INTERN EXPERIENCE AT

URS COMPANY

AN INTERNSHIP REPORT

by

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ABSTRACT

This report describes the author's internship experience with URS Company - Dallas, Texas, from May 1980 to May 1981. The internship company is a consulting engineering firm engaged in providing professional services in the transportation, energy, pollution abatement, water resources, and water and wastewater treatment fields. The author worked as an electrical design engineer during the internship period. The author was also assigned the responsibilities and duties of a project engineer for one of the ongoing porjects.

The internship objectives were set to provide the author with an internship experience that fulfills the requirements of the Doctor of Engineering Program. These objectives were to become familiar with the organizational characteristics of the company; to make an identifiable contribution in the electrical engineering field; and to gain experience in the non-academic activities of the company, industry standards, ethical practices, and the interactions between the company and the industrial environments.

During the internship period the author was involved in designing electrical power distribution, lighting, and control systems for the Dallas East Side Water Treatment Plant and some other projects. The author also developed a computer program to calculate feeder, conduit, and circuit breaker sizes for electrical power circuits. Furthermore, the author gained experience in project management, industry practices, and the internal and external activities of the internship company.

THE INTERNSHIP COMPANY

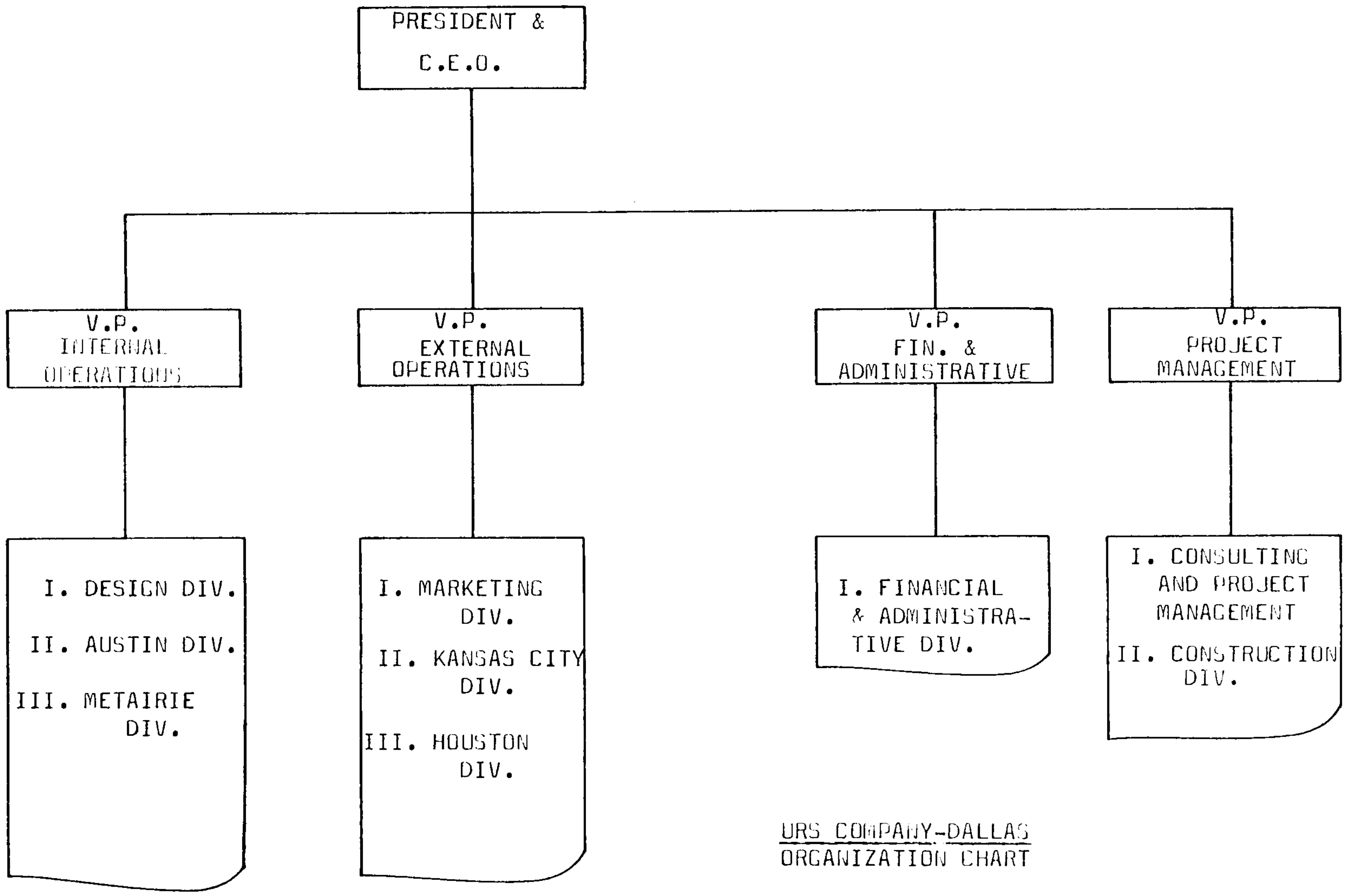
The internship company is an outgrowth of an engineering firm started by Mr. T.C. Forrest, in Dallas, in 1922. The firm was then transformed into the partnership of Forrest and Cotton, Consulting Engineers, Dallas, Texas, by Mr. Forrest and Mr. James Cotton in 1949 and it was incorporated in 1958. In 1972, Forrest and Cotton, Inc. merged with and became a wholly owned subsidiary of URS Corporation, San Mateo, California.

URS Corporation is one of the largest international publicly-owned professional services organizations providing analysis, planning, design and construction management services for clients in the transportation, energy, pollution abatement, water resources, environmental, and health care fields. Those professional services are provided through a unit of the corporation called URS Company which has many offices, or individual companies, throughout the United States. Figure III-1 of appendix III shows the locations of those offices. The corporation is also a leading producer and distributor of video-assisted training courses and owns the Evelyn Wood Company which provides reading enhancement courses.

The internship company is located in Dallas, Texas, and has branch offices in Austin, Texas; Houston, Texas; Kansas City, Missouri; and Metairie, Louisiana. There are 250 employees working in the Dallas office as well as the other four branch offices. Out of the 250 employees about 150 are located in the Dallas office. A breakdown of personnel by discipline is given on page III-2 of appendix III. Although the branch offices mentioned above are part of the Dallas office organization, I will only be referring to the Dallas office throughout this report.

The internship company, henceforth called the company, is primarily engaged in designing water and wastewater treatment systems, water supply and distribution systems, water resources systems, and transportation systems. The spectrum of the clientele of the company includes the industrial sector, municipal, and state and federal governments. Some of the projects undertaken by the company include designing the roadway system of the Dallas/Fort Worth International Airport, the Central Regional Treatment Plant for the Trinity River Authority, the Dallas East Side Water Treatment Plant for the city of Dallas, the Sterling C. Robertson Dam for the Brazos River Authority, the Coleto Creek Dam for the Guadalupe-Blanco River Authority, and the Monticello Dam for Texas Utility Services Inc. The company has also undertaken some projects in a joint venture fashion with other companies or, in some cases, with other URS offices. The company has built a good reputation for providing good professional services in the fields cited above. The company, for example, was selected to interpret the designs of another A/E firm and act as the engineer in supervising the construction of an advanced wastewater treatment plant in Clark County, Nevada. The original A/E firm, in this specific case, was involved in a legal dispute with the client and their contract was terminated.

The basic organization chart of the company is shown in Figure 1. As can be seen from the chart, the company has four major divisions,



URS COMPANY-DALLAS
ORGANIZATION CHART

FIGURE 1

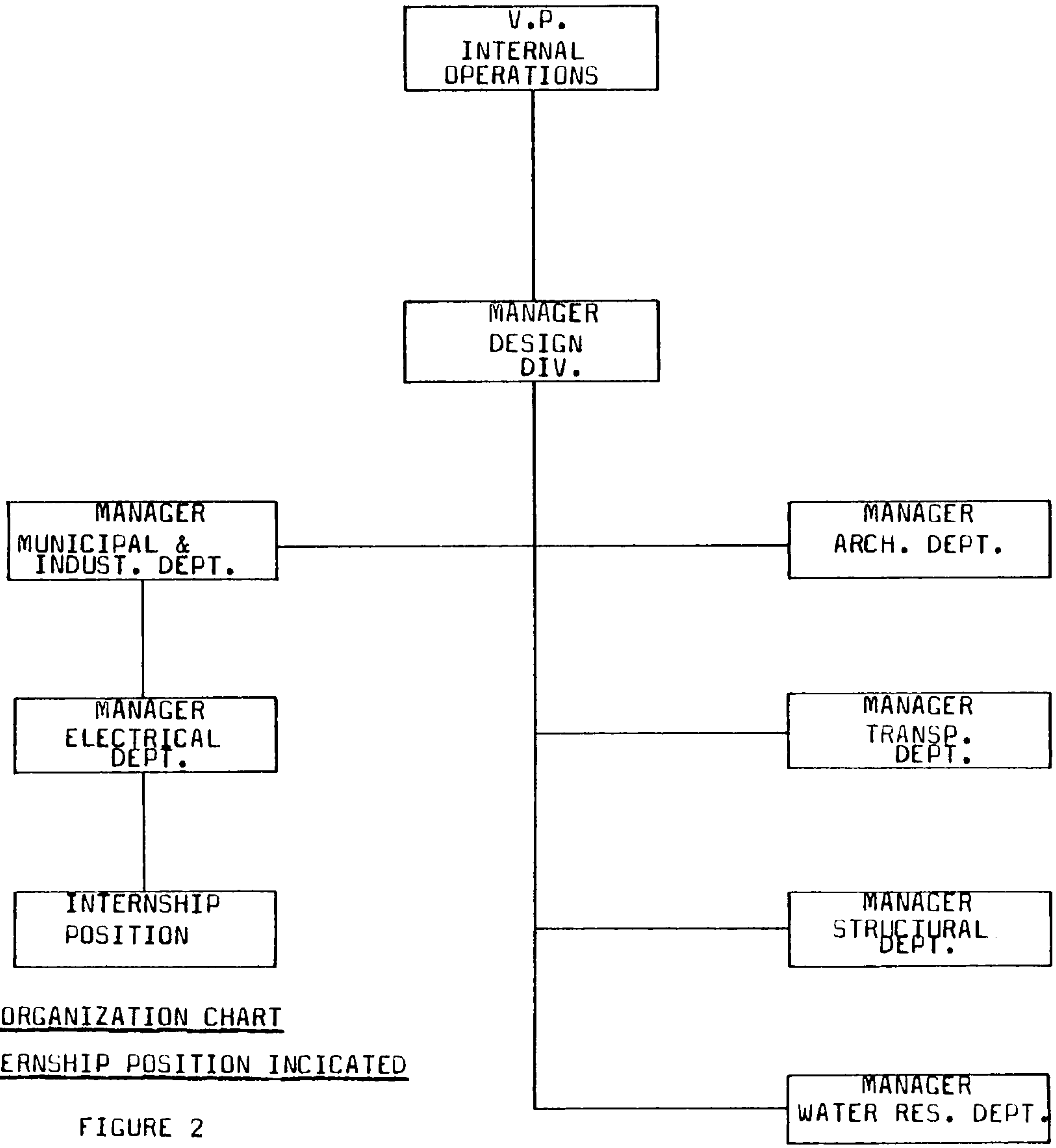
namely, the internal operations division, the external operations division, the financial and administrative division, and the project management division. Each of the major divisions has one or more divisions. The internal operations division, for example, has the design, Austin, and Metairie divisions. In turn, the design division contains the municipal and industrial, the structural, the architectural, the transportation, and the water resources departments. Figure III-2 of appendix III gives the complete and detailed organization chart of the company.

INTERNSHIP POSITION

I was hired by the electrical department as an electrical design engineer. The electrical department is attached to the municipal and industrial department which in turn is part of the design division. Figure 2 shows a partial organizational chart indicating the internship position.

My internship suprevisor is Mr. Gus K. Jones who is the manager of the electrical department. Mr. Jones is a registered professional engineer in the State of Texas. He has extensive experience in the electrical engineering field totaling about thirty years, eight of which have been with the company. He is responsible for all the electrical engineering services provided by the department. That includes the electrical engineering design work, cost estimates, feasibility studies, and special studies as required by clients. The electrical department takes part in projects undertaken by all departments in the design division.

When I joined the company in May, 1980 I was appointed as grade III engineer. According to the company's professional grade description, grade III engineer is designated as staff engineer with the following responsibilities, scope of position, and duties. The staff engineer performs assignments requiring application of engineering knowledge such as engineering design, selecting and determining procedures for the design, research, investigations and other engineering practices, writing specifications and engineering reports, reviewing and recommending action on construction (shop) drawings, and conducting cost analyses and feasibility studies. He is required to have complete knowledge of



PARTIAL ORGANIZATION CHART

WITH INTERNSHIP POSITION INCICATED

FIGURE 2

generally accepted theoretical and practical aspects of his engineering discipline as well as some knowledge of related engineering fields. He is also required to adapt and modify design features and operational methods to meet a variety of situations. The staff engineer can be a design engineer, assistant to project manager, or on-site construction representative.

In the first two months of the internship I worked closely with my supervisor on partial assignments to become familiar with the design procedures as followed by the department. I also devoted some time to familiarize myself with the applicable electrical standards and codes. At the same time I gathered information about the functions and roles of the various departments and the interactions between them. As time progressed, I started to work on total assignments with some supervision from my supervisor. I also worked independently with other engineers in the municipal and industrial department as well as other departments. Toward the end of the internship I was assigned the responsibilities and duties of project engineer for one of the projects. During this time I worked closely with the project manager and gained a good experience in some of the project management procedures and practices.

Although all internships must have the same basic objectives, the way of accomplishing those objectives may differ depending on the internship position which is a function of the internship company. My internship position enabled me to take on an active role in the technical work process in the company. It also helped me achieve some of the internship objectives. Through my interactions with some of the managers of the company I gained enough knowledge and experience to achieve the rest of the objectives.

INTERNSHIP OBJECTIVES

1. To become familiar with the structure of the organization, organizational goals and objectives, departmental responsibilities and functions, project management procedures, technology assessments and engineering decision making procedures, and employees' performance evaluation and motivation.

2. To make an identifiable contribution in the electrical engineering area of projects undertaken by the company.

3. To gain experience in the non-academic technical and business activities of the company and to be aware of the industry standards, ethical practices, and the interactions between the company and the industrial environments.

CHAPTER 1

OBJECTIVE 1:

TO BECOME FAMILIAR WITH THE STRUCTURE OF THE ORGANIZATION, ORGANIZATIONAL GOALS AND OBJECTIVES, DEPARTMENTAL RESPONSIBILITIES AND FUNCTIONS, PROJECT MANAGEMENT PROCEDURES, TECHNOLOGY ASSESSMENTS AND ENGINEERING DECISION MAKING PROCEDURES, AND EMPLOYEES' PERFORMANCE EVALUATION AND MOTIVATION.

INTRODUCTION

In this chapter a discussion of some of the organizational characteristics of the company is presented. The chapter is divided into sections each of which discusses an item of objective 1. The sections were carefully selected to cover the most important organizational concepts and practices adopted by the company. Each section begins with introductory paragraphs to explain, in general terms, the topic of the section. The remainder of each section reflects my experience or knowledge concerning a particular topic as pertinent to the company.

The information in this chapter was obtained by the work experience itself and by discussions with some of the managers of the company. The process of compiling the information was not confined to the last few months of the internship but rather spread throughout the year. This, I feel, has enabled me to compile more information and has given me the chance to learn more about the performance of a consulting engineering business as the days went by.

Throughout this chapter the word technical has been used to indicate engineering, architectural, and surveying work done by the staff of the company.

1. A. Structure of the Organization

The organizational structure is a function of the size of the organization, type of business, nature of projects undertaken, and desired organizational effectiveness. It is determined and set by upper management in a manner that will maximize the organizational effectiveness. The structure may change from one form to another depending on the philosophies and practices of upper management.

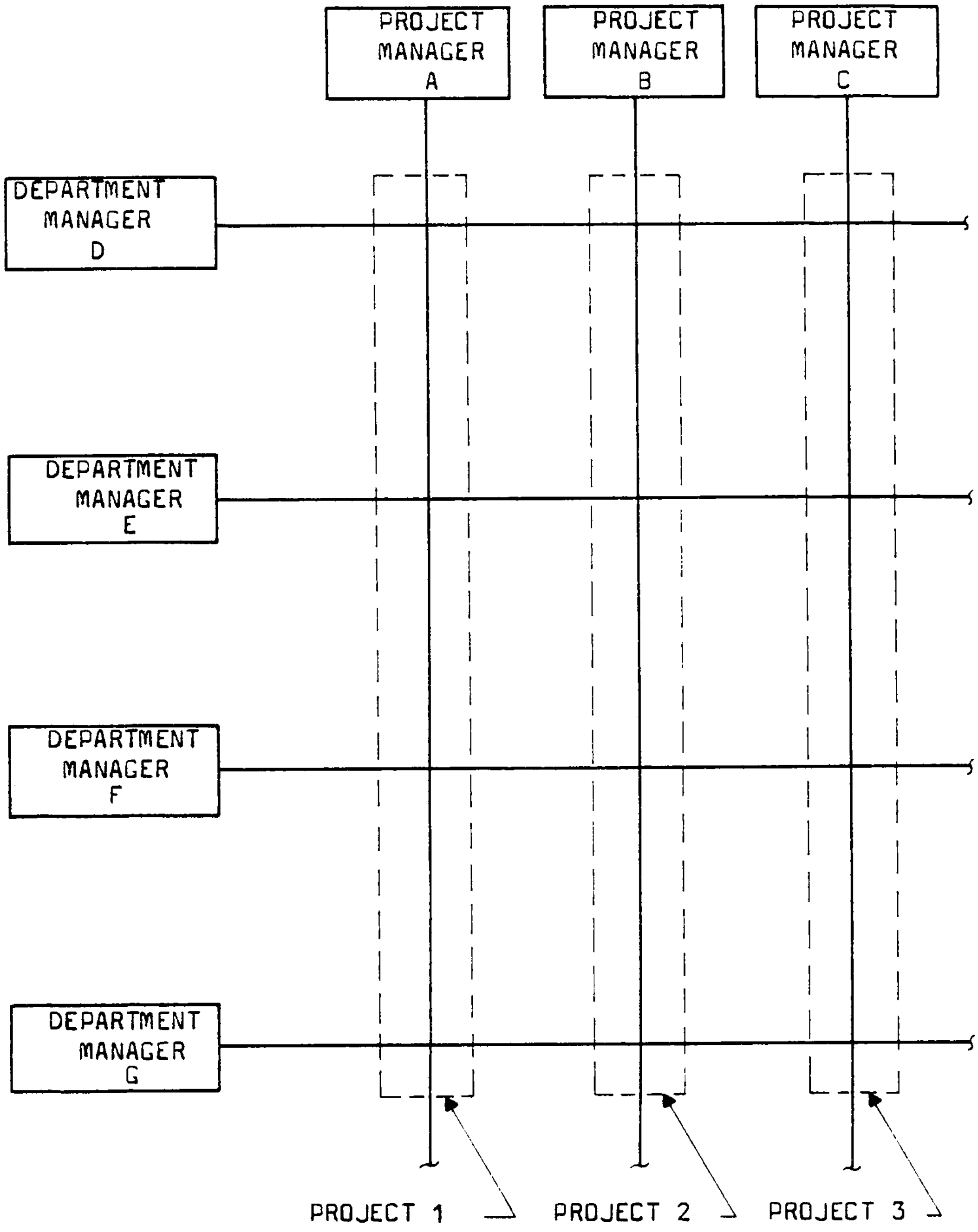
The available organizational structures are the vertical structure, the horizontal structure, and the matrix structure. In the vertical (or line) structure employees' efforts are directed toward achieving the main output or product of the organization. The horizontal (or staff) structure is where the employees' efforts are directed toward achieving a specialized function. The matrix structure is a balanced mixture of both.

