
**User's
Manual**

YEW SERIES 80

**Models SLCD
-151, -181
-251, -281 (Style E)
Indicating Controller**

IM 1B4C1-04E

Notices

■ Regarding This User's Manual

- (1) This manual should be passed on to the end user. Keep at least one extra copy of the manual in a safe place.
- (2) Read this manual carefully and fully understand how to operate this product before you start operation.
- (3) This manual is intended to describe the functions of this product. Yokogawa Electric Corporation (hereinafter simply referred to as Yokogawa) does not guarantee that the functions will suit a particular purpose of the user.
- (4) Under absolutely no circumstances may the contents of this manual in part or in whole be transcribed or copied without permission.
- (5) The contents of this manual are subject to change without prior notice.
- (6) Every effort has been made to ensure accuracy in the preparation of this manual. Should any error or omissions come to your attention however, please contact your nearest Yokogawa representative or our sales office.

■ Regarding Protection, Safety, and Prohibition against Unauthorized Modification

- (1) In order to protect the product and the system controlled by it against damage and ensure its safe use, make certain that all of the instructions and precautions relating to safety contained in this manual are strictly adhered to. Yokogawa does not guarantee safety if products are not handled according to these instructions.
- (2) Be sure to use the spare parts approved by Yokogawa when replacing parts or consumables.
- (3) Modification of the product is strictly prohibited.
- (4) Reverse engineering such as the disassembly or decompilation of software is strictly prohibited.
- (5) No portion of the software supplied by Yokogawa may be transferred, exchanged, leased or sublet for use by any third party without the prior permission of Yokogawa.

■ Force Majeure

- (1) Yokogawa does not make any warranties regarding the product except those mentioned in the WARRANTY that is provided separately.
- (2) Yokogawa assumes no liability to any party for any loss or damage, direct or indirect, caused by the user or any unpredictable defect of the product.

CONTENTS

<i>Section</i>	<i>Title</i>	<i>Page</i>
1.	INSPECTION UPON RECEIPT	1-1
1-1.	Checking Model and Suffix Codes	1-1
2.	GENERAL	2-1
2-1.	Standard Specifications	2-1
2-2.	Optional Specifications	2-2
2-3.	Accessory	2-2
2-4.	Model and Suffix Codes	2-2
3.	INSTALLATION	3-1
3-1.	Wiring	3-1
3-1-1.	Wiring Instructions	3-1
3-1-2.	Terminal Connections	3-2
4.	PRINCIPLES OF OPERATION	4-1
4-1.	Circuit Descriptions	4-1
4-1-1.	Analog Input Circuit	4-1
4-1-2.	Analog-to-Digital Converter Circuit	4-1
4-1-3.	Status Input Circuit	4-1
4-1-4.	Digital Computing Circuit	4-1
4-1-5.	Analog Output Circuit	4-1
4-1-6.	Status Output Circuit	4-1
4-2.	Control Functions	4-3
4-2-1.	PID Control (with reset bias)	4-4
4-2-2.	Proportional Control	4-5
4-2-3.	Nonlinear PID Control	4-5
4-2-4.	Feedforward Control	4-5
4-2-5.	Setpoint Tracking	4-5
4-2-6.	Controller Output (MV) Tracking	4-5
4-2-7.	Preset MV Output	4-5
4-2-8.	Output Limiter	4-5
4-2-9.	Operation Mode Transfer	4-6
4-2-10.	Transferring Operation Mode by Status Input	4-6
4-2-11.	Operation Mode Status Output	4-7
4-2-12.	Input Filter	4-7
4-2-13.	Square Root Extraction (with adjustable low input cutoff)	4-7
4-2-14.	Ratio Computation	4-7
4-2-15.	Linearizing	4-7
4-2-16.	Alarms	4-7
5.	OPERATION	5-1
5-1.	Names and Functions of Components	5-1
5-1-1.	Controller with Moving Coil Indicator	5-1
5-1-2.	Controller with Fluorescent Bar Graph Indicator	5-2
5-1-3.	Names and Functions of Tuning Panel Switches	5-3
5-2.	Preparations for Operation	5-8
5-2-1.	Insure that All Special Parts are Installed	5-8
5-2-2.	Setting for Operation	5-8
5-3.	Start-Up and Operation	5-10
5-3-1.	Manual Startup	5-10

5-3-2.	Alarm Checking and Transfer to Auto Mode	5-11
5-3-3.	Normal Operation	5-11
5-4.	Setting and Display of Self-Tuning Function.	5-11
5-4-1.	Combination of Control Functions with Self-Tuning Function	5-11
5-4-2.	Self-Tuning Parameters.	5-11
5-4-3.	Automatic Start-up	5-14
5-4-4.	On Demand Tuning	5-14
5-4-5.	Display of Self-Tuning Operation	5-15
5-5.	Setting and Display of Adjustable Set-Point Filter Function	5-15
5-5-1.	Effect of Changing the Filter Parameters	5-15
5-5-2.	Method for Tuning PX and PY	5-15
5-6.	Automatic Control	5-16
5-7.	Actions When the FAIL or ALM Lamps Light Up	5-17
5-7-1.	Actions When FAIL Lamp Lights Up	5-17
5-7-2.	Actions When ALM Lamp Lights Up	5-17
5-7-3.	Actions When ALM Lamp Flashes	5-18
5-7-4.	Description of CHECK Display	5-18
5-7-5.	ALARM Status Display	5-18
5-7-6.	STALM Display (SLCD-□81 Only)	5-19
6.	MAINTENANCE	6-1
6-1.	Test Equipment	6-1
6-2.	Test, Calibration and Adjustment	6-1
6-2-1.	Zero Adjustment of Measurement Value Indicator (Moving coil version)	6-1
6-2-2.	Zero Adjustment of Set Point Value Indicator (Moving coil version)	6-1
6-2-3.	Adjustment of Fluorescent Bar Graph Indicator	6-1
6-2-4.	Zero Adjustment of Manipulated Output Indicator	6-2
6-2-5.	Inclined Mounting	6-2
6-2-6.	Brightness Adjustment of Fluorescent Bar Graph Indicator	6-2
6-2-7.	Setting of 4-digit Data Display	6-2
6-3.	Parts Replacement	6-5
6-3-1.	Nameplate (Tag label)	6-5
6-3-2.	Scale Plate	6-5
6-3-3.	Fuse	6-5
6-3-4.	Data-Protect Battery	6-5
6-3-5.	Fluorescent Bar Graph	6-6
6-3-6.	Replacing Power Supply Unit	6-6
7.	TROUBLESHOOTING	7-1
7-1.	Troubleshooting Flow Chart	7-1
7-2.	Disassembly and Reassembly Procedures	7-8
7-2-1.	Removal of Meter Assembly	7-8
7-2-2.	Disassembly of Meter Assembly	7-8
7-2-3.	Removal of Power Supply Unit	7-8
7-2-4.	Disassembly of Control Assembly	7-8
7-2-5.	Replacement of Fluorescent Bar Graph Display Tube	7-10
7-2-6.	Reassembly	7-10
7-2-7.	Power On	7-10
●	Customer Maintenance Parts List	CMPL 1B4C1-04E
●	POWER SUPPLY TERMINALS for PANEL-MOUNTED INSTRUMENTS (for /HTB)	

1. INSPECTION UPON RECEIPT

This instrument was thoroughly tested at the factory before shipment. When the instrument is received, however, check visually for any external damage that may have occurred during shipment. Insure that all standard accessories are supplied.

1-1. Checking Model and Suffix Codes.

The model and suffix codes are indicated on the nameplate (tuning panel) attached to the side of the instrument. Check item against the model and suffix codes given in Section 2-4 to insure that the instrument meets your specifications.

If you have any questions about this instrument, please contact either your nearest Yokogawa Sales & Service Office or Yokogawa Electric Corporation, Tokyo, Japan.

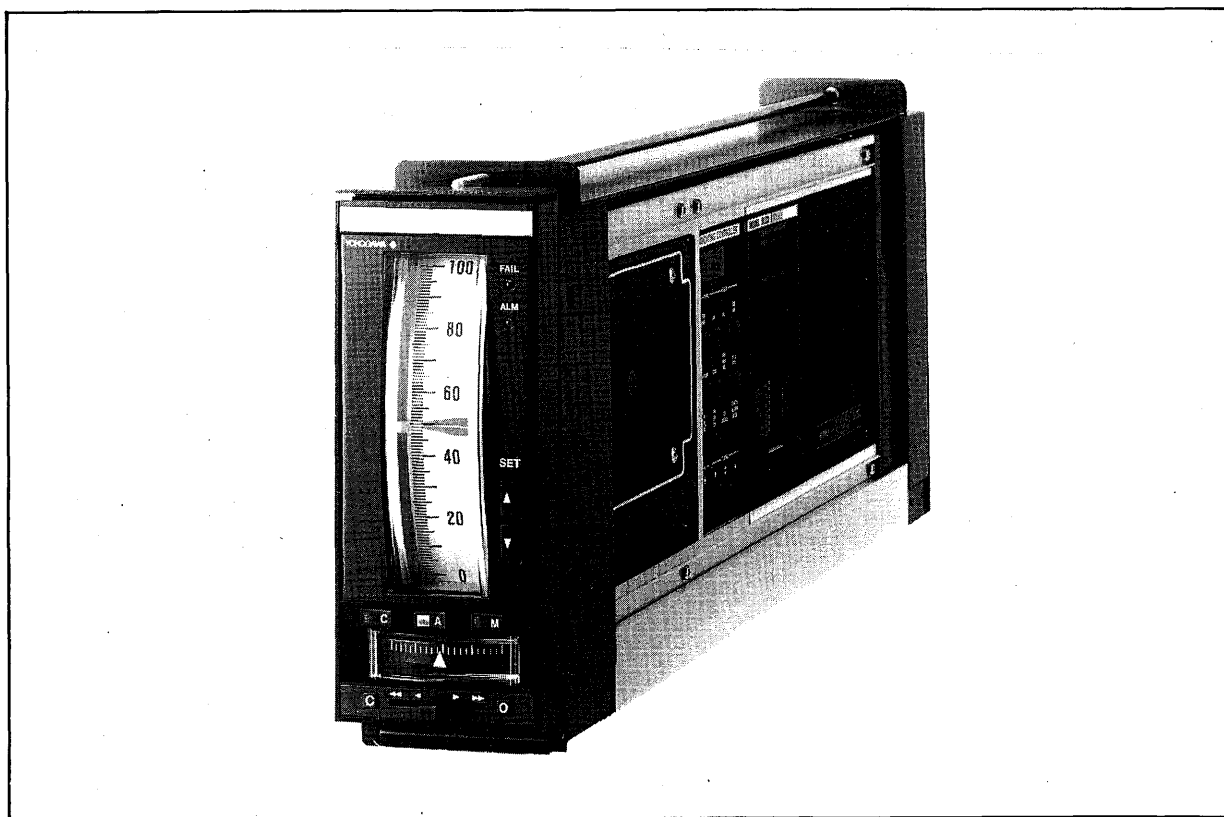


Figure 1-1. SLCD Indicating Controller.

2. GENERAL.

The SLCD Indicating Controller is a micro-processor-based process control instrument where:

- A new intelligent self-tuning model automatically optimizes PID parameters.
- I/O values, parameters, and built-in functions can be set by key switches and DIP switches on the tuning panel, and displayed on the digital display.
- A user-adjustable setpoint filter, used to improve the response to set-point changes, is also provided as a standard feature.
- A communications interface easily establishes a link with a central CRT-display operator station or supervisory computer.
- Self-diagnostics automatically check instrument behavior and input/output signal lines.

2-1. Standard Specifications.

Input/Output Signals

Analog Inputs: 1 to 5 V DC, 4 points each.

Analog Outputs:

1 to 5 V DC, 2 points each.

4 to 20 mA DC, 1 point.

Status Input: Contact or voltage signal, 1 point.

Status Outputs: Transistor contact, 5 points each.

Fail Output: Transistor contact, 1 point.

Contact open during power-failure.

Indicating, Setting and Operation Functions

Process Variable and Setpoint Indicators: Moving coil meter with dual pointers, or fluorescent bar graph with a 4-digit data display.

Output Indicator: Moving coil.

Setpoint Settings:

Manual: Setting speed 40 sec./full scale.

Remote: With input signal or supervisory computer.

Mode Transfer: By front-panel cascade (C)/auto (A)/manual (M) switches or by contact inputs.

Manual Output: Set by two-speed lever action.

Control-Parameter Set and Data Display: Control parameters can be set by the tuning panel switches.

Data can be displayed on the digital display on the tuning panel.

Basic Control Functions

Control Action: PID control + Output limiter.

P (proportional band): 2 to 999.9%.

I (integral time): 1 to 9999 sec.

D (derivative time): 0 to 9999 sec. (*)

Output Limiters: High/low limits; adjustable range -6.3 to 106.3%.

Control Action Switching: DIR (direct) and RVS (reverse).

Control Output Period: 0.2 sec.

Notes: *Action range is 2 to 9999 sec. (0 & 1: OFF)

Extended Control Functions

Control Action: PID/PD switch-selectable (side-panel switch).

Adjustable Filter for Set-Point Changes:

Response to setpoint changes can be adjusted.

Two adjustment parameters (for each set point).

Self-tuning Function (in SLCD-□81) Features:

Self-tuning selector (ON/OFF switch) (can be operated by status input);

Settable limits for tuning of PID parameters.

Reset Bias: 0 to 106.3% (for PID control)

Manual Reset: -6.3 to 106.3% (for PD control)

Nonlinear Control:

Nonlinear gap 0.0 to 100%.

Nonlinear gain 0.000 to 1.000.

Feedforward Control: Feedforward gain computation is carried out.

Preset Value Output: -6.3 to 106.3% (switched by status input).

Mode Transfer: M/A/PMV/TRK switches on the tuning panel can set control modes:

M: Mode changes from cascade (C) or auto (A) to manual (M) or vice versa.

In cascade or automatic mode, manual control can be carried out by the status input.

A: Mode changes from cascade (C) to auto (A) or vice versa.

In cascade mode, automatic control can be performed by the status input.

PMV: Outputs preset value.

In cascade mode, automatic control can be carried out by the status input.

TRK: Output tracks an external signal.

In automatic or cascade mode, output tracks an external signal by the status input.

Mode-Setting Signal Output (two contacts):

Operation Mode	C	A	M
C/(A-M) contact	Closed	Open	Open
(C-A)/M contact	Closed	Closed	Open

Computation Functions

Square Root Extraction: Measurement input or remote-set input for cascade control can be square-root extracted (low-level signal cut is adjustable).

Line-segment Function: Ten line-segment computations for measurement input are possible.

First-order Lag: This function can be set for measurement input, remote set input, output tracking, and feedforward input (adjustable time constant).

Ratio and Bias Computations: Ratio and bias computations for cascade control can be set.

Gain and Bias Computations: Feedforward input gain and bias settings are possible.

Alarm Functions

Alarm Action: High/low limits, and deviation alarm.

Input High-limit Alarm Setting: -6.3 to 106.3%.

Input Low-limit Alarm Setting: -6.3 to 106.3%.

Deviation Limit Alarm Setting: 0.0 to 112.5%.

Output Contact: High-limit, low-limit, and deviation output contacts.

When an alarm occurs, the output contact opens or closes (selected by the tuning panel switches).

When the power is turned OFF, the output contact opens.

Alarm Display: Front ALM lamp lights up.

Communication Functions

Communication with a supervisory system.

Items	Functions
Target device	LCS card in YEWPACK and μ XL Field Control Unit.
	LCS card in CENTUM-XL Field Control Station.
Signals transmitted	Process variable (for monitoring), set value, controller output, operation mode, output limiter set value, and PID parameters.
C (cascade) mode selection	Cascade input (analog) signal and supervisory computer set signal can be set when in C mode.
DDC/SPC mode	DDC or SPC mode can be set from the supervisory computer.
	In DDC mode, controller output can be directly manipulated by communications with supervisory computer. In SPC mode, set value can be set by communications with supervisory computer.
Backup	Backup AUTO mode. Backup MAN mode.
Data transmission distance	100 m max. Use an SCCD cable.

Mounting

Style: Flush panel mounting. Instruments are in housings, and may be mounted individually or side by side.

Inclined Mounting: Instrument may be inclined with the front up to 75° from vertical (rear of the instrument lower than the front). (Zero indicator may need readjustment.)

Wiring

Signal Wiring to/from Field: ISO M4 size (4 mm) screws on terminal board.

Power and Ground Wiring:

100 V version: JIS C 8303 two-pin plug with grounding (IEC A5-15, UL498)

220 V version: CEE 7 VII (CENELEC standard) plug. Cable Length: 300 mm. (11.8")

Housing Dimensions: 182.5 (H) X 87 (W) X 480 (D) (depth behind panel) (mm).

(7.2"(H) x 3.4"(W) x 18.9"(D))

Weight

Controller Unit: 3.4 kg (7.5 lb).

Housing: 2 kg (4.4 lb) (excluding mounting kit).

Normal Operating Conditions

Ambient Temperature: 0 to 50°C. (32 to 122°F)

Ambient Humidity: 5 to 90% relative humidity (no moisture condensation).

Power Supply: Two versions, for "100 V" (standard) or "220 V" (optional/A2ER). Both versions may use AC or DC, without change to the instrument:

Version	100 V	220 V
DC (polarity reversible)	20 to 130 V	120 to 340 V
AC (47 to 63 Hz)	80 to 138 V	138 to 264 V

2-2. Optional Specifications.

/A2ER: For "220 V version" power supply.

/MTS: Controller supplied with a kit for separate mounting. For separate mounting, /MTS must be specified.

/SCF-G□M: Mounting kit bezel color change from standard color (black). Choose color from set of optional colors (see GS 22DIF1-E). Specify color code in space □.

/NHS: No housing, instrument only. See GS 1B4FI-E to order housing separately.

/NPE: Letters engraved on front panel nameplate.

2-3. Accessory.

Fuse (1 A): 1

Note: The fuse (S9510VK) is the dedicated fuse, Do not use it for other products.

2-4. Model and Suffix Codes.

Model	Suffix codes	Style	Option codes	Description
SLCD	.....	.....	.....	Indicating Controller
Indicator	-1 .....	.....	.....	Moving coil
	-2 .....	.....	.....	Fluorescent bar graph ^{*2}
Functions	5 .....	.....	.....	Enhanced model, with adjustable filter
	8 .....	.....	.....	Enhanced model, with adjustable filter and self-tuning function
	1 .....	.....	.....	Always 1
Style code		*E .....	.....	Style E
Common options			/A2ER /MTS /SCF -G□M /NHS /NPE	220V power supply ^{*1} With mounting kit Bezel color change Without housing Nameplate engraving

*1 Specify /A2/NHS to order without housing

*2 The order acceptance of fluorescent bar graph is discontinued.

3. INSTALLATION.

For general information on installation and mounting, refer to Instruction Manual IM 1B4F1-01E, "Installation Manual for Panel Mounted Instruments".

3-1. Wiring.

Connect external wires, including process variable input, to the terminal board on the rear of the controller housing with M4 (4 mm) size screws.

Table 3-1 shows the terminal designations and signals to be connected. Connect wires in accordance with the model and suffix codes of the controller.

3-1-1. Wiring Instructions.

- (1) Be sure to use solderless crimp-on lugs on all cable connections.
- (2) External contact and voltage input must be the proper rating. (See Figures 3-1 and 3-2) Excess conductor resistance and the consequent voltage drop must be taken into account.
- (3) When driving remote equipment using transistor contacts, such as fail output, alarm output and status output, make the wiring in accordance with the following instructions:
 - Do not connect any load which exceeds the contact rating (30 V DC, 200 mA).
 - When driving a relay or other inductive device, connect a surge absorber (protective diode) in parallel with the load. (See Figure 3-3.)
 - When connecting a power supply to an external load, observe the correct polarity (see Figure 3-3).
 - Note that transistor contacts cannot be connected directly to an AC load. Use a relay to switch an AC circuit. (See Figure 3-4.)

Status Input	ON	OFF
External contact	CLOSED (input resistance less than 200 ohms)	OPEN (input resistance at least 100 k ohms)
Voltage input	LOW (input voltage -0.5 to 1. V DC)	HIGH (input voltage 4.5 to 30 V)

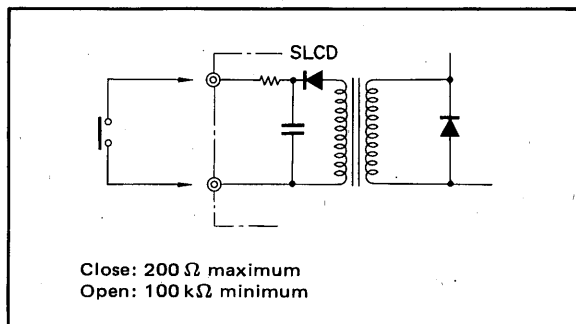


Figure 3-1. External Contact (Status) Input Connections.

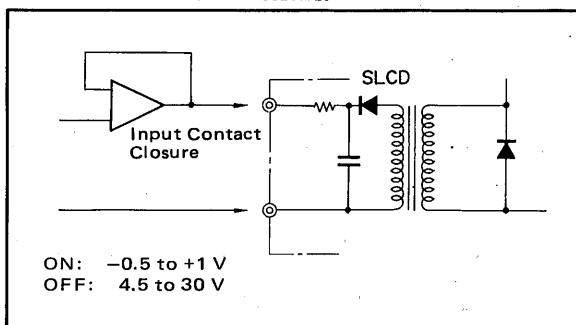


Figure 3-2. Voltage Level Input Connection.

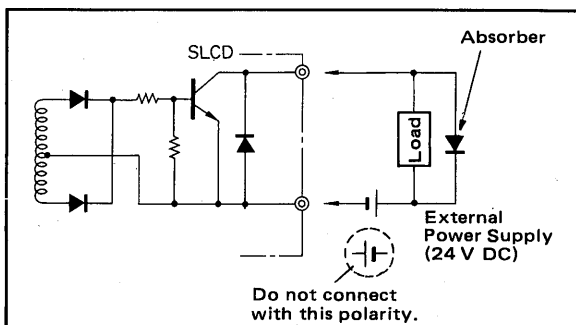


Figure 3-3. Surge Absorber Connection.

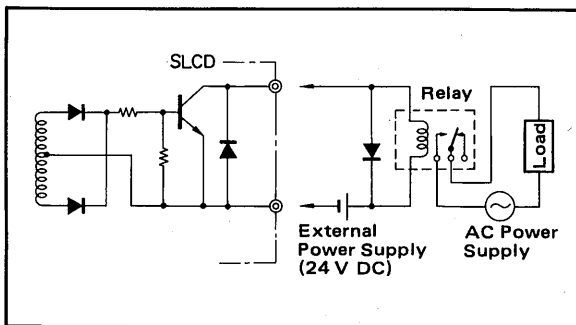


Figure 3-4. Connections for an External AC Power Supply.

3-1-2. Terminal Connections.

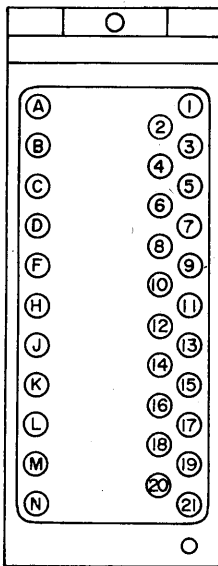


Figure 3-5. Terminal Layout.

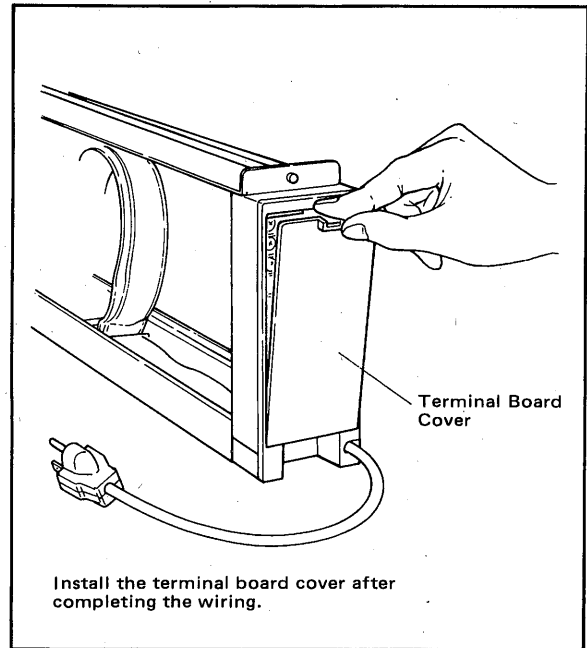


Figure 3-6. Removing Terminal Board Cover.

Table 3-1. Terminal Board Wiring.

