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Programmable Controllers at New Pellet Terminal

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Programmierbares Kontrollsystem in einer neuen Pellet-Hafenumschlagsanlage
Contrôleurs programmables à un nouveau terminal de pellets
Controladores programables en una nueva terminal de pellets
新ペレットターミナルにおけるプログラム可能な制御システム
新颗粒物质卸货码头上的程序控制器
أجهزة التحكم القابلة للبرمجة الموجودة بمحطة بيليت الجديدة

Summary

Programmable Controllers are utilized extensively at the Lorain Pellet Terminal in Lorain, Ohio, USA. This facility was commissioned in August, 1980 making it the latest and most modern transshipment terminal on the Great Lakes. Several different types of iron ore pellets are received by self-unloading lake vessels, stockpiled and then loaded into smaller vessels which can navigate the winding Cuyahoga River or rail cars for delivery to various steel plants.

The Programmable Controller (P.C.) is a solid state control device that is fast replacing conventional hardwired relay or solid state systems for sequential control functions. The Lorain Pellet Terminal not only uses P.C.s for sequential interlocking and control of the conveyors, dust collectors, gates, shiploader, and train loadout station, but also for data logging. Many types of management reports are generated including the inventory status of each type of pellet and the mode of each shipment. Railroad freight waybills for each rail car are automatically printed out, correlating the information provided by the railroad company on punched cards with the actual weight of pellets loaded.

CRTs are utilized at four locations for graphic display of the system being operated, fault annunciation and display of electrical control ladder diagrams.

The Lorain Pellet Terminal is a model installation, utilizing many innovations and the latest technology. The P.C. system, which can be easily understood and maintained by plant electricians, will be an effective tool for both the operating staff and management.

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Abbreviations used

ASCII Code	— American Standard Code for Information Interchange
CRT	— Cathode Ray Tube
CWT	— Hundred Weight
I/O Rack	— Input Output Rack
MCC	— Motor Control Centre
MLU	— Math-Logic Unit
P.C.	— Programmable Controller

1. Introduction

Republic Steel Corporation's new iron ore pellet transshipment terminal located just inside the Lorain, Ohio, USA, harbour at the mouth of the Black River, was completed in August, 1980 (Fig. 1). It is the first terminal specifically designed to transship pellets from 1000 ft lake vessels to rail cars or other vessels. The facility provides storage for 500,000 tons of pellets separated by walls into four areas designated A, B, C, and D. Self-unloading vessels deposit pellets into one of these areas depending on the type of pellets delivered. Underneath these piles are two reclaim tunnels with a total of 36 hydraulically operated gates that feed pellets to tunnel conveyors C1 or C2. Conveyor C3 conveys the material from the tunnels to a movable stone box at the rail loadout station. The stone box directs pellets either to a surge bin at the rail loadout station (Fig. 2); or to the fixed shiploader via conveyor C4 (Fig. 3).

The control system is designed so that the entire facility can be operated either from the rail loadout operator's cab or from the shiploader operator's cab (Fig. 4). Two 16K, Square 'D' Model 8881 programmable controllers are utilized to achieve control and data management.

Fig. 1: General view of Lorain Pellet Terminal

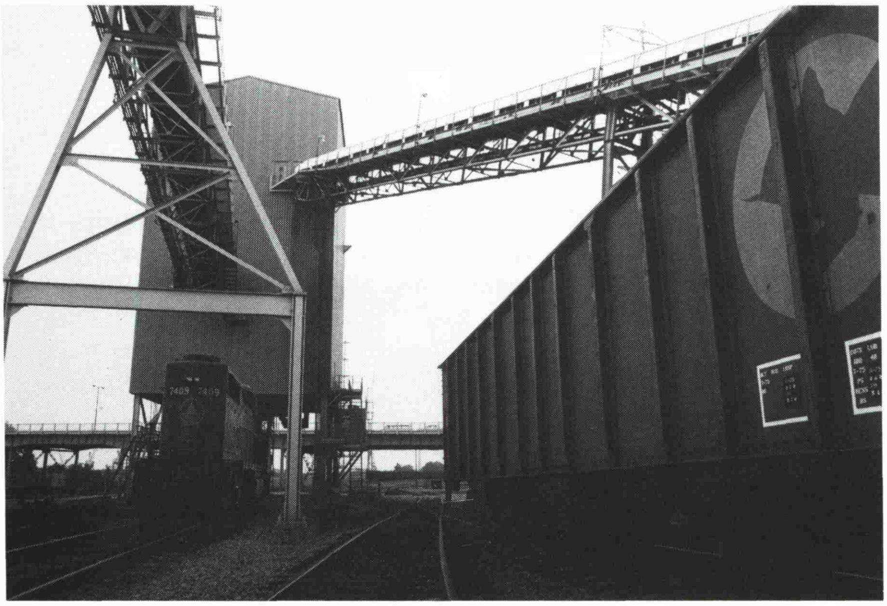

Fig. 2: View of the rail loadout

Fig. 3: View of the shiploader

2. Programmable Controller System Description

A programmable controller (P.C.) is a solid state control device which has a user programmable memory to store instructions for specific functions such as input/output (I/O) control logic, timing, arithmetic, data logging and dynamic graphics. A basic P.C. is an industrially rugged device which typically is programmed using relay-equivalent symbols to perform functions equivalent to relay logic or hardwired solid state logic systems.

