GEK-28624

INSTRUCTIONS

PM1000 * CONTROL

For Plastic Processing Machines

IC 7966

* Trademark of General Electric Company

GENERAL ELECTRIC COMPANY
INDUSTRIAL CONTROL PRODUCTS DEPARTMENT
~~SALEM,~~ VIRGINIA 24153

INSTRUCTIONS **GEK-28624**

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The information contained herein is intended to assist users and dealers in the servicing of control furnished by the General Electric Company. It does not purport to cover all details or variations in equipment or provide for every possible contingency to be met in connection with installation, operation or maintenance.

Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to the machinery manufacturer through his normal service channels.

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GENERAL ELECTRIC

CONTENTS

I. GENERAL DESCRIPTION

The *PM1000 control system described herein is designed to provide predetermined customer control functions for plastic-processing machines. Functions covered by this control may include power-disconnecting, zone heater control, machine-sequencing including timers and static power switching devices.

All machine functions are provided using integrated circuitry, where practical. The logic outputs are converted, through the use of solenoid drivers, to control the solenoids at the 115-volt control-voltage level.

This method of control offers numerous distinct advantages which include small size, keeping floor space required to a minimum; high reliability inherent in static devices, reducing downtime since moving parts are minimal; and shorter cycle times due to solid state versus electro-mechanical switching.

POWER

The incoming line, disconnect switch, and power contactor (if used) are mounted with separation from the logic circuitry. The heater power is switched on and off by static a-c power switches. A typical power compartment is shown in Photo No. 1.

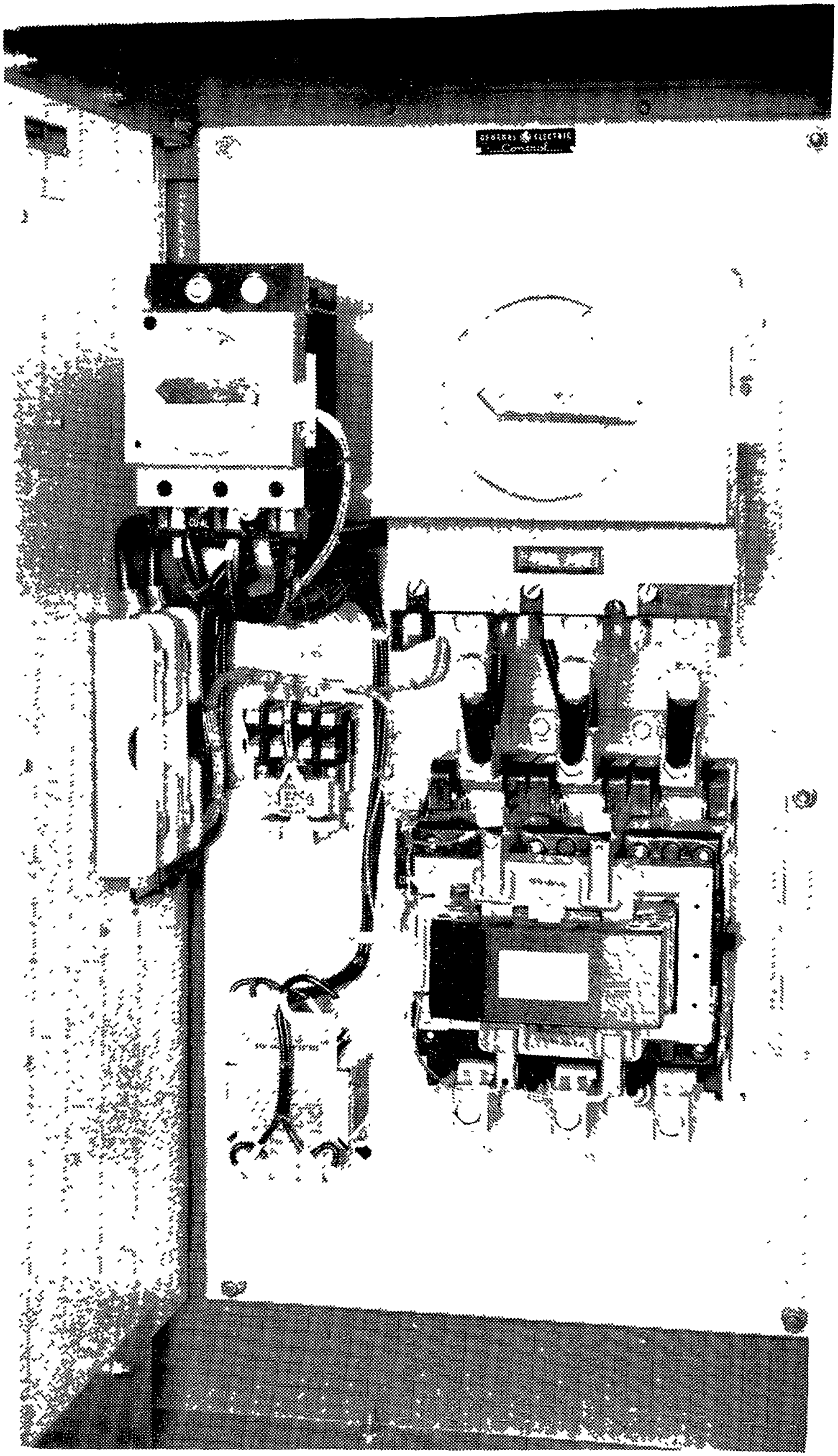


PHOTO NO. 1

TYPICAL INCOMMING POWER COMPARTMENT

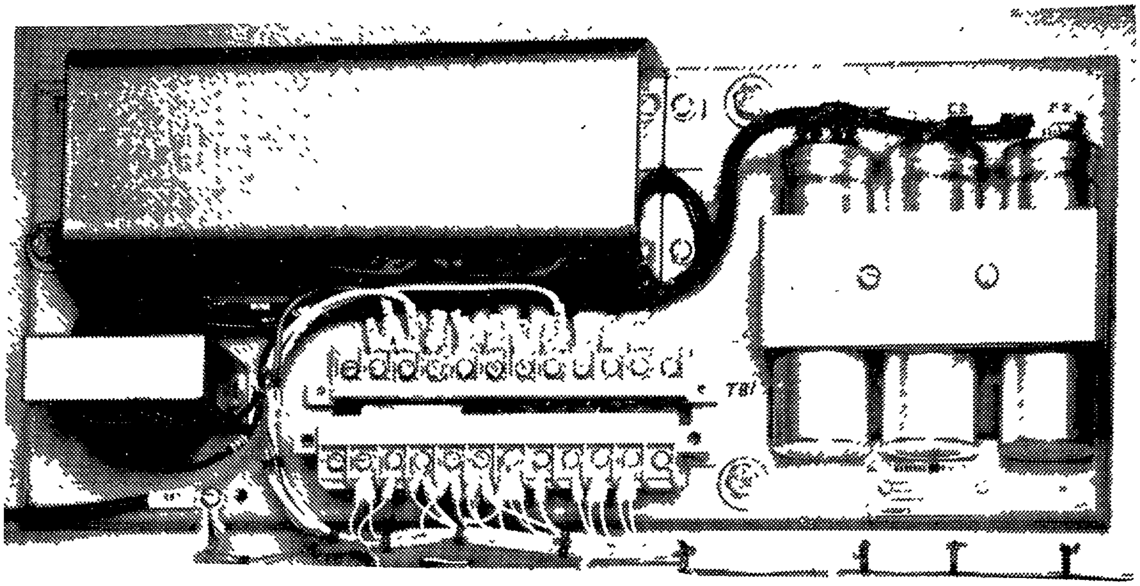


PHOTO NO. 2

D-C POWER SUPPLY MODULE

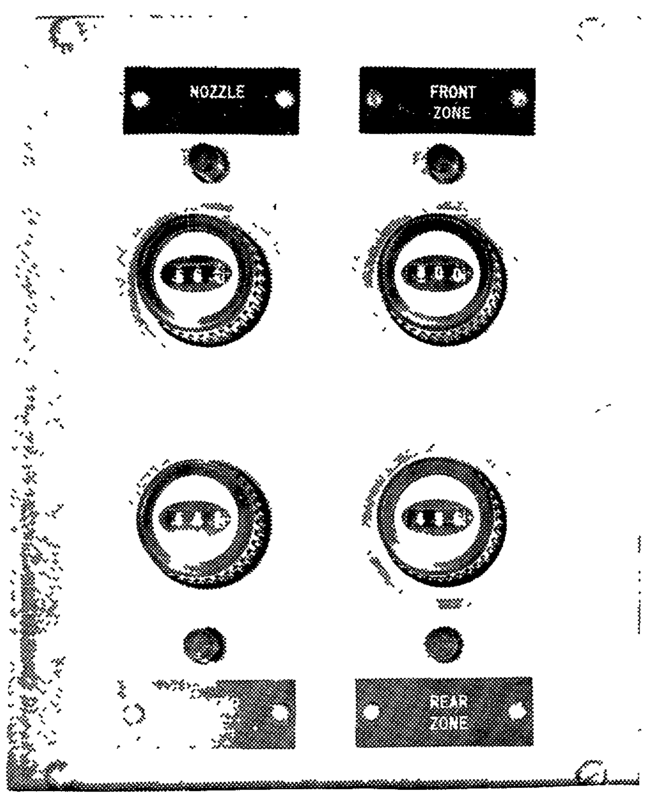


PHOTO NO. 3

FOUR ZONE TEMPERATURE REGULATOR

DC POWER SUPPLY

The power supply module provides isolation, voltage regulation, electrical noise suppression and all voltages required by the static control circuitry. The power supply module is shown in Photo No. 2.

TEMPERATURE CONTROL

The zone heat control is provided by logic circuitry whose input reference is a digital readout potentiometer, normally mounted on the top panel of the desk-type enclosure. Resistance temperature detectors (RTD), furnished by the machine builder, sense the zone temperatures and provide the feedback signals for temperature comparisons. When the feedback is below the set-point reference, an output signal is provided to gate the static power switch. When the set point is matched or in the regulating band the regulator will cycle the heater power on and off to maintain temperature at the set point by time proportion. When the set point is exceeded the regulator will remove heater power. Thus, the temperature is held at the set point within a narrow band. A four zone temperature regulator is shown in Photo No. 3.

HEATER DRIVERS

The heater drivers must be considered a part of the temperature control. While the heater driver is a distinct separate module in the overall control, it must operate in conjunction with the temperature regulator. The regulator and heater driver are coupled through an isolation transformer, the transformer secondary provides the gate signal to the heater drivers permitting a-c heater power to the heater bands. A typical heater driver installation is shown in Photo No. 4.

