Reading Control Schematics

1. THINGS WE NEED TO KNOW:

   (a) What are schematics?
   Graphic representation of circuitry and components of a working system.

   (b) WHAT IS THE PURPOSE OF THE SYSTEM?
   To pump chlorinated water from a well to a storage tank automatically.

   (c) COMPONENT APPLICATION
   Function together in a logical manner to produce predetermined end result.

   (d) HOW DO THE COMPONENTS OPERATE?
   Reference to individual component description.

   (e) WHAT DO VERTICAL AND HORIZONTAL LINES MEAN?
   Vertical lines are power wiring that supply voltages and currents for operation of components and circuitry.
   Horizontal lines (rungs of the ladder) are current paths (from left to the right) from one supply line through interconnecting wiring to active components and finally terminating at the other supply line. Hence, a “ladder” schematic.

   (f) WHY USE BOTH A.C. & D.C. SUPPLY VOLTAGES?
   A.C. is used at line voltage for power devices requiring relatively large amounts of current which is available directly from power lines. A.C. current is easily transmitted from one voltage to another without excessive loss. (The controls all operate at 24V AC and 24V DC for personal safety.
   D.C. is desirable for control devices that are electronically sensitive and require more very small operating signals and currents.
   A.C. circuits used in small signal and current application are susceptible to many difficulties.

   (g) WHAT ARE THE LIGHTS ANS SWITCHES FOR?
   Lights are indicators of system status. Lights show if motors are running, voltages are present, alarms are activated. Helpful in troubleshooting.
   Selector switches are used for selecting modes of operation and for quickly testing the system. Test switches are a must for troubleshooting. These switched allow bypassing of the pilot devices without disturbing any wiring, to isolate any trouble. Alarms signal an
undesirable condition of the system which, if not corrected, could lead to improper
operation, hazardous conditions, partial or complete breakdown of the system. Low
chlorine could be hazardous to health, low well level could burn out pump, etc. An
overload light for a pump motor shows that the pump has been overloaded and should be
corrected. Critical circuits are tied into the alarm circuits to shut equipment down to
prevent hazards damage or hazards.

(h) WHAT ARE DOTTED LINES ON SCHEMATICS?

Dotted lines show equipment, components, or wiring that is external of the control panel,
but are still considered part of the system: pilot devices, motors, flow switches, etc.

(i) WHAT ARE THE NUMBERS BY LINES AND COMPONENTS?

Numbers under horizontal lines indicate numbered wires in the control panel. All wires
that have the same number are physically and electrically connected together in the panel,
not necessarily as shown on the schematic, due to spacing of connected components and
their physical location from each other.

Numbers to the right of ladder refer to other line numbers that have more associated
circuitry.

Numbers above horizontal lines and placed next to components indicate the component’s
pin or terminal number, as pins on relay sockets.

Squares with a number indicate terminal strip numbers.

Numbers to the left of the vertical lines are line numbers used for reference from relays to
their controlled contacts.

2. PARTS OF A CONTROL SYSTEM

(a) Pilot devices: float switches, flow switches, pressure switches, thermostats,
probes.

(b) Relays

(c) Power Source.

(d) Power devices (motor starters)

(e) Indicators

(f) Alarms
CONTROL SYSTEM COMPONENTS

PILOT DEVICES

Detects a pressure, level, flow, temperature set point and generates a signal that is sent back to the control panel. Float switches, pressure switches, thermostats, flow switches, and well probes are all pilot devices.

FLOAT SWITCH

Generally of plastic outer construction, housing a module containing a mercury switch that closes or open when the float is tilted from its normal posture. Hermetically sealed and extremely rugged. Used for monitoring or control of liquid levels in tanks or sumps.

FLOW SWITCHES

A device for regulating or monitoring flow of fluids or gases within a pipe or conduit. A popular type uses a flat vane, which when placed in the flow stream, is depressed to actuate a switch. Others incorporate transducers which generate an electric signal proportional to flow rate.

PRESSURE SWITCHES

Of various construction. Some use mercury switches, others use micro switches or other means of contact closure.

Mercury type generally are tilted by a bourdon tube actuator (spiral hollow tube which displaces its end when subjected to a change of pressure). Others actuate a switch by means of a flexible diaphragm or membrane.

Sensitivities are varied as to application. Some pressure switches are single acting (turn “ON” at a specific setting and “DROP OUT” at some value slightly less). Others are differential types that allow individual adjustment of “ON” or “OFF” settings.

