

**DT968C
C.T. BATH
CONTROLLER
MANUAL**

DT968C CONSTANT TEMPERATURE BATH CONTROLLER

The Model DT968C is a microprocessor based controller/timer. It monitors temperature utilizing a Type J thermocouple sensor and controls bath temperature with a standard three mode (PID) control scheme, with anti-reset windup. Numerous status and alarm functions are incorporated to monitor various system parameters. Additionally, a down-count/up-count programmable timer, with cumulative over timer and pre-warn is integrated into the system. A optional relay may be provided for the DRAIN function.

MODEL NO.	VOLTS	RS232	POWER SWITCH ACTIVE	DRAIN RELAY	REMOTE STR/STP SILENCE	REMOTE POWER	REMOTE SILENCE	REMOTE RETURN KEY
DT968C	208VAC	NO	YES	YES	YES	NO	NO	NO
DT968CA	120VAC	NO	YES	NO	YES	NO	NO	NO
DT968CB	120VAC	NO	YES	YES	YES	NO	NO	NO
DT968CC	208VAC	NO	YES	NO	YES	NO	NO	NO
DT968CCX	208VAC	NO	NO	NO	YES	NO	NO	NO
DT968CD*	208VAC	NO	YES	NO	NO	YES	YES	YES
DT968AC2	208VAC	YES	YES	NO	YES	NO	NO	NO
DT968ACD	208VAC	YES	YES	YES	YES	NO	NO	NO
DT698ACX	208VAC	YES	NO	NO	YES	NO	NO	NO
DT968CCX-24	24VAC	NO	NO	NO	YES	NO	NO	NO

* This model uses a RTD for the Process Temperature sensor

A built-in 20 amp, photoisolated, solid-state power controller is used to control the heater. This allows the microprocessor to maintain the most accurate temperature possible without any concern for excess cycling. The power controller contains a zero cross detection scheme. This insures that no RFI (Radio Frequency Interference) is generated when the load is switched on and off.

An independent high limit circuit is provided. It is powered by an isolation transformer that draws power from the primary side of the master relay. The sensor is a Type J thermocouple. This circuit shuts off the internal master relay should an over temperature condition occur.

A thermal cutoff input is included. Two leads are brought through the rear of the unit to connect an external thermal cutoff. If no thermal cutoff is to be used, a connection between the two leads must be made in order to operate the controller. If the connection between the two leads opens the unit will be shut off and the power to the HR terminal, which controls an external contactor, will be removed.

Twelve discrete LEDs are utilized to indicate system and display status as well as

annunciate various alarms. A 12 key membrane switch keyboard is incorporated on the front panel to allow for user setup and adjustment of the system, plus full timer control.

Two numeric displays are utilized to allow the viewing of both the process temperature and the timer simultaneously. Additionally, each of the displays has multiple diagnostic and setup functions that may be activated by the keyboard or by the microprocessor during various setup and alarm conditions.

The microprocessor section consists of two circuit boards, one for display and the other for control. The control board contains two transformers and provides the isolated DC supplies (+5 and +12 volts) necessary to run the system. In addition, it contains an instrumentation amplifier, A/D converter, EEPROM memory, and the microprocessor. The display board contains all of the seven segment and LED displays as well as the audio transducer.

MODES*****

The six primary status modes are indicated by LEDs on the faceplate and are marked NORMAL, STANDBY, ALARM, SETUP, HEAT and DRAIN.

NORMAL - This mode is the normal condition for the system. It indicates that the system is operating within the defined parameters.

STANDBY - This mode is a standby condition for the unit. It allows all normal monitoring and timing functions, but disables the heater. The only way to exit this mode is by depressing the 'RETURN' key. NOTE: For safety, the unit always starts up in this mode initially or after a power failure. When in this mode the process display reads "Hold".

ALARM - The various alarm conditions are activated by many sources and annunciated by both the displays and audio tone. The mode indicator shows that an alarm has occurred and that the system is still performing under the special conditions required by that alarm. The only way to exit this mode is to clear the alarm.

DRAIN (optional) - This LED is illuminated whenever the drain relay is active.

HEAT - This LED is illuminated whenever the heater is on. Note that when the unit is near the setpoint, the LED will continually cycle on and off.

