DIGITAL

proportional pH

CONTROLLER

PPH-1

USERS GUIDE

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SPECIFICATIONS

Range:	0 to 14pH with 0.01pH resolution
Display:	3 1/2 digit LCD display
Indicators:	LED lights indicate set point operation mode, flow and configuration status.
Calibration:	All calibration parameters are programmed into non-volatile memory.
Electrode:	BNC, external of housing.
Temperature compensation:	Manual compensation selected in the configuration menu. Temperature range from 0 to 100^{o}C. Automatic compensation possible with a TP150 electrode connected.
Signal output:	4-20mA software configured over range 0-14pH. Screw terminals for fully isolated 4-20mA output located by removing front section. Maximum termination impedance for 20mA is 1000 Ohms.
Control range:	Set point range 0pH to 14pH
Output relay:	240 VAC, 5 Amps max. Resistive load. 3 terminals provide earth, neutral and active. 5A fuse protects instrument and relay output.

Pulsed output: Selected through setup program. Pulse width adjusts automatically to suit dosing requirements. On time changes from continuous to minimum 1.5 seconds. Pulse interval increases / decreases to further fine-tune a dosing cycle.

Output relay: 240 VAC, 5 Amps max. Resistive load. 3 terminals provide earth, neutral and active. 5A fuse protects instrument and relay output.

Alarm relay: Potential free contacts.

Power: 240VAC 50Hz 7VA max.

Housing: Thermoplastic with transparent lid. Rated IP 55

Dimensions: (W)130mm x (H)95mm x (D)85mm.

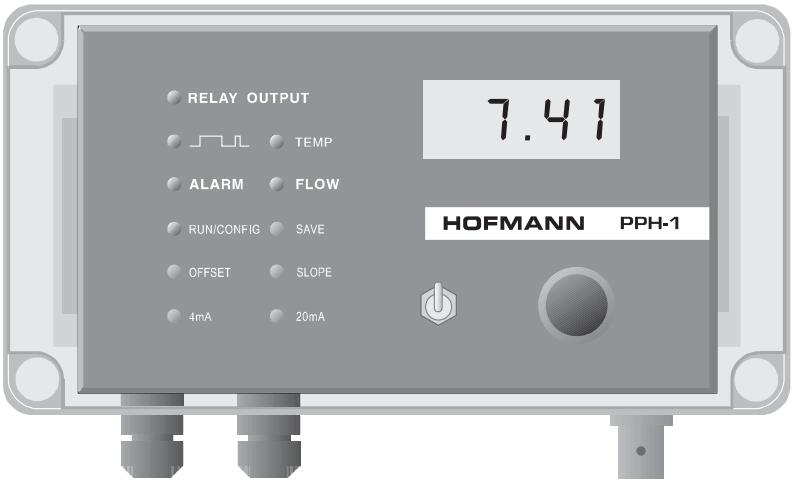

FIG 1 *PPH-1 controller*

INTRODUCTION

The PPH-1 measures and controls the full range of 0-14pH. The basic installation of a control system requires no more than simply fastening the unit to an instrument panel or wall, hard wire the pump cables via the cable glands and connect the electrode to the BNC socket situated on the bottom of the instrument.

The signal generated from a pH electrode is extremely weak with a very high impedance and therefore very sensitive to electrical interference. This necessitates the use of shielded cable for the connection of the electrode. A coaxial cable with an additional outer layer of carbon must be used to ensure a steady pH signal. The PPH-1 converts the electrode signal with a precision input amplifier and then further processes the electrical signal for display, alarm, signal and set point controls.

The large LCD display shows either signal input, configuration or calibration values such as set point or high/low alarm as selected by an operator.

LED's show the operational status of the instrument or setup program currently available. Pressing the momentary switch prepares for performing configurations or calibrations. Rotating the encoder now clockwise and pressing the switch again enters the configuration menu to set up the instrument. Rotating the encoder anticlockwise and pressing the switch enters the calibration menu. You scroll through menus with the encoder knob and once a menu is selected values are then increased or decreased by rotating the encoder knob clock- or anti-clockwise. The desired value is selected and saved with the momentary push switch.
(See configuration)

☞ *The rotary encoder only becomes active if invoked through the instrument configuration program. This feature avoids a setpoint or calibration values being changed inadvertently.*

Three modes of set point control are possible:

Normal dosing

This is the normal dosing mode with simple on/off operation of the output relay. Up or down dosing is possible with normal dosing.

Normal Proportional dosing

The relay output starts to pulse with a shortening of the ON cycle and a lengthening of the OFF cycle as the pH moves to less than 1.00pH of the setpoint value. Up or down dosing is possible with normal proportional dosing.

Adaptive proportional dosing.

The relay output of the PPH-1 instrument is controlled through a complex algorithm that continuously monitors the difference between actual mV and set point. The output starts to pulse and varies the ON/OFF cycle as the pH-input approaches the set point value. The ON/OFF cycle however is also adjusted from a 'correction factor', which in turn is governed by the history of a previous dosing cycle. This makes for a fully dynamic dosing control, which adapts for widely varying conditions in a cooling tower or other plant installations.

Dosing for an excessive period of time without a corresponding increase in mV is recognized as a possible failure. The output begins to pulse, preventing overdosing.

The pulse output exhibits a very wide duty cycle. The ON and OFF times are both dynamic, both varying from 1.5 to 60 seconds.

Up or down dosing is possible with "Adaptive proportional Dosing".

☞ *The program of the PMV-1 prevents gross overdosing in the event of a process upset or electrode failure. (Adaptive mode only)*

Temperature compensation is set for 20^{o}C by default. This can be changed manually in the configuration program from 0 to 100^{o}C. A TP150 temperature electrode connected to the terminals enables the option for automatic compensation.