WELL PROBES

Electrodes (usually three) are placed in a well at different levels to insure that the well pump will not run un a dry condition.

The information from the probes is used in control circuitry to either allow the pump to run when sufficient water is available, or to lock out the pump when the level is low in order to protect the pump from damage. Probes operate by sensing electrical conductivity of water when immersed, through sensitive D.C. relay circuits.
THERMOSTAT

Used for controlling temperature. Typical operation is by a bi-metallic element attached to a micro-switch or cam-operated switch. The Bi-metallic element consists of a narrow sandwich of metals having different thermal coefficients of expansion. When subjected to a change of temperature, the two metals elongate or shrink at a different rate, causing the sandwich strip to bend. This bending movement is caused to operate a switch which turns heating or cooling on or off as required to maintain desired temperature.

RELAYS

Electro-Mechanical device which opens and/or closes up to three sets of contacts.

Operation is by magnetic attraction of an armature to an electrically magnetized pole piece consisting of a soft iron core wound with fine wire. When an electric current is passed through the coil or wire, the magnetic field produced attracts the armature to which the contacts are attached thus effecting switching operation. Relays are of several types. Some are designed to operate on A.C., some on D.C. – different operating voltages and sensitivities are available. More sensitive types employ built-in solid state circuitry which enables the relay to operate with an extremely small signal input, usually of the D.C. type.

Relays are acted upon by pilot devices causing them to be in one of two conditions; either “ON” or “OFF”. Relays may sometimes be used to control another “RELAY”. A relay to control a motor starter in this manner is necessary when operating a motor of relatively large current demand, because the power handling ability of pilot device operated relays generally is not sufficient to handle a motor. In this case, the first relay operates a motor starter which in turn controls the motor. Relays are also used when more than one item in a control circuit must be operated independently at the same time.

TIME DELAY RELAYS

Operate to open or close a circuit after a period of time has elapsed. Various types are available:

“ON” Delay- circuit opens or closes some time after being energized. Relay resets upon removal of power. TDOE- TIME DELAY ON ENERGIZATION.

“OFF” Delay- circuit opens or closes some time after being de-energized. Relay resets upon reapplication of power. TDOE- TIME DELAY ON DE-ENERGIZATION.

“INTERVAL OR SINGLE SHOT” – circuit opens or closes immediately upon being energized, and remains in that state for a period of time, then reverts to its normal state. Relay resets upon removal of power. ICTO INSTANTANEOUSLY CLOSED, TIMED OPEN.

MONITOR RELAY

Monitors three phase power input to control panels. If loss of power or phase reversal in any one of the three incoming lines occurs, or if voltage drops below a predetermined value in any of the three lines, the relay actuates to disconnect the control circuitry.
If any of the above would occur without the relay and while controlling motors or pumps, the motors or pumps could be damaged beyond repair. With the relay, if conditions are restored after any of the above occurs, the relay allows the system to return to normal operation. A fail-safe device.

POWER SOURCE

Most common is derived from commercial power lines.

Controlled devices (motors) utilize this source directly, while control devices are generally operated at a lower voltage (for safety and other reasons) and is accomplished by transforming line voltage to 24 volts or less. Power sources derived from the line may be either A.C. or D.C. depending upon the application or design.

Other sources include batteries or power generators.

D.C. POWER SUPPLY

Transforms alternating current to direct current by circuitry and components which allow current to flow in only one direction.

Used for operation of D.C. relays and low level sensing circuits, which on A.C. operation would be prone to various problems such as unwanted inductive or capacitive coupling effects, producing faulty control operation. D.C. supplies are overloaded and short circuit protected; that is they limit the amount of current output to a value that will not damage the supply. If overload is removed, the supply returns to its normal operation automatically.

An integral transformer first steps down the input to 24 volts A.C. before converting it to D.C.

STANBY ALARM SUPPLY

In some locations a standby battery operated alarm circuit is necessary, consisting of a rechargeable battery, isolation diode, and current limiting resistor. Under normal panel operation, the battery is kept charged by the D.C. power supply. If for some reason the power to the panel fails, alarm horn is still operative by the battery. Battery capacity is sufficient to operate the alarm for 24 hours minimum.