Consulting engineering firms are some of the organizations that use the matrix structure. The matrix structure came into existence due to increased technological complexities, increased volume of work, increased suborganizational interdependencies, and an increase in the diversity of tasks.[1,2] It helps to increase the organizational effectiveness for some organizations. However, some intercommunication and dual leadership difficulties are associated with improper application of the matrix structure. To eliminate these difficulties, upper management should balance the delegated authorities and assigned responsibilities between the line and staff functions.

The company is based on a matrix structure in providing professional and technical services. Projects are handled by a combination of efforts from project management (line function) and departmental management (staff function) with some supervision from upper management. The combination of the efforts take on a mesh or matrix form as shown in figure 3. Any given project will have a project manager who is the company's contact with the client. He coordinates budget and contract matters with upper management and staffing with department managers. On the other hand, department managers are responsible for providing the technical staff needed for all ongoing projects. Department managers also supervise their staff and sometimes participate in the technical design work.

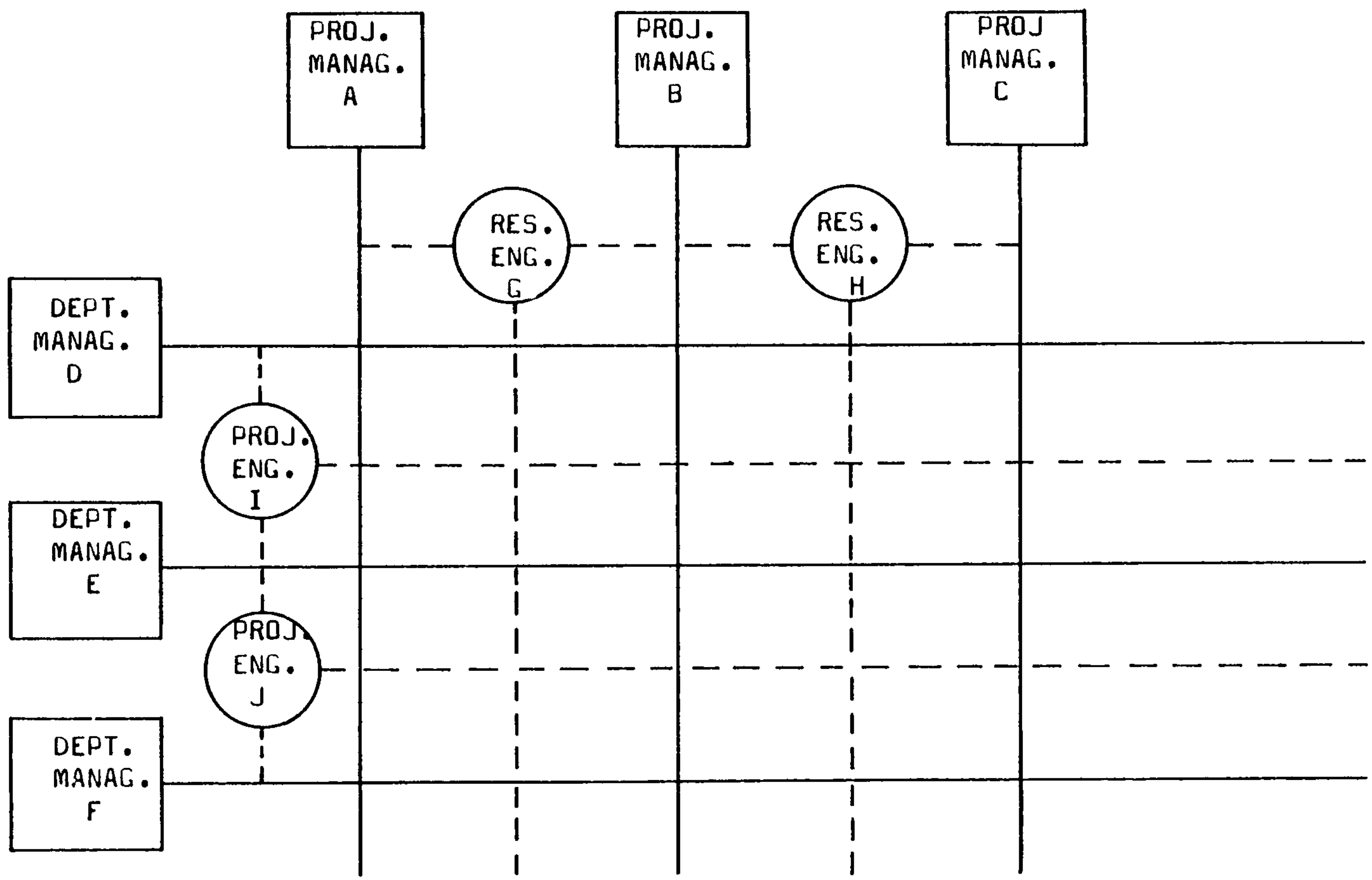
Some projects have a "second layer" matrix, in addition to the first layer matrix described above, as shown in figure 4. In this second layer matrix the efforts of a project engineer and a resident engineer merge together or with those of project managers and/or department managers. The project engineer works closely and on a day-to-day basis with all the technical staff and technicians working on a project. He is responsible for the daily work flow and solving any design conflicts among the various technical disciplines. He provides the information to department and project managers for their decision making procedures. The resident engineer, on the other hand, works closely with the contractor responsible for the construction of a project. He supervises the construction work and makes sure that the contractor adheres to the design drawings and specifications. He resolves problems in the field by coordinating with the project engineer, department managers and the project manager. He also informs the project manager about the client's requirements for additions or modifications to the original design. It should be noted that there is a time gap between the performance of duties of the project engineer and that of the resident engineer. While the project engineer performs his duties during the design phase of the project, the resident engineer performs his during the construction phase. However, their efforts combine together in an indirect manner in one phase or another. That is to say that the project engineer is often called upon to aid in the construction management process and similarly the resident engineer is sometimes called upon to aid in the design process due to his experience in previous projects with similar circumstances.

Since my internship position in the company was primarily that of a design engineer, I have worked with project managers, department managers, project engineers, and resident engineers. In the process of working with the above roles I have gained an insight into how each role contributes to the work flow of projects and how these roles interact with each other in the matrix structure of the company. I have also learned about the delegation of authorities and assignment of responsibilities to the various roles as they take place in the matrix structure of the company. The learning process was enhanced especially in the last three months of my internship where I was assigned the responsibilities and duties of a project engineer for one of the projects undertaken by the company.



<u>MATRIX STRUCTURE</u>

FIGURE 3



NOTE: THE DOTTED MATRIX IS
THE SECOND-LAYER MATRIX.

MATRIX STRUCTURE WITH BOTH FIRST & SECOND

LAYER MATRICES SHOWN

FIGURE 4

1. B. Organizational Goals and Objectives

Every organization must have some kind of goals and objectives for it to succeed in conducting its course of business. The goals and objectives play an extremely important role in defining the direction that upper management would like the organization to take. Furthermore, they provide upper management with a basis for the evaluation of the organizational effectiveness. Objectives are ideas, statements of principle, or optimal situations that the organization sets to help in the attainment of goals. On the other hand, goals are states of affairs which the organization strives to attain.[3] Organizational effectiveness can be measured by evaluating the extent of accomplishing the organizational goals and objectives.

Defining and setting the organizational goals and objectives must be incorporated in the overall organizational planning process. In the planning process upper management assesses the financial and human resources available to the organization as well as the available market opportunities and sets the goals and objectives accordingly. The organizational goals and objectives should incorporate those of the departments and divisions which constitute the organization. This is an effective way to obtain coherence and unison in the organization and to arrive at common objectives and goals. The integration of the objectives and goals of the suborganizational entities is one element of a form of management known as management by objectives (MBO). The MBO principle has been proven to increase the organizational effectiveness.[3]

In studying the company's goals and objectives I started with the goals and objectives of the electrical department and the municipal and industrial department then proceeded to the organizational goals and objectives of the company. The objectives of the electrical department are to take on different and challenging jobs, to have professional and experienced staff, and not to exceed the time and budgetary limits for any project. The goals of the electrical department are to attain maximum efficiency and cost effectiveness and to provide good professional services to the clients. Similarly, the municipal and industrial department has the same objectives but on a broader spectrum. The objectives of this department also include the achievement of maximum coordination and cooperation among the technical staff in the department and between the department and other departments or project management. The goals of the municipal and industrial department are the same as those of the electrical department.

Proceeding a step further I learned that the overall organizational objectives are:

1) to increase the company's manpower and consequently be able to handle more projects,

2) to encourage the technical staff to attain the highest professional standings,

3) to undertake new types of projects such as:

   a. commercial and industrial facilities

   b. hospitals, schools, public facilities, and community development projects

   c. mining facilities

d. telecommunication systems.

4) to maintain the company's high level of performance in providing professional services for municipal and industrial water and wastewater treatment projects, water resources projects, and transportation projects.

The overall organizational goals of the company are:

1) to become one of the highly recognized professional services organizations, and

2) to attain a reasonable profit.

1. C. Departmental Responsibilites and Functions

Almost every type of organization has departments performing line, staff, or support functions. The distinction among these three functions depends on the business of the organization. The line function in an investment firm, for example, includes financing, acounting, and marketing; the staff function includes legal, real estate, and economics; and the support function includes engineering and computer applications. On the other hand, in a consulting engineering firm the main function includes upper and project managements; the staff function includes the various engineering and architectural disciplines; and the support function includes marketing, accounting, personnel, computer applications, and legal.

In every organization the work load and responsibilities are distributed among the various departments according to functions. Authority should also be delegated to the departments according to the work flow and the responsibilities. Some organizations keep the authority at the upper management level and do not delegate any to the suborganizational entities. This, in my opinion, could cause the departments not to carry out their responsibilities effectively. The organizational structure plays an important role in determining departmental functions. Departmental functions are determined by the experience and educational background of the personnel in the department.

Since the company's structure is a matrix structure the responsibility for any given project is divided between the line function (project management) and the staff function (technical department management). Each function is responsible for its share of the work load and both are collectively responsible for the entire project. Although the responsibilities assigned to the line and staff functions are not equal but rather depend on the project and upper management philosophies, the authority delegated to each function equally matches that function's share of responsibility. In the following I will try to explain the responsibilities and roles of the various departments in the staff function.

The roles of the various technical departments in the company are distinct. Some departments provide technical services in one discipline such as the electrical department, structural department, architectural department, and surveying department. Other departments provide project oriented technical services involving more than one engineering discipline such as the municipal and industrial department, transportation department, and the water resources department. The municipal and industrial department provides technical services for municipal and industrial water and wastewater treatment projects and related projects such as pump stations, pipelines etc. The water resources department provides services for projects such as dams, lakes, and reservoirs. The transportation department provides services for projects such as roads, bridges, and railroad systems. The other one-discipline departments provide technical services in their specialty disciplines.

Each department is responsible for providing its share of technical expertise and knowhow for all ongoing projects. The department managers are responsible for scheduling and coordination while the technical staff is responsible for carrying out the assignments in a professional manner. As a typical example, the municipal and industrial department manager, in a given project, coordinates with upper and project management matters such as budget and scope of work. In the process, upper management delegates certain authorities and assigns certain responsibilities to him. In turn he hires new personnel if needed, assigns duties and responsibilities to the engineers and technicians in the department. He also establishes guidelines and objectives for the department in order to provide acceptable professional services and complete the project in the allotted time.

1.D. Project Management Procedures

Engineering project management, or engineering line function, as practiced by project managers and to some extent by project engineers, is a very important part of any engineering organization. The procedures adopted for the purpose of project management depend on the organizational structure, type and scope of work of the project, and the manager himself. The organizational structure, for example, determines the manager's interactions, responsibilities and authorities. The type and size of project determines the necessary organizational structure, for that project, which in turn affects the procedures. The human factor also affects the procedures where some managers are autocratic, some are authoritative, and yet some are in between.

The role of the project manager is a two fold organizer-manager type role. As an organizer he establishes the project objectives to be achieved, while as a manager he is responsible for the project from the time of project initiation through project completion. The project objectives are both technical and financial. That is to say that the project manager sets objectives for the quality of the professional services to be provided, project deadline, and budget. The project manager is given authority in order to carry out his responsibilities and prosecute his duties.[4]

Project management procedures in the company are basically functions of the project managers and type of projects involved. At times upper management might provide the project manager with some guidelines to help him develop the procedures. This occasional input from upper management is introduced either at the initial stages or at the final stages of the project. Upper management's input at the initial stages could be related to the contracts with clients (contracts for engineering services), while the input at the final stages is more of a feedback as in the in-house review of the design drawings and specifications.

By working with project managers as a design engineer as well as a project engineer I have learned some of their management philosophies and concepts. In the remainder of this section I will attempt to reflect on some actual project management concepts and procedures as practiced by some project managers in the company.

Mr. Don McDuff is a project manager for municipal and industrial water and wastewater treatment projects. Mr. McDuff emphasizes that the company is a professional service oriented organization where, in most cases, the client knows exactly what he needs and wants the company to provide such services as design, feasibility study, appraisal, planning, or construction management. He, as a representative of the company, negotiates with the client to prepare the contract and define the scope of work. In doing so he works with upper management to finalize the budget and time schedule for any project.

Mr. McDuff believes that the structure for any given project is strictly a function of the size of the project. He prefers a vertical structure for projects with over 100,000 total man-hours, matrix (or hybrid) structure for projects with 50,000-100,000 total man-hours, and horizontal structures for small projects with less than 50,000 total man-hours. He also believes in the importance of having a project engineer for each and every project. This is because the project engineer, in Mr. McDuff's opinion, improves the communication links among the participants in a project and increases their effectiveness as a group. He delegates some of his authorities to the project engineer to go along with the responsibilities he assigns to him. He also believes that a resident engineer is essential, especially for large projects, to work closely with the contractor. This will solve many construction problems and eliminate future additions and modifications.

Mr. McDuff believes that every project must have objectives. Normally his top priority objective for almost all projects is to provide an optimal design work that is cost effective but not necessarily aesthetically superior. Some clients, however, emphasize aesthetics in addition to technical design superiority. Sometimes the objectives are dependent on the client and his needs. Municipal clients, for example, usually require designs which minimize future maintenance and operation problems. Industrial clients, on the other hand, emphasize cost effectiveness and lower initial investments. Mr. McDuff's top priority goal is to serve the needs of the community and to satisfy all clients.

Mr. E.E. Ericson is another project manager for municipal and industrial water and wastewater treatment projects that I worked with and learned his thoughts and concepts in engineering project management. Mr. Ericson emphasizes that the project manager is totally responsible for the project from inception through completion. This responsibility is carried out at best by implementing a carefully planned set of procedures. At the initial phase of any project he contacts the client, prepares a contract for engineering services with some input from upper management, coordinates the budget and the allocations with upper management and relevant department managers, and reports to the client on the scope of work and time schedule. He starts the design phase by developing an assignment schedule for the staff assigned to the project by their department managers. Throughout the design phase he maintains contact with the client to incorporate any special requirements. He also interacts with department managers for design related matters.

Mr. Ericson believes strongly in the matrix structure for the type of projects undertaken by the company. He also believes that a project engineer is essential to any project but must be appointed by department managers and not by the project manager. He emphasizes that the interaction with upper management is minimal and limited to the initial and final phases of any project. In between the two phases the project manager represents the company in dealing with the client and is responsible for the project as a whole.

1. E. Technology Assessments and Engineering Decision Making Procedures

In a dynamic society as ours today, old technologies become obsolete and new technologies evolve to meet the changing needs of the society. Engineering organizations providing professional services are affected by those technological changes for two reasons. On one hand, the needs and requirements of the clients change as per the technological changes. On the other hand, the industrial environments providing services or products to the engineering organizations change in order to meet the change in the technology.

Engineers of all disciplines working in engineering organizations are affected most by the technological changes. They must be at least aware, if not part, of such changes in order to be able to function professionally. This is particularly true for the dynamic competitive world of consulting engineering where design requirements change with time and circumstances. The engineers must follow and keep up with all the technological innovations in their respective trades and try to apply them whenever feasible. However, one must remember that there are certain constraints associated with the implementation of new technologies. In other words, the criterion for implementing any new technology should incorporate regulations and impact on society and environment in addition to availability and cost effectiveness. The systematic process of evaluating a new technology and determining whether any constraints would be violated, upon the implementation of the technology, is the technology assessment.[5]

Technology assessment should be part of the engineering thought process and decision making procedures. The generalized engineering decision making procedures are:[5]

1) definition of the problem,
2) identification of feasible solutions and alternatives,
3) selection of evaluation criteria,
4) technology assessment,
5) selection of application (design) criteria, and
6) analysis of feedback.

Engineers are trained to think and function in a systematic manner along the steps outlined above. This is logical because engineering problems are complex and must be approached in an organized and efficient way. Engineering schools, organizations, and work experience are sources of training that help the engineer develop the engineering thought process and decision making procedures.

