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Computer-Aided Manufacturing in Egypt:

Principal Research Findings of the Science and Technology Project

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PREPARED BY

SCIENCE AND TECHNOLOGY COOPERATION PROJECT
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INTRODUCTION

This report covers the achievements of the Science and Technology Cooperation Project (STC) in the field of Computer-Aided Manufacturing. It is one of a series of reports documenting the key areas of work undertaken by STC researchers in the fields of computer-aided manufacturing, biotechnology and genetic engineering, industrial waste management, and municipal waste management.

STC is a project funded by a grant from the U.S. Agency for International Development which is supplemented by in-cash and in-kind contributions from the Government of Egypt and the end-users. The goals of STC are improving the productivity and welfare of the Egyptian people by applying technology to specific development problems and building science and technology research capacity in selected fields. To this end, STC has funded 81 research subprojects.

Part I of this report represents a synthesis and analysis of key findings and conclusions from nine STC research subprojects. Part II of this report comprises summaries of the nine research subprojects that formed the basis for part I. These summaries were prepared by a PRIDE team led by Dr. Walid Gamaledin. Members of the team included Ms. Naglaa El Bialy, Dr. Farida El Dars, and Dr. Dina El Naggar. This team was assisted by Ms. Nivene El Koshairi and Ms. Hala Rafik. The subproject summaries were based on reports issued by subproject research teams, interviews with Principal Investigators, and site visits. Dr. Ben Wang graciously provided expert comments on an early draft of this report.

The views expressed in this report do not necessarily reflect those of the Project in Development and the Environment or USAID.

TABLE OF CONTENTS

		Page
PART I	**SYNTHESIS AND ANALYSIS**	
	INTRODUCTION TO PART I	i
SECTION I	**TECHNOLOGY TRANSFER TO INDUSTRY**	
	A. General Overview	I-1
	B. Lines of Technological Development	I-1
	C. Real Life Applications	I-2
	D. A Typical Computer-Based Technology Project Steps	I-3
SECTION II	**ANALYSIS AND MODELING OF INDUSTRIAL PROCESSES**	
	A. Process Description	II-1
	B. Locations For Potential Improvement	II-1
	C. Measurements and Observation	II-1
	D. Modeling Studies	II-3
	E. Productivity Calc· iations	II-6
SECTION III	**DESIGN OF COMPUTER-BASED SYSTEMS**	
	A. System Hardware Components	III-1
	B. System Software Components	III-4
	C. Main Features of System Configuration	III-5
	D. Comparing System A'ternatives	III-6
	E. Detailed Design and System Specification	III-7
SECTION IV	**SYTEM IMPLEMENTATION AND COMMISSIONING**	
	A. Installing Hardware Systems	IV-1
	B. Installing Software Systems	IV-2
	C. Commissioning and Testing Integrated System	IV-3
SECTION V	**MANAGEMENT INFORMATION SYSTEMS (MIS)**	
	A. Basic MIS Configuration	V-1
	B. MIS Hierarchy	V-1
	C. Examples of Tasks Performed by MIS	V-2
	D. Decision Support System	V-4
SECTION VI	**TRAINING, MAINTENANCE, AND UPGRADING**	
	A. Staff Training	VI-1
	B. Maintenance Programs	VI-2
	C. Upgrading Strategies	VI-2
PART II	**SUBPROJECT SUMMARIES**	

PART I

SYNTHESIS AND ANALYSIS

INTRODUCTION TO PART I

Industry and administration in Egypt can increase production considerably through process automation and its related modernization aspects, and improving the organization of their decision-making process. Given today's rapidly changing business environment, and information, flows in daily business operations, managerial decisions have become more complex. Factors have underscored the need to use process automation and an improved decision-making system.

Technology transfer to industry continues to be very successful. It is mainly directed to achieve tasks with multiple objectives, such as increasing productivity, saving raw materials and energy, lowering operation costs, and improving product quality. ***Computer technology*** is one of the main technologies that is transferred to industry. Currently, a wide variety of computers is available at reduced costs with high computational power and the ability to network.

There are diverse areas of technology that are transferred to industry. They vary from the use of ***computer control*** or direct control to ***management*** and ***planning*** functions. Computers can be used for data acquisition and logging, signal processing, modeling and simulation, fault detection and isolation, and system design. In addition, computers with management information systems equipped with optimization-based models can help managers make more rational decisions.

This report presents a review of the nine Science and Technology Cooperation (STC) projects on computer-based technology transfer to industrial processes. These projects can be divided: data acquisition; supervisory control; distributed computer control; computer-aided design/manufacturing and other computer-assisted projects. A summary of these projects is in part II below.

In most of the developed systems, hierarchy of control starts with an industrial process that connects directly to the sensors, actuators, and measuring elements. Above that level, there are the distributed programmable controllers and instrumentation. Through data communication network and interface units, the hierarchy is connected to a computer station, including an engineering design station. In this configuration, the system consists of engineering workstation; distributed controllers of intelligent types; module buses; computer interfaces; and sensors/ actuators. Most of these systems can be operated under three modes: *manual, automatic*, and *computerized*.

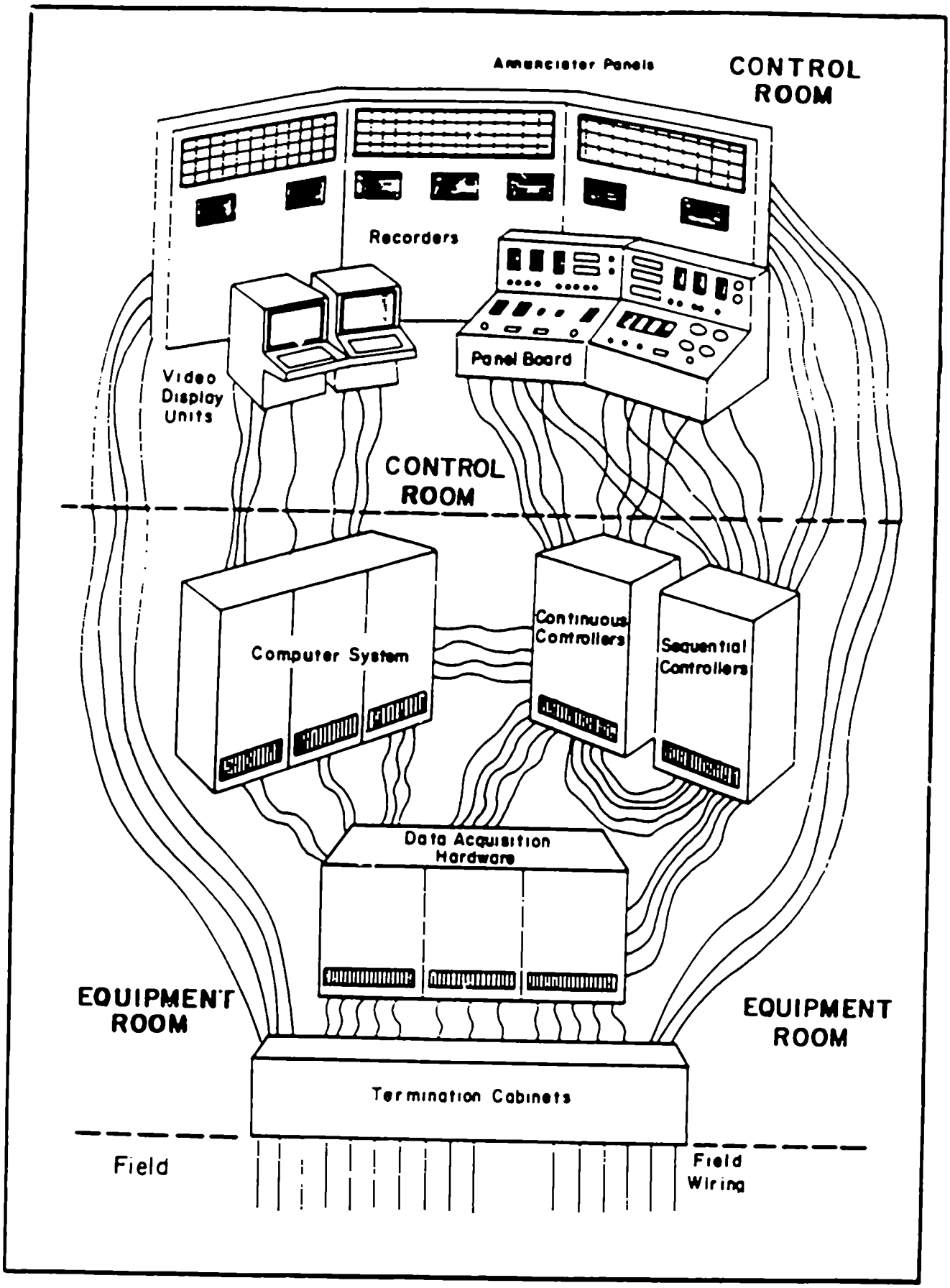
Another aspect is developing of decision support systems for production management. These systems are linked to the management information systems for production planning. The decision support system includes several operations research-based models that aid in enhancing the decision making process for production.

Recent trends in the area have shown many advancements that can be summarized as follows:

- Better strategic automation solutions
- New configurations and engineering tools
- Improved software programming
- Introducing more network capabilities and open systems architectures

- More dedicated distributed and integrated control
- Larger memories for programmable controllers
- Improved real time strategic management

Finally, the development and advancement process is a continual enterprise. For that, each company must continue to seek further development after the project ends. In fact, the process computer operation remains a lucid example of how universities and industries can cooperate fruitfully to solve real life problems. It can also demonstrate how technology transfer can be carried out in Egyptian industries, where industry staff shares with university experts all development and execution phases. This leaves industry with a highly trained personnel that could take the lead for any further refinements or modifications.



A Distributed Contol System

SUMMARY OF STC COMPUTER-BASED TECHNOLOGY PROJECTS.

Serial No.	STC Project No.	Project Title	Project Objectives and Scope
1	2	Integrated Computerized Control in Textile Industry. Company : STIA and VESTIA	To design and Implement a pilot system for the control of the production process of the Spining and Weaving industry, including building data acquisition systems interfaced with production machinery for productivity measurements.
2	4	Design and Application of Computer-Based Technology for The Development of Food Industry Company: EDFINA CO. FOR PRESESRVED FOOD	Designing and implementing computer-based process schemes for computer control and management of three main production lines. Three modes of operation are installed : manual, automatic and computerized.

SUMMARY OF STC COMPUTER-BASED TECHNOLOGY PROJECTS (Cont'd).

Serial No.	STC Project No.	Project Title	Project Objectives and Scope
3	8	Development of Jacquard Looms with Device to Translate Design Stored on Magnetic Discs to Mechanical Action Company: ORIENTAL WEAVERS	This project is directed towards designing and implementing computer controlled electromechanical system to translate weaving designs on floppy discs to mechanical movements controlling wrap thread, instead of punched cards.
4	18	Design, Development and Implementation of Computer-Based Control System for EGYPTALUM Calciner and D. C. Casters Company : ALUMINUM Co. of EGYPT	'Developing, modernizing and implementing control/systems in the coke calcination unit and D. C. caster in order to improve quality. The study includes process analysis, supervisoy control, system modeling, design, 'implementation and performance analysis.

SUMMARY OF STC COMPUTER-BASED TECHNOLOGY PROJECTS (Cont'd).

Serial No.	STC Project No.	Project Title	Project Objectives and Scope
5	23	Introduction of Computer - Based Technology to The New Electric Furnace at AHLIA co. Company: NATIONAL METALLIC INDUSTRIES	The project aims to introducing computer-based technology to the new arc furnace shop and the Open Hearth Furnace shops at Ahlia Co., including both control and management functions.
6	66	Development of Process Computer Systems for Production and Quality Improvement for The Egyptian Co. of Yeast. Company : EGYPTIAN CO. OF STARCH, YEAST AND DETERGENTS	This project is devoted for designing and implementing process computer control/management to the Mother Yeast process. Developed system includes manual, automatic and computer control operation, via an advanced intelligent distributed control technology.

SUMMARY OF STC COMPUTER-BASED TECHNOLOGY PROJECTS (Cont'd).

Serial No.	STC Project No.	Project Title	Project Objectives and Scope
7	67	Arab Computational Linguistics Company: AL AHRAM ORGANIZATION	To develop real life applications based on natural language understanding that relies on solid theories of computational linguistics and linguistic infrastructure.
8	74	Computer-Based Quality Improvement of The Electronic Products For The International Electronics Co. Company : INTERNATIONAL ELECTRONICS CO.	The main objectives of the project are 1. Developing techniques for automatic testing of large production volumes for quality assurance 2. Introducing new mold fabrication technology to replace high cost imported molds.

SUMMARY OF STC COMPUTER-BASED TECHNOLOGY PROJECTS (Cont'd).

Serial No.	STC Project No.	Project Title	Project Objectives and Scope
9	80	Production of Quality Spare Parts for Spinning and Textile Equipment Using CAD/CAM Systems. Company MISR COMPANY FOR FINE SPINNING AND WEAVING	This project aims to improving : 1. Quality of the materials used in manufacturing of the spare parts through induction heat treatment. 2. Spare parts design by introducing computer technology and CAD/CAM methods.

SECTION I
TECHNOLOGY TRANSFER TO INDUSTRY

A. General Overview

There are diverse applications of advanced computer technology for industrial processes. They vary from data acquisition systems to sophisticated distributed control systems. They can also build management information systems to evaluate process productivity or help to implement computer-aided manufacturing. With process computer control, three main activities usually arise, namely: ***data logging***, ***supervisory control***, and ***direct digital control***, see Fig. (1.1).

Data logging is one of the first computer applications in ***process control*** used for rapid and efficient data collection of process variables. The proper operation of a process industry depends on analyzing historical data generated during operations to determine a more efficient and optimized operation for the process. A computer can be used to record the data automatically and then analyze the data using pre-programmed instructions. This greatly improves the mechanism of tuning the process for maximum efficiency.

The use of computers for ***data logging analysis*** had led naturally to the decision that computers could be used to adjust automatically the operation of a process control system. This is known as ***supervisory control***. In the previous case, after control and process engineers analyze computer data, a decision might be made to reset many loop set points for more optimum operation of the overall process. Under supervisory control, the computer itself makes the set point adjustments following programmed instructions. To perform supervisory control, it is only necessary to have the computer output set point information back to the analog loop.

Direct digital control is the use of computers for the complete control function. In this case, the process control loop is still kept intact, but almost completely replaced by software. The measurement function and the final control operation remain, for the most part, analog in nature. The error detector and controller are now contained entirely within the computer software.

In sum, it is necessary to use the same control strategies adopted for historical analog process control, but now they are implemented via computer programs. Thus, control will still be provided by normal techniques such as proportional, integral, and derivative action on the controlling variable error, but this will occur in computer instructions rather than ***electronic*** or ***pneumatic*** hardware.

One of the most powerful computer techniques in process control is the ***Distributed Control System (DCS)***. This system offers an economical, reliable, and efficient solution to the process control engineer, for both large and small systems. In the last few years, most DCS manufacturers have delivered to the market microcomputer-based systems at a reduced cost and nearly the same capabilities of minicomputer-based systems.

B. Lines of Technological Development

The lines of technological development can be divided into the two separate streams illustrated in Fig. (1.2). The upper stream with its two branches is more traditional and includes the evolution of analog controllers and other discrete devices, such as relay logic and motor controllers. The second stream is more recent and comprises the use of large-scale digital

computers and their mini and micro descendants in industrial process control. These streams have merged into the current mainstream of distributed digital control system.

As a result of the development described above, industrial control system architectures came to dominate the scene by the end of the 1970s. These systems have been accompanied by the appearance of ***programmable logic controllers (PLC)*** and other intelligent controllers. With the increase of complexity of control systems, distributed digital control has progressed and its normal architectures began to evolve. One of the salient classes of these advanced systems are known as SCADA, an abbreviator of ***Supervisory Control*** and ***Data Acquisition Systems***. These progresses had a direct impact in the operator interface as they have drastically reduced the number of operators needed for each process. The new operators deal with the computer-based workstations that completely master all activities conducted at the process level.

With the rapid progress of computer-technology and the appearance of an **open system** in the 1990s, advanced distributed control/management systems have emerged, (see Fig. 1.3). These systems have used the power of computers and programmable units to achieve various tasks of system monitoring, control optimization, and decision making assistance.

The majority of computer and control vendors have set common standards that enable proper communication between various elements and ensure full integration. These features have also been transferred to most software systems developed, permitting complete connectivity, and making these system operate as **open systems**. This trend of open architecture has accompanied most of the systems in the 1990s, giving industry freedom to select components from different vendors from all over the world.

C. Real Life Applications

The computer-based technology market in general and the automation market specifically are very broad. Almost all industrial production lines can be upgraded in one form or another by using computer-based technology. Simple processes may only require data logging, others may need supervisory control; the majority can be improved by employing computer control. The computer control systems available on the market also vary considerably from a simple PC-based control, to a more sophisticated mini-computer (or higher)-based distributed network.

As a general review of the automation network, process computer control can be introduced in various ***continuous, batch***, and ***discrete production*** (see Fig. 1.4). It also covers different operations such as extraction, processing, finishing, and assembly.

The following are examples of industries that can benefit from implementing advanced process computer control:

- Petrochemical and refining
- Chemical industries including cement processing
- Food and pharmaceutical industries
- Pulp and paper
- Textile industry, including spinning and weaving
- Metals making, rolling/finishing, including BOF Steel making, electric furnace, aluminum processing, etc.
- Electrical power generations and utilization
- Medical and biomedical industries

Many other industries also use automated industrial lines. In general, it is now understood that all new industrial processes will include some sort of computer control. On the other hand, old factories can be upgraded by process control if it is technically and economically feasible. Finally, over time, there will be price reductions in process computer control configurations, which will be predominanct in the industrial world.

Under the STC, there are nine different projects in the field of computer-based technology. A summary of the projects and their scope are illustrated in Table 1.1.below. In the table, project scopes are classified as: data acquisition; supervisory control; process control; management information systems (MIS); computer-aided design and computer-aided manufacturing (CAD/CAM); and other computer-assisted systems (Character Recognition, Arabic Linguistics).

D. Typical Computer-Based Technology Project Steps

The work plan for the development, design and installation of computer control/management system for a *typical project* can be summarized as follows.

D1. Preparing Detailed Project Plans and Setting Priorities

This includes the following tasks:

- The preparatory meeting and discussion of detailed plans with the company.
- Studying priorities of the automatic control/management system for the company.
- Surveying recent trends in process computer control/management theory and practice.
- Setting comprehensive plans and agreeing with the company on strategies and objective of the study.

D2. Evaluating Process Status of Project and Determining Requirements

This task comprises:

- Investigating present project conditions and evaluating productivity supported by measurements and analysis.
- Determining company requirements for development and their ranking in order of importance.
- Preparing preliminary future views for modernizing the project and improving its productivity.
- Investigating the scope of the management information systems and needed tools for decision making.
- Development of mathematical model governing the process operation, based on observation and measurements.
- Training on the new advancement in the computer process control/management.
- Investigating system bottlenecks and reasons for difficulties, and conducting fault diagnostic study.

D3. Preliminary Development of Logical Design of Anticipated Systems

This aspect will include:

- Preliminary development of proposed architecture.
- Preliminary development of hardware system components.
- Preliminary development of the types of computer packages needed for system operation.
- Setting automatic control strategies for the system.
- Determining the basic requirements of the strategic production management system.
- Preparing a preliminary view of the proposed integrated systems tailored to company needs.
- Proposing systems alternatives, comparing them technically and making the best selection.
- Training on hardware components and interfaces.

D4. Setting Final View on Proposed Process Computer Control/Management System

This aspect will include the following tasks:

- Setting final view of the system architecture
- Writing the technical specifications for the tender of the proposed system.
- Announcing tender documents among selected specialized companies and selecting the best bid.
- Commencing mechanical modifications of the process and site preparation for the installation process.
- Building the process computer control room with necessary power connections.
- Training on the computer controls using distributed networks.

D5. Installation, Project Management and Final Testing

This is a crucial step that guarantees project success. It includes the following activities:

- Performing laboratory tests of the system components and assembly prior to installation.
- Installing system hardware/software for all project activities and preparing execution plans.

- Making the necessary checks to ensure the highest proficiency of system hardware and software integration.

- Conducting preliminary and final project operation tests in cooperation with the company.

- Developing the management information system and the decision-making programs.

D6. Developing Procedures for Optimal Project Operation and Continuous System Upgrades

This aspect encompasses the following tasks:

- Developing procedures for project optimal operation, setting control strategies, and making the necessary modifications for controlling variables.

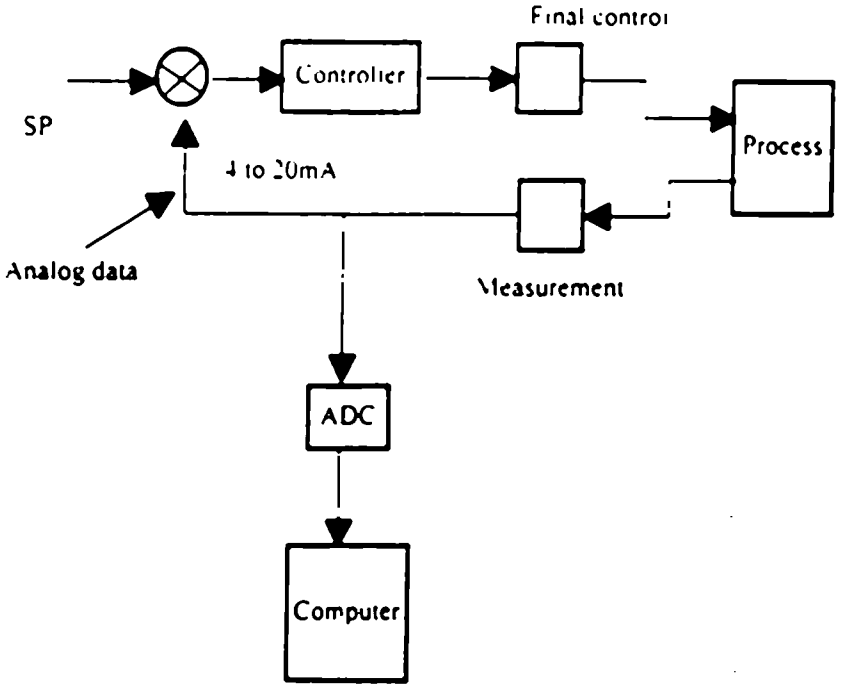
- Cooperating with company staff to develop final strategic and ordinary management information systems tailored to their needs.

- Conducting an intensive training to prepare skilled staff for system operation, preventive maintenance and modification.

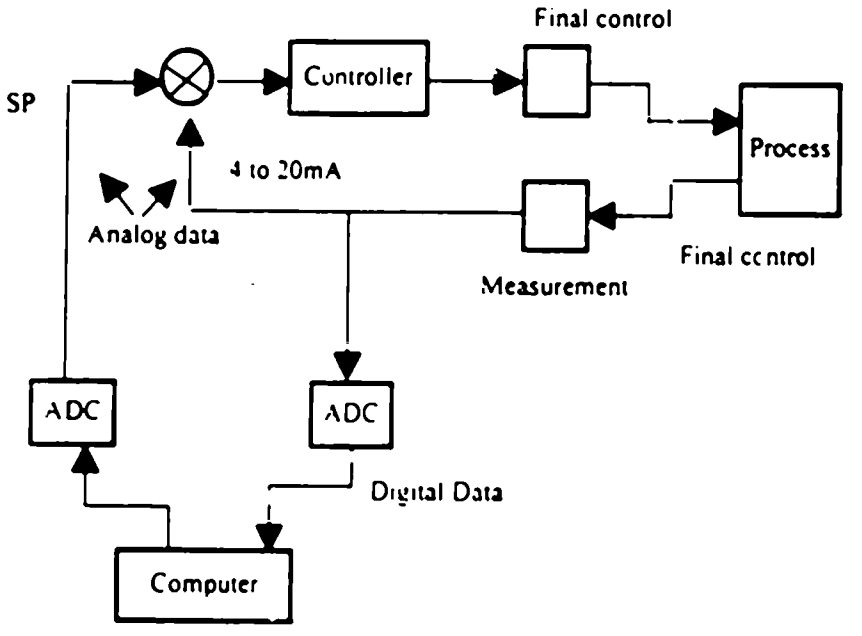
- Establishing an electronic group for performing all local maintenance and repair duties for the proposed system with the company technical staff.

- Discussing the economic return expected from upgrading together with conducting the actual economical feasibility study, based on the measured performance after modernization.

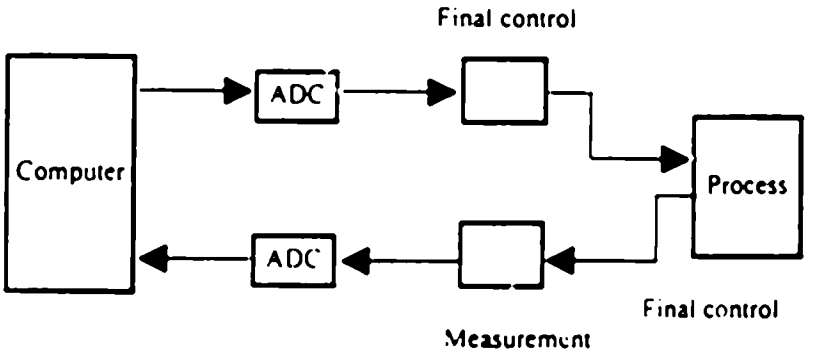
- Setting integrated plans for continuous system upgrading to include new technology.



a) **Data Logging.**



b) **Supervisory Control.**



c) **Direct Digital Control.**

Fig. (1.1) Different Classifications of Process Computer Control.

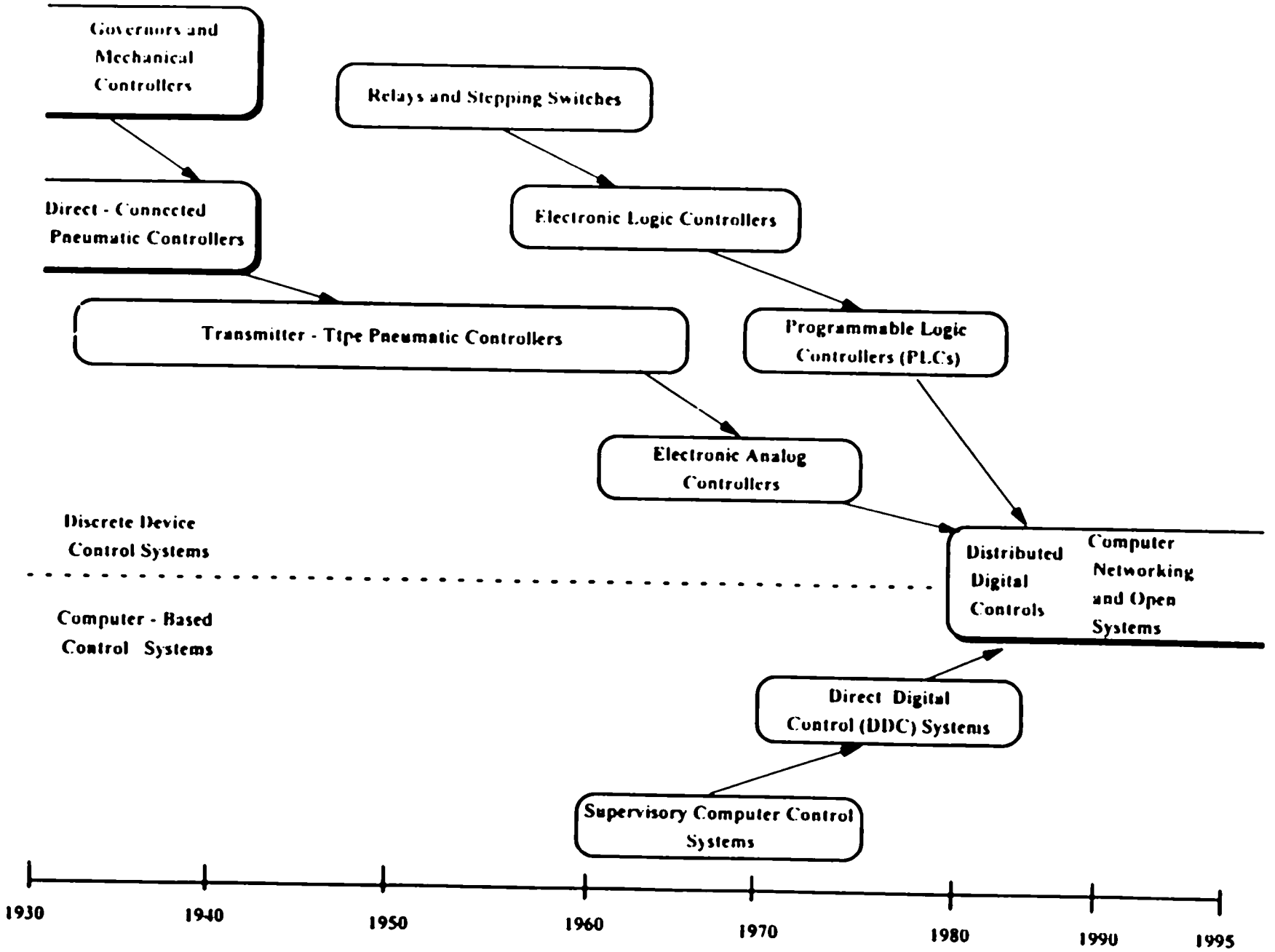


Fig. (1.2) Evolution of Industrial Control Technology.

