PROGRAMMABLE LOGIC CONTROLLERS

and

SUPERVISORY CONTROL and DATA ACQUISITION

A System Design for Increased Availability

A Thesis Presented to

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Master of Science

by

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The author wishes to express sincere appreciation to Dr. Dennis Irwin for his numerous consultations and perpetual courtesy. Also for the supporting efforts of the staff at Ohio Automation.

Warmest regard goes out to my Father; may he rest in peace. Also to my mother and wife for their relentless support and guidance.
ABSTRACT

The control and monitoring system presented in this thesis incorporates programmable logic controllers (PLCs) for machine level control and a supervisory control and data acquisition (SCADA) system for remote CRT displays. The given control and monitoring system design was conceived to increase the availability of the associated materials handling system for which it is applied.

The materials handling units, which incorporate the control and monitoring system described, are utilized to transport raw coal from the underground sections of Meigs Mine 31 to the surface facilities. The "availability" for the system is a term used to describe the percentage of hours in a given time (usually a production shift) that the handling system is usable to transport coal. Prior to installing PLCs and SCADA units the given materials handling system had a 62.5% average availability. With PLCs and SCADA units incorporated 70 - 75% system availability has been attained.

The main attributes of the chosen control and monitoring system are the inherent reliability of PLCs, the PLC processor-to-processor communications capabilities, and the remote CRT displays of the SCADA units.
WordPerfect 5.0 was implemented to incorporate all PLC, SCADA, and graphics along with the additional text into one document. AutoCAD was utilized to create the graphics in DXF format. The GRAPHCNV.EXE module of WordPerfect was implemented to convert the DXF graphics files to WordPerfect's graphics format. The PLC and SCADA software utilized is capable of creating the associated files in ASCII format which is directly readable into WordPerfect.
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PROGRAMMABLE LOGIC CONTROLLERS
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A System Design for Increased Availability

CHAPTER I

The control system design presented in this thesis was
developed to increase the availability of the given bulk
materials handling system. This materials handling system is
utilized to transport raw coal from the working sections of an
underground mine to the surface facilities. The mine in
question is the Meigs 31 operation of American Electric
Power's Southern Ohio Coal Company.

"Availability" is the term used to describe the amount of
time out of a total shift that the working sections of the
given mine are able to load coal onto the outbound conveyors.
By increasing the availability of the haulage system the total
production (coal output of the mine) will increase.
The control system design presented in this thesis makes use of programmable logic controller (PLC) and supervisory control and data acquisition (SCADA) hardware and software to increase the haulage system availability. The original control systems were composed of relays and hardwire designs.

Ia. Mine and Materials Handling System Layout

The mine in question was originally two separate mines, Meigs Mine 1 and Raccoon Mine 3. The raw coal from the underground sections of Mine 1 was transported to the surface facilities at "Parker Run" as depicted in Figure 1.

**Figure 1.** Mine 1 Underground Development and Haulage System Layout
The raw coal from the underground sections of Mine 3 was transported to the surface facilities at the "Raccoon Portal" as depicted in Figure 2.

![Raccoon Mine 3 Complex Diagram]

**Figure 2.** Mine 3 Underground Development and Haulage System Layout

These two mines, Mine 1 and Mine 3, were combined underground to form Mine 31 as depicted in Figure 3. As can be seen from Figure 3 there is a narrow passage where the "S. Mains" conveyor extends from the "Bunker" to the "West A" conveyor. This S. Mains conveyor is utilized to transport raw coal from the old Mine 3 to the old Mine 1. The raw coal from both the old Mine 1 and Mine 3 is then transported to the
surface facilities at Parker Run. The conveyors on the old Mine 3 side of Mine 31 from the "5 East" to the old Raccoon Portal were removed from service. The "6 East", "7 East", and "2 W. Mains" conveyors of the old Mine 3 now run in the opposite direction and carry raw coal toward the Bunker.

Figure 3. Mine 31 Underground Development and Haulage System Layout

As can be seen in Figure 3 the underground workings of this mine, Mine 31, span a ten square mile area.
Figure 4 depicts Mine 31's main line materials handling system from the West B conveyor (which services the North-West reserves) and the S. Mains conveyor (which services the South-West reserves) to the "M6 Silo".

![Diagram of Mine 31's Main Line Materials Handling System]

**Figure 4.** Mine 31's Main Line Materials Handling System

For the raw coal to be transported from the longwall section to the surface it first is loaded onto the "longwall section" conveyor (projected lengths up to 10,000 feet). The raw coal is then carried to the 5,000 foot "6 East" conveyor where it merges with the raw coal from other sections.
operating in the South-West reserves. The raw coal is then
carried by the 1,000 foot "7 east" conveyor to the 5,000 foot
"2 W. Mains" conveyor. The 2 W. Mains conveyor discharges the
cal into the underground temporary storage facility
("Bunker"). From the discharge of the Bunker the coal is
loaded onto the 5,000 foot "S. Mains" conveyor utilizing a
vibratory feeder to control the feed rate. The raw coal is
carried by the S. Mains conveyor to the 5,000 foot "West A"
conveyor where the coal merges with material from the North-
West sections. The raw coal is then carried to the 500 foot
"S. Bin" conveyor. The S. Bin conveyor carries the raw coal to
the second underground temporary storage facility, "Bin 1" and
"Bin 2". From the discharge of Bin 1 and Bin 2 the raw coal is
loaded onto the fifty foot "collecting" conveyor, again,
utilizing vibratory feeders to control the feed rate. The
collecting conveyor carries the raw coal to the 1,800 foot
"MS7" conveyor. The MS7 conveyor carries the raw coal up to
the surface on a sixteen degree slope and discharges it into
a rotating screen. The rotating screen separates the six inch
and larger material and diverts this material to a refuse bin.
The smaller raw coal flows through the screen to the 1,200
foot "M76" conveyor which in turn carries the material to the
"M6 Silo". The M6 silo is a raw coal storage facility capable
of holding at least one week's mine production.
The sections operating in the South-West reserves of Mine 31 are capable of producing raw coal at rates up to 2,000 tons per hour combined. The average production of the South-West sections is 1,200 tons per hour.

The conveyors which carry the coal to the Bunker from the South-West reserves are designed to handle 2,000 tons per hour. Since the average production from the South-West sections is 1,200 tons per hour the Bunker was incorporated to "buffer" the 2,000 tons per hour surges and then discharge onto the S. Mains conveyor at a constant rate; the West A and S. Bin conveyors will not accommodate these surges. The S. Mains conveyor was designed to handle up to 1,800 tons per hour.

The raw coal from the North-West reserves is produced at rates up to 1,000 tons per hour. The only means to regulate the rate at which the "West B" conveyor carries coal to the "West A" transfer is to control the North-West sections' production.

The West A and S. Bin conveyors are rated at 2,000 tons per hour. With the raw coal coming from both the North-West and South-West reserves the Bunker is utilized to control the total load on the West A and S. Bin conveyors. In order for
the vibratory feeder of the Bunker to be controlled appropriately the instantaneous loading on all associated conveyors must be taken into consideration.

Figure 5 depicts a belt-to-belt transfer which is typical of any of the six(6) such transfer points associated with the raw coal transportation from the longwall section. There is no surge capacity designed into the chute work of these transfer points.

![Typical Belt-to-Belt Transfer](image)

**Figure 5.** Typical Belt-to-Belt Transfer

Figure 6 depicts the Bunker with associated input conveyor (2 W. Mains), vibratory feeder, and discharge conveyor (S. Mains). This is one of the two underground
temporary storage facilities associated with transportation of the longwall section raw coal. The Bunker is capable of holding approximately one hour of mine production (2000 Tons). The overall Bunker operation is described in CHAPTER II.

![Bunker Transfer and Appurtenances](image)

**Figure 6.** Bunker Transfer and Appurtenances

Figure 7 depicts the Bin 1 and Bin 2 underground temporary storage facility with its associated input conveyor (S. Bin), vibratory feeders, and discharge conveyor (Collecting). Bin 1 and Bin 2 combined are capable of holding approximately fifteen minutes of mine production (500 Tons). The overall Bin 1/Bin 2 operation is described in CHAPTER II.
Figure 7. Bin 1 and Bin 2 Transfer and Appurtenances

Ib. Trend Toward New Controls

There were two overwhelming circumstances which mandated the need to improve the overall control capabilities of the original conveyor drives, temporary storage facilities, and vibratory feeders. First, is the fact that mine production increased from approximately 1000 tons per hour average (per mine) to over 1800 tons per hour for one mine (Mine 31). Secondly, the working sections of the mine had transversed further from the mine mouth and therefore, additional conveyors and temporary storage facilities were being added underground.
With the belt-to-belt transfers, temporary storage facilities, and vibratory feeders of Mine 31 there were numerous operating demands which were beyond the control of an economically priced relay and hardwired system. In the original materials handling system each conveyor drive and the vibratory feeders of Bin 1 and Bin 2 incorporated electromechanical relays, pneumatic timers, and hardwiring to facilitate control.

When the Bunker installation was being considered there were several discussions with the original equipment manufactures concerning the available controls. Mine management introduced several criteria which required numerous control and monitoring provisions in addition to those discussed earlier. First and foremost was the desire to have two points at which the Bunker could be controlled and monitored. One control and monitoring point was to be local to the Bunker installation. The second control and monitoring point was to be located at the head end of the S. Mains conveyor which is 5000 feet from the Bunker installation (the head of the S. Mains is where the raw coal from the South-West reserves merges onto the West A conveyo with the raw coal from the North-West reserves). These two panels were, by management's desire, to have duplicate capabilities. Figure 8 depicts the front panel layouts of the associated panels.
Figure 8. Local and Remote Bunker Control and Monitoring Panels
As can be seen from Figure 8 there are sixteen indicating lights, nine push buttons, and two selector switches on each panel. For hardwired control connections between these two panels thirty-three wires would be needed. There are also five ammeters on each panel. Shielded wiring would be required from each source (up to 9000 feet away) to drive these meters with hardwiring. The cost of thirty-six conductor cable is 5000 feet x $3.70/foot = $18,500.

With an Allen Bradley PLC 5/15 programmable logic controller (PLC) installed in each of the above panels all thirty-six wires can be replaced with one twin axial cable.¹ The cost of twin axial cable is 5000 feet x $.19/foot = $950.

Figure 9 depicts the processor connection of the two PLC 5/15s with the twin axial cable link.¹ With the PLCs and twin axial connection shown in Figure 9 the analog data required for the meters shown in Figure 8 can also be transmitted.² Electrical "noise" problems can be reduced dramatically by use of PLC-to-PLC communications.
Figure 9. PLC to PLC Communications Link
As can be seen in Figure 8 the display of motor currents for the S. Bin, West A, West B, S. Mains, and 2 W. Mains was desired at each location. The desire to have analog displays as well as additional digital information from these conveyors at the two Bunker panels introduced an advantage in installing PLCs in the starters of the S. Bin and West A conveyors in addition to the Bunker panels.

As the advantages of PLCs became apparent mine management gave their approval to utilize PLCs in the two Bunker panels as well as the S. Bin and West A starters. Therefore, the ability to exploit additional PLC capabilities was a matter of further design.

CHAPTER II outlines the chosen PLC system configuration; additional features of the PLCs which were exploited in the new bulk materials handling system control scheme are also discussed.

CHAPTER III outlines a supervisory control and data acquisition (SCADA) system design for this materials handling system. The SCADA system is utilized to create remote CRT displays.
CHAPTER IV outlines the results of modifying the given controls of this materials handling system. The increase in system availability is discussed and presented in graphic form. The availability is depicted for several months before the PLCs were used and several months with PLCs installed.

CHAPTER V outlines some additional features of the given PLC and SCADA systems which are not incorporated in the design presented in this thesis. The conclusions of this thesis are also presented in CHAPTER V.
CHAPTER II

The Allen Bradley PLC 5 family of programmable logic controllers (PLCs), as shown in Figure 9, was chosen for Mine 31's system. The processor-to-processor communication capabilities of the PLC 5s are the main reasons for utilizing these units.\(^2\) Sequence logic controllers (SLCs) and other products manufactured by Allen Bradley have proven to be extremely reliable for various applications throughout Mine 31. Product support from Allen Bradley was also more than adequate.

II a. PLC Configuration

As mentioned in CHAPTER I there are four locations where various inputs and outputs are desired for control and monitoring of Mine 31's underground main line materials handling system. The S. Bin conveyor starter, the West A conveyor starter, and the two Bunker panels were the four units mentioned in CHAPTER I. Each of these four locations will require one Allen Bradley chassis in which the input and output modules are housed.

Figure 10 depicts a standard chassis with its associated processor and I/O modules.\(^1\)\(^-\)\(^16\)
In order to incorporate all Mine 31's main line materials handling components as shown in Figure 4 two additional chassis were needed, one was for the "Bin Area" and the second was for the "Hoist House".\textsuperscript{1} The Bin Area I/O is to service the Bin 1 and Bin 2 appurtenances including the two vibratory feeders in this location. The Hoist House I/O is to service the units from the collecting conveyor to the M6 silo.

With these six individual I/O chassis installed there were three options, available with the PLC 5 units, for communicating between them.\textsuperscript{1,2}

One option was to install one PLC 5 processor, configured for "scanner" mode, in anyone of the six chassis and install 1771-ASB remote I/O adapters in place of the processor in the other five chassis.\textsuperscript{1,2} Figure 11 depicts the connection between a processor and 1771-ASB adapters; as shown the communications would be via the "REM I/O" network of the PLC processor.

The second option for communications was to install a PLC 5 processor in each of the six chassis and configure them all in scanner mode.\textsuperscript{1,2} With the six processors in scanner mode communications between the chassis would be via the "PEER COMM INTFC" network as shown in Figure 12.
Figure 11. PLC 5 Processor with 1771-ASB Adapters
Figure 13. PLC 5 Processors Communicating in Scanner Mode
Figure 13. PLC 5 Processors Communicating in Adapter Mode
The third option for communications between the six chassis was to install a PLC 5/25, configured for scanner mode, in one chassis and PLC 5/15s in the other five chassis configured for "adapter" mode.\textsuperscript{1,2} Figure 13 depicts the scanner/adapter configuration.

As can be seen in Figures 11 and 13 the communications link is via the "REM I/O" port of the given processor(s) with these PLC system configurations. As mentioned above, the configuration of Figure 12 implements the "PEER COMM INTFC".

The "REM I/O" and "PEER COMM INTFC" are two separate communications networks built into the Allen Bradley PLC 5 processors. These data links are referred to as the "remote I/O" and "data highway plus" networks, respectively, throughout the associated Allen Bradley manuals.\textsuperscript{1-16}

In Mine 31's system the desire to have stand alone capabilities for each of the six I/O chassis rules out the configuration of Figure 11.\textsuperscript{1,2} The 1771-ASB remote I/O adapters will not control the local I/O without the communication link to the associated remote processor. Therefore, if this link is severed the I/O in the chassis of the 1771-ASB adapter is rendered inoperative. The stand alone capability is crucial for Mine 31's system because of the inherent conditions of the
underground areas. There is a high probability that the twin axial cable connection of the communications link will be severed by roof falls, trolley poles, moving equipment, etc.

The PLC configurations shown in Figures 12 and 13 will each provide stand alone capabilities. With a processor installed in each chassis the given communications link can be cut and the I/O of each chassis will continue to be controlled by the associated local processor.

There is one fundamental advantage in implementing the configuration of Figure 13 over that of Figure 12.

The data highway plus network of Figure 12 is connectable, by Allen Bradley design, to a host of RS-232C communication devices including PLC programming terminals, data loggers, supervisory control and data acquisition (SCADA) systems, etc.1 CHAPTER III discusses connection of a SCADA system to the data highway plus.15

The remote I/O network, on the other hand, excludes connection to any units other than 1771-ASB remote I/O adapters, PLC 5s configured for adapter mode, and a few other "passive" Allen Bradley devices.1
Each network, the remote I/O and data highway plus, utilizes a token passing protocol for communications. Each device attached to the given network receives and shares a common "token" bit. This token is passed around to each device on the network, one unit holds it at a given time, to obtain structured communications. The unit holding the token performs its programmed data transfer (communications) then passes the token on.

With the data highway plus network open to the various PLC programmers, SCADA units, and other RS-232C "active" devices the token of this network is shared with, and held by, these units which can dominate the tokens overall time. In other words the PLC processor-to-processor communications is held up for lengthy periods of time when the data highway plus network is implemented (i.e. when the processors are all configured for scanner mode). This is unacceptable for control data transfer.

When the one processor is configured for scanner mode and the other five are configured for adapter mode the PLC processor-to-processor communication is performed utilizing the remote I/O network. Therefore, the PLC configuration of Figure 13 is implemented for Mine 31's system.
Figure 14 depicts the chosen PLC processor configuration with the S. Bin's processor set for scanner mode and the other five processors operating in adapter mode.

![Diagram of PLC system configuration]

**Figure 14.** Mine 31's PLC System Configuration

The PLC adapter mode configuration has an additional feature which is exploited in Mine 31's system. With the configurations of Figures 11 and 12 the block transfer read (BTR) and block transfer write (BTW) instructions of the Allen Bradley PLC 5 programming software are required for all data transfer, both analog and digital, between chassis. With the adapter mode configuration, Figure 13, the "rack 3" I/O
image table of each adapter mode processor is available for direct digital data transfer between processors. This concept is discussed throughout this chapter. Basically, this direct digital data transfer is exploited for control. This direct digital data transfer is performed at extremely high rates, thereby providing immediate control response.

In order to allow each of the six processors incorporated in this system to pass information to one another and to their respective I/O a series of hardware configuration steps must first be completed.\(^1\) Figure 15 is a chart which depicts the dip switch settings for all six chassis and processors.

![Dip Switch Settings Chart](image-url)

**Figure 15.** Dip Switch Settings for All Six Chassis and Processors
There are four sets of dip switches associated with the configuration process of each of the six Allen Bradley PLC 5 chassis and associated processor incorporated in Mine 31's system. Three sets of these switches (designated "switch assembly 1", "switch assembly 2", and "switch assembly 3") are located on each processor module. The fourth switch assembly depicted in Figure 15 is located on the chassis backplane.

Switch assembly 1 located on each processor sets the data highway plus address (from 00 to 77) of the given unit. Switch assembly 2 located on each processor sets the remote I/O address of the given unit (those in adapter mode). Since the S. Bin processor is in scanner mode switch assembly 2 is not used; this processor is automatically addressed by the adapter mode processors as "rack 3" (this is discussed in detail throughout this chapter). Switch assembly 3 located on each processor sets the built in end of line terminating resistor of the given units data highway plus and remote I/O trunks; these switches are on for the "hoist House" and "Bunker" processors only.¹

The chassis backplane switch assembly is utilized to set the unit for half, single, or two slot addressing (single slot addressing is used exclusively in this system design). This
backplane switch assembly is also utilized to set EEPROM and processor memory and fault action. Once the above hardware configuration is established the additional processor-to-processor and processor-to-I/O module communication is facilitated via the associated processor program.

Allen Bradley 6200 Series software was utilized to produce the six processor programs. These six programs are included in Appendices A - F. The following sections of this CHAPTER explain, with pseudo code and pictorials, the function of each processor and its associated program as well as the 6200 series programming software.

II b. Hoist House PLC

The "Hoist House" PLC was incorporated as a data acquisition unit for the M76 conveyor, the rotary breaker, the MS7 conveyor, the collection conveyor, and the status of the two vibratory feeders in the Bin 1 and Bin 2 installation.

This chassis was installed in the main control panel of the "Hoist House" which houses the control relays associated with the given materials handling units. This PLC was not designed to control any of the given units. As depicted on the wiring diagram for this PLC in Appendix A, the run/no run status for the units mentioned above is provided via a
"normally open" contact driving a given PLC input. When the respective contact closes, 120Vac is applied to the associated input module channel, in turn the particular input is rendered "true" (energized state of "1").

Figure 16. Typical PLC Digital Input

Figure 16 represents a pseudo ladder type branch ("rung") from the associated processor program for input of the given digital information. Refer to Appendix A for the actual wiring diagram and PLC program of the Hoist House processor.

In order to obtain the associated analog information of the given motor drive currents a number of components are required. Figure 17 is a sketch of the required devices.

Figure 17. Typical Drive Motor Current PLC Input
The current transformer scales the actual drive motor current to a 0 - 5Aac value.

**EXAMPLE:**

Actual drive motor current = 100A \textbf{max}

current transformer ratio = 100/5

>>> Transducer input = 100 * 5/100 = 5A \textbf{max}

The AC/DC transducer converts the 0 - 5Aac current to a 4 - 20mA \textit{dc} value. This transformation is required for the Allen Bradley analog input modules (i.e. these modules accept either DC mA or low voltage DC as inputs).\textsuperscript{11-14}

The following code (Figures 18a and 18b) represents the rungs required in the associated processor program to move the data from the analog input module to a given data file in the local processor:\textsuperscript{2}

```
N10:1
|-----------------|-----------------|----------------|
| 15              | BTW--------------| BLOCK TRNDFR WRITE
|                 | RACK 0           | (EN)---
|                 | GROUP 6          | (DN)---
|                 | MODULE 0         | ---
|                 | CONTROL BLOCK N10:1 | (ER)---
|                 | DATA FILE N10:100 | ---
|                 | LENGTH 37        | ---
|                 | CONTINUOUS N     | ---
```

**Figure 18a.** PLC Processor-to-Analog Module Communications
Figure 18b. PLC Processor-to-Analog Module Communications

The block transfer write (BTW) statement is used to write to the analog input module the desired configuration. This configuration is contained in the given block of "data file" elements. This configuration tells the module how you want the analog to digital (A/D) data conversion to be scaled. In Mine 31's system the analog values (4 - 20mAdc) are scaled to 0 - 4095 digital and stored in integer elements of the associated processor (integer elements are preceded with N as shown above). The block transfer read (BTR) statement is utilized to read the scaled digital information from the analog input module and to obtain status information from the module itself.

Each element of the given data file associated with a PLC 5 processor is a sixteen bit "word". The "length" which is specified in the BTR and BTW statements defines the number
of words in the given data file. The address shown at the "data file" entry is the first word of the file. Entering "1" or "0" in each bit of every word has a specific meaning to the analog module.11-14

The "rack", "group", and "module" entries define to the processor the location of the given module. The "control block" is one word of the processor data file utilized to store various status information for the associated analog module. The "enable" bit of this word is utilized to interlock the BTR and BTW statements, as shown in Appendix A, to prevent a second instruction processing if it is already "enabled".

II c. Bin Area PLC

The "Bin Area" PLC was incorporated into Mine 31's materials handling system for control and monitoring of the raw coal levels in Bin 1 and Bin 2.

As mentioned in CHAPTER I the S. Bin conveyor carries raw coal to the Bin 1 and Bin 2 temporary storage facility at an average rate of 1800 tons per hour.

Originally a partition between Bin 1 and Bin 2 existed. This partition was removed to allow raw coal to flow from the discharge of the S. Bin conveyor into both bins. The bottom
of each bin was not modified, therefore, each bin presently funnels raw coal to a particular vibratory feeder as shown in Figure 7. The capacity of Bin 1 and Bin 2, total, is 500 tons (approximately fifteen minutes of mine production). Each vibratory feeder is capable of discharging raw coal at a rate of 1200 tons per hour maximum and 400 tons per hour minimum.

In order to minimize wear on the chute work of the bins it is desirable to leave approximately fifty tons of raw coal in the discharge chutes of each bin. To allow for automatic feeder starting and stopping, level sensing instruments were installed on each bin. Figure 19 depicts the hardware utilized to obtain Bin 1 and Bin 2 levels for PLC inputs.

![Figure 19. Bin 1 and Bin 2 Level Sensing Equipment](image)

The Miltronic Air Ranger unit is a dual channel device which utilizes ultra sonic technology to sense the elevation
of material in a given installation. The detected level(s) are converted to 4 - 20mA dc signal(s), proportional to level, which are compatible with the Allen Bradley analog input modules.

Each vibratory feeder is capable of discharging coal at 1200 tons per hour. This rate is variable via a variable transformer which drives a "high slip" induction motor. Each transformer was manually set to drive the associated vibratory feeder at a 950 tons per hour discharge rate. At these rates the two vibratory feeders, together, discharge raw coal faster than the 1800 tons per hour input to the Bins.

The following rung (Figure 20) is a pseudo code representation of two "less than" (LES) statements, two "greater than" (GRT) statements, an auxiliary output contact, and output which is used to control the given vibratory feeders:

![Figure 20. Automatic Feeder On/Off PLC Control](image-url)
First both MS7 drive motor currents have to be below forty amperes for the two "LES" instructions to be true (section IIg explains the method used to transfer this analog data from the Hoist House processor).² If the bin level rises above fifty tons the first "GRT" instruction goes true and the output stays deenergized. If the bin level rises above 75 tons the second "GRT" instruction goes true and the output is energized, in turn the "output aux" contact closes. With this auxiliary contact now "shorting" out the second "GRT" statement, the bin level will have to fall below fifty tons or one of the MS7 drive motor currents will have to go above forty amperes before the output is deenergized. The use of the "output aux" in this manner provides a differential level to prevent jogging the feeder on and off [i.e. if the second "GTR" instruction was omitted the bin level could go just above fifty tons (turn the feeder on) then the input feed to the bin diminish, the level would immediately fall below fifty tons, and the feeder would shut off]. The resulting operation is essentially a hysteresis effect as shown in Figure 21.

![Figure 21. Hysteresis Effect of Feeder Control](image-url)
The analog inputs are manipulated with the BTR and BTW instructions as described in SECTION II b. The actual wiring diagram and processor program for the Bin Area PLC are included in Appendix B.

