AN INTEGRATED APPROACH TO PRODUCTION, ACCOUNTING AND FINANCE FUNCTIONS IN A METAL PROCESSING INDUSTRY WITH SPECIFIC EMPHASIS ON PRODUCTION AND FINISHED GOODS INVENTORY SIMULATION

By

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TABLE OF CONTENTS

Page

Page

CHAPTER I

INTRODUCTION

1.1 Objectives of the Study

The main objective of this study is to develop a methodological framework for the analysis and evaluation of an enterprise using systems approach to management. It has been a well known fact that the solution of small problems generally yield small rewards and the goal should be to find management policies and organizational structures that lead to greater successes. Consequently an integrated approach covering production, finance and marketing functions, has been taken in this study.

Three major large scale models, to simulate total activities of a firm, have been developed in recent years.

1. The Industrial Dynamics Model
2. The Bonini Model
3 The Systems Development Model

All of these models focus attention on the information system of the firm, which links activity throughout the firm, and makes available the information which is acted upon by the decision maker. The first Model, Industrial Dynamics Model, has been developed by Professor Forrester. According

to his definition industrial dynamics is the study of information-feedback characteristics of industrial activity to show how organization structure, amplification in policies and time delays in decisions interact to influence the success of the enterprise. Industrial dynamics treats the interaction between flows of information, money, orders, material, personnel and capital equipment in a company, industry or a national economy and provides a single framework for integrating functional areas of management such as marketing, production accounting, research and development and capital investment. [1]

The distinguishing element of the Bonini's general model of simulation is that the decisions are not simply the results of applying a decision rule to a given set of information inputs. According to Professor Bonini decision is a behavioral or organizational phenomenon and the model should reflect these elements of the decision making process. So in this model some behavioral concepts have been utilized for example each decision maker in the model is given an index of felt pressure, this index represents pressure or

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I Jay,W Forrester,Industrial Dynamics ,(Cambridge Mass:The M.I.T. Press,1965),p.

slack as a function of performance relative to expectations, and it provides the bridge for tying together information and behaviour and provides for contagion of pressure within the organization.[2] The third model that has been mentioned above ie The systems Development Model has not become fully operational so it will not be described here.

One inevitably faces difficulties if he tries to solve applied business problems through these universal models because in many of the cases the needs and sources of a specific system do not meet the particular requirements of these models. This has also been the case for Günterm, the manufacturing firm that will be the subject of the study, at the begining of the study an attempt has been made to apply the industrial dynamics model to the firm for examining the effects of alternative decisions on the overall effectiveness of the operations of the system. But we have faced numerous practical limitations such as, expressing the dynamic relationships in terms of mathematical statements or lack of data that is needed to carry out the application of the model. So to reach the objectives of the study a more practical method

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2 Mc Millan,C and R.F.Gonzalez,Systems Analysis A Computer Approach to Decision Models,(Homewood Ill.:Irwin, I965),p.

has been chosen ie, developing a bimulation model that will suit to the specific requirements of the system under consideration. The objective of this model is to simulate alternative heuristic production decision rules for the purpose of optimizing total production and inventory carrying costs while avoiding stockouts.

1.2 Scope of the Study

Güntorm is a multi-product manufacturing firm and in this study only the major product of the firm, Convectors, will be taken into consideration. Secondly the heuristic production decision alternatives that have been tested are not exhaustive and there may be other alternatives that have not been considered in this study. The analysis will cover production marketing and finance functions of the system. However due to the limitation of time available to carry out the study some of the detailed aspects required by the analysis will not be taken into consideration, for instance a detailed marketing research or a complete organization planning will be out of the scope of the study. Furthermore, only production planning and finished goods inventory planning will be considered and a detailed raw materials inventory planning will not be taken into consideration in the study.

1.3 Methodology of the Study

The plan of the study can be summarized as follows; General information on the theoretical background

of systems approach to management will be given at the beginning of Chapter 2. Then the boundaries of the market in which the firm operates, its competative position and technical characteristics of the product will be described. Existing organizational structure of the firm will be analytically described in the following section of the chapter. After describing the organization, the analysis of the main functions of the system as a whole will be made. The objective of these analysis will be to find out main problem areas that exist in the system. So firstly an analysis of the production function will be done. The plant location, its layout and the production process will be described, and the main problems of the function will be summarized. Secondly the finance function will be taken into consideration and main emphasis will be on the comparative analysis of the financial statements of the firm to find out the underlying reasons of the basic financial weaknesses of the firm. Thirdly an analysis of the Marketing function will be made. Although marketing function has been carried out by a separate firm, it has been included into the scope of the study because, otherwise the analysis of the system would have been incomplete. The analysis of the marketing function has been carried out from the point of view of four basic marketing variables namely, product, Place, Price and Promotion. A sample marketing research has been conducted to learn the views of the customers on policies

and practices of the firm as a whole. At the end of the chapter all of the problems developed throughout the analysis of functional areas have been classified and integrated in a matrix. The objective of this section is to show the interrelatedness of the problems of the system. Out of these problems a strategic one is chosen, the problem of production planning and Finished goods inventories, the solution of which is supposed to increase the overall effectiveness level of the system.

To solve the production planning and inventory problems of the firm a simulation system has been designed in chapter 3. Firstly the objectives of designing a simulation system and alternative methods of solving the problem are explained. Then description of the Demand Generating simulation model, its inputs, outputs and evaluation of the outputs have been made. Thirdly the production and finished goods inventory simulation model has been explained. The assumptions, inputs (calculation of the production costs for alternative capacity utilization levels), the mathematical model used for determining optimum composition of residual aggregate production planned and outputs of the program have been described.

An evaluation of the outputs of simulation from production, finance and marketing point of views have been made in Chapter 4. Firstly the plan and coding of simulation has been explained. Secondly an evaluation of the outputs from the point of view of the production function is made, and those simulation sets that have produced minimum total cost figures are selected. Thirdly an evaluation of the outputs from the point of view of the finance function has been made and a system of determining monthly cash outflows and inflows have been designed to help in financial planning. Finally an evaluation of the outputs from the point of view of the marketing function has been done. Certain suggestions have been made to increase the level of effectiveness of the operations of the firm in Chapter 5.

Data for the analysis were obtained from:

1. The financial statements of the firm and their supporting documents.
2. Observation of the activities in the plant and Ti-Sa.
3. Interviews with the responsible personnel.
4. Interviews with the customers of the firm.
5. Previous research made in this field.
6. Publications containing relevant information. (they are listed in the Bibliography)

Background information on the mathematical model that has been utilized in the Production and Inventory simulation model is given in appendix(II). Moreover the computer programs, their detailed FORTRAN flowcharts and complete set of the inputs, and outputs of the simulation are also given in the appendices.

The work on this study started in September 1969. The research work at Günterm and Ti-Sa and the theoretical background studies ended in January 1970. The work on computer programs and the testing of alternatives ended at the beginning of April 1970. The final copy was typed and presented in May 1970.

CHAPTER 2

ANALYSIS OF THE FIRM FROM SYSTEMS POINT OF VIEW

2.1 The Systems Theory

2.1.1 Definition of the Theory; Before going into the definition of the Systems Theory let's define what is meant by the term "System" and by "Business Firm". The term System is defined as a collection of interrelated elements that are relevant to a prestated purpose, so the basic notion of a system is the interrelatedness of the elements that compose it and the degree of wholeness which makes the whole something different from and more than, the individual units considered separately.[3] And the Business Firm is defined as a purposive organization whose behaviour is directed toward identifiable end purposes or objectives.[4] So a business firm may be considered as a system of higly interrelated elements functioning as a whole to achieve economic performance. By highly interelated elements we mean basic functions of a firm such as, Production, Marketing, Finance and Personnel.

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[3] Seymour Tilles, "The Manager's Job: A Systems Approach," Harvard Business Review, Vol. XLI (1963), p. 74.

[4] Igor, H Ansoff and J, Fred Weston, Corporate Strategy, (New York: Mc Graw-Hill, Inc, 1964), p. 29

Up to recent years many theories have been developed on the behaviour and analysis of a Business Firm. For instance social scientists and Personnel executives viewed the firm as only a social system. Finance oriented people viewed it as only a system of Fund Flows and Marketing oriented people evaluated the firm only from their point of view. As a matter of fact all of these theories have a value in themselves but they do not mean much when we view the business firm as a System. Supporters of the Systems Theory maintain that these individual theories should be synthesized and a meaningful and integrated concept of the Firm should be obtained. So Systems theory views a Business Firm as a set of interrelated parts, namely Production, Finance, Marketing and Personnel functions interrelated by different flows as information, money, material, equipment and order, functioning as a whole to achieve the objectives of the set. The emphasis is now being placed on predicting how the combined parts will function as a unit rather then studying the parts.

The analysis of a business firm from Systems point of view brings about the problem of Effectiveness versus Efficiency which will be discussed in the next section of the Chapter.

2.1.2 Effectiveness versus Efficiency

By the term effectiveness we mean the degree of meeting overall objectives of the firm as a system. And by efficiency we mean the degree of meeting objectives of a particular subsystem. So here the term efficiency is related to the problem of the operational level and effectiveness is related to the Starategic problems of the Firm. These terms are not mutually exclusive ie, a firm may function both at its highest level of effectiveness while achieving maximum efficiency in each of its subsystems. On the other hand the system as a whole might operate at a high level of effectiveness but from the stand point of divisional objectives it might not be that efficient. For example, let us assume that overall objective of the firm is to achieve,

"Return over Investment	Treshold	10 %
	Goal	15 %
Sales Growth	Treshold	5 %
	Goal	10 %

This particular firm will be considered as an effective firm if it earns 15 % return on its total investment and also achieves 10 % growth in its total sales volume. But this may require the suboptimization of the divisional efficiencies.

From the point of view of the Systems Theory significant criteria in measuring the performance of a firm, is the level of effectiveness achieved rather than divisional efficiencies. As stated by William Moran, basic functions of a business firm namely Production, Marketing, Finance and Personnel functions, have been institutionalized because they all require specific skills and they are most efficiently performed by different individuals. This separation produced individual traditions and planning procedures and divisional efficiency problems caused conflicts among these functions.[5] This tendency towards achieving functional objectives obviously violates the systems concept that have been developed above.

Although Planning Committees or inter - divisional Commissions have been organized to perform the coordination function among basic functions of a firm it has always been difficult to get divisions graciously accept certain restraints on their objectives. Because the optimization of the behaviour of the total system frequently requires the suboptimization of its component divisions.[6] The author of

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[5] Martin,K Starr,Production Management:Systems and Synthesis,(Englewood Cliffs,N.J:Prentice-Hall Inc,1964), p.472.

[6] Ibid.,p.472.

this study supports the idea that, it is the frame of thought of the individual managers that must be oriented towards thinking in systems terms, and it can be attained through training programs.

Throughout this Chapter The Firm will be analyzed from a systems angle. So our first step will be the identification of the broader system, the industry, of which the firm is a part. Then an overall analysis of the system of the Firm will be made, with specific emphasis on the product and existing organization of the Firm. Thirdly an analysis of each formall subsystem such as Production, Marketing and Finance subsystems, will be made to determine their places within the overall system of the firm and also their specific problems. Finally an integration of the problem areas of each subsystem will be done to single out a strategic problem the solution of which will improve the effectiveness level of the Firm.

2.2 The Market in Which The Firm Operates

GÜNTERM is one of the multi-product medium sized manufacturing firms in the field of Convector, Boiler and vantilator Production. So Güntern is a part of "Heating and Air Conditioning Apparatus Production" section of the Metal Processing Industry. It is a family-owned Limited Partnership.A Major manufacturing Firms operating in this section of the Industry are Alarko, Selnikel, Sungurlar,

Izsal, Uda, Ygnis, Demir Döküm, Erkoç and Günterm. Table I illustrates the classification of the Firms according to the Products they produce.

TABLE I
FIRMS AND PRODUCTS THEY PRODUCE

Name of the Product	Name of the Manufacturing Firm
Convector	Günterm, Alarko
Boiler, Air Conditioning apparatus etc.	Günterm, Alarko, Sungurlar, Selnikel, Uda, Ygnis, Demir Döküm, Erkoç
Radiator	Demir Döküm, İzsal

Only the production of Convectors will be taken into the scope of the study. So in convector production Günterm operates in a promising large market with only one major competitor Alarko. Convector is a perfect substitute of a radiator, it performs the same function and it is also a part of central heating systems as a radiator. So Demir Döküm and İzsal are also considered as direct competitors of Günterm.

Table 2

An Analysis of Competitors vs

Günterm

Name of the firm:	Günterm	Alarko	Sungurlar	Demir Döküm
Present Capital:	I.000.000	I0.000.000	8.000.000	50.000.000
Number of workers	I23	500	500	2000

I could not make a detailed analysis to determine the competive status of the firm in the Heating Industry.In fact,it is extremely difficult to obtain relevant information about the operations of the Competitors.As observed in Table 2,Günterm has a relatively smaller size than other firms that operate in the same industry.Its capital is almost I/I0 th of the Capital of Alarko which is the major competitor of the firm.The number of workers employed by Günterm is also smaller than the number of workers employed by Alarko,Demir Döküm or Sungurlar.In order to complete the picture,we need at least the capacities of the plants of the competitors,their annual sales ,geographical distribution of sales etc,.In general one might claim that Günterm operates in a promising market with relatively stronger competitors.

2.3 The Product

Although the firm is one of the multi-product manufacturing firms, scope of the study covers only the production of Convectors. Firstly, because it is the major type of products that the firm produces and more than 50 % of the productive forces have been concentrated on the production of Convectors. Secondly the share of convector sales in total annual profit of the firm have always been greater than the share of other products.

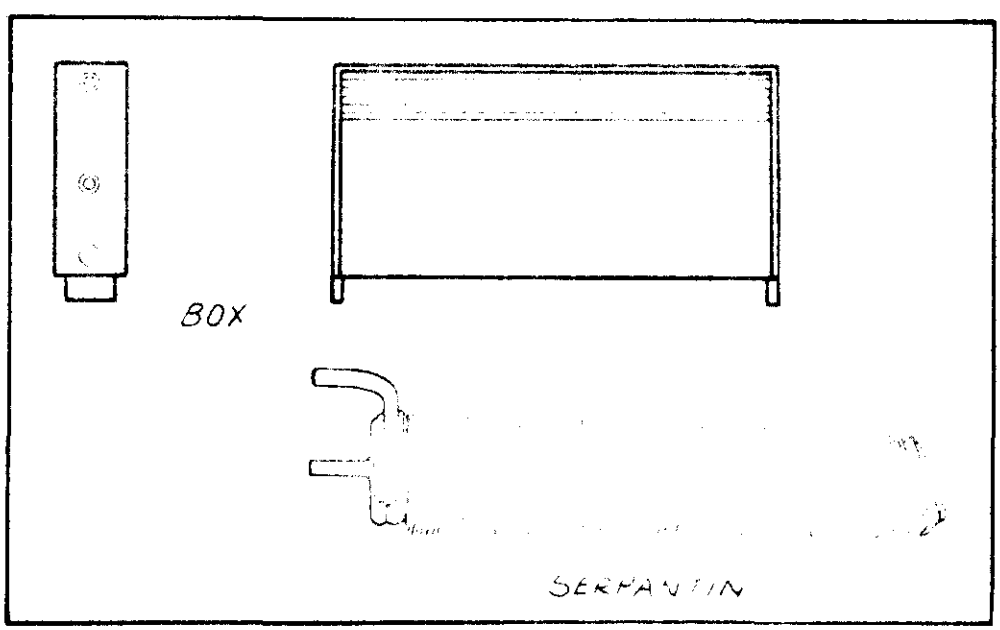

Figure 1. Structure of a Convector.

As it has been stated in section (2.2), a convector is a part of central heating systems, and functions as a radiator. Major difference that exist between a convector and a radiator center around their shapes, internal mechanisms and basic raw materials used in their production. A convector is made up of two main parts;

1. The Box
2. Serpantin

The box of a convector with its internal mechanism (Serpantin) is illustrated in figure 1.

At present the production line of convectors covers four different models namely model A, model B, model E, and model F. Furthermore each of the models A, B, F are divided into 15 different sizes of different calories. Model E has 8 different sizes. Total number of convector types produced is 53. In order to decrease the amount of routine work of the study this number has been decreased to eight standard models. The purpose of the study is to develop a method of analysis so for practical purposes the method that is developed in Chapters Two and Three can be enlarged to cover whole product range of the Firm. The calculations made to obtain sizes of these eight standard convectors are given below:

The production capacity of the plant is 40 units/shift for convectors of sizes up to 140 cm. The production capacity drops to 30 units/shift for sizes larger than 140 cm. So each model is divided into two groups, the first group included convectors of sizes up to 140 cm. and the second group included convectors of sizes larger than 140 cm. Then arithmetic mean of sizes of the components of each group is taken to find out two standard sizes of each model.

Table 3 illustrates the results of the calculation described above.

TABLE 3

SIZE AND PRICE OF MODELS
USED IN THE STUDY

MODEL	A SIZE (cm)	TL. PRICE
A_1	87	319
A_2	199	672
B_1	86	314
B_2	209	699
E_1	98	360
E_2	180	600
F_1	91	290
F_2	257	793

2.4 Existing Organization and Objectives of the Firm

Günterm employs 123 workers and 10 employees. The same family also owns and operates two additional firms that function in a coordinated fashion with Günterm. Their commercial names are TEP TESİSAT LTD. and TEKHİN CİHAZLARI TİCARET LTD. ŞTİ., (Ti-SA). Marketing and sales activities of Günterm have been carried out by Ti-Sa, it functions as a general distributor for the products of Günterm. Tep Tesisat is a contractor firm and it is among major customers of Günterm. The interrelationship between Ti-Sa and Günterm will be analyzed at section (2.7) in detail. All of these firms are managed by the members of the family.

The present Organization Chart of the Firm is illustrated in page 14 The organization consists of a Board of Directors, a General Manager and his Legal adviser, and three major Departments such as Accounting Department, Production Department and Technical Department, directly reporting to the general manager of the firm. Membersof the Board of Directors belong to the same family and the chairman of the Board is also the General Manager of the firm. As in the case of most small organization, the organization of Günterm is also of Functional type ie, related activities

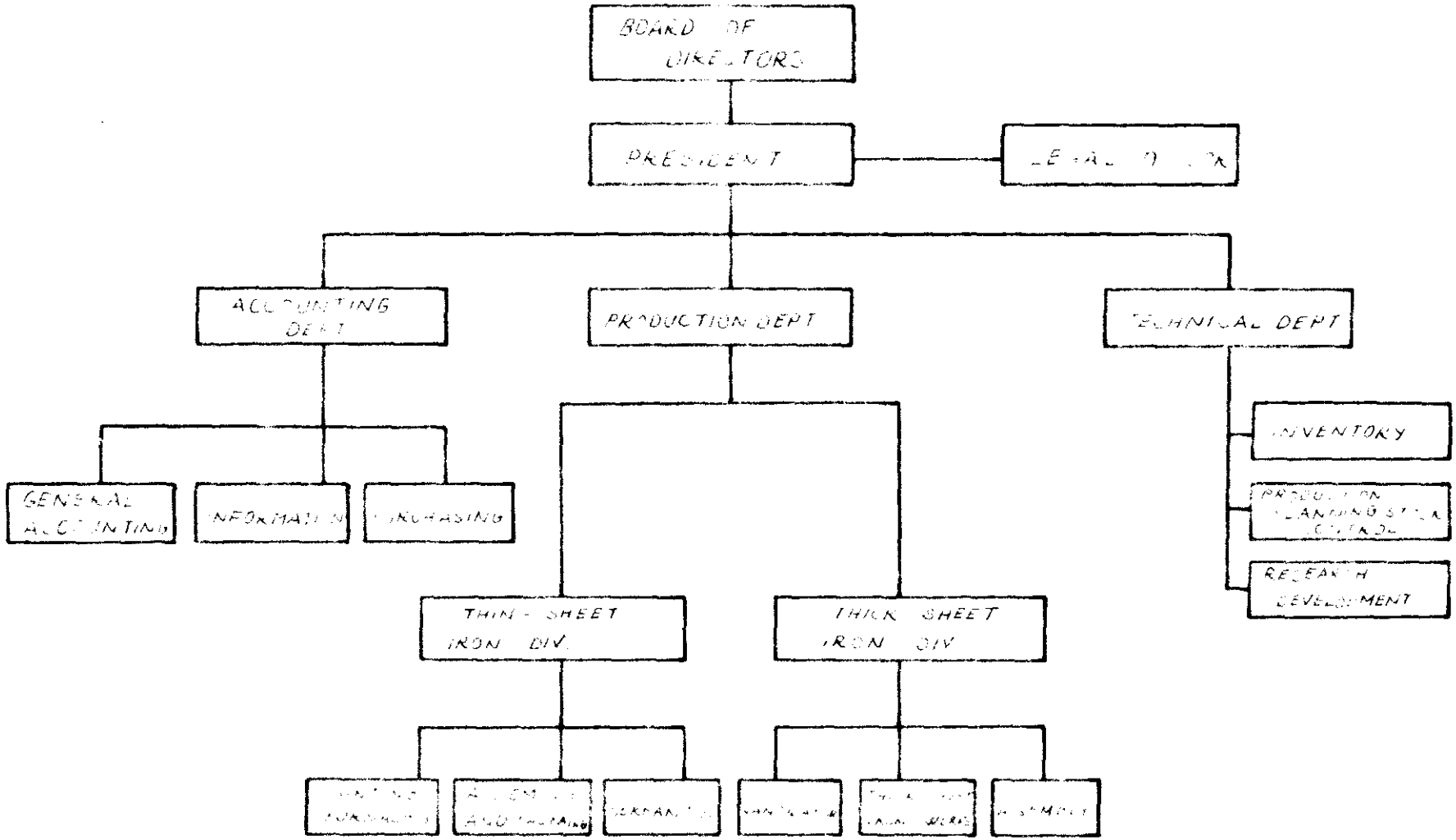

Figure 2 Present Organization Chart
of the Firm

aimed at a primary purpose are grouped together. Although the major benefit of this type of organization is in getting the specific functional work accomplished, this has not been so in the case of Günterm. Mainly because this chart is just an approximation of the existing system and there is actually no clear cut functional groupings in the firm. The specific functions, authorities and responsibilities of the existing personnel have not been explicitly defined. There are numerous administrative bottlenecks that require improvement, channels of information and paper flow are not clear and as a result many disturbances occur. There is actually no formal reporting system and most of the information is transmitted informally.