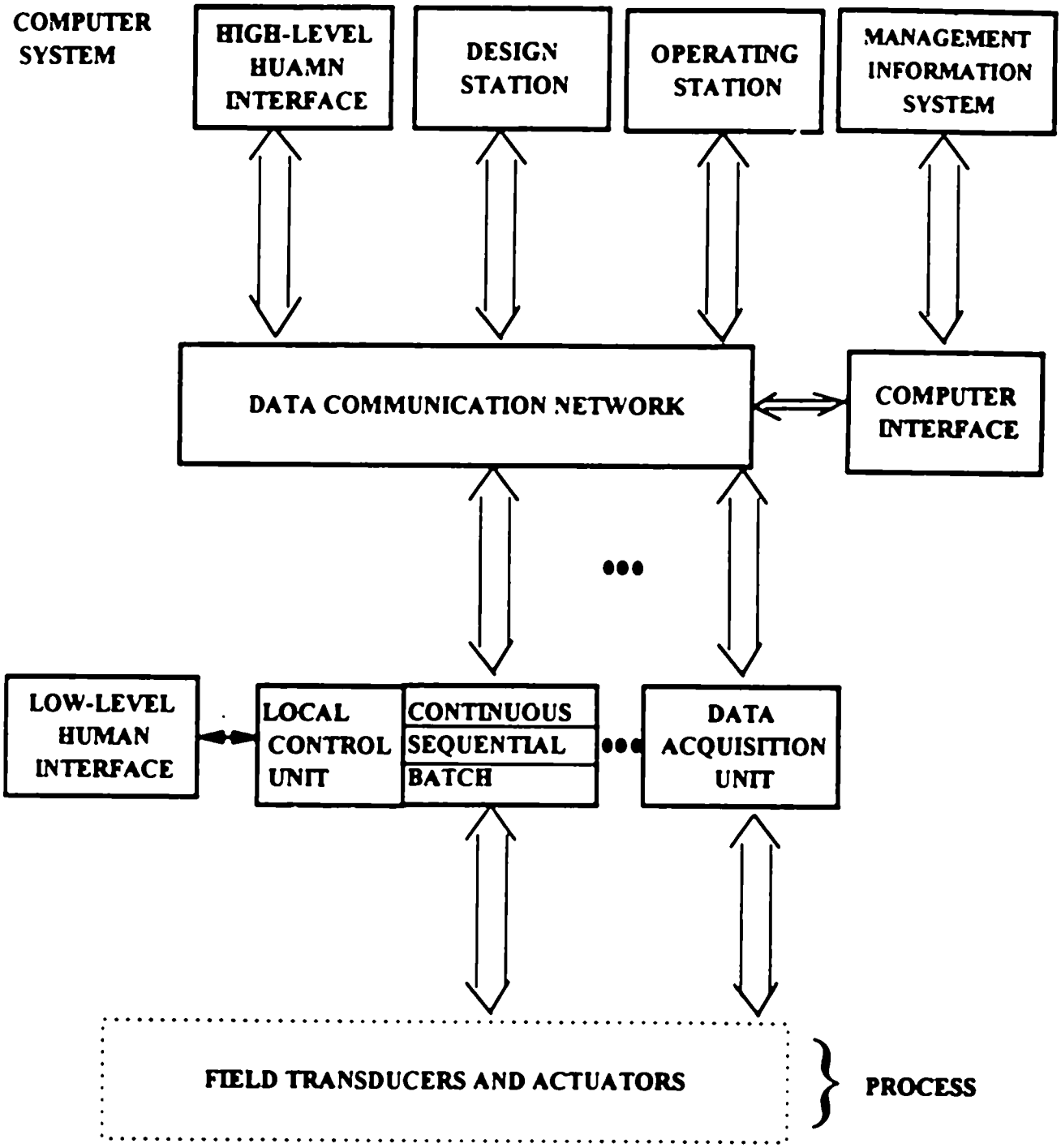


Fig. (1.3) Distributed Control/ Management System Structure

Automation Market

Processes, Applications and Industries

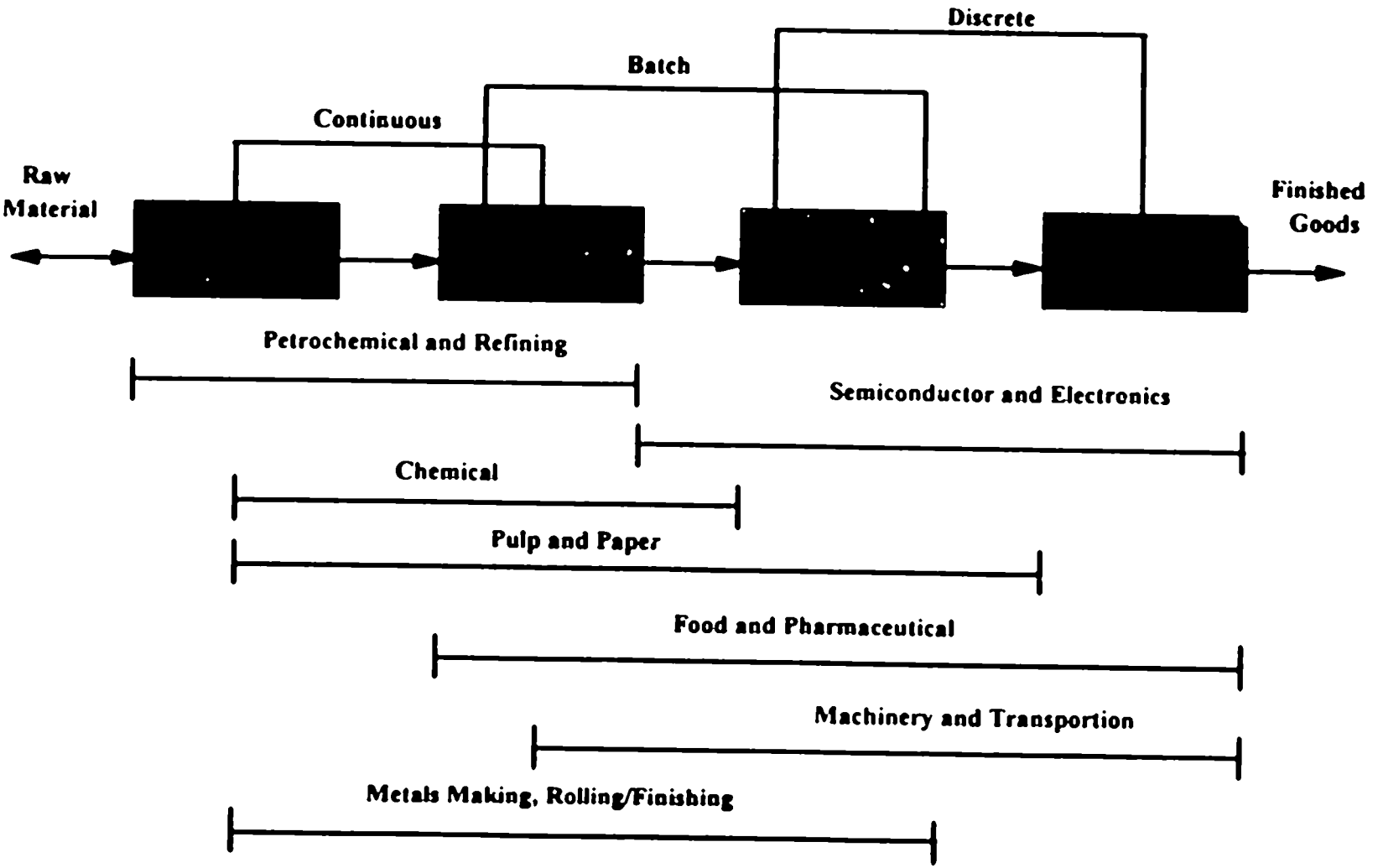


Fig. (1.4) Overview of Process Computer Control Avenues of Applications.

Table (1.1) List of STC Computer-Based Technology Projects

No.	Project No.	Project Title	Type of Industry	Project Scope					
				Data-Acquistion	Supervisory Control	Process Control	MIS	CAD/CAM	Other Computer Assisted
1	2	Integrated Computerized Control in Textile Industry (STIA and Vestia Campanies)	Textile	√	√		√		
2	4	Computer-Based Technology for Food Industry (Edfina Co.)	Food			√	√		√
3	8	Development of Jacquard Loom (Oriental Weavers Co.)	Textile			√			√
4	18	Computer-Based Process Control to EGYPTALUM	Metallic		√	√			
5	23	Computer-Based Technology to the New Electric Furnace (Ahlia Company)	Metallic	√	√		√		
6	66	Process Computer Control for Yeast Company	Food			√	√		√
7	67	Arab Computational Linguistics	Administration						√
8	74	Computer-Based Improvement of Electronic Products (Interanational Electronic Co.)	Electronic	√	√				√
9	80	Production of Quality Parts Using CAD/CAM System (Misr Co.)	Textile					√	

SECTION II
ANALYSIS AND MODELING OF INDUSTRIAL PROCESSES

A. Process Description

The first step in applying computer-based technology to an industrial process is to visit the facility to obtain a complete process description. This is done usually by a team of specialists from different disciplines, including an expert in industrial process. The description will contain a process layout and includes different production lines and their interrelationship.

Process layout is the next step to be drawn showing motors, pumps, valves, tanks pipes, etc., with detailed written dimensions. This layout is usually referred to as ***piping diagram***, (see Fig. 2.1) for the process layout of a yeast plant.

Together with the layout process description, block diagrams are sketched showing the various steps in processing. These are prepared usually with the cooperation of process engineers operating in the plant and by referring to the system catalogs.

B. Locations For Potential Improvement

Once a detailed process description is prepared, the modernization team starts to locate areas for further development. In general, several areas are selected and then ranked in order of importance.

In selecting the final areas for improvement, certain measures are considered. Among these are modernization costs, effects of the area in overall quality, benefits gained, etc. Usually, the decision maker owning the facility participates extensively in this selection.

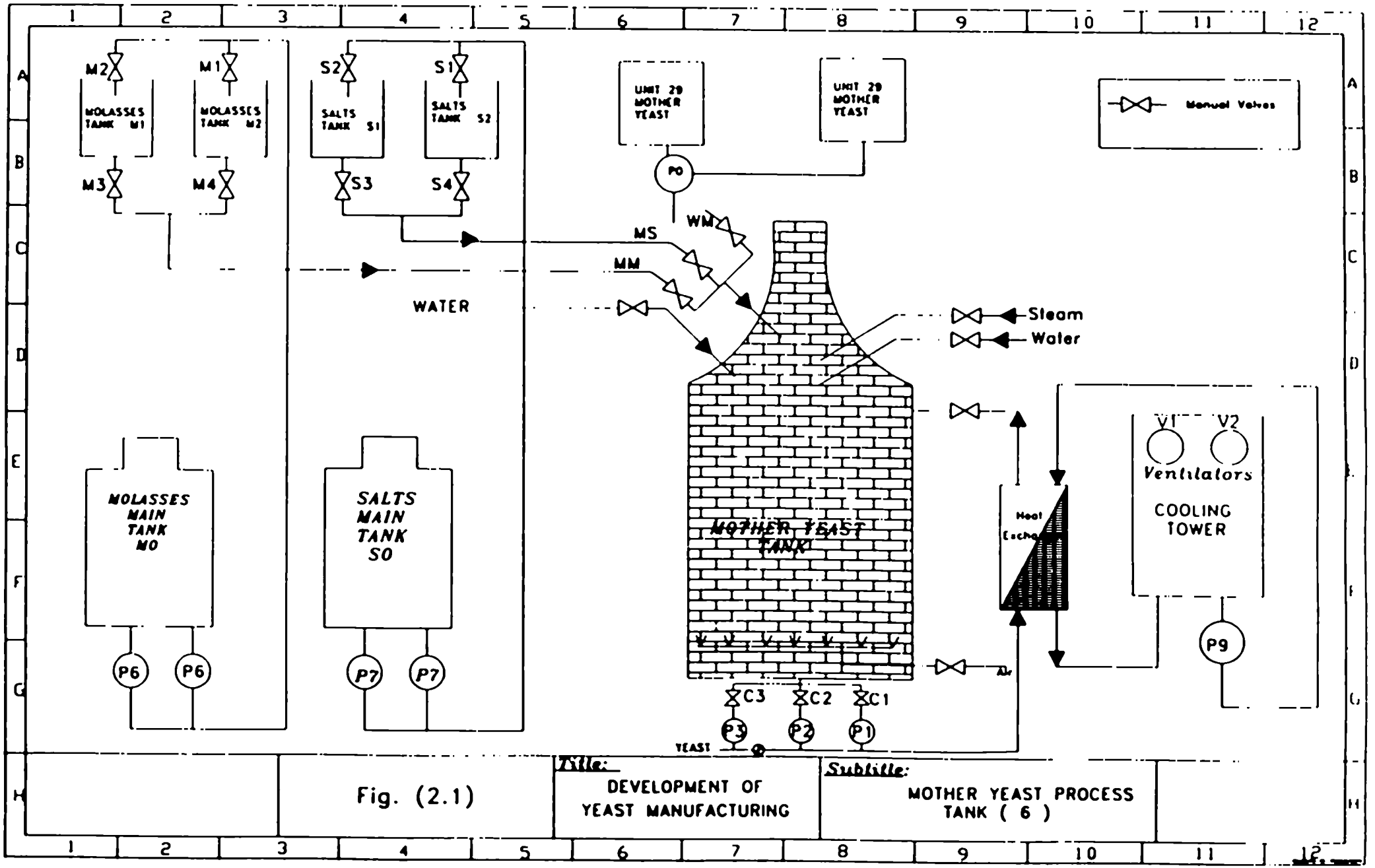
Within the selection, measurement and control tentative needs are specified and an overall view of improvement is proposed. This is shown in Fig. (2.2) for the Martin furnaces and Electric Arc furnaces of Ahlia Company. Fig. (2.3) shows the specifying control system strategy of a juice mixing unit in the Edfina Company.

C. Measurement And Observation

After selecting the process to be modernized, measurements are carried out to understand more of the process and to reveal ranges of variability in process parameters. Observations can also serve in locating system bottlenecks and in carrying out fault diagnosis studies.

Fault analysis can lead to optimum system use by:

- Identifying the faults that could be avoided through specific precautions.
- Locating the bottlenecks, where even small faults lead to complete shutdowns, and placing these points under special controls.
- Investigating the consistency of the fault to determine the repair time and to determine precise recommendations for reducing the repair times.


M2
M1
MOLASSES TANK M1
MOLASSES TANK M2
M3
M4
S2
S1
SALTS TANK S1
SALTS TANK S2
S3
S4
UNIT 29 MOTHER YEAST
UNIT 29 MOTHER YEAST
PO
Manual Valves
WM
MS
MM
WATER
Steam
Water
MOLASSES MAIN TANK MO
SALTS MAIN TANK SO
MOTHER YEAST TANK
Heat Exchanger
V1
V2
Ventilators
COOLING TOWER
P9
P6
P6
P7
P7
C3
C2
C1
P3
P2
P1
YEAST
Fig. (2.1)
Title:
DEVELOPMENT OF YEAST MANUFACTURING
Subtitle:
MOTHER YEAST PROCESS TANK (6)

- Determining the weak points, where repetitive faults occur, and whether a special review or redesign may be needed.

In general, the faults can be classified as follows:

Minor faults, which cause little interruption to the production flow, such as fuse replacement or on-line mechanical adjustments.

Moderate faults, which result in an interruption for some time but without the complete shutdown of the production flow, such as faults that lead to temporary use of alternative production units.

Major faults, which lead to a complete shut-down until repaired.

D. Modeling Studies

The next step is to develop the process model. ***Mathematical models***, represent an understanding of the formulation of the process. They provide the basis for controlling the process performance. In this case, the effects of control variables on the process must be identified and described by models which can then be referenced when making control decisions in a computerized environment. Furthermore, it is indispensable in the calculation of both ***static*** and ***dynamic*** optimal operating conditions.

Computers are used in both stages of model formulation and application. In the first stage, model formulation requires systematic study and the identification of the effects of the various model parameters and variables. The study can be accomplished in an experiment in a fully-controlled environment so that the negative or undesired effects of other variables are eliminated or at least minimized.

Computers are also employed in manipulating the collected data and identifying the model parameters. Once a model has been constructed, computer simulation is carried out. The use of a computer with a mathematical model to control optimization requires trial and error until a good model is obtained.

While agreement between the model and data is necessary, it is insufficient to claim the validity of particular model, especially if the data is required from a limited set of conditions.

Computers have become an integral part of the industrial system. They have proven to be a vital instrument for those engaged in research and production. The success of a computer application, however, depends on the development of better on-line instrumentation, high fidelity mathematical models, and advanced control schemes. The prerequisite to true and meaningful optimization of an industrial process is an accurate mathematical model that is capable of describing various behaviors of the process under consideration. The prerequisite to a successful mathematical model, on the other hand, is the availability of sensors to detect and record accurately, either directly or indirectly, various types of relevant responses. This relationship between computer and sound mathematical models is a two-way interaction.

13

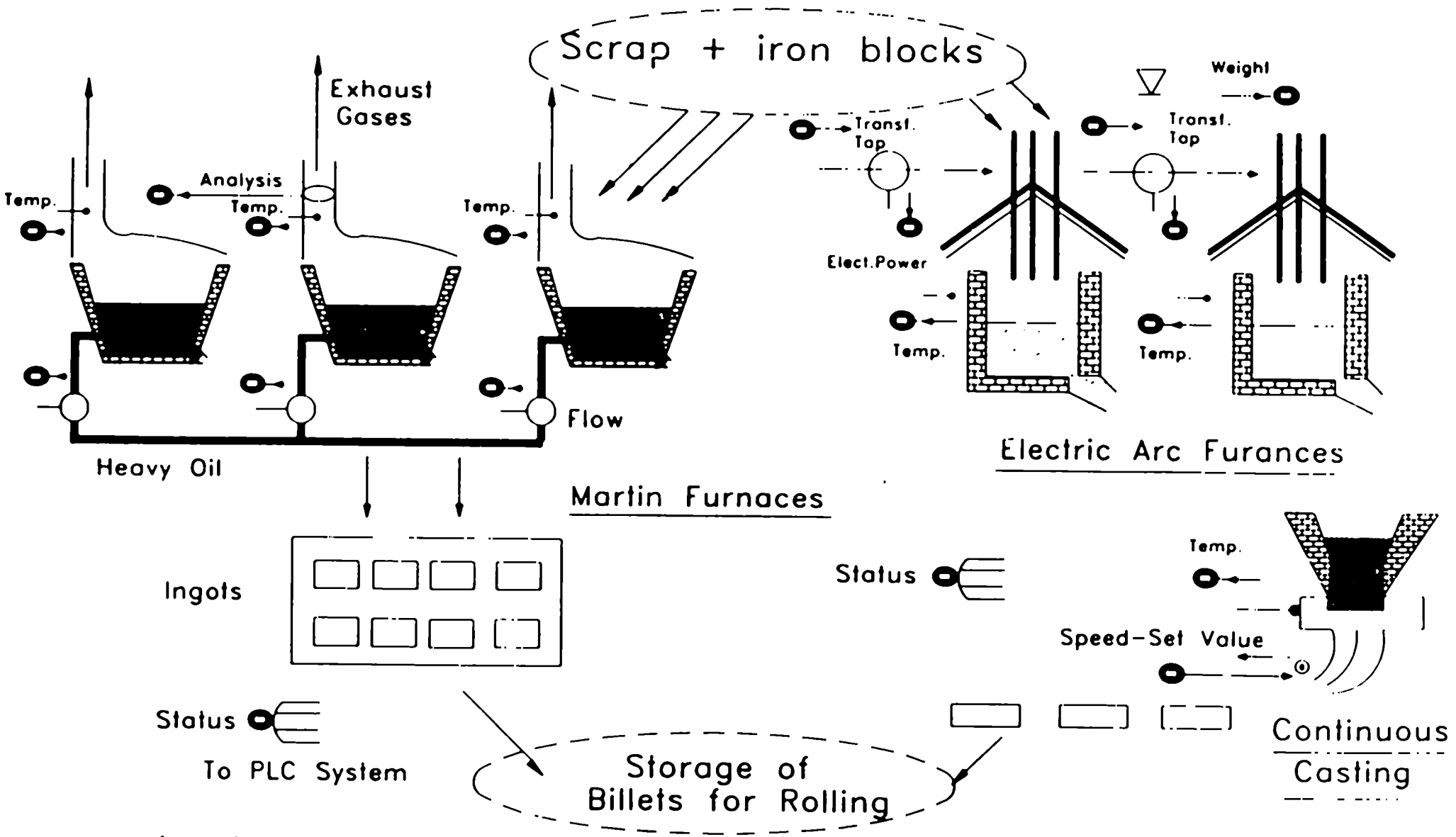
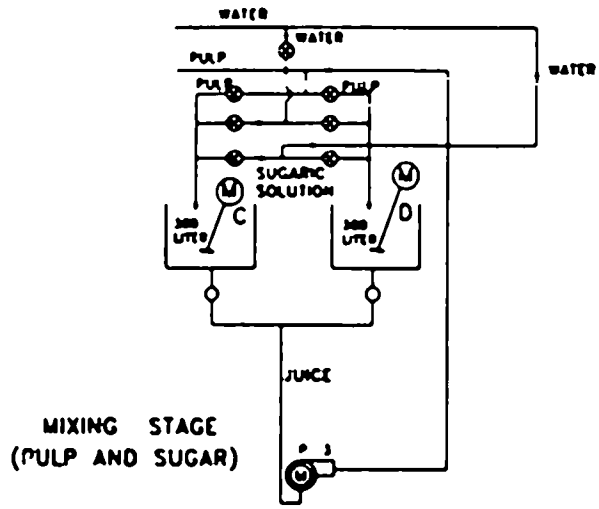


Fig. (2.2) Proposed Measurment and Control Actions in The Steel Production Shops at AHLIA CO.



The control system requirements can be elucidated, as follows:

- Target: Prepare an amount (batch) of juice with a specified concentration.
- Operation: Mixing specified amounts of a sugar solution with the known concentration and a pulp with known concentration and water.
- Sensors: Manual concentration measurement and level measurement.
- Actuators: A group of manual valves and starters for electric motors which drive the pumps.

Control Strategy

A closed-loop control of concentration is necessary. The controlled variable is the water quantity, under the assumption of correct dosing of pulp and sugar solution. Sequence and timing control are also needed.

A controller which would perform the control actions should have the following inputs and outputs respectively:

- Continuous level measurement
- Concentration measurement
- Starting the valves
- Starting and stopping the driving electric motors of the pumps
- Starting and stopping the mixing electric motors

Fig. (2.3) Proposed Control System Strategy of Juice Mixing Unit

E. Productivity Calculations

Quality is the combination of attributes or characteristics of a product that have significance in determining the degree of acceptability of the product to user, and that determines its value or worth. As used by the industry, it is a concept involving degree of purity, strength, flavor, color, size, maturity, and any other distinctive product attribute or characteristic.

Many large companies attain their position by maintaining the quality control of the products they process. They do not process a product that is lacking in uniformity, but a uniform quality product that will continue to build their reputation. Thus, a quality control program informs management not only of the quality and the condition of the products being packed, but also of the industry trends.

Similarly, recent studies have indicated that company productivity measures are low. Productivity is critical for a company's survival and prosperity. Increasing productivity strengthens a company's competitive position in market place, counteracts increased costs of raw materials, energy, and labor, provides funds needed for expansion and modernization, and can furnish higher pay and better fringe benefits for employees. Hence, productivity improvement should be one of the main targets for industrial companies in Egypt.

There are many techniques that can be applied to improve productivity. These techniques are based on traditional industrial engineering, marketing, systems control, operations research, computer engineering, management, and other disciplines. They can be classified into five classes of techniques: technology-based; employee-based; product-based; task-based; and material-based.

- Technology-based techniques
  - Computer-aided manufacturing (CAM)
  - Energy technology
  - Maintenance management
  - Rebuilding old machinery
  - Energy conservation
  - Computer-aided quality control
  - Computer networking
- Employee-based techniques
  - Financial incentives
  - Fringe benefits
  - Training
  - Worker participation
  - Improving working conditions
  - Quality circles
  - Concurrent engineering design teams
- Product-based techniques
  - Product diversification and simplification
  - Product-mix selection
  - Value engineering

- Advertising and promotion
- Quality control
- Group technology

- Task-based techniques

  - Work study
  - Job design
  - Job safety
  - Production scheduling
  - Computer-aided data processing

- Material-based techniques

  - Inventory control
  - Quality control
  - Material reuse and recycling
  - Material handling systems
  - Waste control
  - Material requirement planning
  - Just-in-time production

The methods used to measure productivity may differ in form, but they all have the same economic control and interpretation. The choice of a particular method will depend on:

- Objective and scope of measurement.
- Time horizon of study.
- Data available.
- Time allocated to conduct the study.
- Economic analysis.

To measure output, one of the following methods can be used:

- **Physical method**, where output or production is measured in physical units as ton, liter, etc.

- **Modified physical method**, where coefficients of equivalence are introduced to transform quantities of different products into a quantity of a standardized product.

- **Monetary method**, where monetary units measure output as value of production, value added.

- **Labor method**, where output is measured in terms of labor units and standard time or actual time can be used.

These aspects are usually considered in process improvement and in developing decision making assistance packages.

SECTION III
DESIGN OF COMPUTER-BASED SYSTEMS

A. System Hardware Components

The process computer control system requirements can be briefly described as: managerial and decision making assistance; and supervisory or direct control, monitoring, and alarming. To realize these functions, a computer-based distributed control/management system is needed. The system configuration is specified into two main categories: hardware and software.

The hardware specifies the needed system equipment. The equipment can be classified in four main groups, namely:

- Field equipment
- Intelligent terminals (panel equipment)
- Data communication
- Computer units

A brief description of each group as follows, see also Fig. (3.1):

A1. Field Equipment

The field elements include the sensors/transducers, transmitters and actuating devices. These devices are described below, (see Fig. (3.2)).

Sensors/Transducers. A particular measuring device may involve a "primary element" or "sensor" which is in direct physical contact with, or in close proximity to, the process medium, and a "secondary element," which causes a display or control signal to be generated, as a result of the stimulus applied to the sensor. Primary elements tend are varied, have many components, and cannot be transmitted to the locations of control panels without power. Therefore, transmitters are used for increasing the signal power level up to the standard value.

Transmitters. A transmitter is a device for converting the response of a primary element into a usable signal, which is then transmitted either to an indicating instrument or to a controller.

The most common output signals generated by the transmitters are either pneumatic pressure signals, or DC currents in the four to 20 mA range. However, this electrical range is not exclusive, and alternative DC current, DC voltage, AC voltage, and digital transmissions are sometimes used.

