SPEED REGULATOR (TYPE II)
MULTI LOOP CONTROLLER

I. GENERAL DESCRIPTION

The type II controller consists of a PI controller with proportional speed feedback. This results in a "zero velocity error" system. A speed controlled drive with a type II controller will track a ramp without an error. The speed response to a step reference change shows always an overshoot.

Three variations of the module design provide a fixed current limit, externally adjustable current limit or tapered current limit adjustment feature. Each module can provide a droop adjustment feature and can be used in either regenerative (DUAL CONVERTER) or uni-direction (SINGLE CONVERTER) drive applications.

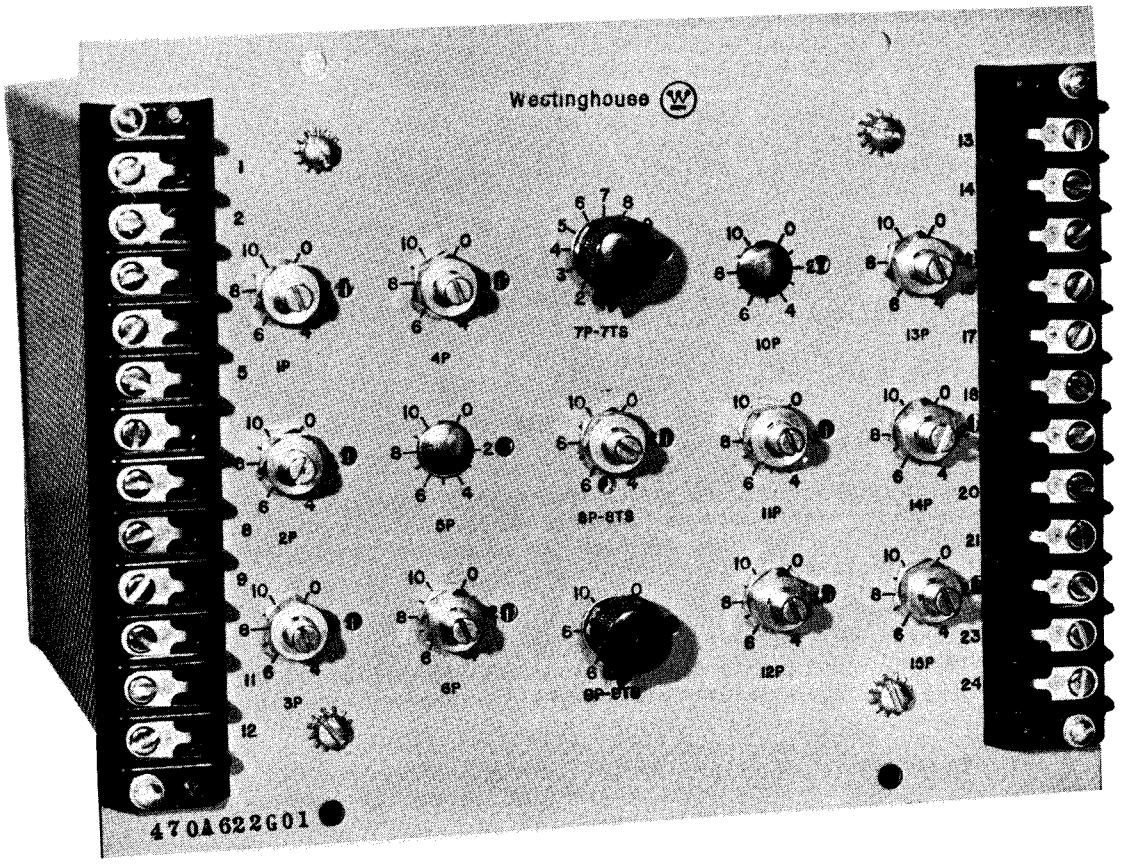

FIGURE #1

The module shown in Figure 1, contains P101A operational amplifiers (IL 16-800-24) their associated function boards, limiter circuit boards and sequencing relay boards extending from a 9" x 7" faceplate on which are mounted front accessible adjusting potentiometers, selector switches and screw type terminals to which all external connections are made.