The PPH-1 features an alarm relay with potential free contacts. Low and high alarm points are set in the configuration menu.

The flow switch input is configured to operate as N/O or N/C. *(normally open or normally closed)* The output relay is locked out and the relay LED flashes if no flow is detected. The flow LED indicates this condition.

The inherent accuracy and range configuration of the 4-20mA constant current output together with full electrical isolation make it possible to interface into a microprocessor, logic controller or data logger to further expand the combination of installations with the PPH-1.

Wiring the PPH-1 is easy. Simply unclip the front panel to reveal all the terminals. The output terminal for the relay provides switched 240VAC with active, neutral and earth. A pump or valve can be wired directly without the need for additional junction terminals.

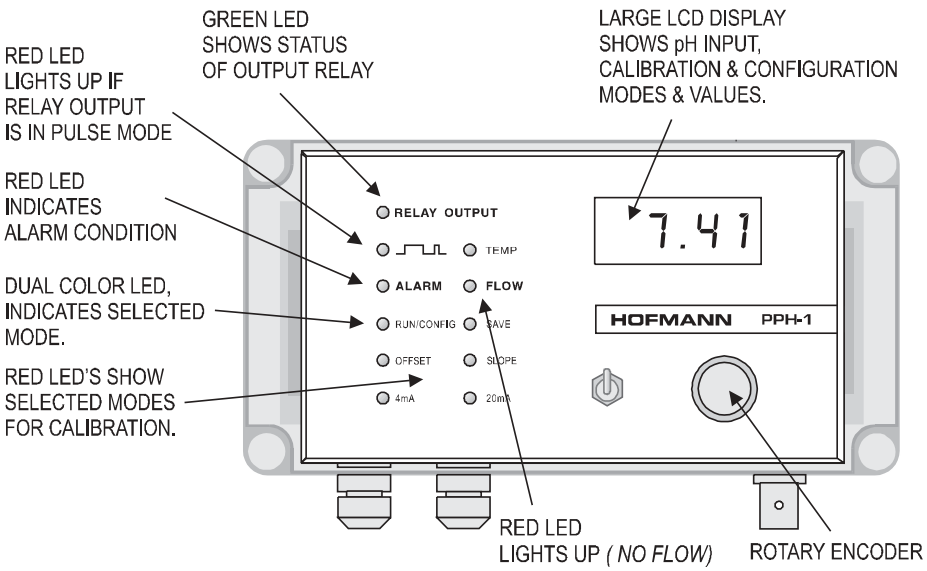

FIG 2 *LED' s show different mode of operation*

INSTALLATION

Select a position for the controller to be mounted on a wall, not facing into direct sunlight and protected from the weather elements as much as possible. The instrument should be installed within the distance of the sensor coaxial cable length. If this is not possible extra coaxial cable can be supplied to suit, however if cable lengths are to exceed 10 metres in length a preamplifier may be required. Remove the front transparent cover from the enclosure and gently separate the removable module from the rear enclosure. Disconnect the flat cable connector from the rear circuit board.

The instrument is fastened to a wall or sub panel by means of four screws. The mounting holes are revealed after removal of the front cover. *(See Fig.3)*

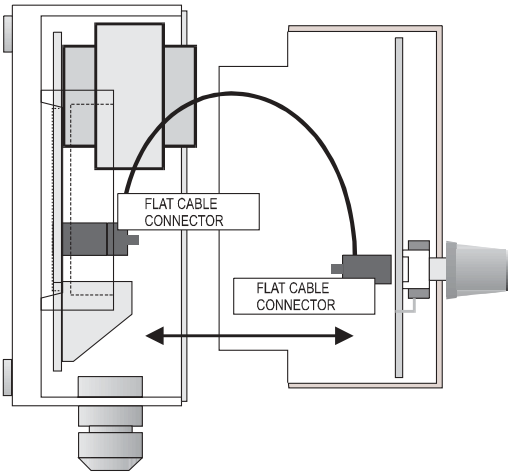

FIG 3 *CHASSIS & removable FACIA of the PPH-1*

The 3 terminals for the SET POINT each provide an earth, neutral and switched 240VAC active screw connector. A metering pump, solenoid valve or other device requiring 240V can be connected.

The alarm relay terminal has potential free contacts. *(N/O C N/C)* Adjacent is a 3 way terminal providing 240VAC active neutral and earth. This helps in wiring the alarm relay with an appliance requiring 240VAC. Wire a small loop from 'common' to active of the second terminal. The 240VAC appliance is now wired to 'normally open' of the alarm terminal, neutral and earth of the additional terminal. *(See Fig.4)*

It is imperative that all connections are wired through the cable gland and the transparent lid is always tight to ensure that no corrosive liquids inadvertently splash into the instrument.

