

THE SECOND BIENNIAL
SYMPOSIUM AND EXHIBITION
ON
MOVABLE BRIDGE
DESIGN AND TECHNOLOGY

DATA ACQUISITION SYSTEM
FOR MOVABLE BRIDGES

BY
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DEDICATION

This paper and the paper titled "Low Speed-High Torque Fluid Motor Drive for Movable Bridges" are dedicated to the following:

To the Bridge Design Division of the Wisconsin Department of Transportation and the City Engineer of Manitowoc Wisconsin for their confidence in Hazelet + Erdal to design a completely new State-of-the-Art hydraulically operated system for their new Chicago type Rolling Lift Bridge to carry 10th Street over the Manitowoc River in Manitowoc, Wisconsin.

To the Bridge Design Division of the Indiana Department of Highways for their confidence in Hazelet + Erdal to also provide a similar design for their two new Chicago type Rolling Lift Bascule Bridge to carry Indianapolis Blvd. and Dickey Road over the Indiana Harbor canal in East Chicago, Indiana.

DATA ACQUISITION SYSTEM

General.

A Data Acquisition System (DAS) can be provided as part of the Programmable Logic Controller (PLC) Systems,. A DAS could be as described herein and could consist of, but not be limited to, a Data Controller Modules (one for each PLC), current transformers, current transducers, process signal amplifiers, load converters, torsional shaft strain gauges, signal conditioner/amplifiers, data switches, modem and printer. The DAS system components must be compatible with the PLC's and be interfaced to operate and print data automatically when the PLC is in the Run mode. The DAS system shall monitor and print data for the items listed in the Operator's Instructions, Description of Operation and the Printed Messages herein.

Printed Log Format.

A 8-1/2" X 11" printed log with a 1" margin on the left side for binding should be automatically generated every time the Control Circuit selector switch is turned to Automatic, Emergency or Monitor positions and the PLC is operational. The printed log could consist of variable data and messages as described with the Printer Messages and should be printed on the log in the following recommended format. The PLC manufacturer or Systems House should submit the proposed exact log format as part of the PLC Program Documentation Package.

Statements within brackets on the proposed log format are not to be printed. These statements are for reference only. Numbers on log are message numbers which correspond with printer message numbers shown on the PLC ladder diagrams. Printer Messages. All other statements shown are section headings and column headings and shall be printed as part of the log using upper case letters.

All messages shown on the proposed log, unless noted, shall be printed for Automatic and both methods of Emergency Operation but not for Monitor. If the bracketed references are noted with an A (Automatic), E (Emergency) or M (Monitor) the messages shall be printed for the indicated mode(s). All printed messages listed in special provisions paragraph D, Printer Messages listed but not indicated on the proposed printed log indicate diagnostic, advisory or emergency conditions and will not normally be printed. These messages will only be printed when necessary as determined by the PLC control program and will be printed in order of incident occurrence. Variable data may be interrupted by these messages. Diagnostic, advisory or emergency condition messages not dependent on bridge operation may also be printed when the control system is in the Monitor mode.

Printed Log Format

INITIAL STATUS

1(PLC1) or 1(PLC2)	[Control Power on for Automatic - A]
57	[Klaxons on - A,E,M]
4(PLC1) or 4(PLC2)	[Control Power on for Emergency test - E]
5(PLC1) or 5(PLC2)	[Control Power on for Monitor mode - M]
208	[Normal Electric Power available - A,E,M]
209	[Normal Electric Power connected - A,E,M]
210	[Standby Electric Power available - A,E,M]
211	[Standby Electric Power connected - A,E,M]

SOUTH LEAF:	BOTH:	NORTH LEAF:
75		74 [Leaves Fully Closed]
43		39 [Traffic Gates
47		51 Fully Up]
170		225 [Raise/Lower Mode at off position - E]
	235	[Traffic Signal Manual Control at Green
		Position]
	199	[Green Traffic Signals on]
175		181 [Emergency
176		182 Brakes Set]
189		191 [Rear Locks
190		192 Fully Driven]

TRAFFIC WARNING SYSTEM

	37	[Traffic Warning System activated]
	236	[Traffic Signal Manual Control at Yellow
		Position]
	200	[Yellow Traffic Signals on]
	237	[Traffic Signal Manual Control at Red
		Position]
	201	[Red Traffic Signals on]
49		41 [Traffic Gates
45		53 Fully Down]

Printed Log Format (Cont.)

BRIDGE OPENING

56 [Bridge Raise PB depressed - A]

SOUTH LEAF:	BOTH:	NORTH LEAF:
169		224 [Bridge Lower Mode Selected - E]
171		177 [Emergency Brakes SS at Release Position- E]
173		179 [Emergency Brakes
174		180 Released]
65		64 [Lower - Creep Speed on - A]
	183	[All Rear Locks SS at Withdraw Position- E]
185		187 [Rear Locks
186		188 Fully Withdrawn]
73		72 [Raise - Full Speed on - A]
168		223 [Bridge Raise Mode Selected - E]

SOUTH LEAF: OPENING DATA

LEAF ANGLE (DEGREES)	HYDRAULIC PRESSURE (PSI)		SHAFT STRAIN (MICROIN.)		RACK PINION SHAFT HP		ELECT. POWER USAGE (KW)	LEAF MOTOR POWER (KW)	MOTOR CURRENT (AMPS)	LEAF CON- TROLLER OUTPUT (VDC)
	SW	SE	SW	SE	SW	SE				
132	116	117	127	128	216	217	124	126	221	194
83	[Advanced Nearly Open Position - A]									
92	[Raise - Creep Speed On - A]									
85	[Nearly Open Position - A]									
87	[Fully Open Position]									
175	[Emergency									
176	Brakes Set.]									
81	[South Leaf Fully Stopped]									
170	[Raise/Lower Mode at off position - E]									

NORTH LEAF: OPENING DATA

LEAF ANGLE (DEGREES)	HYDRAULIC PRESSURE (PSI)		SHAFT STRAIN (MICROIN.)		RACK PINION SHAFT HP		LEAF MOTOR POWER (KW)	MOTOR CURRENT (AMPS)	LEAF CONTROLLER OUTPUT (VDC)	
	NW	NE	NW	NE	NW	NE				
131	118	119	129	130	218	219	125	222	193	
82	[Advanced Nearly Open position - A]									
91	[Raise - Creep Speed on - A]									
84	[Nearly Open Position - A]									
86	[Fully Open Position]									
181	[Emergency									
182	Brakes Set]									
80	[North Leaf Fully Stopped]									
225	[Raise/Lower Mode at off position - E]									

Printed Log Format (Cont.)

BRIDGE CLOSING

88 [Bridge Lower PB depressed - A]

SOUTH LEAF:	BOTH:	NORTH LEAF:	
169		224	[Bridge Lower Mode Selected - E]
171		177	[Emergency Brakes SS at Released Position - E]
173		179	[Emergency
174		180	Brakes Released]
90		89	[Lower - Full Speed on - A]

SOUTH LEAF: CLOSING DATA

LEAF ANGLE (DEGREES)	HYDRAULIC PRESSURE (PSI)	SHAFT STRAIN (MICROIN.)	RACK PINION SHAFT HP	ELECT. POWER USAGE (KW)	LEAF MOTOR POWER (KW)	MOTOR CURRENT (AMPS)	LEAF CON- TROLLER OUTPUT (VDC)
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	SW	SE	SW	SE	SW	SE				
132	116	117	127	128	216	217	124	126	221	194

79 [Advanced Nearly Closed Position - A]
 77 [Nearly Closed (Locking) Position - A]
 65 [Lower - Creep Speed on - A]
 75 [Fully Closed Position.]
 81 [South Leaf Fully stopped]

NORTH LEAF: CLOSING DATA

LEAF ANGLE (DEGREES)	HYDRAULIC PRESSURE (PSI)	SHAFT STRAIN (MICROIN.)	RACK PINION SHAFT HP	LEAF MOTOR POWER (KW)	MOTOR CURRENT (AMPS)	LEAF CONTROLLER OUTPUT (VDC)
----------------------------	--------------------------------	-------------------------------	-------------------------------	--------------------------------	----------------------------	---------------------------------------

	NW	NE	NW	NE	NW	NE			
131	118	119	129	130	218	219	125	222	193

78 [Advanced Nearly Closed Position - A]
 76 [Nearly Closed Clear Position - A]
 64 [Lower - Creep Speed on - A]
 74 [Fully Closed Position.]
 80 [North Leaf Fully stopped]

Printed Log Format (Cont.)