Although a functional type of Organization Chart had been prepared by a management consultant in 1967 it has not been put into practice because of its unsuitability to the needs and financial sources of the firm. This chart is given in appendix (1). According to this proposal two staff positions have been established to provide advice directly to the General Manager on Financial and Technical problems. In the existing system the general manager have only one staff personnel who provides advice on legal problems of the firm. At this level of the analysis, one might ask question such as, are those staff positions

absolutely necessary ? Will an important objective go unrealized unless such positions are established ? Staff positions usually serve to gain the specialization benefit and helps the general manager in focusing his attention on more crucial problems. However in the case of a medium sized manufacturing firm such as Günterm the general manager should be able to cope with the problems through a coordinated effort with his three department managers. So these staff positions are not absolutely necessary and their elimination decrease the payroll costs of the firm.

A position of vice-presidency that will assist to the General Manager and be responsible for marketing and accounting activities of Günterm is proposed in this new system of organization. Within the framework of this position new concepts such as purchasing Planning, Financial analysis and Planning, Cost accounting and Budgeting, Marketing research and sales Planning and a finished goods inventory system have been proposed. None of these developments have been applied in practice. First of all existing personnel is far from meeting specific skills required to perform these new functions and secondly financial requirements of the proposal were rather high. The new system also have two additional Departments namely The Technical Department and the Production Department. The Technical Department is

composed of five sections namely, research and Development Section, Production Planning Section, Quality Control Section, Organization and Industrial Engineering Section and finally the maintenance section. The production of convectors is placed under the responsibility of the Production Manager. On the other hand, the thick sheet-iron products section is directly attached to the responsibility of the General Manager. Moreover two sections namely, Service and Personnel sections are also directly attached to the General Manager of the firm. Furthermore the consultant, proposed a system of periodic meetings for Planning and Control at different levels of the organizational structure. Such as Monthly Planning and Control Meeting to be held by the General Manager of the firm, Assistant General Manager (who is also responsible from Marketing and Accounting functions), Manager of the Technical Department, Production Manager, Head of Thick-sheet-iron section, Head of Services Section, Head of the Personnel section and Head of the Purchasing Section, moreover a monthly meeting on commercial and Financial problems and a monthly technical meeting have been proposed. At the other extreme there is the present organizational structure of the firm, with two departments, The Accounting Department and Production Department and a detailed analysis of their organizational problems will be made in section 2.5, 2.6 and 2.7 .

We have defined the business firm as a purposive organization that function to achieve certain objectives. As defined by Professor Ansoff an objective is a measure of efficiency of the resource conversion process and they become multi use tools in appraisal of performance control, coordination as well as the phases of the decision process.[7] So before going into the analysis of the functions of the firm it will be worthwhile to state the objectives of the owners of the firm. As in the case of majority of the business firms in our country there is no formal and explicit statement of objectives of the firm. The objectives that are stated here are just the strongly held convicitions of the owners, and they are worthwhile to consider because some of the owners are also the managers of the firm. Their first objective is to achieve at least 20 % rate of return on their total investment after taxes. Their next objective is to increase convector sales by 100 % during the next four years.

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7 Ansoff, op.cit., p. 40.

Naturally under the present circumtances many obstacles exist in achieving these objectives. For instance there is the absence of systematic short term and long term business planning, etc. These obstacles will be the main subject of the following sections.

2.5 Analysis of The Production Function

2.5.1 Plant Location and Layout : The Plant is located in Silahtaraga/Istanbul. The plant is a one storey building and a two storey building for administrative offices and raw materials and parts inventory department, is attached to the main building of the Plant. Naturally the layout Plan of the Plant presented in Page 19, cannot be considered as the most efficient one. There has been no study on alternative layouts which would increase the level of effectiveness of the production system.

2.5.2 The Production Process. The production of the Plant is on one shift per day basis. Here only process flow chart of Convector production will be explained.

The manufacturing process of a convector can be analyzed in three major sections:

1. Manufacturing the Box, Standard operations required for box manufacturing are;
   A. Horizontal and vertical shearing of sheet-iron.
   B. Corner shearing and holing.
   C. Body bending.

A

25

1

1a

BOILER PRODUCTION

24

ASSEMBLY AND PACKAGING

2

2a

2b

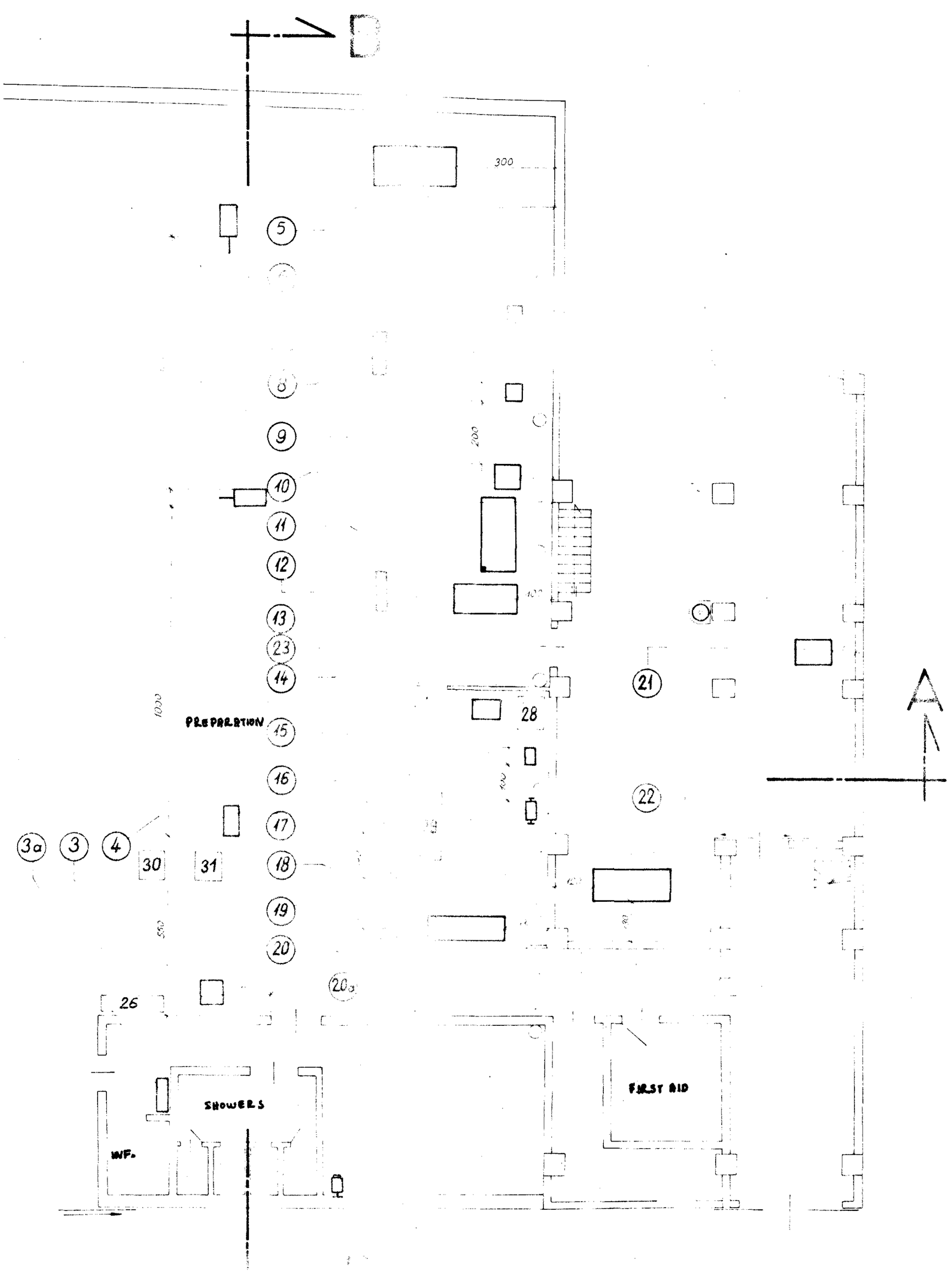
2c

PAINTING

27

FINISHED GOODS STORAGE

PRESENT PLANT LAYOUT : 1/100



1	DRILL
1a	VANTILATOR
2	BRULOR
	BRULOR
	ASPIRATOR
	"
3a	CARD PUNCHING MACH.
3	PRESS
4	PUNTA
5	ABKANT
6	PUNTA
7	PRESS
8	SHEAR
9	PRESS
10	PRESS
11	SHEAR
12	BENDING MACH.
13	PUNTA
14	SAKA
15	DRILL
16	EMERY STONE
17	DRILL
18	EMERY STONE
19	LATHE
20	CORD. MACH.
20a	ASPIRATOR
21	SAWER
22	SHEAR
23	DRILL
24	PIPE BENDING MACH.
25	FURNACE
26	SHEAR
27	OXYGEN, CUTTING MACH.
28	LATHE
29	
30	BENDING MACH.
31	PRESS

D. Electrical soldering of the corners.

E. Painting.

F. Furnacing.

2. Manufacturing Serpantin. Standard operations required to manufacture a serpantin are;

A. Horizontal and vertical shearing of aluminium Plates.

B. Shearing-copper pipes.

C. Cutting the iron pipe (gaga)

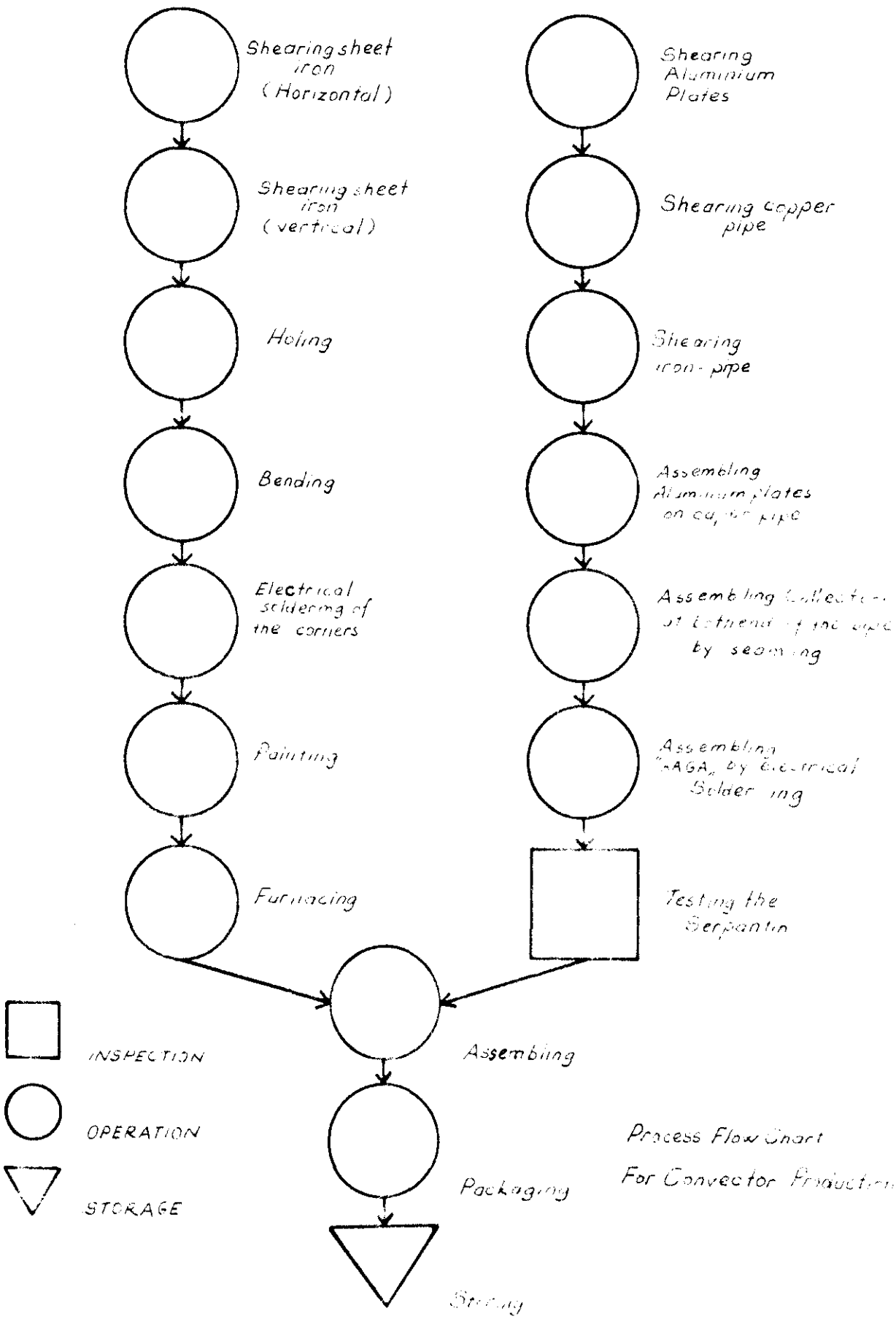
E. Assembling Collectors at both ends of the copper-pipe by seaming.

F. Assembling "Gaga" on to the copper pipe by electrical soldering.

G. Testing the serpantin in water press.

3. Final Assembly-Assembling the serpantin into its box and packaging.

There is only one mechanical engineer who is responsible for production process design, production planning and contral, designs and computations for the standard products and for special orders. He is responsible almost for everything at the factory level. There is no clear cut organization for the proper performance of the production function. Formally the Production Department has two subdivisions namely, Thin sheet-iron Products Division and Thick Sheet-iron Products Division. Our interest is mainly



Process Flow Chart
For Convector Production

concentrated on the former Division in which the convectors are produced. As it is observed from the formal organization chart of the firm there is a Technical Department in addition to the production Department that is mentioned above. The functions of this department have been specified as; 1. Production Planning, Finished goods and Raw Materials Inventory Planning and Control. 2. Research and Development.

3. Quality control.
4. Manager of Raw Materials and Finished Goods Inventories.

In reality this Department and its specified functions only exist on the paper. First of all there is no Production Planning and control activity. When an order comes to the factory an arbitrary date of delivery is given to the customer depending on the personal judgement of the Production Manager and as it will be explained, almost 90 % of the ordershave not been delivered on time. In parallel to this fact there is no Finished Goods and Raw Materials Inventory Planning and control activitiy. Capacities of the machines, raw materials required, materials waste to be expected, number of units of production to be expected from a given input of raw materials, time required to set up for the operations to be performed, time required to perform them and allowable manufacturing tolerance have not been measured.

Semi-skilled labor is required for the major portion of the job. However existing level of waste due to the lack of training is considerably highand in many instances goods with production defects have been offered for sale. And on the job training program with a low cost can be arranged. Conditions of work are weak, safety and health factors have not been into consideration.

Basic raw maderials required for the production of convectors are :

- Sheet Iron
- Sheet Aluminium
- Copper pipe
- Iron pipe
- Paint

There are serious ilimitations in the supply of these critical raw materials and the Firm has faced loses due to the shortages of copper pipe and sheet iron.

2.5.3 Summary of the Production Problems of the Firm

In summary the problems of the Production function are;

1. Organizational problems
2. No planning activity
3. Existence of production defects on the products
4. No finished goods inventory system and an arbitrary system of raw materials inventories.

2.6 Analysis of the Finance Function

The objective of this section is to analyze financial structure of the firm to find out its financial problems. One of the worst managed functions of the firm is finance. As in the case of Production Function there is no clear out organizational set up and functions of the existing personnel have not been clearly defined. Only Accounting Section of the Department has been established and functions of the existing personnel have been limited to book keeping.

As in the case of many family-owned firms important managerial positions such as finance have been filled by the members of the family who have no formal background education in their respective positions. The person who is supposed to be in charge of the financial problems of the firm is actually a foreman of boiler production but one of the members of the family. In the proposed system introduction of a cost accounting system, budgeting and financial planning sections have been observed. None of these developments have been applied.

2.6.1 Comparative Analysis of the Financial Statements

In this section comparative analysis of Balance Sheets and Profit and Loss Statements of the years 1967 and 1968 will be made. Although there is a general lack of industry standards and industry wide percentages analysis of past and present financial statements of the firm will be sufficient to

provide enough data to judge solvency asset relations, and indicate major financial problems of the firm.

2.6.2 Balance Sheet Analysis

Vertical and Horizontal % analysis; For computational purposes actual figures of balance sheets have been reduced to nearest '000 TL. Using group subtotals as a starting point relative size of the asset groups and liabilities are shown on table 4.

As seen on table 4 major portion of the total asset structure is formed by the current assets (64 % in 1967 and 68 % in 1968). During this period share of the current assets as a percentage of total assets increased, and share of fixed assets decreased around 4 %. In general the firm realized an increase of 48.3 % in its total assets. Assets composition of the firm becomes clearer if we continue our vertical % analysis further to show a breakdown of current assets. Relative share of cash and notes receivable (bank and trade) in total current assets have increased while relative share of inventories (work in process and raw material inventories have decreased since 1967. Moreover as it is observed from table 4 receivables constitute a major portion of the total current assets.

ASSETS	I967	I968	%67	%68
Short term:				
Cash.....	I7	92	.59	2.04
N/R(Bank)..	475	III0	I6.6I	24.58
N/R(Trade).	II8	3I7	4.I3	7.02
Acc/Rec....	II26	I9II	39.37	42.33
Inventory..	I094	I055	38.25	23.37
Prepaid exp..	30	30	I.05	.66
Total.....	2860	45I5	I00.	I00.
			64.40	68.52
Fixed Assets				
Land.....	-	I9	-	.92
Building...	647	685	4I.39	33.27
Installments.	I84	563	II.77	27.34
Transp.equip.	II0	95	7.04	4.6I
Machinery....	555	626	35.5I	30.4I
Furnishings..	68	67	4.03	3.25
Rights.....	4	4	.26	.20
Total.....	I563	2059	I00.	I00.
			35.I9	3I.25
Long term/N..	6	7	.I4	.II
Org.Expense..	I2	8	.27	.I2
Total Assets.	4441	6589	I00.	I00.

EQUITY	I967	I968	%67	%68
Short term:				
Accounts/P....	I393	2560	47.I9	50.I2
N/P(Bank)...	400	902	I3.55	I7.66
N/P(Trade)..	II59	I646	39.26	32.22
Total.....	2952	5I08	I00.	I00.
Long Term...	0	0	66.47	77.52
Capital.....	I000	I000	22.52	I5.I8
Reserves....	II8	347	2.66	5.27
Ret.Earn....	37I	I34	8.35	2.03
Total Equi.	4441	6589	I00.	I00.

Table 4

Comparative Balance Sheets

I967-I968 '000 TL.

TABLE 5

Comparison of Receruables

and Sales

	1967 %	1968 %
Net Sales	100	166
Receivables	100	161

Especially in 1968, 43 % of total current Assets was composed of Accounts receivable and 25 % of total current assets was composed of notes receivable (bank). As it is observed from table 5 the % increase in net sales and accounts receivables have been almost the same.

Vertical percentage analysis of the liabilities and equity balances to gauge balance in sources of capital; First of all we should note that there is no long term liability of the firm, liability sections of the balance sheets have been composed of short term liabilities and capital of the partners. Relative size of accounts payables have increased from 47 % to 50 %. In general share of short term debt in capitalization of the assets have increased by II %. Partner's capital composed 34 % of the total equity section in 1967 and 22 % of the total in 1968. so share of the owners in total capitalization of the firm have decreased.

Horizontal percentage analysis of the liabilities also indicate that the firm has utilized short term bank money heavily. For instance accounts payable to banks have

increased by 502 thousand TL. Other Accounts payables have increased by 209 thousand TL.

FUNDS FLOW ANALYSIS

To gain insight on the structure of the flow of funds of the firm I have prepared a Statement of Balance Sheet changes and made a funds flow analysis for the firm.

TABLE 6
STATEMENT OF
SOURCES AND USES OF FUNDS (1967 - 1968)
('000 TL.)

SOURCES of FUNDS	
Short term	
Decrease in inventory	39
Decrease in transportation equip	15
Decrease in organization expense	4
Increase in notes payable 1167	
Increase in accounts payable	989
Long term	
Increase in net worth	229
Total sources of funds	2443

USES of FUNDS

Short term		
Increase in acc. Rec.....	785	
Increase in notes Rec.....	834	
Increase in prepaid charges	1	
Long term		
Increase in land	19	
Increase in building	38	
Increase in tesisat	379	
Increase in mach and equip	71	
Increase in office equip	4	
Decrease in profit	237	
Total uses of funds		2368
Excess of sources over uses		75
Net increase in cash balance		75

Analysis of the sources and uses of funds reveals that basic sources of funds for the firm have been in the form of short term notes payable and accounts payable. On the other hand only 9 % of the funds have been provided by the owners' capital. Moreover we observe that 39 thousand TL. or 1.5 % of total sources of funds have been provided through a decrease in the level of inventories. All of these facts are unfavorable for a growing firm.

From the stand point of uses of funds we observe that 72 % of total sources of funds have been used to finance increases in current assets in the form of accounts receivable and notes receivables. On the other hand increases in fixed assets by 511 thousand TL. have also been financed through short term sources. Although it is necessary for the Accounts receivable and notes receivables to increase with accompaniying increase in the volume of sales short term financing of long term assets creates unfavorable financial results for the firm.

2.6.3 Analysis of the Profit and Loss Statements

In this section an analysis of the profit and loss statements of the years 1967 and 1968 will be made to isolate the revenue and expense factors which need explanation.

TABLE 7

Results of Operations for The Years

1967 - 1968

	1967	1968	vert.% 1967	vert.% 1968	1967=100 1968
Sales	5142	8480			165
Less returns.....	169	225	3	3	133
Net Sales	4973	8255			166
Interest earned	6	13	12	15	217
Other revenues	268	132			49
Gross revenues	5247	8400			160
Costs and expenses					
Cost of goods sold	4375	7123	83	85	163
Shipping and delivery expense	83	135	2	2	163
Org. expenses	4	4	1	1	
Interest and commissions.....	106	215	2	3	203
Selling expense.....	180	584	3	7	324
Allowance.....		110		1	
Other exp. cultural etc..	102	69	2	1	68
Income tax	26	26	.50	.31	
	4676	8266			169
Net income for the year..	371	134	6.50	1	
			100	100	gross rev

Analysis of the percentage changes might indicate some of the reasons of the decrease in net income by 237 thousand TL. There is a decrease of 136 thousand TL. in the volume of other revenues. On the other hand Selling Expenses (Discounts and premiums to dealers) Shipping and delivery expense and interest, commissions expenses increased more than 100 %. There is no significant increase in the cost of goods sold.

2.6.4 Ratio and Financial Leverage Analysis

1. Current and quick ratios are used to measure roughly the firm's ability to meet its current debt;

		1967	1966
Current ratio =	$\frac{\text{current assets}}{\text{current liab.}}$	.96	.88
Quick ratio		.53	.67

So the firm has not been able to cover the claims of short term creditors.

2. Turnover ratios to measure the degree of effectiveness in the utilization of the assets.

		1967	1966
Receivables turnover=	$\frac{\text{annual sales}}{\text{year end trade Acc. Rec.}}$	4.41 times	4.32 times

So on the average trade receivables are collected 4 times a year and the firm has to wait around 91 days for the return of its funds invested in receivables. In 1968 the firm had bad debts amounting to 289 thousand TL. (almost 6.5 % of total assets of the firm in 1968), so worsening of current position can partially be attributed to careless collection of accounts receivables.