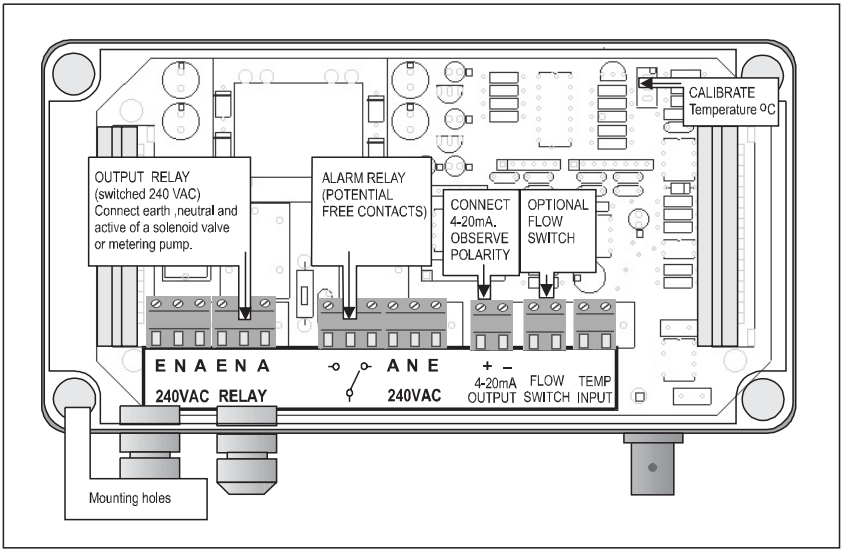

FIG 5 *Terminal layout of the PPH-1.*

You need to determine the N/O or N/C of a flow switch when connecting for proper configuration later on. Polarity does not matter when wiring a flow switch.

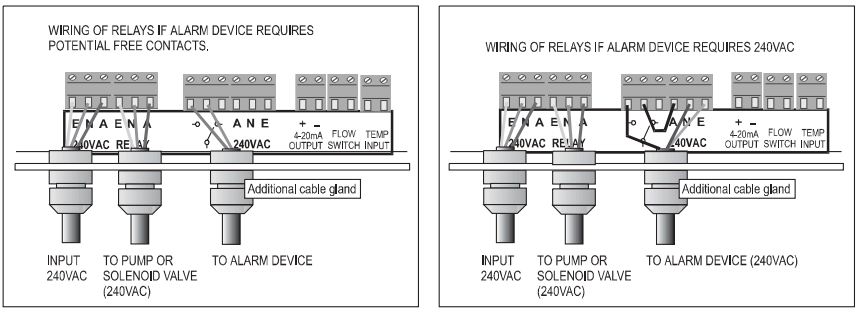

FIG 4 *Wiring examples for the relay outputs.*

Polarity need not be observed when connecting a TP-150 temperature electrode to the “TEMP INPUT” terminal.

☞ *The Set point relay terminals connect to earth, neutral and switched active 240V. (240VAC is supplied to these terminals when activated by the set point.)*

Signal output

The 4-20 mA signal current output can be used for event recording or to expand the control facilities for additional relay contacts. This output can be wired directly to a computer interface without causing earth loop problems. Correct polarity wiring is essential.

☞ *Correct polarity has to be observed when connecting the 4-20mA signal output.*

Installing the electrode

Select the appropriate position in the system for the electrode, and install the electrode so that it is vertical with the sensor tip facing down in the sample tee. Always install the sensor in a sample line that can be isolated, as the sensor has to be cleaned and checked regularly.

Special consideration must be given when placing an electrode in a treatment bath or pool. The point of injection of neutralising agent and placement of the electrode *(distance between them)* largely determines the dosing characteristics of the PPH-1.

Starting up the Instrument.

After you have installed the instrument and checked all the wiring and connections open the isolation valves to the sensor to allow water flow across it. Plug the power cord into the supply and switch on the PPH-1. The “RUN/CONFIG” LED will light up green and the digital display shows the measured input value.

CONFIGURATION

Looking at menus and values without changing or saving.

The PPH-1 is now in 'RUN' mode and processes the pH signal, output and alarm relays and the signal output. This condition is indicated with the green 'RUN/CONFIG' light. Turning the encoder knob has no effect.

Press the momentary switch. The LED changes to flashing red. Turn the knob clockwise. The LED changes to steady red and the display shows ***CnF***. Now press the momentary switch to move to the first configuration mode. The display shows ***UP***. Slowly rotate the knob to sweep through all the modes:

Dosing = ***UP***, setpoint = ***7.00***, Dosing mode = ***no.d*** *(normal dosing)*
Temperature compensation = ***+ °C***,
Low alarm pH = ***2.00***
High alarm pH = ***12.00***
Flow switch = ***OP*** *(normally open)*
4-20mA Signal = ***nor*** *(normal signal output)*
pH ***2.00*** = 4mA, pH ***12.00*** = 20mA.

The corresponding LED light up for each of the above position to show which mode is indicated with the LCD display.

The next step shows ***End***, here you can exit back to 'RUN' by pressing the momentary switch or continue to step clock-wise or anti-clockwise to look at the configurations again. There is no need to exit manually as the PPH-1 automatically returns to 'RUN' after 2 minutes if left anywhere in the configuration or calibration menu.

☞ *The PPH-1 automatically returns to 'RUN' after 2 minutes if left anywhere in the configuration or calibration menu.*

If a program mode is entered inadvertantly by pressing the momentary switch simply press the switch again until the 'SAVE' LED flashes. The same mode or value is retained as was previously programmed.

Default values for the PPH-1 instrument

The PPH-1 is shipped with default values programmed in non-volatile memory. These values are always retained in the instrument even if the power is switched off.

Dosing = UP	***UP***
Setpoint = 7.00	***7.00***
Dosing Mode = normal dosing	***no.d***
Temperature Compensation	
Manual (+20.0^{o}C)	***S.^{o}C (+20.0)***
Low Alarm pH = 2.00	***2.00***
High Alarm pH = 12.00	***12.00***
Flow Switch = Normally open	***OP***
4-20mA signal output mode = normal	***nor***
4mA = 2.00pH	***2.00***
20mA = 12.00pH	***12.00***

Of course all values can be customised through the configuration setup. Entered values are stored in non-volatile memory and are not lost through power failure.

Changing and Saving Values in Configuration.

This chapter only explains the different selections available and how to change modes or values. Look up “OPERATION” for more details of when to use different settings.