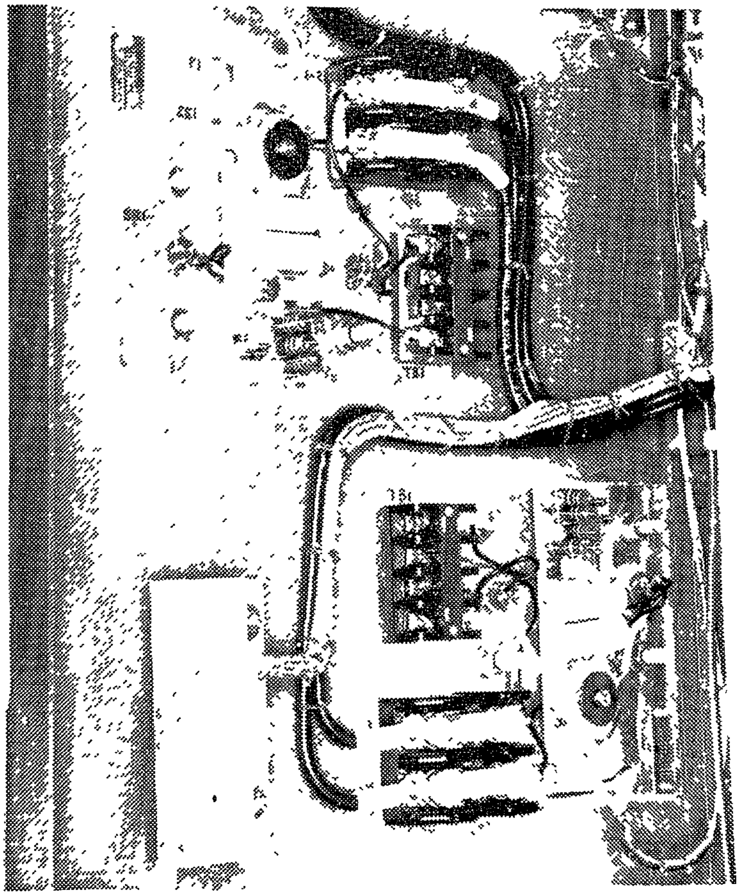


PHOTO NO. 4

TYPICAL HEATER DRIVER MODULE INSTALLATION

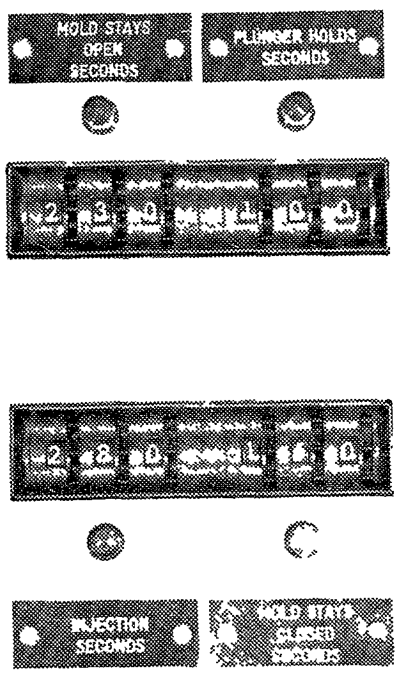


PHOTO NO. 5

FOUR UNIT DIGITAL TIMER MODULE

TIMING

Machine operation requirements dictate the need for certain time delays which may be digital or analog. The process timers, normally of the digital type, are of integrated circuitry design. The timing reference for the digital timers is provided by thumbwheel switches representing time in seconds and tenths of seconds. A clock and scan function uses the line synchronized clock pulses to produce a synchronized count that is compared to the thumbwheel reference. A gate input signal initiates the clock. Removal of the initiate signal resets the clock to zero. The scan signal is used to selectively gate the appropriate process timer for comparison. The time-comparison function compares the clock output with each time-setting reference. When a comparison is obtained, the individual process-timer output signal is provided to indicate that the set time has elapsed. An indicating lamp is provided with each process timer to indicate the timing period. The digital timer module is shown in Photo No. 5.

The analog timer makes use of transistorized circuitry, with a rheostat provided for the timing adjustment. The rheostat may be mounted either internal or external to the control enclosure. It has a preferred range in mutliples of 10 to 1. A typical analog timer adjustment module is shown in Photo No. 6.

OPERATOR'S PANEL

The operator's panel provides for set-up devices, manual-cycle operators devices and displays as required.

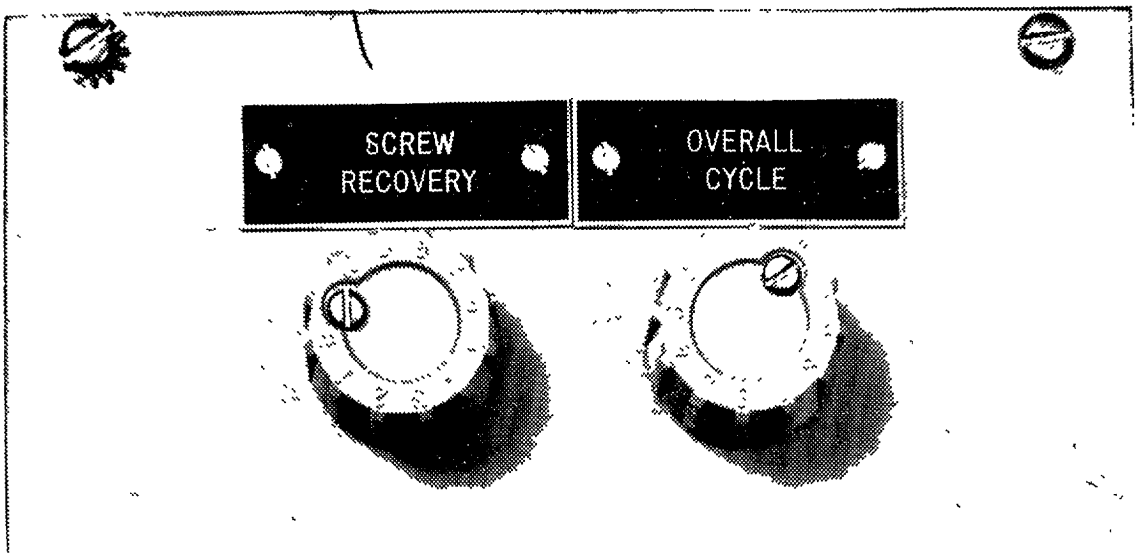


PHOTO NO. 6

TYPICAL ANALOG TIMER MODULE

OPERATOR'S PANEL (Continued)

The operator's panel may be provided as a pendent station or may be an integral part of the control console.

Front and rear views of typical operator's panels are shown in Photo No. 7 and 8.

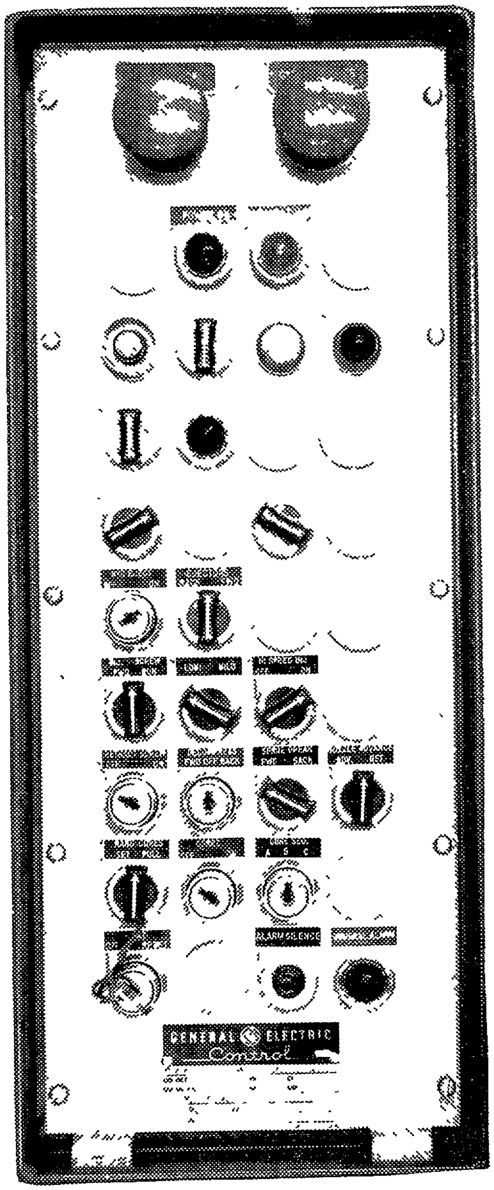


PHOTO NO. 7

TYPICAL OPERATORS PANEL
(FRONT VIEW)

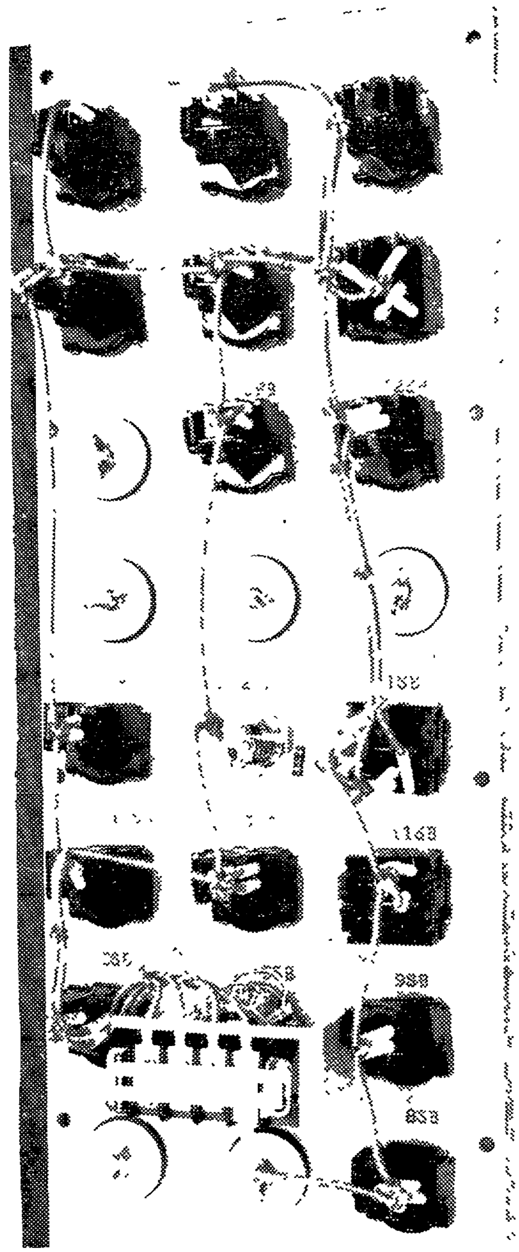


PHOTO NO. 8

TYPICAL OPERATORS PANEL
(REAR VIEW)

II. GENERAL SPECIFICATIONS

These general specifications are intended only as information as to the equipment available and not to be construed as a bill of material. The actual list of equipment supplied will be determined by the requirements of the particular machine.

VOLTAGES - The input power may be 460-volts or 230-volts. The input transformers are reconnectable to accept either of the above voltages. A control transformer is provided to supply 115-volts for control power. Controls so specified may be designed for either 50 or 60 Hertz operation.

HEATER KW RATINGS

The following table indicates the standard heater-driver modules available:

HEATER DRIVER CAT. NO.	KW	VOLTAGE
IC3625DA4U25	6.9KW	460-Volt, 1 Phase or 230-Volt, 3 Phase (Open "V" load only)
	11.5KW With external heat sinks	
IC3625DA2S25	5.75KW or 2.875	230-Volt, 1 Phase or 115-Volt, 1 Phase
IC3625DA4U05	2.3KW	460-Volt, 1 Phase or 230-Volt, 3 Phase (Open "V" load only)
IC3625DA2S05	1.15KW or .58KW	230-Volt, 1 Phase 115-Volt, 1 Phase
IC3625DB4S50	23 KW or 11.5 KW	460-volt, 1 Phase 230-Volt, 1 Phase

TIMER RANGES

Analog timers are used in some cases where extremely accurate times are not required. The range of the analog timers has been determined by the machine builder and is limited to 10 to 1 range. Preferred timing ranges available are 0.1 to 1 seconds, 0.2 to 2 seconds, 0.5 to 5 seconds, 1 to 10 seconds, and 5 to 50 seconds. Accuracy is ±10% of set time setability. Repeatability is ±1 percent of set time at stable ambient temperature.

Digital timers are used where precise accuracy is required. Digital timer ranges available are 0.0 to 9.9 seconds and 00.0 to 99.9 seconds both adjustable in 0.1 seconds increments. Standard digital timers are designed for operation on 60 Hertz system. Upon specific request, timers may be provided for 50-Hertz operation. Maximum error will be 5 clock pulses. Repeatability is within 1 clock pulse.

POWER SUPPLY

Input - 95-120 Volts a-c 50/60 Hertz

Outputs - P15V-15-Volts positive d-c 500 Ma Max
N15V-15-Volts negative d-c 500 Ma Max
P90FW-90-Volts minimum 105-volts nominal positive fullwave rectified unfiltered 30 Ma Max

INTEGRATED CIRCUITRY

The integrated circuits used in the PM1000 control are of high-level logic resulting in high reliability and good noise rejection.