II. RANGE OF APPLICATION

Cross-over frequency of speed loop adjustable at 40, 20 and 10 rad per sec for critically damped speed loop. Current limit setting of inner current loop between 100% and 300% of rated current.

IR - Droop of motor between 2% and 10%.

Tach voltage representing top speed between 50 and 125 volts. Reference voltage representing top speed 10 volts or higher. Mechanical time constant of drive between 30 and 300 msec. Maximum field weakening range 1:3.

III. DESCRIPTION OF OPERATION

The following description covers all features available in the multi loop speed regulator module, it is recommended that the reader check the Regulator Systems Diagram and Regulator Signal Distribution Diagram of customer's schematic for features required for his application. The schematic diagram for fixed current limit applications is shown in Figure 2; the schematic for externally adjustable current limit applications is shown in Figure 3; the schematic for tapered current limit applications is shown in Figure 4.

The multi-loop speed control consists of a current and speed controller connected in series. The current controller output feeds directly into the inner voltage controller while the speed controller output acts as an input to the current controller.

The current controller is a PI controller with a fixed lead in the current feedback. The lead of PI controller is fixed and is necessary in order to cancel the delay associated with the inner voltage loop. The four inputs to the current controller, terminals #1, #2, #3 and #4, are as follows:

Terminal #1 - is for current feedback signal, and is composed of a lead of 26 ms and a small delay 1 ms.

Terminal #2 - is for output of speed controller and potentiometer 3P is used for current limit adjustment.

Terminal #3 - is for spare input.

Terminal #4 - is for non-regenerative (single converter) power supplies and is where the output of the reverse current simulator is connected.

For control of current zero, relay 1CR should be de-energized, thereby removing all inputs from the current controller except current feedback. Relay 2CR is an initial condition relay which will be picked up once the current loop has been closed and the thyristors energized. This is to prevent the output of the current amplifier from drifting from its zero position.

Dynamic adjustment of the current loop is by means of pot 2P and switch 7TS. Switch 7TS changes the values of resistances associated with the pot setting 2P, and has the same effect on the integrating time constant as changing the capacitance in the feedback of the amplifier. Switch 7TS and pot 2P are used to change the crossover frequency of the current loop without changing the response of this loop.

The current controller has a symmetrical limiter associated with it - this limiter - using only 1 zener diode ensures that the limit in the positive and regenerative direction are very close to one another.

Type II speed regulator is a PI controller with a proportional speed feedback. The four inputs for the Type II speed regulator are as follows:

Terminal #13 - is where the speed feedback is connected to the speed controller through a small filter.

Terminal #14 - is used for reference and pots 14P and 15P are for adjusting the reference feeding into the controller.

Terminal #15 - can be used either as an additional vernier input, or when a load balance is employed, it is used as the input terminal from the load balance controller.

Terminal #16 - is used for test input.

The lead in the PI controller is adjustable by means of pot 8P and can be adjuste from 80 ms to 400 ms. The choice of the value of the lead will be determined by the speed of the response required.

There is no adjustment for varying tachometer voltages, the output of the tachomet r being connected. directly to terminal #13. Compensation is made by means of potentiometer 14P and 15P which change the reference signal.

For speed control by armature voltage only, terminal #17 and #18 should be jumpered For speed control by armature voltage and field weakening, an adaptive gain feature can be incorporated by connecting a 5k pot between terminals #17 and #18. The pot is driven by a MOR, and the resistance will vary between zero at base speed to 5k at top speed.

Dynamic adjustment is by means of the ntegrating time constant of the speed controller, and is adjustable by means of switch 9TS and pot 12P.

Droop can be added by means of pot 13P.