General:

Table 1 is an overall diagram of all the variables that can be changed in configuration. The LCD display shows a mode or value and the appropriate LED lights up to show which position is presently showing. Pressing the momentary switch activates the encoder to change this value. This is indicated by the LED flashing. To save a change press the switch until the yellow “SAVE” LED flashes twice. The change is now saved in non-volatile memory and will be used by the PPH-1.

This manual from now on will say:

Pressing the momentary switch: **'PRESS'**

Pressing the momentary switch until the save LED flashes twice: **'SAVE'**

Clockwise direction of the encoder knob: **Rotate 'CW'**

Counter-clockwise direction of the encoder knob: **Rotate 'CCW''**

Either direction of the encoder: **"Rotate'**

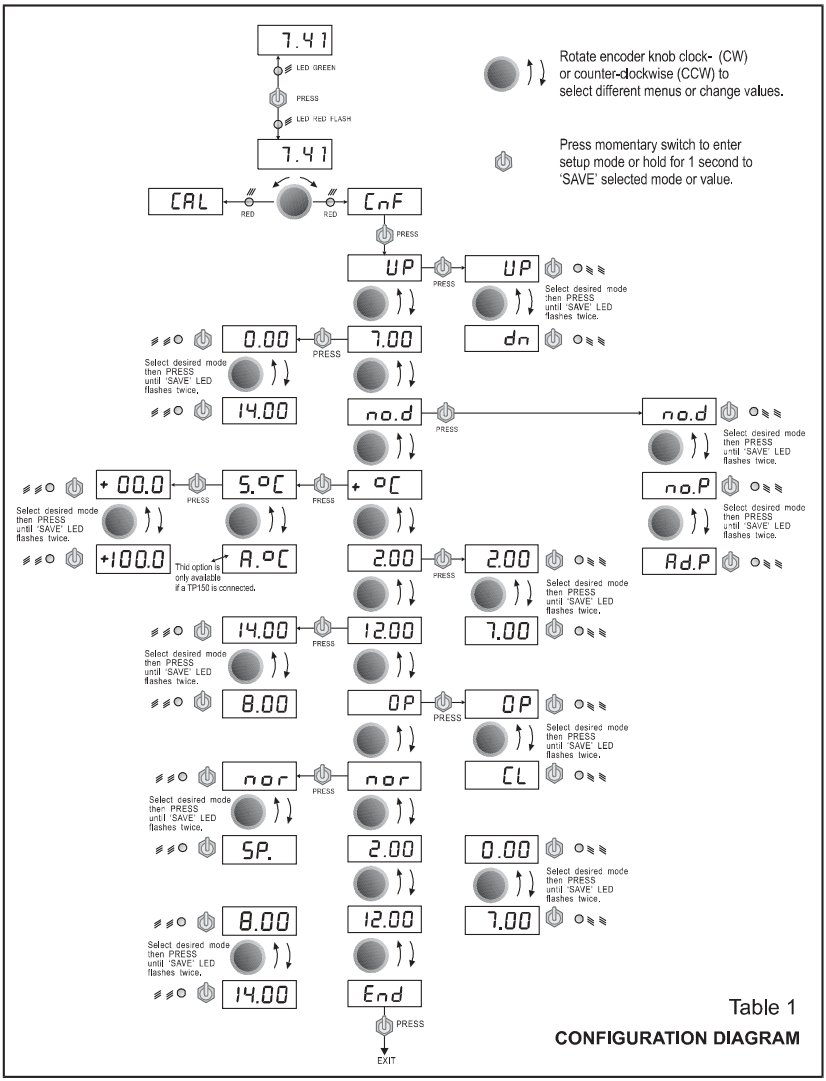

Table 1

CONFIGURATION DIAGRAM

When dialing up numbers such as the setpoint, the encoder steps in single digits if turned slowly. To change large numbers quickly rotate the encoder in a “flicking” manner.

☞ *To change large numbers quickly rotate the encoder in a “flicking” manner.*

Modes:

Dosing mode is selected for up [***UP***] or down [***dn***].
Setpoint is selected between 0.00 to 14.00pH.
Next select the relay output mode. There are three options.
Normal dosing [***no.d***], Normal Proportional dosing [***no.P***]
and Adaptive Proportional dosing [***Ad.P***]

Temperature compensation is selected manually in +^{o}C mode. ‘PRESS’ and dial up the new temperature. Range is 0 to 100^{o}C.

Connecting a TP150 temperature electrode enables the PPH-1 to use automatic compensation. Select ***S^{o}C*** for manual or ***A^{o}C*** for auto compensation. In ***A^{o}C*** mode the actual temperature is displayed. Exit without saving by rotating the encoder *(Temp LED goes off)* and then ‘PRESS’. Press ‘SAVE to accept automatic compensation.

A low and high pH alarm is set in the next menu. The alarm LED flashes slowly when dialing a low pH alarm, fast when dialing a high pH alarm. Low alarm range is from 0.00 to high pH alarm. High alarm range is from low pH alarm to 14.00pH.

☞ *A flashing LED indicates that a value can be modified in this position.*

Flowswitch configuration mode is selected for normally open [***OP***] or normally closed. [***CL***]

4-20mA output is configured for normal [***nor***] or setpoint [***SP.***] operation. The pH for 4mA and 20mA is selected with the next configuration. First the 4mA LED flashes to allow entering and ‘SAVE’ a pH for 4mA. Repeat this procedure for 20mA. 4mA range is from 0.00 to 7.00pH. 20mA range is from 8.00 to 14pH.

