

**PROGRAMMABLE LOGIC CONTROLLER-BASED
MODERNIZATION OF A PLATE NORMALIZING FURNACE**

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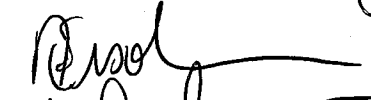
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ABSTRACT

PROGRAMMABLE LOGIC CONTROLLER-BASED MODERNIZATION OF A PLATE NORMALIZING FURNACE

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In this work, modernization of an industrial plate normalizing furnace was realized by using a programmable logic controller (PLC). No changes were made on the heating control of the furnace.

In the modernization, SIMATIC S5 series 115U programmable logic controller was programmed in STEP-5 language in the form of ladder diagrams. New alarm systems, indicating lamps, load cells and amplifiers, PLC panel, operator desk, and necessary field sensors were designed and installed for the new control system.

After running the process with the new controller, system performance has been improved : eg. electrical fault rate of the furnace was decreased by 50%, productivity has increased by 35% on the base of ton/hour production.

Key words: plate normalizing furnace, programmable logic controller, STEP-5 programming language, ladder diagrams, load cell.

SCIENCE CODE : 619.04.01.

ÖZET

BİR LEVHA NORMALİZASYON FIRINININ PROGRAMLANABİLİR DENETLEYİCİ YARDIMIYLA MODERNİZASYONU

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Bu çalışmada, programlanabilir denetleyici kullanarak bir endüstriyel levha normalizasyon fırının modernizasyonu gerçekleştirilmiştir. Fırının ısı denetiminde herhangi bir değişiklik yapılmamıştır.

SIMATIC S5 serisi 115U programlanabilir denetleyicisi STEP-5 dilinde programlanmış ve merdiven diyagramları hazırlanmıştır. Yeni denetim sistemi için gerekli alarmlar, gösterge lambaları, yük hücresi ve yükselticisi,

PLC paneli, operatör masası ve diğer sensörler tasarımlanmış ve montajı yapılmıştır.

Yeni denetleyici sistemin performansını oldukça yükseltmiştir. Sistemdeki arıza oranı %50 azalma gösterirken üretim %35 oranında artmıştır.

Anahtar sözcükler: Levha normalizasyon fırını,
programlanabilir denetleyici,
STEP-5 programlama dili,
merdiven diyagramları, yük hücresi.

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CHAPTER 1

INTRODUCTION

Full-automation of an industrial plate normalizing furnace was realized by the use of a programmable logic controller (PLC). PLC is a real time microprocessor-based electronic controller, specially designed for industrial environment [1]. Performance of the furnace, which has been in operation at Erdemir hot mill since 1979, was improved by introducing software control instead of relay-logic control.

1.1. Normalization in General

Normalization involves the recrystallization of the work hardened strip, the drastic reduction in dislocation density and development of a new crystallographic texture. In normalizing operations, the plate is heated up to temperatures around 1700 °F (927 °C) above the upper critical temperature and cooled down naturally at a rate which permits the formation of ferrite with desired grain size [2]. After the normalization, mechanical properties

of the plate (strength, hardness, etc.) is improved without any change in chemical composition.

1.2. Types of Normalizing Furnaces

Normalizing furnaces are built in two types in general: continuous and catenary.

Continuous type of furnaces are designed to heat plates singly or in thin packs of two, three or four sheets. They usually have three sections (preheating, soaking and cooling zones), with the plates moved through the zones on disc rollers. They are built up to 5 meters in width, vary from 37 to 62 meters in length, utilized fuel at a rate of 2.0 to 4.5 million Btu/ton and have throughputs in the range of 3 to 12 tons per hour. Such furnaces utilize gas or oil and do not employ protective atmospheres. Thus the workpieces scale during the heat treatment [2], [3].

Second type of normalizing furnaces have been built so as to provide a free loop or catenary of the sheet in the furnace as it is unwound from coils. Furnaces of this type with steam or water quenching facilities and pickling or descaling equipment at the exit end are widely used for the heat treatment of the stainless steels at temperatures in the range of 1000 to 1200 °C [3].

Since normalizing furnace process is slow, sequence of it can be controlled by electromechanical relays and

such devices. Limit switches, photo-electric cells, thermocouplers, PID controllers are the sensors which are widely used in this field. PLC controlled normalizing furnace is the first time implemented within the scope of this thesis. Main reasons of leaving these industrial processes in their initial technological level are the slowness of the process and more importantly low demand of normalized products in the market.

1.3. Features of Erdemir Normalizing Furnace

Erdemir normalizing furnace was built in 1979 by STEIN-SURFACE, a french company. System is continuous type but has no preheating zone. Normalizing is used to homogenize structures in "mild" (low) carbon steels, particularly heavy forgings [4].

1.3.1. Normalizing Temperature

The sheet will be uniformly heated up to a temperature which permits complete transformation of ferrite into austenite, ie. a temperature of approximately 927 °C (1700 °F). The holding time of this temperature during normalization will be sufficient to allow transformation throughout the entire metal. After discharging, the sheet will be cooled in free air.

1.3.2. Steel Grades

Hot-rolled mild steel sheets of the following steel grades are normalized in Erdemir plate normalizing furnace: [4]

ASTM-A. 31	ASTM-A.455	ERDEMIR QUALITY :	3237	6252	6352
A.258	A.515		3242	6284	6704
A.299	A.516		3335	6341	6838
A.442	A.537		3702	6347	6850

1.3.3. Plate Dimensions

Dimensions of the plates normalized in the furnace are as follows:

Thickness: 6.35 mm - 50.8 mm (0.25" - 2")

Width : 508 mm - 2896 mm (20" - 114")

Length : 13.72 m max. (45 ft max) - 5.00 m min.

1.3.4. Type of Equipment

The equipment under investigation within the scope of this thesis is a sheet normalizing roller-hearth furnace with an annual production capacity of 45,000 tons, and a reference production capacity of 6.7 metric tons/hour. This capacity is not approved by the contractor (Stein-Surface) and never reached by Erdemir throughout several production years.

1.3.5. Utilities

Inputs to the furnace during normalization process are as follows:

a) Fuel:

Coke-oven gas

GHV : 4300-4500 Kcal/m³ (483-506 Btu/ft³)

Supply pressure : 0.07-0.14 Kg/cm² (1-2 psig)

Sulphur content : Less than 1% of sulphuric hydrogen.

b) Electric power:

380 V, 3 phase, 50 Hz.

c) Service water:

4 Kg/cm² (57 psig) at 25 °C (77 °F)

1.3.6. Normalizing Time

Normalization time of the plates can be calculated from the following formula:

Heating time (minutes): $1.18 \times \text{Thickness of the plate (mm)}$

Holding time : 20 minutes.

Normalization time(min): Heating time + Holding time

1.3.7. Entry Table

Data of the entry table is as follows:

Length : 15,250 mm

Number of roller : 26
Spacing : 610 mm
Effective roller length : 3,600 mm
Table speed : 30 m/m

1.3.8. Furnace

Data of the furnace is as follows:

Effective hearth length : 15,900 mm
Width, inside walls : 3,500 mm
Effective chamber height: 2,070 mm
Number of doors : 2 (at both ends
of the furnace)

Roller hearth

. Number of roller : 33
. Roller spacing : 510 mm
. Entry speed : 30 m/m
. Reciprocating speed : 3 m/m
. Discharging speed : 30 m/m

Number of burners of the furnace : 44

. Top : 30 (98,000 Kcal/hr)
. Bottom : 14 (54,000 Kcal/hr)

1.3.9. Discharge Disk Roller Table

Data of the discharge table is as follows:

Length	: 15,250 mm
Number of roller	: 26
Roller spacing	: 610 mm
Transfer speed	: 30 m/m
Cooling speed	: 3 m/m

1.3.10. Exit Table

Data of the exit table is as follows:

Length	: 15,250 mm
Number of roller	: 26
Transfer speed	: 30 m/m
Cooling speed	: 3 m/m

1.3.11. Electrical Equipments

There exists a motor control center having 16 compartments in. Electrical drive system for rollers consists of 11 ac motors ranging from 7.5 HP to 30 HP. All of them are squirrel-cage induction types and on-off controlled. (See single line diagram in figure A1) All the drive systems are by ac motors except furnace doors and charging table bumpers which are driven by air cyclinders (valves). Motors are directly switched-on from the supply network. A relay bank compartment exists for sequence control of operation.

Control system is composed of following items: 63

relays, 4 electromechanical counters, 8 counter drivers, 4 inductive proximity switches and their drivers, 13 limit switches, a heat treatment timer, 11 indicating lamps, 6 alarms, 3 clutch solenoids, 2 brake solenoids, and ac drive groups with their speed reducers. Overall system equipments are as shown in figure A2.

1.4. Problems of Erdemir Normalizing Furnace

Erdemir plate normalizing furnace was built at Hot Strip Mill by Stein-Surface, a French company, in 1979. After operation of few years, system has failed to work efficiently because of mechanical problems and lack of material to be normalized. Because of irregular demand in normalized products in the market, normal maintenance of the system hasn't been performed. Under these conditions, semi-automatic mode of operation has been lost and system has worked in only manual mode.

But after the year 1986, the market demand to normalized products has significantly increased in a regular manner. Therefore the normalization process has needed modernization. This work has been implemented as a master thesis in METU EEE and also an internal project for Erdemir. Under these circumstances, firstly old operation process of this system has been analyzed. Main problems observed about this system are given below :

- I. Many operator movements between three pulpits are required for one cycle of process, because of semi-automatic nature of the control system. Therefore much idle time has been met during operation. Full-auto mode is required. Pulpit locations need modifications.
- II. Limit rods (sensor) within the furnace frequently causes down times and roll deformations during operation. Instead of it, new sensing methods must be developed.
- III. Control system electromechanical devices such as relays, counters, timers, etc. are frequently have failed to operate correctly. New control system is necessary.
- IV. Cooling tables, ie. discharging and exit tables, are unable to reciprocate plates longer than 10 meters in length. Therefore, for example 12-meter-long plates are divided into two parts for two tables because of mentioned problem. New controller should be able to reciprocate 12 meters long plates on each cooling table.
- V. Number of operator indicating lamps and alarms were not enough: 6 alarms and 11 indicating lamps. More warning lamps and alarms are necessary for the safety of operation.

1.5. Solutions to Problems

Problems mentioned in previous section can be solved by the following proposals, correspondingly:

- I. Full-automatic sequence control will be performed by the use of PLC. One of the pulpits (discharge pulpit) will be discarded by transferring its functions to the main pulpit.
- II. Load cell sensors can be located under the 4th and 30th rolls of furnace roller table. Electronic amplifier is needed for sensor output.
- III. Operation will be performed by PLC with software control.
- IV. Operator will set the plate length via a thumbwheel switch and hence cooling problem will be solved.
- V. A group of 30 alarms and 25 total indicating lamps will be installed on the operator desk for easy observation.

1.6. PLC in General

1.6.1. Introduction

A programmable controller is currently defined by NEMA (National Electrical Manufacturers' Association) as a "Digital electronic device that uses a programmable memory

to store instructions and to implement specific functions such as logic, sequence, timing, counting and arithmetic to control machines and processes."

1.6.2. Brief history of PLC

In the early 1960s, industrial control systems had been constructed from traditional electromechanical devices, such as relays, drum switches, and paper tape readers. The control relay was the most widely used device for controlling discrete manufacturing processes. Relays were susceptible to mechanical failure, they required large amount of energy to operate, and they generated large amount of electrical noise.

In the late 1960s, the need to design more reliable and more flexible control systems became apparent. For example, the automotive industry was spending millions of dollars for rewiring control panels in order to make relatively minor changes to the control systems at the time of the yearly model changeover. In 1968 a team of electrical engineers wrote a specification for what they called a "programmable logic controller". What they specified was a solid-state replacement for the relay logic. The first commercially successful programmable controller introduced in 1969. By today's standards, it was a massive machine containing thousands of electronic parts.

In the late 1970s, the microprocessor became a reality and greatly enhanced the role of the PLC, permitting it to evolve from simply replacing relays to the sophisticated control system component that it has become today. Programmable controllers now have the ability to manipulate large amounts of data, perform mathematical calculations, and communicate with other intelligent devices, such as robots and computers. Concurrent with the increased capability and flexibility of the PLC was the expansion into many other industrial applications, including the control of machine tools, material handling systems, food-processing operations and, use in the continuous process control field.

1.6.3. Characteristic Functions of a PLC

1. Field programmable by the user.
2. Contains preprogrammed functions.
3. Scans memory and input/output (I/O) in a deterministic manner.
4. Provides error checking and diagnostics.
5. Can be monitored.
6. Packaged appropriately.
7. General-purpose suitability. [1]

1.7. Scope of the Thesis

Solutions, mentioned in section 1.5, have been obtained by applying the new operation principle. Application of new operation principle, which will be explained in section 2.4.2., has resulted in expected solutions to problems mentioned in section 1.5. Necessary hardware has been chosen and suitable software has been developed according to the new operation principle. Furnace started production with the new system in february 1990. Within the author's knowledge, this is the first application of PLC to a plate normalizing process in the world.

Old and new normalization processes have been explained in chapter 2. Chapter 3 describes the hardware and software developments for the new system. Performance measurements for the new system are also carried out and the results obtained and the related conclusions are presented in Chapter 4.

The overall performance of the furnace was shown to be successfully improved by applying the new controller (PLC) and implementing solutions mentioned in section 1.5. Number of electrical faults has been reduced by 50%. Productivity has been increased by 35 % on production base of ton steel plate per hour.

CHAPTER 2

DESCRIPTION OF NORMALIZATION PROCESS

2.1. Normalization Process

In normalizing operations, the plate is heated up to a temperature of around 927°C (above the upper critical temperature) and cooled down naturally to the ambient temperature at a rate which permits the formation of ferrite with desired grain size. With normalization, mechanical properties of the plate (strength, hardness, etc.) are improved without any change in chemical composition.

Normalized plates are used in petro-chemical industry, military weapons, automotive industry, agricultural machinery, dam-ship building, boiler constructions etc. [5]

Mild steel plates would be normalized in the furnace and cooled down to the ambient temperature naturally. Depending on the composition of the plates to be normalized, normalizing temperature is about 1700°F (927°C).

Plate normalizing time is calculated by the following empirical formula:

$$\text{Normalizing Time(min)} = \text{Heating Time} + \text{Holding Time}$$

where, Holding time= 20 min.

$$\text{Heating time(min)} = 1.18 \times t \quad ; \text{in here,}$$

t = Plate thickness in mm and

1.18 = constant coefficient. See Table A.1 in Appendix A.

Hourly realized production is 4.7 ton/hour which is only 70% of the ultimate reference production.

2.2. Zones of Normalization Process

Normalizing furnace area can be divided into four zones according to their functions. These are charging zone, normalizing zone, discharging zone, and exit zone. Detailed equipment drawings can be seen in figure A2, in Appendix A.

2.2.1. Charging Zone

In this zone, charge is prepared before normalization. Sensors of this zone are limit switches: LS1-LS4-LS5-LS6. There are three different equipments in

functionality.

First of all, charging roller table is utilized for charging the plate into the furnace. It has a 15 KW, 1500 RPM cage induction motor. Two directions exist: forward and reverse, performed by interchanging motor supply two phases in between. Table speed is 30 MPM.

Second equipment on this zone is centering beam which has a 11 KW, 750 RPM motor, and its brake solenoid and is used for centering (guiding from the width) the plate on the charging table by its sideguards. Sideguards of centering beam normally stay on the two sides of the table.

Third equipment is the bumpers driven by solenoid valves. It has a function of lowering the charge, coming from the hoist, down to the table during charge preparation cycle. Bumper arms are located in parallel with the charging rolls.

2.2.2. Normalizing Zone

Normalizing zone starts after the charging zone. In this zone, plates are normalized at a temperature of 927°C. There is a furnace and within it a roller table exists. There are two load cells, one proximity switch and six limit switches (LS) : LS8-LS9-LS10-LS11-LS12-LS13 as sensors.

Furnace roller table is driven by either high speed

motor or low speed motor according to the operation. During plate charging or discharging high speed motor drives the table, on the other case ie. heat treatment, low speed motor runs. High speed motor is 15 KW and 1500 RPM, however low speed motor is 5.5 KW and 1500 RPM speed. There is a gear box for speed reduction of ac motors and also clutch-solenoids for differentiation of two motors from the load shaft. High speed motor has single direction ie. forward, while low speed motor has two directions. Table speed is 5 RPM when low speed motor is running and 50 RPM when high speed motor is running. Corresponding linear speeds are 3 MPM and 30 MPM

In this zone, there are two furnace doors: entry and exit door. Both doors are separately activated from air cylinders during charging or discharging.

2.2.3. Discharging Zone

This zone comes after the normalizing zone from south to north. In this zone, there is only roller table for cooling the normalized products from 927°C down to a few hundred °C. Discharge table has special disc rolls because it has to withstand that much temperature. It has also a drive group of high speed and low speed motors of 15 KW, 1500 RPM and 5.5 KW, 1500 RPM; speed reductor gear box and clutch solenoid. High speed motor runs during plate discharging from the furnace or transfer from

discharge to exit table. During all the other cases, it reciprocates forward to reverse and reverse to forward via low speed motor. Only sensors are the proximity switches. When a metallic piece is close enough (mm range) to the proximity switch then it operates and changes its state. They are mounted near to a sprocket which is actually a wheel connected to a disk roll shaft. When one revolution of the sprocket is completed, proximity sensor produces a number of pulses corresponding to the tooth number of the sprocket which is 30.

2.2.4. Exit Zone

After the discharging zone, exit zone starts. In this zone, there is a roller table and tilting mechanism between the rolls. There are two limit switches: LS3-LS7 and electronic pulser mounted very close to the rotating wheel.

Exit roller table cooles the plate from a few hundred degrees down to the ambient temperature via reciprocating it. It has a drive of high speed and low speed motors which has 15 KW-1500 RPM and 5.5 KW-1500 RPM characteristics. High speed motor runs for only during plate transfer from discharge to exit table. Low speed motor runs during reciprocation of the plate.

The other equipment in this zone is the tilting mechanism. It has a 15 KW, 750 RPM ac motor, gear box,

brake solenoid and has seven tilting arms between exit rolls. When tilting motor is energized, the brake is released and tilting arms tilt the plates and hence making 3 degree with the horizontal, and then returns to its original position with the aid of limit switch LS7. 3 degree tilt is enough for the plates to be sliding down to the stacking arms.

Other than all above mentioned zones, there exist combustion air and exhaust fans for furnace heating and gas flow (figure A1).

2.3. Old Normalization Process

Production flow can easily be understood from figures 1 and 2. CPM diagram in figure 1, explains how operation is performed. In figure 2, physical locations and production flow is shown. It is a relatively slow process. Reciprocation speed of the furnace roller table during heat treatment is 3 meters per minute. The same speed is valid also for discharge and exit table reciprocations. Plate transfer speeds are all 30 meters per minute: from charging to furnace, furnace to discharge, and discharge to exit tables.

2.3.1. Old Operation Sequence

In order to charge the furnace, operator moves to the

ENTRY PULPIT	MAIN PULPIT	DISCHARGE PULPIT
1 * Operator puts the plates onto the charging table by the aid of overhead crane. 2 * Operator manually centers the plates by the use of centering beam control switches. 3 * If the furnace is unloaded, then presses a push-button switch to charge the furnace. 4 * OPERATOR MOVES TO THE MAIN PULPIT in order to set the heat treatment timer and to follow the operation. 10 * ONE CYCLE HAS COMPLETED.	5 * According to the plate normalizing time table Operator sets the timer. (Table 1) 6 * Operator follows and scans all the indicating lamps and alarms to react any abnormality. 7 * Observes the timer to come down to zero. 8 * Before the timer coming to zero OPERATOR MOVES TO THE DISCHARGE PULPIT. 13 * Follows the timer until it comes to zero. 14 * When discharging time comes, understood by lamp indication and timer, OPERATOR MOVES TO THE DISCHARGE PULPIT. 17 * Resets system and in order to load the furnace, if plate ready on the charging table, MOVES TO THE ENTRY PULPIT.	9 * Operator decides by just eye inspection, plates cooled enough. 10 * Then, he unloads the previously normalized plates from the exit table by using tilting arms. 11 * Then, he runs exit table and discharge tables high speeds. Plate on the discharge table has been transferred to the exit table. 12 * RETURNS TO THE MAIN PULPIT. 15 * When the "discharging order" lamp lights on, then operator discharges the plates from furnace by pressing a push-button. 16 * If plates are needed to division, operator passes some of them to exit table. Then OPERATOR MOVES TO THE MAIN PULPIT to reset the system for reciprocate automatically.

Figure 1 Old CPM Diagram of Normalizing Furnace.

entry pulpit. If the plate is ready, charging permission lamp lights up and hence operator gives the charging order. The duration from discharging to new charging into furnace is about five minutes. When the charging order comes, entry door (13) solenoids are energized. During that time furnace table stops. Upon opening of the door, both charging (03) and furnace (06) tables run at high speed until front edge of the plate touches the front limit rods end, furnace high speed and charging forward stops, door is closed (13) automatically. The plate, within the furnace, reciprocates between back and front limit rods and treatment timer runs. Then the operator returns to the main pulpit to observe the system while the treatment timer is expiring down.

Operator starts tilting (11) at any time before the heat treatment timer coming to zero. Therefore the operator moves to the discharge pulpit for tilting. The normalized plate reciprocating on the exit table (09) can be moving either direction, when the operator starts tilting. If the plate is going reverse direction (09), when the order comes; then the plate completes the tour and comes to the end of the exit table limit switch-3. When it touches the LS3, exit table low speed stops and tilting starts and the plates slide down from the tilting arms to the stacking yard arms (See figure 3).

Upon completion of tilting, plate transfer from discharge (08) to exit (10) table starts by running their

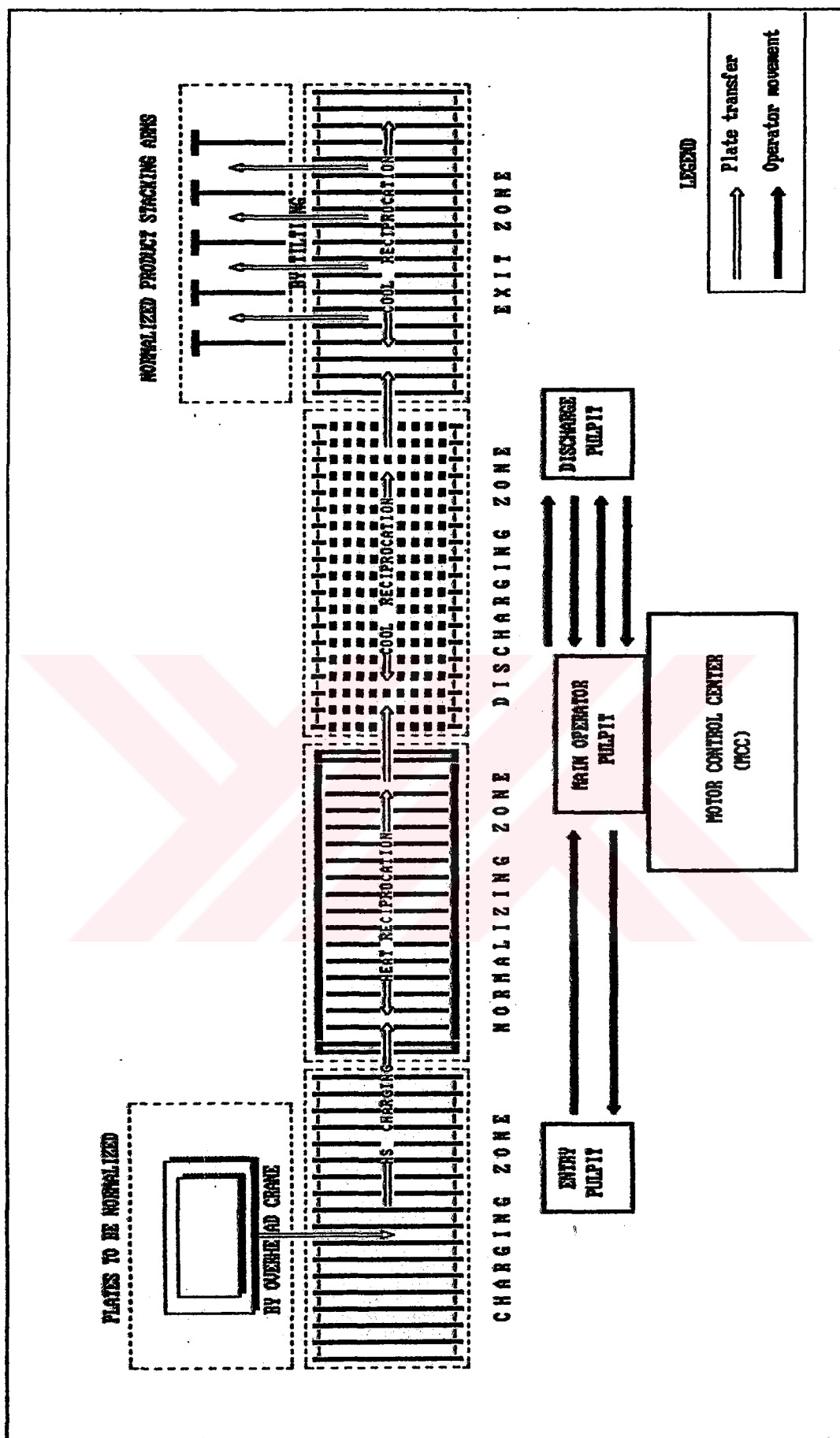


Figure 2 Old Production Flow Diagram.

high speed motors. This operation also ends when the plate's edge touches LS3. Then the exit table low speed starts and reciprocates the plate on it. During that time, discharge table reciprocates without plate on it at low speed in order to cool down the disc rollers. All these manipulations have to be completed, before the normalizing time of the plate in the furnace ends. Reciprocation of cooling tables is performed by their own proximity switch sensors which in turn drive the related electromechanical counters. Tables reciprocate with a fixed plate length. It corresponds to 10 meter long plate reciprocation.

As it is seen from the above explanations that, in all these operations the master is the furnace and others are slaves of it.

From the timing diagram, after tilting and transfer operations, discharging comes. When the timer comes down to zero, then an indicator lamp warns the operator for discharging. If the operator decides to keep the charge within the furnace due to various reasons, the normalized plate continues to reciprocate in the furnace. When the discharging order comes, the plate reciprocates and comes to the back of the exit door. Limit rods are used for head end position detection of the plate within the furnace, near to the two doors. When the plate touches the limit rods, then the furnace roller table stops and exit door solenoids (14) are energized. During that time

furnace roller table and discharge roller table running at low speed stop. Upon opening the exit door, both furnace (06) and discharge (08) tables run high speed for about 40 seconds and discharges the plate. When discharging is completed after counting a preset number of pulses received from the proximity switch mounted to the roll shaft wheel. The discharged plate can be reciprocated only by utilizing the two cooling tables. Since a plate is already reciprocating on the exit table, manual tilting is necessary to unload the exit table. After completion of manual tilting, operator resets the both tables and opens and closes the exit door for new charging and performing as if the plate is just discharged from the furnace. Then the normalized hot plates can reciprocate with utilizing both discharge and exit tables.

Above mentioned manual manipulations are performed at the discharge pulpit. After these operations, in order to charge the furnace, operator moves to the entry pulpit. If the plate is ready, charging permission lamp lights up and hence operator gives the charging order. The duration from discharging to new charging into furnace is about five minutes. Upto here explanation of one cycle is completed. The control system repeats the cyclic operation sequence continually, in the same manner. One complete cyclic operation takes about 34 minutes for the thin (6 mm thick) plates and, about 86 minutes for the thick (50 mm thick) ones.

2.3.2. Main Limitations of the Process

Since control of the old operation sequence is performed by electromechanical relays (See figure 4), there has been many electrical problems and hence downtime in production. We can mainly classify the bottlenecks as follows:

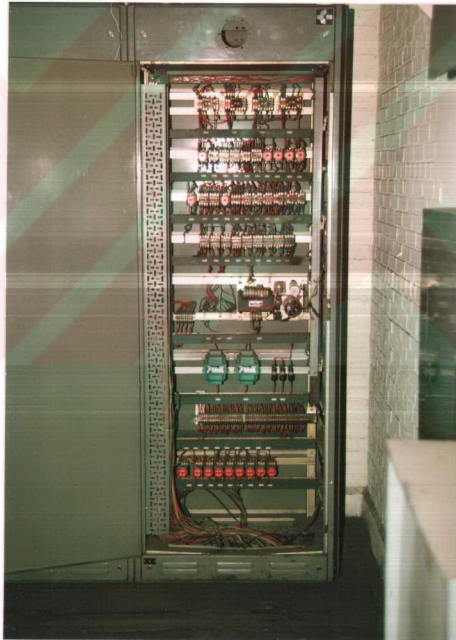


Figure 4 A General View of Old Relay Panel.

1. Old control system was not able to perform all three operation modes; automatic, semi-automatic, and manual. During operation, it was necessary, at any time, to change the operation mode because of, abnormal plate shapes, gas interruptions etc.
2. For one cycle of operation, operator has to move between the three pulpits (entry, main, and discharge pulpits) which are located at different places. This causes main delay in production.
3. In old operation, there were limit rods near to the two furnace doors and are used for sensing the front and back edges of the plates (See figure 5). When the edge of the plate is detected, the low speed motion is stopped in the furnace table, then the reverse of the previous direction is started. However, these rods were broken down once a month or biveekly, and hence operation stops for at least two days. Worse than that, furnace roller under the hot plates was sagging because of high temperature when the furnace reciprocation has stopped.
4. Electromechanical timers and counters caused many operation faults and delays. Since there were not enough number of indicators and alarms, it would be difficult for electricians to find out the location of the fault.

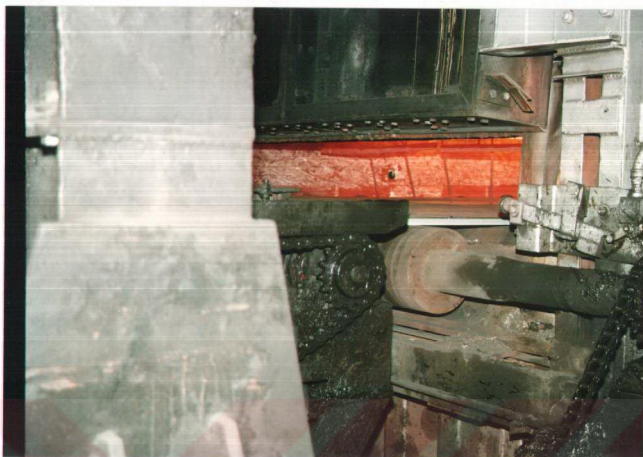


Figure 5 A General View of Furnace Limit Rods.

5. Old control system was incapable of reciprocating plates that longer than 10 meters, on the cooling tables. In those cases, operator manually resets both cooling tables, and then plate is reciprocated on the unified area of two cooling tables.
6. The automation level of the old system was semi-automatic. Operator has to press push buttons for tilting, discharging and, charging purposes.

Sequence diagram of old operation is as shown in figure 3. It is easily seen from timing diagrams that operator must interact with the controller several times for sequence control logic. Without these actions, sequence wouldn't progress to the next

operation. When the furnace was discharged, it's taken five minutes to reload it. That is also a typical example of wasting the time.

2.4. New Normalization Process

2.4.1. Introduction

In order to eliminate the limitations and bottlenecks mentioned on section 2.3, a new operation principle was prepared. Parts of the old system were also replaced by new equipments and sensors for upgrading the process. A suitable programmable controller was chosen for the purpose. The author has analyzed the old system and proposed the following operation sequence.

2.4.2. Principle of New Operation

System will be automatic, semi-automatic and manual (without PLC). Idle-time after the plate discharging will be eliminated with the new design. The new CPM diagram in figure 6 shows the principles of operation.

Rolled plates are picked by a hoist from the plate yard and transferred to the charging roller table. Normalizing furnace operator manually lifts the bumper arms before the plates are placed on the table. When the plate is lowered onto the bumpers, the operator

ENTRY PULPIT	MAIN PULPIT
1 * Operator puts the plates onto charging table by the aid of overhead crane. 2 * Operator manually centers the plates by his centering control switches. 3 * When manual operations are finished, presses "plate ready" push-button and RETURNS TO THE MAIN PULPIT.	4 * Observes the system and indications. 5 * When treatment timer indicates 10.0 minutes, plate reciprocating on exit table is tilted automatically. 6 * Upon completion of tilting, both cooling tables run high-speed for 50 sec. or until pushing limit switch 3. 7 * When timer comes to zero, an alarm horn warns the operator. Plate in the furnace completes its last tour and comes to the exit door. Door is opened for 32 sec. and furnace is unloaded. 8 * Upon discharging, if plate ready on the charging table, operator only sets plate length and pushes "read plate length". Then entry door is opened and furnace is charged. 9 * During heat treatment, if charge is delivered by the hoist, then operator moves to the entry pulpit and prepares the next charge.

Figure 6 New CPM Diagram of Normalizing Furnace.

manually lowers them and hence the charge lays on the table. This operation continues until enough number of plates prepared.

During charge preparation, there may be plates in the furnace, on the discharging and exit tables. There exist a digital timer which is set by the operator to a predetermined value (in minutes) and it expires down to zero. Heat treatment timer determines the time of discharging. When 10 minutes left to discharging, then the plates reciprocating on the exit table is tilted by tilting arms and, hence exit table is emptied. Immediately after that, the plates on the discharge table are transferred to the exit table with both tables driven by high speed motors. When the digital timer comes to zero minute, since the discharge table is emptied, exit door is opened and normalized plates are transferred from furnace rollers table to the discharge table at high speed. Upon discharging, new plates can be charged to the furnace, if they are ready.

This sequential operation is repeated periodically. Plate is charged, then cooled plates are tilted from the exit table. And after tilting, discharge to exit transfer occurs. When the treatment is completed in the furnace, exit door is opened and plate is discharged from the furnace. Since the furnace is unloaded, it will be ready for loading from the charging roller table. Production flow diagram can be seen in figure 7.

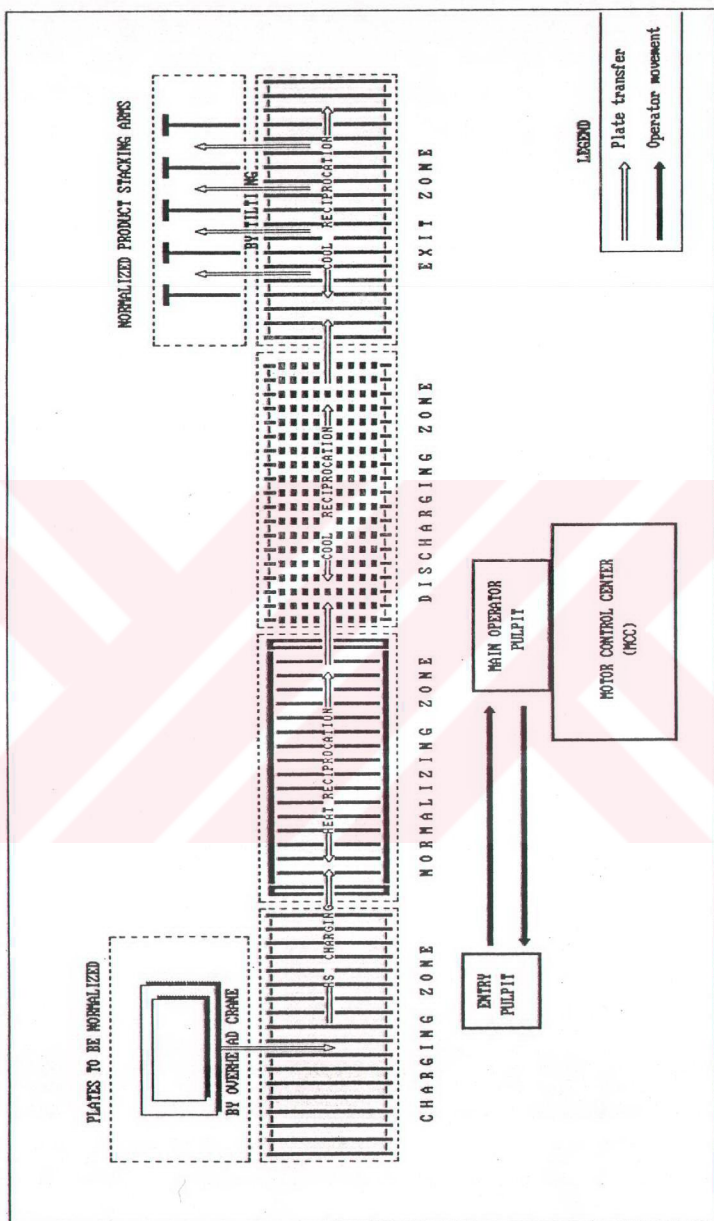


Figure 7 New Production Flow Diagram.

2.4.3. New Operation Sequence

Fully-automatic operation mode will be explained here. During automatic sequence, operator can switch-on to any manual operation by the selector-switches. This mode is known as semi-auto mode. If the operator selects all the switches to non-auto position, that is called manual mode. This can be with or without PLC. If PLC stops running for any reason, the operator can control the roller tables manually.

New operation is fully automatic except plate charging. However plate charging can also be automatically achieved; but it is a common practice in industry to give the operator an interface to the process in order to follow the production line carefully. The new process is as shown figure 8.

Plates are manually feeded to the charging table by a crane. Operator manually prepares them for charging at the entry pulpit. After the preparation of the charge, the operator pushes the plate-ready-push-button and plate-ready-indicator lights up. Then the operator leaves the entry pulpit and doesn't come until the new preparation cycle start and stays on the main pulpit.

In old system, tilting was started by the operator at any time. But here, tilting (11) starts when ten minutes left to discharging. When the front edge of the plate

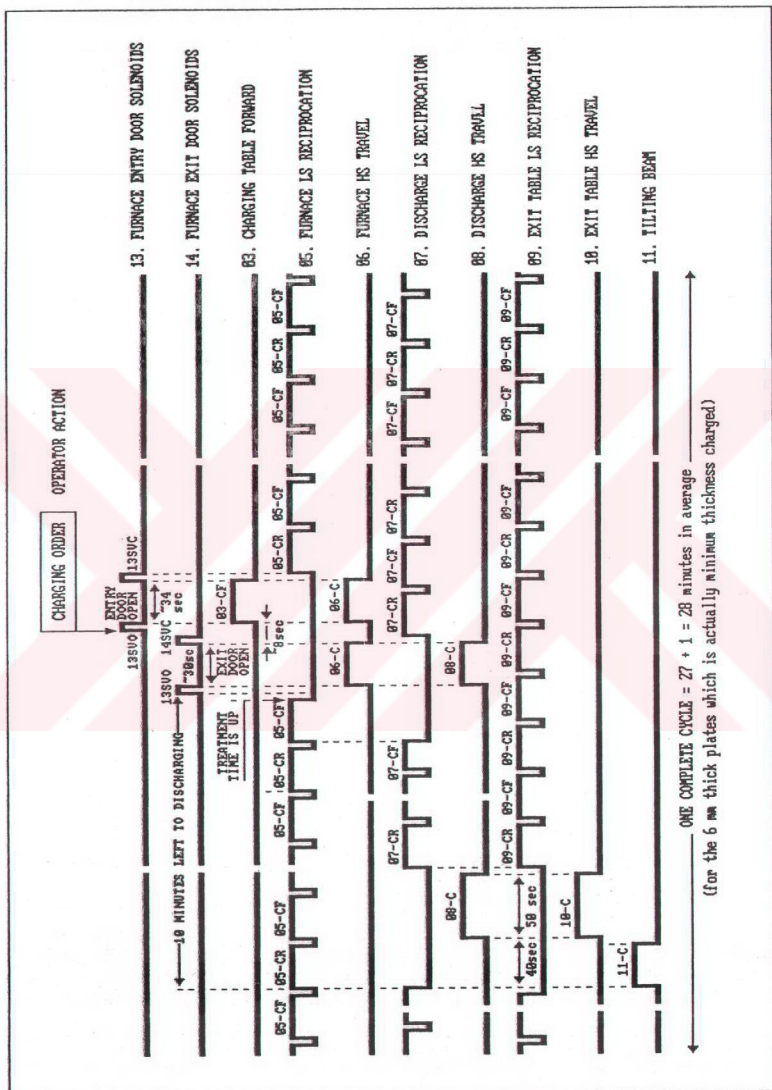


Figure 8 New Operation Timing and Sequence Diagram.

touches LS3, exit table (09) low speed motor stops the plate and doesn't let it go reverse direction but tilting motor energized. After tilting starts, discharging table (07) low speed is stopped. Tilting takes for about 40 seconds. Upon tilting arms come to park position, discharge (08) and exit (10) high speed run for about 50 seconds. During that time, plate is transferred from the discharge table to the exit table. After that tables running high speed stop and both tables low speed motors are energized. On both cooling tables, ie. discharge and exit tables, new electronic sensors are used instead of proximity switches.

When the treatment timer lowers to zero, normalized plate completes its last tour and comes onto the exit door. Within the furnace, forward-reverse reciprocation is performed by new sensors ie. load cells. Entry door side is named as load cell-1 and exit door side named as load cell-2. Normalized plate comes onto the load cell-2 and stops there. Then exit door is opened and both furnace and discharge tables run at high speed to discharge the plates out of the furnace by using software timers for 30 seconds. After discharging, during closing the door, charge permission warns the operator to push the read-plate-length-push-button in order to charge the plate into the furnace. This operator interruption is intentionally inserted into the software control system. Because this action forces the operator to follow the

production line more carefully.