SOUTH LEAF:	BOTH:	NORTH LEAF:
	184	[All Rear Locks SS at Drive Position - E]
189		191 [Rear Locks
190		192 Fully Driven]
172		178 [Emergency Brakes SS at Set Position - E]
175		181 [Emergency
176		182 Brakes Set]
170		225 [Raise/Lower Mode SS turned to Off - E]
	198	[Raise All Gates SS turned to "Manual Raise"
		- E]
47		39 [Traffic Gates
43		51 Fully Up]
	235	[Traffic Signal Manual Control at Green
		Position]
	199	[Green Traffic Signals on]

MAINTENANCE

139 [Maintenance items needing
140 attention as required]
141
142
143
144
145
146
147
148

LOG COMPLETED

Printer Messages

See Programmable Logic Controller (PLC) Ladder Diagrams for location of messages within PLC program. All messages shall be generated by PLC No. 1 or PLC No. 2, whichever is used for bridge operation, unless noted by message number.

Each message shall be printed once when the program logic has produced a TRUE or ON state for the corresponding input conditions. Program logic must turn the input condition off and then back on to print the message again. Messages shall be printed in order of input condition occurrence. See last page for legend.

Message No. (PR#)	Message Printed
1(PLC1)	(d,t) : CONTROL POWER ON. AUTOMATIC OPERATION - PLC NO. 1
1(PLC2)	(d,t) : CONTROL POWER ON. AUTOMATIC OPERATION - PLC NO. 2
2(PLC1)	(d,t) : CONTROL POWER ON. PLC NO. 1 FAULT USE PLC NO. 2 OR EMERGENCY
2(PLC2)	(d,t) : CONTROL POWER ON. PLC NO. 2 FAULT USE PLC NO. 1 OR EMERGENCY
3(PLC1)	(t) : LOW BATTERY POWER - PLC NO. 1 CHECK PLC NO. 2 BATTERY.
3(PLC2)	(t) : LOW BATTERY POWER - PLC NO. 2 CHECK PLC NO. 1 BATTERY.
4(PLC1)	(d,t) : EMERGENCY OPERATION WITH SERVOS- TEST USING PLC NO. 1.
4(PLC2)	(d,t) : EMERGENCY OPERATION WITH SERVOS- TEST USING PLC NO. 2.
5(PLC1)	(d,t) : MONITOR MODE WITH PLC NO. 1.
5(PLC2)	(d,t) : MONITOR MODE WITH PLC NO. 2. (d,t) : PLC NO. 2 FAULT. (d,t) : PLC NO. 1 FAULT.

- (d,t) : CONTROL POWER ON. PLC NO. 1 & PLC NO. 2 FAULTS - USE EMERGENCY.
- (t) : EMERGENCY AIR HORN ON.
- (t) : EMERGENCY AIR HORN OFF.
- (t) : LOW HYDRAULIC FLUID LEVEL AT SW BRIDGE DRIVE POWER UNIT.
- (t) : LOW CHARGE PRESSURE AT SW BRIDGE DRIVE POWER UNIT.
- (t) : HIGH DIFFERENTIAL PRESSURE AT SW CHARGE FILTER, REPLACE FILTER.
- (t) : LOW FLUID TEMPERATURE AT SW BRIDGE DRIVE HYDRAULIC POWER UNIT.
- (t) : SERVO CONTROL MALFUNCTION AT SW BRIDGE DRIVE PUMP.
- (t) : BYPASS ON, LOW FLUID LEVEL.
- (t) : BYPASS ON, LOW CHARGE PRESSURE.
- (t) : BYPASS ON, HIGH SUCTION FILTER VACUUM.
- (t) : BYPASS ON, LOW FLUID TEMPERATURE.
- (t) : BYPASS ON, SERVO CONTROL MALFUNCTION
- (t) : BYPASS ON, ALL BRAKES RELEASED.
- (t) : BYPASS ON, ALL REAR LOCKS DRIVEN.
- (t) : TRAFFIC WARNING SYSTEM ACTIVATED.
- (t) : SW TRAFFIC GATE NOT FULLY UP, CHECK LS.
- (t) : SW TRAFFIC GATE FULLY UP.
- (t) : SW TRAFFIC GATE NOT FULLY DOWN, CHECK LS.
- (t) : SW TRAFFIC GATE FULLY DOWN.
- (t) : NORTH TRAFFIC GATES ELECTRIC EYE TRIPPED.
- (t) : SOUTH TRAFFIC GATES ELECTRIC EYE TRIPPED.

- (t) : BRIDGE RAISE PUSHBUTTON DEPRESSED.
- (t) : MACHINERY ROOM KLAXONS ON.
- (t) : SW EMERGENCY BRAKE NOT RELEASED.
CHECK PRESSURE SWITCH.
CHECK FOR LOW HYDRAULIC PRESSURE.
CHECK MOTOR OVERLOAD
- (t) : BYPASS ON, ALL GATES DOWN.
- (t) : LOWER - CREEP SPEED ENERGIZED,
SOUTH LEAF.
- (t) : SW REAR LOCK NOT FULLY WITHDRAWN.
CHECK LIMIT SWITCH AND LOCK.
- (t) : RAISE - FULL SPEED ENERGIZE,
SOUTH LEAF.
- (t) : SOUTH LEAF FULLY CLOSED.
- (t) : SOUTH LEAF AT NEARLY CLOSED
(LOCKING) POSITION.
(ra) ANGLE OF OPENING.
- (t) : SOUTH LEAF AT ADVANCED NEARLY
CLOSED POSITION. (ra) ANGLE OF
OPENING.
- (t) : SOUTH LEAF FULLY STOPPED AT
(ra) DEGREES.
- (t) : SOUTH LEAF AT ADVANCED NEARLY OPEN
POSITION. (ra) ANGLE OF OPENING.
- (t) : SOUTH LEAF AT NEARLY OPEN POSITION
(ra) ANGLE OF OPENING.
- (t) : SOUTH LEAF AT FULLY OPEN POSITION.
70.8 ANGLE OF OPENING.
- (t) : BRIDGE LOWER PUSHBUTTON DEPRESSED.
- (t) : LOWER - FULL SPEED ENERGIZE,
SOUTH LEAF.
- (t) : RAISE - CREEP SPEED ENERGIZE,
SOUTH LEAF.

- (t) : SOUTH LEAF FULLY CLOSED MAGNET OPERATED LIMIT SWITCH INOPERATIVE, CHECK MAGNET.
- (t) : NORMAL STOP PUSHBUTTON DEPRESSED.
- (t) : EMERGENCY STOP PUSHBUTTON DEPRESSED.
- (t) : INCORRECT INPUT FROM LINEAR TRANSDUCER AT SW SHOCK ABSORBER - USE PLC NO. 2 CHECK TRANSDUCER & SHOCK.
- (t) : SW REAR LOCK NOT FULLY DRIVEN. CHECK LIMIT SWITCH AND LOCK. CHECK ACTUATOR OVERLOAD
- (t) : HIGH FLUID TEMPERATURE AT SW BRIDGE DRIVE HYDRAULIC POWER UNIT.
- (t) : HIGH DIFFERENTIAL PRESSURE AT SW1 MAIN LINE FILTER - REPLACE FILTER
- (t) : HIGH DIFFERENTIAL PRESSURE AT SW2 MAIN LINE FILTER - REPLACE FILTER
- (P*) [PSI - Hydraulic Pressure at SW Bridge Drive Hydraulic Power Unit.]