Only the 20mA slope is entered in mA Setpoint. Range for the mA slope is 0.5 to 5.00 pH. 4mA always is setpoint. It is important to note that dosing mode [***UP, dn***] is properly selected if ***SP.*** mode is used.

If additional changes are necessary rotate 'CW' or 'CCW' to return to any of the above mentioned options. Only a single configuration change can be made if necessary. There is no need to configure from beginning to end.

When all configurations are done step to the next menu [***End***] to exit. 'PRESS' returns to operating mode. The PPH-1 always returns to operating mode after 2 minutes if left in configuration or calibration mode.

☞ *A single configuration change can be made if necessary. There is no need to configure from beginning to end.*

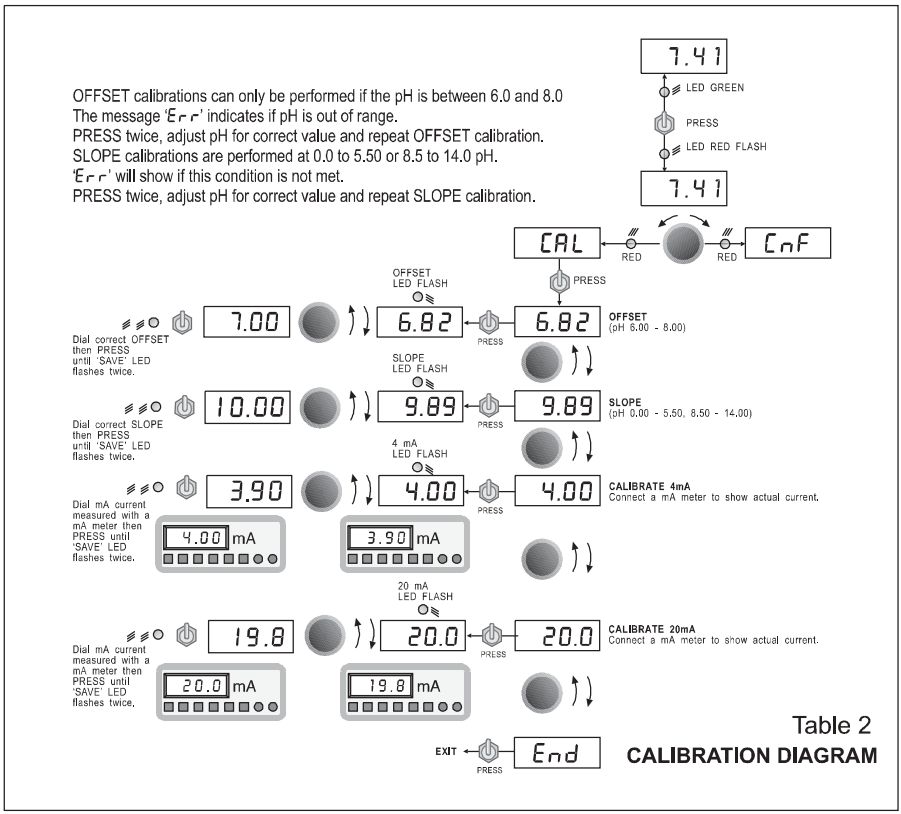

Table 2
CALIBRATION DIAGRAM

OPERATION

Initial check of the PPH-1.

After the instrument is properly installed, an electrode or pH simulator connected and the power applied, the “RUN” LED will light up. The output relay may latch depending on the current pH measured. Sweeping across the range with a simulator will activate the relay and “RELAY OUTPUT” LED at some point, provided the pH value of the simulator is within the range of 0-14pH.

Calibrating the PPH-1 with a simulator.

The operator should be familiar with the different effects if OFFSET and SLOPE calibrations are carried out. Offset adjustments increase or decrease the reading regardless of the absolute measured value. pH7 is a prefixed iso-potential and increasing the slope always moves the reading away from pH7. Readings below pH7 therefore decrease in the displayed value. Readings above pH7 increase in the displayed value. *(Fig.6)*

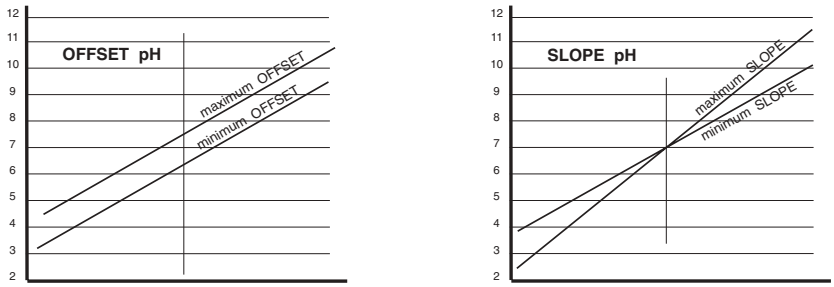

FIG. 6 *THE DIFFERENT EFFECTS OF OFFSET AND SLOPE.*

OFFSET calibrations should be carried out first, however offset and slope calibrations can be performed separately and need not be done consecutively.

Set the simulator to pH 7.00

‘PRESS’ and ‘Rotate CCW’ to go to CAL. ‘PRESS’ turns on the offset LED. ‘PRESS’ again, the offset LED now flashes and the display shows

"live" pH input. 'Rotate' until 7.00 shows on the display and 'SAVE'. Offset is now calibrated.

An offset calibration can only be performed if the pH is between 6.00 and 8.00. The display shows ***Err*** if a value outside these parameters is present. If this happens 'PRESS' two times, the display shows "live" pH to allow the operator to correct for a valid offset pH value. 'PRESS' now returns to the offset calibration menu to repeat the procedure.

Rotate 'CCW' goes to ***End*** then 'PRESS' to exit. Rotate 'CW' proceeds to the slope calibration.