The company is based on the professional and technical skills of the engineers from upper management to design engineers. (Out of 150 employees there are about 50 engineers in the company.) This means that engineering decision making procedures are applied at all levels of the company. The design engineers apply the engineering decision making procedures in their daily design work, middle and project managers apply them in managing staff and projects respectively, and upper managers apply them in managing the company.

As a design engineer I have learned to systematically arrange my thoughts in line with the engineering decision making procedures. This not only improved the quality of my work but also improved communications with other engineers. Since engineers work on projects in teams or groups, it is imperative that they follow the procedures in order to enhance the effectiveness of such groups. Periodical meetings between a project manager and members of a group focus on the procedures as a method of discussing the progress on a given project. Engineering reports are also written in a manner that is based on the procedures.

The engineers in the company keep up with the technological changes by studying and reading textbooks, engineering handbooks, technical journals, manufacturers' literature, and industrial standards. In addition to that, they have discussions with the various sales representatives and attend seminars and presentations. The company maintains a library with all sources of information such as technical and trade journals, handbooks, and industrial standards. The company also buys handbooks or textbooks upon the request of department or project managers. Furthermore, the company encourages engineers to subscribe to technical societies and attend technical conferences and seminars. The company even pays for such expenses as membership dues or attending conferences. Engineers are encouraged to pursue higher education, if they so desire, and the company pays 75% of tuition and fees. All this indicates that the company is willing to invest in the improvement and betterment of its staff because the return not only will benefit the staff but the company as well.

1. F. Employees' Performance Evaluation and Motivation

I stated in section 1.B. that organizational goals and objectives are essential to every organization in evaluating overall performance and effectiveness. Since the employees are the most important element of any organization, their performance determines the overall performance and effectiveness of the organization. In other words, the overall performance of any organization should basically be the sum of the individual performances of the employees. By evaluating employees' performance, the employer can identify and correct deficiencies on the part of some employees in order to increase the organizational effectiveness. Another facet to the employees' performance evaluation process is recognizing and rewarding good performers.

Every employees' performance process should be followed by a motivation process. Motivation is defined as "the condition responsible for variation in the intensity, quality, and direction of ongoing behavior".[3] So, typically, motivation will induce poor performers to do better and encourage good performers to continue to do well. Many theories in management and behavioral sciences indicate that individuals tend to be motivated differently depending on their needs and expectations. This means that it is important not only to know when but also how to motivate employees. Such information can easily be obtained from the employees' performance evaluation process. The process in itself can be formal for the whole organization or informal on the departmental level.

The company's upper management conducts one yearly formal employee performance evaluation process. In this process, department managers fill out individual forms for the employees in their departments. (Samples of such forms are included on pages III-5, III-6, and III-7 in appendix III). The managers disucss the information included in the forms with the respective employees to provide them with a feedback about their performances. This discussion also helps clarify some of the items that were not clear in the manager's mind. The managers then submit the forms along with their recommendations to a special committee composed of upper managers. The committee, based on the available information, authorizes certain pay raises according to merit and performance. However, promotions and status adjustments do not necessarily follow this evaluation process but take place throughout the year as dictated by circumstances.

I believe that there should be more than one performance evaluation process in a year. This is because the evaluation process not only furnishes information to the employer about employees' performance but also furnishes the employees with some kind of information about how the managers value their performances. I also believe that the evaluation forms should include a space for the employees to write their personal goals and objectives. This will provide the employees with a self checking criterion from one evaluation process to the other. The managers will also benefit from such information in developing and setting the goals and objectives for their departments or when assigning duties and responsibilities.

Employee motivation in the company is totally informal and depends on the manager. I believe that managers should take special interests in motivating their staff on a continuous basis. Having informal evaluation processes on the departmental level or more than one yearly formal evaluation process will provide the managers with an adequate data base for motivation.

RESUME

This chapter has dealt with the items of objective 1, namely, the organizational characteristics of the company. The company, as most consulting engineering firms, is organized into a matrix structure where the services of project managers and department managers combine to design projects. The company's objectives are to increase the staff and encourage them to attain higher professional standings in order to be able to undertake new and different projects and to continue providing high quality professional services in the current projects. The goals are to become one of the highly recognized professional services organizations and to attain a reasonable profit.

An account of the departmental responsibilities and functions of the various departments was given. The municipal and industrial department, for example, handles municipal and industrial water and wastewater treatment projects while the water resources department handles dam and reservoir projects.

The project manager represents the company in negotiating with the client and he is responsible for the project from the beginning to the end. Since the company is primarily involved in providing engineering services, engineering decision making procedures are applied at all levels in the company. The company conducts one formal employees' performance evaluation each year. Upper management uses the information obtained from the process to authorize pay raises.

CHAPTER 2

OBJECTIVE 2:

TO MAKE AN IDENTIFIABLE CONTRIBUTION IN THE ELECTRICAL ENGINEERING AREA OF PROJECTS UNDERTAKEN BY THE COMPANY.

INTRODUCTION

The majority of the internship period was devoted to designing electrical systems for the various projects undertaken by the company. This chapter covers my major contributions to the electrical engineering design during that period. The chapter is divided into two sections. The first deals with the main project I worked on, namely, Dallas East Side Water Treatment Plant expansion project. The second section discusses some other assignments as well as my contributions to other smaller projects.

The design work for the Dallas East Side project included preparation of drawings and specifications regarding the power distribution, lighting, control, and instrumentation for the proposed facilities. This design work constituted about 70% of the internship period. I also prepared an economic analysis and a cost estimate for the Dallas East Side project.

My contributions to all other projects included preparation of computer programs, compiling the electrical master specifications, reviewing shop or construction drawings, preparing cost estimates, attending seminars and technical meetings, and supervising field testing and installation. I also designed electrical power distribution and lighting systems for a small project and was assigned the responsibilities and duties of a project engineer for another project.

2. A. Dallas East Side Water Treatment Plant Project

In the following few paragraphs I will attempt to present the theory and technologies generally used in water treatment plants.* This will provide the reader with the essential background information before going into the details of my design work.

A water treatment plant is a complete system that transforms raw water into an acceptable and safe potable water that meets the drinking water standards. Raw water can either be from surface water sources, such as rivers or lakes, or ground water sources, such as springs, wells, or streams. The treatment of surface water is different from that of ground water. In the following discussion I will focus on surface water treatment methods as the Dallas East Side Plant treats surface water from Lake Ray Hubbard and Lake Tawakoni.

The surface water treatment process is basically a chemical clarification process. This primary process consists of coagulation, sedimentation, and filtration as shown in Figure 5.[6] Coagulation is where suspended material in the raw water agglomerate and form flocs that are easy to remove. The most commonly used coagulants are aluminum sulfate (alum) and ferric sulfate. In some instances coagulant aids, such as activated silica, are used to improve flocculation. The word coagulation is usually used to describe the mixing of coagulants with raw water as well as the flocculation that takes place because of coagulation. Sedimentation is where particulate matter, agglomerated

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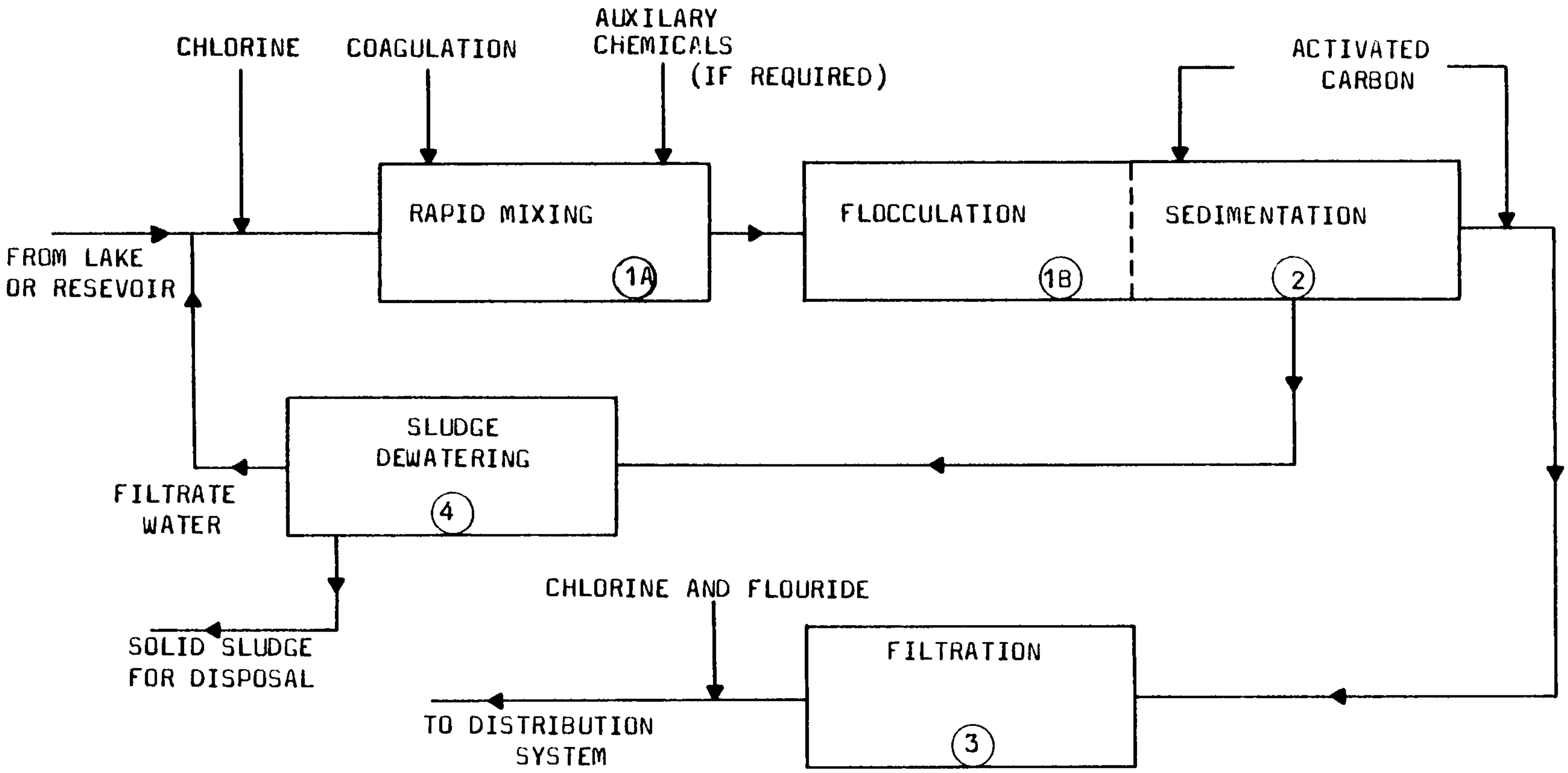
*Most of the theoretical information regarding water treatment technology was obtained from reference 6 .



NOTE: Steps (1A), (1B), (2) & (3) constitute the main water treatment process while step (4) is the auxiliary sludge removal and treatment process

TYPICAL SURFACE WATER TREATMENT PROCESS

FIGURE 5

flocs, and other suspended solids are removed. The sedimentation process takes place in a sedimentation basin where a scraping mechanism removes the settled material from the bottom of the basin for disposal. Filtration is the final stage in the water treatment process. It removes any nonsettleable flocs or suspended matter that escaped coagulation and sedimentation. Filtration is done by using gravity sand filters which basically are concrete boxes with a layer of sand on top of another layer of gravel. Water passes downward through the filter bed filtering out the suspended solids. Chemicals are added before and after the filtration stage, as required, to bring the quality of water to within the acceptable standards. Sample testing usually determines the quantity of chemicals to be added. Carbon in a slurry form is added during the process to eliminate unacceptable odor or taste. Lime is also added to soften the water, increase bactericidal action, remove iron, and aid in clarifying turbid surface water. After this treatment process, a supply of potable water is ready for distribution and human consumption.

A secondary process in a water treatment plant is sometimes needed for treating the plant discharge or refuse as required by the Environmental Protection Agency. This discharge is commonly referred to as sludge. Sludge is dewatered into solid residue which can be easily hauled and discharged at designated locations. Dewatering of sludge can be done by using lagoons, drying beds, centrifugation, or gravity thickeners and filter presses. Lagoons and drying beds are used for small plants where the sludge is left to dewater without the aid of mechanical systems. In the centrifugation method a mechanical drive is used to create centrifugal forces that separate the solids from water. Gravity thickeners have a mechanical raking mechanism that thickens or increases the concentration of sludge. The thickened sludge is directed to filter presses for complete dewatering. Pressure filtration is a process where sludge is subjected to pressure in filter presses which have porous filter plates. Due to pressure, water passes through the filter plates leaving cakes of solids trapped between the plates.

The Dallas East Side Water Treatment Plant is owned and operated by the City of Dallas, Texas. The initial plant was designed by the company, then known as Forrest and Cotton, Consulting Engineers, Inc., in 1960. An expansion of the plant, increasing its capacity from 100 MGD (million gallons per day) to 250 MGD, was also designed by the company in 1970. The company also designed some other facilities in the plant such as a second transfer pump station to pump potable water to the distribution system. During my internship the company was involved in designing a third stage expansion for the plant to increase the capacity to 400 MGD. The scope of work included chemical mixing facilities, flocculation and sedimentation basins, filtration facilities, and sludge handling and dewatering facilities. I was responsible for the design of electrical power distribution, lighting, control, and instrumentation systems for the chemical mixing facilities, flocculation and sedimentation basins, and sludge handling facilities. In the remainder of this section I will discuss my design work for the above mentioned facilities.

2. A. 1. Chemical Mixing Facilities

Mixing in a water treatment process increases the dissolvability and dispersion of the chemical additives within the time required by the chemical reaction kinetics. The mixing facilities consist of flash (or rapid) mixers which are motors with shafts and impellers mounted at the raw water inlet structure or basin where chemicals are added. The selection of the horsepower rating of the mixers is the responsibility of the process and/or mechanical engineer. The electrical design portion includes selecting the sizes of feeder protection, feeder and starter. It also includes routing the feeder from the power source to the mixer and all associated conduits, pull or junction boxes, trenching, and terminations. The same also applies for motorized sluice gates which are located at the same basin and used for shutting off water flow to certain basin sections for maintenance and clean-up operations.

The Dallas East Side Plant has an existing flash mixing facility that is located at the raw water inlet to the whole plant. However, additional mixers and sluice gates were required due to the plant expansion. Furthermore, a new auxiliary flash mixing facility was designed to facilitate shutdown of the main facility for maintenance or modifications in the future. The auxiliary facility has less mixing capacity (fewer mixers) than the main facility because the maintenance period is during the Fall-Winter season and water production during this period is minimal.

The design calls for 4-15 HP mixers and 4-7.5 HP motor operated sluice gates for each of the two facilities. Power for all motors, at both facilities, is supplied from an existing panelboard in the existing chemical building via one main feeder which is spliced at an electric manhole in the field. Feeder and circuit breaker selection was based on total load modified by a certain diversity factor. I used the "CABLE SIZE" computer program described in section 2.B to select the main feeder, branch feeders, main circuit breaker, and individual motor starters and circuit breakers. Each individual motor has a combination magnetic and thermal starter located near the motor. The starters are enclosed in weatherproof enclosures which are mounted on the handrails of the basins.

The main reason for designing one main feeder for the total load and splicing it to provide branch feeders for the individual loads was twofold. On one hand, the existing panelboard had limited space area available to mount new circuit breakers. On the other hand, the available spare conduits already laid in a concrete duct in the vicinity of the chemical building would not accommodate the large number of wires and cables for the individual loads. This scheme of designing one main feeder and splicing it to provide branch feeders is adequate for this application and is accepted by the National Electric Code (NEC).[7]

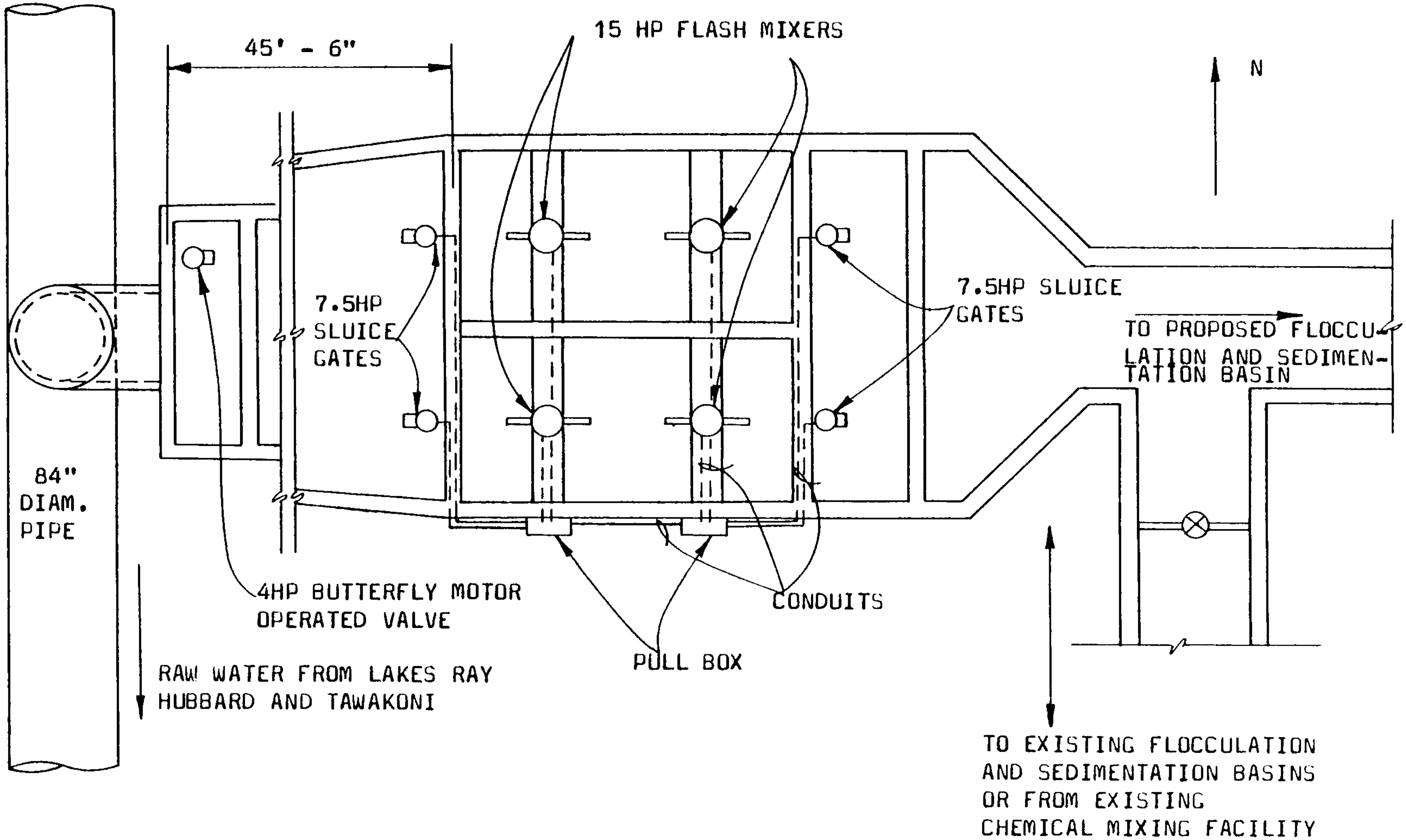
The design also includes providing basin lights, weatherproof receptacles, and two butterfly motor operated valves for the auxiliary flash mixing facility. The criterion for selecting and locating the light fixtures was based on providing adequate working light in case normal or emergency operations were required at the basin during the night. Power for the light fixtures and receptacles is supplied from a local lighting panel (or miniload center) which is mounted on the handrail of the basin. The service voltage is 480 V for all motors and 120 V for lights and receptacles. Figure 6 is a plan view of the auxiliary flash mixing facility showing location of mixers, motorized gates and valves, and basin lights.