DATA ACQUISITION SYSTEM

The DAS automatically activates when the CONTROL CIRCUIT selector switch is turned to AUTOMATIC or MONITOR positions and either PLC NO. 1 or PLC NO. 2 is operational. DAS will also activate when CONTROL CIRCUIT switch is at EMERGENCY position if at least one PLC is functioning properly and the PLC SELECTOR switch is turned to that PLC. This permits monitoring of bridge hydraulic, electrical and mechanical systems and operating procedure during and Emergency Operation test. The following items are monitored and printed.

- Time and date of Power On & Bridge Opening
- Operating Mode (Auto, Monitor or Emergency)
- Operational Status of PLC's
- Normal or Standby power connected
- Status of electrical system bypasses
- Circuit breaker tripped
- Traffic warning system and traffic gate operation
- Traffic gate electric eye operation
- Rear lock operation
- Brake operation
- Hydraulic system parameters (See Separate List)
- Main motor electric currents
- Electrical system power consumption
- Rack pinion shaft strain and stress on all four shafts
- Operating horsepower
- Angle of opening for each leaf
- Limit switch malfunction
- Machinery maintenance intervals

DAS automatically deactivates when the CONTROL CIRCUIT switch is turned to OFF position. Printer may continue to print data for a short period of time.

The following accessories shall be provided at each HST hydraulic power unit.

- a. Low Fluid Level Switch. Contacts rated 3 amps (continuous inductive), 120 VAC. Switch shall have single pole single throw snap action switching elements which close at low fluid level and automatically reset. Low fluid level switch shall be adjusted to give an electrical signal when the fluid has fallen to a level such that 20 gallons is remaining in the reservoir. Low fluid indication level shall be field adjustable.
- b. Low Fluid Temperature Switch. Contacts rated 10 amps (continuous inductive), 120 VAC. Switch shall have single pole double throw snap-action switching elements which automatically reset. contacts shall close when fluid temperature falls to 45 degrees F. Low fluid temperature indication setting shall be field adjustable.
- c. High Fluid Temperature Switch. Shall be similar in construction to low fluid temperature switches. Contacts shall close at high temperature and automatically reset. High temperature setting shall be 140 degrees F. Setting shall be field adjustable.
- d. Immersion Heater. To maintain required fluid viscosity for cold weather starting. Immersion heaters shall be dry well types, with 2.25 KW output and operate on 240 VAC. A thermostat shall be provided to automatically maintain a minimum fluid temperature of 60 degrees F. Thermostats shall be field adjustable.
- e. Pressure Gages and Shut-Off Valves. To indicate system operating pressure and charge pump pressure. System pressure gauges shall have a pressure range of 0-5000 psi and charge system gauges shall have a pressure range of 0-1000 psi. A shut-off valve shall be provided for each gauge.
- f. Pressure Transducers. Strain gage type pressure transducers of stainless steel construction shall be provided. Transducer excitation range shall be 14-30 VDC and output shall be 4-20 mA, suitable for input to programmable controllers. Transducers shall have an operating pressure range of 0-5000 psi with a safe over pressure rating of 7500 psi and a burst rating of 15,000 psi. Minimum operating temperature range shall be -20 to 185 degrees F. and minimum compensated temperature range shall be 0 to 150 degrees F. Accuracy shall be ± 0.4 percent full scale output or better.
- g. Charge Pressure Switch. Contacts rated 10 amps (continuous inductive), 120 VAC. Switch shall have single pole double throw snap-action switching elements which automatically reset. Contacts shall close when charge pressure falls to 150 psi at the charge pump. Pressure switch shall be factory set and not field adjustable.

Time and Date

The PLC has a digital clock recording time in seconds, which normally appears on the "DIAGNOSTIC DISPLAY" on the center of the console. The month, day, and year are also displayed. This data is also available for the printed messages as required.

Traffic Controls (See Plate 1)

The electrical schematic diagram shows the monitoring and self diagnostic circuits for the two traffic gates on the south approach. When the operator starts a bridge operation the raise contactor CG2R, is not activated. The gate limit switch, LS13, is shown closed which would provide power to the white gate "UP" indicating light WL28. When the operator pushes the gate "LOWER" pushbutton, it activates the gate lowering contactor, CG2L. An auxiliary contact closes and provides input 56 to the PLC. I-56 tells the timer T15 to count out the seconds that the contactor is closed. When the gate reaches the "Down" position the limit switch LS14, closes and activates Input 57. The red gate "Down" indicating light RL21 is turned on. Input 57 activates the printer which types out the time and the function, that the SE gate is down. However, its input 57 normally closed contact is not opened before the timer T15, counts to 10 seconds the signal is flashed on the display for a few seconds and the printer types out the time and statement "Check SE Gate Down Limit Switch". The display will continue to the message in a rotating order of all the messages that are pertinent until the limit switch is closed or bypassed. If the gate is slow in lowering, the maintenance personnel can tell from the times, how long it took the gate to close. Routine maintenance can be performed to keep the gate in good operating condition.

Resolvers (See Plate 2)

Resolvers are attached to the shafts that are one open gear train from the shafts on which the LSHT motors are mounted. The resolvers - decoders receive the series of voltages from the resolvers and determines the angular position to one tenth of one degree of rotation.

TIMER MOTION POSITION TRANSDUCER (LMPT) (See Plate 3)

The LMPT is provided to give a positive indication that the jaw leaf on the near side is actually in the "window" to receive the diaph leaf on the far side. The LMPT is supported and activated by a shock absorber. The spring in the shock absorber keeps itself and LMPT extended until the jaw leaf comes down and compressed the shock absorber. The amount of movement of the LMPT sends a signal in milliamps (MA) back to the PLC.

The relative difference in MA between the fully extended MA and the fully compressed MA will indicate the exact position of the jaw leaf since there is a straight line variation. The position of the LMPT is monitor in the AUTO (I2) and MONITOR (I3) Modes at the fully compressed position and the fully extended. If both positions do not check out within very close tolerances, the Display D51, will read:

SW LMPT MALFUNCTION
USE PLC 2, CHECK LMPT

and printer message PR97, will read:

(time): INCORRECT INPUT FROM LINEAR TRANSDUCER AT SW SHOCK ABSORBER -
USE PLCZ, CHECK TRANSDUCER AND SHOCK.

PRESSURE TRANSDUCERS (See Plate 4)

Pressure Transducers are provided on the manifold of each of the four hydraulic power units. A shuttle valve allows the higher pressure of the hydraulic fluid going to drive the low speed high torque motor to be recorded at the same five degree intervals as the strains are measured. The revolutions per minute of the shaft together with the data from the LSHT motor will be used to determine the volume being pumped. The pressure transducer will be recording the pressure in psi at which the fluid is being pumped.

Strain Measurements (and Calculated Horsepower on Output Drive Shafts) (See Plate 5)

Strain gages are mounted (by welding) on the 4 output shafts carrying the drive pinions. The strain is recorded in micro-inches at each degree for the first five degrees of opening and then at five degree intervals as the position of the moving leaves are indicated by the output of the resolvers. Simultaneously, the rotation of the resolver provides the revolutions per minute needed to calculate the output horsepower.

We are going to compare the input horsepower to the electric motors, to the output horsepower of the gear train to determine the efficiency of the new hydraulic drive system.

Observation of the horsepower required to open the moving leaf will be compared to the corresponding horsepower (at the same angle of the leaf) required to close the "moving leaf". When no wind load is present, the difference will indicate the amount of unbalance of the moving leaf at each 5 degree angle of opening.

When the counterweight blocks have been placed in a predetermined sequence it is possible to calculate the amount and location of counterweight blocks required to be added, relocated or even removed to place the center of gravity of the moving leaf at the center of roll. This means the moving leaf will be in balance over the entire length of roll. The only power required to open or close the moving leaf will be that required to overcome rolling friction of the segmental castings on the track castings and the friction in the gear trim. (With the use of roller bearing this is greatly reduced). This results in the maximum horsepower available to overcome the design operating horizontal wind load of 10 pounds per square foot. The wind load increases as the leaves roll open exposing more of the roadway and sidewalks deck to the horizontal design wind.