In addition to performing standard control functions, the P.C.s selected for use at the Lorain Terminal have the capability to store and manipulate data for report generation, graphically display the operation of the terminal and interface data with the operators.

Programming consists of two software languages:

1. A relay equivalent ladder diagram format which uses normally open and closed contact symbols and coil symbols easily understood by plant maintenance personnel (Figs. 5 & 6) and;
2. A data transfer and report generation format using common programming terms such as, "let", "get", "put" and "print". This format, although not as universally understood as the ladder diagram format, can be readily taught and understood by plant personnel.

A program is entered and stored into processor memory by using a keyboard associated with the CRT. The program can also be stored and transferred via a cassette/recorder.

The programmable controller was selected for use at Lorain because it permitted design and programming to continue while equipment was being installed in the field. Required changes were quickly accomplished by reprogramming. Start-up time was minimized by the trouble-shooting features of the P.C. system.

A hardwired system would have lengthened design field wiring and start-up time considerably. Data handling would have required the addition of a small computer. Interfacing the computer and controls would have necessitated additional components; adding to the complexity of the system and reducing reliability. Additionally, the computer would have required programming by a specialist in computer programming, in a language unfamiliar to the maintenance personnel at the facility.

The control system utilized in Lorain consists of two control processors each with a 16K (16,000 word) magnetic core memory. This type of memory requires no power back-up to retain the program in the event of loss of normal power, thus providing maximum reliability.

The programmable controller is capable of interfacing with I/O locations as far away as 5,000 ft by utilizing a series of transceivers which communicate serially with each remote I/O. Local I/Os are connected to the processor in a parallel communication network.

The processor also connects to a math logic unit (MLU) which contains a number of three digit (12 bit) data storage locations. The MLU also provides the system with arithmetic capability.

The equipment noted above will perform the basic control functions of an equivalent relay system; plus providing arithmetic functions. The addition of the processor interface (PR-3) provides the capability to expand the system to communicate with the human element. The PR-3 interface includes data ports