The design drawings include one line diagrams, power distribution, area plan view, and motor control schematics and details for both facilities. The electrical items are also specified in the various electrical sections of the electrical specifications. I was responsible for developing these drawings and writing the specifications. During the design phase I worked with engineers from other disciplines to coordinate design procedures and to provide a complete working system.

2. A. 2. Flocculation and Sedimentation Basins

The raw water after leaving the mixing basins flows by gravity through water flumes to the flocculation and sedimentation basins. In the flocculation and sedimentation basins raw water flocculates and settles at the bottom of the basins. The sludge is directed to sludge withdrawal manholes at the sides of the basins by means of a clarifying mechanism. The size of the basins depends on the volume of raw water treated and the retention time required. The equipment used in such basins are flocculators, clarifiers, and flash mixers. Usually there are primary and secondary basins to allow for complete flocculation and thus more efficient water treatment. The mixers are located at the secondary basins to aid in dissolving and dispersing additional chemicals that are applied at that point.

The scope of the Dallas East Side Plant expansion project includes designing two primary and two secondary flocculation and sedimentation



AUXILIARY CHEMICAL MIXING FACILITY
SCALE 3/32" = 1' - 0"

FIGURE 6

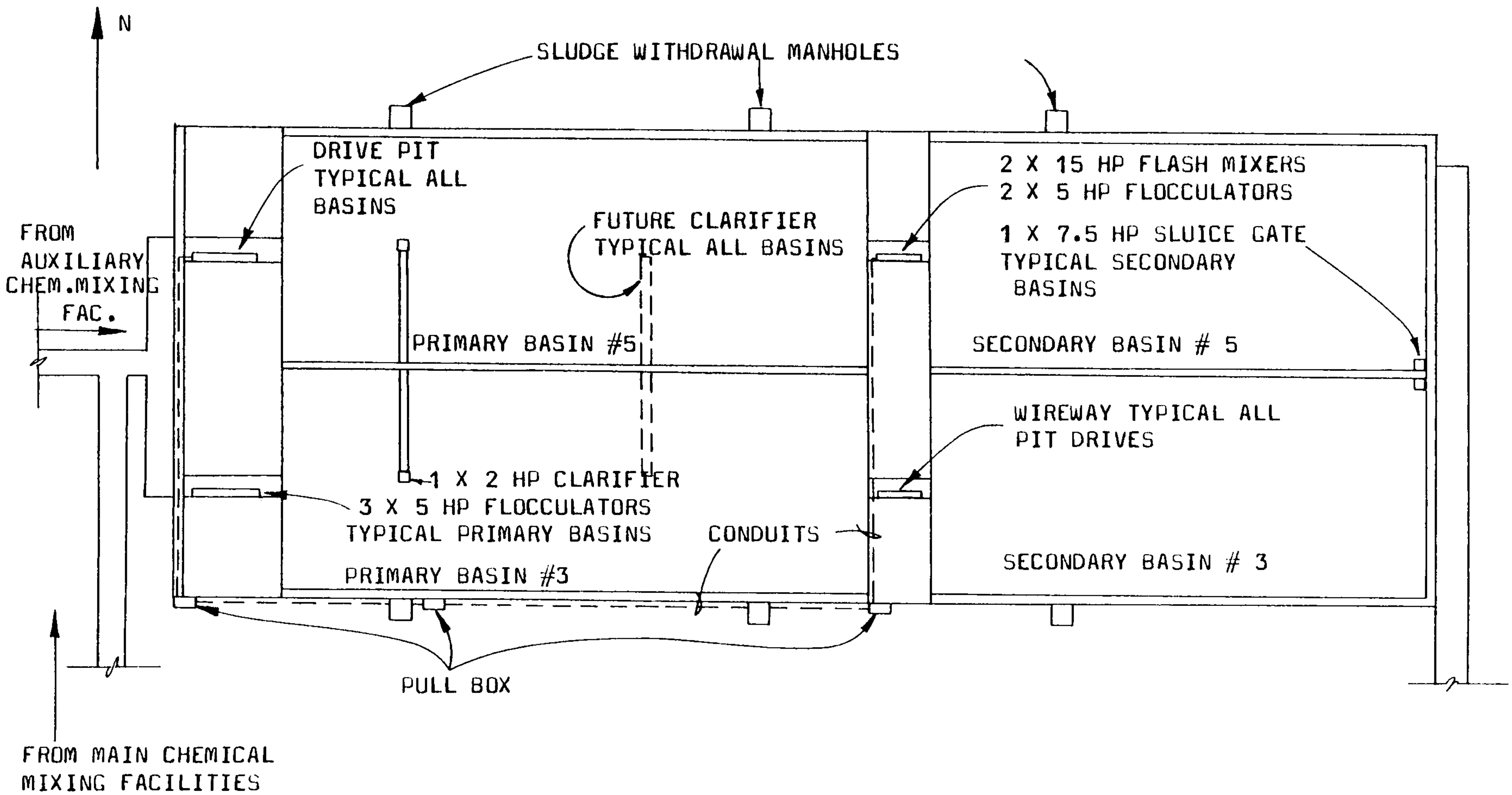
basins. Electric power for each basin is supplied from an existing panelboard in the chemical building. I selected two 175A and two 150A main circuit breakers for the primary and secondary basins respectively. This selection was based on the total design load as well as future load. I used the "CABLE SIZE" computer program which I developed earlier to verify the selection of the sizes of main circuit breakers, main feeders, branch feeders, branch circuit breakers, starters, and conduits. I also used the "BOX SIZE" computer program to verify the selection of the sizes of pull and junction boxes. A description of both computer programs is given in section 2.B.

According to the loads and voltage drops, the main feeders originally selected were 4-2/0 AWG for the primary basins and 4-3/0 AWG for the secondary basins. However, I finally selected 4-4/0 AWG as the size of the main feeder for each basin. This was because I designed each two circuits to be pulled into one conduit which meant that the ampacity of each feeder is actually less due to derating. The availability of existing spare conduits in an existing concrete duct from the chemical building to a manhole about 500 feet from the basins had a major effect on my decision. Those conduits were designed as spare for this project from the previous plant expansion project. This example indicates that the design engineer when designing any facility expansion has to take advantage of existing items or, sometimes, is restricted by what is available. By the same token, the engineer should take into account future expansion projects and should incorporate certain future items in his design whenever possible and feasible. In my design I allowed for future plant expansion in some respects.

Power to the individual motor and equipment loads in each of the basins is provided by means of splicing the main feeder inside a weatherproof wireway. The motor combination starters, breakers, and lighting and power panels are enclosed in weatherproof enclosures which are mounted on the handrails of the basins. Power and control wires are pulled in conduits that are embedded in the concrete on the walkways or attached by means of conduit hangers to the walls of the basins above the water level. The structure of the basins and the multiplicity of conduits had an effect on the way I designed the conduit routing. Furthermore, practical considerations such as difficulty in pulling wires in conduits forming many angles prompted my decision to specify pull boxes at certain locations.

All of the integral horsepower motors and larger loads are designed for a service voltage of 480 V (3ø, 4W). Most of the fractional horsepower motors are designed for a service voltage of 120V (1ø, 3W). However, few fractional horsepower motors are designed for 208V (3ø, 4 W). The local lighting and power panels, as the name implies, supply power circuits to light fixtures, receptacles, and fractional horsepower motors at a service voltage of 120V or 208V. There are 480V area lights in addition to the 120V equipment light fixtures. Figure 7 is a plan view of the flocculation and sedimentation basins.

My design responsibility with respect to the flocculation and sedimentation basins included preparation of drawings and writing specifications. The drawings included one line diagrams, power distribution, details, and control schematics. The control schematics are control drawings showing the control wiring and relay



FLOCCULATION AND SEDIMENTATION BASINS

AREA PLAN VIEW

SCALE: 1" = 100' - 0"

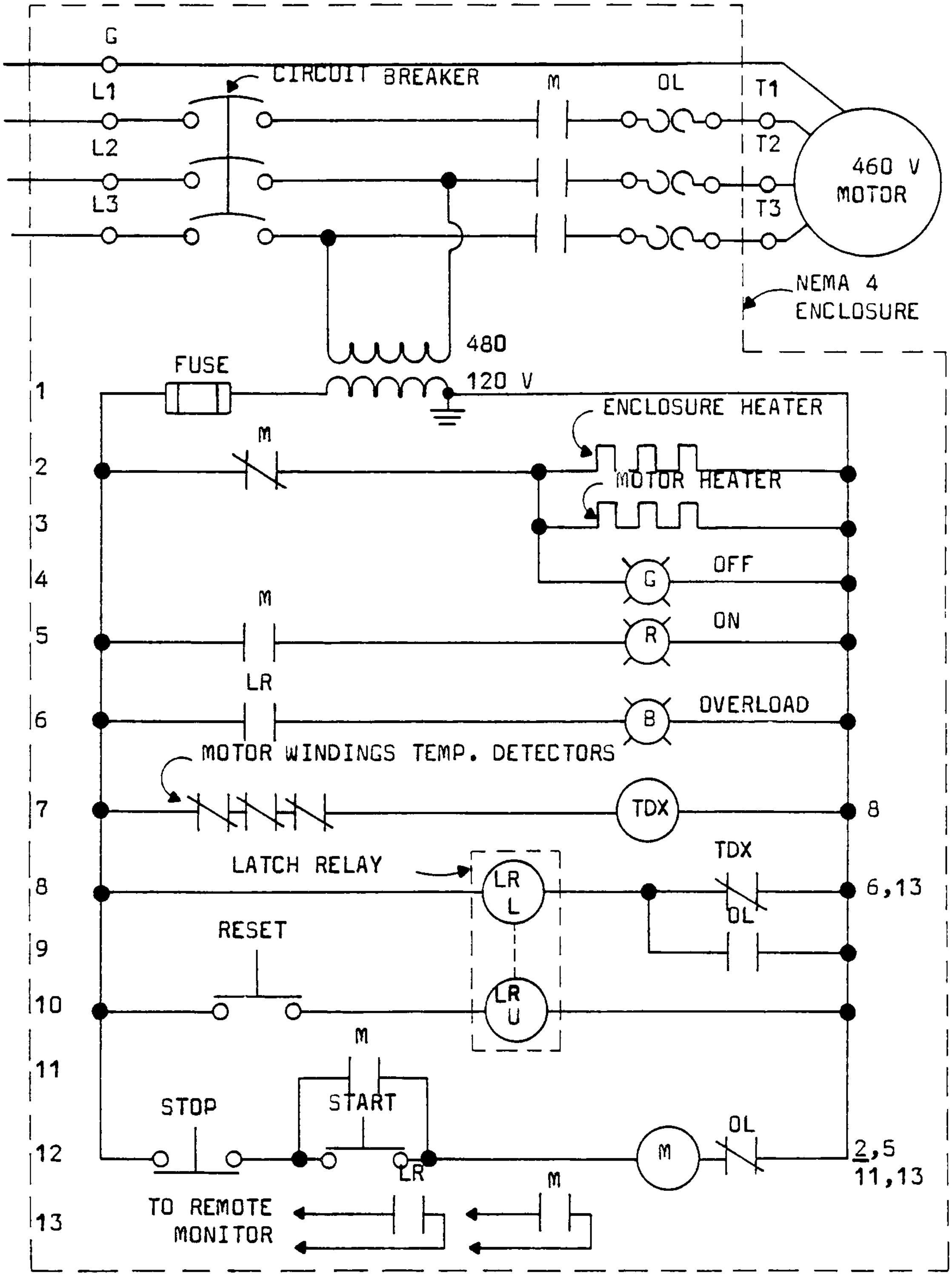
FIGURE 7

interconnections required for the operation of a certain motor or piece of equipment. Figure 8 is a typical control schematic for a flocculator or mixer. The specifications included sections covering general items such as motors, wires and cables, conduits, starters, etc. for the whole project.

So far I have discussed the electrical design features and my design responsibilities with respect to the chemical mixing facilities and the flocculation and sedimentation basins. The electrical design of the remainder of the water treatment process, namely, the filtration facilities, was the responsibility of another engineer and will not be discussed in the report. In the remainder of this section I will discuss the design features of the secondary treatment process or sludge handling facilities.

2. A. 3. Sludge Handling Facilities

As mentioned earlier, the sludge is drawn from the bottom of the flocculation and sedimentation basins. This sludge is primarily lime and ferric sulfate. where the former is used as softener and the latter as coagulant in the treatment process. It also consists of settled solids from presedimentation. The sludge concentration when it is withdrawn from the basins is only 1-5% by weight and it is thus called dilute sludge. The dilute sludge flows by gravity to a pump station where it is pumped to two gravity thickeners. In the gravity thickeners the sludge concentration increases to 10% solids by weight and is pumped via a second pump station to six storage tanks and eventually to the dewatering building. The storage tanks are primarily used to store sludge in excess of the capacity of the filter presses in the dewatering building or during non-working hours. The process,



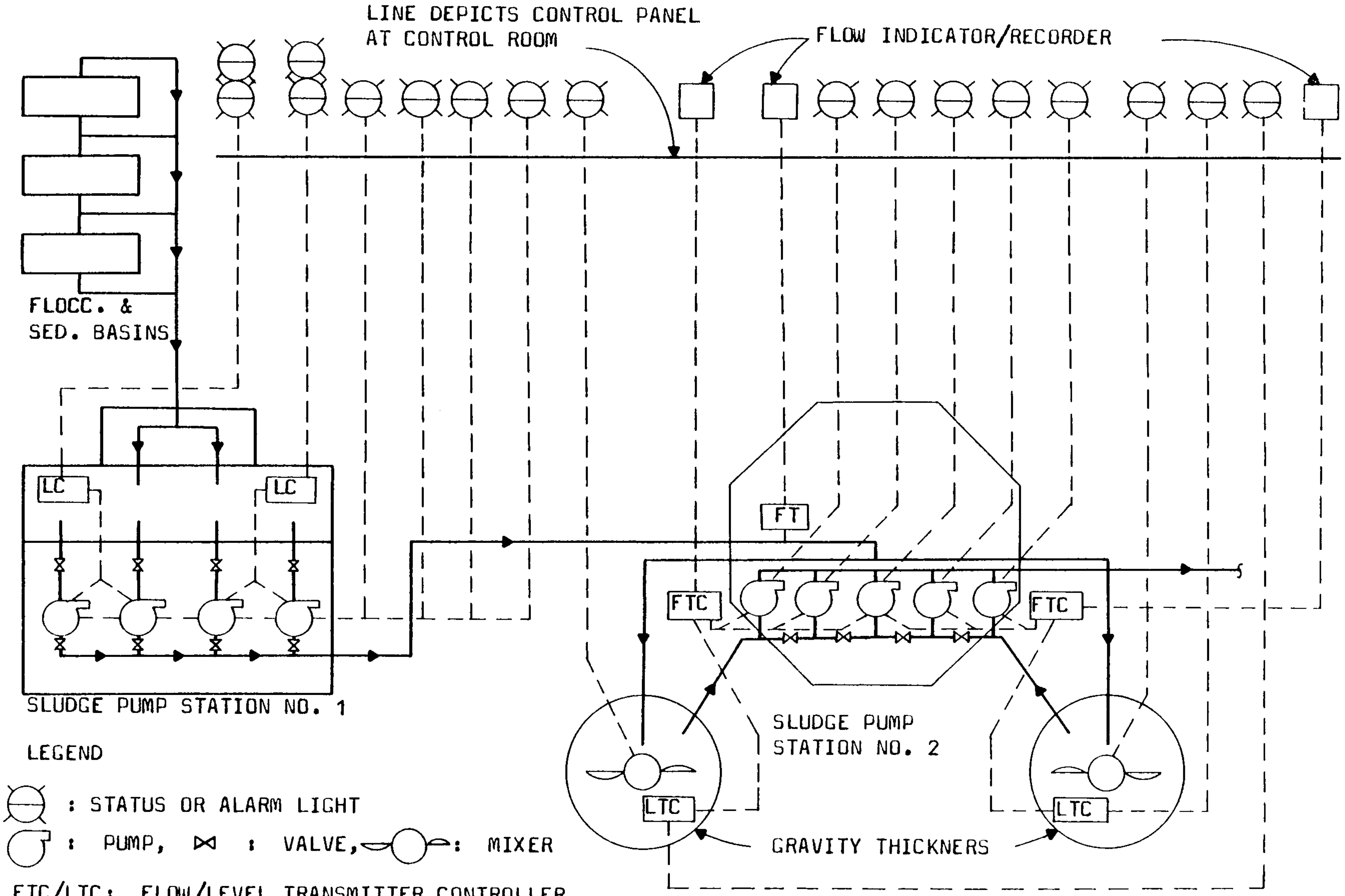
FLOCCULATOR AND MIXER CONTROL SCHEMATIC

FIGURE 8

mechanical, and instrumentation diagram (or PM&ID) for sludge pump stations No. 1 and No. 2, which I designed, is shown in figure 9. This diagram, as the name implies, shows the process flow, the mechanical items involved, and the instrumentation used.