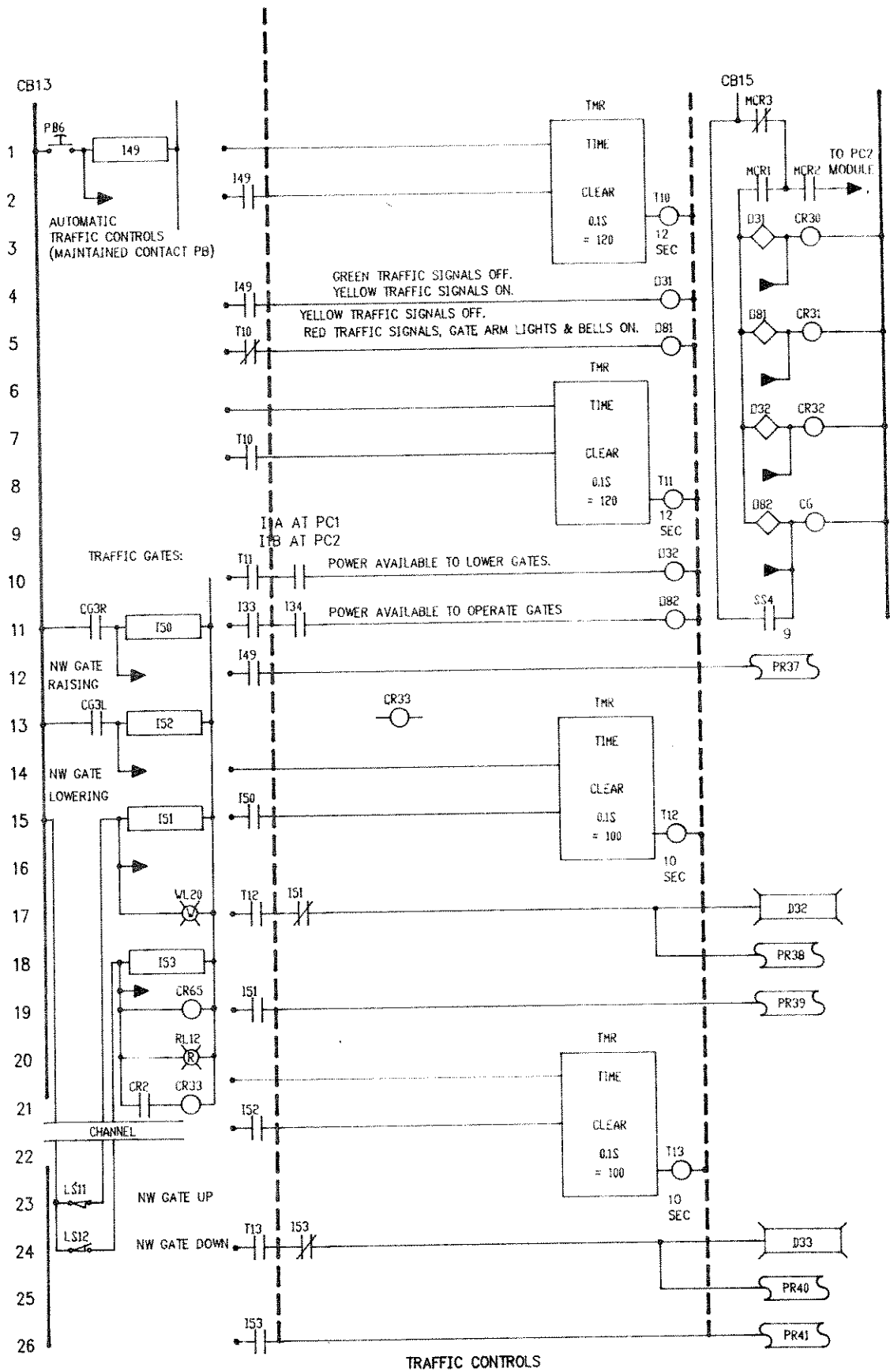
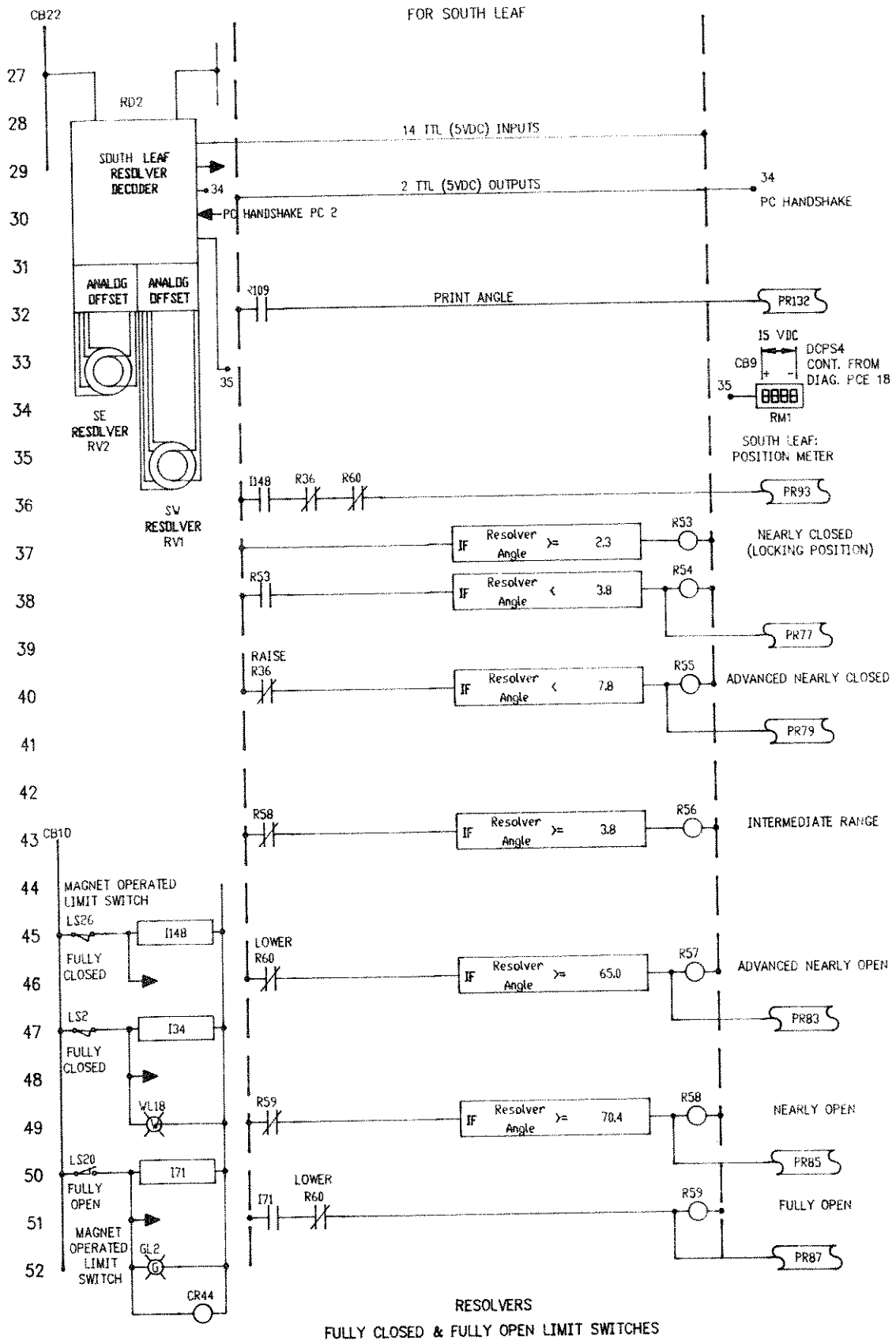