Operating temperature - 0°C to 70°C

Voltage operating range - 13.8 to 16V

D-c noise immunity - 6.5V minimum

A-c noise immunity - 10V at 150NS

III. RECEIVING, HANDLING AND STORAGE

Upon receipt, the equipment should be c arefully unpacked to avoid damaging the appartus and inspected for any damage sustained in transit.

The *PM1000 controls are equipped with lifting eyes for crane handling or may be conviently carried by a lift truck. Reasonable care should be exercised to avoid undue abuse in handling.

If the equipment is not to be used as soon as it is unpacked, it should be stored in a clean, dry and protected area. Particular care should be exercised to avoid storing the equipment in a location where construction work is in progress.

IV. INSTALLATION

All of the instructions furnished with the equipment should be read carefully before any work is performed on the equipment. Do not apply power until the instructions have been studied and the start-up conditions have been met.

Possible damage to wiring and machinery will be avoided if all of the connections are made correctly in accordance with the interconnection diagram provided with the equipment. Care should be exercised in locating the control panel to avoid placement near sources of excessive heat or restriction of free movement of air around heat sinks (when used).

No special tools are required for installation. The normal complement of hand tools such as screw drivers, pliers, wrenches, etc. is all that is needed for installation.

Normally, no special instruments are required. A Simpson Model 260 VOM or equivalent is sufficient in most cases.

BEFORE APPLYING POWER

The following precautionary steps must be taken before applying power to reduce the possibility of damage to the equipment when power is applied.

MECHANICAL INSPECTION

Look for obvious damage that may have occurred during installation. Also look for loose hardware, loose or broken wires and foreign material.

ELECTRICAL INSPECTION

All system grounds should terminate at one point only. This system ground point should be connected to earth ground. Lifting the ground at this point should open the circuit to ground. Physically check that all ground and power connections are tight.

Check that control transformer(s) is set for the proper 460 or 230 volt input connection.

Check the heater devices for a jumper between J1 & J2 per the following table:

HEATER DRIVER	SYSTEM VOLTAGE	J1 - J2 CONNECTION
Cat. No. IC3625DA4U25	460V	No Jumper
	230V	Jumper
IC3625DA4U05	460V	No Jumper
	230V	Jumper
IC3625DA2S25	230V	No Jumper
	115V	Jumper
IC3625DA2S05	230V	No Jumper
	115V	Jumper

VERIFY POWER SUPPLY BUSSES

The plug should be removed from the power supply and the following measurements made at the plug with an ohm meter, Simpson Model 260 or equivalent. All busses should measure a resistance to common, never zero. The 15-volt busses P15V & N15V to common should be a minimum of 30 ohms with the loads connected.

CUSTOMER MODIFICATIONS

Where a permanent modification is required, use a different color wire of compatible size and insulation for easy identification of control changes. Do not use temporary clip leads just to save time. Clips can fall off, hitting other exposed pins resulting in damage to components. Use pressure connectors for all wiring changes.

CAUTION: Never make any modifications with the power on. This can cause malfunction or result in damage to components.

V. INTERCONNECTIONS

Included with the *PM1000 control is an interconnection diagram indicating the wiring necessary between the main control and operators station and the various machine devices. Before power is applied make certain all interconnections have been made according to the interconnection diagram, preferably by continuity checking each circuit.

Logic wiring and power wiring should be separated to eliminate possibility of electrical noise and extraneous signals. Follow the guide in the interconnection diagram.

APPLYING POWER

Make certain the panel ground provided is securely connected to earth ground. Set temperature regulators to approximately ambient temperature or below. After necessary a-c input connections have been made, make certain the main control disconnect device is open, then energize the feeder.

Remove the power-supply output plug and after the above precautions have been made, turn on the main disconnect switch. Measure the voltage at the input terminals and make certain the control transformer(s) has the proper output voltage (normally 115Va-c). Measure the power-supply module output-bus voltages. These voltages should be + 15 V d-c, - 15 V d-c and + 90 V d-c. If these voltages are within $\pm$20%, remove the incoming power and plug in the power-supply module output plug. Again apply power and recheck the power-supply voltages. If the voltage is not within 5% of their nominal voltages, recheck the incoming voltage and transformer connections and refer to power-supply trouble-shooting guide, Table II.

MOTOR ROTATION

Check the pump motor for proper rotation by momemtarily starting. At this time any auxiliary motors that may be included may be checked for proper rotation.

TEMPERATURE REGULATORS

The temperature regulators can be checked for operation before the heater power is applied, by adjusting the set point somewhat above the known ambient temperature. The RTD sensors must be connected. The regulator indicating light will energize indicating the set point is above the RTD temperature. Readjust the set point to a temperature below the ambient. The indicating lamp will extinguish. At approximately ambient setting the lamp will cycle on and off. Failure to obtain the foregoing indicates temperature-regulator trouble. Refer to the trouble-shooting section for further information.(Tables III and/or IV)

Heater power may now be applied by closing the heater disconnect switch. Bring up the barrel temperature gradually making certain the heater bands are heating properly.

VI. MACHINE START-UP

Since different machines have different sequences, all variations of detailed sequence cannot possibly be covered in these instructions. The machine builder will provide the detailed machine sequencing instructions for the particular machine.

START-UP AND ADJUSTMENT

Following the machinery manufacturers sequence instructions, observing the necessary precautions, the set-up and manual functions should be checked out for proper operation. The machine should be operated in the manual mode making any and all required adjustments. When satisfied that the manual operation and safety features are performing correctly, the semi-automatic mode requires all run permissives to be present and closure of the front safety gate. One complete machine cycle will be obtained in this mode, stopping at the end of the cycle. Opening and reclosing the front gate will produce another machine cycle. Any additional required adjustments should be made in the semi-automatic mode. Switching to the automatic mode with all run permissives will cause the machine to cycle and recycle continuously without the necessity of opening and closing the front safety gate. Any refinements in adjustments may be made as required.

VII. LOGIC CIRCUITRY

The logic circuits used in these controls are digital in nature. Static control principles and logic function terminology represent changes from conventional relay circuits. It is necessary only to think in terms of the functions which are required.

AND

The AND function means that all inputs to a unit must be energized in order to have an output. In relay circuitry (Figure 1a) there is a circuit between 1 and 2 when both A and B contacts are closed.

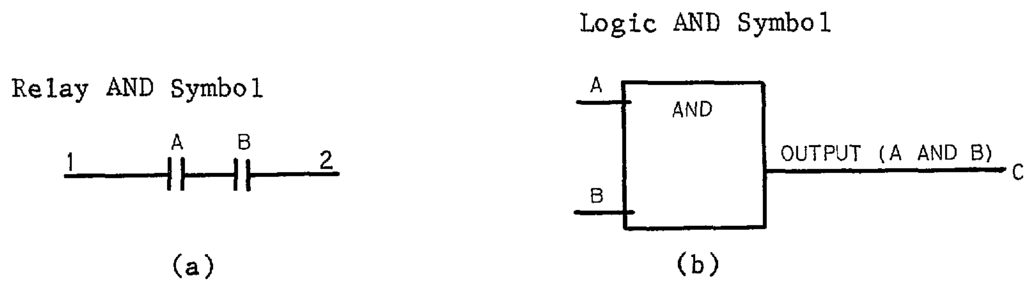


FIGURE 1

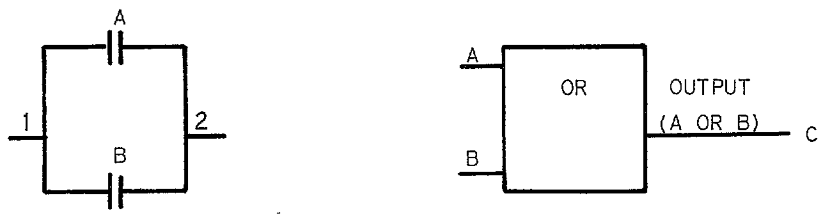
In logic representation (Figure 1b) there is an output when both inputs A and B are present.

OR

The OR function means that at least one input to a unit must be energized in order to have an output. This is equivalent to parallel relay contacts as shown in Figure 2a. Either A or B (or both) contacts must be closed in order to have a circuit between 1 & 2.

Relay OR Symbol

Logic OR Symbol



(a) (b)

FIGURE 2

In logic representation (Figure 2b) there is an output when either A or B input (or both) are present.

These two basic logic elements represent the simplest forms of analogies between static-device terminology and conventional relay circuits. To expand further into the area of understanding the terminology of the Integrated Process Control equipment logic function, several basic definitions are in order.

1. STATES IN BINARY LOGIC

   The two physical states on each terminal of a signal line to a logic element are referred to as the 0-state and the 1-state. No other states are allowed to exist. The 0-state may be called the de-energized (reference) state and the 1-state the energized (significant) state.

   Any convenient voltage level may be selected as the logic level in static controls. In the case of *PM1000 control the 0-state has a nominal voltage of zero volts (to common) and the 1-state has a nominal voltage of positive 15-volts (to common).

2. TRUTH TABLES

   Truth tables describe the behavior of the device for a particular combination of input states. A truth table includes all possible combinations of input states. It contains one row for each combination and each row is a complete and independent statement. The basic truth table does not take into account previous history of time or dependence of the device.

The basic truth table for a two input AND Figure 1 is shown in Figure 3.

INPUTS		OUTPUT
A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

FIGURE 3 Two input AND truth table.

The basic truth table for a two input OR Figure 2 is shown in Figure 4.

INPUTS		OUTPUT
A	B	C
0	0	0
1	0	1
0	1	1
1	1	1

FIGURE 4 Two input OR truth table.

3. <u>LOGIC NEGATION</u>

The output of logic negation (or inversion) operation takes on the 1-state whenever the input takes on the 0-state. It is an auxiliary symbol only used with one of the regular symbols to indicate negation. A small circle drawn at the point where a signal line joins a logic symbol indicates logic negation.

Many combinations can be employed for graphic representation of logic circuitry. Only basic logic functions such as AND or OR, or combinations such as NAND function are described in this publication. For Integrated Process Control equipment, General Electric has standarized its logic approach on the NAND function.

The output of a NAND function assumes the 0-state only if all inputs assume the 1-state. The *PM1000 logic is designed to accept a positive 10-15-volts as the 1-state and 0-4.6-volts as the 0-state.

The logic symbol used for performing a two-input AND function with inversion is shown in Figure 5.

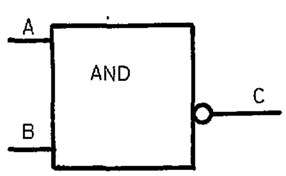


Figure 5 Logic Inverted AND Symbol

Expanding the basic 2 input AND truth table to include the use of this inversion function results in the following truth table; Figure 6.

INPUTS		OUTPUT
A	B	C
0	0	1
0	1	1
1	0	1
1	1	0

FIGURE 6

Two input Inverted AND truth table.

One way of reading this logic would be, "A and B will not give C". It should be noted that the output (C) is a zero only when both inputs (A and B) are logic level 1.

The logic symbol used for performing a two-input OR function with inversion is shown in Figure 7.

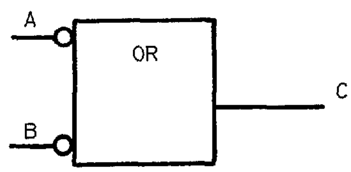


FIGURE 7 Logic Inverted OR Symbol

The truth table for the two-input OR function with inversion is shown in Figure 8.

INPUTS		OUTPUT
A	B	C
0	0	1
0	1	1
1	0	1
1	1	0

FIGURE 8

Two input inverted OR truth table.

One way of reading this logic would be "Not A or Not B gives C". Note that the output is a logic level 1 when either, or both, inputs is a zero.

Note that the "truth tables" for performing the AND and OR functions with inversion logic are identical.

Thus, these AND and OR functions are one and the same. The decision to call it an AND or an OR is determined only by the way the unit is used in the circuit.