Sludge pump station No. 1 pumps dilute sludge coming from the flocculation and sedimentation basins to the gravity thickeners. The pump station is designed to be built underground. The building consists of a dry well, two wet wells, and a pump room. The pump room has four 60 HP pumps. The four pumps have one common discharge header while each wet well supplies dilute sludge to one pair of pumps. The sequence of operation of the pumps is automatically controlled by the level in the wet wells. This is accomplished by level probes, control relays, and automatic alternators. The level probes are installed at certain depths in the wet well such that the lower one energizes a relay that starts the first pump and the upper one similarly starts the second pump. The alternator is basically a solenoid coil with a double pole-double throw switch (DPDT) connected to it. It alternates the starting pump each pumping cycle. Additional level probes are also provided for high and low level alarms.

Power for the pump station is provided from an existing spare cubicle of a 4160 V pad mounted switching station. In calculating the total load of the pump station to size the cable and transformer, I included some capacity for a future flocculation and sedimentation basin. The high voltage cable is 4-1/0 in an underground concrete encased 3" conduit. The transformer is a 500 KVA pad mounted oil filled type with a 5% impedance and 2-2½% taps above and below nominal voltage. The 480V motor control center (MCC) is an eight cubicle



LEGEND

: STATUS OR ALARM LIGHT

: PUMP, ⋈ : VALVE, : MIXER

FTC/LTC: FLOW/LEVEL TRANSMITTER CONTROLLER

SLUDGE PUMP STATION 1 & 2 AND GRAVITY THICKENERS PM & ID

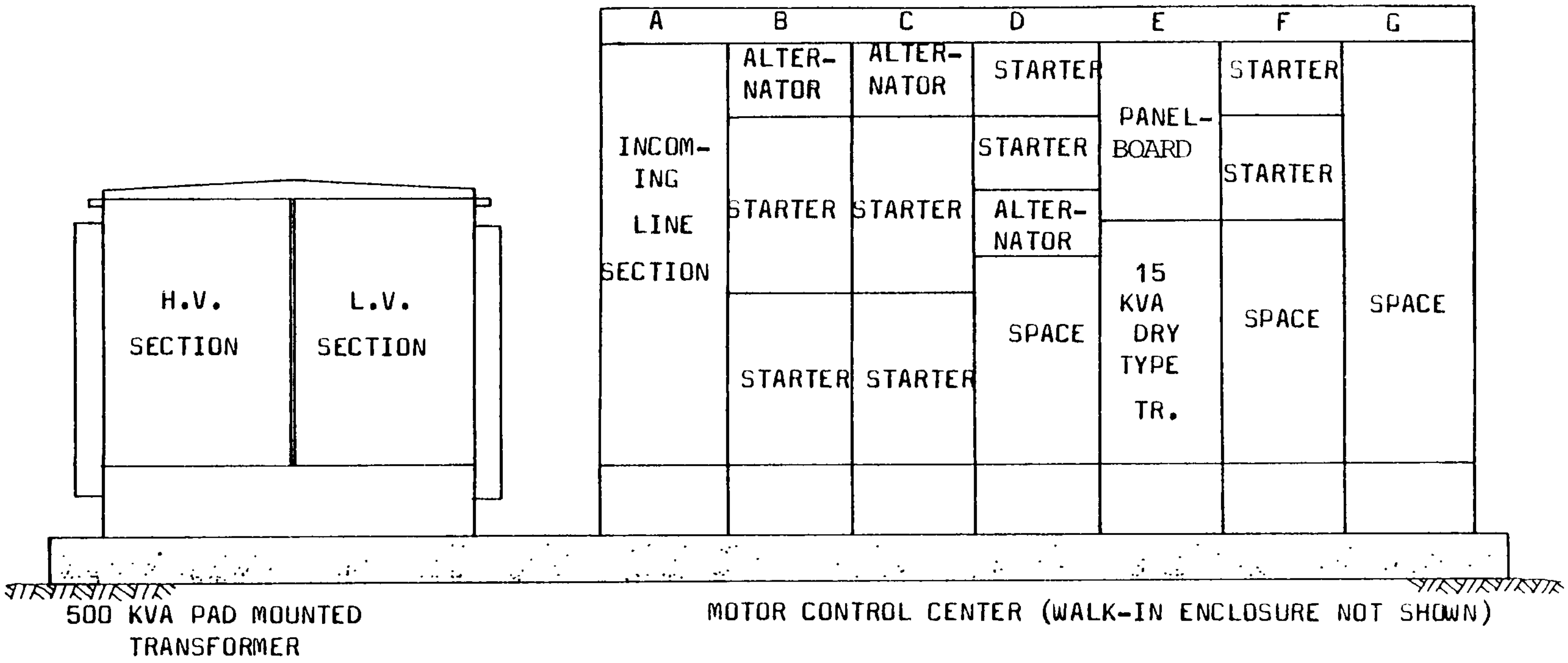
FIGURE 9

outdoor walk-in type. The reason for locating the control center outside the building is because the building is below grade level and the possibility of water flooding is not remote. An elevation view of the transformer and the motor control center is shown in figure 10.

The MCC feeds the dilute sludge pumps, sump pumps, electric space heaters, area and roadway lights and a miniload center. Those loads have a 480 V service voltage. Building lights, receptacles, exhaust fan, level controls, and pump alternators are all single phase 120V and supplied from the panel of the miniload center. Power and control wires are pulled in conduits from the motor control center into the building. Inside the building, conduits are run in concrete slabs of floors and walls.

The building of sludge pump station No. 2 is designed in an octagonal shape. The main structure of the building is below grade level. A meter vault and water distribution box are located on top of the building. Dilute sludge from pump station No. 1 enters into the meter vault where the flow is recorded by means of a venturi tube and a differential flowmeter as shown in figure 11. The flowmeter measures the differential pressure across the venturi tube and converts it to flow. The sludge then enters the distribution box where it is distributed to two gravity thickeners. The sludge is thickened (or its concentration is increased) by means of the gravity thickener mechanism. The thickened sludge flows by gravity back to sludge pump station No. 2 where it is pumped by five diaphragm-air operated pumps to the storage tanks and dewatering building.

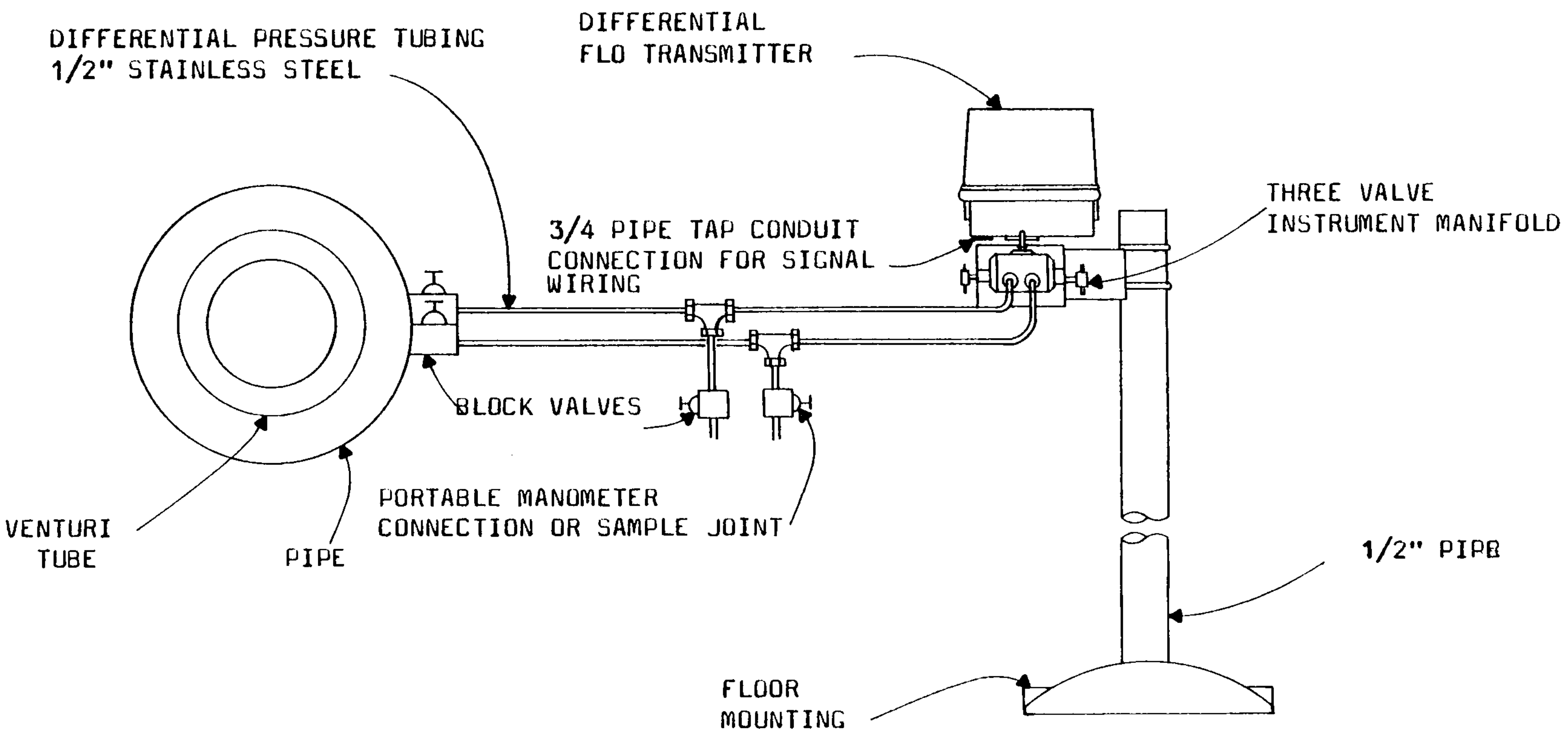
When I first designed the power supply to the pump station, I



OUTDOOR PAD MOUNTED TRANSFORMER & MOTOR CONTROL CENTER ELEVATION VIEW

SCALE 3/8" = 1' - 0"

FIGURE 10



DIFFERENTIAL FLOWMETER INSTALLATION DETAIL

N.T.S.

FIGURE 11

located the motor control center in the vicinity of the building. However, due to practical considerations I changed the location to the top of the building. This motor control center provides 480V, 3ø service to three air compressors, one air dryer, two sump pumps, a hoist crane, electric space heater, two gravity thickeners, and a miniload center. The miniload center provides 120V, 1ø or 208V, 3ø service to various lighting and power loads in the building. Figure 12 is the panel schedule for the miniload center in sludge pump station No. 2. This schedule serves as a directory to identify each circuit, the load it serves, and the circuit breaker.

The motor control center is completely enclosed in a NEMA 3R walk-in type enclosure as shown in figure 13. (The NEMA or National Electric Manufacturers Association[8] enclosure designation is one of the industry standards widely used by the electrical engineering profession). The motor control center is subfed from another motor control center located in the vicinity of the sludge storage tanks. Both control centers are supplied from a 500 KVA 4160V to 480V pad mounted transformer. I selected two sets of 4-250 MCM and 1-4/0 AWG (ground) cables as the main feeder for the MCC of sludge pump station No. 2. The cables are pulled in two 3 inch conduits. I provided for additional spare conduits in the same conduit run for future loads or expansion.

The three air compressors are designed to provide air supply for the operation of the sludge diaphragm pumps. The ratings of the air compressors are 30 HP, 60 HP and 100 HP. The design also calls for provision for a future 100 HP compressor. I interacted with the mechanical engineer, who is responsible for the mechanical design, in

PANEL SCHEDULE PNL SPX. 15KVA. 480V, 3Ø TO 120/208V, 3Ø, 4W

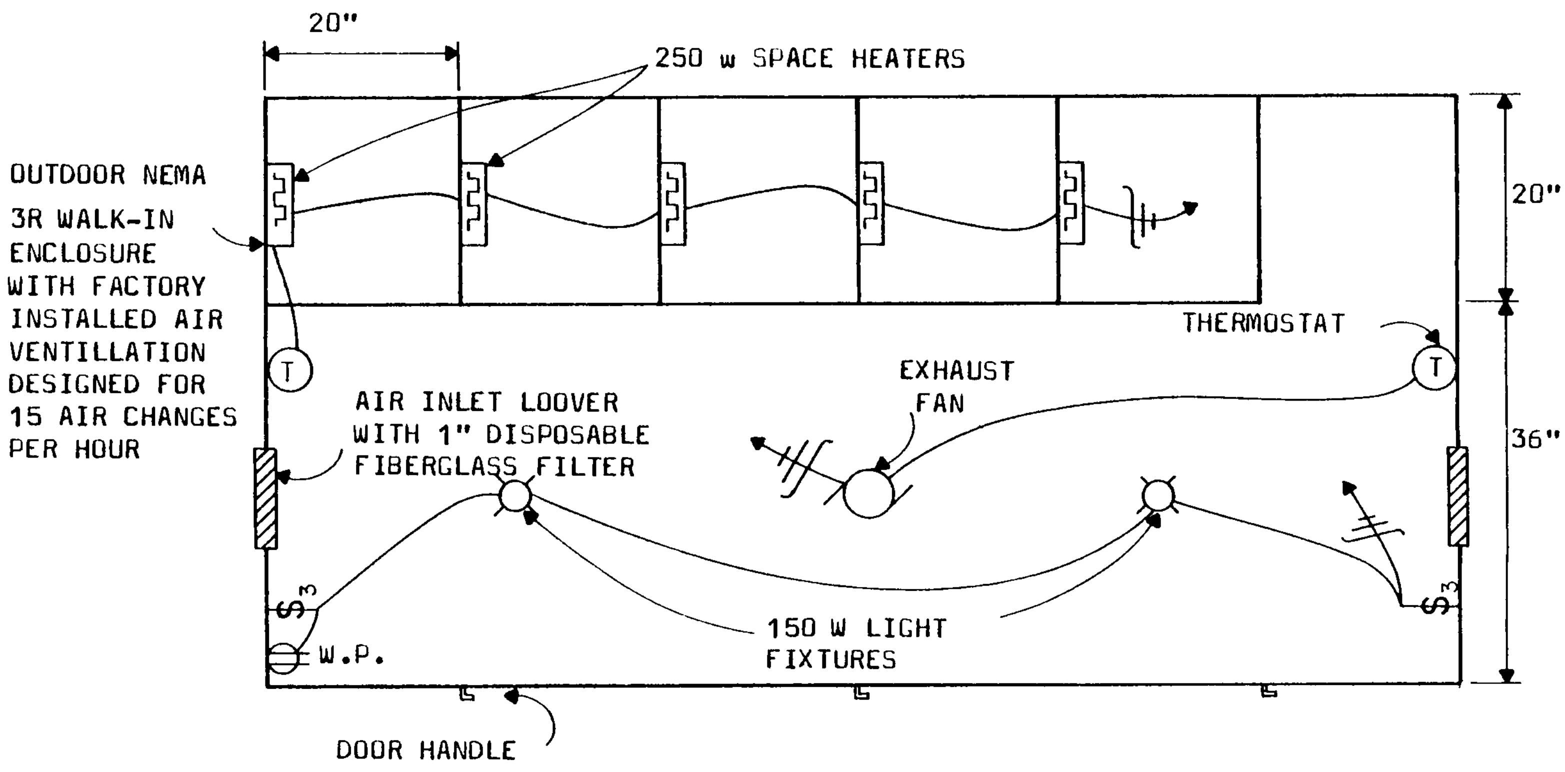
SERVICE 120/208 3Ø, 4W	[X] MAIN BREAKER IN MCC [X] SECONDARY BRKR. IN PANEL	CABINET MOUNTING	[X] SURFACE [ ] RECESSED

IDENTIFICATION	LOAD	NO.	A B C	NO.	LOAD	IDENTIFICATION
EXHAUST FAN 1 , 1/4 HP	187	1	A	2	187	EXHAUST FAN 2, 1/4 HP
TWO PUMP ALTERNATOR	20	3	B	4	1250	MCC SPACE HEATERS
MCC EXHAUST FAN	100	5	C	6	300	MCC LIGHTS
FLOW TRANSMITTER	10	7	A	8	1000	DISTRIBUTION BOX LIGHTS FIX.A-1
METER VAULT LIGHTS FIXTURE D	300	9	B	10	450	BLDG. LIGHTS FIXTURE D
BLDG. LIGHTS FIXTURE D	450	11	C	12	600	BLDG. LIGHTS FIXTURE D
BLDG. RECEPTACLES	200	13	A	14	10	COMPRESSED AIR ALARM (LR)
BLDG. LIGHTS FIXTURE D	600	15	B	16	50	DIAPHRAGM PUMPS CONTROLS NO. 1
DIAPHRAGM PUMPS CONTROLS NO. 2	50	17	C	18	20	GRAVITY THICKENER 2 LEVEL INST.
GRAVITY THICKENER 1 LEVEL INST.	20	19	A	20	200	BLDG. RECEPTACLES
SPARE		21	B	22		SPARE
SPARE		23	C	24		SPARE
SPARE		25	A	26		SPARE
SPARE		27	B	28		SPARE
SPARE		29	C	30		SPARE
PANEL TYPE			SOLID NEUTRAL	Ø A 1814W	Ø B 2660W	Ø C 1520W

ALL BREAKERS TO BE 20 AMPRER SINGLE UNIT BREAKERS UNLESS OTHERWISE NOTED.
ALL WIRE TO BE #12 UNLESS OTHERWISE NOTED ON PLANS.
ALL CIRCUITS SHALL HAVE INDIVIDUAL NEUTRAL WIRE.
PANEL SHALL BE EQUIPPED WITH GROUND BUS AND ALL CIRCUITS SHALL BE GROUNDED.

