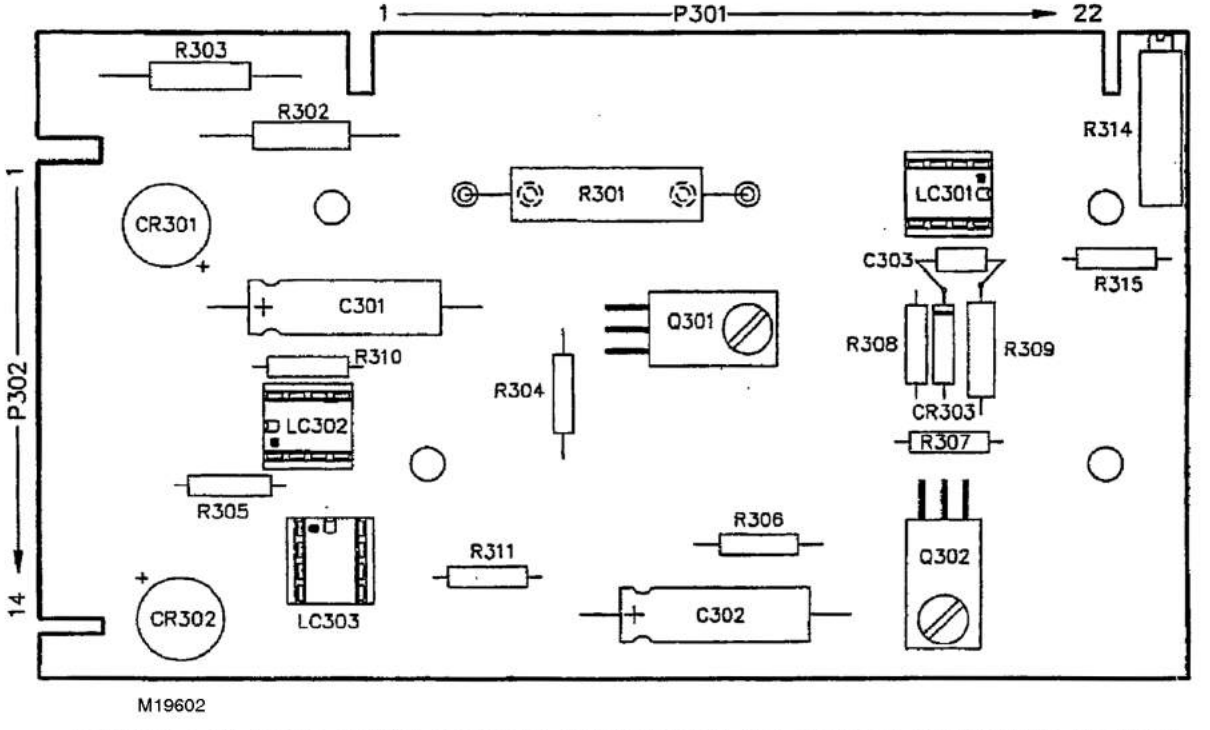
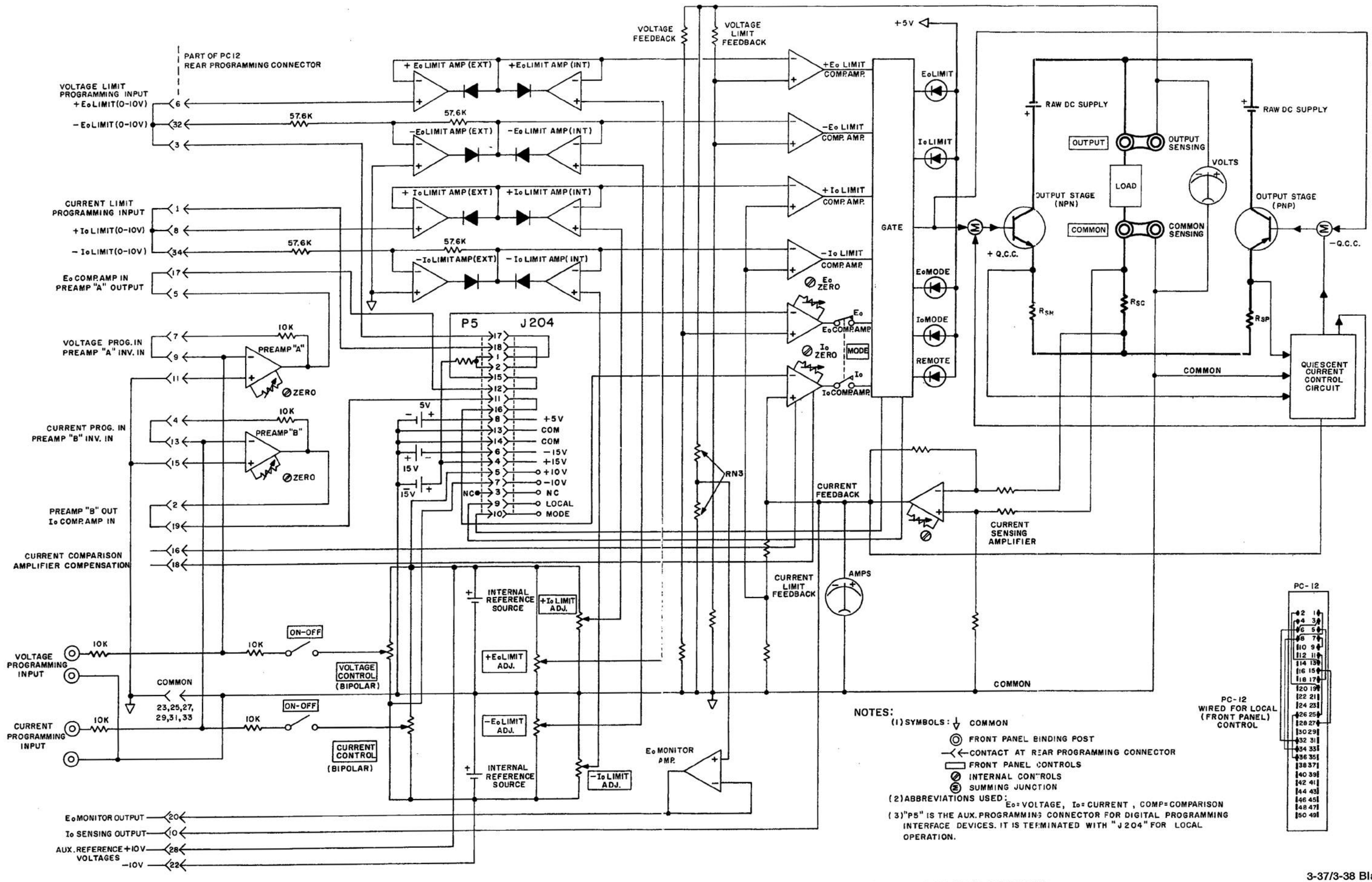


FIGURE 3-34 COMPONENT LOCATION, DRIVER ASS'Y (A3), BOP 200-1M, BOP 200-1D ONLY



NOTES:

(1) SYMBOLS: ↓ COMMON; ◎ FRONT PANEL BINDING POST; —≺← CONTACT AT REAR PROGRAMMING CONNECTOR; ▭ FRONT PANEL CONTROLS; ⊘ INTERNAL CONTROLS; Ⓢ SUMMING JUNCTION

(2) ABBREVIATIONS USED: Eo = VOLTAGE, Io = CURRENT, COMP = COMPARISON

(3) "P5" IS THE AUX. PROGRAMMING CONNECTOR FOR DIGITAL PROGRAMMING INTERFACE DEVICES. IT IS TERMINATED WITH "J 204" FOR LOCAL OPERATION.

FIG. 3-35 SIMPLIFIED SCHEMATIC DIAGRAM, BOP SERIES.

BOP—05-0186A

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