Upon pushing the read-plate-length-push-button, entry door (13) is opened. Then both charging forward (03) and furnace (06) tables are running at high speed altogether until either the timer counting finishes (34 sec.) or load cell-2 senses the plate. Then entry door is closed and furnace table reciprocates starting from reverse direction. Operator sets the timer to a predetermined value from the time table (Table A.1). Plate is heated in the furnace infinitely time, if the timer isn't set running.

By introducing PLC, one complete cycle is reduced for about five minutes from 33 minutes to 28 minutes, for 6 mm thick plates. This means average 10% hourly production improvement from 4.7 to 5.1 ton/hour.

2.4.4. Newly Added Sensors and Equipments

1. **Operator Desk:** New operator desk is designed for the main pulpit instead of the old one. All the selector switches, push buttons, alarms (30), indicators (25), heat treatment timer (999.9 min.) and thumbwheel switch for plate length reading were mounted to the desk. A general view of new operator desk is shown in figure 9.

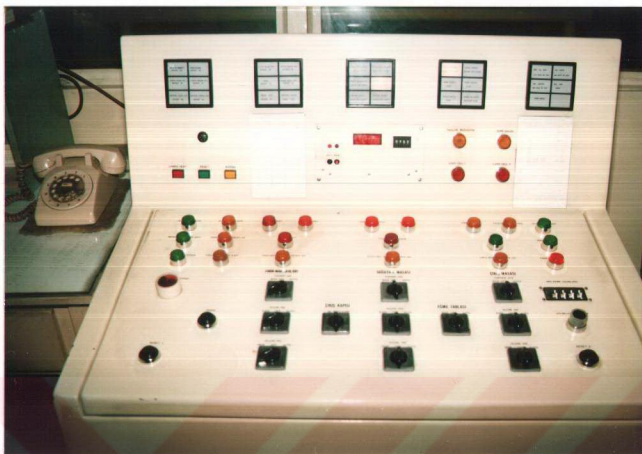


Figure 9 A General View of New Operator Desk.

2. **Programmable Controller Interface Panel:** Programmable controller itself, its rack fan, load cell's amplifier stage, input relays (110V AC), output relays (24V DC), 24V DC unregulated power supply (diode rectifier), circuit breakers, and related connectors are mounted on the interface panel. A general view of PLC interface front panel is shown in figure 10.
3. **Limit Switch-1:** This sensor is located on the charging table near to furnace entry door. It is actually a group of chains for detecting front edge position of the plate to be charged. Electrical circuit diagram is shown in figure 11. A general view of the sensor is as shown in figure 12.

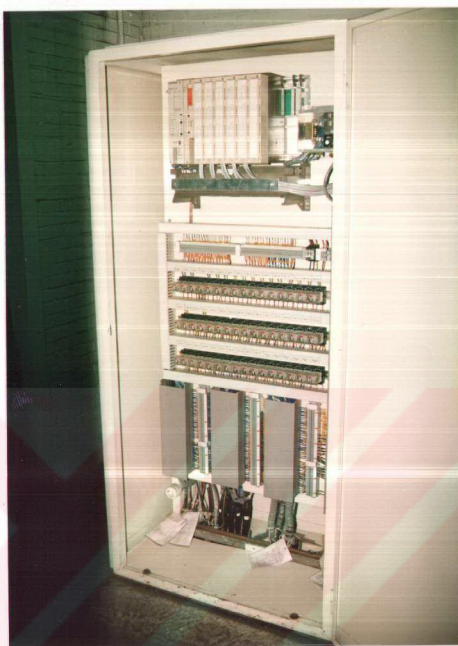


Figure 10 A General View of PLC Interface Panel.

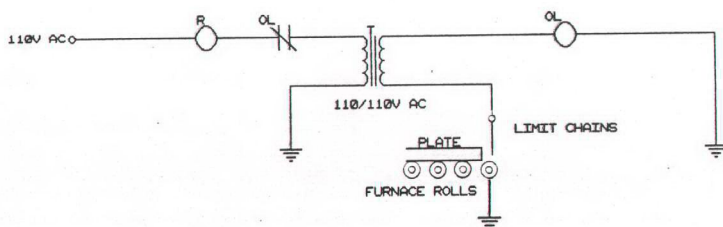


Figure 11 Circuit Diagram of Limit Switch-1.

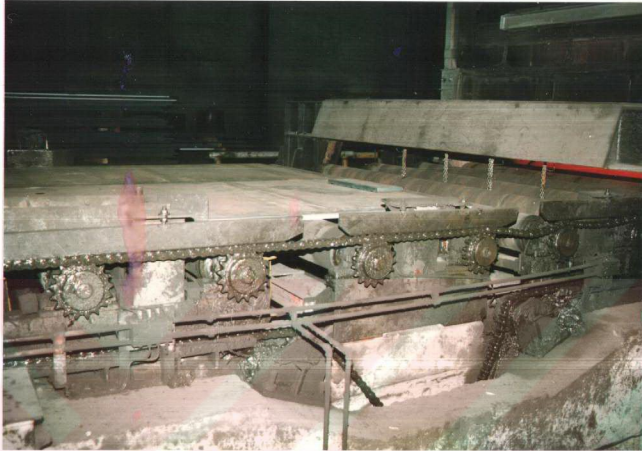


Figure 12 A General View of Limit Switch-1.

When the plate touches the chain, then current flows through the secondary of transformer T and OL relay. Therefore relay R is deenergized through 110V AC supply indicating that the plate is sensed.

4. **Cooling Table Sensors:** In old system, there had been three proximity switch sensors which were sensitive to the distance between sprocket and their sensing edges. They were mounted closely to the sprockets (wheels) connected to the shaft of the cooling rolls. But time

to time, roll shaft has slid away from the sensor (proximity switch) and motion was not detected and hence operation has stopped. This causes long downtime in the process.

In new system however, an electronic circuit was utilized to count the pulses. A light source is focused through the wheel to an electronic circuit. Circuit diagram is shown in figure 13. When photo transistor is imposed to light, then it saturates resulting in zero output voltage. Otherwise when no light comes, the transistor is cut-off providing high output: 24VDC. Problem is eliminated using this simple pulser. A general view of the sensors are as shown in figure 14.

5. **Load Cell and Related Parts:** They consist of two load cell sensors, their construction platforms, and electronic amplifier stages.

Load cell is a sensor that was used for measurement of mechanical weight pressed on it. Sensing means are generally by strain gages. Maximum displacement under full load is about 0.1 mm in most load cells. Strain gage excitation voltage is between 10-12 VDC and output is in the range of mvolts.

The load cell, used in this thesis, was a strain gage in cylindrical shape with a capacity of 10,000 lbs (4,500 kg) (a product of BLH Electronics). These load cells are precision transducers for measurement

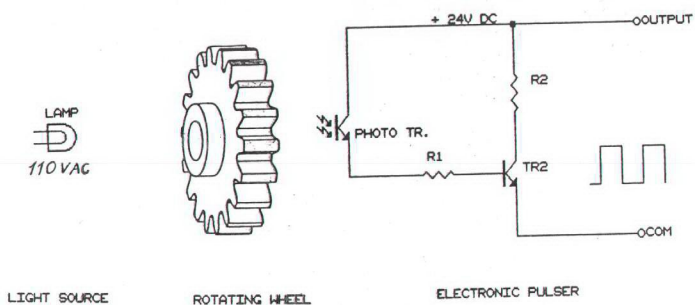


Figure 13 Circuit Diagram of Cooling Table Sensors.



Figure 14 A General View of the Cooling Table Sensors.

of weight and other linear forces. They contain strain gages bonded to internal load bearing elements which are stressed by applied tension or compression forces. The strain gages produce changes in the electrical output proportional to the applied force [7]. Load cells are generally utilized in weighing systems. This is a very special application of load cells in normalizing furnace operations. Before the modernization, many sensors eg. gamma ray detectors, light detectors, limit rods were installed by the maintenance personnel, but none of them has given successful results. The load cell of the above type has been applied to this process successfully within the scope of this thesis work. Because the main bottleneck of the furnace was the internal furnace sensor which has caused furnace roller deformation and long furnace shut downs.

The successful integration of the load cell into the old system seems to be a valuable contribution to the field of normalizing furnace control.

Load detection sensors were installed under the two specific roll of furnace roller table. They were continuously sensing about 2,500 kg roller weight under which the load cell installed. Mechanical figure of load cell platform is shown in figure 15.

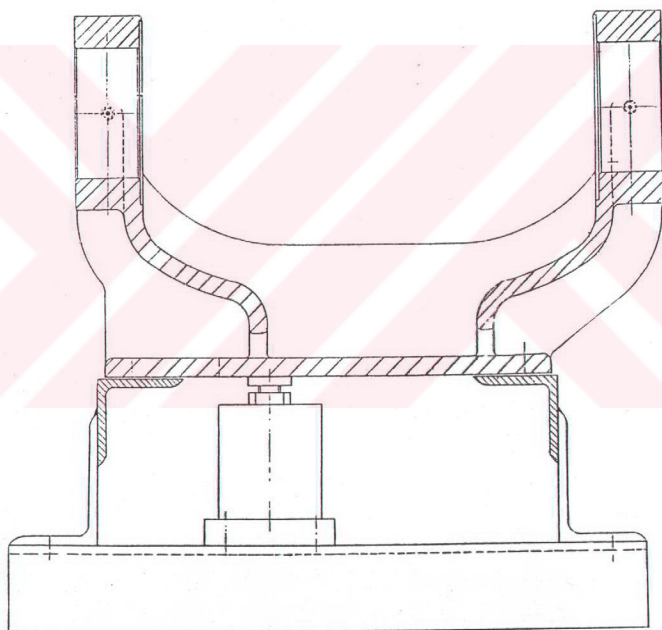


Figure 15 Mechanical Diagram of Load Cell.

A general view of load cell is given in figure 16.

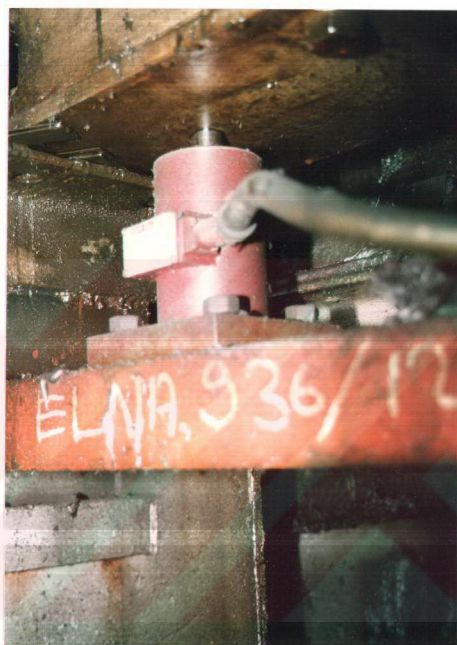


Figure 16 A General View of the Load Cell Installed.

1. Short Explanation of Load Cell Amplifier Stage:

Circuit diagram of the amplifier stage is shown in figure 17. First two circuits from the top are the amplifier stages of both load cells.

The circuitries of the both cells are exactly the same as each other except names. Bottom circuit is power supply of load cell strain gages and amplifier stages. Load cell amplification factor is 3 mV/volt (excitation). Therefore, for the rated load case, 30 mV output from the strain gages will be obtained.

Load signal coming from the load cell strain gages is amplified by an operational amplifier (LM725) with a fixed gain. This signal is amplified, negatively polarized and applied to an operational amplifier (LF353) and finally two oncoming signals are added. Output of that circuit is compared with a threshold voltage level. If this voltage exceeds the threshold level then the transistor in the last stage of the circuitry (BC639) is driven from its base thus energizing the relay coil. By this way, main control unit receives an electrical signal indicating that the pile of the plates has pressed on the load cell.

A load cell strain gages needs DC excitation. (+5VDC) and (-5VDC) are utilized instead of +10VDC. Power supply used for this purpose

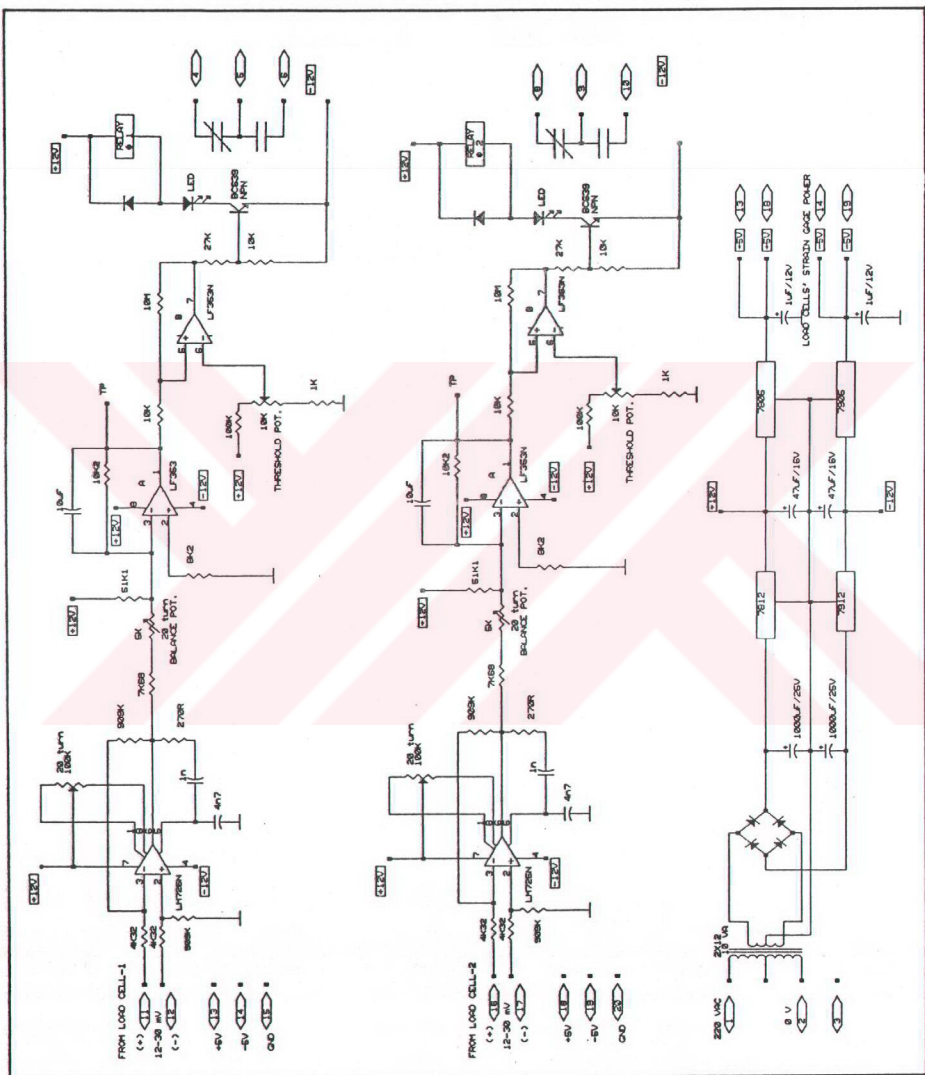


Figure 17 Load Cell Amplifier Circuit.

consists of a 10VA, 220/2 x 12 volt transformer and a full bridge rectifier. Rectifier output is smoothed out by means of a 1000uF capacitor and regulated by a 7812 regulator chip for +12VDC output, and by a 7912 regulator chip for -12VDC output. These voltages are utilized at amplifier stages for biasing purpose. Then regulated 5VDC generation is performed by the use of regulator chips (7805 and 7905) which are connected in shunt with the 12VDC output. 5 volt outputs are utilized at load cell strain gage excitation.

A general view of the amplifier circuit box is shown in figure 18. Amplifier gains are so adjusted that the desired minimum weight is detectable. The load cell has produced about 12 mvolt in detection of the lightest plates which are the most critical weights for the position detection.

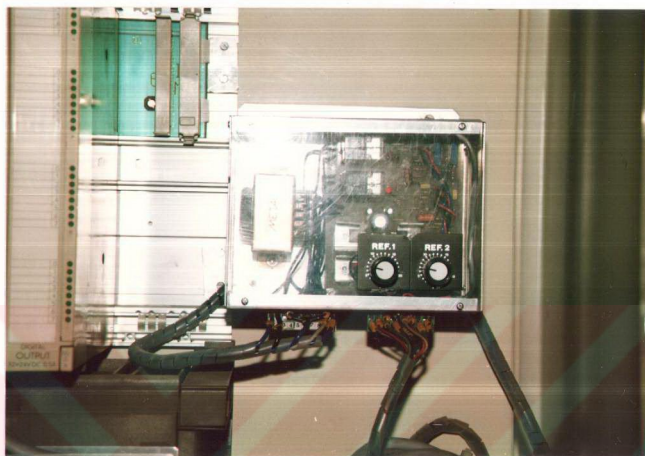


Figure 18 A General View of the Load Cell Amplifier.

CHAPTER 3

PLC and PROGRAMMING

3.1. Hardware Structure and Development

3.1.1. Introduction

A programmable controller is currently defined by NEMA (National Electrical Manufacturers' Association) as a "Digital electronic device that uses a programmable memory to store instructions and to implement specific functions such as logic, sequence, timing, counting and arithmetic to control machines and processes."

1. **Field programmable by the user:** This characteristic allows the user to write and change programs in the field without rewiring or sending the unit back to the manufacturer for this purpose.
2. **Contains preprogrammed functions:** PLC's, when procured, are already programmed with at least logic, timing, counting, and memory functions that the user can access through some type of control-oriented

language.

3. **Scans memory and input/output (I/O) in a deterministic manner:** This feature allows the engineer to precisely determine how the machine or process will respond to the program.
4. **Provides error checking and diagnostics:** A PLC will periodically run internal tests on its memory, processor, and I/O systems to insure that they are functioning properly.
5. **Can be monitored:** A PLC will provide some form of monitoring capability, either through indicating lights that show the status of inputs and outputs, or by an external device that can display program execution status.
6. **Packaged appropriately:** Modern PLC's are designed to withstand the temperature, humidity, vibration, and noise found in most factory environment.
7. **General-purpose suitability:** Generally, a PLC is not designed for a specific application, but it can handle a wide variety of control tasks effectively.

3.1.2. Comparison between PLC and Other Systems

Initial cost of PLC systems is higher than any other hard-wired logic and relay controllers [8]. But if the I/O number exceeds 50-60, then PLC has become comparable with the others (See figure 19). Following criteria must

be satisfied for the application of PLCs to the field of process control or machine control:

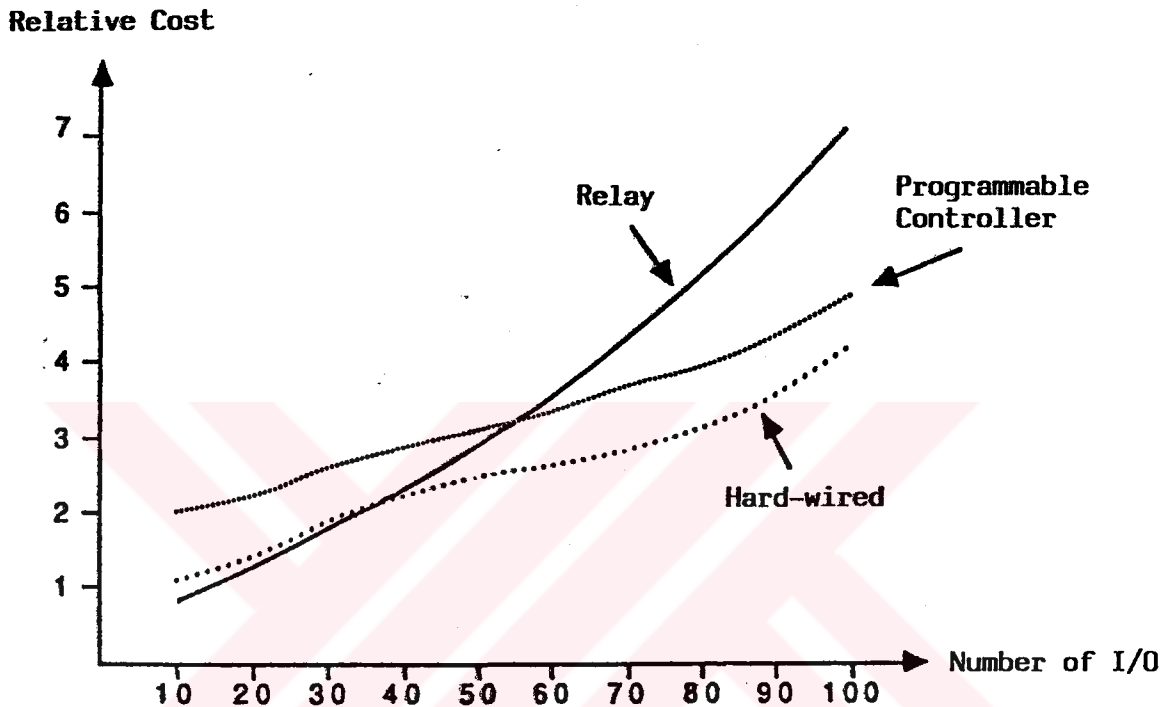


Figure 19 Relative Cost Comparison of PLC and Others.

- A higher automation level can be developed with using PLC instead of hard-wired or relay systems.
- Initial cost for PLC systems will be greater than the others, if the I/O number is low.
- Healthy operation hours of PLC systems are much greater than the others. MTBF (Mean Time Between Failures) of PLC is greater than 8,000 hours.

- d. Operation speed is very high in PLC systems with compared the others.
- e. Changes in the operation sequence or logic can easily be made in PLC systems without need to any hardware. But relay and hard-wired systems need much wirings and effort.
- f. Troubleshooting is easier than the others in PLC systems.
- g. PLC systems utilize lower power and space.

Since I/O number has very much exceeds 60 in this application, a PLC based control system will obviously be the most suitable choice for Erdemir plate normalizing furnace.

3.1.3. Hardware Structure of PLC

A simplified model of a PLC is shown in figure 20. The input converters convert the high-level signals that come from the field devices to logic-level signals that the PLC can read directly. The logic solver reads these inputs and decides what the outputs should be based on the user's program logic. The output converters take the logic-level signals output from the logic solver and convert them into high-level signals that are needed by the various field devices. The program loader is used to enter and/or change the user's program into the memory and

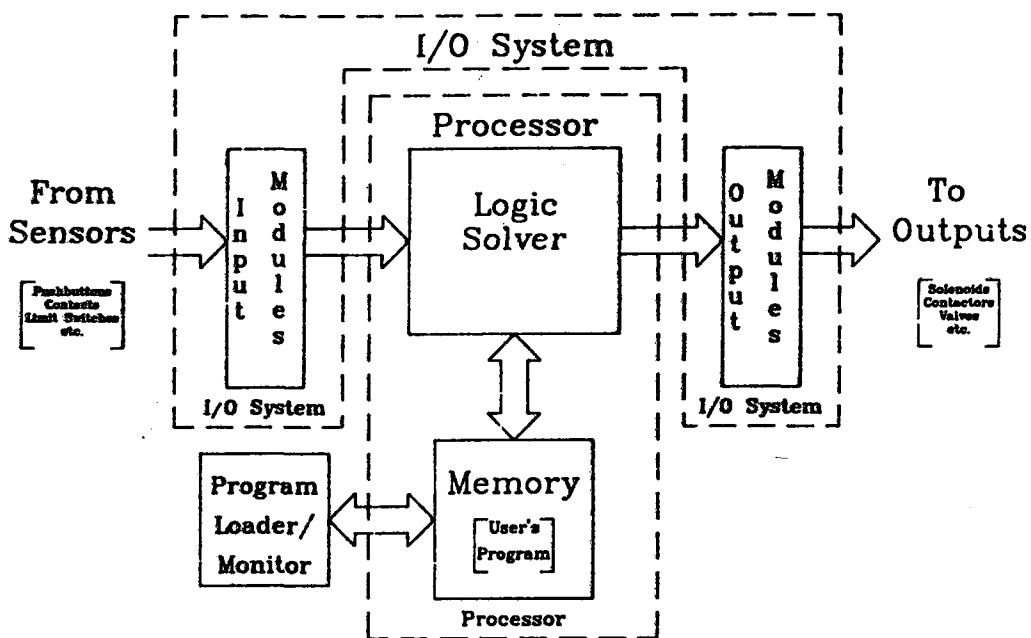


Figure 20 Simplified Block Diagram of a PLC.

to monitor the execution of the program [9].

The accumulator is a buffer used for loading timers and counters and for the execution of comparison functions by the PLC.

Flags are memory elements in which the processor stores signal states.

The program is written into the PLC memory with a programmer (program loader). After power-up, the processor sends out an initialising pulse to set the timers, non-retentive counters and flags, accumulator and process image to zero.

The S5-115U operates cyclically. At the beginning of each cycle, the processor reads the signal states of all

inputs and stores them in a process input image. During execution of the program, the processor always refers to the process image (figure 21).

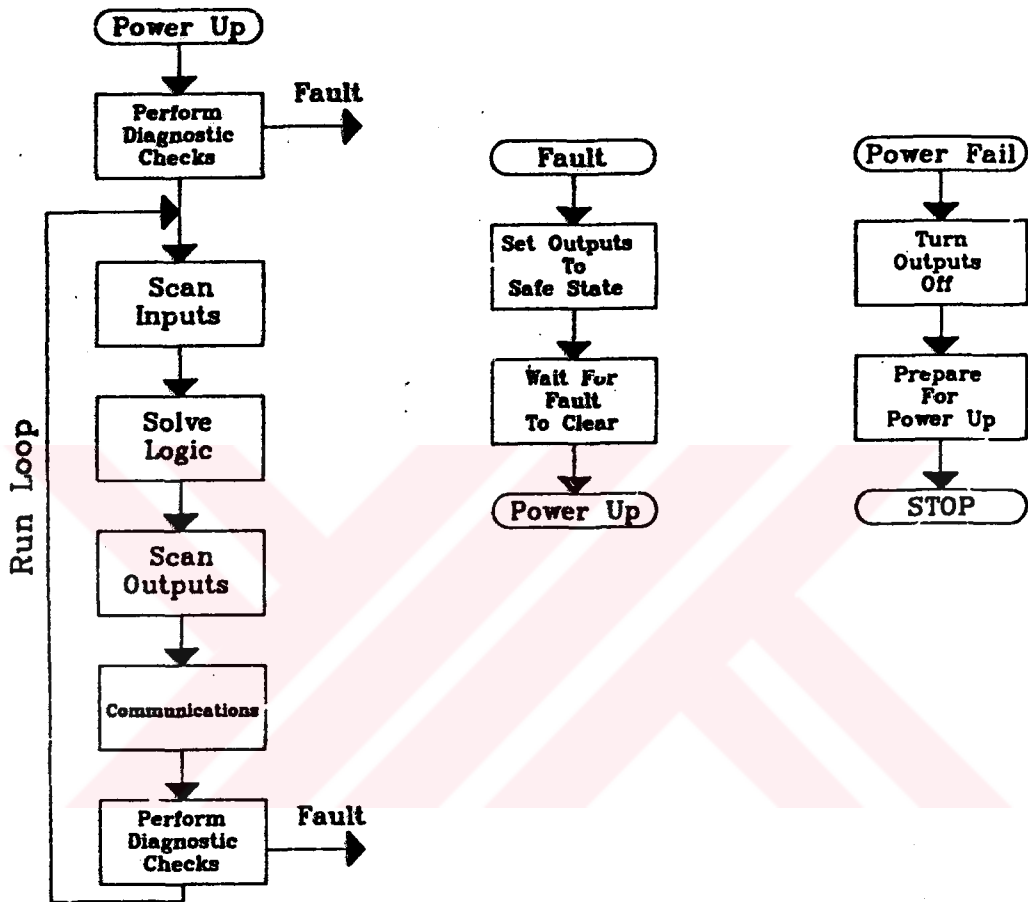


Figure 21 Control Loop of a PLC.

When the program is being executed, the processor reads program memory locations one after another, starting from the beginning. The program is executed in accordance with the statement list. If an output has to be set as required by the program, the processor stores the state of that output in the process output image. At the end of a

cycle, the processor transfers the information from the process output image to the outputs. A typical configuration for single input and single output PLC is as shown in figure 22.

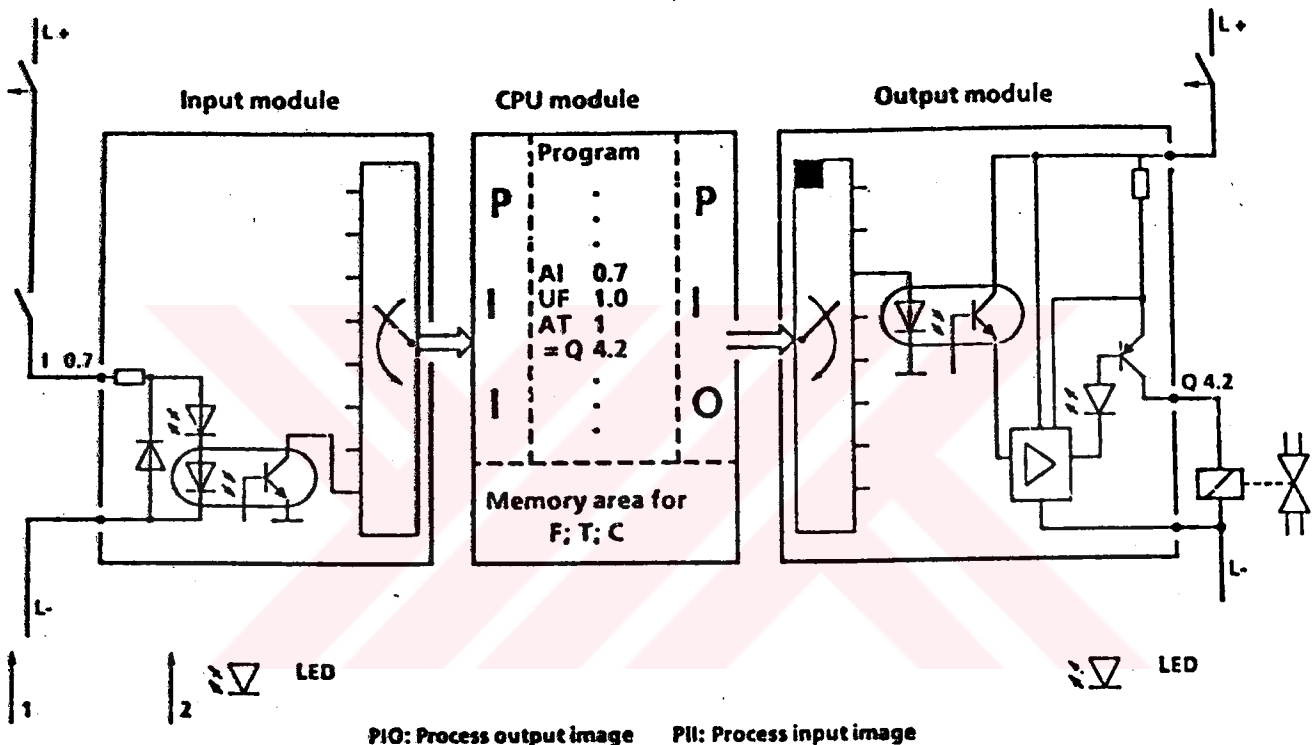


Figure 22 A typical I/O Configuration of a PLC.

3.1.4. Hardware Development

Several control schemes were examined, but none offered the versatility, reliability, low cost, and range of applications of the programmable controller.

Following chart (Spider-Graph) is very useful for

selection of correct PLC type (See figure 23). Spider-graph selection system is based on eight generalized criteria, namely:

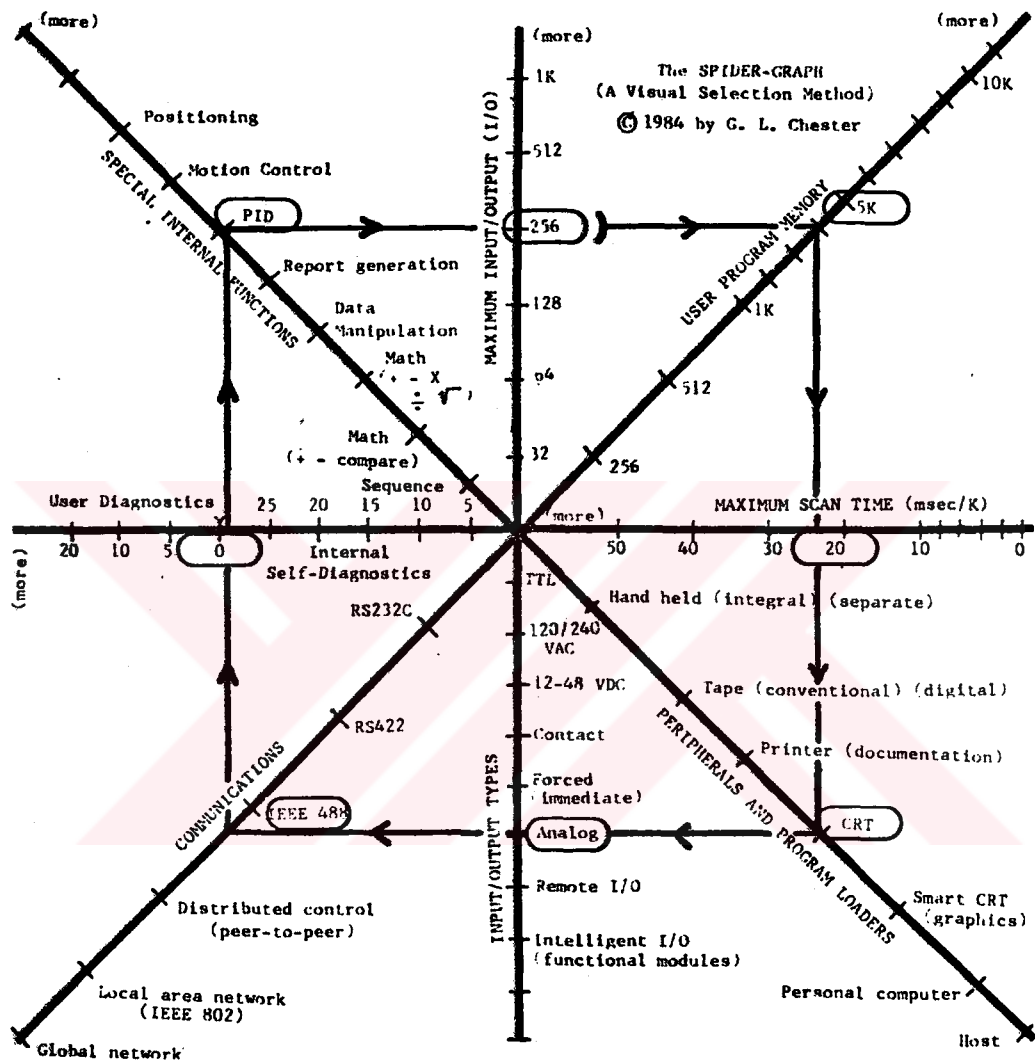


Figure 23 PLC Technical Selection Chart.

1. Maximum number of input/output
2. Input/Output types

3. Maximum scanning time
4. User program memory capacity
5. Special internal functions
6. Peripherals and program loaders
7. Communications
8. Diagnostics

It is designed to assist engineers in specifying and purchasing a programmable controller with features best suited for a given application. In order to decide which specifications were needed for the modernization, the chart was traced in clockwise direction starting from "maximum number of input/output (I/O)" and following circled specifications were obtained : (1) 256 I/O (2) 5 Kbyte internal memory, (3) 20 msec/K scan time (4) CRT program loader (5) analog and digital I/O's, (6) IEEE 488 communication mode, (7) many internal self diagnostic tests, and (8) PID control functions.

All the above mentioned functions were best met by S5-115U. I/O capacity and internal memory size of S5-115U was greater than the chart specified ones. Scan time of S5-115U is 18 msec/K. CRT programmer was readily available in Erdemir.

SIMATIC S5 series S5-115U meets the specifications. It is a mid-range PLC which has 10 Kbyte internal RAM memory, scans 1024 I/O, handle PID loops, has 1024 internal relay, 127 timer, 127 counter software modules

[10]. SIMATIC S5 technical specifications are given in Appendix C. User can generate 256 program blocks in 115U. 3 input modules and 3 output modules were installed. Input modules are digital and each has 32 inputs of 24VDC type. The same is also valid for output modules. One output module is spare. Overall input/output configuration of programmable controller of normalizing furnace is shown in figure 24.

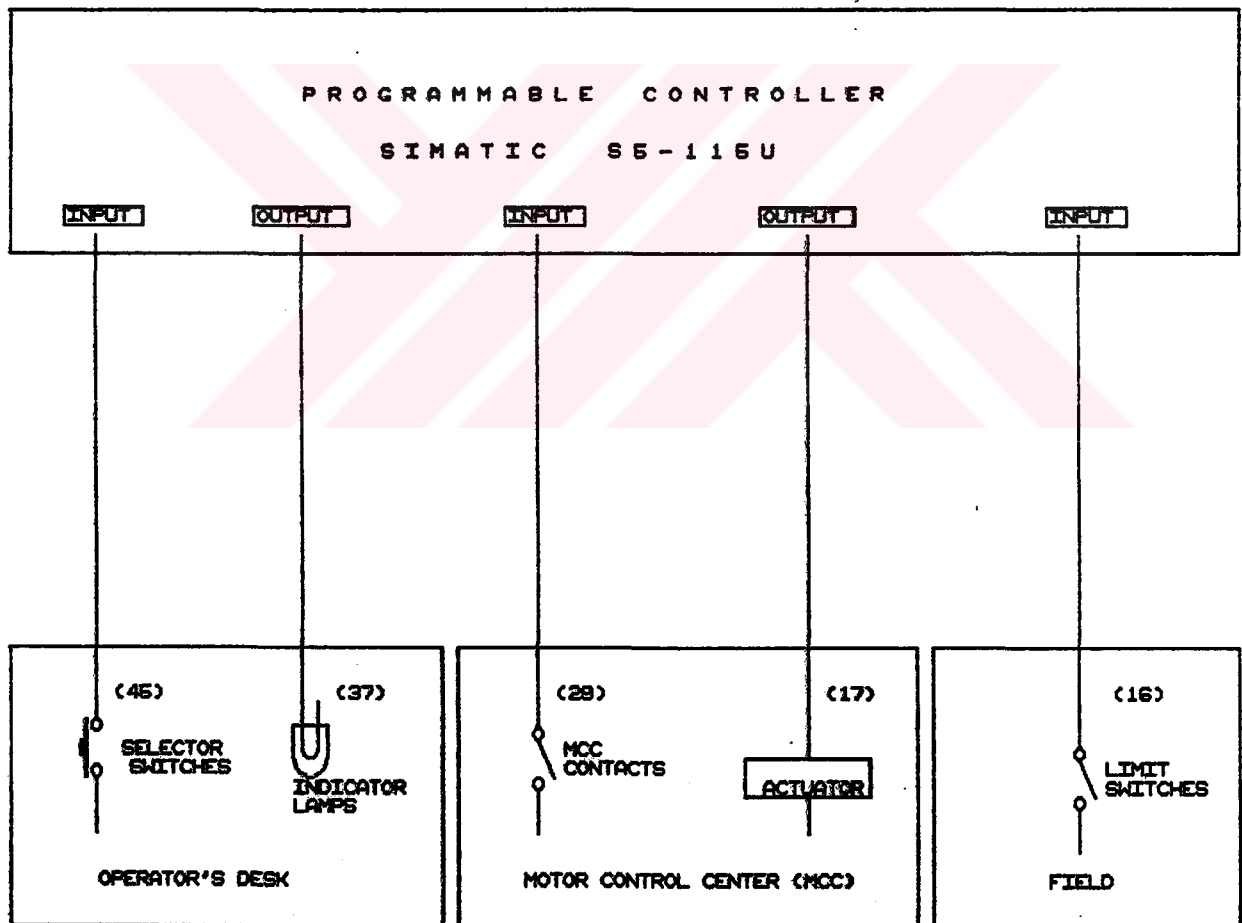


Figure 24 Single-line I/O's of PLC in Normalizing Furnace.

Inputs are selector switches, MCC contacts, and field limit switches which are summed up to 90. Since there are $(3 \times 32 = 96)$ inputs, 6 of them will be spare. Number of digital outputs is 54. They are contactors, solenoid valves, indicator lamps, and alarms. 10 digital outputs are free. PLC I/O connections with field and other project drawings are given in Appendix B.

3.2. Software Development

3.2.1. Tools for Software Development

In order to develop a program, the user needs a programming language and a programming media, ie. programmer. STEP 5 is the programming language for the SIMATIC S5 series programmable controllers. This language offers the user optional program representation in the form of control system flowchart, ladder diagram, or statement list. The far reaching correspondence with the representation of the control problem to be solved simplifies the use of this programming language [11].

Using the PG 675 programmer (CRT type) the user can write STEP 5 programs or data direct into the SIMATIC S5 programmable controller memory (on-line). If the programmer and the programmable controller are not connected (off-line), programs can be developed and stored on diskette, hard disk or in an EPROM or EEPROM submodule [10].

STEP 5 programs can be entered and displayed in the ladder diagram (LAD), control system flowchart (CSF) or statement list (STL) methods of representation. The most suitable method for the maintenance personnel understand the program, is the ladder diagrams.