ISOLATION TRANSFORMER

“Isolates” or electronically separates two alternating current circuits. Conductors of both circuits have no physical connection with each other. Isolation is accomplished by inductive coupling of the two circuits by separate multi-turns of wire wound together on a single iron core. Transformers may be varied as to input and output voltage. Transformers are also used for stepping up or reducing the primary voltage (input) to a different value (secondary output). For control panel operation, usually a 115 volt supply is transformed to 24 volts (control transformer). Transformer size varies proportionately to connected load. Required for UL listing of control panels.
CIRCUIT BREAKER

A thermo-magnetic circuit protective device. Used in series with the line and the load in order to protect wiring and electrical devices and loads in case of any condition that causes a damaging or dangerous overload.

Similar in operation to motor starter, except they are manually operated with a physically positioned toggle switch. Must be reset manually once tripped. Multiple pole breakers trip simultaneously even though overload may occur in only one of the lines. Magnetic only circuit breakers (MCP) are used for protection and are adjustable.

MCP- MOTOR CIRCUIT PROTECTOR

Similar to circuit breakers. Used for greater protection of motors than that afforded by circuit breakers. Contain only magnetic trip mechanism which is adjustable over a considerable range of trip current. Called “INSTANTANEOUS TRIP” breakers, they act faster than thermomagnetic breakers. Used with motor starters that have motor overload heaters, they afford excellent protection for motors under all conditions of overload or short circuits.

Trip adjustment is matched to its motor after connections are made, and the motor ready for operation.

Horsepower of the motor determines which MP to select.

MOTOR STARTER

Oversized relay used for turning on or off motors. Starters differ from standard type control relays in that they are more massively constructed in order to handle a greater amount of power through their contacts. They also incorporate internal motor protective devices. Such devices sense a connected overload such as a motor drawing too much current due to bearing failure, short-circuiting, or overload. Internal heaters disconnect the abnormal load by heating a thermally activated trip mechanism within the starter. After correction of the cause of overload, the starters are reset manually. Starters are available in several sizes, depending upon the power and load requirements.

SOLENOIDS

Operation is similar to relays that instead of opening and closing contacts, the armature is attached to a spring loaded cord that slides linearly inside the tube. The core is attached to the device which is to be actuated; for instance a solenoid controlled valve used for transfer of fluids or gases.

INDICATORS

Show system status information. Give immediate evaluation of system performance and operation.
Panel lights, operation counters, running time meters, dials, pressure gauges, recording meters are all indicators that monitor equipment operating parameters to detect any malfunction. Troubleshooting problems on all but the most simple is very difficult without indicators of some type.

**ALARMS**

Alarms can be audio-visual or electrical. Horns, sonalerts, signal lights, and electrical signals sent over wires to a remote location are sometimes part of an alarm system; necessary for the same reason as above.

**OPERATION COUNTER**

A pawl and ratchet operated counting device. Actuation is by a coil and armature connected to pawl (ref. Solenoids). For each input of current, the counter advances one count. Used for a number of operations versus time of pumps or motors. A motor control may short cycle and have 1,000 start-stop operations in only 0.1 hour which may damage the motor if not detected.

**RIM (RUNNING TIME METER)**

Totalizes the time of operation of the connected device such as motors and pumps. Contains a clock movement and associated dial drive mechanism.

Useful for determining maintenance schedule of associated equipment, and when used together with an operations counter, can detect abnormal operation of equipment such as pumps or motors starting and stopping an excessive number of times, thus causing wear. In a system where alternator pumps or motors used, they can indicate an unequal duty, and therefore, a faulty condition.

**HOA SWITCH – HAND-FOO-AUTO**

A 3 position switch used to select one of three modes of motor operation- Hand (runs continuously), off (does not run), Auto (turns on and off by automatic control circuitry).

Useful for testing motors by bypassing control circuitry which may be faulty, or disabling motors so that testing may be performed on the control circuitry without operating motors.

**TEST SWITCHES**

Similar to HOA switches in construction and function except smaller physically and electronically because it switches low currents or voltages. Used for testing pilot devices (float switches, flow switches, etc.). The three modes usually designated open – auto-closed. Switches can simulate pilot devices by substituting for their external operation in order to determine if the pilot device is operating properly. Switches also allow bypass of pilots in order to perform a function such as simulating a tank float switch calling for more water. Control circuitry can be tested in this manner at will directly from the control panel.

**GFI- GROUND FAULT INTERRUPTER**
Detects leakage current from a “hot” line or equipment to ground in a circuit due to poor insulation, shorts or partial shorts, or inadequate equipment or wiring grounds.

Device is for protection of persons who may inadvertently place themselves across a live circuit and ground. Operation is such that before a current of such a magnitude considered dangerous can flow, the device will trip itself to an “off” condition, thus disconnecting the lethal source. This device is currently required in control panels and by underwriter’s laboratories, as well as an isolation transformer.