II d. S. Bin and West A PLCs

The PLCs were installed in the S. Bin and West A conveyor starters to provide all control and data acquisition for these units. In Mine 31's system a conveyor starter is utilized to start and stop the drive motors of the given conveyor. The S. Bin conveyor has one 250 horsepower drive motor and the West A conveyor has two 300 horsepower drive motors; These motors are squirrel cage induction motors. The associated starters are full voltage non-reversing with Toshiba vacuum contactors for line connection.

There are several safety and control devices wired as inputs to the PLCs. The following rung (Figure 22) is a pseudo code representation of a branch in the associated processor program which turns the line starter(s) on and off:

```
COVEYOR REMOTE BELT HYDRAULIC FIRE CST
START AUX LINE INPUT SLIP AUX TAKEUP AUX DET AUX OT AUX
---] [--------] [--------] [--------] [--------] [-

GOG OUT OUTPUT INPUT TO LINE STARTER
-----] [-------( )---
```

*Figure 22. PLC Line Starter Control*
The "conveyor start aux" is an auxiliary contact from a branch in the given processor program which provides for manual and automatic conveyor operation. The manual operation defeats the "sequence" input of the unit ahead of the given conveyor. Figure 23 is a pseudo code representation of the "conveyor start aux" branch circuit. The conveyor automatic and manual selector switch has a third position for conveyor "off" selection.

![Figure 23. PLC "Conveyor Start Aux" Circuit](image)

The "sequence input" for each conveyor makes use of the adapter mode direct digital data transfer capability. The S. Bin conveyor is sequenced from the level in Bin 1 and Bin 2. If the level is 100%, the S. Bin conveyor is automatically shut off. Since the West A conveyor is in sequence with the S. Bin conveyor it also shuts off. The following pseudo code (Figure 24) represents the rungs required for the sequence to be passed between the given processors (this code represents conveyor to conveyor interlocks):
<table>
<thead>
<tr>
<th>Adapter Mode Processor</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAWKEYE</td>
</tr>
<tr>
<td>DRIVE MOTOR</td>
</tr>
<tr>
<td>INPUT</td>
</tr>
<tr>
<td>AUX CONTACT</td>
</tr>
<tr>
<td>SEQUENCE TO RACK 3</td>
</tr>
<tr>
<td>OUTPUT IMAGE TABLE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final Sequence Associated</th>
</tr>
</thead>
<tbody>
<tr>
<td>With the Above Master Processor</td>
</tr>
<tr>
<td>Output Image Table Reflected</td>
</tr>
<tr>
<td>To This Adapter Mode Processor's</td>
</tr>
<tr>
<td>Input Image Table</td>
</tr>
</tbody>
</table>

---

**Figure 24.** PLC Adapter Mode Conveyor Sequencing

The first rung is in the adapter mode processor and it moves the desired sequence bit to an arbitrary rack three output image table bit address. This bit automatically (directly) appears in the master(scanner mode) processor's input image table with the rack address associated with the sending adapter mode processor (these addresses are depicted in Figure 16). The second rung is in the master processor and is used to transfer the associated bit from the input image table to the output image table which corresponds with the desired recipient of this bit (i.e. the adapter mode processor which requires the sequence information). The third rung is
finally in the sequenced processor's program and is utilized as described above for the "conveyor start aux" branch (this direct digital data transfer is described in detail in SECTION IIf).

With the "Hawkeye Input" and "drive motor aux contacts" from the lead conveyor in series with the sequence signal to the sequenced conveyor this branch performs a valuable function. The lead conveyor, on startup, will not signal for the sequenced conveyor to start until this lead conveyor is up to full speed (i.e. both the drive motor aux contacts and the hawkeye input close). This "delayed" start of the sequenced conveyor is provided by the hawkeye unit requiring detection of full speed motion of the lead conveyor prior to energizing the given sequence input. This is important because if the sequenced conveyor were to start prior to the lead conveyor reaching full speed the transfer point has the potential of being overloaded ("gobbled out").

The lead conveyor, on shut down, will signal the sequenced conveyor to shut down immediately when this lead conveyor drive motor aux contacts open. Therefore, the two conveyors will coast to a stop simultaneously. This is also important because if the sequenced conveyor kept running until the hawkeye input of the lead conveyor were to signal it to
stop this sequenced conveyor would run longer than the lead conveyor, overloading the transfer point.

Prior to utilizing PLCs the sequencing described above was only possible if a "hardwired" circuit were installed from the lead conveyor's drive motor(s) auxiliary contact(s) and from the hawkeye.

The use of PLCs, configured as in Figure 13, allows all this information to be transmitted over the remote I/O network (single twin axial cable). By sending this sequencing information to all PLC units shown in Figure 14 all conveyors can be started via the respective lead conveyor and stopped via the S. Bin conveyor's motor auxiliary contacts. This method immediately deenergizes all conveyors, from the West B and S. Mains to the West A, in the event the S. Bin conveyor is shut off.

The "remote line" input as shown in Figure 22 requires no auxiliary circuit for its operation. This input is actually a group of switches which are installed along the given conveyor. All the given switches are wired, with normally closed contacts in each, in series to the one remote line
input. The given conveyor can be stopped by opening any one of these switches. The conveyor is restarted when the switch is reclosed.

The "belt slip aux" is for conveyor protection against slippage of the conveyor belt on the drive pulley(s). Figure 25 depicts the hardware utilized for belt slip detection.

![Diagram of belt slip hardware]

**Figure 25. Typical Belt Slip Hardware**

Figure 26 is a pseudo code representation of the "belt slip aux" branch in the associated processor program. As shown this circuit makes use of the "reset" and "belt slip" inputs. The timer and auxiliary coil are internal devices of the given PLC.
Figure 26. PLC Belt Slip Auxiliary Circuit

The "belt slip aux" circuit normally maintains the "belt slip aux coil" in an energized state. The branch with the timer's contact and the belt slip auxiliary contact keeps the belt slip auxiliary coil energized when the conveyor drive motors are off and the conveyor is not moving. When the drive motor(s) start and the line starter auxiliary contacts initiate the timer, the conveyor is coming up to full speed. If the timer times out before the "belt slip input" closes, the drive motors will be shut off via the belt slip auxiliary contact(i.e. indicating the conveyor belt did not move when the drive pulley was). If the "hawkeye belt slip detector" senses conveyor belt movement the associated belt slip input closes and maintains the belt slip auxiliary coil energized. The reset input is for resetting this circuit, if tripped.
The "hydraulic takeup aux", "fire detection aux" and "CST OT aux" circuits, as shown in Figure 22, are as indicated in Figure 27.

```
_INPUT_ [--------------] [------------------( )----------]
          [RESET] [-----]

AUX COIL
```

**Figure 27. Typical PLC "Latching" Circuit**

The circuit of Figure 27 provides a "latching" operation for the given input. In other words if the given input trips the reset has to be closed(pushed) before the conveyor will restart.

The "gobout input" of Figure 22, like the remote line input, requires no auxiliary circuit for desired operation. If either of these two inputs is opened the drive motors are shut off. When the given input again closes the conveyor will automatically restart(i.e. no reset is required).

The desired analog data is input as described in SECTION IIa. This analog data is sent via the remote I/O network to the two Bunker control and monitoring panels utilizing BTR and BTW instructions as described in SECTION IIg.
The PLC wiring diagrams and processor programs for the S. Bin and West A conveyors are included in Appendices C and D, respectively. A description of operation for the controlled start transmission (CST) for these conveyors is given in CHAPTER V with a recommended improvement included.

II e. **Bunker Control and Monitoring Panels' PLCs**

As mentioned in CHAPTER I, the initial trend toward the use of PLCs was to facilitate the two (duplicate) control and monitoring panels for the Bunker.

In addition to Bunker control and monitoring the panel located at the head end of the S. Mains conveyor provides control and data acquisition facilities for the West B and S. Mains conveyor starters. The panel at the Bunker location includes control and data acquisition for the 2 W. Mains conveyor starter. The main function of these two panels is to allow control and monitoring of the Bunker from either the Bunker or from the head end of the S. Mains conveyor.

The Bunker is essentially a set of rail road cars which are moved back and forth over a given discharge point as shown in Figure 6. When moved away from the 2 W. Mains conveyor the bottom of the cars are sealed with a moving belt. As the cars move past the transfer, away from the 2 W. Mains conveyor,
they store coal. When they move toward the 2 W. Mains conveyor the raw coal is discharged from the cars into the associated vibratory feeder.

There are five major components which actually control the raw coal level in the Bunker; there are two capacitance probes which sense raw coal level at the transfer point (head of the 2 W. Mains conveyor), a hydraulic pack which moves the Bunker cars from end to end, a vibratory feeder to control the Bunker discharge rate, and a scale on the tail of the S. Mains conveyor to provide "feed back" for control of the vibratory feeder.

One of the capacitance probes is installed near the top of the Bunker transfer chute work. The second capacitance probe is installed near the bottom of this chute work. If raw coal piles up in the chute and triggers the upper capacitance probe the hydraulic pack is signalled to move the Bunker cars away from the 2 W. Mains conveyor and raw coal is stored. If raw coal is covering the bottom capacitance probe but is feeding out as fast as it comes in off the 2 W. Mains conveyor the top probe remains uncovered, therefore, the Bunker cars remain stationary. If the raw coal feed out of the vibratory feeder exceeds the 2 W. Mains input the bottom capacitance probe will detect no coal around it and will trigger the
hydraulic pack to move the Bunker cars toward the 2 W. Mains conveyor, thereby, emptying the cars. The Bunker cars are equipped with magnetic switches to indicate the position of the cars to the PLC; this prevents the cars from over traveling on either end. If the Bunker becomes full and the raw coal is on the upper capacitance probe the 2 W. Mains conveyor is automatically turned off. If the Bunker becomes empty and the bottom capacitance probe detects no raw coal, the vibratory feeder is automatically turned off. The two Bunker panels are equipped with manual controls to operate the hydraulic pack and feeder independent of the capacitance probes.

Figure 28 depicts a block diagram for the automatic control of the Bunker's vibratory feeder discharge rate.²

![Figure 28. Block Diagram for Vibratory Feeder Discharge Control]
The discharge of the Bunker, as mentioned in CHAPTER I, is the raw coal "regulator" to the West A conveyor. With various sizes of raw coal with varying moisture content transferred through the Bunker it is necessary to adjust the feed rate of the vibratory feeder continually in order to maintain a constant discharge rate.

The proportional, integral, derivative (PID) instruction of the PLC 5 processor is perfectly suited for the purpose of the above mentioned control. The PID instruction compares an input (process variable), in this case the scale reading, to a given set point (desired tonnage in this case) and adjusts an output (control variable) to obtain the desired process variable.\(^2\) In this case the control variable is the feed rate signal to the feeder.

The feeder drive in the Bunker system implements a SCR controlled variable voltage source to adjust the speed of a "high slip" induction motor. The SCR controller accepts a 4 - 20mA signal for speed control and adjusts its voltage output to the feeder proportionally.

The Milltronics belt scale installed on the S. Mains conveyor provides a 4 - 20mA output, proportional to tonnage, as input to the PLC. Because both the input (process variable)
and output (control variable) are 4 - 20mA, the BTR and BTW statements can be used as described in SECTION IIb to communicate with the analog modules. SECTION IIh fully defines the associated parameters of the PID instruction and describes the parameters used for the Bunker vibratory feeder control. Appendices E and F contain the wiring diagram and processor program for the Bunker Panel 1 (S. Mains head unit) and Bunker Panel 2, respectively.

II f. Digital Data Transfer Between Processors

As mentioned in CHAPTER I there is a direct digital transfer capability of the chosen PLC configuration which is extremely useful in Mine 31's system. This direct digital data transfer facility is utilized in Mine 31's system whenever digital data input to one I/O chassis module is needed at a second chassis. The operation of the two Bunker Panels fully exploits this feature. An example of the rungs required for transferring a given "bit" of information from one Bunker panel to the other is given.

Our example is "Rung 2:0", the first rung of the "S. Mains PLC" (Bunker Panel 1) processor program. The "S. Mains Remote Line Input" is wired to a digital input module which is located in the left most slot of the given I/O chassis (refer to Appendix E). The address of this given input is
"I:000/02". A normally open contact of this input drives an output with address "O:030/02". The rack number, number 3, is the significant part of this address. As mentioned in CHAPTER I, the rack 3 I/O image tables of the adapter mode processors automatically transfer to the scanner mode(Master) processor of the PLC system; for Mine 31's system the master processor is the S. Bin's. An explanation of the associated input and output addresses used in "Rung 2:0"² are shown in Figure 29.

**Figure 29.** Typical PLC Adapter Mode Data Transfer
As can be seen, the arbitrary entries of the adapter transfer address were chosen to match the associated input address; this facilitates ease of following the processor programs. The above output bit "O:030/02" automatically appears in the S. Bin's processor input image table at address "I:050/02". The "5" reflects the fact that the S. Mains PLC (Bunker panel 1) processor is set for address number 5 on Mine 31's system remote I/O network (refer to Figure 15). Notice the rack 3 bit is transposed to rack 5 transparently to any program.

In "Rung 2:58" of the S. Bin's processor program (Appendix C) input image table bit, I:050/02, is transferred to the associated processor's output image table bit address "O:060/02" (the "6" is due to the fact that the Bunker processor is set for remote I/O network address 6). This output bit is automatically transferred to the input image table of the Bunker processor, address "I:030/02".

As can be seen in the Bunker's processor program (Appendix F) "Rung 2:45" this bit, I:030/02, finally is used to turn on and off a light which indicates whether or not S. Mains conveyor's remote line is OK. This digital data transfer method, although program intensive, is extremely fast.
II g. Analog Data Transfer Between Processors

In SECTION IIb the BTW and BTR statements which are required to transfer data from an analog input module to the given processor were shown Figure 18. These same instructions are utilized to transfer analog data between processors. Figure 30 is an example of both a BTR and BTW instruction which are included in the S. Bin's processor program.

<table>
<thead>
<tr>
<th>N30:5</th>
<th>BTW-----------------------------</th>
<th>(EN)---</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BLOCK TRNDFR WRITE</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>RACK 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GROUP 0</td>
<td>(DN)---</td>
</tr>
<tr>
<td></td>
<td>MODULE 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CONTROL BLOCK N30:5</td>
<td>(ER)---</td>
</tr>
<tr>
<td></td>
<td>DATA FILE N50:154</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LENGTH 8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CONTINUOUS N</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N30:6</th>
<th>BTR-----------------------------</th>
<th>(EN)---</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BLOCK TRNDFR READ</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>RACK 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GROUP 0</td>
<td>(DN)---</td>
</tr>
<tr>
<td></td>
<td>MODULE 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CONTROL BLOCK N30:6</td>
<td>(ER)---</td>
</tr>
<tr>
<td></td>
<td>DATA FILE N50:154</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LENGTH 8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CONTINUOUS N</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 30.** PLC Instructions to Transfer Analog Data Between Processors
The BTR instruction reads the given "analog" data file from the S. Mains' (Bunker panel 1) processor "Rack 5". This analog data is stored in the same elements of the S. Bin's processor as was the case in the S. Mains' processor (elements specified by the "data file" and "length" entries). The BTW instruction writes this analog data to the Bunker processor "Rack 6". Again the transfer is to and from the same data file elements.

The BTR instruction in the S. Bin's processor program could have been replaced with the following rung, Figure 31, inserted in the S. Mains' (Bunker panel 1) processor:²

```
N50:5
[--------------------------]
15
--------------------------
BTW-------------------------(EN)---
BLOCK TRNDFR WRITE
RACK 3
GROUP 0-(DN)---
MODULE 0
CONTROL BLOCK N50:5-(ER)---
DATA FILE N50:154
LENGTH 8
CONTINUOUS N
```

**Figure 31.** Alternate to Figure 30 BTR Instruction

The above BTW instruction would write the analog data from the S. Mains' processor to the S. Bin's processor, which is "Rack 3" to the adapter mode processor. Similarly, the BTR
instruction of the S. Bin's processor program could be replaced by inserting the following rung, Figure 32, in the Bunker processor: The above BTR instruction would read the analog data from the S. Bin's processor to the Bunker processor.

```
N60:5     BTR-------------
15        BLOCK TRNDFR READ EN
          RACK 3
          GROUP 0 DN
          MODULE 0
          CONTROL BLOCK N60:5 ER
          DATA FILE N50:154
          LENGTH 8
          CONTINUOUS N
```

**Figure 32.** Alternate to Figure 30 BTW Instruction

For Mine 31's system the BTW and BTR instructions used to transfer data between processors are all written in the S. Bin's processor program; this approach simplifies following the given data transfers. Table 1 depicts the analog file structure for Mine 31's PLC system.
<table>
<thead>
<tr>
<th>PROCESSOR</th>
<th>ANALOG INPUTS</th>
<th>ANALOG OUTPUTS</th>
<th>DATA RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUNKER</td>
<td>N60:154-N60:161</td>
<td>N60:200-N60:203</td>
<td>0 - 4095</td>
</tr>
</tbody>
</table>

This file structure allocates eight data file elements for inputs and four data file elements for outputs to each processor; this configuration is sufficient for one analog input module and one analog output module per chassis.

As can be seen from Table 1 and Figure 15, the data file elements relate to the given processors' data highway plus address (N1.., N2.., etc). Looking at the BTR and BTW instructions in the preceding sections of this CHAPTER the reader can see which elements of the data files are for actual input data and which are for module configuration.

II h. **PID Instruction**

Figure 33 depicts the PID instruction of the Allen Bradley PLC 5 programming software.
Figure 33. Typical PLC PID Instruction

The PLC 5 PID equation is programmable in one of two ways. Equation 1 is the ISA equation with dependent gain terms.

**EQUATION 1:**

\[ CV = K_e \left| E + \frac{1}{T_i} \int_0^t E \, dt + T_o \frac{E-E(n-1)}{dt} \right| + \text{Bias} \]

**WHERE:**

- \( CV \) = output
- \( K_e \) = controller gain constant (unitless)
- \( T_i \) = reset gain constant (minutes per repeat)
- \( T_o \) = rate gain constant (minutes)
- \( dt \) = time between samples (minutes)
- Bias = feed forward or output bias
- \( E \) = error equal to \((PV - SP)\) or \((SP - PV)\)

The second form of the PLC 5 PID equation, Equation 2, is the independent gains equation. This equation is much more flexible as far as tuning the PID loop.
EQUATION 2:

\[ CV = K_p E + K_i \int_0^t E dt + K_d [E - E(n-1)]/dt + BIAS \]

WHERE:

- CV = output
- \( K_p \) = proportional gain constant (unitless)
- \( K_i \) = integral gain constant (1/sec)
- \( K_d \) = derivative gain constant (sec)
- \( dt \) = time between samples (sec)
- Bias = feedforward or constant bias
- \( E \) = error equal to (PV - SP) or (SP - PV)
- \( E(n-1) \) = error from last sample
- PV = process variable
- \( PV(n-1) \) = process variable from last sample

In Mine 31's system the independent gains equation, Equation 2, is implemented for vibratory feeder control as mentioned in SECTION IIf.

Twenty-six "words" of the processor's data file are needed to configure the PID instruction and to manipulate the associated parameters (namely the set point, process variable, and control variable). For the Bunker's vibratory feeder words N60:175 through N60:197 are allocated for the PID instruction configuration and words N60:154, N60:200, and N60:198 are utilized for the process variable, control variable, and tie back, respectively; Figure 34 outlines the use of each word.
Word "0"
(N60:175)
Enable (EN)
Done (DN)
Set point out of range
Output alarm, lower limit
Output alarm, upper limit
DB, set when error is in DB

<table>
<thead>
<tr>
<th>Word</th>
<th>Description</th>
<th>Term</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(N60:176)</td>
<td>RESERVED for future use</td>
<td>SP</td>
<td>0 - 4095</td>
</tr>
<tr>
<td>2(N60:177)</td>
<td>SETPOINT (unscaled)</td>
<td>SP</td>
<td>0 - 4095</td>
</tr>
<tr>
<td></td>
<td>SETPOINT (scaled engineering units)</td>
<td>Smin - Smax</td>
<td></td>
</tr>
<tr>
<td>3(N60:178)</td>
<td>PROPORTIONAL GAIN unitless</td>
<td>Kp</td>
<td>0 - 327.67</td>
</tr>
<tr>
<td>4(N60:179)</td>
<td>INTEGRAL GAIN (1/sec)</td>
<td>Ki</td>
<td>0 - 32.767</td>
</tr>
<tr>
<td>5(N60:180)</td>
<td>DERIVATIVE GAIN (sec)</td>
<td>Kd</td>
<td>0 - 32.767</td>
</tr>
<tr>
<td>6(N60:181)</td>
<td>FEEDFORWARD or BIAS</td>
<td>FF/Bias</td>
<td>0 - 4095</td>
</tr>
<tr>
<td>7(N60:182)</td>
<td>MAX SCALING</td>
<td>Smax</td>
<td>-32,768 to +32,767</td>
</tr>
<tr>
<td>8(N60:183)</td>
<td>MIN SCALING</td>
<td>Smin</td>
<td>-32,768 to +32,767</td>
</tr>
<tr>
<td>9(N60:184)</td>
<td>DEADBAND (unscaled)</td>
<td>DB</td>
<td>0 - 4095</td>
</tr>
<tr>
<td></td>
<td>DEADBAND (scaled engineering units)</td>
<td>Smin - Smax</td>
<td></td>
</tr>
<tr>
<td>10(N60:185)</td>
<td>SET OUTPUT</td>
<td>SETOUT</td>
<td>0-100%</td>
</tr>
<tr>
<td>11(N60:186)</td>
<td>MAX OUTPUT LIMIT (% of output)</td>
<td>Lmax</td>
<td>0-100%</td>
</tr>
<tr>
<td>12(N60:187)</td>
<td>MIN OUTPUT LIMIT (% of output)</td>
<td>Lmin</td>
<td>0-100%</td>
</tr>
<tr>
<td>13(N60:188)</td>
<td>LOOP UPDATE TIME (sec)</td>
<td>dt</td>
<td>.01-327.67</td>
</tr>
<tr>
<td>14(N60:189)</td>
<td>SCALED PV VALUE (displayed)</td>
<td>CV</td>
<td>Smin - Smax</td>
</tr>
<tr>
<td>15(N60:190)</td>
<td>SCALED ERROR VALUE (displayed)</td>
<td>CV</td>
<td>Smin - Smax</td>
</tr>
<tr>
<td>16(N60:191)</td>
<td>OUTPUT (% OF 4095)</td>
<td>CV</td>
<td>0-100%</td>
</tr>
<tr>
<td>17-20</td>
<td>INTERNAL STORAGE (Do not manipulate)</td>
<td>CV</td>
<td>0-100%</td>
</tr>
</tbody>
</table>

(N60:192-N60:197)

Figure 34. PID Data Elements

The above listing, Figure 34, depicts a "range" for the given entries of the PID equation. The following pictorial, Figure 35, is a representation of the screen which appears
when the PID instruction is being monitored and/or edited; the actual values used for the Bunker's vibratory feeder control are shown.

| equation: | 1 (0:AB/1:ISA) | feed forward: | 0 |
| mode: | 0 (0:auto/1:manual) | max scaled input: | 100 |
| error: | 0 (0:SP-PV/1:PV-SP) | min scaled input: | 0 |
| output limiting: | 0 (0:NO/1:YES) | deadband: | 3 |
| set output mode: | 0 (0:NO/1:YES) | set output value %: | 0 |
| deriv input: | 0 (0:PV/1:error) | upper CV limit %: | 100 |
| deadband status: | 0 | lower CV limit %: | 0 |
| up CV lim alarm: | 1 | scaled PV value: | 30 |
| low CV lim alar: | 0 | scaled error: | 5 |
| setp out range: | 0 | current CV %: | 56 |
| PID done: | 1 | setpoint: | 60 |
| PID enabled: | 1 | proportional gain constant (K_p) [.01]: | 100 |
| | | integral gain constant (K_i) [.01]: | 30 |
| | | derivative gain constant (K_d) [.01]: | 45 |
| | | loop update time [.01]: | 20 |

Enter value or press <ESC> to exit monitor.
N60:177 =
remote prog no forces dec dat decimal addr PLC-5/15 Addr

**Figure 35.** Bunker's Vibratory Feeder PID Control Configuration

The "scaled PV value", "scaled error", and "current CV" as shown in Figure 35 will change as the PID instruction executes (i.e. the values shown are instantaneous values). The "setpoint" entry reflects the fact that the desired vibratory
feeder output is 60% of the 2000 ton per hour maximum of the given feeder, or 1200 tons per hour.

The proportional, integral, and derivative gain constants are the entries which control the PID equation's ability to drive the control variable to obtain the given setpoint. Manipulation of the three gain constants is referred to as "tuning" the given PID equation. There are several reference guides to tuning PID loops. In the case of the Bunker's vibratory feeder the gain constants were manipulated on line(i.e. interactively while the PID instruction was executing). This method provides immediate results. In other words the PLC programmer changes a given parameter and observes the process variables reaction to see if it stays close to the setpoint. This method works in this case because the raw coal discharge from the given feeder does not vary at a high rate.

The PID loop of the Bunker's vibratory feeder control was tuned empirically. The individual gain values were manipulated one at a time and the feeder discharge rate (the scale reading was observed). When the scale reading began to stabilize the given gain values were stored in the processor's data file. There was a bit of a trade off in stabilizing the scale reading and stabilizing the feeder (i.e. the feeder was
continually speeding up and slowing down if the scale was maintained at too close of a tolerance). The net result was to allow the scale reading (feeder discharge) to vary by +/- 4%.