For users who have had years of experience in programming contactor (relay) controllers who maintain on-site installations, the ladder diagram is probably the most acceptable method. It should be noted that in the USA, the ladder diagram currently enjoys a high preference.

It is common practice to document controller tasks in "CSF" to provide nontechnical personnel with a completely commonly understood language medium.

For other users who are experienced in handling process computers or microcomputers, the computer-oriented program [statement list (STL)] approach may be the most preferred method.

3.2.2. Programming in STEP 5

To facilitate an understanding of the essential functions in STEP 5, the smallest autonomous unit of the program will be introduced, namely, the statement. A statement is a command for the processor and consist of two parts (1) an operation part, (2) an operand consisting of an identifier and a parameter. (figure 25)

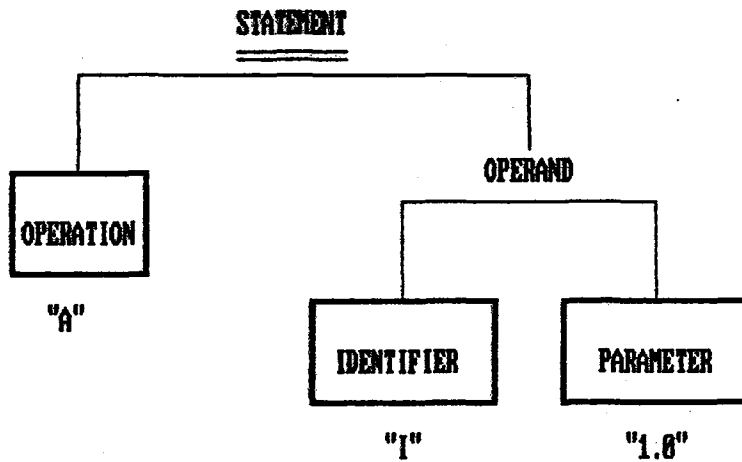


Figure 25 STEP 5 Instruction Based on Example AI 1.0.

The operation describes the function to be performed by the processor. The operand includes the information necessary to execute the operation. The programming language "knows" the following essential operand fields in connection with basic functions:

Inputs "I"...These represent the interface
from the process to the controller.

Outputs "Q"...These represent the interface
from the controller to the process.

Flags "F"...These are used for storing
intermediate binary results.

Data "D"...These are used for storing
intermediate digital results.

Timer "T"...These are used to realize

time functions.

Counter "C"...These are used to realize counting functions.

Constants "K"...These represent a constant number.

An example illustrating STEP 5 statement structure was given in figure 26.

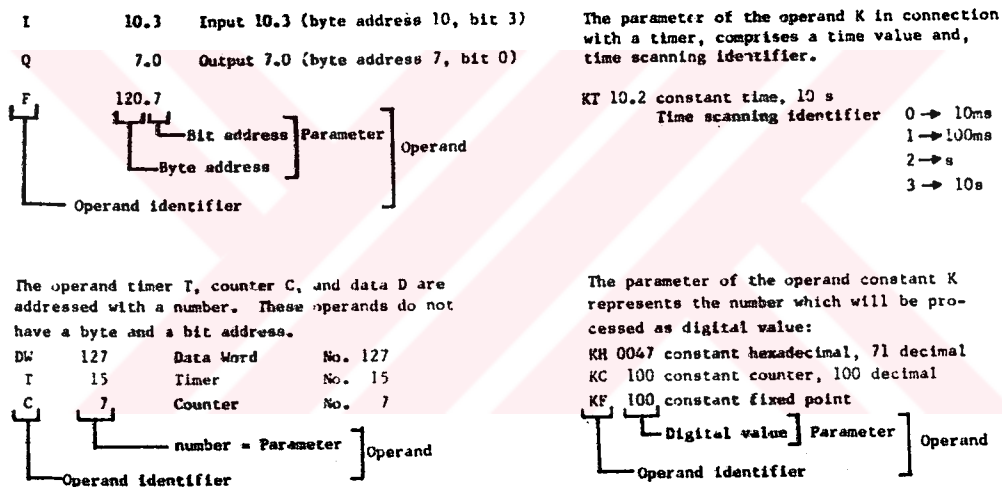


Figure 26 STEP 5 Statement Structure.

The operand consist of identifier and parameter. For addressing an operand, the respective parameter must be entered.

The parameter is the address for a particular identification. The operand inputs I, outputs Q, and

flags F are divided in byte and bit address. A period (.) separates the bit address from the byte address. Individual inputs/outputs (bit 0 to 7) are called with the bit address. Note: Two bytes (B) are considered a word (W), that is, a 16-bit wide data format.

Typical functions were compared in the three language methods given in figure 27.

3.2.2.1. Structured Programming in STEP 5

Structured programming means the subdivision of the user program into easily manageable sections known as program blocks (PBs). By assigning one program block to each technological process, the generated program is a reconstruction of the technological structure of the controlled process.

Structured programming enables software rationalization. The basic idea is that, for example, a 20,000-statement-long program should not be written down line by line beginning with statement 1; instead it should be subdivided into organization blocks (OB), program blocks (PB), function blocks (FB), and data blocks (DB) for easier manageability, transparency, and cost efficiency (See figure 28) in as much as the cost for each programmed instruction increases considerably with the length of an unstructured program. The reasons for this cost increase of an unstructured program is the lack of transparency

generated through too many unconditional jump operations [1].

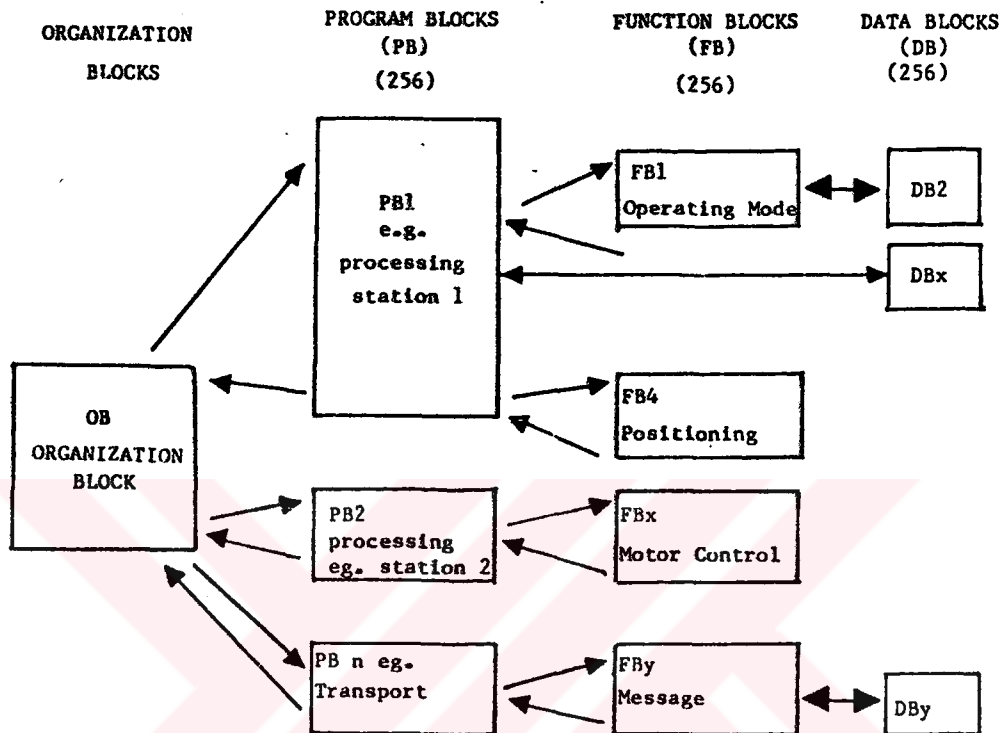


Figure 2B Structured Programming in STEP 5.

How the individual program blocks are to be processed and in which sequence is determined by the organization block.

Function blocks are standardized program parts of frequently occurring and universally applicable functions and are compiled in a standard software library (eg., divider, multiplier, code converter, shift register, message functions, etc.). These "parameterizable" function blocks can be inserted into the program flow and

frequently called. For example, fifty equivalent valves are to be controlled by a programmable controller. The control function to drive a valve is programmed once within a certain function block. The function block can be called fifty times and provided with different parameters.

3.2.3. Development

Program development was made on a simulation model (training set) of SIMATIC S5 series programmable controller 150K by using program loader PG 675 (programmer of SIMATIC S5) which was already available in Erdemir electronic shop. This model has 16 digital inputs (micro switches) and 16 digital outputs (LED's).

The author has worked out all the SIMATIC series programmable controller manuals, training documents, and related PLC installations available at Erdemir plant [10], [11], [12]. A good knowledge of programmable controller has gained from the training set. Developed programs were tested and simulated part by part by the use of this set.

Program was developed according to the following flowcharts: flowchart for charging and discharging sequence in figure 29; second flowchart for discharge and exit zone control shown in figure 30. Flowcharts were prepared in accordance with the proposed new operation sequence described in section 2.4.2.

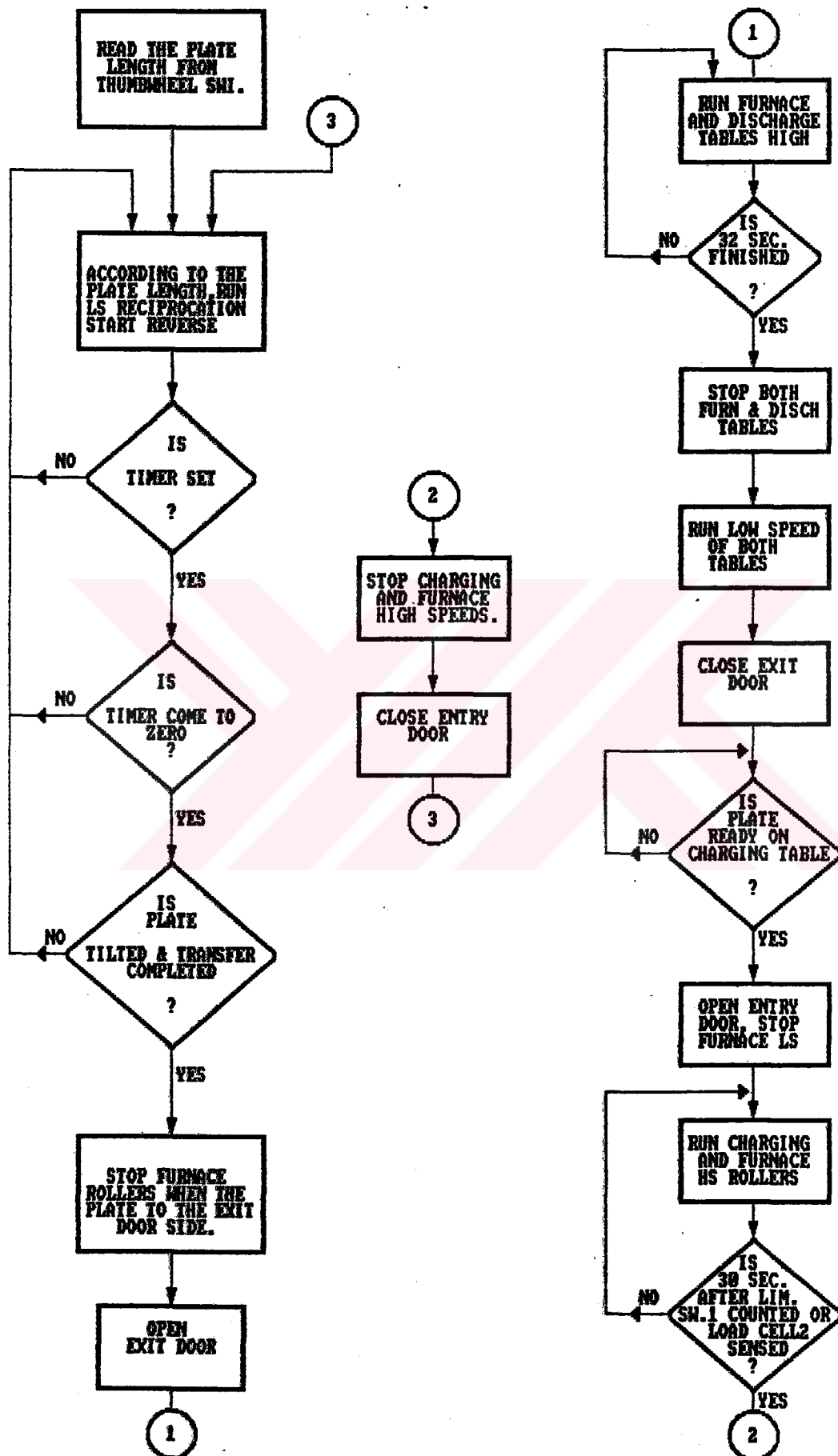


Figure 29 Flowchart of Plate Charging and Discharging.

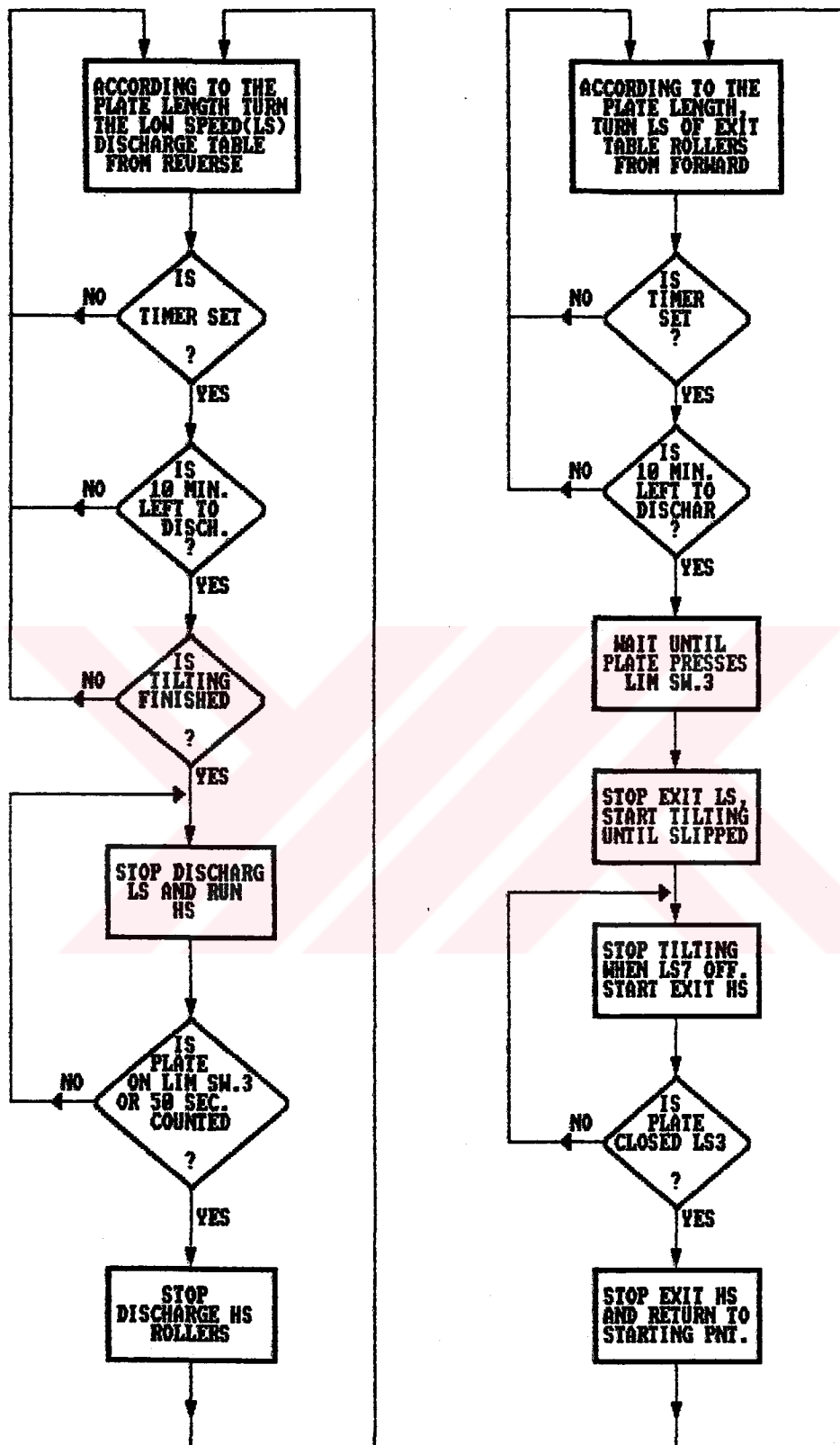


Figure 30 Flowchart of Discharge and Exit Zone Control.

In development, ladder diagram form was preferred because of the following advantages:

1. It is easy for users to understand and simplifies training.
2. The language provides graphical display of program execution by showing power flow through the diagram.
3. It is fast.
4. It generates more readable programs for sequence control.
5. The language has generally good functionality.

Because of above mentioned advantages, program lists were prepared in ladder diagram form except OB 1, FB 200, and PB 50. They were written in STL form. Each block has its own explanation at its first lines.

There are four major group of programs in PLC RAM memory. These are organization block, program blocks, function block, and data block. Program structure of normalizing furnace is shown in figure 31.

1. **Organization Blocks(OB's):** In OB1, main program flow and jumps were described and also digital timer control was performed. Plate length read operation was performed via function block FB200, with conditional jump.

Rather than OB1, OB22 was processed for initial start after "power on". In OB22, all the inputs and

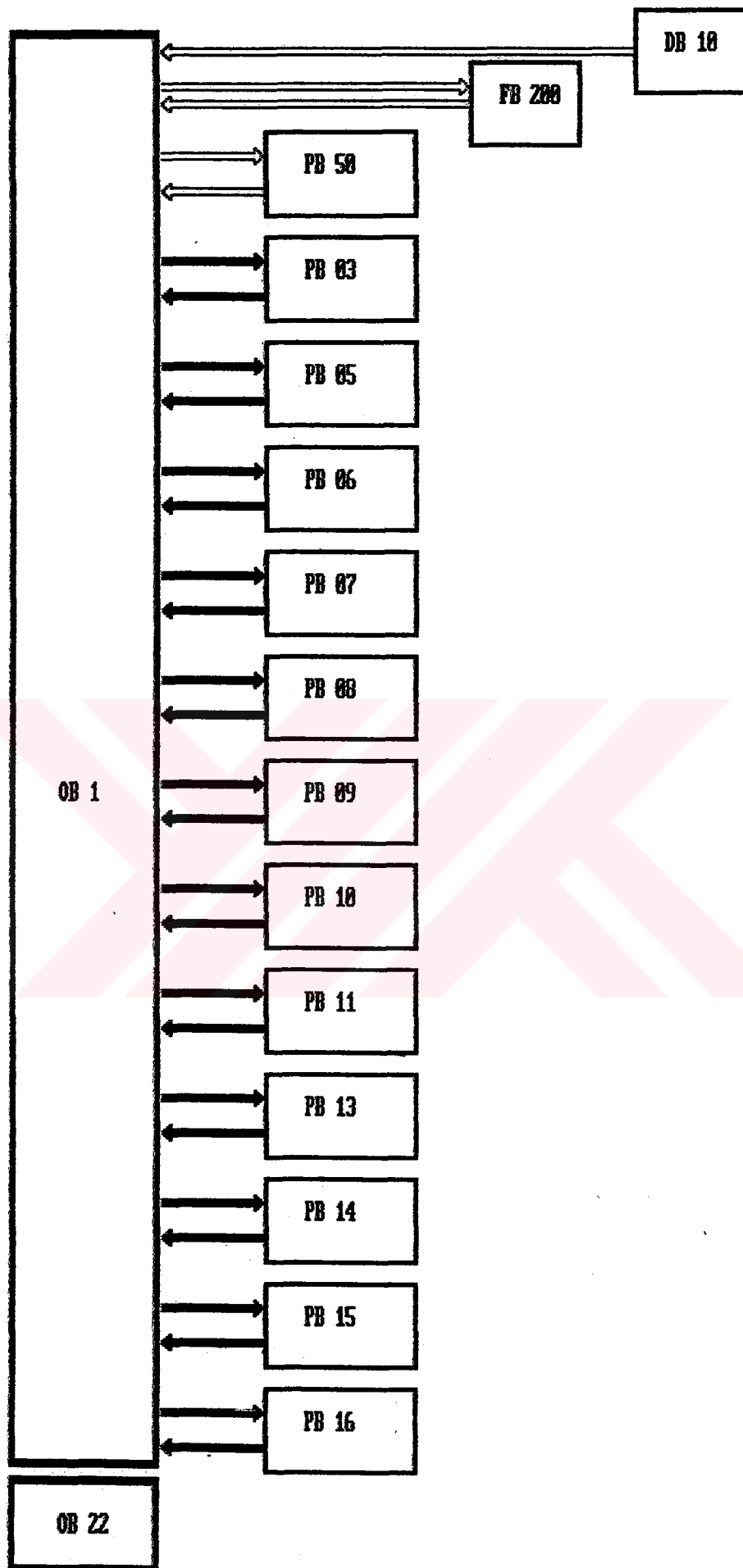


Figure 31 Program Structure of Normalizing Furnace.

outputs were checked whether they were addressable or not. If any nonaddressable I/O was found, then PLC has stopped further execution.

2. **Program Blocks (PB's):** There have been 13 program blocks numbered according to the motor for which the program was written. All of them were executed unconditionally except PB50:

PB3 : Related to the charging rollers control.

PB5 : Related to the furnace low speed control.

PB6 : Related to the furnace high speed control.

PB7 : Related to the discharging low speed control.

PB8 : Related to the discharging high speed control.

PB9 : Related to the exit table low speed control.

PB10: Related to the exit table high speed control.

PB11: Related to the tilting beam control.

PB13: Related to the furnace entry door control.

PB14: Related to the furnace exit door control.

PB15: Related to the operation alarms.

19 of 30 alarms are controlled

by PLC, others (11) comes

directly from relay contacts.

PB16: Related to the operator indicators.

In this program block, 18 of 23 operator desk indicators are controlled. The rest (5) comes from the field limit switches to the operator desk.

d

PB50: Related to general heat treatment
timer.

Ladder diagrams of first and last page of PB 5 is
as shown in the following figure 32.

The state of the output contactors and new
sensors were checked against logic conditions for
agreement. A disagreement has generated a malfunction
signal ie. an alarm signal on the operator desk.
Available alarms in PB 15 were as the followings:
charging forward stop, furnace low speed stop, furnace
low speed fault, furnace high speed fault, discharge
low speed stop, discharge low speed fault, discharge
high speed fault, exit low speed stop, exit high speed
fault, tilting stop, entry door stop, exit door stop,
both furnace doors open, PLC and fan power off, PLC
inputs power off, PLC outputs power off, PLC fan stop,
treatment time up. Others are overload contacts for
11 ac motors present in the system.

Available indicators in PB 16 were the
followings: plate ready, entry door open, exhaust fan
running, combustion air fan running, PLC and fan power
okey, PLC I/O power okey, charging limit switch 1,
charging permission, forward motion in furnace,
reverse motion in furnace, furnace charged, furnace
high speed running, discharge high speed running, exit

SEGMENT 1 0000 FURNACE ROLLERS L/S FORM. MOTION.

THIS IS THE COMMENT OF PROGRAM BLOCK 5

FURNACE ROLLERS TABLE IS DRIVEN EITHER BY LS MOTOR OR HS MOTOR. IN THIS PB, LS MOTOR (O3-M) CONTROL IS PROGRAMMED. DURING LS MOTION OF THE TABLE, THE PLATE IS HEATED TO THE TEMPERATURE OF 927 C AND, THEN, MOVED AT THAT TEMP. FOR 20 MINUTES. DURING ALL THESE CONDITIONS, THE TABLE IS RECIPROCATED FORM-REV WITHIN THE FURNACE BY LS MOTOR. NORMALLY, PROGRAM WILL RECIPROCATATE THE ROLLERS CONTINUALLY BY USING A PROXIMITY SWITCH. PROX SW IS LINKED TO A GEAR LINKED TO THE ROLL SCAFFT. FOR ONE REVOLUTION OF THE GEAR, PROX SW PRODUCES 30 PULSES. THESE PULSES ARE EVALUATED AT THE COUNTERS OF C1 & C2. FORWARD AND REVERSE MOTION PERMISSIONS COME FROM ABOVE COUNTERS. BECAUSE OF THE CLOSED-LOOP CONSIDERATIONS AND POSSIBLE ERRORS IN COUNTING PULSES, TWO LOAD-CELL ARE LOCATED UNDER THE TWO END-ROLL. WITH THE AID OF LOAD CELLS, PLATE RECIPROCATION IS GUARANTEED WITHIN THE FURNACE. LS MOTOR DRIVE IS A 3.5 KW, 1500/10/30 = 3 RPM, CAGE INDUCTION MOTOR. IT IS COUPLED TO THE HS MOTOR WITH A CLUTCH SOLENOID. WHEN THE LS MOTOR CONTACTOR IS CLOSED, CLUTCH IS ALSO ENERGIZED AND HENCE LS MOTOR CHOSEN AS THE DRIVE SOURCE. THE CHAIN OF THE ROLLERS IS TWO-SIDED: ON WEST & EAST SIDE.

1-03AUTO-F F 5.2 F 20.6 -LSB F 8.4

OS AUTO-F-1 1.5 FURN. ROL. LS AUTO-FORM.S.S. (IR-14)
LS8 = 1 5.2 ENTRY DOOR OPEN HI-LS8.(IR-43)

INTERLOCK FOR FORWARD MOTION.

F 4.7 F 4.5 F 28.0 F 23.0 F 29.1 F 20.6

SEGMENT 3 000D FURNACE ROLLERS LS REV. NOTION.

-05AUTO-R F 3.2 F 4.6 F 5.0 F 19.5 -LSB F 0.5

05AUTO-R= I	1.6	FURN. ROL. LS AUTO-REV.S.S.	(IR-15)
LSB = I	3.2	ENTRY DOOR OPEN HI-LSB.(IR-43)	

INTERLOCK FOR REVERSE MOTION.

Factor	5.1	8.6	4.5	28.0	24.7	25.1	19.5
F	5.1	8.6	4.5	28.0	24.7	25.1	19.5

QUARTERLY JOURNAL OF THE

```

      IF 7.7 F 10.0
      IF 11.9 F 10.0

```

FORWARD ACTION DOWN-COUNTER.

```

SEGMENT 23 C 2
--FBN PROX] [----]CD
--CU
--F 3.0] [----]S
--LOADCEL1!
--] [----]
--CV 81-
DEI-
--F 3.0] [----]R 01-

```

```

FURNACE PROX. SW.
ENTRY SIDE LOAD CELL-1.(IR-57)
FURNACE RESET P.B. (IR-2)
EXIT SIDE LOAD CELL-2.(IR-58)

```

SEGMENT 24 00F6 ON-DELAY FROM HS TO F 3.2 (SET)

F 9.1 -08-C
[---] [---] [---] [---]
KT 005.2 --TV BI-
; DEI-
;
;-R 01--

F 11.4
---()---

38

08-C = I 3.2 DISC. TABLE HS 08-C.(IR-27)

Figure 32 Programming Examples Taken from PB5.

high speed running, charging forward motion, auto, time up, discharge permission, furnace in waiting state. Other indicators come from field as; load cell-1 sensed, load cell-2 sensed, bumpers low, centering back, tilting limit switch, exit end limit switch.

3. Data and Function Block:

DB10 : In this program, there was a table of plate lengths and corresponding pulse numbers.

FB200: This program has used DB 10 and decides on the plate length and pulse number.

Explanation of each program block and details of programming are given in Appendix D.

CHAPTER 4

EXPERIMENTAL RESULTS AND CONCLUSIONS

4.1. Experimental Results

Operation of the furnace with the new control system was started in February 1990. Since then, overall performance of the system has been observed carefully. Idle-times of old system during normal operations has been reduced from 5 minutes to a few seconds, because of full-automation implemented with PLC.

A typical operation cycle was taken on 30'th August 1990, at 8.30-16.30 shift. Corresponding figures are given below:

Charged plate dimensions = 1500 mm width,
6000 mm length,
25 mm thickness.

Number of plates inserted into the furnace : 8. They are divided into four groups each containing two plates one at

the top of the other. After laying plates, total dimensions:

Total length = 12000 mm,
Total width = 3000 mm,
Total thickness = 50 mm.

For this shift various performance figures are measured and given in Table 1 in comparison with the theoretical predictions.

	THEORETICAL DATA	EXPERIMENTAL DATA
Charging Time	34 sec.	34 sec.
Treatment Time	79 min.	79min+05sec
Discharge Time	30 sec.	30 sec.
Cycle Time	80min+4sec	80min+09sec

Table 1 Comparison Between Theoretical and Experimental Results.

It is seen from Table 1 that, experimental results in agreement with predicted values.

Performance data of the new control system are also

recorded in the long term, from the view point of fault rate and productivity. New figures related to the fault rate are given in figure 33, in comparison with the corresponding figures of the old system.

Fault rate has been reduced considerably, this amounts to 50% on the average for seven month comparison (from February to August). This considerable drop in fault occurrence number is an expected result because of the realization of the proposals improving the system performance. Note that all the data were driven from the shift foreman reports. Sources of these faults were not written down in the reports. Recorded faults of the new system are originating from electromagnetic clutches of the motors. No interruption has been recorded due to a fault arising from the PLC related systems.

Productivity is the most important performance index of the plate normalizing furnace. After installing the new control system, productivity of the plate normalizing furnace is increased by 35% on the basis of tons production per hour. Monthly production figures are given in figure 34, for the comparison of new and old system performances.

4.2. Conclusions

Control of an industrial plate normalizing furnace was developed by the use of programmable logic controller. No changes were made on the heating control.

ELECTRICAL FAULT COMPARISON

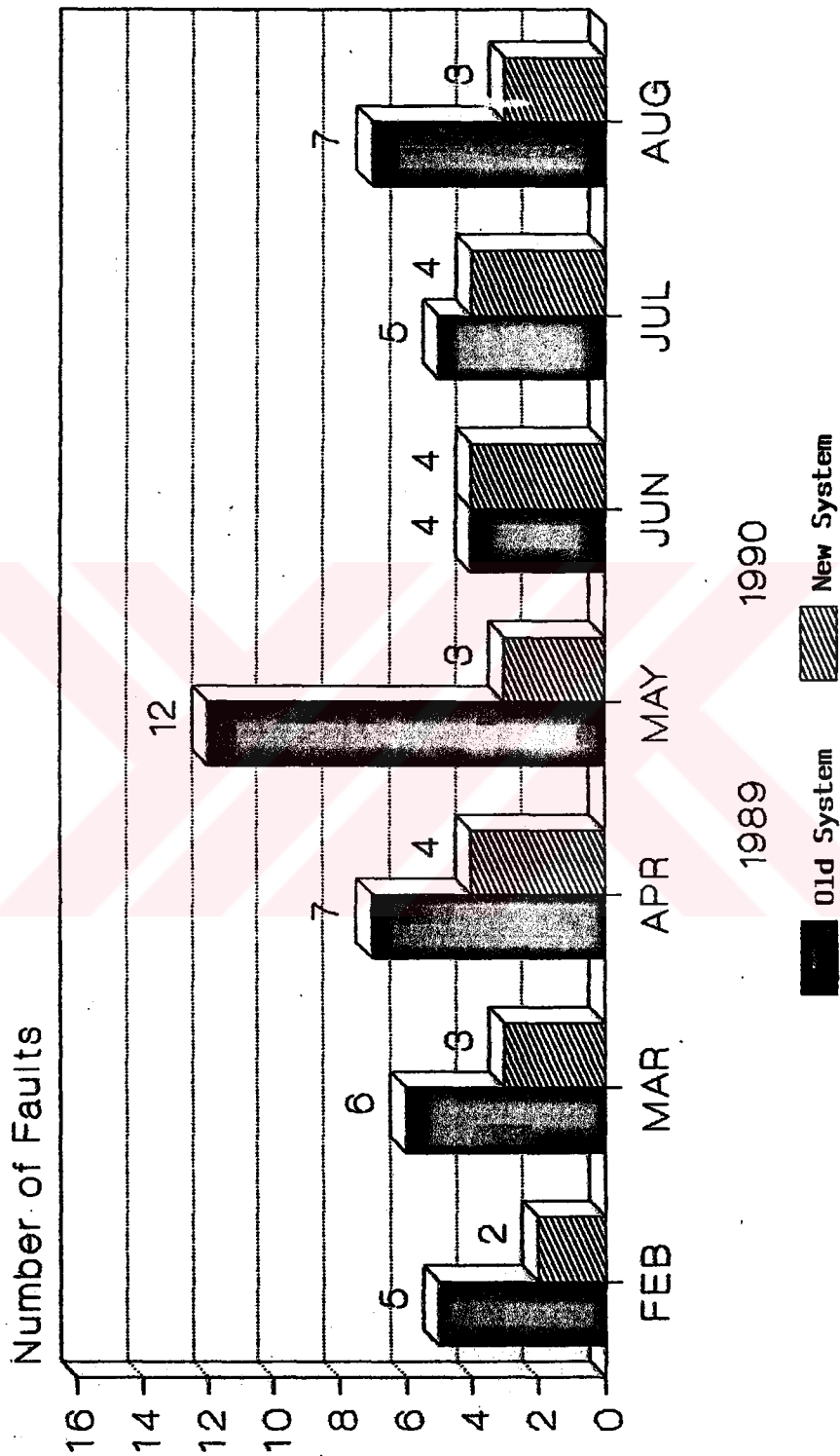


Figure 33 Electrical Fault Comparison.

PERFORMANCE OF NORMALIZING FURNACE

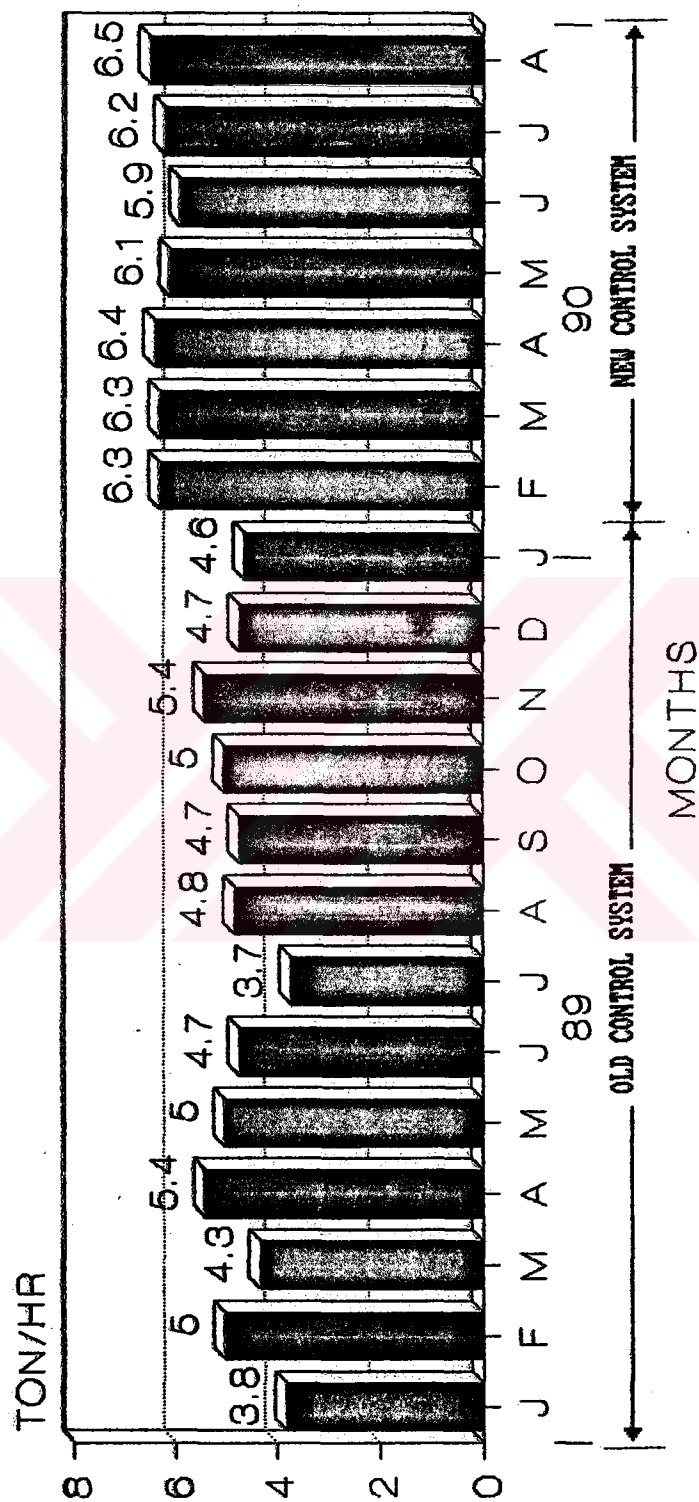


Figure 34 Performance of Normalizing Furnace.

Programmable controller was used instead of relay-based controller. Operation sequence was upgraded from semi-automatic mode to fully-automatic mode. Man-machine interface was improved by adding several new indicating lamps and alarms to the system. Idle times of operation was reduced significantly. Electrical fault rate was reduced almost 50%. Hence productivity was increased by 35% on ton/hr base.

The use of programmable controller in the normalizing furnace has led to several financial benefits. If this project were realised as a turn-key project, it would cost more than US\$ 100,000. But the real expense has come out US\$ 20,000 (with early 1989 prices). This has resulted in a saving of at least US\$ 80,000.

One benefit that cannot be dollarized, but which may provide a higher return than any of the preceding benefits, is the knowledge gained while designing and programming such a programmable logic controller based control system.

Overall improvements can be stated as follows:

1. After installation of the new electronic controller, system performance was getting better. One of the three operator pulpit was eliminated (discharge pulpit), and its functions were transferred to the main pulpit. Hence, operator movements are rationalized.

2. Furnace roller table low speed control was performed by two kind of sensors. One kind of which was proximity switch and the others were load cells installed under the specific furnace rolls. Open-loop control could only be realized with proximity switch sensors, but in the case of load cells it was a closed-loop control. Since any faulty operation in the furnace will be dangerous, both sensors were used in the program and they were followers of each other against to any misoperation. Therefore furnace roller table has to reciprocate in any case. Otherwise instrumentation control system would stop the gas input to the furnace and hence the furnace could shut down to protect the table rolls.
3. After installation of about 25 indicator lamps and 30-group alarm system, operator control has become very reliable, smooth and healthy.
4. Operator chooses the plate length by the use of a thumbwheel switch for single or a group of plates. By this way, optimum reciprocation was achieved without any problem.
5. Problems, originating from electromechanical device failures, would not be met, because such logic sequences were realized in software. Also cooling table sensors were changed with electronic counterparts designed.

6. After start-up of new control system, production has increased for about 35% . It is seen from figure 26 that production (ton/hour) was fluctuating between 3.5-5.4 over the period where the old system was in operation. But starting from February 1990, production has risen to a higher level of 6.3-6.4 ton/hour monthly average.

It is assumed that the programmable controllers have proven to be an economical solution to the needs of industrial control systems.

4.3. Proposals for Further Improvements

Following suggestions can be made on the light of this study:

1. Two different speed was obtained by using speed reducers. Load switching from one motor to the other was performed by a clutch solenoid which was again an electromechanical device. New design of two speed system without using clutch solenoid will be a significant improvement for the system.
2. Operator pulpits were located on the same altitude as the production line. Operator at the main pulpit can only see the furnace exit door and cooling tables. A single pulpit can be constructed at a height of 3-4

1

meters with respect to the production line. If the layout could be modified in this manner, entry pulpit of the present system might be redundant. All its functions can be transferred to the new high-in-location pulpit. Hence operator could be able to observe all the zones and follows the system in a more accurate manner.

3. Periodic production and fault reports can automatically be obtained from a printer connected to a communication processor (CP) of 115U. An additional CP card and a printer would be needed in that case.
4. Kind and source of the electrical faults need to be recorded by the shift operator for further fault analysis.
5. Furnace heating control can also be controlled by the same programmable controller for fuel saving by using additional analog and intelligent I/O cards. Then suitable software needs to be developed, in STEP 5 language.

REFERENCES

- [1]. Considine, Douglas M., Standard Handbook of Industrial Automation, pp. 152-168, Chapman and Hall Ltd, Great Britain, 1986.

- [2]. Roberts, William L., Cold rolling of Steel, pp. 723-731, Marcel Dekker Inc., New York, 1978.

- [3]. Drever, Horace and Willis, N.K., "Continuous Normalizing and Heat Treating Equipment for Steel Plate" pp. 513-518, Iron and Steel Engineer Yearbook 1957.

- [4]. Camcı, Demir, General Description of I. Hot Mill, 1979.

- [5]. Lyman, Taylor, Editor, Metals Handbook, pp. 10-14, vol.2, Heat Treating, American Society For Metals, 1964.

- [6]. Sam S. Anzelmo JR, "Automating a mineral crushing plant using a simulation model, programmable controller, and personel computer," IEEE Trans. Ind. Appl., vol. IA-23, no. 6, Nov./Dec. 1987.
- [7]. BLH Electronics, load cells operating and service manual, 1988.
- [8]. Kaynak, Doç. Dr. Ökyay, Programlanabilir Denetleyiciler, p. 7, Boğaziçi Üniversitesi, Haziran 1988.
- [9]. R.A. Gilbert and J. A. Llevellyn, Programmable Controllers, Practices and Concepts, International Training Corporation, 1985.
- [10]. SIMATIC S5 115U Programmable Controller, Catalog ST 52.3, 1988 Edition.
- [11]. Berger, Hans, Programming of Control Systems in STEP 5, 1984.