SETUP - This is the setup mode. When in this mode the 'SETUP' key causes the controller to step through the parameters. The following is a table of the displays that will appear:

<u>CODE</u>	<u>DESCRIPTION</u>	<u>SETTING RANGE</u>
CS	Clock Setpoint	0:00 to 99:59 Minutes:Seconds
PA	Pre-Alarm Offset	:00 to :59 Seconds
PS	Process Setpoint	0.0 to 199.9°C*
DR	Drain Setpoint (optional)	0.0 to 199.9°C*
HI	High Alarm Setpoint	0.0 to 199.9°C*
LO	Low Alarm Setpoint	0.0 to 199.9°C*
AC	Access Code	0000 to 9999
CR	Cycle Rate	0 to 19 Seconds
Pb	Proportional Band	0 to 19.9°C
rE	Reset	0 to 19.9 Minutes
rA	Rate	0 to 19.9 Minutes
CA	Calibration	+ or - 9.9°C
CD	Clock Direction	UP/DN (Up or Down)

* For Model DT968C/CA/CB/CC/CCX/CD

While in this mode, depressing either the 'up' or 'down' key will cause the display to advance or retard. Depressing the key once and releasing will allow the accurate setting of the least significant digit. Holding either key down will activate the automatic, rapid incrementing or decrementing of the display. To exit this mode 'Return' is depressed.

This system may operate in either a one, two or three mode configuration. Setting the 'Rate' or 'Reset' variables to 0.0 will eliminate the respective function. It should be noted that the rate and reset settings adjust the sampling period directly in tenths of minutes. Thus, smaller numbers create more rapid sampling.

The Calibration 'CA' adjustment allows the elimination of various sensor and system errors. Thermocouple sensors are manufactured within a specific tolerance. The tolerance may lead to a difference between the actual bath temperature and the temperature displayed. This error coupled with the differential error caused by sheathing the sensor in materials such as Teflon® may cause a difference in the actual bath temperature and display temperature. This can simply be corrected by monitoring the bath temperature and utilizing the offset to add or subtract the appropriate number of degrees to bring the display into compliance with the actual bath temperature.

While in the Program mode, depressing the 'Save' key will cause the setup parameters to be written into the EEPROM memory. This is a permanent (10 year minimum life) memory that does not require battery backup. The save routine takes about two seconds to complete and is indicated by a series of dashes through the displays. This feature provides the O.E.M. with the ability to program in initial conditions prior to shipment. It then allows the user to modify these conditions and permanently save his new parameters all from the keyboard.

ALARMS*****

There are six alarm LEDs. They are essentially visual annunciators of the system functions.

SYSTEM - This alarm is a catch-all indicator for the miscellaneous diagnostics. An example would be the malfunction of the EEPROM save routine. This would simply indicate to the user that something has gone wrong and he should either repeat the command or reset the unit.

SENSOR - This alarm is to indicate a defective "SENSOR". This indicates that the sensor is either open or not connected. Special circuitry has been incorporated to monitor the sensors for an open circuit. The processor continually monitors the input and if it detects an open sensor, it shuts off the heater output and activates the "SENSOR" alarm. The process display will alternately flash the temperature and "OP" for open sensor.

H LIMIT - This is "High Limit" alarm. The LED is wired directly to the high limit circuit and lights whenever the high limit turns the master relay off. Since it is powered by the high limit power supply it remains on even after the master relay has de-energized and shut the controller off. This alerts the operator that the system has shut down and why.

H TEMP - This is the "High Temperature" alarm. It is activated anytime the process temperature exceeds the high alarm setpoint. When activated, it shuts off the heater output and the process display alternately displays the process temperature and the code "HI".

L TEMP - This is the "Low Temperature" alarm. It acts like the "High Temperature" alarm, except it compares the process temperature to the low alarm setpoint. If the process temperature drops below the setpoint once it has initially come out of the warmup mode, this alarm will be activated. In this case, the code "LO" is alternately flashed with the process temperature. This alarm will not shut off the heater output.

L LEVEL - This is the "Liquid Level" alarm. It monitors an optional remote liquid level sensing circuit and activates when a low liquid level is detected. The code "LL" is alternately flashed with the process temperature and the heater output is shut off.

All of the alarms activate the audio tone as well as the alarm status LED and the individual alarm annunciator. The tone and the LEDs alternate on and off to draw attention to the alarm. As has been noted above, many of the alarms have additional visual displays to further define or draw attention to them.

KEYS*****

VIEW - This key is used to View the Process Setpoint and Programmed Clock Setpoint, when not in the Setup mode. It is a momentary key that will change displays to show the corresponding setpoints, as long as it is held down.