Inventory turnover ratio (to have an idea on how rapid is the flow of funds through the inventory pool and how current that inventory is)

	1967	1968
Inventory turnover = $\frac{\text{Cost G.S}}{\text{Inv.level}}$	3.99	6.75

There has been a considerable increase in the rate of inventory turnover since 1967, and a TL. investment in stock is converted each three months in 1967 and each 1.7 months in 1968.

3. Debt to net worth;	1967	1968
$\frac{\text{total debt}}{\text{net worth}}$	2.63	3.78

In 1967 the creditors have put up 2.63 TL. in relation to 1 TL. of the partners and in 1968 the share of the creditors increased to 3.78 TL. Funds of the owners is very low in comparison to the amount that is raised by debt.

Therefore chances of securing additional borrowed funds might be smaller in near future.

4. Earning Power of the Firm;

		1967	1968
Rate of return on sales=	$\frac{\text{Net income}}{\text{net sales}}$	7.4 %	1.6 %

there has been a considerable decrease in the earning power of the firm.

$$\% \text{ earning on total debt.} = \frac{\text{earnings on tot. Assets}}{\text{total debt.}} \qquad 5\ \%$$

So the firm earns 5 % on investment and they cannot get funds from financial market at a lower interest rate. On the other hand they are heavily depending upon short term debt which is quite expensive at least at an interest rate of 25%.

2.6.5 Summary of the Financial Problems of The Firm

As a result of an analysis of the facts reported on the comparative financial statements of the years 1967 and 1968 together with inquiry of personnel responsible for financial operations these conclusion are drawn;

Organizational Problems: There is no clear cut organizational set up and functions of the existing personnel has not been clearly defined. There has been no attempt towards rational

scientific financial management.

Level of education of the existing personnel on financial problems is considerably low.

Existing system of accounting has been oriented towards keeping of financial books. There is no managerial accounting system.

Financial Problems: First of all current position of the firm has worsened. There has been a heavy increase in the amount of accounts and notes receivables. Bad debts of the firm amounted to 16 % of the accounts receivables. Furthermore turnover of receivables slowed down in 1968. There has been heavy volume of short term capitalization. There is almost no long term liability while short term liabilities have shown significant increases in the form of Notes and accounts payables. Heavy use of short term bank money created various financial problems for instance management of the firm has not been able to pay adequately and regularly wages and salaries of the existing personnel. So there has been two strikes since January 1969.

Earning power of the firm decreased considerably in 1968. It has a high debt to net worth ratio

and very low capacity to meet its current obligations. Moreover selling expenses (discounts and interest expenses (interest and commissions) have increased by more than 100 % since 1967.

2.7 Analysis of the Marketing Function

The objective of this section is to have a descriptive analysis of the present marketing decision making structure and problems of Günterm. Marketing and Sales activities of Günterm have been carried out by Ti-Sa. There is no marketing activity at the level of Günterm. Although the proposed organization chart had included a marketing and sales department it has not been put into practice. According that Chart Marketing and Accounting functions were integrated under the authority and responsibility of a vice president and a concept of forecasting and planning for marketing activities had been introduced. Today some of the functions specified by that chart, such as advertising, sales and delivery of products, are placed under the responsibility of the general manager of Ti-Sa. The organization chart of Ti-Sa is illustrated in figure (5).

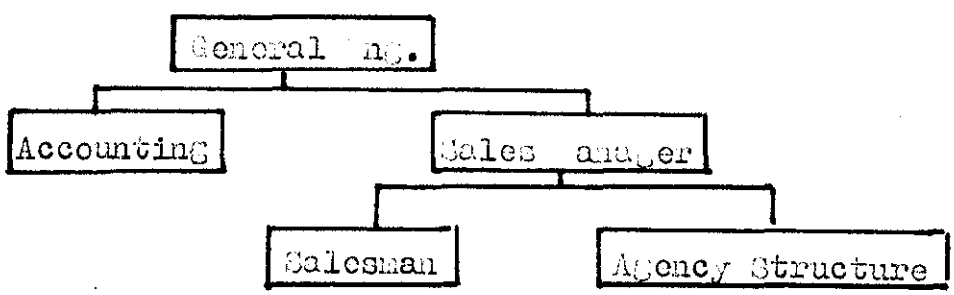


Figure 5, Present Organization Chart of Ti-Sa

The reason underlying the inclusion of Ti-Sa into the scope of our analysis are twofold, firstly, without the analysis of Ti-Sa our description of the overall system would have been incomplete and secondly it is one of the most significant components of the system. The firm is located at one of the business centers of İstanbul, Samanpazarı. The same organizational deficiencies that we have described for Production and Finance functions are also valid for the function of marketing.

2.7.1 Product Policy : Present production of Güntem covers the products that are illustrated below:

1. Standard Products
   a) Convectors
   b) Boiler (for central heating systems)
   c) Air conditioning Apparatus
   d) Santrifuj
   e) Package type boiler models
   f) Water tanks
2. Special Production
   a) The moblocks
   b) Drying equipment
   c) Vantilators

All of these products mentioned above are being produced at the factory on order basis. And major portion of the productive forces have been concentrated on the production

of convectors. There is no marketing research, sales forecasting or sales analysis so managers of the firm do not know what additional products should be included into their production line or which products should be discharged from their production line.

In Ti-Sa sales of the products are made on the basis of delivery at the factory. All expenses of transportation, insurance and packaging belong to the customer. Ti-Sa gets certain amount of premium for the products sold. General Manager of Ti-Sa has the authority to transfer up to 50 % of this premium to the customers in the form of price discounts. On the other hand the authorized dealers of the products of Günterm send 35 % (minimum 25 %) of the order price in cash to Ti-Sa. Remaining 65 % of the bill is paid at the delivery of the ordered products to the customer, and 40 % of it may be paid in the form of notes of n/121 days.

Authorized Dealers function on premium basis. A dealer gets 7.5 % premium from convector and package type boiler sales, 10 % premium from sales of vantilators and 5 % premium from boiler sales. Normal and urgent orders are treated in the same way by Ti-Sa. The factory (Günterm) is immediately informed when an order is received at Ti-Sa and an arbitrary date of delivery is given to the customer depending on the personal judgement of the production manager of Gunterm.

As observed from the table (8) there have not been substantial cancellation of orders.

TABLE 8

Sales and Returns in '000 TL.

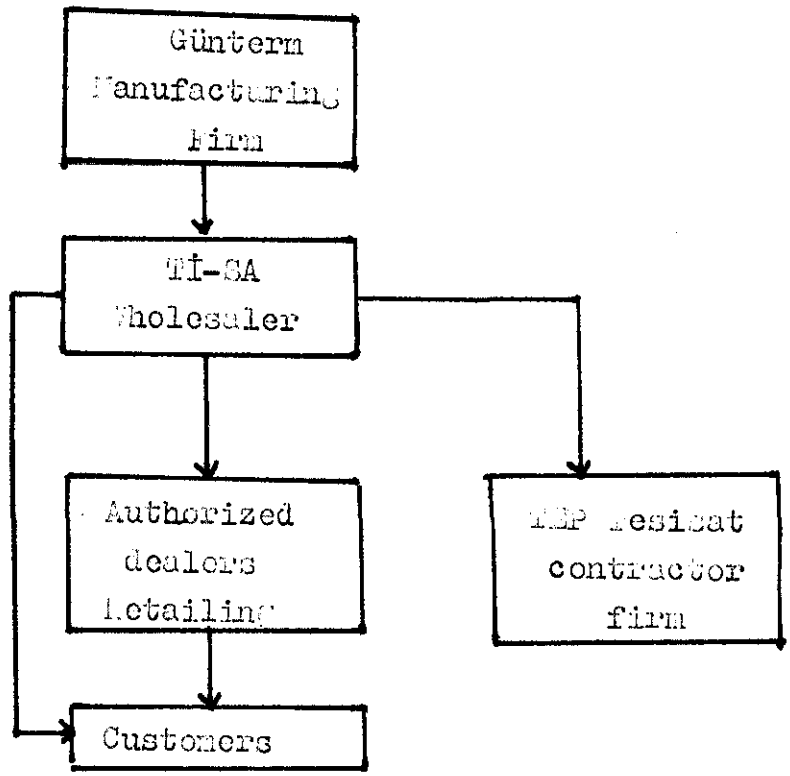
	1967	1968
Sales	5142	8480
Returns.....	169	225
R as % of S.....	3.2 %	2.1 %
Sales increase %	100.	166.

So although sales have increased by 66 % the relative share of returns in total sales of Günterm has decreased from 3.2 % to 2.1 %.

2.7.2 Place Policy: Ti-Sa makes the decisions on where, when and by whom the products of Günterm will be offered for sale.

As observed from the chart Ti- Sa plays the leading role in the distribution of goods manufactured. The system of distribution is exclusive. Ti-Sa selects the dealers; if there is more than one application for dealership the following selection criterias are applied :

Figure 6, The Present Channel of Distribution of the Products of Günterm



1. Authorized Dealer should have a technical advisor who will be able to carry out the technical responsibilities of the products of Günterm. He should also be able to promote the products.
2. Authorized Dealer should have necessary facilities to display and advertise products of Günterm.
3. Authorized Dealer cannot sell the products of the competitors of Günterm.

Present Authorized Dealers of the products of Günterm are located at Ankara, İzmir, Bursa, Kayseri, Erzurum, Trabzon and Samsun.

2.7.3 Price Policy: One of the major variables of the marketing mix, price, is determined by Günterm. Ti-Sa is responsible to maintain same price level (excluding packaging, transportation and insurance expenses) in all of the sales territories.

In determining the prices of its products, objective of Günterm is to have a certain rate of return on its sales and they use a cost oriented method in pricing their products.

Selling Price of a product = Material cost Direct, Indirect + Labor cost Direct, Indirect + Other expenses such as energy, and rent + 20 % rate of return on total cost

No premium is given to the authorized dealers for sales of special products hence the dealers sell these products by adding a certain % of profit to the price fixed by Ti-Sa.

Convector prices of Günterm are a little bit higher than the radiator prices. Besides the price range of the convector models of Günterm is higher than the convector prices of Alarko.

2.7.4 Promotion Policy and a Sample Survey: Ti-Sa is responsible for the promotion of the products of Günterm. According to the provisions of an Agreement between Ti-Sa and Günterm, the former has the right to reserve 1 % of the sales revenues for promotional activities. As in the case of all other variables, no planning is involved in promotion decisions.

Present Promotion methods used are;

- Personal Selling
- Advertising through
- Journal of Mechanical Engineers
- Various Newspapers

Personnal selling activities are confined to İstanbul region. Two salesmen were employed for this purpose. One of them works at Kadıköy area, he is a trained salesman and works on a premium basis. The second salesman handles Rumeli region of İstanbul and receives both a salary and a premium-on-sales. Their main task is to get orders from construction contractors. The General Manager of Ti-Sa has stated that the one who works in Kadıköy region has been very succesful in performing his function.

General Manager of Ti-Sa personally takes care of advertising activities. According to him, it is better to give advertisements when the salescurve is decreasing ie, Winter and Spring seasons and cut down advertisements while the sales curve is increasing ie, Summer and Fall seasons.

He asserts that the products of Günterm cannot be included into the consumer goods category, so it is not necessary to have a continuous program of advertising. The suggestions and comments on the advertising policy of the firm will be made in Chapter 5.

No customer survey has been made for Günterm. The analysis of the sales invoices of the year 1963 indicate that the major customers of the products of Günterm are various construction firms and Tep-Tesisat. The preparation and execution of a complete marketing research program is beyond the scope of this study. On the other hand a small customer survey has been made to analyze and evaluate, the competitive status of the convectors of Günterm, and the views of the customers on product price, distribution channel and advertising policies of the firm. The scope of this survey covers only Istanbul sales area. In order to complete the picture this type of surveys should also be made with the Authorized Dealers of the products of the firm, located in other sales areas. Convectors of Günterm have been sold to a total of 56 different construction firms during 1963. A random selection of 10 firms out of this total was made and interviews were carried out with the responsible personnel of the selected firms.

The questions that were asked during the interview are given below:

Questionnaire Form

For the Customers of Günterm

1. The name and place of the firm.
2. What is the main business of the firm?
   1. Apartment Construction
   2. Large scale construction (Factories, Hospitals etc.)
   3. Others.
3. What are the models that you usually purchase for your constructions?

Model	Cal/Group
A.....	
B.....	
E.....	
F.....	

4. Are you satisfied with the present number of convector models? If not, what new models or calory groups should be added into the product line of Günterm?

Model	Cal/Group
A.....	
B.....	
E.....	
F.....	

5. Have you seen advertisements of the products of Günterm? Where?

6. Do you have complaints from the convectors that you have purchased from Günterm? If yes, will you list them?

Are you satisfied with the present packaging of the convectors?

8. Would you purchase convectors prior to the construction season (ie. in Winter and Spring) if you were given a price discount? If yes, at what discount level?

9. How do you compare convectors of Günterm with those of Alarko? in terms of :

1. Price — Higher / Same / Lower
2. Quality — Higher / Same / Lower
3. Presentation
4. Others

10. Were you visited by our salesman?

Evaluation of the Results of the Interviews.

The answers of these questions were collected and classified at the end of the survey. The objectives of the survey have been defined first and then the questions have been formulated so we may claim that they measure what was intended to measure. Moreover the questions were personallized and asked directly to the responsible personnel of the selected firms, who know the preferences and responses of their customers on the pricing and quality of convectors. Secondly, we might also claim that the degree of destortion in the information that is given to the interviewer is negligible, because it was to their benefit if they provided the right information.

Second significant question that we might ask ourselves in evaluating structure of the survey is, whether the results are actually representative or not? Here we can consider the results as representative at least for the İstanbul sales region because the firms that have been interviewed were randomly chosen and the resulting composition of the sample was representative. However the difficulty is in determination of the eventual margin of error.

Out of 10 randomly selected, 6 were located at the Rumeli Region and the remaining 4 were located at Kadıköy region of İstanbul. Eight of them were involved in small scale apartment construction business only two of these

firms were also involved in large scale contracting agreements. The answers of the first question are summarized in table 9, the figures in boxes indicate the number of firms that prefer the specific model and calory group.

TABLE 9

Summary of the Answers of Questions

Model / KCal.	A	B	E	F	Total
500	-	-	1	-	1
1000	4	-	2	-	6
1250	1	-	-	-	1
1500	2	1	-	-	3
1750	1	3	-	-	4
2000	1	2	-	4	7
2250	1	-	-	-	1
2500	-	1	-	-	1
2750	1	-	-	1	2
Total	11	7	3	5	26

The analysis of table 9 indicate that 27 % of the firms have preferred the calory group of 2000, 23 % preferred 1000 Cal. and 15 % preferred 1750 Cal. 11 % preferred 1500 Cal. and the remaining 24 % preferred various other calory groups. The priority of preference according to the models have been in the form of A, B, F and E. Seven

firms were satisfied with the present number of convector models. One of the remaining three firms asked for the production of 4500 Cal/size of model A other two firms asked for the production of over 4000 Cal/sizes of Model B.

60 % of the interviewes have seen the advertisement of the products of Günterm, of which 40 % have seen the advertisements in Milliyet and Cumhuriyet newspapers and the remaining 20 % in journal of Mechanical Engineers. The main complaints of the customers from the convectors of Günterm have centred around the following points;

1. In many cases convectors do not meet the specific color requirements of the customer.
2. In many instances goods with production defects have been offered for sale.
3 Products have not been delivered to the customer at the time set by the production manager of Günterm.

All of the interviewes were satisfied with the packaging of the convectors. 80 % of the firms have indicated that they would purchase convectors prior to the construction season if they were given, at least 10 % reduction in the price level of convectors. All of the interviewess stated that the price level (in general because the models of Alarko are different) of the convectors of Günterm is same with those of Alarko. However three of them found that the

quality of the convectors of Alarko,higher than the convectors of Günterm,and four of them stated that the products of Alarko were presented in a better way than the products of Günterm.Five of the firms were visited by salesmen of Tİ-SA and three of these five firms located at the Kadıköy sales region.The suggestions to improve the marketing activities of the system based on this survey,prior analyses and simulation results will be done in Chapter5.

2.7.5 Summary of the Marketing Problems of the Firm.

As a result of the observations and interviews with the personnel responsible for the marketing operations of the firm and customers,following conclusions and problems are drawn:

I.There is no clear cut organizational set up for the pr
proper performance of the marketing function.
functions of the existing personnel have not been clearly defined.Existing personnel do not have formal education and proper background in the field of marketing.No scientific tool have been used in making important marketing decisions,there is no marketing research,sales forecasting and sales analysis.The target markets have not been clearly defined.

2.There has been a lack of coordination between the

authorized dealers and Ti-Sa.The number of authorized dealers is very limited,it is also difficult to find adequate dealers. Problems between dealers and Ti-Sa frequently arise due to:

-inability of the firm to deliver orders at specified times.

-Production failures on products of the firm.

-Inability to match the color of the delivered products with the customers' color specifications

3.Promotion policy is not effective.There is no planning activity.There is no clear cut policy on advertising activities.Present advertising budget is not enough to carry out promotional activities of Günterm.

4.There is a considerable lack of coordination between Günterm and Ti-Sa.

2.8 A Possible Integration of the Problem Areas:

The problems that have been derived in the preceding sections of the chapter are illustrated in a matrix form in Table I@.As observed in this matrix,the problems of the firm have been divided into three categories:

I.Administrative Problems.

2.Operational Problems.

3.Strategic Problems.

The first category covers the problems related to th

to the structuring of the firm's resources in a way which creates a maximum performance potential,such as,problems related to the structuring of authority and responsibility relationships,workflows,information flows and coordination.By operational problems we mean specific problems of each function such as,the production defects on the products,worsening of cu current financial position or problems that exist between the customers and the firm.By the term strategic,we mean those problems that have greater influence on the overall effectiveness level of the system and they are selected out of the problems of the first and second categories.In fact this categorization of the problems mainly serves the purpose of illustrationbecause of the high level of interdependence that exist among all of the problems.For instance,worsening of the current position is related to mainly organizational (administrative) weaknesses.Order based production system with no planning results in an inadequate raw materials inventory policy with no finished goods inventory system.When high level of seasonal fluctuations of sales is added to the facts stated above,we obtain the delivery problem,ie:the problem that arises because of the frequent failure of the firm in delivering ordered products to the customers on time.This is one of the most important problems that face the management of Günterm.In spite of the increase in the level of annual sales of convectors, there have been a great loss of confidence among the construc-

TABLE 10
MATRIX OF PROBLEMS

FUNCTION / PROBLEM	FINANCE	PRODUCTION	MARKETING
ADMINISTRATNE PROBLEMS	No clear cut organizational set up Inadequate Personnel No managerial Acc. system.	No clear cut organizational setup Functions of the existing Personnel have not been defined. No adequate coordination with TI_SA.	No clear cut org setup. No scientific tool in making marketing decisions. Lack of coordination with TI_SA-GUNTERM- AUTH. DE[illegible]
OPERATIONAL PROBLEMS	Current position worsened Inadequate credit Policy No long term liability High debt [illegible] tworth ratio High volume of selling and interest exp. Decrease [illegible] ting power	No production planning Contol No inventory " " Production defects. No delivery on time labor problems strike low morale	Problems with Authorized Dealers. inability to deliver on time goods with Production defech Color problem Promotion problem
STRATEGIC PROBLEMS	Problem of Long Term Capitalization	Problem of Production Planning and Control	Utulization of marketing tools good distribution channel Promotion Policy

tion contractors against the firm.This heavy loss of goodwill may decrease the relative share of Günterm in the competitive market that has been described in section 2.2.A possible solution of this problem is the reorganization of the system.The overall reorganization problem is beyond the scope of this study.But,one of the components of this proposal ie:the establishment of a production planning system will be the subject of the next Chapter.

CHAPTER 3

PRODUCTION AND FINISHED GOODS INVENTORY SIMULATION SYSTEM

3.I Objective of Designing the System

One of the significant conclusions of Chapter 2, have been the frequentfailure of the firm in delivering ordered products to the customers on time.Production of the firm is on order basis and there is no production planning.Consequently the firm also does not possess a finished goods inventory system and this is the major reason of the problem that is stated above.That is to say,inexistance of a finished goods inventory system together with the high level of seasonal fluctuations in sales have resulted in an extremely inefficient system of customer services.So there have been a considerable loss of goodwill of customers against the firm.On the other hand,due to the order based and inefficient production systemthere have been wide fluctuations in the number of units produced per period ,causing high costs at the factory level.

Analysis of the problem matrix that was developed in Chapter 2 reveals the fact that,effectivenesslevel of the overall system might be improved if an appropriate production planning and finished goods inventory system is introduced into the system.Firstly,there will be a decrease in the number of

stockouts and secondly,there will be a decrease in the number of production rate variances leading to lower production costs. Furthermore,as a normal consequence of these developments a raw materials inventory system will be established leading to a considerable decrease in the existing level of raw material costs because of the large gap between prices of the regular raw material suppliers and that of the market.

3.I.2 Proposed solution and its Objective

The objective of the present Chapter is to design a production-inventory simulation model which will be used to optimize total production and inventory carriying costs while avoiding stockouts under different demand conditions and production decision rules.Simulation technique has been chosen to explore various courses of action under alternative decision making situations and to anticipate the consequences of each alternative without actually trying themout in the existing system.

3.I.3 Alternative Solutions

An alternative of designing a simulation system is producing the product on demand.This would mean preservation of the existing system and its weaknesses have already been explained.Another alternative is to design a raw materials inventory system only.This will be a partial solution of the problem because the firm will continue to meet stockouts due large seasonal fluctuations of sales.Finally,the firm might prefer to lose business.However ,as it is stated in Chapter2

more than 50% of the production facilities of the firm have been concentrated on the production of convectors and the share of convectors in total annual revenue of the firm is higher than the share of other products that the firm produce.

3.2 Description of the simulation System as a Whole

The System is composed of three major elements;

1. A general order simulation model that is used to generate expected monthly order for each product for a period of 12 months.
2. A Production and Finished Goods inventory simulation model that acts on the forecasts provided by the order simulation program and applies alternative heuristic aggregate production plans with alternative production priority rules and keeps record of the outcomes of these applications.
3. Evaluation of the outcomes.(Figure 7)

A detailed description of the elements of the simulation system will be done in the following sections of the Chapter.