[12]. PG 675 Programming Unit, Manual, 1983.



APPENDIX A
TABLE and FIGURES

PLATE THICKNESS	NORMALIZING TIME	PLATE THICKNESS	NORMALIZING TIME
(in mm)	(in minutes)	(in mm)	(in minutes)
6.....	27	29.....	54
7.....	28	30.....	56
8.....	30	31.....	57
9.....	31	32.....	58
10.....	32	33.....	59
11.....	33	34.....	60
12.....	34	35.....	61
13.....	35	36.....	63
14.....	37	37.....	64
15.....	38	38.....	65
16.....	39	39.....	66
17.....	40	40.....	67
18.....	41	41.....	68
19.....	43	42.....	70
20.....	44	43.....	71
21.....	45	44.....	72
22.....	46	45.....	73
23.....	47	46.....	74
24.....	48	47.....	76
25.....	50	48.....	77
26.....	51	49.....	78
27.....	52	50.....	79
28.....	53		

Table A.1 Plate Normalizing Time Table.

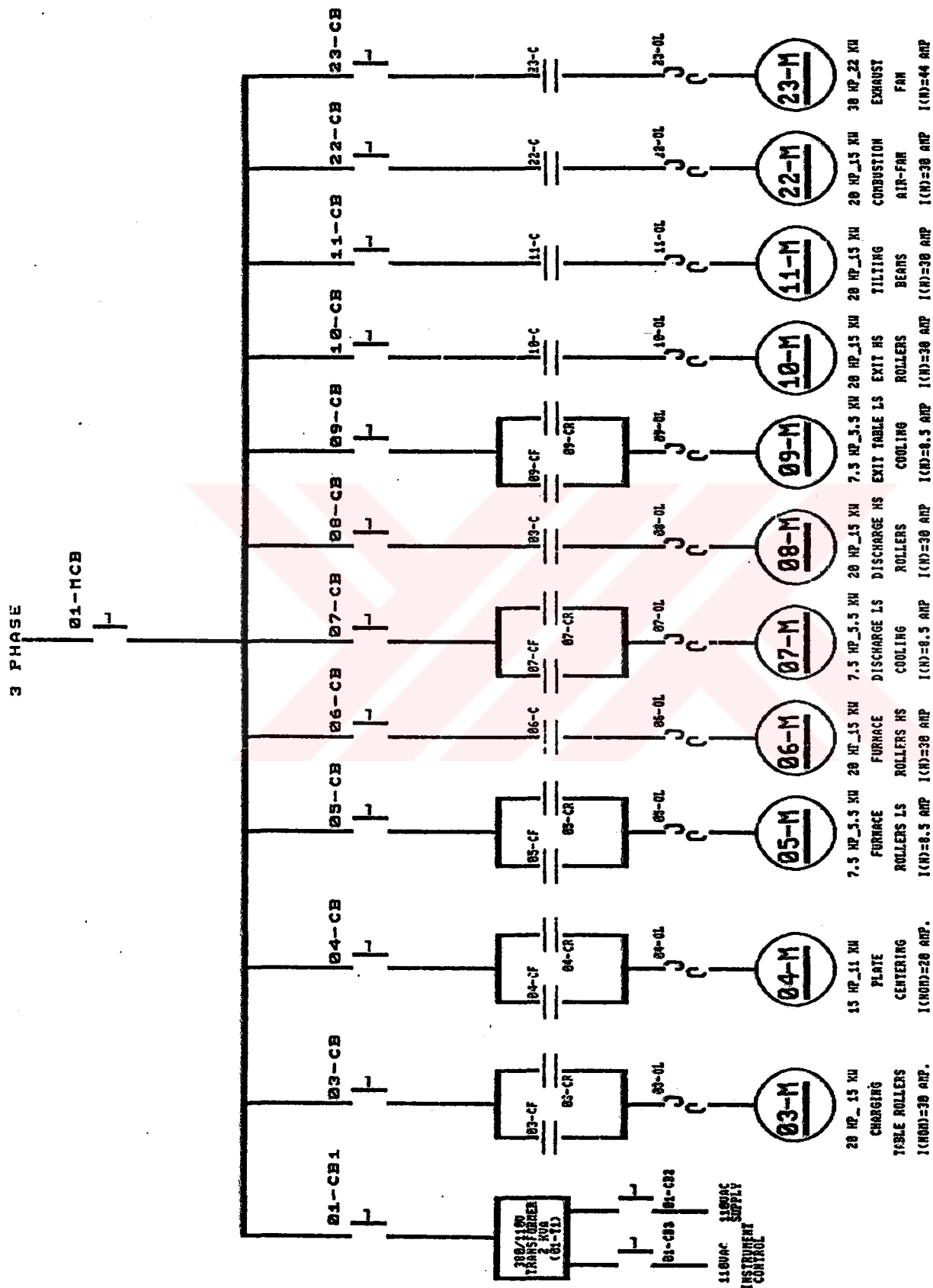


Figure A1 Single-line Diagram of Furnace ac Drives

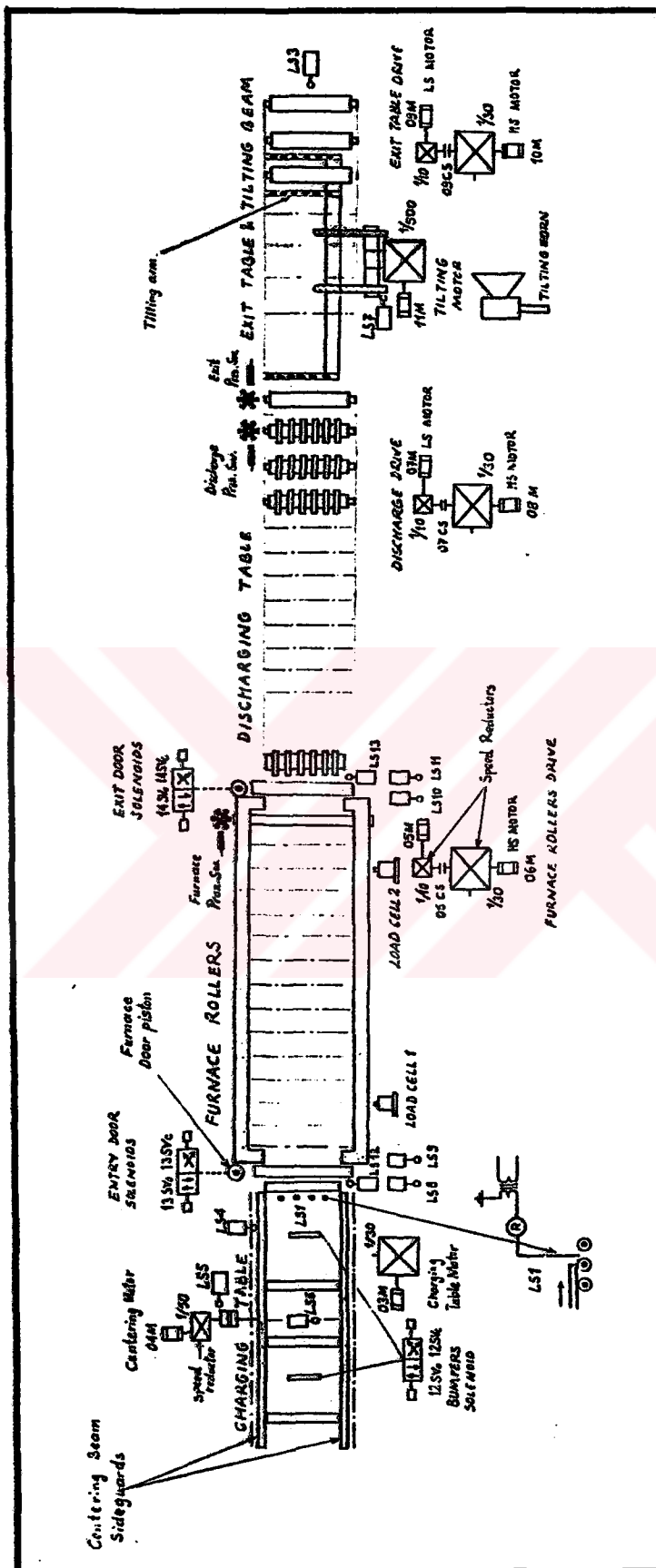
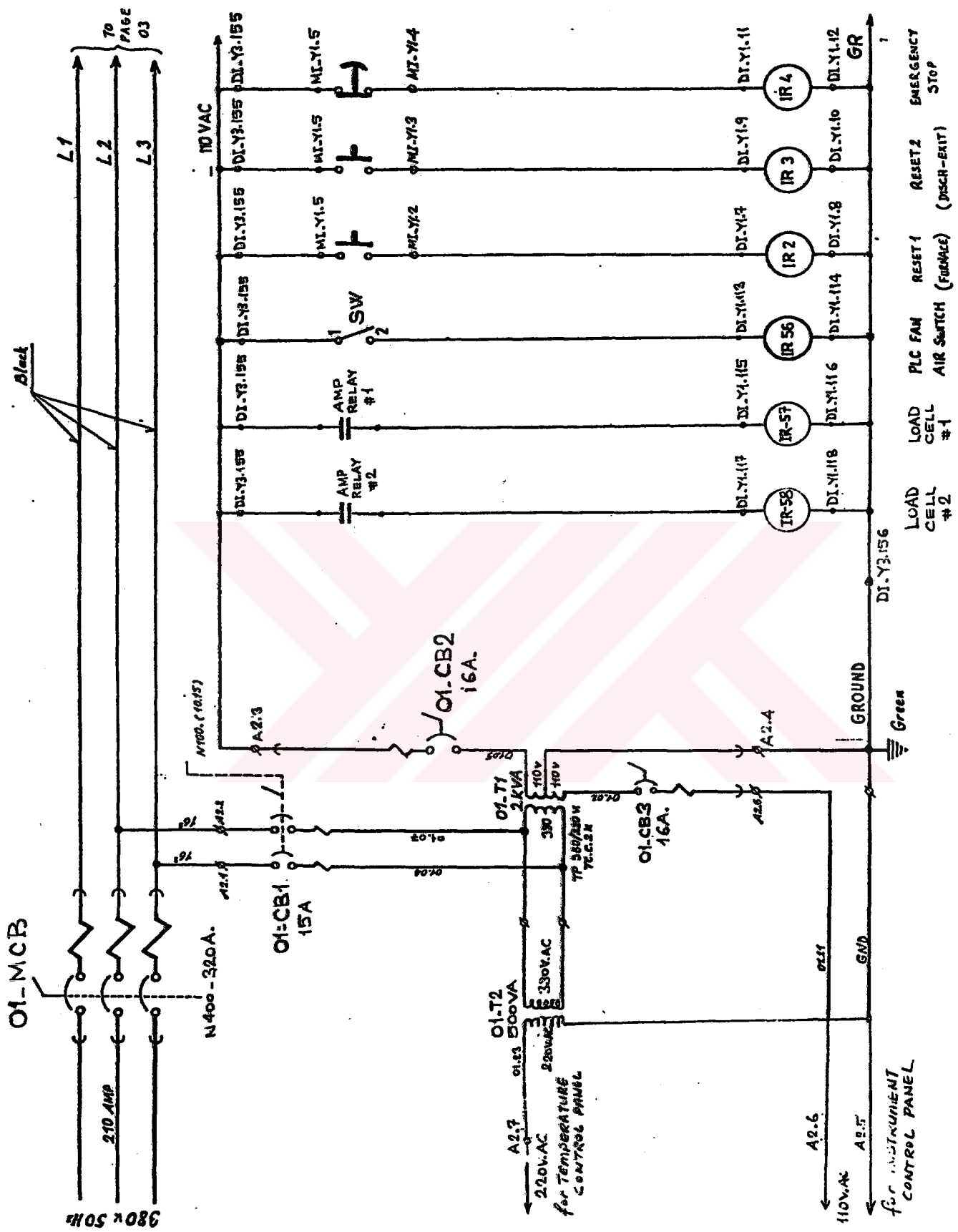
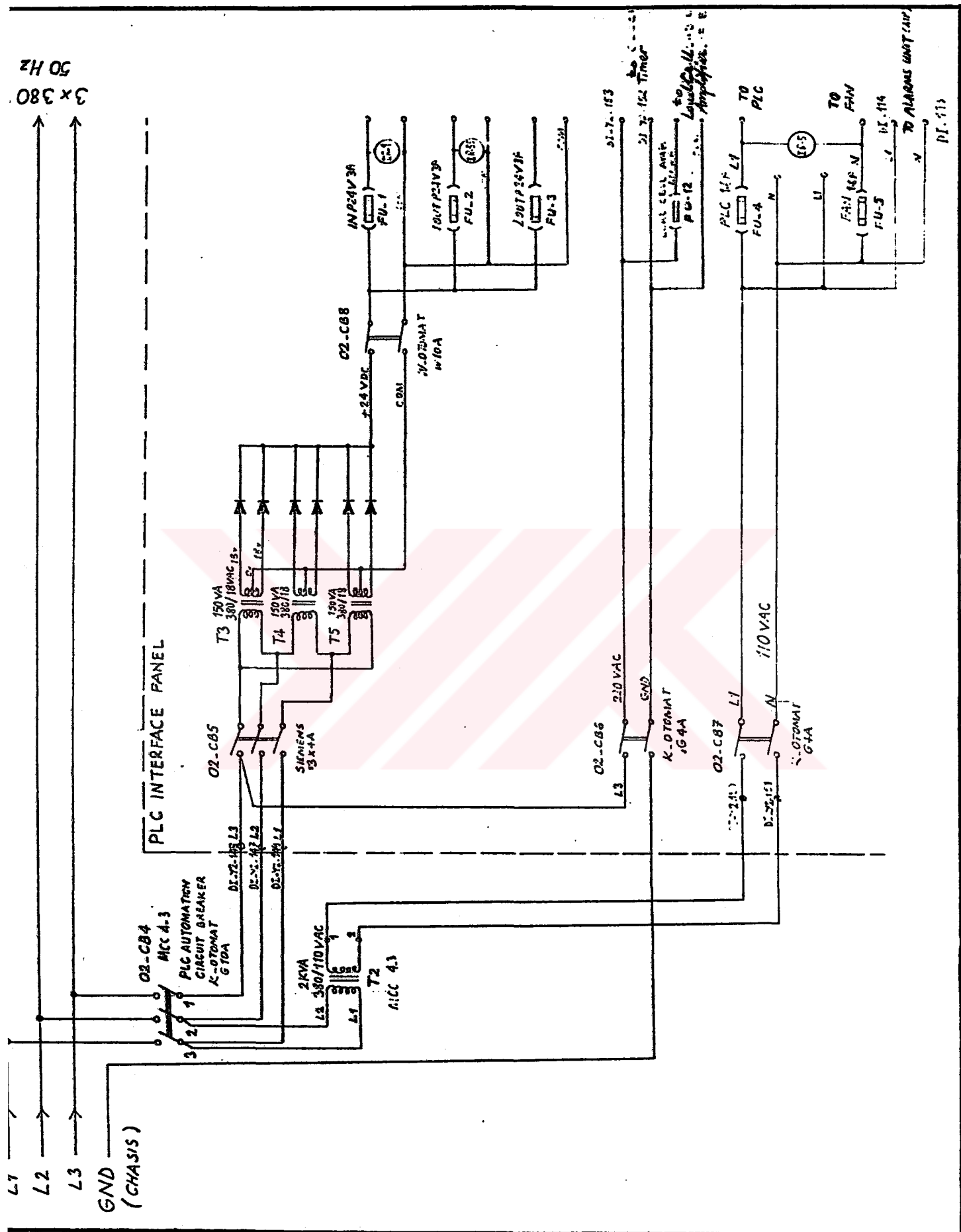
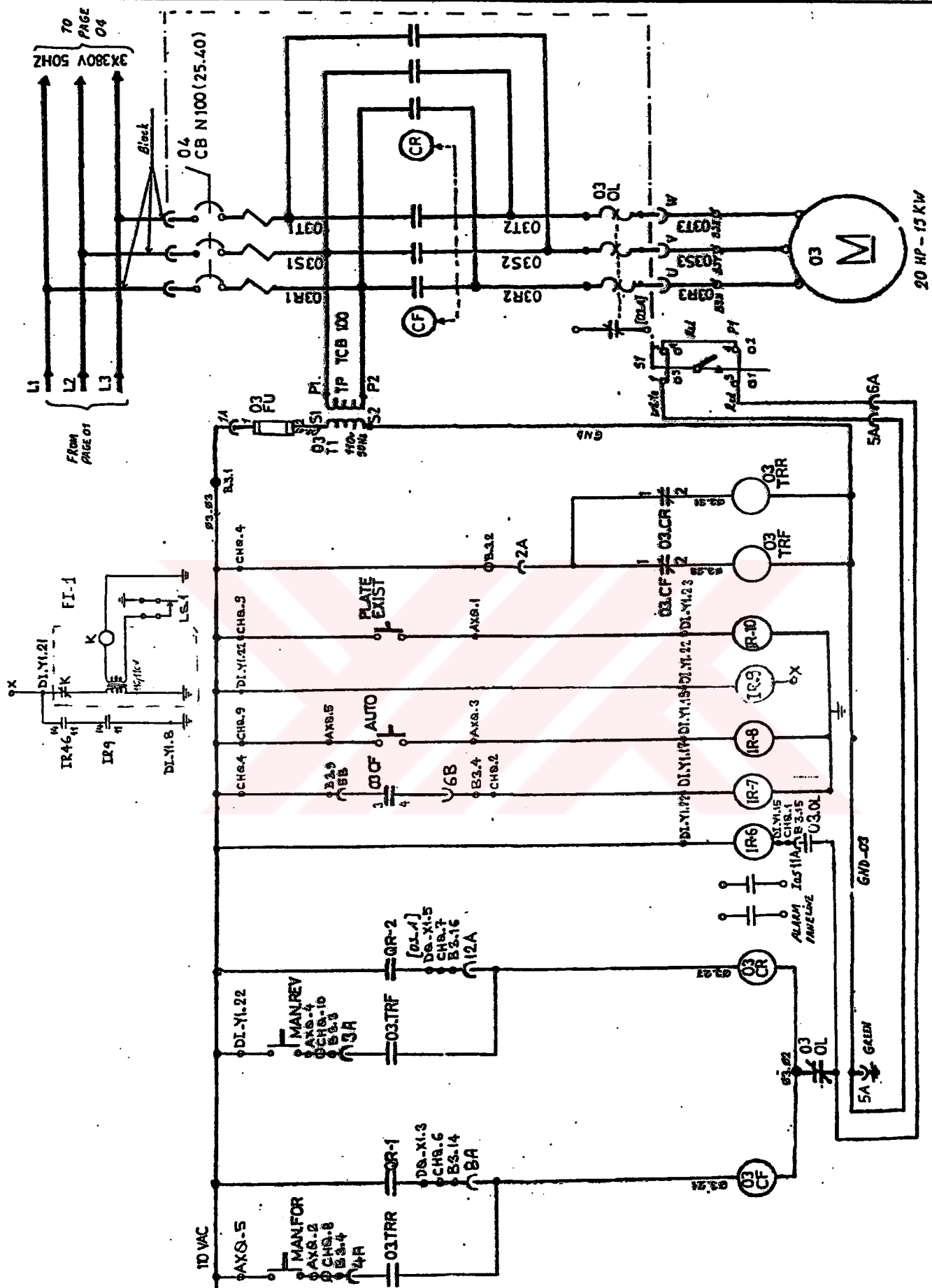


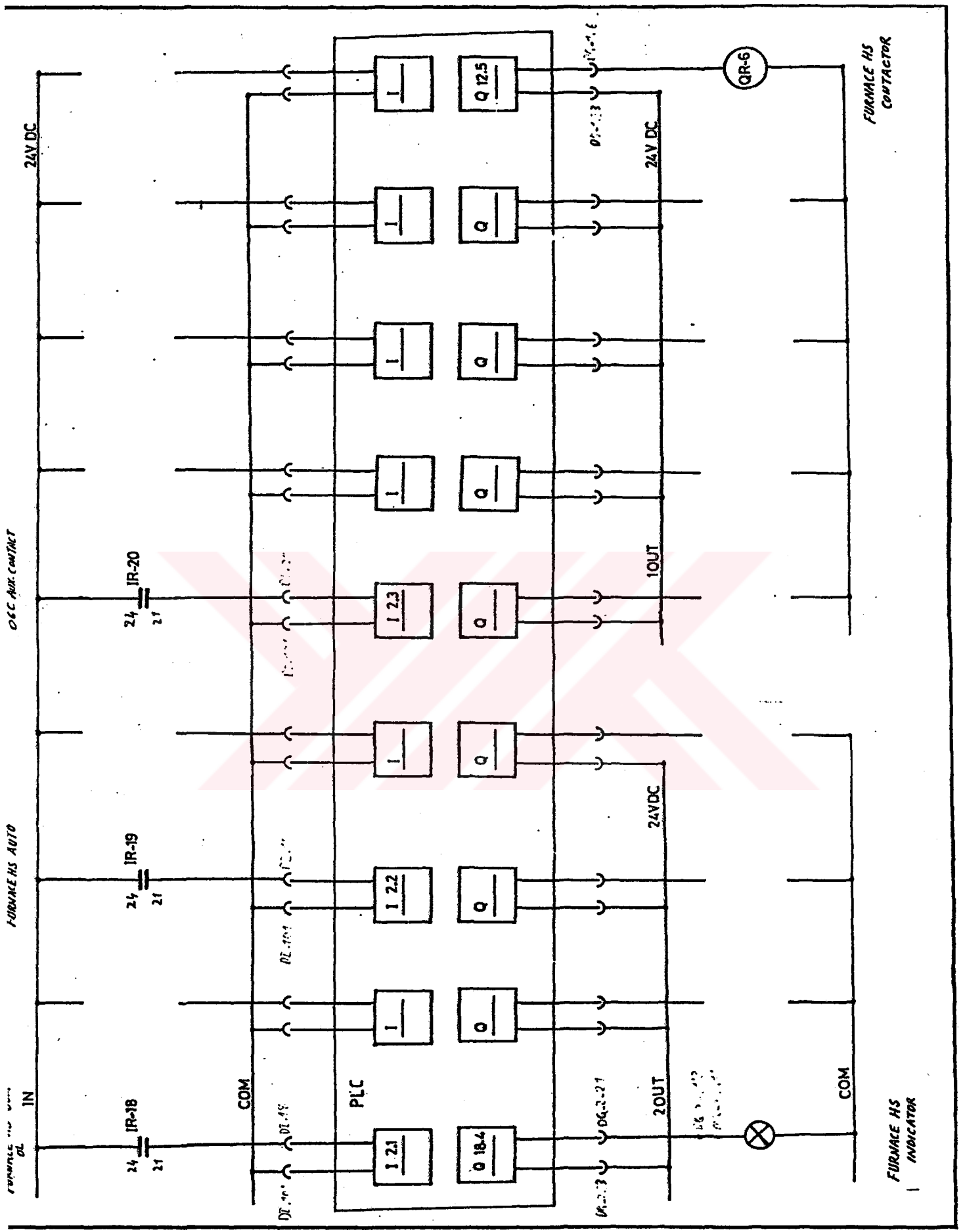
Figure A2 Normalizing Furnace Equipment.

APPENDIX B
PLC I/O CONNECTION DIAGRAMS

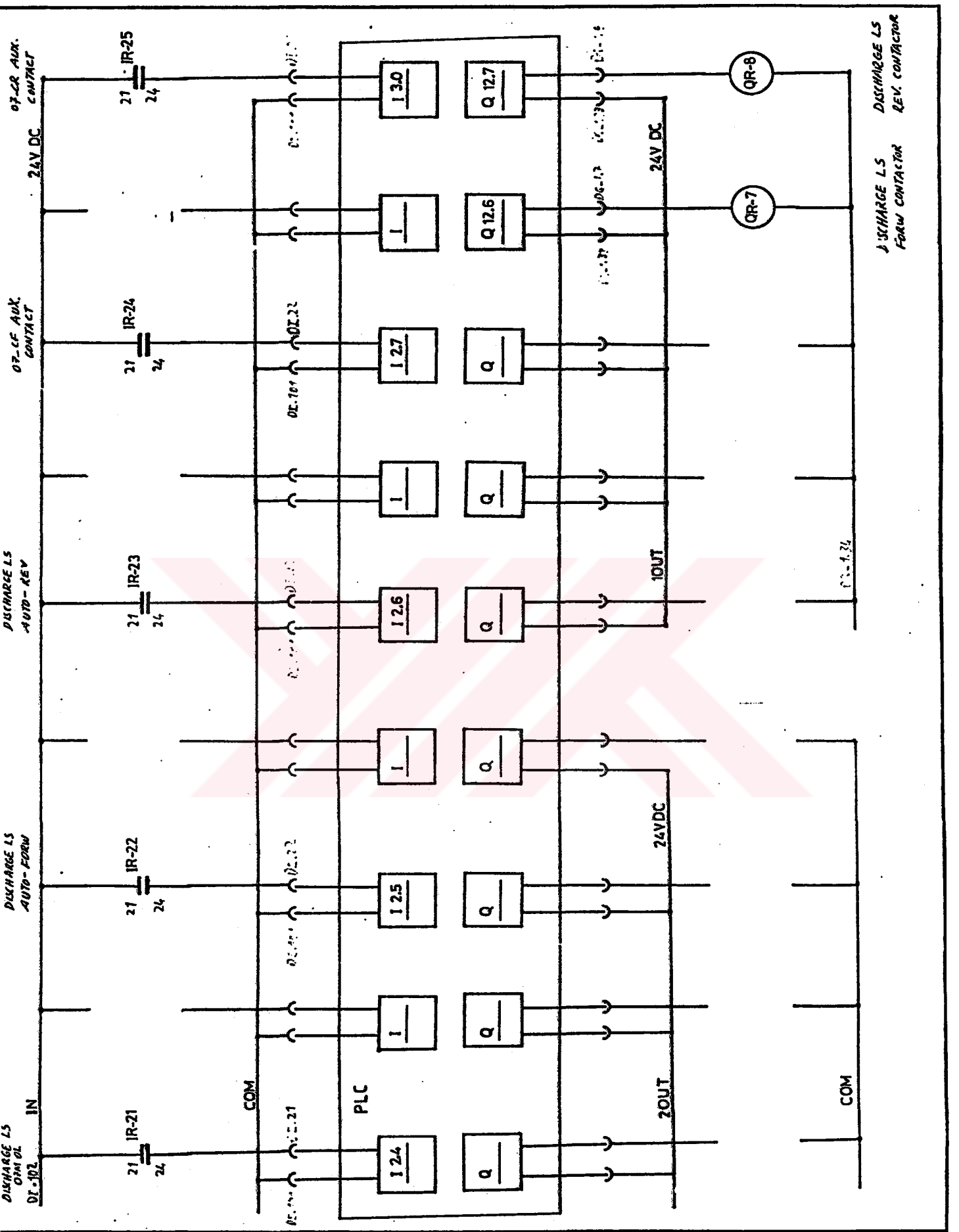


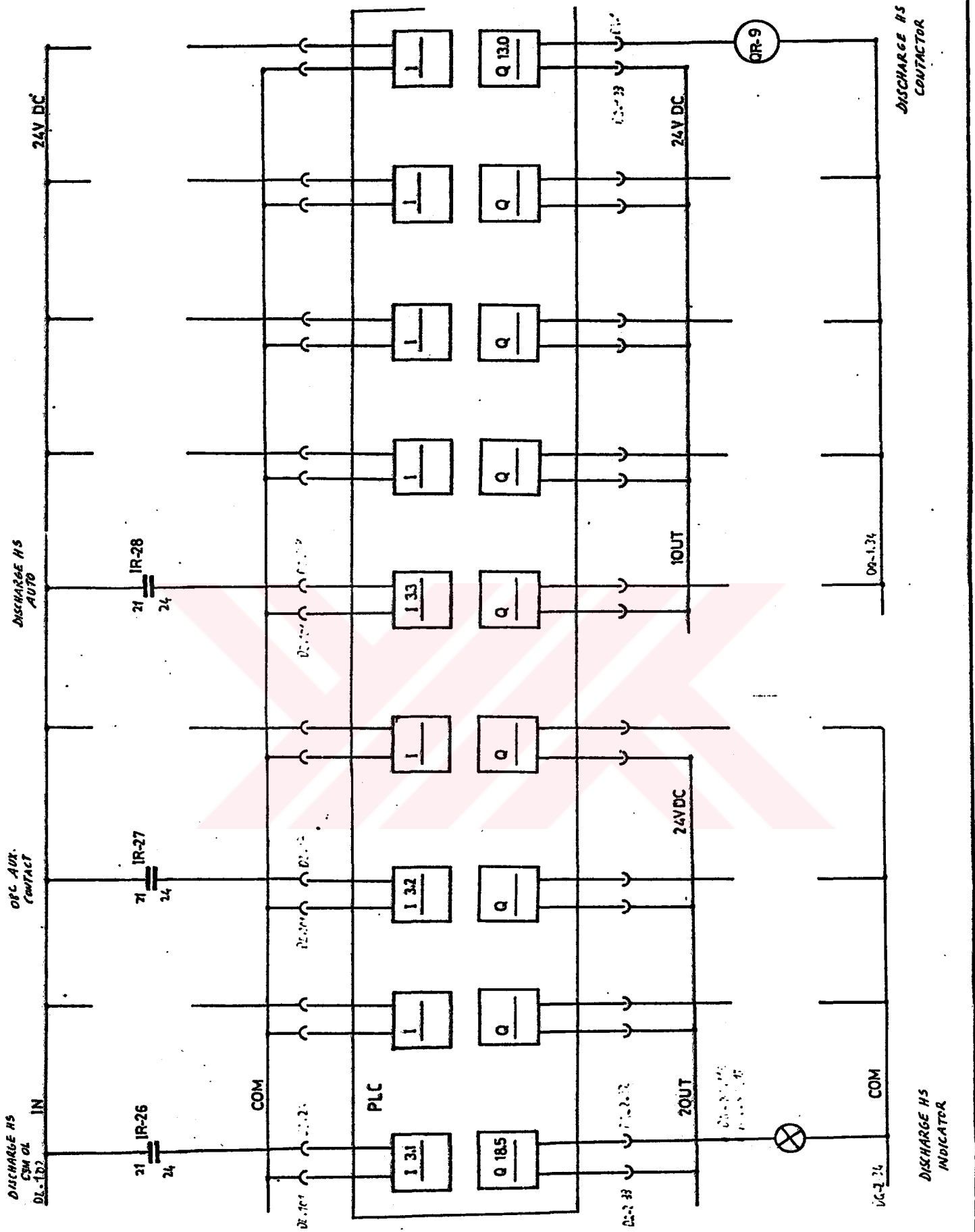




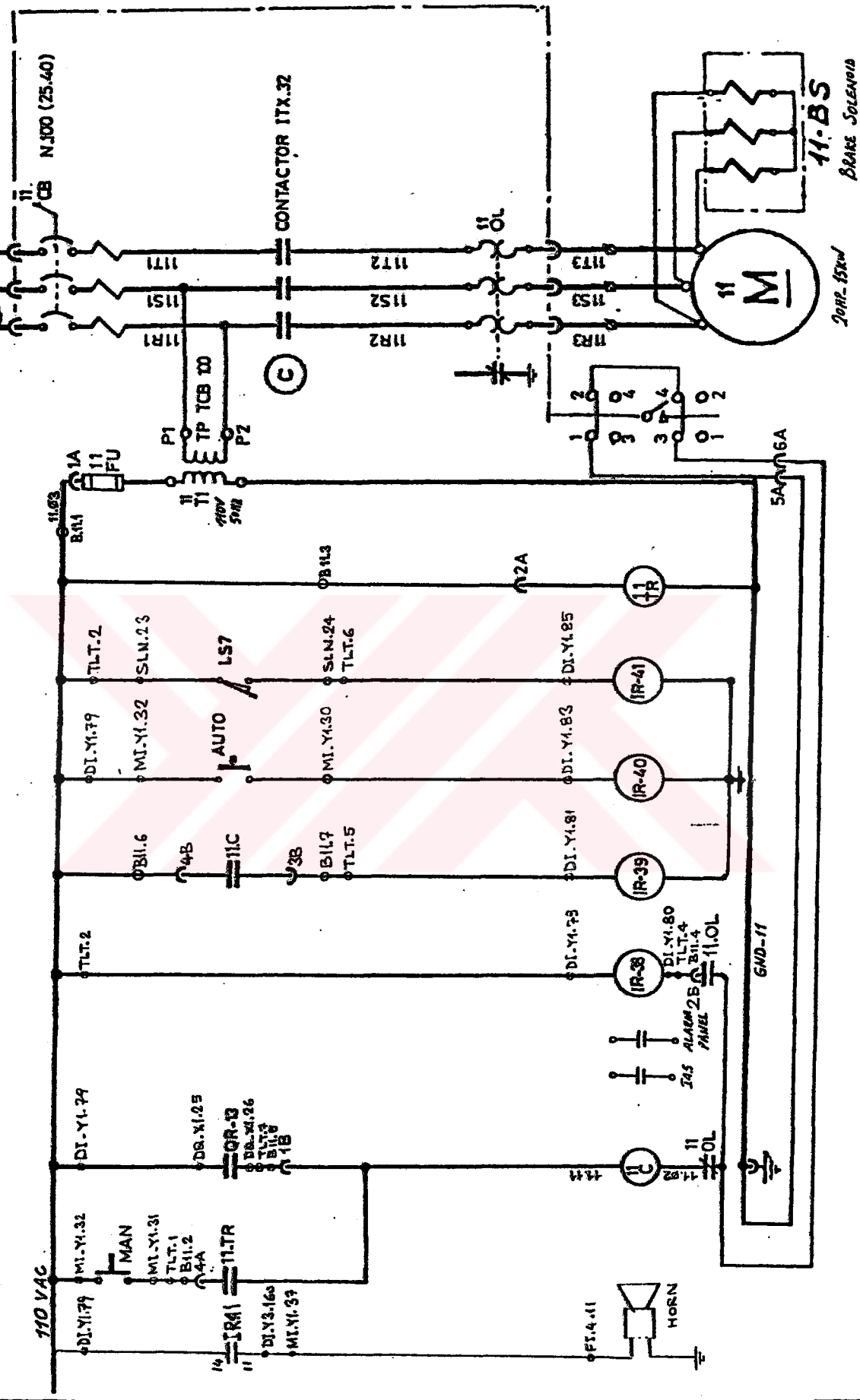


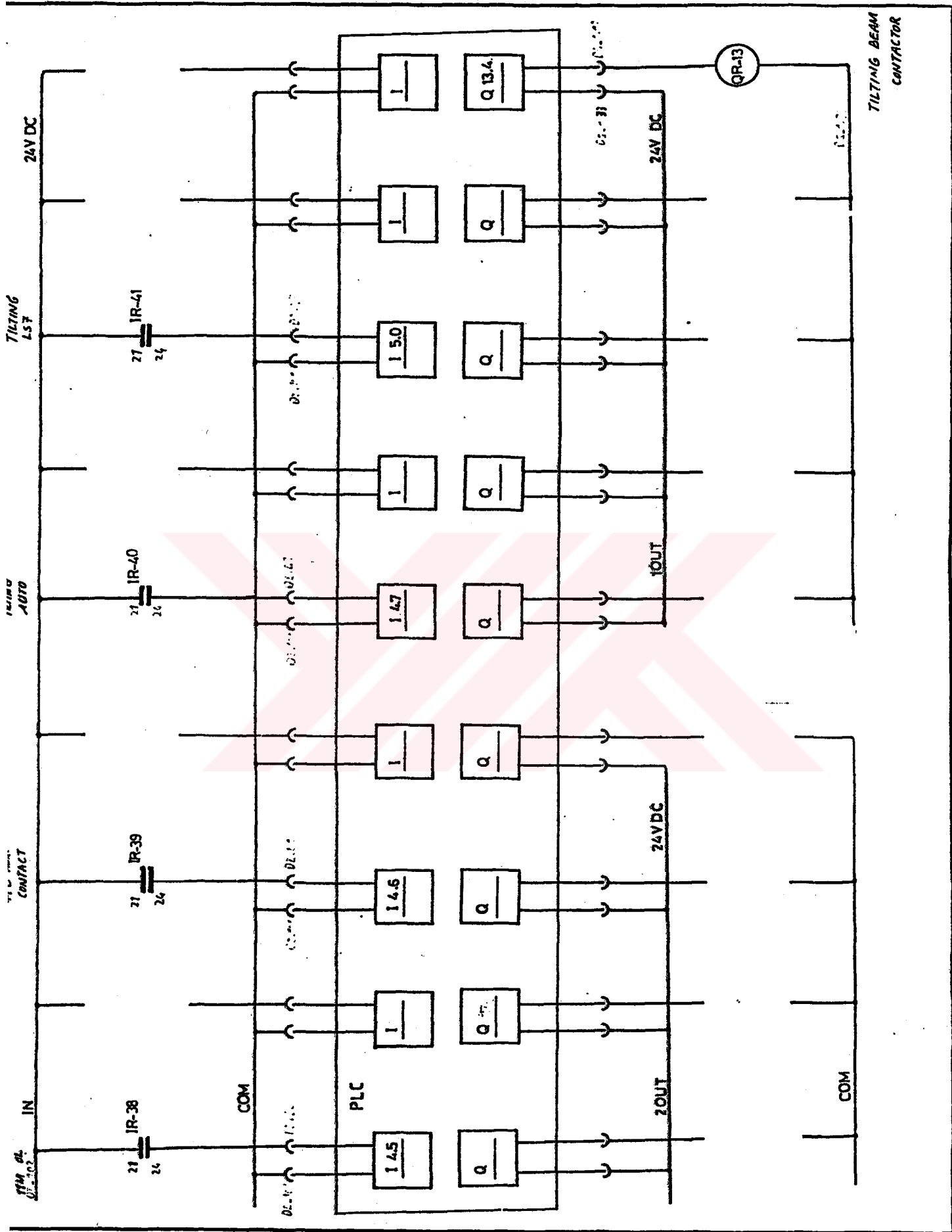






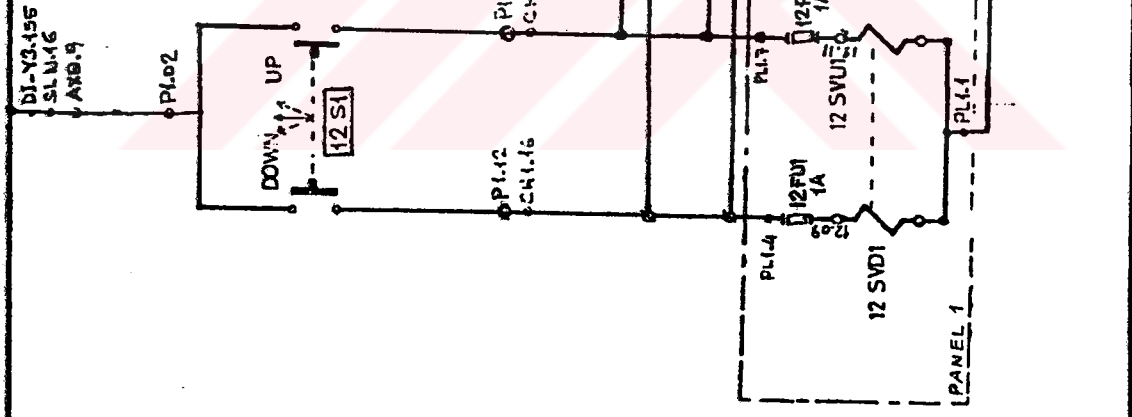
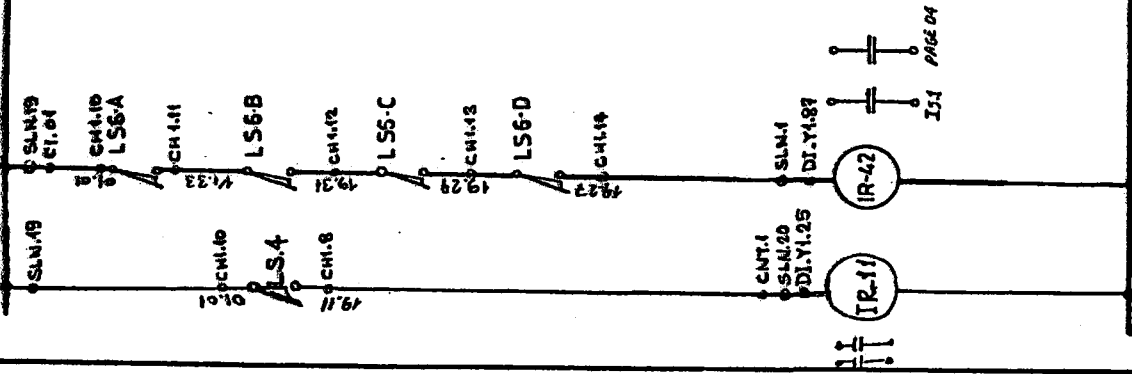
11
 12
 13
 FROM
 PAGE
 10
 380V AC
 50 Hz
 TO
 PAGE
 22