SETUP - This key is used to put the system into the SETUP mode and once in that mode, advance through the parameters. Depressing the key once will place the unit into the SETUP mode. (Note: if the access code protection is selected, an additional step is required, see Access Code below). Depressing the key after entering the SETUP mode will allow the user to scroll through the SETUP parameters. To exit the SETUP mode, the RETURN key is depressed.

UP - In the SETUP mode, depressing the 'UP' key will cause the display to advance. Depressing the key once and releasing will allow accurate setting of the least significant digit. Holding the key down will activate the automatic, rapid incrementing of the display.

DOWN - In the SETUP mode, depressing the DOWN key will cause the display to decrease. Depressing the key once and releasing will allow the accurate setting of the least significant digit. Holding the key down will activate the automatic, rapid decrementing of the display.

SILENC ALARM - The alarm silence key is provided to allow for the elimination of the audio portion of the alarm as well as the portion of the alarm display that effects the process display. This essentially allows the unit to be returned to a functional condition where setpoints can be examined and reset without the interference of the special alpha displays. However, the alarm status and annunciator LEDs continue to flash to indicate the alarm and where applicable, the output to the heater is turned off to protect the equipment from any potential damage.

RETURN - This key is used to return the system from the SETUP mode, if in SETUP. If in 'HOLD', it will exit the HEATER HOLD mode.

SAVE - This key is only active in the SETUP mode and is used to permanently save the system parameters.

STANDBY - This key will put the unit into the HOLD (or STANDBY) mode. It disables the heater output. This mode is exited by depressing the 'RETURN' key. Note: for safety, the unit always starts up in this mode initially or enters it after a power failure. When in this mode the timer display reads 'HOLD'.

START-TIMER - This key is used to activate the timer. It will start the system if it is reset or it will continue if the Timer has been placed in the HALT mode (see STOP/RESET).

STOP/RESET-TIMER - This is a multifunction key whose function varies with the current system mode:

RUN MODE - If the Timer is running, depressing STOP/RESET will stop the count and place it in the HALT mode.

HALT MODE - If the Timer is in the HALT mode, depressing this key will RESET the Timer in preparation for the next run.

POWER ON/OFF - This key is utilized to toggle the internal electronic latch and master relay. This turns the main power to the controller ON and OFF.

DRAIN ON/OFF - This key is utilized to control the optional Drain function.

OPERATION*****

TIMER - The Timer may be configured to either countup or countdown. In the SETUP mode, the Timer is programmed to a specific time, a specific pre-alarm offset and a count direction.

The UP/Down count timer is presettable and will count down from the preset time or count up to the preset time depending on the mode selected. In both cases it has the additional feature of accumulating overcount. In the countdown mode this means that once it counts down to zero it begins counting back up to record the time that has elapsed past the preset time. In the up count mode once it has reached the preset value, it returns to zero and again counts up to record the time that has elapsed passed the preset time. In both cases, the display flashes to indicate that the displayed count is an overcount. The 'View' key may be used to examine the Preset time. This value and the initial preset time are stored in the EEPROM memory, thus they automatically are ready when initially powered up.

The "START" key is used to start the timer. When this key is depressed, the timer will begin counting, if the unit is in the normal mode and the timer has been reset. The "STOP/RESET" key is used to stop the timer. Anytime the timer is in the RUN mode, this key will halt its operation. The display will be frozen on the current timer value. If the count is "over", the display will flash. A second depression of this key will cause the timer to reset. This will place the preset value in the timer display, stop the display flashing and cancel any timer audio tones. If the START key is hit when the timer is in the HALT mode, the timer will continue from its current count.

The pre-warn tone has a 50/50 duty cycle and a 1/2 second period. After the preset time has elapsed, it turns into a continuous tone. The timer must be stopped to enter the Program Mode. In the Setup Mode the preset time and pre-warn time are entered (see SETUP).

HIGH LIMIT - The unit contains special High Limit Circuitry. This circuitry actually consists of a redundant single setpoint temperature monitor built into the same package. This section is powered by a separate isolation transformer and utilizes the totally independent high limit thermocouple. Its purpose is to monitor the bath for excessive temperature and should such a condition occur, physically turn the unit off.

It should be noted that this is different than the High Alarm Setpoint which is a software function under microprocessor control. This is a redundant hardware function that is capable of turning the controller "Off", independent of the basic control system.

The High Limit Thermocouple is processed through an instrumentation amplifier that also provides the reference and cold junction compensation. This signal which is a measure of the thermocouple temperature, is compared to a pre-calibrated mechanical setpoint. If the temperature at the thermocouple exceeds the preset value, the circuit turns off the internal load carrying master relay. It also lights the High Limit LED alarm light.