Some non-mechanical transmitters are also manufactured and the majority involve integrated circuit technology. Many electronic converters feature in these transmitters, together with some amplifier circuits. The advantages arising from the use of solid state technology include:

- Fast response
- High linearity

- Low power requirement
- Physical compactness

Types of sensors/transducers. There are different types of sensors such as:

- Temperature: Expansion Thermometers, and Resistance Temperature Detector (RTD).
- Pressure: Diaphragms, Bellows, Bourdon Tubes, and Manometer.
- Flow: Orifice Plate, Venturi, Nozzle and Magnetic flowmeter.
- Level: Direct and Differential.

Actuators (Final Control Elements). Final control elements for fluid amplifiers are mainly linear actuators for rectilinear motion and rotary actuators and motors for rotary movement. Hydraulic, pneumatic, and electrical elements are used to apply the needed actions.

In many process control loops, control of the system variables is affected by manipulating the flow rate of a fluid in a pipeline. Where sufficient pressure head exists at the flow source, the flow rate may be manipulated by inserting a variable, controllable restriction such as a flow control valve. Valves have a rectilinear motion such as the gate, wedge, needle, diaphragm, and angle types. Valves also have a limited rotary motion such as the butterfly, ball and plug types.

A2. Panel Equipment

There are different control and measuring units which have to be accommodated in a panel, usually inside the control room, (see Fig. (3.3)). The main panel equipment are given below.

Controllers. Commercially-available general purpose controllers can be subdivided into:

- **On-off temperature controllers**: simple controllers that switch a heat supply on and off to pre-set values to obtain the target temperature.
- **General purpose process controllers**: feedback, cascade, feedforward, and ratio controllers, depending on the type of action which each is required to provide. These controllers have PID-control characteristic with analog display and auto/manual transfer capabilities. Digital process controllers with microprocessor-based structure have introduced improved reliability and flexibility, and the ability to use the controllers to perform dedicated functions such as self-tuning, self-checking, programming, and communication with other intelligent units.
- **Motor speed controllers**.
- **Sequence controllers**: Programmable Logic Controllers (PLC) are designed around dedicated microprocessors; they replace relay and contactor networks. They are capable of performing sequence, timing, counting and logic actions. In addition to the control functions the PLC can communicate with other intelligent units in the plant, such as other PLCs or controllers, computers and printers, through direct connection or a network.

A3a. Recorders, Totalizers, Indicators, and Annunciators

These panel-mounted units are essential aids for the operating staff to monitor the process on line, as well as providing hard copy to the trends of main process variables.

Recorders generate charts with time base, and different scaling and speeds for one or more tags. Microprocessor-based recorders include complex mathematical functions and improved display facilities. They can communicate with other intelligent units and computers. The role of recorders is becoming less important with the advent of computer control-based systems because all display functions are performed on the video terminal units and hard copies for all trends can be obtained easily.

The **totalizers** are assigned the function of time integration of a certain variable. They are usually applied in case of fluid or gas flow and weighing of materials. Totalizing functions can be also included in computer control software.

Indicators can have an analog or digital display with the appropriate scaling and marking. Usually indicators are coupled directly with transducers to guarantee real values display. **Mimics** are also a form of indication where symbolic graphics for the process are represented with indicating lights to monitor the status of important units. Manual operating switches are part of the panel. They are used mainly to: start-up; shut-down; apply needed manual actions; and set and reset process operation. The alarm signals are usually grouped in an annunciator panel with flashing or sustained lights and audible signals.

A3B. Data Communication

Two types of data communication are available. The first type is used to transfer data between intelligent terminals to realize some control and monitor functions. At the same time, data can be transferred bi-directionally to the computer data base. A communication module is needed to control and supervise the data transfer. This module is capable of multiplexing, decoding, and sending and receiving programmable IC's. All intelligent terminals are coupled over data highway comprising special cables and conversion units. Serial communication is usually adopted with high baud rates.

The second type of data communication is used for massive and fast data transfer between computers. It is characterized by a high transmission speed reading few Mips. This type of communication allows coupling supervisory and management computers in real time mode. Both hardware and software units are needed to perform and organize the communication data.

Computer units. Computer units serve three main tasks:

- Engineering and design
- On-line supervision and monitoring of the process
- Managerial activities

Usually the design computer is used in the initial stage to configure the system and tune the parameters. In the operation stage, the supervision computer enables the operator to monitor the process status and control actions through the keyboard.

In recent computer control applications, managerial activities can be performed in real time mode. This requires on-line data transfer between the supervisory and management computers over a high speed data link.

B. System Software Components

There are two levels of software, namely, *low level* machine-oriented software is used by most intelligent controllers and *high level* software for computer programming. A description of this software is as follows:

B1. Programming of Intelligent Controllers

Standard programming modules are usually available to configure the intelligent terminals using hand held programming units. The same work can be done using the engineering computer. Simple programming language with graphic representation has been developed to ease the configuration procedure.

B2. Design of Process Supervision and Monitoring

This task is performed using high level languages and executed on computer level. Ready-made software packages are available by different manufacturers. Common features of these packages are: (see Fig. (3.4)):

- Status monitoring
- Limit value monitoring
- Trend monitoring and reporting
- Process display with dynamic values
- Event logging and reporting
- Statistical and operational reporting
- Sequential actions
- Expert system modules
- Database functions

B3. Management Activities

These activities relate to special functions that the company defines. A real-time database can be created within the supervisory software to supply needed data. The supervisory software can execute decisions and set values when transferred to the database.

Some of the functions performed by the management routines are:

- Inventory control
- Maintenance scheduling and management
- Cost analysis
- Report generation and documentation
- Productivity and quality tracking

Other managerial functions are elaborated in Section E.

2'

C. Main Features of System Configuration

The system selected to achieve the objectives of industrial projects should possess the following features:

Scalability. The system should encompass wide range of potential control needs and permit expansion without changing pieces already in place.

Communications. The system should use a multilayered communications hierarchy to assure tight coupling of information regardless of system size.

Control performance. The system should use powerful processing for running modules. The system capabilities should cover artificial intelligence and expert systems, on-line statistical process control, remote serial multiplexing of smart field devices, and other application-specific strategies.

Reliability. The system structure should permit easy implementation of redundant security control and ensure contained control system reliability in the event of interrupted communications.

Operator interface. A line of dynamic interactive consoles should assure effective user interface. Advancing monitoring and control, logging, trending, archiving and alarm management capabilities ensure efficient use.

Engineering tools. To facilitate configuration, evaluation and documentation, engineering assistance should be available on- and off-line using the PC-based engineering workstation. At the local level, handheld configuration terminals should be used to monitor and tune varied functions on demand. The available functions should comprise:

- Computer-aided design, and engineering, such as finite element analysis, dynamic analysis, life prediction, etc.
- Ladder logic
- Console configuration
- Batch language
- Expert system language
- Relational or object-oriented database

Controller modules. Distributed system modules should work individually to isolate and implement critical tasks, then work together to merge these tasks into an integrated process management strategy. The available modules should include:

- Analog input/output
- Digital input/output
- Pulse input slave module
- Control input/output slave module
- Remote input/output module
- Interface module

22

Operating interface. Computer-based console should integrate operator information requirements for both process control and business decision making. The available display formats should have:

- Process overview graphic
- Group display graphic
- Process detail display
- Alarm summary
- Trend display
- Help display

Data management. The system should offer a variety of software which integrate plant-wide information and process management strategies.

The above options should also have the ability to handle: data processing, preventive maintenance, alarm management, creation of historical records, statistical process control, production/inventory control, batch recipe editor, and laboratory data entry.

D. Comparing System Alternatives

Once the system requirements are specified, several system design alternatives are suggested. These designs include:

- Field equipment such as on/off valves, regulated valves, sensors/transducers and indicators
- Microprocessor-based controllers to perform control and data acquisition functions
- Control panel for housing the controllers, indicators, annunciators, and manual switches
- A supervisory control and monitoring computer station with the appropriate software

There is a wide variety of control and measuring equipment in the market. The best types of equipment can be selected using the following criteria:

- Field equipment with standard input/output characteristics
- Controllers that can handle batch process including analog/digital signals, continuous and sequential control action
- Monitoring and supervising control functions which enable response recording, alarm, reporting, recipe adjustment, manual/automatic station transfer, etc.
- Reliability, expandability and easy maintenance
- Cost

Other factors should be considered in the equipment selection such as:

22

- Experience of the project team in programming and operating the computer control system
- Experience of the operating personnel in the company with control systems
- Software capabilities of the supervisory control and monitoring system

Considering the cost and the above factors will lead to selecting the best alternative to the modernization problem. This solution is then scrutinized for detailed designing and setting its complete system specification.

E. Detailed Design and System Specification

Once the final process control system architecture is selected, a detailed system design will be carried out. This includes preparing piping diagrams with instrumentation and actuators (see Figures (3.5) and (3.6)). For each apparatus, a specification sheet will be completed based on process operating conditions as in Figures (3.7) and (3.8). Most of these instrumentations are based on sensors that give their output in the standard mode 4-20 milli Amp or 0-4 Volts.

Other design details should include the panel shape that will accommodate all controllers, push buttons, and indicators. The panel is usually located beside the production line or in a separate central control room. Cablings are needed to establish the control network. Normally, two types of cabling are needed. These are *control* or *signal* cables that are shielded to avoid interference and *power* cables (unshielded) to supply the needed power to equipment.

Detailed specifications are also needed for process controllers, computers, printers, and software. The system should be equipped with an uninterruptible power supply (UPS) to feed the power to critical locations in case of power source interruption. It must be emphasized that the specifications should comply with the *open system* requirement to ensure proper integration between various system components.

The detailed design and specifications are tendered to various vendors. The tender selection is usually a matter of compromise between performance and cost. The components are ordered, installed and commissioned.

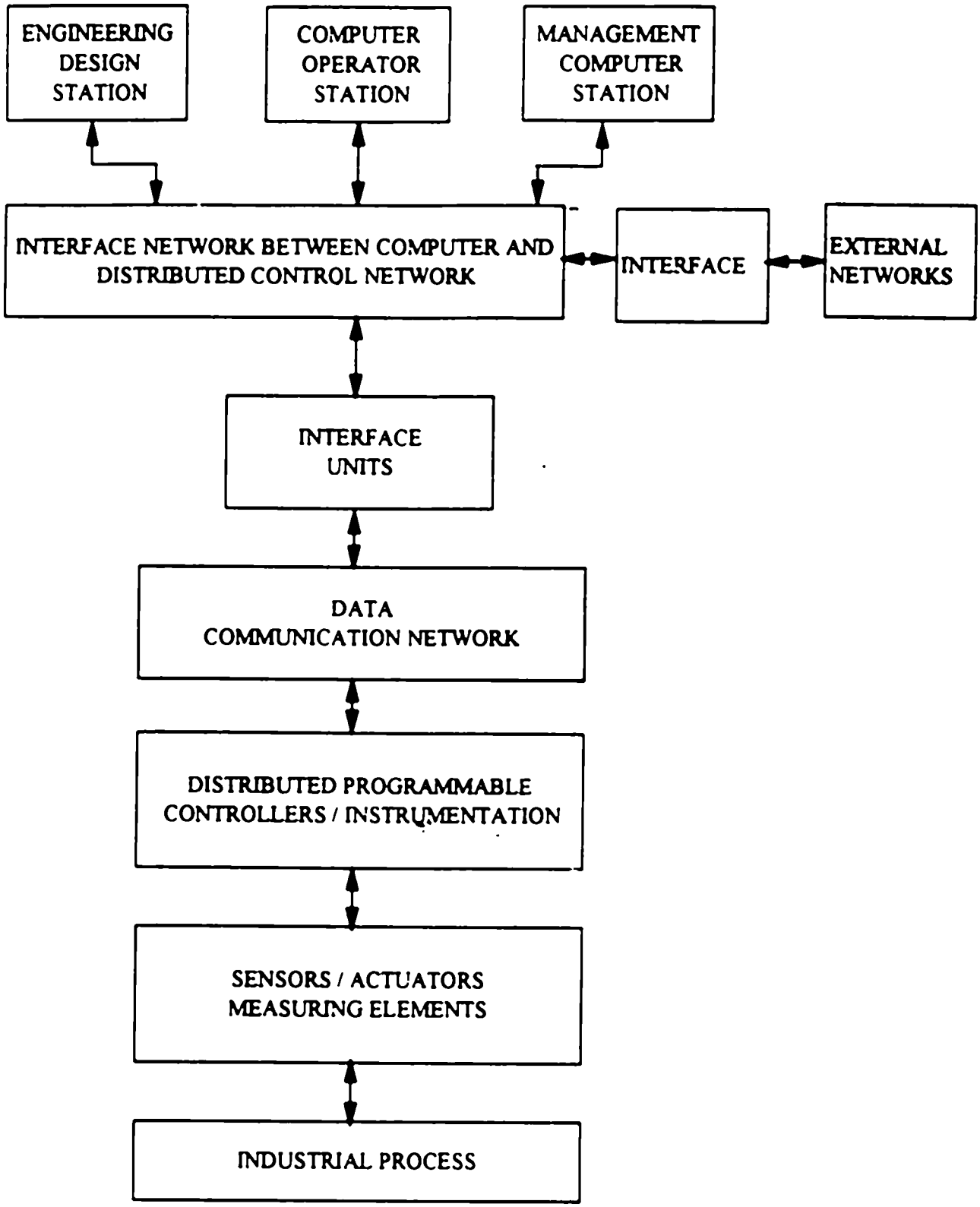


Fig. (3.1) Hierarchy of Modern Distributed Computer Control / Management of an industrial Process.

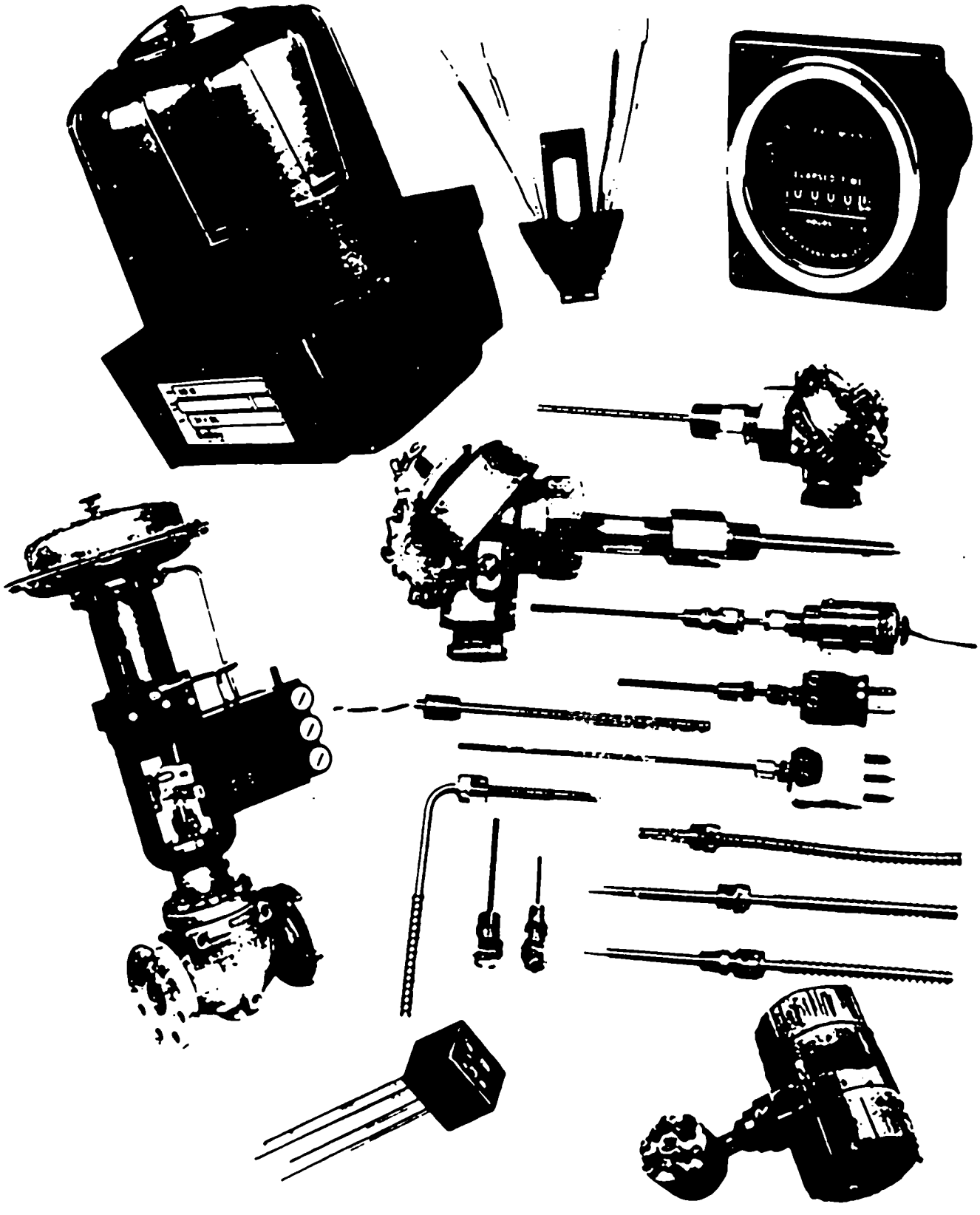


Fig. (3.2) Examples of Some Field Measuring Devices.

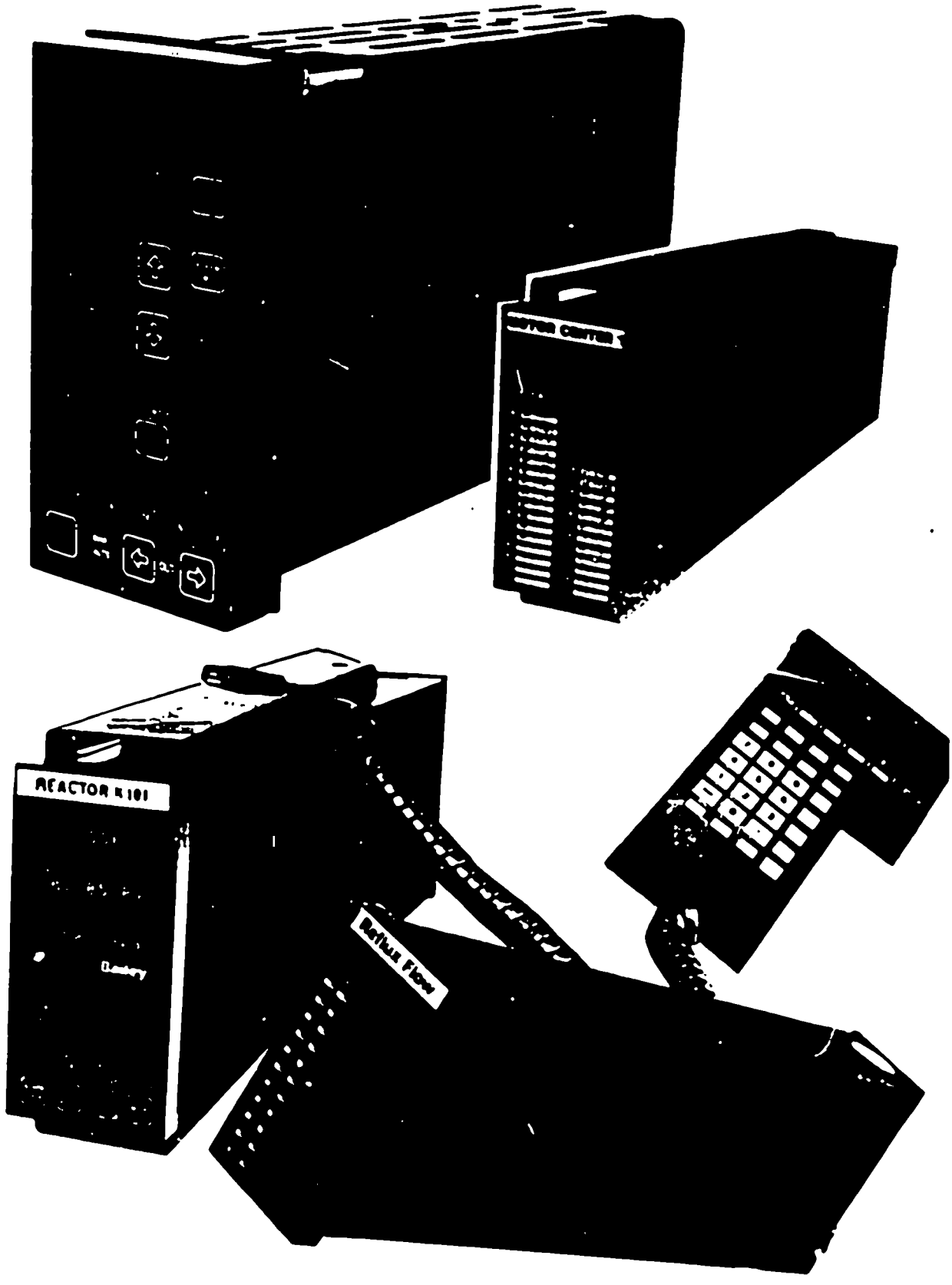


Fig. (3.3) Example of Some Controllers Forming Part of Panel Equipment.

21

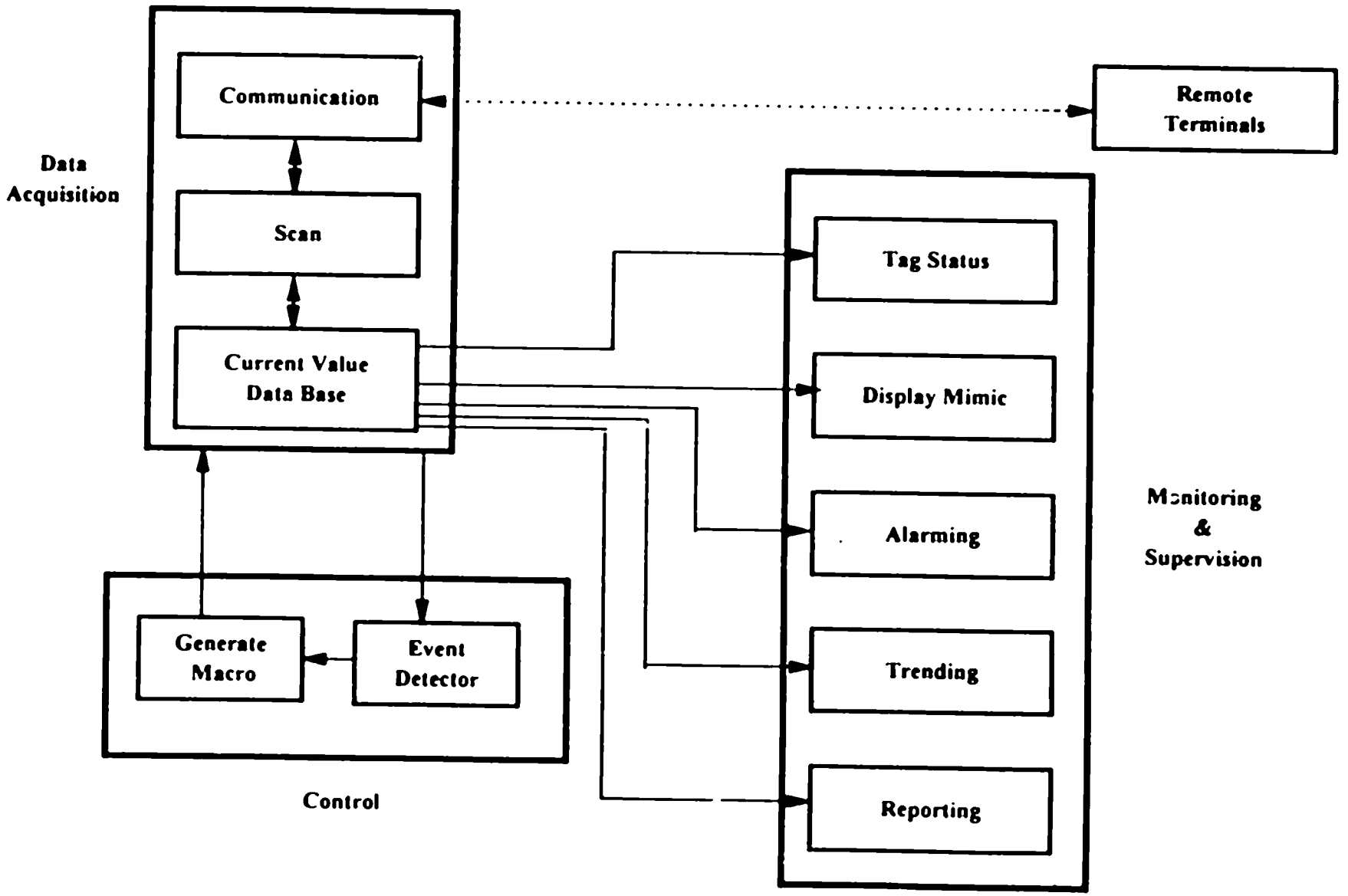


Fig. (3.4) Example of The Structure of On-Line Control Software.

PROCESS LINE	COMMON ALARM	GLOBE VALVE	SELF-OPERATED PRESSURE CONTROL VALVE
INSTRUMENT AIR LINE	SIGHT FLOW INDICATOR	CHECK VALVE	DIAPHRAGM OPREATED CONTROL VALVE
LOCAL MOUNTED INSTRUMENT	TEMPERATURE ELEMENT	BUTTERFLY VALVE	BALL VALVE
CENTRAL BOARD MOUNTED INSTRUMENT	REDUCER	BUTTERFLY VALVE MANUALLY OPERATED	MOTOR - OPERATED VALVE
LOCAL INSTRUMENT NEAST	DRAIN TO SEWER	PLUG VALVE	PISTON - OPERATED VALVE
CENTRAL INSTRUMENT NEAST	ORIFICE	HOSE CONNECTION	SOLENOID VALVE
ELECTRICAL SUPPLY REQUIRED	SPECTACLE PLATE OPEN	DOUBLE BLOCK GATE VALVE	DIAPHRAGM OPERATED BALL TYPE CONTROL VALVE WITH POSITIONER
AIR SUPPLY REQUIRED	SPECTACLE PLATE CLOSED	ANGLE VALVE	VAPOR TRAP
HIGH	GATE VALVE MANUALLY OPERATED	PRESSURE RELIEF VALVE	IN - LINE STRAINER
LOW	GATE VALVE	VALVE NORMALLY CLOSED	INSTRUMENT ELECTERICAL LINE

Fig.(3.5) Symbol List of Actuators ..nd Sensors

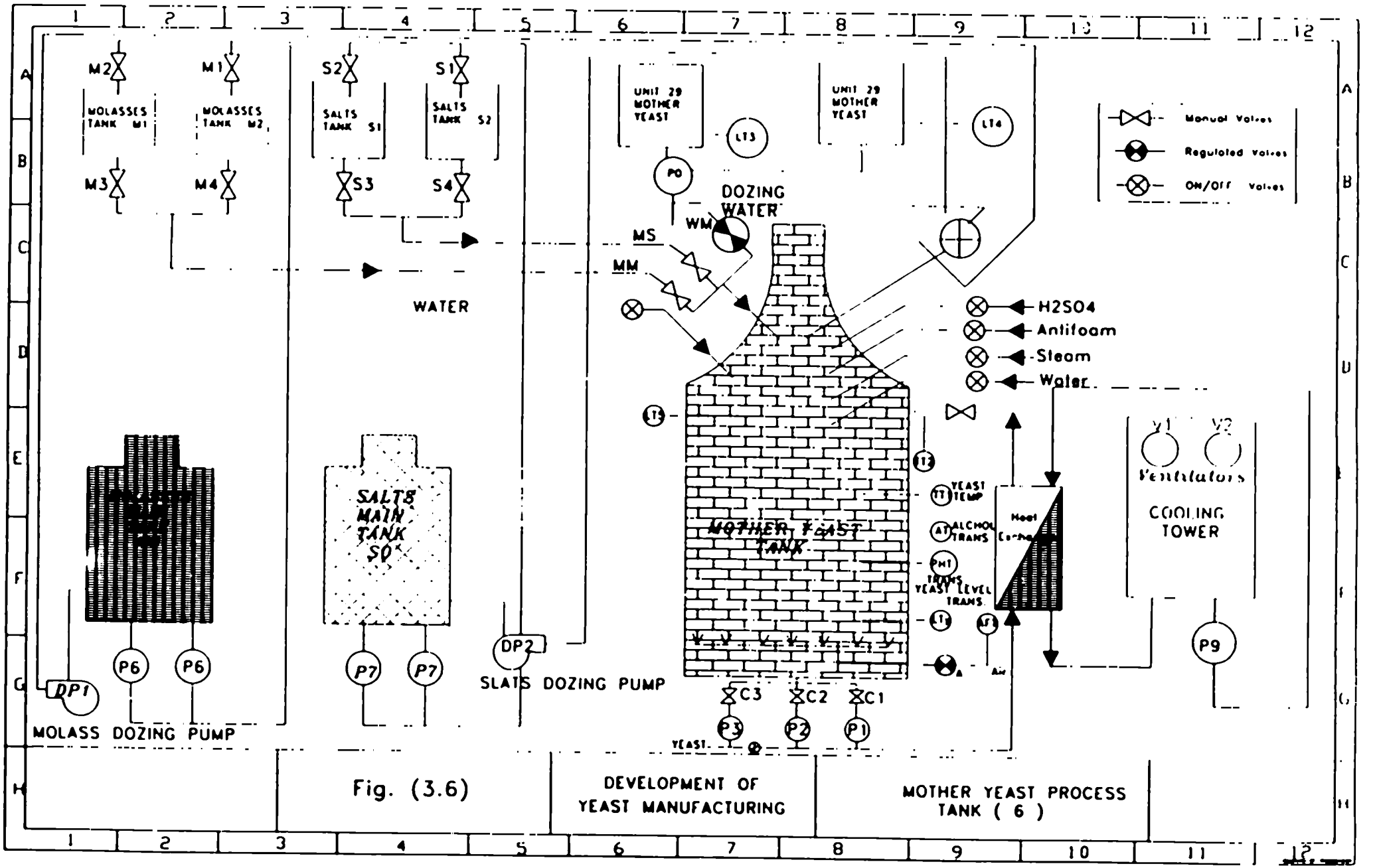


Fig. (3.6)

DEVELOPMENT OF YEAST MANUFACTURING

MOTHER YEAST PROCESS TANK (6)

INSTRUMENTATION SPECIFICATION SHEET

Project Name:
Project Location:

Component(s) of Interest/Range(s):

..... /..... [ ]% [ ] ppm Other
.....
...../..... [ ]% [ ] ppm Other
.....
...../..... [ ]% [ ] ppm Other
.....