SLOPE calibration.

Set the simulator lower than pH 5.50 or higher than pH 8.50

'PRESS' turns on the slope LED. 'PRESS' again, the slope LED now flashes and the display shows "live" pH input. 'Rotate' until the correct slope value shows on the display and 'SAVE'. Slope is now calibrated.

An accurate slope calibration can only be performed if the pH is lower than 5.50 or higher than 8.50 The display shows ***Err*** if a value inside these parameters is present. If this happens 'PRESS' two times, the display shows "live" pH to allow the operator to correct for a valid the pH value. 'PRESS' now returns to the slope calibration menu to repeat the procedure.

Rotate 'CCW' two times goes to ***End*** then 'PRESS' to exit. Rotate 'CW' proceeds to mA calibrations. *(See 4-20mA output)*

Calibrating the PPH-1 and electrodes with buffers.

☞ *Allow several minutes before trying to calibrate the instrument to allow for a settling period of the sensor in the water.*

The electrode should be left in a KCL solution preferably overnight, to condition the glass membrane of the electrode. This is especially important for unused electrodes that have been in store for extended periods.

You will need at least 2 buffer solutions. One buffer should have its value near the pH7 point, the other near the range to be measured. This will mean a buffer of pH4 or lower for the acid range and pH9-10 or above for the alkali range.

The temperature compensation must be set as close as possible to the temperature of the buffer solution.

☞ *The pH values of the buffers are also temperature dependent. It is therefore important for an accurate calibration to take note of the buffer pH values versus temperature usually printed onto the buffer container label.*

1.) Insert electrode into the buffer with its value near pH7 or 7 precisely. Check the displayed value of the instrument and calibrate the offset as mentioned above.

2.) Rinse the electrode thoroughly with distilled water and insert into the second buffer.

3.) Check the displayed value of the PPH-1 and adjust any errors with the slope calibration as mentioned above.

The whole procedure may be repeated for assured accuracy. Rinse electrodes with water between measurements. Always throw away any used buffers.

☞ *Never attempt to calibrate an electrode directly taken from a treatment plant without proper rinsing and storing in a KCL solution or distilled water.*

Selecting Modes of Operation.

Dosing

When treating acidic water with an alkali neutralising agent dosing is up the pH scale and is considered "dosing up". The pH of the water treated is below the pH setpoint, therefore dosing is set to ***UP***

If the water is alkali and treated with acidic neutraliser dosing is down the pH scale and is considered as "dosing down". The pH of the water treated in this situation is above the pH setpoint, therefore dosing is set to ***dn***

Setpoint

Once the actual pH reaches the selected setpoint pH value the output relay switches off. A deadband of 0.15pH is used in normal mode. The relay output switches on again at 0.15pH above/below setpoint. *(depending on UP/dn mode)*

Dosing mode

In normal dosing mode [***nod***] the output relay simply switches on and off below or above the setpoint. *(depending on UP/dn mode)*

In normal Proportional mode [***no.P***] the relay output starts to pulse on and off once the actual pH moves to within 1pH of the setpoint.
See Fig. for on/off ratio of relay output.

Up or down mode is possible with normal Proportional dosing.

In Adaptive Proportional mode [***Ad.P***] the relay output is controlled through a complex algorithm that continuously monitors the difference between actual pH and set point. The output starts to pulse and varies the ON/OFF cycle as the pH-input approaches the set point value. The ON/OFF cycle however is also adjusted from a 'correction factor', which in turn is governed by the history of a previous dosing cycle. This makes for a fully dynamic dosing control, which adapts for widely varying conditions in a cooling tower or other plant installations.

Dosing for an excessive period of time without a corresponding movement in pH is recognized as a possible failure. The output begins to pulse, preventing overdosing.

The pulse output exhibits a very wide duty cycle. The ON and OFF times are both dynamic, varying from 1.5 to 60 seconds.
Up or down mode is possible with Adaptive Proportional dosing.

The time taken for the PPH-1 to register the neutralising effect of the chemicals injected depends on the mixing and retention time of the plant installation. The distance between the injection point of neutralising agent and the electrode greatly effects the quantity released into the system.

Therefore which dosing mode to use largely depends on an installation and can possibly only be determined on site after some initial running of the plant.

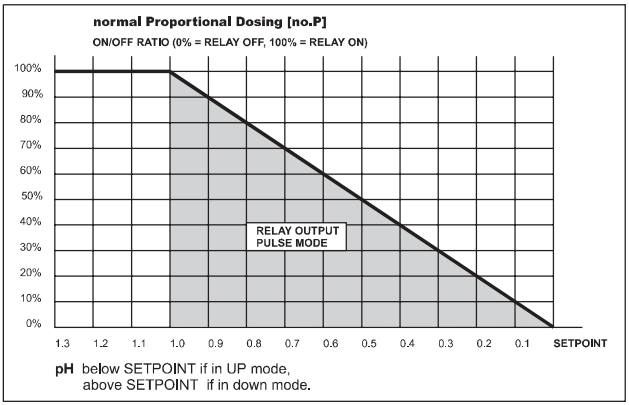

FIG 7 *Normal Proportional Dosing.*

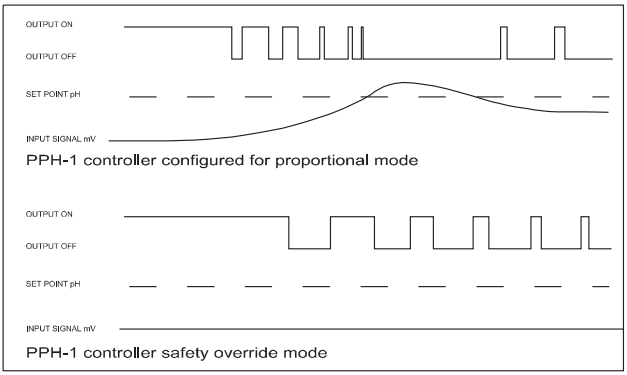

FIG 8 *Adaptive Proportional Dosing.*

Automatic temperature compensation with a TP150 sensor.