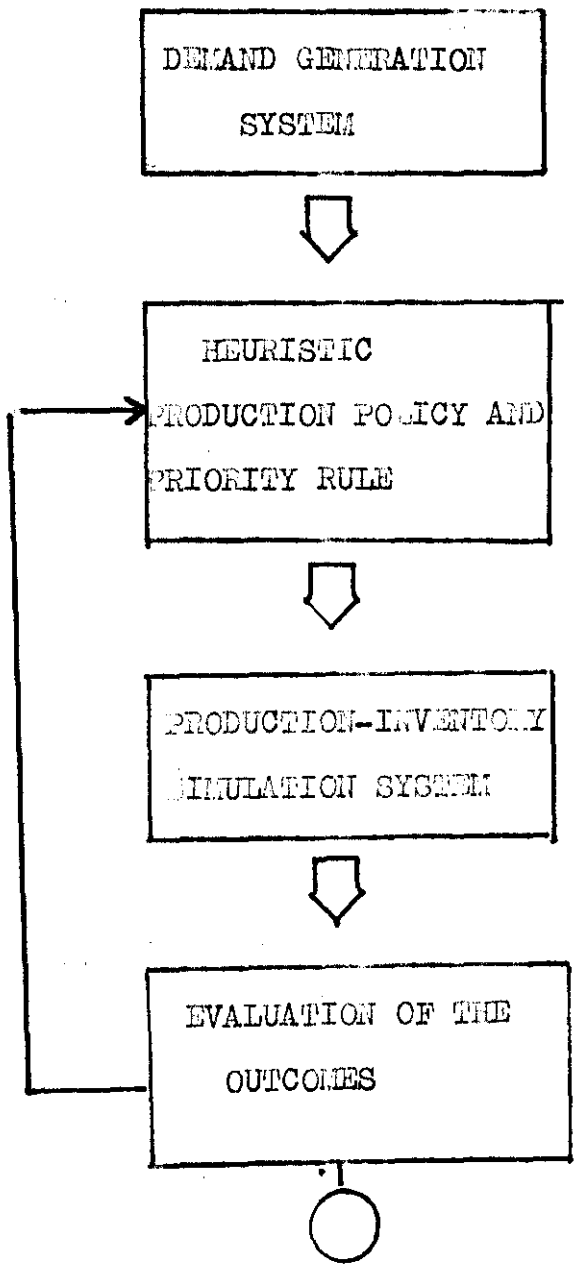
3.3 Demand Generating Simulation Program

This program generates monthly orders of eight convector models for a period of 12 months.The outputs of the program are used as the orders to be produced by the production-

inventory simulation model.

Figure 7

Flow Chart of the Simulation System



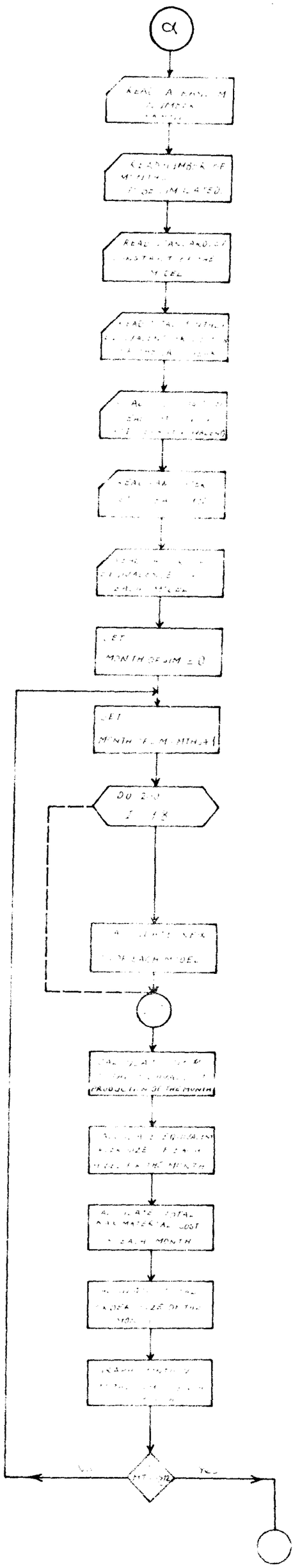
3.3.I Description, Assumptions and the Flow-chart of the Program

In order to make the calculations to generate monthly order size of each model of convector, this program makes the computer to read a random number, number ofmodels to be simulated, number of months to be simulated, equivalent total monthly production of last year, production percentages of each model for that month and the standard devuation constant for each model. Moreover factor of equivalence of each model and their total raw material costs are given as inputs to the program to calculate total raw material cost of the orders generated for each month.

To obtain new production percentages for each model the random number, the standard deviation constant of that model and production percentages of each model for the month are multiplied together and the product is added to the production percentage of the model for the month. To obtain new equivalent order size of each model for the month, new production percentages calculated are multiplied with equivalent total monthly production of the last year. The order size of each model in actual units , for the month, is obtained by dividing the equivalent order size of each model into its factor of equivalence. Then, order size of each model in actual units are multiplied by the raw material cost of each model and the

FIGURE 3.3 FLOW CHART OF THE PROGRAM

GENERATING SIMULATION PROGRAM



results are added together together to obtain total raw material cost figure of the month.

Assumptions of the Program:

I.Monthly demand of each model of convectors is distributed normally. (Figure 9)

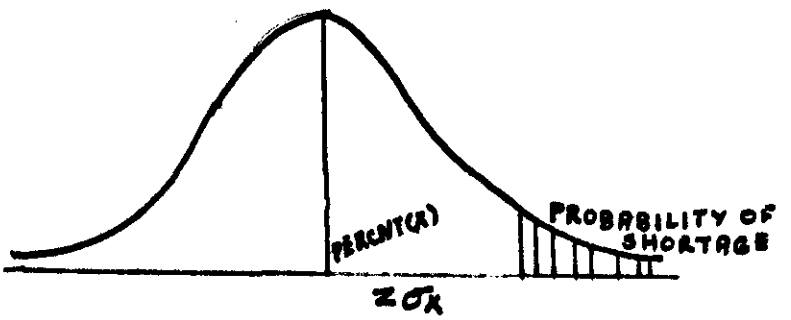


Figure 9:Probability Density Function of montly sales.

2.Mean of the distribution is equal tothe percentage share of the model in the last year's total equivalent demand for the same month.

3.Standard deviation of the distribution is assumed tobe equal to the product of a given constant with the mean of the distribution.The standard deviation constant of each product is determined through experience and it is usually between 0.50 and I.00 . Although it is possible to make a statistical analysis of the orders for the past years to determine these constants,here,they are assigned arbitrarily because

of the lack of actual sales data of past years.

$$Q(x) = FK(x) \cdot PERCNT(x)$$

$$Z = \frac{NPERCNT(x) - PERCNT(x)}{Q(x)}$$

$$NPERCNT(x) = (Z)(Qx) + PERCNT(x)$$ Where;

Q(x): Standard deviation of demand for product x

FK(x). Standard deviation constant of that product.

PERCNT(x). Mean of the distribution

Z. RAND(-RAND)

NPERCNT(x). New percentage share of the model for the month.

4. Equivalent factor numbers are assumed to be proportional to the direct labor content of the product.

3.3.2 Inputs of the Program

Here, inputs of the Demand Generating Simulation Program and the methods of their calculations will be described.

I. A random number is obtained from a random number generator.

2. Number of months to be simulated; in this study the simulation is made for 12 months.

3. Number of products to be simulated; the simula-

tion is performed for eight different models of convectors.

4.Factor of equivalence for each model is obtained by dividing the maximum per shift production capacity among eight models into per shift production capacity of the model.Maximum per shift production capacity belongs to covectors of sizes smaller than I40 cm,and it is 40 units/shift.On the other hand,the production capacity drops to 30 units/shift for the convectors having sizes larger than I40 cm.So,

Production capacity/shift for A_1, B_1, E_1, F_1 is 40 units,

Production capacity/shift for A_2, B_2, E_2, F_2 is 30 units.

For example:the factor of equivalence for model A_2 is $\frac{40}{30}$=I.33

5.Equivalent total production of each month of the last year(I968) and the size of each product order as a percentage of total equivalent orders of the month;actual amount of production of each model for each month of the past year is obtained from the records of the factory.Then these figures are multiplied by their respective equivalence factors to obtain equivalent production of the model for the month and they are added together to determine total equivalent production of the month.The equivalent percentage share of each product in total equivalent production of the month is obtained by dividing total equivalent production of the month into equivalent production of the model for that month.

6.The standard deviation constant of each model is assigned arbitrarily.

7.Total raw material cost of each model.These costs are calculated according tothe data taken from the records of the firm.

3.3.3 Outputs of the Program

Two types of output are obtained from simulating the demand generating simulation program;

I.A matrix of simulated equivalent orders of eight models for I2 months,their equivalent totals and total raw material costs for each month.

2.A graph on which simulated total equivalent production of each month is plotted.

We have ran the program for ten times with different random numbers in order to see the effect of each random number on the simulated equivalent orders of each model.

3.3.4 Evaluation of the outputs of simulation

As observed in table II,there is not much difference between total actual equivalent order size of the year I969 and total equivalent demand levels that have been simulated under alternative random numbers.A comparison of actual and simulated demand of the first three months of I969 is made in Table I3.As observed in this table,actual total

Table II

Total Simulated Demand in Equivalent Units

For the Year I969

Actual Demand of I969	First Sim. Random No: .4543I	Second Sim. Random No: .32225	Third Sim. Random No: .4I02I	Fourth Sim. Random No: .I92I3
5330	54I0	5369	5II2	5I02

Table I2

Actual and equivalent Orders for the First Three Months of I969

Model	EFACT. (A)	ADEM. Jan. (B)	EDEM. Jan. (A)x(B)	ADEM. Feb. (C)	EDEM. Feb. (A)x(C)	ADEM. March. (D)	EDEM. March. (A)x(D)
A_I	I.00	24	24	29	29	24	24
B_I	I.00	I22	I22	I8	I8	8	8
E_I	I.00	I0	I0	I5	I5	I2	I2
F_I	I.00	4	4	I9	I9	I	I
A_2	I.33	2I	27	II	I4	I0	I3
B_2	I.33	55	72	29	38	8	I0
E_2	I.33	I	2	9	I2	I	I
F_2	I.33	42	55	I3	20	II	I4
TOTAL.		I79	3I6	I45	I65	75	83

EFACT: Factor of equivalence

ADEM:Actual Demand

EDEM:Equivalent Demand.

Table I3

A Comparison of Actual and Simulated Orders

For the First Three Months of I969

Model	ADEM? jan.	SDEM. jan.		ADEM. Feb.	SDEM. Feb.		ADEM. Mar.	SDEM. Mar.	
		.32225	.I2345		.32225	.I2345		.32225	.I2345
A_I	24	48	49	29	I4	I4	24	I2	I2
B_I	I22	I70	I74	I8	I8	22	8	2	2
E_I	I0	33	4I	I5	5	6	I2	I4	I4
F_I	4	7	7	I9	9	I2	I	I	I
A_2	27	I2	I2	I4	36	29	I3	2I	25
B_2	72	24	25	38	I0	I0	I0	2	2
E_2	2	4	4	I2	I7	I7	I	I	I
F_2	55	3	3	20	6	6	I4	30	3I
TOTAL	3I6	300	3I6	I65	II5	II6	83	90	88

SDEM:Simulated Demand

monthly demand and simulated total monthly demands of alternative random numbers donot have significant differences. Random number .32225 will be used to generate demand in the following Chapters of the study.

3.4 Production and Finished Goods Inventory Simulation Model

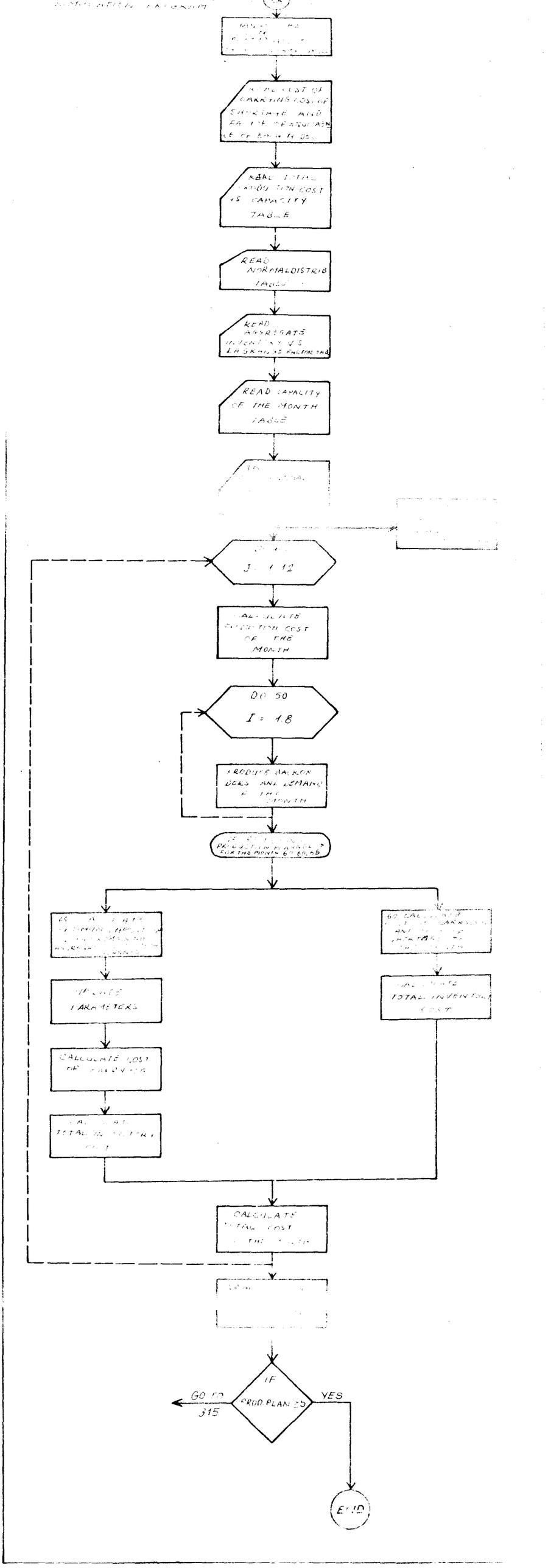
This program simulates a given demand matrix under alternative production plans and production priority rules and calculates the total cost of each simulation.

Total Cost=Total cost of Production+Total Raw Materials Cost+Total cost of carrying+Total Cost of Shortage.

A general flowchart of the program is illustrated in Figure IO and its detailed FORTRAN flowchart is given at Appendix 3.

3.4.IDescription and Flowchart of the Program

Firstly,the demand matrix generated by the Demand Generating simulation program,(EC(J,I),J=I,I2 I=I,8), is stored into a new matrix called EMP(J,I).Then, a production priority rule is read that will alter the places of the columns of the original demand matrix.Secondly,cost of shortage, inventory carrying cost and factor of equivalence of each model are read.Thirdly,standard deviation of the monthly demand distributionof each model is read.Then,table of "Lagrange Factors and Corresponding Aggregate Inventory Levels" and "Normal Distribution Table",are read.Then,total production capacity of the plant for each month of simulation are read. Following table of " Annual Capacity of the Plant",the first heuristic production plan that will be applied to the demand


READ COST OF MARKETING COST OF SUBSTITUTE AND
READ TOTAL PRODUCTION COST VS CAPACITY TABLE
READ NORMALDISTRIB TABLE
READ AGGREGATE INVENTORY VS EMERGENCY FACTOR TAB
READ CAPACITY OF THE MONTH TABLE
DO 1 J = 1,12
CALCULATE DEPRECIATION COST OF THE MONTH
DO 50 I = 1,8
PRODUCE RANDOM NUMBERS AND DEMAND OF THE MONTH
IF (I.EQ.1) PRODUCTION PLAN=X FOR THE MONTH BY HAND
UPDATE PARAMETERS
CALCULATE COST OF FOLLOWING
CALCULATE TOTAL INVENTORY COST
CALCULATE TOTAL INVENTORY COST
CALCULATE TOTAL COST OF THE YEAR
IF PROD.PLAN=25
GO TO 315
YES
END

matrix generated is read.Then monthlycapacity utulization factor of the production plan is calculated and total production cost of that capacity utulization factor is read by the computer.Moreover,the program makes the beginning inventory of each model for the first month equal to zero.Then,demand of the month is produced according tothe production priority rule by the production loop.If aggregate production figure planned for the month is greater than total demand of the month plus backorders of the month of each model,the difference is calculated and optimum composition of the remaining aggregate production planned is found through a mathematical model which will be described in section 3.4.4 .Equivalent ending ending stock on hand figures are transformed into actual figures by dividing ending stock on hand of each model into t their corresponding factor of equivalences.Actual ending stock on hand of each model is multiplied by its corresponding cost of carrying to obtain total inventory carrying cost of the model for the month.Then,total inventory carrying cost of each modelis added together to obtain total inventory carrying cost of the month.If aggregate production planned for the month is less than or equal to the total demand of the month plus beginning inventories of each model for the same month,amount of stockouts of each model computed by the production loop are transformed into actual units by dividing them into their

corresponding equivalence factors.Then,actual stockout of each model is multiplied by its inventory shortage cost to obtain total inventory shortage cost of each model for the month. Finally,total inventory shortage cost of each model is added together to obtain total inventory shortage cost of the month. Then,total inventory carrying cost of the month is added to the total inventory shortage cost of the month to obtain total inventory cost of the month.Total cost of the month is obtained by adding total cost of production and total cost of inventory together.The stockouts of the month are backordered tothe next month and ending stock on hand figuresof the month are transferred as beginning inventories of the next month.This process of computation is repeated for a period of I2 months and as a whole the process is repeated for five annual production plans.The ending inventory at the end of each year, whether in the form of poducts or backorders,are tranferred to the first month of the next year.Since simulation process covers a period of one year,they will not be taken into consideration here.However,their inventory carrying or shortage costs are included into the total cost figure of the last month of the simulation period.

3.4.2. Assumptions of the Program

I.Total production decisions are made at the beginning of each year and total production,its monthly

distribution is determined for the entire period in aggregate equivalent units.

2. A production period is to be taken one month and the production plan of the month is put into effect at the start of that month.

3. The production is in lots and the detailed timing of production within the month is not included in this study.

4. At the beginning of a new month the products that are out of stock are the first to go into production. Then new demand of the product is satisfied.

5. The monthly demand of the products have a normal distribution.

6. It is further assumed that two costs are effected by the inventory decisions, ie; cost of shortage and cost of carrying.

Specific assumptions related to the calculation of the costs will be given at section 3.4.3 of the chapter.

3.4.3 Inputs of the Program

In addition to the Demand matrix generated by the Demand Generating Simulation Program, two major groups of input data will be taken into consideration in this section of the Chapter. These two groups and their internal classification can be summarized as;

1. Cost Inputs:

A. Production Costs of the firm

B. Inventory Costs of the firm

2. Production Inputs and Tables

A. Annual Aggragate Production Plans

B. Production Priority Rules

C. Total monthly production capacity of the Plant for 12 months

D. Table of "Lagrange factors and their corresponding Aggragete Inventory levels"

E. Table of Normal Distribution.

F. Capacity vs Total Production Cost Table

1. Cost Inputs:

A. PRODUCTION COSTS OF THE FIRM

Production costs of the firm are divided into three categories as Fixed Costs, Semi-Fixed Costs and Variable Costs. Fixed costs of the firm are Rent, Salaries of the administrative personnel, Depreciation, interest and Commissions paid, Office expenses, sales expenses and set-up costs. Cost of labor is analyzed as a semi-fixed production cost. Only cost of electricity is taken as the variable cost here. Raw material cost of the products are calculated in Demand Generating Simulation Program.

Fixed Costs: Cost figures are taken from the Financial Statements of the Firm for the year 1966, and they are assumed to remain constant during the period of simulation. Moreover only 50 % of the relevant fixed costs have been allocated to the production of convectors because; as it has been stated the production line of the firm includes products other than convectors, and as estimated by the managers of the firm more than 50 % of the production facilities have been allocated to the production of convectors. The fixed costs are expected to be as follows;

TABLE 14

Fixed Costs of The Firm Monthly

in TL.

Depreciation	4375
Selling exp.	24333
Shipping and delivery	5625
Interest, commission	3958
Office exp.	166
Salaries	10000
Set up cost	500[1]
Rent	500
Total	55057 TL.

[1]Set up cost includes the cost of man-hours required for set up plus cost of having the machines idle whise being set-up. The cost of each set up is calculated as 100 TL. and it is assumed that there will be on the average eight set ups per month. So total monthly set up cost is 800 TL. In practice, there may be small variation in the total number of monthly set ups, but, since set up cost of each model is relatively small this variance will not be considered here.

Semi-fixed Costs: The cost of direct labor per shift is independent of the number of convectors produced. However according to the law a worker must receive 50 % additional premium to work overtime so, cost of labor increases by 50 % when the capacity utilization level of the plant is between 1.00-1.50.For capacity utilization levels over 1.50 up to 2.00 (ie, two shifts per day) the firm has to employ additional labor while doubling its total cost of labor. The cost of hiring additional workforce for the second shift is almost zero becuse cost of the time consumption of the personnel clerk is relatively so small that it may be neglected.

Cost of Labor Table 15

Department	No. of Workers	Average Wage/hr. TL.
Preparation	26	331
Painting	5	337
Serpantin	22	263
Last Assembly	3	315
Nightwatchmen	4	312
Stockroom pers.	7	280
Electrician	3	390
Delivery pers.	4	240
	74	

TABLE 16
Monthly Capacity Utilization vs Total Labor Cost Table

Capacity Utilization Range	Total Monthly TL. Labor Cost
.26-1.00	54369
1.01-1.25	75599
1.26-1.50	96230
1.51-2.00	109936

Variable costs: Variable costs of the firm are raw material costs of the units produced and variable overhead costs. Raw material cost of the monthly orders have been calculated while monthly equivalent orders of each model are being generated by the Demant Generating Simulation Program. The total cost of electricity is 1295.60 TL./month for cap. Utilization Level of.26

2567.20 TL/month for cap.Utilization Level of .51
3880.80 " " " " .76
5174.40 " " " " 1.01
6468.00 " " " " 1.26
7761.60 " " " " 1.51
9055.20 " " " " 1.76
10348 .80 " " " " 2.00

Innconclusion, the Total Production Cost Table (excluding cost of raw materials) for different capacity utulization levels are given below:

Table I7

Total Production Cost Table

Capacity Utulization level	Total Cost of Production
.26	III32o
.5I	II26I3
.76	II5906
I.0I	II5200
I.26	I37I24
I.5I	I59048
I.76	I74050
2.00	I75344

B. INVENTORY COSTS OF THE FIRM

As it has been stated in section (3.4.2) two major costs are effected by the inventory decisions, Inventory carrying cost and the cost of being out of stock.