LIGHTING PROTECTORS

Used to protect equipment and circuitry from damage by lightning strikes or high transient voltages that may be induced into the electrical system. Elements are gas gap type which dissipate transient energy to ground through the gas in the form of an Arc discharge, Units are self-restoring.

STRIP HEATERS

Low wattage heaters should be incorporated into control panels in order to prevent damage to panel and controls from moisture by keeping the enclosure above the dew point. Outside of panel must be in heated environment to prevent corrosion damage.

APPLICATION – “CAUSE & EFFECT”

Problem: We need to fill a water tank.

What is needed? Obviously a water pump and motor. We also need to stop the pump when the tank is full. We also want to refill the tank when the tank level has dropped. Finally, we need to do all this automatically without any personal supervision.

A float switch would be fine for turning the pump on and off. Or would it? Float switches are fragile electronically, and can switch only a limited amount of current without burning its contacts. Pump motors require a lot of power; considerably more than the float switch can handle.

Furthermore, it would not be good practice to run high voltages and current all the way to the tank and back again to the control panel to operate the pump.

Solution: Send 24 volts to the float switch to operate a relay (controlled device) which is in turn caused to operate a motor starter. These devices handle progressively greater currents.

The float switch causes the relay to operate, which causes the motor starter to operate, which causes the pump motor to run (EFFECT).

This is a simple example of control logic and is basic in all control systems either simple or complex.
BASIC RULES

1. Float switches are drawn as if they were hanging down in an empty tank. If the contacts are open, it is a normally open switch. If the contacts are closed, it is a normally closed switch.

2. Pressure switches are drawn as if they were subjected to no pressure other than atmospheric.

3. Flow switches are drawn as if they were in still fluid or gas.

4. Thermostats are drawn as if they were at their coolest possible temperature.

5. Relays, contactors, circuit breakers, and starters are drawn as if there were no power applied to the control panel, or circuits.

6. HOA switches are drawn in three possible positions. The solid line indicates that the switch contacts are in the position shown. The other two positions show what condition occurs in the position indicated by an “X”.

7. Single pole switches are drawn in the “off” position.

8. Test switches are drawn in the “Automatic” position.
READING A SCHEMATIC- THE NITTY GRITTY

In order to read a schematic diagram, we must know how components represented on a schematic, have a reasonable understanding of what the system is supposed to do, how the components operate, and how they are integrated into the system.

PROCEDURES

We have in front of us a schematic diagram of a well tank, which we wish to examine. Reference to the electrical legend is useful in component identification.

PANEL POWER

Since all control panels operate electrically let us start with the incoming power. We see that there are four lines coming into the panel marked N, L1, L2, and L3. The squares are connections for the power line conductors. The three lines L1, L2, and L3 tell us that the system is fed by three phase power. A neutral N is also connected to the system.

Another terminal G is shown connected to a ground symbol. All metal chassis parts, transformers, hardware, and sometimes power supplies are all connected to this point which in turn is connected to a water pipe and ground rods. This prevents metal parts and equipment from being an electrical hazard.

As the panel is fed by three phase power with a neutral, we have available three choices of voltage; 120 volts single phase between L1 and N or L3 and N and we have 240 volts single phase between any two of L1, L2 and L3. L2 is not used in this panel for single phase as the voltage to N is unsuitable due to line transformer connections (Delta).

Before incoming power goes anywhere, it must proceed through the main circuit breaker CB6.

If CB6 is closed, all vertical lines connected to CB6 are energized (think of lines as electrical conductors). Note that the lines are now designated P1, P2 and P3, because they have passed through a device which can be in two conditions; either open or closed, therefore the lines can be “hot” or “dead” as opposed to L1, L2, and L3 which are “hot” all the time.

The dotted lines through the main breaker indicate that the three poles of the breaker are internally actuated simultaneously.

The breaker shows a control handle with two possible positions; off or on. Switches and circuit breakers are drawn in the “off” or “open” position. Arrow on schematic informs that the breaker has a capacity of 100 amperes.

POWER SUPPLY DERIVATION

From the proceeding, we know we have single and three phase power in the panel and how it is turned on or off.

Are there any other power supplies in the panel? Let’s see.
We have traced the power to vertical lines P1, P2 and P3. Since all other power is derived from these lines, we should trace these lines into the schematic.