There is only a moderate dependence of pH versus temperature. In most cases manually setting the temperature of the water will suffice but if very accurate measurements are required or large temperature fluctuations are present a TP150 sensor should be used, Once connected, automatic compensation can be selected. The PPH-1 also allows the operator to simply view the temperature thus using the instrument as a "digital thermometer".

Select ***A.°C*** for the display to show "live" °C. 'SAVE' to accept automatic compensation or exit by 'ROTATE' and 'PRESS'

Alarm

A second relay with potential free contacts controlled through configured low and high alarm pH points can be connected to an alarm device or use the potential free relay contacts for event monitoring or recording digital data into a central processor system. The relay can be used as a second setpoint control output. The adjacent 240VAC terminal assists if a device requiring active, neutral and earth is wired to the alarm terminals. *(See Fig.4)*

Flow-switch

A flow-switch connected to the PPH-1 prevents dosing chemicals if for any reason the water flow has stopped. Two types of flow-switches exist: The term "normally open" is used if the contacts are open with flow and close if flow stops. Select OP mode if this type of switch is used.

The term "normally closed" is used if the contacts are closed with flow and open if flow stops. Select CL mode for this type of switch.

If it is not certain what type of switch is in the system operate the PPH-1 and configure for OP or CL until normal operation of the relay output is established with water flowing. If no water flows through the system the PPH-1 prevents the relay from switching and flashes the green LED.

4-20mA signal output.

The PPH-1 features two modes of operation for the 4-20mA signal output. In normal operation [***nor***] a "window" is configured by selecting a low pH for 4mA and a high pH for 20mA current. The 4mA point is selected between 0.00 and 7.00 pH. The 20mA point is selected between 8.00 and 14.00 pH.

This shows that pH can be traced over the entire pH range or as little as 1.00 pH. *(See Fig. 9)*

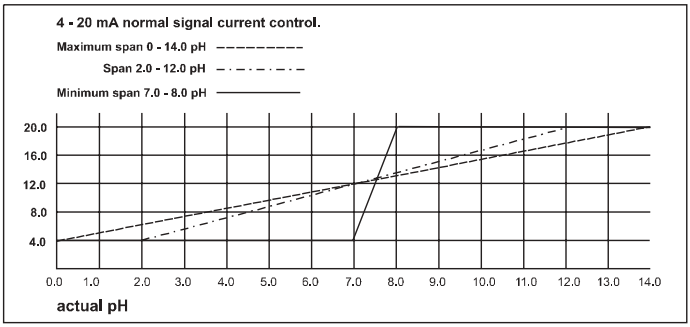

FIG 9 *4-20mA normal Signal current control.*

Choosing setpoint control [***SP.***] fixes the 4mA to the programmed setpoint. The signal current increases as the actual pH moves away from the setpoint. In ***UP*** mode the signal current increases as the pH falls below the setpoint. In ***dn*** mode the signal current increases as the pH rises above the setpoint. *(See Fig.10)*

The amount of current increase versus pH is governed by the programmed slope that can be selected from 0.5 to 5.00pH. *(Do not confuse the term "slope here with the slope calibration of pH).*

Example:

Mode is ***UP***, setpoint is 7.00 and mA slope is set at 2.00 pH.

Signal current output is 20mA as long as the pH is below 5.00, starts to decrease as the pH moves to 7.00 at which point signal current is 4mA.

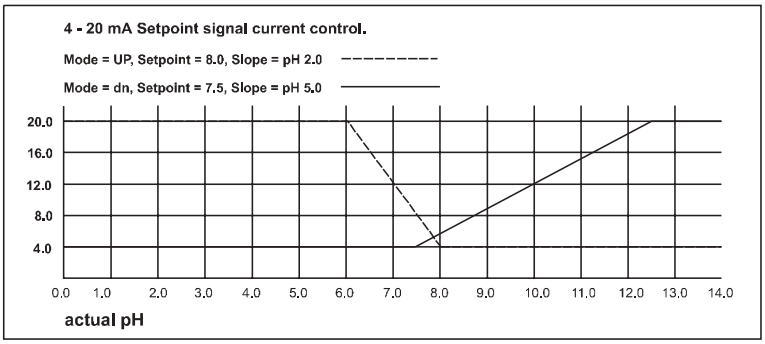

FIG 10 *4-20mA Setpoint Signal current control.*

Calibrating 4mA and 20mA with a multimeter.

A real current calibration is carried out by connecting the multi meter across the terminals *(no termination resistor is required)* to measure the mA current.

The meter can also be connected in series in an already existing installation. *(See Fig.11)*

Enter calibration [***CAL***] and 'Rotate' until the 4mA LED lights up. 'PRESS' to enter 4mA calibration. The display shows 4.00. Dial the measured mA with 'Rotate'. 'SAVE' and the actual current is corrected to 4.00mA. Move to 20mA and proceed the same way. If a calibration is not exactly accurate the first time simply repeat the procedure until the current output reads correctly.