Background (list all background components):

Component Concentration (min/max/normal)

...../..... [ ]% [ ] ppm Other
.....
...../..... [ ]% [ ] ppm Other
.....
...../..... [ ]% [ ] ppm Other
.....
...../..... [ ]% [ ] ppm Other
.....

Sample phase : [ ] Gas [ ] Liquid
Sample System : [ ] Vendor [ ] By Customer (attach piping diagram)
Preferred Materials of Construction : .....
Inlet Sample Pressure (min/max/normal) : .../.../... [ ] psig [ ] atm other ....
Outlet Sample Pressure (min/max/normal) : .../.../... [ ] psig [ ] atm other ....
Sample Temperature (min/max/normal) : .../.../... [ ] °F [ ] °C other .....
Sample Dewpoint (min/max/normal) : .../.../... [ ] °F [ ] °C other .....
Particular Loading: [ ] No [ ] Yes:..... [ ] mg/m3 [ ] grains/lt^3 other .....
Area Classification:..... If Div. is hazardous [ ] Yes [ ] No
Control [ ] integral [ ] remote @ approx. distance ... Location: [ ] Indoors [ ] outdoors
[ ] Signal output (specify) ..... [ ] Alarm(s) (for 2, hi or low) .....
Analyzer Mounting: [ ] freestanding enclosure [ ] wall mount enclosure of [ ] rack or [ ] panel only.
Enclosure dimensions ....x....x.... (width x height x depth) in [ ] inches or Other ....
Ambient (min/max/normal) : .../.../... [ ] °F [ ] °C Other .....
Relative Humidity .....
Utilities Cooling Water [ ] Yes, Temp ..., [ ] No, Steam [ ] Yes, type ..., Temp ... [ ] No.
Instrument Air [ ] Yes, pressure ..... [ ] No
Power: [ ] 110v, 60 Hz [ ] 220v, 50Hz other .....
Additional Comments: .....
.....
.....
.....

Fig. (3.7) Example of Instrumentation Specification Sheet

FLOW MEASUREMENTS METER SELECTION CONSIDERATION

In selecting the best flowmeter, guidelines answer the following questions:

1. What type of fluid is to be handled?

   - Is the fluid a liquid, gas, or vapor?
   - Is the fluid clean, dirty, or slurry?
   - Is the fluid corrosive?

2. What are the process conditions? The temperature and pressure limits?

3. What are the installation conditions?

   - Is an open-channel or closed-conduit measurement planned?
   - What is the line size?
   - What is the operating pipe Reynolds number?
   - Is adequate upstream length available?
   - Can flow conditioners be used?
   - Is there excessive pipe vibration?
   - Will the flow be steady or pulsating?
   - What are the ambient or room temperature and humidity conditions?

4. What are the performance and general flow measurement requirements?

   - What overall accuracy is required, and over what range?
   - Is the flowmeter normally used at a specific flow rate or over a range of flows?
   - Is the flowmeter to be used for control only, and what frequency of response is necessary?
   - What is the range of flow rates to be measured, and what rates will occasionally be experienced?

5. What are the installation and operation costs?

   - Initial cost of the primary and secondary devices and auxiliary equipment.
   - Installation cost, including labor and piping.
   - Energy cost to operate the flowmeter and pumping cost to compensate for the overall pressure loss.
   - Reliability versus maintenance cost.
   - Availability of parts and service facilities.
   - Possible uses in future applications.
   - The risks in trying a new flowmeter type.

Fig. (3.8) Flow Measurements Meter Selection Consideration

SECTION IV
SYSTEM IMPLEMENTATION AND COMMISSIONING

A. Installing Hardware Systems

The principal items of system design include:

- Using computers-based controllers to implement continuous and sequential functions.
- Equipping all controllers with a communication facility with a data transfer bus which is connected to a personal computer through an interface unit.
- Using the design packages to configure the controllers and generate mimic screens for on-line operation.
- Using on-line software to implement supervisory control and data acquisition (SCADA).
- Replacing obsolete field equipment with new ones, especially those for concentration measurement and controlled valves.
- Using the control panel to include the distributed controllers, control relays, annunciators, and manual operating switches.
- Establishing a central control room with good vision on the process, to accommodate the computer system, the needed interface, and peripherals.

Once hardware components are procured, installation begins, highlights of which are given below. The main components of the hardware (see Fig. (4.1)) are:

- Computers in the control room working as engineering work stations (EWS) and as operator interface stations (OIS)
- Computer interfacing unit (CIU): This unit is responsible for the interfacing between the computers and the controllers
- A module bus is the data highway link between the different controllers and the computers
- Sensors and transmitters measure different parameters
- Programmable logical controllers
- Actuators (on/off and regulatory types)
- Cables (on/off and regulatory types)
- A panel with the field equipment

- Computers for the management information system (MIS)

- An uninterruptible power supply (UPS)

To connect the whole hardware system, the sensors are mounted on site and all controllers and computers are located in a central control room near the plant.

A1. Central Control Room

Several options should be considered in selecting the location of the **central control room**. The room should be close to the process to reduce cabling costs. Fig. (4.2) shows an example of the layout of the room.

The central control room layout allows three group operators to handle the entire process. The first group will take care of panel readings, alarms, and controllers' settings. They can also operate manually the system from the panel in case of emergencies. The second group of operators will administer the computer control mode, observe MIMICS, check ongoing trends, and warn the first operating group of any abnormalities. The third group of operators will manage the production data through the second computer coupled with the planned management information system.

A2. Control Panel

The ***control panel*** is usually manufactured to accommodate all indoor equipment. It is either located beside the process or inside the control room. Full operation of the process can be handled through the panel's buttons and switches. In the panel, indicators, annunciators, and overload alarms are added. Some designs include a hardware MIMIC in the front of the panel with lamps indicating the status of each part process.

A3. Other Installations

These will include the following:

- Testing pumps and motors and making necessary repairs or replacement
- Determining and making process mechanical modification or rehabilitation
- Selecting the positions of sensors and actuators, and mounting and testing
- Establishing cabling connections for control, communication, and the computer and power supply networks
- Testing panel connections and all operating switches

The controllers should have a human interface capable of providing a bar charting representation of the main signals (measured, set-value, output), manual/automatic switch-over, manual adjustment of the set-value and outputs, and a digital display of values and status. Configuration of the controllers should be done carefully using a separate programming unit or the design computer. Unauthorized personnel may misuse the faceplate for programming.

B. Installing Software Systems

Software installations include main software and customization for specific applications. These include:

B1. Building a Data Communication Network

It is useful to achieve the integrity between the local intelligent controllers in such a way that some states in certain units can affect the control loops or control sequence in other units. Moreover, it is important to integrate communication between the local control units (with a high level human interface and management and design stations) and the operating interface stations.

B2. Building of Operating Interface Station

One of the most important modules in distributed control is the operating interface station. It is also called the man machine interface (MMI), as it allows the interface between the process and the operator. During the design of operating station, database and graphics functions must be considered. The design steps are given below.

B2a. Building Database Files For The Measured Tags

These files specify the following:

- Tag name
- The address of loop of the tag
- The alarm limits of the measured tag, namely: High-High, High-Low, Low-High and Low-Low
- Engineering unit of the measured tag
- Type of measured tag such as digital value, analog value, etc.

This database integrates the measured tag structure *whenever* or *wherever* this tag is used within the distributed control system.

B2b. Building Group Display Screens

Each group display screen indicates prespecified tag groups which the operator needs to monitor. They may be a station form indicating measured, set point, and output values, that when on-line can:

- Monitor the real time values for this tag
- Modify the set point at certain loops under automatic mode
- Force the output to certain values under manual mode
- Force discrete variables on or off, under the manual mode

B2c. Building of Trends Group Display

This stage specifies the tag that must be measured against time or when plotting two tags against each other. Design steps are as follows:

- Determine tag names to be drawn
- Determine archival file the name for this tag
- Select sampling periods for these tags (seconds, minutes,)
- Specify total duration of the archival file

The on-line operating system, can be used to:

- Monitor the tag variations against time
- Replace the function of traditional chart recorders

Off-line, the tag archival file, can be used to:

- Study the reasons for abnormal events
- Determine personnel responsibilities for faults during certain periods

An example of the trends display is shown in Fig. (4.3).

B2d. Designing of Graphics Group Display (MIMICS)

There are a number of steps that to follow in designing the graphics display of a certain process. These can be summarized as follows:

- Making engineering drawings for the industrial plants
- Transferring these drawings to graphic screens on the computer indicating tags (continuous of ON/OFF) in their real shapes
- Under the on-line operating system, having the mimic screens show the real time data transferred from local control units to the operating interface stations.

An example of a mimic for a food processing application is shown in Fig. (4.3).

C. Commissioning and Testing Integrated System

After completing the above steps, the next step is to integrate the hardware and software, which includes:

- Connecting the different controllers (sequence and batch) to the module bus following the peer-to-peer (multi-drop) communication scheme

- Giving each module an address and adjusting it to the deep switches

- Adjusting the modules (through specific deep switches) to the appropriate baud rate

- Adjusting the modules to accept voltage (because the modules can work in one of two modes, either current or voltage)

- Connecting the computer interface unit (CIU) to the module bus and then to the engineering workstation (EWS) through the previously prepared serial cable.

- Adjusting the baud rate of the CIU

- Dividing the off line configuration phase into two steps:
  - Downloading and testing the control strategy of the different controllers
  - Testing the layout of the different production lines (mimics)

Testing to investigate the calibration of each element separately begins, then integration. The commissioning begins by manually operating the system to adjust set-values and various operational procedures. After the successful manual operation, testings start at the automatic mode through the programmable controllers, then through the computer interfacing control. During the commissioning stage, training on operation and maintenance takes place as discussed in Section VI.

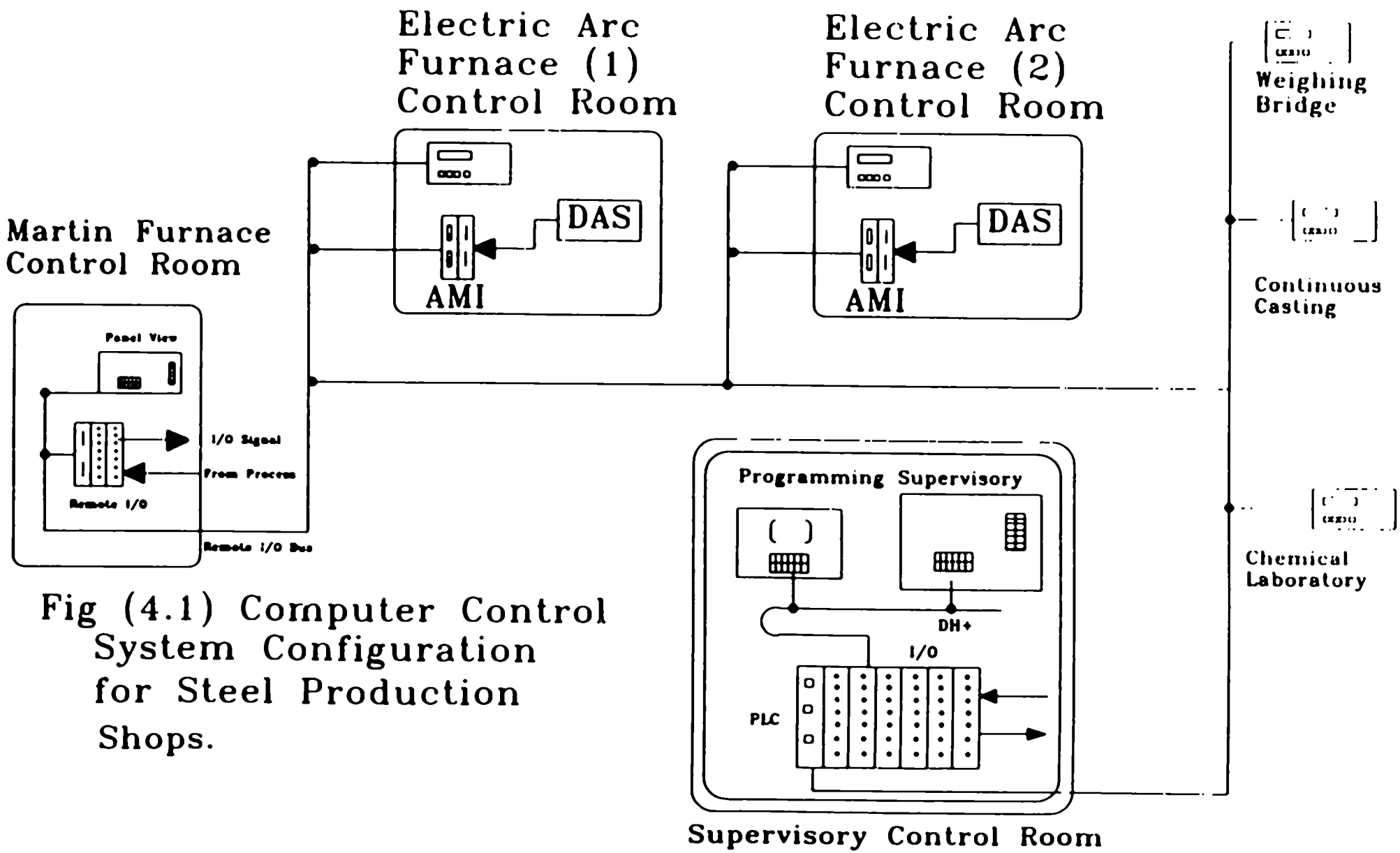


Fig (4.1) Computer Control System Configuration for Steel Production Shops.

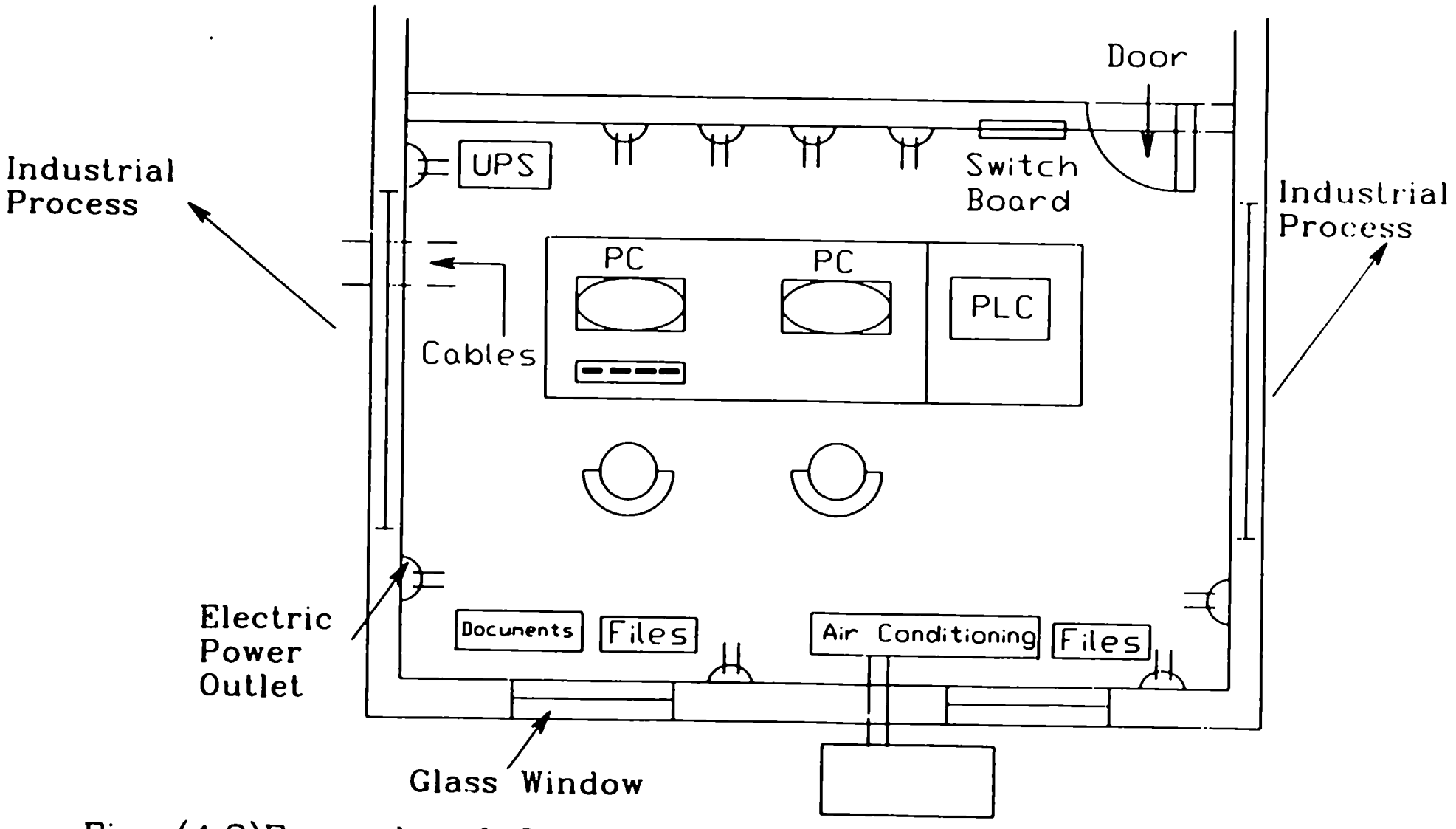


Fig. (4.2)Example of Control Room Layout With Installations.

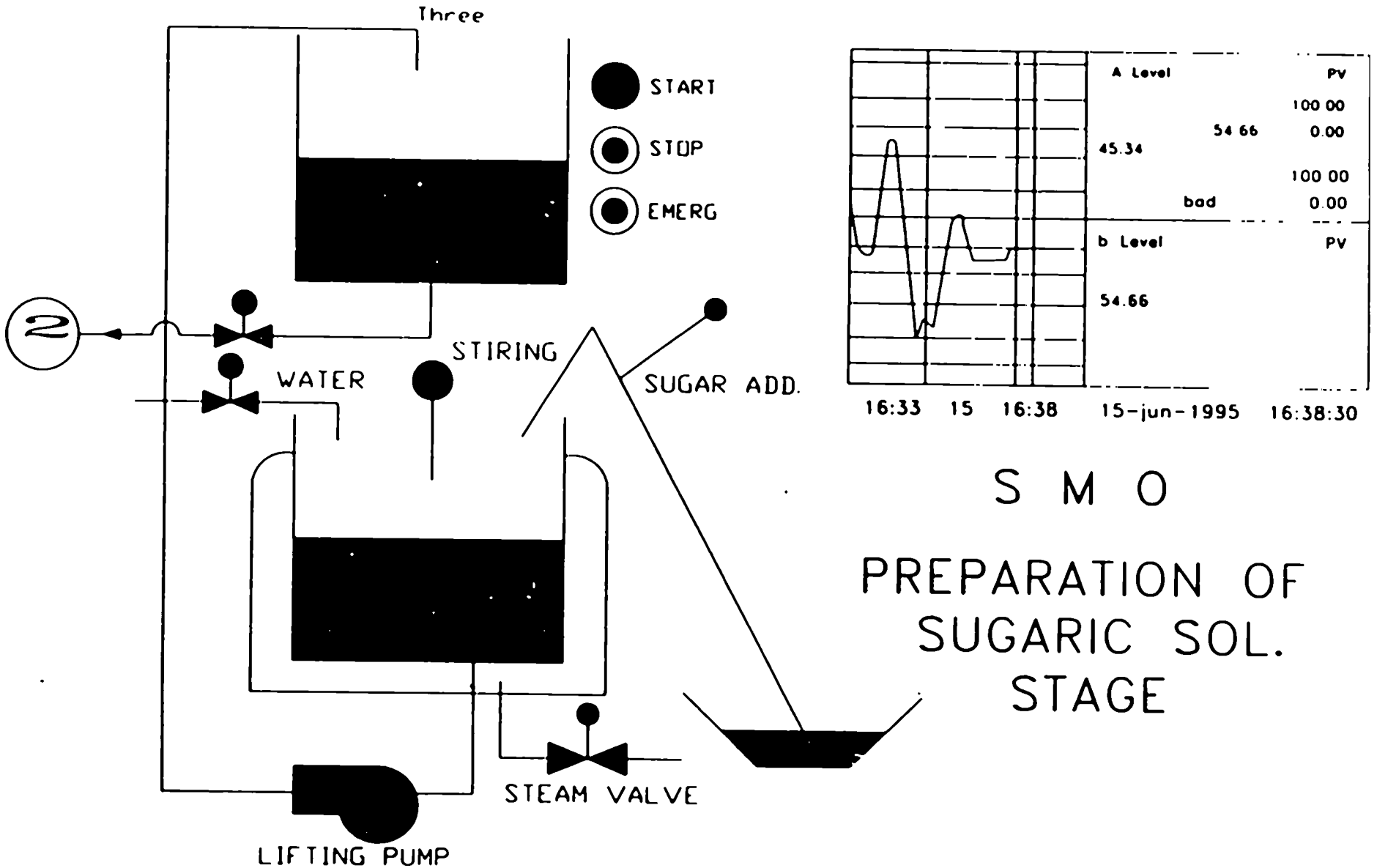


FIG.(4.3) Sample of Mimic Screen For Food Processing Application.

SECTION V
MANAGEMENT INFORMATION SYSTEMS (MIS)

A. Basic MIS Configuration

In addition to process automation and its related modernization aspects, industry can raise considerably its productivity by organizing better the decision making process. With today's rapid and unpredictable changes and information flows in daily operations, managerial decisions have become more complex. All these factors have made computers necessary for management and decision making.

Using computers for process management will increase production. The system is capable of dealing quickly with large amount of information. Moreover, the system can provide optimization policies at different levels of production and marketing. It can handle contradictory conditions and relieve the personnel from routine tasks to concentrate on process improvement.

There are two basic configurations needed for management information system in process computer control centers:

A1. Strategic Production Management Systems (SPMS)

SPMS integrate with the main distributed process computer control network and have the capability of automatically performing on-line management operation. This system can handle process schedule network information, store process data, etc. This system usually runs under an open system protocol, using an additional computer or terminal devoted only for strategic managerial tasks.

A2. Ordinary Management Information Systems (MIS)

Management information systems are devoted to off-line tasks in a special personal computer or terminal that is also connected to the network. The system can handle inventory control, accounting, transaction routines, documentation, reporting, personnel information, etc. The system can be programmed also in both English and Arabic according to the needs of the company. There is a wide range of packages on the market for building such an MIS.

The main ordinary database management information system configuration consists of:

- Relational data model
- Multi-user capability
- Security constraints
- Data dictionary
- Fourth generation language define clearly
- Batch and on-line processing support
- Support for the business applications of a company

The two systems cited above complement each other. They represent an excellent forum for decision making assistance and can be integrated with the distributed computer control network to guarantee that all goals are achieved.

B. MIS Hierarchy

In designing the anticipated management systems, three different levels of management could be considered, namely:

Level 1: Routine Operations, including:

- Recording of customer orders
- Processing transaction orders
- Maintaining the inventory records
- Invoicing
- Cost
- Payroll

Level 2: Well-defined management operations, such as:

- Setting working budgets
- Sales management
- Short-term forecasting
- Routing personnel administration

Level 3: Strategic planning and decision making, that includes:

- Determination of markets
- Long-term forecasting
- Choosing new product lines
- Setting financial policies

The data needed for the three levels are likely to differ in nature. Data for routine processing may be in files designed for the corresponding operation. Data routine operations may be organized for specific forms of human inquiries or dialogues. Data for top-management is likely not to include the details in lower-level files.

C. Examples of Tasks Performed by the MIS

A number of tasks could be performed by the management information system for industrial projects. Examples of these tasks include: (see Figs. (5.1) and (5.2)):

- **Sales Management** provides:
  - Tracking customer transactions
  - Different orders and accounting
  - Price, discount, tax, and due date per items
  - Invoicing
  - Interface to inventory and costs ledgers
  - Sales analysis including market analysis and predictions
  - Customer information and status
  - Customer statements

- **Production Management** provides:
  - Time schedules of operation requirements
  - Computation of allocations and work operations
  - Control of operation tasks
  - Dispatch list by work center and due date
  - Interfaces to inventory, costs and ledgers

- **Inventory Control** includes:
  - Inventory planning using a flexible strategy
  - Quantities allocation.
  - Summary of receipts and transfers.
  - Order policies.
  - Cross-reference to alternative items.
  - Cost calculations
  - Integration with sales and financial management

- **Financial Management** includes:
  - Budget, planning and reporting
  - Balance sheet
  - Audit trial reports by transaction and account

- **Maintenance Management** provides:
  - Multilevel structure of plants and items
  - List of equivalent plant and/or item
  - Analysis of reliability and availability
  - Failure and cost analysis
  - Computation of the cost maintenance of cost procedures
  - Allocation of plant and personnel to procedures
  - Interfaces to inventory control and production management
  - Handling spare parts

- **Documentation Management** includes:
  - Automatic indexing
  - Documentation of different document types
  - Creation of files directly from screen images
  - Capability to handle large scale documentation work

- **Personnel Management** includes:
  - Employment history, job grading, and function
  - Employee education, training, experience, and skills
  - Details about salary, income tax statistics, medical insurance, and bank data for automatic funds transfer
  - Payroll

D. Decision Support Systems

Computer technology can transfer easily ***operations research*** and ***management science technology*** to industry. Such a technology is likely to have a strong impact on integrating organizational development with its environment. The environment is seen as the major factor influencing the direction of an organization's development while the organization's responsiveness is a key factor in determining the company's performance. Therefore, ***organization***, ***environment***, and ***computer management control*** form a triangle that represents the main structure for the operation of any industrial company. A subset of this triangle is the smaller triangle formed from the operations research, management science, and information system.