Terminals	Description	Terminals	Description
1	+ Process Variable Input (1 to 5 V DC)	17	+ Communications *1
2	-	18	-
3	+ Cascade Set-Point Input (1 to 5 V DC)	19	+ Deviation Alarm Output
4	-	20	-
5	+ Tracking Input (1 to 5 V DC)	21	- FAIL Output (Negative Terminal)
6	-	A	+ Manipulated Output (MV) (4 to 20 mA DC)
7	+ Feedforward Input (1 to 5 V DC)	B	- *2
8	-	C	+ Manipulated Output (MV) (1 to 5 V DC)
9		D	-
10		F	+ Set-Value Output (SV) (1 to 5 V DC)
11	+ Mode Transfer Input	H	-
12	-	J	+ High-limit Alarm Output
13	+ Contact output for identifying C, A or M mode. In M mode, output opens.	K	-
14	-	L	+ Low-limit Alarm Output
15	+ Contact output for identifying C, A or M mode. In C mode, output is closed.	M	-
16	-	N	+ FAIL Output (Positive Terminal)

Notes:

- *1. Use SCCD shielded twisted pair cables.
- *2. Short-circuit these terminals when not in use.

4. PRINCIPLES OF OPERATION.

4-1. Circuit Descriptions.

See the SLCD circuit block diagram in Figure 4-1.

4-1-1. Analog Input Circuit.

A voltage input signal enters the input circuit consisting of R_{IN} , R_1 , and C_1 .

R_{IN} uses a high value of resistance ($1\text{ M}\Omega$), so it does not affect normal circuit operation. However, if the input circuit opens (input disconnected), it provides a DC path between the (+) and (-) input terminals to prevent the buildup of a static charge on the (+) input line. 0 V DC input (e.g. input open) is equivalent to -25% of range.

R_1 and C_1 form an input filter with a time constant of approximately 0.1 sec.

All analog-input negative leads are connected to a common line inside the SLCD.

4-1-2. Analog-to-Digital Converter Circuit.

Analog input signals entering the input circuit are amplified and sequentially selected by the input multiplexer. The comparator compares an input signal with the output of the digital-to-analog converter circuit, and the CPU adjusts the converter output so that the two signals are equal - basically, a successive-approximation type analog-to-digital converter. The corresponding digital value is stored in data memory (RAM).

4-1-3. Status Input Circuit.

Each status input signal is isolated by a transformer in the input circuit. Input status is read via an input port and transmitted via the data bus to RAM.

At the same time as the status inputs are read, the switch statuses (SET, C, A, M, and MV) on the front panel as well as keyswitch and slide switch statuses, which are on the tuning panel, are also read and stored in RAM.

4-1-4. Digital Computing Circuit.

When all the input data is read, the microprocessor (CPU) carries out data processing according to the computation/control program stored in ROM.

The results of computation and control are output via the digital-to-analog converter circuit or output ports.

If a supervisory system is connected, data communications are performed via a communications interface. The communications line is isolated from the controller by a photocoupler.

The watch-dog timer (WDT) connected to the CPU supervises the CPU operation - it causes the FAIL lamp to light up and outputs a fail contact signal if the CPU fails.

If the CPU fails, the manipulated output current signal is automatically isolated from the digital circuit, and can be varied manually. The measurement indicator then automatically indicates the value of the input signal.

4-1-5. Analog Output Circuit.

The analog output signals, after digital-to-analog conversion, are fed via the output demultiplexer and buffer amplifier to the current and voltage output circuits.

The analog output signal negative line is common, and is directly connected to the analog input signal common negative line.

4-1-6. Status Output Circuit.

The digital output signals are transformer-isolated and output to the field as open-collector contact signals.

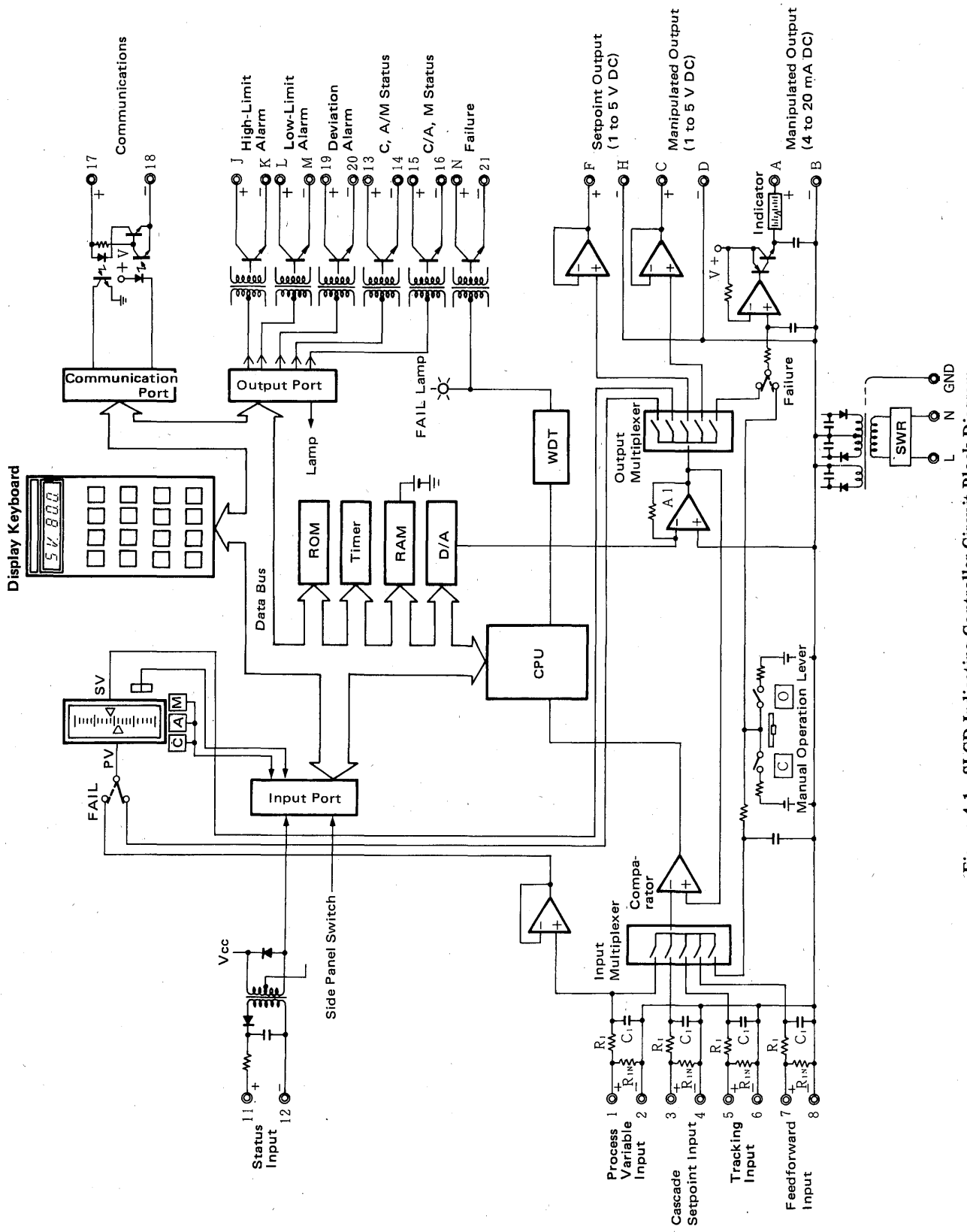


Figure 4-1. SLCD Indicating Controller Circuit Block Diagram.

4-2. Control Functions.

Figure 4-2 shows the functional block diagram of the SLCD Indicating Controller.

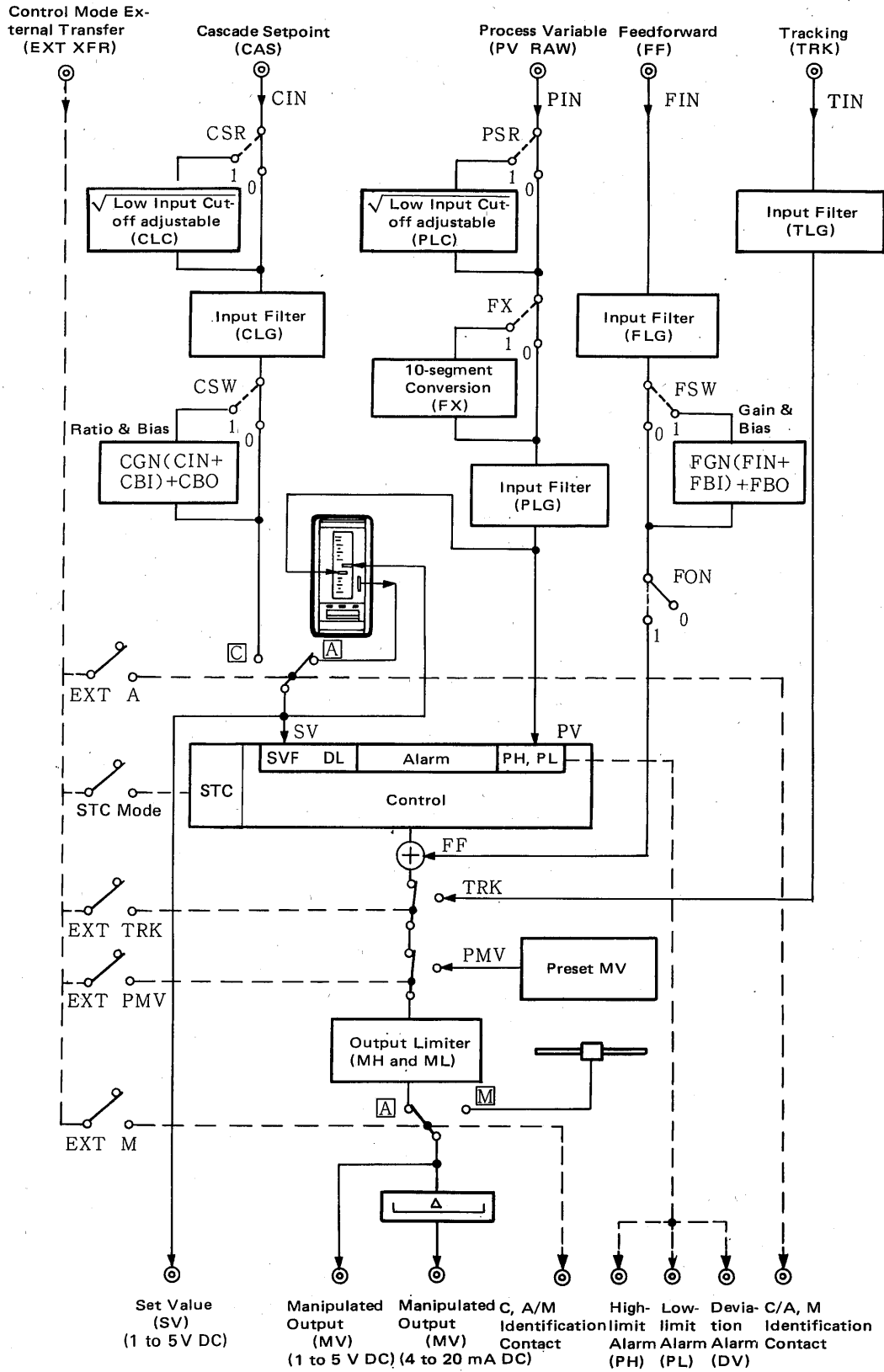


Figure 4-2. SLCD Indicating Controller, Functional Block Diagram.

4-2-1. PID Control (with reset bias).

The SLCD's control action consists of additive operations with independent integral and derivative terms. It is free, therefore, of interference from integral and derivative time constants. The derivative action is a type of process-variable derivative operation.

Two types of control computation expressions can be used. In fixed set-point control mode (in A mode), select the control computation expression from Table 5-2 for control-mode setting; whereas in set-point follow-up control mode (in C mode), use Equation 4-2 below.

(1) Fixed Set-Point Control Mode.

In fixed set-point control mode, proportional action acts upon process variables only. This offers enhanced control of disturbances and also provides consistent control performance, without abrupt changes in manipulated output in the event of setpoint changes or direct entry of numeric values from a supervisory system.

(2) Set-Point Follow-up Control Mode.

In set-point follow-up control mode (C mode), the proportional band acts upon deviation values, allowing quick response to setpoint changes.

Figure 4-3 shows a graphic representation of the SLCD's PID control response characteristics. The control arithmetic expressions are given in Equations 4-1 and 4-2.

Fixed set-point control mode

$$MV = \frac{100}{P} \left(PV + \frac{1}{T_I S} \cdot E + \frac{T_D S}{1 + \left(\frac{T_D}{m}\right) S} \cdot PV \right)$$

..... Eq. 4-1

Set-point follow-up control mode

$$MV = \frac{100}{P} \left(E + \frac{1}{T_I S} \cdot E + \frac{T_D S}{1 + \left(\frac{T_D}{m}\right) S} \cdot PV \right)$$

..... Eq. 4-2

where

- MV = Controller output
- E = deviation
- PV = process variable
- P = proportional band
- T_I = integral time
- T_D = derivative time
- m = derivative action gain
- S = operator

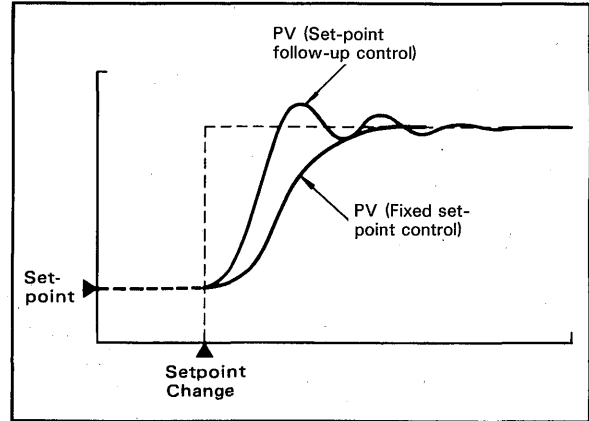


Figure 4-3. Response to Setpoint Changes.

Reset Bias.

While the SLCD's PID control action provides stable control with little overshoot, batch control applications require quick response characteristics as well as stability.

Reset bias action can optimize control response characteristics by increasing or decreasing the bias value as appropriate. Figure 4-4 shows examples of reset bias values and response characteristics.

The reset bias (RB) value is set with tuning panel switches.

Setting the RB value to 0% initiates PID control action without RB operation.

Then, increase the RB value gradually to improve response characteristics. Determine the optimal RB value by observing the response characteristics.

Further increases in the RB value result in oscillatory response characteristics.

When the RB value is set to 106.3%, corrective action is initiated after the setpoint and the process variable are reversed. PID control action with reset bias can thus be used in special-purpose control actions, such as pressure-relief valves.

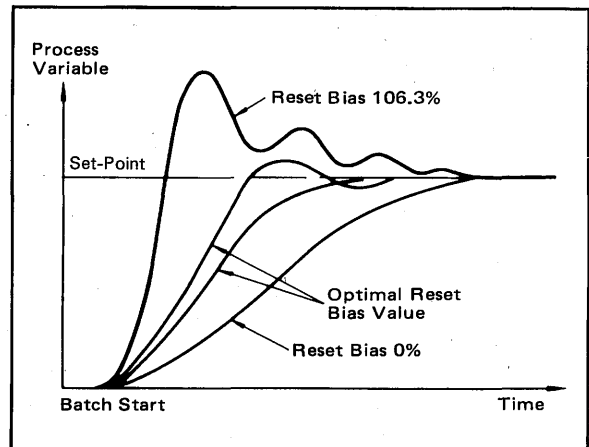


Figure 4-4. Examples of Reset Bias and Response Characteristics.

4-2-2. Proportional Control.

Proportional control action, which consists of PID control action minus integral action, is aimed at achieving special control effects.

The proportional control computation is expressed by Equation 4.3:

$$MV = \frac{100}{P} \left(E + \frac{T_D S}{1 + \left(\frac{T_D}{m}\right) S} \cdot PV \right) + B \quad \text{Eq. 4-3}$$

In the above equation, B denotes a manual reset (bias) to compensate for residual deviations caused by proportional control.

First-order lag follow-up switching is provided to prevent output bumps during operation mode transfer.

Table 4-1. Operation Mode Transfers.

Variable Operation Mode Transfer	Setpoint	Manipulated Output
A → C	Immediately Responsive	First Order Lag Follow-up
M → A	Unchanged	First Order Lag Follow-up

(Other types of operational mode transfer are carried out in the same manner as PID control.)

4-2-3. Nonlinear PID Control.

Nonlinear PID control is the PID control mode which multiplies a deviation by a preset nonlinear gain when the deviation is smaller than the nonlinear gap. (See Figure 4-5.)

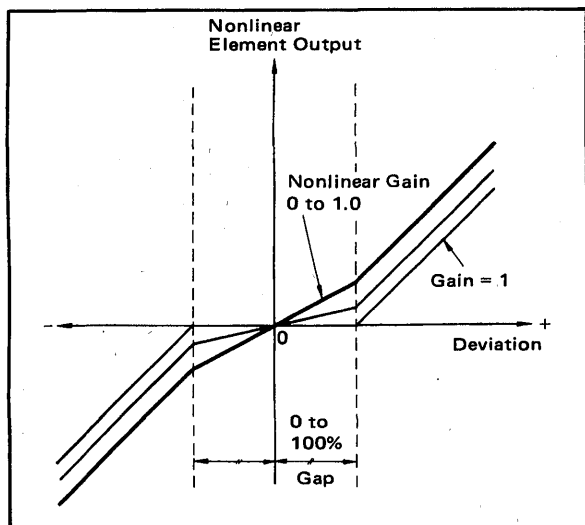


Figure 4-5. Nonlinear Control Action.

4-2-4. Feedforward Control.

In the feedforward control, a feedforward signal is added onto a PID-controlled output to provide a manipulated output (MV). The following computations are executed for the feedforward input signal.

$$FF = FGN (FIN + FBI) + FBO \quad \text{Eq. 4-4}$$

- where FF: Feedforward output
- FIN: Feedforward input
- FGN: Feedforward gain
- FBI: Input bias
- FBO: Output bias

Using the tuning panel switch (FF), users can set the feedforward signal output and additional computation (shown above) with computation constants.

4-2-5. Setpoint Tracking.

When the proportional gain is high or when there is a substantial difference between the internal set point and the cascade set point, switching the operation mode from auto to cascade produces a sizable variation in manipulated output.

A set point tracking function allows the internal set point to be matched with the cascade setpoint during manual operation. In switching the operation mode from auto to cascade, therefore, variations in manipulated output can be averted by transferring auto mode to manual mode before finally converting to cascade mode.

The pushbutton operation sequence at this time is from **A**, to **M**, then back to **A** and finally to **C**.

The set-point tracking function is selectable with a DIP switch on the tuning panel.

4-2-6. Controller Output (MV) Tracking.

DIP switches on the tuning panel allow users to switch the PID-controlled output to a remote tracking signal with a remote status signal. Balanceless and bumpless transfer from the output tracking status to PID-controlled output is accomplished.

The controller output tracking function can be selected with a DIP switch on the tuning panel.

4-2-7. Preset MV Output.

Using DIP switches and keyswitches on the tuning panel, users can select the preset MV output and set its value. Transfer from the PID-controlled output to the preset MV value is accomplished with a status input.

4-2-8. Output Limiter.

The SLCD is complete with integral (reset) windup prevention output limiters, which are actuated only while in C or A mode.

If $ML \leq -5.0\%$ is set, the operation which tightly shuts an output works. When the linear characteristic is required, set it inside the range of -4.9 to 106.3% .

4-2-9. Operation Mode Transfer.

The SLCD has three modes of operation: C (cascade), A (auto), and M (manual). These three modes are selectable with the front-panel C, A, and M pushbutton switches.

M → **A** transfer: Balanceless and bumpless.

A → **C** transfer: The set point is immediately responsive to an external set-point signal. Manipulated output can be switched smoothly without an abrupt change even when it is not in agreement with the set point during mode transfer. In a control loop not using C mode, pressing the C pushbutton turns on the ALM lamp, instead of effecting a transition to C mode, to prevent operator error.

C → **A** transfer: The set point is held; balanceless and bumpless.

C → **M** transfer: Both the set point and manipulated output are held.

M → **C** transfer: Not allowed; M mode must be switched first to A mode before transferring to C mode. A set-point tracking function is provided, which places the set point in agreement with the cascade setpoint before a transfer is made from M mode to C mode. Direct transfer from M to C mode is possible when the computer is in DDC operation in the C mode CMP state.

4-2-10. Transferring Operation Mode by Status Input.

Transferring operation mode can be accomplished through input (see Table 4-2). DIP switches on the tuning panel allow operation mode to be specified.

Table 4-2. Operation Mode Transfers by Status Input.

Mode Designation by Status Input	Operational Mode		Input	
			CLOSED (Low)	OPEN (Hi)
M (Cas → Man) (Auto → Man)	C (Cascade)	Setting	Cascade	Local
		Operation mode	Auto	Manual
		Indicator lamp	Lamp "C" lights	Lamp "C" flashes
	A (Auto)	Setting	Local	
		Operation mode	Auto	Manual
		Indicator lamp	Lamp "A" lights	Lamp "A" flashes
M (Manual)	Operation mode	Always manual operation		
A (Cas → Auto)	C (Cascade)	Setting	Cascade	Local
		Operation mode	Auto	
		Indicator lamp	Lamp "C" lights	Lamp "C" flashes
	A (Auto)	Operation mode	Always auto operation	
M (Manual)	Operation mode	Always manual operation		
Preset MV Output	C (Cascade)	Setting	Cascade	
		Operation mode	Auto	Preset MV value
		Indicator Lamp	Lamp "C" lights	Lamp "C" flashes
	A (Auto)	Setting	Local	
		Operation mode	Auto	Preset MV value
		Indicator lamp	Lamp "A" lights	Lamp "A" flashes
M (Manual)	Operation mode	Always manual operation		
TRK (Output Tracking)	C (Cascade)	Setting	Cascade	
		Operating mode	Auto	Tracking
		Indicator lamp	Lamp C lights	
	A (Auto)	Setting	Local	
		Operation mode	Auto	Tracking
		Indicator lamp	Lamp A lights	
M (Manual)	Operation mode	Always manual operation		

Note: Operation modes, which are transferred with status input open, are shown above. However, even with status input closed, operation modes can be transferred. Selection of operation modes is carried out by DIP switches on the tuning panel (see Table 5-2).

4-2-11. Operation Mode Status Output.

The SLCD controller local status can be transmitted with (C, A)/M status output CLOSED or OPEN, and C/(A, M) status output CLOSED or OPEN, as shown in Table 4-3.

Table 4-3. Status Output List.

Operation Mode	Mode Designation by External Contact Input	Internal Controller Status	Contact Output	
			(C, A)/M Status Output	C/(A, M) Status Output
C	OFF (designation release)	C	CLOSED	CLOSED
	Preset MV output	C	CLOSED	CLOSED
	Output tracking	C	CLOSED	CLOSED
	EXT. Auto	A	CLOSED	OPEN
	EXT. Man.	M	OPEN	OPEN
A	OFF (designation release)	A	CLOSED	OPEN
	Preset MV output	A	CLOSED	OPEN
	Output tracking	A	CLOSED	OPEN
	EXT. Man.	M	OPEN	OPEN
M	(Always manual mode)	M	OPEN	OPEN

4-2-12. Input Filter.

The input filters – PLG, CLG, TLG and FLG – can perform first-order lag computations with time constants ranging from 0 to 799.9 seconds for the input signals (process variable, cascade set point, output tracking and feedforward input, respectively). The time constants can be set by DIP switches on the tuning panel.

4-2-13. Square Root Extraction (with adjustable low input cutoff).

The SLCD Controller can perform square-root extractions for the process variable and cascade setpoint signals with adjustable low input cutoff. When the input signal is lower than a predetermined adjustable level, the corresponding output is the same level as the input.

Selection of this function and cutoff level setting are performed by DIP switches on the tuning panel.

4-2-14. Ratio Computation.

For the cascade setpoint, the ratio computation expressed by Equation 4-5 can be calculated:

$$CSV = CGN (CIN + CBI) + CBO \dots \text{Eq. 4-5}$$

where CSV: Ratio-computed output
 GIN: Cascade setpoint input
 CGN: Gain
 CBI: Input bias
 CBO: Output bias

When the cascade setpoint input is ratio-computed, control computation is carried out with the computation output (CSV) as the set point (SV). DIP switches on the tuning panel allow selection of this function and setting the computation constants.

4-2-15. Linearizing.

Nonlinear process variable signals can be linearized with the 10-segment function. DIP switches on the tuning panel allow selection of this function and setting of the output values.

4-2-16. Alarms.

Built-in alarms consist of high- and low-limit alarms for process variable inputs and a deviation alarm whose positive/negative limits are not individually identified.

Each of the three alarms is furnished with an independent contact. The alarm output status (open or closed) can be set by the DIP switches on the tuning panel.

The front-panel ALM lamp lights up when any one alarm condition is established.

5. OPERATION.

5-1. Names and Functions of Components.

5-1-1. Controller with Moving Coil Indicator.