NAND

The NAND function logic element, is the basic building block of the General Electric *PM1000 logic system. It can be used directly to implement combinations of logic decisions such as would be found in a machine "start-stop" sequence. In certain instances a signal inversion may be desirable and is accomplished by a NAND (inverter) function. The NAND symbol is shown in Figure 9.

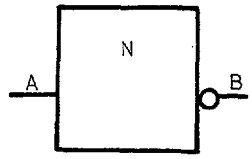


FIGURE 9 Inverter or Nand Symbol

A logic 1 at the input "A" will give a logic 0 at the output "B". Conversely a logic 0 at the input "A" will give a logic 1 at the output "B".

These basic elements may be used in combinations to form higher order logic functions such as flip-flops, counter, time delays, etc.

FLIP-FLOPS

The flip-flop is a combination of two nand elements interconnected to provide a memory function. The input to the flip-flop is a two input "OR" function. (23 or 24) When either input is taken to a logic "0" we "set" the flip-flop and the output (25) becomes a logic "0". This signal is fed back to seal the combination in this state, even if the or inputs are returned to a logic "1".

When the "clear" input (28) is taken to a logic "0" the output (25) becomes a logic "1" and again the combination retains this state even if the clear signal returns to a logic "1", and until a "set" signal becomes logic "0".

If both a set and clear signal (logic "0") appear at the same time the clear condition (output logic "1") will predominate.

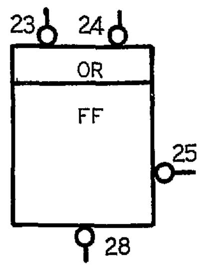


FIGURE 9A
FLIP-FLOP

TIME DELAYS

The time delay is used in the *PM1000 control system and may be provided in either of two forms, digital or analog.

ANALOG TIMER

The analog timer is symbolized in the *PM1000 control as shown in Figure 10.

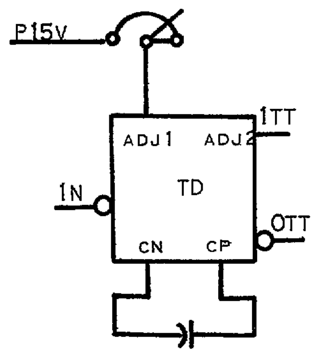


FIGURE 10
Analog Timer Symbol

The analog timer is the un-initiated condition will have a logic "1" at the input terminal, a logic "0" at the 1TT output, and a logic "1" at the OTT output. The input signal will be taken to logic "0" to initiate the timer.

This begins the timing period. After a time delay as determined by the rheostat setting the 1TT output will become logic "1" and the OTT output will become logic "0". These outputs will retain these states until the input signal is returned to logic "1". At the same time outputs 1TT and OTT will revert to logic "0" and "1" respectively. This timing is shown graphically in the timing chart of Figure 11.

The time delays available in analog-timer forms are limited to practical 10 to 1 ranges such as 0.1 to 1 seconds, 5 to 50 seconds. The adjusting knob is marked in 10 divisions for, reference and is not intended as a calibration for any specific time interval.

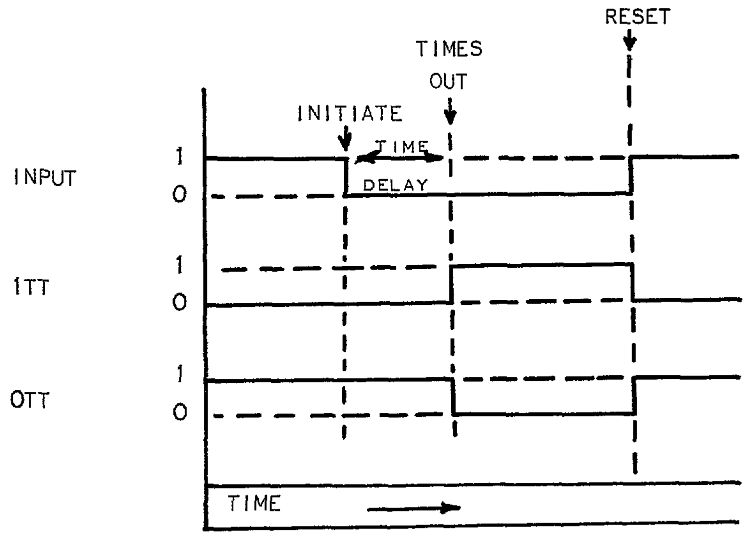


FIGURE 11 Timing graph of an Analog Timer

DIGITAL TIMER

The digital timer is symbolized in the *PM1000 control as shown in Figure 12.

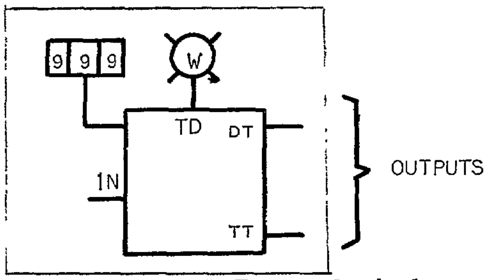


FIGURE 12 Digital Timer Symbol

The digital timer in the un-initiated condition will have a logic "0" at the input terminal. The DT output will be at a logic "0", and the TT output will be at a logic "1". The input signal will be taken to logic "1" to initiate the timer. At the same time DT output will become a logic "1". The TT output will remain a logic "1" for the time delay set by the thumbwheel switches as the time reference. During this timing period, the indicating lamp is illuminated to indicate the timer is initiated but not timed out.

The time reference set by the thumbwheel switches is compared with line synchronized clock pulses after initiation. When a comparison is made indicating the end of the time delay, the DT output goes to logic "0" and the TT output goes to logic "0". The indicating lamp extinguishes indicating the time delay-period has ended. These conditions are maintained until the timer is reset by returning the initiate signal to logic "0". At this time DT is already logic "0" and retains this state. TT goes to logic "1". This timing is shown graphically in the timing chart of Figure 13.

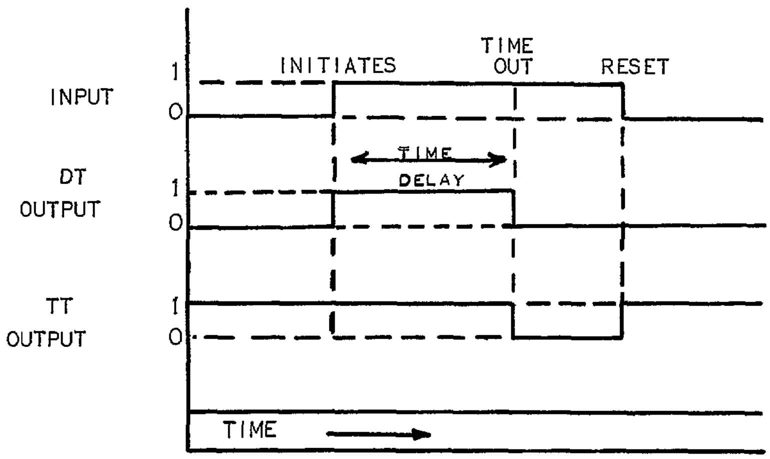


FIGURE 13 Timing graph of digital timer

SIGNAL FILTER

The input signal filters receive the 115-volt a-c control voltage from operator's devices and limit switches, and converts these signals to half wave rectified voltages. The output of the signal filter is applied to the appropriate input buffer as a positive d-c voltage at approximately 15-volts with a superimposed sawtooth ripple. If the signal filter output is not connected to an input buffer, the output terminal will assume the 115-volt a-c voltage.

The signal filter is symbolized as Figure 14.

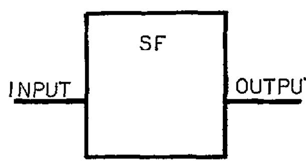


FIGURE 14 Signal Filter Symbol

INPUT BUFFER

The input buffer is symbolized on the drawings as shown in Figure 15.

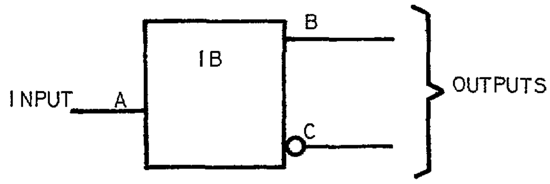


FIGURE 15 Input Buffer Symbol

The input buffer is an element that will accept a voltage from the signal filter convert it to an output of the logic level compatible to the control logic. Either or both a normal output and an inverse output are available as required. The input will normally be from an operator device or a limit switch, through a signal filter. Either a normally open or normally closed contact may be used. The drawing will indicate the switch action to perform a function by the prefix SC (switch close) or SO (switch open) when the device is operated.

An example of this might be a switch is closed when the gate is opened. The input would be identified as SCGO. In this case, referring to Figure 15, with the switch closed, 25 volts would be applied at the input "A". The output "B" would go to logic "1" and output "C" would go to logic "0". When the switch is opened, output "B" will go to logic "0" and output "C" will go to logic "1".

A. C. SOLENOID DRIVER

The A. C. solenoid driver cards are constructed with up to eight circuits per card, and provide a corresponding number of separate control switches. The card layout (Figure 16b) is such that the 115 volt a-c inputs are applied to the terminals at the bottom of the card (T2 through T9) and the controlled outputs to the solenoids are at the terminals at the top of the card (T12 through T19). The control is provided by the logic control at the logic level. When the input is taken to a logic "0" level, the solenoid switch is turned on applying 115-volts a-c at the output terminal to provide solenoid power. All logic level control connections are made at the pins on the sides of the cards, odd number pins on the left side and even number on the right. Control connections may be made on either side of the card, odd or even pin, whichever is most convenient.

Typical Solenoid driver cards are shown in Photo No. 9.

The solenoid drivers are symbolized on the drawing as shown in Figure 16a.

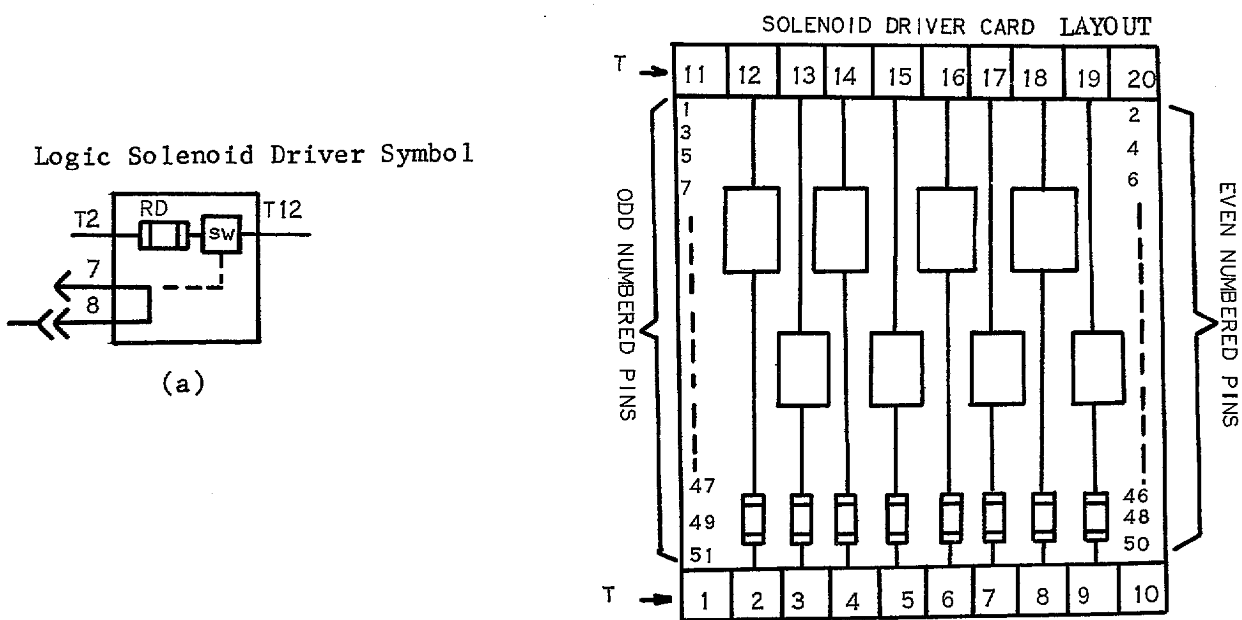


FIGURE 16 Solenoid Driver

D. C. SOLENOID DRIVERS

The D. C. solenoid driver cards are constructed with eight solenoid switch circuits and two lamp driver circuits per card. The card layout (Figure 16b) is such that the 24 volts d-c inputs are applied to the terminals at the bottom of the card (T1 through T10) and the controlled outputs to the 24 volts dc solenoids and indicating lamps are at the terminals at the top of the card (T11 through T20). The control is provided by the logic control at the logic level. When the logic input is taken to a logic "0" level, the solenoid switch is turned on applying 24 volts d-c at the output terminal to provide solenoid or lamp power. All logic level control connections are made at the pins on the sides of the cards, odd number pins on the left and even number pins on the right. An odd and even number pair are connected together allowing logic connections to be made on either side of the card, odd or even, which ever is most convient.