Inventory Carrying Cost: In the calculation of the cost of carrying a product in inventory only opportunity cost of money that is tied up will be taken into consideration, because

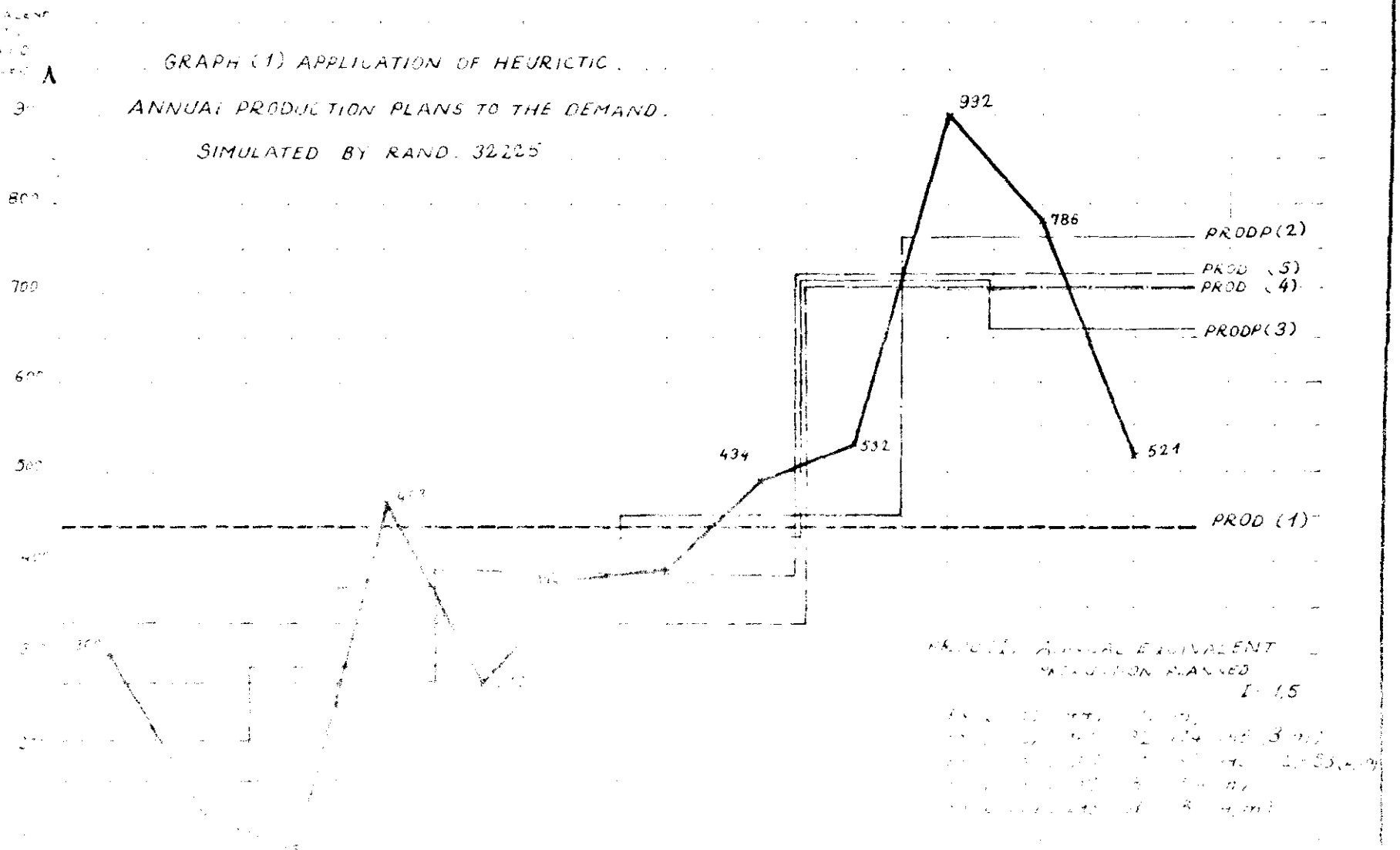
ample space for storage is available with actually zero cost to the firm.Secondly,the convectors are not subject to deterioration for a considerable length of time.Thirdly,no insurance cost is incurred for the products kept in the inventories. Opportunity cost of money for the firm is taken as 14%.This is also a valid assumption because existing market rate of interest on marketable securities is around 13-14 %.So total cost of each model is multiplied by the monthly opportunity cost of money percentage to obtain per unit inventory carrying cost of each model for a period of one month.For example,the cost of keeping a unit of model A_1 in the inventories of the firm for a month is 3.82 TL.

Inventory Shortage Cost:As it has been stated previously,the firm usually cannot fill the orders on time, and due to the downpayment clause of the Sales Contract the customer is forced to wait,to have his order filled.Interviews with a sample of customers indicated the fact that,customers were dissatisfiedto a large extend because of the frequent failure of the firm in delivering their products on time.Although there is no scientific way of measuring the cost of this dissatisfaction or loss of goodwill,it is one of the most significant inventory cost factors for the firm.Consequently, we have estimated the cost of being out of stock per unit as 20 TL.

2.Production Inputs and Tables.

A.ANNUAL AGGREGATE PRODUCTION PLANS :Total production decisions are made at the beginning of each year. So firstly,the expected demand matrix for the year I969 has been simulated by the Demand Generating Simulation Program assuming that the decision maker is at December I968.Then,five different annul aggregate production plans are prepared to meet the order pattern generated for the year.Naturally there are numerous possible aggregate annual production plans that can be applied to the simulated annual demand.Here it is practically impossible to test all of these alternatives,so I have selected those five production plans heuristically, ie, I have picked out those plans that seem interesting or likely to work and I have tried to evaluate them using the simulation model that have been described in the previous sections of the study.

The first production plan is designed according to a constant production rate per month.This constant production rate is obtained by dividing total annual demand,generated by the Demand Generating Simulation Program,into I2 months. The total annual demand generated for the year have been 5369 equivalent units so monthly distribution of the production plan is determined by dividing this figure into I2 ie,447 equivalent units per month.The monthly distribution of the second production plan is calculated by taking the arithmetic


GRAPH (1) APPLICATION OF HEURICTIC.
ANNUAL PRODUCTION PLANS TO THE DEMAND.
SIMULATED BY RAND. 32225
932
786
PRODP(2)
PROD (5)
PROD (4)
PRODP(3)
434
532
521
PROD (1)

mean of the each three month periodtotals of the simulated demand matrix.For instance,the total equivalent demand of of the first three months of the year is 505 equivalent units (300+II5+90)and their arithmetic mean is equal to I68 equivalent units per month.So I68 equivalent units of production is planned for each month for a period of first three months of the year.The third production plan is obtained by taking the arithmetic mean of the bi-monthly demand.The fourth production plan has been designed as to maintain a constant production level for the first eight months of the year and then a higher level of production for the last four months of the year.Arithmetic mean of the four monthly total demand is taken to obtainthe monthly production distribution of the fifth plan.

B.PRODUCTION PRIORITY RULES

The production priority rule defines the order of production that is planned for the month.It is the answer of the question,"Which model's monthly aggregate order will be satisfied first,second..etc ?"In this study two production priority rules will be tested under alternative production plans and demand matrices and the effect of each rule on total cost of the year will be evaluated.The first production priority rule is,"Produce in accordance with the order provided by the original demand matrix."So,satisfy aggregate monthly

order of the model A_1 first, then $B_1, E_1, F_1, A_2, B_2, E_2, F_2$. The second production priority rule is, "Produce in the order of percentage share of each model in total demand of the month." So, if this rule is in application the aggregate monthly demand of model B_1 will be satisfied first, because this model has the highest % share in total demand of the year 1968. Then, models $A_2, F_2, A_1, B_2, F_1, E_1, E_2$ will be produced in the same order they are written here.

Naturally one may design many production priority rules. The purpose of this study, however, is to illustrate the effect of a change in the order of production priorities on total cost of the year.

C. Total Production Capacity of the Plant for 12 months: There is no work on Saturdays, Sundays, National and Religious Holidays. Total working days per year is 257 and production capacity of the plant is 40 equivalent units per day. Total production capacity of the plant for each month is obtained by multiplying number of working days in that month with daily production capacity of the plant.

D. Table of Lagrange Factors and Their Corresponding Aggregate Inventory levels: The derivation of this Table will be explainedin section 3.4.4.

E. Table of Normal Distribution.

F. Capacity vs Total Production Cost Table.

3.4.4 Description of the Mathematical Model for Determining Optimum Composition of Residual Aggregate Production Planned.

If aggregate production figure planned for the month is greater than total demand of the month plus backorders of each model for the month, optimum production composition of the residual aggregate production planned is computed with the help of this routine. The objective of this mathematical model is to reach an optimum inventory decision rule for residual production planned that achieves an economic balance between cost of carrying and cost of shortage of each model, taking into account the forecast of sales for the period. All of the assumptions that have been stated in section 3.4.2 are relevant for the model. The detailed derivation of the model is given in Appendix 2. According to the model, optimum inventory rule for each model is obtained by eqI.

$$(I) \qquad OSOH(I) = -Q(I)\, N^{-1}\left(\frac{CC(I)-/\_\_\_}{CC(I)+CS(I)}\right) \qquad I=I,8$$

From the definition of aggregate inventory,

$$(27 \qquad PROD = \sum_{I=1}^{8} OSOH(I)$$

$$(3) \qquad PROD = \sum_{I=1}^{8} Q(I)N^{-1}\left(\frac{CC(I)-\lambda}{CC(I)+CS(I)}\right)$$

Where; N^{-1}= Inverse function of the normal distribution.

OSOH(I)= Optimum inventory rule for model (I) I=I,8.

Q(I)=Standard deviation of the demand distribution for model(I).

CC(I)=Inventory holding cost of a unit of model(I) for a month.

CS(I)=Cost of being out of stock by one unit of model(I).

PROD=Aggregate inventory constraint for the month.(ie,Residual aggregate production planned)

λ =Lagrange Factor.

Here,the Graphical Method of solution will be used to solve eq(3),explicitly for λ and PROD.This method of solution is composed of the following steps:

1.Firstly,alternative values will be assigned to λ.

2.Secondly,the corresponding value of PROD for each value of λ will be computed.

3.Thirdly,the resulting pair of values of λ and PROD will

be plotted on a graph.

4. Fourthly, these values will be interpolated to obtain a graphical relationship between the two variables.

5. After the calculation of the curve, aggregate inventory level corresponding tothe residual aggregate production planned for the month will be determined and the value of λ of that aggregate inventory level will be obtained from the Graph.

6. Finally, this value of λ will be inserted into eq(I) to obtain optimum inventory rule for each model.

Computation of Aggregate Inventory vs λ curve for the Firm: In order to obtain able of Lagrange Factors and Their Corresponding Aggregate Inventory Levels, the graphical solution method that is described above has been used.

Table I8: Input values TL.

Model	No	CC(I)	CS(I)	(I)
A_1	I	3.82	20.00	I0.00
B_1	2	3.77	20.00	I0.00
E_1	3	5.40	20.00	I0.00
F_1	4	3.48	20.00	I0.00
A_2	5	8.06	20.00	I0.00
B_2	6	8.38	20.00	I0.00
E_2	7	5.40	20.00	I0.00
F_2	8	5.40	20.00	I0.00

TABLES FOR THE GRAPHICAL SOLUTION

$$PAREA(I)=.5\frac{CC(I)-\lambda}{CC(I)+CS(I)}$$

Where PAREA(I) is the pobability of the shaded area of the normal distribution curve illustrated in figure(IO).

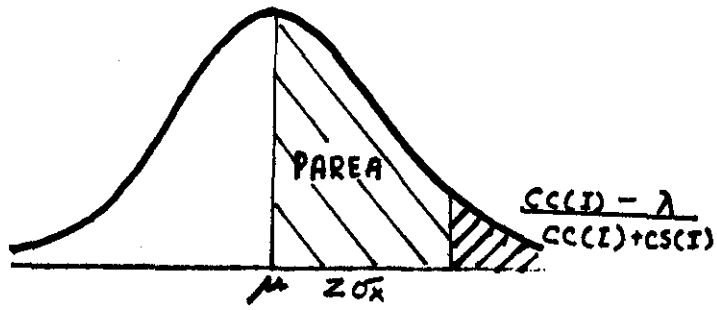


Figure IO:The normal distribution curve and probability of shortage.

Table I9

	PAREA(I)							
I :	I	2	3	4	5	6	7	8
λ								
0	.I60	.I59	.2I3	.I48	.287	.295	.2I3	.2I3
.5	.I39	.I38	.I93	.I27	.26[illegible]	.27[illegible]	.I[illegible]3	.I[illegible]3
I	.II8	.II6	.I73	.I06	.252	.260	.I73	.I73
I.5	.097	.095	.I54	.082	.234	.242	.I54	.I54
2	.076	.074	.I34	.063	.2I6	.225	.I34	.I34
-3	.286	.286	.33I	.276	.394	.40I	.33I	.33I
-5	.370	.369	.409	.36I	.465	.47I	.409	.409
-6	.4I2	.4II	.448	.403	.499	.499	.449	.449

Table 20

Table of Standard Deviation Coeeficients

	ZAREA(I)							
I:	I	2	3	4	5	6	7	8
Δ								
0	I	I	.8	I	.5	.5	.8	.8
.5	I	I	.8	I.I	.6	.5	.8	.8
I	I.I	I.2	.9	I.2	.6	.6	.9	.9
I.5	I.3	I.3	I	I.3	.7	.7	I	I
2	I.4	I.4	I.I	I.5	.7	.7	I.I	I.I
-3	.5	.5	.4	.5	.2	.2	.4	.4
-5	.3	.3	.2	.3	.I	.I	.2	.2
-6	.2	.2	.I	.2	0	0	.I	.I

Asymptotes: The detailed description of the calculations to find asymptotes of the curve will be made in Appendix 2.

Left Asymptote, MAX(-CS(I)) = -20

Right Asymptote, MIN(CC(I)) =3.48

Table 2I

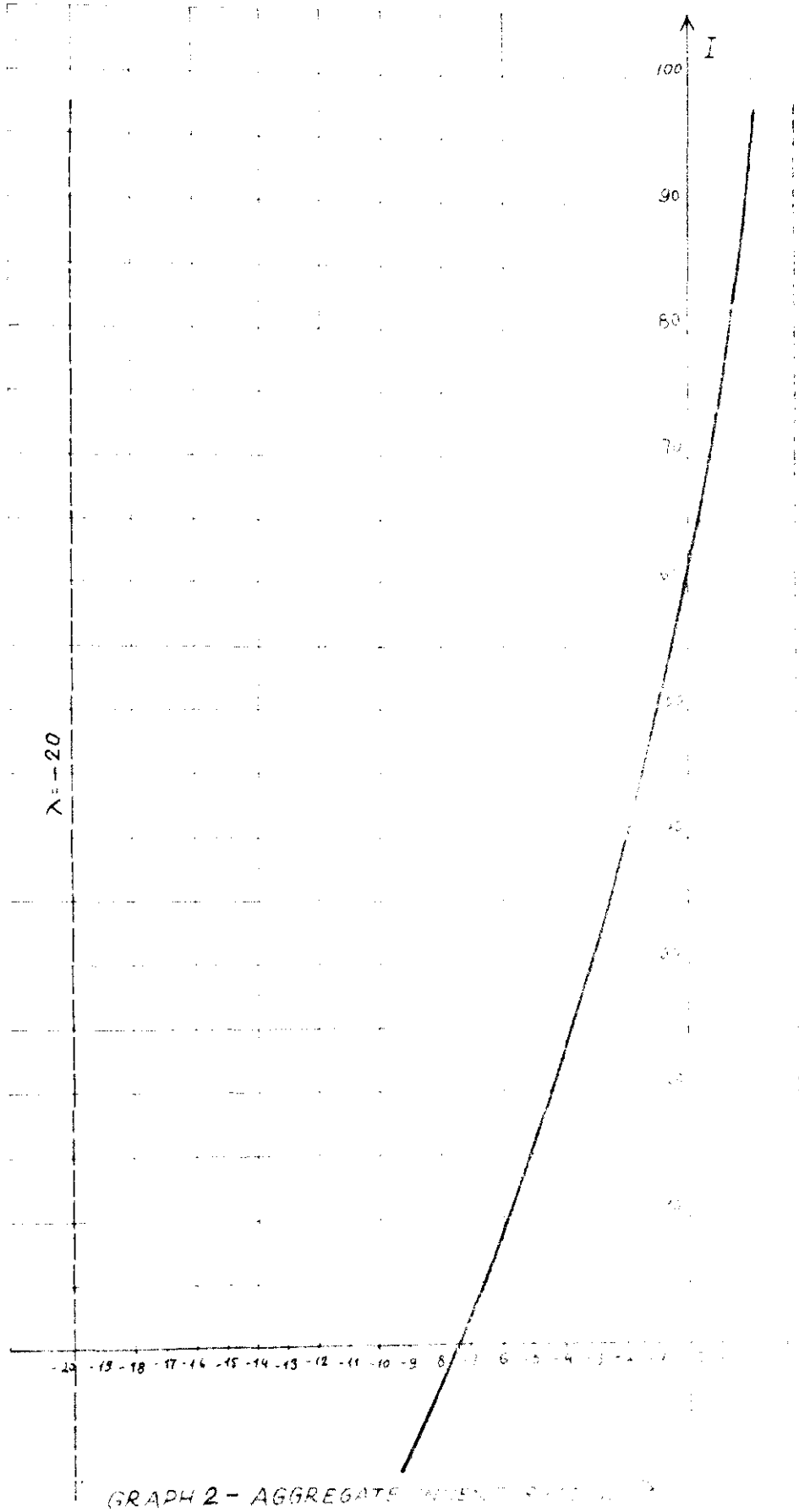
Optimum Stock Composition Table

OSOH(I)=ZAREA(I)xSDEV(I)

λ	I: I	2	3	4	5	6	7	8	$\sum_{I=1}$ OSOH(I)
0	I0	I0	8	I0	5	5	8	8	64
.5	I0	I0	8	II	6	5	8	8	66
I	II	I2	9	I2	6	6	9	9	74
I.5	I3	I3	I0	I3	7	7	I0	I0	83
2	I4	I4	II	I5	7	7	II	II	90
-3	5	5	4	5	2	2	4	4	3I
-5	3	3	2	3	I	I	2	2	I7
-6	2	2	I	2	0	0	I	I	9

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
ARNAVUTKÖY, İSTANBUL



GRAPH 2 – AGGREGATE

Table 22

Aggregate Inventory vs Lagrange Factor(λ) Table.

I	AINV(I)	λ(I)
I	I0	-6.0
2	I5	-5.2
3	20	-4.5
4	25	-3.8
5	30	-3.2
6	35	-2.8
7	40	-2.2
8	45	-I.7
9	50	-I.2
I0	55	-0.7
II	60	-0.2
I2	65	0.3
I3	70	0.7
I4	75	I.I
I5	80	I.4
I6	85	I.7
I7	90	2.0
I8	I00	2.5
I9	I50	2.6
20	400	2.7

3.4.5 Outputs of the Program.

Two types of output are obtained from the simulation of Production and Finished Goods Inventory Simulation Program.

I.A matrix of simulated ending inventory figure of each model for each monthly period,in equivalent units.The units that are backordered to the next month are printed as negative ending stock on hand in the outputs of the simulation. Moreover,the total cost of carrying,total cost of shortage and total cost,(total production cost + Total inventory cost), of each month are printed.

2.A graph on which Total cost of shortage and Total cost of carrying per month are plotted.

Table 23

The sample Output of the Application of Production Plan 3 with Production Priority RuleI on normal Demand Data Simulated by the Random number .32225.

Month	Ending Stock on Hand(eq units)								TCC(TL)	TCS	TC
	I: I	2	3	4	5	6	7	8			
I	0	-II	-33	-7	-I2	-24	-4	-3	0	I057	II2900
2	0	o	0	0	0	0	0	-a	0	23	III300
3	27	28	23	29	I9	I9	23	23	975	0	II3500
.	..	..	..	..	..	..	..		..	..	..
I2									373	0	II4200
									3350	3702	I367000

CHAPTER 4

EVALUATION OF THE OUTPUTS OF SIMULATION

4.I Plan and Coding of Simulation

Input data of both Simulation Programs are changed according to a simulation plan, to analyze the response of the system as a whole under different decision making situations. The changes made in the input data can be described at two levels;

I. Changing the inputs of Demand Generating Simulation Program.
   A. Aggregate Monthly Demand level variations.
   B. Changing the percentage composition of models in a given aggregate monthly demand level.

2. Changing the inputs of Production and Finished Goods Inventory Simulation Program.
   A. Changing the Production Plans.
   B. Changing the Production Priority Rules.

I.A: Aggregate Monthly Demand Level Variations. The purpose of changing aggregate monthly demand levels is to analyze the effect of promotion campaigns on total cost structure

of the firm.It is assumed that,as a result of this campaign an increase of I00 equivalent units per month in the level of monthly aggregate demand will be realized ie,an increase of I200 units in total equivalent demand of the year is estimated. The second alteration brings about a demand increase of 200 equivalent units per month.The third and the fourth variations smooth out seasonal fluctuations of demand.Their objective is to analyze the effects of a prom tion campai n which is directed to alter the seasonal pattern of sales.

Letter "N" is used to designate Original monthly Aggregate Demand levels.

I_1 indicates that monthly aggregate demand levels have been increased by I00 equi.units/month

I_2 indicates that monthly aggregate demand levels have been increased by 200 equi.units/month.

S_1 indicates the first seasonal variation.

S_2 indicates the second seasonal variation.

B.Changing the percentage Composition of Models in a Given Aggregate Monthly Demand level.Besides changing aggregate monthly demand levels their respective percentage compositions have been altered to analyze the effects of promoting certain models at the expense of others.

$\%_1$ denotes the original percentage composition of eight models in total aggregate demand of each

month.Here,it is assumed that the original percentage composition will continue to exist during the simulation period.

$\%_2$ Denotes that models B_1, A_2, F_2 have been promoted at the expense of other models.Here,it is assumed that the % share of models B_1, A_2 and F_2 in monthly total equivalent demand will increase by IO% each,while the % share of remaining models will decrease by that amount as a result of a promotion campaign that is concentrated on B_1, A_2 and F_2.

Table 23

A Sample Table to Illustrate % Composition Variation:

MONTH	%	% composition								TOTAL
		A_1	B_1	E_1	F_1	A_2	B_2	E_2	F_2	
I	$\%_1$	.I6	.57	.II	.02	.04	.08	.0I	.0I	I00.00
I	$\%_2$	.02	.67	.02	.0I	.I4	.02	.0I	.II	I00.00

2.A.Changing the Production Plans.Five different production plans (sec.3.4.3) have been designated to apply alternative demand levels and percentage compositions.The

monthly production rates of these production plans are also increased when they are applied demand levels of I_1 and I_2.

B.Changing Production Priority Rules.(see sec. 3.4.3)

P_1 denotes the First production Priority rule;

$A_1, B_1, E_1, F_1, A_2, B_2, E_2, F_2$.

P_2 denotes second production priority rule;

$B_1, A_2, E_2, A_1, B_2, F_1, E_1, E_2$.