We find P1, and P2 at the upper left corner on lines 3 and 4, connected to a circuit breaker that has a capacity of 15 amperes. It has two poles and either stops P1 and P2 or lets them through. If CB1 is closed P2 continues to a terminal of CT1 (control transformer No.1). P1 is blocked by open contacts MR1 and MR2.

By looking around a little, we find a circle with “MR” in it coming off P1, P2 and P3 and its protective circuit breaker CB8. This is a monitor relay that we told of previously.

Normally, with power on the panel and CB8 closed, the relay’s contact will be closed. Line reference numbers next to the relay refer us to lines 2 and 3. Looking at lines 2 and 3 we find two sets of contacts (MR1 and MR2). Being energized, these Monitor relay contacts will now be closed, allowing P1 to its termination at CT1, thus energizing the transformer.

Since P1 and P2 are two lines of a three phase 120/240 volt supply, they will apply 240 volts to the transformer. In this case, the transformer is rated at .5KVA (kilo-volt amps).

We see that 240 volts on the input of the transformer, we get 115 volts out.

The transformer isolates the secondary circuit, and also lowers the voltage. One leg of CT1 goes directly to ground and the other goes to CB2. Closing CB2 applies power to G.F.I. (ground fault interrupter). From this point on, all circuitry is isolated by the transformer ahead of it, and ground fault protected.

The two lines coming from G.F.I. are now 115V and are designated “A” and “N1”.

This is our first supply derivation and is used to operate 115 volt equipment or loads.

Looking vertically down supply lines A and N1 we see that the input to the D.C. Power supply line 12, external alarm light circuitry lines 9 and 10, and another transformer line 44 are all connected to this 115 volt supply.

Going back to the D.C. power supply line 13, we derive our second supply of 24 volts D.C. These supply lines are designated + and -. The + line may be broken momentarily by PB3 (push button switch No. 3). By examination we see that pilot devices (float switches) and other circuitry are connected to this supply, because of the use of D.C. relays and sensitive circuits.

Continuing on down the lines A and N1 are finally terminated at a step-down transformer CT2. The 24 volt A.C. output of this transformer is the power supply for all our 24 volt A.C. relays and circuits. This supply is designated “A1” and “C”.

There is one more supply to look at. Line 25 shows a resistor, a diode, a circuit breaker and a battery all in series. This comprises the standby alarm supply.

Therefore, there are five separate power supplies in this panel:

(a) Powerline
For operating heavy demand equipment: motors, pumps.

(b) **115 Volts A.C.**

For an external alarm light, power for the 24 volt D.C. and A.C. supplies.

(c) **24 Volt D.C.**

For operating sensitive circuits that have pilot devices external and considerable distances from the panel.

(d) **24 Volt A.C.**

For operating internal control circuitry that is not required to be sensitive.

(e) **24 volt D.C. Standby**

For operating alarm horn in case of complete power failure. Knowing that there are five supplies, and what circuits they supply will narrow the area of a problem considerably when troubleshooting.

**COMMAND, INHIBIT, OVERRIDE**

Systems contain command, inhibitor, and override circuits.

**COMMAND – “GO”**

(ignore line 15).

At line 17 we send the +24 volt line to one terminal of terminal pair #3, from there to external float or level switch LS3 (in the water tank), back again to the other terminal or terminal pair #3, to a test switch TS3, through the test switch, to one terminal of terminal pair #2, from there to external float or level switch LS2 (in the water tank), back again to the other terminal of terminal pair #2, to another test switch TS2, through the test switch, to a relay coil R1, through the coil and finally ending the circuit by terminating at the – line of the 24 volt supply.

All this happens assuming that the contacts are closed as shown in the schematic.

Starting at the beginning, LS3 says “GO” to the 24 volts applied to it and sends it on.

TS3 says “GO”, LS2 says “GO”, TS2 says “GO” and finally relay R1 operates.

**INHIBIT – “STOP”**

If any of the float switches or test switches are not closed the relay will not operate (inhibits action).

Inhibitors may:

(a) Stop an action when its function is complete.

(b) Modify or “Supervise” an action.
**OVERRIDE**

Exercises supreme authority over one or more actions. In simple terms overrides can either ignore and make ineffective, or force actions to take place regardless of other influences.

Let us continue with our example on line 17.

We have traced the 24 volt D.C. + control line through the float switches and test switches to the relay R1 which indicates that this circuit is called “Well Pump Start.”