The D. C. solenoid driver utilizes terminals T2 through T9 and T12 through T19 for the solenoid circuits and in addition T1 - T11 and T10 - T20 provides two lamp driver circuits. These two circuits are limited to lamp loads. The solenoid circuits are fused at 1.5 amps and the lamp circuits are fused at 0.25 amps. Pico micro fuses are used in both cases. The solenoid driver is symbolized in the elementary drawings as shown in Figure 16a.

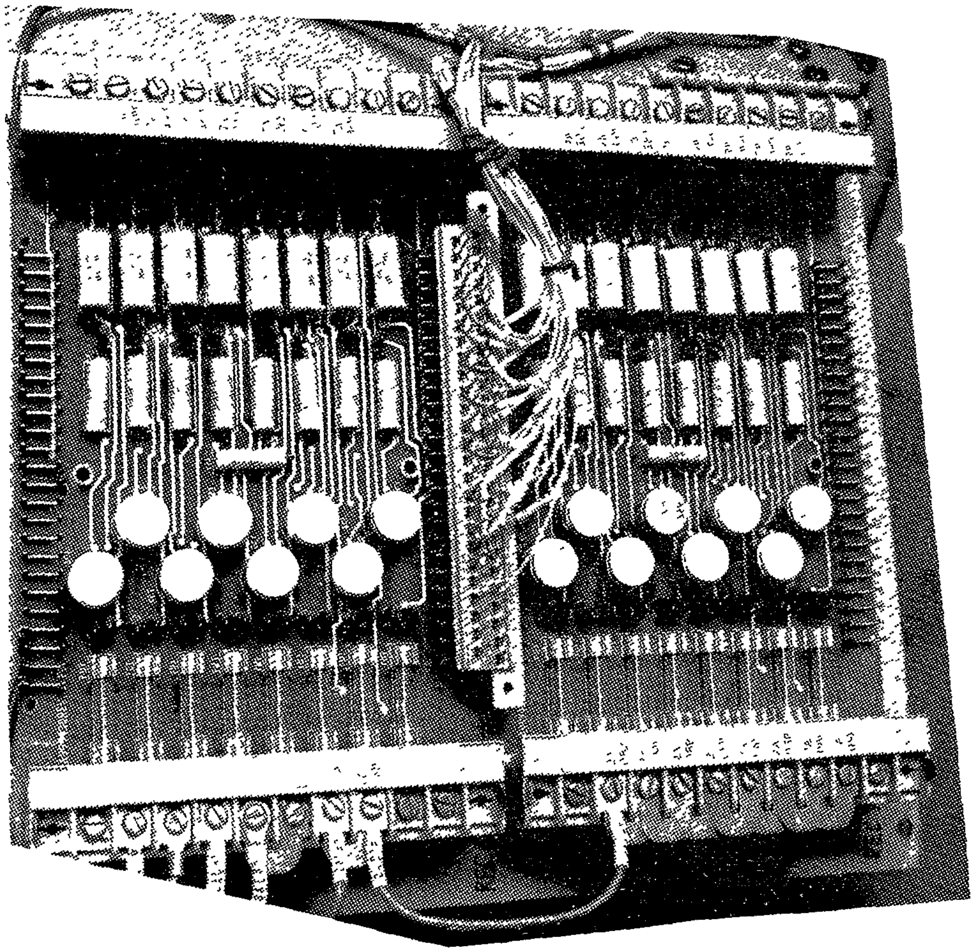


PHOTO NO. 9

TYPICAL SOLENOID DRIVER CARDS

HEATER DRIVERS

The heater drivers are available for either single-phase or three-phase power circuits.

The heater drivers are symbolized on the drawings as shown in Figure 17.

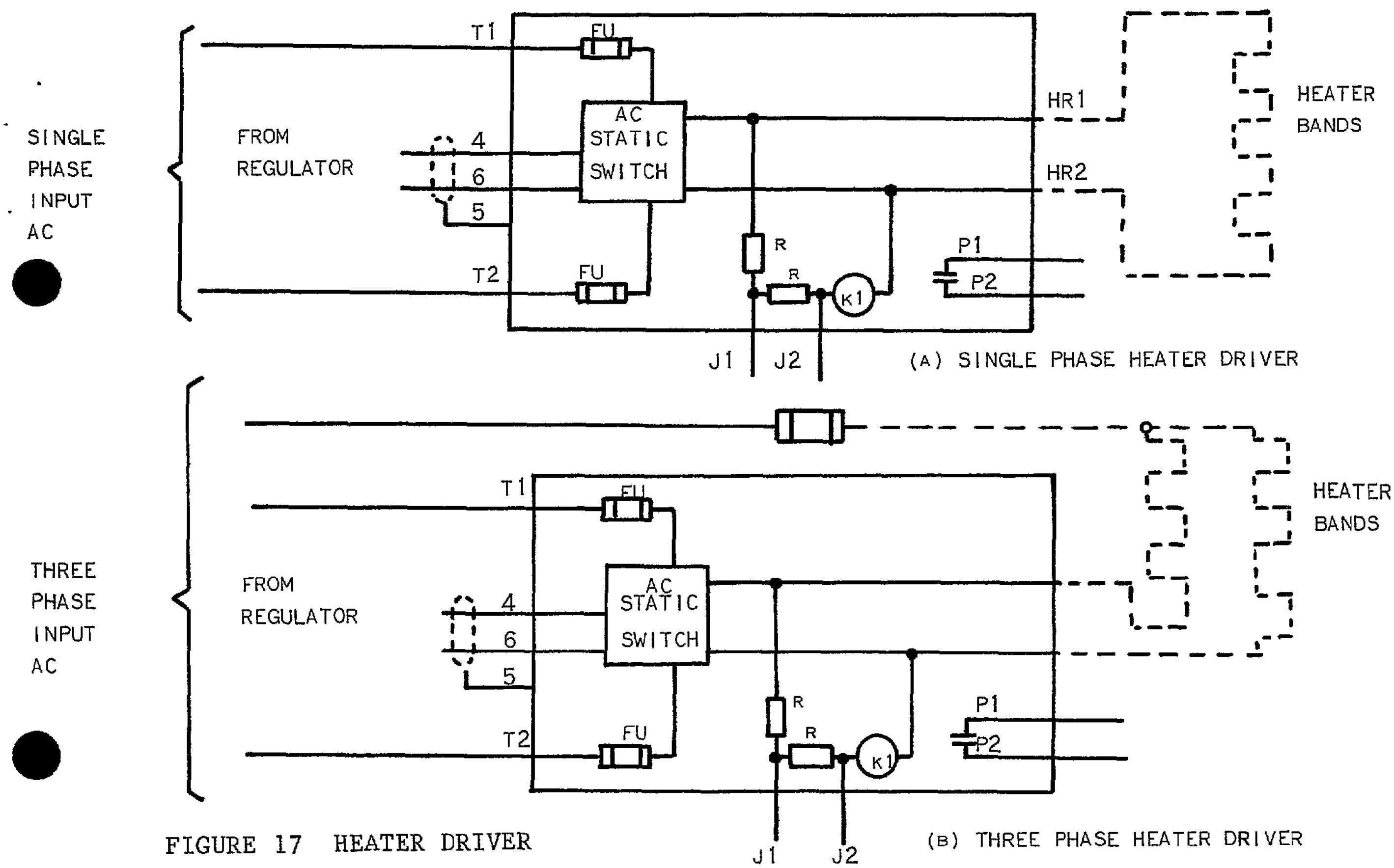


FIGURE 17 HEATER DRIVER

When the regulator is calling for heat, the transformer secondary in the heater driver will provide the gating current to turn on power to the heating zone. When the regulator is calling for no heat, there is no gating signal to turn on the heater driver.

Several different heater driver modules are available. The selection of the model used is determined by the application. One model is designed to operate on either a 460 volt single phase a. c. power supply or a 230 volt 3 phase "V" a. c. power supply. A second model is designed for operation on either a 230 volt single phase or 115 volt single phase a. c. power supply. In either case, when operating on the lower voltage, the jumper J1 - J2 must be in place.

On the higher voltage, the jumper J1 - J2 must be removed.

A third model is available for application requiring higher power requirements. This model is designed for single phase operation only and will normally be applied to 460 volt power supplies however this model will also operate on 230 volt or 115 volt single phase a. c. supply.

The heater drivers of ratings up to and including 11.5 KW are mounted on the interior side wall of the enclosing case or may be mounted on the base plate of the control panel, the case or base plate assisting in the dissipation of heat. To obtain good heat transfer, a liberal coating of silicone grease (Dow Corning No. 340 or equivalent) is applied between heater driver base and case surface. This procedure is recommended when a heater driver module is replaced.

The 23 KW (or 50 amp) heater driver is separately mounted and is totally enclosed for electrical hazard protection. Each module provides its own heat sinking and special heat dissipation considerations are not required beyond assuring free movement of air through and around the heater driver modules.

The contact P1 - P2 is for a monitor function. The temperature regulator periodically turns the heater driver off. When the heater driver turns off, the contact P1 - P2 opens to indicate the heater driver has turned off. If the driver fails to turn off during the check period P1 - P2 remain closed. This signal is available to the monitor card to indicate a driver failure.

MONITOR CARD (OPTIONAL)

The temperature monitor card is an optional card, available in two forms.

Form 1 - Monitors sensor conditions, heater control conditions and deviation from set point.

Form 2 - Monitors sensor conditions and heater control conditions.

If the RTD sensor resistance rises to a value greater than approximately 800 ohms, the monitor will sense this as an open RTD and produce a signal to alarm and/or trip the heater breaker.

If the RTD sensor resistance drops to a value less than approximately 50 ohms, the monitor will sense this as a shorted RTD and produce a signal to alarm and/or trip the heater breaker.

The drivers are periodically monitored for failure to turn off by a circuit in the monitor card. Approximately every 100 seconds, the driver is turned off. If in a period of approximately 15 seconds the drivers do not all turn off, the monitor card senses this malfunction as a failure and a signal is produced to trip the heater breaker or to sound an alarm. When all drivers have turned off, the timer is reset and regulation proceeds eliminating the remainder of the 15-second time interval.

In the Form 1 monitor, the option of high-low deviation monitoring is available. In this mode, the deviation between the temperature of the barrel sensed by the RTD sensors and the set point on the input reference rheostat is continuously monitored and compared to the allowable deviation set-point rheostat setting. If the deviation between the barrel temperature and the regulator set point exceeds the allowable deviation, a logic-level signal is produced to inhibit appropriate functions. Exceeding the low set point may be used to inhibit screw rotation. Exceeding the high set point may be used to trip the heater circuit breaker. The deviation rheostats are adjustable over a range of deviation from 0° to 100°F from set point.