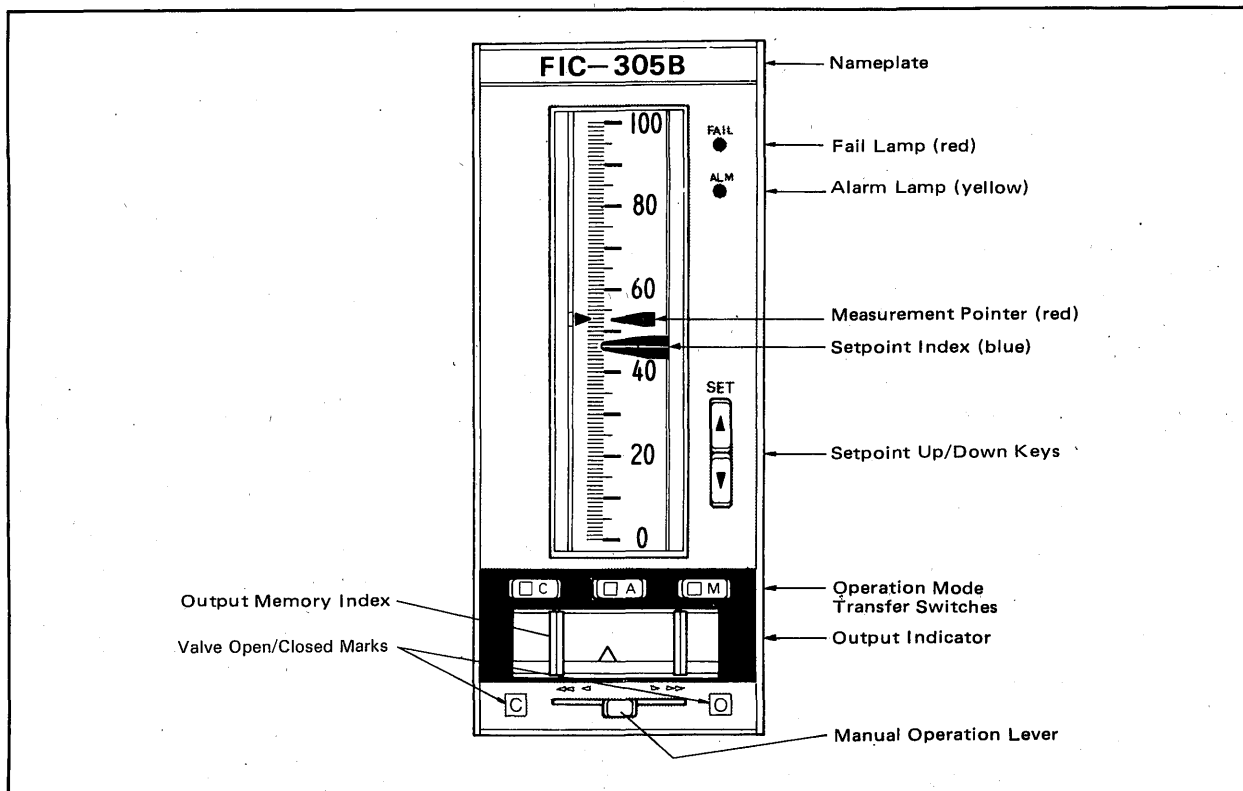


Figure 5-1. Front View.

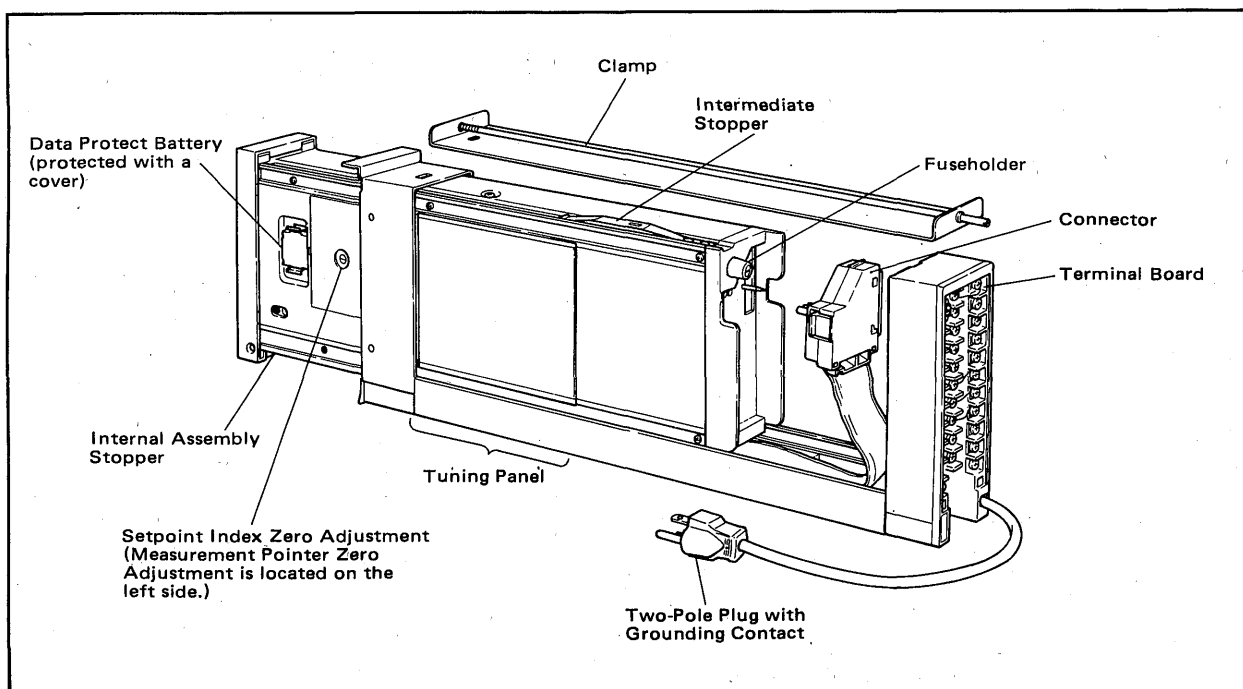


Figure 5-2. Right Side View.

5-1-2. Controller with Fluorescent Bar Graph Indicator.

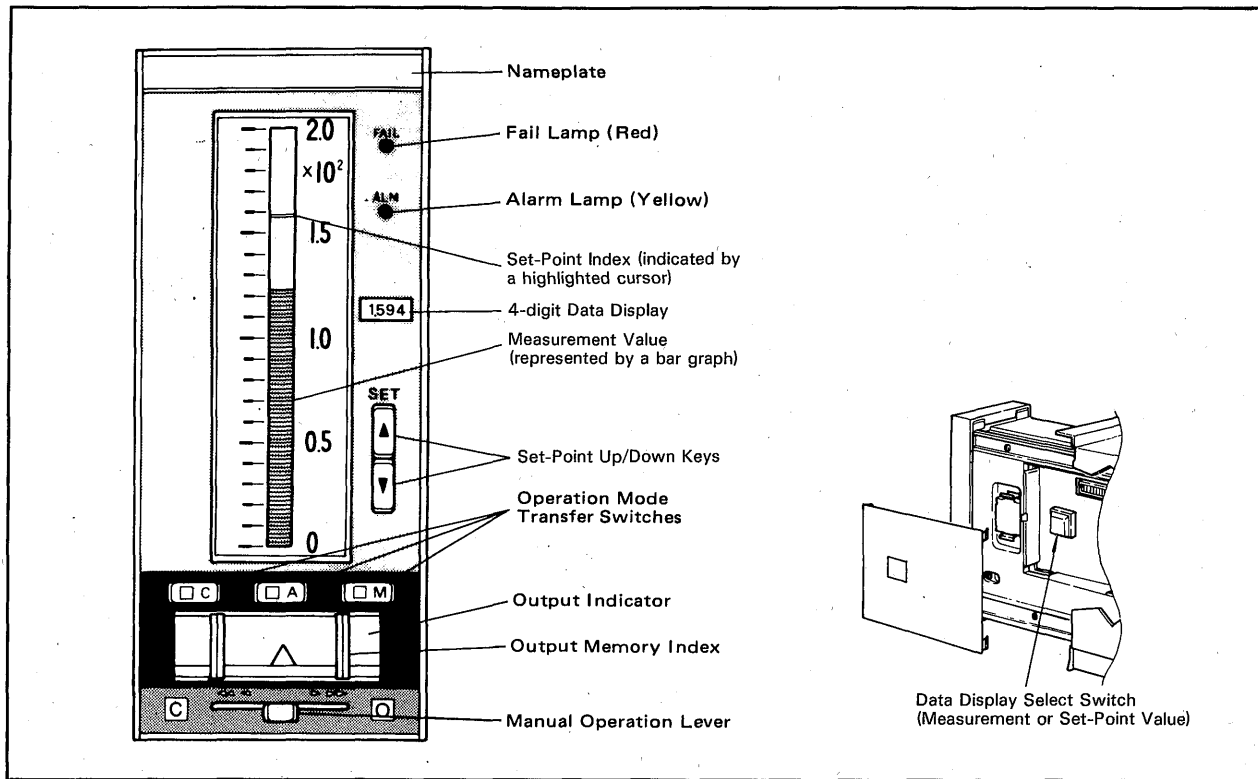










Figure 5-3. Front and Right-Side Views.

- (1) **FAIL lamp**
The FAIL lamp comes on when a failure occurs in the controller.
- (2) **ALM lamp**
The ALM lamp comes on when any alarm condition is established. It flashes in the event of a voltage drop in the data-protect battery.
- (3) **4-digit data display**
This display normally indicates a process variable in the appropriate engineering unit (4-digits). It indicates a set point while the side-panel select switch is pressed. (See Figure 5-3.)
- (4) **Set-point up/down keys**
These keys are operative when the controller is in A or M mode.
Press  to increase the set point.
Press  to decrease the set point.
(The setpoint freezes when the two switches are pressed at the same time.)
Setting speed: 40 sec./full scale
Fine adjustment: Pressing the switches momentarily (for about 0.2 sec.) changes the setpoint by 0.1%.
- (5) **C/A/M operation mode transfer switches**
Press the appropriate pushbutton to select the indicated operation mode. A built-in indicator lamp comes on concurrently with the mode selection.
- (6) **Output indicator**
The output indicator indicates current output signals in the range of 4 to 20 mA DC.
- (7) **Manual operation lever**
This lever is operative while the controller is in M mode.
Move the lever to the left to decrease the manipulated output signal; move it to the right to increase the signal.
Setting speeds:
 ,  40 sec./full scale
 ,  4 sec./full scale
Fine adjustment: Moving the lever from the neutral position to  or  momentarily (for about 0.2 sec.) changes the manipulated output signal by 0.1%.

5-1-3. Names and Functions of Tuning Panel Switches.

■ Tuning Panel.

The SLCD Indicating Controller incorporates the tuning panel for setting parameters and monitoring data on its side panel (see Figure 5-4).

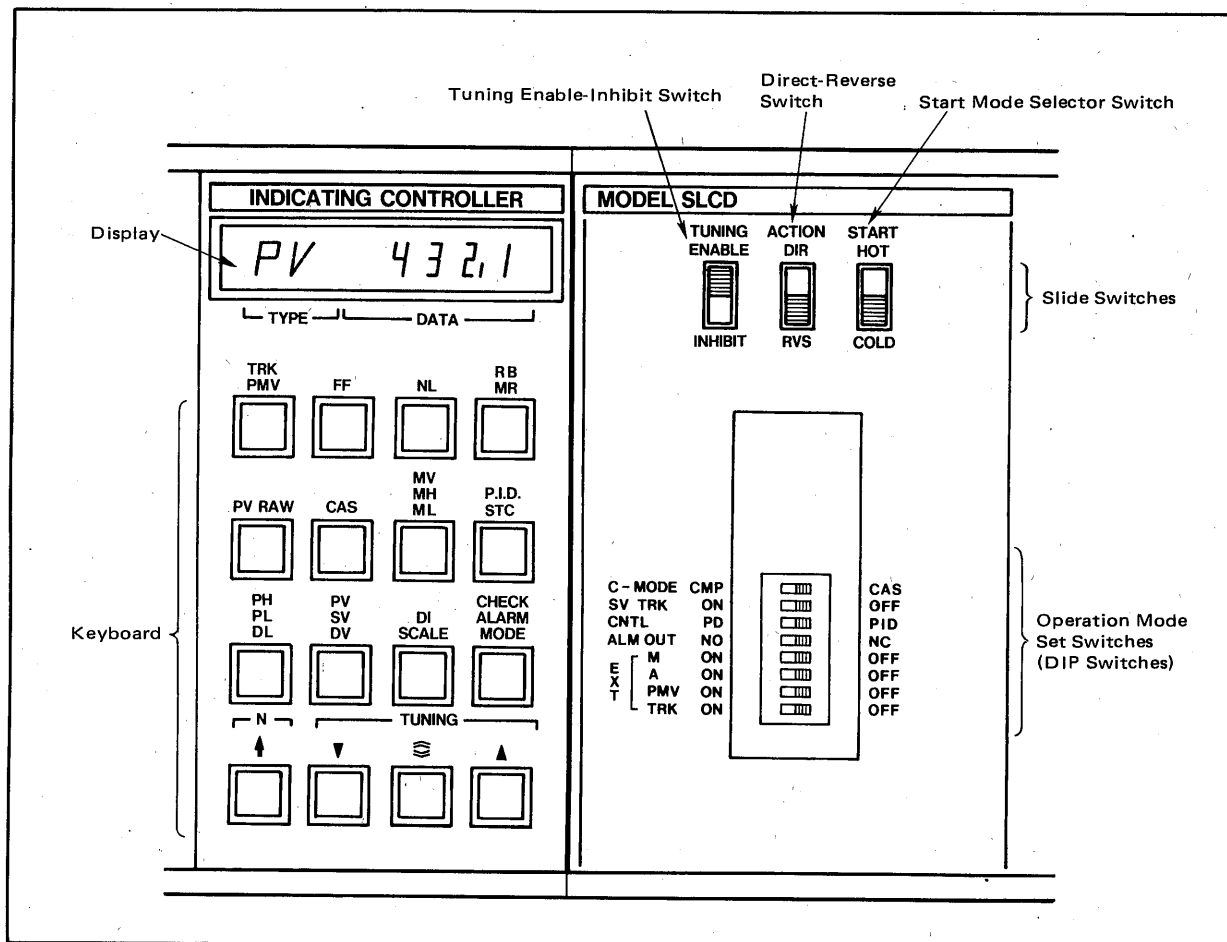
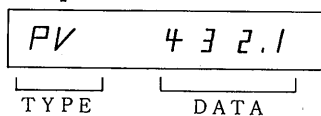


Figure 5-4. Tuning Panel.

(1) Display – to display data types and numeric data.

< Display Example >



(2) Keyboard.

Sets parameters, calls data to be monitored, and changes the data set.

Names and functions of the keyswitches are described in Tables 5-1 and 5-2.

Table 5-1. Names and Functions of Tuning Panel Keyboard Switches. (1/2)

Type	Number (N)	Name and Function	Display/Setting Range	Unit	Settable	Initial Value
TRK		Tracking input computation and preset output				
PMV						
TIN		Tracking input value	-25.0 to 135.0	%	x	-
TLG		First-order lag, time constant	0.0 to 799.9	sec.	o	0.0
TRK		Output tracking value	-6.3 to 106.3	%	x	-
PMV		Preset output value	-6.3 to 106.3	%	o	-6.3
FF		Feedforward input computation				
FIN		Feedforward input value	-25.0 to 135.0	%	x	-
FLG		First-order lag, time constant	0.0 to 799.9	sec.	o	0.0
FSW		Feedforward gain computation	0 : No setting 1 : Set	-	o	0
FGN		Feedforward gain	-8.000 to 8.000	-	o	0.000
FBI		Feedforward input bias	-106.3 to 106.3	%	o	0.0
FBO		Feedforward output bias	-800.0 to 800.0	%	o	0.0
FF		Feedforward output addition	-100.0 to 200.0	%	x	-
FON		Feedforward output addition set	0 : No setting 1 : Set	-	o	0
NL		Nonlinear control				
GW		Nonlinear control dead band	0.0 to 100.0	%	o	0.0
GG		Nonlinear control gain	0.000 to 1.000	-	o	1.000
RB		Reset bias	0.0 to 106.3	%	o	0.0
MR		Manual reset	-6.3 to 106.3	%	o	-6.3
PX(*1)		Adjustable setpoint filter parameter α	0.000 to 1.000	-	o	0.000
PY		Adjustable setpoint filter parameter β	0.000 to 1.000	-	o	0.000
PVRAW		Process variable computation				
PIN		Process variable input	-25.0 to 135.0	%	x	-
PSR		Square root extraction set	0 : No setting 1 : Set	-	o	0
PLC		Low input cutoff for square root extraction	0.0 to 100.0	%	o	1.0
FX		10-segment function set	0 : No setting 1 : Set	-	o	0
F	01 to 11	10-segment function output	0.0 to 100.0	%	o	Linear output
PLG		First-order lag time constant	0.0 to 799.9	sec.	o	0.0
CAS		Cascade set input computation				
CIN		Cascade set input	-25.0 to 135.0	%	x	-
CSR		Square root extraction set	0 : No setting 1 : Set	-	o	0
CLC		Low input cutoff for square root extraction	0.0 to 100.0	%	o	1.0
CLG		First-order lag time constant	0.0 to 799.9	sec.	o	0.0
CSW		Ratio computation set	0 : No setting 1 : Set	-	o	0
CGN		Ratio computation gain	-8.000 to 8.000	-	o	1.000
CBI		Ratio computation input bias	-106.3 to 106.3	%	o	0.0
CBO		Ratio computation output bias	-800.0 to 800.0	%	o	0.0
CSV		Cascade set point	-6.3 to 106.3	%	x	-
MV(*2)		Controller output	-20.0 to 106.3	%	o	-
MH		Controller output, high-limit set point	-6.3 to 106.3	%	o	106.3
ML		Controller output, low-limit set point	-6.3 to 106.3	%	o	-6.3

- Notes: *1 PX and PY are effective for SLCD-□51 and SLCD-□81.
*2 Can be set only when the SLCD is in manual operation.
*3 STC and STC parameters are effective only for SLCD-□81.
*4 Ranges that can be set - are displayed in engineering unit, corresponding to % in initial values.
*5 Can be set only when the SLCD is in A (Automatic) or M (Manual) mode.
*6 Action range is 2 to 9999 sec. (0 & 1: OFF)

Table 5-1. Names and Functions of Tuning Panel Keyboard Switches. (2/2)

Type	Number (N)	Name and Function	Display/Setting Range	Unit	Settable	Initial Value
PID STC(*3) STC(*3) PB TI TD IP to GM		Control parameters Self-tuning function STC mode designation Proportional band Integral time Derivative time STC parameters	See section 5-4 2.0 to 999.9 1 to 9999 0 to 9999 (*6) See section 5-4	— % sec. sec. —	○ ○ ○ ○ ○	— 999.9 1000 0 —
PH(*4) PL(*4) DL(*4)		Process variable, high-limit alarm setpoint Process variable, low-limit alarm setpoint Deviation alarm setpoint	-6.3 to 106.3 -6.3 to 106.3 0.0 to 112.5	% % %	○ ○ ○	100.0 0.0 100.0
PV SV(*5) DV		Process variable input for compensation Control setpoint Control deviation	Engineering unit Engineering unit Engineering unit	— — —	x ○ x	— — —
DI SCALE DI HI LO DP		Operation mode transfer status display Decimal-point position set Status input Engineering unit (corresponding to 100%) Engineering unit (corresponding to 0%) Decimal point position (<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>)	Engineering unit 0 : OPEN (Hi) 1 : Closed (Low) -9999 to 9999 -9999 to 9999 1 to 4	— — — — —	x ○ ○ ○ ○	— — 1000 0 3
CHECK ALARM STALM MODE	1 to 9	Displays code for self-diagnostic test result Displays alarm status code STC alarm: code displaying cause of alarm Operation mode	See Section 5-7-4. See Section 5-7-5. See Section 5-7-6. See Table 5-2.	— — — —	x x x ○	— — — —

Table 5-2. Operation Mode.

Mode (N)	Set-point	Operating Status	Initial Value										
1 PID control in "auto" operation (see Note 1)	0	PID control in fixed set-point control mode (Equation 4-1).	0										
	1	PID control in follow-up control mode (Equation 4-2).											
	2	PID control in SVF mode (See section 5-5).											
2 Operation mode status transfer (see Note 2)	0	Operation mode transfer by status input (OPEN).	0										
	1	Operation mode transfer by status input (CLOSE).											
3 STC stop function by status input (see Note 3)	0	STC stop function by status input not provided.	0										
	1	STC stop function by status input provided. <table border="1" style="margin-left: 20px;"> <tr> <td style="text-align: center;">Status input</td> <td style="text-align: center;">OPEN</td> <td style="text-align: center;">CLOSED</td> </tr> <tr> <td style="text-align: center;">MODE 2</td> <td style="text-align: center;">STOP</td> <td style="text-align: center;">not STOP</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">STOP</td> <td style="text-align: center;">not STOP</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">not STOP</td> <td style="text-align: center;">STOP</td> </tr> </table>		Status input	OPEN	CLOSED	MODE 2	STOP	not STOP	0	STOP	not STOP	1
Status input	OPEN	CLOSED											
MODE 2	STOP	not STOP											
0	STOP	not STOP											
1	not STOP	STOP											
4 Supervisory system backup (see Note 4)	0	If the supervisory system fails, controller mode transfers to M (Manual).	0										
	1	If the supervisory system fails, controller mode transfers to A (Automatic). Normal control operation continues.											
5 Supervisory system setting (see Note 4)	0	Supervisory system can set operation mode.	0										
	1	Supervisory system cannot set operation mode (only monitoring is possible).											
6 Process variable ("Measuring") tracking (see Note 5)	0	—	0										
	1	When manual control mode, setpoint tracks process variable.											
7 (Not used)	0	—	0										
8 (Not used)	0	—	0										
9 Communication with SGWU, and YEWMAC	0	Normally 0	0										
	1	Set to 1 only when SLCD is combined with YEWMAC-V ₀ , V ₁ or SGWU (style A)											

- Notes:
- In cascade control, PID control with the fixed set-point control is always performed.
 - Operation mode can be transferred with status input.
 - Effective only for SLCD-□81. When use this function, turn all the DIP switches of "EXT" (See Table 5-3) to OFF.
 - Used when the SLCD communicates with the supervisory system.
 - When using this function, turn SV TRK of DIP switch off; if it is ON state, mode 6 is unavailable.

(3) Slide and DIP Switches.

Table 5-3 lists the functions of slide and DIP switches on the tuning panel.

Table 5-3. Slide and DIP Switch Functions.

Switches	Functions	Description
TUNING	Enables and inhibits data set switches (▼, ⊞, and ▲).	ENABLE : Enables data set. INHIBIT : Disables data set.
ACTION	DIR-RVS switch sets a "direct" or "reverse" acting controller.	DIR : deviation = process variable value - set value RVS : deviation = set value - process variable value
START	Operation restart status setting when power reverts to normal.	HOT : Restarts in the same operating condition as it was immediately before power failure. COLD : Restarts in M mode, with an output of -6.3% (1 to 5 V DC output); with an output of -20% (4 to 20 mA output). (Note : Always restarts in the HOT mode, regardless of the switch position in case of a power failure of less than 2 seconds.)
C-MODE	Specifies the set point input in C mode.	CMP : Set-point signal from the supervisory computer. CAS : Analog cascade signal.
SV TRK	In M mode, specifies local set point to track remote set point.	ON : In M mode, local set point follows cascade setpoint. OFF : Invalid set-point tracking.
CNTL	Specifies control action.	PID : PID control. PD : PD control.
ALM OUT	Specifies alarm output status.	NO : Normally open. NC : Normally closed. (Note : During power failure, alarm contacts remain open.)
EXT	Specifies operation mode with status input.	
M	Transfer from C (cascade) or A (Automatic) to M (manual) mode or vice versa.	ON : M (manual) operation when status input is on. OFF : Invalid status input.
A	Transfer from C (cascade) to A (automatic) mode or vice versa	ON : A (automatic) operation when status input is on. OFF : Invalid status input.
PMV	Preset MV output.	ON : In C or A mode, outputs preset MV values with status input on. OFF : No preset MV output (invalid status input).
TRK	Output tracking.	ON : In C or A mode, output signals track remote signals when status signal is on. OFF : Invalid status input (no output tracking).

- Notes: 1. Only one of the M, A, PMV and TRK switches may be turned ON in EXT switch setting. The switching priority is M, A, PMV, and TRK in order.
If more than two switches are turned ON simultaneously, only the higher priority switch can be turned ON.
2. For setting status input mode (open or close), use MODE key (N=2) (see Table 5-2).

■ Operation of Keyboard (See Figure 5-5).