All this has occurred because we assumed:

(a) water tank is empty.
(b) Test switches are in “A” or automatic position.
(c) Panel is energized.

When R1 operates two things are caused to happen. Line reference numbers next to R1 tell us to look at lines 20 and 52. Line 20 shows a set of open contacts RIA that are connected across the “well pump on” float switch, that will close when R1 is energized. These contacts serve to “override” the action of the float switch which will open when the water level starts rising. In other words RIA contacts “force” the relay R1 to remain energized even though the float switch has opened, therefore, the pump keeps filling the tank. The level will continue to rise until the upper float switch will open and turnoff the power to R1. When R1 contacts line 20 open again, it allows float switch to function normally again if called on to do so.

How could the pump have been made to run with what we have described?

It couldn’t have. The other reference number 52 tells us that R1 is doing something elsewhere. Line 52 is a mess. Involved are relays R6, R7, R14, R8, and R1 plus two selector switches, followed by R5 and M1 (motor starter).

To make a long story shorter, the object of the circuitry on line 17 is to “control” the pump being on or off by controlling R1.

By removing everything on line 52 and line 50 except for RID contacts and M1, the pump would operate and keep the water tank full with only the circuitry we have already described.

However we need to have the pump operate only on certain conditions.

The pump should run because of the following:

(a) Chlorinator motor overloaded. (R6 contacts)
(b) Pump Motor Overloaded. (R5D contacts)
(c) Low level in the Chlorine tank. (R14B contacts)
(d) Low water flow. (R7B contacts)
(e) Low water level in the well. (R8B contacts)

Any of these conditions require that we inhibit the motor control circuitry so that pump operation is not possible.
Also, we need a method of manually inhibiting, or if we choose “overriding” the control circuitry. Selector switches are the means for this (HOA).

Back at the ranch, on line 52 are inserted these inhibitors in the form of relay contacts, and selector switches in series with our controlling contacts RID.

In order for the pump to run, all the contacts and selector switches have to be closed on addition to our controlling contacts RID.

If any inhibitor circuit operates (pump overload, low flow, etc.), the circuit is opened and the pump is prevented from being turned on until condition is corrected.

Inhibitors are necessary for protection of the system.

Line 52 show R6A open contacts and line 50 shows R5D open contacts.

By examination of the circuits controlling R6 and R5 we find that the normal condition of these relays would be that they are energized. The open contacts shown would then be closed. (We always draw relay contacts as if there were no power applied to the relay- remember?)

Following this pump start circuitry to its conclusion, we will continue from where we stopped- M1 or motor starter #1.

Next M1 we have other line reference numbers.

(a) Line 56 has an auxiliary set of contacts (M1A in series with SS2 (selector switch #2), R6D and M2 (motor starter #2).

(b) Line 57 has another auxiliary set of contacts (M1B) to control the operations counter, running time meter, and green motor “run” light.

(c) Line 68 has another auxiliary set of contacts (M1C), a pilot flow switch FS1, a test switch TS7, and time delay relay TD1.

(d) Lines 101, 102, and 103 are motor starter contacts that control the well pump motor.

Providing that there are no inhibitors, and selector switches SS1 and SS2 are in “Auto”, M1 starter when operated causes several actions to occur:

1. The chlorinator pump motor starter is energized.
2. The well pump motor O.C., RTM, and run light operates.
3. Time delay relay TD1 is energized.
4. Power is applied to the well pump motor.

Besides starting our well pump, we have commanded the chlorinator motor starter to operate, the well pump indicators have been energized, and we have started a time delay in another circuit.

The last action remains to be seen.
When TD1 is energized through MIC contacts, the flow switch FS1, and closed test switch TS7, TD1 does not operate immediately as it is an “on delay” relay. This time delay relay waits to see of the flow switch will open in a reasonable length of time due to water being pumped to the tank. If there is no flow, or a restricted one that could cause harm to the pump or pump motor, TD1 actuates. TD1 references to line 70 where its contacts close causing R7 to energize.

Reference line 52 (underlined numbers refer to closed contacts) shows R7 to be an inhibitor in the pump motor circuit.

Therefore, if there is no flow or low flow, the pump will not be permitted to continue operating. Line 71 shows that R7 also lights the low flow alarm light and locks in R7 through its own contacts. Line 85 shows R7 also energizes the general alarm circuit and light.

What has just been described is the basic function the system was designated to do. The remaining circuitry is comprised of fault alarms, indicators, and inhibitors or override circuits which make up the complete system. By following the above procedure the other circuits may be analysed.