Diverse operations research models can be transferred to enhance the decision making process in industry. They can be as simple as linear programming models or as sophisticated as stochastic nonlinear programming models. In general, these models operate as a satellite of the MIS, and will provide the necessary optimization forum for tackling operational problems. In general, these models are devoted to increasing a company's productivity. Productivity has many definitions; one is based on the following formula:

$$\text{PRODUCTIVITY} = \frac{\text{PRODUCTION} + \text{QUALITY} + \text{SERVICE}}{\text{MONEY} + \text{FACILITY/EQUIPMENT} + \text{LABOR}}$$

An information system alone is of limited benefit to managers. Nevertheless, if such information is fed into operations research/management science (OR/MS) techniques, it will help managers to achieve goals. In general, introducing OR/MS methodologies into an MIS requires changes in the information flow within the production company. A successful computer-based management system will play a role in all company activities and will be an integral part of the company's management systems and organization.

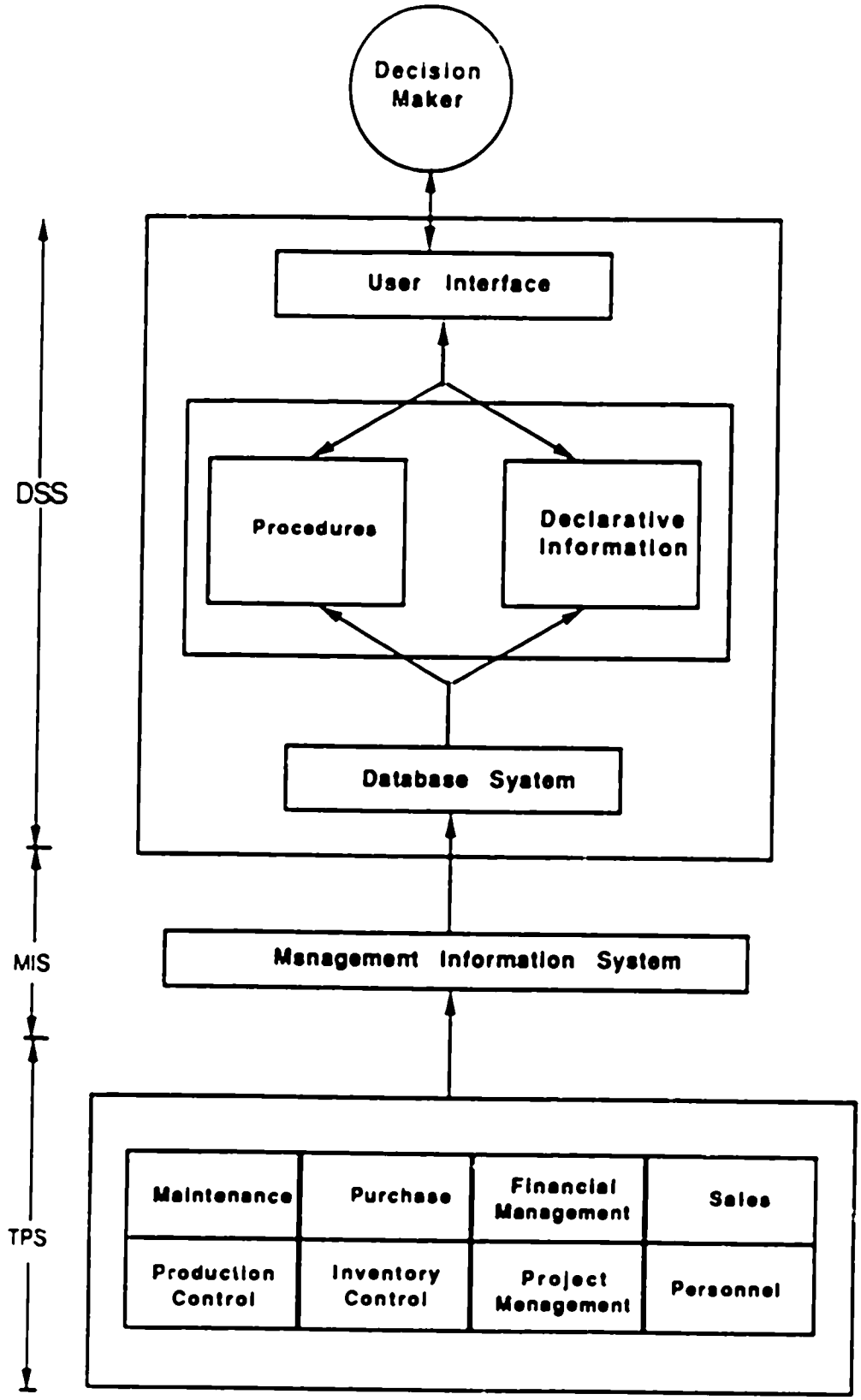


Fig. (5.1) Sample of The DSS Environment of an Industrial Company.

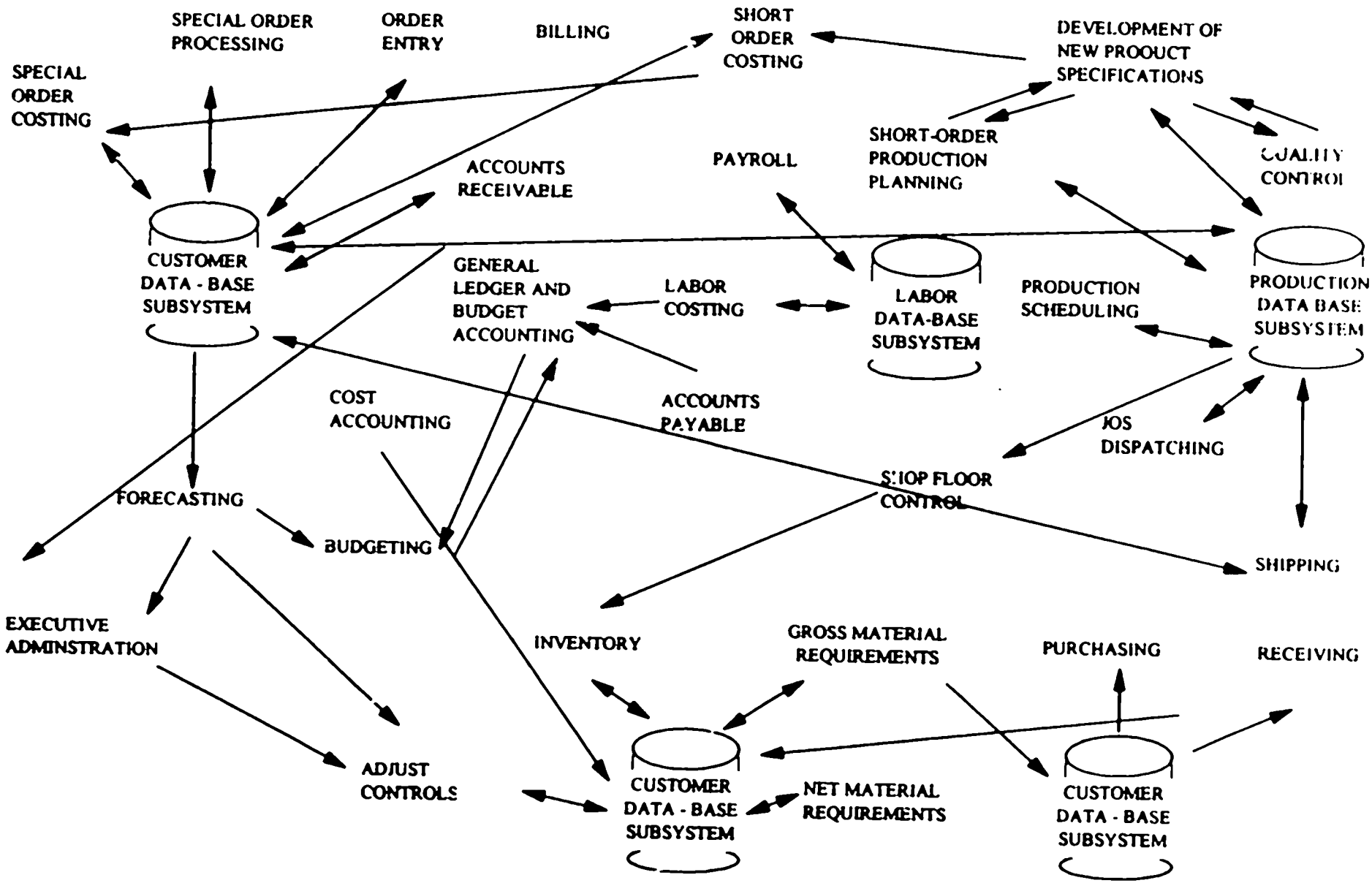


Fig. (5.2) COMPLEX NETWORK OF RELATIONS FOR A COMPANY INTEGRATED DATABASE.

SECTION VI
TRAINING, MAINTENANCE, AND UPGRADING

A. Staff Training

To ensure project success, effective training of company staff is needed to understand the design and operate modern system components.

For on-site training, instruction media should be in both English and Arabic. Due to the diversity of areas incorporated in each project, several programs should be arranged within the project. A sample of these programs is given below.

Program 1: Refresher Course for Real-Time Control System Components and Requirements

The program will help to introduce advancements in real-time control systems and to acquaint company staff with the main features and capabilities of the modern ***computer control and management systems*** of 1990s. The course content has been designed as follows:

Subjects:

- Principles of real-time control system hardware, and industrial electronics
- Principles of real-time control system software
- Principles of systems configuration and integration
- Industrial management-decision support system

Program II: Basic Real-Time Control System Description

This on-site program is devoted toward familiarizing company staff with the elements of modern real-time control systems. This will give insights into the appropriate selection of these elements to satisfy project upgrading needs. The syllabus of this course could be as follows:

Subjects:

- Field equipment: sensors, transducers, actuators
- Measuring and recording systems
- Intelligent controllers: continuous controllers (PID)
- Programmable logic controllers (PLC), batch controllers
- Programming for intelligent controllers: ladders for PLC, and modulars for PID and batch
- Control strategies: sequential, ratio, self tuning, cascade, feedforward, etc.

Program III: Integrated Distributed Computer Control/Management Systems

This is another on-site course to train company technical staff on the general configuration of advanced distributed computer control/management system and their integration to meet various system targets. The course should include the following:

41

Subjects:

- Distributed systems functions and capabilities
- Distributed systems configuration, remote units, computer units, data and transmission networks interfaces
- Computer system function and software: Design-Operation-SCADA
- Strategic production management system (hardware, communication networks, software)
- System specifications, standards, and maintenance routines

In addition to these academic programs, there are other types of training for system operation that can be tailored for the needs of each system. Moreover, there is additional training for ongoing hardware and software maintenance of installed systems. Most of these programs are offered at two levels. The **first level** is for engineers and covers relatively advanced methods. The **second level** is for technicians and focuses on the fundamentals and basics.

B. Maintenance Programs

To achieve the highest maintenance efficiency, an ***Electronic Maintenance Workshop*** in the company needs to be established to serve during the installation and modifications stage. This workshop will facilitate necessary maintenance of the incoming electronic equipment. It will include ***preventive*** and ***repair maintenance***.

A study of preventive maintenance programs in various industries over a period of years indicates that in most instances, failure was due to frustration and problems involving systems or procedures. Technical problems rarely led to failure. Since each project is directed toward improving the overall scope of effectiveness in dealing with preventive maintenance, the first step is to overcome the obstacles which produce failures.

Preventive maintenance encompasses all planning and action necessary to identify and rectify deteriorating influences or conditions before they advance to the stage where the emphasis shifts from preventive to to repair maintenance.

Repair maintenance has several levels depending on the ability of maintenance workshop from an equipment point of view and staff qualifications. Usually, a maintenance workshop can be divided into board and component level classes.

At the board level, the maintenance workshop is equipped so that the fault location can be determined. In this case, the factory usually has spares of the main boards to replace the faulty equipment. Later, the faulty board can be examined for the necessary replacement. The component level maintenance workshop should be well equipped. The technical staff should be at higher level.

C. Upgrading Strategies

The final step in modernization is to set long-term upgrading strategies. Each project extension should depend on the same technological concepts that were developed in the original project. These concepts are mainly the computer control/management technologies of the 1990s. In this technology, hierarchical control starts with the industrial process that connects directly to the sensors, actuators and measuring elements. Above that level, there are the distributed programmable controllers and instrumentation. Through the data communication network and

interface units, the hierarchy is connected to computer stations, including engineering design station.

Another aspect is to develop continually ***decision support systems*** for production management. These systems will be linked to the management information system for production planning. The decision support system should include several operations research-based models that aid in enhancing the decision making process in production.

The recent trends in the area have shown many advancements, such as:

- Better strategic automation solutions
- New configurations and engineering tools
- Improved software programming under Windows software
- More network capabilities and open systems architectures
- More dedicated distributed and integrated control systems
- Larger memories for programmable controllers
- Improved real-time strategic management

The process of systems development and advancement continues. To that end, each company must upgrade its systems after the end of the initial computer modernization project. In fact, the process of computer control operation remains a good example of how universities and industries can cooperate to solve real life problems. It also demonstrates how technology transfer is carried out in Egyptian industries, where industry staff share in all phases of development and execution. In this process, industry gains highly trained personnel who can take the lead in making additional refinements or modifications.

PART II

SUBPROJECT SUMMARIES

TABLE OF CONTENTS

PART II: PROJECT SUMMARIES

Subproject No. 2	Integrated Computerized Control in the Textile Industry
Subproject No. 4	Design and Application of Computer-Based Technology for the Development of the Food Industry
Subproject No. 8	Development of Jacquard Looms with a Device to Translate Designs Stored on Magnetic Discs to Mechanical Actions that Control Loom Movement
Subproject No. 18	Development of Computer-Based Control for Calciner and D.C. Casters of the Aluminum Company of Egypt
Subproject No. 23	The Introduction of Computer-Based Technology to the New Electric Furnace Production Shop at the National Metal Industries - Ahlia
Subproject No. 66	Development of Process Computer Control Systems for Production and Quality Improvement for the Egyptian Yeast, Starch and Detergents Company (EYSD)
Subproject No. 67	Arabic Computational Linguistics
Subproject No. 74	Development of Computer-Based Quality Improvement of Electronic Products for the International Electronics Company (IEC)
Subproject No. 80	Production of Quality Spare Parts for the Spinning and Textile Equipment Using CAD/CAM Systems

SUBPROJECT NO. 2
INTEGRATED COMPUTERIZED CONTROL IN THE TEXTILE INDUSTRY

Awardee	Electronics Research Institute
End-User	STIA and Vestia Companies
Principal Investigator	Professor Dr. Ayman El Dessouki
Period	1/ 2/ 1990 - 31 / 1/ 1993

Budget Breakdown

			LE
USAID/STC	$295,000 and	LE 686,900	**1,689,900**
In Cash	GOE End-user	None 40,000	**40,000**
In Kind	GOE End-user	LE 282,000 LE 126,000	**408,000**
Total			**1,137,900**

A. Subproject Description

This subproject aims to establish a data acquisition network and implement an integrated production planning system at one of the major textile producers in Egypt.

STIA is one of the major state owned companies in Egypt. Located in the Alexandria metropolitan area, the STIA factory produces a wide variety of wool fabrics that are marketed in both the local and regional markets. Recently, the company has been recognized in international markets as a well-noted contender in the textile and ready-to-wear industries.

The process of wool fabric production can be summarized in the following steps (Figure 2.1):

- Yarn preparation
- Spinning and twisting
- Winding and yarn folding
- Fabric weaving

Weaving operations at STIA are performed by 80 automatic looms of two brands. Even though different brands may perform the same operation, they vary in their production capacities, speed and some other technical specifications.

For years, setting annual production plans has been a difficult task for STIA management. This was due to the technological complexities within the textile industry, varying machine capacities, availability of the labor force and raw materials, changing prices, and market trends.

The "Integrated Production Planning Package" devised for implementation at the STIA factory has been designed taking into account the above technical and economic constraints. The objective is to optimize the weaving process. Weaving operations have been identified by the subproject team as having a significant influence on overall productivity and the efficiency of other production operations. The schematic presenting the configuration of the data acquisition system is shown in Figure 2.2.

Following data input, the system structures a model production plan with a defined processing time and operations capacities. From there the system progressively formulates the plan. Throughout the production process, input from the individual instrumentation is received at the supervisory computer control stations and fed into the production database. This allows for a continuous check on the progress of work. Operational parameters are constantly checked against the pre-set monitoring plan. These are adjusted according to the type of operation taking place.

B. Financial Analysis

The project's annual or expected profits had not been quantitatively estimated by the subproject team. Hence it has been difficult to calculate the net present value. However, data provided during the meeting with members of the subproject team was used to provide a qualitative description of the economic benefits of the subproject as detailed in the following section.

C. Subproject Achievements

C1. Design of an Integrated Production Planning Package (IPPP)

Designed in a user friendly format, the computerized production planning package implemented within this subproject is a valuable decision support tool for high and intermediate level management. The package can be used to modify the process and resource demands in response to the complexities within the textile industry and its dynamic market trends.

C2. Planning Optimization

The IPPP has been designed to prepare an optimized plan that maximizes sales volume, total profit, and total contribution, or minimizes total production costs.

C3. Decision Making Alternatives

The IPPP is capable of developing "what/if" scenarios that allow the user to evaluate and compare different production plans.

C4. Monitoring Product Quality

The data acquisition network installed contains data on product quality and maintenance defects. Upon their correlation, both data sets can be used to upgrade product quality.

C5. Design of a Low-Cost Data Acquisition Network

A direct economic benefit of the Data Acquisition Network designed within this subproject is evident in the savings made in project investment costs. Compared to similar systems installed in other companies, this data network costs 95 percent less. This investment is based on the cost of a similar system at El Amerya Company which reached Sterling Pound 250,000 (LE 1,325,000), as compared to the implemented system in Vestia Co, which cost LE 69,400. Assuming that maintenance costs account for 10 percent of the overall investment, the IPPP features an additional economic benefit by reducing maintenance costs.

C6. Reduction in Down Time

The installed IPPP decreases down time by identifying problems and providing quick solutions thus increasing productivity. Down time has been reduced by 5 percent according to the technical reports of this subproject.

C7. Reduced Need For Supervisory Staff

The fault detection function of the IPPP reduces the need for machine supervisors. It also allows for more precise fault identification, location and treatment.

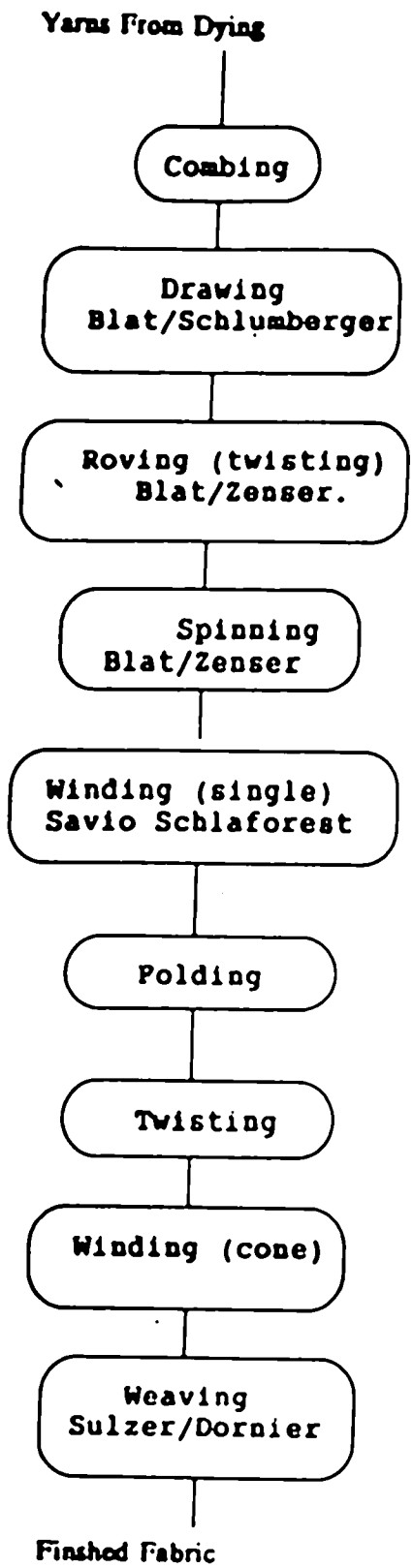


Figure 2.1 Major Operations in Wool Fabrication Process - STIA

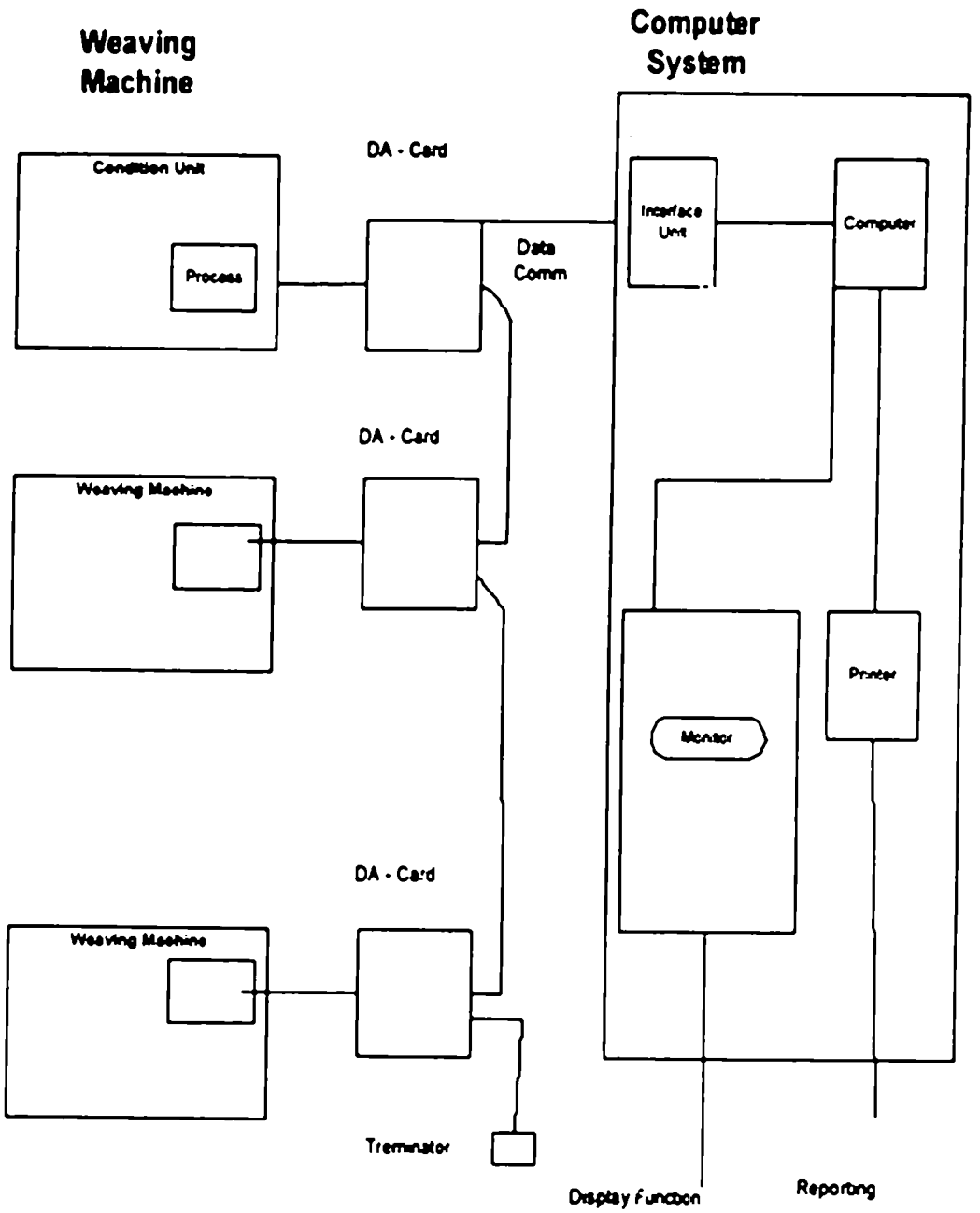


Figure 2.2 Schematic Representation of Data Acquisition System Configuration

SUBPROJECT NO. 4
DESIGN AND APPLICATION OF COMPUTER-BASED TECHNOLOGY FOR THE DEVELOPMENT OF THE FOOD INDUSTRY

Awardee	Faculty of Engineering, Cairo University
End-User	Edfina Company for Preserved Foods
Principal Investigator	Professor Dr. Hassan T. Dorrah
Period	1/ 1/ 1990 - 30 / 6/ 1994

Budget Breakdown

			LE
USAID/STC	$ 311,500 and LE 842,925		**1,901,925**
	GOE None		
In Cash	End-user	LE125,000	**125,000**
In Kind	GOE 270,000		
	End-user	LE300,000	**570,000**
Total			**2,596,925**

A. Subproject Description

This subproject aims at facilitating the widespread application of computer-based technologies in the Egyptian food processing sector. Edfina Company has been selected as a pilot site for testing this application. The subproject's objectives can be summarized as follows:

- To design and implement process control systems at the three main production lines of canning plant "A" of the Edfina Company.
- To design and implement a computerized process for data acquisition, management information and follow-up of the manufacturing operations.
- To identify the means for fault diagnosis and resolving system bottlenecks.
- To develop a permanent training and electronics maintenance center in the Edfina Company.

Edfina is a major state-owned food processing enterprises. Established in May 1956, the company has three main branch factories in Alexandria, Port-Said, and Damietta. Edfina

produces a wide variety of food products including juices, natural concentrates, jams, honey, frozen and packed vegetables, fish, and poultry.

Modernization of the company's production lines through the application of process control techniques is considered essential to improve the quality of its products and minimize production losses. Process control techniques will also reflect favorably on the company's status within the local and export markets.

The Edfina Alexandria factory (Fig 4.1) is the largest of the company's facilities. The factory includes a number of production and support units, namely:

Cannery Plant A. Cannery Plant A houses three production lines for the manufacture of tomato paste, juice and natural concentrate as well as jam.

Cannery Plant B. Cannery Plant B has three production lines for the manufacturing of juice, jam and packaging of honey.

- Three can production units
- Three freezing plants for vegetable, fish, and poultry
- Three deep freeze storage units (500 tons at -20° C)
- Two boilers
- One compressed air generation station
- Electric diesel generators

There are also storage facilities, workshops for mechanical and electrical maintenance, and a laboratory facility where final product quality control and assurance activities take place.

Production lines in plants A and B are equipped with relatively modern features. These features allow the company to produce different sizes of easy-to-use and economical packages (e.g., aluminum foil packages for juice and polyethylene packages for jam and honey).

Mechanical and electrical faults and failures because of the inadequate maintenance have plagued the company's main production lines. This has led to considerable losses as a result of lowered product quality.

The subproject team focused their research on the production lines of Plant A, where major activities are being carried out. This selection was made in agreement with the company's technical and managerial staff.

Production lines in Edfina's plants share the same steps in their preparatory and final phase. These are:

A1. Preparatory Phase

- Raw material weighing and inspection
- Raw material sorting
- Fruit washing in water tanks

A2. Final Phase

- Product packing and sealing
- Heating and cooling of contained product
- Periodic incubation
- Labeling and packaging
- Storage for further distribution

Production steps between the preparatory and final production phases vary for individual production lines in Plant A. These steps were investigated thoroughly by the subproject team and an extensive fault analysis was conducted. The analysis included an identification of faults likely to occur along the production lines, their location and a ranking system to determine their magnitude.

The subproject team has classified faults into three groups according to source as follows:

Operator faults: Badly operated machines or erroneous repair or maintenance.

Machine faults: Mechanical and electrical failures usually occurring as a result of overcharging and the use of old instrumentation.

Replacement faults: When unsuitable components are used as replacements.

The need for a computerized process control system is quite clear. The application of such a system to the food industry serves to monitor and control the concentration doses of ingredients, mixture consistency, temperature adjustments, and timing of the entire production operations within each line. The system has been designed to operate on three mode levels: manual, automatic, and computer control modes. The switch across these modes can be easily done.

The installed Decision Support System or Management Information System (MIS) for the Edfina Company has been designed with the ability to integrate internally compiled data with other information provided from additional sources. The Edfina MIS can thus be viewed as three systems in one, as it can be fed with three different types of data sets: quality control data, production data, and technical operation data.

Initially, the process control systems were applied to the sugar solution preparation units, juice mixing units, jam concentration units, and tomato paste line.

The subproject team conducted on-site training for the company's technical and research staff. Training was particularly targeted to electrical and mechanical technicians, maintenance engineers, and process operators.