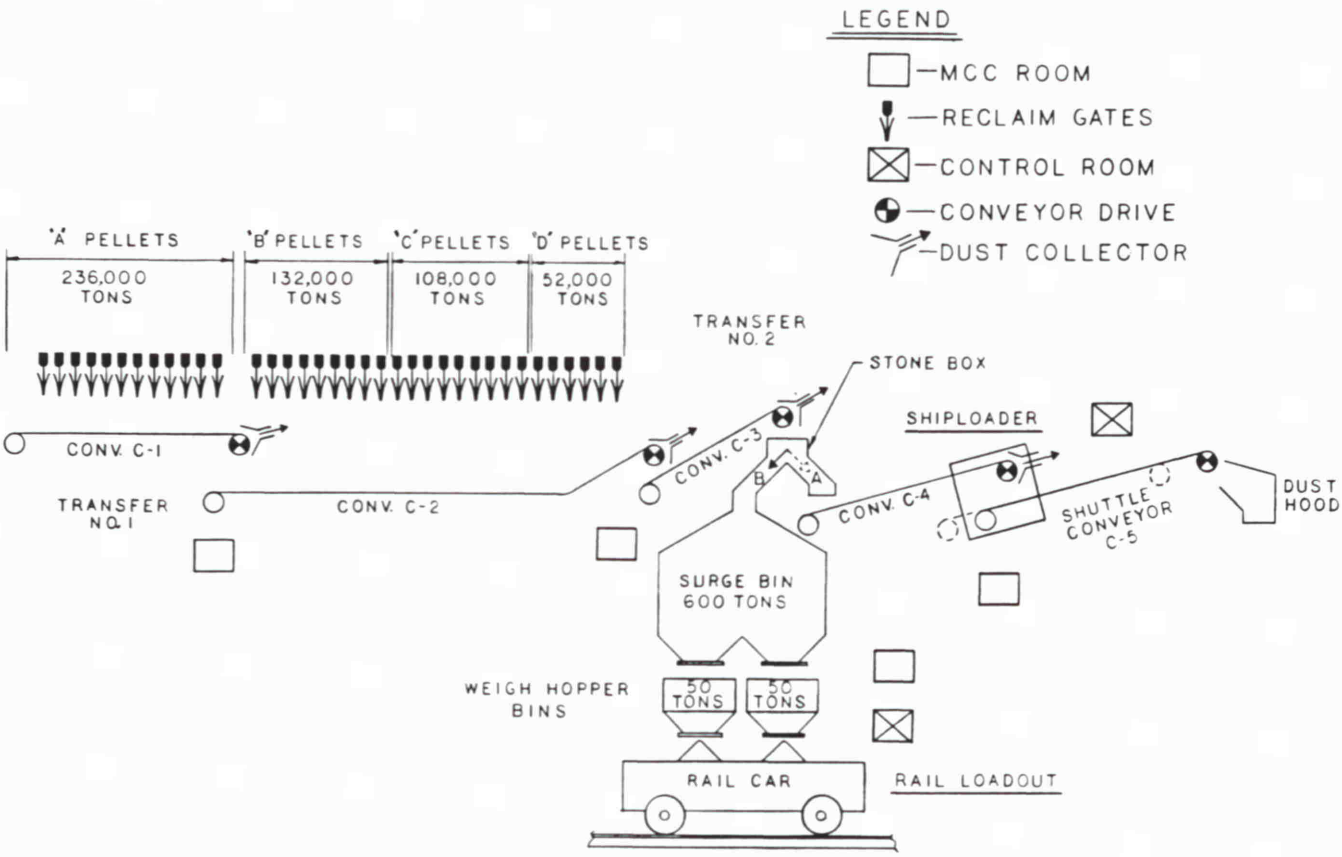

Fig. 4: Flow diagram of the facility

which transmit and receive ASCII coded information to additional peripheral equipment such as the card reader, printers and CRTs. This particular PR-3 interface is also utilized as the standard programmer interface thus making the purchase of additional programming equipment unnecessary.

The two processors are located in the rail loadout MCC room and are wired by one twisted pair shielded cable to each of the five (5) remote I/O stations located in Transfer No. 1 MCC room, Transfer No. 2 MMCroom, Shiploader MCC room, Rail loadout operator's cab and Shiploader operator's cab (Fig. 7). The field devices such as starters, push buttons, thumbwheel switches and L.E.D. displays are wired to the I/O rack (Fig. 8).

Operational control and information are required at various locations throughout the site. To provide this, switching interfaces were designed which allow three CRTs and three printer terminals to be connected to a single set of data ports on the PR-3. A fourth CRT is used for maintenance in the diagnostic centre.

The control logic program of the system is divided between the two processors. Processor No. 1 controls the rail loadout equipment and conveyors Nos. 1, 2 and 3. Processor No. 2 controls the shiploader equipment and conveyors Nos. 4 and 5.

Communication of data between processors could not be done in a normal mode due to the number of peripheral devices attached to the system. To transfer information, a set of 16 inputs and outputs in each processor was used as a parallel data link and information was multiplexed through this channel.

The facility is operated sequentially in two modes; rail loadout and shiploading. The starting of each mode is in reverse sequence, i.e. the last conveyor to receive pellets starts first to prevent material pile up at transfer points. The operator may select to start the system automatically in the fixed sequence described below or manually. Manual operation requires the operator to start each piece of equipment in the same sequence by pressing the pushbutton for each device. A third method of operation permits testing each device out of sequence by actuating a local jog pushbutton.

3. Operation Sequence

3.1 Mode 1 — Rail Loadout

In this mode, the stone box is positioned to direct pellets to the surge bin (Position B of stone box) by setting the system selection switch to the rail loadout mode. The system is then started automatically in the following sequence with 10 second time intervals between items c) & d), f) & g), and i) & j):

a) Dust Collector — Rail Loadout
b) Hydraulics — Rail Loadout
c) Hydraulics — Tunnel
d) Blower — Conveyor No. 3
e) Conveyor No. 3
f) Dust Collector — Transfer No. 2
g) Blower — Conveyor No. 2
h) Conveyor No. 2
i) Dust Collector — Transfer No. 1 (only if Stockpile A is to be reclaimed)
j) Conveyor No. 1 (only if Stockpile A is to be reclaimed)
k) Stockpile reclaim gate (selected one at a time)