STANDARD EJECTORS CARD (OPTIONAL)

A standard ejector card is available which contains universal circuits with input and output logic flexibility to perform ejector operations. The standard ejector card is designed as a plug in rack mounted card with the discrete and integrated circuit components being printed circuit wired with only the necessary input and output points being brought out. Implementation of various modes of operation and options are performed by the variations in the external connections.

Four modes of operation are available. These are normal single shot, pulsating ejectors, delayed ejectors forward and a combination of these three modes. The standard ejector card is compatible with either solenoid or spring return ejectors. It is also compatible with the circuit for the Society of Plastics Industry core sequence. Other variations and features include such items as if solenoid return system is used and in automatic mode, the ejectors remain in back position until initiated and they remain back continuously when turned off.

The ejectors may be initiated at the clamp back position if the initiate signal fails.

The machine recycle may be inhibited under the following conditions:

If the ejectors have not gone full forward

If pulsating timer is running

If delay timer is timing

If either forward or back limit switch has failed

Selected condition such as if ejectors are not back

In manual mode, the ejectors may be operated between forward and back limit switches by means of a selector switch or pushbuttons.

RETURN SOLENOID - BASIC OPERATION

A. GENERAL

Basic Operation is defined as a single stroke of the ejectors. A forward and a retract solenoid and an ejectors forward and an ejectors back limit switch are used. Both automatic and manual mode are provided. An initiate ejectors forward signal is required for the automatic mode. This signal can be from an eject position limit switch or from other source such as clamp open. Output signals are provided to energize the forward and the retract solenoids. An output signal is also available to inhibit the next machine cycle until the ejection stroke is complete.

B. AUTOMATIC MODE

1. Initial Conditions

   A. Ejectors On (1EO)

   B. Machine in Automatic Run Permissive (1AUTP)

   C. Ejectors Not Forward (1EF1 a Zero)

2. OPERATION

   A. The machine will cycle normally to the end of cure time, then before die lock up signal 1DLU is lost, it and the clamp open permissive signal (1CLOP) will set a seal circuit which makes the initiate ejectors circuit permissive.

   B. The initiate ejectors signal (O1E) will set a seal circuit that calls for ejectors forward.

B. AUTOMATIC MODE (Continued)

2. OPERATION (Continued)

C. If safety conditions of die not locked up (ODLU a one) and cores permissive (O1CRP) are met the drive ejectors forward signal (ODEF) will be provided to the ejectors forward solenoid driver until the forward limit switch is activated. ODEF will inhibit the drive ejectors back signal (ODEB).

D. Ejectors forward limit switch signal (OEF1) will de-energize the solenoid driver and the 1EF1 signal will reset the seal circuits established in steps A and B.

E. Once the ODEF signal is lost the ejectors not back signal (OEB a one) will initiate a drive ejectors back signal (ODEB) to the ejectors retract solenoid driver. ODEB signal will continue until ejectors back limit switch is activated and signal OEB is a zero.

F. The cycle start inhibit signal (OCS1) is provided to inhibit another machine cycle until the ejectors are permissive.

C. MANUAL MODE

1. Initial Conditions

A. Ejectors On (1EO)

B. Machine is manual run permissive (1MRP)

C. Cores (if provided) are permissive (O1CRP is a one)

2. Eject Cycle

A. Permissive Conditions can be selected by connecting inputs

1. OEF2 - Inhibit ODEF once ejectors are forward

2. ODLU2 - Inhibit ODEF when dies are locked up

3. 1IE - Permit manual operation only at the initiate ejectors position.

2. Eject Cycle (Continued)

A. Continued

4. 1S3 - Optional Input available

B. Manual eject forward signal (1MEF) will initiate drive ejectors forward signal ODEF within limits established by Step A.

3. Retract Cycle

A. Permissive conditions are met

1. Not ejecting forward (ODEF is a one)

2. Ejectors delayed either completed timing or not used

3. OEB - Inhibit ejectors back signal (ODEB) once ejectors are back

B. Other permissive conditions that can be selected by connecting inputs

1. 1S6 - Optional input available

2. 1IE and 1S3 same as 2. A, 3. 4, 4.

C. Manual ejector back signal (1MEB) will initiate drive ejectors back signal (ODEB) within limits established by Step B.

DELAYED EJECTORS FORWARD - OPTIONAL OPERATION

A. General

Operation is the same as for basic operation except that the drive ejectors back signal ODEB is delayed beyond the time required for the ejectors to reach the ejectors forward limit switch. Ejector circuit will provide a time delay initiate signal OITDE and will inhibit the ODEB signal until the timer timed out signal OTTDE is received as an input.

B. Initial Conditions

1. Ejectors on (1EO)

2. Machine set for automatic run permissive (1AUTP)

3. Pulsating ejectors selected (1PON)

B. Initial Conditions (Continued)

4. Jumper OPEJ1 to OPEJ2 to be added to connect in circuit.

C. Operation

1. The pulsating ejectors on signal 1PON and the pulsating cycle not complete (OPST a one) will provide an override signal of 1EF1 to the ejectors forward circuit so the ejectors will keep cycling forward until the pulsating cycle is complete OPST goes to a zero and permits the 1EF1 signal to functions to reset the seal circuits prohibiting ejectors forward operation until established by the next machine cycle.

SPRING RETURN EJECTORS - OPTIONAL OPERATION

A. Operation is the same as for return solenoid except that by not having the solenoid the ODEB signal is not used and inputs for that portion of the are not required. OEB signal or 1S6 to common assures that ODEB does not interfere with logic operation.

B. Operation for delayed ejectors forward requires adding jumper ODEP-1SS1 so timer initiate signal maintains ODEF signal to hold ejectors forward against the spring until the delay time is over.

C. Operation for pulsating ejectors requires the OEB signal to insure full stroke operation.

OPERATION WITHOUT FORWARD LIMIT SWITCH - OPTIONAL

Operation is possible without the forward limit switch by using the delay timed timed out signal as the ejectors forward signal.

STANDARD CORES CARD (OPTIONAL)

A standard core sequence card is available which contains the circuitry to perform the four standard Society of Plastics Industry, core sequences. The card is designed as a plug in rack mounted card with the discrete and integrated circuit components being printed circuit wired with only the necessary input and output points being brought out.

Available features of the standard core sequences card are as follows:

1. Selection of core sequences A, B, C, D, or OFF.

   A. Sequence A

      1) Reset ejectors

      2) Set cores in clamp back position

      3) Close clamp

      4) Inject

      5) Open clamp to adjustable stop position

      6) Pull cores

      7) Continue to open clamp

      8) Eject

   B. Sequence B

      1) Close clamp to lock-up

      2) Set cores

      3) Inject

      4) Pull cores

      5) Open Clamp

      6) Eject

C. Sequence C

1) Set cores in back position

2) Close clamp

3) Inject

4) Open clamp

5) Pull cores in back position

6) Eject

D. Sequence D

1) Close clamp - set cores while closing

2) Inject

3) Open Clamp - Pull cores while opening

4) Eject

2. Manual or Automatic Operation

3. Selection of core pull by spring return or by a momentary or maintained solenoid. (Core set is usually a maintained solenoid, however, standard card can be used with spring return set).

4. Band of operation for sequence D using an adjustable limit switch to start set or pull operation and another limit switch to stop clamp motion if the set of pull is not completed.

5. Compatible with the standard ejector circuit.

6. Inhibit circuit for recycle if cores are selected and not pulled. Signal is also used for eject permissive.

7. Injection inhibit if cores are not set no matter what sequence.

8. A new sequence can be established using spare inputs 1S1, 1S2, 1S5 and 1S6.

9. Sequence selection inputs for pull and set are separate bus runs though tied together on the card. This permits future splitting so that one sequence for set and another for pull could be selected.

10. Cores can be made to pull anytime they are not fully pulled with cores off, if the signal 1COR is connected to 1S2.

B. Nomenclature for the core sequence circuit input and output signals is consistent with the standards for *PM1000 control. (See Application Sheet DP-N1 or the back sheet of the control elementary drawing for definition.)

C. Pin designations for standard operation carry nomenclature for the inputs required. Option pins labeled spares (1S#) are available to modify standard operation.

OPERATION

Sequence A, B, C, or D may be selected for automatic operation. Manual operation is performed by manual core selector switch to set or pull. In manual operator controls sequence.

A. Automatic Operation

1. Initial conditions

    A. Machine set for automatic operation (1AUTP)

    B. Ejectors are back.

    C. Select core sequence A, B, C, D (1SQA, 1SQB, 1SQC, or 1SQD)

    D. Cores are pulled (0COP2)

2. To set cores in all sequences the following conditions are necessary:

    A. In automatic (1AUTP is a logic "1").

    B. Ejectors are full back (1EB is a logic "1").

A. Automatic Operation (Continued)

2. Continued

C. Spare #3 (1S3) is permissive (Logic "1").

D. Cycle run is permissive (1CRP is a Logic "1").

E. A given core sequence is selected A, B, C, or D (OSQA, OSQC Logic "0" or 1SQB, 1SQD Logic "1").

F. Clamp is in the appropriate position to set the cores (Clamp back for sequence "A" and "C", clamp closed for sequence "B", and clamp closing where limit switch (SCD) is tripped (is a Logic "1") for sequence D.

When all conditions listed are met, cores will set. With a maintain set solenoid, cores will remain set until initiated to pull.

3. Associated with setting the cores will be a signal O1CLC. When this signal is a Logic "0" the clamp will be inhibited from closing,therefore, for sequences A, B, C, and D the clamp will be inhibited under the following conditions.

a. In sequence "A" or "C" the clamp will not close until the cores are fully set. When this happens OCOS will go to a Logic "0" causing O1CLC to go to a Logic "1", allowing the clamp to close.

b. In sequence "B" the clamp will not close unless the cores are fully pulled (OCOP a Logic "0"). At clamp closed position, ODLU becomes a Logic "0" which keeps O1CLC a Logic "1" as cores start to set and OCOP becomes a Logic "1".

c. In sequence "D" the mold will close to limit switch 1SCD which tells the cores to set. Clamp will continue to close as cores are setting. However, if OPCD limit switch is connected, and the cores are not set by the time the clamp reaches this limit switch,

A. AUTOMATIC OPERATION (Continued)

3. Continued

   c. OPCD goes to logic "1" causing O1CLC to become Logic "O" which stops the clamp from closing. (This limit switch is connected so that there is protection for cores and mold). You will notice that once the mold has locked-up (ODLU a Logic "O") O1CLC will not inhibit mold close.

4. To pull the cores in all sequences the following conditions are necessary.

   a. In automatic (1AUTP is a Logic "1").

   b. Initiate cores set signal is no longer present (OSC is a Logic "1").

   c. Spare #4 (1S4) is permissive (1S4 is a Logic "1").

   d. Cores are not pulled (OCOP1 is a Logic "1").

   e. Cycle run is no longer permissive (OCRP is a Logic "1").

   f. Core sequence A, B, C, or D is selected.

   g. Clamp is in the appropriate position to pull the cores (Clamp at limit switch position 1PCA in sequence "A", clamp is closed for sequence "B", clamp is back for sequence "C", and clamp has tripped 1PCD (becomes a Logic "1") limit switch on opening for sequence "D").

   When all conditions listed above are met, cores will pull. With a momentary pull solenoid, cores continue to pull until cores are pull out (OCOP1 is a Logic "O"). For a maintain pull solenoid, OCOP1 is not connected, therefore cores will continue to pull until initiated to set.

5. Associated with pulling the cores is the signal O1CLOP which is used

A. AUTOMATIC OPERATION (Continued)

5. to inhibit clamp opening when 01CLOP becomes a Logic "0". Therefore, the clamp will be inhibited with the following conditions:

   A. In sequence "A" with limit switch 1PCA tripped (Logic "1") clamp will not open beyond 1PCA until the cores are fully pulled (0COP2 is a Logic "0").