FROM PAGE 01

110V AC TO PAGE 13



Notes:
 P1 = Auxiliary Pulpit
 CH1 = Charging Junction Box

COMMONING BACK

24V DC

24V DC

24V DC

21 IR 42

24 IR 11

24

24

COM

24V DC

24V DC

PLC

1 51

1 12

1 1

1 1

1 1

1 1

1 1

Q

Q

Q

Q

Q

Q

Q

10UT

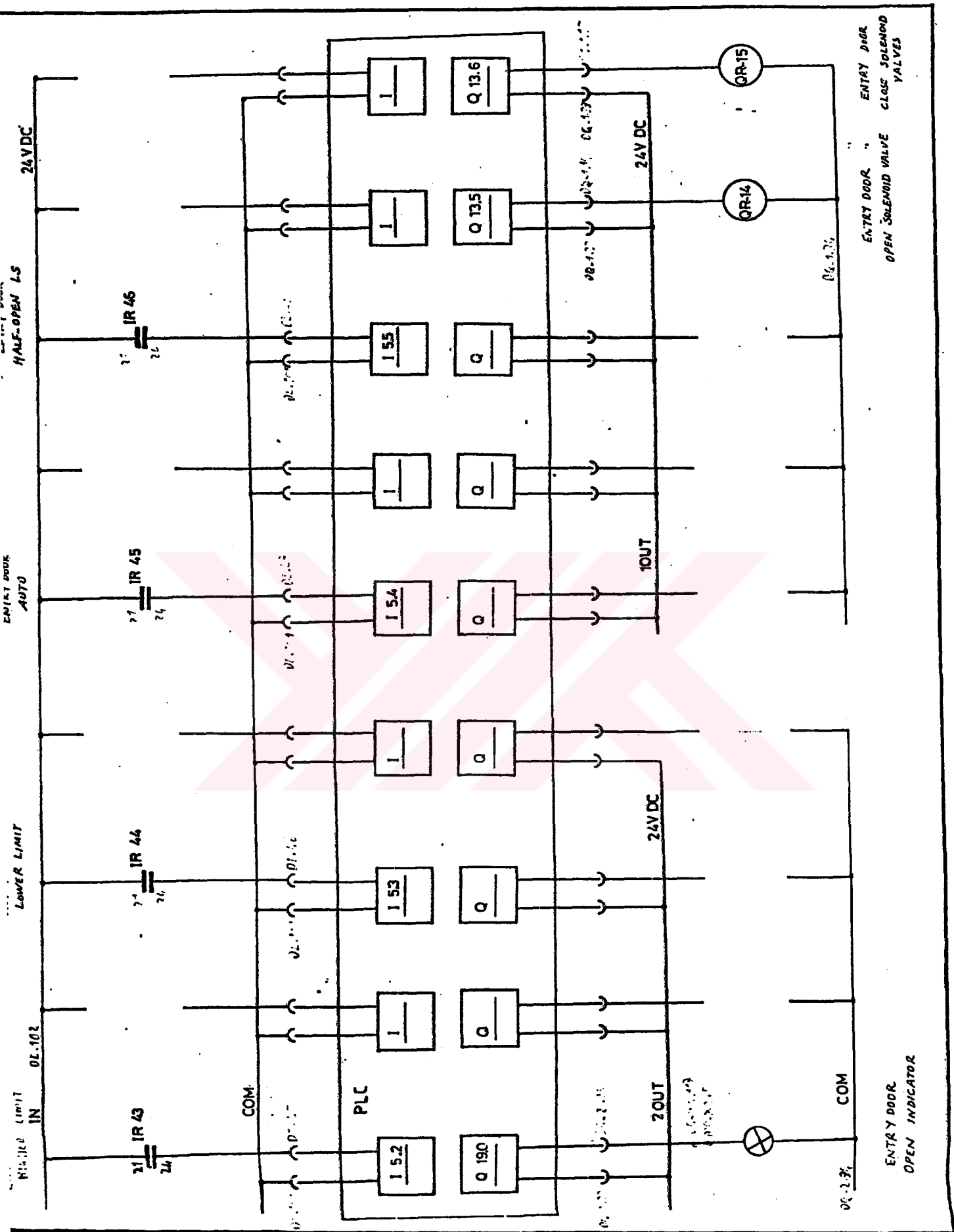
24VDC

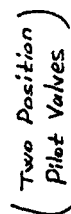
20UT

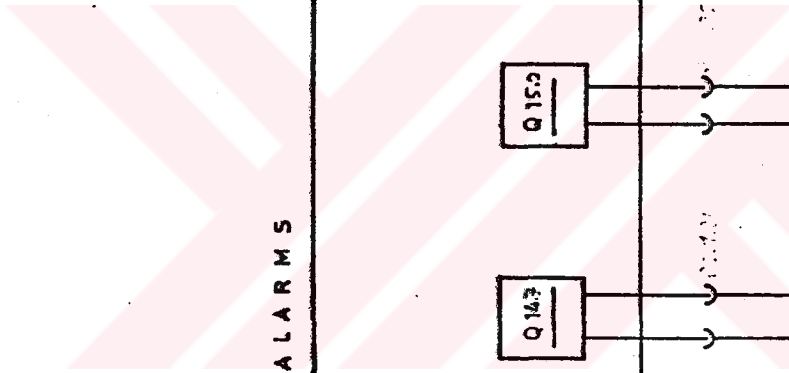
24V DC

COM

114





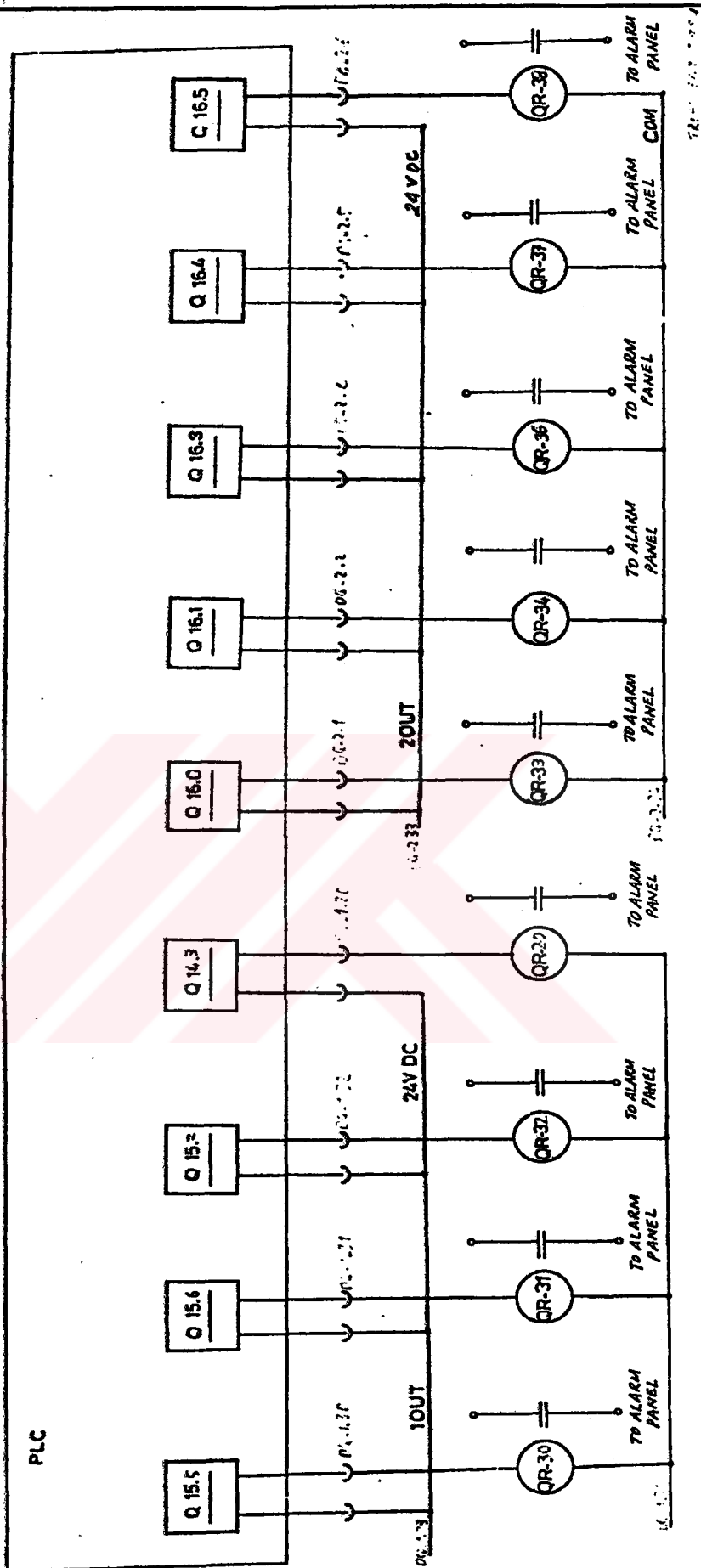


ALARMS

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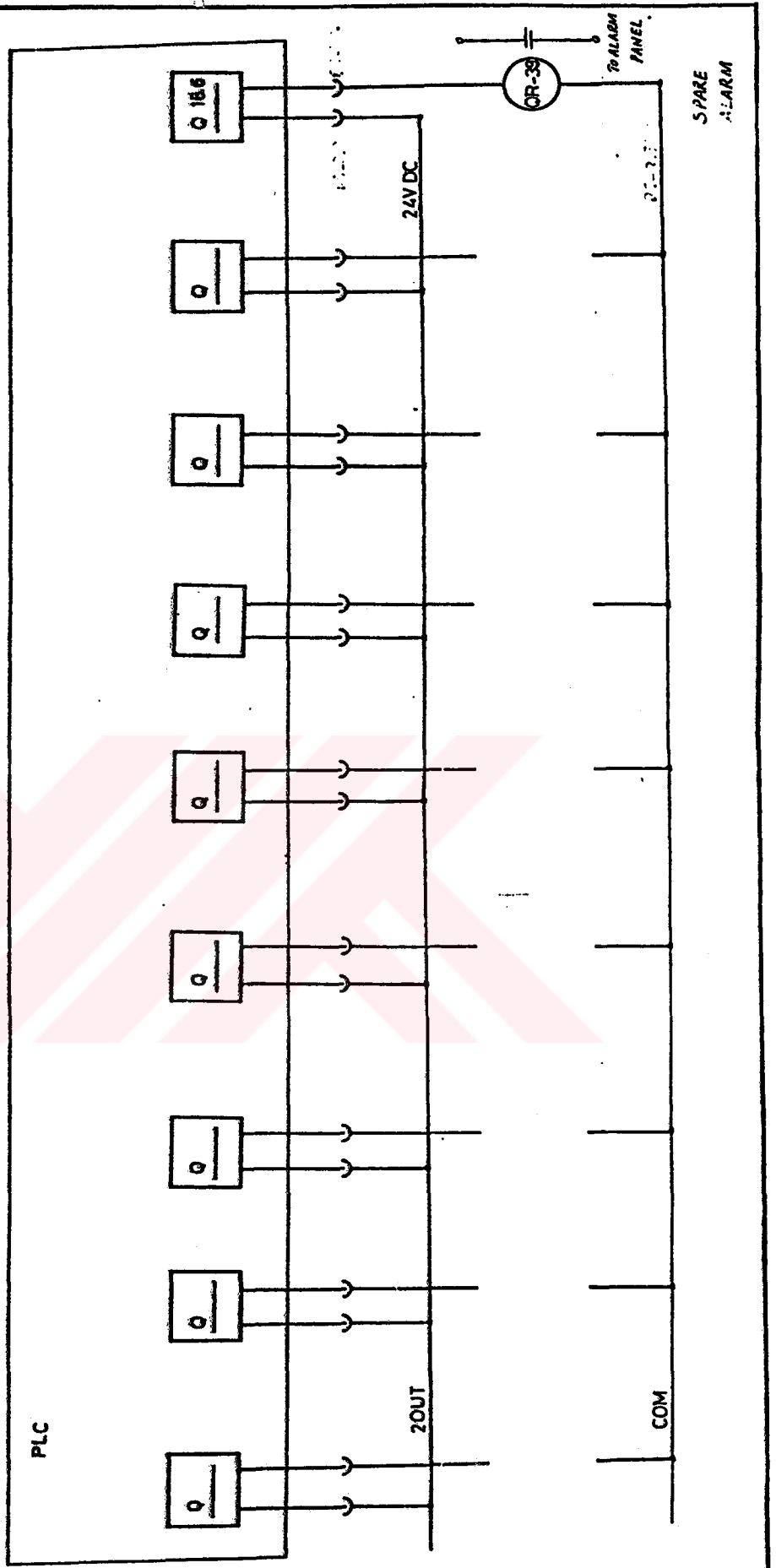
Q152

ALARMS

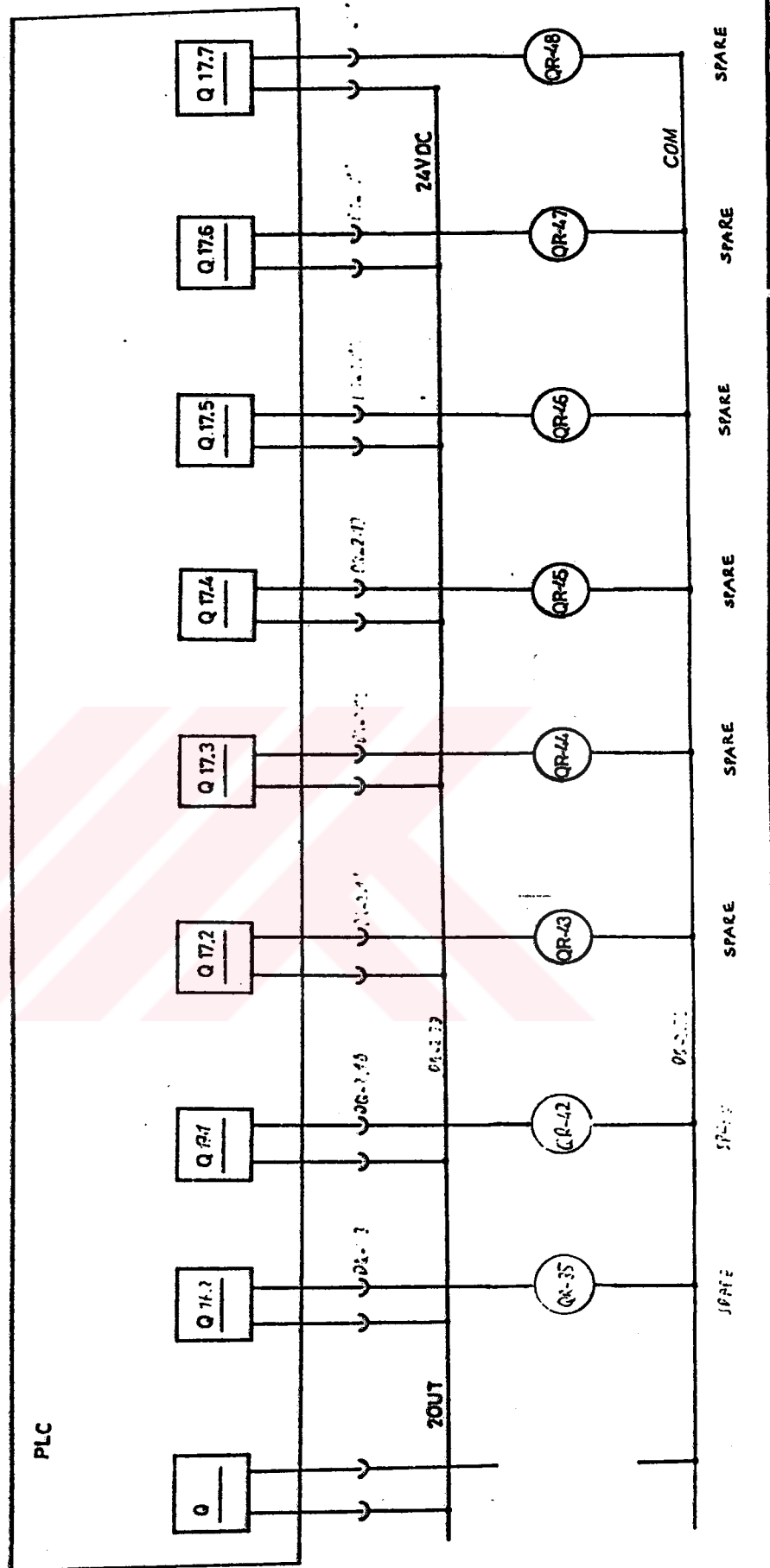


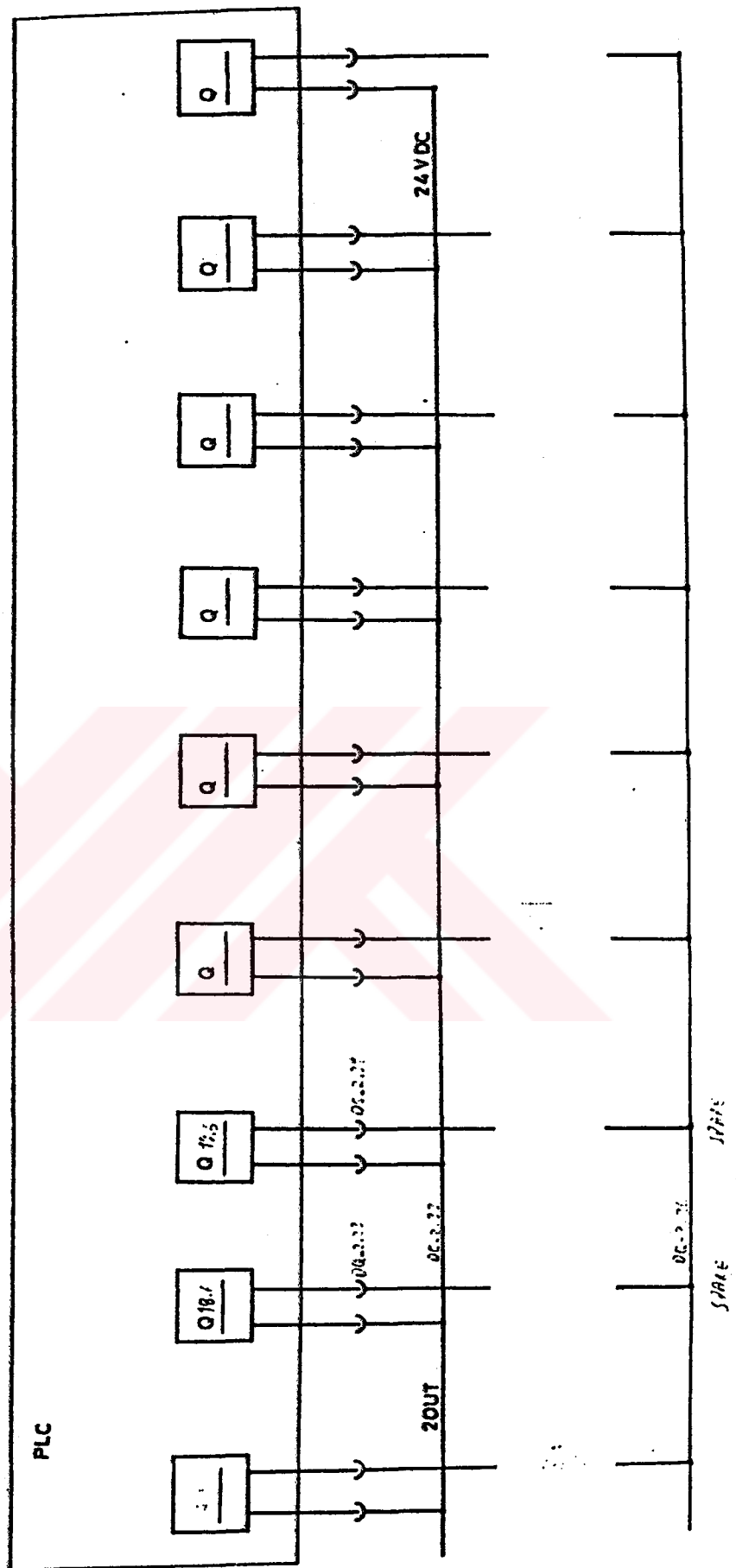
ENTRY DOOR PROBLEM	EXIT DOOR PROBLEM	BOTH DOORS LEFT OPEN	CHARGING TABLE FORM. PROBLEM	PLC POWER SUPPLY 110 V AC OFF	INPUTS POWER SUPPLY 24VDC OFF	OUTPUTS POWER SUPPLY 24VDC OFF	PLC FAN NOT RUNNING
-----------------------	----------------------	-------------------------	---------------------------------	----------------------------------	-------------------------------------	--------------------------------------	------------------------

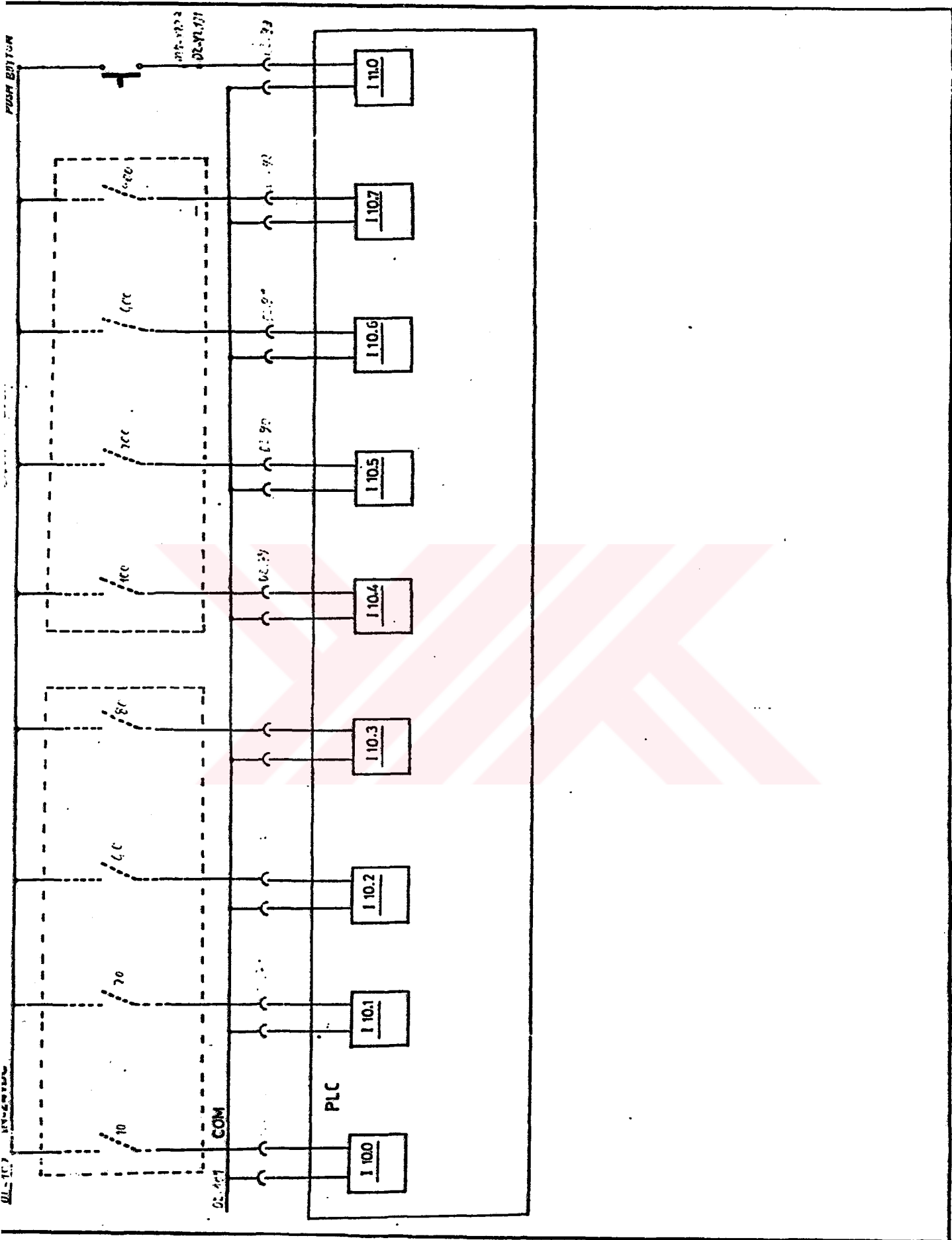
ALARMS

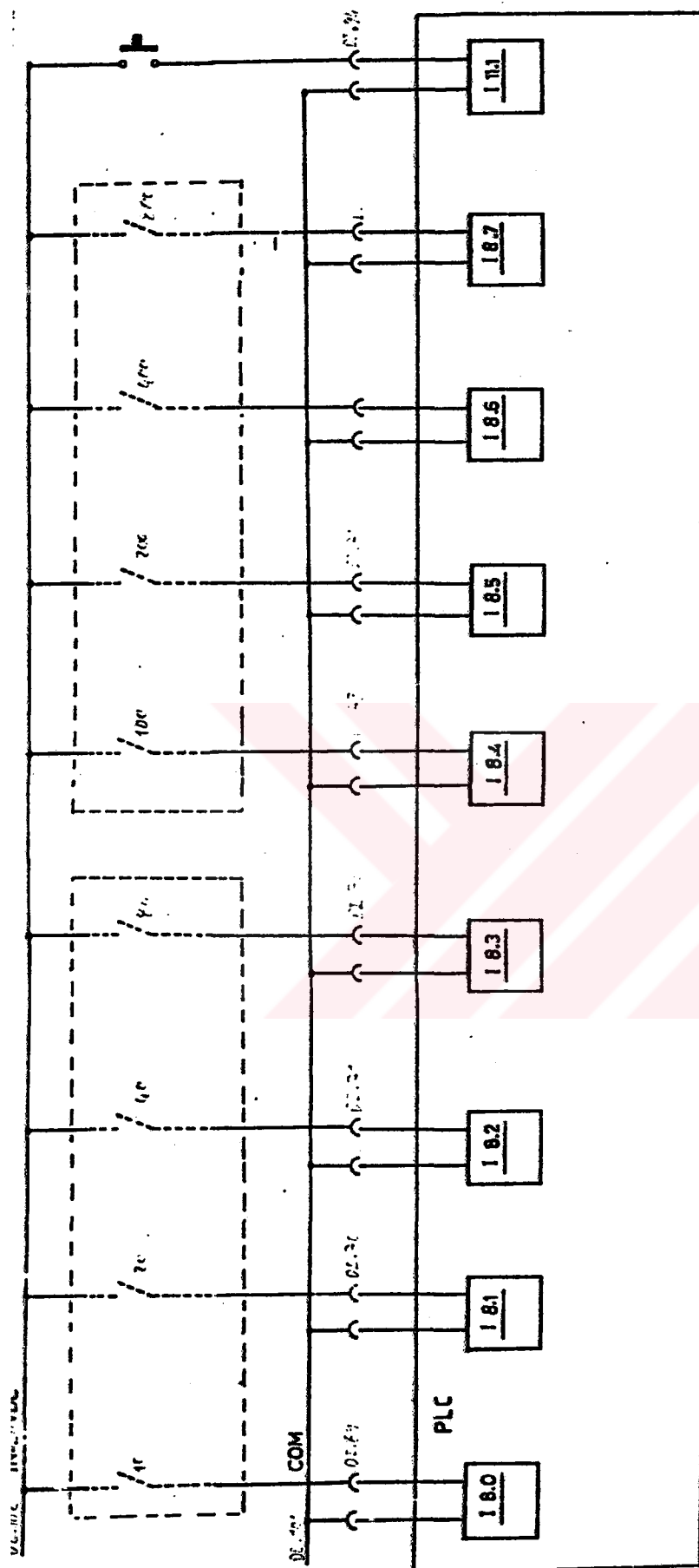


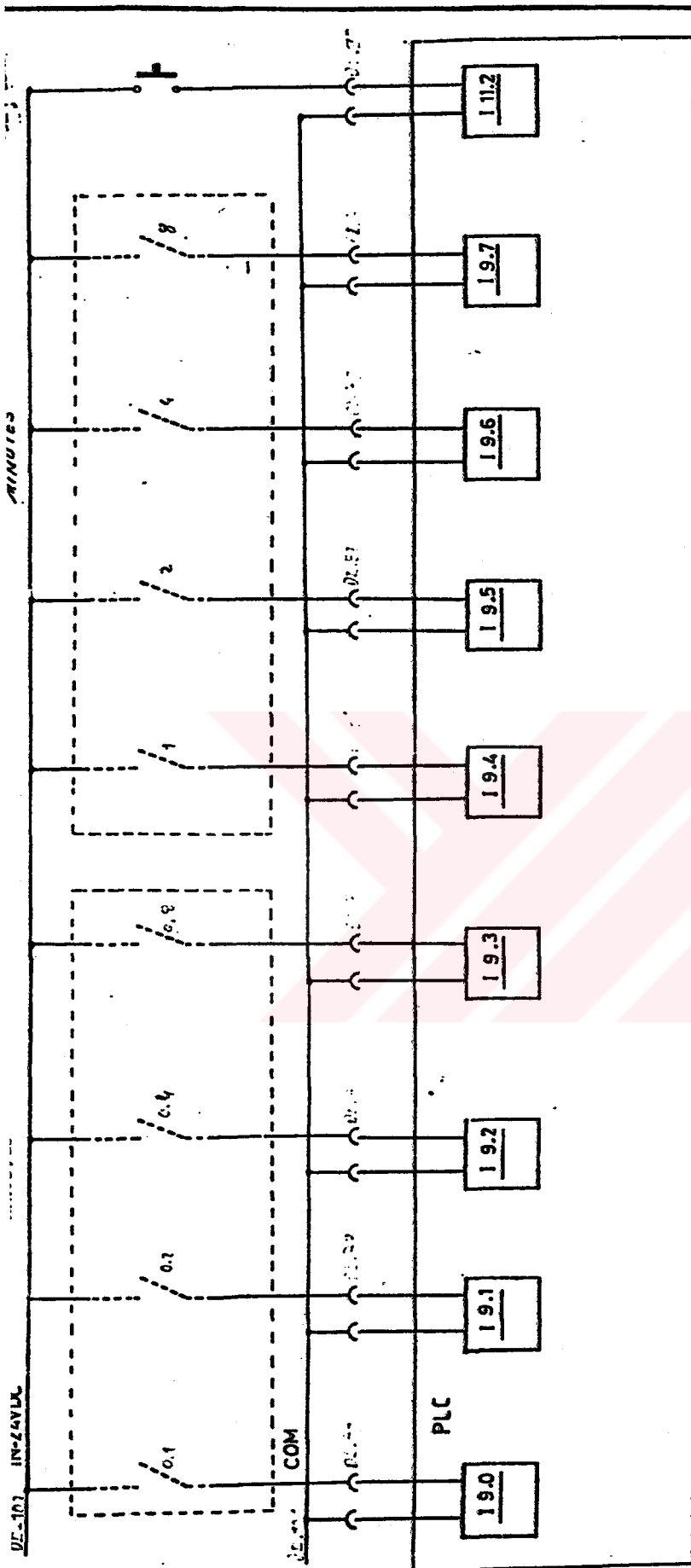
SPARE OUTPUT RELAYS

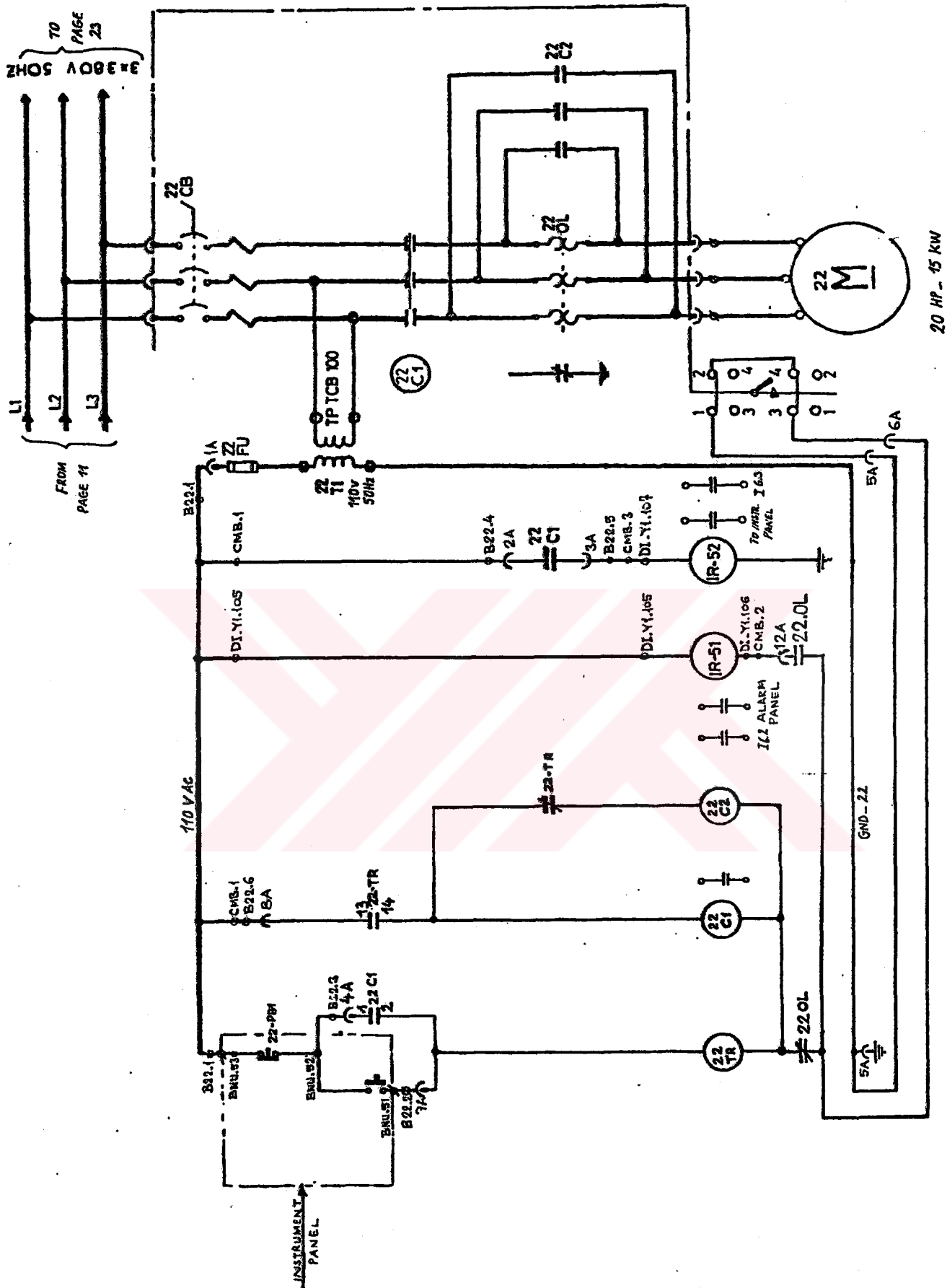


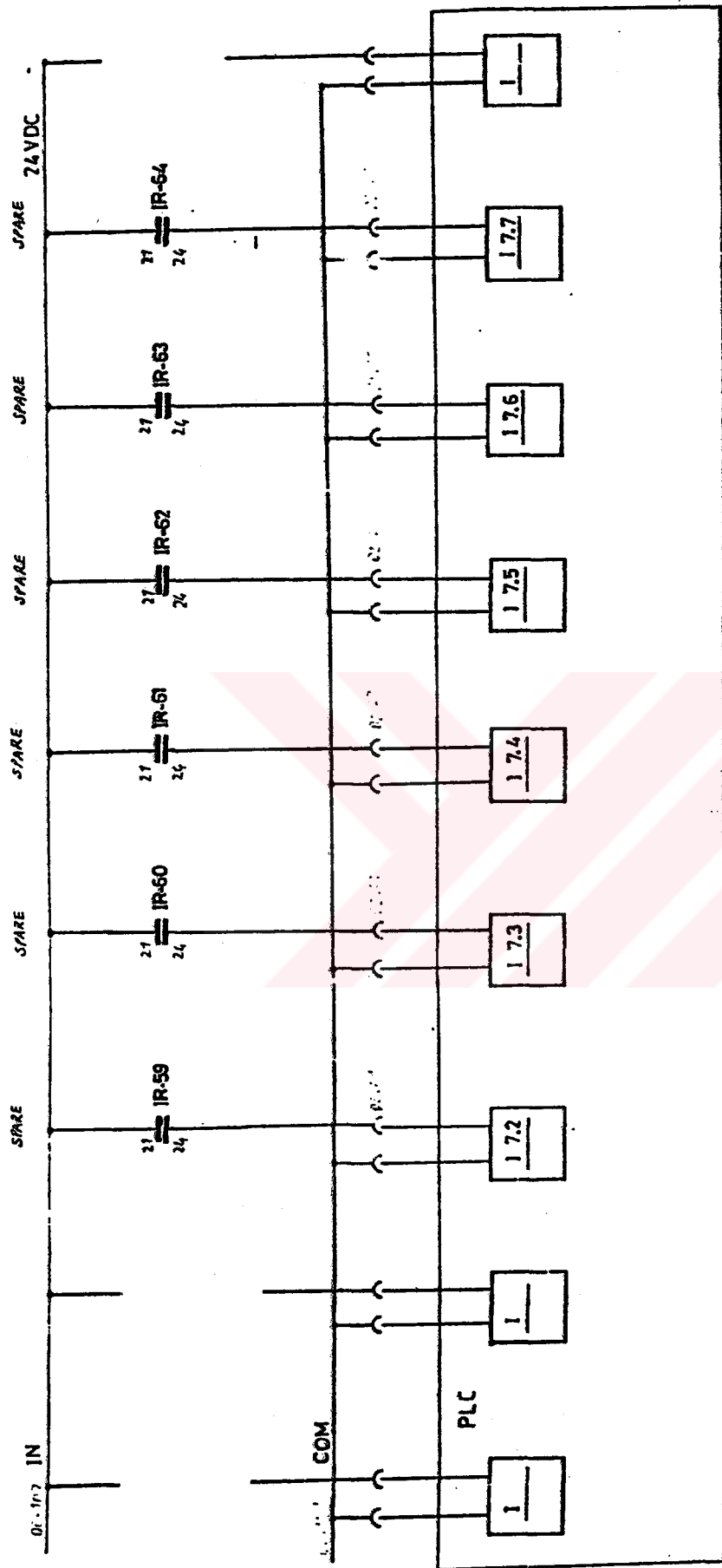












NOT: R le bobinleri  emalarda g sterilmemi tir.
Gerekliliinde ilgili yerlere ba lanacaktır.

APPENDIX C

S5-115U TECHNICAL SPECIFICATIONS

Operation			Operand identifier (permissible)	Processing time in μ s			Description
Representation as State- ment list	Control system flowchart (not possible with PG 605U and PG 615)	Ladder diagram					
STL	CSF	LAD		941 CPU 942 CPU 943 CPU	STL	CSF	LAD

Logic operations

A			I	Q	F	T	C	2.2	1.6	1.6	Scan for "1" and AND with result of previous logic operation	Normally open contacts in series
AN			I	Q	F	T	C	2.2	1.6	1.6	Scan for "0" and AND with result of previous logic operation	Normally closed contacts in series
O			I	Q	F	T	C	2.2	1.6	1.6	Scan for "1" and OR with result of previous logic operation	Normally open contacts in parallel
ON			I	Q	F	T	C	2.2	1.6	1.6	Scan for "0" and OR with result of previous logic operation	Normally closed contacts in parallel
O								2.2	1.6	1.6	ORing of AND operations	Return path for connecting two circuits in parallel
A(								97	1.6	1.6	ANDing of bracketed expressions (6 nesting levels)	Start of a branch
O(								95	1.6	1.6	ORing of bracketed expressions (6 nesting levels)	Return path and start of a branch
)								95	1.6	1.6	Right parenthesis (termination of a bracketed expression)	Branch termination

Setting/resetting operations

S			I	Q	F			2.2	1.6	1.6	Set if result of logic operation "1"; no effect if "0"
R			I	Q	F			2.2	1.6	1.6	Reset if result of logic operation "1"; no effect if "0"
=			I	Q	F			2.2	1.6	1.6	Assign "1" if result of logic operation "1"; assign "0" if result of logic operation "0"

Loading operations: the contents of the operand or the value of the constant are stored in the accumulator (an intermediate store)

L	These statements must be entered as STL	These statements must be entered as STL	IB	QB	67	1.6	1.6	Load a byte from the process image
L			IW	QW	72	1.6	1.6	Load a word from the process image
L			PB		84	72	72	Load a byte from an input module (bypassing the process image)
L			PW		104	92	92	Load a word from an input module (bypassing the process image)
L			FS		69	1.6	1.6	Load a flag byte
L			FW		74	1.6	1.6	Load a flag word
L			DL		94	82	3.4	Load the left byte of a data word of the actual data block
L			DR		96	84	3.4	Load the right byte of a data word of the actual data block

Instruction Set of STEP 5 Language.