II i. 6200 Series Software

The 6200 Series software developed by Allen Bradley was utilized to create all six of the processor programs for Mine 31's system.

As mentioned in SECTION IIa, once the hardware configuration and dip switch settings are complete, the subsequent PLC system operation is dictated by the processor program(s). These processor programs determine the means by which the individual processor(s) communicate with their I/O modules as well as other processors.

Processor to I/O module communication is fairly straightforward for most all PLC systems. The processor-to-processor communications, on the other hand, can be extremely tedious. With the Allen Bradley 6200 Series software and the PLC 5 family of processors even the processor-to-processor communications is well defined. The programmer of the Allen Bradley PLC 5 processors needs to know the processor addresses (dip switch settings), the data file structure, and
the BTR, BTW, or MSG commands. The remaining data transfer structure is inclusive in the 5's protocol. In other words the programmer does not have to be concerned with the microscopic details of data transfer, such as the network commands.

A reader familiar with systems such as OPTO 22's LC4s would be overwhelmed by the complexity involved in sharing data between processors, especially with more than two(2) processors as in Mine 31's system. The network open commands, data transfer protocol, data validity checks, network close commands, network token passing, processor "hand shaking", etc. with OPTO 22's LC4s are all a part of the written program. With Allen Bradley's PLC 5s and 6200 Series software, the intricacies of the data transfer structure between processors is transparent to the programmer. The individual tasks from the network open command to the token passing are inherent in the BTR, BTW, and MSG statements. The programmer of the Allen Bradley PLC 5s inserts a rung in the processor program, such as those shown in SECTION IIg, and the data is transfered between the desired processors.

The programs developed for Mine 31's system could have been written in a host of alternate fashions; starting with the PLC system configuration, as described in SECTION IIa; to
the particular logic utilized in the individual processor programs, there are numerous options to accomplish the same system function.

For instance the "Belt Slip" circuit, Figure 26, shown on page 43. This circuit makes use of the internal relays and timers of the 6200 Series software. This circuit could be built using an external timer and relay via additional inputs and outputs. However, use of the internal devices makes for a much more structured and less hardware intensive design. Mine 31's management personnel initially wanted to use external timers in order to allow adjusting the time delays to accommodate varying conveyor startup times.

As mentioned in SECTION Vb the reason for varying conveyor starts was due to the controlled start transmission's (CST's) control scheme. The CST control is an additional item which has numerous variations with use of the PLC unit. For Mine 31's system the PLCs were configured as shown in Figure 14 for the reasons discussed in SECTION IIa. The single slot address scheme could have been replaced with two or half slot addressing. The single slot addressing was chosen because of the ease in identifying I/O points. With Mine 31's system the single slot addressing scheme has the "group" entry of the given I/O addresses corresponding directly to the given
chassis slot where the module resides. When trouble shooting
the system, it is easy to correlate between the processor
programs and the physical I/O points of the associated
chassis. With half or two slot addressing this correlation is
not quite so straight forward.\textsuperscript{1,2} The reader should thoroughly
explore these differences before beginning to program a
system. It is extremely time consuming to modify the
addressing in an entire program.

For Mine 31's system the programs for the Hoist House and
Bin Area processors took about four hours each to create. The
remaining four programs each took approximately ten hours.
Prior to starting the actual programming, many hours were
spent determining which system configuration would best serve
the application and the exact data file structure for both the
digital and analog data. Determining these issues prior to
programming ensures the overall system integrity and provides
for a structured and logical approach to the application.

Another feature which makes the chosen program logic
worthy of mentioning, is in the West A conveyor's program.
Rungs 2:49, 2:51, and 2:53 are the rungs which energize the
individual outputs which in turn energize the given line
starters for the conveyor drive motors. The reader can follow
through these rungs and see that no matter which of the three starters are utilized, a set sequence is established for motor starting. The lowest number (1 -3) of the starters selected to run will start immediately when a start is initiated and the next higher number motor starter will be started one second later. This scheme again has many alternative approaches, however, many of the alternatives will give different starting times depending on the units selected to run. For the West A starter the chosen scheme is important because one of the three starters is always in standby(spare).

As can be concluded from the above discussions the 6200 Series software allows for a wide range of system variations. The programmer has to take particular precautions prior to beginning the programs in order to ensure the desired results.
Supervisory control and data acquisition for Meigs Mine 31's system, as mentioned earlier, is utilized to facilitate remote CRT displays. The Allen Bradley PLCs described in CHAPTER II incorporated a structured data file format.

Meigs Mine 31 has two monitoring systems installed in addition to the Allen Bradley equipment. One of these systems, OPTO 22, is utilized to monitor the ventilation fans and substations on the surface; these facilities are crucial to the Mine. The second system, Mine Safety Appliance (MSA), is installed to monitor for carbon monoxide and methane throughout the underground mine. These two systems initially incorporated lights and sonolerts at the office facilities to annunciate alarms. With the Allen Bradley, OPTO 22, and MSA equipment operating and with the desire to incorporate a SCADA system for the Allen Bradley units it was decided to look for a SCADA software which would support all three systems.

Intellution's FIX DMAC software is the only software which supports the MSA hardware. Intellution also has the I/O drivers for Allen Bradley and OPTO 22 products, as well as for many other manufacture's PLCs.¹⁷
A second feature of the Intellution software which was applicable to Meigs Mine 31's needs is the ability to network the personal computers running the DMAC software.

IIIa. SCADA System Hardware Configuration

Figure 36 depicts the hardware configuration of Mine 31's SCADA units from the intelligent line controllers (ILCs), of each of the three PLC packages, to the CRT of each of the two SCADA nodes.

Figure 36. Mine 31's Supervisory Control and Data Acquisition System
In this CHAPTER, as in CHAPTERS I and II, the detailed presentation is limited to the Allen Bradley hardware associated with the main line bulk materials handling equipment. The ILC utilized to interface the Allen Bradley PLCs, of this system, to the SCADA units is the A/B 1785-KE module as depicted in Figure 37. This module is located in the first slot of the S. Bin PLC chassis, shown in Appendix C. This module is a protocol converter designed to transfer data to-and-from the data highway plus network (which incorporates a proprietary communications protocol) to a RS-232C communications device (in this system a personal computer). The format of data on the RS-232C side of this module is public knowledge.

Figure 37. Allen Bradley 1785-KE Communications Module (ILC)
As can be seen in Figure 36 the RS-232 side of this unit is connected via a modem link to the port (port 3) of the ARTIC card which is installed in the "Parker Run" computer. ARTIC, which is an acronym for A Real Time Interface Coprocessor, cards are manufactured and sold by IBM. Intellution's DMAC software utilizes the 80186 processor and 1M RAM of the ARTIC card to handle all data acquisition and storage functions of the scan, alarm, and control (SAC) modules of this software. The database of each SCADA node, in Mine 31's system, resides in the RAM of the ARTIC card (a given database with its "TAG" file is presented later in this CHAPTER).

Intellution's DMAC software implements the 80386 processor and 80387 math coprocessor in Mine 31's system to handle all software module control for the CRT displays. A "screen" which displays information about the main line materials handling system is presented later in this CHAPTER along with the "LINK" file which ties the CRT display to the database TAGs. Figure 38 depicts the flow of data from the PLCs to the screen which is described later. As can be seen in Figure 38 the "TAG" file is used to move data from the PLCs to the database of the personal computer. The "LINK" file is used to link portions of the screen to the desired tag of the associated database.
The last pieces of hardware, related to the SCADA systems, which is presented in Figure 36 is that associated with "networking" the SCADA computers(nodes). The unique feature of this network facilitates the 3.5 mile link between SCADA nodes at "Salem" and "Parker Run" offices. The standard thin line coaxial physical link of an Ethernet network is limited to 600 feet. The hardware required to "bridge" the
Ethernet network to a phone line link, used in this system, requires no additional programming by the SCADA programmer. This hardware, the two Ethernet bridges and two modems (one each per end of the phone line), were purchased from Black Box Inc. Again, the unique feature is that this equipment is totally transparent to the two SCADA units (i.e. the SCADA TAG and LINK files as well as the system software configuration is no different than if the two SCADA units were within 600' connected by the thin line coaxial physical link). The Black Box hardware utilized to facilitate this configuration (Ethernet/phone line link) cost approximately 15,000 dollars, however, no equivalents (which do not require additional programming) are available.

The remainder of this CHAPTER is devoted to presenting the TAG and LINK files of the Intellution program which drive the CRT display as depicted in Figure 39.

The configuration procedures for the hardware and software associated with the SCADA system is presented in references 15 - 18 of this thesis. The Intellution TAG and LINK file creation is detailed in references 19 and 20; these references were utilized exclusively throughout the remainder of this CHAPTER.
Figure 39. Mine 31's Main Line Handling System Overview

IIIb. SCADA System Screen and Database

The following TAG is a representation of a digital input block. The text inside the ***** TEXT ***** explains the meaning of the given entry. The actual TAG and LINK database is included in Appendix G.

*** The "TAG" is an arbitrary, but unique, maximum of 10 alphanumeric characters used to identify an I/O address for the DMAC database.

*** TAG.............. M76S
*** The "DESC" is a maximum forty(40) alphanumeric string ***
*** used to describe a particular TAG for future use. ***
DESC............. STATUS OF M76 BELT

*** The "DV-DEVICE" tells DMAC which I/O driver to use to ***
*** obtain I/O status. In this case the Allen Bradley ***
*** Highway.
DV-DEVICE....... ABH

*** The HT-H/W OPTIONS" further identifies to DMAC which ***
*** type PLC the I/O point is to be acquired from. ***
HT-H/W OPTIONS.. PLC5

*** The "IO-ADDR" is the address of the I/O point from the***
*** port of the ARTIC card(3 in our case) and the PLC data***
*** highway plus address, dip switch setting,(1 in this ***
*** case) to the PLC I/O address which is as described in ***
*** Chapter II
IO-ADDR........... 3:1:I:001/00

*** The "OT-OPEN TAG" tells DMAC the user's definition ***
*** of the "0" state of the particular I/O point. ***
OT-OPEN TAG...... OFF

*** The "CT-CLOSED TAG" tells DMAC the user's definition ***
*** of the "1" state of the particular I/O point. ***
CT-CLOSED TAG... ON

*** The "IS-INIT SCAN" tells DMAC if it should include ***
*** this TAG in the initial scan; ON indicates it should ***
*** be.
IS-INIT SCAN.... ON

*** The "ST-SCAN TIME" tells DMAC how often to scan this ***
*** I/O point. In this case once every 3 seconds. ***
ST-SCAN TIME.... 3

*** The "NX-NEXT BLOCK" is utilized if several TAGs are ***
*** to be cascaded together in controlling a particular ***
*** LINK.
NX-NEXT BLOCK... *** Blank indicates it is unused. ***
*** The "AT-ALM TYPE" tells DMAC to alarm when the bit is ***
*** open (a 0) or closed (a 1); in this case when 0. ***
AT-ALM TYPE..... OPEN

*** The "AP-ALM PRI" tells DMAC the alarm priority; in ***
*** this case it is set low(L) because their are few to ***
*** compete.
AP-ALM PRI...... L

*** The "AE-ALM ENABLE" tell DMAC to enable or inhibit ***
*** the alarm feature for this TAG.
AE-ALM ENABLE... ENABLE

*** The "PA-PLANT AREA" tells DMAC where to send alarms. ***
*** In this case ALL indicates screen, PC audible and ***
*** printer.
PA-PLANT AREA... ALL

*** The "II-INVERT" tells DMAC to interpret a "0" state as***
*** a "1" and vise-versa for the TAG if a YES is entered. ***
II-INVERT....... NO

*** The "IA-INIT A/M" tells DMAC to AUTOnomatically make ***
*** the alarm when the data base is loaded or wait for a ***
*** MANUAl signal from an operator.
IA-INIT A/M..... AUTO

The following TAG represents an analog input block. Again
the actual TAGs are included in Appendix G.

*** The first five entries are as described above. ***
TAG................. M76A
DESC.............. CURRENT OF M76 DRIVE MOTOR
DV-DEVICE....... ABH
HT-H/W OPTIONS.. PLC5
IO-ADDR......... 3:1:N10:154

*** The "SC-SIG COND" tells DMAC the range of raw data. ***
*** In this case LVZ indicates a 4-20mA range. ***
SC-SIG COND..... LVZ
*** The "EL-LO EGU" tells DMAC the real value of 4mA. ***
EL-LO EGU...... 0

*** The "EH-HI EGU" tells DMAC the real value of 20mA. ***
EH-HI EGU...... 41

*** The "ET-EGU TAG" tells DMAC the units of measure. ***
ET-EGU TAG...... AMP

*** The "SM-SMOOTHING" is used if data requires damping. ***
SM-SMOOTHING.... 0

*** The next three entries were described above. ***
IS-INIT SCAN.... ON
ST-SCAN TIME.... 3
NX-NEXT BLK.....

*** The "LL-LO LO ALM" is the EGU value for which the ***
*** LO LO alarm should be set; equivalently for the LO, ***
*** HI, and HI HI alarms. ***
LL-LO LO ALM.... 10
AL-LO ALM....... 10
AH-HI ALM....... 45
HH-HI HI ALM.... 50

*** The "RC-ROC ALM" is the rate of change alarm. The 0 ***
*** indicates it is unused in this case. ***
RC-ROC ALM...... 0

*** The "DB-DEAD BAND" is used in conjunction with ***
*** smoothing. ***
DB-DEAD BAND.... 0

*** The next four entries are as described above. ***
PA-PLANT AREA... ALL
AP-ALM PRI..... L
AE-ALM ENABLE... ENABLE
IA-INIT A/M..... AUTO
The following LINK represents a "color link" utilized to tie the individual screen areas of Figure 38 to the "digital input blocks" presented above.

*** The "NODE" is an arbitrary, but unique, maximum of ten(10) alphanumeric character name utilized in the system configurator to identify all personal computers and ARTIC cards in the SCADA setup.

NODE: PARKER

*** The "TAG" is as described above.

TAG: M76S

*** The "FIELD" describes the format of any text or numerical value to be displayed. It is unused for Mine 31's color LINKs.

FIELD:

*** The "BLINK ON ALM" either makes the colors blink(Y) or not blinks(N) when alarm conditions are present.

BLINK ON ALM: Y

*** The "FCOLOR" is the desired foreground color displayed.

FCOLOR: GREEN

*** The "BCOLOR" is the desired background color displayed.

BCOLOR: RED

*** The "COLOR BY" entry lets the user control how the following "STAT/VAL" entries will effect this LINK's color. The DEFLT uses the defaults since the color links in this system are representing digital, not analog, TAGs.

COLOR BY: DEFLT

<table>
<thead>
<tr>
<th>STAT/VAL</th>
<th>FOREGND</th>
<th>BACKGND</th>
<th>BLK</th>
</tr>
</thead>
<tbody>
<tr>
<td>OK</td>
<td>GREEN</td>
<td>BLACK</td>
<td>N</td>
</tr>
<tr>
<td>LOLO</td>
<td>RED</td>
<td>BLACK</td>
<td>Y</td>
</tr>
<tr>
<td>LO</td>
<td>GREEN</td>
<td>BLACK</td>
<td>N</td>
</tr>
<tr>
<td>HI</td>
<td>GREEN</td>
<td>BLACK</td>
<td>N</td>
</tr>
<tr>
<td>HIHI</td>
<td>RED</td>
<td>BLACK</td>
<td>N</td>
</tr>
<tr>
<td>RATE</td>
<td>GREEN</td>
<td>BLACK</td>
<td>N</td>
</tr>
<tr>
<td>COS</td>
<td>GREEN</td>
<td>BLACK</td>
<td>N</td>
</tr>
<tr>
<td>CFN</td>
<td>GREEN</td>
<td>BLACK</td>
<td>N</td>
</tr>
</tbody>
</table>
The following LINK represents a "value link" utilized to tie the individual screen areas of Figure 38 to the "analog input blocks" presented above.

*** The first three entries are as described above. ***
NODE:........ PARKER
TAG:......... M76A
FIELD:....... F.CV *** This indicates the F format is used***
            *** to display the current value(CV). ***

*** The "LINK ID" is unused in Mine 31's system; it is to ***
*** enable the operator to display the LINK options without***
*** using the general help feature. ***
LINK ID:.....

*** The "MODIFIABLE" entry is used to allow the user to ***
*** modify the display format on line if Y is entered; ***
*** not if N. ***
MODIFIABLE:.. Y

*** The "CONTROLLABLE" feature allows the displayed value ***
*** to be controlled. In this case it is not. ***
CONTROLLABLE: N

*** The remaining entries are as described above. ***
BLINK ON ALM: Y
FCOLOR:...... BLUE
BCOLOR:...... WHITE
FORMAT:...... #####
STAT/VAL FOREGND BACKGND BLK
OK     BLUE   WHITE   N
LOLO   RED    YELLOW  N
LO     RED    YELLOW  N
HI     RED    YELLOW  Y
HIHI   RED    YELLOW  Y
RATE   RED    YELLOW  Y
COS    RED    YELLOW  Y
CFN    RED    YELLOW  Y

The TAGs and LINKs shown above and in Appendix G depict the actual entries utilized for Mine 31's SCADA system.
CHAPTER IV

As mentioned in CHAPTER I of this thesis the desired results of the Programmable Logic Controller and Supervisory Control and Data Acquisition System was to provide a system design for increased availability. This result was to be obtain through use of the PLCs' processor-to-processor communications(to replace various out dated hardware), the PLCs' inherent reliability, and the remote monitoring provided by the SCADA system.

Prior to installing PLCs in any of the given materials handling units, Mine 31's system had an average availability of 62.7% as shown in Figure 40. The conversion of the given control system to PLCs began in late 1989. Figure 41 depicts the monthly availability for the South reserves system beginning with December of 1989.

![Figure 40. Mine 31's Materials Handling System Availability Prior to PLCs](image)

**Figure 40.** Mine 31's Materials Handling System Availability Prior to PLCs
In November of 1989 the S. Bin and West A PLC based starters were put into service. These two conveyors were the first two CST type starters installed in Mine 1 (The two Mines were not yet connected). The availability of the overall materials handling system decrease for a period. This initial decline was attributed to the learning curve associated with maintenance personnel's ability to work on the CST drives. As can be seen from the above graph the system availability began to increase from February of 1990 to the present.

In March of 1990 the two mines were combined and the Bunker was put into service. The overall system availability began to significantly increase during the remainder of 1990. The PLC system was not fully implemented until mid September,
even then the Hoist House and Bin Area PLCs had not yet been installed. During September and October the PLC system was fully employed as described in CHAPTER II, the SCADA system had not yet been connected.

In mid November of 1990 the SCADA system was installed at the Parker Run office. As can be seen from the above graph there has been a marginal increase in availability since the installation of the SCADA system. The only screen developed for the SCADA system is that of Figure 38. This screen enables the personnel at Parker Run to identify when a particular unit is disabled, however, it does not depict the cause of the shut down. The slight increase in availability can be attributed to the improved response time of the maintenance personnel. When the additional screens of CHAPTER V are developed an additional increase in availability can be expected.

With all the improvements made to Mine 31's system (the CST drives, the Bunker, the PLCs, and SCADA units) it is hard to say exactly what portion of the increased availability was due to the PLCs and SCADA units. The above graph depicts an increase of 10% availability in sixteen months.

The maintenance personnel report significant reductions in conveyor sequencing problems, especially those associated
with "gobbing out" the transfer points. This can be attributed to the use of the processor-to-processor communications and the conveyor sequencing discussed in CHAPTER II.

The management reports for Mine 31 depict a decline from nearly fifteen outages per month to eleven. This decline can be attributed to a host of sources including the inherent reliability of PLCs. These reports also depict a decline in the duration of outages since the SCADA unit was installed at Parker Run.

With 120 hours scheduled for Mine 31's system to be running per week a ten percent increase in availability reflects an additional twelve hours per week of run time. With the average production at 1800 tons per hour an additional 21,600 tons per week can be obtained due to a ten percent increase in availability.

The mine production has not increased by the above amount but it has increased some 10,000 - 15,000 tons per week since early in 1990. The discrepancy seems to be in the fact that the individual miner sections and the longwall unit were not able to take full advantage of the increase in conveyor availability.
CHAPTER V

Again, as stated in CHAPTER I, the purpose of this system was to minimize the duration of downtime inducing events for Mine 31's main line materials handling system, thereby, increasing system availability. The PLC processor-to-processor communications features, the inherent reliability of PLCs, and the information capabilities provided by the SCADA units are the key features of the chosen solution.

Va. Additional Uses of the SCADA System

The CRT display, Figure 39, presented in CHAPTER III allows individuals, in particular maintenance managers working in the office buildings to have real time knowledge of the status of all major components of the main line materials handling system. With the screen depicted in Figure 39 individuals can see which units are running from the remote locations. Figure 42 depicts another screen which further emphasizes the ability of the SCADA units.
Figure 42. A Suggested Screen for Trouble Shooting

While viewing the screen of Figure 39 a person can only tell if the unit(s) are running or not. If a particular conveyor shows to be down from the Figure 39 screen maintenance managers can switch to the screen depicted in Figure 42 to see why the unit is not running (one screen such as Figure 42 is required per unit).

With screens like Figure 42 the maintenance managers can decide more quickly which person(s) to dispatch to re-start or repair the unit (i.e. if it is only a pullcord, for
instants, many people are capable of resetting it, however, if the hydraulic takeup unit is the cause, a mechanic can be immediately dispatched). This remote information (CRT display) allows the utilization of maintenance personnel to be optimized.

With the Allen Bradley PLC equipment configured as described in CHAPTER II the remote personal computers can also be utilized to get on line with the individual processors. This feature allows maintenance personnel at the remote locations to restart units, reset faults, check for processor status, etc. An example of how this would be useful is if Figure 39 screen shows a unit to be down and Figure 42 screen shows no problem (implying a nuisance trip occurred) the remote personal computer can be used to restart the unit without dispatching anyone (the Allen Bradley 6200 Series software is required to implement this feature).

Figure 43 depicts a third screen useful for unit maintenance. A screen such as this is attainable utilizing the Historical Trending feature of the DMAC software. This particular trend is of the drive motor currents.
Vb. **Controlled Start Transmission (CST) Control**

In order to provide a smooth start for the conveyors in Mine 31's materials handling system CSTs are utilized to gradually bring the conveyors up to full speed; remember the drive motors are started across the line (i.e. induction motors started with full voltage).

The CST is essentially a **clutch** which has a rotor that is directly coupled to the drive motor by the input shaft of the CST. The output shaft of the CST is connected on one end to a series of clutch plates and on the other to the drive pulley of the given conveyor via the output shaft. The series
of clutch plates are hydraulically actuated and grip and release the CST rotor to speed up and slow down the output shaft, respectively. During conveyor starting the clutch plates gradually grip the CST rotor tighter and tighter until the belt is up to full speed, thereby, facilitating a "soft" start.

The CST control is set to gradually bring the conveyor to full speed over a period of time. This time is maintained regardless of the loading on the given belt (i.e. the conveyor is brought to full speed in the same time weather it is fully empty, partially loaded or fully loaded). This set time starting is accomplished by use of a "black box" controller which compares a tachometer voltage input to a predetermined ramp throughout the start cycle to maintain the hydraulic pressure applied to the clutch plates at a needed value. The "black box" controller has three outputs; one to energize a pressurizing solenoid, one to energize a bleed solenoid, and the third to energize a dump solenoid. When initiated by the given conveyor's PLC the black box begins to energize the pressurization and bleed valves in succession to apply the desired pressure to the clutch plates. When the given PLC CST initiate output is opened the black box energizes the dump solenoid and releases the clutch plates.
The black box in this CST is essentially a PID controller with the process variable being the tachometer input, the set point being the internal ramp, and the solenoid outputs the control variable. As described in SECTION IIh the PLC 5's PID facility is perfectly suited for this type control. By wiring the tachometer to an analog input and the three solenoids to individual outputs, internal PLC programming can be produced to take the place of the CST black box.

The black box unit is extremely sensitive to moisture and has external start time adjustments. These two detriments combined have resulted in many instances where conveyors have not started at all or have jerked the conveyor belts in two. By utilizing the PLC, the given PID parameters will not be affected by temperature and will not be prone to people adjusting them.

Vc. **Conclusion**

Production personnel can make as much use of the SCADA system presented in this thesis as do operations staff. Shift reports containing individual unit availability, storage capacities utilized/remaining and instantaneous scale readings are just a few of the options available. These reports can easily be programmed by utilizing the DMAC's Report Generation facility.
Exploiting the Historical Trending (as shown in Figure 43), the Report Generation feature, and the additional screens such as the one depicted in Figure 42 along with the CST improvement are the main recommendations of this thesis.

As mentioned in CHAPTER II the unique feature of the adapter mode PLC configuration presented in this thesis is that control data is not competing for network time with the SCADA units. Therefore, the SCADA units can be utilized to their fullest extent without affecting the PLC's ability to control the given equipment.

With the two SCADA nodes, one at Salem office and the other at Parker Run office, the desired information about the main line material handling system can be displayed at either location. This feature is incorporated even though the physical link directly to the Allen Bradley hardware is only at Parker Run. The Salem SCADA unit implements the PC network, Ethernet, over the 3.5 mile phone line link to acquire data from the Parker Run unit.