   B. In sequence "B" clamp will stay fully closed until cores are fully pulled (0COP2 go to a Logic "0").

   C. In sequence "C" clamp will open regardless of core position.

   D. In sequence "D" clamp will continue to open beyond 1PCD (Limit switch to start pulling cores) until 0SCD is tripped (0SCD becomes a Logic "1"). If cores are pulled (0COP2 is a Logic "0") by this time, clamp continues to open. However, if cores are not fully pulled by the time 0SCD becomes a logic "1" the clamp will stop opening because 01CLC will become Logic "0".

6. Injection permissive 1CIP - Regardless of sequence selected, before injection can take place, the cores must be set (0COS a Logic "0") or the cores must be off (1COR a Logic "0").

7. Cycle run inhibit 01CRP - Regardless of sequence selected, before cycle run is permissive, the cores must be pulled (0COP a Logic "0") or the cores must be off (1COR a Logic "0").

B. MANUAL OPERATION

1. Initial Condition

   A. Machine set for manual operation (1MRP is a Logic "1").

   B. Cores are selected (1COR is a "1").

2. Set Cores

B. MANUAL OPERATION (Continued)

2. Set Cores (CONTINUED)

   A. Ejectors are back (1EB is Logic "1").

   B. Switch set for set cores (1SC Logic "1"). The set cores solenoid will be energized for the time the switch is held to core set position.

3. Pull Cores

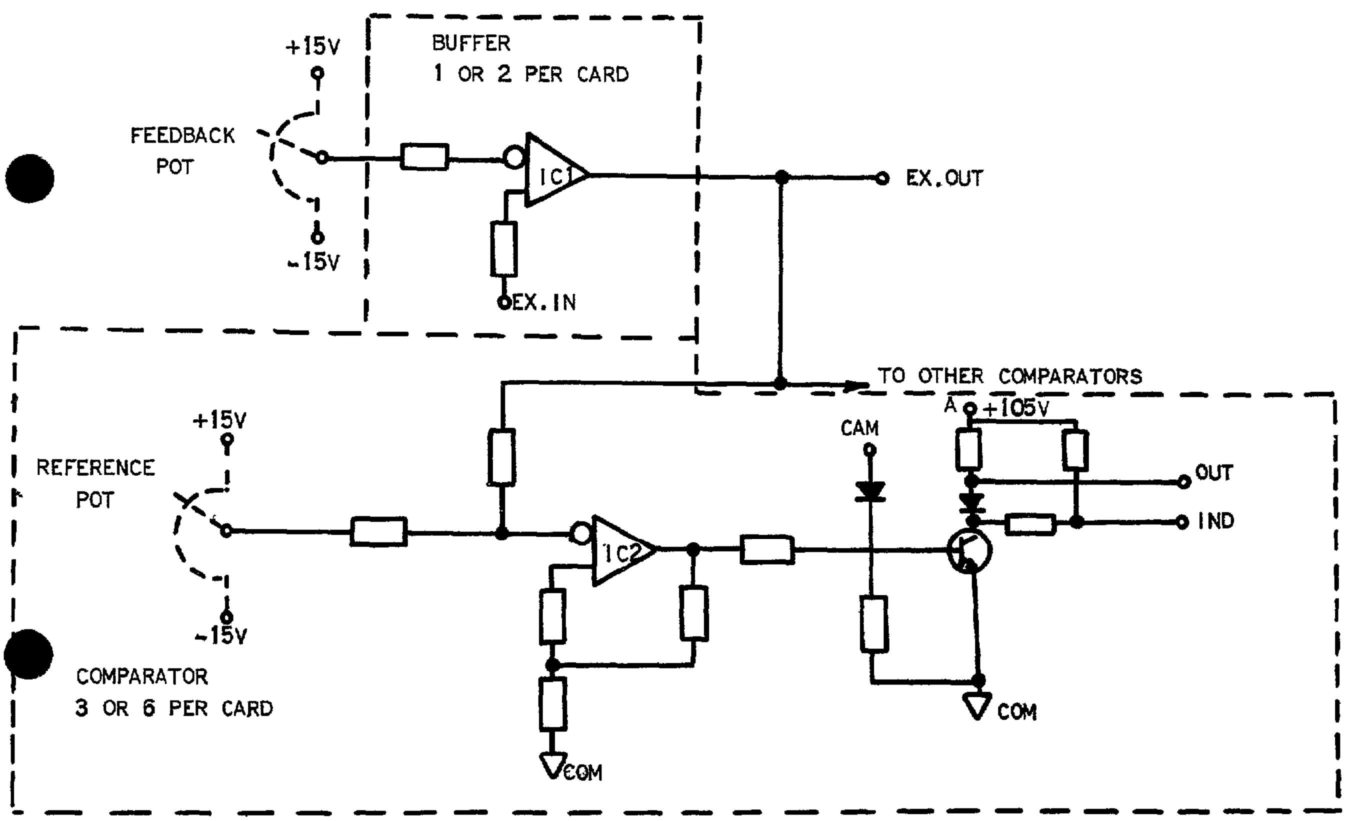
   A. Cores not pulled (OCOP a Logic "1") if connected.

   B. Switch set for pull cores (1PLC a logic "1"). The pull cores solenoid will be energized for the time the switch is held or until the cores are pulled.

POSITION SENSOR

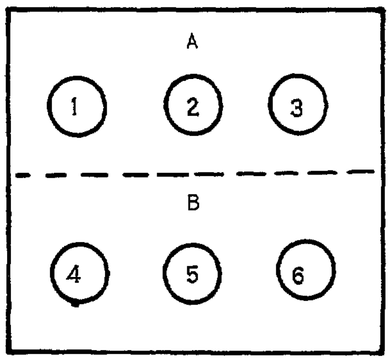
The position sensor (or static limit switch) is a module available for use in the PM1000 controls to sense machine position and provide signals for use in the sequence circuitry.

The machine motion is mechanically geared to a feedback potentiometer, the wiper voltage is fed into a buffer circuit (IC1) and comparator where this voltage is compared with a reference voltage. When the feedback and reference voltages are equal, the switching circuitry (IC2) and associated components will cause a voltage to appear at the output and the indicating light will indicate the switch is made.



Several arrangements of modules are available. Reference pots may be either one turn or ten turn or combinations thereof. Modules may contain 2, 3, 4, 5 or 6 reference pots in various combinations.

Each module can accept two feedback pots with three reference pots on each, or one feedback pot can be used for all comparison circuits utilizing all six reference pots with the same feedback pot. Reference pots 1, 2, and 3 are used with buffer A and reference pots 4, 5, and 6 are used with buffer B.



The output will be less than one volt when the voltage from the feedback pot is greater than the voltage from the reference pot and the indicator lamp will be extinguished.

When the feedback voltage is less than the reference voltage, the circuit will be switched on with the output assuming the power source voltage of 105 volts and the indicator lamp will be on. Positive feedback is provided to obtain snap action.

The controlled voltage is 105 volts and may be either filtered or unfiltered. This will normally be obtained from the PM1000 power supply such as the P90FW voltage. Thus, the output from the position sensor must be fed into an input buffer for use in the PM1000 logic control, the same as with a conventional mechanically operated limit switch.

When driving the complete module from the single feedback pot, the EX. OUT of the A buffer is fed into the EX. IN of the B buffer to make the second half of the module follow the feedback circuit.

A cam operation function may be obtained by connecting any two reference circuits together so that the output of one drives the cam input of the second circuit. The second circuit is used as the cam output, and its reference is set to trip first, giving an output. As the machine progresses, the first circuit will trip when the feedback matches its reference, and as this output is fed into the cam input of the second circuit, the second circuit will turn off again providing the cam function.

VIII. MAINTENANCE

The *PM-1000 control being static requires very little maintenance. The enclosure is gasketed, therefore, the chance of foreign material entering the enclosure is minimal. Periodic inspection of the gaskets should be performed to insure the exclusion of oil, water, and dust.

Periodic cleaning by use of a light vacuum is recommended. Cleaning by compressed air is not recommended. In general, the quality of shop air pressure, may produce more contaminants in the form of oil and water than are removed. In addition, excessive air pressure could possibly physically damage components.

Freon should be the only cleaning agent used, as other agents such as trichlorethelene can cause damage to internal components.

The control enclosure provides for the heater driver heat dissipation and in some cases may have heat sinks. For this reason, the case should be kept reasonably clean and when heat sinks are provided they must be kept clean and unrestricted for free movement of air.

REPLACEMENT OF CARDS

Flat Pack Cards - IC3620

The flat pack solenoid driver and temperature monitor cards are mounted, as the name implies, on a flat panel on stand-offs with the component side away from the panel. Six mounting screws attach the card to the base panel, one in each corner and one at each side at approximately the center of the card. The four corner mounting screws are accesible only after removal of the high level connection terminal boards. These terminal boards across the top and bottom of the card are for the high level voltage connections and are plug-in to the card and retained by a spring clip on each end. Releasing the spring clip and pulling the terminal board forward will release the stab-in connections making the mounting screws accessible. This eliminates the need for removal of any of the wired terminal connections. Always make certain power has been removed from the panel before removing any connectors.

The low level voltage or logic connections are made through the pin connections on either or both sides of the card. The external circuits are brought into the pin connections through a receptacle that plugs on to the card pins. Jacking screws are provided to assist in obtaining a good tight connection with no possibility of virbrating loose and to also assist in removal of the receptacle from the pins. Upon replacing a plug-on receptacle, make certain the card pins line up properly in the receptacle holes before tightening the jacking screws.

The signal filter card is also a flat pack card mounted in a similar manner as the solenoid driver and monitor card except there are four high level voltage terminal boards on each card. The mounting screws are again accessible by removal of the terminal boards, a total of eight screws, two at each terminal board receptacle. The low voltage or logic connections are taken out from the 51 pins across the center of the card, through the plug-on receptacle.

Miscellaneous Size Cards - IC3621

The modules used in *PM-1000 controls using this size cards includes the timer reference, timer multiply output, heater driver auxiliary, power supply, temperature regulator and position sensor.

These cards are an integral part of the modules in which they are used and the approach at this time is module replacement, therefore if trouble is encountered in any of the modules employing these cards, our recommendation is to replace the entire module. Defective modules should be returned to the General Electric Company for repair and return through the normal procedures established. Out of warranty modules will be repaired and returned or replaced at nominal cost.

Plug-In Cards - IC3622

The input buffer, high level logic, high level gate expanders and analog time delay cards are built in the standard Directo-matic packaging arrangement. Card rack mounting is provided with the standard 51 pin receptacle to accept the 51 pin cards.

The cards are removed with the aid of a card puller (provided with each control). The card puller contains wire fingers that insert in holes at the front upper and lower corners of the card and upon squeezing the handle exerts pressure between the card rack and the card to extract the card. Reinsertion of the card is accomplished by sliding the card into the card slot, making certain the pins are properly aligned with the socket and applying firm and steady pressure until the card is firmly secured.

It is strongly recommended that power be removed from the panel prior to either removing or reinserting printed circuit cards.

Modules - IC3625 - Removal and Replacement

The modules used in *PM-1000 control consist of heater drivers, power supply, temperature regulator, digital timer and position sensor.

Temperature regulator, digital timer, position sensor

The temperature regulator, digital timer and position sensor modules are normally mounted in a disk top enclosure in the control or may by mounted in a separate operators control cabinet.

Each of these modules are provided with pins for the electrical connections and all external wiring is carried through plug-on receptacles. Four mounting screws, one in each corner of each module allows front removal making access to the electrical connection, thus making easy removal and replacement.

Heater Drivers

The heater drivers up to and including 11.5KW are mounted in the enclosing case, either on the side wall or on the base plate. They are secured by four stud mounted bolts with a liberal coating of silicone grease (Dow Corning 340 or equivalent) to provide good heat transfer. For removal, the module base plate will adhere due to the grease. Three tapped holes are provided to permit jacking screws to be used to break this seal. Upon replacement, make certain the jacking screws are backed out and apply a liberal coating of silicone grease before securing the replacement heater driver in place.

The gating circuit is removed by loosening two screws holding the retaining bracket for the plug on the printed circuit board.