If the unit is on when this condition occurs, it will shut off. If the unit is off, it can not be turned on until this high limit is cleared. Again, it should be noted that the high limit circuit is powered by its own transformer and thus remains on at all times even when the power switch is off. The heater and microprocessor sections are electrically connected to the master relay output and thus are disabled by this alarm.

ACCESS CODE - In some cases, it may be desirable to restrict access to the SETUP mode. An access code system is incorporated. If access code is set to 0000 the function is eliminated and the system operates as previously described. The code is any number from 1 to 9999 as programmed into the system by the customer's authorized personnel. Once this code is entered into the EEPROM, any attempt to enter the SETUP mode will cause 'AC' to appear in the data display. The UP and DOWN keys are then used to enter the access code. Once the proper code has been selected, the user simply depresses the SETUP key.

RATE/RESET - The controller may operate in either a one, two or three mode configuration. Setting the RATE or RESET variables to 0.0 will eliminate the respective function. It should be noted that the rate and reset setting adjust the sampling period directly in tenths of minutes; smaller numbers will create a more rapid sampling. (see Tuning)

DRAIN FUNCTION - The optional DRAIN function provides a Temperature Interlocked Drain Cycle. In the setup parameters, the user may program the temperature (DR) above which the Drain function will not work. The Drain key may be used to start the Drain Cycle and also stop it.

TUNING*****

The control scheme used in this controller is a standard PID system with anti-reset windup. This section will briefly review PID control as it relates to this system. It should be noted that this discussion specifically relates to this device and may be somewhat different than other systems.

The terms PID and 3 Mode are interchangeable. The first mode of control, "P" (Proportional) refers to the basic control scheme. The concept is that the controller will determine the percentage of heat required by the system and adjust the average power input to the heater to balance the system. The power to the heater is either fully on or fully off. The proportioning is obtained by controlling the ratio between the amount of time 'on' to the amount of time 'off'. Thus proportional control in this application is more correctly termed Time Proportioning.

The Cycle Rate (CR) setting is used to determine the rate at which the heater power is turned on and off. The proportioning of the output power is accomplished by varying the percentage of time that the unit is on during the period. For example, if CR = 10, then the unit will cycle on and off once every 10 seconds. If the process has determined that the system requires only half of the full power output of the heater to maintain a specific temperature, the output will be ON for 5 seconds and OFF for 5 seconds in a continuous cycle. As the heat requirement varies, this percentage will increase to slightly longer periods ON, such as 5.1 seconds ON, 4.9 seconds OFF. The opposite is true for decreasing heat load requirements. Thus, when the system is at or near the setpoint, the HEAT LED in the status box will continually flash to indicate the time proportioning of the heater.

To compute the required percentage of "on" time, the system utilizes the Proportional Band (PB) as set in the programming mode. It is over this band that the output will vary from 0 to 100%. If for example, the setpoint is at 100°C. and the proportional band is set at 10°C., the controller will time proportion the output from 100% to 0% when the process temperature varies from 90 to 100°C. When the process temperature is at 90°C. and less, the output will be fully on, between 90 and 100°C. the output will time proportion from 100% down to 0%. At any temperatures above 100°C., the output will be fully off.

At this point it is important to note that we are discussing systems in which the Rate and Reset functions are not used. Rate and Reset will cause a shifting in the Proportional Band and vary the percentages just discussed. However, Rate and Reset do not affect the basic theory, only the position of the Proportional Band at any moment in time.

Now we will tie the Proportional Band and Cycle Rate together in the example used above. We had a cycle rate of 10 seconds with a Proportional Band of 10°C. and a setpoint of 100°C. When the process temperature is 96°, we will note that it is 40% into the Proportional Band. Based on this position we require 40% heater output, with the 10 second cycle rate, this means that the heater will be ON for 4 seconds and OFF for 6 seconds.

Obviously, a proportional control requires a certain degree of error to have the heat on. Therefore, in the example just given if we find that only 10% of the heat is required to maintain the desired temperature. The unit will cycle 1 second ON and 9 seconds OFF and the temperature will stabilize at 99°. This is not the desired 100°. The difference between the two is termed Droop. Droop is the difference between the setpoint and the control point in a proportional system.

To remove this Droop, we need the 2nd mode. This is the I (Integral) mode or commonly termed Automatic Reset Mode. The program calculates the difference between the current process temperature and the desired setpoint and mathematically corrects the system to compensate for this error. How often this is done, is based on the parameter that is

programmed in the "RE" (Reset Adjustment).