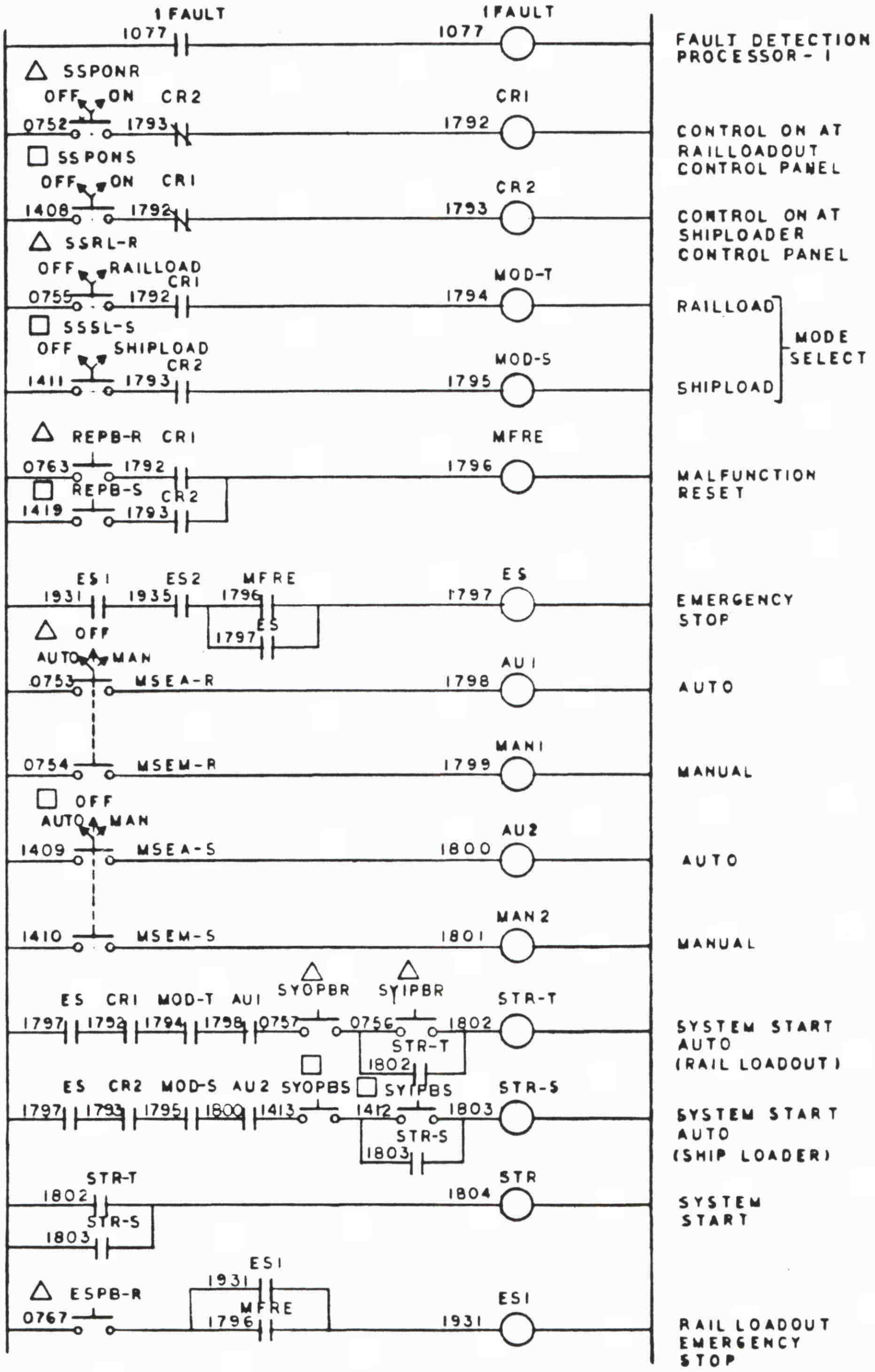

Fig. 5: Typical control schematic as programmed into the processor

3.2 Mode 2 — Shiploading

In this mode, the stone box is positioned to direct pellets to Conveyor No. 4 (Position A of stone box) by setting the system selector switch to the shiploading mode. The system is then started automatically in the following sequence with 10 second time intervals between items d) & e), g) & h), j) & k) and m) & n):

a) Hydraulics — Shiploader
b) Hydraulics — Rail Loadout
c) Hydraulics — Tunnel
d) Dust Collector — Transfer No. 4
e) Blower — Conveyor No. 4
f) Conveyor No. 4
g) Dust Collector — Rail Loadout
h) Blower — Conveyor No. 3
i) Conveyor No. 3
j) Dust Collector — Transfer No. 2
k) Blower — Conveyor No. 2
l) Conveyor No. 2
m) Dust Collector — Transfer No. 1 (only if Stockpile A is to be reclaimed)
n) Conveyor No. 1 (only if Stockpile A is to be reclaimed)
o) Stockpile reclaim gates (selected one or two at a time)

4. Rail Car Loading Operation

The unit train to be loaded is made up of 100 rail cars which could be in a random mix of 50, 75 and 100 ton capacity cars. The train is split up into four drags of up to 30 cars each for loading at the rail loadout station. Each car is positioned under the rail loadout chutes by a locomotive under radio control of the operator.

The railroad company provides the following information for each of the cars:

a) Sequence numbers of cars in each drag.
b) Owner and identification number for each car.
c) Car capacity in CWT.

This information is transferred to the processor by feeding punched cards into a card reader remotely located in the railroad company's agency office. The cards are prepared by the railroad's computer utilizing ASCII coding. The P.C. stores this information in memory until a drag is loaded and all print-out routines are completed. The system can store information for a maximum of four 30-car drags.

The operator enters the reclaim gate number to be opened by setting a thumbwheel switch on the control console. The first car is positioned under the rail loadout and the system start pushbutton is depressed. The system starts in the sequence described earlier and pellets are loaded into the surge bin over the weigh hoppers. The quantity of pellets required to be loaded into a particular car are pre-weighed by the load cell system on the weigh hoppers to the car capacity information in processor memory. The load cells provide a signal to open and close the gates below the surge bin to accurately charge to weigh hoppers. When the weigh hoppers are charged and the surge bin gates closed, the weigh hopper gates open to load the car. After a time delay, sufficient to permit complete discharge of the weigh hoppers, the weigh hopper gates close and the surge bin gates open to charge the weigh hoppers for the next car.

While the next car is being positioned under the rail loadout chutes, the printer provided in the railroad company's agency office prints out a freight waybill for the car previously loaded. The waybill is a pre-printed form and is filled out in triplicate with the following information (Fig. 11):

a) Car owner and identification number
b) Waybill date
c) Routing, showing carrier and each junction en route
d) Name of shipper with address
e) Name of consignee with address
f) Type of iron ore pellets
g) Net weight of pellets loaded

After loading a complete drag of cars, a statement of car loading is printed out in the clerical office of the General Manager of the terminal. This statement provides the following information to the management of the terminal for accounting purposes:

a) Sequence numbers of cars in the drag
b) Owner and identification number of each car
c) Capacity in CWT of each car
d) Weight of pellets actually loaded in CWT
e) Total weight of pellets loaded in the drag.