The training program focused on the salient aspects of troubleshooting within the system and fault clearance of various systems components, in addition to maintenance and repair of electrical and mechanical parts.

B. Financial Analysis

All calculations used for this analysis are based on the data obtained from Prof. Hassan T. Dorrah, the principal investigator on this project. The net present value of the project was calculated and used as an indicator of the project's feasibility. The investment and annual costs were tested against the annual revenue over the life of the project.

The STC grant and the GOE contributions were used as the project's capital expenditures. Meanwhile, end-user contributions were divided over the life of the project (five years) and assumed to account for the project's annual expenses. Quantifiable annual benefits generated as a result of implementation of phases I and II were considered to be revenues.

The results of the analysis indicated that there is a positive net present value of approximately LE 5.074 million over the six-year projected cash flow period. Testing the net present value over a 10-year life of project resulted in a sum of LE 8.378 million. This is based on the assumption that the machinery and equipment being used will not be fully depreciated after six years. The positive net present value in both cases is due to the annual benefits that exceed initial costs added to annual operational and maintenance costs.

Relevant calculations and assumptions to this analysis are attached to this document.

C. Subproject Achievements

C1. Development of the Food Industry

The design and implementation of process computer control and management systems for the production lines within the food industry as demonstrated by the Edfina Company for processed food is a substantial step toward local industrial development and improved product quality. Edfina company, along with other major food exporters will benefit from the use of computer-based technologies in their production processes, particularly at a time of increasing worldwide awareness and strict regulations concerning food product quality and safety issues.

C2. Reduced Maintenance Problems and Improvement of Maintenance Skills

The use of computer-based technologies allows for early and precise detection of faults within the production process and consequently, immediate and effective rectification. The technologies have also allowed for the development of preventive maintenance schemes which would reduce the incidence of operational faults and equipment failure and consequently costs of repair, spare parts or replacements This benefit has been fully realized within this project through training provided on maintenance works and the establishment of the maintenance center.

C3. Establishment of a Permanent Training and Maintenance Center

Undoubtedly, this project component will facilitate the provision of on-going training to workers in other factories and will provide for a base for experience dissemination and transfer of know-how. The establishment of a maintenance unit as part of the training center will allow trainees to undertake on-the-job training and will reduce the need to seek external support for the repair of the electronic systems.

C4. Better Decision-making at the Factory Level

The introduction of management information systems within this project will facilitate decision-making at the factory level. For this to occur without such a system, time and resource-consuming activities such as the close monitoring of processes and extensive record keeping, among others, would have to be used.

C5. Replicability within the Egyptian Industrial Sector

The Egyptian food processing sector has witnessed progressive development over the past 20 years in terms of the types of technological processes employed, public vs. private sector competition, and expansion of the local and export market bases. Hence the potential for replicability within the sector is significant, and with its long standing position in the public food industry, Edfina Company could well act as a base for the demonstration of experience and the transfer of know-how. The overall costs of installation stated in this case will undoubtedly be reduced when it is replicated because of savings in time and extra costs spent on the design of the technologies.

C6. Increased Economic Yield

The average benefits gained from applying the new automated system in one year at Edfina Company are approximately LE 2.605 million, which is LE 0.19 million more than the total budget (LE 2.596 million). In addition, during the project life expectancy, cost will amount to about LE 2.5 million as opposed to a LE 9 million gain. This strongly indicates the economic viability of the subproject.

C7. Enhanced Operational Efficiency

Operational efficiency will rise through reduction of material losses and rejected products. This will reflect well on the company's revenues and overall technical operation efficiency.

Figure 4.1 Layout of Edfina Factory - Ras El Soda - Alexandria

62

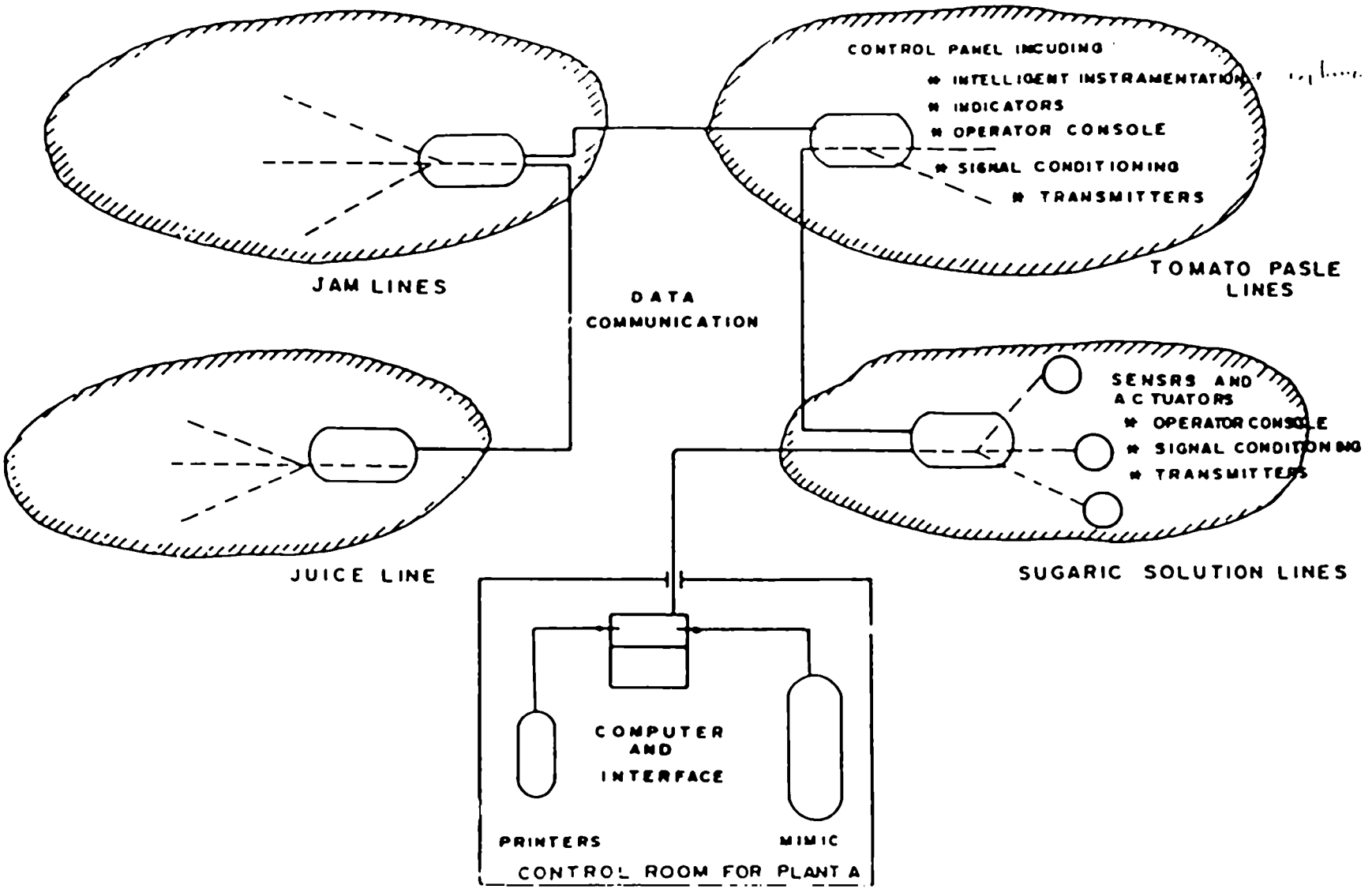


Figure 4. 2 Control System Configuration - Edfina Company - Alexandria

Projected Cash Flow and Financial Returns (in LE 000's)

(LE 000's)

Description	Commencing	Projected 1	2	3	4	5	6	7	8	9	10
CAPITAL EXPENDITURE											
EGAIDW STC grant in LE	843										
EGAIDW STC grant in $	1,059										
End User contribution	425										
GOE contribution	270										
Total Cap. Exp	2,597	0	0	0	0	0	0	0	0	0	0
O&M EXPENSES											
Salaries, supplies, and reg. work		208	218	229	241	253	265	278	292	307	322
Total expenses		208	218	229	241	253	265	278	292	307	322
ANNUAL PROFITS											
Phase 1											
1 Organic Selection and Juice Units		900	945	992	1,042	1,094	1,149	1,206	1,266	1,330	1,396
2 Jam Production		385	404	424	446	468	491	516	542	569	597
3 Management Information		55	58	61	64	67	70	74	77	81	85
4 Electronic Maintenance Workshop		95	100	105	110	115	121	127	134	140	147
5 Training Company Personnel		65	68	72	75	79	83	87	91	96	101
Phase 2											
1 Organic Selection and Juice Units(2)		675	710	746	803	843	887	931	978	1,027	1,078
2 Jam Production (unit 2)		185	404	424	446	468	491	516	542	569	597
3 Training Company Personnel		25	26	28	29	30	32	34	35	37	39
Total Annual Gains		2,605	2,790	2,880	2,974	3,072	3,176	3,285	3,399	3,519	3,645
Annual Surpluses (Deficits)	(2,697)	2,397	2,572	2,651	2,733	2,820	2,911	3,006	3,107	3,212	3,323
NPV (Discount rate 12%) 6 years	5,074										
NPV (Discount rate 12%) 10 years	8,378										

Assumptions :

The above capital expenditure are the actual project expenditures as funded by either the STC or directly incurred in cash by the end user or GOE. Only half of the in kind contributions is considered since the contributors gain indirect benefits from subsidiary equipment, traveling, and research benefits equivalent to that amount

The time of the project is 6 years

Operating expenses are 8% of the total yearly budget

All operating expenses and annual gains are inflated by 5% annually Cost of Capital is 12%

All figures are based on data gathered from the summary report of the sub-project

The research team is led by the principal investigator Prof Hassan T Dorrah

SUBPROJECT NO. 8
DEVELOPMENT OF JACQUARD LOOMS WITH A DEVICE TO TRANSLATE DESIGNS STORED ON MAGNETIC DISKS TO MECHANICAL ACTIONS THAT CONTROL LOOM MOVEMENTS

Awardee	Electronics Research Institute
End-User	Oriental Weavers Company
Principal Investigator	Prof. Dr. Esmat Abdel Fattah
Period	23/ 1/ 1991 - 22 / 1/ 1992

Budget Breakdown

			LE
USAID/STC	$155,000 and	LE 323,000	**850,000**
In Cash	GOE	None	
	End-user	None	**None**
	Oriental Weavers		
In Kind	GOE	LE 458,000	
	End-user	LE 280,000	**738,000**
Total			**1,588,000**

A. Subproject Description

Carpet production in Egypt is based on the use of jacquard looms. A recent survey of this industrial sector in Egypt revealed that more than 5000 jacquard looms of different types are being used for carpet and fabric production. Most of the machinery use electronic-controlled systems for their overall operation.

The operation of any jacquard loom depends on the use of a large set of punched cards of a special type that are punched according to a specified weave pattern. About 1,560 cards are used per square meter of carpet. In other words, for an average two by three meter carpet, a total of 9,360 cards are required.

Oriental Weavers company, the end-user of this subproject, is a leading private sector carpet manufacturer. The company's competitiveness depends on the quantity, price, and variety of carpet designs that it can make available to the local and regional consumers. Replacing the current applied punched card systems for the jacquard looms with a computer-controlled electromechanical system facilitates operations and allows the company to create more designs. By discontinuing the use of punched cards, weave errors will be controlled thus improving the quality of the woven carpets. Furthermore, this will enable the company to react more swiftly to

a wide range of customer and market needs. This is because changing designs under the new system is much faster and less expensive than under the old system.

The looms are operated by a Programmable Logic Control (PLC) system. This is a computerized control system with an internal configuration designed to provide functions and time sequence control of discrete-state operations. After detailed analyses of the existing loom system, the subproject team was able to set the appropriate system configuration for the operation of the electromechanical unit (see Figure 8.1). This electromechanical unit replaces the needle-controlling mechanism of the loom that controls the movements of the machine.

The electromechanical unit is fed by the control signals emitted by the PLC to control the movements of the loom. Data received at this unit is further subjected to a processing program that translates the descriptive data of jacquard design into the design pattern of the carpet. After receiving data concerning the status of the various devices, the machine triggers a set of commands to the PLC and to a conditioning unit. This conditioning unit generates the electrical signals or pulses needed for the electromechanical unit to activate the needles in the required timing and sequence. Furthermore, this unit receives the required jacquard data pre-set input and transmits it to drive the electromagnet for programmed design execution.

The overall operation of carpet weaving is further controlled by mounted electronic cards on top of the loom. These cards also provide for the mechanical coordination of the operation of the jacquard head on the same loom. After the successful program initialization, system monitors the loom operations to identify machine stoppage and operation faults as well as to observe the timing and sequence of overall operations.

B. Financial Analysis

To examine this project financially, all calculations were based on the data gathered from the meeting with the principal investigator of the project, Dr. Esmat Abdel Fattah. The STC grant, the GOE contribution and the end-user contributions were used as the project's capital expenditures.

Two scenarios were used in testing the project viability. The first scenario is the actual case in which the Oriental Weavers Company used six locally-adapted electronic jacquard head units in their factory. The factory has 20 jacquard looms, 14 of which were imported from abroad. Therefore, only six locally adapted electronic heads are needed.

The second scenario is the case in which the Oriental Weavers Company would use the locally- manufactured electronic heads with the 20 classical looms instead of importing new ones.

Analysis of the first scenario showed that the actual cost of each locally-adapted electronic head is LE 50,000. The total cost of the system is LE 300,000. Assuming operation and maintenance costs to be 10 percent of the capital expenses of the project, LE 30,000 would be used for the calculations. This number was inflated by 5 percent annually. The annual gains made in this case would therefore be LE 0.255 million.

On the other hand, the total cost of the system in the second scenario would be LE 1 million (20 looms x LE 50,000 per head). Assuming annual operational expenses to be 10 percent of the total system cost, they would reach LE 100,000 per year (with a 5 percent annual inflation rate). The annual gains made in this case would be LE 0.850 million.

By examining the two scenarios mentioned above, it was found that the first scenario resulted in a negative net present value (LE -0.059 million). This is because the project budget is high and the implementation of the project with only six jacquard looms is not economically feasible, unlike the second scenario. The second scenario yielded a positive net present value over the 10-year with projected cash flow that amounts to LE 3.507 million. This illustrates that it is economically feasible to implement the project on 20 jacquard looms.

With respect to the above analysis, calculations and assumptions can be found in the table following this case study.

B. Subproject Achievements

Savings in the cost of punched cards. A square meter of carpet requires about 1,560 cards. The average carpet design (two by three meters) requires about 9,360 cards. The price of each card (before punching) is about PT 25. Thus, the average carpet design would cost LE 2340 for only unpunched cards (in 1991-1992) prices. According to 1994-1995 prices, this figure has doubled.

Saving additional costs attached to the use of punched cards. The use of punched cards would have additional costs attached to it such as :the cost of preparing the required designs, punching and fixing the cards on the loom, the time consumed in this operation, maintaining punching machines and providing large storage areas. Therefore, for this system to be economically feasible, large lots of carpets with the same pattern should be produced. However, rapid changes in consumer demand and aggressive market competition necessitates a continuous variation in designs and the production of smaller lots.

Using the new electromechanical system would omit weave errors. There is a lower probability for errors with the electromechanical system. This would decrease rejects, increase efficiency and improve the company's product quality.

Savings in capital cost of the locally manufactured as compared to the imported heads. The total cost of the locally-adapted electronic jacquard head is about LE 50,000. The total capital cost of classical jacquard loom is LE 250,000. Therefore, total investment cost of locally-adapted electronic jacquard loom would reach LE 300,000. On the other hand, the capital cost of the imported electronic jacquard loom is about 15 million Belgian francs which is equivalent to LE 1.8 million.

As a result, the cost saving resulting from using one modified electronic jacquard loom instead of importing it is equal to (LE 1.8 million minus LE 0.3 million) LE 1.5 million which is equal to the total budget of this project.

Reduced workers' exposure to hazards generated within the weaving chambers. The project's Principal Investigator believes that the new procedure would require less workers' involvement (approximately a 25 percent reduction of level of effort required) with a subsequent reduction in exposure time to fibers and noise from machines within the production chamber.

This is important because prolonged daily exposure to fibers could potentially result in a series of respiratory disorders usually manifested in the form of asthma, predisposing one to an increased incidence of respiratory infections and chronic airway obstruction, ending in respiratory failure. Occupational safety precautions taken to lessen the incidence of disorders and/or

67

complications are not sufficiently available at the factory level. In this regard, reducing exposure time will most likely result in a lower incidence of disorders and related complications.

In the same way, prolonged exposure to loud noise in the weaving chambers without taking necessary occupational safety precautions such as using ear plugs, intermittent presence in the chamber, isolation of the noise-producing machinery, pre-employment and periodic hearing testing, among other measures, usually results in various degrees of conductive deafness. Eventually, this may lead to complete loss of hearing sensation in one or both ears. Reduced exposure to the loud noise produced in the weaving chambers will most likely reduce the incidence of hearing impairment among workers.

It is, however, difficult to quantify these improvements occurring as a result of exposure to fibers and noise in the absence of health data for workers taken at regular intervals. Medical services provided at the factory level are more of a curative rather than screening or preventive nature.

C. Project Replicability

As indicated in the project's technical reports and stated by the project's Principal Investigator, there exist 5,000 looms nationwide that could benefit from the experience gained by this subproject. Every loom employs on the average 1 to 3 workers with a total of 5,000 to 15,000 workers employed in the practice nationwide. Accordingly, it could be assumed that 1,250 to 3,750 workers would benefit from reduced exposure to hazards generated within the weaving chambers.

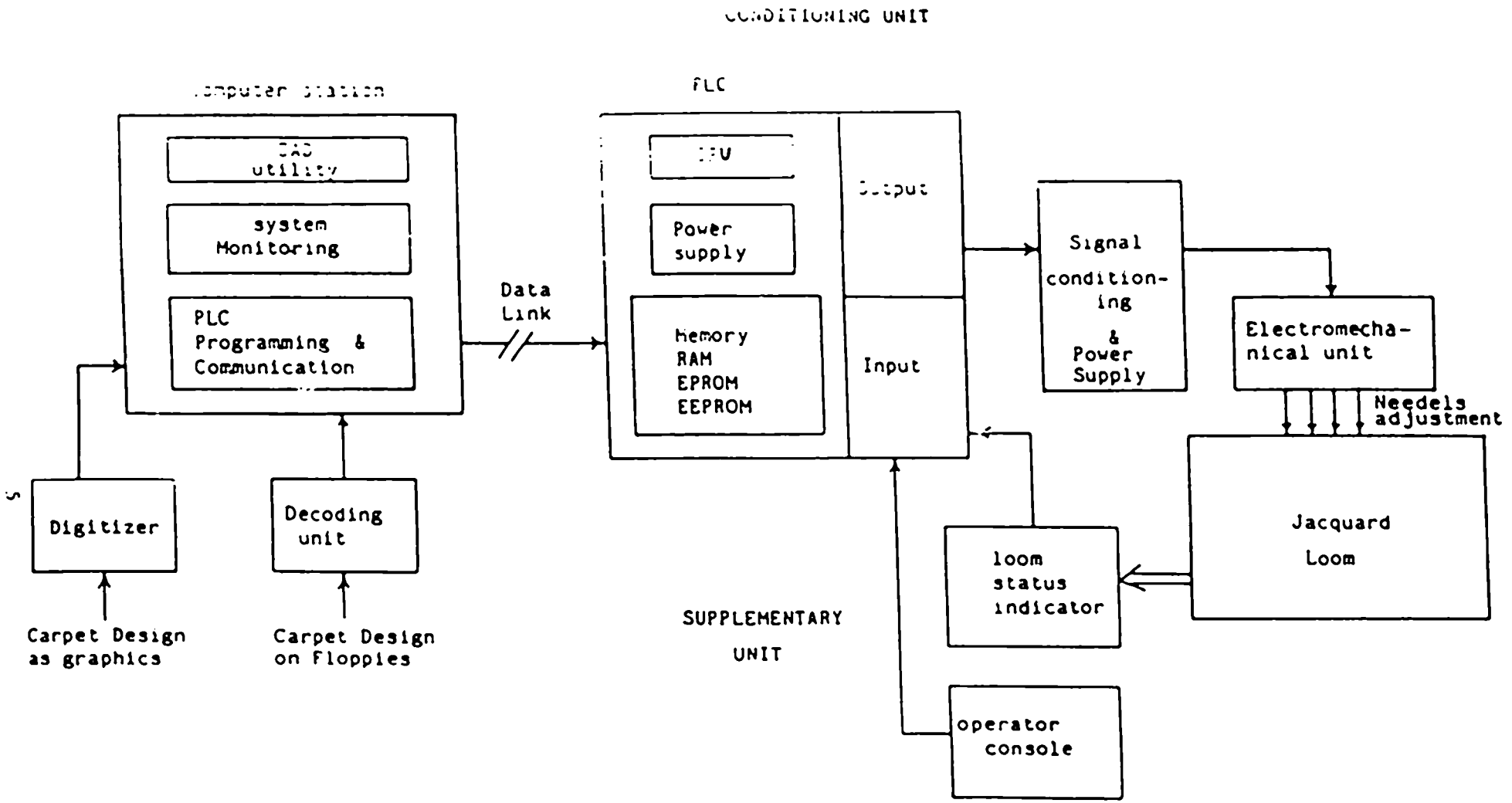


Figure 8.1 Control System Configuration - Jacquard Looms

Projected Cash Flow and Financial Returns (in LE 000's)

Scenario 2 : Adopting the local electronic Jacquard heads for the 20 classical Jacquard looms (LE 000's)

Description	Pre [illegible]	Projected 1	2	3	4	5	6	7	8	9	10
CAPITAL EXPENDIT.											
USAID/STC grant in LE	323										
USAID/STC grant in $	527										
End-User contribution	280										
GOE contribution	458										
Total Cap. Exp.	1,588	0	0	0	0	0	0	0	0	0	0
O&M EXPENSES											
Salaries, supplies, and eng. work		100	105	110	116	122	128	134	141	148	155
Total expenses		100	105	110	116	122	128	134	141	148	155
ANNUAL PROFITS											
Direct saving		850	893	937	984	1,033	1,085	1,139	1,196	1,256	1,319
Total Annual Gains		850	893	937	984	1,033	1,085	1,139	1,196	1,256	1,319
Annual Surpluses (Deficits)	(1,588)	750	788	827	868	912	957	1,005	1,055	1,108	1,163
NPV (Discount rate 12%)	3,507										

Assumptions :

The above capital expenditures are the actual project expenditures as funded by either the STC or directly incurred by the end user or GOE

Life time of the project is 10 years

Operating expenses are calculated as being 10% of the total cost of the system on the average (LE 50,000 per loom x 20 looms)

All annual expenses and revenues are inflated by 5% annually Cost of Capital is 12%

All figures are based on data gathered from the feasibility study of the sub-project

The research team is led by the principal investigator Prof Dr Esmat Abd El Fattah

Projected Cash Flow and Financial Returns (in LE 000's)

(LE 000's)

Description	Pre-[illegible]	1	2	3	4	5	6	7	8	9	10
	Projected										
CAPITAL EXPENDIT.											
USAID/STC grant in LE	323										
USAID/STC grant in $	527										
End-User contribution	280										
GOE contribution	458										
Total Cap. Exp	1,588	0	0	0	0	0	0	0	0	0	0
O&M EXPENSES											
Salaries, supplies, and eng. work		30	32	33	35	36	38	40	42	44	47
Total expenses		30	32	33	35	36	38	40	42	44	47
ANNUAL GAINS											
Direct saving		850	893	937	984	1033	1,085	1,139	1,196	1,256	1,319
			0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0
Total Annual Gains		850	893	937	984	1033	1,085	1,139	1,196	1,256	1,319
Annual Surplus (Deficits)	(1,588)	820	861	904	949	997	1,047	1,099	1,154	1,212	1,272
NPV (Discount rate 12%)	3,983										

Assumptions :

The costs encountered here are the actual project expenditures in cash as funded by either the STC or directly incurred by the end user

Life time of the project is 5 years

All operating expenses are constant since they are calculated by devided the end user direct and in kind share by 5 years

All annual gains are inflated by 5% annualy Cost Cost of Capital 12%

All figures based on data obtained from the summary report of the sub-project

The research team is led by the principal investigator Prof. Hassan T. Dorrah

71

SUBPROJECT NO. 18
DEVELOPMENT OF COMPUTER-BASED CONTROL FOR CALCINER AND D.C. CASTERS OF THE ALUMINUM COMPANY OF EGYPT

Awardee	EGYPTALEN (RD & E Center of the Aluminum Company of Egypt)
End-User	Aluminum Company of Egypt (EGYPTALUM)
Principal Investigator	Eng. Aly Sarhan
Period	1/ 1/ 1991 - 30 /9/ 1993

Budget Breakdown

			LE
USAID/STC	$210,000		**714,000**
In Cash	GOE	None	
	End-user	LE 470,000	**470,000**
	Aluminum Company of Egypt		
In Kind	GOE	LE 200,000	
	End-user	LE 300,000	**500,000**
Grantees	EGYPTALEN (RD & E Center of Aluminum Company Egypt)		
Total			**1,684,000**

A. Subproject Description

This subproject provides for the research, design, installation, startup, and performance evaluation of two automatic control systems at the Aluminum Company of Egypt (EGYPTALUM), one of the major public sector enterprise companies. The company satisfies domestic demand for aluminum and its alloys and exports about $ 180 million worth of its production to the international market. The main industrial activities of this company are conducted within its gigantic facility located at Nag Hammadi, Qena governorate.

Two major industrial operations were selected by the end-user and the research team to be the main focus of the subproject presented within the current case study. These operations are the calciner unit and metal D.C. casting unit. Preliminary investigations of the operations of these units indicated that certain deviations from the designed operational parameters influenced the quality and consistency of final metal product. This was also reflected in the high percentage of metal rejects produced at the final casting stages.

The production of calcined petroleum coke is essential in the overall production of aluminum. The calciner unit produces the required high quality carbon electrodes from petroleum coke and coal tar that are, in turn, utilized in the reduction of alumina to the metal. Through the calcination process, the solid petroleum green coke is heated below melting point (1000 to 1400°C.) to promote the desired physical and/or chemical changes. The purpose of this heating is to drive off volatile matter and pre-shrink the coke thus reducing the material shrinkage and breakage during successive baking process of products, to increase the electrical conductivity of electrodes as well as remove surface moisture.

There is relatively high consumption rate of this type of electrodes during the studied process. It was reported that about 0.4 to 0.5 pound of carbon is needed for the production of one pound of aluminum metal. EGYPTALUM has an annual production capacity of calcined petroleum coke of 180,000 tons, of which 70,000 to 100,000 tons are consumed during the factory production operations and the remainder is being exported.

Egyptalum has installed a rotary hearth calciner system (structure shown in Figure 18.1). This system is effective in the promotion of full calcination of the petroleum coke through process heat propagation resulting from the internal combustion of volatile compounds, carbon content and flue gas associated with the coke. The overall structure of the apparatus further promotes heat radiation and transfer during the overall operation to ensure the completion of the reactions within.

The heat transfer step within the hearth system has been set as the calcination process controlling step. It is monitored through an installed analog control scheme. However, the original system exhibited significant instability of its two controlling variables, namely the process pressure and temperature. Further investigations were done on the dependence of these variable on the various operation modes of the machine. The study revealed that the internal temperature parameter can be effectively applied as the overall process control parameter. The installation of a dynamic control scheme to adjust and monitor this parameter improves unit productivity and product quality.

The other process analyzed by the research team was the operation of the metal D.C. casting units. The factory has two casting houses comprising four casting lines producing a total of 180,000 ton/year of metal. The D.C. casting unit is composed of three main parts: the furnace, the filter, and the casting machine. The general layout of the unit is shown in Figure 18.2. In the mixer furnaces, the chemical composition of the melt is adjusted by the addition of master alloys. The melt is then passed through the filter before being introduced to the casting molds. This filter has the main function of ridding the liquid metal from impurities and gases by adding covering fluxes on top of the liquid metal.

The overall casting operation depends upon a number of factors and variables associated with the metal from the melting and filtering processes. Investigations indicated that the microstructure of alloy and casting defects were influenced by the operating conditions prevailing at the casting lines. However, other parameters do set control limits to the introduction of liquid metal into the casters from the furnace through the filter.