Anti-Reset Windup is a special feature incorporated in the software that locks out the Reset function when the system is outside of the Proportional Band. Obviously, if the system were automatically adjusting the DROOP before the system was nearing stability, large errors would occur. Anti-Reset Windup is used to eliminate such potential errors.

The third mode in the PID scheme is the D (Derivative) mode commonly referred to as RATE. When a system has large step changes in heat requirements, it may require this third mode to compensate for such changes. Its primary function is to eliminate overshoots as the temperature is stabilizing. It controls the rate of change of the temperature when large temperature fluctuations occur. On systems where overshoot is not a problem, the rate function may be eliminated for simplicity.

In general, bath control requires reset on all occasions. Rate may not be required and should be set to zero, unless overshooting occurs.

BACKDOOR CODE*****

A special code has been incorporated into the software to insure factory access to all functions no matter what the customer has done with the access codes. This code is 333.

SPECIFICATIONS

RANGE (Temperature):	0.0 - 199.9°C.															
RESOLUTION (Temperature):	0.1°C.															
NOISE REJECTION:	NMR - 60 db @ 60 HZ; CMR -120 db @ 60 HZ															
RANGE (Time):	0:00 - 99:59 Min:Sec															
RESOLUTION (Time):	1 Sec.															
MEASURING TIME:	4 Conversions/Sec															
DISPLAY:	Eight, 0.56 Inch High, Seven Segment, LED Uniplanar numerals. Twelve Discrete LEDs (Red, Green, Amber).															
ANNUNCIATOR:	Audio Tone, ~ 2500 HZ															
SETUP MEMORY:	EEPROM, All Parameters															
MEMORY RETENTION:	10 Years w/o Power															
SENSOR:	Standard - Type J Thermocouple, Cold Junction Compensation, Up Scale Break Protection.															
CONTROL:	PID with Anti-Reset Windup.															
ADJUSTMENT:	<table> <tr> <td>Cycle Rate:</td> <td>00 - 19.0</td> <td>Second/s</td> </tr> <tr> <td>Proportional Band:</td> <td>0.1 - 19.9</td> <td>Degree/s C</td> </tr> <tr> <td>Reset (Integral):</td> <td>0.1 - 19.9</td> <td>Minute/s</td> </tr> <tr> <td>Rate (Derivative):</td> <td>0.1 - 19.9</td> <td>Minute/s</td> </tr> <tr> <td>Calibration Offset:</td> <td>-9.9 - +9.9</td> <td>Degree/s C</td> </tr> </table>	Cycle Rate:	00 - 19.0	Second/s	Proportional Band:	0.1 - 19.9	Degree/s C	Reset (Integral):	0.1 - 19.9	Minute/s	Rate (Derivative):	0.1 - 19.9	Minute/s	Calibration Offset:	-9.9 - +9.9	Degree/s C
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Rate (Derivative):	0.1 - 19.9	Minute/s														
Calibration Offset:	-9.9 - +9.9	Degree/s C														
OPERATING RANGE:	0 to 50°C															
STORAGE RANGE:	-40 to 60°C															
CONSTRUCTION:	Enclosure - Kydex [®] ; Face - Lexan [®] , Back Printed															
SIZE:	7"H x 6"W x 5 1/4"D, (178 x 152 x 133mm)															
WEIGHT:	< 4 Lbs. (1.8 kg)															
CONNECTION:	Rear, Screw-Type, 3/8 Inch Centers; T/C - Miniature, Type J, Jack.															
OUTPUT:	SSR, Optically isolated, zero cross, 20Amp, 208VAC Relay: 1 HP, 250 VAC (optional); BUZ, HS: 20ma, 12 VDC (provided).															
POWER:	<table> <tr> <td>(p/n 306870)</td> <td>11 VA, 208 VAC ±10%, 50/60 HZ, or</td> </tr> <tr> <td>(p/n 306850)</td> <td>11 VA, 120 VAC ±10%, 50/60 HZ, or</td> </tr> <tr> <td>(p/n 306870-24V)</td> <td>11 VA, 24 VAC ±10%, 50/60 HZ.</td> </tr> </table>	(p/n 306870)	11 VA, 208 VAC ±10%, 50/60 HZ, or	(p/n 306850)	11 VA, 120 VAC ±10%, 50/60 HZ, or	(p/n 306870-24V)	11 VA, 24 VAC ±10%, 50/60 HZ.									
(p/n 306870)	11 VA, 208 VAC ±10%, 50/60 HZ, or															
(p/n 306850)	11 VA, 120 VAC ±10%, 50/60 HZ, or															
(p/n 306870-24V)	11 VA, 24 VAC ±10%, 50/60 HZ.															