TYPICAL PANEL SCHEDULE

FIGURE 12



PLAN VIEW OF MOTOR CONTROL CENTER WITH WALK-IN ENCLOSURE

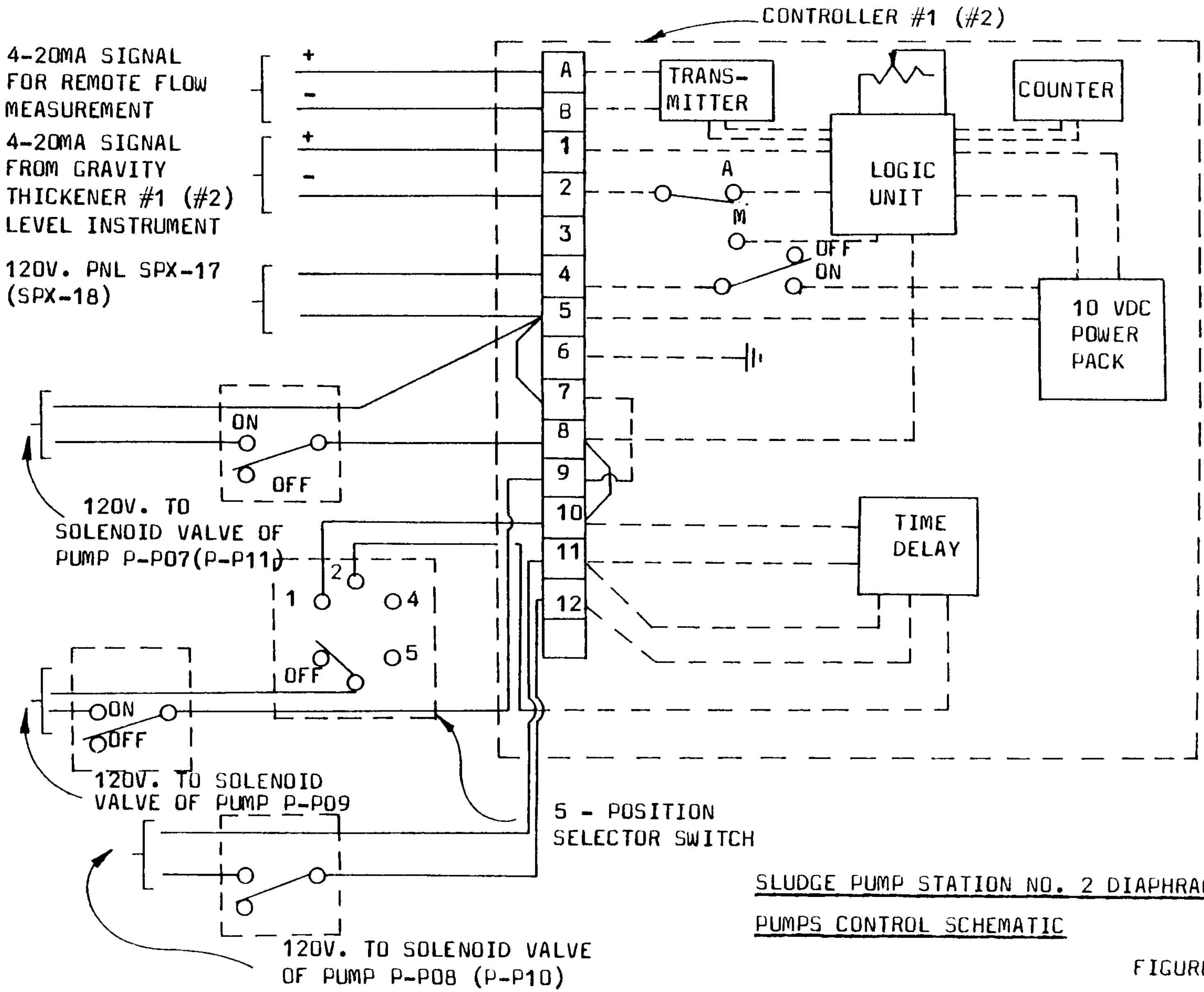
N.T.S.

FIGURE 13

designing the controls of the compressed air system. The sequence of operation of the 30 HP and the 60 HP compressors is automatically controlled to maintain a certain air pressure while the 100 HP compressor is manually operated, designed for back-up operation. The air drives the sludge diaphragm pumps which work as pistons to pump the sludge.

The operating principle of the diaphragm pumps is as follows: sludge flows from the gravity thickeners to the diaphragm pumps. A level instrument at each gravity thickener measures the sludge blanket level in the tank. The instrument transmits a 4-20 mA analog signal, which is proportional to the sludge blanket level, to the diaphragm pump controllers. Each pair of pumps is controlled by one solid state controller while the fifth pump is spare and can replace any of the four pumps. The controller upon receiving the analog signal converts it to pumping commands. That is, the sludge level determines the pumping rate in such a manner that a high sludge level requires a higher pumping rate and vice versa. The pumping commands from the controller cause a solenoid valve to open letting air into the associated diaphragm pump. The air pressure causes displacement of the diaphragm which pumps the sludge present in the cavity of the pump. The controller also integrates the pumping commands over one minute and converts that to a flow quantity in GPM (gallons per minute). A schematic diagram of the diaphragm pump controller is shown in Figure 14.

The storage tanks, as I stated earlier, were designed to store the excess sludge until it is time for dewatering. This was a special requirement by the client because the sludge handling and dewatering



SLUDGE PUMP STATION NO. 2 DIAPHRAGM PUMPS CONTROL SCHEMATIC

FIGURE 14

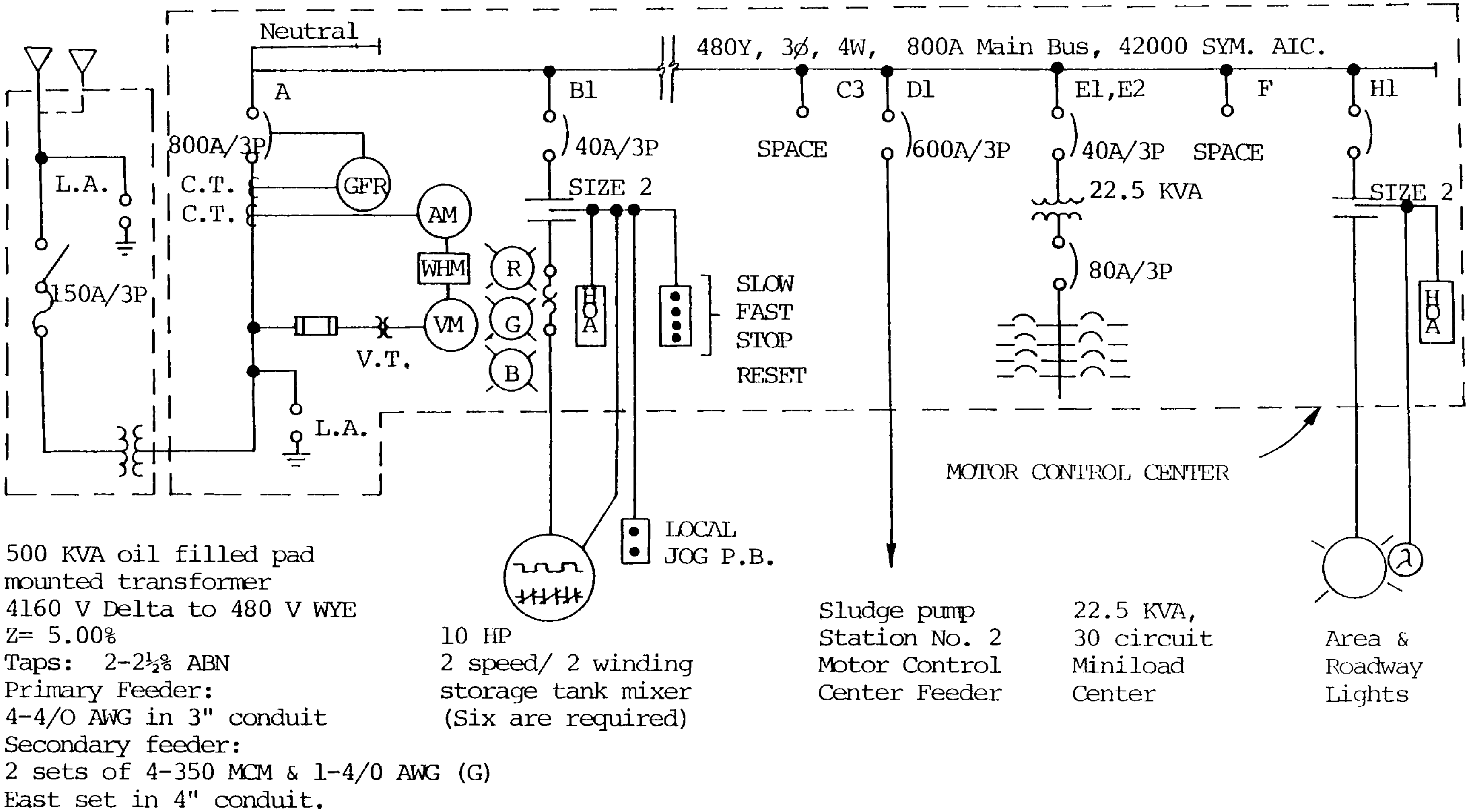
facilities will not be operated on weekends or more than two shifts on a weekday. However, the water treatment plant is operated continuously. Each storage tank is 30 feet in diameter and 32 feet high. A mixer mounted on top of the tank operates, as long as there is sludge in the tank, to prevent the sludge from settling. Each mixer motor is 10 HP two speed/two winding with a 480V service voltage (3ϕ, 7W). Mixer operation is either manual or automatic. The automatic mode of operation is dependent on the sludge level in the tank which is measured by a sonic level instrument. At designated levels some relay contacts in the level instrument close. Those contacts are connected in the mixer motor controls which cause the mixer to automatically shift from slower speed to faster speed at medium level or to stop at low level.

Sludge is pumped from pump station No. 2 to the storage tanks via an 8 inch pipe. This tank influent line splits into two headers inside a pipe gallery where each feeds three storage tanks. The pipe gallery also has two tank effluent headers to the dewatering building as well as drain and flush headers. There are 51 ball and plug valves of different sizes in the pipe gallery. Forty-three of these valves have air actuators with electric solenoid operators while the remaining 8 valves are hand valves. These valves control the flow of sludge to and from the storage tanks, the flow to the dewatering building,and the flushing and draining of tanks and headers.

During the working hours of the dewatering facilities, sludge is designed to flow to the dewatering building with the provision that excess sludge can be directed to one or more storage tanks. During non-working hours all the sludge is directed to the storage tanks. The valving system operation is designed to have manual and automatic modes. The automatic mode is primarily for non-working hours but either mode may be used during working hours. The valve controls include relays, selector switches, and contacts from level instruments or other valve relays. The valve controls are located in the control room in the dewatering building. All power and control wires are run in conduits through the pipe gallery. I designed all conduit runs to go through the pipe gallery including those to the storage tanks and sludge pump station No. 2 motor control center.

Power to the storage tank mixers, area and roadway lights, and pipe gallery equipment is provided from a 480V, 3ϕ, 4W motor control center. The MCC is enclosed in a NEMA 3R walk-in type enclosure mounted on a concrete pad. The control center is fed from a 500 KVA pad mounted oil filled transformer with a 5.00% impedance and 2-2½% taps above and below nominal voltage. A one line diagram showing the transformer, MCC, and the various loads is shown in figure 15.

In designing the electrical power distribution systems for the Dallas East Side Water Treatment Plant project I did some voltage drop calculations, short circuit studies, and protection coordination analysis. The short circuit studies, for example, included selecting a KVA base and calculating the per unit impedances of transformers, cables, and the equivalent of motor contributions. I then used the per unit impedances and the KVA base to calculate the short circuit currents at the various 480V bus bars of motor control centers. These



ONE LINE DIAGRAM (SLUDGE DEWATERING AREA)

Figure 15

short circuit values were used to select and specify the bracing of the bus bars and the short circuit capabilities of protective devices. I also designed the various lighting, control, and instrumentation systems.

My internship supervisor was very helpful in advising and directing me to solve the complex design problems. Furthermore, I had some inputs from my colleagues in the department. In some instances the design was the outcome of a combination of efforts on my part as well as on the part of other engineers. I also obtained some information through my interactions with some manufacturers' representatives with respect to the application aspects of the various items.

2. B. Miscellaneous Projects

During the internship period I worked on many ongoing projects in addition to the Dallas East Side Water Treatment Plant expansion project. My duties and responsibilities with respect to these projects included design work, preparing computer programs, compiling and preparing electrical master specifications, reviewing shop drawings, preparing economic analyses and cost estimates, coordinating project progress with clients and contractors, and supervising field testing and installation by contractors. In the remainder of this section I will discuss my contributions to some of the important projects that I was involved in.

2. B. 1. Computer Programs

On several occasions in the past, the electrical department used a commercially available computer program for sizing feeders and selecting feeder protection. This computer program is owned by Automated Procedures for Engineering Consultants, Inc. (APEC). The department used to prepare the data in a specific format for processing by APEC.

During the early period of my internship my supervisor and I thought that the department should have a computer program on file, at the company's computer, for the same purpose. Developing such a program was one of my early assignments. I started by reviewing the literature and the APEC program itself. However, I could not find any algorithm that would satisfy the concept which I had in mind. The APEC program, for example, has many restrictions that limit the user such as motor and other loads cannot be mixed on one feeder, no more than three conductors in any one conduit, and no provision for splicing a feeder. This and the fact that I wanted a computer program that could be used for all practical applications prompted me to develop a computer program which I called "CABLE.SIZE".

"CABLE.SIZE" not only calculates main and branch feeder sizes but also calculates feeder protection trip and frame settings, conduit sizes, and motor starter sizes. The feeder sizing calculation is based on the total connected load and the voltage drop. The voltage drop criterion is based on the following formula:

Voltage Drop=$(R \cos \theta + x \sin \theta)\ I.L$

where,

R,x: resistance and reactance of feeder per foot

$\cos \theta$: power factor of load

$\sin \theta$: reactive factor of load

I : current in amperes

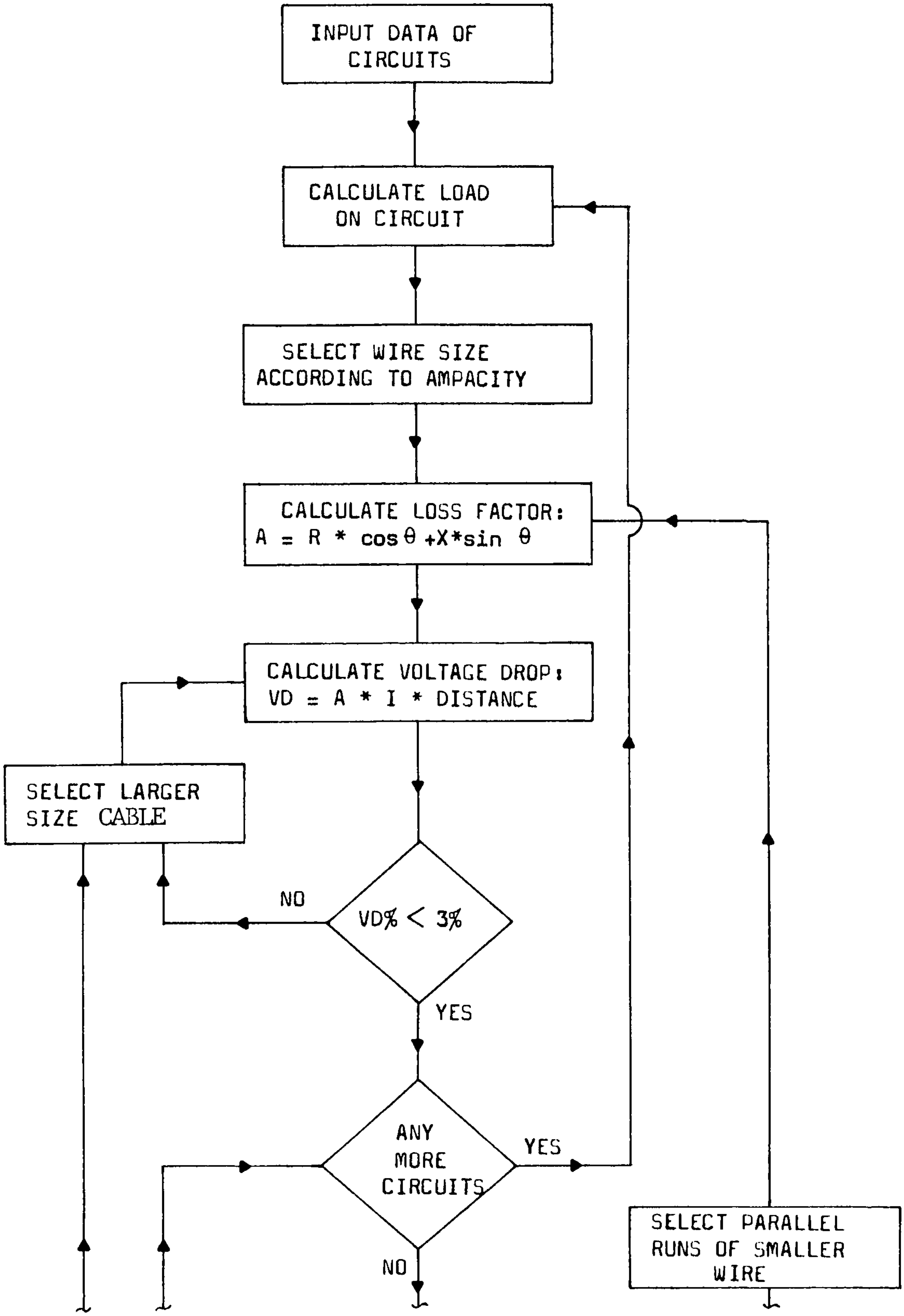
L : length of feeder in feet.

The user can set the maximum allowable percentage drop to any value desired. Based on this value and the input data provided the algorithm proceeds in an iterative procedure until it selects the feeder size which has the ampacity to carry the given load without exceeding the voltage drop set value. The algorithm includes a provision to calculate the size of spliced branch feeders. The calculations do not violate the rules of the National Electric Code. The NEC has two rules regarding sizing spliced feeders.[7] The 10-foot rule permits splicing with any size conductor provided that the spliced feeder is not over 10 feet long, is enclosed in a raceway, and has enough ampacity to carry the connected load. The 25-foot rule permits splicing with a smaller conductor provided that the spliced feeder is not over 25 feet long, has an ampacity that is at least 1/3 the ampacity of the main feeder, and it terminates in a protective device.

The computer program is versatile and has the capability to handle many different situations. Furthermore, the calculations, for the most part, are based on the worst cases to provide conservative output. The program also incorporates many of the industry standards such as the maximum conduit fill criterion, motor starter sizing, and providing for the magnetizing current in selecting protective devices for motors and transformers. Figure 16 is the flow chart of the "CABLE.SIZE" computer program and appendix I includes a complete listing of the program.