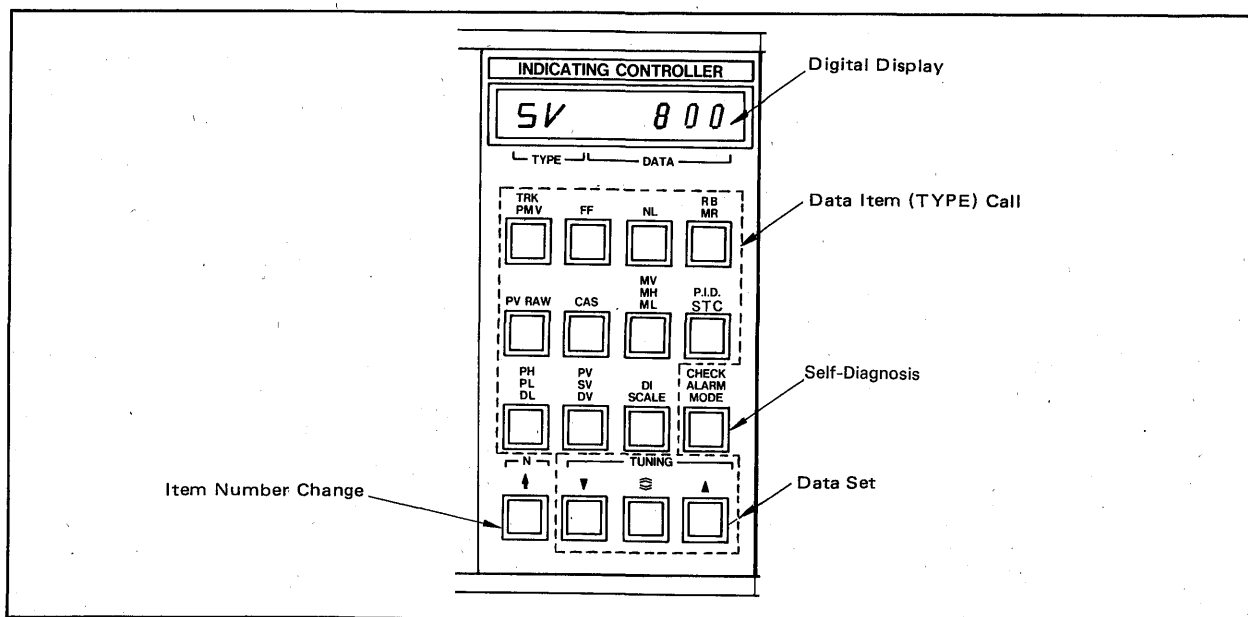


Figure 5-5. Keyboard.

(1) Calling Data Item (TYPE).

When the desired data item key is pressed, the corresponding key (TYPE) and data can be displayed (see Figure 5-5). Several data items are assigned to each key and data items are changed in turn whenever the key is pressed.

< Pressing Keys and Display Examples >

1) MV/MH/ML key.

When the MV/MH/ML key is pressed three times, data item (TYPE) – MV to MH to ML – is displayed in order.

→ MV → MH → ML

2) DI/SCALE key.

When the DI/SCALE key is pressed four times, data item (TYPE) – DI to HI to LO to DP – is displayed in order.

→ DI → HI → LO → DP

(2) Updating Data Item Number.

When the N \uparrow key is pressed, the data item number can be updated.

< Pressing Keys and Display Example >

For “F” (10-segment function) in PVRW already set:

→ F01 → F02 → F03 F10 → F11

When the N \uparrow key is pressed, the data item number (following F) is updated.

“F01” up to “F11” is displayed, pressing this key eleven times (see the example below)

(3) Updating Data.

When the TUNING keys (\blacktriangledown , \square , and \blacktriangle) are pressed, data can be increased or decreased. These keys are enabled when the “TUNING ENABLE-INHIBIT” switch is in the ENABLE position.

\blacktriangle : Increases data.

\square : Increase/decrease data value fast (Press concurrently with \blacktriangle or \blacktriangledown).

\blacktriangledown : Decreases data.

(4) Self-Diagnosis.

When the CHECK/ALARM/MODE key is pressed, the controller operating status can be checked automatically. Calling procedures are the same as (1) above. For more information, see Sections 5-5-4 and 5-5-5 provided later in this manual.

(5) Display Turns OFF Automatically.

Data display turns off automatically 30 minutes after all data are entered.

This is to save electric power. When data is entered again, the display turns ON.

5-2. Preparations for Operation.

Before starting to operate the SLCD indicating controller, make preparations for operation of the controller.

■ Withdrawing the Controller from the Housing.

- (1) Holding the instrument, push up the latch on the front bottom of the controller and withdraw the internal assembly from the housing until the rear latch on top of the internal assembly engages (see Figure 5-6). This position allows access to the tuning panel.

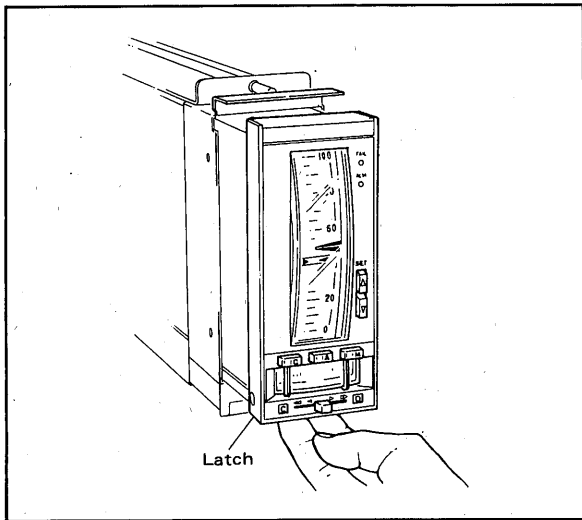


Figure 5-6. Pushing Up the Bottom Latch.

- (2) To completely remove the internal assembly from the housing, pull it out while pressing the rear latch (see Figure 5-7).

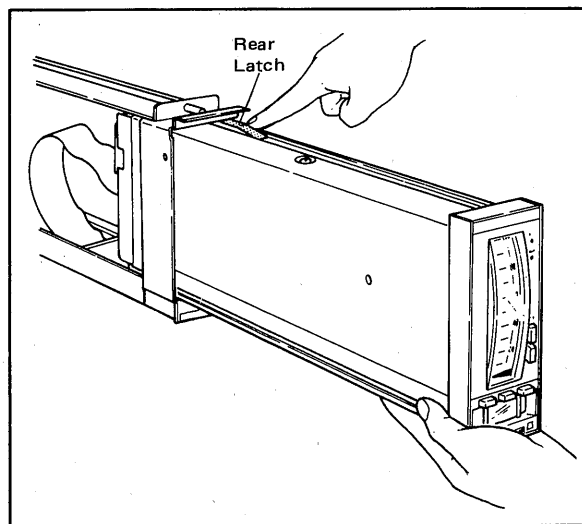


Figure 5-7. Removal of Internal Assembly.

- (3) Detach the connector from the internal assembly, its front panel facing down, as shown in Figure 5-8. The internal assembly can now be separated from the housing. (See Figure 5-8.)

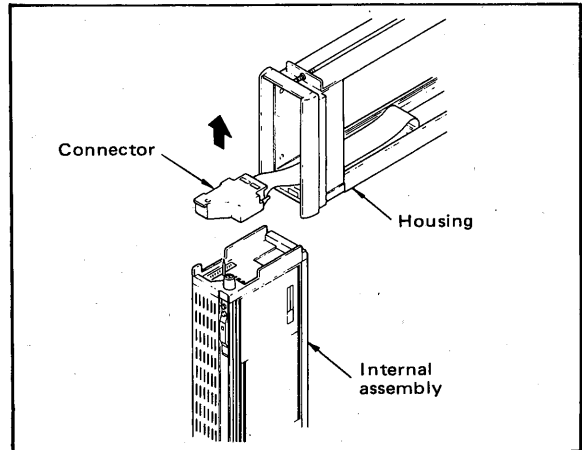


Figure 5-8. Detaching Connector.

5-2-1. Insure that All Special Parts are Installed.

Check to see that the fuse, data-protect battery, scale plate, and tag plate have been installed in the proper positions.

If any of them has not been installed, refer to Section 6-3, "Parts Replacement," for installation procedures.

5-2-2. Setting for Operation.

- (1) Setting Valve Open/Closed Indexes (See Figure 5-9.)

Position the valve open/closed indexes on the front panel to match with the control valve action (direct or reverse).

The open/closed indexes can be removed manually or with a pair of tweezers.

- C : CLOSED (valve closing direction)
- O : OPEN (valve opening direction)

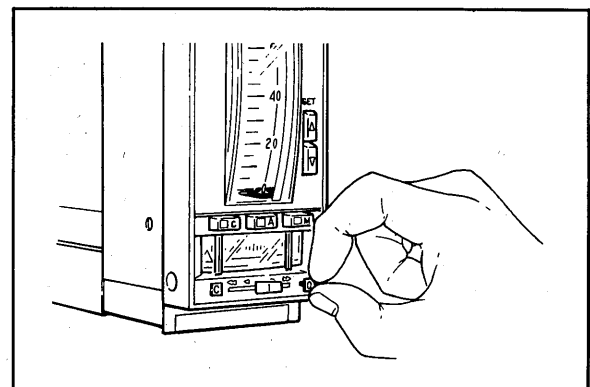


Figure 5-9. Setting Valve Open/Closed Indexes.

(2) Setting Switches.

Prior to applying the power, set the slide and DIP switches on the tuning panel (see Figure 5-10).

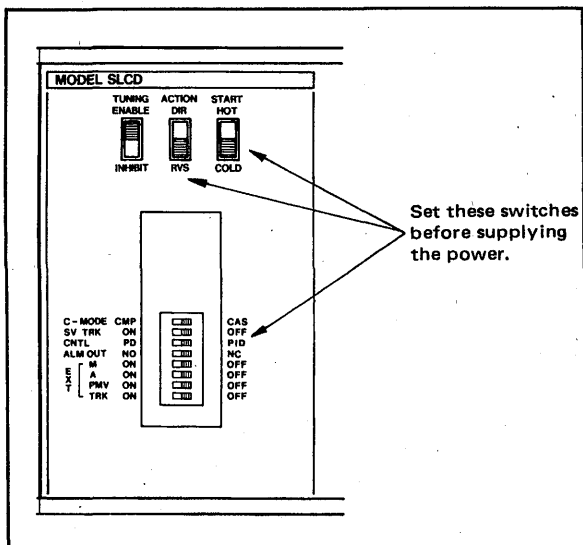


Figure 5-10. Setting Switches.

After completing the above setting, apply the power to the Controller and set the TUNING ENABLE-INHIBIT switch to the ENABLE position. Thus parameters can be set by the switches on the keyboard.

(3) Setting Mode.

Select the operation mode from the keyboard and press the \blacktriangle or \blacktriangledown key to set any of the operation modes described below:

< Mode Setting and Display Example >

Tuning Switch	Display	Description
MODE	MODE1 0	
\blacktriangle	MODE1 1	Go to the next step if "0" is O.K.
\uparrow	MODE2 1	
\blacktriangledown	MODE2 0	Go to the next step if "1" is O.K.
\uparrow	MODE3 0	
:	:	

A new mode is displayed about one second after the \blacktriangle or \blacktriangledown key is pressed.

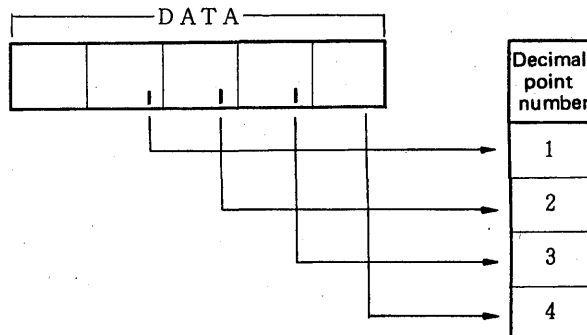
(4) Setting Scale.

Scales which display process variables and set values in engineering units are generated in order of maximum (full) scale value, minimum scale value and decimal point.

Full scale value (HI) : Sets the full scale value (four-digit integer) when internal data is 1.0.

Minimum scale value (LO) : Sets the minimum scale value (four digits and "-" symbol when internal data is 0.0).

Decimal point (DP) : Sets the position of a decimal point. Decimal point numbers (1 to 4) described below are used to position the decimal point. Set the number for positioning the decimal point.



< Example > Entering data -10.00 to 40.00


Switch	Display	Description
SCALE	HI 1000 LTYPE LDATA	Displays current HI value on the data display.
\blacktriangle	HI 4000	Can be used with [] key.
SCALE	LO 0 LTYPE LDATA	Displays current LO value on the data display.
\blacktriangledown	LO -1000	Can be used with [] key.
SCALE	DP 3	Displays current DP value on the data display.
\blacktriangledown	DP 2	For details of decimal point, see the figure above. However, use the \blacktriangle , \blacktriangledown keys to change a setting.

(5) Setting Parameters.





Set control and computation parameters completely. Parameters and their ranges that can be set are listed in Table 5-1.

< Parameter Set Example >

To set the integral time (TI) to 600 seconds:

Switch	Display	Description
P. I. D	TI 1000	Displays current TI value.
▼	TI 600	Can be used with  key.

Other parameters can be set as follows:

- 1) Call data items with eleven keys (see Figure 5-5).
- 2) Call item numbers and update them with the  key.
- 3) Set data with the , , and  keys.

(6) Initial Values.

Initial values are factory default values. (See Tables 5-1, 5-2 and 5-5.) If the data set is lost during a power failure or due to memory backup battery voltage drop, initial values are read as set data.

In this case, the values of some parameters are different from the factory default values. (PH=106.3, PL=-6.3, DL=112.5, STC=0)

(7) Inclined Mounting.

When the controller is mounted on a slanted front panel, it requires a zero adjustment of the indicator on the left side of the controller. See Section 6-2 Calibration Adjustment for more detailed information.

After preparations of operation are completed, connect the power plug to the panel power outlet and connect all process input and output signal lines.


5-3. Start-Up and Operation.

NOTE

This section describes how to start up and operate the PID Controller.

5-3-1. Manual Start-Up.

(1) Manual operation with the manual operation lever

- a. Press the  mode transfer switch. (The built-in indicator lamp comes on.) (See Figure 5-11.)

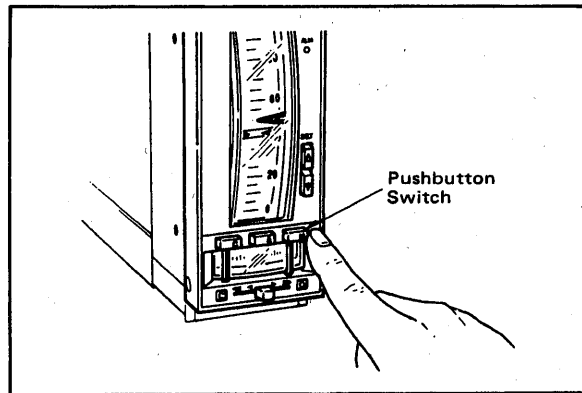


Figure 5-11. Selecting Manual Mode.

- b. Adjust the manipulated output signal by moving the manual operation lever to the left or right. (See Figure 5-12.)

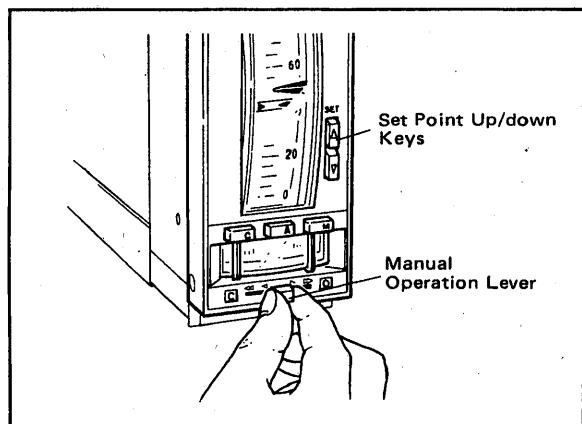


Figure 5-12. Manual Output Operation.

- c. Set a desired set point by using the Set-Point up/down keys. (See Figure 5-12.)

5-3-2. Alarm Checking and Transfer to Auto Mode.

Assume that smooth response characteristics have been achieved through manual operation and the process variable has reached a state of equilibrium at or in the vicinity of the set point.

(1) Alarm Checking (See Figure 5-13.)

When the front panel ALM lamp is on, it indicates that some errors occur. Press the CHECK/ALARM/MODE key on the tuning panel. Find and remove the possible causes of errors. When the FAIL lamp is on, it indicates that a failure has occurred in the SLCD indicating controller itself. See Section 5-5.

(2) Transfer from Manual Operation to Automatic Operation.

Press the **[A]** mode transfer pushbutton switch. The built-in lamp comes on to indicate auto mode is established. This mode transfer requires no balancing operation, as they occur bumplessly.

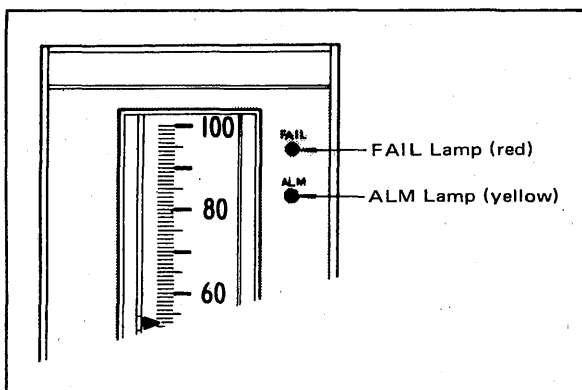


Figure 5-13. FAIL and ALM Lamps.

5-3-3. Normal Operation.

(1) Operation Mode Transfer.

The SLCD indicating controller can be switched to any mode by simply pressing the **[C]**, **[A]**, or **[M]** mode transfer pushbutton switch. However, direct transfer from M mode to C mode cannot be accomplished. Mode transfers require no balancing operation, as they occur bumplessly.

(2) Parameter Setting on the Tuning Panel.

Controller parameters can be set or reset as necessary by simply pulling out the internal assembly and entering the parameters on the tuning panel. After setting parameters, slide the ENABLE-INHIBIT switch to the INHIBIT position to prevent from invalid setting.

5-4. Setting and Display of the Self-Tuning Function.

The self-tuning function of the SLCD-□81 automatically adjusts P, I and D parameters to their optimum values depending on the characteristics of the controlled system.

5-4-1. Combination of Control Functions with the Self-Tuning Function.

When control functions of SLCD and self-tuning function are combined, some combinations are not recommended. (See Table 5-4)

Table 5-4. Control Functions Which Can Be Used With Self-Tuning.

Control Functions		Can be used with STC
PID control with output limiter		○
PID control with reset bias		○
PID control with nonlinear element		○
PID control with feedforward		x
PD control with manual reset		—
Operation mode switching by status input	Cas ↔ Auto switching	○
	C, A ↔ Man switching	○*
	Output tracking	○*
	Preset MV	○*
Operation Mode	Cas, Auto, SPC	○
	Man, DDC	—

Key ○ = Can be used with self-tuning.

x = Not recommended (difficult to use with self-tuning)

— = Can't be used with self tuning

* = Self tuning is stopped in MAN mode, Output-tracking mode, and Preset MV mode

5-4-2. Self-Tuning Parameters.

Table 5-5 lists the setting parameters which are related to the self-tuning function. These parameters are assigned to the **[PID/STC]** key on the tuning panel.

(1) STC (Setting STC mode)

STC mode is set as follows.

OFF	The STC action is stopped.
0	New PID values are displayed. (PID values are not automatically updated.)
1	STC ON. PID values are automatically updated.
2	Automatic start-up. (Refer to Paragraph 5-4-3.)
0, 1	On-demand tuning. (Refer to Paragraph 5-4-4.)

For setting the STC mode, use the ▼ and ▲ keys on the tuning panel as shown below. Note that STC = 2 can be set only in MAN mode.

▲ key: OFF → 0 → 1 → 2

▼ key: 2 → 1 → 0 → OFF

(2) PB, TI, TD (PID parameters)

These PID parameters are used in control computations.

When self-tuning action starts at STC = 1, the initial settings of these parameters are used; self-tuning automatically updates these values.

Table 5-5. Names and Descriptions of Self-Tuning Parameters.

Type	Number	Name/description	Display/setting range	Unit	Initial value	Data setting (Note 2)			
						OFF	0	1	2
STC	-	STC mode	OFF, 0, 1, 2	-	OFF	○	○	○	-
PB	-	Proportional band	2.0 to 999.9	%	999.9	○	○	○	-
TI	-	Integral time	1 to 9999	sec	1000	○	○	○	-
TD	-	Derivative time	0 to 9999 (Note 3)	sec	0	○	○	○	○
IP	-	Process type	0, 1	-	0	-	○	○	-
TR	-	Process response time	4 to 9999	sec	300	-	○	○	-
NB	-	Noise band	Engineering unit equivalent to 0 to 20%	-	0.0	-	○	○	-
OS	-	Desired response pattern type	0, 1, 2, 3	-	2	-	○	○	○
MI	-	MV applied signal amplitude	0.0 to 20.0	%	5.0	-	△	△	○
R (Note 1)	1	P.B. high-limit value	2.0 to 999.9	%	999.9	-	○	○	-
	2	P.B. low-limit value	2.0 to 999.9	%	2.0	-	○	○	-
	3	Integral time high-limit value	1 to 9999	sec	9999	-	○	○	-
	4	Integral time low-limit value	1 to 9999	sec	1	-	○	○	-
	5	Derivative time high-limit value	0 to 9999	sec	2000	-	○	○	-
PA	-	New P.B. calculated value	2.0 to 999.9	%	999.9	/	/	/	/
IA	-	New integral-time calculated value	1 to 9999	sec	1000	/	/	/	/
DA	-	New derivative-time calculated value	0 to 9999	sec	0	/	/	/	/
CR	-	Probable error	0.00 to 99.99	%	0.00	/	/	/	/
RT	-	Distributed signal ratio	0.000 to 9.999	-	0.000	/	/	/	/
LM	-	Equivalent dead-time	0 to 9999	sec	0	/	/	/	/
TM	-	Equivalent time constant	0 to 9999	sec	0	/	/	/	/
GM	-	Equivalent process gain	0.000 to 9.999	-	0.000	/	/	/	/

Note 1: R1 to R5 are limit values for PB, TI and TD.

Note 2: ○ : Setting is required / : For display only
 - : Setting is not required △ : In on-demand mode

Note 3: Action range is 2 to 9999 sec. (0 & 1: OFF)

(3) IP (Process Type)

This specifies whether the process is static-controlled or integral-controlled. In an integral-controlled process, when step input is applied, the measured value is increased or decreased infinitely. Processes excluding the level control process are almost all static-controlled.

(4) TR (process 95%-response time)

This specifies a 95%-response time to a step input in the process. STC controllers calculate the desired sampling time as well as time required to observe a measured signal waveform.

Set an appropriate TR in the following ways:

① Estimate the TR from the step-response waveform of the process.

Set the TR to the time required for a process variable change (ΔPV) until it reaches 95% of the settling value. If the response time can be approximated with dead-time L and first-order-lag time constant T , $TR = L + 3T$.

② When the process is integral-controlled:

When a pulse input is applied, set the TR to the time required for a process variable change (ΔPV) until it reaches 95% of the settling time.

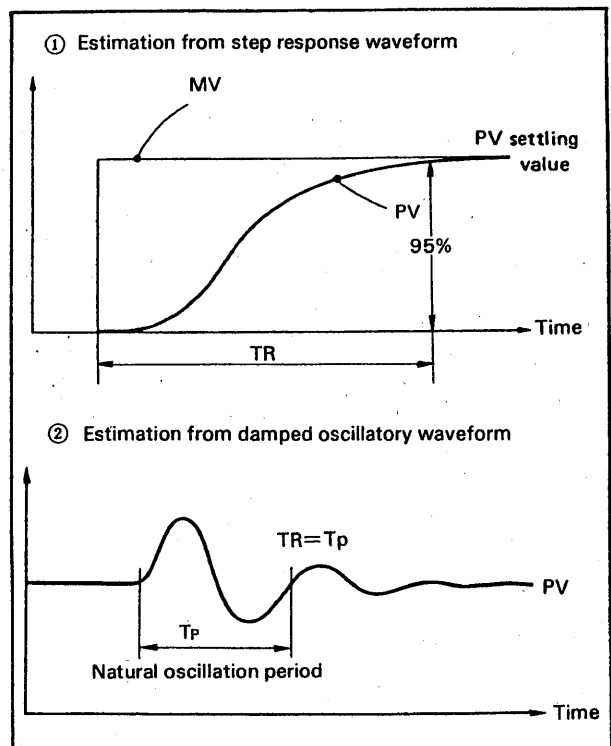


Figure 5-14. Method of Estimating TR.

- ③ Estimate from the continuous operating conditions

Read the attenuation wave cycles T_p that are considered normal, and set $TR = T_p$.

- ④ When response time variations are estimated: Select the desired response time. When the response time between an increase and a decrease in the measured temperature for furnace temperature measurements differs, for example, select whichever response time is greater.

- ⑤ Notice:

1/20 of the TR is the sampling period T_s for estimating the process, so a response waveform less than $2T_s$ cannot be captured correctly.

Generally, when the TR is larger than the correct TR value, it has fewer process-characteristic errors. If the TR changes, data files are initialized during a response time of $4TR$, so the STC does not operate.

- (5) NB (Noise Band)

Set the NB to twice the peak value of the noise signal superimposed on the measured signal. The NB is used to prevent the process from being influenced by a noise signal.

- (6) OS (desired response pattern)

Set the type of desired response pattern (a criteria for self-tuning).

0	Overshoot zero
1	Overshoot about 5%
2	Overshoot about 10%
3	Overshoot about 15%

- (7) MI (Signal Applied to the MV)

When the STC is set to mode 2 or the on-demand mode, set an additional signal that is applied to the manipulated variable (MV) so that the measured value overshoots by about 5% of the full-scale. When the STC is in mode 2, it is operating manually. Therefore, apply the MI so that the current controlled deviation is maintained. When the STC is in the on-demand mode, it is in automatic operation. Therefore, apply the MI so that the controlled deviation decreases.