With the PLC and SCADA hardware of this thesis in place, the additional features of the DMAC software can be fully exploited simply by programming the desired information to be displayed.
For systems, such as Mine 31's, which have several locations, far apart, with many I/O points at each, and the desire to have remote information available, the PLC and SCADA technologies provide an extremely flexible solution.
HOIST HOUSE PLC

DATA HIGHWAY
ADDRESS........"01"
ONE SLOT ADDRESSING
REMOTE I/O
ADDRESS........"02"

1771-P7 POWER SUPPLY
1771-A2B CHASSIS
Allen-Bradley Co.
6200 Series Software
PLC-5 Programming Terminal Software
Release 2.22
Program Listing

Processor File: HOIST_H.ACH
17 March 1991 - 18:41
Ladder Listing

Processor File: HOIST_H.ACH

Rung 2:0
M76 BELT RUNNING TO INPUT MODULE "001" CHANNEL "00"

Rung 2:1
ROTORY BREAKER RUNNING TO INPUT MODULE "001" CHANNEL "01"

Rung 2:2
MS7 BELT RUNNING TO INPUT MODULE "001" CHANNEL "02"
2
Ladder Listing
Processor File: HOIST_H.ACH
Rung 2:3

Rung 2:3
COLLECTING CONVEYOR RUNNING TO INPUT MODULE "001" CHANNEL "03"
| COLLECTING | CONVEYOR |
| RUNNING | INPUT |
| I:001 | 03 |

0:
-] [- 2:3

O:031/03 - ( ) - 2:3

Rung 2:4
FEEDER 1 RUNNING TO INPUT MODULE "001" CHANNEL "04"
| FEEDER 1 | |
| RUNNING | INPUT |
| I:001 | 04 |

0:
-] [- 2:4

O:031/04 - ( ) - 2:4

Rung 2:5
FEEDER 2 RUNNING TO INPUT MODULE "001" CHANNEL "05"
| FEEDER 2 |
| RUNNING | |
| INPUT |
| I:001 | 05 |

0:
-] [- 2:5

O:031/05 - ( ) - 2:5
Rung 2:6
BLOCK TRANSFER WRITE STATEMENT TO ANALOG INPUT MODULE "050" TO CONFIGURE
THE MODULE FOR DESIRED 4-20mA <-> 0-4095 A/D CONVERSION

```plaintext
Rack 0
Group 5+(DN)
Module 0
Control Block N10:1+(ER)
Data file N10:100
Length 37
Continuous N
```

N10:1
-BTW- 2:6

N10:1/15
-]/[- 2:6

Rung 2:7
BLOCK TRANSFER READ FROM ANALOG INPUT MODULE "050" TO ACQUIRE DATA IS
STORED IN REGISTERS N10:154-N10:161

```plaintext
Rack 0
Group 5+(DN)
Module 0
Control Block N10:2+(ER)
Data file N10:150
Length 20
Continuous N
```

N10:2
-BTR- 2:7

N10:2/15
-]/[- 2:7
Ladder Listing  Processor File: HOIST_H.ACH  Rung 2:8

Rung 2:8
BLOCK TRANSFER WRITE TO ANALOG OUTPUT MODULE "070" TO CONFIGURE MODULE FOR 0-4095 <--- 4-20mA D/A CONVERSION AND TO WRITE DATA TO REGISTERS
N10:200-N10:203 (NO DATA DESIRED 8/4/90)

N10:3

---[--------------------------]

15

+BTW------------------------+

+BLOCK TRANSFR WRITE +(EN)++

| Rack 0 |
| Group 7+- (DN) |
| Module 0 |
| Control Block N10:3+- (ER) |
| Data file N10:200 |
| Length 13 |
| Continuous N |

---[--------------------------]

N10:3

-BTW- 2:8

N10:3/15

-]/[- 2:8

Rung 2:9
BLOCK TRANSFER READ FROM ANALOG OUTPUT MODULE "070" TO OBTAIN STATUS REGISTER INFORMATION (NONE REQUESTED 8/4/90)

N10:4

-BTR- 2:9

--------------------------[END OF FILE]--------------------------
Ladder Listing

NO RUNGS IN FILE 3
## Ladder Listing

**Processor File:** HOIST_H.ACH

**REPORT OPTIONS SUMMARY**

<table>
<thead>
<tr>
<th>Option</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Page Width</td>
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<td>Page Length</td>
<td>66</td>
</tr>
<tr>
<td>Graphics Capabilities</td>
<td>NO</td>
</tr>
<tr>
<td>Right Power Rail</td>
<td>YES</td>
</tr>
<tr>
<td>Address Comments</td>
<td>YES</td>
</tr>
<tr>
<td>Symbols</td>
<td>YES</td>
</tr>
<tr>
<td>Rung Comments</td>
<td>YES</td>
</tr>
<tr>
<td>Cross References</td>
<td>ALL</td>
</tr>
<tr>
<td>Starting Rung</td>
<td>2:0</td>
</tr>
<tr>
<td>Ending Rung</td>
<td>3:32767</td>
</tr>
</tbody>
</table>
Allen-Bradley Co.
6200 Series Software
PLC-5 Programming Terminal Software
Release 2.22
Program Listing

Processor File: BIN_AREA.ACH
17 March 1991 - 18:31
Ladder Listing

Processor File: BIN_AREA.ACH

Rung 2:0
BIN 1 HIGH LEVEL TO INPUT MODULE "001" CHANNEL "00"
| BIN 1 HIGH LEVEL |
| INPUT |
| I:001 |
| --- ] [--- |
| 00 |
| I:001/00 |
| - ] [- 2:0 |
| O:031/00 |
| - ( )- 2:0 |

Rung 2:1
BIN 1 HIGH-HIGH LEVEL TO INPUT MODULE "001" CHANNEL "01"
| BIN 1 HIGH |
| HIGH LEVEL |
| INPUT |
| I:001 |
| --- ] [--- |
| 01 |
| I:001/01 |
| - ] [- 2:1 |
| O:031/01 |
| - ( )- 2:1 |

Rung 2:2
BIN 2 HIGH LEVEL TO INPUT MODULE "001" CHANNEL "02"
| BIN 2 HIGH LEVEL |
| INPUT |
| I:001 |
| --- ] [--- |
| 02 |
| I:001/02 |
| - ] [- 2:2 |
| O:031/02 |
| - ( )- 2:2 |
Rung 2:3
BIN 2 HIGH-HIGH LEVEL TO INPUT MODULE "001" CHANNEL "03"

| BIN 2 HIGH |
| HIGH LEVEL |
| INPUT |
| I:001 |
| 03 |

I:001/03
(-) - 2:3

O:031/03
(-) - 2:3

Rung 2:4
BLOCK TRANSFER WRITE STATEMENT TO ANALOG INPUT MODULE "050" TO CONFIGURE
THE MODULE FOR DESIRED 4-20mA <-> 0-4095 A/D CONVERSION

| BLOCK |
| TRANSFER |
| ENABLE |
| INTERLOCK |
| N20:1 |
| +BTW---------------+ |
| 15 |
| +BLOCK TRNSFR WRITE +-(EN)-- |
| Rack 0 |
| Group 5+- (DN) |
| Module 0 |
| Control Block N20:1+- (ER) |
| Data file N20:100 |
| Length 37 |
| Continuous N |

N10:1
-BTW- 2:4

N10:1/15
(-) - 2:4
Ladder Listing

Processor File: BIN_AREA.ACH

Rung 2:5
BLOCK TRANSFER READ FROM ANALOG INPUT MODULE "050" TO AQUIRE DATA IS
STORED IN REGISTERS N10:154-N10:161

---]/{--------------------------+BLOCK TRNSFR READ +(EN)---
15
| Rack 0 |
| Group 5+(DN) |
| Module 0 |
| Control Block N20:2+(ER) |
| Data file N20:150 |
| Length 20 |
| Continuous N |

N10:2
-BTR- 2:5

Rung 2:6
BLOCK TRANSFER WRITE TO ANALOG OUTPUT MODULE "070" TO CONFIGURE MODULE
FOR 0-4095 <-> 4-20mA D/A CONVERSION AND TO WRITE DATA TO REGISTERS
N10:200-N10:203 (NO DATA DESIRED 8/4/90)

---]/{--------------------------+BLOCK TRNSFR WRITE +(EN)---
15
| Rack 0 |
| Group 7+(DN) |
| Module 0 |
| Control Block N20:3+(ER) |
| Data file N20:200 |
| Length 13 |
| Continuous N |

N10:3
-BTW- 2:6

Rung 2:5
Ladder Listing  
Processor File: BIN_AREA.ACH  
Rung 2:7

```
Rung 2:7
BLOCK TRANSFER READ FROM ANALOG OUTPUT MODULE "070" TO OBTAIN STATUS
REGISTER INFORMATION (NONE REQUESTED 8/4/90)

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>TRANSFER</th>
<th>ENABLE</th>
<th>N20:4</th>
</tr>
</thead>
<tbody>
<tr>
<td>+BTR---</td>
<td>---------</td>
<td>+---(EN)---</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>+BLOCK_TRNSFR READ +-(DN)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Rack 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Group 7-(DN)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Module 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control Block N20:4+(ER)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Data file N20:250</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Length 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Continuous N</td>
</tr>
</tbody>
</table>

N10:4
-BTR- 2:7

N10:4/15
-)][- 2:7

Rung 2:8