As each car is positioned for loading, the operator verifies the car serial number and capacity with that shown on the CRT. Data shown for the rail car is obtained through the card reader. This

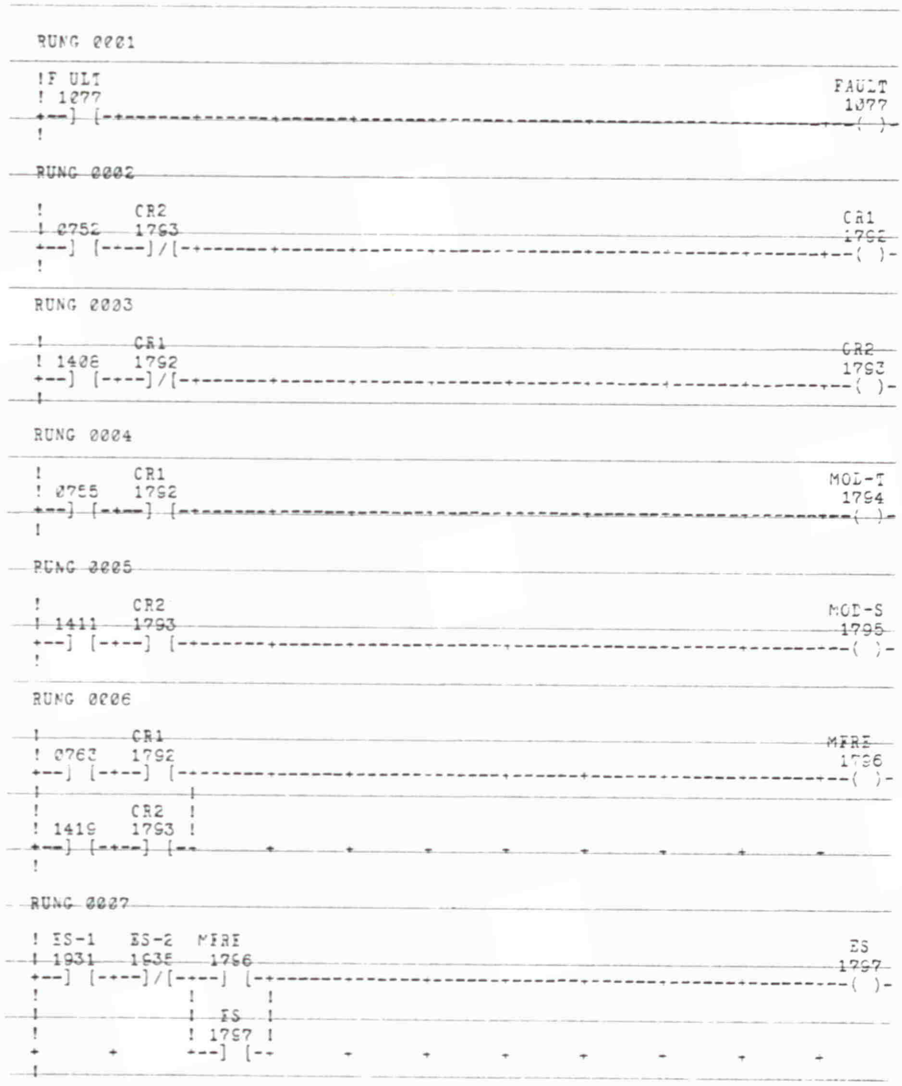

Fig. 6: Typical control schematic as printed out by the processor

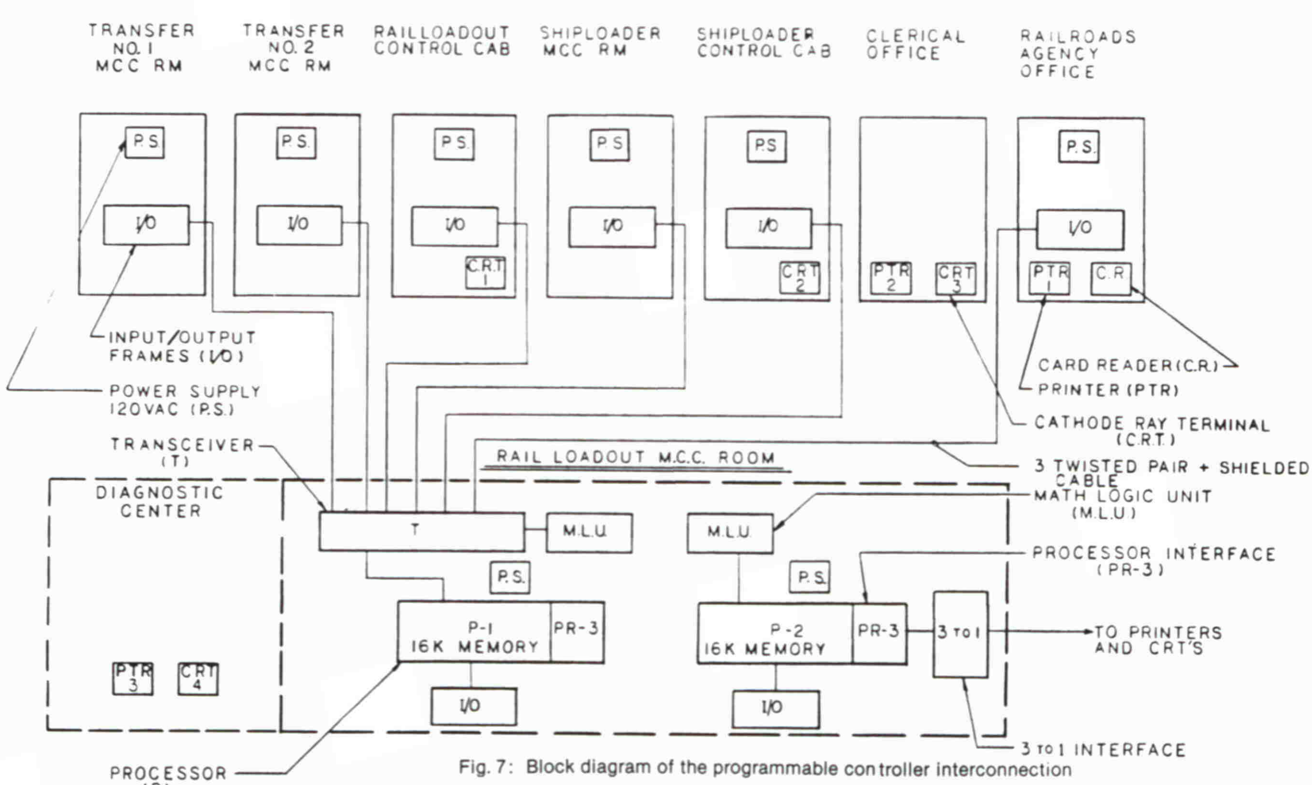

Fig. 7: Block diagram of the programmable controller interconnection

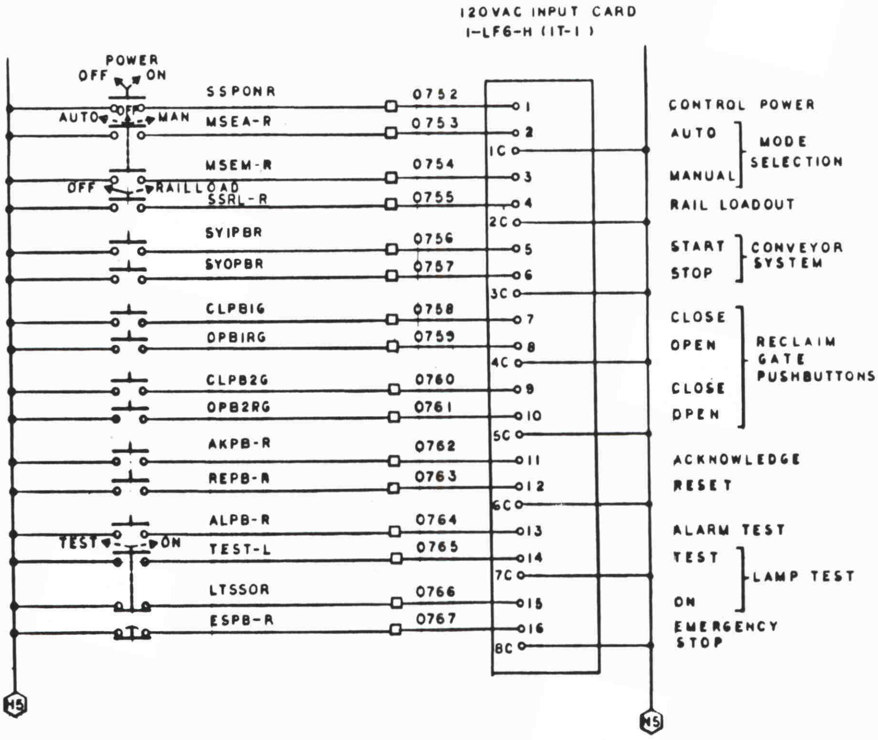

Fig. 8: Typical interconnection of the field devices to I/O racks

is updated to the next car after each car is loaded. If necessary, he selects the drag information edit routine to correct erroneous data.

The processor also calculates the point in loading when the capacity of the remaining cars to be loaded equals the weight of material on the belts. At that point the reclaim gate automatically closes and the conveyors are automatically purged into the surge bin.

5. Shiploading Operation

Shiploading is controlled from an operator's cab on top of the shiploader. The vessel is positioned under the shiploader shuttle by ship's gear. The shiploader operator verifies the position of the shuttle over a closed circuit T.V. system. Then he selects the type of pellets to be loaded into the vessel and enters the reclaim gate numbers to be opened by setting thumbwheel switches on the control console. He also sets thumbwheel switches for the tonnage of pellets required to be loaded in the hatch as directed by the vessel's mate.