Specifically, these are the melt temperature and flow rate of liquid alloy from the furnace to the filter. Once the metal reaches the casting machine, it is the pouring temperature, casting speed, and cooling water rate that control the level of the metal in launder and establishes the pressure needed for the liquid metal to reach thump. Overheating the existing temperature

transducers and sensors connected to the system analog control leads to inaccurate measurements of the metal level in the launder and the casting operations.

The developed control system has the main function of regulating the temperature parameter at the caster and effectively adjusting the casting speed through a given set of desired values. After system initialization, data is inputted to adjust the speed of the casting to 60 percent of the full rate. This speed is gradually increased to reach the full rate which is further controlled through the interfacing temperature transducers circuits placed to measure and control cooling water. The rate of cooling water is also adjusted according to the measured filter temperature and the input casting speed. Achieving a synchronized control of these two parameters therefore improves upon the metallic structure and quality of the final product.

B. Financial Analysis

In analyzing the financial returns of this project, calculations were based on the data from the Principal Investigator's report. In the analysis, the STC grant, the GOE contribution, and the end-user contribution were used as the project's capital expenditures. Ten percent of that amount was used as the project's annual expenses.

In most cases, annual operating costs should be calculated as a percentage of the actual total system cost which amounts to LE 0.893 million. However, for precautionary reasons, the total project budget of LE 2.144 million was used to calculate the yearly operating costs.

On the other hand, the cost savings (in raw material, energy, annual rejects and training) resulting from the implementation of the project were counted as the annual returns.

The analysis showed the subproject to be exhibiting a positive net present value of approximately LE 11.383 million over a five-year projected cash flow period, while a net present value of LE 21.301 million is reached over a lifetime of ten years. In both cases, the annual cost savings exceed initial and annual operational costs.

The calculations and assumptions related to the above analysis can be found in the table following this case study.

C. Subproject Achievements

Economic benefits. The direct economic benefits of this project are based on the expected net annual savings to EGYPTALUM over the next five years.

This subproject has achieved full implementation of two major control systems, the calciner plant and D.C. casting machine. This has led, to considerable savings in raw materials, energy consumption, and product rejects.

Total cost savings resulting from project implementation amounts to LE 2.66 million annually divided as follows:

Calciner System: (cost savings of LE 2.308 million + 0.033 million annually). The consumption of green coke per ton of calcined coke was decreased from 1.328 tons to 1.261 tons due to the application of the automatic control. This represents a considerable saving in operation cost. In 1993-1994, the amount of calcined coke gained due to improvement in extraction

efficiency was 4779.8 tons. At $142 per ton, this is equivalent to a gain of $0.678 million (equal to LE 2.308 million). Thus, gains made due to this part of the project only have covered the actual project's budget in less than eight months.

In addition, there is a considerable reduction in fuel consumption by approximately 20 percent (LE 0.033 million per year).

D.C. Casting System: (cost savings of LE 0.353 million annually). Annual rejects have been decreased from 5 to 3 percent because of the improvement of one D.C. casting machine. This has meant an increase in production of 384 ton/year. The saved costs are as follows:

1. Cost of remelting 384 tons =

384 tons x LE 100 = LE 38,400

2. Cost of recasting 384 tons =

384 tons x LE 200 = LE 76,800

3. The price of waste metal due to remelting =

384 tons x 1.5% x LE 3500 = LE 20,160

The total saving in cost due to automating one casting machine =

38400 + 76800 + 20160 = LE 135,360

If the annual production is projected to be 50,000 tons per year, automating the D.C. casting system is expected to save remelting and recasting costs of LE 352,500 annually.

On the other hand, the total cost of implementing the control system for one machine is LE 45,000 which can be reclaimed in 1.5 months.

Training: (cost savings of LE 0.120 million in the first year). The end-user staff have acquired the necessary experience to operate and maintain the new systems. The on-the-job training period can be considered be comparable to the cost of conducting such training by an independent professional training agency for a period of eight months. Hence the benefit of this item is estimated as LE 120,000.

Improving and increasing production. Implementation of this control system improved on the production efficiency of the company. The total production of the calciner unit increased to 94,739 tons per year from 74,016 tons while maintaining high product consistency. This also entailed a reduction of total energy consumption of the unit from 2568.9 to 2052.7 megawatts hour.

Reduction of rejects. Improving the operation of the casters reduced the percentage of metal rejects from 5 percent of the total production capacity (for the unautomated line) to 3 percent. This is equivalent to an additional production capacity of 384 tons per year and a net profit of LE 20,160 per year.

Occupational hazard reduction. The positive occupational aspects of this subproject are among the most significant benefits resulting from this endeavor. The automated system presents no significant hazards to its operators, while relieving engineers from the negative health impacts resulting from the inhalation of coke dust and SO_2 emissions.

Improved environmental and public health conditions. The subproject aims to resolve major environmental concerns associated with the production of aluminum metal at both the factory and area levels. These emissions are comprised of hydrogen fluoride, other fluoride salt gases, as well as carbon and particulates. More importantly, the subproject provided proven environmental benefits for factory the employees. The improvement of the operation of these units promotes the reduction of excessive air emissions and improves the quality of ambient air in the factory's surroundings. Decreased emission of fluorides leads to a decreased incidence of upper respiratory disease. The project has led to an improvement in ambient readings of fluorides.

Improved working environment. The calciner operating crew now works in a clean control room approximately 75 meters away from the scattered coke dust, thereby greatly reducing exposure to harmful fumes, dust and risk of respiratory disease. This leads to better productivity, reduces absenteeism, and better overall performance.

Increased workers' motivation. Perhaps unique among STC subprojects, the work conducted under this subproject was performed mainly by a team of company employees. The participatory approach employed in the development of the control system by the O & M engineers, R & D engineers and university professors led to a thorough understanding of the system, enhanced cooperation among these parties and increased motivation to improve the overall technical efficiency of the operation.

Local market creation. The designed controller system is locally manufactured and assembled. Wider use of this system by appropriate industries would provide new employment opportunities, acquisition of new skills, and the creation of a new local market from which controllers could be manufactured, delivered, operated and serviced at a reasonable cost.

Improved technical performance. The results of testing during the experimentation period of the automated system indicate an improvement in overall performance. This improvement can be seen in the following indicators that were applied first in 1991-1992 before the computer control system was used, and then in 1993-1994 after it was implemented.

	1991/94	**1993/94**
Annual Production	74,016	94,739
Stoppage and Failure	3,319.8	2,991.8

Positive environmental impacts. The subproject provides a good example of where a computer automated control system can be used not only for economic benefits but also for the improvement of occupational health and the environment. By virtue of improving upon the mechanical and electrical efficiency of the installed instrumentation, reductions in process air emissions and thermal heat radiation were achieved in the immediate and neighboring surroundings. Such efficiency in machinery operations further promotes other important environmental aspects within the industry and will directly lead to raw material and energy conservation as well as waste minimization.

76

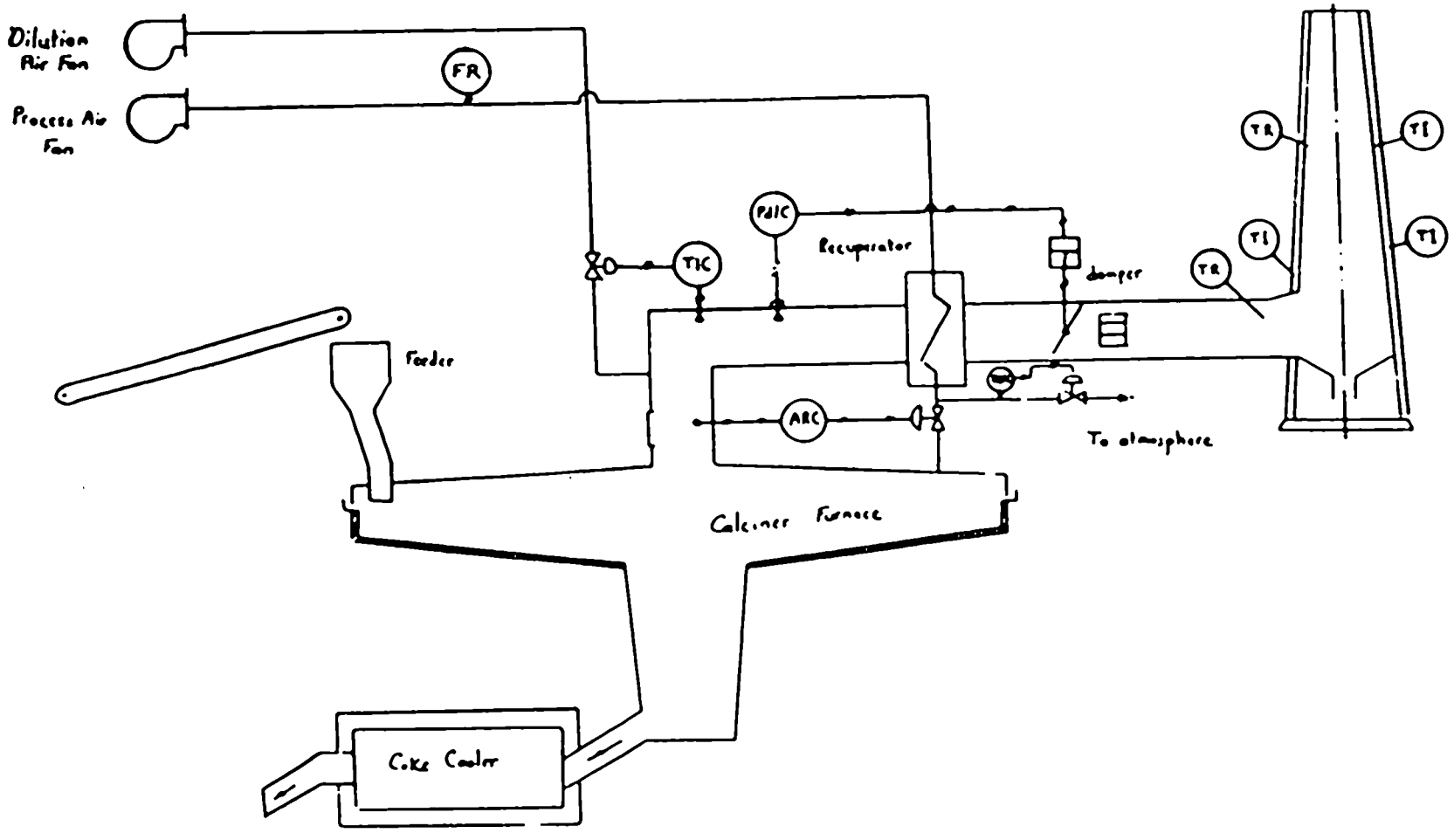


Figure 18.1 Schematic Diagram of Calciner - Egyptalum

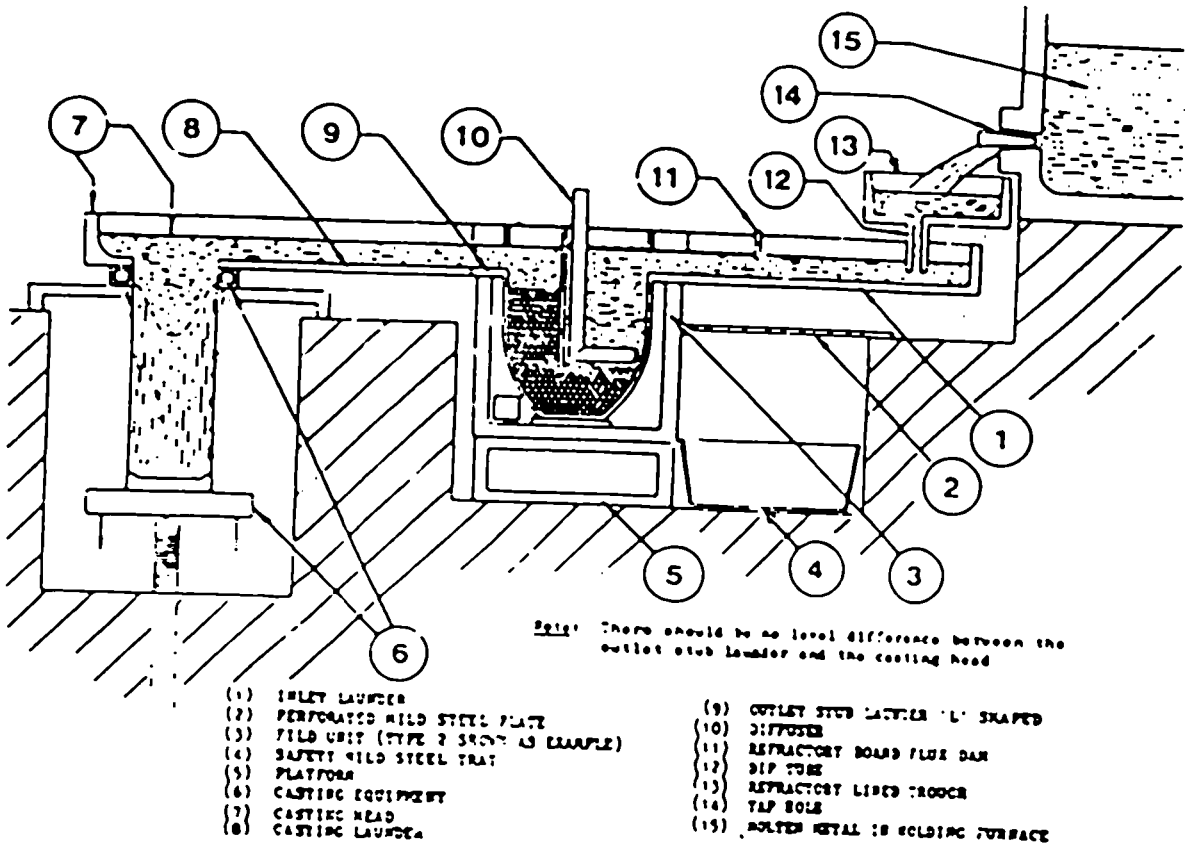


Figure 18.2 Schematic Diagram of D.C. Caster - Egyptalum

Projected Cash Flow and Financial Returns (in LE 000's)

(LE 000' s)

Description	Pre investment	Actual 93/94	Projected 1	2	3	4	5	6	7	8	9	10
CAPITAL EXPENDIT.												
USAID/STC grant in LE	714											
End User contribution	770											
GOE contribution	200											
Total Cap. Exp.	1,684		0	0	0	0	0	0	0	0	0	0
O&M EXPENSES												
Maintenance and spare parts		168	177	186	195	205	215	226	237	249	261	274
Total expenses		168	177	186	195	205	215	226	237	249	261	274
COST SAVINGS												
Rubber control system :												
Excess amount of rubber rolls		2,308	2,518	2,792	3,072	3,379	3,717	4,088	4,497	4,947	5,441	5,986
Savings in energy			33	34	36	38	40	41	44	46	48	50
DC cutting machine control system :												
Savings in annual rejects		333	388	427	469	516	568	624	687	756	831	914
Savings in cost of training			120									
Total savings		2,640	3,079	3,253	3,577	3,932	4,324	4,754	5,228	5,748	6,321	6,950
Annual Surpluses (Deficits)	(1,684)	2,492	2,902	3,067	3,382	3,728	4,109	4,528	4,991	5,499	6,060	6,676
NPV (Discount rate 12%) 5 years	11,383											
NPV (Discount rate 12%) 10 years	21,301											

Assumptions :

The above capital expenditure are the actual project expenditures as funded by either the STC or directly incurred by the end user or GOE

Life time of the project is 10 years

Operating expenses are calculated as being 10% of the total project budget for conservative factors (cost of the newly adopted system - computers and PLC's - reached LE 893,000 only)

All annual expenses and revenues are inflated by 5% annually Cost of Capital is 12%

Revenues are equal to cost savings

All figures are based on data gathered from the economic assessment of the sub-project report

The research team is led by the principal investigator Eng Aly Sarhan

SUBPROJECT NO. 23
THE INTRODUCTION OF COMPUTER-BASED TECHNOLOGY TO THE NEW ELECTRIC FURNACE PRODUCTION SHOP AT THE METALLIC INDUSTRIES COMPANY AHLIA

Awardee	Faculty of Engineering, Cairo University
End-User	The National Metallic Industries Company, Ahlia
Principal Investigator	Prof. Dr. Ahmad Bahgat
Period	15/5/1991 to 14/7/1993

Budget breakdown

				LE
USAID/STC	$186,000	and	LE 314,400	**946,800**
In Cash	GOE		None	
	End-user		LE 50,000	**50,000**
	National Metallic Industries Co.			
In Kind	GOE		LE 110,000	
	End-user		LE 170,000	**280,000**
Grantees	Faculty of Engineering, Cairo University			
Total				**1,276,800**

A. Subproject Description

The National Metallic Industries (Ahlia) is a public sector enterprise that produces various sizes of steel re-bars (used for construction purposes) using mainly scrap and slag as raw materials. The company's factory is located in the mixed residential and industrial area of Abu Zabaal, just north of the Greater Cairo Urban Region. In recent years, the company has invested in research projects directed toward developing new techniques for producing special types of high resistive steel as a means to upgrade production capacity and quality. These programs have resulted in the introduction of more modern technologies and procedures in steel-making.

In 1988, the company commissioned the construction of two new electric arc furnaces (EAF) with a capacity of 35 tons each as a means to upgrade its production operations which were totally depended on the available open hearth furnaces. Each furnace is linked to a three strand continuous casting machine (CCM) that produces billets that are subsequently rolled into re-bars of different diameters.

The metal scrap and small amounts of pig iron are fed into the EAF with the addition of materials such as coke and burnt lime for the melting and conversion into steel with the desired specifications. The molten metal is then transferred to the continuous casting machine (CCM) by the use of a 35-ton capacity steel ladle for the production of billets according to pre-set dimensions. At the final stage, the billets are conveyed to the rolling mill for the production of reinforcing bars.

The EAF has two distinct advantages over the open hearth furnace: it can use much cheaper metal charge with or without the addition of pig iron to produce high quality steel; and it requires lower energy per ton of metal produced. The combination of both these features made the introduction of the furnaces into the overall process a more economically viable option.

The company reported in its first year of EAF operation (1989-1990), an annual production of 170,000 tons of steel re-bars. However, progressive, deviations from the manufacturers set parameters of operation of the EAF were observed. These deviations were: the increase in the scrap melt-in time (220 minutes instead of the supposed 145 minutes); higher energy consumption per ton metal produces (750 kwh instead of 550 kwh); and higher slag consumption (13330 kg/ton instead of 1085 kg/ton). At the same time, production of the metal cast shop production decreased to 80,000 tons per year from the design capacity of 158,000 tons. The company's electricity bill amounted to LE 1.2 million in one year, which accounts for 14 to 20 percent of the overall operation cost.

The subproject focused on the optimization of the overall system operation to achieve target product quality through the study of the overall operation. A preliminary survey of factory operations was performed to identify deficiencies in the areas of process supervision and operations control. These were mainly related to the improper functioning of the existing control sensors for monitoring and adjustment of molten metal temperature and its level in both the furnace and casting unit. The survey also considered the controlling parameters for the speed and temperature control operations at the metal rolling unit as well as the materials weighing systems.

A series of on-site observations of the overall EAF and CCM operations further indicated inadequate coordination between the nonsequential operation of the two furnaces. This made a considerable contribution to the off-setting of the continuous casting operation as well as to the furnace system.

Therefore, improving the overall system required upgrading the efficiency of the individual operations to improve their performance and to develop an overall supervisory control systems for better coordination and sequential operation of the casting units with both arc furnaces. This raises productivity, improves product quality, and controls the electrical energy consumption of the furnaces. This was achieved by maintaining a constant furnace power input by controlling the desired arc length and retaining the optimum position of the electrodes. The system also developed the needed operational regimes for setting and controlling the operation of the two arc furnaces in sequence with the continuous casting machine.

For the system to fulfill its designed functions, additional control instrumentation was installed to ensure optimum operating conditions for each component. The new system will allow the EAF operators to set the necessary operation modes from the supervisory computer that will,

in turn, advise the operator on the appropriate tap setting. According to this scheme, two stands of the continuous casting machine will become operational, leaving a third set as a stand-by. This arrangement has been implemented to prolong the casting time to match the duration required to operate the two furnaces in sequence.

Some of the production problems encountered were a direct result of inadequate information. The Alilia Management Support Database incorporates three main components: a user interface, a decision model, and a hardcore database to provide both management and technical staff with projections that enable them to make sound decisions.

B. Financial Analysis

The financial analysis of this subproject is based on the data gathered from the progress reports of this subproject.

The initial investment expenditures of this project were calculated by using the STC grant in U.S. dollars or Egyptian pounds, the GOE, and the end-user contributions. Annual operating expenses were calculated as 10 percent of the initial system cost (LE 0.764 million), since the rest of the project budget consists of items that do not require running costs (such as research, travel, and consultancy), and are thus considered as non-recurring.

Item	Cost
Computer system	LE 200,000
Establishing control room	LE 120,000
Equipment and construction	LE 140,000

Other project expenses such as salaries, travel, consumables, consultation, and other direct costs reached a total amount of LE 200,000. The rest of the equipment, with a value of $30,000 equivalent to LE 100,000, is used in the laboratory. The total cost of the computer control system reached LE 0.76 million. This led to annual operating cost of LE 0.076 million.

On the other hand, the revenues come from three main sources:

Production information system	LE 100,000 yearly
Monitoring and supervisory control	LE 240,000 yearly
Training and repair facilities	LE 5,000 yearly

In light of the analysis, the positive net present value obtained is approximately LE 0.786 million over the 10-year projected cash flow period. This is due to the annual benefits exceeding initial and annual operational and maintenance costs.

The calculations and assumptions related to the above analysis can be found in the table following this case study.

C. Subproject Achievements

Economic benefits. The benefits of this subproject, as is the case with many other projects

in the automation field, are not only financial but include greater production efficiency and improvements in management control and decision making.

There are three distinct economic benefits with respect to the current project.

Effective production information system. The new system is providing the production manager and the decision makers in the company with all required production reports and statistics. The initial system cost may reach an amount of LE 60,000. Expected annual benefits, which can be gained through improving production scheduling, maintenance and labor efficiency, could reach LE 100,000.

Improved monitoring and supervisory control. The new system facility enables the supervisory engineers to monitor the process and to introduce corrective actions concerning the application of the developed operational systems.

System development, design, and installation cost approximately LE 70,000. The system, however, results in annual savings of LE 24,000 as a result of a three percent energy conservation in the arc furnace shop.

New training and repair facilities. These facilities are intended to offer technical training for the engineers in the areas of computer control, power electronics, and process control. The repair workshop will support the maintenance of electronic devices which are now increasingly used in the plant. The design and installation of these facilities cost LE 40,000, an amount that could be recovered in one year.

Such a simple system can offer monitoring and supervisory control with a relatively small investment which is an advantage in itself. The project's major efforts have been directed toward reducing the electrical energy cost and increasing production through better scheduling of the two furnace operation.

Positive environmental impacts. The effect of upgrading the efficiency of the overall operations in the National Metal Industries (Ahlia) is expected to improve the parameters associated with the installed instrumentation as well as increase production capacity. Improving the instrumentation operational parameters will, in effect, improve the quality of the working environment in and around the areas of the furnace and casting shop. A reduction of air emissions inside the factory as well as the ambient temperatures around the instrumentation will directly affect the workers' health and, indirectly, the population of the residential area outside the factory premises.

Projected Cash Flow and Financial Returns (in LE 000's)

(LE 000's)

Description	Pre-commence	Projected 1	2	3	4	5	6	7	8	9	10
CAPITAL EXPENDIT.											
USAID/ STC grant in LE	314										
USAID/ STC grant in $	632										
End-User contribution	220										
GOE contribution	110										
Total Cap. Exp.	1277										
O&M EXPENSES											
Maintenance and spare parts		76	80	84	88	93	98	102	108	113	119
Total expenses		76	80	84	88	93	98	102	108	113	119
ANNUAL GAINS											
Production information system		100	105	110	116	122	128	134	141	148	155
Monitoring and supervisory control		240	252	265	278	292	306	322	338	355	372
Training and repair facilities		40	42	44	46	49	51	54	56	59	62
Total Annual Profits		380	399	419	440	462	485	509	535	561	590
Annual Surpluses (Deficits)	(1,277)	304	319	335	351	369	387	407	427	449	471
NPV (Discount rate 12%) (for 10 years)	786										
NPV (Discount rate 12%) (for 5 years)	(81)										

Assumptions :

The above capital expenditures are the actual project expenditures as funded by either the STC or directly incurred by the end user or GOE

Life time of the project is 10 years

Operating expenses are 10% of the total cost of the system (764 LE)

All annual expenses and revenues are inflated by 5% annually, Cost of Capital is 12%

All figures are based on data gathered from the progress report # 11 of the project

The research team is led by the principal investigator Prof Dr Ahmed Bahgat

SUBPROJECT NO. 66
DEVELOPMENT OF PROCESS COMPUTER-CONTROL SYSTEMS FOR PRODUCTION AND QUALITY IMPROVEMENT FOR THE EGYPTIAN YEAST, STARCH AND DETERGENTS COMPANY

Awardee	Faculty of Engineering, Cairo University
End-User	Egyptian Yeast, Starch and Detergents Company (EYSD)
Principal Investigator	Professor Dr. Hassan T. Dorrah
Period	18/ 9/ 1994 - 30 / 6/ 1995

Budget Breakdown

			LE
USAID/STC	$ 175,000 and LE 550,000		**1,145,000**
In Cash	GOE	None	
In Kind	GOE End-user	LE 200,000 LE 450,000	**650,000**
Total			**1,795,000**

A. Subproject Description

The subproject aims at designing and implementing a computerized process control and management system at the Egyptian Yeast, Starch and Detergent Company (EYSD).

Established in 1923 as a large state-owned enterprise, the EYSD is based in the Moharam Bey area of the city of Alexandria. The company is the largest producer of commercial yeast in Egypt. The majority of EYSD's industrial operations take place within its nine large production units, all located on the same premises in Alexandria. These units have additional capacity to supply the market with other products such as starch and detergents.

Recent privatization prospects have encouraged the company to undertake efforts toward expansion and upgrading of its yeast production lines. To this end, the EYSD set to apply process quality control throughout the entire production line as a pre-requisite to increasing its efficiency, obtaining high quality products, and augmenting the production capacity.

The production process for commercial yeast may be classified as follows (Figure 66.1):

- Laboratory fermentation
- Mother yeast formation
- Final enlargement of the mother yeast in commercial fermentation units

The production process requires the addition of ingredients such as salts and molasses to promote yeast consistency and control individual internal fermentation processes. Air and steam are introduced for the control of final product consistency. These are provided to the units through commercial compressors and boilers. In general, the overall production is complex and requires the adjustment of quantities and timely addition of the above elements for successful production operations. The sequence of units used in the production operations and their functions are as follows:

Primary yeast units. These units receive the yeast cells from the laboratory to be processed and passed on to the intermediate units. At this stage salts, water and molasses are added manually to the mix.

Intermediate yeast units. These units are used to activate the yeast growth processes as it circulates between the primary and mother units. Activation is done through the addition of water, salt, and molasses with the introduction of air and steam.

Mother yeast unit. This unit prepares the product mix prior to its introduction into the commercial yeast units. At this stage, yeast growth is further activated by air and steam.

Separation units. In these two units, separation of the solid yeast from excess water takes place through the application of centrifugal forces.

Washing units. In these units, the yeast mix is washed as it exits the mother yeast unit prior to its entry into the commercial yeast units.

Commercial yeast units. These are five units (tanks) in total. Yeast received in these tanks is processed isothermally with the appropriate additions of salt, water and molasses.

Milk cream unit. This cooled unit represent the final stage of the yeast growth processes.

Storage unit. This is a double jacketed tank provided with a stirrer. It acts as a preservation site for the product (output of mother yeast unit after separation and washing) until it is required for delivery to the commercial units.

Drying and compressing units. These units operate to rid the product of excess moisture content using drying and compression filters. The yielded output of these units is a ready-to-pack product.

Packing units. At this stage, the final product is paper packed in ½ kg blocks then wrapped in plastic containers for customer delivery.