A set of simulation of generating the annual demand matrix with its Graph and application of five different production plans to the matrix generated,under a given production priority rule.Each set of simulation takes 40 minutes of computer time (IBM IØ20)and I4 sets of data have been simulated for evaluation.

Evaluation of the results of simulation will be performed at three levels.Firstly,an evaluation will be done from the point of view of the production function.Secondly,the results will be evaluated from the point of view of the Finance function and thirdly,the results will be evaluated from the point of the marketing function.The first seven tables present a summary of the total costs obtained from fourteen sets of simulation.

4.2 Evaluation of the Outputs from Production Point of View.

The analyses of the Cost Tables (Tables 26-32) reveals the fact that generally the minimum total costs have been provided by the third and the fifth production plans. For the following simulation sets,

$N\%_1P_1$, $N\%_2P_1$, $I_2\%_1P_1$,

$N\%_1P_2$, $N\%_2P_2$, $I_2\%_1P_2$ Production Plan(3) provided the minimum total cost and

for , $I_1\%_1P_1$, $I_1\%_2P_1$, $I_1\%_1P_2$, $I_1\%_2P_2$ Production Plan(5) provided the minimum total Cost.

On the other hand, the application of the production plan (I) generally resulted in maximum total costs. In none of the simulation sets production plan (5) resulted in maximum total cost.

The application of the first production priority rule always resulted in lower total costs than the application of second production priority rule.(Table 25)

As observed from Table 26, the production plan 3 changes the level of monthly total production at every two months, reaching its maximum levels in September and in October. On the other hand, the production plan 5, alters the level of monthly production at every four months reaching its maximum level in the last four months of the year.

TOTDEMAND
5363

ORGINAL AGGREGATE DEMAND LEVEL
ORIGINAL % COMPOSITION

	PRODUCTION PRIORITY RULE 1					PRODUCTION PRIORITY RULE 2				
Production Plan Number	1	2	3	4	5	1	2	3	4	5
TOTAL COST OF CARRYING	45604	1170	3550	10920	5033	45640	1170	3550	10920	5033
TOTAL COST OF SHORTAGE	18510	12160	5702	7829	7879	19510	14130	6537	3283	9408
TOTAL PRODUCTION COST + TOTAL INVENTORY COST	1423000	1372000	1367000	1381000	1375000	1424000	1374000	1367000	1381000	1377000
TOTAL RAW MATERIAL COST	[illegible]					1070311				
TOTAL COST	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TOTDEMAND
6511

AGGREGATE DEMAND LEVEL I_1
ORIGINAL % COMPOSITION

	PRODUCTION PRIORITY RULE 1					PRODUCTION PRIORITY RULE 2				
Production Plan Number	1	2	3	4	5	1	2	3	4	5
TCC	46160	1328	3773	11350	5228	46160	1328	3773	11350	9528
TCS	18310	11318	5[illegible]4	7692	7097	19060	13400	5896	9421	8784
TPC + TIC	[illegible]	1 402 [illegible]	1 396 [illegible]	1 [illegible]	1379000	1432 000	1404000	1 397000	1 385000	1 380000
TRMC	[illegible]	"	"	"	"	1 [illegible]367	"	"	"	"
TC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]3	[illegible]53	2708367	2696367	2691[illegible]

TOT DEMAND
7774

AGGREGATE DEMAND LEVEL I_2
ORIGINAL % COMPOSITION

3

	PRODUCTION PRIORITY RULE 1					PRODUCTION PRIORITY RULE 2				
Production Plan Number	1	2	3	4	5	1	2	3	4	5
TCC	46440	1540	4063	11730	5435	46440	1540	4063	11730	5435
TCS	17540	10580	4588	7465	6437	1836	12810	5640	9433	8152
TPC + TIC	1438[illegible]	145[illegible]	1424000	1456[illegible]	1451000	1939000	1453000	1425000	1465000	145[illegible]
TRMC	[illegible]	"	"	"	"	[illegible]	"	"	"	"
TC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TOT DEMAND
5261

NORMAL AGGREGATE DEMAND LEVEL
CHANGED % COMPOSITION $\%_2$

4

	PRODUCTION PRIORITY RULE 1					PRODUCTION PRIORITY RULE 2				
Production Plan Number	1	2	3	4	5	1	2	3	4	5
TCC	44520	1427	3410	9684	4146	44520	1427	3410	9684	4146
TCS	14210	17360	9744	8525	9743	16260	20650	11460	10340	11640
TPC + TIC	illegible	illegible	illegible	illegible	illegible	1413000	1381000	1372000	1381000	1378000
TRMC	illegible	"	"	"	"	illegible	"	"	"	"
TC	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible

TOT DEMAND
6444

INCREASED AGGREGATE DEMAND LEVEL I_1
CHANGED % COMPOSITION $\%_2$

5

	PRODUCTION PRIORITY RULE 1					PRODUCTION PRIORITY RULE 2				
Production Plan Number	1	2	3	4	5	1	2	3	4	5
TCC	43310	1469	3370	3415	4063	43310	1469	3370	9415	4063
TCS	12790	19240	11520	9416	11290	15020	23100	13770	11770	13660
TPC + TIC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1425000	1413000	1405000	1385000	[illegible]
TRMC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TOT DEMAND
7648

INCREASED AGGREGATE DEMAND LEVEL
CHANGED % COMPOSITION %2

	PRODUCTION PRIORITY RULE 1					PRODUCTION PRIORITY RULE 2				
Production Plan Number	1	2	3	4	5	1	2	3	4	5
TCC	42140	1643	3428	9368	4103	48460	1643	3425	9992	4112
TCS	11516	21710	13580	11030	13300	12980	22650	14450	11610	14260
TPC+TIC	[illegible]	[illegible]	[illegible]	[illegible]	1457000	1436000	1463000	1433000	1461000	1457000
TRMC	[illegible]	"	"	"	"	1514520	"	"	"	"
TC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TOT DEMAND 7784	SEASONAL DEMAND LEVEL-I ORIGINAL % COMPOSITION PRODUCTION PRIORITY RULE 1					TOT DEMAND 7816	SEASONAL DEMAND LEVEL-II ORIGINAL % COMPOSITION PRODUCTION PRIORITY RULE 2				7
Production Plan Number	1	2	3	4	5	1	2	3	4	5	
TCC	3056	449	449	454	454	46280	1022	5497	12510	5794	
TCS	1745	121200	107600	87419	165200	10240	2235	2442	2918	1132	
TPC+TIC	1379000	1511[illegible]00	1523000	1527[illegible]	1513000	1431000	1442000	1423000	1455000	1447[illegible]	
TRMC	[illegible]	"	"	"	"	15[illegible]218	"	"	"	"	
TC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

Table 25

Comparison of production Priority Rules

Code	TC(P_1)TL.	TC(P_2)TL.	Difference
N $\%_1 3$	2437911	2437911	0
$I_1 \%_1 5$	2690367	2691367	- 1000
$I_2 \%_1 3$	2976024	2977024	- 1000
N $\%_2 3$	2405864	2407864	- 2000
$I_1 \%_2 5$	2657111	2659111	- 2000
$I_2 \%_2 3$	2942520	2947520	- 5000

Table 26

Third and Fifth Production Plans

Month	Total equivalent units planned per month 1	2	3	4	5	6	7	8	9	10	11	12
P.Plan 3	207	207	279	279	337	337	445	445	762	762	653	653
5	243	243	243	243	391	391	391	391	706	706	706	706

Moreover, the total cost of carrying and total cost of shortage figures produced by the minimum total cost production plans, are always less than those of other production plans of each set of simulation. For example, the analysis of the

results of simulation set N $\%_1 P_1$ is given below:

Table 34

Comparison of Costs Produced by

Production Plans I and 3

	P.Plan I	P.Plan 3	Difference
Tot.Cost of carrying.....	45640	3550	42090
Tot.cost of Shortage.....	I85I0	5702	I2808
Total Cost.....24939II		24429II	50900

Since total raw material cost for the year is assumed to be same,it has no effect on total cost of the year for the same set of simulation.As observed in Table 34,the objective of simulation ie,the minimization of the total inventory cost,has been reached.

4.3 Evaluation of the Outputs from Finance Point of view.

Basic financial weaknesses of the firm have been described in section 2.6.5,of Chapter 2.The objective of this section is to make an analytical evaluation of the simulation results within the framework of these limitations.The scope of evaluation covers only those simulation sets that have

produced minimum total cost figures.Moreover,only the results that have been obtained by using production priority rule I will be taken into consideration because this rule have always produced smaller total cost figures than the second production priority rule.So,following simulation sets will be analyzed, $N\,\%_1P_13, I_1\%_1P_15, I_2\%_1P_13, N\,\%_2P_13, I_1\%_2P_15, I_2\%_2P_1I, S_1\%_1P_1I, S_2\%_1P_13$.

Furthermore the analyses will be done on monthly basis and only out of pocket costs will be taken into consideration ie,total cost of shortage,total cost of carrying and total set up cost of each month will not be taken into account since all of them are opportunity costs and do not represent actual flow of cash.

Determination of monthly Cash Outflow:To obtain total monthly cash outflow,total production cost of the month (excluding set up costs) and total raw material cost of the month before last two months are added together.Present raw material purchasing practice of the firm is mostly carried out with short term notes payable,(n/120 and at an 18% annual rate of interest),and none of the present raw material suppliers of Günterm require downpayment.So,total cost of raw materials that is purchased in January 1969 will be paid to the suppliers at the end of April 1969 with its accrued interest.For example,total raw material cost of January 1969

is 57230 TL. this amount will be paid to the suppliers at the end of April 1969 with the 6% interest rate accrued ie,3433 TL.

$OC_i = PC_i + TRMC_{i-3} + IC_{i-3}$ Where;

i= month 1,12

OC=Outflow of cash

PC=Production cost of the month

TRMC=Total raw material cost

IC=Accrued interest cost.

Moreover,for demand levels I_1 and I_2 and percentage composition $\%_2$,additional promotion cost will be included.As indicated in section 2.7.4 of Chapter2,Yi-Sa has the right to reserve 1% of sales revenue for promotional activities.Table35 illustrates total annual revenues and their corresponding advertising budgets of different sets of simulation.

Table 35

Advertising Budgets

Sim.Set	Tot.Annual revenue TL.	Advertising Budget TL.
$I_1\%_1P_15$	2720856	27209
$I_2\%_1P_13$	3367294	33673
$I_1\%_2P_15$	2889072	28891
$I_2\%_2P_1I$	3432749	34327

As it has been claimed by the General manager of Ti-Sa, present level of advertising budget is not enough to carry out promotion activities for the products of Günterm. So let us assume that we need an advertising budget of 40000TL to increase the monthly demand level by 100 equivalent units and 50000 TL to increase the monthly demand level by 200 equivalent units. It is beyond the scope of this study to determine when and where to advertise, here, a continuous advertising campaign is assumed. So, there will be an additional monthly cash outflow of 3334 TL for demand level I_1 and 4167 TL for demand level I_2.

As a result of the interviews that have been made with the customers of Günterm, we have found out that 10% discount in the existing level of convector prices might make the customers to purchase convectors prior to the construction season. So there will be 10% reduction in convector prices during January, February, March, April, May and June to smooth the level of sales by S_1. In the case of S_2, this reduction will be done in February, March, May, July and December. For example, the simulated total equivalent demand for demand level I_2 during January 1969 is 465 units and simulated total equivalent demand for S_1 during the same month is 531 units. So, the difference between two demand levels is 66 units ie, we plan to sell 66 equivalent units more in January to smooth out the

seasonal fluctuation of sales.This is illustrated in Graph3.

Determination of Monthly Cash Inflow:As indicated in section 2.7.I,the Authorized Dealers send 35% of the order price in cash to Ti-Sa.Remaining 65% of the bill is paid at the delivery of the ordered products to the customer and 40% of it may be paid in the form of notes of n/I2I days.Here,it is assumed that ordered products will be delivered in the same month they are ordered.So,60% of total sales revenue will be collected in the same month and remaining 40% of the total sales revenue of the month will be realized three months later.For example,in the case of M_1P_1B,total sales revenue of January is I046I8 TL,60% of this amount is received during the same month ie,627?I TL and remaining 40% 4I847 TL will be received at the end of April I96).

$$IC_i = .60SR_i + .40SR_{i-3}$$ Where;

IC_i =Total cash inflow of the month i.

SR_i =Total sales revenue of the month i.

So,if $IC_i > OC_i$ there will be a cash surplus for the month i and if $IC_i < OC_i$ additional cash inflow will be required to finance the operations of the month i.Total monthly cash inflow,outflow and the difference between these flows for each set of simulation have been tabulated in Table 36.

TABLE 36(A) TABLE OF TOTAL MO[illegible]
CASH INFLOW AND OU[illegible]WS

SIM SET		JANUARY	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.	TOTAL
N%, P, 3	OUT FLOW OF CASH	320883	268142	222204	172476	132302	131565	207136	192868	184560	205229	229152	215813	366360
	INFLOW OF CASH	236199	170966	141104	163178	116104	118757	186718	178200	206962	274032	300160	240188	186863
	DIFF	84684	97176	81095	9298	16198	12808	20418	14668	-22402	-68803	71008	24650	149497
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]														

TABLE 36(B)

SIM SET		JANUARY	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT	OCT	NOV	DEC	TOTAL
$N\%_{O_2}P_1 3$	OUT FLOW OF CASH	320438	248142	222204	174778	134483	133506	211659	188562	186160	204493	226526	224128	
	IN FLOW OF CASH	242223	172804	142870	179799	117741	119634	192618	200090	213624	331616	253374	229413	
	DIFF	78215	75338	79334	- 5021	16742	13872	19041	- 11528	27464	- 127123	26848	- 5285	99733
					195315	151486	162237	240172	221604	203535	341855	253392	248652	
$\%_{O_2}P_1 5$						144435	168706	238755	251825	258534	373457	233341	273631	
							1469	1417	- 30221	- 18353	- 31602	- 19948	- 24979	- 69303

As observed in Table 36, the firm will be permanently in need of cash to finance its operations if it operates at the original level of demand ie, N. This simulation result is completely in parallel with the actual operations of the firm. The management have faced three major strikes since I968. The underlying reason of these strikes have been the frequent failure of the firm in paying the wages of the workers on time. When the annual demand and the production levels are increased to I_1 and I_2, the firm generally faces cash shortages in the first three months of the simulation period and cash surplusses in all of the remaining months of the year. Moreover, total annual difference figure always have a negative sign indicating a cash surplus for the year. For example, total difference of cash outflows and inflows of the simulation set N $\%_1 P_1 3$ is I49497 TL ie, the firm needs additional I49497 TL to finance its operations for the year. On the other hand, this difference amounts to -I48I30 TL in the case of $I_1 \%_1 P_1 5$ ie, the firm has a surplus of cash of that amount. The main reason of this large difference between the relative cash positions of the firm is the existing level of capacity utulization which is considerably low. Table 37 illustrates capacity utulization percentages and their corresponding total production costs (excluding cost of set up) under alternative production plans for January I96[illegible].

The analysis of this table clearly illustrates the fact that under normal production and demand conditions, only half of the monthly production capacity of the plant has been utulized. When the monthly demand level and production planned for the month is increased by 100 equivalent units per month the monthly capacity utulization level increases to 65%, but no increase is observed in the level of monthly production cost.

Table 37

Capacity utulization % vs Total Production Cost (January 1960)

Prod.Plan No	A equi.units planned(N)	B CAPM	N CAPF	TPC	I_1 CAPF	TPC	I_2 CAPF	TPC
1	447	840	.53	113906	.65	113906	.77	114400
2	168	840	.20	110520				
3	207	840	.24	110520				
4	317	840	.37	111813				
5	243	840	.29	111613				

CAPM=Total equivalent production capacity of the month.

CAPF(N)=Capacity utulization factor of the month at normal level of operations, A/B.

CAPF(I_1)=Capacity utulization factor of the month at level I_1

$$= \frac{A+100}{B}$$

CAPF(I_2)= $$= \frac{A+200}{B}$$

TPC=Total Production cost of the month .

For production level I_2,only a slight difference in total production cost is observed.The calculation and assumptions of total monthly production cost of different capacity utulization levels have been explained in section 3.4.3 of Chapter 3.So,only total raw material cost of the demand of the month increases in parallel to the increase in the level of aggregate monthly demand.On the other hand,cash inflow of the month increases rapidly as we increase the level of demand and cosequently these are the major reasons of difference among relative cash positions under alternative simulation sets.

A considerable increase in the level of annual cash surplus is observed when the plant operates at demand and production level of I_2.For example,total annual cash surplus for the set $I_1\%_1P_1$5 is -I46I30 TL and total annual cash surplus for the set $I_2\%_1P_1$3 is -38756 TL,so the surplus of I_2 is more than twice of I_1.

There are alternative ways of meeting the financial needs of the firm.In its current financial position it is very difficult for Günterm to acquire long term funds for the purpose of financing its current operations.Commercial Banks hesitate to extend long term credit to the firm and it would also be a weak assumption to think that the management could acquire long term funds through issuing bonds at I3 %

or 14% rate of interest.So,in its present position only two alternatives are feasible for the firm.The first one is to increase the level of equity in total capitalization of the firm and the second one is to acquire funds from unofficial financial market at a high rate of interest,25% annual.The owners of the firm do not want to increasetheir share in total capitalization of the firm.So,here it is assumed that Günterm acquires necessary funds from unofficial capital market at that rate of interest.Table 30 illustrates a summary of monthly cash surpluses or shortages generated by different sets of simulation.The method of obtaining monthly cash outflow and inflow figures have been explained in the previous paragraphs.Their differences have been tabulated in Table 30.So,as observed in this table, the firm will be in need of 71925 TL in January to finance its monthly operations as a result of the simulation set $I_1 P_1 T_1$. This amount will be borrowed from the capital market at an annual interest rate of 25%.The dotted lines indicate the period when borrowed fund can be paid back by internally generated funds. The management of the firm will be able to pay back the amount 71925TL,borrowed in January,at the end of October with its accrued interest 14360 TL.Interest cost of the borrowed fund is obtained by multiplying the amount of money borrowed and interest rate that is applicable to the period

TABLE 38 SUMMARY OF MONTHLY CASH SURPLUSESAND SHORTAGES UNDER ALTERNATIVE SIMULATION SETS

SIMSET		JAN 1	FEB. 2	MARCH 3	APRIL 4	MAY 5	JUNE 6	JULY 7	AUGUST 8	SEPT. 9	OCT. 10	NOV. 11	DEC. 12	TOTAL
	$OF_1 - IF_1$ DIFFERENCE	71325	76327	55319	-11310	-6586	-8728	5441	414	-43290	-153038	-86942	-47662	-148130
$I_1^0 I_1 F_1$	Interest on the sum it will be paid	14360	14288	14280				453	16					38332
														-109198
	DIFFERENCE	-5[illegible]	51598	26248	-34403	-41387	-34033	-14539	-13850	-45626	154689	-108942	-75186	-387566
$I_2^0 I_2 F_2$	[illegible]	[illegible]												14632
	[illegible]													-312933
	[illegible]							-[illegible]	-30221	-48833	-31672	-33948	-24379	-63303
														[illegible]
														[illegible]

TABLE 39 MONTHLY CASH SURPLUS OR SHORTAGES FOR SEASONALLY SMOOTHED SALES

		1 JAN.	2 FEB.	3 MARCH	4 APRIL	5 MAY	6 JUNE	7 JULY	8 AUGUST	9 SEPT.	10 OCTOB	11 NOV.	12 DEC.	TOTAL
S_1 P_1	OUTFLOW OF CASH	328345	276183	227664	215806	231869	259267	264818	321741	244426	246599	264491	236935	
	INFLOW OF CASH	273[illegible]4	289733	285430	2[illegible]112	3038[illegible]2	273[illegible]2[illegible]	236644	230157	271823	279[illegible]53	28[illegible]771	30[illegible]162	
	DIFFERENCE	5[illegible]F1	[illegible]2[illegible]4	[illegible]5[illegible]34	[illegible]4[illegible]3[illegible]4	-71393	-2[illegible]153	-2[illegible]174	31584	-27403	-32454	-2[illegible]385	-65067	-171685
	INTEREST													2703
														-168982

of usage.For example,The interest cost of 7I925 TL for a period of IO months is, 7I925x.208 =I4960 TL,this cost is deducted from the total surplus of cash that is obtained for the set $I_1\%_1P_1$5.

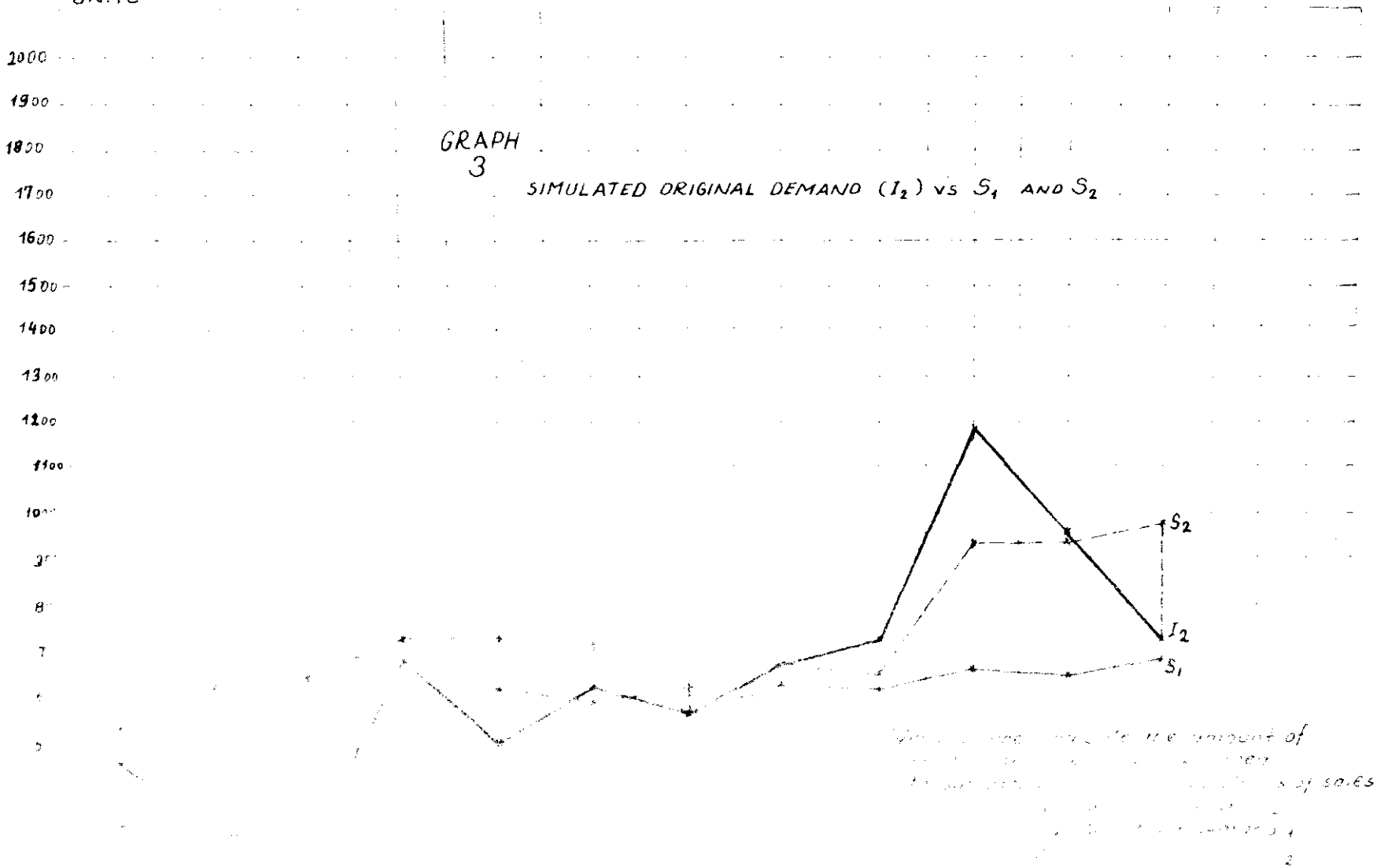
The analyses of the total difference columns of Table 38 obtained after deducting all of the accrued interest costs of each simulation set,clearly indicati that the amount of surplus produced by the demand and production level I_2 is more than twice of that of level I_1.Furthermore, the highest level of cash surplus is obtained by the simulation set $I_2\%_2P_1$I.