Operation			Operand identifier (permissible)	Processing time in μ s			Description
Representation as State- ment list	Control system flowchart	Ladder diagram					
STL	CSF	LAD				941 CPU 942 CPU 943 CPU	

Loading operations (continued)

L	These statements must be entered as STL	These statements must be entered as STL	DW	98	86	3.9	Load a data word of the actual data block
L			KB	69	57	2.8	Load constant as 1-byte number
L			KS ¹⁾ KF ¹⁾	115	1.6	1.6	Load constant as symbol (characters) or fixed-point number
L			KH ¹⁾ KM ¹⁾	115	1.6	1.6	Load constant as hexadecimal number or bit pattern
L			KY ¹⁾ KT	115	1.6	1.6	Load constant as 2-byte number or time
L			KC	115	1.6	1.6	Load constant as counter
L			T C	104	1.6	1.6	Load the contents of a timer or counter (in binary code)
LC			T C	173	161	3.5	Load the contents of a timer or counter (in BCD code)

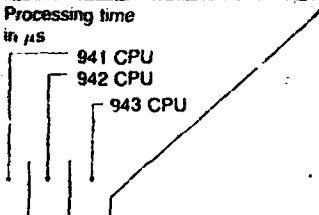
Transfer operations (the contents of the accumulator are transferred to the operand)

T	These statements must be entered as STL	These statements must be entered as STL	IB QB	59	1.6	1.6	Transfer a byte to the process image
T			IW QW	65	1.6	1.6	Transfer a word to the process image
T			PB	80	68	68	Transfer a byte to an output module (the process image is also modified)
T			PW	109	97	97	Transfer a word to an output module (the process image is also modified)
T			FB	61	1.6	1.6	Transfer a byte to the flags
T			FW	67	1.6	1.6	Transfer a word to the flags
T			DL	87	75	2.2	Transfer a byte to a data word (left) of the actual data block
T			DR	90	78	2.2	Transfer a byte to a data word (right) of the actual data block
T			DW	93	81	2.7	Transfer a word to a data word of the actual data block

Instruction Set of STEP 5 Language.

Operation			Operand identifier (permissible)	Processing time in μ s			Description
Representation as State-ment list	Control system flowchart (not possible with PG 605U and PG 615)	Ladder diagram		941 CPU 942 CPU 943 CPU			
STL	CSF	LAD					
Timer operations (the value of a timer to be started must first be loaded into the accumulator; RLO = result of the logic operation)							
SP			T	155	153	3.7	Start timer as pulse on positive going edge of RLO (signal contracting). If RLO = "0", the time is set to "0".
SE			T	165	153	3.7	Start timer as extended pulse on positive-going edge of RLO (signal contracting and stretching). If RLO = "0", the timer remains unchanged.
SR			T	169	157	3.7	Start timer with "On" delay on positive-going edge of RLO. If RLO = "0", the timer is set to "0".
SS			T	169	157	3.7	Start timer with stored "On" delay on positive-going edge of RLO. If RLO = "0", the timer remains unchanged.
SF			T	162	150	3.7	Start timer as "Off" delay on negative-going edge of the RLO. If RLO = "1", the timer is set to "0".
R			T	110	98	3.7	Reset (to "0") a timer if RLO = "1". no effect if RLO = "0".
Counter operations							
CU			C	120	108	3.7	Increment counter by "1" on positive-going edge of RLO
CD			C	133	121	3.7	Decrement counter by "1" on positive-going edge of RLO
S			C	159	147	3.7	Set counter if RLO = "1"; the value must first be loaded into the accumulator; if RLO = "0", no effect
R			C	110	98	3.7	Reset counter (to "0") if RLO = "1"; If RLO = "0", no effect.
Comparison operations (for fixed-point numbers; the result of the last operation is always stored in the accumulator)							
I = F				118	1.6	1.6	Compare for equal to: previous accumulator contents = last value loaded?
> < F				118	1.6	1.6	Compare for not equal to: previous accumulator contents $\neq$ last value loaded?
> F				118	1.6	1.6	Compare for greater than: previous accumulator contents $>$ last value loaded?
> = F				118	1.6	1.6	Compare for greater than or equal to: previous accumulator contents $\geq$ last value loaded?
< F				118	1.6	1.6	Compare for less than: previous accumulator contents $<$ last value loaded?
< = F				118	1.6	1.6	Compare for less than or equal to: previous accumulator contents $\leq$ last value loaded?

Instruction Set of STEP 5 Language.

Operation			Operand Identifier (permissible)	Processing time in μ s			Description
Representation as Static statement list	Control system flowchart (not possible with PG 605U and PG 615)	Ladder diagram					
STL	CSF	LAD					

Arithmetic operations (the result of the last operation is always stored in the accumulator)							
+ F	These statements must be entered as STL	These statements must be entered as STL		73	1.6	1.6	Addition of fixed-point numbers previous contents of accumulator + last value loaded
- F	These statements must be entered as STL	These statements must be entered as STL		75	1.6	1.6	Subtraction of fixed-point numbers previous contents of accumulator - last value loaded

Multiplication and division are not directly available as operations, but can easily be implemented using the standard function blocks integrated in the operating system of the CPUs.

Block call operations							
JU			FB	209	197	6.7	Unconditional function block call
JC			FB	219	207	6.7	Conditional function block call
JU			SB	207	195	6.7	Unconditional sequence block call
JC			SB	217	205	6.7	Conditional sequence block call
JU	These statements must be entered as STL	These statements must be entered as STL	PB	207	195	6.7	Unconditional program block call
JC			PB	212	200	6.7	Conditional program block call
C	These statements must be entered as STL	These statements must be entered as STL	DB	90	80	3.6	Data block call

Block end operations							
BE	BE	BE		135	124	5	Block end (last operation in a block)
BEC	BEC	BEC		137	126	5	Block end, conditional
BEU	BEU	BEU		135	124	5	Block end, unconditional (within a block, e.g. during system start-up; not in an organization block)

No, Stop, Image construction operations							
NOP 0	These statements must be entered as STL	These statements must be entered as STL		53	1.6	1.6	No operation, all bits reset (to "0")
NOP 1	These statements must be entered as STL	These statements must be entered as STL		22	1.6	1.6	No operation, all bits set (to "1")
STP	STP	STP		63	51	51	Stop: the scanning cycle is completed and the outputs are then disabled.
BLD	BLD	BLD		53	1.6	1.6	Image construction statements for the programmer. The program sequence in the PC is not influenced by this.

Instruction Set of STEP 5 Language.

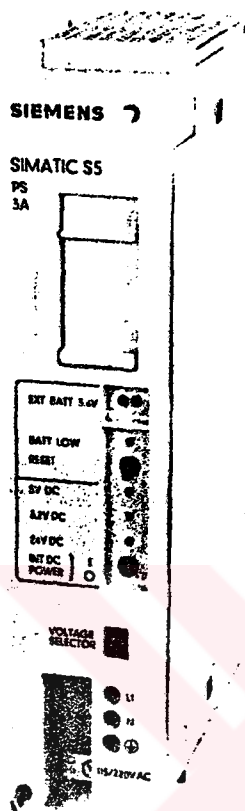
Table 2-3. Execution Times in μ sec. (rounded off)

	Run time in			
	CPU 941	CPU 942	CPU 943	CPU 944
Boolean logic operations	2.2	1.6		
Load/Transfer operations (I, Q, F, T, C)	67 - 115	1.6		
Comparison/ Arithmetic operations	73 - 115	1.6		
Jump/ Conversion operations	59 - 108	1.6		
Timer/Counter operations	110 - 160	88 - 157	3.7	
Block call operations	90 - 219	80 - 207	1.7 - 6.7	
Load/Transfer operations (DW)	87 - 98	75 - 86	2.2 - 3.9	
Substitution operations (formal operands) *	170	160	160	7.2
Load/Transfer operations (Periph., LIR, TIR, TNB) **	80 - 120	80 - 115	80 - 115	6
Processing operations (DO DW, DO FW)	135 - 160	130 - 155	130 - 155	7.2/5.2
Bit test operations	211	206	206	206

	CPU 941	CPU 942	CPU 943	CPU 944
Execution time per - 1000 statements (For specific information, see Appendix A.)	Approximately 30 msec.	Approximately 18 msec.	Approximately 10 msec.	Approximately 3 msec.
Internal program memory (RAM)	2 kilobytes	10 kilobytes	16 kilobytes	96 kilobytes
Total program memory, maximum	Sum of internal program memory & submodule**			
	18 kilobytes	42 kilobytes	48 kilobytes	96 kilobytes
Scan monitoring time	500 msec.	500 msec. - can be changed		
Program scanning	Cyclic, inter- rupt driven	Cyclic, interrupt driven, time driven		
Address range, maximum (digital inputs)	512*** I 0.0...I 63.7	1024 I 0.0...I 127.7		
Address range, maximum (digital outputs)	512*** Q 0.0...Q 63.7	1024 Q 0.0...Q 127.7		
Address range, maximum (analog inputs)	64 PW 128...PW 254			
Address range, maximum (analog outputs)	64 PW 128...PW 254			
Flags - optionally retentive - nonretentive	1024 1024	:	F 0.0...F 127.7 F 128.0...F 255.7	
Timers - optionally retentive - nonretentive	64 64	:	T 0...T 63 T 64...T 127	
Counters - optionally retentive - nonretentive	64 64	:	C 0...C 63 C 64...C 127	
Time range	0.01... 9990 sec.			
Counting range	0...999			
Operation set	Approximately 170 operations			
SS-115U PID control	No	Yes	Yes	Yes

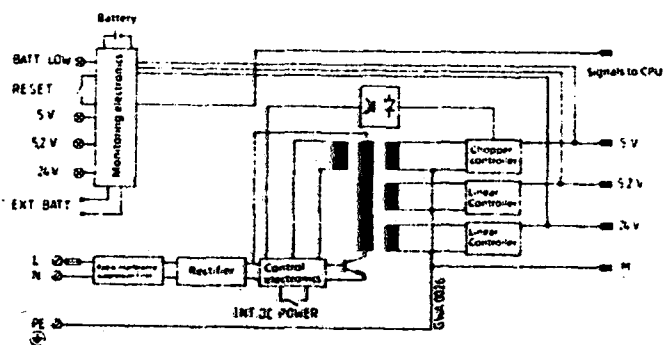
Comparison of 115U CPU types.

(6ES5 951-7LB14)



Technical Specifications

Input voltage L1		
- rated value	115 V AC/230 V AC	
- permissible range	94...132 V/ 187...264 V	
Line frequency		
- rated value	50 Hz	
- permissible range	47...63 Hz	
Input current at 115 V 230 V		
- rated value	0.4/0.7 A	
- inrush current	maximum 54 A	
- I ² t	1 A ² s	
Power consumption (active power)		48 W
Output voltage		
- rated value	5 V	
- tolerance	± 2%	
Output current		
- rated value without fan	3 A	
- rated value with fan	3 A	
- permissible range	0.3 A...3 A	
Short-circuit protection		electronic
Fault indicator		no
Fuse (primary circuit)		integral
Class of protection		Class 1
Floating		no
Isolation rating	according to VDE 0160	
- isolation group	C	
- tested with	2700 V DC	
RI specifications		A
	according to VDE 0871	
Power loss of the module	typically	23 W
Weight	approximately	1.6 kg (3.53 lbs.)



Simplified Schematic

Power Supply Module of 115U used in this thesis.



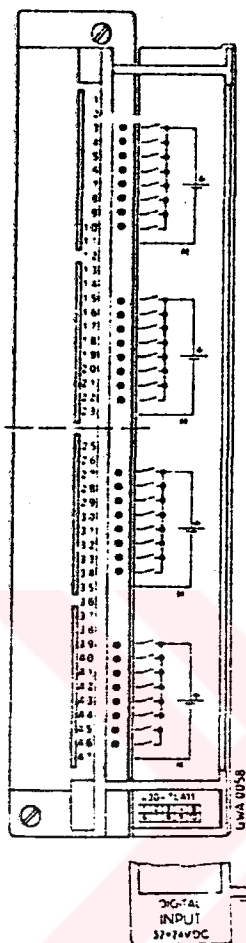
Technical Specifications

Memory capacity (total)		maximum	21504 statements¹
- internal memory		maximum	5120 statements¹
- memory submodule (RAM)		maximum	16384 statements¹
- memory submodule (EPROM)		maximum	16384 statements¹
- memory submodule (EEPROM)		maximum	8192 statements¹
Execution time			
- per binary operation		approximately	1.6 µsec.
- per word operation		approximately	1.6...200 µsec.
Scan time monitoring		approximately	500 msec. (can be modified)
Flags			2048; of these, 1024 are optionally retentive²
Timers			
- number			128; of these, 64 are optionally retentive²
- range			0.01...9990 sec.
Counters			
- number			128; of these, 64 are optionally retentive²
- range			0...999 (count up, count down)
Digital inputs			
Digital outputs - total	maximum		2048
Analog inputs			
Analog outputs - total	maximum		128
Organization blocks	maximum		256
Program blocks	maximum		256
Function blocks	maximum		256 (can be assigned parameters)
Sequence blocks	maximum		256
Data blocks	maximum		254
Operations set		approximately	170 operations
Back-up battery			Lithium battery, size C (3.6 V/5 Ah)
- Back-up time	minimum		1 year (at 25°C and constant backup of the CPU)
- Service life		approximately	5 years (at 25°C)
Current consumption			
- from 5 V (internal)			0.8 A
- from 24 V (when a PG 60S or PG 61S programmer is connected)			0.02 A
Power losses of the module	typically		4.0 W
- with programmer	typically		4.5 W
Weight		approximately	1.5 kg (3.3 lbs.)

¹ A statement usually takes up two bytes in the program memory.

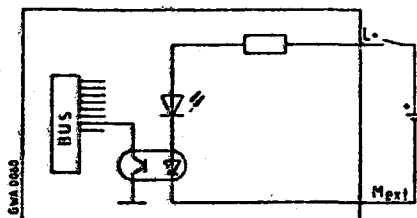
² Use back-up battery for retentive feature.

(6ES5 430-7LA11)



Number of inputs		32
Type of inputs		floating (optocoupler)
- in groups of		8
Input voltage L +		
- rated value		24 VDC
- for "0" signal		-30... + 5 V
- for "1" signal		13...30 V
Input current		
- at "1" signal	typically	8.5 mA
Response time		
- from "0" to "1"		1.4...5 msec.
- from "1" to "0"		1.4...5 msec.
Cable length		
- shielded	maximum	1000 m (3281 ft.)
- unshielded	maximum	600 m (1969 ft.)
Isolation rating		according to VDE 0160
Rated isolation voltage (between groups)		30 V
- isolation group		C
- tested with		500 V
Rated isolation voltage (L + to $\perp$)		30 V
- isolation group		C
- tested with		500 V
Connection of 2-wire BERO proximity switches		possible
- quiescent current		≤ 1.5 mA
Current consumption		
- from 5 V (internal)		≤ 5 mA
Power losses of the module	typically	6.5 W
Weight	approximately	0.7 kg (1.54 lb.)

Terminal Assignment

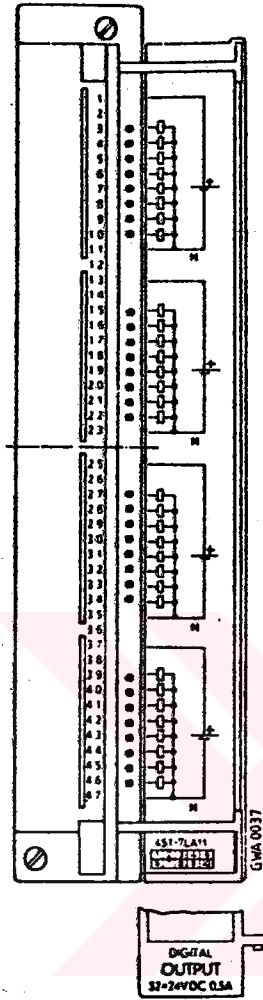


Simplified Schematic

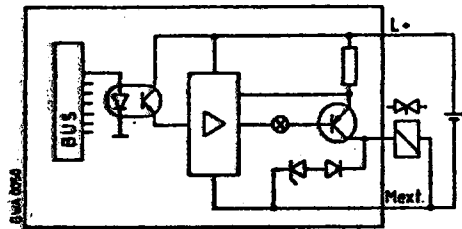
Digital Input Module of 115U used in this thesis.

Digital Output Module 32 x 24 V DC; 0.5 A, Floating

(6ES5 451-7LA11)



Terminal Assignment



Simplified Schematic

Technical Specifications

Number of outputs	32
Type of outputs	floating (optocoupler)
- in groups of	8
Load voltage L +	
- rated value	24 V DC
- permissible range	20...30 V
- surge voltage at $t \leq 0.5$ sec.	35 V
Output voltage	
- at "1" signal	minimum $L + - 2.5$ V
Output current at "1" signal	
- rated value	0.5 A
- lamp load	maximum 5 W
Leakage current at "0" signal	maximum 1 mA
Parallel connection of outputs	not possible
Permissible total current of outputs	
- at 25 °C	100%
- at 55 °C	50%
Short circuit protection	electronic
Limitation of the voltage induced on circuit interruption	- 15 V
Switching frequency	
- inductive load	maximum 0.5 Hz
- resistive load	maximum 100.0 Hz
Cable length	
- shielded	maximum 1000 m (3281 ft.)
- unshielded	maximum 600 m (1969 ft.)
Isolation rating	according to VDE 0160
Rated isolation voltage (between groups)	30 V DC
- isolation group	C
- tested with	500 V AC
Rated isolation voltage (L + to ---)	30 V DC
- isolation group	C
- tested with	500 V AC
Current consumption	
- from 5 V (internal)	100 mA
- from L + (without load)	17 mA / per group
Power losses of the module	typically 20 W
Weight	approximately 0.7 kg (1.54 lb.)

Digital Output Module of 115U used in this thesis.

APPENDIX D
PLC PROGRAM LISTS
IN LADDER DIAGRAM FORM

PB	3 :-	LENGTH :	31
PB	5 :-	LENGTH :	262
PB	6 :-	LENGTH :	79
PB	7 :-	LENGTH :	157
PB	8 :-	LENGTH :	66
PB	9 :-	LENGTH :	137
PB	10 :-	LENGTH :	148
PB	11 :-	LENGTH :	40
PB	13 :-	LENGTH :	94
PB	14 :-	LENGTH :	57
PB	15 :-	LENGTH :	793
PB	16 :-	LENGTH :	180
PB	50 :-	LENGTH :	19
FB	200 :-	LENGTH :	191
OB	1 :-	LENGTH :	69
OB	22 :-	LENGTH :	18
DB	2 :-	LENGTH :	2019
DB	3 :-	LENGTH :	1737
DB	10 :-	LENGTH :	42

LENGTH : PB 2063

LENGTH : SB 0

LENGTH : FB 191

LENGTH : OB 87

LENGTH : DB 3798

LENGTH : 6139

HOT STRIP MILL PLATE NORMALIZING FURNACE PLC PROGRAM LISTS

This program or part of it cannot be copied or reproduced without permission.
Middle East Technical University, Electrical and Electronics Engineering Dept.

+OB 1+-DB 10-
I
+-FB200-
I
+-PB 50-
I
+-PB 3-
I
+-PB 5-
I
+-PB 6-
I
+-PB 7-
I
+-PB 8-
I
+-PB 9-
I
+-PB 10-
I
+-PB 11-
I
+-PB 13-
I
+-PB 14-
I
+-PB 15-
I
+-PB 16-

+OB 22-

HOT STRIP MILL PLATE NORMALIZING FURNACE PLC PROGRAM LISTS

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	SYMBOL	ABSOLUTE	OPERAND	COMMENT
0 :	SL= INP24VDC	= I 0.0		ALL INPUT CARDS P24V (IR-1)
22 :	SL= RESET-1	= I 0.1		FURNACE RESET P.B. (IR-2)
44 :	SL= RESET-2	= I 0.2		COOLING TABLES RESET P.B. (IR-3)
69 :	SL= EM STOP	= I 0.3		EMERGENCY STOP P.B.(IR-4)
90 :	SL= 110VCONT	= I 0.4		PLC & FAN 110VAC CONTROL. (IR-5)
115 :	SL= 03M-OL	= I 0.5		CHARGING TABLE MOTOR OL. (IR-6)
139 :	SL= 03-CF	= I 0.6		CHARGING TABLE 03-CF. (IR-7)
163 :	SL= 03-AUTO	= I 0.7		CHARGING TABLE AUTO S.S. (IR-8)
187 :	SL= CHR LS1	= I 1.0		CHARGING TABLE LS1. (IR-9)
211 :	SL= PL READY	= I 1.1		PLATE READY (IR-10)
238 :	SL= CENT LS4	= I 1.2		CENTERING BACK LS4. (IR-11)
265 :	SL= 04M-OL	= I 1.3		CENTERING MOTOR 04M OL. (IR-12)
292 :	SL= 05M-OL	= I 1.4		FURN. ROL. LS 05M OL. (IR-13)
319 :	SL= 05AUTO-F	= I 1.5		FURN. ROL. LS AUTO-FORW.S.S. (IR-14)
346 :	SL= 05AUTO-R	= I 1.6		FURN. ROL. LS AUTO-REV.S.S. (IR-15)
373 :	SL= 05-CF	= I 1.7		FURN. ROL. LS 05-CF.(IR-16)
395 :	SL= 05-CR	= I 2.0		FURN. ROL. LS 05-CR.(IR-17)
417 :	SL= 06M-OL	= I 2.1		FURN. ROL. HS 06M OL.(IR-18)
440 :	SL= 06-AUTO	= I 2.2		FURN. ROL. HS AUTO S.S.(IR-19)
464 :	SL= 06-C	= I 2.3		FURN. ROL. HS 06C.(IR-20)
485 :	SL= 07M-OL	= I 2.4		DISC. TABLE LS 07M OL.(IR-21)
508 :	SL= 07AUTO-F	= I 2.5		DISC. TABLE LS AUTO-FORW.S.S.(IR-22)
535 :	SL= 07AUTO-R	= I 2.6		DISC. TABLE LS AUTO-REV.S.S.(IR-23)
561 :	SL= 07-CF	= I 2.7		DISC. TABLE LS 07-CF.(IR-24)
584 :	SL= 07-CR	= I 3.0		DISC. TABLE LS 07-CR.(IR-25)
607 :	SL= 08M-OL	= I 3.1		DISC. TABLE HS 08M OL.(IR-26)
630 :	SL= 08-C	= I 3.2		DISC. TABLE HS 08-C.(IR-27)
652 :	SL= 08-AUTO	= I 3.3		DISC. TABLE HS AUTO S.S.(IR-28)
676 :	SL= 09M-OL	= I 3.4		EXIT ROL. LS 09M OL.(IR-29)
698 :	SL= 09AUTO-F	= I 3.5		EXIT ROL. LS AUTO-FORW.(IR-30)
722 :	SL= 09AUTO-R	= I 3.6		EXIT ROL. LS AUTO-REV.(IR-31)
745 :	SL= 09-CF	= I 3.7		EXIT ROL. LS 09-CF.(IR-32)
767 :	SL= 09-CR	= I 4.0		EXIT ROL. LS 09-CR.(IR-33)
789 :	SL= 10M-OL	= I 4.1		EXIT ROL. HS 10M OL.(IR-34)
811 :	SL= 10-AUTO	= I 4.2		EXIT ROL. HS AUTO S.S.(IR-35)
834 :	SL= 10-C	= I 4.3		EXIT ROL. HS 10-C.(IR-36)
855 :	SL= END LS3	= I 4.4		EXIT ROL. END LS3.(IR-37)
876 :	SL= 11M-OL	= I 4.5		TILTING BEAM 11M OL.(IR-38)
898 :	SL= 11-C	= I 4.6		TILTING BEAM 11-C.(IR-39)
919 :	SL= 11-AUTO	= I 4.7		TILTING BEAM AUTO S.S.(IR-40)
942 :	SL= TIL LS7	= I 5.0		TILTING BEAM LS7.(IR-41)
963 :	SL= LS6	= I 5.1		BUMPERS LOW LS6.(IR-42)
983 :	SL= LS8	= I 5.2		ENTRY DOOR OPEN HI-LS8.(IR-43)
1007 :	SL= LS9	= I 5.3		ENTRY DOOR CLOSE LO-LS9.(IR-44)
1031 :	SL= 13-AUTO	= I 5.4		ENTRY DOOR AUTO S.S.(IR-45)
1053 :	SL= LS12	= I 5.5		ENTRY DOOR HALF-OPEN LS12.(IR-46)
1078 :	SL= LS10	= I 5.6		EXIT DOOR OPEN HI-LS10.(IR-47)
1102 :	SL= LS11	= I 5.7		EXIT DOOR CLOSE LO-LS11.(IR-48)
1126 :	SL= 14-AUTO	= I 6.0		EXIT DOOR AUTO S.S.(IR-49)
1148 :	SL= LS13	= I 6.1		EXIT DOOR HALF-OPEN LS13.(IR-50)
1173 :	SL= 22M-OL	= I 6.2		COMB. AIR FAN 22M OL.(IR-51)
1196 :	SL= 22-C1	= I 6.3		COMB. AIR FAN 22-C1.(IR-52)
1218 :	SL= 23M-OL	= I 6.4		EXH. FAN 23M OL.(IR-53)
1238 :	SL= 23-C	= I 6.5		EXH. FAN 23-C.(IR-54)
1257 :	SL= 10UTP24V	= I 6.6		OUTPUT CARD NO:1 (P24V) (IR-55)

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1283 :	SL= PLC FAN = I 6.7	PLC FAN AIR SWITCH.(IR-56)
1305 :	SL= LOADCEL1 = I 7.0	ENTRY SIDE LOAD CELL-1.(IR-57)
1329 :	SL= LOADCEL2 = I 7.1	EXIT SIDE LOAD CELL-2.(IR-58)
1352 :	SL= SPARE = I 7.2	(IR-59)
1374 :	SL= SPARE = I 7.3	(IR-60)
1396 :	SL= SPARE = I 7.4	(IR-61)
1418 :	SL= SPARE = I 7.5	(IR-62)
1440 :	SL= SPARE = I 7.6	(IR-63)
1462 :	SL= SPARE = I 7.7	(IR-64)
1484 :	SL= CLK 10 = I 8.0	CLOCK BCD 10
1499 :	SL= CLK 20 = I 8.1	CLOCK BCD 20
1514 :	SL= CLK 40 = I 8.2	CLOCK BCD 40
1529 :	SL= CLK 80 = I 8.3	CLOCK BCD 80
1544 :	SL= CLK 100 = I 8.4	CLOCK BCD 100
1559 :	SL= CLK 200 = I 8.5	CLOCK BCD 200
1574 :	SL= CLK 400 = I 8.6	CLOCK BCD 400
1589 :	SL= CLK 800 = I 8.7	CLOCK BCD 800
1604 :	SL= CLK 0.1 = I 9.0	CLOCK BCD 0.1
1619 :	SL= CLK 0.2 = I 9.1	CLOCK BCD 0.2
1634 :	SL= CLK 0.4 = I 9.2	CLOCK BCD 0.4
1649 :	SL= CLK 0.8 = I 9.3	CLOCK BCD 0.8
1664 :	SL= CLK 1 = I 9.4	CLOCK BCD 1
1679 :	SL= CLK 2 = I 9.5	CLOCK BCD 2
1694 :	SL= CLK 4 = I 9.6	CLOCK BCD 4
1709 :	SL= CLK 8 = I 9.7	CLOCK BCD 8
1724 :	SL= THB 10 = I 10.0	THUMBW. SW. BCD 10
1742 :	SL= THB 20 = I 10.1	THUMBW. SW. BCD 20
1760 :	SL= THB 40 = I 10.2	THUMBW. SW. BCD 40
1778 :	SL= THB 80 = I 10.3	THUMBW. SW. BCD 80
1796 :	SL= THB 100 = I 10.4	THUMBW. SW. BCD 100
1814 :	SL= THB 200 = I 10.5	THUMBW. SW. BCD 200
1832 :	SL= THB 400 = I 10.6	THUMBW. SW. BCD 400
1850 :	SL= THB 800 = I 10.7	THUMBW. SW. BCD 800
1868 :	SL= READ PB = I 11.0	READ THUMBW. SW.P.B.
1887 :	SL= RUN CLCK = I 11.1	RUN CLOCK P.B.
1903 :	SL= SET CLCK = I 11.2	SET/LOAD CLOCK P.B.
1921 :	SL= FRN PROX = I 11.3	FURNACE PROX. SW.
1938 :	SL= DSC PROX = I 11.4	DISCHARGE PROX.SW.
1956 :	SL= EXT PROX = I 11.5	EXIT TABLE PROX.SW.
1974 :	SL= THB 1000 = I 11.6	THUMBW. SW. BCD 1000
1993 :	SL= 2OUTP24V = I 11.7	OUTPUT CARD NO:2 (P24V)
2014 :		

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	SYMBOL	ABSOLUTE	OPERAND	COMMENT
0 :	SL= 03-CF	= Q 12.0	CHARG.ROLL.FORW.CONTACTOR.....	(QR-1)
28 :	SL= 03-CR	= Q 12.1	CHARG.ROLL.REV.CONTACTOR.....	(QR-2)
56 :	SL= PL READY	= Q 12.2	INDICATOR:PLATE READY.....	(QR-3)
84 :	SL= 05-CF LS	= Q 12.3	FURN.ROLL.LS FRW CONTACTOR.....	(QR-4)
112 :	SL= 05-CR LS	= Q 12.4	FURN.ROLL.LS REV.CONTACTOR.....	(QR-5)
140 :	SL= 06-C HS	= Q 12.5	FURN.ROLL.HS CONTACTOR.....	(QR-6)
168 :	SL= 07-CF LS	= Q 12.6	DISC.ROLL.LS FORW.CONTACTOR.....	(QR-7)
196 :	SL= 07-CR LS	= Q 12.7	DISC.ROLL.LS REV.CONTACTOR.....	(QR-8)
224 :	SL= 08-C HS	= Q 13.0	DISC.ROLL.HS CONTACTOR.....	(QR-9)
252 :	SL= 09-CF LS	= Q 13.1	EXIT TABLE LS FORW.CONTACTOR.....	(QR-10)
281 :	SL= 09-CR LS	= Q 13.2	EXIT TABLE LS REV.CONTACTOR.....	(QR-11)
310 :	SL= 10-C HS	= Q 13.3	EXIT TABLE HS CONTACTOR.....	(QR-12)
339 :	SL= 11-C TLT	= Q 13.4	TILTING BEAM CONTACTOR.....	(QR-13)
368 :	SL= 13-SVOP	= Q 13.5	ENTRY DOOR OPEN SIND.VALVES.....	(QR-14)
397 :	SL= 13-SVCL	= Q 13.6	ENTRY DOOR CLOSE SIND.VALVES.....	(QR-15)
426 :	SL= 14-SVOP	= Q 13.7	EXIT DOOR OPEN SIND.VALVES.....	(QR-16)
455 :	SL= 14-SVCL	= Q 14.0	EXIT DOOR CLOSE SIND.VALVES.....	(QR-17)
484 :	SL= FAN ON	= Q 14.1	INDICATOR:EXHAUST FAN ON.....	(QR-18)
513 :	SL= FRN RCPR	= Q 14.2	FURN.LS RECIPR. TO INS.PANEL.....	(QR-19)
542 :	SL= ALARM 03	= Q 14.3	ALARM:CHARGING TABLE FORW-PROBL..	(QR-20)
571 :	SL= ALARM 05	= Q 14.4	ALARM:FURNACE ROLLERS LS STOPPED.	(QR-21)
600 :	SL= ALARM05N	= Q 14.5	ALARM:FURNACE ROLLERS LS FAULT...	(QR-22)
629 :	SL= ALARM 06	= Q 14.6	ALARM:FURNACE ROLLERS HS PROBLEM.	(QR-23)
658 :	SL= ALARM 07	= Q 14.7	ALARM:DISCHARGE TABLE LS STOP..	(QR-24)
687 :	SL= ALARM07N	= Q 15.0	ALARM:DISCHARGE TABLE LS NOT STOP	(QR-25)
716 :	SL= ALARM 08	= Q 15.1	ALARM:DISCHARGE TABLE HS PROBLEM.	(QR-26)
745 :	SL= ALARM 09	= Q 15.2	ALARM:EXIT TABLE LS STOPPED.....	(QR-27)
774 :	SL= ALARM 10	= Q 15.3	ALARM:EXIT TABLE HS STOPPED.....	(QR-28)
803 :	SL= ALARM 11	= Q 15.4	ALARM:TILTING BEAM STOPPED.....	(QR-29)
832 :	SL= ALARM 13	= Q 15.5	ALARM:ENTRY DOOR FAULT.....	(QR-30)
861 :	SL= ALARM 14	= Q 15.6	ALARM:EXIT DOOR FAULT.....	(QR-31)
890 :	SL= ALARM DO	= Q 15.7	ALARM:ENTRY&EXIT DOORS LEFT OPEN.	(QR-32)
919 :	SL= ALRM PLC	= Q 16.0	ALARM:PLC & FAN 110VAC OFF.....	(QR-33)
948 :	SL= ALRM INP	= Q 16.1	ALARM:PLC INPUTS 24VDC OFF.....	(QR-34)
977 :	SL= SPARE QR	= Q 16.2	SPARE RELAY.....	(QR-35)
1006 :	SL= ALRM OUT	= Q 16.3	ALARM:PLC OUTPUTS 24VDC OFF.....	(QR-36)
1035 :	SL= ALRM FAN	= Q 16.4	ALARM:PLC FAN NOT RUNNING.....	(QR-37)
1064 :	SL= ALRM TIM	= Q 16.5	ALARM:TREATMENT TIME IS UP.....	(QR-38)
1093 :	SL= SPARE AL	= Q 16.6	ALARM:SPARE.....	(QR-39)
1122 :	SL= PLC 110V	= Q 16.7	INDICATOR:PLC & FAN 110VAC OKEY..	(QR-40)
1151 :	SL= ALI24VDC	= Q 17.0	INDICATOR:ALI I/O 24VDC OKEY.....	(QR-41)
1180 :	SL= FRN LS1	= Q 17.1	INDICATOR:FURNACE CHARGING LS1...	(QR-42)
1209 :	SL= SPARE QR	= Q 17.2	SPARE RELAY.....	(QR-43)
1238 :	SL= SPARE QR	= Q 17.3	SPARE RELAY.....	(QR-44)
1267 :	SL= SPARE QR	= Q 17.4	SPARE RELAY.....	(QR-45)
1296 :	SL= SPARE QR	= Q 17.5	SPARE RELAY.....	(QR-46)
1325 :	SL= SPARE QR	= Q 17.6	SPARE RELAY.....	(QR-47)
1354 :	SL= SPARE QR	= Q 17.7	SPARE RELAY.....	(QR-48)
1383 :	SL= CHR PERM	= Q 18.0	INDICATOR:CHARGING PERMISSION.	
1407 :	SL= FRN FORW	= Q 18.1	INDICATOR:FORW.MOTION IN FURNACE	
1432 :	SL= FRN REV	= Q 18.2	INDICATOR:REV.MOTION IN FURNACE	
1456 :	SL= PLATE IN	= Q 18.3	INDICATOR:FURNACE CHARGED.	
1478 :	SL= FRN HS	= Q 18.4	INDICATOR:FURNACE HI-SPEED	
1500 :	SL= DSC HS	= Q 18.5	INDICATOR:DISCHARGE HI-SPEED	
1523 :	SL= SPARE	= Q 18.6		

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1531 :	SL= EXIT HS = Q 18.7	INDICATOR:EXIT TABLE HI-SPEED
1554 :	SL= DOOR OPN = Q 19.0	INDICATOR:ENTRY DOOR OPEN LSB
1577 :	SL= FAN ON = Q 19.1	INDICATOR:COMBUSTION AIR FAN RUNNING
1604 :	SL= CHR HS = Q 19.2	INDICATOR:CHARGING ROLLERS FORW.HS
1630 :	SL= AUTO = Q 19.3	INDICATOR:AUTO CHAIN
1649 :	SL= TIME UP = Q 19.4	INDICATOR:TREATMENT TIME FINISHED
1674 :	SL= DSC PERM = Q 19.5	INDICATOR:DISCHARGE PERMISSION.
1698 :	SL= SPARE = Q 19.6	
1706 :	SL= WAITING = Q 19.7	INDICATOR:FURNACE IN WAITING STATE.
1732 :		



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SEGMENT 1

```

I-----I
I-----I
I          THIS IS THE COMMENT OF ORGANIZATION BLOCK 1          I
I-----I
I    CALLING AND EXECUTION CONDITIONS OF ALL PROGRAMS ARE CONTROLLED BY    I
I    THIS BLOCK. FB 201 AND PB50 ARE JUMPED CONDITIONALLY. BUT PB3.PB5.    I
I    PB6.PB7.PB8.PB9.PB10.PB11.PB13.PB14.PB15.PB16 ARE UNCONDITIONALLY    I
I    JUMPED. OB1 IS LIKE A TREE OF PROGRAM EXECUTION.                I
I-----I

```

```

0000      :STL
0001      :A   F 0.0          ZERO IS STORED IN F 0.0
0002      :R   F 0.0
0003      :AN  F 0.1          ONE IS STORED IN F 0.1
0004      :S   F 0.1
0005      :
0006      :C   DB10
0007      :***

```

SEGMENT 2

```

0008      :A   -READ PB   I 11.0
0009      :JC   FB200
000A NAME :PULSE
000B IB10 :    IB10
000C DW1  :    DW1
000D DW2  :    DW2
000E DW3  :    DW3
000F DW4  :    DW4
0010 DW5  :    DW5
0011 DW6  :    DW6
0012 DW7  :    DW7
0013 DW8  :    DW8
0014 DW9  :    DW9
0015 DW10 :    DW10
0016 DW11 :    DW11
0017 DW12 :    DW12
0018 DW13 :    DW13
0019 DW14 :    DW14
001A DW15 :    DW15
001B DW16 :    DW16
001C DW17 :    DW17
001D DW18 :    DW18
001E DW19 :    DW19
001F DW20 :    DW20
0020 DW21 :    DW21
0021 DW22 :    DW22
0022 DW23 :    DW23
0023 DW24 :    DW24
0024 DW25 :    DW25
0025 DW26 :    DW26
0026 DW27 :    DW27
0027 FW52 :    FW52

```

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003F :BE

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0 : KH= 0000;
1 : KH= 0012;
2 : KH= 0011;
3 : KH= 0010;
4 : KH= 0009;
5 : KH= 0008;
6 : KH= 0007;
7 : KH= 0006;
8 : KH= 0005;
9 : KH= 0004;
10 : KH= 0060;
11 : KH= 0075;
12 : KH= 0090;
13 : KH= 0105;
14 : KH= 0120;
15 : KH= 0135;
16 : KH= 0150;
17 : KH= 0165;
18 : KH= 0180;
19 : KH= 0120;
20 : KH= 0150;
21 : KH= 0180;
22 : KH= 0210;
23 : KH= 0240;
24 : KH= 0270;
25 : KH= 0300;
26 : KH= 0330;
27 : KH= 0360;
28 : KH= 0100;
29 : KH= 0001;
30 : KH= 0015;
31 : KH= 2400;
32 : KH= 0010;
33 : KH= 0002;
34 : KH= 0100;
35 : KH= 0040;
36 : KH= 0120;
37 :

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SEGMENT 1

```

I-----I
I-----I
I      THIS IS THE COMMENT OF FUNCTION BLOCK 200      I
I-----I
I      PLATE LENGTH READ FROM THUMBWHEEL SW IS PROCESSED AND CORRESPONDING I
I      PULSE NUMBERS TRANSFERRED TO FW 52 & FW 55. PLATE LENGTHS MUST BE I
I      BETWEEN 4-12 METERS. FOR EACH LENGTH. A UNIQUE NUMBER IS STORED AT I
I      DB 10. FB200 IS CALLED. WHEN THE OPERATOR UPDATES THE PLATE LENGTH. I
I-----I

```

NAME :PULSE

```

DECL :IB10      I/Q/D/B/T/C: I  BI/BY/W/D: BY
DECL :DW1       I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW2       I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW3       I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW4       I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW5       I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW6       I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW7       I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW8       I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW9       I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW10      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW11      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW12      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW13      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW14      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW15      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW16      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW17      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW18      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW19      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW20      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW21      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW22      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW23      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW24      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW25      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW26      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :DW27      I/Q/D/B/T/C: I  BI/BY/W/D: W
DECL :FW52      I/Q/D/B/T/C: Q  BI/BY/W/D: W
DECL :FW55      I/Q/D/B/T/C: Q  BI/BY/W/D: W

```

```

005F      :L  IB10
0060      :T  FW51
0061      :L  DW9
0062      :L  FW51
0063      :>F
0064      :JC  =M001
0065      :L  FW51
0066      :L  DW1
0067      :>F
0068      :JC  =M002
0069      :L  FW51
006A      :L  DW1

```

PLATE LENGTH < 4 M

PLATE LENGTH > 12 M

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006B	:!=F	
006C	:JC =M002	PLATE LENGTH = 12 M
006D	:L FW51	
006E	:L DW2	
006F	:!=F	
0070	:JC =M003	PLATE LENGTH = 11 M
0071	:L FW51	
0072	:L DW3	
0073	:!=F	
0074	:JC =M004	PLATE LENGTH = 10 M
0075	:L FW51	
0076	:L DW4	
0077	:!=F	
0078	:JC =M005	PLATE LENGTH = 9 M
0079	:L FW51	
007A	:L DW5	
007B	:!=F	
007C	:JC =M006	PLATE LENGTH = 8 M
007D	:L FW51	
007E	:L DW6	
007F	:!=F	
0080	:JC =M007	PLATE LENGTH = 7 M
0081	:L FW51	
0082	:L DW7	
0083	:!=F	
0084	:JC =M008	PLATE LENGTH = 6 M
0085	:L FW51	
0086	:L DW8	
0087	:!=F	
0088	:JC =M009	PLATE LENGTH = 5 M
0089	:L FW51	
008A	:L DW9	
008B	:!=F	
008C	:JC =M001	PLATE LENGTH = 4 M
008D M002	:L DW10	
008E	:T FW52	
008F	:L DW19	
0090	:T FW55	
0091	:BEU	
0092 M003	:L DW11	
0093	:T FW52	
0094	:L DW20	
0095	:T FW55	
0096	:BEU	
0097 M004	:L DW12	
0098	:T FW52	
0099	:L DW21	
009A	:T FW55	
009B	:BEU	
009C M005	:L DW13	
009D	:T FW52	
009E	:L DW22	
009F	:T FW55	
00A0	:BEU	
00A1 M006	:L DW14	
00A2	:T FW52	

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00A3	:L	DW23
00A4	:T	FW55
00A5	:BEU	
00A6 M007	:L	DW15
00A7	:T	FW52
00A8	:L	DW24
00A9	:T	FW55
00AA	:BEU	
00AB M008	:L	DW16
00AC	:T	FW52
00AD	:L	DW25
00AE	:T	FW55
00AF	:BEU	
00B0 M009	:L	DW17
00B1	:T	FW52
00B2	:L	DW26
00B3	:T	FW55
00B4	:BEU	
00B5 M001	:L	DW18
00B6	:T	FW52
00B7	:L	DW27
00B8	:T	FW55
00B9	:BF	

HOT STRIP MILL PLATE NORMALIZING FURNACE PLC PROGRAM LISTS

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```

I-----I
I-----I
I          THIS IS THE COMMENT OF PROGRAM BLOCK 50          I
I-----I
I    B C D (BINARY CODED DECIMAL) OUTPUT OF THE DIGITAL TIMER (CLOCK) IS    I
I    CHECKED OUT AT THIS BLOCK. WHETHER THE TIMER IS AT 10 MIN. OR ZERO      I
I    MIN. WHEN THE TIMER COMES DOWN TO THE ABOVE PREDETERMINED VALUES.      I
I    RELATED FLAGS (F 2.2 -F 2.5) ARE SET.                                I
I-----I

```

```

0000      :STL
0001      :L   IW8          LOAD DIGITAL CLOCK IN BCD.
0002      :L   DW29        LOAD ACCUMULATOR WITH 0 MIN.
0003      :!=F            COMPARE IF THEY ARE EQUAL.
0004      :=   F 2.2       TREATMENT TIME IS UP.
0005      :L   IW8          LOAD DIGITAL CLOCK IN BCD.
0006      :L   DW28        LOAD ACCUMULATOR WITH 10 MIN.
0007      :!=F            COMPARE IF EQUAL.
0008      :=   F 2.5       10 MIN LEFT TO DISCHARGING.
0009      :***

```

SEGMENT 2

000A :***

SEGMENT 3

000B :***

SEGMENT 4

000C :***

SEGMENT 5

000D :BE

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EMERGENCY STOP.

:BE

160

SEGMENT 5 001D

OFF-DELAY FROM ENTRY DOOR.

! T 39

!F 3.7

+---| |---+!O!-!T!

!KT 005.1 --!TV BI!-

! DE!-

! !

! !

! !

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SEGMENT 6 0027

ON-DELAY FROM REV. TO FORW.

! T 8

!F 8.5

+---| |---+!T!-!O!

!KT 005.2 --!TV BI!-

! DE!-

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SEGMENT 7 0031

REV. CONTACTOR RELEASED.

! T 63

!-05AUTO-R F 8.5

+---| |---+!T!-!O!

!KT 001.2 --!TV BI!-

! DE!-

! !

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05AUTO-R= I 1.6 FURN. ROL. LS AUTO-REV.S.S. (IR-15)

05-CR = I 2.0 FURN. ROL. LS 05-CR.(IR-17)

SEGMENT 8 003D

ON-DELAY FROM FORW. TO REV.

! T 9

!F 8.4

+---| |---+!T!-!O!

!KT 005.2 --!TV BI!-

! DE!-

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HOT STRIP MILL PLATE NORMALIZING FURNACE PLC PROGRAM LISTS

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SEGMENT 9 0047 FORW. CONTACTOR RELEASED.