```

<table>
<thead>
<tr>
<th>+LESS-</th>
<th>+LESS-</th>
<th>+GRT-</th>
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</thead>
<tbody>
<tr>
<td>+++LESS THAN</td>
<td>+++LESS THAN</td>
<td>+++GREATER THAN</td>
</tr>
<tr>
<td>Source A N10:156</td>
<td>Source A N10:157</td>
<td>Source A N20:158</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Source B 4000</td>
<td>Source B 4000</td>
<td>Source B 500</td>
</tr>
</tbody>
</table>

```

N10:156
-LES- 2:8 2:9

N10:157
-LES- 2:8 2:9
Ladder Listing  

Processor File: BIN_AREA.ACH  

Rung 2:8

N20:158  

- GRT- 2:8 2:8  

0:003/00  

- ] [- 2:8  

- ( )- 2:8  

Rung 2:9  

| + GRT- --------------- | + GRT- --------------- | + GRT- --------------- | >  
| + LESS THAN + LESS THAN + GREATER THAN + >  
| Source A N10:156 | Source A N10:157 | Source A N20:159 | >  
| | | |  
| Source B 4000 | Source B 4000 | Source B 500 |  

< + GRT- --------------- | 0:003 |  

< + GREATER THAN +++++( )+++  

< | | | |  

| Source A N20:159 | 01  
| | | |  

| Source B 750 |  
| | | |  

| | | |  

| O:003 |  
| | | |  

| | | |  

| + GRT- --------------- | 01  

| + GRT- --------------- | 01  

N10:156  

- LES- 2:8 2:9  

N10:157  

- LES- 2:8 2:9  

N20:159  

- GRT- 2:9 2:9  

O:003/01  

- ] [- 2:9  

- ( )- 2:9  

Rung 2:10  

[END OF FILE]
Ladder Listing

NO RUNGS IN FILE 3

Processor File: BIN_AREA.ACH

Rung 3:0
**REPORT OPTIONS SUMMARY**

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<tr>
<th>Option</th>
<th>Setting</th>
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<tr>
<td>Graphics Capabilities:</td>
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</tr>
<tr>
<td>Right Power Rail:</td>
<td>YES</td>
</tr>
<tr>
<td>Address Comments:</td>
<td>YES</td>
</tr>
<tr>
<td>Symbols:</td>
<td>YES</td>
</tr>
<tr>
<td>Rung Comments:</td>
<td>YES</td>
</tr>
<tr>
<td>Cross References:</td>
<td>ALL</td>
</tr>
<tr>
<td>Starting Rung:</td>
<td>2:0</td>
</tr>
<tr>
<td>Ending Rung:</td>
<td>3:32767</td>
</tr>
</tbody>
</table>
Allen-Bradley Co.
6200 Series Software
PLC-5 Programming Terminal Software
Release 2.22
Program Listing

Processor File: BS0309.ACH
17 March 1991 - 18:17
Ladder Listing

Rung 2:0

PULLCord TO INPUT MODULE "001" CHANNEL "00"

<table>
<thead>
<tr>
<th>PULLCord</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT</td>
</tr>
<tr>
<td>I:001</td>
</tr>
<tr>
<td>00</td>
</tr>
</tbody>
</table>

-] [- 2:0

I:001/00

N7:51/0

-] [- 2:1 2:39 2:41 2:42

-( )- 2:0

Rung 2:1

PULLCord AUXILIARY (INTERNAL) RELAY TO OUTPUT MODULE "004" CHANNEL "00"

<table>
<thead>
<tr>
<th>PULLCord</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUXILIARY</td>
</tr>
<tr>
<td>N7:51</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

LAMPTEST

| N7:51 |

-] [- 2:1 2:39 2:41 2:42

-( )- 2:0

N7:51/0

N7:51/14


-( )- 2:26

O:004/00

-( )- 2:1

Rung 2:2

SEQUENCE TO INPUT MODULE "001" CHANNEL "01"

<table>
<thead>
<tr>
<th>SEQUENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT</td>
</tr>
<tr>
<td>I:001</td>
</tr>
<tr>
<td>01</td>
</tr>
</tbody>
</table>

-] [- 2:2 2:121

I:001/01
Ladder Listing

N7:51/1
-] [- 2:3 2:41 2:42
-() - 2:2

Rung 2:3

SEQUENCE AUXILIARY (INTERNAL) TO SEQUENCE LIGHT OUTPUT MODULE "004"
CHANNEL "01"

<table>
<thead>
<tr>
<th>SEQUENCE</th>
<th>SEQUENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUXILIARY</td>
<td>LIGHT</td>
</tr>
<tr>
<td>N7:51</td>
<td>O:004</td>
</tr>
</tbody>
</table>

-] [------------------]

1
LAMPTEST
N7:51
[------]

N7:51/1
-] [- 2:3 2:41 2:42
-() - 2:2

N7:51/14
-() - 2:26

O:004/01
-() - 2:3

Rung 2:4

BELT SLIP TO INPUT MODULE "001" CHANNEL "02"

<table>
<thead>
<tr>
<th>BELT SLIP</th>
<th>BELT SLIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT</td>
<td>AUXILIARY</td>
</tr>
<tr>
<td>I:001</td>
<td>N7:51</td>
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</tbody>
</table>

-] [------------------]

I:001/02
-] [- 2:4 2:121

N7:51/2
-] [- 2:5 2:39
-() - 2:4
Rung 2:5

BELT SLIP LIGHT OUTPUT MODULE "004" CHANNEL "02"

BELT SLIP
AUXILIARY

N7:51

LAMPTEST
N7:51

N7:51/2

N7:51/14

0:004/02

Rung 2:6

HYDRAULIC TAKEUP PRESSURE TO INPUT MODULE "001" CHANNEL "03"

HYDRAULIC TAKEUP AUXILIARY
I:001 N7:51

FAULT RESET PUSHBUTTON
N7:51

I:001/03

N7:51/3

N7:51/15
Rung 2:7

HYDRAULIC TAKEUP LIGHT OUTPUT MODULE "004" CHANNEL "03"

HYDRAULIC
TAKEUP
AUXILIARY
N7:51

---------

3
LAMPTEST
N7:51

---------

03

N7:51/3

[- 2:6 2:7 2:39
-() - 2:6

N7:51/14

-() - 2:26

O:004/03

-() - 2:7

Rung 2:8

GOB-OUT SWITCH TO INPUT MODULE "001" CHANNEL "04"

GOB-OUT
INPUT
I:001

---------

4
FAULT
RESET
PUSHBUTTON
N7:51

---------

4

I:001/04

[- 2:8

N7:51/4

[- 2:8 2:9
-() - 2:8

N7:51/15

[- 2:6 2:8 2:12 2:14 2:16 2:33
-() - 2:27
Rung 2:9

GOB-OUT LIGHT OUTPUT MODULE "004" CHANNEL "04"

GOB-OUT
AUXILIARY
N7:51

4
LAMPTEST
N7:51

14

N7:51/4
-] [- 2:8 2:9
-( )- 2:8

N7:51/14
-( )- 2:26

O:004/04
-( )- 2:9

Rung 2:10

FIRE DETECTION TO INPUT MODULE "001" CHANNEL "05"

FIRE DETECTION
INPUT
I:001

05

I:001/05
-] [- 2:10

N7:51/5
-] [- 2:11 2:35 2:39
-( )- 2:10

Rung 2:11

FIRE DETECTION LIGHT OUTPUT MODULE "004" CHANNEL "05"

FIRE DETECTION
AUXILIARY
N7:51

5

+++ +++
Ladder Listing

Processor File: BS0309.ACH

Rung 2:11

+++ +++

| LAMPTEST |
| N7:51 |
| 14 |

N7:51/5
-] [- 2:11 2:35 2:39
-( )- 2:10

N7:51/14
-( )- 2:26

O:004/05
-( )- 2:11

Rung 2:12

TRANSFORMER OVERTEMP TO INPUT MODULE "001" CHANNEL "06"

| TRANSFORM | TRANSFORM | TRANSFORM |
| OVERTEMP | OVERTEMP | OVERTEMP |
| INPUT | AUXILIARY | AUXILIARY |
| I:001 | N7:51 | N7:51 |

6
[-----] [-----] [-----] [-----]

6
FAULT
RESET
PUSHBUTTON
N7:51

I:001/06
-] [- 2:12

N7:51/6
-] [- 2:12 2:13 2:39
-( )- 2:12

N7:51/15
-] [- 2:6 2:8 2:12 2:14 2:16 2:33
-( )- 2:27
Rung 2:13

TRANSFORM OVERTEMPERATURE LIGHT OUTPUT MODULE "004" CHANNEL "06"
TRANSFORM
OVERTEMP
AUXILIARY
N7:51

------------
6
LAMPTEST
N7:51
----------
14

N7:51/6
- [- 2:12 2:13 2:39
-( )- 2:12

N7:51/14
-( )- 2:26

O:004/06
-( )- 2:13

Rung 2:14

MOTOR #1 OVERLOAD TO INPUT MODULE "001" CHANNEL "07"
MOTOR #1
OVERLOAD
INPUT
I:001

---------
07
FAULT
RESET
PUSHBUTTON
N7:51
---------
15

I:001/07
- [- 2:14

N7:51/7
- [- 2:14 2:15 2:38
-( )- 2:14

N7:51/15
- [- 2:6 2:8 2:12 2:14 2:16 2:33
-( )- 2:27
Rung 2:15

MOTOR #1 OVERLOAD LIGHT OUTPUT MODULE "004" CHANNEL "07"

MOTOR #1
OVERLOAD
AUXILIARY
N7:51

--- [ ] --- [ ] ---
7
- LAMPTEST
- N7:51
--- [ ] ---
14

N7:51/7
-] [- 2:14 2:15 2:38
-( )- 2:14

N7:51/14
-( )- 2:26

O:004/07
-( )- 2:15

Rung 2:16

MOTOR #2 OVERLOAD TO INPUT MODULE "004" CHANNEL "10"

MOTOR #2
OVERLOAD
INPUT
N7:51

--- [ ] --- [ ] ---
10
- FAULT
- RESET
- PUSHBUTTON
- N7:51
--- [ ] ---
15

I:001/10
-] [- 2:16

N7:51/10
-] [- 2:16 2:17 2:38
-( )- 2:16

N7:51/15
-] [- 2:6 2:8 2:12 2:14 2:16 2:33
-( )- 2:27
Rung 2:17

MOTOR #2 OVERLOAD LIGHT OUTPUT MODULE "004" CHANNEL "10"

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<th>MOTOR #2</th>
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<td>OVERLOAD</td>
</tr>
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<td>LIGHT</td>
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<td>O:004</td>
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</tbody>
</table>

10

---

LAMPTEST

---

N7:51

14

N7:51/10

| - ] [- 2:16 2:17 2:38 |
| -( )- 2:16 |

N7:51/14

| -( )- 2:26 |

O:004/10

| -( )- 2:17 |

Rung 2:18

CIRCUIT BREAKER #1 TO INPUT MODULE "001" CHANNEL "11"

| CIRCUIT | CIRCUIT |
| BREAKER #1 | BREAKER #1 |
| INPUT | AUXILIARY |
| I:001 | N7:51 |

11

I:001/11

| - ] [- 2:18 |

N7:51/11

| - ] [- 2:19 2:37 |
| -( )- 2:18 |
Ladder Listing

Rung 2:19

CIRCUIT BREAKER #1 OUTPUT MODULE "004" CHANNEL "11"

CIRCUIT
BREAKER #1
AUXILIARY
N7:51

----[
  LAMPTEST
  N7:51
  ----[

N7:51/11
-] [- 2:19 2:37
-( )- 2:26

N7:51/14
-( )- 2:26

O:004/11
-( )- 2:19

Rung 2:20

CIRCUIT BREAKER #2 TO INPUT MODULE "001" CHANNEL "12"

CIRCUIT
BREAKER #2
INPUT
I:001

----[
  12

I:001/12
-] [- 2:20

N7:51/12
-] [- 2:21 2:37
-( )- 2:20
11
Ladder Listing
Processor File: BS0309.ACH

Rung 2:21

CIRCUIT BREAKER #2 LIGHT OUTPUT MODULE "004" CHANNEL "12"

CIRCUIT BREAKER #2
AUXILIARY
N7:51

12
LAMPTEST
N7:51

N7:51/12
-] [- 2:21 2:37
-( )- 2:20

N7:51/14
-( )- 2:26

O:004/12
-( )- 2:21

Rung 2:22

AUTO-OFF-MAN SELECTOR SWITCH AUTOMATIC TO INPUT MODULE "001" CHANNEL "13"

AUTO-OFF-MAN
AUTOMATIC
INPUT
I:001

13

I:001/13
-] [- 2:22

N7:51/13
-] [- 2:39
-( )- 2:22

Rung 2:23

AUTO-OFF-MAN SELECTOR SWITCH MANUAL TO INPUT MODULE "001" CHANNEL "14"

AUTO-OFF-MAN
MANUAL
INPUT
I:001

14

14
Ladder Listing

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Rung 2:23

I:001/14
[-] [- 2:23

N7:52/1
[-] [- 2:41 2:42
-( )- 2:23

Rung 2:24

MOTOR #1/MOTOR #2 SELECTOR SWITCH MOTOR #1 TO INPUT MODULE "001" CHANNEL "15"

<p>| MOTOR #1/ | MOTOR #1/ |
| MOTOR #2 | MOTOR #2 |
| MOTOR #1 | MOTOR #1 |
| INPUT | AUXILIARY |</p>
<table>
<thead>
<tr>
<th>I:001</th>
<th>N7:52</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>(- )</td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

I:001/15
[-] [- 2:24

N7:52/2
[-] [- 2:41
-]/ [- 2:37 2:38 2:40
-( )- 2:24

Rung 2:25

MOTOR #1/MOTOR #2 SELECTOR SWITCH MOTOR #2 TO INPUT MODULE "001" CHANNEL "16"

<p>| MOTOR #1/ | MOTOR #1/ |
| MOTOR #2 | MOTOR #2 |
| MOTOR #2 | MOTOR #2 |
| INPUT | AUXILIARY |</p>
<table>
<thead>
<tr>
<th>I:001</th>
<th>N7:52</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>(- )</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

I:001/16
[-] [- 2:25

N7:52/3
[-] [- 2:42
-]/ [- 2:37 2:38 2:40
-( )- 2:25

Rung 2:26

LAMP TEST PUSHBUTTON TO INPUT MODULE "001" CHANNEL "17"

<p>| LAMP TEST | LAMP TEST |
| PUSHBUTTON | PUSHBUTTON |
| INPUT | AUXILIARY |</p>
<table>
<thead>
<tr>
<th>I:001</th>
<th>N7:51</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>(- )</td>
</tr>
<tr>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>
Ladder Listing

Processor File: BS0309.ACH

17 March 1991 Page 13
Rung 2:26

I:001/17
   -) [- 2:26

N7:51/14
   -( )- 2:26

Rung 2:27

FAULT RESET PUSHBUTTON TO INPUT MODULE "002" CHANNEL "00"

   FAULT
   RESET
   PUSHBUTTON
   INPUT
   I:002

   00

I:002/00
   -) [- 2:27

N7:51/15
   -) [- 2:6 2:8 2:12 2:14 2:16 2:33
   -( )- 2:27

Rung 2:28

MOTOR #1 CONTACTOR TO INPUT MODULE "002" CHANNEL "01"

   MOTOR #1
   CONTACTOR
   INPUT
   I:002

   01

I:002/01
   -) [- 2:28

N7:52/5
   -) [- 2:29 2:40
   -( )- 2:28

Rung 2:29

MOTOR #1 HOUR METER/START COUNTER OUTPUT MODULE "004" CHANNEL "13"

   MOTOR #1
   CONTACTOR
   AUXILIARY
   N7:52

   0:004

   13
Ladder Listing

Processor File: BS0309.ACH

17 March 1991 Page 14
Rung 2:29

N7:52/5
-] [- 2:29 2:40
-() - 2:28

O:004/13
-() - 2:29

Rung 2:30

MOTOR #2 CONTACTOR TO INPUT MODULE "002" CHANNEL "02"

MOTOR #2
CONTACCTOR
INPUT
I:002
02

--] [---------------------
| 6

I:002/02
-] [- 2:30

N7:52/6
-] [- 2:31 2:40
-() - 2:30

Rung 2:31

MOTOR #2 HOUR METER/START COUNTER OUTPUT MODULE "004" CHANNEL "14"

MOTOR #2
CONTACCTOR
AUXILIARY
N7:52
6

--] [---------------------
| 14

N7:52/6
-] [- 2:31 2:40
-() - 2:30

O:004/14
-() - 2:31

Rung 2:32

PROCESSOR ERROR BIT LIGHT OUTPUT MODULE "004" CHANNEL "16"

PROCESSOR
ERROR BIT
S:7
0

--] [---------------------
| 16

O:004/16
-() - 2:32
Ladder Listing

S:7/0
-] [- 2:32

Rung 2:33

CST OVERTEMPERATURE TO INPUT MODULE "002" CHANNEL "03"

<table>
<thead>
<tr>
<th>CST</th>
<th>CST</th>
<th>OVERTEMP</th>
<th>OVERTEMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT</td>
<td>AUXILIARY</td>
<td>I:002</td>
<td>N7:52</td>
</tr>
</tbody>
</table>

---

03
-] [- 7
FAULT
RESET
PUSHBUTTON
N7:51

++++] [-----

15

I:002/03
-] [- 2:33

N7:51/15
-] [- 2:16 2:8 2:12 2:14 2:16 2:33
-() - 2:27

N7:52/7
-] [- 2:33 2:34 2:39
-() - 2:33

Rung 2:34

CST OVERTEMPERATURE LIGHT OUTPUT MODULE "004" CHANNEL "17"

<table>
<thead>
<tr>
<th>CST</th>
<th>CST</th>
<th>OVERTEMP</th>
<th>LIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUXILIARY</td>
<td>OVERTEMP</td>
<td>N7:52</td>
<td></td>
</tr>
</tbody>
</table>

+++] [-----

7
LAMPTEST
N7:51

++++] [-----

14

N7:51/14
-() - 2:26

N7:52/7
-] [- 2:33 2:34 2:39
-() - 2:33

O:004/17
-() - 2:34
Ladder Listing  

Rung 2:35

**TIMER FOR TIME DELAY TO OUTPUT CIRCUIT BREAKER UV's**

FIRE DETECTION AUXILIARY

<table>
<thead>
<tr>
<th>N7:51</th>
</tr>
</thead>
</table>
| +TOF- ----------------------------+
| 5    |
| +TIMER OFF DELAY ++(EN)+
| Timer T4:26 |
| Time base 0.01+-(-DN) |
| Preset 200 |
| Accum 0 |

N7:51/5

-] [- 2:11 2:35 2:39
-( )= 2:10

T4:26

-TOF- 2:35

Rung 2:36

**FIRE DETECTION TIME DELAY OUTPUT MODULE "004" CHANNEL "15"**

FIRE DETECTION TIME DELAY

<table>
<thead>
<tr>
<th>T4:26</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>O:004/15</th>
</tr>
</thead>
<tbody>
<tr>
<td>-( )= 2:36</td>
</tr>
</tbody>
</table>

T4:26.DN

-] [- 2:36
Ladder Listing

Rung 2:38

**OUTPUT CIRCUIT OVERLOAD/MOTOR #1 - MOTOR #2 SELECTOR INTERLOCK**

<table>
<thead>
<tr>
<th>MOTOR #1</th>
<th>MOTOR #2</th>
<th>OVERLOAD/MOTOR #1 - MOTOR #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERLOAD</td>
<td>OVERLOAD</td>
<td>AUXILIARY</td>
</tr>
<tr>
<td>AUXILIARY</td>
<td>AUXILIARY</td>
<td>AUXILIARY</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N7:51</th>
<th>N7:51</th>
<th>N7:53</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>MOTOR #1</td>
<td>MOTOR #1</td>
<td>1</td>
</tr>
<tr>
<td>MOTOR #2</td>
<td>MOTOR #2</td>
<td></td>
</tr>
<tr>
<td>AUXILIARY</td>
<td>AUXILIARY</td>
<td></td>
</tr>
<tr>
<td>N7:52</td>
<td>N7:52</td>
<td></td>
</tr>
</tbody>
</table>

N7:51/7

- [- 2:14 2:15 2:38]
- ( )- 2:14

N7:51/10

- [- 2:16 2:17 2:38]
- ( )- 2:16

N7:52/2

- [- 2:41]
- /[- 2:37 2:38 2:40]
- ( )- 2:24

N7:52/3

- [- 2:42]
- /[- 2:37 2:38 2:40]
- ( )- 2:25

N7:53/1

- [- 2:39 2:41 2:42]
- ( )- 2:38

Rung 2:39

**STARTER HEALTHY AUXILIARY**

<table>
<thead>
<tr>
<th>BELT SLIP</th>
<th>AUTO-OFF</th>
<th>BREAKER</th>
<th>OVERLOAD</th>
<th>HYDRAULIC</th>
<th>CST</th>
<th>FIRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUXILIARY</td>
<td>MANUAL</td>
<td>MOTOR #1</td>
<td>MOTOR #1</td>
<td>TAKEUP</td>
<td>OVERTEMP</td>
<td>DETECTION</td>
</tr>
<tr>
<td>AUTOMATIC</td>
<td>MOTOR #2</td>
<td>MOTOR #2</td>
<td>AUXILIARY</td>
<td>AUXILIARY</td>
<td>AUXILIARY</td>
<td>AUXILIARY</td>
</tr>
<tr>
<td>N7:51</td>
<td>N7:51</td>
<td>N7:53</td>
<td>N7:53</td>
<td>N7:51</td>
<td>N7:52</td>
<td>N7:51</td>
</tr>
</tbody>
</table>

| 2 | 13 | 0 | 1 | 3 | 7 | 5 |
Ladder Listing

17 March 1991  Page 19
Rung 2:39

| PULLCORD | TRANSFORM | STARTER |
| AUXILIARY | OVERTEMP | HEALTHY |
| AUXILIARY | AUXILIARY |

< N7:51  N7:51  N7:53
<--- ] [--------] [----------( )--------
< 0 6 2

N7:51/0
- ] [ 2:1 2:39 2:41 2:42
-( )- 2:0

N7:51/2
- ] [ 2:5 2:39
-( )- 2:4

N7:51/3
- ] [ 2:6 2:7 2:39
-( )- 2:6

N7:51/5
- ] [ 2:11 2:35 2:39
-( )- 2:10

N7:51/6
- ] [ 2:12 2:13 2:39
-( )- 2:12

N7:51/13
- ] [ 2:39
-( )- 2:22

N7:52/7
- ] [ 2:33 2:34 2:39
-( )- 2:33

N7:53/0
- ] [ 2:39 2:41 2:42
-( )- 2:37

N7:53/1
- ] [ 2:39 2:41 2:42
-( )- 2:38

N7:53/2
- ] [ 2:41 2:42
-( )- 2:39
Ladder Listing

Rung 2:41

MOTOR CIRCUIT #1 START CIRCUIT OUTPUT MODULE "007" CHANNEL "00"

| STARTER | SEQUENCE | MOTOR #1 |
| HEALTHY | AUXILIARY | MOTOR #2 |
| AUXILIARY | | STARTER |
| | | MOTOR #1 |
| N7:53 | N7:51 | N7:52 |

[-------------] [-------------] [-------------] [-------------] [-------------]

2 1 2 1 0

AUTO/OFF/ BREAKER/ OVERLOAD/ PULLCORD
MANUAL MOTOR #1 - MOTOR #1 - AUXILIARY
MANUAL MOTOR #2 - MOTOR #2 -
AUXILIARY AUXILIARY AUXILIARY
N7:52 N7:53 N7:53 N7:51

[-------------] [-------------] [-------------] [-------------] [-------------]

1 0 1 0

N7:51/0

-] [- 2:1 2:39 2:41 2:42
-( )- 2:0

N7:51/1

-] [- 2:3 2:41 2:42
-( )- 2:2

N7:52/1

-] [- 2:41 2:42
-( )- 2:23

N7:52/2

-] [- 2:41
-]/[- 2:37 2:38 2:40
-( )- 2:24

N7:53/0

-] [- 2:39 2:41 2:42
-( )- 2:37

N7:53/1

-] [- 2:39 2:41 2:42
-( )- 2:38

N7:53/2

-] [- 2:41 2:42
-( )- 2:39

O:007/00

-( )- 2:41
Ladder Listing

Rung 2:42

MOTOR CIRCUIT #2 START CIRCUIT OUTPUT MODULE "007" CHANNEL "01"

| STARTER | SEQUENCE | MOTOR #1/ |
| HEALTHY | AUXILIARY | MOTOR #1 |
| AUXILIARY | | MOTOR #2 |

N7:53 N7:51 N7:52 O:007

1 2 3

AUTO/OFF/ BREAKER/ OVERLOAD/ PULLCord
MANUAL MOTOR #1 - MOTOR #1 - AUXILIARY
MANUAL MOTOR #2 MOTOR #2
AUXILIARY AUXILIARY AUXILIARY

N7:52 N7:53 N7:53 N7:51

1 0 1 0

N7:51/0
- [ - 2:1 2:39 2:41 2:42
-() - 2:0

N7:51/1
- [ - 2:3 2:41 2:42
-() - 2:2

N7:52/1
- [ - 2:41 2:42
-() - 2:23

N7:52/3
- [ - 2:42
-)[(- 2:37 2:38 2:40
-() - 2:25

N7:53/0
- [ - 2:39 2:41 2:42
-() - 2:37

N7:53/1
- [ - 2:39 2:41 2:42
-() - 2:38

N7:53/2
- [ - 2:41 2:42
-() - 2:39

O:007/01
-() - 2:42
Rung 2:43
BLOCK TRANSFER WRITE TO ANALOG INPUT MODULE "110" TO CONFIGURE THE
MODULE FOR 4-20mA <-> 0-4095 A/D CONVERSION
| BLOCK
| TRANSFER
| READ
| ENABLE
| INTERLOCK

N30:1

+BTW-----------------------+-BLOCK TRANSFER write +-(EN)-

| 15
| Rack 1
| Group 1+- (DN)
| Module 0
| Control Block N30:1+- (ER)
| Data file N30:100
| Length 37
| Continuous N

N30:1

-BTW- 2:43

N30:1/15

-)/(=- 2:43

Rung 2:44
BLOCK TRANSFER READ FROM ANALOG INPUT MODULE "110" TO OBTAIN DATA FROM
REGISTERS N30:154-N30:161
| BLOCK
| TRANSFER
| WRITE
| ENABLE
| INTERLOCK

N30:2

+BTW-----------------------+-BLOCK TRANSFER READ +-(EN)-

| 15
| Rack 1
| Group 1+- (DN)
| Module 0
| Control Block N30:2+- (ER)
| Data file N30:150
| Length 20
| Continuous N

N30:2

-BTR- 2:44

N30:2/15

-)/(=- 2:44
Ladder Listing

132

Rung 2:45
BLOCK TRANSFER WRITE TO ANALOG OUTPUT MODULE "130" TO PUT DATA IN
REGISTERS N30:200-N30:203 (NO DATA DESIRED 8/4/90)

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>TRANSFER</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENABLE</td>
<td>WRITE TO OUTPUT MOD</td>
</tr>
<tr>
<td>N30:3</td>
<td>+BTR-------------+</td>
</tr>
<tr>
<td>15</td>
<td>+BLOCK TRANSFER WRITE +-(EN)++</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rack 1</td>
</tr>
<tr>
<td></td>
<td>Group 3+- (DN)</td>
</tr>
<tr>
<td></td>
<td>Module 0</td>
</tr>
<tr>
<td></td>
<td>Control Block N30:3+- (ER)</td>
</tr>
<tr>
<td></td>
<td>Data file N30:200</td>
</tr>
<tr>
<td></td>
<td>Length 13</td>
</tr>
<tr>
<td></td>
<td>Continuous N</td>
</tr>
<tr>
<td></td>
<td>+-----------------</td>
</tr>
<tr>
<td></td>
<td>N30:3 -----------BTR-- 2:45</td>
</tr>
<tr>
<td></td>
<td>N30:3/15 -]/[- 2:45</td>
</tr>
</tbody>
</table>

Rung 2:46
BLOCK TRANSFER READ FROM ANALOG OUTPUT MODULE "130" TO OBTAIN STATUS
REGISTER INFORMATION (NONE REQUIRED 8/4/90)

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>TRANSFER</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENABLE</td>
<td>READ FROM OUTPUT MOD</td>
</tr>
<tr>
<td>N30:4</td>
<td>+BTR-------------+</td>
</tr>
<tr>
<td>15</td>
<td>+BLOCK TRANSFER READ +-(EN)++</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rack 1</td>
</tr>
<tr>
<td></td>
<td>Group 3+- (DN)</td>
</tr>
<tr>
<td></td>
<td>Module 0</td>
</tr>
<tr>
<td></td>
<td>Control Block N30:4+- (ER)</td>
</tr>
<tr>
<td></td>
<td>Data file N30:250</td>
</tr>
<tr>
<td></td>
<td>Length 5</td>
</tr>
<tr>
<td></td>
<td>Continuous N</td>
</tr>
<tr>
<td></td>
<td>+-----------------</td>
</tr>
<tr>
<td></td>
<td>N30:4 -----------BTR-- 2:46</td>
</tr>
<tr>
<td></td>
<td>N30:4/15 -]/[- 2:46</td>
</tr>
</tbody>
</table>
Rung 2:47
BLOCK TRANSFER WRITE TO SEND ANALOG INFORMATION FROM THIS PROCESSOR TO
THE S. MAINS PROCESSOR
---

15

---

N30:5

---

+BTW-------------

15

---

N30:5

---

- BTW- 2:47

N30:5/15

---

- )/[ - 2:47

Rung 2:48
BLOCK TRANSFER WRITE TO SEND ANALOG INFORMATION FROM THIS PROCESSOR TO
THE BUNKER PROCESSOR
---

15

---

N30:6

---

+BTW-------------

15

---

N30:6

---

- BTW- 2:48

N30:6/15

---

- )/[ - 2:48

---


Rung 2:49
BLOCK TRANSFER READ TO OBTAIN ANALOG INFORMATION FROM THE WEST A PROCESSOR TO THIS PROCESSOR

BLOCK
TRANSFER
ENABLE
INTERLOCK
N30:7

-----]/*--------------------------+BLOCK TRANSFER READ +(EN)+

Rack 4
Group 0+- (DN)
Module 0
Control Block N30:7+- (ER)
Data file N40:154
Length 8
Continuous N

+-----------------------------+

N30:7
-BTR- 2:49

N30:7/15
-]/* 2:49

Rung 2:50
BLOCK TRANSFER WRITE TO SEND ANALOG INFORMATION FROM WEST A PROCESSOR TO THE S. MAINS PROCESSOR

BLOCK
TRANSFER
ENABLE
INTERLOCK
N30:8

-----]/*--------------------------+BLOCK TRANSFER WRITE +(EN)+

Rack 5
Group 0+- (DN)
Module 0
Control Block N30:8+- (ER)
Data file N40:154
Length 8
Continuous N

+-----------------------------+

N30:8
-BTW- 2:50

N30:8/15
-]/* 2:50
Ladder Listing

Rung 2:51
BLOCK TRANSFER WRITE TO SEND ANALOG INFORMATION FROM THE WEST A PROCESSOR TO THE BUNKER PROCESSOR
BLOCK
TRANSFER
ENABLE
INTERLOCK
N30:9
+/([-)
15

+BTW-----------------------+
+BLOCK TRANSFER WRITE +-(EN)+
Rack 6
Group 0+(DN)
Module 0
Control Block N30:9+- (ER)
Data file N40:154
Length 8
Continuous N

N30:9
-BTW- 2:51

N30:9/15
-]/[- 2:51

Rung 2:52
BLOCK TRANSFER READ TO OBTAIN ANALOG INFORMATION FROM THE S. MAINS PROCESSOR TO THIS PROCESSOR
BLOCK
TRANSFER
ENABLE
INTERLOCK
N30:10
+/([-)
15

+BTR-----------------------+
+BLOCK TRANSFER READ +-(EN)+
Rack 5
Group 0+(DN)
Module 0
Control Block N30:10+- (ER)
Data file N50:154
Length 8
Continuous N

N30:10
-BTR- 2:52

N30:10/15
-]/[- 2:52
Ladder Listing

Rung 2:53
BLOCK TRANSFER WRITE TO SEND ANALOG INFORMATION FROM THE S. MAINS PROCESSOR TO THE BUNKER PROCESSOR

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>BLOCK</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSFER</td>
<td>TRANSFER</td>
</tr>
<tr>
<td>ENABLE</td>
<td>WRITE TO</td>
</tr>
<tr>
<td>INTERLOCK</td>
<td>BUNKER PC</td>
</tr>
</tbody>
</table>

+BTW- -----------+
+BLOCK TRANSFR WRITE +-(EN)-

| Rack | 6 |
| Group | 0+- (DN) |
| Module | 0 |
| Control Block | N30:11+- (ER) |
| Data file | N50:154 |
| Length | 8 |
| Continuous | N |

N30:11
-BTW- 2:53
N30:11/15
- )/[- 2:53

Rung 2:54
BLOCK TRANSFER READ TO OBTAIN ANALOG INFORMATION FROM THE BUNKER PROCESSOR TO THIS PROCESSOR

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>BLOCK</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSFER</td>
<td>TRANSFER</td>
</tr>
<tr>
<td>ENABLE</td>
<td>READ FROM</td>
</tr>
<tr>
<td>INTERLOCK</td>
<td>BUNKER PC</td>
</tr>
</tbody>
</table>

+BTR- -----------+
+BLOCK TRANSFR READ +-(EN)-

| Rack | 6 |
| Group | 0+- (DN) |
| Module | 0 |
| Control Block | N30:12+- (ER) |
| Data file | N60:154 |
| Length | 8 |
| Continuous | N |

N30:12
-BTR- 2:54
N30:12/15
- )/[- 2:54
Ladder Listing

Rung 2:55
BLOCK TRANSFER WRITE TO SEND ANALOG INFORMATION FROM THE BUNKER PROCESSOR TO THE S. MAINS PROCESSOR

```
BLOCK
TRANSFER
ENABLE
INTERLOCK
N30:13
```

```
+BTW--------------------------+
  +BLOCK TRANSFR WRITE +-(EN)+
    | Rack 5 |
    | Group 0+- (DN) |
    | Module 0 |
    | Control Block N30:13+- (ER) |
    | Data file N60:154 |
    | Length 8 |
    | Continuous N |

+--------------------------+
```

```
N30:13

-BTW- 2:55
N30:13/15

-]/[- 2:55
```

Rung 2:56
THE FOLLOWING 64 RUNGS OF LOGIC ARE UTILIZED TO MOVE ALL DIGITAL INPUTS OF THE S. MAINS PROCESSOR TO THE BUNKER PROCESSOR AND ALL DIGITAL INPUTS OF THE BUNKER PROCESSOR TO THE S. MAINS PROCESSOR. THIS TRANSFER OF INPUTS IS TO FACILITATE THE CONTROL/ANNUNCIATION OF ALL POINTS AT EITHER POINT FOR METERS, LIGHTS, PUSHBUTTONS, ETC.

```
<table>
<thead>
<tr>
<th>I:050</th>
<th>O:060</th>
<th>0:060</th>
</tr>
</thead>
</table>
```

```
I:050/00

-] [- 2:56
```

```
O:060/00

-( )- 2:56
```

Rung 2:57
```
<table>
<thead>
<tr>
<th>I:050</th>
<th>O:060</th>
<th>0:060</th>
</tr>
</thead>
</table>
```

```
I:050/01

-] [- 2:57
```

```
O:060/01

-( )- 2:57
```

Rung 2:58
```
<table>
<thead>
<tr>
<th>I:050</th>
<th>O:060</th>
<th>0:060</th>
</tr>
</thead>
</table>
```