- (8) R1 to R5 (P, I, D limit values)

These parameters can be used to limit the adjustable ranges of P, I and D parameters. If "high limit value \leq low limit value" is set, the parameter concerned is fixed at the low limit value.

- (9) PA, IA, DA (new calculated P, I, D values)

If $STC = 0$ (for display only of calculated P, I and D values), the "optimum" parameter values calculated by the STC functions can be displayed, but are not used in control computation. When $STC = OFF$ or 1, displaying PA, IA and DA values results in the same values as for PB, TI and TD, respectively.

- (10) CR (Probable Error)

An error when process characteristics are estimated. The STC controller requires PID parameter settings when the CR is less than 5%.

- (11) RT (Signal Distribution Ratio)

This indicates the ratio of the PV distributed value to the model distributed value. STC controllers calculate a signal distribution ratio using a final model ($STC = 1$ for the STC mode set to 0) to find process-characteristic variations. When the distributed value of the process signal matches that of the model output signal, RT is about 1. When RT is greater than or equal to 2 or when it is less than or equal to 0.5, an alarm occurs.

- (12) LM, TM, GM (Equivalent Model)

STC controllers indicate a simulated process model with an approximation of the dead-time and first-order-lag system. LM, TM and GM indicate equivalent dead-time, the equivalent first-order-lag time constant, and equivalent gain, respectively. For LM, TM and GM, respective values when the STC mode is 1 and when the CR is 5% or less are retained. Calculated PID parameters are related to PB, TI and TD.

The CR is updated by the process characteristics. When the CR is greater than 5%, LM, TM and GM are not updated.

5-4-3. Automatic Start-Up.

STC mode is set to 2 for automatic start-up mode. In this state, the STC parameters (PB, TI, TD, IP, TR, NB, R) are automatically calculated by the step-response method.

(1) Setting parameters

STC, OS and, if required, TD are set.

Set TD = 0 for PI control.

TD is set to 1 or greater for PID control.

Automatic start may result in PI control.

(2) Operation procedure

① First make sure that no STALM (Refer to Paragraph 5-7-6) has occurred.

② In MAN mode, set STC to 2.

③ Manually stabilize the process variable signal to an appropriate value.

④ Switch the control mode to AUTO or CAS (automatic start up begins).

The [A] or [C] lamp on the front of the instrument blinks.

In automatic start-up mode, PID control does not start for 30 seconds, but the controller automatically applies a step change (MI%) to the manipulated output in the safe direction (to increase the deviation rather than reverse its sign). The controller calculates the self-tuning parameters from the process response to this step change.

⑤ When the process variable signal stabilizes, the controller automatically returns the manipulated output to its initial value.

⑥ When all of the parameter settings are complete, STC mode is automatically switched to 1, and PID control starts. The [A] or [C] lamp then changes from blinking status to ON.

(3) Check items in conducting the automatic start-up

① The process must be such that a 5% output change will have no undesirable effects.

② If process gain is high, and the process variable changes by more than 1.5MI%, the manipulated output is automatically returned to its initial value.

③ If process gain is low, and the change in the process variable is less than 2%, automatic start-up is considered inappropriate, and after the maximum observation time (about 80 minutes) has passed, the operation mode switches to MAN and an STC alarm is issued.

④ The PID limit values (R1 to R5) are automatically set to four times (for high limit values) or 1/4 (for low limit values) of the initial PB, TI and TD values obtained by automatic start-up.

⑤ If a power failure occurs during automatic start-up, the operation mode is transferred to MAN mode with STC = 0 after the power recovers.

⑥ If a STALM (Refer to Paragraph 5-7-6.) occurs during automatic start-up, the start-up operation is stopped and operation mode is transferred to MAN with STC = 0.

⑦ If, during automatic start-up (with the [A] or [C] lamp blinking), the operation mode is switched to MAN, automatic start-up is stopped (STC is set to 0).

5-4-4. On-Demand Tuning

In the on-demand mode, an STC controller allows the operator to carry out self-tuning from the PV response by applying a test signal to the MV value as required.

(1) Applicable conditions

An on-demand tuning operation is possible when the following conditions are all satisfied:

- When only basic control BSC or cascade control CSC is selected. (When selector control SSC is selected, on-demand tuning is not available.)

- When the control operation is in the AUTO or CASCADE mode. (When the DDC or SPC mode is selected, on-demand tuning is not available.)

- When the STC mode is set to 0 or 1.

(2) Setting parameters and operation

- Set parameters when the STC is set to 0 or 1.
- MI: Sets the amplitude of an applied test signal. Set a value that overshoots by about 5% of the PV. The MI is added to the MV value so that the controlled deviation decreases depending on the DIR/RVS switch position and the current controlled deviation. For an integral-controlled process, a pulse signal with an amplitude of TR/5 is added.

(3) Operation procedures

(a) Check that MI values are correct.

(b) Check that the STC mode is set to 0 or 1.

(c) Press the [N] key once and check that the tuning request ("RQ") comes up.

(d) Then press the [N] key again. If the tuning request is canceled, press any key.

(e) Thus, the MI is added to the MV. "RQ" will blink for about TR/5 seconds. While "RQ" is blinking, the [N] key, even if pressed, is omitted.

5-4-5. Display of Self-Tuning Operation.

(1) Side tuning panel

When $STC = 0$ or 1 and the self-tuning function is operating, "0" or "1" blinks. When $STC = 2$ and start-up is being executed, "2" blinks. When either operation is stopped, or the controller is in MAN mode, the lamp on the tuning panel is lit continuously (not blinking).

(2) C, A, M mode display lamps (front of instrument)

While $STC = 2$ and during start-up, the **C** or **A** lamp blinks.

5-5. Setting and Display of Adjustable Set-Point Filter Function.

The adjustable set-point filter (abbreviated as SVF) is the function to improve set-point follow-up characteristics, holding the optimum tuning status to the process variable change by disturbance. The effect of the filter can be adjusted by two parameters to continuously change the set-point follow-up characteristics between PI-D type and I-PD type.

SLCD-□51 and SLCD-□81 are equipped with this function.

5-5-1. Effect of Changing the Filter Parameters.

Figure 5-16 shows examples of set point follow-up waveforms observed when parameters PX (α) and PY (β) are separately changed from 0 to 1.

The PX parameter has the greater effect on the follow-up waveform. The larger the value of PX , the faster the rise time of the follow-up waveform. The PY parameter, on the other hand, has a fine adjustment effect — and the larger the value of PY , the smaller the overshoot.

5-5-2. Method for Tuning PX and PY .

(1) When no self-tuning is provided:

- ① Make a step change in the manipulated variable output, and calculate optimum P , I and D values from the response.
- ② Make a step change in the set point, and adjust PX so that the intended followup characteristic is obtained. When derivative action is provided, fine adjustment by PY is possible.
- ③ The recommended values of PX and PY are $PX = 0.5$ and $PY = 0.0$.

(2) When self-tuning is provided:

- ① After setting $PX = 0.5$ and $PY = 0.0$ (recommended values), start operation using the self-tuning function.

PX is optimized to provide the best response to set-point changes; PID parameters are optimized to provide the best response to an external disturbance.

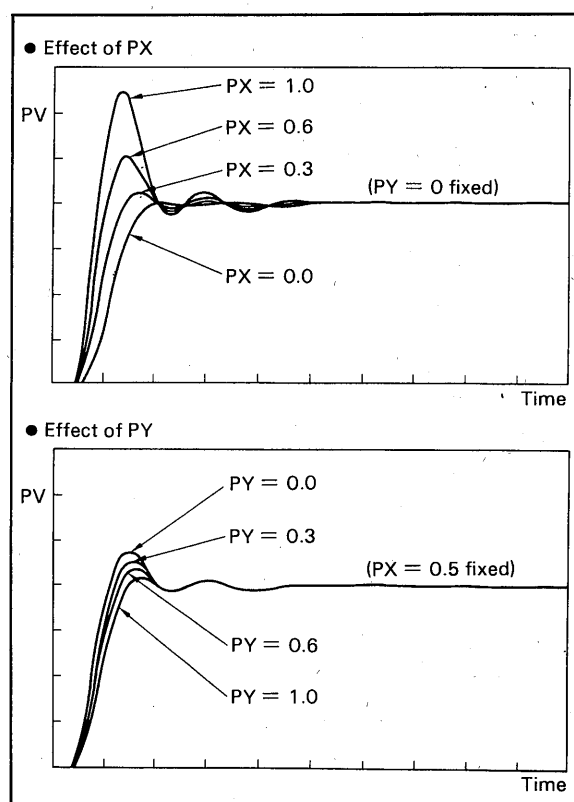


Figure 5-15. Effects of PX and PY Parameters.

5-6. Automatic Control.

When applying the controller to an unknown process, it is useful to examine the performance of the process in manual mode.

This can be useful in estimating the proportional band, integral time and derivative time required for automatic mode.

For example, if a small change in the controller output causes a large fluctuation in the process variable value, the width of the proportional band must be increased (the gain reduced) to assure stability. Conversely, the proportional band must be narrowed.

For a process which responds quickly to a change in the controller output, the integral and derivative time constants must be short. Conversely, for a process having a long recovery time, the integral and derivative time constants must be long.

(1) "Proportional + integral" controller

- a. Set the control mode to **M** and manually adjust the process variable until it agrees with the set point. Set the integral time to 9999 seconds. Set the proportional band to a sufficiently large value, and then set the derivative time to 0.
- b. Set the control mode to **A**.
- c. Perform the following operations to obtain the optimum value for the proportional band. Lower the proportional band in steps from a sufficiently large value (for example, 100% → 50% → 20%). Take a sufficiently long time for each step, so that the control state can be fully observed. Continue this operation until the control loop begins cycling. (Cycling refers to periodic oscillation of the process variable pointer around the set point. This phenomenon is caused by setting the proportional band narrower (the gain higher) than the optimum value for the process.) The optimum proportional band is approx. 2.2 times that of the proportional band which causes such cycling. Next, measure the cycling period. The optimum integral time can be obtained by multiplying this oscillation period by approx. 0.83. Up to a point, decreasing the integral time improves the control response. But, if the integral time is decreased past a limit, which is decided by the lag characteristic of the process, cycling will start. If this happens, increase the integral time gradually until the cycling stops.

(2) "Proportional + integral + derivative" controller

- a. Set the operation mode to **M** and manually adjust the process variable until it agrees with the set point. Set the integral time to 9999 seconds. Set the proportional band to a sufficiently large value, and set the derivative time to 0.
- b. Set the control mode to **A**.
- c. Change the proportional band as described above, and find the point where cycling just starts to occur. Measure the proportional band value (PBu) at this point and the cycling period (Pu).
- d. The optimum settings can be determined as follows.

Proportional band = 1.7 PBu

Integral time = 0.5 Pu

Derivative time = 0.125 Pu

The method explained above is called the Ziegler-Nichols threshold sensitivity method, and provides a response characteristic with approximately 25% amplitude attenuation.

Various adjustment methods — such as the step-response method — have been proposed as alternatives to the Ziegler-Nichols method; please refer to textbooks on automatic control.

5-7. Actions When the FAIL or ALM Lamps Light Up.

The SLCD indicating controller is furnished with a FAIL lamp and an ALM lamp to visually indicate failures in the controller itself and signal errors, respectively. Whenever a lamp lights up or begins to flash, take appropriate corrective action promptly.

5-7-1. Actions When FAIL Lamp Lights Up.

The FAIL lamp, when lit, indicates that a serious failure has occurred in the controller.

- (1) Monitor the current output signal and set it, with the manual operation lever, to a value that does not adversely affect the process.

The measurement indicator gives correct readings at this time.

(If the FAIL lamp lights up, the controller holds analog and output to just before the failure occurs. The manual operation lever directly controls the current output during failure. But, this cannot hold the controller output for a long time. If the output has to be held, use the SPBD manual control station as described in the next step (2). Voltage output signals will gradually decrease with time. For either output, an incorrect value may be held depending on which part of the circuit failed.

- (2) Insert the cable from the SPBD manual control station into the jack at the bottom of the housing and switch the output signal from the SLCD to the SPBD. (See Figure 5-16.)
- (3) Select the CHECK switch on the tuning panel for possible causes of a failure. If the failure is attributable to a hardware fault, remove the instrument from the panel and troubleshoot it as instructed in Chapter 7.

5-7-2. Actions When ALM Lamp Lights Up.

The ALM lamp, when lit, indicates that the controller's high or low limit alarm is actuated or the input/output line is open.

Select the CHECK and ALARM switches on the tuning panel for possible causes of a failure (see Sections 5-7-4 and 5-7-5).

Take appropriate corrective action depending on the cause of the problem.

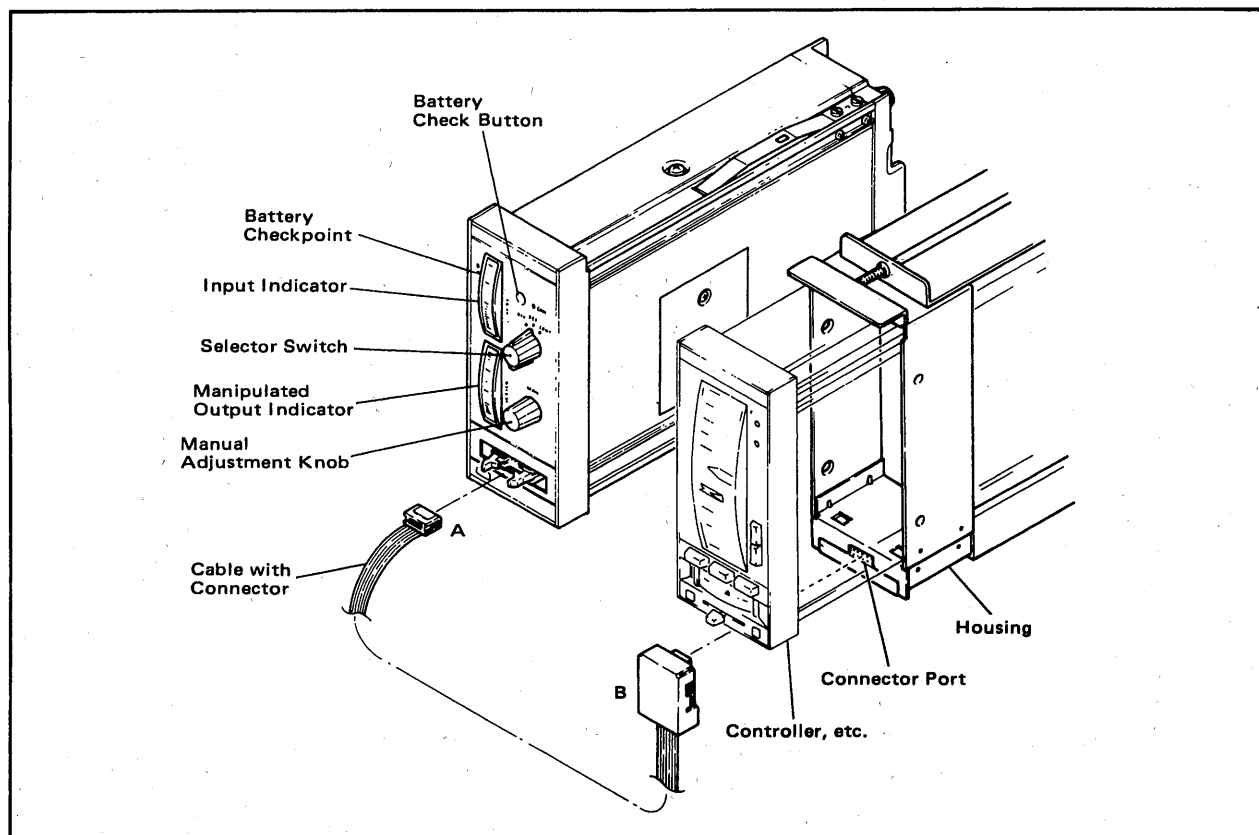


Figure 5-16. SPBD Connection.

5-7-3. Actions When ALM Lamp Flashes.

The ALM lamp begins to flash when the data-protect battery voltage drops. Replace the battery as instructed in Section 6-3-4.

Notes:

- (1) When the ALM lamp begins to flash during normal operation, replace the battery immediately.
- (2) A flashing ALM lamp overrides a continuously lit alarm lamp. No alarm status can be indicated, therefore, while the ALM lamp is flashing. (Other alarms can still be displayed on the tuning panel.)

5-7-4. Description of CHECK Display.

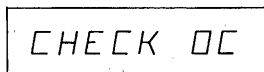
Items displayed when the CHECK/ALARM/MODE switch is in the CHECK position are as follows:

Lamp	CHECK Code	Self-Diagnostic Functions
—	00	Normal.
FAIL	01	A/D converter abnormal.
FAIL	02	D/A converter abnormal.
ALM	04	Computing range overflow.
ALM	08	Process variable input overrange.
ALM	20	Memory backup battery not installed or voltage too low (lamp flashing).
ALM	40	Current output line open or overload.
ALM	80	Internal data lost (see Note below).
ALM	PWR ERR	Supply voltage too low.
FAIL	—	Instrument fails.

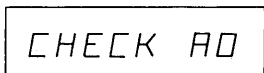
Note: If ALM lamp lights and CHECK code 80 is displayed, parameters have been already initialized. Check PID parameters and reset them.

If two or more faults occur simultaneously, the hexadecimal sum of their code numbers is displayed.

< Example >



0C = 04 + 08 (computation range overflow, process variable input out of range)



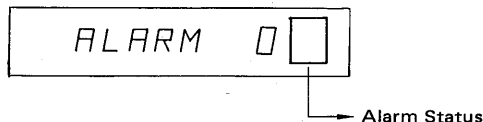
A0 = 20 + 80 (memory backup battery voltage too low, internal data lost)

When the cause of the fault is removed, the lamp turns OFF and the display reverts to 00 (normal). But code 80 does not revert to 00; press the key to set 00.

5-7-5. ALARM Status Display.

If an alarm occurs, the ALM lamp turns on and the alarm status is displayed with one digit (see below).

< Display Example >



Alarm Code	Diagnosis
00	Normal.
01	High-limit alarm.
02	Low-limit alarm.
04	Deviation alarm.

If two or more faults occur simultaneously, the hexadecimal sum of their code numbers is displayed.

< Example >



6 = 2 + 4 (low-limit alarm and deviation alarm)

When the cause of the fault is removed, the alarm code reverts to 0 (normal).

5-7-6. STALM Display (SLCD-□ 81 Only).

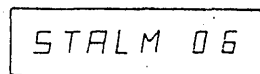
STALM is assigned to the

CHECK ALARM MODE

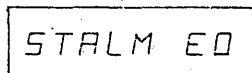
 key and, when the self-tuning function cannot operate normally, displays STALM using a 2-digit number. Table 5-6 shows the diagnoses which correspond to STALM display codes. The ALM lamp also lights up.

When two or more alarms occur simultaneously, the sum of the individual alarm display codes is displayed (i.e., addition of hexadecimal numbers).

Examples:



6 = 2 + 4 (PID values at limits, manipulated variable output stuck at limit)



E0 = 20 + 40 + 80 (STC mode switching, current output open, process variable input over-range)

The display value returns to 0 as soon as the corresponding alarm returns to normal.

Table 5-6. Self-Tuning Alarm Display Items.

STALM display	STC mode	Diagnosis	STC action	To clear alarm
00	All	Normal (always 00 when STC = OFF)	Continue	—
01	0, 1	○ There has been an attempt to use a control (PD control with manual reset) whose use in combination with STC is prohibited.	Stop	○ Remove cause of alarm(s). ○ Turn STC OFF ○ Press [N] key
02		○ P, I and D values are at high or low limits.	Continue	
04		○ Current output open.	Stop	
		○ The manipulated variable output is limited by the output limiter.	Continue	
08		○ Process variable input value is out of range.	Continue	
10	2	○ There has been an attempt to use a control (PD control with manual reset) whose use in combination with STC is prohibited.	MAN mode, transfer to STC=0 Stop.	○ Re-start STC = 2 ○ Turn STC OFF ○ Press [N] key ○ Must eliminate cause of alarm
20		○ STC mode was changed (ex., switching STC = 2 → 0) ○ STC was stopped by external switching. ○ The operation mode was transferred to BACK UP MAN or EXT MAN.		
40		○ Power failure. ○ Current output open. ○ There is a possibility that a step change in MV may cause the output value to reach the limit value or MV over range.		
80		○ Process variable input is out of range. ○ The change in the process variable was too small for automatic start-up to be executed (and the maximum observation time (about 80 minutes) has passed).		

6. MAINTENANCE.

This chapter explains the relatively easy adjustment and parts replacement procedure for the SLCD indicating controller.

6-1. Test Equipment.

DC voltage/current standard

Yokogawa Electric Model 7651 or equivalent : 1 unit

Digital multimeter

Yokogawa Electric Model 7562 or equivalent : 1 unit

6-2. Test, Calibration and Adjustment.

6-2-1. Zero Adjustment of Measurement Value Indicator (Moving coil version).

- (1) Apply a voltage of 3.0 VDC to process variable input terminals (terminals 1 (+) and 2 (-)) from the DC voltage/current standard.
- (2) Check that the measurement pointer indicates the 50% calibration mark on the scale plate $\pm 0.5\%$.
- (3) If the reading is not in this range, adjust the zero point adjustment screw to the 50% point, as shown in Figure 6-1.
- (4) Change the input signal to 1.0 V, 2.0 V, 4.0 V, and 5.0 V, and check that the readings are 0%, 25%, 75%, and 100% accordingly on the calibration marks. The tolerance is $\pm 0.5\%$ of span.

Check each calibration mark at the position where the line of sight and set-point value indicator are horizontal.

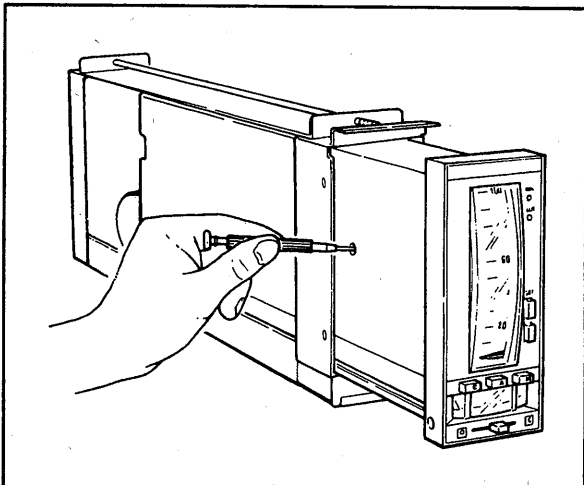


Figure 6-1. Zero Adjustment of Measurement Value Indicator.

- (5) If the tolerance is exceeded in (4), apply 3.0 V DC again and make fine adjustments within the range of $50\% \pm 0.5\%$.
- (6) Repeat (4) and (5) until the readings at all input points are within the tolerance.

6-2-2. Zero Adjustment of Set-Point Value Indicator (Moving coil version).

- (1) Apply a voltage of 3.0 V DC to cascade set-point input terminals (terminals 3 (+) and 4 (-)) from the DC voltage/current standard.
- (2) Set the controller in **C** mode.

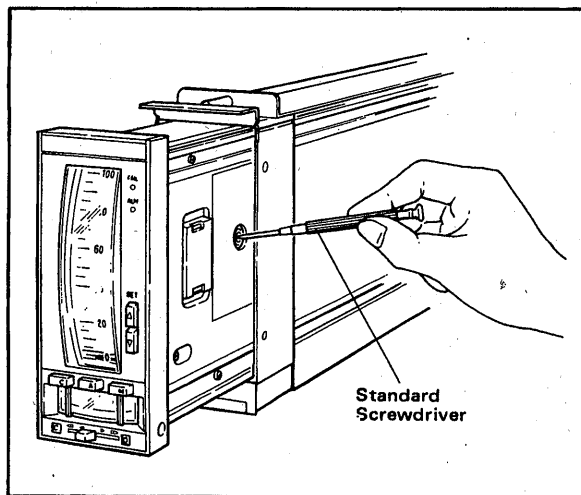


Figure 6-2. Zero Adjustment of Set-point Value Indicator.

- (3) Thereafter, make adjustments as in Section 6-2-1. See Figure 6-2 for the zero adjustment of the set-point value indicator.

6-2-3. Adjustment of Fluorescent Bar Graph Indicator.

The fluorescent bar graph indicator requires no zero adjustment for either the measurement value or set-point value. Repeat steps (1), (2) and (4), Section 6-2-1.

6-2-4. Zero Adjustment of Manipulated Output Indicator.

- (1) Connect an ammeter (Model 7562) to manipulated output terminals (terminals A (+) and B (-)), and set the controller in **M** mode.
- (2) Position the output pointer at the major scale graduation in the center of the scale by adjusting the manual operation lever. Verify that the ammeter reads 12 mA. (The tolerance is $\pm 2.5\%$.) Check each major scale graduation at the position where the line of sight and output pointer are vertical.