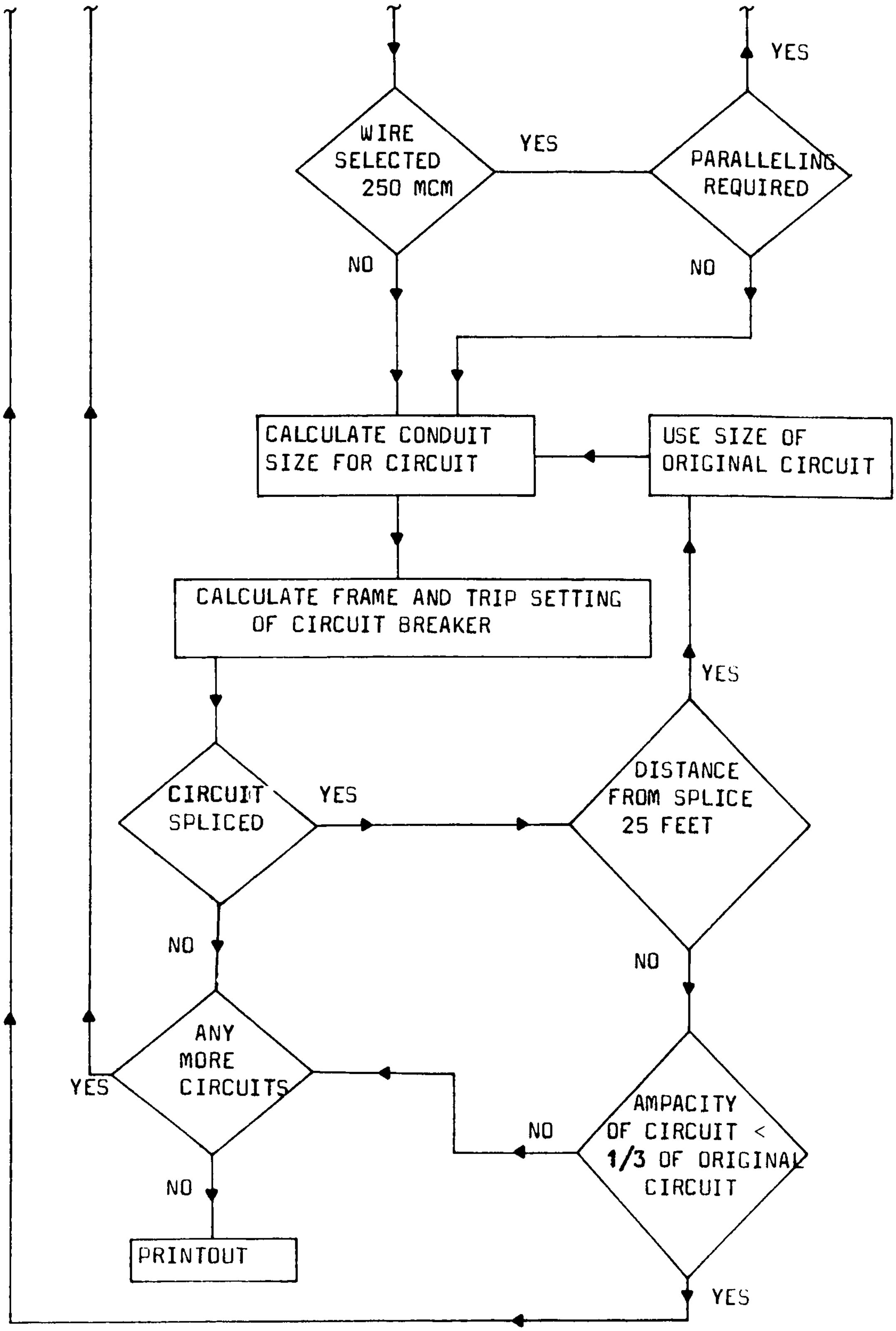
I also developed another computer program whick I called "BOX. SIZE". This program calculates the size of pull and junction boxes based on the number, size, and situation of entry of conduits. Pull and junction boxes are used in the electrical installations to facilitate pulling or splicing wires and cables. The box size must be large enough to accommodate splices or to make pulling cables easier and possible. The difficulty of pulling wires and cables into conduits is maximum when the conduits make many turns or when the run is very long.

The program does not suggest locations to install boxes. The user must determine this and enter the conduit data and situation of entry accordingly. The algorithm is very simple and efficiently



"CABLE SIZE" PROGRAM FLOW CHART

FIGURE 16



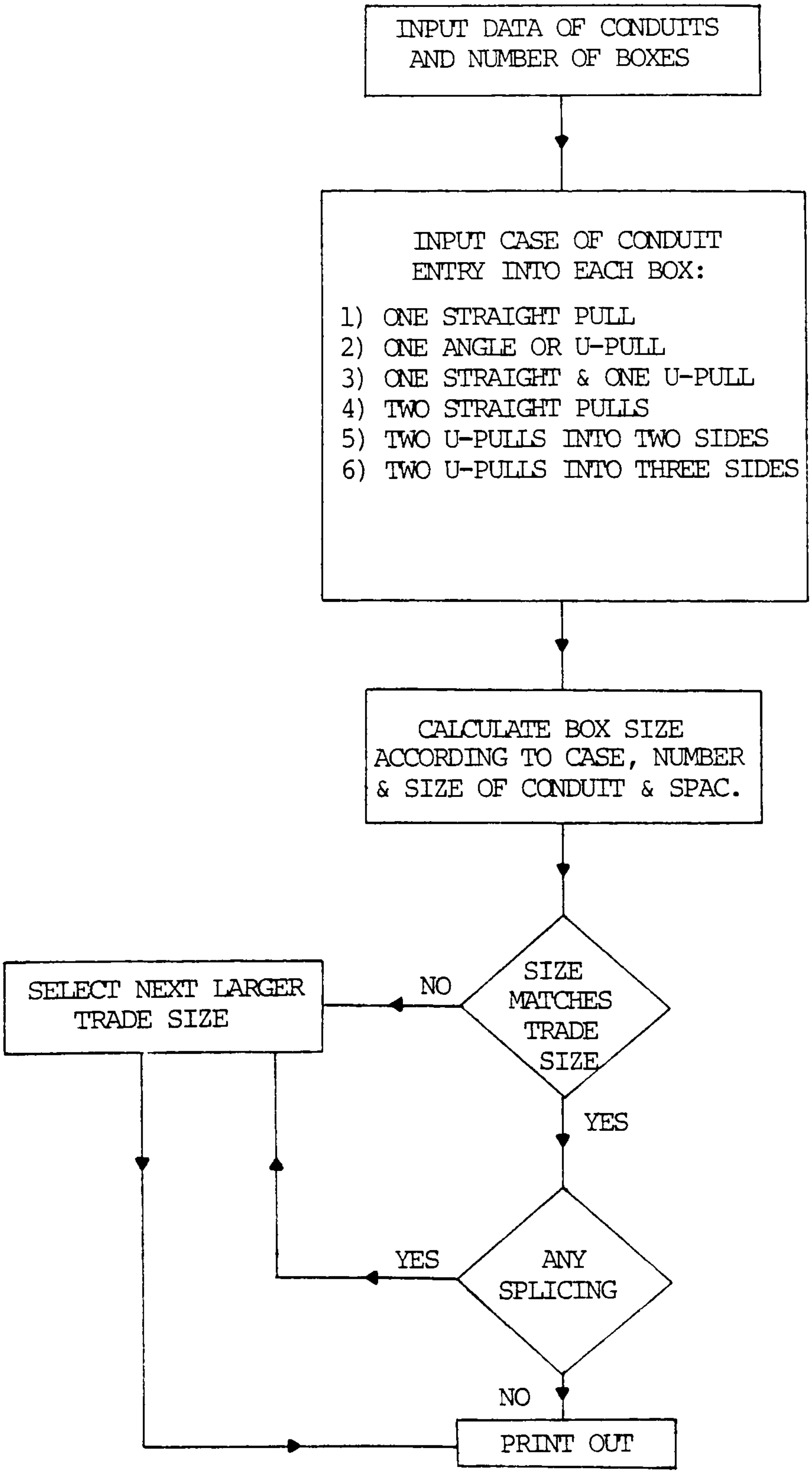
"CABLE SIZE" PROGRAM FLOW CHART (cont'd) selects box trade sizes for all practical situations. The flow chart of the algorithm is shown in figure 17 and the complete listing of the "BOX.SIZE" computer program is included in appendix I.

I used both programs, to some extent, in designing the electrical power distribution for the Dallas East Side Plant expansion project. The programs were also used to verify and check some design work of another electrical engineer. The main intention of developing both computer programs was to use them for large proejcts or for checking and verifying the engineering design of smaller projects.

2. B. 2. Bachman and Elm Fork Water Treatment Plants

The City of Dallas owns and operates two other water treatment plants in addition to the Dallas East Side Plant. Those two plants are Bachman and Elm Fork Water Treatment Plants. The company did not do the original plant design for either plant. However, during my internship period the company was asked to design some modifications and additions to the ammoniation system at both plants. I was assigned the responsibilities of a project engineer for this project. The design phase was essentially completed by the time I started working on this project. My responsibilities and duties included reviewing shop drawings and coordinating work progress with the client on one hand and the contractor on the other. My interaction with the contractor included clarifying the drawings and the specifications, and solving construction problems.

In spite of the fact that I did not participate in the design process of this project, I gained a valuable experience in designing ammoniation systems. I also became familiar with some of the design



<u>"BOX.SIZE" PROGRAM FLOW CHART</u>

FIGURE 17

procedures of other engineering disciplines in addition to project management procedures which was mainly due to the interactions that I had with the project manager. The project manager for this project was Mr. F.G. Honeycutt who is a vice president of the company and has a great deal of experience in water quality and water treatment projects.

2. B. 3. Electrical Master Specifications

Master specifications for each engineering discipline and architecture are kept on file in the company's computer. For any given project the design engineers select the applicable specification sections and adjust them to match the design requirements. The adjustments are easily incorporated by using word processors, which are interfaced with the computer. Using master specifications is a very effective way to reduce the time required to prepare the specifications for any project. All master specifications are arranged in accordance with the standard format of the Construction Specifications Institute (CSI).

The electrical department did not have electrical master specifications when I started my internship. My internship supervisor assigned me the responsibility of preparing a set of master specifications for the department. I started this assignment by reviewing the standard format of the CSI[9] and the electrical specifications of previous projects undertaken by the company. I wrote 14 new specification sections which are required in specifications for most projects. (See the second monthly report in appendix II for a list of these sections.) I also updated and adjusted some of the existing sections. This experience provided me with an overview of all the electrical specifications and I gained some experience in the process of writing and compiling the specifications.

2. B. 4. Shop Drawings Review

After the completion of the design work and awarding the construction contract to a contractor for any given project, the contractor submits construction or shop drawings to the company for approval. These drawings include information on certain equipment to be installed or material to be used in the construction and installation. They also include methods of construction, installation, and connection selected for the particular project. The contractor does not commence the construction work until the engineering staff has approved the submittals. However, he can segment the construction project in a manner where he can start working on certain items as they are approved without having to wait for the approval of the rest of the submittals. Usually the submittals are associated with trades or engineering disciplines. Furthermore, the submittals are identified by the various specification sections.

To review shop drawings, one should be familiar with the design, the design requirements, and the scope of work. Usually the engineer who designed the project does the review. However, in my case all of the shop drawings which I reviewed were for projects that I did not design. This meant that I had to study the design drawings and specifications prior to reviewing any submittal. I also referred to some technical handbooks and textbooks to aid me in reviewing some submittals. In the following two paragraphs I will discuss two major shop drawing submittals which I reviewed.

The first submittal was in connection with the Trinity River Authority-Livingston Water Treatment Facilities. The design drawings and specifications called for cathodic protection system to protect steel structures in clarifier tanks and filter tanks. The contractor submitted manufacturer's connection diagrams and control schematics. The cathodic protection system was based on the impressed current method with immersed anodes in the tanks. The anodes are connected to the positive terminal of the dc power source while the structure to be protected is connected to the negative terminal. Current flows from the dc source to the anodes and through the water (electrolyte) to the protected structure and eventually back to the source. This scheme protects the structure from the electrochemical reactions (or corrosion) by letting the anodes, which can easily be replaced, get corroded instead. Before reviewing the submittal I studied the design requirements and referred to the literature and some manufacturers' manuals to properly evaluate the proposed system.

The other submittal was for Clark County Advanced Wastewater Treatment Plant project. This project was designed by another consulting engineering firm, however, the contract was terminated before the construction of the plant due to litigation. The company was asked to serve in place of the designer and supervise construction. The submittal consisted of all the control, instrumentation, and computer interface loops. These loops are connection diagrams which describe the functions of the various controllers and instruments. They also depict the interconnections among the controllers, instruments, equipment in the plant, and the computer. A multiplexer system was proposed to convey the supervisory control commands and equipment status signals in addition to flow, level, temperature and PH signals from the instruments. I spent a great deal of time studying the design drawings and specifications before I started the lengthy review of the submittal.

2. B. 5. Onalaska Regional Sewage Treatment Plant

This project was designed by the company for the Trinity River Authority. The maximum design capacity of the plant is only 0.2 MGD. Although the size of the project was small, I gained a good experience in designing a complete wastewater treatment plant. The plant includes an aeration basin, an equalization basin, two clarifier tanks, an influent pump station, a sludge pump station, and sludge drying beds. The aeration basin in a wastewater treatment plant aerates the wastewater and enhances the bacterial activities. Several lift stations pump the sewage from the community of Onalaska to the plant.

My design responsibilities, with respect to this project, included designing the power distribution, lighting, and equipment control. I prepared the one line diagram, the power distribution and lighting drawing, and the motor and equipment control details for the plant. I also prepared the power distribution drawing for the lift stations. Furthermore, I prepared the electrical specifications.

The plant receives power from the power company at a service voltage of 480V. The design also included a diesel engine-generator set as a standby power source. Since some of the lift stations are located in remote rural areas, the available power to these stations is 240V,1ø. Consequently I specified a static phase converter to convert the available single phase power supply to a three phase power supply. This decision was made because the motor HP ratings were large and motor manufacturers do not make single phase motors for those large ratings. Furthermore, the phase converters are widely used in rural areas and they are adequate for the application in hand.

2. B. 6. Economic Analyses and Cost Estimates

I conducted some economic analysis and cost estimate studies in addition to the other design duties during the internship period. I participated, for example, in determining the construction cost estimate for the Dallas East Side Water Treatment Plant expansion project. My assignment was to compute the cost of electrical items and the cost of installing them. The total construction cost estimate for any project is usually submitted to the client to be used for bid evaluation or project financing.

I also conducted an economic analysis to evaluate the economic feasibility for replacing all existing mercury vapor area and roadway lamps with high pressure sodium (HPS) lamps at the Dallas East Side Plant. HPS lamps are more efficient than mercury vapor lamps, i.e., they have higher lumens per watt. Furthermore, HPS lamps have longer life. This means that in the long run the client would save money. If the annual savings over the life of the lamps exceed the initial investment then the replacement is feasible. I used the Net Present Value (NPV) method in this study in order to include the cost of capital and the time value of money in the calculations.

One of the cost estimates that I worked on was for the Trinity River Authority-Central Wastewater Treatment Plant. The client wanted to know the cost of providing a complete dual high voltage power supply to three pump stations in the plant. I prepared the electrical design for the proposed system. The design included high voltage fused disconnect switches, transformers, circuit breakers, power cables and conduits, and transfer switches. I used the Richardson Rapid Construction Cost Estimating System[10] and the Means Construction Cost Data[11] for calculating the cost estimate. I also obtained some price information from one of the local electrical systems suppliers.

2. 8. 7. Seminars and Technical Meetings

Attending seminars and technical meetings is an effective method to keep abreast of technological changes and advancements. I attended several seminars and technical meetings during the internship period. Some of these were related to certain projects and some were promotional seminars sponsored by certain manufacturers. One of the seminars which I attended was sponsored by the ASCO Company. The topic was about automatic transfer switches and their technical features. I attended another presentation about the Cutler-Hammer Directrol multiplexer system. I also attended a one-day seminar about Programmable Controllers and their applications in distributed control. The seminar was sponsored by Texas Instruments; IC Systems, Inc.; and Lynn Elliot Company.

2. B. 8. Sterling C. Robertson Dam

The company designed this project for the Brazos River Authority in 1975. Although the dam has been in operation since it was constructed in 1977, the instrumentation system which was designed for the automatic control and operation of the equipment of the dam has never worked. The subcontractor claims that the instruments were damaged by transients from the overhead power line. The contractor and I visited the site several times and installed a Dranetz microporcessor based disturbance analyzer to determine whether or not the line contained any transients. Before installing the distrubance analyzer I studied its operational features and method of connection. It is capable of identifying any surge, impulse, or slow change in the voltage waveform. It prints out on a paper tape the time of occurance of any transient event, the amplitude, and the duration.

I also supervised the contractor's adjustment and maintenance of an automatic transfer switch. The switch is responsible for automatically transferring from the main overhead line to the standby diesel engine-generator upon failure or phase reversal of the main power source. It also transfers back to the main power source upon the restoration of supply.

RESUME

A presentation of my technical contribution to the electrical engineering design and related economic studies was given in this chapter. Furthermore, my contribution to the project management process for one project was also discussed.

The major design work was related to the Dallas East Side Water Treatment Plant expansion project. In this project I designed the electrical power distriubtion, lighting, instrumentation, and control for the chemical mixing facilities, flocculation and sedimentation basins, and the sludge handling facilities.

The remainder of my technical contribution was related to several projects. These projects included preparing computer programs, carrying out the duties of a project engineer for Bachman & Elm Fork Water Treatment Plants Ammoniation Systems, and writing electrical master specifications. The work also included shop drawings review; designing power distribution, lighting, and control for Onalaska Regional Sewage Treatment Plant; conducting cost analysis and cost estimate studies; attending seminars and technical meetings; and supervising contractor's field testing at Sterling C. Robertson Dam.

CHAPTER 3

OBJECTIVE 3:

TO GAIN EXPERIENCE IN THE NON-ACADEMIC TECHNICAL AND BUSINESS ACTIVITIES OF THE COMPANY AND TO BE AWARE OF THE INDUSTRY STANDARDS, ETHICAL PRACTICES, AND THE INTERACTIONS BETWEEN THE COMPANY AND THE INDUSTRIAL ENVIRONMENTS.

INTRODUCTION

This chapter is devoted to the two related topics of internship objective 3, namely, the experience in the company's non-academic activities and the knowledge of the industry practices. Each section starts with a discussion that describes the importance and relevance of the topic to engineering organizations in general.