The 23KW or 50 amp heater driver is separately mounted and the location of mounting is determined by the machinery builder. Holes are provided in the four corners of the base for mounting. For removal, the module enclosing cover is removed by removal of four screws and sliding the cover away from the base. The incoming power leads and outgoing heater leads are accessible when the cover is removed. The gating leads are brought in from the temperature regulator and are terminated on the firing card at terminals 4 - 5 - 6. When replacing these leads it is important these do not get re-terminated incorrectly. As a check the following relative values should be obtained if question exists as to wire location:

Shield to black	Low ohms = 0.3 ohms
Shield to white	Higher ohms = 0.6 ohms
Black to white	Sum of both = 0.9 ohms

Shield on terminal 5

Black on terminal 4

White on terminal 6

Power Supply

The power supply is mounted on the base plate by four mounting bolts, one in each corner. The electrical connections are through a stab in connector, therefore it is not necessary to break any other electrical connections for removal or replacement of the power supply module.

IX. TROUBLE SHOOTING

The following tables covering suggestions on possible causes and remedies for trouble-shooting are offered as an aid.

Every contingency cannot possibly be covered in these trouble-shooting guides but every effort has been made to cover the majority of possibilities.

The most effective trouble-shooting comes from an intimate knowledge of the machine operation and a thorough understanding of the circuitry. It is recommended those charged with the maintenance of these controls familiarize themselves with the circuitry involved and machine operation. With this knowledge and the following trouble-shooting guides, minimal difficulty should be experienced in maintaining these controls.

TABLE I - POWER CIRCUITS TROUBLE-SHOOTING GUIDE

SYMPTOM	PROBABLE CAUSE	REMEDY
1. No control power - feeder power available	A. Control disconnect not closed	A. Close control switch or circuit breaker
	B. Blown main fuses or circuit breaker tripped	B. Replace blown fuse or reset circuit breaker
2. No heater power - Feeder power Available	A. Heater disconnect open	A. Close heater switch or circuit breaker
	B. Undervoltage coil in heater circuit breaker not energized	B. Check for gate voltage on appropriate solenoid drivers. If voltage is present replace defective coil. If gate voltage not present refer to specific solenoid driver instructions.
3. Main power available no 115-volt control power	A. Blown control fuse	A. Replace blown fuse.
	B. Defective control transformer	B. Replace control transformer
4. Pump motor will not run.	A. Motor starter not energized	A. Check proper machine sequence. Refer to elementary diagram.
	B. Thermal overload tripped	B. Reset TOL device.
	C. Blown fuses.	C. Replace blown fuses.

TABLE II - POWER SUPPLY MODULE TROUBLE-SHOOTING GUIDE

SYMPTOM	PROBABLE CAUSE	REMEDY
1. No output at P15, N15V, P90FW	A. Ground on bus or excessive load	A. Remove output plug, if output OK, locate & eliminate ground or excessive loading
	B. Open constant-voltage transformer	B. Check input AC1-AC2 & output AC5-AC6, replace power supply
	C. Open T2 transformer	C. Check input AC5-AC6 & output AC7-AC8, replace power supply
	D. Defective component on card	D. Replace power supply

TABLE III - TEMPERATURE SYSTEM TROUBLE-SHOOTING GUIDE

A-C Heater Power Available - without Monitor Card

SYMPTOM	PROBABLE CAUSE	REMEDY
1. No heat & no regulator indication- 1 zone	A. Open RTD	A. Check resistance of RTD - if over 400 ohms, replace.
	B. Defective temperature regulator	B. Replace regulator module
2. No heat & no regulator regulator indication - all zones	A. Loss of power-supply voltage	A. Check power-supply connection to regulator P90FW (pin 44B) P15V (pins 24A, 30A, 32A) N15V (pin 28A) Measure to common (pin 26A)
	B. Set points, all zones, below barrel temperature	B. Machine not properly set-up - check settings
	C. Defective temperature regulator	C. Replace temperature regulator module
3. No heat but regulator indication-on 1 zone	A. Open heater band	A. Check for open band-replace
	B. Blown heater-driver fuses	B. Replace defective zone-heater fuses Caution: Use only electronic fuses of same rating
	C. Loose heater-driver firing card	C. Check & correct
	D. Defective heater-driver module	D. Replace heater-driver module.**
	E. Defective temperature regulator	E. Replace temperature regulator module.

4. System heats but one zone stays full on	A. One heater driver fuse open. (Applicable only in 3-phase heater configuration may be heater-drive-module fuse or return leg fuse)	A. Replace defective fuse.
	B. Shorted RTD	B. Check resistance of RTD if less than 100 ohms, replace.
	C. Defective heater-driver module	C. Replace heater-driver module.**
	D. Defective temperature regulator	D. Replace temperature regulator module

** The heater-driver modules will adhere tightly to the enclosing case surface due to a liberal coating of silicon grease (Dow Corning No. 340 or equivalent). Threaded holes in the base plate serve for jacking screws to break this seal. When replacing, apply silicon grease to ensure good heat transfer.

TABLE IV - TEMPERATURE SYSTEM TROUBLE-SHOOTING GUIDE

A-C Heater Power Available - with Monitor Card

SYMPTOM	PROBABLE CAUSE	REMEDY
1. No heat & no regulator indication-1 zone (RTD trouble light on & * high-band light on & machine sequence stops)	A. RTD Open	A. Check RTD resistance if over 400 ohms replace
2. No heat & no regulator indication-1 zone (RTD trouble light out & * all trouble indicating lights out).	A. Defective temperature regulator	A. Replace temperature regulator module
3. No heat & no regulator indication-all zones (all trouble indicating lights out.)	A. Loss of power-supply voltage	A. Check power-supply connection to regulator P90FW (pin 44B) P15V (pin 24A) N15V (pin 28A) Measure to common (pin 26A)
	B. Set point, all zones, below barrel temperature	B. Machine not properly set-up. Check all settings
	C. Monitor card inhibiting temperature regulator	C. Check pins 30A & 32A to common pin 26A should be 8 to 15 volts for regulator permissive.
	D. Defective temperature regulator	D. Replace temperature-regulator module
4. No heat & no regulator indication-all zones (all trouble lights out & heater circuit breaker tripped)	A. Defective heater driver	A. Locate defective heater-driver module & replace** (Remove fuses from one heater driver at a time & reapply power to determine defective heater driver modules.)

	B. Open Heater Band	B. Check for open heater band. If not used remove the module fuses.
5. No heat but regulator indication OK-1 zone	A. Open heater band	A. Check for open band replace
	B. Blown heater-driver fuses	B. Replace defective zone-heater-driver fuses. CAUTION; Use only electronic fuses of same rating
	C. Loose heater-driver firing card	C. Check & correct
	D. Defective heater-driver module	D. Re place heater-driver module.**
	E. Defective temperature regulator	E. Replace temperature-regulator module
6. System heats but one zone stays full on (RTD light on *low band light on	A. Shorted RTD	A. Check RTD resistance-if below 100 ohms replace
	B. Defective temperature regulator	B. Replace temperature-regulator module
7. System heats but one zone stays full on (RTD light out * high band light on)	A. Deviation set point too low	A. Check & reset deviation set point
	B. Improper machine set-up e.g. excessive screw speed or excessive back pressure	B. Check & readjust set-up
	C. Defective temperature regulator	C. Replace temperature regulator module
8. Zone temperature low-RTD light off *low-band light on.	A. Deviation set-point setting too low. NOTE: for cold-start temperature set point should be kept within deviation set-point limits).	A. Check & reset deviation

	B. One zone fuse open	B. Check & replace fuse
	C. Defective temperature regulator	C. Replace temperature-regulator module
9. Heater-control-system failure when none of above proves to be the cause	A. Defective monitor card	A. Check for presence of all possible failure functions. Replace monitor card.

* In Form 1 monitor cards only

** The heater-driver modules will adhere tightly to the enclosing case surface due to a liberal coating of silicon grease (Dow Corning No. 340 or equivalent). Threaded holes in the base plate serve for jacking screws to break this seal. When replacing, apply silicon grease to ensure good heat transfer.

TABLE V - SOLENOID SWITCHES
TROUBLESHOOTING GUIDE

SYMPTON	PROBABLE CAUSE	REMEDY
	A. C. SOLENOID SWITCHES	
1. A-C input, no output	A. Blown fuse	A. Replace fuse, use Slo-blo of same rating
	B. No gate signal.	B. Check for logic "0" at input pin. If logic "0", replace solenoid switch card. If logic "1", gate signal is not present, trouble is in sequence circuitry. Refer to elementary diagram.
	C. Loss of logic power supply to solenoid driver card	C. Measure P15V (pin 24 to common - pin 26) If missing check P.S. Table II
	D. Open Triac	D. Replace solenoid switch card.
2. Solenoid will not de-energize	A. Shorted Triac.	A. Replace solenoid-switch card.
	B. Gate signal present	B. Check for logic "1" at input pin. If logic "0" trouble is in sequence circuitry. Refer to elementary diagram.
	D. C. SOLENOID SWITCHES	
1. D-C input, no output	A. Blown fuse	A. Replace fuse, use pico fuse of same rating.
	B. No gate signal	B. Check for logic "0" at input pin. If logic "0", replace solenoid switch card. If logic "1", gate signal is not present, trouble is in sequence circuitry. Refer to elementary diagram.

SYMPTON	PROBABLE CAUSE	REMEDY
	D. C. SOLENOID SWITCHES ---- (Continued)	
	C. Loss of logic power supply to solenoid driver card	C. Measure P15V (pin 24 to common - pin 26) If missing check P.S. Table II
	D. Defective component	D. Replace solenoid switch card.
2. Solenoid will not de-energize	A. Defective component	A. Replace solenoid switch card
	B. Gate signal present	B. Check for logic "1" at input pin. If logic "0" trouble is in sequence circuitry. Refer to elementary diagram.

TABLE VI - DIGITAL TIMER MODULE TROUBLE-SHOOTING GUIDE

SYMPTON	PROBABLE CAUSE	REMEDY
1. Timer will not time	A. No clock Pulse	A. Check for P90FW on pins 6 & 20 to common pin 26.
	B. Voltage missing.	B. Check P15V (pin 24) N15 (pin 28) to common (pin 26) at timer-module input.
	C. No initiate signal	C. Check initiate signal at appropriate input pin (need logic "1").
	D. Defective timer module	D. Replace timer module
2. Timing period too long or too short	A. Timer being initiated while another timer is timing - set-up error or control problem.	A. Check initiate signal. Correct set-up or control mal-function.
	B. Defective timer module.	D. Replace timer module.

APPENDIX A

RECOMMENDED - RTD SENSOR

MECHANICAL:

The end of the probe should be silver for greater tip sensitivity.

The sensor and the spring should be stainless steel.

The unit will be exposed to 800^{o}F temperature back 10 inches from the end of the sensor

Wire from that point back will be No. 24 AWG, Teflon insulated, shielded.

Potting compound will be sauereisen cement or equivalent, organic (epoxy) compounds are unacceptable.

PERFORMANCE CRITERIA:

Temperature Range - The sensor shall meet the requirements of this specification throughout the temperature range of 32^{o}F to 800^{o}F.

Resistance - Temperature Relationship - Each sensor shall conform to the resistance-temperature relationship expressed by the Callendar-Van Dusen equation over the temperature range of 32^{o}F to 800^{o}F (0.003920 ohms/ohms/^{o}C)

Resistance at 0^{o}C - The resistance of the sensor shall be 100 ohms at 0^{o}C.

Repeatability - After 25 rapid temperature shocks from 32^{o}F to 800^{o}F the sensor's resistance at 0^{o} shall not have changed by more than $\pm$ 0.1 ohm.

Insulation Resistance - The electrical insulation resistance shall exceed 100 megohms when measured from any lead to the case, using a test potential of 50-volts d-c.

Interchangeability - The transducers shall be interchangeable within $\pm$ 3°F at 600°F.

GENERAL ELECTRIC