IV. START-UP PROCEDURE

The following assumes the basic regulator is working.

1.0 Disconnect wire leading to terminal #1, and input to inner voltage controller. Turn pots 2P, 3P, 4P, 6P, 13P and 14P together with switches 7TS and 8TS full CCW. Turn pots 1P, 11P and 15P to 50%.

2.0 Check Basic Regulator

Apply variable voltage source to inner voltage loop reference. Apply power to thyristors and slowly increase reference so that machine turns over. Connect Simpson to PSC and with other lead check polarity of current feedback and reference feeding inner voltage loop. These must be of the same polarity. Check polarity of speed feedback and reference feeding into inner voltage loop - these must be of opposite polarity. Reduce reference to zero, de-energize thyristor power supply. Reconnect current feedback to terminal #1 and input to inner voltage loop.

CAUTION: The following tests are carried out without field on the motor. Take care to continually monitor the speed of the drive to prevent it from taking off. Also, do not linger while passing armature current through stalled motor. Return armature current to zero and allow adequate cooling time, if required.

3.0 Adjustment of Inner Current Loop

3.1 Remove motor field supply.

3.2 Energize thyristors and relay 2CR.

3.3 Adjust pot 1P for zero current. (For single converters adjust 1P to give a small value of armature current and then reduce this value to zero by 1P).

3.4 Apply +10 volt signal into terminal #2.

3.5 Slowly increase 3P CW till rated current is flowing in armature circuit.

3.6 Apply step reference to terminal #2 and record current responses.

3.7 Turn 7TS and 2P CW till current response starts to oscillate then turn 7TS one position CCW.

3.8 The current loop is now dynamically adjusted.

4.0 Adjustment of Gate Pulse Suppression

For gate pulse suppression adjustment, do not circulate armature current for more than 25 seconds, allowing at least two minutes for cooling after current is reduced to zero.

4.1 Turn gate pulse suppression pots 4P & 5P full CW.

4.2 Apply +15 volts into terminal #2 and increase pot 3P CW until 115% current limit is reached.

4.3 Turn gate pulse suppression pot 4P (forward converter) slowly CCW until GPG suppresses pulses.

4.4 Turn 3P full CCW.

For dual converter drives.

4.5 Apply (-) 15 volt signal to terminal #2, and increase pot 3P CW to 115% current limit.

4.6 Turn gate pulse suppression pot 5P (reverse converter) slowly CCW until GPG suppresses pulses.

4.7 Turn 3P full CCW.

4.8 Remove reference from terminal #2.

4.9 Reconnect speed controller output to terminal #2.

5.0 Current Limit Adjustment

5.1 Fixed current limit.

5.1.1 Apply -10 volts in to terminal #16.

5.1.2 Energize relay 3CR and check output terminal #20 for approximately +10 volts.

5.1.3 Turn 3P slowly CW till current limit is reached.

For dual converter drives.

5.1.4 Reverse polarity of reference to terminal #16.

5.1.5 Turn 6P slowly CW till current limit (regenerative) is obtained.

NOTE: Asymmetrical dual converters have unequal current limit values.

5.2 Externally Adjusted Current Limit (using P811 Limiter)

The positive and negative limits of the Voltage Reference Controller TOA are separately controlled by positive (E+) and negative (E-) control voltages connected to terminals #5 and #6. These control voltages can be obtained from potentiometers, amplifier outputs or any other voltage source having a source impedance of 10K ohms or less.

5.2.1 Apply a positive signal to terminal #5 whose magnitude is to represent stall current limit.

5.2.2 Apply -10 volt reference to terminal #16.

5.2.3 Energize relay 3CR.

5.2.4 Check the output terminal #19 with Simpson, the voltage should be equal to the voltage applied to terminal #5.

5.2.5 Adjust pot 3P CW to obtain desired current limit.

For dual converter drives

5.2.6 Reverse the polarity of signal into terminal #16.

5.2.7 Slowly increase the negative signal applied to terminal #6 until desired current limit is obtained.

5.3 Tapered Current Limit (using P810 Limiter)

The symmetrical positive and negative limits of the Voltage Reference Controller TOA are controlled by the absolute value of a (positive or negative) control voltage connected to terminal #5.