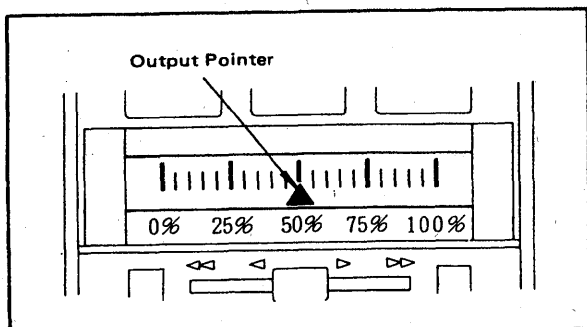


Figure 6-3. Output Indicator Major Scale Graduation.

- (3) When the reading is outside of tolerance, adjust the zero adjustment screw so the output pointer points to the major scale graduation in the center of the scale. (Figure 6-4).
- (4) Next, set the output pointer at the leftmost major scale graduation, at the second major scale graduation from the left, at the second major scale graduation from the right, and at the rightmost major scale graduation. Verify that the ammeter reads 4 mA, 8 mA, 16 mA, and 20 mA respectively. (The tolerance is $\pm 2.5\%$.)

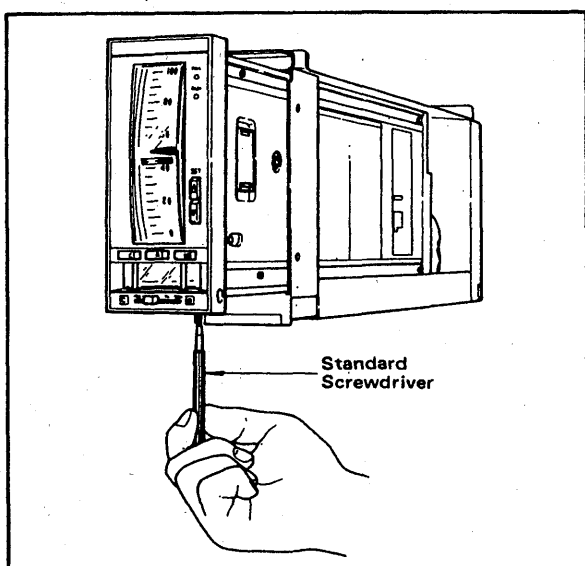


Figure 6-4. Zero Adjustment of Output Indicator.

- (5) If the tolerance is exceeded in (4), return to (2) and make fine adjustments with the readings until all readings fall within the tolerance.
- (6) Repeat (4) and (5) until the readings at all points are within tolerance.

6-2-5. Inclined Mounting.

For an inclined controller, set it up at the actual mounting angle and adjust its measurement pointer and set point as instructed in Sections 6-2-1 and 6-2-2, respectively.

6-2-6. Brightness Adjustment of Fluorescent Bar Graph Indicator.

Adjust the brightness of the fluorescent bar graph when it is low. (See Figure 6-5.)

Note: An excessive increase in the brightness could have a harmful effect on the fluorescent tube life.

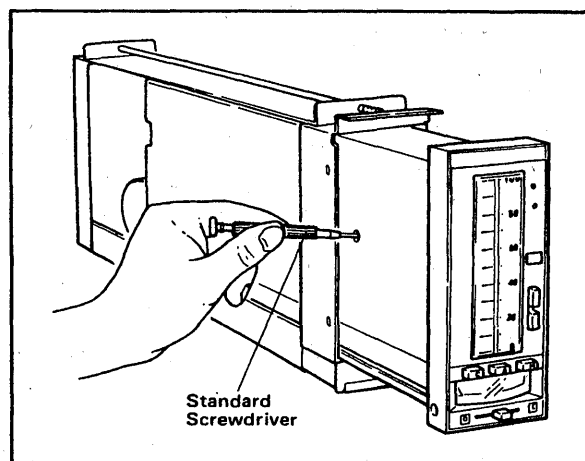


Figure 6-5. Brightness Adjustment of Fluorescent Bar Graph Indicator.

6-2-7. Setting of 4-digit Data Display.

Note: The eight-position DIP switches should be set with extreme care, using a finger nail or a small screwdriver.

The fluorescent bar graph version has a four-digit data display to the right of the bar graph indicator on the front panel.

The digital display has been set equivalent to the scale marks on the scale plate.

When the scale plate has been replaced due to changes in the specifications, alter the display setting as follows:

- (1) Remove the cover as shown in Figure 6-6.
- (2) Two 8-position DIP switches are located inside the cover (L and R). (See Figure 6-6.)
- (3) The DIP switch setting directions are printed on the scale plate. (See Figure 6-7.)
- (4) Set the DIP switches according to the indicated setting directions so the digital display conforms to the scale graduation on the scale plate.

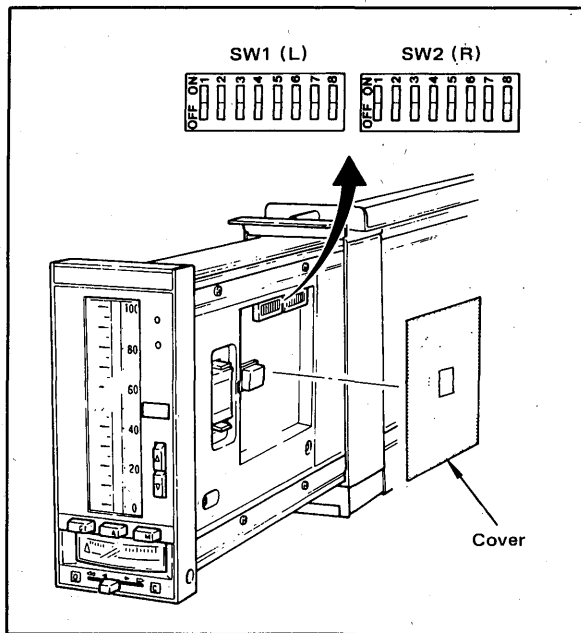


Figure 6-6. Eight-Position DIP Switches.

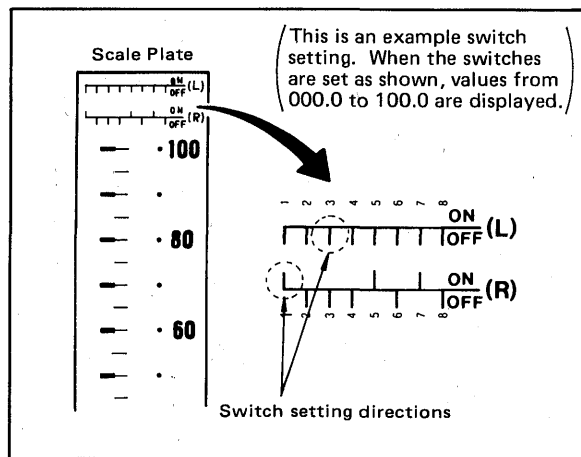


Figure 6-7. DIP Switch Setting Directions Printed on Scale Plate.

(5) When a scale range different from the scale values needs to be displayed by the four-digit display unit, set the 8-digit DIP switch as follows:

- Select the desired display values (minimum and maximum values) from Table 6-1.
- Set binary values which correspond to these minimum and maximum values on SW1(L) and SW2 (R). Nos. 1 to 7 of SW1 (L) are used for setting the minimum value, and Nos. 2 to 8 of SW2 (R) are used to set the maximum value.

Notes:

- Values outside those given in Table 6-1 cannot be displayed.
- The display range of the four-digit display unit is -1999 to 4999.
- The reading in the four-digit display unit is linear in relation to the input (1 to 5 V DC).

(6) Decimal Point Position (D.P.) Setting.

When the four-digit display values include decimal points, a separate decimal-point setting is required in addition to the maximum and minimum value setting described above.

Set No. 8 of SW1 (L) and No. 1 of SW2 (R) as follows depending on the decimal point position required. (See Figure 6-8).

Table 6-1. Display Values Given by Digital Display Unit and Corresponding DIP Switch Settings.

Display Value (Minimum or Maximum Value)	DIP Switch Setting	Display Value (Minimum or Maximum Value)	DIP Switch Setting
-1999	1101100	1600	0010000
-1900	1101101	1700	0010001
-1800	1101110	1800	0010010
-1700	1101111	1900	0010011
-1600	1100000	2000	0010100
-1500	1110001	2100	0010101
-1400	1110010	2200	0010110
-1300	1110011	2300	0010111
-1200	1110100	2400	0011000
-1100	1110101	2500	0011001
-1000	1110110	2600	0011010
-0900	1110111	2700	0011011
-0800	1111000	2800	0011100
-0700	1111001	2900	0011101
-0600	1111010	3000	0011110
-0500	1111011	3100	0011111
-0400	1111100	3200	0100000
-0300	1111101	3300	0100001
-0200	1111110	3400	0100010
-0100	1111111	3500	0100011
0000	0000000	3600	0100100
0100	0000001	3700	0100101
0200	0000010	3800	0100110
0300	0000011	3900	0100111
0400	0000100	4000	0101000
0500	0000101	4100	0101001
0600	0000110	4200	0101010
0700	0000111	4300	0101011
0800	0001000	4400	0101100
0900	0001001	4500	0101101
1000	0001010	4600	0101110
1100	0001011	4700	0101111
1200	0001100	4800	0110000
1300	0001101	4900	0110001
1400	0001110	4999	0110010
1500	0001111		

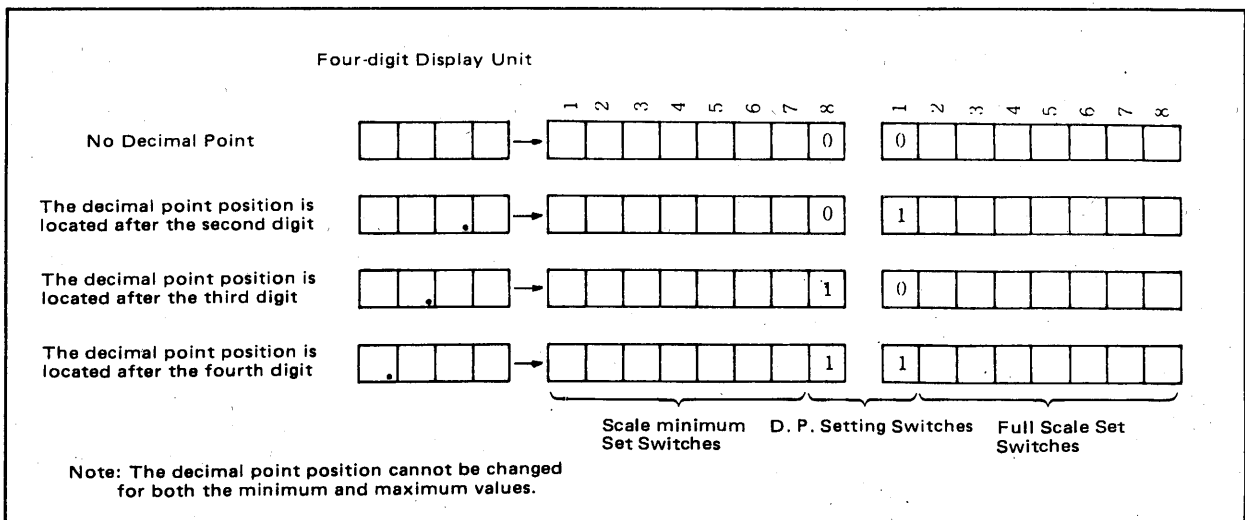


Figure 6-8. Decimal Point Position Setting.

6-3. Parts Replacement.

6-3-1. Nameplate (Tag Label).

Pull the internal assembly out slightly from the housing. Open the top lid of the internal assembly, and replace the nameplate. (See Figure 6-9).

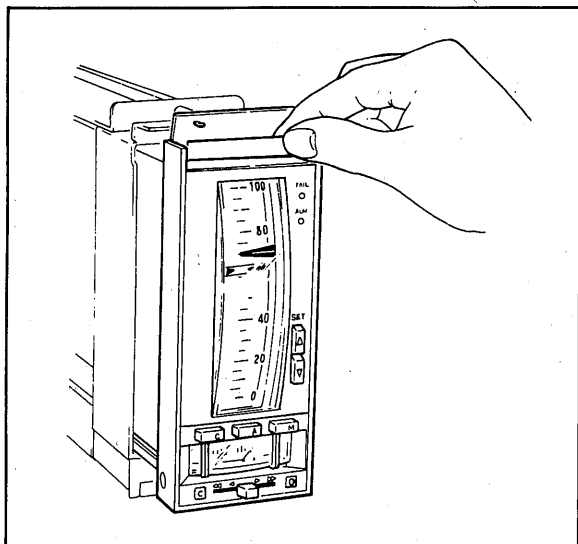


Figure 6-9. Replacing the Nameplate.

6-3-2. Scale Plate.

- (1) Pull the internal assembly out slightly from the housing.
- (2) Using a pair of tweezers, remove the scale plate retainer and the scale plate in this order. (See Figure 6-10.)
Note: The bar graph version has no scale plate retainer.
- (3) Insert a new scale plate, and ascertain that both the measurement pointer and the set point indicate the 0% point on the scale plate when measurement input and the setpoint are at their 0% values.

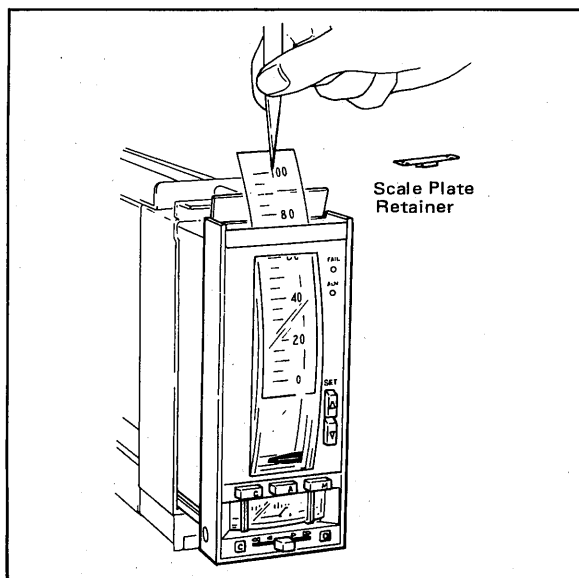


Figure 6-10. Replacing the Scale Plate.

6-3-3. Fuse.

Open the fuse holder in the rear of the internal assembly, and replace the cartridge fuse inside. (See Figure 6-11.)

Fuse rating: 1 A

Part number: S9510VK

Recommended replacement interval: About 3 years.

After the replacement, screw the cap firmly into the fuse holder.

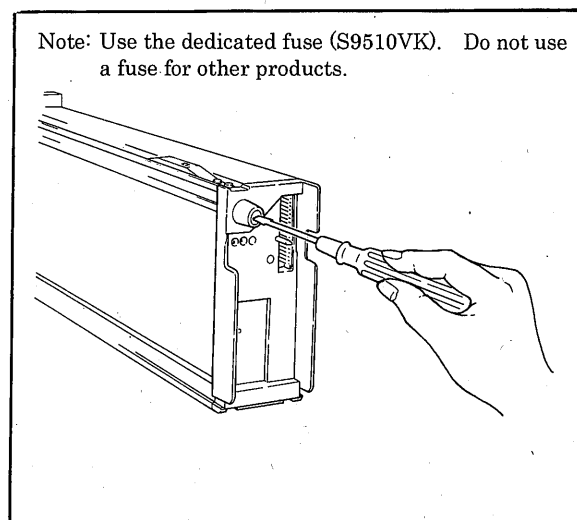


Figure 6-11. Fuse Replacement.

6-3-4. Data-Protect Battery.

If the ALM lamp on the front panel of the instrument begins flashing, please replace the battery without delay.

Recommended replacement intervals:

About 5 years (charging, at ambient temperatures below 45°C)

About 1 year (shelf-life, at ambient temperatures below 45°C)

Note 1: To prevent loss of internal data, replace the data-protect battery only when the power is being supplied to the unit.

- (1) Pull the internal assembly out from the housing, and remove the battery cover and the battery case (the case and the battery are a single unit). (See Figure 6-12.)

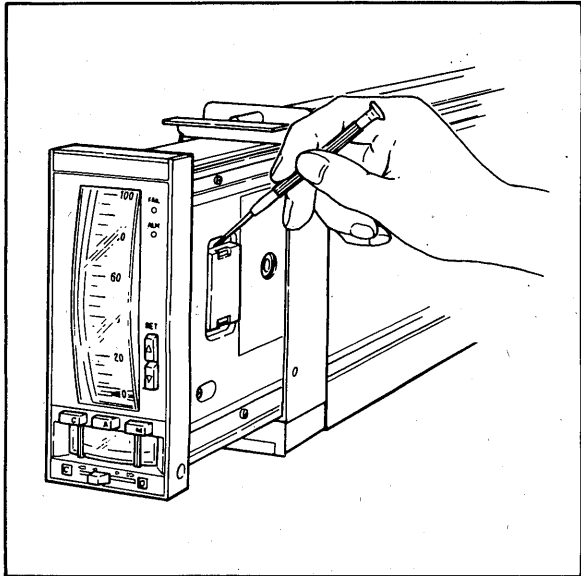


Figure 6-12. Removing the Data-Protect Battery Cover.

- (2) Insert a new battery together with its case, and re-place the cover. (See Figure 6-13.)
- (3) Ascertain that the front-panel ALM lamp is not flashing.

Note 2: Always replace the battery with its case as one unit; never replace the battery without its case.

Note 3: Never measure the battery voltage with a multimeter or similar test instrument with a low input impedance.

Note 4: To reinsert the battery in the case after it has been removed for some reason, observe the battery polarity, by insuring that it matches the symbols on the case.

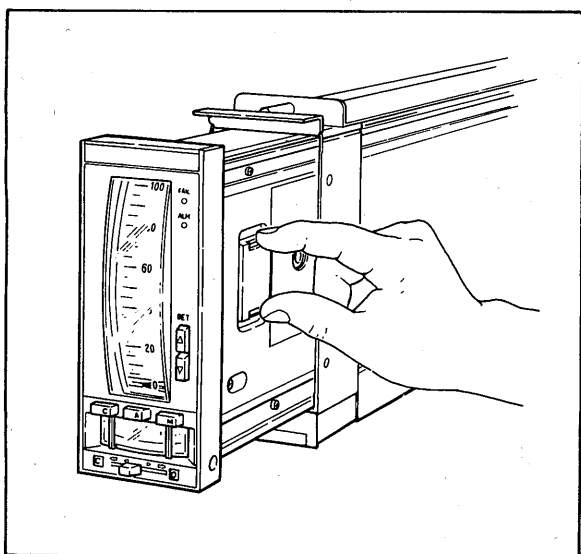


Figure 6-13. Replacing the Data-Protect Battery.

Handling and Storage Instructions for the Data-Protect Battery

- (1) Ambient temperature: -10 to 60°C .
Ambient humidity: 5 to 95% R.H.
Store in an environment free from corrosive gases.
- (2) Do not attempt to charge the battery.
- (3) Do not throw the battery into a fire.
- (4) Do not short the poles of the battery together.
- (5) Do not heat or disassemble the battery.
- (6) Observe correct battery polarity when wiring.

6-3-5. Fluorescent Bar Graph.

The fluorescent bar graph loses its brightness with time.

The brightness is adjustable to some degree with the side-panel brightness adjustment volume. If the desired degree of brightness cannot be restored, replace the fluorescent bar graph.

Recommended replacement interval: Three to five years.

For the replacement procedure, refer to Section 7-2.

6-3-6. Replacing Power Supply Unit.

Electrolytic capacitors used in the power supply unit may be affected by ambient temperatures. The power supply unit should be replaced every five to ten years. For replacing the power supply unit, see Section 7-2.

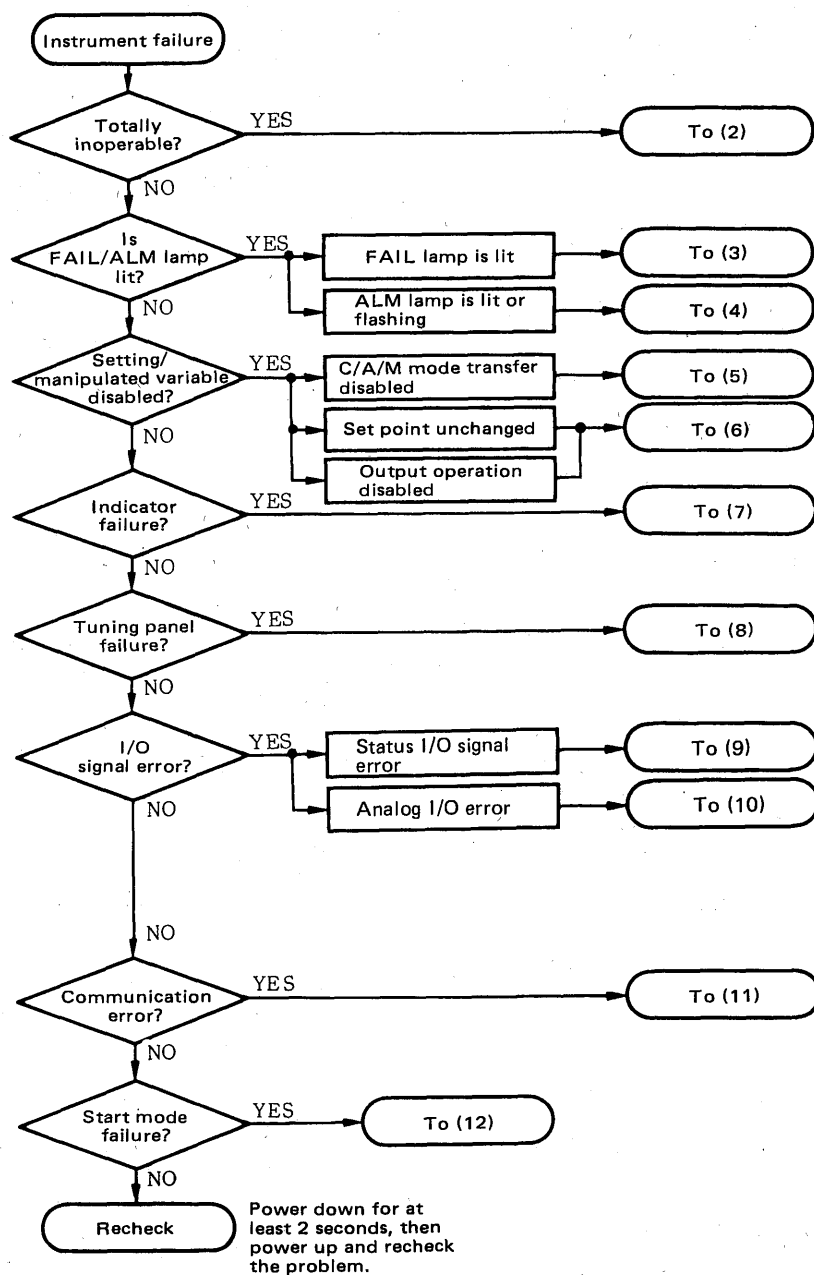
7. TROUBLESHOOTING.

If operational problems occur in the SLCD Indicating Controller, identify the problems fully and resolve them according to the troubleshooting flowcharts shown in Section 7-1. Troubleshooting can be facilitated by the use of the extension cable contained in the service kit (SSKD).

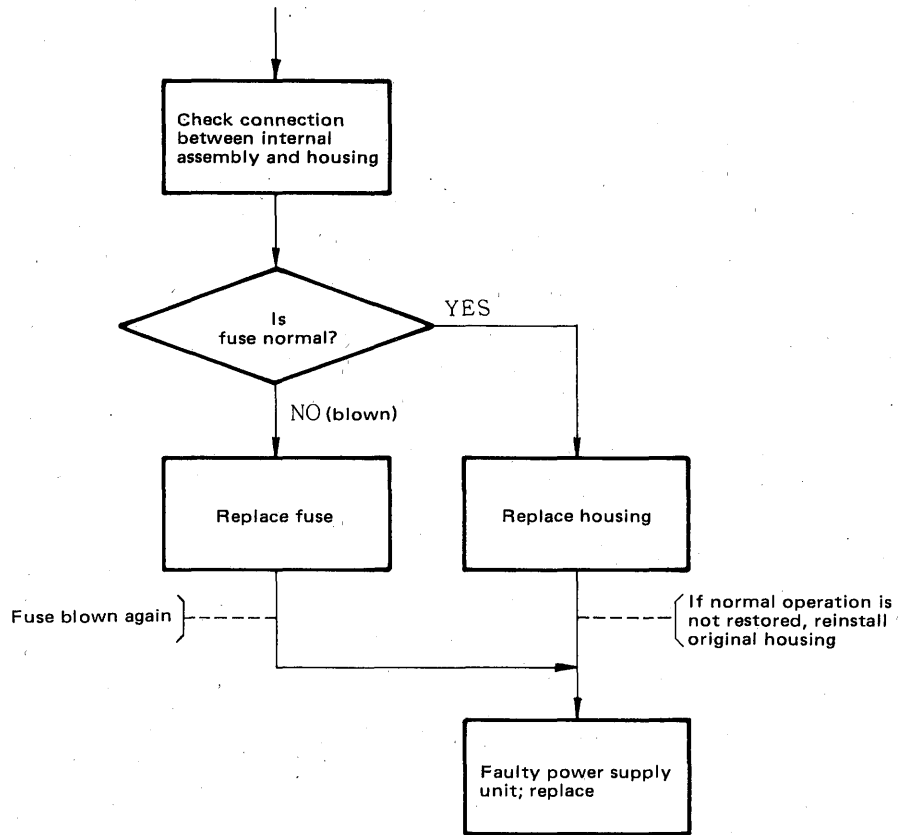
When the trouble is difficult to locate, consult the YOKOGAWA service center serving your area.