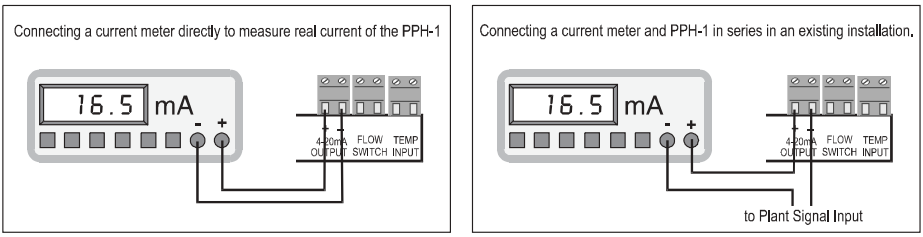

FIG 11 *4-20mA Setpoint Signal current control.*

PPH-1 / PMV-1 AND SWIMMING POOLS

Maintaining a swimming pool with a PPH-1 and a PMV-1 is simple and cost effective. *(Fig.12)* The PMV-1 monitoring a metal electrode controls the liquid chlorine for the pool. Chlorine is a caustic liquid and increases the pH level when added to the pool water. The PPH-1 connected to a pH electrode maintains pH at 7.2 to 7.6 by dosing acidic neutraliser. The electrodes are installed in a drain configuration, drawing off a small amount of pool water. This method has proved to work better than a conventional by-pass installation.

Settings for swimming pools.l

1.) Configure the PMV-1 controlling the chlorine for dosing [***UP***]. Adjust the setpoint to +750mV and select an appropriate mode of operation.

Some adjustments will have to be made during the actual operation of the pool. The correct mV setting will be somewhere between +600mV and +850mV.

2.) Configure the PPH-1 controlling the pH level for dosing [***dn***] Adjust the setpoint to 7.50 and select an appropriate mode of operation. Measure the pool water temperature and set the TEMP. ^{o}C to the pool temperature or use a TP150 for automatic temperature compensation.

The actual settings will be found after maintaining the pool for some time as each installation will exhibit its own characteristics.

This is only a brief description and is beyond this manual for complete information regarding pool installations and maintenance.

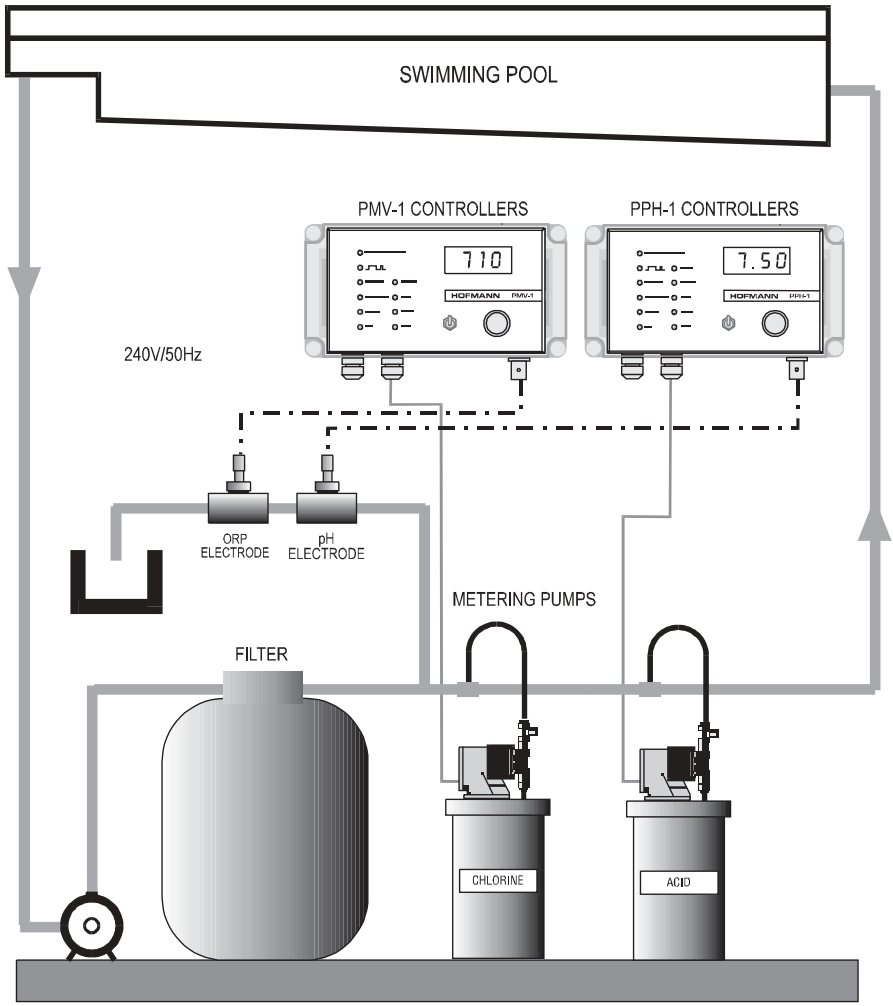

FIG 12 *SWIMMING POOL .*

NOTES:

Due to a continuing effort to improve the product the manufacturer reserves the right to change or alter the product without notices.

WARRANTY

We, **HOFMANN ELECTRONICS,** guarantee this unit against defects due to faulty manufacture or breakdown of components for a period of twelve month from the date of purchase, subject to the following provisions:

- The guarantee will cover original failure of parts and natural defects due to manufacturing causes. Otherwise repair charges are to be to the owners cost.
- The warranty does not cover any carriage costs.

The warranty is void if:

- The instrument is damaged due to rough handling or transport after purchase.
- The article has not been used in accordance with the operating instructions.
- Any parts in the instrument have been changed or have been altered in any way.
- The serial number is removed or defaced.

All other warranties and conditions, express or implied, are void.

- PPH-1 SERIAL No.