5.3.1 With motor field disconnected and armature loop closed, turn pot 10P full CCW.

5.3.2 Energize relay 3CR.

5.3.3 Apply (-)ive reference to terminal #14 and turn 14P full CW.

5.3.4 Check the output of the voltage reference controller terminal #19. The voltage should be limited to approximately +10 volts.

5.3.5 Slowly adjust pot 3P CW until current limit is reached.

5.3.6 Turn pot 14P full CCW.

5.3.7 Apply 10 volt signal to terminal #5 and turn 14P CW.

5.3.8 Adjust pot 10P (P810 Limiter) CW until current limit is obtained.

5.3.9 Remove signal feeding into terminal #5.

For asymmetrical dual converters.

5.3.10 Reverse polarity of signal feeding into terminal #14.

5.3.11 Slowly adjust 6P CW until current limit (regenerative) is obtained.

5.3.12 Turn pot 14P full CCW.

6.0 Adjustment of Dynamics of Speed Loop

6.1 De-energize thyristor power supply and relays 1CR and 2CR.

6.2 Reconnect motor field.

6.3 For field weakening drives jumper terminals #17 and #18.

6.4 Turn Pot 8P to 80%, and switch 9TS and pot 12P full CCW.

6.5 Energize thyristor power supply and then energize relay 1CR, 2CR, 3CR.

6.6 Apply -10 volt signal to terminal #14.

6.7 Turn 14P CW till motor starts turning.

6.8 Apply reference in steps to terminal #14 and record speed response of drive.

6.9 Turn 9TS and 12P CW till speed response to small step input is approximately 1 sec. with 20% overshoot.

6.10 To halve the response time, turn 8P to 30% and switch 9TS one position CW.

6.11 To halve response time again, turn 8P to 5% and 9TS one position CW.

NOTE: The 20% overshoot obtained with the type II speed regulator is an inherent feature of this control system. It does not result from poor damping, but is due to initial conditions. Any adjustment made to reduce this overshoot will result in a very sluggish load response.

7.0 Reference Calibration

7.1 Turn pot 14P full CCW.

7.2 Apply full reference to terminal #14.

7.3 Turn 14P CW till top speed is reached.

7.4 For fine adjustment use pot 15P.

8.0 Droop Adjustment

8.1 De-energize thyristor power supply.

8.2 Apply ± 24V power supply.

8.3 Energize 3CR.

8.4 Apply (-)ive reference to terminal #14 corresponding to speed droop in % of top speed at stall current limit. (Example: Reference at top speed at terminal #14 is -10 volts. Desired droop at current limit is 5%. Apply -.5 volts reference into terminal #14).

8.5 Connect Simpson between PSC and terminal #19. Speed controller should be limited at +10 volts approximately.

8.6 Gradually turn 13P CW until amplifier starts to come out of saturation, which represents the desired droop setting.

VI. SERVICE

Using the procedure outlined in Section V, any problem can be isolated to either a component on a function board or a faulty A101A transistorized operational amplifier. Our component board designs, utilizing stand-off terminals, facilitate the replacement of components using the proper sized (wattage) soldering iron. However, proper servicing of the A101A TOA requires instruments and techniques particular to transistorized, low noise level circuits. Customers without the proper facilities are advised to return the defective unit to:

Westinghouse Electric Corporation
Industrial Systems Division
P. O. Box 225
Buffalo, New York 14240