STANDARD LIQUID LEVEL DEVICE
LEVELITE GLL 100240 LIQUID LEVEL SENSOR

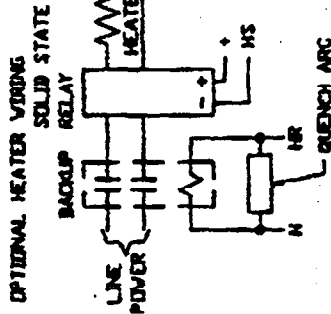
LLO — GREEN
C O — BLACK
+5O — RED
+ O — NO CONNECTION

TURCK BC10-M30-VMAX LIQUID LEVEL DEVICE

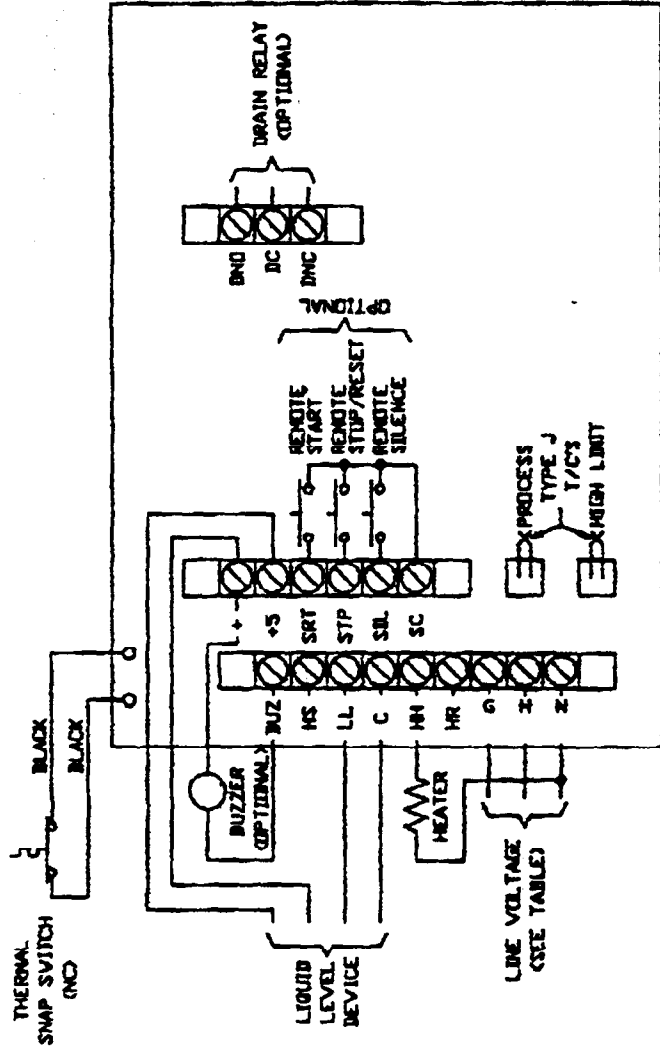
LLO — WHITE
C O — BLUE
+5O — NO CONNECTION
+ O — BROWN

CARLO GAVAZZI EC 302SP/APL LIQUID LEVEL SENSOR

LLO — BLACK
C O — BLUE
+5O — NO CONNECTION
+ O — BROWN



NOTE:
WE RECOMMEND THE USE OF A QUENCH ARC ON EVERY MECHANICAL RELAY AND SOLENOID IN THE SYSTEM. USE PAKTRON P/N 104466CC100 OR EQUIVALENT.



- NOTES
1. + TERMINAL RATED 12 - 20 VDC UNREGULATED (100MA).
2. JUMPER LL TO + TO SILENCE.

MODEL	VOLTAGE
968CA	120 VAC
968C3	120 VAC
968C	208 VAC
968CC	208 VAC
968CCX	208 VAC

JPC CONTROLS A DIVISION OF JERRY INDUSTRIES, INC.
REAR PANEL

DATE OF REV	REV	DATE OF REV	REV
1971	13	09681E3	20 00

ALL DIMENSIONS ARE IN INCHES
PARTS - 1/16" (0.0625") UNLESS OTHERWISE SPECIFIED