```

!
! T 62
!-05-AUTO-F F 8.4 -----
+---| |---+---| |---+!T!-!O!
!           KT 001.2 --!TV BI!-
!           ! DE!-
!           !
!-05-CF           ! F 24.7
+---| |---+---+!R Q!+-----+---( )--!
!
!

```

05-AUTO-F= I 1.5 FURN. ROL. LS AUTO-FORW.S.S. (IR-14)
 05-CF = I 1.7 FURN. ROL. LS 05-CF.(IR-16)

SEGMENT 10 0053 FORWARD CONTACTOR (05-CF)QR-4

```

!
! F 20.2 F 8.4 -05-CF LS
+---| |---+---| |---+-----+---( )--!
!

```

05-CF LS= Q 12.3 FURN.ROLL.LS FRW CONTACTOR.....(QR-4)

SEGMENT 11 0057 REVERSE CONTACTOR (05-CR)QR-5

```

!
! F 20.2 F 8.5 -05-CR LS
+---| |---+---| |---+-----+---( )--!
!

```

05-CR LS= Q 12.4 FURN.ROLL.LS REV.CONTACTOR.....(QR-5)

SEGMENT 12 005B ON-DELAY FROM HS TO LS MOTOR.

```

!
! T 7
! F 8.6 -----
+---| |---+---| |---+!T!-!O!
!           KT 004.2 --!TV BI!-
!           ! DE!-
!           !
!           !
!           ! F 4.6
!           +!R Q!+-----+---( )--!
!
!

```

SEGMENT 13 0065 HS CONTACTOR RELEASED.

```

!
! T 3
!-06-AUTO F 8.6 -----
+---| |---+---| |---+!T!-!O!
!           KT 001.2 --!TV BI!-
!           ! DE!-
!           !
!-06-C           ! F 25.1
+---| |---+---+!R Q!+-----+---( )--!
!
!

```

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F 3.2

T 11

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SEGMENT 23 00E5
! C 2

```

!-FRM PROX -----
+---] [---+ !CD !
!
!
!
! +!CU
!
!F 5.0 !
+---] [---+ !S !
!
!
!--LOADCEL1! !
+---] [---+ !
!FW 52 --!CV BI--
! DE!
!F 5.0 !
+---] [---+ !R Q!
-----
!F 8.6 !
+---] [---+
!
!--RESET-1 !
+---] [---+
!
!--LOADCEL2!
+---] [---+
!
```

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```

!      T 23
!F 9.1   -08-C -----
+---| |---+---| |---+ !T!-!O!
!           KT 005.2 --!TV BI!-
!               ! DE!-
!               ! 
!               ! 
!               ! 
!               ! F 11.4
+---!R Q!+-----+-----+-----+-----+-----( )--!
!               -----
!
!                                     :BE

```

08-C = I 3.2 DISC. TABLE HS 08-C. (IR-27)

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SEGMENT 8 003B

LS CONTACTORS RELEASED.

```

!
!                                T 34
!-05AUTO-F -05AUTO-R F 8.4    F 8.5    -----
+---1 [---+---1 [---+---1/1---+---1/1---+!T!-!O!
!                                KT 001.2 --!TV BI!-
!                                !    DE!-
!                                !    !
!-05-CF      -05-CR            !    !
+---1/1---+---1/1---+-----+---!R  Q!+-----+---F 25.3
!                                -----
!
!
!
!                                :BE
!

```

```

05AUTO-F= I 1.5    FURN. ROL. LS AUTO-FORW.S.S. (IR-14)
05AUTO-R= I 1.6    FURN. ROL. LS AUTO-REV.S.S. (IR-15)
05-CF   = I 1.7    FURN. ROL. LS 05-CF.(IR-16)
05-CR   = I 2.0    FURN. ROL. LS 05-CR.(IR-17)

```

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SEGMENT 1 0000

DISCHARGING ROLLERS LS FORWARD.

```

I-----J
I-----J
I      THIS IS THE COMMENT OF PROGRAM BLOCK 7      I
I-----J
I      IN THIS PB. LS COOLING OF THE DISCHARGED PLATES ARE PERFORMED VIA
I      RECIPROCATING THEM WITH THE AID OF PROX SW PULSES. DRIVE GROUP IS
I      THE SAME AS THE FURNACE LS-HS COUPLING.ROLLERS ALWAYS RECIPROCATES
I      EXCEPT HS RUNNING. AGAIN WE'VE USED COUNTERS FOR PULSE COUNTING:
I      C 3 (F10.5) FOR REVERSE MOTION AND C 4 (F 10.4) FOR FORWARD MOTION.
I      NORMALIZED PLATES ARE COOLED DOWN TO A FEW HUNDRED C ON THIS TABLE.
I      MOTION CONTROL IS AN OPEN-LOOP,BECAUSE NO FEEDBACK EXIST ON PLATE'S
I      POSITION.
I-----J

```

```

!-07AUTO-F F 11.7 F 7.0 F 9.1 F 27.3 -LS10 F 8.7
+---1|---+---1|---+---1|---+---1|/---+---1|/---+---1|/---+---( )---!
!

```

```

07AUTO-F= I 2.5 DISC. TABLE LS AUTO-FORW.S.S.(IR-22)
LS10 = I 5.6 EXIT DOOR OPEN HI-LS10.(IR-47)

```

SEGMENT 2 0008 DISCHARGING ROLLERS LS REVERSE.

```

!-07AUTO-R F 12.0 F 7.1 F 9.1 -LS10 F 9.0
+---1|---+---1|---+---1|---+---1|/---+---1|/---+---+---( )---!
!

```

```

07AUTO-R= I 2.6 DISC. TABLE LS AUTO-REV.S.S.(IR-23)
LS10 = I 5.6 EXIT DOOR OPEN HI-LS10.(IR-47)

```

SEGMENT 3 000F INTERLOCK FOR FORWARD SEQUENCE.

```

!F 33.3 F 9.4 F 26.5 F 10.4 F 11.7
+---1|---+---1|/---+---1|/---+---1|---+---+---+---( )---!
!

```

SEGMENT 4 0015 INTERLOCK FOR REVERSE SEQUENCE.

```

!F 33.3 F 26.4 F 27.3 F 10.5 F 12.0
+---1|---+---1|/---+---1|/---+---1|---+---+---+---( )---!
!

```

SEGMENT 5 001B INTERLOCK FOR BOTH DIRECTIONS.

```

!F 6.0 F 7.2 F 11.3 F 3.2 F 12.3 F 33.3
+---1|/---+---1|---+---1|/---+---1|---+---1|/---+---+---( )---!
!

```

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[illegible]

07-CF LS= 0 12.6 DISC.ROLL.LS FORM.CONTACTOR.....(QR-7)

```
SEGMENT 7      0026          REVERSE CONTACTOR ( 07-CR ) QR-8  
!  
!F 20.2   F 9.0                                     -07-CR LS  
+---| |---+---| |-----+-----+-----+-----+-----+-----( )--!  
!
```

07-CR LS= Q 12.7 DISC.ROLL.LS REV.CONTACTOR.....(QR-8)

```

SEGMENT 8      002A          ON-DELAY FROM REV. TO FORM.
!               T 18
!F 9.0         -----
+---1/1---+!T!-!O!
!KT 006.2 --!TV BI!-
!              ! DE!-
!              !
!              !
!              !
!              !
!              !
!              F 7.0
+!E Q!+-----+-----+-----+-----+-----+-----+-----+-----+-----+

```

```

SEGMENT 9      0034      REV. CONTACTOR RELEASED.
      T 37
!-07AUTO-R F 9.0      -----
+---1 1---+---1/1---+!T!-!0!
      KT 002.2 --!TV BI!-
      ! DE!-
      ! !
!-07-CR      ! !      F 26.5
+---1/1---+---+!R Q!+-----+-----+-----+-----+---( )---!

```

07AUTO-R= I 2.6 DISC. TABLE LS AUTO-REV.S.S.(IR-23)
07-CR = I 3.0 DISC. TABLE LS 07-CR.(IR-25)

[illegible]

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SEGMENT 11 004A FORW. CONTACTOR RELEASED.

```

!-----T 4-----
|-07AUTO-F F 8.7-----
+---1|---+---1/I---+!T!-!O!
!KT 002.2--!TV BI!--
!DE!--
!
!-07-CF!F 26.4
+---1/I---+---+!R Q!+---+---+---+---( )---+
!-----

```

07AUTO-F= I 2.5 DISC. TABLE LS AUTO-FORM.S.S.(IR-22)
07-CF = I 2.7 DISC. TABLE LS 07-CF.(IR-24)

SEGMENT 12 0056 ON-DELAY FROM HS TO LS MOTOR.

T 20

F 9.1 -----
+---1/1---+-!T!-!O!
!KT 005.2 --!TV BI!--
 ! DE!--
 !
 !
 !

+--!R Q!-----F 7.2
 ()--!

SEGMENT 13 0060 HS CONTACTOR RELEASED.

```

T      38
!-03-AUTO F 9.1 -----
+---| |-----| |-----|T|-10|
          KT 002.2 --|TV BI|--
                        DE|--
!-08-C              !           !                               F 27.3
+---| |-----+---|R Q|-----+-----+-----+-----+-----( )-----+

```

08-AUTO = I 3.3 DISC. TABLE HS AUTO S.S. (IR-28)
08-C = I 3.2 DISC. TABLE HS 08-C. (IR-27)

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SEGMENT 14 006C REVERSE MOTION DOWN-COUNTER.

```

!
!-DSC PROX          C 3
+---|/|---+-----+!CD !
!
!
!          +---!CU !
!
!F 10.4   F 9.1   !
+---|/|---+---|/|---+!S !
!
!-RESET-2          !
+---| |---+-----+ !
!
!          FW 52   --!CV BI!-
!                  !  DE!-
!
!F 9.1   -RESET-2   !
+---| |---+---|/|---+!R  Q!+-----+-----+-----+-----+---( )---!
!
!F 10.4   !
+---| |---+
!
!

```

DSC PROX= I 11.4 DISCHARGE PROX.SW.
 RESET-2 = I 0.2 COOLING TABLES RESET P.B. (IR-3)

SEGMENT 15 007F SET FOR FORWARD DOWN-COUNTER.

```

!
! T 22
!F 10.5   -----
+---|/|---+!T!-!O!
!KT 005.1 --!TV BI!-
!          !  DE!-
!
!
!
!
!          +---!R  Q!+-----+-----+-----+-----+---( )---!
!
!

```

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SEGMENT 1 0000

DISCHARGING ROLLERS HS RUNNING.

PAGE 1

THIS IS THE COMMENT OF PROGRAM BLOCK 8

DISCHARGE HS CONTROL IS PROGRAMMED IN THIS PB. DISCHARGE TABLE RUNS DURING PLATE DISCHARGING AND TRANSFER FROM DISCHARGE TO EXIT TABLE. DISCHARGING IS CONTROLLED BY A TIMER(T 25) AS AN OPEN LOOP. SEQUENCE IS AS FOLLOWS: F 11.2(PB14)-F 11.3(PB14)-F 11.5(PB8). TABLE SPEED IS 1500/30 = 50 RPM AT HS. ROLLERS TURN ONLY IN FORWARD DIRECTION.

```

!-08-AUTO F 11.5 F 6.7 -11-C F 25.4 F 21.4 F 9.1
+---| |---+---| |---+---| |---+---| |---+---| |---+---( )---!
      !
      !F 6.0 !
      +---| |---+
      !
      !F 12.4 !
      +---| |---+

```

08-AUTO = I 3.3 DISC. TABLE HS AUTO S.S. (IR-28)
11-C = I 4.6 TILTING BEAM 11-C. (IR-39)

SEGMENT 2 000C HS CONTACTOR (08-C) 0R-9

F 30.2 F 9.1 -08-C HS
+---| |---+---| |---+---+---+---+---+---()---!

08-C HS= 0 13.0 DISC.ROLL.HS CONTACTOR.....(08-9)

SEGMENT 3 0010 ON-DELAY FROM LS TO HS MOTOR.

```

T      17
F 8.7   F 9.0 -----
+---I/I--+---I/I--+!T!--O!
KT 003.2--!TV BI!--
            !DE!--
            !    !
            +!R Q!-----+-----+-----+-----+----( )---!

```

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T 36

07AUTO-F= I	2.5	DISC. TABLE LS AUTO-FORM.S.S.(IR-22)
07AUTO-R= I	2.6	DISC. TABLE LS AUTO-REV.S.S.(IR-23)
07-CF = I	2.7	DISC. TABLE LS 07-CF.(IR-24)
07-CR = I	3.0	DISC. TABLE LS 07-CR.(IR-25)

T 25

```
LS10      = I  5.6   EXIT DOOR OPEN HI-LS10.(IR-47)
14-AUTO   = I  6.0   EXIT DOOR AUTO S.S.(IR-49)
```

:BE

78

09-CR LS= Q 13.2 EXIT TABLE IS REV.CONTACTOR.....(QR-11)

SEGMENT 6 0024

ON-DELAY FROM FORM. TO REV.

! T 12

!F 9.2 -----

+---1/1---+!T!-!0!

!KT 004.2 --!TV BI!-

! DE!-

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F 6.1

()--!

SEGMENT 7 002E

FORM. CONTACTOR RELEASED.

! T 44

!-09AUTO-F F 9.2 -----

+---1/1---+!T!-!0!

! KT 002.2 --!TV BI!-

! DE!-

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F 28.2

()--!

09AUTO-F= I 3.5 EXIT ROL. LS AUTO-FORM.(IR-30)

09-CF = I 3.7 EXIT ROL. LS 09-CF.(IR-32)

SEGMENT 8 003A

ON-DELAY FROM REV. TO FORM.

! T 13

!F 9.3 -----

+---1/1---+!T!-!0!

!KT 004.2 --!TV BI!-

! DE!-

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F 6.2

()--!

SEGMENT 9 0044

REV. CONTACTOR RELEASED.

! T 45

!-09AUTO-R F 9.3 -----

+---1/1---+!T!-!0!

! KT 002.2 --!TV BI!-

! DE!-

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F 28.3

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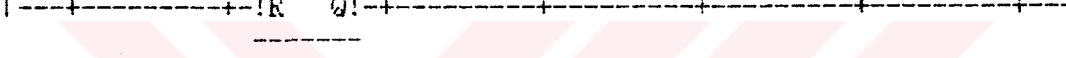
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SEGMENT 10 0050 ON-DELAY FROM HS TO LS MOTOR.
! T 33

```
!F 9.4 -----
+---|/|---+!T!-!O!
!KT 004.2 --!TV BI!-
!           ! DE!-
!           !     !
!           !     !
!           !     !
!           !     !
!           !     !
!           +-----+-----+-----+-----+-----+-----+
!R Q!-----+-----+-----+-----+-----+-----+-----+-----+-----+
!                                           F 14.0
```

SEGMENT 11 005A HS CONTACTOR RELEASED.
T 59

!-10-AUTO F 9.4
+---| |---+---|/Γ---+-!T!-!O!
! KT 001.2 --!TV BI!--
! ! DE!--
! !
! -10-C ! ! F 14.6
+---|/Γ---+---+---R Q!--+-----+()--!



10-AUTO = I 4.2 EXIT ROL. HS AUTO S.S. (IR-35)
10-C = I 4.3 EXIT ROL. HS 10-C. (IR-36)

```

SEGMENT 12      0066      REVERSE MOTION DOWN-COUNTER.
1         6      5

```

[illegible]

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```
RESET-2 = I 0.2 COOLING TABLES RESET P.B. (IR-3)
END LS3 = I 4.4 EXIT ROL. END LS3. (IR-37)
```

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SEGMENT 1 0000 EXIT TABLE HS RUN.

```

I-----I
I-----I
I      THIS IS THE COMMENT OF PROGRAM BLOCK 10      I
I-----I
I      IN THIS PB, HS CONTROL OF EXIT TABLE IS WRITTEN. HS MOTOR RUNS FOR I
I      ONLY PLATE TRANSFER FROM DISCHARGE TABLE TO EXIT TABLE. THERE EXIST I
I      TWO CONDITIONS:1- WHEN PLATE EXIST ON THE TABLE. 2- OR NOT EXIST ON I
I      TABLE. FOR THE 1ST CONDITION, F 12.2 (PB10) -F 12.6 (PB10)- F 12.3 I
I      (PB10) -F 12.4 (PB10) SEQUENCE COMES. FOR THE 2ND CONDITION, F 24.3 I
I      (PB10) -F 5.7 (PB10) -F 6.0 (PB10) SEQUENCE EXISTS. WHEN THE EDGE I
I      OF THE PLATE TOUCHES THE END LS3, HS IS STOPPED. TABLE SPEED IS I
I      1500/30=50 RPM. I
I-----I

```

```

!-10-AUTO F 6.0 F 6.4 -TIL LS7 -END LS3 -11-C F 25.6 F 9.4
+---1|---+---1|---+---1|---+---1|---+---1|---+---1|---+---( )---!
!
!      !F 12.4 !
!      +---1|---+
!

```

10-AUTO = I 4.2 EXIT ROL. HS AUTO S.S.(IR-35)
 TIL LS7 = I 5.0 TILTING BEAM LS7.(IR-41)
 END LS3 = I 4.4 EXIT ROL. END LS3.(IR-37)
 11-C = I 4.6 TILTING BEAM 11-C.(IR-39)

SEGMENT 2 000C HS INTERLOCK.

```

!F 21.4 F 25.5 F 25.6
+---1|---+---1|---+---+---+---+---+---+---+---( )---!
!

```

SEGMENT 3 0010 HS CONTACTOR (10-C) QR-12

```

!F 20.2 F 9.4 -10-C HS
+---1|---+---1|---+---+---+---+---+---+---+---( )---!
!

```

10-C HS= Q 13.3 EXIT TABLE HS CONTACTOR.....(QR-12)

SEGMENT 4 0014 10 MINUTES LEFT FOR DISCHARGING.

```

!      F 24.3
!-END LS3 F 2.1 F 6.0 -10-AUTO -----
+---1|---+---1|---+---1|---+---1|---+---1|---+---!S !
!
!F 6.0 !
+---1|---+---+---+---+---+---+---+---+---!R Q!-
!
!-END LS3 !
+---1|---+
!

```

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END LS3 = I 4.4 EXIT ROI. END LS3.(IR-37)

```

SEGMENT 8      0040      AFTER AUTO-TILTING, FLIP-FLOP SET
!
!F 9.5      -11-C      -11-AUTO      -----
+---| |---+---| |---+---| |---+ |S      !
!
!F 9.5
+---| |---+---+---+---+ |R      Q!-
!
!
!

```

11-C = I 4.6 TILTING BEAM 11-C.(IR-39)
11-AUTO = I 4.7 TILTING BEAM AUTO S.S.(IR-40)

```

SEGMENT 9      0048      ON-DELAY AFTER TILTING OPERATION
!              T 26
!F 12.2 -END LS3 -----
+---| [---+---|/T---+!T!-!O!
!              KT 005.1 --!TV BI!--
!                  DE!--
!                  !
!                  !
!                  !
!                  +!R Q!+-----+-----+-----+-----+ F 12.6
!                      ( )--!

```

END LS3 = I 4.4 EXIT ROL. END LS3. (IR-37)

```

SEGMENT 10      0053      AFTER KICK-OFF.RUN BOTH TBLS HS.
!              T  27
!F  12.6      -----
+---| |---+!T!-!S!
!KT 003.2  --!TV BI!-
!              DE!-
!              !
!-END LS3      !              F  12.3
+---| |---+!R  Q!+-----+-----+-----+-----+-----+-----+
!              !              ( )-!
!F  15.0      !
+---| |---+
!
!

```

END LS3 = I 4.4 EXIT ROL. END LS3. (IR-37)

```

SEGMENT 11      005F              DISCH. & EXIT TABLES RUN HS.
!
! F 12.3   -TIL LS7                      F 12.4
+---| |---+---| / |---+---+---+---+---+---+---+---+---( )---!
!
```

TIL LS7 = I 5.0 TILTING BEAM LS7.(IR-41)

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SEGMENT 12 0063 ON-DELAY FROM LS TO HS MOTOR.

```

!
! T 15
!F 9.2 F 9.3 -----
+---|/|---+---|/|---+!T!-!0!
! KT 003.2 --!TV BI!-
! DR!-
!
!
! F 6.4
+---|/|---+---|/|---+!R Q!+-----+---( )---!
!
!

```

SEGMENT 13 006E LS CONTACTORS RELEASED.

```

!
! T 36
!-09AUTO-F -09AUTO-R F 9.2 F 9.3 -----
+---|/|---+---|/|---+!T!-!0!
! KT 001.2 --!TV BI!-
! DE!-
!
!
! -09-CF -09-CR F 25.5
+---|/|---+---|/|---+!R Q!+-----+---( )---!
!
!

```

09AUTO-F= I 3.5 EXIT ROL. LS AUTO-FORM.(IR-30)
 09AUTO-R= I 3.6 EXIT ROL. LS AUTO-REV.(IR-31)
 09-CF = I 3.7 EXIT ROL. LS 09-CF.(IR-32)
 09-CR = I 4.0 EXIT ROL. LS 09-CR.(IR-33)

SEGMENT 14 007D IF NO PLATE ON DISC TBL.STOP HS.

```

!
! T 32
!F 12.4
+---|/|---+!T!-!0!
! KT 060.2 --!TV BI!-
! DE!-
!
!
! F 15.0
+---|/|---+---|/|---+!R Q!+-----+---( )---!
!
!

```

SEGMENT 15 0087 10 MIN. LEFT TO DISCHARGING.

```

!
! F 13.1
!F 2.1 F 2.5 -----
+---|/|---+---|/|---+!S !
!
!
!F 2.1
+---|/|---+---|/|---+!R Q!-
!
!
!F 2.5
+---|/|---+
!
!

```

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SEGMENT 5 0013 CHARGING PERMISSION SEQUENCE.

[illegible]

CENT LS4= I 1.2 CENTERING BACK LS4. (IR-11)
 READ PB = I 11.0 READ THUMBW. SW.P.B.
 RESET-1 = I 0.1 FURNACE RESET P.B. (IR-2)

SEGMENT 6 0020 CHARGING PERMISSION'S INTERLOCK.

!-LS11 F 2.1 F 22.4

LS11 = I 5.7 EXIT DOOR CLOSE LO-LS11.(IR-48)

SEGMENT 7 0024 DISCHARGE FEEDBACK FOR AUTO-CHAR

[illegible]

```
LS10      = I  5.6   EXIT DOOR OPEN HI-LS10.(IR-47)
06-C      = I  2.3   FURN. ROL. HS 06C.(IR-20)
06-AUTO   = I  2.2   FURN. ROL. HS AUTO S.S.(IR-19)
08-C      = I  3.2   DISC. TABLE HS 08-C.(IR-27)
08-AUTO   = I  3.3   DISC. TABLE HS AUTO S.S.(IR-28)
```

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SEGMENT 8 0039

FOR CHARGE PERMISSION INTERLOCK.

F 6.5

IF 3.5

```

+---| |-----+!S      !
|           |         !
|-RESET-1-|         !
+---| |-----+         !
|           |         !
!F 8.6    F 8.0    F 4.5   !
+---| |-----| |-----| |-----+!R Q!-

```

RESET-1 = I 0.1 FURNACE RESET P.B. (IR-2)

SEGMENT 9 0042

ENTRY DOOR OPENING INTEELOCK.

F 3.6

1-FL READY

```

+---1 |-----+-----+-----+!S      !
|                                     |    |
!F 4.5   F 8.0   F 8.6             :    | F 19.4                       F 3.7
+---1 |-----+---1 |-----+---1 |----+!R Q!+---1 |-----+-----+---( )---!
|                                     |    |
!-RESET-1                          :    |
+---1 |-----+-----+-----+

```

PL READY= I 1.1 PLATE READY (IR-10)

RESET-1 = I 0.1 FURNACE RESET P.B. (IR-2)

SEGMENT 10 004F

ON-DELAY FOR ENTRY DOOR CLOSE.

E-1 35

!F 2.3

+---1/5---+---!T!-!O!
 !KT 028.2 --!TV BI!-
 ! : DE!-

[illegible]

137

HOT STRIP MILL PLATE NORMALIZING FURNACE PLC PROGRAM LISTS

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SEGMENT 1 0000 EXIT DOOR OPENING.

THIS IS THE COMMENT OF PROGRAM BLOCK 14

EXIT DOOR CONTROL IS WRITTEN ON THIS PB. EXIT DOOR IS OPENED, WHEN THE CHARGE IS NORMALIZED. VIA SOLENOID VALVES. OPENING AND CLOSING OPERATIONS ARE PERFORMED. WE HAVE 3 LIMIT SWITCHES FOR UPPER AND LOWER POSITIONS OF THE DOOR.(LS10, LS11, LS13). PROGRAM SEQUENCE IS FOLLOWS: F 11.2(PB14)- F 11.3(PB14).

```

-14-AUTO F 11.3 F 9.5 F 6.0 F 12.4 F 1.2 -LS10 F 1.1
+---| |---+---| |---+---|/|---+---|/|---+---|/|---+---|/|---+---|/|---+---( )---!
|

```

```
14-AUTO = I 6.0 EXIT DOOR AUTO S.S.(IR-49)
LS10    = I 5.6 EXIT DOOR OPEN HI-LS10.(IR-47)
```

SEGMENT 2 0009 EXIT DOOR CLOSING.

```
!-14-AUTO F 11.5 F 28.1 F 1.1 -LE11 F 1.2  
+---| |---+---| |---+---| |---+---| |---+---+---+---+---( )---!  
!
```

```
14-AUTO = I 6.0 EXIT DOOR AUTO S.S.(IR-49)
LS11    = I 5.7 EXIT DOOR CLOSE LO-LS11.(IR-48)
```

SEGMENT 3 0010 ON-DELAY FROM OPEN TO CLOSE.

```

T 81
F 1.1
+---1/5---+T!-10!
KT 008.2 --TV BI:-
            DE:-
                                                    F 28.1
+!R Q!+-----+-----+-----+-----+-----+-----+

```

SEGMENT 4 001A OPEN SLN VALVE(14-SVOP) QR-16

!F 20.2 F 1.1 -14-SVOP
+---| |-----| |-----+-----+-----+-----+-----()--!

14-SVOP = Q 13.7 EXIT DOOR OPEN SLND.VALVES.....(QR-16)

SEGMENT 5 001E CLS SLN VALVES(14-SVCL1/2) QR-17

```
!F 20.2 F 1.2 -14-SVCL  
+---| |---+---| |---+---+---+---+---+---+---+---+---( )--!
```

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SEGMENT 4 001D

FURN. LS FORW. CONT. NOT PULLED.

! T 60

!F 8.4

+---| |---+!T!-!0!

!KT 015.1 --!TV BI!-

! DE!-

!-05-CF

!-05-CF

+---| |---+!R Q!+

F 24.4

()--!

05-CF = I 1.7 FURN. ROL. LS 05-CF.(IR-16)

SEGMENT 5 0028

FURN. LS REV. CONT. NOT PULLED.

! T 61

!F 8.5

+---| |---+!T!-!0!

!KT 015.1 --!TV BI!-

! DE!-

!-05-CR

!-05-CR

+---| |---+!R Q!+

F 24.5

()--!

05-CR = I 2.0 FURN. ROL. LS 05-CR.(IR-17)

SEGMENT 6 0033

FURN. LS MOTION DETECTOR.

!F 8.4

+---| |---+!F 24.4

F 17.3

+---| |---+!F 8.5

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

+---| |---+!F 17.3

+---| |---+!F 24.5

HOT STRIP MILL PLATE NORMALIZING FURNACE PLC PROGRAM LISTS

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ALARM:FURNACE ROLLERS LS STOPPED

----- () -----!

[illegible]

ALARM 05= Q 14.4 ALARM: FURNACE ROLLERS LS STOPPED. (QR-21)

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SEGMENT 21 00E7 DISC. LS MOTION DETECTOR.

```

!F 8.7      F 26.7                                F 17.7
+---| |---+---|/|---+-----+-----+-----+-----+---( )---!
!F 9.0      F 27.0 !
+---| |---+---|/|---+

```

SEGMENT 22 00E8 DISC. LS PULLED. BUT NO MOTION.

```

!      T 42
!F 17.7
+---| |---+!T!-!0!
!-07-CF ! ! !
+---| |---+ ! ! !
!-07-CR ! ! !
+---| |---+ ! ! !
!KT 002.2 --!TV BI!-
!      ! DE!-
!-DSC PROX ! !
+---| |---+!R Q!+-----+-----+-----+-----+---( )---!

```

07-CF = I 2.7 DISC. TABLE LS 07-CF.(IR-24)
 07-CR = I 3.0 DISC. TABLE LS 07-CR.(IR-25)
 DSC PROX= I 11.4 DISCHARGE PROX.SW.

SEGMENT 23 00F8 DISC. LS PULLED BUT NO MOTION.

```

!      T 43
!F 17.7
+---| |---+!T!-!0!
!-07-CF ! ! !
+---| |---+ ! ! !
!-07-CR ! ! !
+---| |---+ ! ! !
!KT 002.2 --!TV BI!-
!      ! DE!-
!-DSC PROX ! !
+---|/|---+!R Q!+-----+-----+-----+-----+---( )---!

```

07-CF = I 2.7 DISC. TABLE LS 07-CF.(IR-24)

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07-CR = I 3.0 DISC. TABLE LS 07-CR.(IR-25)
DSC PROX= I 11.4 DISCHARGE PROX.SW.

SEGMENT 24 0108 DISC.IS TO HS DELAY.

T 53

IF 17.7

+---] / [---+-----+---!T!-!O!

! KT 010.2 --!TV BI!-

! ! DE!-

! ! !

!F 9.1 -08-C ! ! F 23.6

+---+ [---+---] | ---+-!R Q!-+-----+-----+-----+-----+----()--!

08-C = I 3.2 DISC. TABLE HS 08-C.(IR-27)

SEGMENT 25 0114 DICH.NS TO LS DELAY.

! T 87

!F 9.1 -08-C

$+\dots 1/\Gamma \dots + \dots 1/\Gamma \dots + \dots !T! \dots !O!$

! KT 010.2 --!TV BI!-

! DE!-

[illegible]

!F 8.7 ! ! F 25.7

+---7 | |---+-----+-!R Q!-+-----+-----+-----+----()--!

[illegible]

MF 9.0

$\frac{1}{\sqrt{2}} \begin{pmatrix} 1 & -i \\ 0 & 1 \end{pmatrix}$

08-C = I 3.2 DISC. TABLE HS 08-C. (IR-27)

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-ALARM 07

$$+ \cdots + I - \cdots + \cdots + \cdots + R$$
$$+ \cdots + \frac{1}{r} \cdots +$$
$$+ \dots 1/5 \dots + \dots$$

+---1/1---+---+---+---+

+--- 1/5 ---+

-----1/1-----

$$+ \cdots \} \{ \cdots + \cdots \} \{ \cdots + \cdots$$
[illegible]
$$+ \cdots - 1 \quad 1 - \cdots +$$

$\begin{array}{c} + \text{---} | \text{---} + \\ \text{---} \end{array}$

+- - - 7 [- - - +

-----77-----

+---+ | +---+

+---1/5---+

+---7/1---+

LS STOP..(QR-24)

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SEGMENT 27 013B

ALARM:DISCH.ROLL.IS FAULTY OP.

! -ALARM07N

!F 26.4

+---1/I---+!R !

!F 26.5

+---1/I---+ !

!F 26.4

+---1/I---+!S Q!

F 27.1

+---1/I---+ !

!F 26.5

+---1/I---+ !

ALARM07N= Q 15.0 ALARM:DISCHARGE TABLE LS NOT STOP(QR-25)

SEGMENT 28 0144

DISC. HS CONT.NOT PULLED.

! T 70

!F 9.1

+---1/I---+!T!-!O!

!KT 001.2 --!TV BI!-

! DE!-

!-08-C

+---1/I---+!R Q!

F 27.2

+---1/I---+ !

08-C = I 3.2 DISC. TABLE HS 08-C.(IR-27)

SEGMENT 29 014F

DISC. HS PULLED BUT NO MOTION.

! T 56

!F 9.1 F 27.2

+---1/I---+!T!-!O!

!-08-C

+---1/I---+ !

!KT 015.1 --!TV BI!-

! DE!-

!-DSC PROX

+---1/I---+!R Q!

F 14.3

+---1/I---+ !

08-C = I 3.2 DISC. TABLE HS 08-C.(IR-27)

DSC PROX= I 11.4 DISCHARGE PROX.SW.

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EXIT LS CONT.PUL'D BUT NO MOTION

+---()--!

EXT PROX= I 11.5 EXIT TABLE PROX.SW.

+-+-()-+!

11-C = I 4.6 TILTING BEAM 11-C.(IR-39)

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SEGMENT 43 0200

EXIT TABLE HS NOT PULLED.

! T 58

!F 9.4

+---7 {---+-!T!-!O!

!KT 001.2 --!TV BI!-

! ! DE!-

! ! !

!-10-C ! !

F 14.5

+---1 | ---+!R Q!-+-+-----+-----+-----+-----+----()--!

10-C = I 4.3 EXIT ROL. HS 10-C.(IR-36)

SEGMENT 44

EXIT HS PUL'D BUT NO MOTION.

! T 82

!F 9.4 F 14.5

+-+1 [-++-+]/[-++-!T!-!O!

! ! !

-10-C ! ! - !

+-+ | | -+-----+ ! !

KT 015.1 --!TV BI!

! ! DE!

F 28.4

100-443887-100

10-C = I 4.3 EXIT ROL. HS 10-C. (IR-36)

```
EXT PROX= I 11.5 EXIT TABLE PROX.SW.
```

SEGMENT 45

EXIT HS PUL'D BUT NO MOTION.

T 83

!F 9.4 F 14.5

+-+--+ | -+--+--+ | / [-+--+--+ !T! -!O!

! ! !

!-10-C ! ! !

+-+-+ | | - - - + - - - - - - - - + ! !

KT 015.1 --!TV BI!

DE!

F 28.5

FILE FROM F 22 5

10-C = I 4.3 EXIT ROL. HS 10-C. (IR-36)

EXT PROX= I 11.5 EXIT TABLE PROX.SW.

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```
LS10      = I  5.6      EXIT DOOR OPEN HI-LS10.(IR-47)
LS13      = I  6.1      EXIT DOOR HALF-OPEN LS13.(IR-50)
```


CHR LS1 = I 1.0 CHARGING TABLE LS1. (IR-9)

```

SEGMENT 65      02F7      ALARM:PLC&FAN POWER 110VAC OFF.
!               -ALRM PLC
!-110VCONT -----
+---1 |---+!R      !
!               !      !
!-110VCONT      !      !
+---1/I---+!S      Q!-
!               -----
!

```

110VCONT= I 0.4 PLC & FAN 110VAC CONTROL. (IR-5)
 ALRM PLC= Q 16.0 ALARM:PLC & FAN 110VAC OFF.....(QR-33)

```

SEGMENT 66      02FD      ALARM:INPUTS 24VDC OFF.
!               -ALRM INP
!-INP24VDC -----
+---1 |---+!R      !
!               !      !
!-INP24VDC      !      !
+---1/I---+!S      Q!-
!               -----
!

```

INP24VDC= I 0.0 ALL INPUT CARDS P24V (IR-1)
 ALRM INP= Q 16.1 ALARM:PLC INPUTS 24VDC OFF.....(QR-34)

```

SEGMENT 67      0303      ALARM:OUTPUTS 24VDC OFF.
!               -ALRM OUT
!-1OUTP24V -2OUTP24V -----
+---1 |---+---1 |---+!R      !
!               !      !
!-1OUTP24V      !      !
+---1/I---+---+!S      Q!-
!               -----
!-2OUTP24V!
+---1/I---+
!

```

1OUTP24V= I 6.6 OUTPUT CARD NO:1 (P24V) (IR-55)
 2OUTP24V= I 11.7 OUTPUT CARD NO:2 (P24V)
 ALRM OUT= Q 16.3 ALARM:PLC OUTPUTS 24VDC OFF.....(QR-36)

```

SEGMENT 68      030B      ALARM:PLC FAN NOT RUNNING.
!               -ALRM FAN
!-PLC FAN -----
+---1 |---+!R      !
!               !      !
!-PLC FAN      !      !
+---1/I---+!S      Q!-
!               -----
!

```

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PLC FAN = I 6.7 PLC FAN AIR SWITCH.(IR-56)
ALRM FAN= Q 16.4 ALARM:PLC FAN NOT RUNNING.....(QR-37)

SEGMENT 69 0311 ALARM:TREATMENT TIME UP.

! F 13.0 -ALRM TIM
+---|-----+-----+-----+-----+-----+-----+-----+-----+---

:BE

ALRM TIM= Q 16.5 ALARM:TREATMENT TIME IS UP.....(QR-38)

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```
!F 3.6                                     -PL READY
+---| |-----+-----+-----+-----+-----+-----+-----+-----+
|
```

		-CHR PERM	
!F 3.6	F 35.0	-----	
+--- ---+--- ---+	!S	!	
!	!	!	
!F 4.5		!	
+--- ---+-----+	!R Q!	-----	
!			

```

!F 8.4      F 17.4      F 17.5      -05M-OL      -FRN FORW
+---| |---+---| |---+---| |---+---+---+---+---+---+---+---+---+
!
!F 24.7
+---| |---+---+---+---+---+---+---+---+---+---+---+
!
!-05-CF      -FRN RCPR      !
+---| |---+---| |---+---+---+---+---+---+---+---+
!

```

05-CF	= I	1.7	FURN. ROL. LS 05-CF.(IR-16)
FRN RCPR=	Q	14.2	FURN.LS RECIPR. TO INS.PANEL.....(QR-19)
05M-OL	= I	1.4	FURN. ROL. LS 05M OL. (IR-13)
FRN FORW=	Q	18.1	INDICATOR:FORW.MOTION IN FURNACE

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SEGMENT 4 0016 FURNACE ROLLERS LS REV. MOTION.