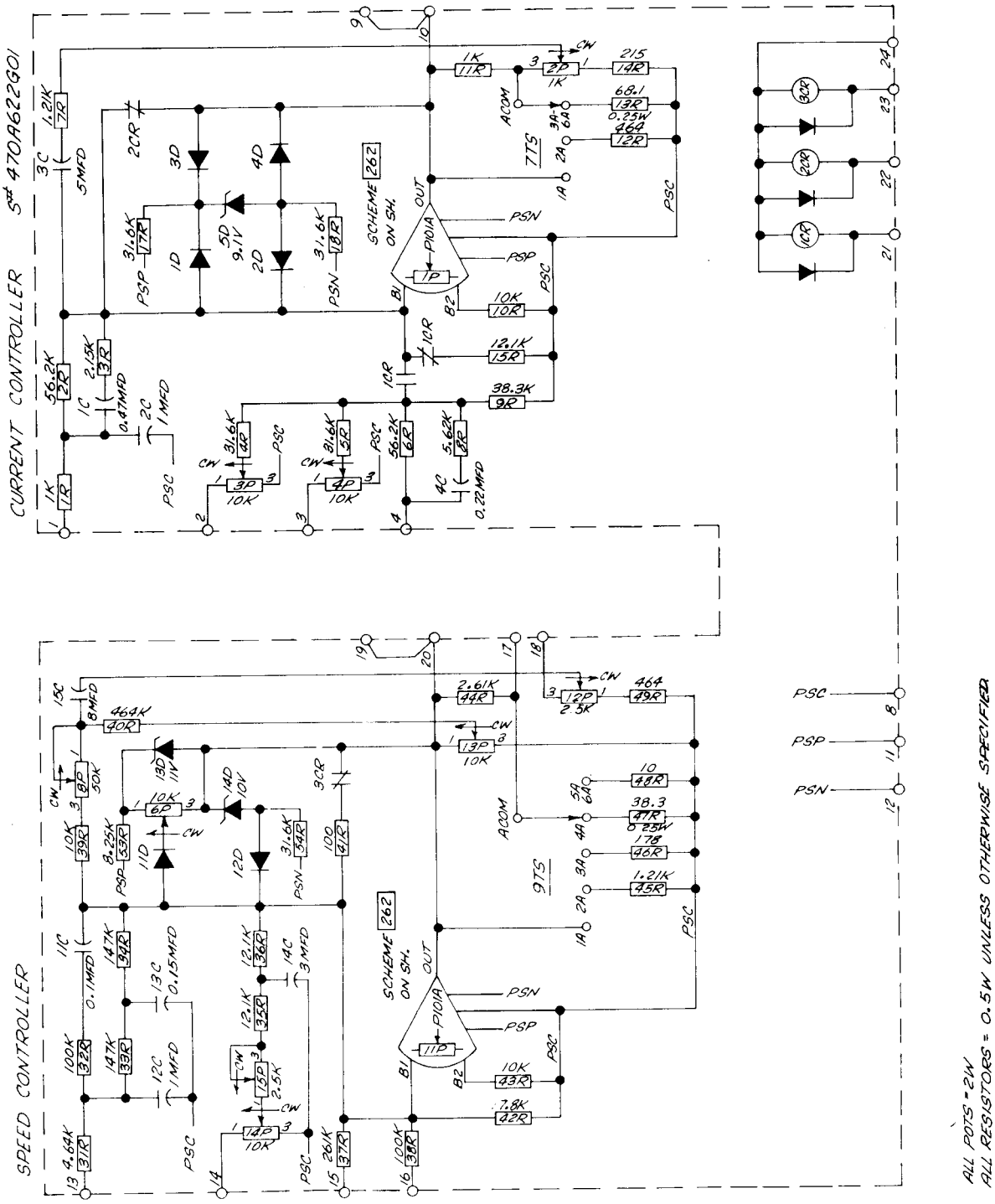

Figure #2

Fixed Current Limit

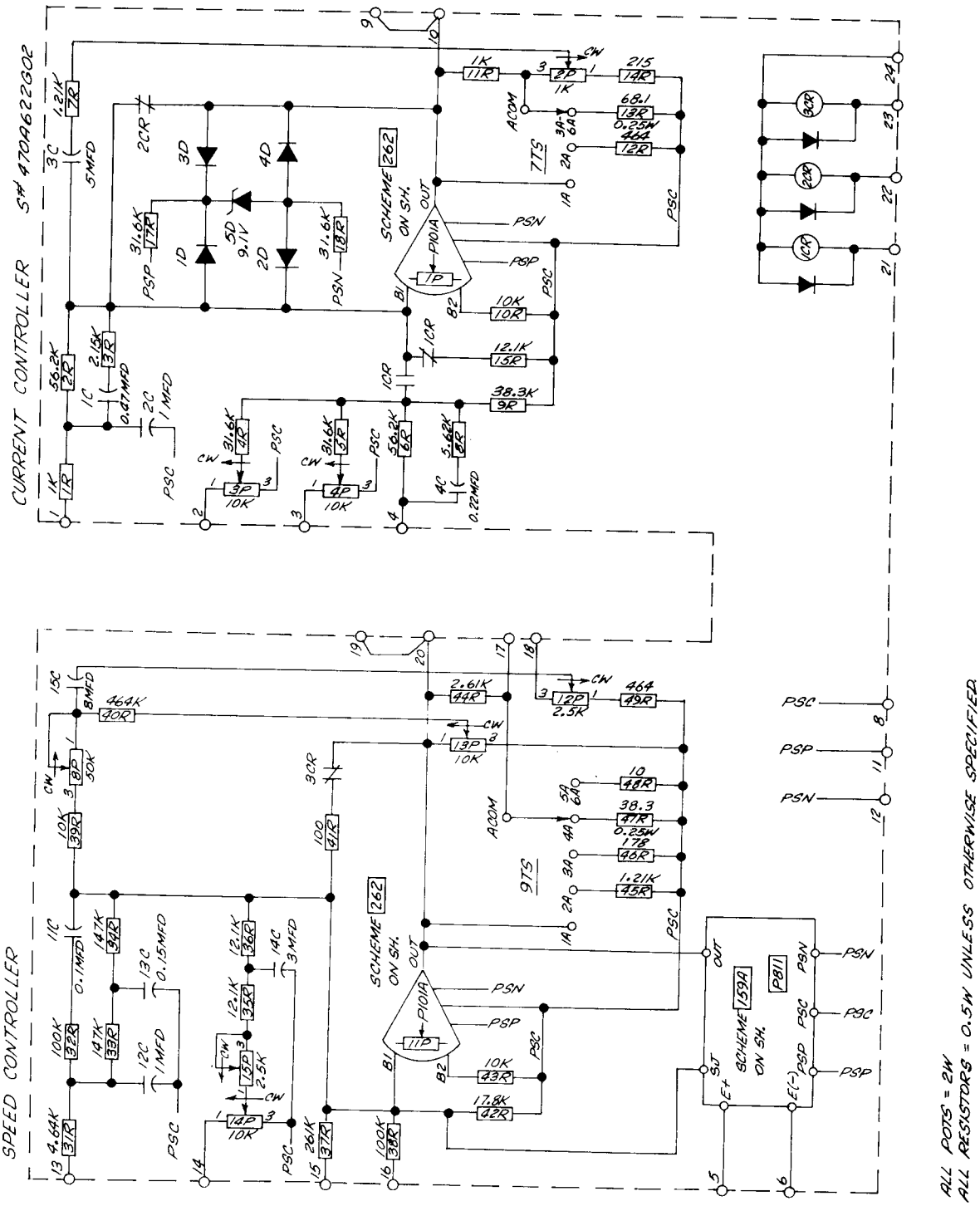