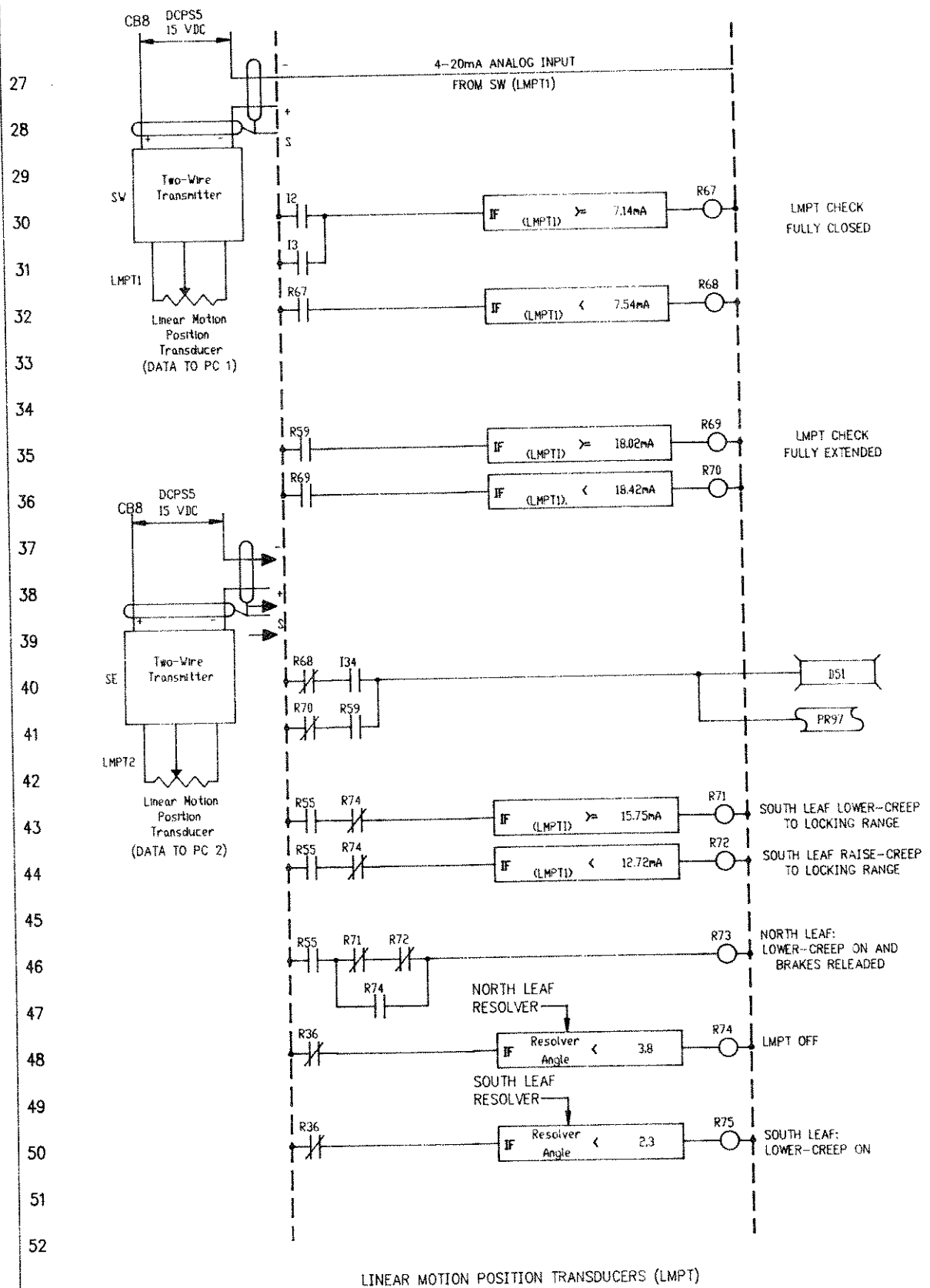
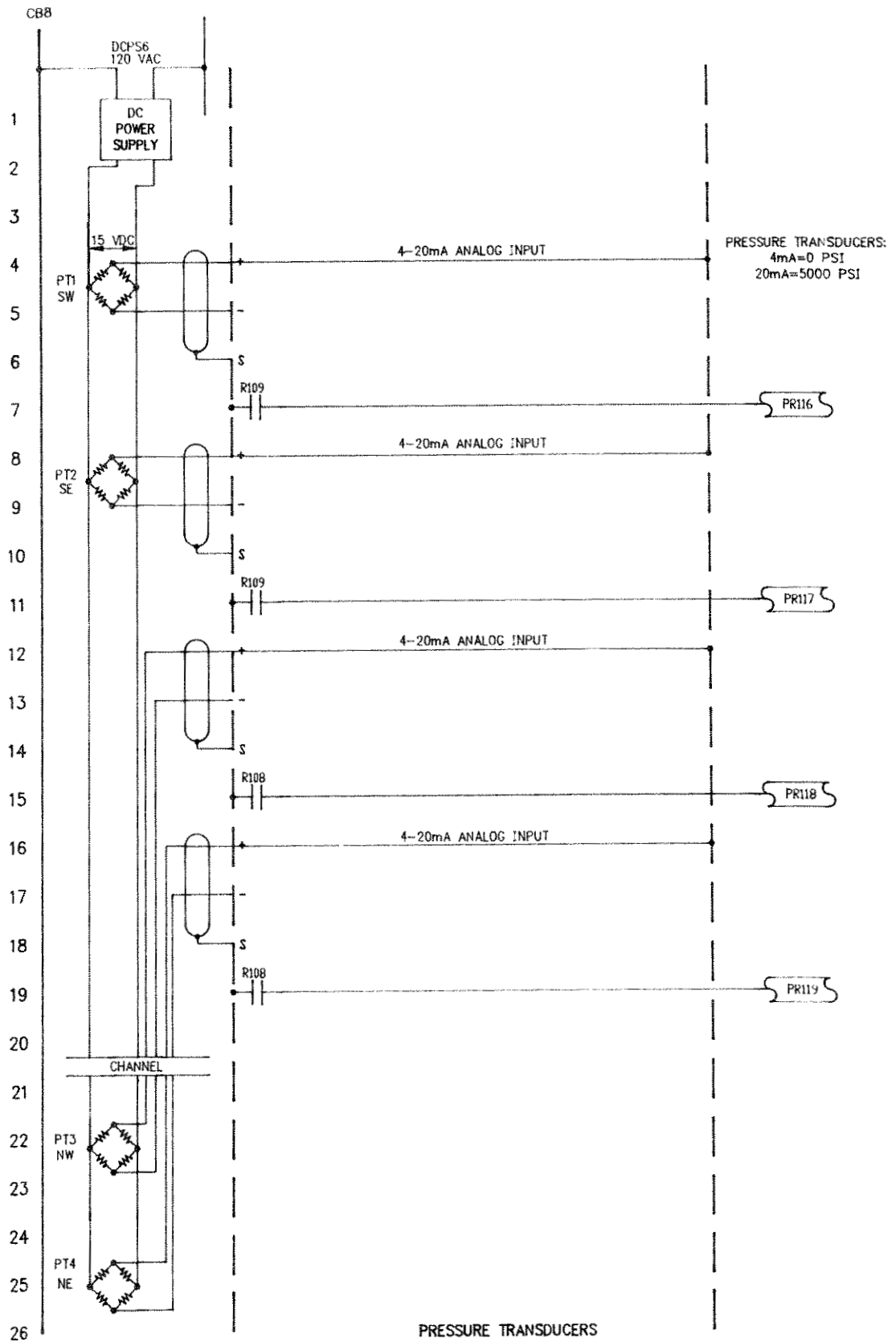