Table 39 illustrates the effect of seasonal smoothing of sales on monthly cash outflow and inflow figures. Total monthly cash outflow figures include the promotion cost of the month for demand level $I_2$and also the interest costs of obtaining additional funds in case of cash shortages. So,simulation set $S_1\%_1P_1$I produced a net cash surplus of I68962 TL and simulation set $S_2\%_1P_1$3 produced a net cash surplus of 266828 TL at the end of the simulation period.

EQUIVALENT UNITS

GRAPH 3

SIMULATED ORIGINAL DEMAND (I_2) VS S_1 AND S_2



4.4 Evaluation of the Outputs From Marketing Point of view:

In this section of the Chapter the effects of alternative Promotion, Product, and Price policies total annual profit of the Firm will be analyzed and evaluated.

TABLE 40

Annual Cash Surplus Under

Alternative Percentage Composition

Demand and Production Level	Percentage Composition % 1 Annual Cash Surplus	Percentage Composition % 2 Annual Cash Surplus	Difference % 1 - % 2
Normal	- 149437	- 99733	- 49704
l_1	109198	45541	63657
l_2	372930	423561	50631
S_1	168982		
S_2	266828		

First the results of Promotion activities will be evaluated. Here the promotion activities involve two kinds of decisions to be made, the first decision is to increase aggregate monthly demand level and the second decision is to promote certain models instead of others. It has been assumed that by investing 40.000 TL. [illegible] the

simulation period in promotion activities, aggregate monthly demand level can be increased by 100 equivalent units, and if the investment increases to 50.000 TL. aggregate monthly equivalent demand level also increases by 200 equivalent units. When the convector models are standardized according to the assumption of section (2.3) of Chapter 2, the firm faces loss if it operates at normal production and demand levels. As it is observed in Table 40 this loss amounts to 14943 TL. under percentage composition 1 and 99739 TL. under percentage composition 2. Normal production and demand level makes the firm to operate below its Break-even point and they will not be taken into consideration here. As observed from the Table 40 annual profit of the Firm increases to 109136 TL. when we increase monthly aggregate demand level by 100 equivalent units. For level l_2 the resulting annual profit figure is more than twice of level l_1. When the percentage composition of monthly demand is changed ie when we promote model B_1, A_2 and B_2 at the expense of other models, the resulting annual profit figure is less than that of % 1for demand and production level l_1. On the other hand at level l_2 maximum total annual profit figure is achieved (423561 TL.) when B_1 A_2 and B_2 models are promoted only. Moreover, the 10 % discount in the prices of products to smooth out seasonal fluctuations of sales have not produced higher annual profit than that of level l_2.

The first smoothed demand level produced a total profit of 168982 TL. which is 203948 TL. lower than the profit provided by normal demand level l_2 . And the seconr smoothed demand level (S_2) produced a total annual of 266028 TL. which is 106102 TL. lower than the profit provided by l_2. Consequently it will be a better policy if the firm promotes models B_1,A_2 and F_2 while increasind the aggregate monthly demand level by 200 equivalent units.

From the point of view of the product policy of the Firm we might claim that concentration on models B_1, A_2 and F_2 produces better results than otherwise.

CHAPTER 5

CONCLUSION

5.1 Suggestions:

As a result of observations, analysis and interviews with the personnel responsible for the operations of the firm major problem areas of the firm have been defined and a computerized model have been developed to solve the production planning and finished goods inventory problems of the firm. Here certain suggestions will be provided to improve the overall effectiveness of the system.

First of all the objectives and the scope of activities of the firm should be explicitly defined and their relative priorities and values should be established. Then a practical organization structure should be planned in accordance with the objectives of the system. The specific methods of organization planning process is beyond the scope of this study. As it is stated above the resulting organization should be practical otherwise it will never be implemented as in the case of the organization study of 1967. As a matter of fact a complete reorganization process is a difficult task and the cost of it will be rather high so it will be a wise policy to use the existing personnel as much as possible.

An alternative organization structure is illustrated in Figure 12. This is also a functional type of organization

Figure 13

SUGGESTED

ORGANIZATION CHART FOR TISA

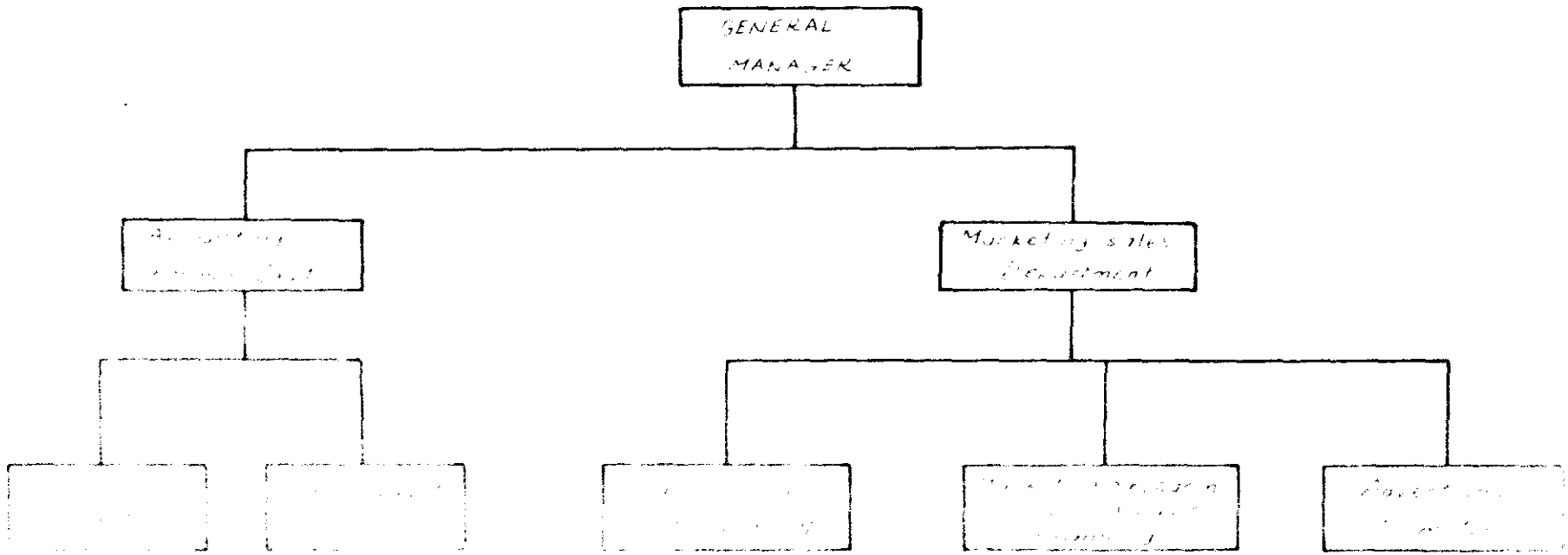
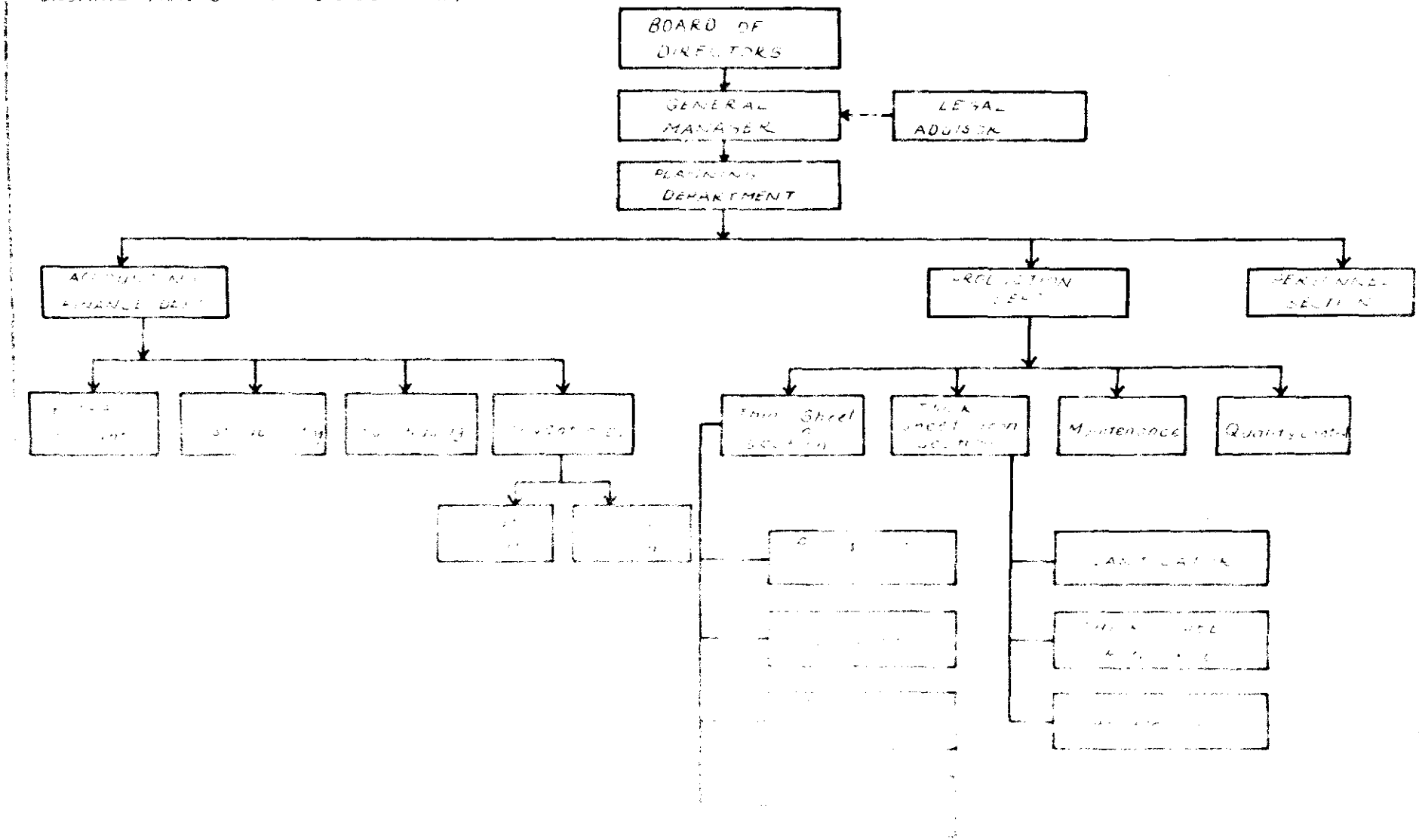


FIGURE 12
SUGGESTED
ORGANIZATION CHART FOR GÜNTERM



and as it is observed the main emphasis is on central planning and coordination of activities, because one of the most important reasons of the failure of the existing system has been the lack of Planning and coordination. The Planning Department will directly report to the General Manager of the Firm and the General Manager will be the major coordinator of the activities of this department. General function of the Planning Department are;

1. Objective and Policy Definition
2. Financial Planning
3. Production inventory and workforce planning

Marketing and sales planning function belongs to Ti-Sa, however it will be performed in close cooperation with the Planning Department of Günterm. As observed from the organization chart there are two department managers and a section head directly reporting to the manager of the Planning Department who is also the General Manager of the Firm. One of these Managers is responsible from the finance and accounting function of the firm and the second manager is responsible from the production function. Existing level of personnel do not necessiate the establishment of a separate personnel department and this function can be handled effectively by a section attached to the Planning Department.

The Accounting and Finance Department will be composed of four Sections:

- General Accounting
- Cost Accounting
- Purchasing
- Inventories

The general accounting section will be responsible from, the post-auditing of plant transactions, maintaining primary books of accounting, setting up methods of cash disbursements accounts receivables and equipment records, cash management, preparation of financial statements and reports and credit approvals, and finally payroll preparation. The second section is responsible for the cost accounting function. This is also a necessary function that should be performed because it will provide a system of measurement of the performance of various functional subunits of the organization. Moreover it will provide a yardstick for the effective utilization of productive factors such as men, materials and facilities and will indirectly to the preparation of the financial and production plans so it will aid largely in decision making process. The third section is responsible for internal and external purchasing activities. This section is also responsible from providing necessary data for purchasing planning that will be prepared at the Planning Department. The fourth section that is attached to the Accounting and Finance Department will be

responsible from the inventories (raw material and finished foods inventories). In addition to the existing personnel a full time cost accountant and a finance manager who has proper educational and practical background on financial affairs should be employed. It is beyond the scope of this study to analyze and evaluate all of the possible alternatives to solve the financial problems of the firm. In our opinion major financial problem of the firm is the inexistance of a long term debt policy and this factor causes difficulties in production and marketing functions too. Leaving aside the organizational and personnel problems of the finance function, a possible solution should first be found to the problem of capitalization of the firm ie; answers of the specific questions such as, what should be the amount and composition of short term capitalization? What should be the amount and composition of the mix of short term and long term capitalization? What should be the level of equity? and through what channels long term funds should be introduced into the capitalization of the firm?

If we take only external sources of funds into account Günterm can acquire necessary long term funds through, 1. Commercial banks in the form of long term credit 2. issuing bonds, Commercial banks actually reluctant to extend long term credit to the firm because partners of the firm do not own the land on which the plant is located. So the only way for the firm to utilise long term bank credit

is to purchase this piece of land that is owned by four individuals and some of them have left Turkey. Consequently it is rather difficult to get a mutual agreement on the sale and price of the land between the actual owners of the land and management of the firm. A reasonable price for the land can be found by employing long term capital investment tools taking into consideration the present and future market conditions, and this price might then be offered to the owners of the land. An alternative solution would be to acquire long term credit through Industrial Investment Bank that extends credit after a careful analysis of the existing financial condition of a firm and the type of business in which it operates. But in its present financial condition it will be a weak assumption to think that the management could acquire long term debt from this bank. Secondly lets' consider the alternative of securing long term credit by issuing bonds. As it has been stated in section 4.2 there are certain drawbacks even if we assume that management have decided on the amount and price of bonds through scientific analysis of the firm and the market because it will be a hard job for the management to sell their bonds without any guarantee as it was the case for Makine Takım Endüstrisi Ltd. Moreover if we assume that it actually gets this guarantee from a major bank, it will not be able to raise long term funds at its present rate of earnings because we have found out that the firm only earned 5 % return on its total debt in 1980 and the present interest rate on guaranteed bonds is 13 %. So earning power of the firm should be improved which is directly related to the type of capitalization and the degree of effectiveness of the marketing and production functions. One of the possible solutions to break this vicious circle would be an increase in the level of Partners' equity.

The benefit of the "Cash inflow and outflow" analysis of Chapter 4 is that the financial manager of the firm will be able to estimate the time and amount of cash shortages that will occur as a result of the operations of the firm. And he will be able to take preventive measures as it is illustrated in Chapter 4. These analysis might also help to the planning department in the determination of the financial objectives policies and procedures.

The second department that should be reorganized is the Production Department. The Manager of this Department will be responsible from Thick sheet-iron products section, Thin sheet-iron products section Maintenance section and quality control section. As observed in this new organization structure we abolished the Technical Dperatment and the inventory management function of that department have placed under the responsibility of the Accounting and Finance function and the function of production planning and control have been placed under the responsibility of both The Planning Department and the Production Department. The production plan will be designed by the planning department and will be implemented by the production manager . One of the main factors in the production process of a convector is the raw material preparation and manufacturing the box. However in both of the proposed and actual organization structures this function has not been considered as a separate

section and many disturbances exist at the factory level because there is no directly responsible person for the section. Horizontal and vertical shearing of sheet iron according to the desired sizes, corner shearing and notching, body bending and electrical soldering of the corners are made at this level of operations and majority of the production defects on the convectors are due to incorrect shearing of the sheet-iron or incorrect corner shearing and body bending operations. This problem may be solved by establishing a "preparation and box" section and by assigning a directly responsible foreman for the operations. A program of on-the-job training can be carried out by this foreman.

An additional bottleneck area in the production department is "Painting and Furnacing Section" The per/shift production capacity of the plant is limited at this section of the production process. (five equivalent units per hour) and the major reason is the lack of adequate number of personnel because the capacity of the furnace 30 units per hour. So the number of workers should be increased. The delivery dates that is given to the customers will be regularized when the production plan is applied. The application of the production plan will also optimize inventory carrying and shortage costs and stabilize the level of operations in the plant. Moreover the application of the production plan will lead to a significant reduction in the level of existing raw material costs of the firm. Table 41 illustrates the

great difference in the level of the prices of regular raw material suppliers such as Rabak or Ereğli Iron and Steel Factory and market prices.

TABLE 41

Comparison of Unit Raw Material Prices of Regular Suppliers and The Market Price/Unit TL.

Raw Material		Regular Supplier	Market	Difference
Sheet-iron	.70 mm.	2.91 TL/Kg.	3.75	.84
	.80 mm.	2.68	3.90	1.22
Copper-pipe	Kg.	37.00	48.00	11.00
Sheet Aluminium		13.75	17.00	3.25

As observed from the Table a K g. of aluminium that is purchased from Rabak is 11 TL. cheaper than the same amount that is purchased from Teknik Aliminyum Ltd. Şti. A production manager with a technical and administrative background should be employed for Production Department moreover additional personnel will be needed for the quality control section of the Department.

Marketing and Sales activities will continue to be performed by Ti-Sa. First of all the problem of coordination of the activities of Güntem and Ti-Sa should be solved, because the solution of this problem will considerabl

increase the overall effectiveness of the system as a whole. An alternative mechanism to achieve this coordination is to establish a formal information and reporting system between Günterm and Ti-Sa. For instance, the existing order flow system is basicly informal, the orders are transferred to Günterm by the General Manager of Ti-Sa through telephone and in the majority of the cases the clerk who receives the order misunderstands the description and technical characteristics of the order. So the order should formally be reported to the Planning Department of Günterm, and the ordered products will be delivered to the customer if they are available at the existing finished goods inventory section of the firm otherwise the order will be processed according to the production plan and Günterm will be able to deliver the products at the time specified by the production manager of the firm. As it has been observed in Chapter 4 the application of an annual production plan optimized both the total cost of shortage and the total cost of inventory carrying.

As observed in the organization chart prepared for Ti-Sa the establishment of an additional department have been suggested. Moreover a new function is added to the existing functions of the Accounting and Finance Department, that is the function of sales budget planning. The second Department will be responsible from the activities of three sections such as, Sales Coordination and Coordination of the Relationship with the authorized Dealers Section, Marketing

Research and Production Marketing Planning Section and Advertising and Promotion Section. In addition to their general accounting function the existing personnel of the Accounting and Finance Department is enough to carry out the function of sales budget planning which will be approved by the Planning Department of Günterm. Moreover at present level of operations both of the managerial positions namely, the General Manager and Manager of Marketing and Sales Department can be handled by the same individual, who the necessary educationl and practical background in the field of Marketing. This Manager will also work in close cooperation with the Planning Department of Günterm. As explained in Chapter 4 the level of promotional activities should be increased for the construction activities and application of central heating systems have been increasing at a considerably fast rate in recent years. Moreover Ti-Sa should play a more active role in its relations with the authorized dealers of the firm and alternative ways should be found to increase the present number of authorized Dealers, and especially the feasibility of getting a Dealer located at the Kadıköy sales region should be searched. A complete marketing research should be carried out both at the level of authorized dealers and also at the level of construction contractors. The product and pricing policy should then be revised according to the results of the complete marketing research.

5.2. Conclusion

As it has been stated, main objective of the study was to develop a methodological framework that would integrate production, marketing and finance functions in a metal processing company within the framework of systems approach to management. The second objective of the study, was to solve production planning and finished goods inventory problems of the firm with the help of computerized simulation techniques. Major factors that have limited the scope of our study are ; the time available to carry out the study and secondly, lack of adequate data at the fim's level and also at the level of the industry.

The outputs of the simulation process have been evaluated in chapter 4 and necessary organizational changes to increase effectiveness level of the overall system have been discussed in the preceding section of the present Chapter. Both of these are a conclusion in themselves. In the case of this specific firm, the first and the most important problem is to have a change in the minds of the owner-managers ie, to make them realize the need for an organized effort to achive their objectives. Although the outputs of the simulation system as a whole were quite satisfactory, it is very difficult to use this technique in actual business practice because

of the absence of a well established computer time-sharing system in our country.However,this is not a major handicup for the management and there are other scientific programming techniques that can be applied without the help of computers.

BIBLIOGRAPHY

Books on Production and Systems Theory

Ansoff,H Igor and Weston,J Fred.Corporate Strategy . New York:Mc Graw-Hill,Inc.,I964.

Bowman,Edward H and Fetter,Robert B.Analysis for Production and Operations Management . Homewood, Illinois:Richard D,Irwin Inc.,3rd ed.I967.

Buffa,Elwood S.Readings in Production and Operations Management.New York:John Wiley and Sons,Inc., I968.

Forrester,Jay W.Industrial Dynamics.Cambridge Mass.: The M.I.T. Press,I965.

Hare,Van Court.Systems Analysis:A Diagnostic Approach. New York:Harcourt,Brace World,Inc.,I967.

Holt,Charles C,Modigliani Franco,Muth John F and Simon Herbert A.Planning Production,Inventories and Workforce.Englewood Cliffs,N.J.:Prentice Hall,Inc.,I960.

Mc Millan,C and R.F.Gonzales.Systems Analysis:A Computer Approach to Decision Models.Homewood,Illinois: Richard D,Irwin,Inc.,I965.