Figure #3

Speed Regulator Type II
Externally Adjusted Current Limit

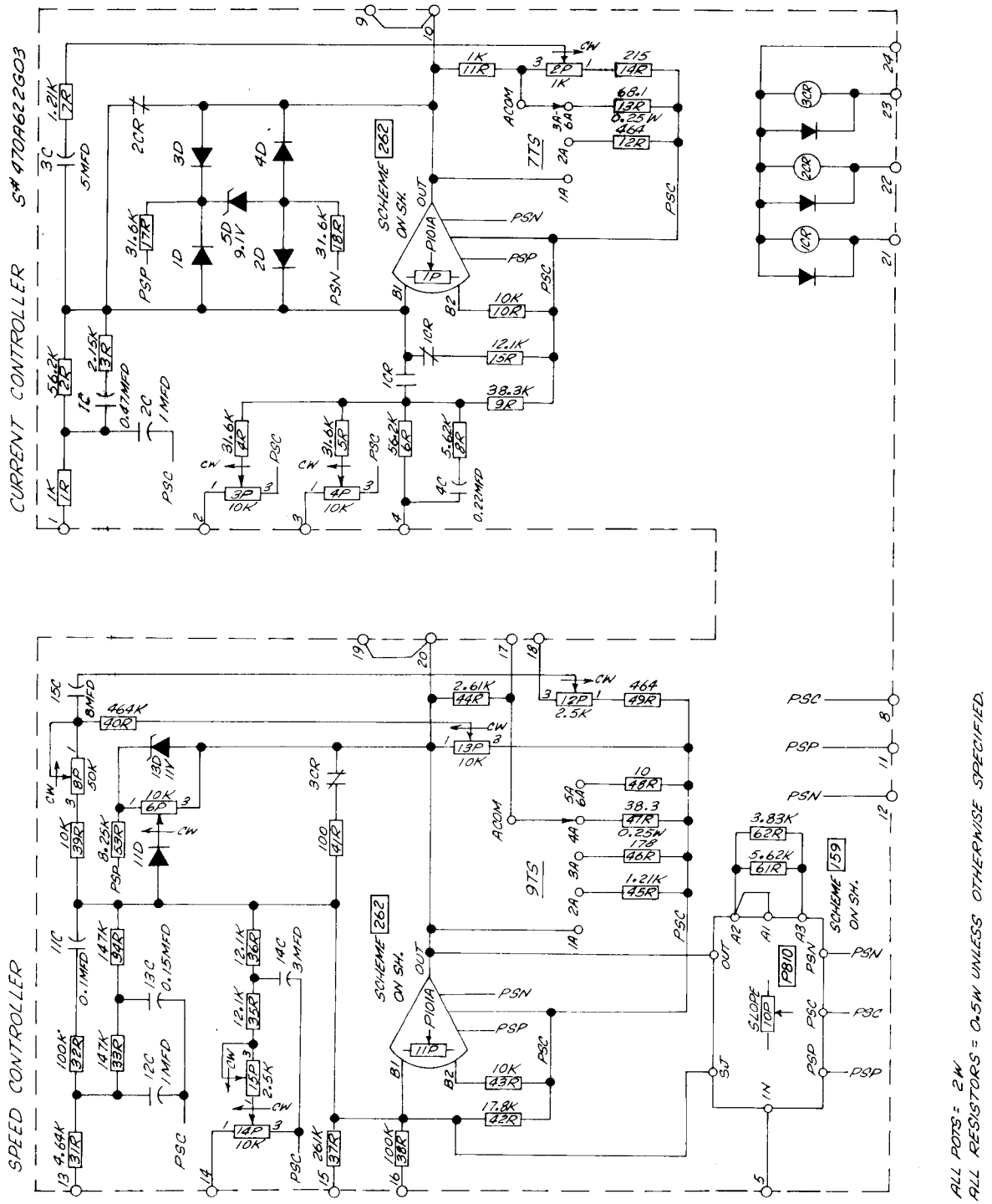

Figure #4

Speed Regulator Type II
Tapered Current Limit