7-1. Troubleshooting Flow Chart.

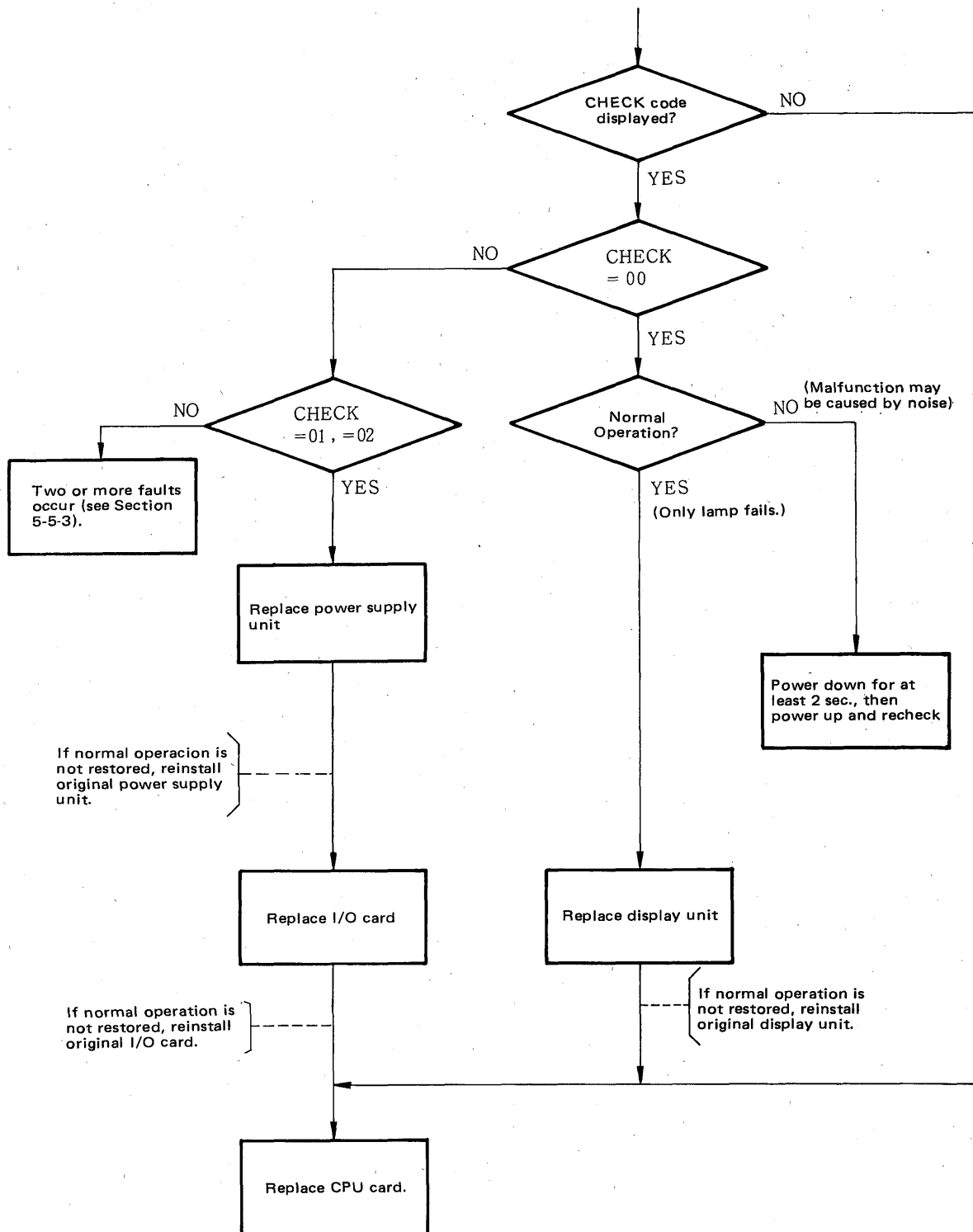
(1) Problem Identification



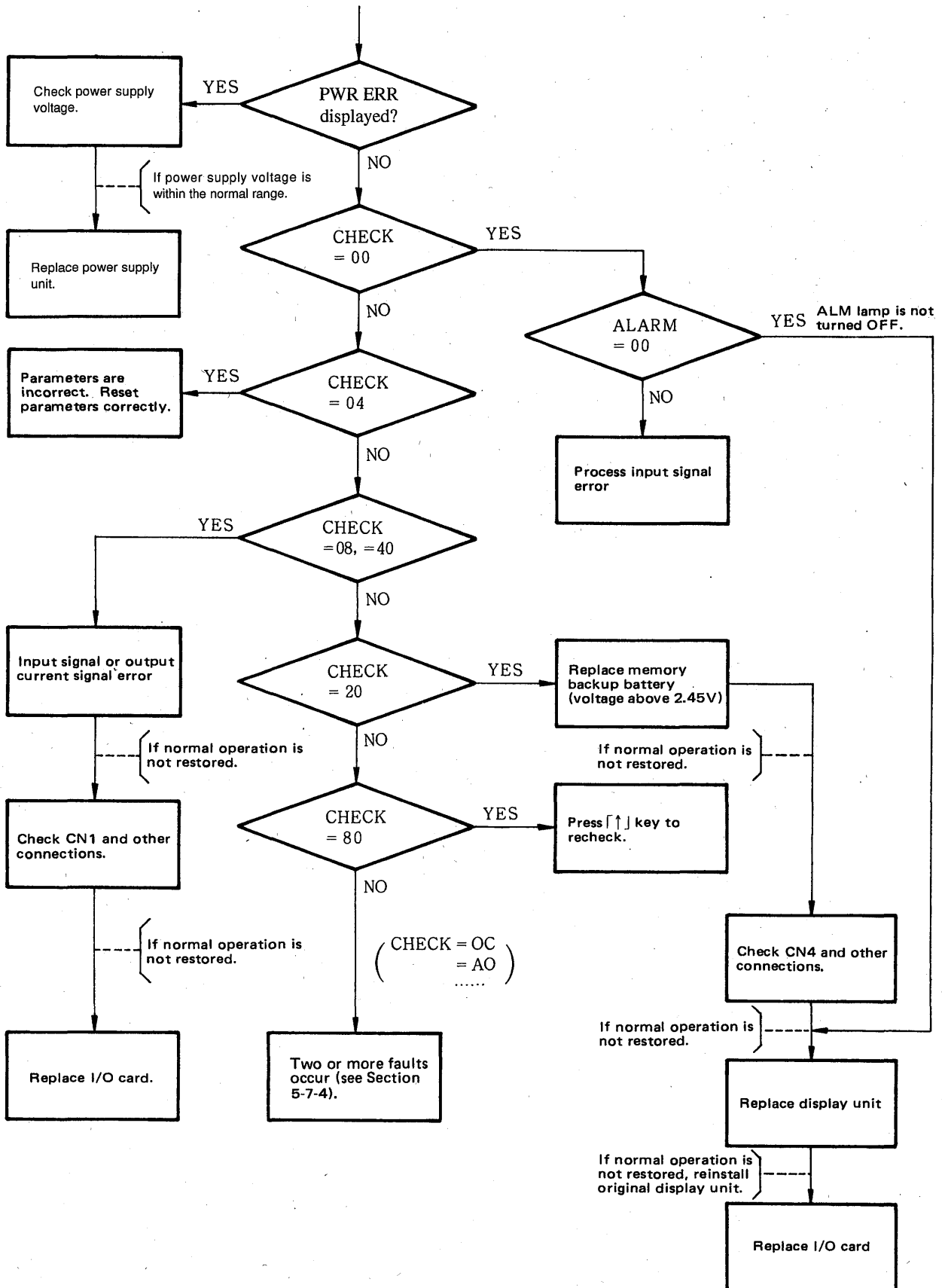
(2) Totally Inoperable



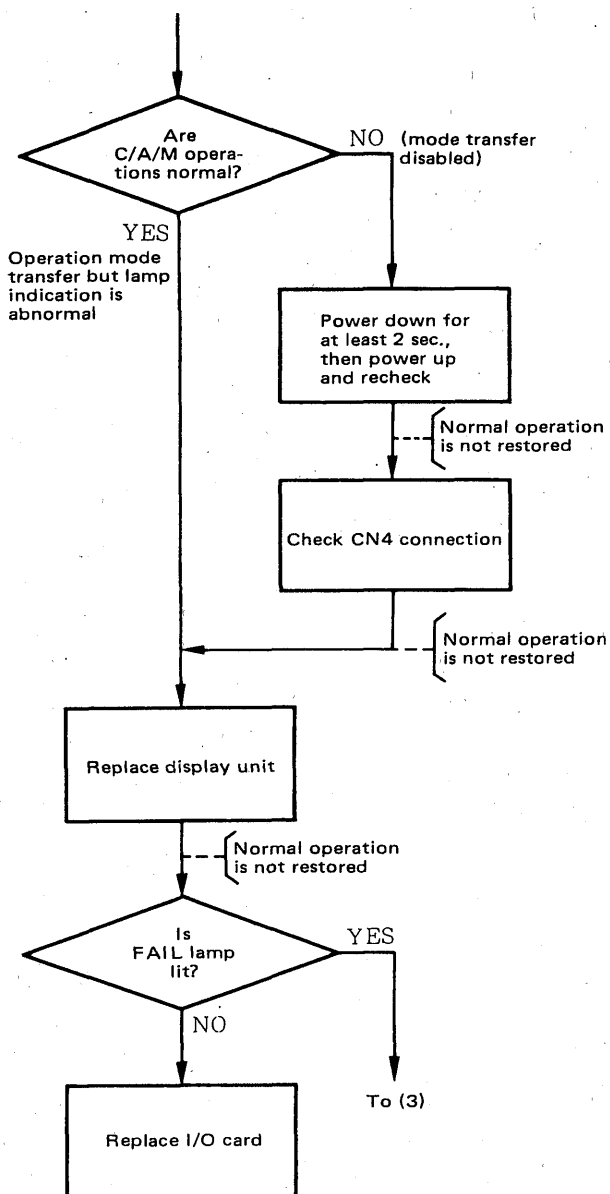
(3) FAIL Lamp is Lit



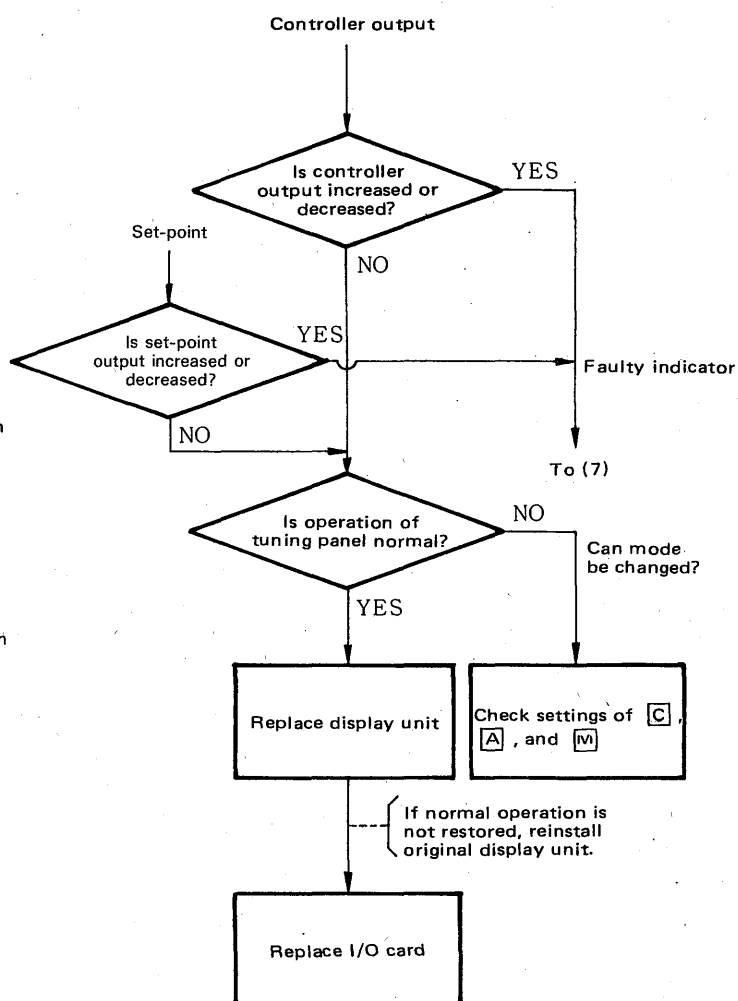
(4) ALM Lamp is Lit or Flashing



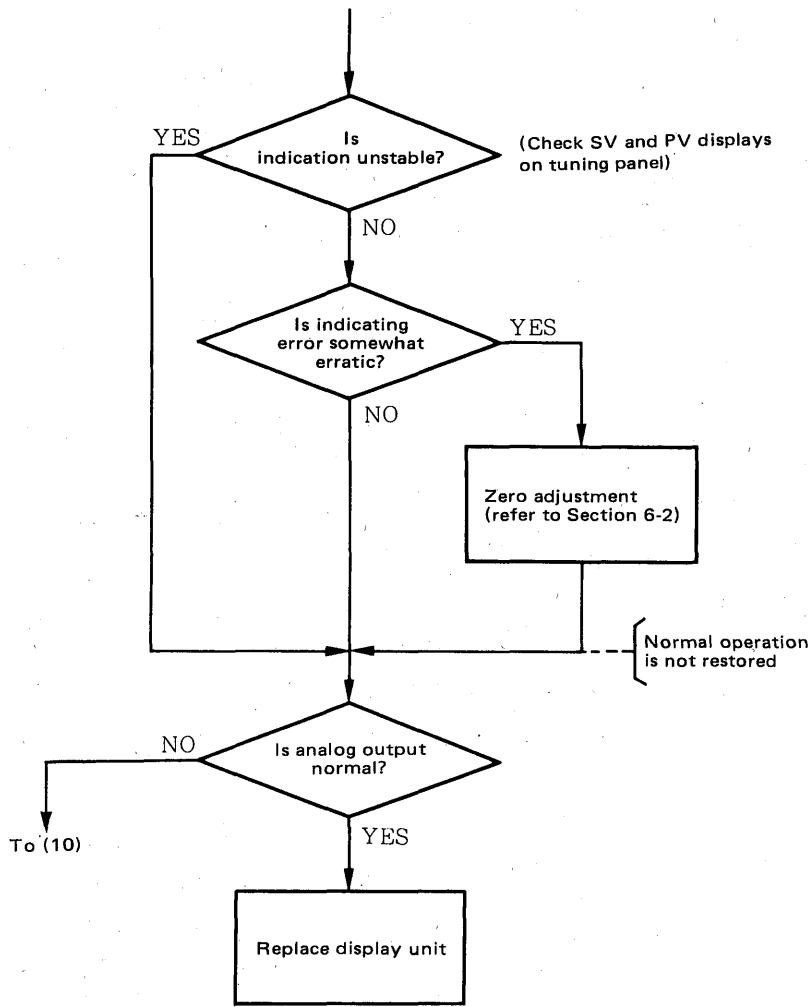
(5) C/A/M Operation Mode Transfer Failure



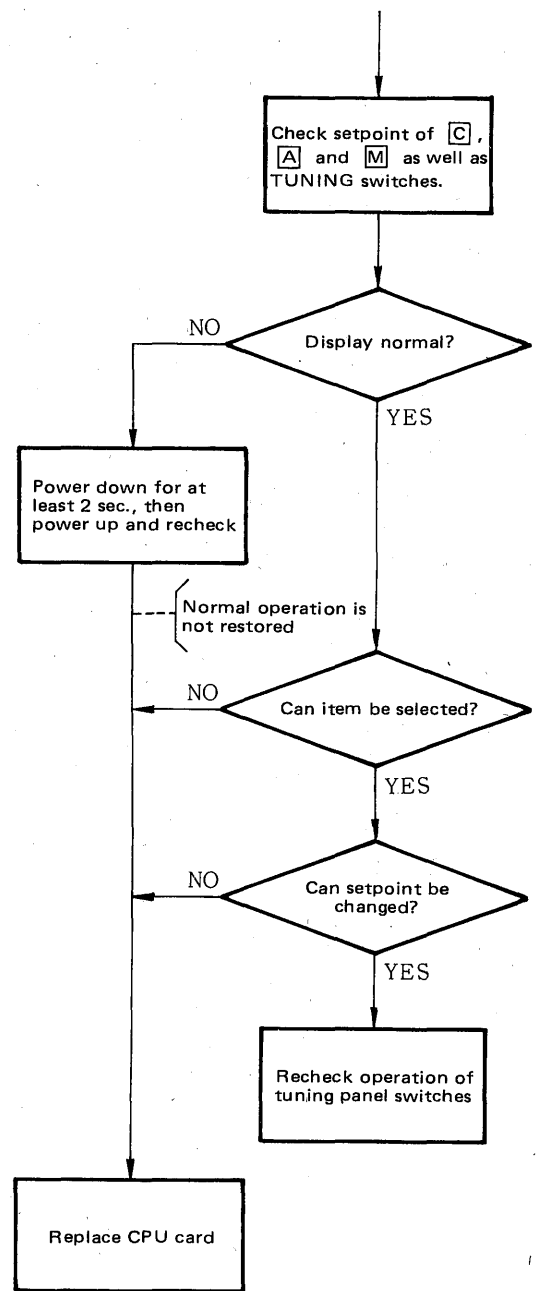
(6) Set Point Indication Unchanged



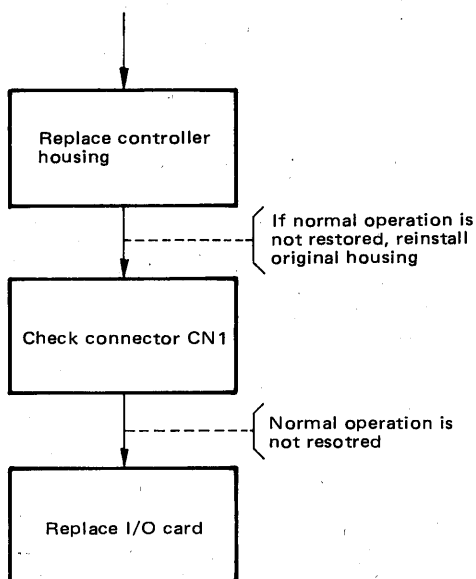
(7) Measurement/Set Point Indicator Error



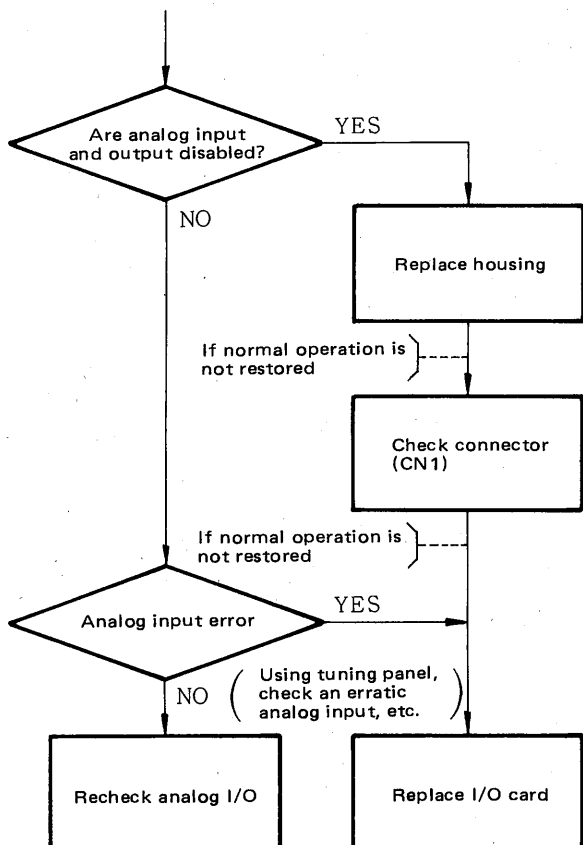
(8) Tuning Panel Failure



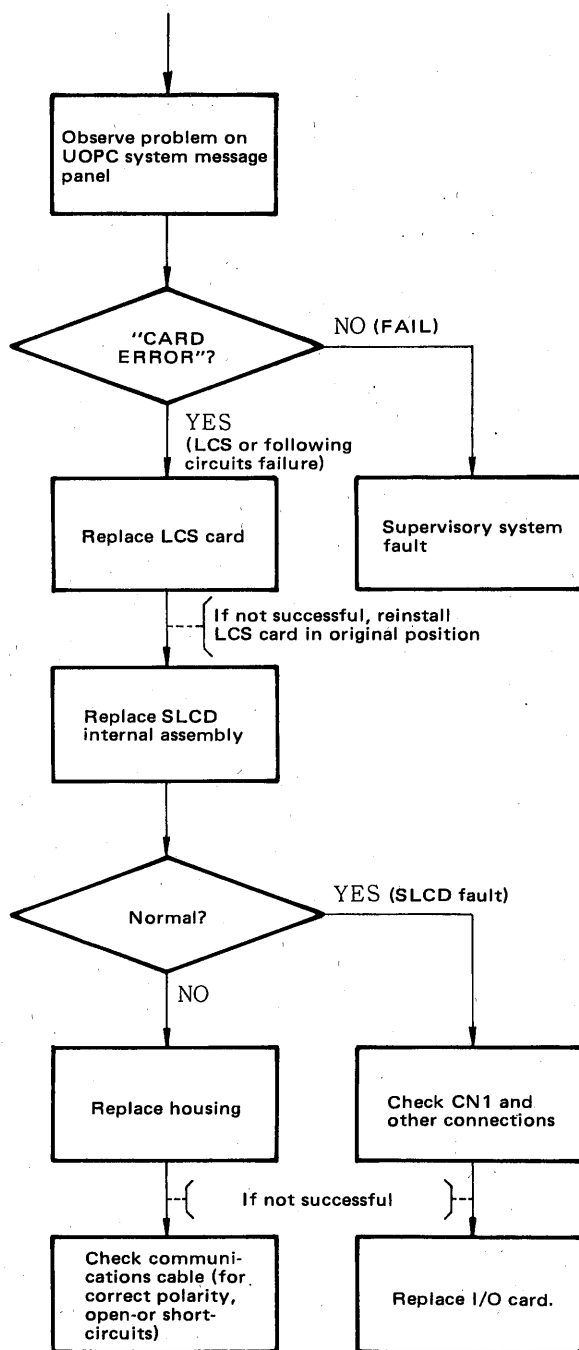
(9) Status I/O Signal Error



(10) Analog I/O Error



(11) Communications Failure



(12) Start-Mode Error

Set the controller START mode to COLD or HOT. If the controller is not started in that mode after power failure within the specified time, the I/O card may be defective.

7-2. Disassembly and Reassembly Procedures.

Follow the disassembly and reassembly procedures in this section to replace possible faulty units.

CAUTION

Limit the scope of overhaul to the minimum required. Have a YOKOGAWA service center replace parts not covered in this section.

First, remove the cover as shown in Figure 7-1.

7-2-1. Removal of Meter Assembly.

- (1) Remove seven screws ② in Figure 7-3.
- (2) Pull the connectors CN3 and CN4 up to disconnect them from the main card.
- (3) Carefully pull the meter assembly out toward the front.

7-2-2. Disassembly of Meter Assembly.

- (1) Pull off the manual operation lever knob ④ in Figure 7-3.
- (2) Remove four screws ⑤ to separate the front frame.
- (3) Pull the A/M unit out and downward by removing two screws ① in Figure 7-2.
- (4) To separate the meter assembly, remove three screws ③ from the molded part. (The meter assembly in the fluorescent bar graph version can be separated in the same manner.)

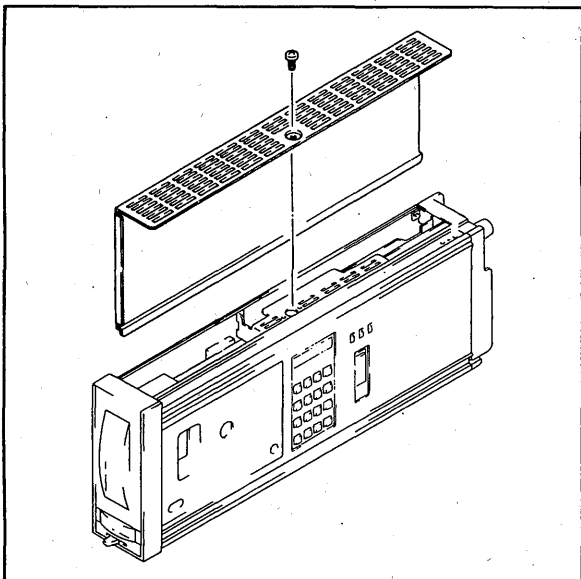


Figure 7-1. Removing the Cover.

7-2-3. Removal of Power Supply Unit.

- (1) Remove four screws ① in Figure 7-3.
- (2) To remove the power supply unit, pull it out toward the rear and detach connector CN2.

7-2-4. Disassembly of Control Assembly.