```
| 02 |
```
Ladder Listing

Processor File: BS0309.ACH

17 March 1991 Page 30 Rung 2:58

I:050/02
   -] (- 2:58
O:060/02
   -(-) 2:58

Rung 2:59
| I:050
++-[--------------------------------------------] 0:060 |
| 03
I:050/03
   -] (- 2:59
O:060/03
   -(-) 2:59

Rung 2:60
| I:050
++-[--------------------------------------------] 0:060 |
| 04
I:050/04
   -] (- 2:60
O:060/04
   -(-) 2:60

Rung 2:61
| I:050
++-[--------------------------------------------] 0:060 |
| 05
I:050/05
   -] (- 2:61
O:060/05
   -(-) 2:61

Rung 2:62
| I:050
++-[--------------------------------------------] 0:060 |
| 06
I:050/06
   -] (- 2:62
Ladder Listing

I:050/12  [- 2:66
O:060/12  -( )- 2:66

Rung 2:67
| I:050  O:060 |
|---|------------------------|--+
|   | 13                     | 13 |
| I:050/13 [- 2:67
O:060/13 -( )- 2:67

Rung 2:68
| I:050  O:060 |
|---|------------------------|--+
|   | 14                     | 14 |
| I:050/14 [- 2:68

17 March 1991 Page 32
Ladder Listing

O:060/14
-( )- 2:68

Rung 2:69
| I:050
|---| [-----------------------------]
| 15
I:050/15
-] [- 2:69
O:060/15
-( )- 2:69

Rung 2:70
| I:050
|---| [-----------------------------]
| 16
I:050/16
-] [- 2:70
O:060/16
-( )- 2:70

Rung 2:71
| I:050
|---| [-----------------------------]
| 17
Ladder Listing

Processor File: BS0309.ACH

17 March 1991    Page 34
Rung 2:71

I:050/17    [- 2:71
  O:060/17    -( )- 2:71

Rung 2:72
 | I:060
  |----------------------------- O:050 |
  | 00
  | 00 |

I:060/00    [- 2:72

O:050/00    -( )- 2:72

Rung 2:73
 | I:060
  |----------------------------- O:050 |
  | 01
  | 01 |

I:060/01    [- 2:73
Ladder Listing

O:050/01
- ( ) - 2:73

Rung 2:74
| I:060
---[-----------------------------------------------( )--
| 02

I:060/02
- ] [ - 2:74

O:050/02
- ( ) - 2:74

Rung 2:75
| I:060
---[-----------------------------------------------( )--
| 03

I:060/03
- ] [ - 2:75

O:050/03
- ( ) - 2:75

Rung 2:76
| I:060
---[-----------------------------------------------( )--
| 04
Ladder Listing

I:060/04
  [- 2:76

O:050/04
  -( )- 2:76

Rung 2:77
  | I:060
  |---] [-------------------------]
  | 05
  | O:050 |

I:060/05
  [- 2:77

O:050/05
  -( )- 2:77

Rung 2:78
  | I:060
  |---] [-------------------------]
  | 06
  | O:050 |

I:060/06
  [- 2:78
Ladder Listing

O:050/06
   -( )- 2:78

Rung 2:79
   | I:060
   | 07
   | 07
   | O:050
   | -( )- 2:79

I:060/07
   [- 2:79

O:050/07
   -( )- 2:79

Rung 2:80
   | I:060
   | 10
   | 10
   | O:050
   | -( )- 2:80

I:060/10
   [- 2:80

O:050/10
   -( )- 2:80

Rung 2:81
   | I:060
   | 11
   | 11
   | O:050
   | -( )-
Ladder Listing

Processor File: BS0309.ACH

17 March 1991 Page 39
Rung 2:83

O:050/13
   -( )- 2:83

Rung 2:84
   | I:060
   ++-] [-----------------------------------------------( )---
       | 14
   |-] [- 2:84
   | 14

O:050/14
   -( )- 2:84

Rung 2:85
   | I:060
   ++-] [-----------------------------------------------( )---
       | 15
   |-] [- 2:85
   | 15

O:050/15
   -( )- 2:85

Rung 2:86
   | I:060
   ++-] [-----------------------------------------------( )---
       | 16
   |
Ladder Listing

I:060/16
-] [- 2:86

O:050/16
-( )- 2:86

Rung 2:87
| I:060
+++ [-----------------------------------------------( )+-
| 17

I:060/17
-] [- 2:87

O:050/17
-( )- 2:87

Rung 2:88
| I:062
+++ [-----------------------------------------------( )+-
| 00

I:062/00
-] [- 2:88
Ladder Listing

Rung 2:89
| I:062  
+-+ [-----------------------------] ( )--  
| 01  

I:062/01  -] [- 2:89

O:052/01  -( )- 2:89

Rung 2:90
| I:062  
+-+ [-----------------------------] ( )--  
| 02  

I:062/02  -] [- 2:90

O:052/02  -( )- 2:90

Rung 2:91
| I:062  
+-+ [-----------------------------] ( )--  
| 03  

Ladder Listing

I:062/10
  -] [- 2:96

O:052/10
  -( )- 2:96

Rung 2:97
  | I:062
  |   [----------]
  |   11

O:052/11
  -( )- 2:97

Rung 2:98
  | I:062
  |   [----------]
  |   12

O:052/12
  -( )- 2:98
Ladder Listing

Processor File: BS0309.ACH

Rung 2:98

O:052/12
- ( ) - 2:98

Rung 2:99
| I:062
++-[-----------------------------( )--+
| 13
I:062/13
-] [- 2:99
O:052/13
- ( ) - 2:99

Rung 2:100
| I:062
++-[-----------------------------( )--+
| 14
I:062/14
-] [- 2:100
O:052/14
- ( ) - 2:100

Rung 2:101
| I:062
++-[-----------------------------( )--+
| 15
Ladder Listing

Processor File: BS0309.ACH

I:062/15
  -] [- 2:101

O:052/15
  -( )- 2:101

Run 2:102
  I:062
  +--+ [-----------------------------------------------
  | 16
  O:052
  -( )- 16

I:062/16
  -] [- 2:102

O:052/16
  -( )- 2:102

Run 2:103
  I:062
  +--+ [-----------------------------------------------
  | 17
  O:052
  -( )- 17

I:052/17
  -] [- 2:103
Ladder Listing

I:064/07
-] [ - 2:111

O:054/07
-( ) - 2:111

Rung 2:112
[ I:064
+-] [----------------------------------------------( )--+
| 10

O:054 |

Rung 2:113
[ I:064
+-] [----------------------------------------------( )--+
| 11

O:054 |

Rung 2:112

I:064/10
-] [ - 2:112

O:054/10
-( ) - 2:112

Rung 2:113

I:064/11
-] [ - 2:113
Ladder Listing

O:054/11
  -( )- 2:113

Rung 2:114
  | I:064
  | ---] [---------------------------( )----
  |   12
  | I:064/12
  |   ] [- 2:114
  | O:054/12
  |   -( )- 2:114

Rung 2:115
  | I:064
  | ---] [---------------------------( )----
  |   13
  | I:064/13
  |   ] [- 2:115
  | O:054/13
  |   -( )- 2:115

Rung 2:116
  | I:064
  | ---] [---------------------------( )----
  |   14
Ladder Listing

I:064/14
-] [- 2:116

O:054/14
-( )- 2:116

Rung 2:117
| I:064
| [------------------------------]
| 15
| O:054 |
|-( )-+ 15 |

I:064/15
-] [- 2:117

O:054/15
-( )- 2:117

Rung 2:118
| I:064
| [------------------------------]
| 16
| O:054 |
|-( )-+ 16 |

I:064/16
-] [- 2:118
Ladder Listing

Rung 2:119

THE NEXT TWO RUNGS PROVIDE THE SEQUENCE TO THE ADDITIONAL CONVEYORS FROM THE WEST A TO THE WEST B AND S. MAINS

HAWKEYE TO
"SEQUENCED CONVEYORS"

O:040/02
-( )- 2:120

Rung 2:121

SEQUENCE INPUT

I:001
-( )- 01

+++ +++
<table>
<thead>
<tr>
<th>Ladder Listing</th>
<th>Processor File: BS0309.ACH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BELT SLIP</td>
</tr>
<tr>
<td></td>
<td>INPUT</td>
</tr>
<tr>
<td></td>
<td>I:001</td>
</tr>
</tbody>
</table>
| | +----] [-------| | +-----(- )------+
| | 02             | | 01                         |
| I:001/01       | -] [- 2:2 2:121          |
| I:001/02       | -] [- 2:4 2:121          |
| O:041/01       | -( )- 2:121              |
| O:051/01       | -( )- 2:121              |
| Rung 2:122     |                            |
|                | +------------------------+---|
Ladder Listing

NO RUNGS IN FILE 3
**REPORT OPTIONS SUMMARY**

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Page Width:</td>
<td>80</td>
</tr>
<tr>
<td>Page Length:</td>
<td>66</td>
</tr>
<tr>
<td>Graphics Capabilities:</td>
<td>NO</td>
</tr>
<tr>
<td>Right Power Rail:</td>
<td>YES</td>
</tr>
<tr>
<td>Address Comments:</td>
<td>YES</td>
</tr>
<tr>
<td>Symbols:</td>
<td>YES</td>
</tr>
<tr>
<td>Rung Comments:</td>
<td>YES</td>
</tr>
<tr>
<td>Cross References:</td>
<td>ALL</td>
</tr>
<tr>
<td>Starting Rung:</td>
<td>2:0</td>
</tr>
<tr>
<td>Ending Rung:</td>
<td>3:32767</td>
</tr>
</tbody>
</table>
WEST A PLC

DATA HIGHWAY
ADDRESS IS ...... "04"
ONE SLOT ADDRESSING
PROCESSOR IS CONFIGURED
FOR ADAPTER MODE REMOTE
I/O ADDRESS IS "04"

1785-LT
1771-HA
1771-OAD
1771-PF
1771-PF2
1771-1771-P7 POWER SUPPLY
1771-A3B CHASSIS

110V

Appendix D
Ladder Listing

Processor File: BS0308.ACH

Rung 2:0

PULLCORD TO INPUT MODULE "001" CHANNEL "00"

PULLCORD
INPUT
I:001
00

PULLCORD
AUXILIARY
N7:51
0
WESTA BELT
PULLCORD
INDICATION
TO S.BIN
O:031
00

I:001/00
-] [- 2:0

N7:51/0
-] [- 2:1 2:46 2:47
-( )- 2:0

O:031/00
-( )- 2:0

Rung 2:1

PULLCORD AUXILIARY (INTERNAL) RELAY TO OUTPUT MODULE "004" CHANNEL "00"

PULLCORD
AUXILIARY
N7:51

PULLCORD
LIGHT
OUTPUT
O:004
00

LAMPTST
PUSHBUTTON
AUXILIARY
N7:51
14

N7:51/0
-] [- 2:1 2:46 2:47
-( )- 2:0

N7:51/14
2:25 2:40
-( )- 2:31

O:004/00
-( )- 2:1
Rung 2:2

SEQUENCE TO INPUT MODULE "001" CHANNEL "01"

SEQNC INPUT
I:001
---] [---
01

I:001/01
-] [ ] 2:2

N7:51/1
-] [ ] 2:3 2:49 2:51 2:53
-() 2:2

O:031/01
-() 2:2

Rung 2:3

SEQUENCE AUXILIARY (INTERNAL) TO SEQUENCE LIGHT OUTPUT MODULE "004" CHANNEL "01"

SEQNC AUXILIARY
N7:51
---] [---
14

N7:51/1
-] [ ] 2:3 2:49 2:51 2:53
-() 2:2

N7:51/14
-() 2:31

O:004/01
-() 2:3
Ladder Listing

Rung 2:4

BELT SLIP TO INPUT MODULE "001" CHANNEL "02"

<table>
<thead>
<tr>
<th>BELT SLIP</th>
<th>BELT SLIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT I:001</td>
<td>AUXILIARY N7:51</td>
</tr>
<tr>
<td>02</td>
<td>2</td>
</tr>
<tr>
<td>WEST A</td>
<td>BELT BELT SLIP INDICATION TO S.BIN</td>
</tr>
<tr>
<td>O:031</td>
<td>02</td>
</tr>
</tbody>
</table>

I:001/02

-] [- 2:4

N7:51/2

-] [- 2:5 2:46 2:47
-( ) - 2:4

O:031/02

-( ) - 2:4

Rung 2:5

BELT SLIP LIGHT OUTPUT MODULE "004" CHANNEL "02"

<table>
<thead>
<tr>
<th>BELT SLIP</th>
<th>BELT SLIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUXILIARY</td>
<td>LIGHT OUTPUT</td>
</tr>
<tr>
<td>N7:51</td>
<td>O:004</td>
</tr>
<tr>
<td>2</td>
<td>02</td>
</tr>
<tr>
<td>LAMPTEST</td>
<td></td>
</tr>
<tr>
<td>PUSHBUTTON</td>
<td></td>
</tr>
<tr>
<td>AUXILIARY</td>
<td></td>
</tr>
<tr>
<td>N7:51</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

N7:51/2

-] [- 2:5 2:46 2:47
-( ) - 2:4

N7:51/14

-( ) - 2:31
Ladder Listing

O:004/02

Rung 2:5

-( )- 2:5

Rung 2:6

HYDRAULIC TAKEUP PRESSURE TO INPUT MODULE "001" CHANNEL "03"

| HYDRAULIC | HYDRAULIC |
| TAKEUP | TAKEUP |
| PRESSURE | AUXILIARY |
| I:001 | N7:51 |

FAULT
RESET
PUSHBUTTON
N7:51

Rung 2:7

HYDRAULIC TAKEUP LIGHT OUTPUT MODULE "004" CHANNEL "03"

| HYDRAULIC | HYDRAULIC |
| TAKEUP | TAKEUP |
| AUXILIARY | LIGHT |
| N7:51 | O:004 |

LAMPTEST
PUSHBUTTON
AUXILIARY
N7:51

N7:51/3

-] [- 2:6 2:7 2:46 2:47
-( )- 2:6
N7:51/14
  2:25 2:40
-() - 2:31

O:004/03
-() - 2:7

Rung 2:8

GOB-OUT SWITCH TO INPUT MODULE "001" CHANNEL "04"
GOB-OUT GOB-OUT
INPUT AUXILIARY
I:001 N7:51

Rung 2:9

GOB-OUT LIGHT OUTPUT MODULE "004" CHANNEL "04"
GOB-OUT AUXILIARY
N7:51

LAMPTEST
PUSHBUTTON AUXILIARY
N7:51

++---] [---
  4
  14
Ladder Listing

Processor File: BS0308.ACH

Rung 2:9

N7:51/4
-] [- 2:8 2:9
-( ) - 2:8

N7:51/14
2:25 2:40
-( ) - 2:31

O:004/04
-( ) - 2:9

Rung 2:10

FIRE DETECTION TO INPUT MODULE "001" CHANNEL "05"

FIRE DETECTION
INPUT
I:001

N7:51
5
WEST A BELT FIRE INDICATION
TO S.BIN
O:031
-( ) - 05

I:001/05
-] [- 2:10

N7:51/5
-] [- 2:11 2:41 2:46 2:47
-( ) - 2:10

O:031/05
-( ) - 2:10

Rung 2:11

FIRE DETECTION LIGHT OUTPUT MODULE "004" CHANNEL "05"

FIRE DETECTION LIGHT
N7:51
5
LAMPTEST
PUSHBUTTON
AUXILIARY
N7:51
-( ) - 05

14
Ladder Listing

Transformer Overtemperature to Input Module "001" Channel "06"

<table>
<thead>
<tr>
<th>Transformer</th>
<th>Transformer</th>
<th>Transformer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overturemp</td>
<td>Overturemp</td>
<td>Overturemp</td>
</tr>
<tr>
<td>Input</td>
<td>Auxiliary</td>
<td>Auxiliary</td>
</tr>
</tbody>
</table>

Rung 2:12

I:001/06

- [ - 2:12

N7:51/6

- [ - 2:12 2:13 2:46 2:47

- ( )- 2:12

N7:51/15

- [ - 2:6 2:8 2:12 2:14 2:16 2:18

- ( )- 2:32

O:031/06

- ( )- 2:12
Rung 2:13

TRANSFORMER OVERTEMPERATURE LIGHT OUTPUT MODULE "004" CHANNEL "06"

TRANSMXRF
OVERTEMP
AUXILIARY
N7:51

LAMMPST
PUSHBUTTON
AUXILIARY
N7:51

N7:51/6

N7:51/14

O:004/06

Rung 2:14

MOTOR #1 OVERLOAD TO INPUT MODULE "001" CHANNEL "07"

MOTOR #1
OVERLOAD
INPUT
I:001

7

FAULT
RESET
PUSHBUTTON

15

I:001/07

N7:51/7

-] [- 2:14 2:15 2:45
-] [- 2:14

WEST A
BELT
MOTOR 1
OVERLOAD
IND TO SBI

0:031

07
9
Ladder Listing  Processor File: BS0308.ACH

N7:51/15
-] [- 2:6 2:8 2:12 2:14 2:16 2:18
-( )- 2:32

O:031/07
-( )- 2:14

Rung 2:15

MOTOR #1 OVERLOAD LIGHT OUTPUT MODULE "004" CHANNEL "07"

<table>
<thead>
<tr>
<th>MOTOR #1 OVERLOAD LIGHT OUTPUT MODULE &quot;004&quot; CHANNEL &quot;07&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOTOR #1 OVERLOAD LIGHT OUTPUT MODULE &quot;004&quot; CHANNEL &quot;07&quot;</td>
</tr>
<tr>
<td>MOTOR #1 OVERLOAD LIGHT OUTPUT MODULE &quot;004&quot; CHANNEL &quot;07&quot;</td>
</tr>
</tbody>
</table>

N7:51/7
-] [- 2:14 2:15 2:45
-( )- 2:14

N7:51/14
2:25 2:40
-( )- 2:31

O:004/07
-( )- 2:15

Rung 2:16

MOTOR #2 OVERLOAD TO INPUT MODULE "004" CHANNEL "10"

<table>
<thead>
<tr>
<th>MOTOR #2 OVERLOAD TO INPUT MODULE &quot;004&quot; CHANNEL &quot;10&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOTOR #2 OVERLOAD TO INPUT MODULE &quot;004&quot; CHANNEL &quot;10&quot;</td>
</tr>
<tr>
<td>MOTOR #2 OVERLOAD TO INPUT MODULE &quot;004&quot; CHANNEL &quot;10&quot;</td>
</tr>
</tbody>
</table>

I:001  N7:51
10  N7:51
10

FAULT
15
RESET

WEST A 10
BELT
MOTOR 2
OVERLOAD
IND TO SBI
O:031
10
-( )- 10
Ladder Listing

I:001/10
-] [- 2:16

N7:51/10
-] [- 2:16 2:17 2:45
-( )- 2:16

N7:51/15
-] [- 2:6 2:8 2:12 2:14 2:16 2:18
-( )- 2:32

O:031/10
-( )- 2:16

Rung 2:17

MOTOR #2 OVERLOAD LIGHT OUTPUT MODULE "004" CHANNEL "10"

<table>
<thead>
<tr>
<th>MOTOR #2</th>
<th>OVERLOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUXILIARY</td>
<td></td>
</tr>
<tr>
<td>N7:51</td>
<td></td>
</tr>
</tbody>
</table>

[----] [----]

| 10 |
| LAMPTTEST  |
| PUSSBUTTON |
| AUXILIARY  |
| N7:51    |

[----] [----]

| 14 |

N7:51/10
-] [- 2:16 2:17 2:45
-( )- 2:16

N7:51/14
-( )- 2:31

O:004/10
-( )- 2:17
Ladder Listing

Rung 2:18

**MOTOR #3 OVERLOAD TO INPUT MODULE "001" CHANNEL "11"**

<table>
<thead>
<tr>
<th>MOTOR #3</th>
<th>OVERLOAD</th>
<th>AUXILIARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>I:001</td>
<td>N7:51</td>
<td></td>
</tr>
</tbody>
</table>

-----] [-------] [--------] [--------] [--------] [--------] [--------]

11

11

WEST A
BELT
MOTOR 3
OVERLOAD
IND TO SBI
O:031
-----] [--------]

11

11

I:001/11

-] [- 2:18

N7:51/11

-] [- 2:18 2:19 2:45

-( )- 2:18

N7:51/15

-] [- 2:6 2:8 2:12 2:14 2:16 2:18

-( )- 2:32

O:031/11

-( )- 2:18

Rung 2:19

**MOTOR #3 OVERLOAD LIGHT OUTPUT MODULE "004" CHANNEL "11"**

<table>
<thead>
<tr>
<th>MOTOR #3</th>
<th>OVERLOAD</th>
<th>LIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>N7:51</td>
<td></td>
<td>OUTPUT</td>
</tr>
</tbody>
</table>

-----] [--------] [--------] [--------]

11

LAMPTEST
PUSHBUTTON
AUXILIARY
N7:51

-----] [--------]

14

N7:51/11

-] [- 2:18 2:19 2:45

-( )- 2:18
Ladder Listing

Processor File: BS0308.ACH

17 March 1991 Page 12 Rung 2:19

N7:51/14

  2:25 2:40
  -( )- 2:31

O:004/11

-( )- 2:19

Rung 2:20

CIRCUIT BREAKER #1 TO INPUT MODULE "001" CHANNEL "12"

<table>
<thead>
<tr>
<th>CIRCUIT</th>
<th>BREAKER #1</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT</td>
<td>AUXILIARY</td>
</tr>
<tr>
<td>I:001</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
</tr>
</tbody>
</table>

-] [- 12

12

WEST A
BELT
CIRCUIT
BREAKER 1
IND TO SB1

O:031
-( )- 12

Rung 2:20

I:001/12

-] [- 2:20

N7:51/12

-] [- 2:21 2:44

-( )- 2:20

O:031/12

-( )- 2:20

Rung 2:21

CIRCUIT BREAKER #1 LIGHT OUTPUT MODULE "004" CHANNEL "12"

<table>
<thead>
<tr>
<th>CIRCUIT</th>
<th>BREAKER #1</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIGHT</td>
<td>OUTPUT</td>
</tr>
</tbody>
</table>

N7:51

-] [- 12

12

LAMPTEST
PUSHBUTTON
AUXILIARY

N7:51

-] [- 14
Ladder Listing

N7:51/12
-} [ = 2:21 2:44
-( )= 2:20

N7:51/14
2:25 2:40
-( )= 2:31

O:004/12
-( )= 2:21

Rung 2:22

CIRCUIT BREAKER #2 TO INPUT MODULE "001" CHANNEL "13"

| CIRCUIT BREAKER #2 |
| INPUT N7:51 |
| I:001 |
| [---|---] | 13 |

---( )---

I:001/13
-} [ = 2:22

N7:51/13
-} [ = 2:23 2:44
-( )= 2:22

O:031/13
-( )= 2:22

Rung 2:23

CIRCUIT BREAKER #2 LIGHT OUTPUT MODULE "004" CHANNEL "13"

| CIRCUIT BREAKER #2 |
| AUXILIARY |
| N7:51 |
| [---|---] | 13 |

---( )---

+++

+++
Ladder Listing

+++ +++

<table>
<thead>
<tr>
<th>LAMPTEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUSHBUTTON</td>
</tr>
<tr>
<td>AUXILIARY</td>
</tr>
<tr>
<td>N7:51</td>
</tr>
<tr>
<td>[---------</td>
</tr>
<tr>
<td>14</td>
</tr>
</tbody>
</table>

N7:51/13
-] [ 2:23 2:44
-( )- 2:22

N7:51/14
  2:25 2:40
-( )- 2:31

O:004/13
-( )- 2:23

Rung 2:24

CIRCUIT BREAKER #3 TO INPUT MODULE "001" CHANNEL "14"

CIRCUIT
BREAKER #3
INPUT]
[---------|
| 14        |

0
WEST A
BELT
CIRCUIT
BREAKER 3
IND TO GBI
O:031
[---------|
| 14        |

I:001/14
-] [- 2:24

N7:52/0
-] [- 2:24 2:44
-( )- 2:24

O:031/14
-( )- 2:24
Rung 2:25

CIRCUIT BREAKER #3 LIGHT OUTPUT MODULE "004" CHANNEL "14"

CIRCUIT
BREAKER #3
AUXILIARY

N7:52

[-------------]

0

LAMPTEST
PUSHBUTTON
AUXILIARY
N7:51

[-------------]

14

N7:51/14

2:25 2:40
-( )- 2:31

N7:52/0

[- 2:25 2:44
-( )- 2:24

O:004/14

-( )- 2:25

Rung 2:26

AUTO-OFF-MAN SELECTOR SWITCH AUTOMATIC TO INPUT MODULE "001" CHANNEL "15"

AUTO-OFF-
MAN
AUTOMATIC
INPUT
I:001

[-------------]

15

1

WEST A
BELT AUTO
SELECT
INDICATION
TO S. BIN
O:0031

[- ( )--]

15

I:001/15

[- 2:26]
Ladder Listing

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Rung 2:26

N7:52/1
-] [- 2:46
-( )- 2:26

O:031/15
-( )- 2:26

Rung 2:27

AUTO-OFF-MAN SELECTOR SWITCH MANUAL TO INPUT MODULE "001" CHANNEL "16"

AUTO-OFF-
MAN
MANUAL
INPUT
I:001

------] [-----------------------------]

16

AUTO-OFF-
MAN
MANUAL
AUXILIARY
N7:52

2
WEST A
BELT MANUA
SELECT
INDICATION
TO S.BIN
O:031

------] [-----------------------------]

16

I:001/16
-] [- 2:27

N7:52/2
-] [- 2:49 2:51 2:53
-( )- 2:27

O:031/16
-( )- 2:27

Rung 2:28

MOTOR #1 ON/OFF SELECTOR SWITCH ON TO INPUT MODULE "001" CHANNEL "17"

MOTOR #1
ON/OFF
ON INPUT
I:001

------] [-----------------------------]

17

MOTOR #1
ON/OFF ON
AUXILIARY
N7:52

3
WEST A
BELT
MOTOR 1
SELECT
IND TO SBI
O:031

------] [-----------------------------]

17
Ladder Listing

I:001/17
   - [ - 2:28

N7:52/3
   - [ - 2:49
   -]/[ - 2:44 2:45 2:48 2:51 2:53
   -( ) - 2:28

O:031/17
   -( ) - 2:28

Rung 2:29

MOTOR #2 ON/OFF SELECTOR SWITCH ON TO INPUT MODULE "002" CHANNEL "00"

MOTOR #2
ON/OFF
ON INPUT
I:002

Rung 2:30

MOTOR #3 ON/OFF SELECTOR SWITCH ON TO INPUT MODULE "002" CHANNEL "01"

MOTOR #3
ON/OFF
ON INPUT
I:002

Note: The image contains a ladder logic diagram with electrical components and connections, detailing the wiring and operation of the motors and switches.
Ladder Listing

I:002/01  -] [- 2:30

N7:52/5   -] [- 2:53
          -]([- 2:44 2:45 2:48
          -( )- 2:30

O:032/01  -( )- 2:30

Rung 2:31

LAMP TEST PUSHBUTTON TO INPUT MODULE "002" CHANNEL "02"

LAMP TEST
PUSHBUTTON
INPUT
I:002

----------------------------------
02

-----------------------------------

I:002/02  -] [- 2:31

          -( )- 2:31

O:032/02  -( )- 2:31
Ladder Listing

Rung 2:32

FAULT RESET PUSHBUTTON TO INPUT MODULE "002" CHANNEL "03"

FAULT
RESET
PUSHBUTTON
INPUT
I:002

----------------------------------------
15
WEST A
BELT FAULT
RESET
INDICATION
TO S.BIN
O:032

----------------------------------------
03

I:002/03
[-] [ - 2:32

N7:51/15
[-] [ - 2:6 2:8 2:12 2:14 2:16 2:18
-( ) - 2:32

O:032/03
-( ) - 2:32

Rung 2:33

MOTOR #1 CONTACTOR TO INPUT MODULE "002" CHANNEL "04"

MOTOR #1
CONTACTOR
INPUT
I:002

----------------------------------------
14
WEST A
BELT
MOTOR 1
CONTACTOR
IND TO SBI
O:032

----------------------------------------
04

I:002/04
[-] [ - 2:33

N7:52/14
[-] [ - 2:34 2:48 2:50
-( ) - 2:33
Ladder Listing

O:032/04
-( )- 2:33

Rung 2:34

MOTOR #1 HOUR METER/START COUNTER OUTPUT MODULE "004" CHANNEL "15"

MOTOR #1
CONTACTER
AUXILIARY

N7:52
+----] [----------------------------]
 | 14
 | 15

N7:52/14
-[ 2:34 2:48 2:50
-( )- 2:33

O:004/15
-( )- 2:34

Rung 2:35

MOTOR #2 CONTACTOR TO INPUT MODULE "002" CHANNEL "05"

MOTOR #2
CONTACTER
INPUT
I:002

N7:52
+----] [---------------------]
 | 05
 | 15

WEST A
BELT
MOTOR 2
CONTACTER
IND TO SBI
O:032
+--( )--+--05

I:002/05
-[ 2:35

N7:52/15
-[ 2:36 2:48 2:52
-( )- 2:35

O:032/05
-( )- 2:35
Ladder Listing

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Rung 2:36

MOTOR #2 HOUR METER/START COUNTER OUTPUT MODULE "004" CHANNEL "16"
MOTOR #2
CONTACTOR
AUXILIARY
N7:52
+-----] [-------------( )-----
  15

N7:52/15
  -] [- 2:36 2:48 2:52
  -] [- 2:35

O:004/16
  -] [- 2:36

Rung 2:37

MOTOR #3 CONTACCTOR TO INPUT MODULE "002" CHANNEL "06"
MOTOR #3
CONTACTOR
INPUT
I:002
+-----] [-------------
  06

I:002/06
  -] [- 2:37

N7:52/6
  -] [- 2:38 2:48
  -] [- 2:37

O:032/06
  -] [- 2:37
Ladder Listing

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Rung 2:38

MOTOR #3 HOUR METER/START COUNTER OUTPUT MODULE "004" CHANNEL "17"

MOTOR #3
CONTAC TOR
AUXILIARY
N7:52

6

-------- [---] [---] ( ) ---

N7:52/6
-] [- 2:38 2:48
-( )- 2:37

O:004/17
-( )- 2:38

Rung 2:39

CST OVERTEMP TO INPUT MODULE "002" CHANNEL "07"

CST
OVERTEMP
INPUT
I:002

07

-------- [---] [---] [---] ( ) ---

I:002/07
-] [- 2:39

N7:52/7
-] [- 2:40 2:46 2:47
-( )- 2:39

O:032/07
-( )- 2:39
Ladder Listing

Rung 2:40

CST OVERTEMP  
LIGH  T OUTPUT MODULE "005" CHANNEL "02"
  
  CST  
  OVERTEMP  
  AUXILIARY  
  N7:52  

  [------] [------------------] [005]  

  7  
  LAMPTST  
  PUSHBUTTON  
  AUXILIARY  
  N7:51  

  [------] [-----+]  

  14  

N7:51/14  

  2:25 2:40  
  -( )- 2:31  

N7:52/7  

  [---] [---:40 2:46 2:47  
  -( )- 2:39  

O:005/02  

  -( )- 2:40  

Rung 2:41

TIMER FOR TIME DELAY TO OUTPUT CIRCUIT BREAKER UV's
  
FIRE  
DETEC  
AUXILIARY  

  [------] [-----------------] ++TOF---  

  5  

  [------] [-----+---------] ++TIMER OFF DELAY ++(EN)---  

  [-----] [---------] ++(DN)---  

[-----] [---------] ++(EN)---  

N7:51/5  

  [---] [---:11 2:41 2:46 2:47  
  -( )- 2:10  

T4:26  

  -TOF-  2:41
### Ladder Listing

#### Processor File: BS0308.ACH

**Rung 2:42**

**FIRE DETECTION TIME DELAY OUTPUT MODULE "004" CHANNEL "00"**