Detailed surveys conducted by the subproject team on-site identified a number of variables that influence the efficiency of the operation. These are :

- Temperature of the fermentation operations
- Regimes for molasses and salt feeding
- pH levels and alcohol generation rates
- Air flow to and from the mix

Given the complexity of the overall process, the subproject team pursued the identification of a single core stage/unit where control procedures would be applied to upgrade the overall production efficiency. The mother yeast unit was selected for this purpose and system bottlenecks identified and described. Information was provided by the subproject team on preventive maintenance procedures to avoid fault occurrences .

The control system was designed to operate on three modes: manual, automatic, and computer controlled modes. The latter allows for optimal input from both the technical and production line staff aided by the computerized system.

Available databases was developed to act as a decision support tool to help the EYSD management in production planning and policy formulation. The technical data supplied from the various production sectors fed into the installed decision support system.

Close cooperation was maintained with the factory staff especially during the installation period. On-site training was conducted for electrical and mechanical technicians, maintenance engineers, and process operators. Training aspects included the salient aspects of troubleshooting within the system, fault clearance of various system components and actual maintenance and repair of its electrical and mechanical parts.

B. Financial Analysis

At the time of this report, the subproject had not yet been completed. Accordingly, all calculations are based on the data available in the project proposal.

The initial and annual project costs were computed on the assumption that the projects capital expenditure includes the STC grant, the GOE and the end-user contributions.

Given that all equipment, software and hardware were purchased from a direct STC grant, it was assumed that 10 percent of the STC grant in dollar or pound constitutes the annual operating expenses.

The expected annual revenues that will result from the subproject achievements will range between LE 0.8 to 1.2 million.

In view of the above analysis, the positive net present value is approximately LE 4.221 million over the 10-year projected cash flow period. This is due to the fact that the annual benefits exceed initial and annual O&M costs. Relevant calculations and assumptions are attached to this document.

B. Subproject Achievements

Reduction in material losses. According to production figures available in the technical reports, material losses range between 3 to 5 percent of the total annual production capacity. It is anticipated that the installation of the process control procedures will lead to a 2 percent reduction in material losses. This will generate annual savings ranging from LE 0.8 to 1.2 million.

Reduced maintenance problems. The installed system allows for a complete fault analysis to be undertaken. A fault diagnostic table has been designed to include information on the nature

81

of the fault, its location, its annual frequency, ranked effect and clearance duration. Additional information on the costs of repair and preventive maintenance measures was provided by the subproject team.

Improved operational efficiency. The three modes provided for system operation—manual, automatic, and computer control—ensure absolute reliability of operation. The design of the system and its switch option allow for the integration of other manually-operated commercial yeast units when they are automated. Production yield is expected to increase by 5 to 10 percent following the application of the automated process control procedures.

Improved product quality to the International Standard Organization Requirement-ISO 9001. The new product yield will satisfy the International Standard Organization Requirement ISO-9001. This will potentially increase the company's export market share. Furthermore, the system is viewed as one of the most advanced computer control/management technologies available at this time.

Support to management capabilities. Organization of the decision-making process will be enhanced through the designed management information system. The use of this system is also expected to contribute significantly to optimizing production and improving marketing policies and plans.

88

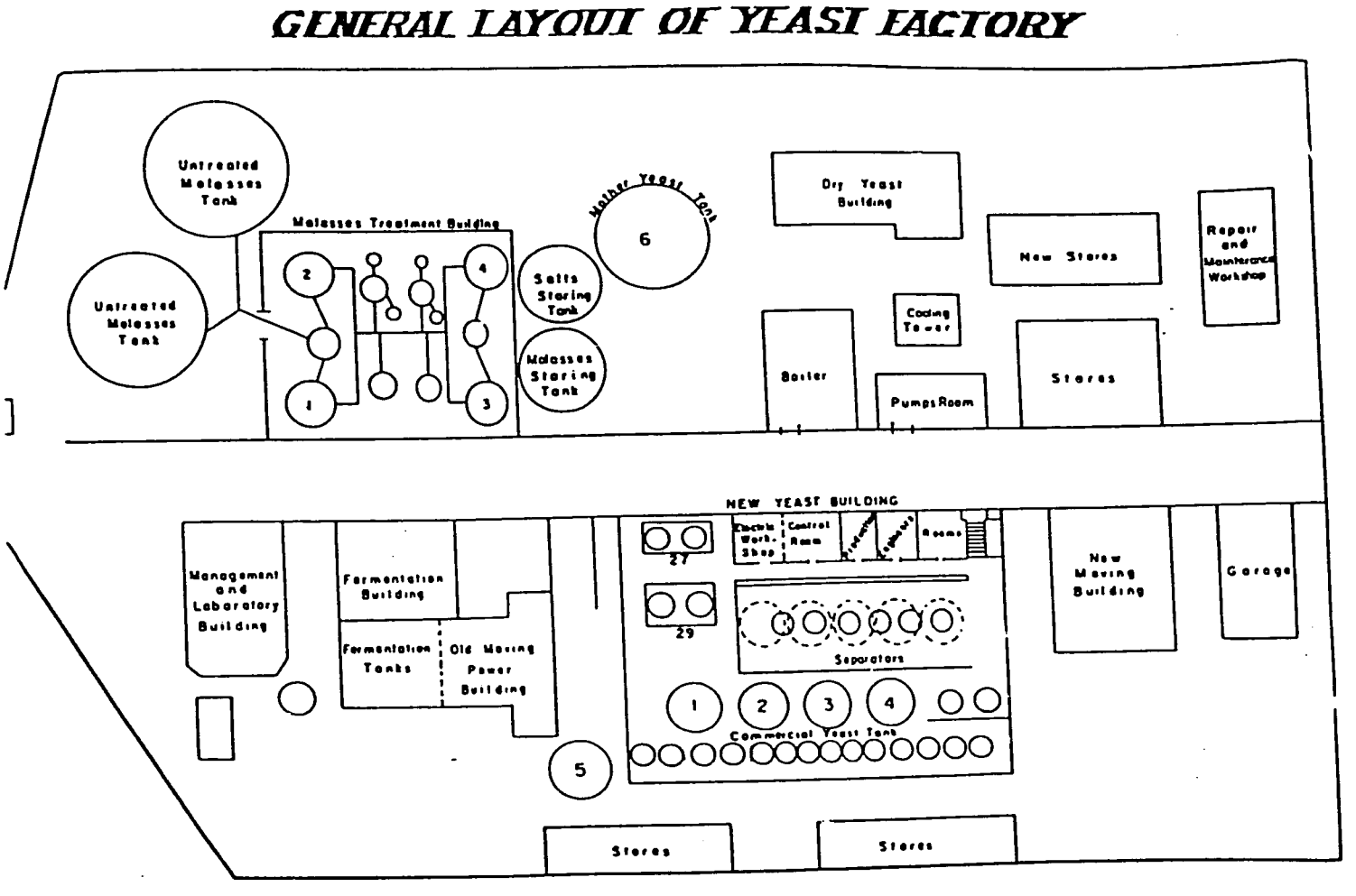


Figure 66.1 Layout of the Egyptian Yeast, Starch and Detergents Company (EYSD) - Alexandria

COMMERCIAL YEAST PROCESSING

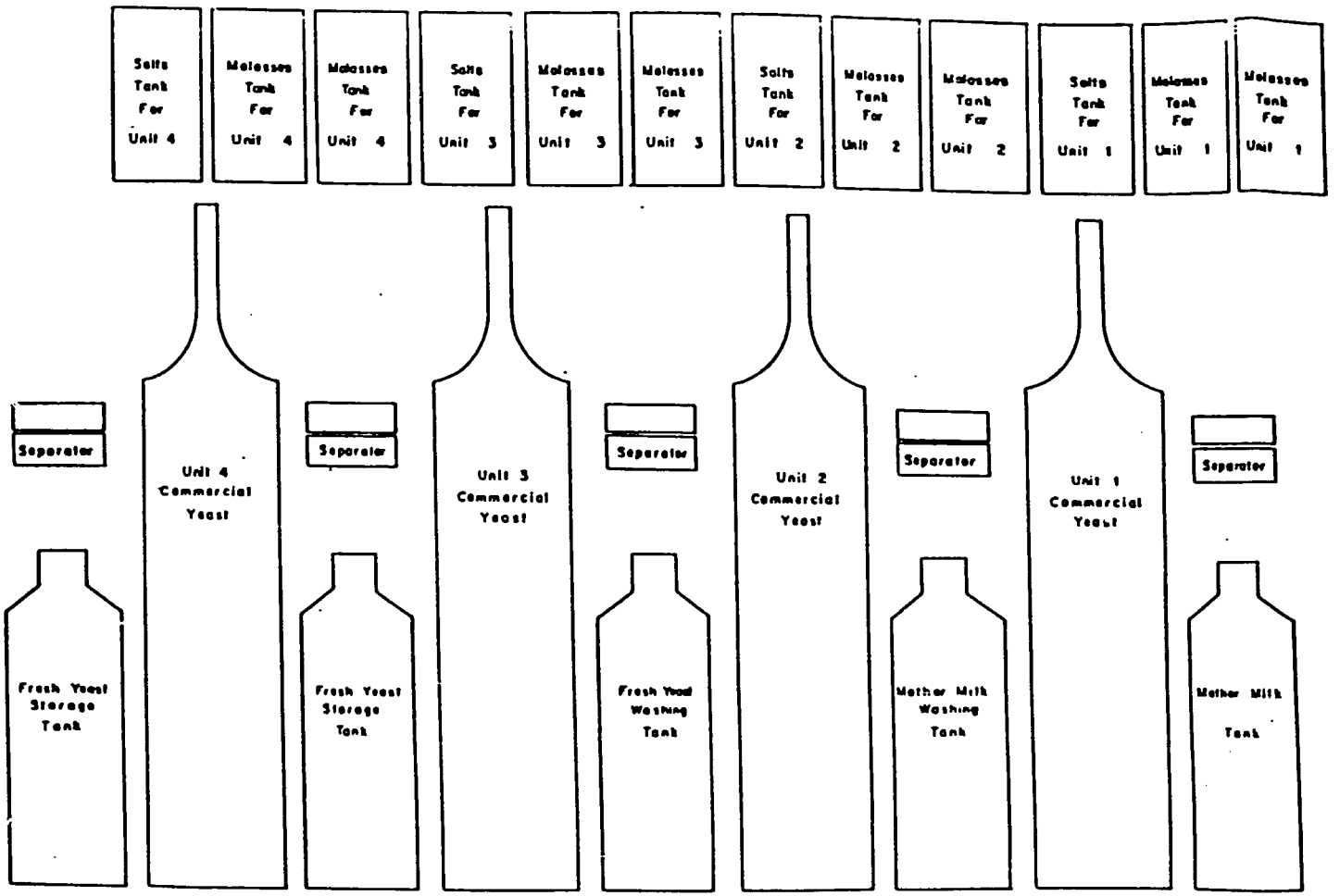


Figure 66.2 Overall Process Flow of Commercial Yeast Production - EYSD

Projected Cash Flow and Financial Returns (in LE 000's)

(LE 000' s)

Description	Pre commissioning	Projected 1	2	3	4	5	6	7	8	9	10
CAPITAL EXPENDIT.											
USAID/ STC grant in LE	550										
USAID/ STC grant in $	595										
GOE contribution	200										
End-user contribution	450										
Total Cap. Exp.	1,795	0	0	0	0	0	0	0	0	0	0
O&M EXPENSES											
maintainance and spare parts		115	120	126	133	139	146	153	161	169	178
Total expenses		115	120	126	133	139	146	153	161	169	178
ANNUAL PROFITS											
financial gains		1000	1050	1103	1158	1216	1276	1340	1407	1477	1551
Total Annual Gains		1,000	1,050	1,103	1,158	1,216	1,276	1,340	1,407	1,477	1,551
Annual Surpluses (Deficits)	(1,795)	886	930	976	1,025	1,076	1,130	1,187	1,246	1,308	1,374
NPV (Discount rate 12%)	4,221										

Assumptions :

The above capital expenditures are the actual project expenditures as funded by either the STC or directly incurred by the end user or GOE .

Life time of the project is 10 years.

Operating expenses are calculated as being 10% of the total cost of the system (assumed to be the STC grant in $ and LE since the other amount are in kind contributions other than equipments)

All annual expenses and revenues are inflated by 5% annually Cost of Capital is 12%.

All figures are based on data gathered from the proposal of the project.

The research team is led by the principal investigator Prof.Dr. Hassan T. Dorrah.

SUBPROJECT NO. 67
ARABIC COMPUTATIONAL LINGUISTICS

Awardee	Egyptian Computer Society (ECS)
End-User	Al Ahram Organization (AMAC)
Pri cipal Investigator	Prof. Dr. Ahmed E. Sarhan
Period	1/ 10/ 1994 - 1 / 7/ 1995

Budget Breakdown

			LE
USAID/STC	LE 666,350		**666,350**
In Cash	GOE	None	
	End-user	None	
	El Ahram Organization		
In Kind	GOE	None	**300,000**
	End-user	LE 300,000	
Total			**966,350**

A. Subproject Description

This subproject aims to create the infrastructure necessary for the development of natural language processing based on the Arabic language.

In recent years, trends in computer technology have favored the shifting toward natural language processing. This trend is expected not only to continue, but to accelerate as well. This implies that computers will be based on natural language, or language as spoken, written, and read by humans. This in turn means that those countries that develop computer software and hardware capable of dealing with their national languages will be able to keep up with the advancements in computer technologies. Conversely, those who do not quickly adapt to these new and radical changes may face the risk of being left out of the computer society. Consequently, they would have to use computers based on foreign languages hence slowing down the propagation of computers in their societies, and forfeiting the many benefits and conveniences that computers can offer.

To avoid this happening, and in an effort to stay in sync with the rest of the world, it was essential that an effort be undertaken to bring the Arabic language fully into the arena of natural language processing. To attain the objectives of the subproject, it was necessary to undertake the following tasks:

- 92

- Define and build a scalable Arabic corpora of existing modern Arabic text covering a wide range of disciplines. The corpora with the computed statistics are needed for modeling the Arabic language in both linguistic and computer applications.

- Define and build a full Arabic lexicon. Each entry in the lexicon will be provided with complete linguistic information. The lexicon will be derived by the needs of lexical based linguistic grammars.

- Define and establish a library of speech and written text processing algorithms.

- Define and build a spoken, typed and handwritten corpora. Such a database will be used as test and analysis media for future advanced application.

- Define and develop a prototype application that demonstrates the validity of the reached results.

Previous efforts undertaken by computer companies have fallen short of providing the Arabic language with the infrastructure it needs to be further developed for regular or specified applications. This can be attributed to the complex nature of the Arabic language which did present a worthwhile challenge for the subproject research team.

B. Financial Analysis

It is not possible to perform a proper financial analysis on this kind of a subproject, since it is a subproject that is designed to create an infrastructure for future work. However, using any objective measure it can be said that the investment made in the subproject is a good one the potential returns could be rather large.

C. Subproject Achievements

Economic benefits. This subproject, when completed, will be result in the creation of a solid foundation that would enable the development of an almost endless variety of software applications using Arabic computational linguistics. This, in turn, would have a tremendous economic impact as the newly-created programs have a potential market of 250 million in the Arab World. Thus, the relatively small amount invested in this project could be parlayed into huge profits by companies operating in the computer field.

Creating infrastructure for Arabic voice- independent computing. The voice recognition component of the subproject aims to reach a voice-independent status using the Arabic language. This would enable computers to recognize and respond to more than one voice. This would be a first for computers using the spoken Arabic language, which traditionally were voice-dependent (i.e., recognizing only the voice of one speaker). To do this, the subproject team devised a group of 500 Arabic words and sentences and had a group of people of both genders and of various age groups read them into the computer to create a library of words and sentences for the computer. This would enable the computer to recognize various voices. An effort was also made to enable the computer to recognize continuous speech.

Wider computer access by the handicapped. The subproject has created the infrastructure that would enable the handicapped to gain better access to computers thus enhancing their

93

learning opportunities and improving their quality of life in general. This is due to the improvements in the OCR capabilities coupled with improvements in voice recognition.

Improved optical character recognition (OCR). The subproject made a serious try to develop an OCR system that is more reliable than existing systems, through the development of new algorithms. The team fed a large number of printed and handwritten Arabic characters and words into the computer through a scanner. This was done in order to enhance the computer's ability to recognize optical characters of various fonts, handwritings, and sizes. This is expected to produce a significant improvement in OCR technology for the Arabic language. In fact, according to the subproject team members, the OCR system developed is over 95 percent reliable.

Improved spell checker. By virtue of the work performed under this subproject, the material necessary to create a better Arabic spell checking program will be made available. This is due to the fact that the Arabic corpora built by the researchers, including over four million words, is more extensive than any corpora previously developed. The corpora also includes some Egyptian colloquial words. The spell checker could be commercialized in about one year.

Extensive lexicon developed. The Arabic Lexicon developed under this subproject is the largest ever. The subproject team managed to enter 4,300 widely used roots, 1,300 more than the subproject's initial objective. For each root, 40 derivatives were entered.

Wider computer access by the Arab public. Having large Arabic corpora, coupled with an extensive lexicon and improved speech and written text processing, will undoubtedly result in facilitating the use of computers, widening the scope of their use, and making them more user-friendly to the Arab user. This in turn should result in enhanced access to by a larger number of people.

Moving a step closer to machine-aided translation. The subproject has created the infrastructure that would facilitate the development of machine-aided translation programs. This would enhance the role of computers in translation to and from Arabic.

Large Arabic corpus entered. The subproject team succeeded in entering over four million Arabic words into the computer, thus creating the largest such corpus in existence. The corpus included words gleaned from various sources, including *inter alia* social, economic, and political writings.

SUBPROJECT NO. 74
DEVELOPMENT OF COMPUTER -BASED QUALITY IMPROVEMENT OF ELECTRONIC PRODUCTS FOR THE INTERNATIONAL ELECTRONICS COMPANY (IEC)

Awardee	International Electronics Company (IEC)
End-User	International Electronics Company (IEC)
Principal Investigator	Professor Dr. Hani Assal
Period	1/10/1994 to 31/12/1995

Budget Breakdown

			LE
USAID/STC	$4,000 and	LE 629,500	**643,100**
In Cash	GOE	None	
	End-user	None	
In Kind	GOE	LE 200,000	
	End-user	LE 250,000	**450,000**
Total			**1,093,100**

A. Subproject Description

This subproject aims at designing and implementing a pilot automatic testing system for a typical company product. The product selected is the main board for a TV set. The subproject also aims at examining alternative designs for the manufacture of local molds.

For a long time, the electronics industry in Egypt has suffered a number of technical problems that have affected the quality of its products. These problems are strongly linked to the type of technology that has been used so far, the unavailability of spare parts, and delayed detection of system faults.

In addition, the electronics industry sector in Egypt is presently relying on the import of plastic molds for its products. The cost of an imported mold for a television set may reach LE 1 million. A locally manufactured mold, on the other hand, may cost only LE 20,000. Furthermore, the range of products is dependent on the number of molds used. The high costs of imported molds have been a constraint to widening the product range within the sector, thus reducing its competitiveness within the local and international markets. Local mold manufacturing has been a problem because of the low quality of raw material used.

95

The International Electronics Company (IEC) is a leading privately-owned enterprise that produces a wide range of electrical and electronic home appliances under international license. The company's operational strategy is to maintain and increase its current local market holdings of 40 percent and to obtain a substantial share of the export market. To realize its strategic objectives, the IEC has pursued modernization of its product testing procedures using computer-aided testing and quality control devices.

To this end, an automated product testing system was designed and implemented at the IEC. The efficiency of the system was tested in the factory. Through extensive simulation with fault models, the subproject team developed a fault dictionary. This relates the different responses to component failures under specific testing excitations. In addition, intensive on-the-job-training was provided for factory employees on system operation.

The subproject team have also examined alternatives for automatic development of mold fabrication that can ensure the quality of locally produced molds through the utilization of computer numerically controlled machines (CNC). The design of the different parts of the mold is first completed using computerized techniques that employ numerically controlled machine codes. The production of the plastic molds is further completed using an automatic laser cutter along with some other equipment.

B. Financial Analysis

All calculations and analysis are based on data for the subproject's technical and financial proposals, and information provided by the Principal Investigator. Capital expenditure has been calculated as the sum of STC grant (in LE or $), the GOE and/or the end user's contributions which totaled LE 1.093 million.

The annual operating expenses were calculated as 8 percent of the total budget. This amount is considered conservative because part of—not all—the budget has been spent on machinery and equipment requiring annual maintenance expenses. Nevertheless, it is preferable to compute the annual operating expenses as a percentage of the total budget for the following reasons:

- The actual annual amount needed for operating expenses is not precisely stated in the available data.

- Computing operating expenses as a percentage of the amount spent on machinery and equipment may underestimate this expense. Optimistic results may be obtained as a consequence of overvaluing the annual cash surpluses.

On the other hand, financial gains are calculated in the subproject proposal to reach LE 1.8 million annually. This amount represents the annual increase in gross income of the company. It is worth noting that there are many other direct and indirect benefits that have and will continue to be realized by the implementation of this project. These have not been included in this analysis due to the absence of quantitative data. These benefits will be stated below as subproject achievements.

After testing the capital and annual expenses against the annual financial returns, the calculations have indicated a positive net present value that is equal to LE 10.5 million over the 10-year projected cash flow period.

46

Relevant calculations and assumptions are attached to this case study.

C. Subproject Achievements

Reject minimization within the electronics sector at large. Automatic testing of products and their components will reduce the quantity of rejects. This will improve productivity and increase operational efficiency. Fault location is facilitated through the use of the fault dictionary designed within the subproject.

Increase in sales and profit. An estimated 2 percent increase in annual gross income of the IEC is expected following the implementation of the automated system.

Better opportunities in the local and export markets. Improved product quality through the installed automated system will enable the IEC to maintain its 40 percent share within the local market. In addition, IEC export shares are expected to show a significant increase in the short term.

Initiated local mold manufacture and reduced reliance on imported molds. A locally manufactured mold costs much less than a similar imported mold, reducing demand for foreign currency and increasing the range of locally produced electronic appliances.

Wide range replicability across the Egyptian electronics sector. The demonstration project value could be shown given that technologies currently employed in Egypt do not allow for monitoring product quality or the introduction of design modifications.

The subproject will result in a revolutionary change within the electronic industry nationwide.

SUBPROJECT NO. 80
PRODUCTION OF QUALITY SPARE PARTS FOR THE SPINNING AND TEXTILE EQUIPMENT USING CAD/CAM SYSTEMS

Awardee	Electronics Research Institute
End-User	Misr Company for Fine Spinning and Weaving (MCFSW) (Kafr El Dawar)
Principal Investigator	Prof. Dr. Ayman El-Dessouki Ibrahim
Period	1/ 12/ 1994 to 30 / 6/ 1995

Budget Breakdown

USAID/STC	$9,000 and	LE 259,450	**LE 290,000**
In Cash	GOE	None	
	End-user	None	
	Misr Company for Fine Spinning and Weaving		
In Kind	GOE	LE 150,000	
	End-user	LE 90,000	**240,000**
Total			**530,000**

A. Subproject Description

This subproject aims at improving the capabilities of the textile industry to design and manufacture the spare parts necessary for the industry. The subproject was conducted at Misr Company for Fine Spinning and Weaving (MCFSW) as representative of the important spinning and weaving sector in Egypt.

The spinning and weaving industry is an important investment sector in Egypt. In total, there are 37 major spinning and weaving companies in the country. Most of these industries apply similar imported technologies that employ the same brands of looms and spinning equipment. The availability of quality spare parts, therefore, affects the operation, product quality and price that such a sector can provide to both the domestic and international markets.

Basically, the availability of quality machinery spare parts is dependent to a large extent on the individual company's finances. This would require the selection of high quality raw materials for the manufacturing of spare parts as they are used in looms and spinning machines that require high speed mechanized operations. Therefore, it is essential to study and provide adequate and

95

affordable alternatives to resolve this problem based on the available local resources for this strategic industrial sector.

The current subproject selected MCFSW, in the area of Kafr El Dawar, as the case study for the application of computer-aided design and computer-aided manufacturing (CAD/CAM) in the production of quality spare parts. The research team first surveyed the spinning and weaving looms operations to identify the number of frequently used parts, parameters and specifications.

The detailed survey focused on studying specific parts of some special gears and cams that form the main operating system within the majority of the weaving looms that exist in the factory. As the research work progressed, two factors were required for the production of consistent high quality spare part. These are the use of high quality raw materials that can be achieved by improving upon the quality of the available materials and improving the design process of spare parts via the application of computer technology and CAD/ CAM techniques.

The first component led to the use of heat induction treatment to improve the quality of metal used in the manufacturing of the spare parts. The main advantages of this technique are to provide high resistive steel and metal parts that can endure the high operating speed and motion frequency. The metal parts obtained using this procedure are also adaptable as machine parts in most industrial applications that require high reactive power.

Proper manufacturing of these parts requires the incorporation of better design measures that assure the quality, flexibility and accuracy. This entailed the introduction of computer-based technology in the design process of the spare parts for looms and spinning machines. This component was provided by the implementation of a computerized-controlled CAD/CAM station to help develop the required parts design with an added efficiency. The introduction of this CAD/CAM system necessitated intensive training for the technical factory staff. This was done to ensure system reliability in providing accurate designs of products and spare parts.

B. Financial Evaluation

At the time of writing this summary, the subproject had not been completed and its final report had not yet been published. Therefore, to evaluate the project financially by calculating its net present value would be difficult. The project's initial and running costs may be determined, but data on its annual gains cannot be estimated quantitatively.

All data obtained have been based on a meeting with Prof. Dr. Ayman El Dessouki (Principal Investigator) and Prof. Dr. Esmat Abdel Fattah (Head of the Electronic Research Institute).

C. Subproject Achievements

Economic benefits

- Faster design and redesign process
- Increase in efficiency by increasing productivity
- The company is able to establish a complete design and manufacturing center that serves other spinning and weaving companies as well, thus potentially producing revenue

Improved design and quality of spare parts. The raw materials used for the manufacture of spare parts are crucial in determining the quality of the final products (spare parts) particularly those used in the spinning and weaving industries. As indicated in the subproject's technical reports, the use of induction heat treatment processes to improve the properties of raw materials used for spare parts manufacture will, to a large extent, contribute to a higher product quality. The improved designs of these spare parts as provided by the installed CAD/CAM station also contribute to ensuring the final product quality and its appropriateness for use.

Improved responsiveness to changing market needs. Changing market trends and policies (i.e., market liberalization) require rapid and progressive development within the production sector. The modern techniques provided by the computerized CAD/CAM systems introduced within this subproject will facilitate the design of spare parts in a more accurate and rapid manner than had been done previously.

Reduced operational problems and maintenance costs. Availability of good quality spare parts within the local markets with design tailored to locally-used machinery and equipment would undoubtedly reduce operational problems and maintenance costs. Moreover, there will be no need to import spare parts. The subproject also allows for better indigenous resource utilization and will enhance local market development.

Development of technical skills. Training provided within the project to the company's staff and workers is part of the development of human resources and serves to upgrade their performance and maintenance skills. This will have a direct effect on the productivity level and reduce the incidence of error. The trained group of workers may act as trainers for newly-employed workers or those from other factories allowing for the transfer of knowledge.

Replicability within the Egyptian textile industrial sector. The textile industry in Egypt is one of the major industrial sectors and is widely spread out across the country. With 37 large-scale spinning and weaving plants and a significant number of smaller-sized plants, using the same brands of equipment, the operational and maintenance problems encountered within the sector are more or less the same. Of these, the local availability of ensured quality spare parts is a prime issue. Hence the potential for replicability of the project experience already demonstrated at MCFSW is very significant.

Occupational health. Workers employed in the engineering and operation of induction heating systems similar to those used in this project for the manufacture of spare parts are exposed to a range of skin effects as a result of the heat. These may be mild skin reactions such as redness or burns that may heal with extensive scar formation. They could also suffer from dehydration and heat strokes if they spend long periods of time subjected to the heat. It is not evident within the report whether or not workers have been protected against these hazards by proper instructions, improved working place design, and other safety measures against the heat.

Positive environmental impact. Improving the overall machinery operations through the installation of good quality, reliable and durable spare parts will decrease production rejects or wastage, as well as the scrap resulting from the frequent consumption of low grade metal parts to sustain the machinery operation.