- (1) Remove the meter assembly and the power supply unit as instructed in Sections 7-2-1 and 7-2-3.
- (2) Separate the control assembly from the chassis by removing two screws ⑥ in Figure 7-3.
- (3) Remove two screws ⑦ and open the cover to access screw ⑧.
- (4) Remove two screws ⑧ and pull connectors CN5 and CN6 down to separate the I/O card from the CPU card.
- (5) Remove three screws ⑩. Remove the CPU card from the bracket.

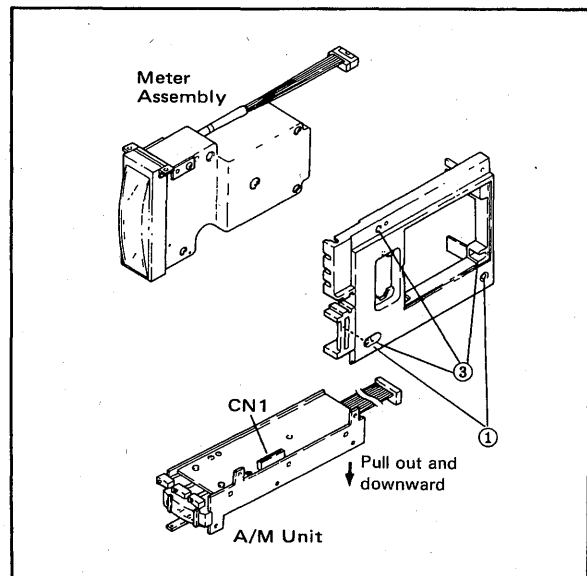


Figure 7-2. Disassembling the Display Unit.

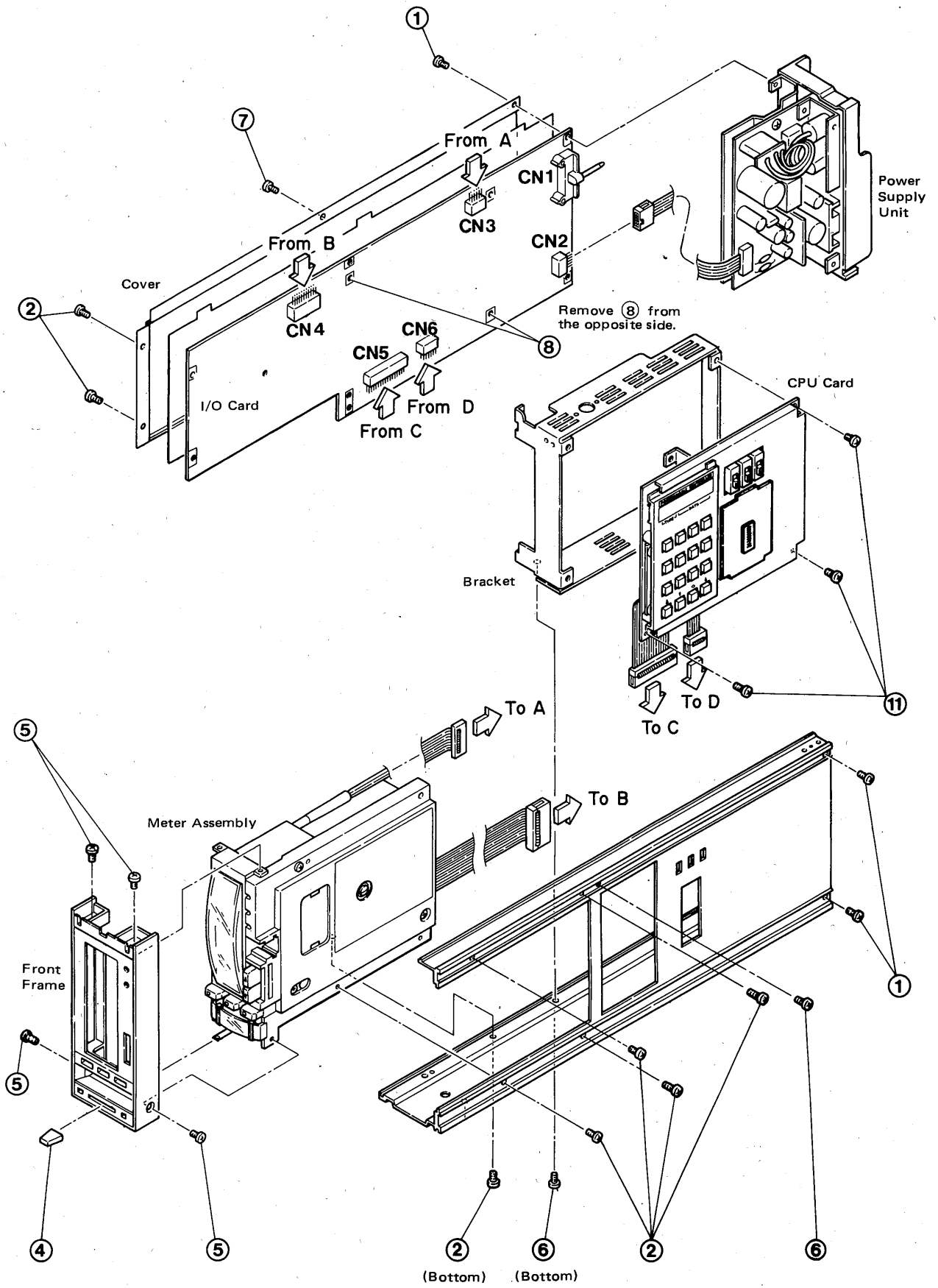


Figure 7-3. Disassembling Main Assembly.

7-2-5. Replacement of Fluorescent Bar Graph Display Tube.

- (1) Disassemble the display assembly as instructed in Sections 7-2-1 and 7-2-2.
- (2) To expose the display tube, remove the cover by unscrewing two screws ① in Figure 7-4.
- (3) Carefully pull the display tube out forward by grasping the PC board.
- (4) Insert a new display tube and install it by reversing the removal procedure above. Take care not to damage the sealed part of the tube during assembly. (See Figure 7-4.)


7-2-6. Reassembly.

To reassemble with new parts, reverse the overhaul procedures.

Assembly Notes

- All screws are of the same type.
- Insure that all necessary connectors have been inserted in proper position.
- When inserting connectors, select the face without the protrusions and mate it with the side of the printed circuit board.

7-2-7. Power On.

Once the SLCD is disassembled, the internal data is lost. When the power is turned ON, the ALM lamp lights up and CHECK code 80 is displayed on the tuning panel. Use the  key to cancel this code and reset the desired data.

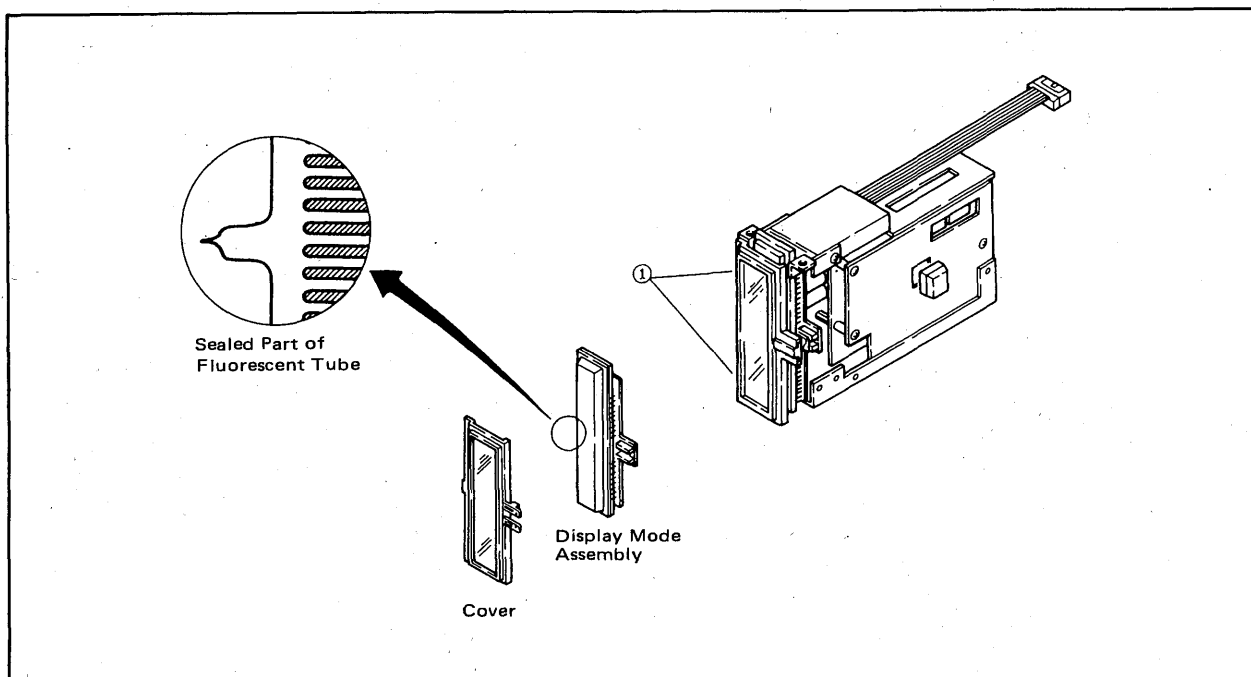
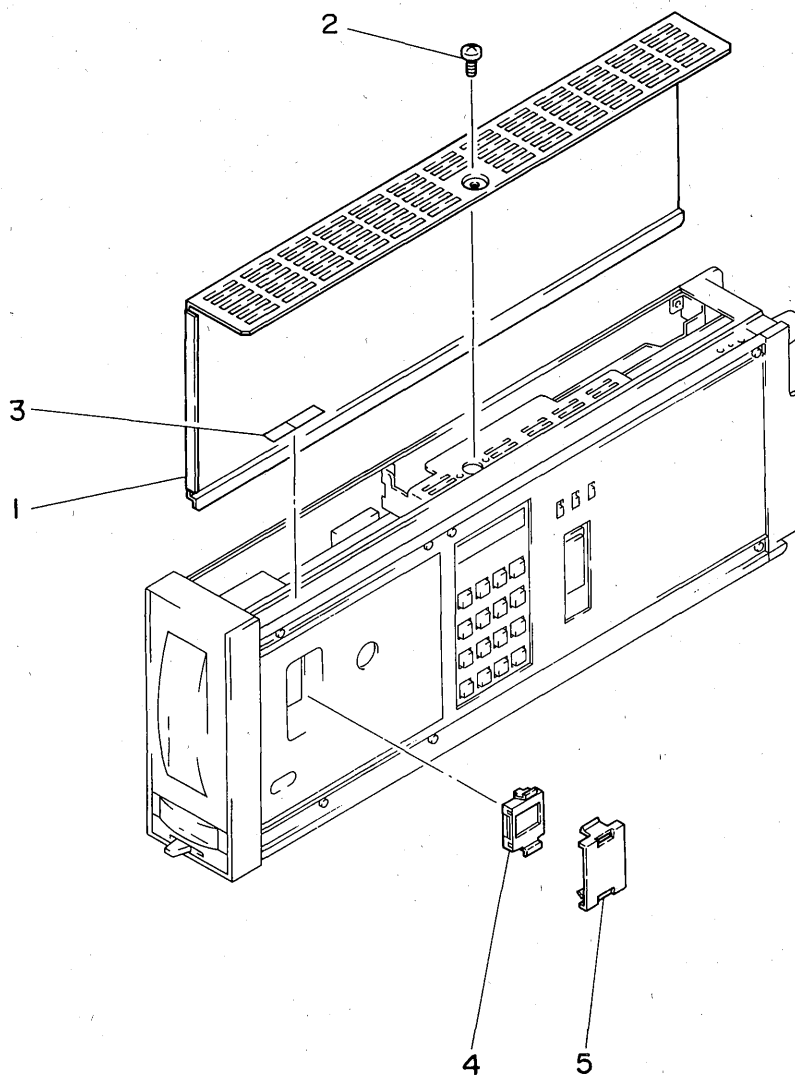


Figure 7-4. Replacing Fluorescent Bar Graph Display Tube.

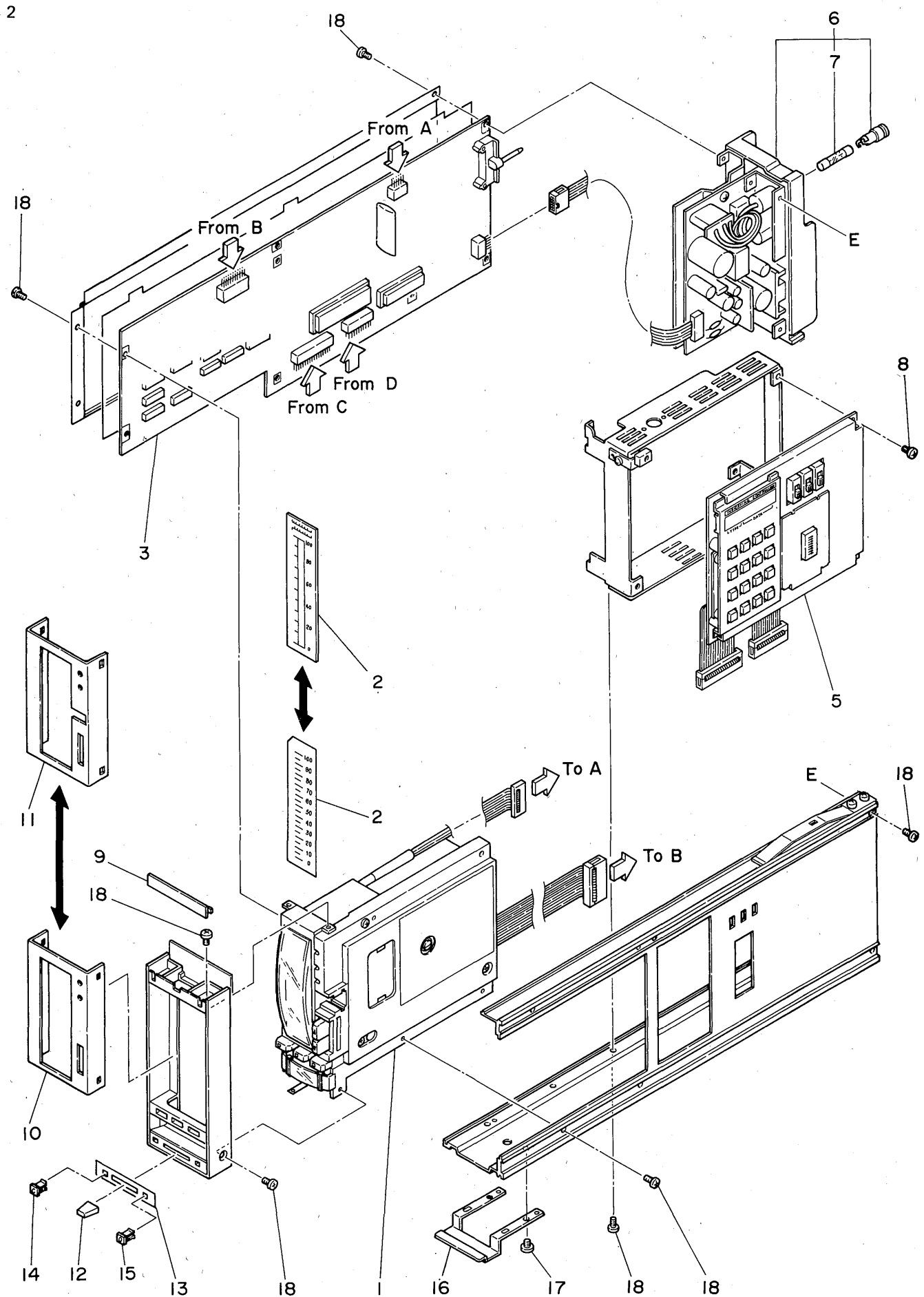
Customer Maintenance Parts List

Model SLCD (Style E)
Indicating Controller

YEW SERIES 80



Item	Part No.	Qty	Description
1	E9711TG	1	Cover
2	Y9405LB	1	B.H. Screw, M4 x 5
3	Y9422NP	1	Tag No. Label (blank)
4	E9711DH	1	Battery Assembly
5	E9711GQ	1	Cover



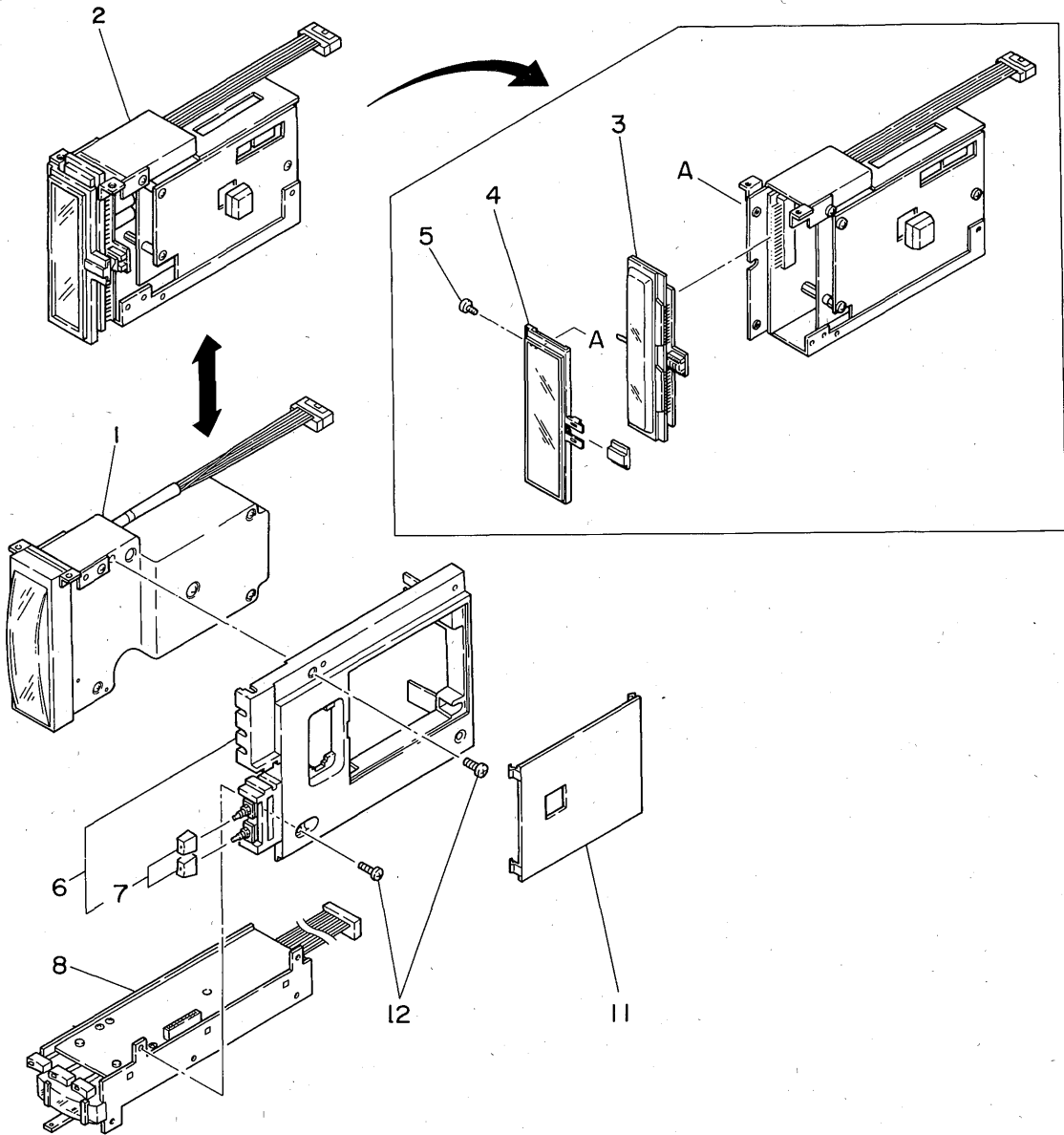
CMPL 1B4C1-04E

Oct. 1989

Item	Part No.	Model	Qty		Description
			SLCD-1□*1	SLCD-2□*1	
1	E9714AW		1		Meter Assembly
	E9711AM			1	Display Assembly
2	—		1	1	Scale (specify range when ordering)
—	—		1	1	Control Assembly
3	E9714LC		1	1	I/O Board Assembly
5	Below		1	1	CPU Board Assembly
	E9714EY				For Models SLCD-151 and SLCD-251
	E9714EV				For Models SLCD-181 and SLCD-281
6	Below		1	1	Power Supply Unit
	E9716YB				For 100 V Version
	E9716YS				For 220 V Version
7	S9510VK		1	1	Fuse — "1A/250 V"
8	Y9306JB		9	9	Pan H. Screw, M3 x 6
9	E9711FG		1	1	Plate (blank)
10	E9711HA		1		Bracket
11	E9711HB		1		Bracket
12	E9711KA		1	1	Knob
13	E9711KE		1	1	Plate
14	E9711KC		1	1	Tip — "C"
15	E9711TD		1	1	Tip — "O"
16	E9711TD		1	1	Stopper
17	E9711TE		2	2	Screw
18	Y9306JB		12	12	Pan H. Screw, M3 x 6

*For suffix code details (indicated by □), refer to YOKOGAWA GS sheets.

E9714AW Meter Assembly
E9711AM Display Assembly



Item	Part No.	Part No.		Description
		E9714AW	E9711AM	
1	E9714AB	1		Meter Assembly
2	E9714AD	1		Display Assembly
3	E9716WN	1		Display Board Assembly
4	E9711FR	1		Cover
5	Y9306JB	2		Pan H. Sxrew, M3 x 6
6	E9711DA	1	1	Frame Assembly
7	E9711FH	2	2	Knob
8	E9711KM	1	1	A/M Unit
11	E9711GP	1	1	Cover
12	Y9306JB	5	5	Pan H. Screw, M3 x 6

Instruction Manual

/ HTB Power Supply Terminal Connections for Panel - mounted Instruments (Option)

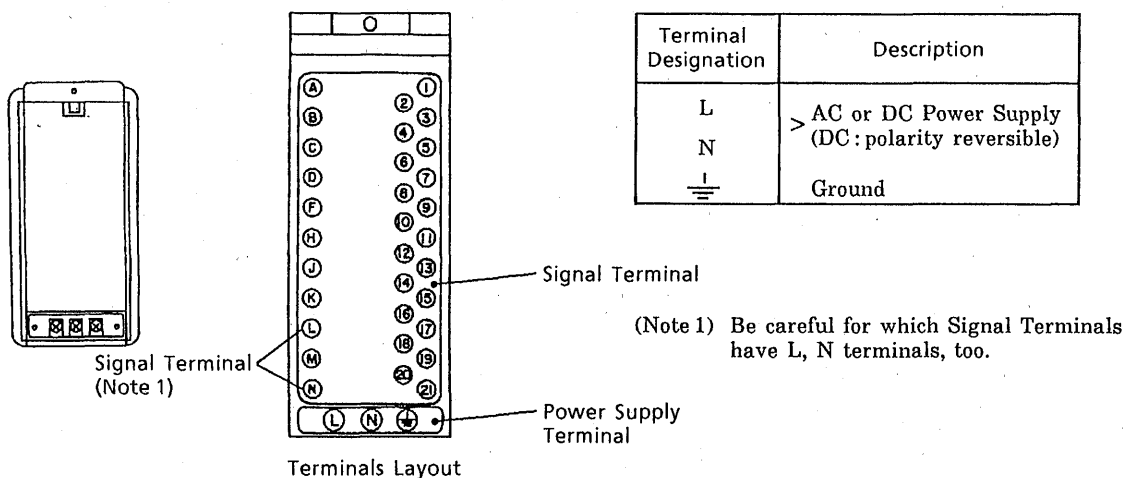
1. GENERAL.

If you specify the terminal board to which the power source is directly connected (suffix code / HTB), the external wiring to the terminal board is necessary.

2. APPLICABLE INSTRUMENTS.

Model	Description
SRVD	Strip Chart Recorder
SIHM	Indicator (With Housing)
SIHF	Bar Graph Indicator (With Alarms)
SIHK	Indicator (With Alarms)
SLCD	Indicating Controller
SLPC	Programmable Indicating Controller
SLMC	Programmable Indicating Controller with Pulse → Width Output
SMLD	Manual Station
SMST	Auto / Manual Station
SMRT	Ratio Set Station
SCMS	Programmable Computing Station
SBSD	Batch Set Station
SLCC	Blending Controller
SLBC	Batch Controller
STLD	Totalizer

3. NAME OF COMPONENTS AND TERMINAL DESIGNATION OF POWER SUPPLY



4. POWER SUPPLY AND GROUND WIRING.

(1) All cable ends must be furnished with crimp-on type solderless lugs (for 4mm screw).

(2) Examples of applicable cables.

Cross-sectional area of the cable conductor : 2.0mm².*

Note * : Power supply cables should be determined from the instrument power consumption
- they must have conductors with cross-sectional area of at least 1.25mm².

Applicable cable : 600V vinyl insulated cable (IV), conforming to JIS C3307.

Vinyl sheathed cables for electric appliances (KIV), conforming to JIS C3316.

(3) After completing the power supply and ground wiring, mount the power terminal cover.