```

!F 8.5      F 17.4      F 17.5      -05M-OL                      -FRN REV
+---1 |-----1|-----1|-----1|-----+-----+-----+-----+---( )---!
!
!F 25.0
+---1 |-----+-----+-----+-----+-----+-----+-----+-----+---!
!
!-05-CR      -FRN RCPR
+---1 |-----1|-----+-----+-----+-----+-----+-----+-----+---!
!

```

05-CR	= I	2.0	FURN. ROL. LS 05-CR.(IR-17)
FRN RCPR=	Q	14.2	FURN.LS RECIPR. TO INS.PANEL.....(QR-19)
05M-OL	= I	1.4	FURN. ROL. LS 05M OL. (IR-13)
FRN REV	= Q	18.2	INDICATOR:REV.MOTION IN FURNACE

SEGMENT 5 0022 FURNACE CHARGED WITH PLATE.

! -PLATE IN

```

!F 32.0      -----
+---| |---+!S      !
!      !      !
!F 3.5      !      !
+---| |---+!R  Q!-

```

PLATE IN= Q 18.3 INDICATOR: FURNACE CHARGED.

SEGMENT 6 0028 CHARGING TIMER.

[illegible]

LS8 = I 5.2 ENTRY DOOR OPEN HI-LS8.(IR-43)
03-CF = I 0.6 CHARGING TABLE 03-CF (IR-7)
06-C = I 2.3 FURN. ROL. HS 06C.(IR-20)

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SEGMENT 7 0038 TREATMENT TIME IS UP.

F 13.0

!F 2.1 F 2.2

+---] [---+---] [---+-----+!S !

! ! !

!F 8.6 F 9.1 F 11.5 ! ! -TIME UP

+---] [---+---] [---+---] [---+!R Q!+-----+-----+----()--!

! !

!-06-C -08-C -LS10 !

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

06-C = I 2.3 FURN. ROL. HS 06C.(IR-20)
08-C = I 3.2 DISC. TABLE HS 08-C.(IR-27)
LS10 = I 5.6 EXIT DOOR OPEN HI-LS10.(IR-47)
TIME UP = Q 19.4 INDICATOR:TREATMENT TIME FINISHED

SEGMENT 8 0046 EXHAUST FAN IS RUNNING.

!

!-23-C -23M-OL -FAN ON

+---] [-++-]/[-+-----+-----+-----+-----+----()--!

23-C = I 6.5 EXH. FAN 23-C.(IR-54)
23M-OL = I 6.4 EXH. FAN 23M OL.(IR-53)
FAN ON = Q 14.1 INDICATOR:EXHAUST FAN ON.....(QR-18)

SEGMENT 9 004A COMBUSTION AIR FAN IS RUNNING.

!

!-22M-OL -22-C1 -FAN ON

+---] / [---+---] | ---+---+---+---+---+---+---()--!

```

22M-OL = I 6.2 COMB. AIR FAN 22M OL.(IR-51)
22-C1 = I 6.3 COMB. AIR FAN 22-C1.(IR-52)
FAN ON = Q 19.1 INDICATOR:COMBUSTION AIR FAN RUNNING

```

SEGMENT 10 004E FURNACE ROLLERS HIGH-SPEED (HS)

!F 8.6 F 24.6 F 14.1 F 14.2 -06M-OL -FRN HS

+---| | ---+---|/|---+---|/|---+---|/| ---+---|/|---+-----+-----+---()--!

100

!F 25.1 !

-----1 | -----+-----+-----+

—

!-06-C F 14.1 F 14.2 !

$$+---| \quad |---+---|/|---+---|/|---+-----+$$

06-C	= I	2.3	FURN. ROL. HS 06C. (IR-20)
06M-OL	= I	2.1	FURN. ROL. HS 06M OL. (IR-18)
FRN HS	= Q	18.4	INDICATOR: FURNACE HI-SPEED

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SEGMENT 11 005C DISCHARGING TABLE HIGH-SPEED(HS)

```

!
!F 9.1   F 14.3   F 14.4   F 27.2   -OBM-OL                      -DSC HS
+---1 |-----1/|-----1/|-----1/|-----1/|-----+---( )---!
!
!F 27.3
+---1 |-----+-----+-----+-----+-----+-----+-----+-----+
!
!-08-C   F 14.3   F 14.4
+---1 |-----1/|-----1/|-----+-----+-----+-----+-----+
!

```

08-C = I 3.2 DISC. TABLE HS 08-C.(IR-27)
 OBM-OL = I 3.1 DISC. TABLE HS OBM OL.(IR-26)
 DSC HS = Q 18.5 INDICATOR:DISCHARGE HI-SPEED

SEGMENT 12 006A EXIT TABLE HIGH-SPEED (HS)

```

!
!F 9.4   F 22.3                      -10M-OL                      -EXIT HS
+---1 |-----1/|-----+-----1/|-----+-----+-----+-----+---( )---!
!
!-10-C   F 28.4   F 28.5
+---1 |-----1/|-----1/|-----+-----+-----+-----+-----+
!

```

10-C = I 4.3 EXIT ROL. HS 10-C.(IR-36)
 10M-OL = I 4.1 EXIT ROL. HS 10M OL.(IR-34)
 EXIT HS = Q 18.7 INDICATOR:EXIT TABLE HI-SPEED

SEGMENT 13 0075 ENTRY DOOR OPEN LS8.

```

!
!-LS8
+---1 |-----+-----+-----+-----+-----+-----+-----+-----+---( )---!
!

```

LS8 = I 5.2 ENTRY DOOR OPEN HI-LS8.(IR-43)
 DOOR OPN= Q 19.0 INDICATOR:ENTRY DOOR OPEN LS8

SEGMENT 14 0078 CHARGING ROLLERS FORM-MOTION.

```

!
!-03-CF   -03M-OL                      -CHR HS
+---1 |-----1/|-----+-----+-----+-----+-----+-----+---( )---!
!

```

03-CF = I 0.6 CHARGING TABLE 03-CF . (IR-7)
 03M-OL = I 0.5 CHARGING TABLE MOTOR OL. (IR-6)
 CHR HS = Q 19.2 INDICATOR:CHARGING ROLLERS FORM.HS

SEGMENT 15 007C AUTO INTERLOCK.

```

!
!-03-AUTO -05AUTO-F -05AUTO-R -06-AUTO -07AUTO-F -07AUTO-R -08-AUTO F 17.0
+---1 |-----1 |-----1 |-----1 |-----1 |-----1 |-----1 |-----+---( )---!
!

```

03-AUTO = I 0.7 CHARGING TABLE AUTO S.S. (IR-8)

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```

05AUTO-F= I 1.5 FURN. ROL. LS AUTO-FORW.S.S. (IR-14)
05AUTO-R= I 1.6 FURN. ROL. LS AUTO-REV.S.S. (IR-15)
06-AUTO = I 2.2 FURN. ROL. HS AUTO S.S.(IR-19)
07AUTO-F= I 2.5 DISC. TABLE LS AUTO-FORW.S.S.(IR-22)
07AUTO-R= I 2.6 DISC. TABLE LS AUTO-REV.S.S.(IR-23)
08-AUTO = I 3.3 DISC. TABLE HS AUTO S.S.(IR-28)

```

SEGMENT 16 0085 AUTO.

```

!F 17.0 -09AUTO-F -09AUTO-R -10-AUTO -11-AUTO -13-AUTO -14-AUTO -AUTO
+---| |---+---| |---+---| |---+---| |---+---| |---+---| |---+---( )---!
!

```

```

09AUTO-F= I 3.5 EXIT ROL. LS AUTO-FORW.(IR-30)
09AUTO-R= I 3.6 EXIT ROL. LS AUTO-REV.(IR-31)
10-AUTO = I 4.2 EXIT ROL. HS AUTO S.S.(IR-35)
11-AUTO = I 4.7 TILTING BEAM AUTO S.S.(IR-40)
13-AUTO = I 5.4 ENTRY DOOR AUTO S.S.(IR-45)
14-AUTO = I 6.0 EXIT DOOR AUTO S.S.(IR-49)
AUTO = Q 19.3 INDICATOR:AUTO CHAIN

```

SEGMENT 17 008E PLC & FAN POWER(110VAC) OKEY.

```

!-110VCONT -PLC FAN -PLC 110V
+---| |---+---| |---+---+---+---+---+---+---+---+---+---+---( )---!
!

```

```

110VCONT= I 0.4 PLC & FAN 110VAC CONTROL. (IR-5)
PLC FAN = I 6.7 PLC FAN AIR SWITCH.(IR-56)
PLC 110V= Q 16.7 INDICATOR:PLC & FAN 110VAC OKEY..(QR-40)

```

SEGMENT 18 0092 PLC INPUTS & OUTPUTS 24VDC OKEY.

```

!-INP24VDC -1OUTP24V -2OUTP24V -ALL24VDC
+---| |---+---| |---+---| |---+---+---+---+---+---+---+---+---( )---!
!

```

```

INP24VDC= I 0.0 ALL INPUT CARDS P24V (IR-1)
1OUTP24V= I 6.6 OUTPUT CARD NO:1 ( P24V ) (IR-55)
2OUTP24V= I 11.7 OUTPUT CARD NO:2 ( P24V )
ALL24VDC= Q 17.0 INDICATOR:ALL I/O 24VDC OKEY.....(QR-41)

```

SEGMENT 19 0097 WAITING CONDITION TIMER.

```

! T 95
!F 6.5 F 22.4 -----
+---| |---+---| |---+---!T!-!O!
! KT 005.2 --!TV BI!-
! ! DE!-
! ! !
! ! !
! ! ! F 31.6
! +!R Q! +---+---+---+---+---+---+---+---( )---!
!

```

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SEGMENT 1

AFTER POWER ON.I/O ADDRESS CHECK

WRITE 0 DIRECTLY INTO THE OUTPUT
WORDS 12.14.16.18.LOAD VALUE OF INPUT WORDS
0.2.4.6.8.10.

0000 :L KF+0
0002 :T FW12
0003 :T FW14
0004 :T FW16
0005 :T FW18
0006 :L PW0
0007 :L PW2
0008 :L PW4
0009 :L PW6
000A :L PW8
000B :L PW10
000C :BE

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PB 3 : PROCESSED
PB 5 : PROCESSED
PB 6 : PROCESSED
PB 7 : PROCESSED
PB 8 : PROCESSED
PB 9 : PROCESSED
PB 10 : PROCESSED
PB 11 : PROCESSED
PB 13 : PROCESSED
PB 14 : PROCESSED
PB 15 : PROCESSED
PB 16 : PROCESSED
PB 50 : PROCESSED
PB 200 : PROCESSED
OB 1 : PROCESSED
OB 22 : PROCESSED



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I	0.0 -INP24VDC	PB 15 : 66 PB 16 : 18
I	0.1 -RESET-1	PB 3 : 5 PB 5 : 15 , 23 PB 6 : 3 PB 13 : 5 , 8 , 9
I	0.2 -RESET-2	PB 3 : 5 PB 7 : 14 , 16 PB 9 : 12 , 13
I	0.3 -EM STOP	PB 3 : 5
I	0.4 -110VCONT	PB 15 : 65 PB 16 : 17
I	0.5 -03M-OL	PB 16 : 14
I	0.6 -03-CF	PB 15 : 61 , 62 , 64 PB 16 : 6 , 14
I	0.7 -03-AUTO	PB 3 : 1 PB 16 : 15
I	1.0 -CHR LS1	PB 6 : 3 PB 15 : 64 PB 16 : 22
I	1.1 -PL READY	PB 13 : 9
I	1.2 -CENT LS4	PB 3 : 1 PB 13 : 5
I	1.4 -05M-OL	PB 16 : 3 , 4
I	1.5 -05AUTO-F	PB 5 : 1 , 9 PB 6 : 8 PB 16 : 15
I	1.6 -05AUTO-R	PB 5 : 3 , 7 , 14 PB 6 : 8 PB 16 : 15
I	1.7 -05-CF	PB 5 : 9 PB 6 : 8 PB 14 : 6 PB 15 : 4 , 7 , 8 , 10 PB 16 : 3
I	2.0 -05-CR	PB 5 : 7 PB 6 : 3 , 6 , 7 , 8 PB 14 : 6 PB 15 : 5 , 7 , 8 , 10 PB 16 : 4

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I	2.1 -06M-OI.	PB 16 : 10
I	2.2 -06-AUTO	PB 5 : 13 PB 6 : 1 PB 13 : 7 PB 16 : 15
I	2.3 -06-C	PB 5 : 13 PB 13 : 7 PB 15 : 9 , 10 , 13 , 14 , 15 PB 16 : 6 , 7 , 10
I	2.5 -07AUTO-F	PB 7 : 1 , 11 PB 8 : 4 PB 16 : 15
I	2.6 -07AUTO-R	PB 7 : 2 , 9 PB 8 : 4 PB 16 : 15
I	2.7 -07-CF	PB 7 : 11 PB 8 : 4 PB 15 : 19 , 22 , 23
I	3.0 -07-CR	PB 7 : 9 PB 8 : 4 PB 15 : 20 , 22 , 23
I	3.1 -08M-OL	PB 16 : 11
I	3.2 -08-C	PB 5 : 17 , 21 , 24 PB 7 : 13 PB 13 : 7 PB 15 : 24 , 25 , 28 , 29 , 30 PB 16 : 7 , 11
I	3.3 -08-AUTO	PB 5 : 17 , 21 PB 7 : 13 PB 8 : 1 PB 13 : 7 PB 16 : 15
I	3.5 -09AUTO-F	PB 9 : 1 , 7 PB 10 : 13 PB 16 : 16
I	3.6 -09AUTO-R	PB 9 : 2 , 9 PB 10 : 13 PB 16 : 16
I	3.7 -09-CF	PB 9 : 7 PB 10 : 13 PB 15 : 35 , 38 , 39 , 41
I	4.0 -09-CR	PB 9 : 9

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PB 10 : 13
 PB 15 : 36 , 38 , 39 , 41

 I 4.1 -10M-OL PB 16 : 12

 I 4.2 -10-AUTO PB 5 : 17 , 21
 PB 9 : 11
 PB 10 : 1 , 4
 PB 16 : 16

 I 4.3 -10-C PB 5 : 17 , 21
 PB 9 : 11
 PB 15 : 40 , 41 , 43 , 44 , 45
 PB 16 : 12

 I 4.4 -END LS3 PB 9 : 13
 PB 10 : 1 , 4 , 5 , 7 , 9 , 10
 PB 11 : 4

 I 4.6 -11-C PB 5 : 19
 PB 8 : 1
 PB 9 : 3
 PB 10 : 1 , 8
 PB 15 : 40 , 41 , 47 , 48 , 49

 I 4.7 -11-AUTO PB 5 : 19
 PB 10 : 8
 PB 11 : 1
 PB 16 : 16

 I 5.0 -TIL LS7 PB 9 : 3
 PB 10 : 1 , 11
 PB 11 : 1 , 3 , 4
 PB 15 : 49

 I 5.1 -LS6 PB 3 : 4

 I 5.2 -LS8 PB 5 : 1 , 3
 PB 6 : 5
 PB 13 : 1
 PB 15 : 51 , 53 , 59
 PB 16 : 6 , 13

 I 5.3 -LS9 PB 13 : 2
 PB 15 : 54

 I 5.4 -13-AUTO PB 13 : 1 , 2
 PB 16 : 16

 I 5.5 -LS12 PB 15 : 53

 I 5.6 -LS10 PB 7 : 1 , 2
 PB 8 : 5
 PB 13 : 7
 PB 14 : 1
 PB 15 : 55 , 57 , 59

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	PB 16 :	7
I 5.7 -LS11	PB 6 :	5
	PB 13 :	6
	PB 14 :	2
	PB 15 :	58
I 6.0 -14-AUTO	PB 8 :	5
	PB 14 :	1 , 2
	PB 16 :	16
I 6.1 -LS13	PB 15 :	57
I 6.2 -22M-OL	PB 16 :	9
I 6.3 -22-C1	PB 16 :	9
I 6.4 -23M-OL	PB 16 :	8
I 6.5 -23-C	PB 16 :	8
I 6.6 -10UTP24V	PB 15 :	67
	PB 16 :	18
I 6.7 -PLC FAN	PB 15 :	68
	PB 16 :	17
I 7.0 -LOADCEL1	PB 5 :	15 , 23
I 7.1 -LOADCEL2	PB 5 :	15 , 23
	PB 6 :	6
I 11.0 -READ PB	PB 13 :	5
	OB 1 :	2
I 11.1 -RUN CLCK	OB 1 :	3
I 11.2 -SET CLCK	OB 1 :	3
I 11.3 -FRN PROX	PB 5 :	15 , 23
	PB 15 :	1 , 2 , 7 , 8 , 14 , 15
I 11.4 -DSC PROX	PB 7 :	14 , 16
	PB 15 :	17 , 18 , 22 , 23 , 29 , 30
I 11.5 -EXT PROX	PB 9 :	12
	PB 15 :	32 , 33 , 38 , 39 , 44 , 45
I 11.7 -20UTP24V	PB 15 :	67
	PB 16 :	18
IB 10 -	FB200 :	1
	OB 1 :	2?
IW 8 -	PB 50 :	1

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Q 12.0 -03-CF S PB 3 : 2*

Q 12.1 -03-CR S PB 3 : 3*

Q 12.2 -PI. READYS PB 16 : 1*

Q 12.3 -05-CF LSS PB 5 : 10*

Q 12.4 -05-CR LSS PB 5 : 11*

Q 12.5 -06-C HSS PB 6 : 2*

Q 12.6 -07-CF LSS PB 7 : 6*

Q 12.7 -07-CR LSS PB 7 : 7*

Q 13.0 -08-C HSS PB 8 : 2*

Q 13.1 -09-CF LSS PB 9 : 4*

Q 13.2 -09-CR LSS PB 9 : 5*

Q 13.3 -10-C HSS PB 10 : 3*

Q 13.4 -11-C TLTS PB 11 : 2*

Q 13.5 -13-SVOP S PB 13 : 3*

Q 13.6 -13-SVCL S PB 13 : 4*

Q 13.7 -14-SVOP S PB 14 : 4*

Q 14.0 -14-SVCL S PB 14 : 5*

Q 14.1 -FAN ON S PB 16 : 8*

Q 14.2 -FRN RCPRS PB 15 : 3*

S PB 16 : 3 , 4

Q 14.3 -ALARM 03S PB 15 : 63*

Q 14.4 -ALARM 05S PB 15 : 11*

Q 14.5 -ALARM05NS PB 15 : 12*

Q 14.6 -ALARM 06S PB 15 : 16*

Q 14.7 -ALARM 07S PB 15 : 26*

Q 15.0 -ALARM07NS PB 15 : 27*

Q 15.1 -ALARM 08S PB 15 : 31*

Q 15.2 -ALARM 09S PB 15 : 34*, 42*

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Q 15.3 -ALARM 10S PB 15 : 46*
 Q 15.4 -ALARM 11S PB 15 : 50*
 Q 15.5 -ALARM 13S PB 15 : 52*
 Q 15.6 -ALARM 14S PB 15 : 56*
 Q 15.7 -ALARM DOS PB 15 : 60*
 Q 16.0 -ALRM PLCS PB 15 : 65*
 Q 16.1 -ALRM INPS PB 15 : 66*
 Q 16.3 -ALRM OUTS PB 15 : 67*
 Q 16.4 -ALRM FANS PB 15 : 68*
 Q 16.5 -ALRM TMS PB 15 : 69*
 Q 16.7 -PLC 110VS PB 16 : 17*
 Q 17.0 -ALL24VDCS PB 16 : 18*
 Q 17.1 -FRN LS1 S PB 16 : 22*
 Q 18.0 -CHR PERMS PB 16 : 2*
 Q 18.1 -FRN FORWS PB 16 : 3*
 Q 18.2 -FRN REV S PB 16 : 4*
 Q 18.3 -PLATE INS PB 16 : 5*
 Q 18.4 -FRN HS S PB 16 : 10*
 Q 18.5 -DSC HS S PB 16 : 11*
 Q 18.7 -EXIT HS S PB 16 : 12*
 Q 19.0 -DOOR OPNS PB 16 : 13*
 Q 19.1 -FAN ON S PB 16 : 9*
 Q 19.2 -CHR HS S PB 16 : 14*
 Q 19.3 -AUTO S PB 16 : 16*
 Q 19.4 -TIME UP S PB 16 : 7*
 Q 19.5 -DSC PERMS PB 16 : 21*
 Q 19.7 -WAITING S PB 16 : 20*

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F	0.0 -	S OB 1 :	1*
F	0.1 -	S OB 1 :	1*
F	1.1 -	S PB 14 :	1*, 2 , 3 , 4
		S PB 15 :	55
F	1.2 -	S PB 14 :	1 , 2*, 5
		S PB 15 :	58
F	2.1 -	S PB 6 :	5
		S PB 8 :	5
		S PB 10 :	4 , 15
		S PB 11 :	3
		S PB 13 :	6
		S PB 16 :	7
		S OB 1 :	3*
F	2.2 -	S PB 16 :	7
		S PB 50 :	1*
F	2.3 -	S PB 13 :	1*, 2 , 3 , 10
		S PB 15 :	51
F	2.4 -	S PB 13 :	1 , 2*, 4
		S PB 15 :	54
F	2.5 -	S PB 10 :	15
		S PB 11 :	3
		S PB 50 :	1*
F	3.0 -	S PB 3 :	1 , 4*
		S PB 13 :	5
F	3.2 -	S PB 5 :	3 , 16*
		S PB 7 :	5
		S PB 15 :	26
		S PB 16 :	21
F	3.3 -	S PB 3 :	1
		S PB 6 :	1 , 4*
		S PB 8 :	5
F	3.5 -	S PB 13 :	7*, 8
		S PB 16 :	5
F	3.6 -	S PB 13 :	9*
		S PB 16 :	1 , 2
F	3.7 -	S PB 5 :	5
		S PB 13 :	1 , 9*
F	4.5 -	S PB 3 :	1
		S PB 5 :	2 , 4
		S PB 6 :	1 , 5*, 7

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S PB 13 : 2 , 5 , 8 , 9
 S PB 15 : 64
 S PB 16 : 2 , 20

 F 4.6 - S PB 5 : 3 , 12*
 F 4.7 - S PB 5 : 2 , 6*
 F 5.0 - S PB 5 : 3 , 15* , 23
 F 5.1 - S PB 5 : 4 , 8*
 F 5.2 - S PB 5 : 1 , 14 , 15 , 23*
 F 5.4 - S PB 11 : 1 , 4*
 F 5.5 - S PB 13 : 2 , 10*
 F 5.7 - S PB 10 : 5* , 7
 F 6.0 - S PB 5 : 17
 S PB 7 : 5
 S PB 8 : 1
 S PB 9 : 3 , 13
 S PB 10 : 1 , 4 , 6 , 7*
 S PB 11 : 3
 S PB 14 : 1

 F 6.1 - S PB 9 : 2 , 6*
 F 6.2 - S PB 9 : 1 , 8*
 F 6.3 - S PB 9 : 2 , 12* , 13
 F 6.4 - S PB 10 : 1 , 12*
 F 6.5 - S PB 13 : 5 , 8*
 S PB 16 : 19

 F 6.7 - S PB 8 : 1 , 3* , 5
 F 7.0 - S PB 7 : 1 , 8*
 F 7.1 - S PB 7 : 2 , 10*
 F 7.2 - S PB 7 : 5 , 12*
 F 7.3 - S PB 5 : 17* , 18
 F 7.4 - S PB 5 : 16 , 18*
 F 7.5 - S PB 5 : 19* , 20
 F 7.6 - S PB 5 : 20* , 21
 F 7.7 - S PB 5 : 21* , 22

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F 8.0 - S PB 3 : 1*, 2
 S PB 13 : 8 , 9
 S PB 15 : 61 , 62
 S PB 16 : 6

F 8.1 - S PB 3 : 3

F 8.2 - S PB 6 : 3*, 7

F 8.3 - S PB 6 : 5 , 7*

F 8.4 - S PB 5 : 1*, 8 , 9 , 10 , 16
 S PB 6 : 4 , 8
 S PB 14 : 6
 S PB 15 : 4 , 6 , 10
 S PB 16 : 3

F 8.5 - S PB 5 : 3*, 6 , 7 , 11
 S PB 6 : 4 , 8
 S PB 14 : 6
 S PB 15 : 5 , 6 , 10
 S PB 16 : 4

F 8.6 - S PB 5 : 4 , 12 , 13 , 14 , 15 , 23
 S PB 6 : 1*, 2
 S PB 13 : 7 , 8 , 9
 S PB 15 : 9 , 10 , 13 , 14 , 15
 S PB 16 : 6 , 7 , 10

F 8.7 - S PB 7 : 1*, 6 , 10 , 11
 S PB 8 : 3 , 4
 S PB 15 : 19 , 21 , 25

F 9.0 - S PB 7 : 2*, 7 , 8 , 9
 S PB 8 : 3 , 4
 S PB 15 : 20 , 21 , 25

F 9.1 - S PB 5 : 17 , 21 , 24
 S PB 7 : 1 , 2 , 12 , 13 , 14 , 16
 S PB 8 : 1*, 2
 S PB 13 : 7
 S PB 15 : 24 , 25 , 28 , 29 , 30
 S PB 16 : 7 , 11

F 9.2 - S PB 9 : 1*, 4 , 6 , 7
 S PB 10 : 5 , 12 , 13
 S PB 15 : 35 , 37 , 41

F 9.3 - S PB 9 : 2*, 5 , 8 , 9
 S PB 10 : 12 , 13
 S PB 15 : 36 , 37 , 41

F 9.4 - S PB 5 : 17 , 21
 S PB 7 : 3
 S PB 9 : 3 , 10 , 11 , 12 , 13

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S PB 10 : 1*, 3
 S PB 15 : 40 , 41 , 43 , 44 , 45
 S PB 16 : 12

F 9.5 - S PB 5 : 19
 S PB 9 : 3
 S PB 10 : 8
 S PB 11 : 1*, 2
 S PB 14 : 1
 S PB 15 : 40 , 41 , 47 , 48 , 49

F 10.0 - S PB 5 : 16 , 22*

F 10.4 - S PB 7 : 3 , 14 , 16*

F 10.5 - S PB 7 : 4 , 14*, 15 , 16

F 11.1 - S PB 7 : 15*, 16

F 11.2 - S PB 14 : 6*, 7

F 11.3 - S PB 7 : 5
 S PB 14 : 1 , 7*

F 11.4 - S PB 5 : 16 , 24*

F 11.5 - S PB 5 : 18 , 19 , 20 , 21 , 22
 S PB 6 : 1
 S PB 8 : 1 , 5*
 S PB 13 : 7
 S PB 14 : 2
 S PB 16 : 7

F 11.7 - S PB 7 : 1 , 3*

F 12.0 - S PB 7 : 2 , 4*

F 12.2 - S PB 10 : 8*, 9

F 12.3 - S PB 7 : 5
 S PB 9 : 3
 S PB 10 : 10*, 11
 S PB 15 : 26

F 12.4 - S PB 5 : 21
 S PB 8 : 1
 S PB 9 : 13
 S PB 10 : 1 , 11*, 14
 S PB 11 : 3
 S PB 14 : 1

F 12.6 - S PB 10 : 9*, 10

F 13.0 - S PB 5 : 16
 S PB 14 : 6 , 7
 S PB 15 : 69

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	S PB 16 :	7*
F 13.1 -	S PB 10 :	5 , 15*
F 13.3 -	S PB 9 :	3
	S PB 10 :	5 , 6*
F 14.0 -	S PB 9 :	1 , 2 , 10*
F 14.1 -	S PB 15 :	14* , 16
	S PB 16 :	10
F 14.2 -	S PB 15 :	15* , 16
	S PB 16 :	10
F 14.3 -	S PB 15 :	29* , 31
	S PB 16 :	11
F 14.4 -	S PB 15 :	30* , 31
	S PB 16 :	11
F 14.5 -	S PB 15 :	43* , 44 , 45 , 46
F 14.6 -	S PB 9 :	3 , 11*
	S PB 15 :	46
F 15.0 -	S PB 10 :	10 , 14*
F 16.1 -	S PB 9 :	1 , 12 , 13*
F 16.4 -	S PB 9 :	1 , 2 , 3*
F 16.6 -	S PB 15 :	52 , 53*
F 17.0 -	S PB 16 :	15* , 16
F 17.3 -	S PB 15 :	6* , 7 , 8 , 9
F 17.4 -	S PB 15 :	7* , 11
	S PB 16 :	3 , 4
F 17.5 -	S PB 15 :	8* , 11
	S PB 16 :	3 , 4
F 17.7 -	S PB 15 :	21* , 22 , 23 , 24
F 18.0 -	S PB 15 :	22* , 26
F 18.1 -	S PB 15 :	23* , 26
F 18.3 -	S PB 15 :	37* , 38 , 39 , 40
F 18.4 -	S PB 15 :	38* , 42
F 18.5 -	S PB 15 :	39* , 42

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F 18.7 - S PB 15 : 49*, 50
 F 19.1 - S PB 15 : 51*, 52
 F 19.3 - S PB 15 : 52 , 54*
 F 19.4 - S PB 13 : 5*, 9
 F 19.5 - S PB 5 : 3 , 4*
 F 19.7 - S PB 15 : 56 , 58*
 F 20.2 - S PB 3 : 2 , 3 , 5*
 S PB 5 : 10 , 11
 S PB 6 : 2
 S PB 7 : 6 , 7
 S PB 8 : 2
 S PB 9 : 4 , 5
 S PB 10 : 3
 S PB 11 : 2
 S PB 14 : 4 , 5
 F 20.5 - S PB 15 : 40*, 42
 F 20.6 - S PB 5 : 1 , 2*
 F 21.1 - S PB 15 : 11*
 F 21.2 - S PB 15 : 26*
 F 21.3 - S PB 10 : 5
 S PB 15 : 42*
 F 21.4 - S PB 8 : 1
 S PB 10 : 2
 S PB 15 : 50*
 F 21.5 - S PB 15 : 52*
 F 21.7 - S PB 15 : 56*
 F 22.1 - S PB 8 : 6
 S PB 15 : 16*
 F 22.2 - S PB 8 : 6
 S PB 10 : 7
 S PB 15 : 31*
 F 22.3 - S PB 10 : 7
 S PB 15 : 46*
 S PB 16 : 12
 F 22.4 - S PB 13 : 5 , 6*
 S PB 16 : 19
 F 22.5 - S PB 15 : 10*, 11

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F 23.3 - S PB 15 : 56 , 57*
 F 23.5 - S PB 15 : 9* , 11
 F 23.6 - S PB 15 : 24* , 26
 F 24.0 - S PB 11 : 3* , 4
 F 24.3 - S PB 10 : 4* , 5
 F 24.4 - S PB 15 : 4* , 6 , 11
 F 24.5 - S PB 15 : 5* , 6 , 11
 F 24.6 - S PB 15 : 13* , 14 , 15 , 16
 S PB 16 : 10
 F 24.7 - S PB 5 : 4 , 9*
 S PB 15 : 12
 S PB 16 : 3
 F 25.0 - S PB 5 : 2 , 7*
 S PB 15 : 12
 S PB 16 : 4
 F 25.1 - S PB 5 : 2 , 4 , 13*
 S PB 15 : 16
 S PB 16 : 10
 F 25.2 - S PB 15 : 63 , 64*
 F 25.3 - S PB 6 : 1 , 8*
 F 25.4 - S PB 8 : 1 , 4*
 F 25.5 - S PB 10 : 2 , 13*
 F 25.6 - S PB 10 : 1 , 2*
 F 25.7 - S PB 15 : 25* , 26
 F 26.0 - S PB 15 : 35* , 37 , 42
 F 26.1 - S PB 15 : 36* , 37 , 42
 F 26.2 - S PB 15 : 41* , 42
 F 26.4 - S PB 7 : 4 , 11*
 S PB 15 : 27
 F 26.5 - S PB 7 : 3 , 9*
 S PB 15 : 27
 F 26.7 - S PB 15 : 19* , 21 , 26

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F 27.0 - S PB 15 : 20*, 21 , 26
 F 27.1 - S PB 15 : 27*
 F 27.2 - S PB 15 : 28*, 29 , 30 , 31
 S PB 16 : 11
 F 27.3 - S PB 7 : 1 , 4 , 13*
 S PB 15 : 31
 S PB 16 : 11
 F 27.6 - S PB 15 : 61*, 63
 F 27.7 - S PB 15 : 62*, 63
 F 28.0 - S PB 5 : 2 , 4 , 5*
 F 28.1 - S PB 14 : 2 , 3*
 F 28.2 - S PB 9 : 2 , 7*
 S PB 15 : 42
 F 28.3 - S PB 9 : 1 , 9*
 S PB 15 : 42
 F 28.4 - S PB 15 : 44*, 46
 S PB 16 : 12
 F 28.5 - S PB 15 : 45*, 46
 S PB 16 : 12
 F 28.6 - S PB 15 : 47*, 49 , 50
 F 28.7 - S PB 15 : 48*, 50
 F 29.0 - S PB 15 : 59*, 60
 F 29.1 - S PB 15 : 1*, 3
 F 29.2 - S PB 15 : 2*, 3
 F 29.3 - S PB 15 : 17*, 26
 F 29.4 - S PB 15 : 18*, 26
 F 29.5 - S PB 15 : 55*, 56
 F 29.6 - S PB 15 : 32*, 34
 F 29.7 - S PB 15 : 33*, 34
 F 30.0 - S PB 15 : 3*, 11
 F 31.1 - S PB 6 : 5 , 6*
 F 31.2 - S PB 8 : 5 , 6*

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F	31.6 -	S PB 16 :	19* , 20
F	31.7 -	S PB 16 :	20*
F	32.0 -	S PB 16 :	5 , 6*
F	33.3 -	S PB 7 :	3 , 4 , 5*
F	35.0 -	S PB 13 :	5*
		S PB 16 :	2
F	40.0 -	S PB 5 :	14* , 15
FW	51 -	S FB200 :	1*
FW	52 -	S PB 5 :	15 , 23
		S PB 7 :	14 , 16
		S FB200 :	1*
		S OB 1 :	2?
FW	55 -	S PB 9 :	12
		S FB200 :	1*
		S OB 1 :	2?



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T	3	-	S PB 5 :	13*
T	4	-	S PB 7 :	11*
T	6	-	S PB 6 :	7*
T	7	-	S PB 5 :	12*
T	8	-	S PB 5 :	6*
T	9	-	S PB 5 :	8*
T	10	-	S PB 11 :	4*
T	11	-	S PB 5 :	17*
T	12	-	S PB 9 :	6*
T	13	-	S PB 9 :	8*
T	14	-	S PB 10 :	5*
T	15	-	S PB 10 :	12*
T	16	-	S PB 6 :	4*
T	17	-	S PB 8 :	3*
T	18	-	S PB 7 :	8*
T	19	-	S PB 7 :	10*
T	20	-	S PB 7 :	12*
T	21	-	S PB 5 :	19*
T	22	-	S PB 7 :	15*
T	23	-	S PB 5 :	24*
T	24	-	S PB 14 :	6*
T	25	-	S PB 8 :	5*
T	26	-	S PB 10 :	9*
T	27	-	S PB 10 :	10*
T	28	-	S PB 5 :	21*
T	29	-	S PB 15 :	64*
T	30	-	S PB 10 :	6*
T	31	-	S PB 13 :	7*

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T	32	-	S PB 10 : 14*
T	33	-	S PB 9 : 10*
T	34	-	S PB 8 : 8*
T	35	-	S PB 13 : 10*
T	36	-	S PB 8 : 4*
			S PB 10 : 13*
T	37	-	S PB 7 : 9*
T	38	-	S PB 7 : 13*
T	39	-	S PB 5 : 5*
T	40	-	S PB 15 : 7*
T	41	-	S PB 15 : 8*
T	42	-	S PB 15 : 22*
T	43	-	S PB 15 : 23*
T	44	-	S PB 9 : 7*
T	45	-	S PB 9 : 9*
T	46	-	S PB 15 : 49*
T	47	-	S PB 15 : 51*
T	48	-	S PB 15 : 54*
T	49	-	S PB 15 : 55*
T	50	-	S PB 15 : 58*
T	51	-	S PB 15 : 40*
T	52	-	S PB 15 : 9*
T	53	-	S PB 15 : 24*
T	54	-	S PB 15 : 14*
T	55	-	S PB 15 : 15*
T	56	-	S PB 15 : 29*
T	57	-	S PB 15 : 30*
T	58	-	S PB 15 : 43*

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T	59	-	S PB 9 :	11*
T	60	-	S PB 15 :	4*
T	61	-	S PB 15 :	5*
T	62	-	S PB 5 :	9*
T	63	-	S PB 5 :	7*
T	64	-	S PB 15 :	13*
T	68	-	S PB 15 :	19*
T	69	-	S PB 15 :	20*
T	70	-	S PB 15 :	28*
T	72	-	S PB 15 :	61*
T	73	-	S PB 15 :	62*
T	74	-	S PB 15 :	10*
T	75	-	S PB 15 :	35*
T	76	-	S PB 15 :	36*
T	77	-	S PB 15 :	41*
T	78	-	S PB 15 :	38*
T	79	-	S PB 15 :	39*
T	81	-	S PB 14 :	3*
T	82	-	S PB 15 :	44*
T	83	-	S PB 15 :	45*
T	84	-	S PB 15 :	47*
T	85	-	S PB 15 :	48*
T	86	-	S PB 15 :	59*
T	87	-	S PB 15 :	25*
T	88	-	S PB 15 :	1*
T	89	-	S PB 15 :	2*
T	90	-	S PB 15 :	17*
T	91	-	S PB 15 :	18*

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T	92	-	S PB 15 :	32*
T	93	-	S PB 15 :	33*
T	94	-	S PB 16 :	6*
T	95	-	S PB 16 :	19*
T	99	-	S PB 15 :	53*
T	100	-	S PB 15 :	57*
T	116	-	S PB 5 :	14*



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C	1	-	S PB 5 :	15*
C	2	-	S PB 5 :	23*
C	3	-	S PB 7 :	14*
C	4	-	S PB 7 :	16*
C	5	-	S PB 9 :	12*



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PB	3	-	S OB	1 :	5
PB	5	-	S OB	1 :	5
PB	6	-	S OB	1 :	5
PB	7	-	S OB	1 :	5
PB	8	-	S OB	1 :	5
PB	9	-	S OB	1 :	5
PB	10	-	S OB	1 :	5
PB	11	-	S OB	1 :	5
PB	13	-	S OB	1 :	5
PB	14	-	S OB	1 :	5
PB	15	-	S OB	1 :	5
PB	16	-	S OB	1 :	5
PB	50	-	S OB	1 :	4
PB	200	-	S OB	1 :	2
DB	10	-	S OB	1 :	1

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FW	0	-	S OB 22 :	1
FW	2	-	S OB 22 :	1
FW	4	-	S OB 22 :	1
FW	6	-	S OB 22 :	1
FW	8	-	S OB 22 :	1
FW	10	-	S OB 22 :	1
FW	12	-	S OB 22 :	1*
FW	14	-	S OB 22 :	1*
FW	16	-	S OB 22 :	1*
FW	18	-	S OB 22 :	1*



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DW	1	-	S FB200 :	1
			S OB 1 :	2?
DW	2	-	S FB200 :	1
			S OB 1 :	2?
DW	3	-	S FB200 :	1
			S OB 1 :	2?
DW	4	-	S FB200 :	1
			S OB 1 :	2?
DW	5	-	S FB200 :	1
			S OB 1 :	2?
DW	6	-	S FB200 :	1
			S OB 1 :	2?
DW	7	-	S FB200 :	1
			S OB 1 :	2?
DW	8	-	S FB200 :	1
			S OB 1 :	2?
DW	9	-	S FB200 :	1
			S OB 1 :	2?
DW	10	-	S FB200 :	1
			S OB 1 :	2?
DW	11	-	S FB200 :	1
			S OB 1 :	2?
DW	12	-	S FB200 :	1
			S OB 1 :	2?
DW	13	-	S FB200 :	1
			S OB 1 :	2?
DW	14	-	S FB200 :	1
			S OB 1 :	2?
DW	15	-	S FB200 :	1
			S OB 1 :	2?
DW	16	-	S FB200 :	1
			S OB 1 :	2?
DW	17	-	S FB200 :	1
			S OB 1 :	2?
DW	18	-	S FB200 :	1
			S OB 1 :	2?
DW	19	-	S FB200 :	1

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S OB 1 : 2?

DW 20 - S FB200 : 1
S OB 1 : 2?

DW 21 - S FB200 : 1
S OB 1 : 2?

DW 22 - S FB200 : 1
S OB 1 : 2?

DW 23 - S FB200 : 1
S OB 1 : 2?

DW 24 - S FB200 : 1
S OB 1 : 2?

DW 25 - S FB200 : 1
S OB 1 : 2?

DW 26 - S FB200 : 1
S OB 1 : 2?

DW 27 - S FB200 : 1
S OB 1 : 2?

DW 28 - S PB 50 : 1

DW 29 - S PB 50 : 1

T. C.
Yükseköğretim Kurulu
Dokümantasyon Merkezi

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