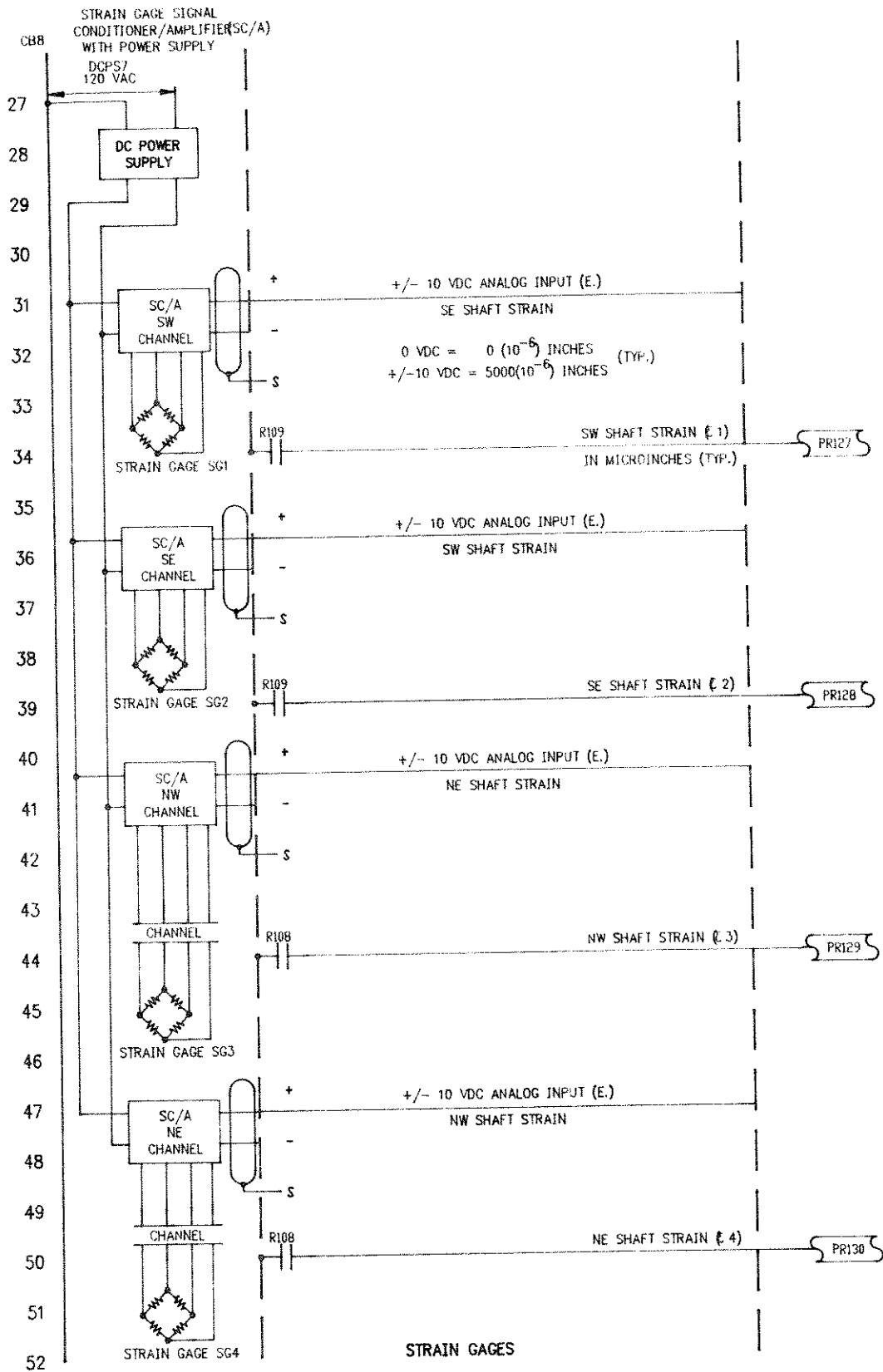
PLATE 1



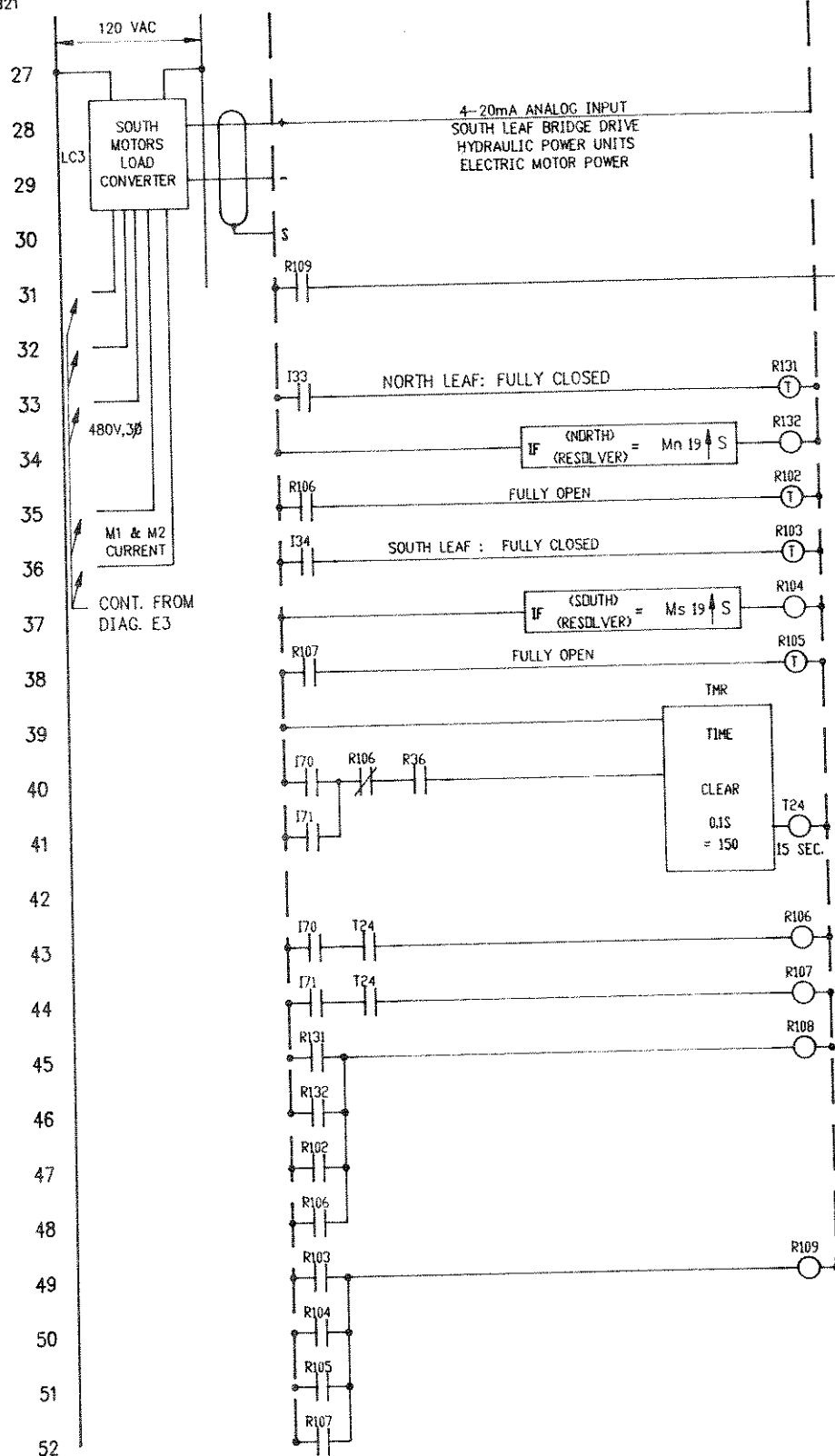


LINEAR MOTION POSITION TRANSDUCERS (LMPT)