```
| FIRE   | FIRE   |
| DETECTION | DETECTION |
| TIME DELAY | TIME DELAY |
| T4:26 | O:005 |
| DN | 0:005/00 |
```

```
O:005/00  -( )- 2:42
```

```
T4:26.DN  -] [- 2:42
```

**Rung 2:43**

**PROCESSOR ERROR BIT TO OUTPUT MODULE "005" CHANNEL "01"**

```
| PROCESSOR | PROCESSOR |
| ERROR BIT | ERROR |
| LIGHT | OUTPUT |
| S:0 | O:005 |
```

```
0:005/01  -( )- 2:43
```

```
S:0/0  -] [- 2:43
```

**Rung 2:44**

**OUTPUT CIRCUIT BREAKER/ON-OFF SELECTOR INTERLOCK**

```
| CIRCUIT | CIRCUIT | CIRCUIT |
| BREAKER #1 | BREAKER #2 | BREAKER #3 |
| AUXILIARY | AUXILIARY | AUXILIARY |
| N7:51 | N7:51 | N7:52 |
```

```
N7:53  ( )
```

```
12  13  0
```

```
12  13  0
```

```
12  13  0
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12  13  0
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12  13  0
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12  13  0
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12  13  0
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12  13  0
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```
12  13  0
```