After positioning the shuttle and dust hood to direct pellets into the hatch he presses the system start pushbutton. The conveyors and dust collectors start up in sequence, the selected reclaim gates open and pellets are loaded into the vessel. Pellets are weighed by a belt scale on conveyor C3. The processor calculates the transport time lags between the selected reclaim gates and the scale and between the scale and the tip of the shuttle conveyor on the shiploader. Based on this calculation, a signal is initiated by the processor to close the reclaim gates at the correct time to assure that the desired tonnage of pellets will be loaded into the hatch when the belts are purged.

The ship is now repositioned under its own power, to bring another hatch under the shuttle conveyor. The procedure is repeated for each hatch till the vessel is fully loaded. The weight and type of pellets loaded into the vessel is stored in the processor memory for inventory purposes.

6. Display of Information

A CRT is located in each operator's cab and the clerical office. On each CRT, any one of the following routines may be selected to be displayed (Fig. 9):

a) Dynamic graphic
b) Material inventory
c) Material inventory edit
d) Drag listing
e) Drag information edit
f) Accumulated conveyor run times
g) Clock/calendar edit

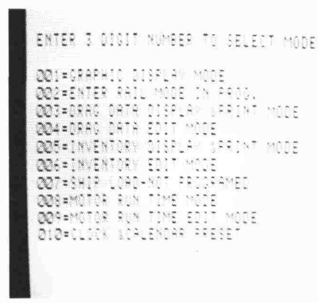

Fig. 9: List of routines displayed on CRT

For normal rail loadout or shiploading operation, the graphic display is selected (Fig. 10). Indication of operating conveyors is shown by flashing bars. Stopped conveyors are shown by steady bars. Should a malfunction

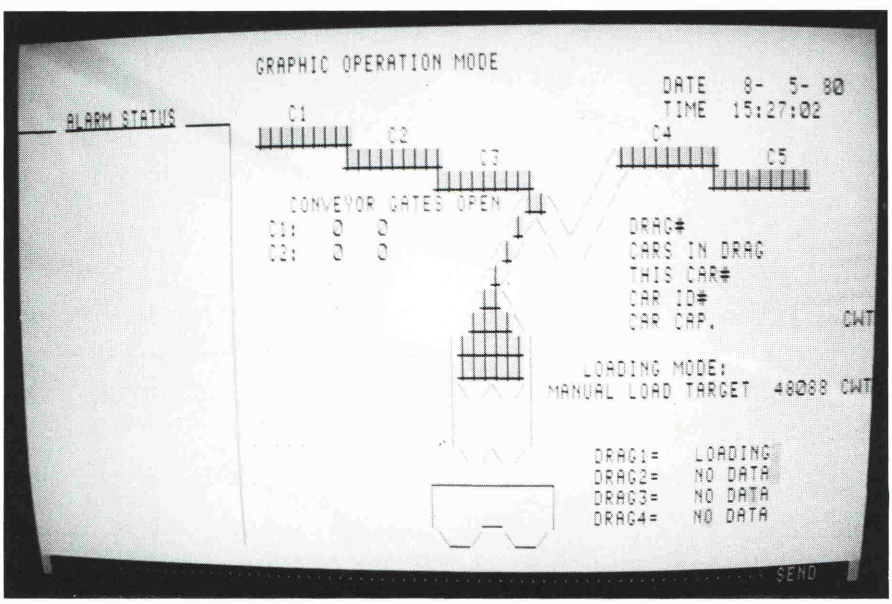

Fig. 10: Dynamic graphic display on CRT

occur on any of the conveyors, dust collectors, or hydraulic systems, the description of the discrete field device and device number is automatically displayed by the processor on the CRT screen as a fault. The operator can then recall the ladder diagram and monitor the fault.
Also, any fault or malfunction, either in the processor hardware or the multiplex system used for communicating between the thirty-six (36) reclaim gates in the tunnel and processor, is displayed on the CRT screen. A total of 124 individual field devices are monitored by the controller.

7. Management Information

Three Teletype Model 40 high speed printers are utilized at the facility. The printer interface is switched automatically by the processor to direct data to the proper location.

A printer located just outside the General Manager's office at the terminal keeps management advised on the day-to-day working of the plant as well as providing an account of the movement and inventory of pellets and planning for preventative maintenance programs. The various reports printed are:

a) All electrical faults and shut-downs. These give the number of the device that malfunctioned, the time it occurred and the time it was cleared.

b) Major equipment run times. This permits preventative maintenance to be scheduled.

c) Inventory status report at 11:59 P.M. each day. This automatically gives the following information for each type of pellet.

   i) Tons received by vessel.
   ii) Tons shipped by rail.
   iii) Tons shipped by vessel.
   iv) Tons on ground.

d) Drag listing at the end of each drag loading. This automatically gives car number, identification number, capacity and loaded weight as well as the total weight of pellets in the drag.

A printer located in the railroad's agency office is activated as each car is loaded. This printer prepares the waybill previously mentioned (see Fig. 11).

A third printer located in the diagnostic centre is activated at the end of each drag to provide a drag listing for plant use. Presently, the processor is programmed to handle up to four (4) different types of pellets and four (4) destinations on the railroad. However, the system has the capability to be expanded, by changing the program, to inventory twenty (20) different types of pellets; and to print out freight waybills for twenty (20) different destinations.