CB21



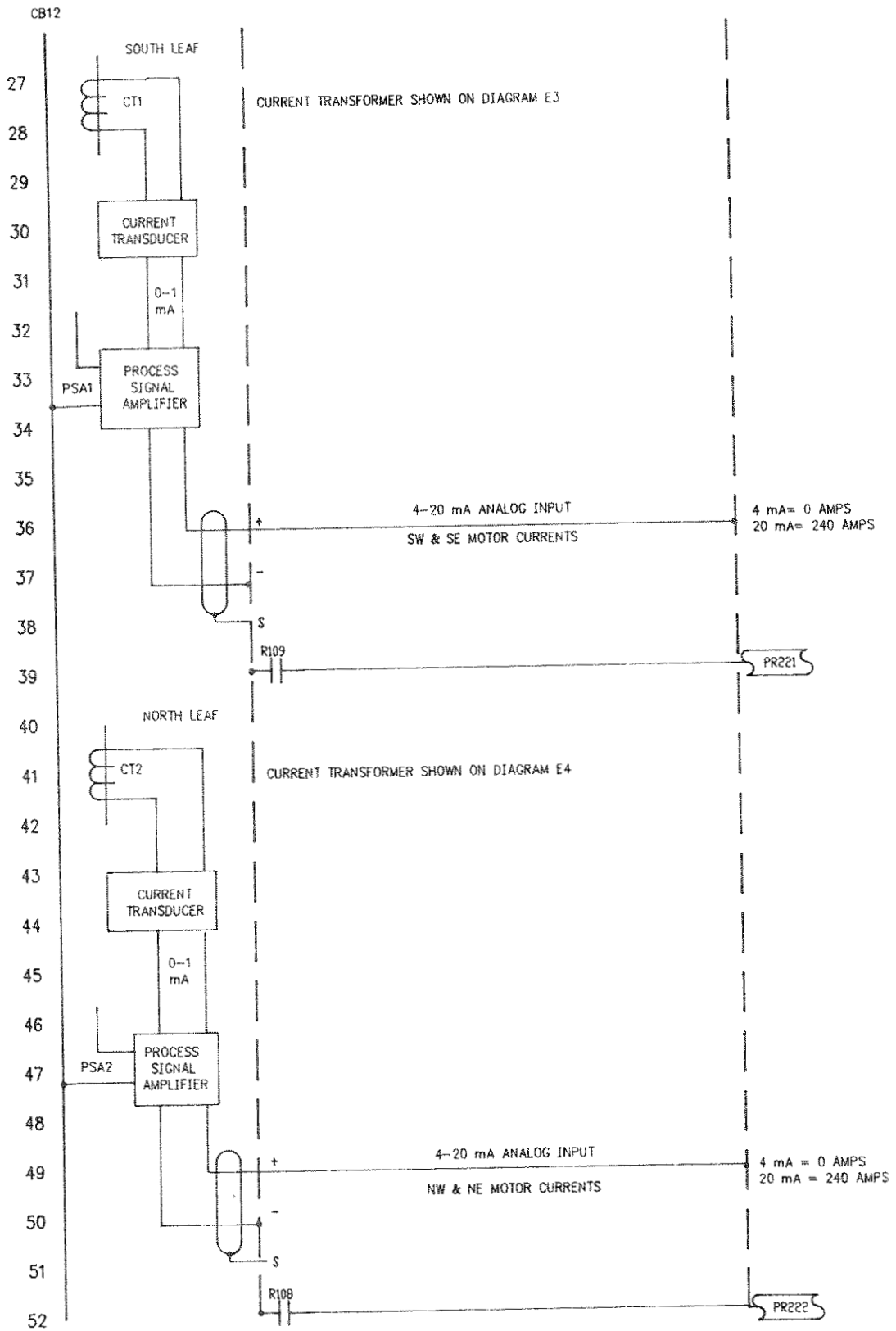
MATRIX (Mn) FOR NORTH LEAF:

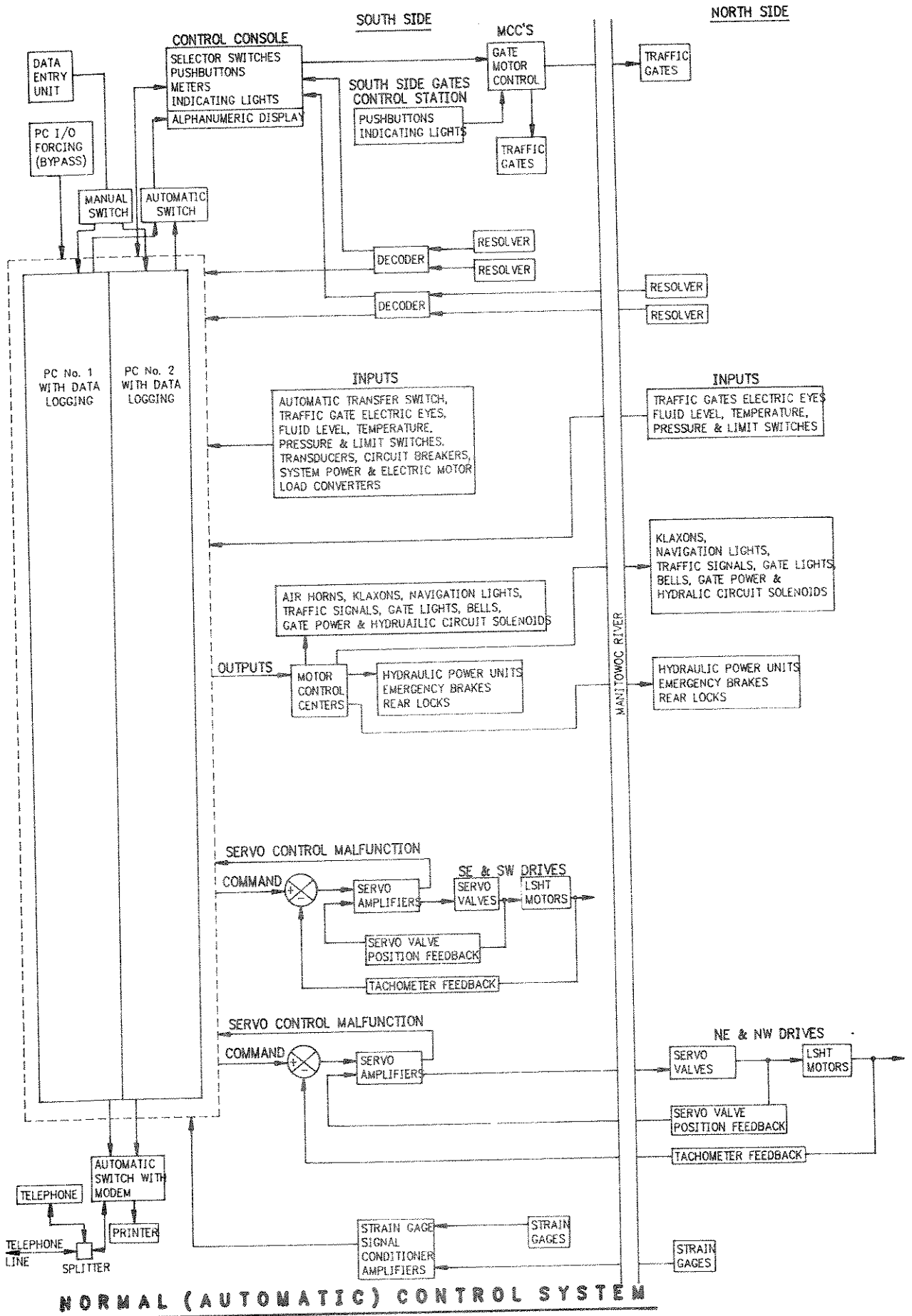
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- S=2
- S=3
- S=4
- S=5
- S=10
- S=15
- S=20
- S=25
- S=30
- S=35
- S=40
- S=45
- S=50
- S=55
- S=60
- S=65
- S=70

MATRIX (Ms) FOR SOUTH LEAF:

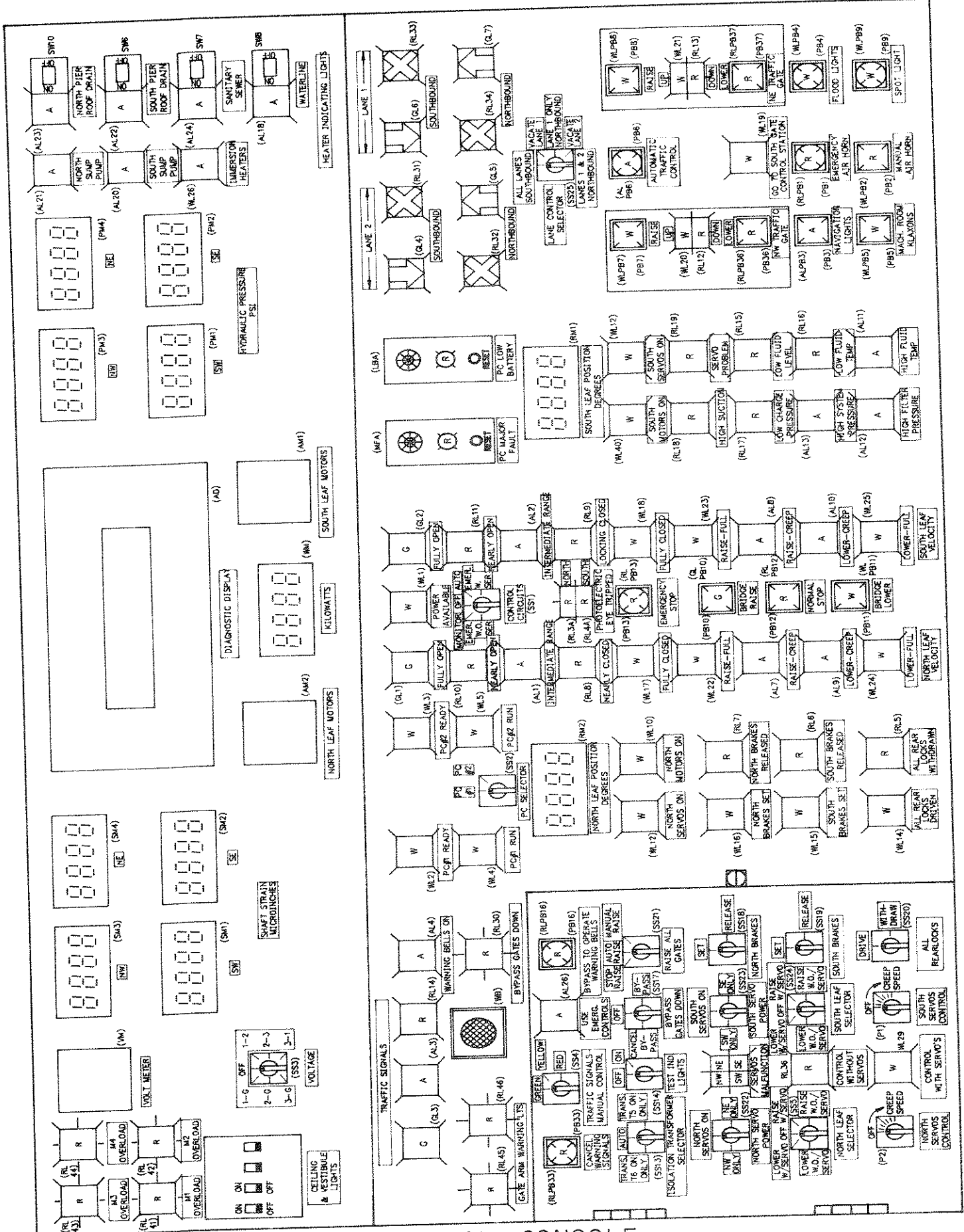
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- S=25
- S=30
- S=35
- S=40
- S=45
- S=50
- S=55
- S=60
- S=65
- S=70

PRINT COMMANDS FOR VARIABLE DATA














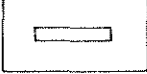


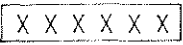



NORMAL (AUTOMATIC) CONTROL SYSTEM



CONTROL CONSOLE
PLATE 9

LEGEND

	PUSHBUTTON MOMENTARY
	PUSHBUTTON-MOMENTARY & ILLUMINATED BUTTON COVER COLOR INDICATED ON SYMBOL
	PUSHBUTTON-MAINTAINED & ILLUMINATED BUTTON COVER COLOR INDICATED ON SYMBOL (MUSHROOM HEAD BUTTON)
	* INDICATING LIGHT, LENS COLOR INDICATED ON SYMBOL
	DUAL INDICATING LIGHTS, LENS COLORS INDICATED ON SYMBOL
	FOUR INDICATING LIGHTS, LENS COLORS INDICATED ON SYMBOL
	* GREEN ARROW LANE CONTROL INDICATING LIGHT (USE THIS LANE)
	* RED X LANE CONTROL INDICATING LIGHT (VACATE THIS LANE)
	SELECTOR SWITCH & POTENTIOMETER (MAINTAINED UNLESS SPRING RETURN REQUIREMENTS GIVEN WITH CONTACT DIAGRAM)
	TOGGLE SWITCHES TO CONTROL OPERATOR'S ROOM AND VESTIBULE LIGHTS
	4 DIGIT, 7 SEGMENT PANEL METER
	20 CHARACTER ALPHANUMERIC DISPLAY
	ANALOG PANEL METER
	ALARM MODULE WITH HORN AND INDICATING LIGHT, LENS COLOR INDICATED ON SYMBOL
	NAMEPLATE
	KEY NUMBER
	* USE A MOMENTARY CONTACT PUSHBUTTON (WITH 1-N.C. AND 1-N.O.) TO PROVIDE A "PUSH-TO-TEST" CIRCUIT FOR THE INDICATING LIGHTS.

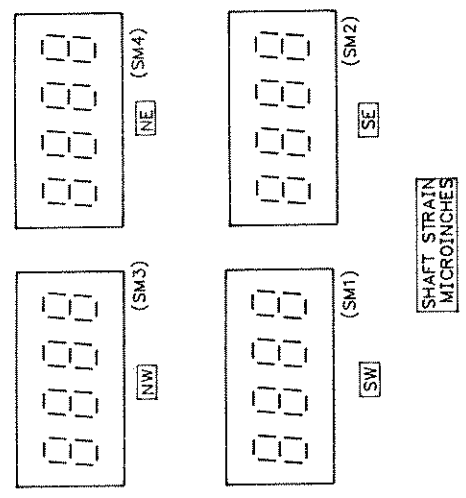
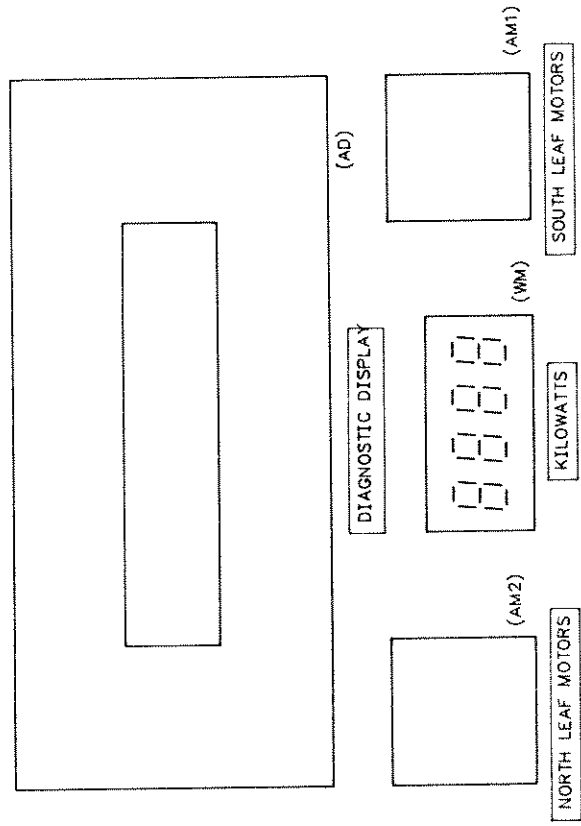
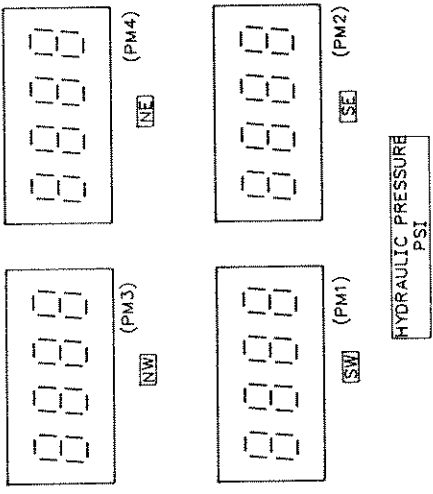


PLATE 11