The first section focuses on the activities of the support functions as performed by personnel and departments in the company. The interrelations and interactions among support function departments and other departments in the company is also presented. The experience I gained in the company's technical and business activities was the outcome of my interactions with the department managers and personnel performing the support functions.

The second section deals with industry standards, ethical practices, and the company's interactions with the various environments. Since the company's major work is providing engineering services, I tried to familiarize myself with the pertinent regulations and standards governing the engineering profession. I also studied the different interactions between the company and the external environments and the effects these interactions have on the activities of the company. This section also discusses the ethical codes and considerations that govern the behavior of the engineers in the company as well as some of the activities of the company itself.

3. A. Experience in Non-Academic Environments

Every engineering organization must have some departments performing support functions to support the engineering main (staff and line) functions. From the overall organization point of view the support functions are essential for the organizational effectiveness. In other words, the support functions compliment the engineering main functions and thus enable the organization to attain its goals. The number and size of the departments performing support functions depend on the size and type of the organization. In some small organizations, for example, the support functions may be performed by upper management. In other organizations one department might assume the responsibility of performing more than one function.

In the consulting engineering organizations the support functions may include: accounting, legal, marketing, personnel and recruiting, financing, purchasing, and computer applications. The support functions can be directly and/or indirectly related to engineering projects. The accounting function, for example, can be project budgeting or payroll. Seeking new opportunities for the organization is accomplished through the marketing function. Financial studies for the organization or for clients are done by the finance department. The legal function is needed when preparing contracts for engineering services or contract bid conditions. Equipment, engineering and drafting tools, and office supplies are all purchased through the purchasing department. Computer applications function is used by the engineering staff as an aid in the engineering design process. The personnel and recruiting department is responsible for hiring new personnel for the organization.

The company has departments and personnel performing the support functions mentioned above. Through my interactions with department managers and personnel I gained some experience and knowledge with respect to the various support function activities. In the remainder of this section I will discuss such activities and point out the responsibilities of the support function departments. I will also mention the interactions among these departments and other departments in the company.

The accounting department is responsible for the payroll, purchasing office supplies and drafting equipment, accounts payable, client billing, and cash flow management. The department also prepares monthly financial statements to the parent company and files state income tax returns in the states where the company has branch offices or has done business. Furthermore, the department interacts with other support function departments, project and upper management, and the parent company. The interaction with the marketing department, for example, includes providing input to marketing reports and computer programs. The accounting department receives information from the personnel department regarding newly hired or promoted employees.

The accounting department provides the project managers with average hourly wages for the various engineering grades and technicians to be used by the project managers in preparing the project assignment reports. In a project assignment report the project manager indicates the total budget for the project as well as the allocations for each staff department. The accounting department also prepares semimonthly project status reports for all ongoing projects. These reports indicate the amount of money spent by each staff department and the ratio of the actual expenses to the allocated expenses.

Client billing is dependent on the type of contract with the client. Billing cycles are either monthly or based on percentage of completed design work. Most contracts for engineering services are flat fee, percentage of construction cost, cost plus fixed fee, or multiplier. A flat, or lump sum, fee contract is a total fixed amount of compensation which is entirely determined by negotiation with the client. Percentage of construction cost means that the fee is equal to an agreed upon percentage of total project construction cost. The percentage usually is between 5 and 8% of the actual awarded bid value. Cost plus fixed fee includes a compensation in the form of fixed fee in addition to payment of all direct and indirect expenses related to the project. The multiplier contract is where the compensation is computed by multiplying the salary cost by a certain agreed upon multiplier. The salary cost is defined as the cost of salaries of engineers, technicians, stenographers, and clerks for time directly chargeable to the project, plus social security contributions, unemployment excise and payroll taxes, employment compensation insurance, and medical and insurance benefits. Some contracts are a combination of more than one type such as percentage of construction cost limited by a fixed fee ceiling.

The company interacts indirectly with the Internal Revenue Service and the Security Exchange Commission through the accounting department. The accounting department prepares yearly income tax reports and financial statements to the parent company. The parent company files a blanket federal income tax return and financial statements to the IRS and SEC respectively. However, the department files state income tax directly to the states where the company has branch offices or is doing business. In some instances the department files zero income tax returns in certain states just to maintain the registration status.

The department's activities with respect to cash flow management are limited to client billing, payroll, and a petty-cash fund. The department does not interact with banks or financial institutions for borrowing or investment purposes. This is because the parent company performs those activities. The parent company redistributes excess cash from one company to another as the need arises.

The personnel and recruiting department is responsible for recruiting new employees and keeping up to date records on all current employees. The department places advertisements in newspapers, technical journals, employment agencies, and the Texas Employment Commission. The advertisements indicate job descriptions, responsibilities, and qualifications and experience requirements. When an applicant applies for an advertised job the department conducts an initial interview to determine the applicant's suitability for the job. During this interview the applicant is asked to fill out an application form and attach it to his/her credentials. The applicant is then interviewed by the particular department that needs a new employee. The final job offer is communicated to the applicant through the personnel department.

The personnel and recruiting department processes employees' applications for financial assistance with educational courses to upper management. The department also handles the distribution of W-2 forms to employees and processes W-4 forms to the accounting department. The department occasionally applies for alien employees labor certification to the Texas Employment Commission.

The company does not have a finance department and all the financing support function activities are handled by upper management. Since the company's major cost of doing business is the salary cost, the major financing activity is cash flow management. Normally, upper management manages cash inflow from client billing in a manner to balance cash outflow for the payroll through the accounting department. When the cash outflow exceeds cash inflow, upper management asks the parent company to furnish funds for the balance. Conversely when cash inflow exceeds cash outflow then the parent company advises upper management of the financing action to be taken.

Upper management, sometimes, provides financial advice to some clients on methods of financing their projects. This may be incorporated in the initial report which the company submits to the client before commencing the design work. The initial report basically describes the scope of work as well as an estimate of the construction cost. This financial activity is usually provided to small municipal clients especially those with no financial personnel on their staff.

The company does not have a legal department and the legal support function is handled by upper management. Upper management, for example, prepares or approves the contracts for engineering services and prepares the bid conditions for construction projects. The company deals with a local law firm on a retainer basis. Upper management may refer to this law firm for legal counseling on more complex legal matters.

The computer applications department provides services for main function departments as well as support function departments. Each department is assigned a number of files in the computer memory according to the amount of computer work needed. The computer applications department offers assistance in programming or, in some cases, prepares computer programs for some departments. The department also provides computer services to the branch offices and sometimes sells computer time to certain clients. In order to do all that, the department manages the time and capacity of the computer very effectively.

The marketing department performs several activities related to the marketing support function. Some of these activities are directly related to specific projects while others are directed to promote the company as a whole. The department, for example, prepares statements of qualifications to be submitted to potential clients soliciting engineering or professional services. Project management and the marketing department together prepare proposals and, in some cases, their representatives appear before review committies that review the proposals.

The department also provides an input to upper management to be used in preparing the annual business plan. This input consists of the outcome of a market research identifying the market needs. Upper management uses this and other information to arrive at the organizational goals and objectives. Once the organizational goals and objectives are set and formalized, the marketing department sets a marketing strategy. The department uses market segmentation to implement its marketing strategy. The department's efforts in performing market segmentation are based on two marketing principles, namely, product differentiation and market positioning.[12] With respect to product differentiation, the department utilizes the difference between the quality of professional services provided by the company and those provided by the competitors. This has been successful in most cases especially in the areas where the company enjoys a good reputation and has the expertise. Market positioning, on the other hand, is used by the department to promote the company in new areas of engineering projects. The department identifies the under-served segments of the market by a market research. This information when incorporated in the market positioning increases its effectiveness.

In setting the marketing strategy for a particular project or for a segment of the market, the marketing department starts by identifying the elements of the strategy. These elements are product, price, and promotion.[12] The department determines the nature and quality of engineering services which the staff is capable of providing (the product). The department also determines the type and quantity of compensation for providing engineering services (the price). The department selects the means of promoting the engineering services (the promotion). After identifying the elements of the strategy the department sets objectives for these elements and tries to accomplish the objectives in an effective manner.

At times the marketing department acts as a public relations department by establishing contacts with public relations or engineering departments of industrial companies and municipal entities. Acting in that capacity, the department acts promptly and courteously to any unsolicited request for proposal. The department also prepares brochures and displays for the purpose of promoting the company in the minds of the public and potential clients.

The marketing department has prepared two computer files to accumulate information about the market, present and potential clients, and engineering contracts. The first file is a data bank that contains information about present clients. The data consists of clients' satisfaction with the quality of work or progress of the design, project related problems, and clients' future needs. Such a file not only provides information about present clients but also potential problems and means of avoiding such problems in similar projects. This is especially true because a high percentage of projects undertaken by the company are of similar scope of work. The second file is basically a listing of engineering projects awarded to other engineering offices. The information for this file is obtained from engineering periodicals such as the "Texas Contractor".

Finally the marketing department arranges some training programs for project and department managers. These training programs include communication skills and promotion techniques. The department also interacts with other support function departments in the course of performing its marketing activities. The accounting department, for example, provides cost and financial information for marketing decision making.

3. B. Knowledge of Industry Practices

Engineering organizations are individual entities that provide services or products to society. To be effective, every organization must properly interact with the surrounding environments in the course of pursuing its endeavor. The interactions are governed by certain regulations, standards, and procedures. The regulations, standards, and procedures are either externally imposed by regulating bodies, formulated by the engineers in the different disciplines or by the organizations themselves.

The Environmental Protection Agency (EPA), the Internal Revenue Service (IRS), the Security Exchange Commission (SEC), and the Occupational Safety and Health Agency (OSHA) are some of the Federal agencies responsible for regulating and monitoring the activities of organizations. Furthermore, some agencies at the state level such as the Department of Health, the Department of Labor and Standards, and the Department of Human Resources are also responsible for regulating and monitoring the activities of organizations. The regulations and procedures are coordinated among the pertinent Federal and State agencies to avoid duplication or contradictions.

The rest of the regulations, standards, and procedures are formulated by the various industrial, technical, and professional societies. These societies include, for example, the National Electrical Manufacturers Association (NEMA), National Fire Protection Association (NFPA), American National Standards Institute (ANSI), American Society of Testing and Materials (ASTM), Institute of Electrical and Electronics Engineers (IEEE), American Society of

Mechanical Engineers (ASME), American Society of Civil Engineers (ASCE), and the National Society of Professional Engineers (NSPE). The societies cited above constitute only a small part of a long list. Some engineering disciplines may each have several industrial and technical societies.

The externally imposed regulations, standards, and procedures are basically governing laws intended to protect the lives, safety, and well being of individuals in the society. The violations of such regulations can subject the violating organization to penalties. One the other hand, the rest of the regulations, standards, and procedures do not have the power of the law but are established to standardize and organize the practices of the various engineering disciplines. They are also formulated to help engineers and organizations provide professional services that are accepted by the industry.

The standards established by the technical, industrial, and professional societies either apply to the technical and industrial practices or the ethical practices. The ethical codes describe the moral values which the engineers, as individuals or organizations, should have as a minimum. They also help in shaping the behavior and unifying the ethical practices of the engineers. The source of such ethical codes may be a professional society such as the NSPE, a technical society, or a policy manual of an organization. Furthermore, Engineers have their own moral values which they have formulated in their own minds from life experiences. To be ethical in all actions, the engineer should base his actions on his moral values as well as the ethical considerations provided by the various codes.

Interaction among engineering organizations and their suppliers is one type of interaction with the surrounding environments. This interaction can be direct as in manufacturing organizations or indirect as in professional service organizations. In a consulting engineering firm, for example, the engineers interact on a day-to-day basis with representatives of various equipment suppliers through discussions, seminars, exhibitions, or conferences. Through these interactions, the engineers become aware of the new equipment, applications, and technological innovations. This information helps the engineers upgrade their design criteria in the design process.

Another type of interaction which many engineering organizations experience is with the public. In some industries this interaction is very important and has some effect on the success of some organizations. However, interactions with the public, or public relations, is minimal in a typical consulting engineering firm. The only public interaction any consulting engineering firm may have is when dealing with private sector clients. This is usually accomplished through the marketing support function department as explained earlier.

Competition among organizations providing the same products or services is another type of interaction. It is an indirect interaction that serves to upgrade the quality of services or products of any given industry as a whole. This is true because competition forces organizations to strive for better organizational effectiveness. A consulting engineering firm, for example, can stay ahead of competitors by providing the highest quality professional services and establishing a good reputation for itself. In the absence of competitive bidding and lowest bid criteria, the reputation of an organization and the quality of the services it provides are the main factors in soliciting services from that organization.

The company is affected by many regulations and standards in the course of conducting its business. In providing professional services for clients in the fields of water and wastewater treatment plants, for example, the company follows the regulations and standards of the State Health Department and the EPA. These regulations and standards effect the engineering design performed by the staff of the company. That is to say that facilities for certain chemical treatment processes have to be incorporated in the design of the plants. The company's compliance with these regulations and standards is maximum because the lives and health of people are involved. In some cases the scope of the design work for some projects undertaken by the company has been to modify existing plant facilities to comply with the applicable regulations and standards. The company also complies with the regulations and standards of the State Highway Department and Department of Public Safety in designing roadway systems.

The engineers of the company follow the standards and practices of their respective trades. Electrical engineers, for example, follow the National Electric Code (which is published by the National Fire Portection Association under the auspices of the American National Standards Institute), Institute of Electrical and Electronics Engineers, Instrument Society of America, Insulated Power Cable Engineers Association, Illuminating Engineering Society, and finally the

National Electrical Manufacturers Association. These standards constitute guidelines, or minimum requirements, which aid the engineers in the design process. As an electrical engineer myself, I became more aware of the standards cited above in performing design work. I also used the standards as guidelines in many different applications and I have learned a great deal about the engineering practices since I joined the company.

Some clients have their own standards or preferences regarding certain applications which must be incorporated in the design. These standards originated mainly from the previous experience of the client's engineering staff with respect to operation and maintenance aspects. The City of Dallas, for example, has certain preferences for the type of wires to be used and type of conduit entry through walls. Field conditions and practical considerations also may affect or influence the design one way or another. These standards and preferences are usually included in the design as the client's special requirements.

There are many ethical considerations that affect the company's activities as an entity and govern the behavior of the engineering staff. The company, for example, does not participate in any competitive bidding because of the Texas Engineering Practice Act.[13] This applies to jobs in the state of Texas as well as in other states. Competitive bidding is also considered unethical by many technical societies of the various engineering disciplines. To avoid competitive bidding the company submits proposals indicating the amount of fee required, to provide engineering services, as a range instead of a fixed figure. This way the proposal is not considered a competitive bid because the company is simply communicating to the potential client its fee for each level of quality of engineering services. The main concern in considering competitive bidding unethical is that the quality of professional services will become secondary to the cost.

Most of the projects undertaken by the company are the result of unsolicited requests for proposals especially from state and municipal clients. This in no form or fashion is considered a violation of any ethical code because it does not constitute a competitive bidding act. Furthermore, the clients request proposals from the company due to the quality of the engineering services it provides or previous satisfactory engagements with the company.

The engineers in the company act ethically in serving clients by preserving the confidence and private information of clients, performing engineering services in a proper and competent manner, and safeguarding the safety and welfare of the public benefiting from the construction of the company's designs. Management encourages the engineers to become registered professional engineers in the State of Texas as well as other states. This is another example of the company's complience with the Texas Engineering Practice Act because registration is one way to eliminate unauthorized engineering practices. The company also encourages the engineers to pursue higher education in order to contribute to the integrity and competency of the engineering profession.

The company policy manual[14] adresses several ethical considerations for the benefit of all employees. It includes a section on conflict of interests. This section defines situations constituting conflict of interests and informs employees, at all levels, that it is unethical and unacceptable. The company policy manual also has some rules of conduct and general practices for all employees. In client relations, for example, the employees are instructed to deal honestly and fairly with the clients; be professional in thought, attitude, and action when discussing competition; provide the client with the best possible professional services; and constantly improve methods and techniques in order to better serve the clients' needs.[14] The company preserves the confidential information of its employees and instructs the employees, in turn, to preserve the trade secrets of the company and the confidence of the company's clients.

The company interacts with many of the surrounding environments in the course of conducting its business. It interacts with the various regulating agencies by incorporating their regulations and standards in the design process. This is done on the project level as well as on all levels of the engineering disciplines. The company also interacts with the clients' engineering staff in all phases of the design process. Furthermore, the company interacts with contractors in the construction process, utility companies for the coordination of power supply to the various project sites, and with equipment suppliers for purchasing equipment on behalf of some clients. Many of the interactions between the company and the surrounding environments have been described under the functions and duties of the various departments.

Engineers in the company interact with the external environments in the course of performing their duties. I experienced some of these interactions while working as a design engineer, and later as a project engineer. I had discussions with sales representatives regarding certain applications and equipment features. I also attended seminars and exhibitions which were beneficial in some aspects of the design process. Furthermore, I interacted with some contractors responsible for the construction of different projects. In many cases the interactions among the engineers in the company and the external environments have become part of the design procedure.

RESUME

In this chapter an account of the experiences and knowledge gained with respect to the company's non-academic technical and business activities and industry practices was given. Accounting, legal, marketing, personnel and recruiting, financing, purchasing, and computer applications are the support functions complimenting the main line and staff functions in the company. The company has departments responsible for all of the above functions except the legal, financing and purchasing functions which are handled by upper management and some other departments.

The accounting department is primarily responsible for the payroll, accounts payable, client billing, preparing monthly financial statements to the corporate office, and preparing project status and cost reports. The personnel and recruiting department is responsible for recruiting and personnel records. The vice president for financial and adminsitrative affairs handles both the financial and legal functions. The financing function includes cash flow management and financial advice to clients on methods to finance projects. The legal function includes writing contracts for engineering services. The marketing department is responsible for promotion, preparing statements of qualifications to potential clients, conducting market research, and preparing a marketing strategy. Finally the computer applications department provides computer services to all departments in the company.

There are certain regulations and standards that govern the company's activities and interactions. The EPA regulations, for example, are taken into consideration when designing wastewater treatment plants. The engineers in the company follow and apply the technical standards of their respective trades as well as some standards or preferences of certain clients.

There are also some ethical codes and considerations that define the proper engineering practices. These codes govern the practices of the staff of the company as well as the company's activities. The company, for example, sets certain rules of conduct for the employees in the company policy manual. The company does not indulge in any competitive bidding and it safeguards the private information of its clients. The engineers in the company are aware of the ethical codes of the technical and professional societies.