```
12  13  0
```

```
12  13  0
```
Ladder Listing

Processor File: BS0308.ACH

Rung 2:44

N7:51/12
-] [- 2:21 2:44
-( )- 2:20

N7:51/13
-] [- 2:23 2:44
-( )- 2:22

N7:52/0
-] [- 2:25 2:44
-( )- 2:24

N7:52/3
-] [- 2:49
-]/[- 2:44 2:45 2:48 2:51 2:53
-( )- 2:28

N7:52/4
-] [- 2:51
-]/[- 2:44 2:45 2:48 2:53
-( )- 2:29

N7:52/5
-] [- 2:53
-]/[- 2:44 2:45 2:48
-( )- 2:30

N7:53/0
-] [- 2:46 2:47
-( )- 2:44

Rung 2:45

OUTPUT CIRCUIT OVERLOAD/ON-OFF SELECTOR INTERLOCK

<table>
<thead>
<tr>
<th>MOTOR #1</th>
<th>MOTOR #2</th>
<th>MOTOR #3</th>
<th>OVERLOAD/ON-OFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERLOAD</td>
<td>OVERLOAD</td>
<td>OVERLOAD</td>
<td>AUXILIARY</td>
</tr>
<tr>
<td>AUXILIARY</td>
<td>AUXILIARY</td>
<td>AUXILIARY</td>
<td></td>
</tr>
</tbody>
</table>

N7:51/7
-] [- 2:14 2:15 2:45
-( )- 2:14
Ladder Listing

N7:51/3
-] [- 2:6 2:7 2:46 2:47
-()- 2:6

N7:51/5
-] [- 2:11 2:41 2:46 2:47
-()- 2:10

N7:51/6
-] [- 2:12 2:13 2:46 2:47
-()- 2:12

N7:52/1
-] [- 2:46
-()- 2:26

N7:52/7
-] [- 2:40 2:46 2:47
-()- 2:39

N7:53/0
-] [- 2:46 2:47
-()- 2:44

N7:53/1
-] [- 2:46 2:47
-()- 2:45

N7:53/2
-] [- 2:49 2:51 2:53
-()- 2:46

Rung 2:47

STARTER HEALTHY AUXILIARY CIRCUIT (FOR MANUAL OPERATION)

BEIL SLIP BREAKER/ OVERLOAD/ HYDRAULIC CST FIRE PULLCORD
AUXILIARY ON-OFF ON-OFF TAKEUP OVERTEMP DETECTION AUXILIARY
INTERLOCK INTERLOCK AUXILIARY AUXILIARY AUXILIARY

N7:51 N7:53 N7:53 N7:51 N7:52 N7:51 N7:51 >
-----] [---------] [---------] [---------] [---------] [---------] [---------] [---------] [---------]>

| 2 | 0 | 1 | 3 | 7 | 5 | 0 |

| TRANSFORM | STARTER |
| OVERTEMP | HEALTHY |
| AUXILIARY | MANUAL |
| AUXILIARY |
< N7:51 N7:53
<===] [---------( )-----+< 6 3

N7:51/0
-] [- 2:1 2:46 2:47
-()- 2:0
Ladder Listing

N7:51/2
-] [- 2:4 2:46 2:47
-( )- 2:4

N7:51/3
-] [- 2:6 2:7 2:46 2:47
-( )- 2:6

N7:51/5
-] [- 2:11 2:41 2:46 2:47
-( )- 2:10

N7:51/6
-] [- 2:12 2:13 2:46 2:47
-( )- 2:12

N7:52/7
-] [- 2:40 2:46 2:47
-( )- 2:39

N7:53/0
-] [- 2:46 2:47
-( )- 2:44

N7:53/1
-] [- 2:46 2:47
-( )- 2:45

N7:53/3
-] [- 2:49 2:51 2:53
-( )- 2:47

Rung 2:48

CST INITIATE OUTPUT MODULE "007" CHANNEL "03"

<table>
<thead>
<tr>
<th>MOTOR #1</th>
<th>MOTOR #2</th>
<th>MOTOR #3</th>
<th>CST</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTACTOR</td>
<td>CONTACTOR</td>
<td>CONTACTOR</td>
<td>INITIATE</td>
</tr>
<tr>
<td>AUXILIARY</td>
<td>AUXILIARY</td>
<td>AUXILIARY</td>
<td>OUTPUT</td>
</tr>
<tr>
<td>N7:52</td>
<td>N7:52</td>
<td>N7:52</td>
<td>0:007</td>
</tr>
</tbody>
</table>

14 15 6 03

<table>
<thead>
<tr>
<th>MOTOR #1</th>
<th>MOTOR #2</th>
<th>MOTOR #3</th>
<th>BELT SLIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON/OFF</td>
<td>ON/OFF</td>
<td>ON/OFF</td>
<td>DELAY</td>
</tr>
<tr>
<td>SELECTOR</td>
<td>SELECTOR</td>
<td>SELECTOR</td>
<td>TIMER</td>
</tr>
<tr>
<td>AUXILIARY</td>
<td>AUXILIARY</td>
<td>AUXILIARY</td>
<td>+TON------</td>
</tr>
<tr>
<td>N7:52</td>
<td>N7:52</td>
<td>N7:52</td>
<td>TIMER ON DELAY</td>
</tr>
<tr>
<td>3 4 5</td>
<td></td>
<td></td>
<td>Timer T4:30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Time base 0.01艁(DN)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Preset 200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Accum 0</td>
</tr>
</tbody>
</table>

+------------------------+
Ladder Listing

Rung 2:49

N7:52/3
-] [ - 2:49
-] [ - 2:45 2:48 2:51 2:53
-( )- 2:28

N7:52/4
-] [ - 2:51
-] [ - 2:44 2:45 2:48 2:53
-( )- 2:29

N7:52/5
-] [ - 2:53
-] [ - 2:44 2:45 2:48
-( )- 2:30

N7:52/6
-] [ - 2:38 2:48
-( )- 2:37

N7:52/14
-] [ - 2:38 2:48 2:50
-( )- 2:38

N7:52/15
-] [ - 2:36 2:48 2:52
-( )- 2:38

O:007/03
-( )- 2:48

T4:30
-TON- 2:48

Rung 2:49

MOTOR CIRCUIT #1 START CIRCUIT OUTPUT MODULE "007" CHANNEL "00"

<table>
<thead>
<tr>
<th>STARTER</th>
<th>SEQUENCE</th>
<th>MOTOR #1</th>
<th>MOTOR #1</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEALTHY</td>
<td>AUXILIARY</td>
<td>ON/OFF ON</td>
<td>STARTER</td>
</tr>
<tr>
<td>AUTOMATIC</td>
<td>AUXILIARY</td>
<td>OUTPUT</td>
<td></td>
</tr>
</tbody>
</table>

---

N7:53
N7:51
I:031
N7:52
O:007

---

2
1
01
03
00

---

AUTO/OFF/
MANUAL
HEALTHY
MANUAL
AUXILIARY
AUXILIARY
N7:52
N7:53

---

2
3
Ladder Listing

I:030/02
- ] [- 2:49 2:51 2:53

I:031/01
- ] [- 2:49 2:51 2:53

N7:51/1
- ] [- 2:3 2:49 2:51 2:53
- ( )- 2:2

N7:52/2
- ] [- 2:49 2:51 2:53
- ( )- 2:27

N7:52/3
- ] [- 2:49
- ]/[- 2:44 2:45 2:48 2:51 2:53
- ( )- 2:28

N7:53/2
- ] [- 2:49 2:51 2:53
- ( )- 2:46

N7:53/3
- ] [- 2:49 2:51 2:53
- ( )- 2:47

O:007/00
- ( )- 2:49

Rung 2:50

TIMER CIRCUIT FOR MOTOR 1/2 START DELAY

MOTOR #1
CONTACTOR
AUXILIARY
N7:52

+---------------------------+TIMER ON DELAY +-(EN)-+
14

+---------------------------+---------------------------+
| MOTOR 1/2 START DELAY     |
| Motor T4:27              |
| Time base 0.01+(DN)      |
| Preset 100              |
| Accum 0                 |

N7:52/14
- ] [- 2:34 2:48 2:50
- ( )- 2:33

T4:27
- TON- 2:50
Ladder Listing  

Motor 2/3 Start Delay Timer Circuit

Motor #2
Contactor
Auxiliary
N7:52

+-------------------+-------------------+
| Timer On Delay | + (EN) |
| T4:25 | Preset 100 |
| Accum 0 | |

N7:52/15

Motor #3 Starter Circuit Output Module "007" Channel "02"

Starter Sequence Motor #2 Motor #1 Motor #1
Healthy Auxiliary On/Off On/Off Contactor
Automatic Auxiliary Selector Selector Auxiliary

N7:53 N7:51 I:031 N7:52 N7:52 N7:53

Motor 1/2 Motor 2/3
Start Start
Delay Delay
T4:25 T4:28

Auto/Off Manual Healthy
Manual Manual
Auxiliary Auxiliary

N7:52 N7:53

2 3

198  
17 March 1991 Page 32
Ladder Listing

Processor File: BS0308.ACH

17 March 1991 Page 33
Rung 2:53

| MOTOR #3  |
| STARTER  |
| OUTPUT   |
| < 0:007  |
| <=---()---->
| < 02     |

I:030/02
-] [- 2:49 2:51 2:53

I:031/01
-] [- 2:49 2:51 2:53

N7:51/1
-] [- 2:3 2:49 2:51 2:53
-() - 2:2

N7:52/2
-] [- 2:49 2:51 2:53
-() - 2:27

N7:52/3
-] [- 2:49
-]/[- 2:44 2:45 2:48 2:51 2:53
-() - 2:28

N7:52/4
-] [- 2:51
-]/[- 2:44 2:45 2:48 2:53
-() - 2:29

N7:52/5
-] [- 2:53
-]/[- 2:44 2:45 2:48
-() - 2:30

N7:53/2
-] [- 2:49 2:51 2:53
-() - 2:46
Ladder Listing

Processor File: BS0308.ACH

N7:53/3
-] [- 2:49 2:51 2:53
-( )- 2:47

O:007/02
- ( )- 2:53

T4:27.DN
-] [- 2:51 2:53

T4:28.DN
-] [- 2:53

Rung 2:54
BLOCK TRANSFER WRITE TO ANALOG INPUT MODULE "110" TO CONFIGURE THE
MODULE FOR 4-20mA <-> 0-4095 A/D CONVERSION

<table>
<thead>
<tr>
<th>BLOCK</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSFER</td>
</tr>
<tr>
<td>ENABLE</td>
</tr>
<tr>
<td>INTERLOCK</td>
</tr>
</tbody>
</table>
N40:1
+BTW-----------------------------+
|------------------------|------------------------|
15 | +BLOCK TRANSFR WRITE +-(EN)- |
| Rack | 1 |
| Group | 1+- (DN) |
| Module | 0 |
| Control Block | N40:1+- (ER) |
| Data file | N40:100 |
| Length | 37 |
| Continuous | N |

N40:1
-BTW- 2:54

N40:1/15
-]/[- 2:54

Rung 2:55
BLOCK TRANSFER READ FROM ANALOG INPUT MODULE "110" TO OBTAIN
DATA FROM REGISTERS N40:154-N40:161

<table>
<thead>
<tr>
<th>BLOCK</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSFER</td>
</tr>
<tr>
<td>READ FROM</td>
</tr>
<tr>
<td>INPUT MOD</td>
</tr>
</tbody>
</table>
N40:2
+BTR-----------------------------+
|------------------------|------------------------|
15 | +BLOCK TRANSFR READ +-(EN)- |
| Rack | 1 |
| Group | 1+- (DN) |
| Module | 0 |
| Control Block | N40:2+- (ER) |
| Data file | N40:150 |
| Length | 20 |
| Continuous | N |
Ladder Listing

N40:2
-BTR- 2:55

N40:2/15
-]/[- 2:55

0:000
-BTR- 2:55 2:57
-BTW- 2:54 2:56

Rung 2:56

BLOCK TRANSFER WRITE TO ANALOG OUTPUT MODULE "130" TO CONFIGURE THE
MODULE FOR 0-4095 &gt;= &lt; 4-20mA D/A CONVERSION AND TO SEND DATA TO
REGISTERS N40:200-N40:203

| BLOCK TRANSFER ENABLE INTERLOCK |
|----------------------------------|----------------|
| Read Transfer Write To Output Mod |<+-BTW-+---------|
| Rack 1 | Group 3+- (DN) |
| Module 0 | Control Block N40:3+- (ER) |
| Data file N40:200 | Length 13 |
| Continuous N |<+-----------------|

Rung 2:57

BLOCK TRANSFER READ FROM ANALOG OUTPUT MODULE "130" TO OBTAIN MODULE
STATUS REGISTER INFORMATION (NONE REQUIRED 8/4/90)

| BLOCK TRANSFER ENABLE INTERLOCK |
|----------------------------------|----------------|
| Read Transfer Output Mod |<+-BTR-+---------|
| Rack 1 | Group 3+- (DN) |
| Module 0 | Control Block N40:4+- (ER) |
| Data file N40:250 | Length 5 |
| Continuous N |<+-----------------|

N40:4
-BTR- 2:57
Ladder Listing

Processor File: BS0308.ACH

N40:4/15

Rung 2:58

[END OF FILE]
Ladder Listing

NO RUNGS IN FILE 3
REPORT OPTIONS SUMMARY

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Page Width:</td>
<td>80</td>
</tr>
<tr>
<td>Page Length:</td>
<td>66</td>
</tr>
<tr>
<td>Graphics Capabilities:</td>
<td>NO</td>
</tr>
<tr>
<td>Right Power Rail:</td>
<td>YES</td>
</tr>
<tr>
<td>Address Comments:</td>
<td>YES</td>
</tr>
<tr>
<td>Symbols:</td>
<td>YES</td>
</tr>
<tr>
<td>Rung Comments:</td>
<td>YES</td>
</tr>
<tr>
<td>Cross References:</td>
<td>ALL</td>
</tr>
<tr>
<td>Starting Rung:</td>
<td>2:0</td>
</tr>
<tr>
<td>Ending Rung:</td>
<td>3:32767</td>
</tr>
</tbody>
</table>
S. MAINS PLC

DATA HIGHWAY
ADDRESS......"05"
ONE SLOT ADDRESSING
REMOTE I/O
ADDRESS......"05"

1771-P7 POWER SUPPLY
1771-A2B CHASSIS

APPENDIX E
Allen-Bradley Co.
6200 Series Software
PLC-5 Programming Terminal Software
Release 2.22
Program Listing

Processor File: S_MAINS.ACH
17 March 1991 - 18:42
Rung 2:0
S. MAINS  ADAPTER
REMOTE  DATA
LINE INPUT  TRANSFER
I:000
02
02

I:000/02
-] [- 2:0

O:030/02
-( )- 2:0

Rung 2:1
S. MAINS  ADAPTER
HEALTHY  DATA
INPUT  TRANSFER
I:000
03
03

I:000/03
-] [- 2:1

O:030/03
-( )- 2:1

Rung 2:2
S. MAINS  ADAPTER
RUNNING  DATA
INPUT  TRANSFER
I:000
04
04

I:000/04
-] [- 2:2

O:030/04
-( )- 2:2

Rung 2:3
REMOTE  ADAPTER
FEEDER  DATA
START PB  TRANSFER
INPUT
I:000
05
05

I:000/05
-] [- 2:3
Ladder Listing  
Processor File: S_MAINS.ACH  
Rung 2:3

O:030/05
- ( ) - 2:3

Rung 2:4
REMOTE
FEEDER
STOP PB
INPUT
I:000
       ] [--------------------------( )------------------------
       06
I:000/06
-] [- 2:4
O:030/06
- ( ) - 2:4

Rung 2:5
REMOTE
POWER PACK
START PB
INPUT
I:000
------- ] [--------------------------( )------------------------
------- 07
I:000/07
-] [- 2:5
O:030/07
- ( ) - 2:5

Rung 2:6
REMOTE
POWER PACK
STOP PB
INPUT
I:000
------- ] [--------------------------( )------------------------
------- 10
I:000/10
-] [- 2:6
O:030/10
- ( ) - 2:6

Rung 2:7
REMOTE
FEED RATE1
SELECT
INPUT
I:000
------- ] [--------------------------( )------------------------
------- 11

Rung 2:11
REMOTE
MANUAL
SELECT
INPUT
I:000

15
I:000/15
-
O:030/15
-

Rung 2:12
ADAPTER
DATA
TRANSFER
I:031

00
I:031/00
-
O:001/00
-

Rung 2:13
ADAPTER
DATA
TRANSFER
I:031

01
I:031/01
-
O:001/01
-

Rung 2:14
ADAPTER
DATA
TRANSFER
I:031

02
I:031/02
-

Processor File: S_MAINS.ACH
Rung 2:11

17 March 1991
Page 210
Ladder Listing

Processor File: S_MAINS.ACH

Rung 2:14

O:001/02
-( )- 2:14

Rung 2:15
ADAPTER
DATA
TRANSFER
I:031

I:031/03
-( )- 2:15

O:001/03
-( )- 2:15

Rung 2:16
ADAPTER
DATA
TRANSFER
I:031

I:031/04
-( )- 2:16

O:001/04
-( )- 2:16

Rung 2:17
ADAPTER
DATA
TRANSFER
I:031

I:031/05
-( )- 2:17

O:001/05
-( )- 2:17

Rung 2:18
ADAPTER
DATA
TRANSFER
I:031

-( )- 06
Ladder Listing

Processor File: S_MAINS.ACH

Rung 2:18

I:031/06
-] [- 2:18

O:001/06
-( )- 2:18

Rung 2:19
ADAPTER
DATA
TRANSFER

I:031

----------
14

O:001

Rung 2:20
ADAPTER
DATA
TRANSFER

I:034

----------
01

O:001

Rung 2:21
ADAPTER
DATA
TRANSFER

I:034

----------
00

O:001

Rung 2:21
ADAPTER
DATA
TRANSFER

I:034

----------
00

O:001

-( )- 2:21
Ladder Listing

Processor File: S_MAINS.ACH

Rung 2:22

ADAPTER
DATA
TRANSFER

I:034
12

2W MAINS
CHASE
BLOCK
LIGHT
OUTPUT

O:001

14

Rung 2:23

ADAPTER
DATA
TRANSFER

I:032
07

BUNKER
PILE
OVERTRAVEL
LIGHT
OUTPUT

O:001

15

Rung 2:24

ADAPTER
DATA
TRANSFER

I:034
04

HIGH WATER
LEVEL
LIGHT
OUTPUT

O:001

17

Rung 2:25

ADAPTER
DATA
TRANSFER

I:034
05

S. MAINS
MISALIGN
LIGHT
OUTPUT

O:002

00
Ladder Listing

Rung 2:29

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>TRANSFER</th>
<th>WRITE</th>
<th>INTERLOCK</th>
</tr>
</thead>
</table>

N50:1

- BTW- 2:29

N50:1/15

- /[- 2:29

Rung 2:30

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>TRANSFER</th>
<th>READ</th>
<th>INTERLOCK</th>
</tr>
</thead>
</table>

N50:2

- BTR- 2:30

N50:2/15

- /[- 2:30
Ladder Listing

Rung 2:31

MOVES DATA
FOR S.BIN
MOTOR
CURRENT TO
OUTPUT FIL

+MOVE

Source  N30:154

Dest  N50:200

N30:154  -MOV-  2:31

N50:200  -MOV-  2:31

Rung 2:32

MOVES DATA
FOR W. MAI
NS A MOTOR
CURRENT TO
OUTPUT FIL

+MOVE

Source  N40:154

Dest  N50:201

N40:154  -MOV-  2:32

N50:201  -MOV-  2:32

Rung 2:33

MOVES DATA
FOR S.MAIN
SCALE TO
ANALOG OUT
MODULE FIL

+MOVE

Source  N60:154

Dest  N50:202

N60:154  0

N50:202  0
Ladder Listing

N50:202
  -MOV-  2:33

N60:154
  -MOV-  2:33

Rung 2:34

MOVES DATA
FOR 2WMAIN
MOTOR
CURRENT TO
OUTPUT FIL

+MOV----

---MOVE---

<table>
<thead>
<tr>
<th>Source</th>
<th>N60:155</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Dest</td>
<td>N50:203</td>
</tr>
<tr>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

N50:203
  -MOV-  2:34

N60:155
  -MOV-  2:34

Rung 2:35

BLOCK
TRANSFER
WRITE
INTERLOCK

---]/[---

15

N50:3

+BTW----

---BLOCK TRNSFR WRITE---

| Rack | 1 |
| Group| 2- (DN) |
| Module| 0 |
| Control Block | N50:3 | (ER) |
| Data file | N50:200 |
| Length | 13 |
| Continuous | N |

N50:3
  -BTW-  2:35

N50:3/15
  -]/[-  2:35
Rung 2:36
BLOCK
TRANSFER
READ
INTERLOCK

N50:4

+----------
| 15
|------------------------
|+-----------------------++
|                         |
|                         |
|                         |
|                         |
|                         |
|                         |
|------------------------

N50:4
-BTR- 2:36

N50:4/15
-}/[ 2:36

Rung 2:37

------------------------------------------[END OF FILE]------------------------------------------
REPORT OPTIONS SUMMARY

Page Width: 80
Page Length: 66
Graphics Capabilities: NO
Right Power Rail: YES
Address Comments: YES
Symbols: YES
Rung Comments: YES
Cross References: ALL
Starting Rung: 2:0
Ending Rung: 2:32767
Rung 2:0
BUNKER
EMPTY
OVERTRAVEL
INPUT
I:000
00

I:000/00
[-] 2:46 2:47
[-]/[- 2:0

O:001/06
( ) 2:0

O:030/00
( ) 2:0

Rung 2:1
BUNKER
FULL
OVERTRAVEL
INPUT
I:000
01

I:000/01
[-] 2:1 2:46
[-]/[- 2:48

O:001/00
( ) 2:1

O:030/01
( ) 2:1
Rung 2:2

<table>
<thead>
<tr>
<th>BUNKER 25%</th>
<th>BUNKER 25%</th>
<th>ADAPTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMPTY</td>
<td>FULL INPUT</td>
<td>DATA</td>
</tr>
<tr>
<td>I:000</td>
<td>I:000</td>
<td>TRANSFER</td>
</tr>
<tr>
<td>02</td>
<td>03</td>
<td></td>
</tr>
</tbody>
</table>

I:000/02
-] [- 2:2 2:47 2:49
I:000/03
-] [- 2:3
-]/[- 2:2
O:001/05
-( )- 2:2
O:030/02
-( )- 2:2

Rung 2:3

<table>
<thead>
<tr>
<th>BUNKER 25%</th>
<th>BUNKER 50%</th>
<th>ADAPTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>FULL INPUT</td>
<td>FULL INPUT</td>
<td>DATA</td>
</tr>
<tr>
<td>I:000</td>
<td>I:000</td>
<td>TRANSFER</td>
</tr>
<tr>
<td>03</td>
<td>04</td>
<td></td>
</tr>
</tbody>
</table>

I:000/03
-] [- 2:3
-]/[- 2:2
I:000/04
-] [- 2:4
-]/[- 2:3
O:001/04
-( )- 2:3
O:030/03
-( )- 2:3
Ladder Listing

Processor File: BUNKER.ACH

Rung 2:9
FEEDER
START PB
INPUT
I:000

11

I:000/11
-] [- 2:9 2:49 2:49

O:030/11
- ( )- 2:9

Rung 2:10
FEEDER
STOP PB
INPUT
I:000

12

I:000/12
-] [- 2:10 2:49

O:030/12
- ( )- 2:10

Rung 2:11
FEED RATE1
SELECTOR
INPUT
I:000

13

I:000/13
-] [- 2:11 2:50

O:030/13
- ( )- 2:11

Rung 2:12
FEED RATE2
SELECTOR
INPUT
I:000

14

I:000/14
-] [- 2:12 2:50

O:030/14
- ( )- 2:12
Ladder Listing

Processor File: BUNKER.ACH

Rung 2:13
FEED RATE
SELECTOR
INPUT
I:000

[ ]
15

I:000/15
-

O:030/15
-

Rung 2:14
POWER PACK
START PB
INPUT
I:000

[ ]
16

I:000/16
-

O:030/16
-

Rung 2:15
POWR PACK
STOP PB
INPUT
I:000

[ ]
17

I:000/17
-

O:030/17
-

Rung 2:16
EMERGENCY
WITHDRAW
PUSHBUTTON
INPUT
I:002

[ ]
00

I:002/00
-

[ ]
15

[ ]
17

[- 2:13 2:50]

[- 2:14 2:46]

[- 2:15]

[- 2:15]

[- 2:15]

[- 2:46]

[- 2:15]
Ladder Listing

Processor File: BUNKER.ACH

Rung 2:16

O:032/00

-( ) - 2:16

Rung 2:17

RESET PB
INPUT
I:002

----------------------------------------( )----------------------------------------

01

I:002/01

-] [- 2:17

O:032/01

-( ) - 2:17

Rung 2:18

AUTO
SELECTOR
INPUT
I:002

----------------------------------------( )----------------------------------------

02

I:002/02


O:032/02

-( ) - 2:18

Rung 2:19

LOCAL
MANUAL
SELECTOR
INPUT
I:002

----------------------------------------( )----------------------------------------

03

I:002/03


O:032/03

-( ) - 2:19

Rung 2:20

REMOTE
MANUAL
SELECTOR
INPUT
I:002

----------------------------------------( )----------------------------------------

04

O:032/04
Ladder Listing

Processor File: BUNKER.ACH

Rung 2:20

I:002/04

-] [- 2:20 2:46 2:49 2:51

O:032/04

-( )- 2:20

Rung 2:21

EMERGENCY

WITHDRAW

SELECTOR

INPUT

I:002

O:032

05

-( )---

05

I:002/05

-] [- 2:21 2:48

O:032/05

-( )- 2:21

Rung 2:22

STOP/TRIPS

HEALTHY

INPUT

I:002

O:032

06

-( )---

06

I:002/06

-] [- 2:22 2:46

O:032/06

-( )- 2:22

Rung 2:23

BUNKER

PILE

OVERTRAVEL

INPUT

I:002

07

-( )---

07

I:002/07

-] [- 2:46

-]/[- 2:23

O:001/07

-( )- 2:23
Ladder Listing

Processor File: BUNKER.ACH

Rung 2:24

W. MAINS B
ENABLE/
INHIBIT
SELECTOR
INPUT
I:002

Rung 2:25

FEEDER
HEALTHY
INPUT
I:002

Rung 2:26

POWER PACK
HEALTHY
INPUT
I:002

Rung 2:27

SCALES
HEALTHY
INPUT
I:002

O:032/07
-( )- 2:23

O:032/10
-( )- 2:24

O:032/11
-( )- 2:25

O:032/12
-( )- 2:26
Ladder Listing

O:034/06
  -( )- 2:36

Rung 2:37
  BUNKER
  FILL PROBE
  INPUT
  I:004
  ---[---------------------]
  07
  -( )- 07

I:004/07
  [- 2:37 2:46 2:48

O:034/07
  -( )- 2:37

Rung 2:38
  BUNKER
  EMPTY
  PROBE
  INPUT
  I:004
  ---[---------------------]
  10
  -( )- 10

I:004/10
  [- 2:38 2:46 2:47

O:034/10
  -( )- 2:38

Rung 2:39
  2 W. MAINS
  HEAD BLOCK
  CHUTE
  INPUT
  I:004
  --[---]
  12
  -( )- 12

I:004/12
  [- 2:39

O:001/10
  -( )- 2:39

O:034/12
  -( )- 2:39
Ladder Listing

I:004/16
-] [- 2:42

O:034/16
-( )- 2:42

Rung 2:43
2 W. MAINS
RUNNING
INPUT
I:004

17

I:004/17
-] [- 2:43

O:034/17
-( )- 2:43

Rung 2:44
S. MAINS
HEALTHY
ADAPTER
DATA
TRANSFER
I:030

03

I:030/03
-] [- 2:44

O:003/03
-( )- 2:44

Rung 2:45
S. MAINS
REMOTE
LINE OK
ADAPTER
DATA TRANS
I:030

02

I:030/02
-] [- 2:45

O:003/04
-( )- 2:45
I:000/00  -] [- 2:46 2:47
         -]/[- 2:0
I:000/01  -] [- 2:1 2:46
         -]/[- 2:46
I:000/16  -] [- 2:14 2:46
I:000/17  -] [- 2:15
         -]/[- 2:46
I:002/04  -] [- 2:20 2:46 2:49 2:51
I:002/06  -] [- 2:22 2:46
Ladder Listing

17 March 1991  Page 18
Rung 2:46

I:002/07
-] [- 2:46
-]/[- - 2:23

I:002/12
-] [- 2:26 2:46

I:004/01
-] [- 2:31 2:46 2:46

I:004/07
-] [- 2:37 2:46 2:48

I:004/10
-] [- 2:38 2:46 2:47

I:004/13
-] [- 2:46
-]/[- - 2:40

I:004/15
-] [- 2:46
-]/[- - 2:41

I:030/07
-] [- 2:46

O:006/03
-( )- 2:46

O:030/10
-]/[-] [- 2:46
-( )- 2:8

Rung 2:47

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| 02 | 02 | 00 | 01 | 00 |

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| 03 | 07 |

I:000/00
-] [- 2:46 2:47
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I:000/02
-] [- 2:2 2:47 2:49
Ladder Listing  
Processor File: BUNKER.ACH  
17 March 1991  Page 19  Rung 2:47

I:000/07
   -] [- 2:7 2:47

I:002/02

I:002/03

I:004/10
   -] [- 2:38 2:46 2:47

O:001/01
   -]([- 2:47
   -( )- 2:6

O:006/00
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02 07 06 01 00 01

EMERGENCY | EMERGENCY |
WITHDRAW | WITHDRAW |
SELECTOR | PUSHBUTTON |
INPUT | INPUT |
I:002 | I:002 |
05 00

LOCAL | BUNKER |
MANUAL | FILL PB |
SELECTOR | INPUT |
INPUT |
I:002 | I:000 |
03 10

I:000/01
   -] [- 2:1 2:46
   -]/[- 2:48

I:000/06
   -] [- 2:6
   -]/[- 2:48

I:000/10
   -] [- 2:8 2:48

I:002/00
   -] [- 2:16 2:48
Ladder Listing

Processor File: BUNKER.ACH

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Rung 2:49

I:000/02
- [ - 2:2 2:47 2:49

I:000/11
- [ - 2:9 2:49 2:49

I:000/12
- [ - 2:10 2:49

I:002/02

I:002/03

I:002/04
- [ - 2:20 2:46 2:49 2:51

I:004/00
- [ - 2:30 2:49 2:49

I:030/04
- [ - 2:49

I:030/05
- [ - 2:49

I:030/06
- [ - 2:49

O:006/02
- ( ) - 2:49

Rung 2:50

LOCAL
MANUAL
SELECTOR
SELECTOR
INPUT
I:002
I:000
N60:10

------- [-----------] [----------[ONS]------------] +MOV--------+
03 13 1
Source
Dest N60:200

------------

FEED RATE1
"ONE SHOT"

SELECTOR IS TRUE
FOR ONE
SCAN AFTER
TRUE/FALSE

-------- [----------] [----------[ONS]------------] +MOVE

------- [-----------] [----------[ONS]------------] +MOVE

------------

FEED RATE2

SELECTOR

INPUT
I:000 N60:10

-------- [----------] [----------[ONS]------------] +MOVE

------------

FEED RATE3

SELECTOR

INPUT
I:000 N60:10

-------- [----------] [----------[ONS]------------] +MOVE

------------

I:000/13 [ - 2:11 2:50
I:000/14 [ - 2:12 2:50
I:000/15 [ - 2:13 2:50
N60:10/1 -ONS- 2:50
N60:10/2 -ONS- 2:50
N60:10/3 -ONS- 2:50
Ladder Listing

Processor File: BUNKER.ACH

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N60:200

- MOV- 2:50 2:50 2:50 2:51 2:51 2:51
- PID- 2:52

Rung 2:51

REMOTE
MANUAL
SELECTOR
INPUT
ADAPTER
DATA TRANS

I:002

04 11 4

REMOTE
FEED RATE1
SELECTOR
ADAPTER
DATA TRANS

I:030

N60:10

+ MOV-------

0

Source 1000

Dest N60:200

R

REMOTE
FEED RATE2
SELECTOR
ADAPTER
DATA TRANS

I:030

N60:10

+ MOV-------

12 5

Source 2000

Dest N60:200

R

REMOTE
FEED RATE3
SELECTOR
ADAPTER
DATA TRANS

I:030

N60:10

+ MOV-------

13 6

Source 4095

Dest N60:200

R

I:002/04

- [ - 2:20 2:46 2:49 2:51

I:030/11

- [ - 2:51

I:030/12

- [ - 2:51

I:030/13

- [ - 2:51

N60:10/4

- ONS- 2:51
Ladder Listing

Processor File: BUNKER.ACH

17 March 1991 Page 24 Run 2:51

N60:10/5
-OFS- 2:51

N60:10/6
-OFS- 2:51

N60:200
-MOV- 2:50 2:50 2:50 2:51 2:51 2:51
-PID- 2:52

Rung 2:52

AUTO
SELECTOR
INPUT

I:002

PID

Control block N60:300
Process variable N60:154
Tieback 0
Control variable N60:200

I:002/02

N60:154
-PID- 2:52

N60:200
-MOV- 2:50 2:50 2:50 2:51 2:51 2:51
-PID- 2:52

N60:300
-PID- 2:52

Rung 2:53

BLOCK
TRANSFER
WRITE
INTERLOCK

N60:1

---]/[-----------------------------++

15

+BTW- BLOCK TRANSFR WRITE ++(EN)+

Rack 1
Group 0++(DN)
Module 0
Control Block N60:1++(ER)
Data file N60:100
Length 37
Continuous N

N60:1
-BTW- 2:53
Ladder Listing

Rung 2:56
| BLOCK
| TRANSFER
| READ
| INTERLOCK

N60:4
------------------------------+
| +BTR--
| BLOCK TRANSFR READ
| +-(EN)-
| 15
| Rack
| Group
| Module
| Control Block
| Data file
| Length
| Continuous

N60:4
--BTR-- 2:56

N60:4/15
-)/[- 2:56

Rung 2:57

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APPENDIX G

TAG................. M76S  
DESC................. STATUS OF M76 BELT  
DV-DEVICE........... ABH  
HT-H/W OPTIONS...... PLC5  
IO-ADDR............. 3:1:I:001/00  
OT-OPEN TAG.......... OFF  
CT-CLOSED TAG........ ON  
IS-INIT SCAN......... ON  
ST-SCAN TIME......... 3  
NX-NEXT BLOCK........ 
AT-ALM TYPE.......... OPEN  
AP-ALM PRI........... L  
AE-ALM ENABLE........ ENABLE  
PA-PLANT AREA........ ALL  
II-INVERT............ NO  
IA-INIT A/M........... AUTO  

TAG................. SCALE#2S  
DESC................. STATUS OF SCALE #2  
DV-DEVICE........... ABH  
HT-H/W OPTIONS...... PLC5  
IO-ADDR............. 3:1:O:003/00  
OT-OPEN TAG.......... OFF  
CT-CLOSED TAG........ ON  
IS-INIT SCAN......... ON  
ST-SCAN TIME......... 3  
NX-NEXT BLOCK........ 
AT-ALM TYPE.......... OPEN  
AP-ALM PRI........... L  
AE-ALM ENABLE........ ENABLE  
PA-PLANT AREA........ ALL  
II-INVERT............ NO  
IA-INIT A/M........... AUTO
TAG................. DRUMS
DESC................. STATUS OF ROTARY BREAKER DRUM
DV-DEVICE........... ABH
HT-H/W OPTIONS..... PLC5
IO-ADDR............. 3:1:1:001/01
OT-OPEN TAG......... OFF
CT-CLOSED TAG........ ON
IS-INIT SCAN........ ON
ST-SCAN TIME........ 3
NX-NEXT BLOCK........
AT-ALM TYPE......... OPEN
AP-ALM PRI........... L
AE-ALM ENABLE........ ENABLE
PA-PLANT AREA........ ALL
II-INVERT............ NO
IA-INIT A/M............ AUTO

TAG................. MS7S
DESC................. STATUS OF MS7 BELT
DV-DEVICE........... ABH
HT-H/W OPTIONS..... PLC5
IO-ADDR............. 3:1:1:001/02
OT-OPEN TAG......... OFF
CT-CLOSED TAG........ ON
IS-INIT SCAN........ ON
ST-SCAN TIME........ 3
NX-NEXT BLOCK........
AT-ALM TYPE......... OPEN
AP-ALM PRI........... L
AE-ALM ENABLE........ ENABLE
PA-PLANT AREA........ ALL
II-INVERT............ NO
IA-INIT A/M............ AUTO
TAG............ COLLECTS
DESC............ STATUS OF COLLECTING CONVEYOR
DV-DEVICE...... ABH
HT-H/W OPTIONS.. PLC5
IO-ADDR......... 3:1:I:001/04
OT-OPEN TAG..... OFF
CT-CLOSED TAG... ON
IS-INIT SCAN.... ON
ST-SCAN TIME.... 3
NX-NEXT BLOCK...
AT-ALM TYPE..... OPEN
AP-ALM PRI....... L
AE-ALM ENABLE.... ENABLE
PA-PLANT AREA.... ALL
II-INVERT........ NO
IA-INIT A/M..... AUTO

TAG............ FEEDER#2S
DESC............ STATUS OF FEEDER#2
DV-DEVICE...... ABH
HT-H/W OPTIONS.. PLC5
IO-ADDR......... 3:1:I:001/04
OT-OPEN TAG..... OFF
CT-CLOSED TAG... ON
IS-INIT SCAN.... ON
ST-SCAN TIME.... 3
NX-NEXT BLOCK...
AT-ALM TYPE..... OPEN
AP-ALM PRI....... L
AE-ALM ENABLE.... ENABLE
PA-PLANT AREA.... ALL
II-INVERT........ NO
IA-INIT A/M..... AUTO
TAG................. FEEDER#3S
DESC................. STATUS OF FEEDER#3
DV-DEVICE........... ABH
HT-H/W OPTIONS..... PLC5
IO-ADDR............. 3:1:1:001/05
OT-OPEN TAG......... OFF
CT-CLOSED TAG....... ON
IS-INIT SCAN........ ON
ST-SCAN TIME........ 3
NX-NEXT BLOCK....... 
AT-ALM TYPE......... OPEN
AP-ALM PRI.......... L
AE-ALM ENABLE....... ENABLE
PA-PLANT AREA....... ALL
II-INVERT........... NO
IA-INIT A/M......... AUTO

TAG................. S.BINS
DESC................. STATUS OF S. BIN BELT
DV-DEVICE........... ABH
HT-H/W OPTIONS..... PLC5
IO-ADDR............. 3:1:0:007/03
OT-OPEN TAG......... OFF
CT-CLOSED TAG....... ON
IS-INIT SCAN........ ON
ST-SCAN TIME........ 3
NX-NEXT BLOCK....... 
AT-ALM TYPE......... OPEN
AP-ALM PRI.......... L
AE-ALM ENABLE....... ENABLE
PA-PLANT AREA....... ALL
II-INVERT........... NO
IA-INIT A/M......... AUTO
TAG.............. WESTAS
DESC............. STATUS OF WEST A BELT
DV-DEVICE........ ABH
HT-H/W OPTIONS.. PLC5
IO-ADDR.......... 3:4:0:007/03
OT-OPEN TAG...... OFF
CT-CLOSED TAG.... ON
IS-INIT SCAN..... ON
ST-SCAN TIME.... 3
NX-NEXT BLOCK...
AT-ALM TYPE..... OPEN
AP-ALM PRI....... L
AE-ALM ENABLE.... ENABLE
PA-PLANT AREA.... ALL
II-INVERT........ NO
IA-INIT A/M...... AUTO

TAG.............. WESTBS
DESC............. STATUS OF WEST B BELT
DV-DEVICE........ ABH
HT-H/W OPTIONS.. PLC5
IO-ADDR.......... 3:5:1:000/16
OT-OPEN TAG...... OFF
CT-CLOSED TAG.... ON
IS-INIT SCAN..... ON
ST-SCAN TIME.... 3
NX-NEXT BLOCK...
AT-ALM TYPE..... OPEN
AP-ALM PRI....... L
AE-ALM ENABLE.... ENABLE
PA-PLANT AREA.... ALL
II-INVERT........ NO
IA-INIT A/M...... AUTO
TAG ............... S.MAINS
DESC .............. STATUS OF S. MAIN BELT
DV-DEVICE........ ABH
HT-H/W OPTIONS.. PLC5
IO-ADDR.......... 3:5:I:000/04
OT-OPEN TAG...... OFF
CT-CLOSED TAG... ON
IS-INIT SCAN.... ON
ST-SCAN TIME.... 3
NX-NEXT BLOCK...
AT-ALM TYPE..... OPEN
AP-ALM PRI...... L
AE-ALM ENABLE... ENABLE
PA-PLANT AREA... ALL
II-INVERT........ NO
IA-INIT A/M...... AUTO

TAG ............... SCALE#1S
DESC .............. STATUS OF SCALE#1
DV-DEVICE........ ABH
HT-H/W OPTIONS.. PLC5
IO-ADDR.......... 3:6:I:004/00
OT-OPEN TAG...... OFF
CT-CLOSED TAG... ON
IS-INIT SCAN.... ON
ST-SCAN TIME.... 3
NX-NEXT BLOCK...
AT-ALM TYPE..... OPEN
AP-ALM PRI...... L
AE-ALM ENABLE... ENABLE
PA-PLANT AREA... ALL
II-INVERT........ NO
IA-INIT A/M...... AUTO
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HT-H/W OPTIONS.. PLC5
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NX-NEXT BLOCK...
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II-INVERT........ NO
IA-INIT A/M...... AUTO

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DESC............. STATUS OF BUNKER
DV-DEVICE....... ABH
HT-H/W OPTIONS.. PLC5
IO-ADDR.......... 3:6:I:002/07
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CT-CLOSED TAG.... ON
IS-INIT SCAN..... ON
ST-SCAN TIME.... 3
NX-NEXT BLOCK...
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AP-ALM PRI....... L
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II-INVERT........ NO
IA-INIT A/M...... AUTO
TAG............. 2W.MAINS
DESC............. STATUS OF 2 W. MAIN BELT
DV-DEVICE....... ABH
HT-H/W OPTIONS.. PLC5
IO-ADDR......... 3:6:I:002/16
OT-OPEN TAG..... OFF
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IS-INIT SCAN.... ON
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AT-ALM TYPE..... OPEN
AP-ALM PRI...... L
AE-ALM ENABLE... ENABLE
PA-PLANT AREA... ALL
II-INVERT........ NO
IA-INIT A/M...... AUTO

TAG............. HYDPACKS
DESC............. STATUS OF HYDRAULIC POWER PACK
DV-DEVICE....... ABH
HT-H/W OPTIONS.. PLC5
IO-ADDR......... 3:6:I:004/01
OT-OPEN TAG..... OFF
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IS-INIT SCAN.... ON
ST-SCAN TIME.... 3
NX-NEXT BLOCK...
AT-ALM TYPE..... OPEN
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II-INVERT........ NO
IA-INIT A/M...... AUTO
TAG.............. M76A
DESC.............. CURRENT OF M76 DRIVE MOTOR
DV-DEVICE....... ABH
HT-H/W OPTIONS... PLC5
IO-ADDR......... 3:1:N10:154
SC-SIG COND..... LVZ
EL-LO EGU........ 0
EH-HI EGU........ 41
ET-EGU TAG....... AMP
SM-SMOOTHING..... 0
IS-INIT SCAN.... ON
ST-SCAN TIME.... 3
NX-NEXT BLK......
LL-LO LO ALM.... 10
AL-LO ALM........ 10
AH-HI ALM........ 45
HH-HI HI ALM..... 50
RC-ROC ALM....... 0
DB-DEAD BAND.... 0
PA-PLANT AREA.... ALL
AP-ALM PRI....... L
AE-ALM ENABLE... ENABLE
IA-INIT A/M...... AUTO

TAG.............. DRUMA
DESC.............. CURRENT OF ROTARY DRUM DRIVE MOTOR
DV-DEVICE....... ABH
HT-H/W OPTIONS... PLC5
IO-ADDR......... 3:1:N10:155
SC-SIG COND..... LVZ
EL-LO EGU........ 0
EH-HI EGU........ 125
ET-EGU TAG....... AMP
SM-SMOOTHING..... 0
IS-INIT SCAN.... ON
ST-SCAN TIME.... 3
NX-NEXT BLK......
LL-LO LO ALM.... 50
AL-LO ALM........ 50
AH-HI ALM........ 145
HH-HI HI ALM..... 150
RC-ROC ALM....... 0
DB-DEAD BAND.... 0
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DESC............... CURRENT OF COLLECTING CONVEYOR DRIVE 1
DV-DEVICE.......... ABH
HT-H/W OPTIONS.... PLC5
IO-ADDR............ 3:2:N20:154
SC-SIG COND....... LVZ
EL-LO EGU.......... 0
EH-HI EGU.......... 75
ET-EGU TAG......... AMP
SM-SMOOTHING....... 0
IS-INIT SCAN....... ON
ST-SCAN TIME...... 3
NX-NEXT BLK........
LL-LO LO ALM....... 30
AL-LO ALM.......... 30
AH-HI ALM.......... 80
HH-HI HI ALM....... 85
RC-ROC ALM......... 0
DB-DEAD BAND...... 0
PA-PLANT AREA...... ALL
AP-ALM PRI......... L
AE-ALM ENABLE...... ENABLE
IA-INIT A/M........ AUTO

TAG................. COLLECT2A
DESC............... CURRENT OF COLLECTING CONVEYOR DRIVE 2
DV-DEVICE.......... ABH
HT-H/W OPTIONS.... PLC5
IO-ADDR............ 3:2:N20:155
SC-SIG COND....... LVZ
EL-LO EGU.......... 0
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ET-EGU TAG......... AMP
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ST-SCAN TIME...... 3
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HH-HI HI ALM....... 85
RC-ROC ALM......... 0
DB-DEAD BAND...... 0
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IA-INIT A/M........ AUTO
TAG.............. S.BINA
DESC............. CURRENT OF S.BIN DRIVE MOTOR
DV-DEVICE....... ABH
HT-H/W OPTIONS.. PLC5
IO-ADDR.......... 3:3:N30:154
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ET-EGU TAG....... AMP
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HH-HI HI ALM.... 260
RC-ROC ALM....... 0
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AE-ALM ENABLE... ENABLE
IA-INIT A/M..... AUTO

TAG.............. WESTAA
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DV-DEVICE....... ABH
HT-H/W OPTIONS.. PLC5
IO-ADDR.......... 3:4:N40:154
SC-SIG COND..... LVZ
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ST-SCAN TIME.... 3
NX-NEXT BLK.....
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AL-LO ALM........ 300
AH-HI ALM....... 620
HH-HI HI ALM.... 630
RC-ROC ALM....... 0
DB-DEAD BAND.... 0
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AE-ALM ENABLE... ENABLE
IA-INIT A/M..... AUTO
TAG.............. WESTBA
DESC............. CURRENT OF WEST B DRIVE MOTORS
DV-DEVICE........ ABH
HT-H/W OPTIONS.. PLC5
IO-ADDR.......... 3:5:N50:155
SC-SIG COND..... LVZ
EL-LO EGU........ 0
EH-HI EGU........ 492
ET-EGU TAG...... AMP
SM-SMOOTHING..... 0
IS-INIT SCAN..... ON
ST-SCAN TIME.... 3
NX-NEXT BLK......
LL-LO LO ALM..... 200
AL-LO ALM........ 200
AH-HI ALM........ 500
HH-HI HI ALM..... 510
RC-ROC ALM....... 0
DB-DEAD BAND..... 0
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AE-ALM ENABLE.... ENABLE
IA-INIT A/M...... AUTO

TAG.............. SMAIN
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ET-EGU TAG...... AMP
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ST-SCAN TIME.... 3
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LL-LO LO ALM..... 200
AL-LO ALM........ 200
AH-HI ALM........ 500
HH-HI HI ALM..... 510
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HH-HI HI ALM..... 620
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IA-INIT A/M...... AUTO

TAG................ SCALE1T
DESC............ TONNAGE READING OF SCALE 1
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HT-H/W OPTIONS.. PLC5
IO-ADDR.......... 3:6:N60:154
SC-SIG COND..... LVZ
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EH-HI EGU........ 1800
ET-EGU TAG....... TON
SM-SMOOTHING..... 0
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ST-SCAN TIME.... 3
NX-NEXT BLK......
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AL-LO ALM........ 100
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HH-HI HI ALM..... 2000
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ST-SCAN TIME...... 3
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AH-HI ALM......... 75
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DB-DEAD BAND...... 0
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HT-H/W OPTIONS.... PLC5
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LO   GREEN   BLACK   N
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| HI         | GREEN    | BLACK   | N   |
| HIHI       | RED      | BLACK   | N   |
| RATE       | GREEN    | BLACK   | N   |
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