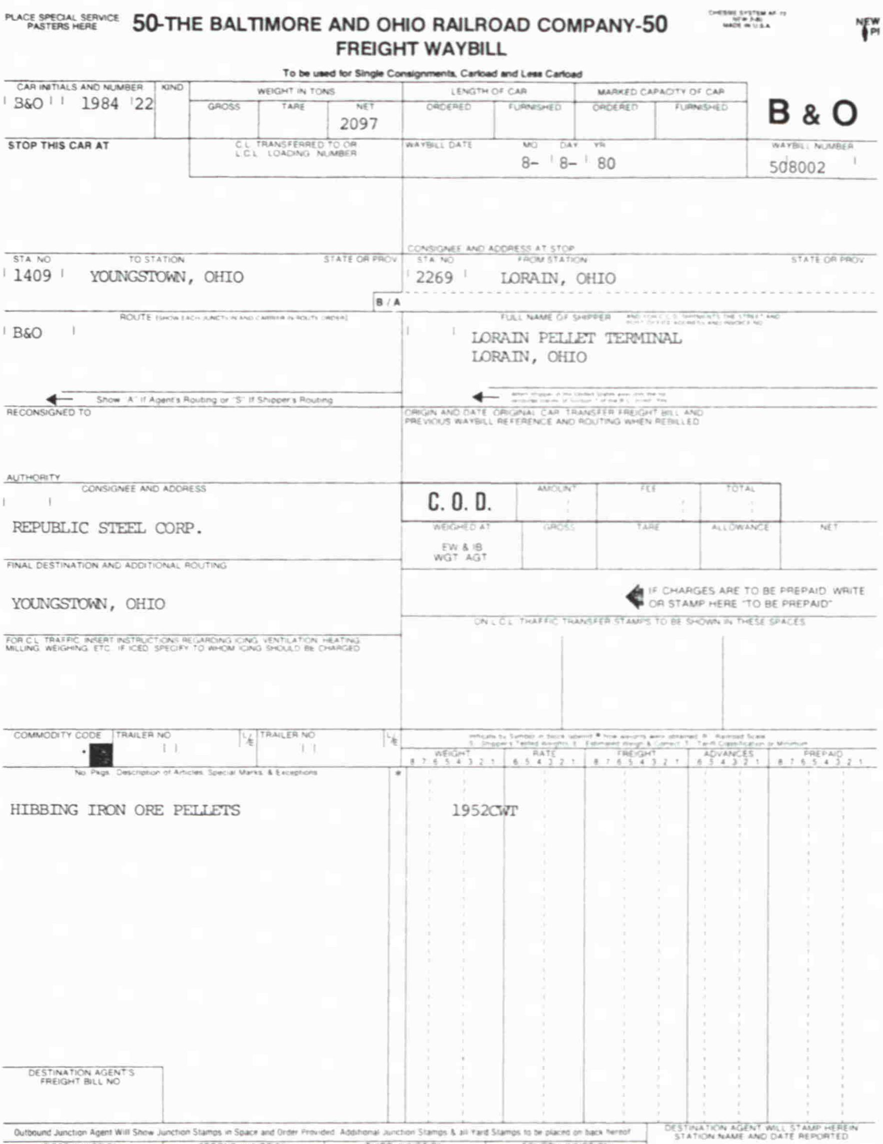
PLACE SPECIAL SERVICE PASTERS HERE
50-THE BALTIMORE AND OHIO RAILROAD COMPANY-50
FREIGHT WAYBILL
To be used for Single Consignments, Carload and Less Carload
B & O
CAR INITIALS AND NUMBER: B&O 1984 | KIND: 22 | NET: 2097
WAYBILL DATE: 8- 8- 80 | WAYBILL NUMBER: 508002
TO STATION: 1409 YOUNGSTOWN, OHIO | FROM STATION: 2269 LORAIN, OHIO
ROUTE: B&O
FULL NAME OF SHIPPER: LORAIN PELLET TERMINAL LORAIN, OHIO
CONSIGNEE AND ADDRESS: REPUBLIC STEEL CORP.
C. O. D.
FINAL DESTINATION AND ADDITIONAL ROUTING: YOUNGSTOWN, OHIO
HIBBING IRON ORE PELLETS 1952CWT

Fig. 11: Freight waybill

8. Conclusion

In the bulk material handling field, the programmable controller provides a solution to the problems of providing reliable control and up-to-date automation. P.C.s provide user-oriented servicing and trouble-shooting aids at a reasonable cost. Design and start-up problems are reduced by the flexibility and versatility of the controller.

"As-Built" electrical control schematics can be produced by the printer immediately after a plant is commissioned, thus enabling electricians to work with updated information rather than with a marked up set of schematics.

Acknowledgement

The terminal was designed and built by ORBA Corporation of Fairfield, New Jersey, USA with turnkey responsibility including the specification, selection, and programming of the software for the programmable controller system. It was completed in record time with the first rail car loading operation in thirteen (13) months after receipt of order and shiploading in eighteen (18) months. The programmable controller hardware was furnished by Square "D" Company, Milwaukee, Wisconsin. The general field contractor was Johnson Brothers, Litchfield, Minnesota; and electrical installation and wiring was by Lake Erie Electric, Lorain, Ohio.