Starr,Martin K.Production Management:Systems and Synthesis. Englewood Cliffs,N.J.:Prentice Hall, Inc.,I964.

Tilles, Seymour "The Manager's Job : A Systems Approach." Harvard Business Review. Vol. XLI (1963), pp.

Books on Finance

Johnson, Robert W. Financial Management. Boston, Mass: Allyn and Bacon, Inc., 3rd ed. 1967.

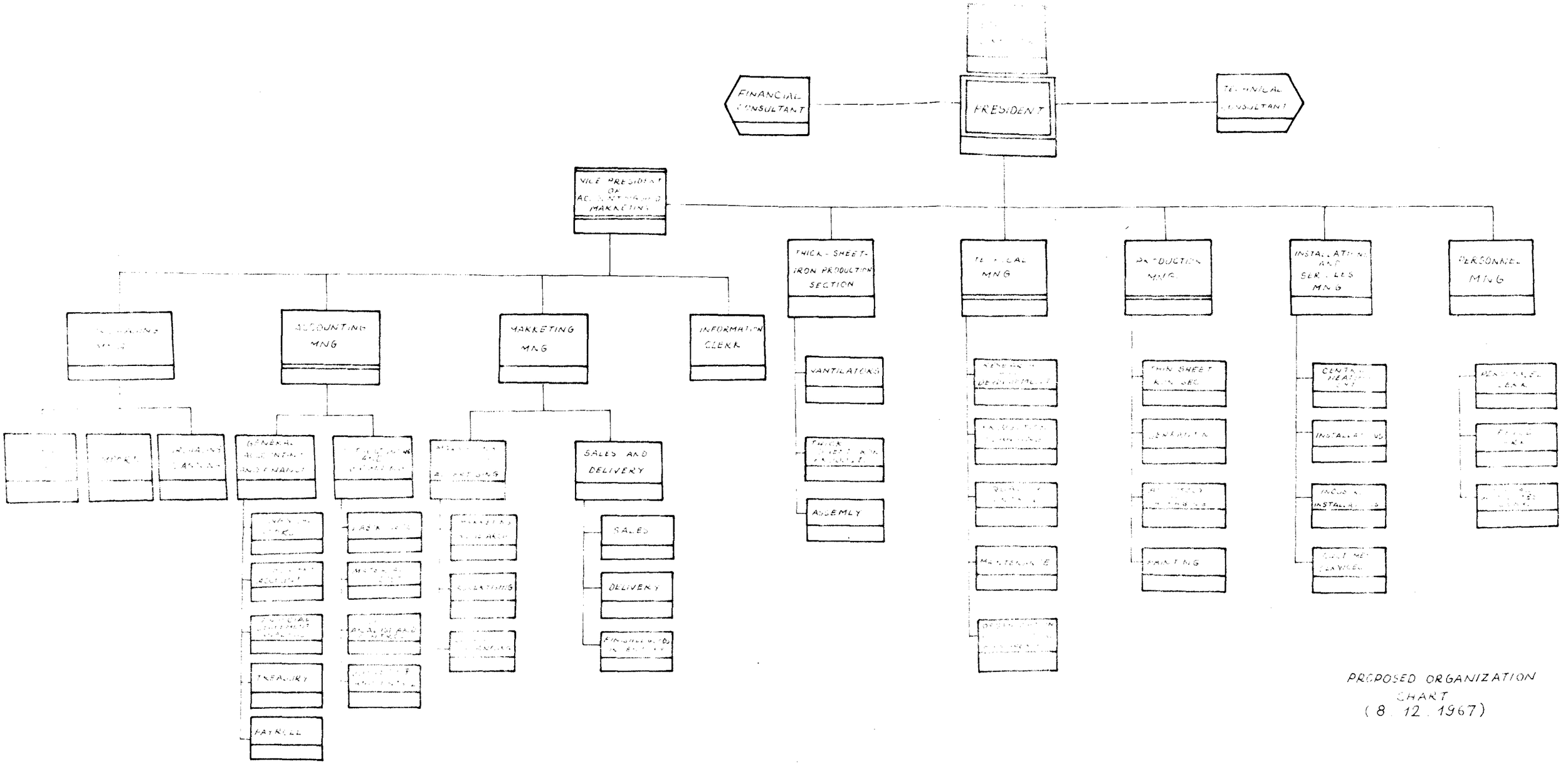
Smith, C Aubrey and Ashburne, Jim G. Financial and Administrative Accounting. New York: Mc Graw-Hill Book Co, Inc., 2nd ed. 1960.

Weston, J Fred and Brigham, Eugene F. Managerial Finance. New York: Holt, Rinehart and Winston, Inc., 3rd ed. 1969.

Books on Marketing

McCarthy, E Jerome. Basic Marketing A Managerial Approach. Homewood, Illinois: Richard D. Irwin, Inc., 3rd ed. 1968.

Richard, D Crisp. Marketing Research. New York: Mc Graw-Hill Book Co, Inc., 1957.



PROPOSED ORGANIZATION CHART
(8.12.1967)

APPENDIX II

Background information on the Mathematical Model used to determine optimal allocation of Inventory in the presence of a constraint on Aggragete Inventory[1]

The objective of this Appendix is to describe the mathematical model that is used in production, inventory simulation model.As it has been stated in Chapter 3,the purpose of this model is to determine optimal allocation of inventoryin the presence of a constraint on aggragate inventory.the model was developed by Professors Holt, Modigliani,Muth and Simon based on the paper,"Decision Rules for Buffer Inventories",written by Profeesor Charles P.Bonini.

Objective of the Model : The objective of this model is to allocate inventory to buffersin an optimum manner, achieving an economic balance between the cost of holding inventory and cost of stockouts.

Assumptions and Description of the Model:

I.Production decisions are made at the beginning of each period and total production is determined for the entire period.

2.The inventory decisions for all the products are made to satisfy a constraint on total production and each item is produced each period.

3.Monthly demand distributions of the products are assumed to be normal.

4.Two costs are effected by the inventory decisions cost of carrying and cost of shortage.

5.The production is in lots and the lot was produced at the middle of the period.(figure I)

6.Determining the amount of production of the i^{th} product during the period is equivalent to determining the inventory at the end of the period, because of the inventory balance conditions.

(I) $I_{it}= I_{it-1}+P_{it}- S_{it}$ Where:

I_{it}.The amount of inventory of inventory of product i at the end of period t.

P_{it}.The production of product i during period t.

S_{it}.The sales of product i during the period t.It is a random number with mean $ES_{it}=\bar{S}_{it}$ and variance Q_i^2.

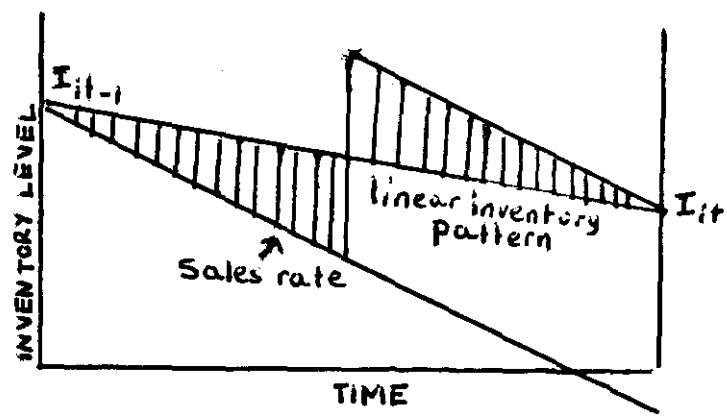
The expected ending inventory will be $(\bar{I}_i)$:

(2) $\bar{I}_i= \bar{I}_{it-1}+P_{it}-\bar{S}_{it}$

So actual inventory differs from expected inventory by the amount of error in sales forecast:

(3) $I_{it}= \bar{I}_{it}+ \bar{S}_{it}-S_{it}$

7.Cost of carriying: Inventory holding costs are assumed to be proportional to the units of inventory held multiplied by the length of time they are held. The expected inventory level is assumed approximately linear within the period.



Figure(I):Inventory pattern with production in one lot.

So the average inventory in period t is $\frac{I}{2}(I_{it-1}+I_{it})$

the average inventory in period t+1 $\frac{I}{2}(I_{it}+I_{it+1})$

If we denote C_{Ii}=Cost of holding a unit of product for the period,Inventory cost for two periods is equal to,

(4)

$$C_{Ii}\left(\frac{I}{2}(I_{it-1}+I_{it})+\frac{I}{2}(I_{it}+I_{it+1})\right)=$$

$$=\underbrace{\frac{I}{2}C_{Ii}(I_{it-1}+I_{it+1})}_{1}+\underbrace{C_{Ii}I_{it}}_{2}$$

First part (I) represents the inventory cost that would arise if $I_{it}=0$

Second part(2) represents the icremental cost resulting from holding a positive inventory at the end of period t.

For: $C_{I_i} \bar{I}_{i,t} > 0$

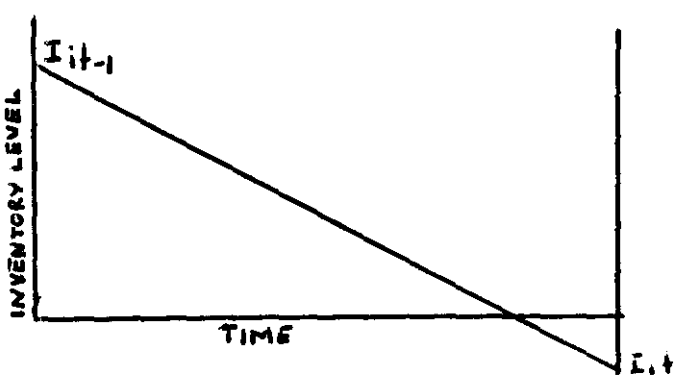
$\bar{I}_{i,t} + \bar{S}_{i,t} > S_{i,t}$

ie,expected ending inventory plus expected sales for the period should be greater than the actual sales S_{it}.

So,expected incremental inventory holding cost of the production decision is equal to,

$$(5) = C_{I_i} \int_0^{\bar{I}_i + \bar{S}_i} (\bar{I}_i + \bar{S}_i - S_i) f_i(S_i) dS_i$$ where $f_i(S_i)$ is the Probability Density Function of Sales.

8.Cost of shortage:Inventory shortage costs are assumed to be proportional to the maximum number of units short of full inventory.



Figure(2):Stockout at the end of period t

The number of units short= $S_i - (\bar{S}_i + \bar{I}_i) > 0$

Let us denote C_{di} as cost of being out of stock by one unit, then ,Expected stockout cost will be equal to:

(6) $$= C_{d_i} \int_{\bar{I}_i + \bar{S}_i}^{\infty} (S_{d_i} - \bar{S}_i - \bar{I}_i) f_i(s_i)\, ds_i$$

9. Total expected inventory cost of the product i will be equal to carrying cost plus the cost of shortage (expected).

(7) $$= C_{I_i} \bar{I}_i - (C_{\bar{I}_i} + C_{d_i}) \int_{I_i}^{\bar{I}_i + \bar{S}_i} (\bar{I}_i + \bar{S}_i - s_i) f_i(s_i)\, ds_i$$

for all products,

(8) $$C = \sum_{i=1}^{n} (C_{I_i} \bar{I}_i - (C_{I_i} + C_{d_i}) \int_{0}^{\bar{I}_i + \bar{S}_i} (\bar{I}_i + \bar{S}_i - S_i) f_i(S_i)\, dS_i)$$

We wish to minimize this total cost function which is subject to the constraint on aggregate inventory imposed by the aggregate production decision. ie,

(9) $\bar{I} = \sum_{i=1}^{n} U_i \bar{I}_i$ U_i: Factor of equivalence of the product i. So if we set up the Lagrangian function:

(10) $$L = C + \lambda(\bar{I} - \sum_{i=1}^{n} U_i \bar{I}_i)$$

set up the partial derivatives of $\bar{I}_i = 0$ to obtain the first order conditions for a minimum:

(11)

$$\frac{\partial L}{\partial \bar{I}_i} = C_{I_i} - (C_{I_i} + C_{d_i})(1 - F_i(\bar{I}_i + \bar{S}_i)) - \lambda U_i = 0 \quad i = 1, 2, \ldots, n$$

F_i = Probability Distribution function.

$$(I2) \qquad F_i(\bar{I}_i+\bar{S}_i)=\int_0^{\bar{I}_i+\bar{S}_i} f_i(s_i)\,ds_i$$

Equation (II) may be simplified as follows:

$$(I3) \qquad I-F_i(\bar{I}_i+\bar{S}_i)=\frac{C_{Ii}-\lambda U_i}{C_{Ii}+C_{di}}$$

We have assumed that $F_i(S_i)$ is the normal distribution so equation I3 becomes,

$$(I4) \qquad I-F_i(\bar{I}_i+\bar{S}_i)=I-N\left(\frac{\bar{I}_i}{Q_i}\right)=N\left(-\frac{\bar{I}_i}{Q_i}\right)=\frac{C_{Ii}-\lambda U_i}{C_{Ii}+C_{di}}$$

Where, N(t): normal probability distribution function.

N^{-1}: Inverse function of the normal distribution..Equation I4 may be solved for the expected inventory to obtain

$$(I5) \qquad \bar{I}_i=-Q_i N^{-1}\left(\frac{C_{Ii}-\lambda U_i}{C_{Ii}+C_{di}}\right)$$

where i=I,2,...,n

From the definition of aggregate inventory ,Eq9,we then find:

$$(I6) \qquad \bar{I}=\sum_{i=1}^{n} U_i Q_i N^{-1}\left(\frac{C_{Ii}+\lambda U_i}{C_{Ii}+C_{di}}\right)$$

The graphical method of solution of Eq.I6 has been described in Chapter3.Once aggregate inventory level $\bar{I}_i$ as a function of marginal cost of inventory λ has been computed,

it can be used repeatedly as long as the cost coefficients and the standard deviation of sales for each item Q_i, are unchanged.

Asymptotes of the graph: As λ is increased it first approaches to the smallest value of $\frac{C_{ri}}{U_i}$ as this occurs $N^{-1}\left(\frac{C_{ri} - \lambda U_i}{C_{ri} + C_{di}}\right) \longrightarrow -\infty$ and hence $\bar{I}_i \to \infty$.

Similarly as λ is decreased it first approaches to the largest value of $-\frac{C_{di}}{U_i}$, hence $N^{-1}\left(\frac{C_{ri} - \lambda U_i}{C_{ri} + C_{di}}\right) \longrightarrow \infty$

and $\bar{I} \to -\infty$.

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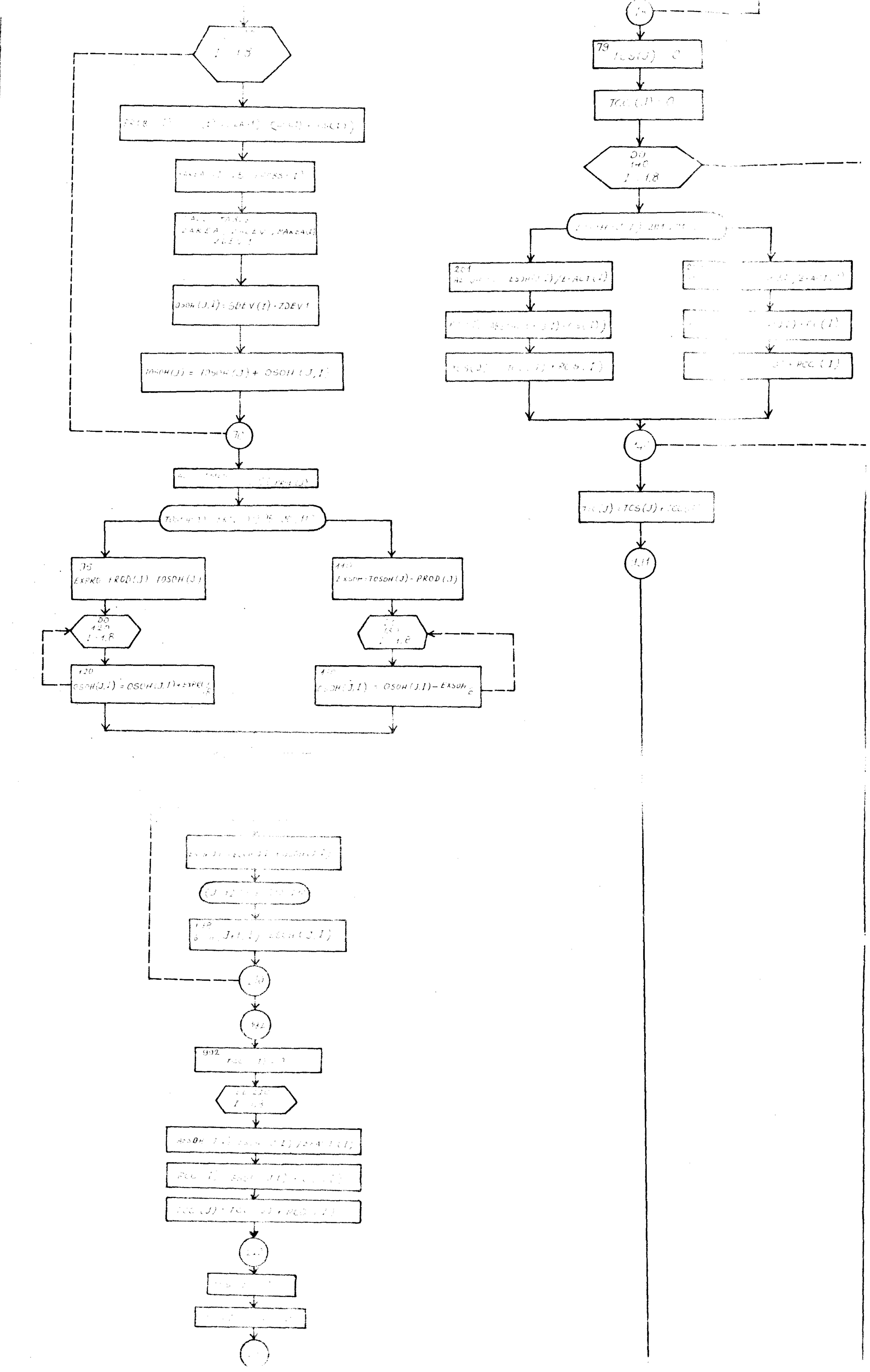
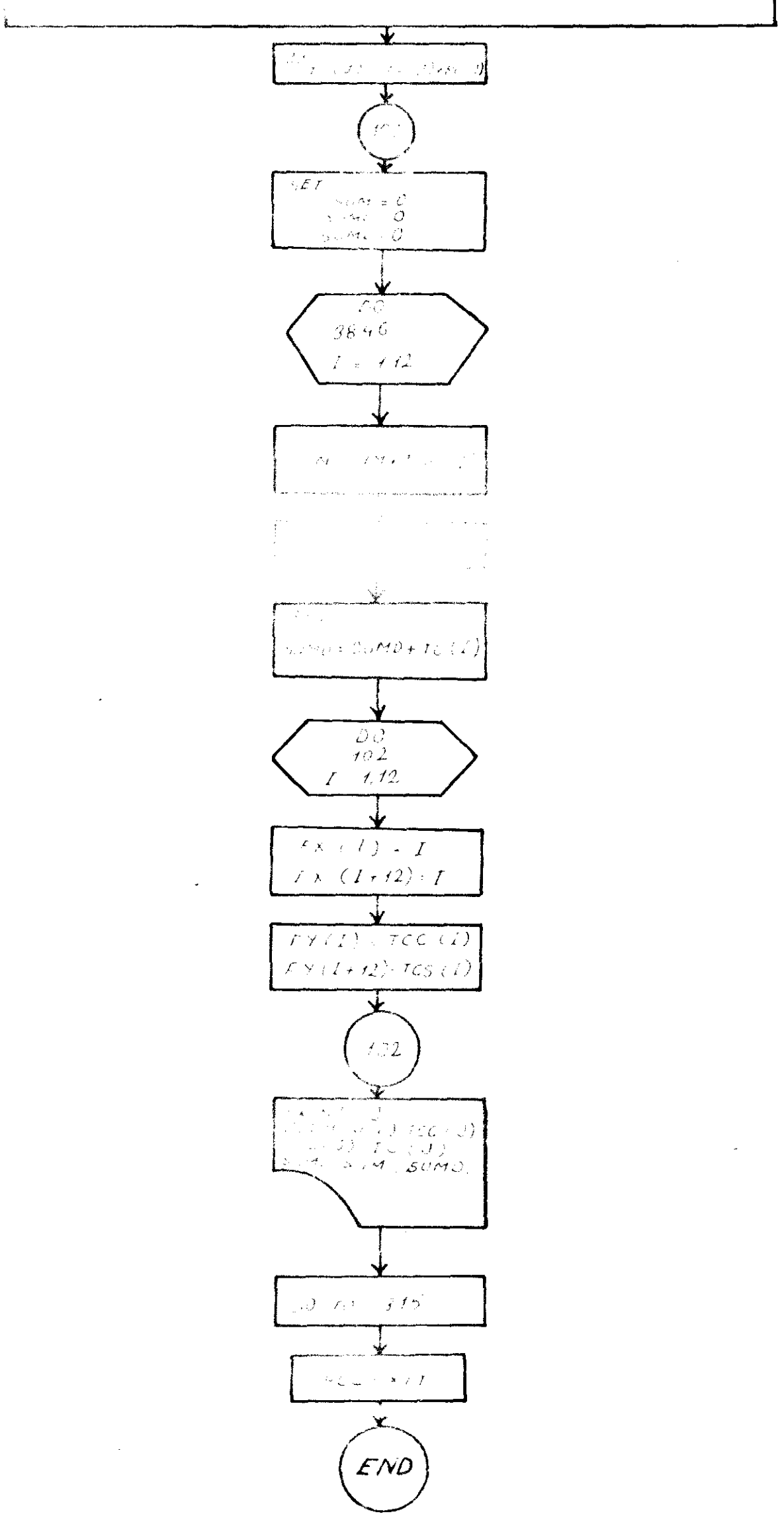
[1] This appendix is based on Chapter II, "Periodic Scheduling of Buffers Stocks With Fixed Lots", of the book, "Planning Production, Inventories and Work Force."

FORTRAN FLOWCHART


79 TCS(J) = 0
DO 140 I = 1,8
201
TCS(J) = TCS(J) + TCC(J)
OSOH(J,I) = SDEV(I) * ZDEV1
TOSOH(J) = TOSOH(J) + OSOH(J,I)
95
EXPRO = PROD(J) - TOSOH(J)
110
EXSOH = TOSOH(J) - PROD(J)
DO 120 I = 1,8
120
OSOH(J,I) = OSOH(J,I) + EXPRO
OSOH(J,I) = OSOH(J,I) - EXSOH
992


SET
DO
3846
I = 1,12
DO
102
I 1,12
102
END