PERFORMANCE OF A VERTICALLY INTEGRATED MANUFACTURER
UNDER INDIRECT REGULATION

DISSERTATION
Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of the Ohio State University

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ACKNOWLEDGMENTS

This research was made possible through the cooperation of the Western Electric Company, Incorporated, which made available the data and information on company operations used throughout the study. The American Telephone and Telegraph Company and the other Bell System Companies, also, permitted the use of pertinent data in the study. I am indebted to all of the Bell System Companies for their helpful cooperation.

I should like to particularly acknowledge the value of the assistance and consultation I received, as the study progressed, from several Western Electric organizations and individuals. The suggestions and comments advanced by the Western Electric Finance Division were most helpful, especially those of Miss Virginia Dwyer, the Corporate Economist. The cooperation of several other Western Electric Divisions and Departments contacted during the research is also appreciated.

Ken Weatherford and Bob Carlson of the Western Electric Company deserve particular citation for their efforts in serving as counselors, advisers and occasionally constructive critics of the project. Their strong support, assistance, and sustained confidence were important factors in the successful completion of
the work. Mrs. Adele Bokelmann and Miss Joanna Manna spent many long and arduous hours in helping with the preparation of the several drafts and the final manuscript.

My teachers and counselors at the Ohio State University, also, had an important influence on this study, and it includes many ideas that were stimulated by my discussions with the teaching and administrative staff. It is particularly appropriate that I mention my obligation to Professor Leo D. Stone for his considerate and thoughtful counseling from the start of the project through its conclusion.

And finally, it is fitting to acknowledge and highlight the contributions of my wife, Rosaline, who has been patient and understanding in the face of the many situations where academic imperatives have taken precedence over domestic custom. Her support and encouragement over so many years have been the most important factors in making possible the successful completion of this research.
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CHAPTER I

INTRODUCTION

Vertical integration as a form of industrial organization continues to generate considerable interest among businessmen and economists. Business people are attracted by the prospects of cost control, the economies of scale, and market advantage. Economists seem to be apprehensive that integration will adversely affect the market structure by tending toward corporate concentration and reduction of competition. Unfortunately, many of the positions that are taken tend to be either subjective or overly theoretical, which suggests that there is either a lack of objective data on vertical integration or a reluctance to accept the findings of experience.

The purpose of this research is to add to the body of business knowledge by an intensive study of the business performance of a vertically integrated manufacturing company which is owned by a public utility. This particular situation is unusual in the structure of the American economy and provides opportunities to develop new data and new insights which should be of value in broadening total knowledge in the field. The capital goods producer integrated within a regulated consumer service organization faces unusual constraints. One is the impact of indirect
government regulation on the operations of the manufacturer. Vertical integration imposes another constraint on corporate behavior, and influences the business performance of the fully integrated manufacturer. This is another major area that is developed in this study.

The manufacturer is the Western Electric Company, Incorporated, which is owned by the American Telephone and Telegraph Company (AT&T), and which serves as the principal equipment supplier for the Bell System. The Bell System includes the parent American Telephone and Telegraph Company, the Western Electric Company, Incorporated, the Bell Telephone Laboratories, Incorporated, and the several Bell Telephone Operating Companies. Western Electric has been part of the Bell System for over eighty years during which corporate organization and relationships within the integrated structure have developed into the present pattern. Over this period, there have been numerous changes in organization in response to internal needs and the requirements generated by the growing size and complexity of the economy. The present structure reflects much experience and provides opportunities for the study of data and trends within a good continuum.

Objectives of the research

The specific objectives of this research are:

1. To examine the vertical integration relationships between a durable goods manufacturing company
and its utility parent, and compare these relationships with other vertically integrated structures.

2. To establish performance standards and evaluate the performance of Western Electric in the areas of productivity, innovation, and customer service.

3. To identify the impact of indirect government regulatory constraints on the integrated manufacturer.

4. To evaluate the behavior and performance of the integrated manufacturer as related to the national economic objectives of full employment, stability of prices, and national growth.

5. To consider the validity of extending the findings and conclusions of this study to other business situations.

The hypothesis

Related to and underlying these objectives, is the hypothesis that the corporate incentives and performance normally derived from competition in the market place can also be provided by a combination of regulation, structural balance, and unusual management techniques in the situation treated in this dissertation where a durable goods producer is vertically integrated within a utility system. The research also considered the concept that there is a
universality in these techniques and organizational methods which suggests that they can be applied with benefit to vertical integration in the broader non-regulated business area.

Research methods and sources of data

In pursuing the objectives of the study, a search and review of all secondary sources was made including books, periodicals, and other writings in the field. The subjects of vertical integration, regulation, corporate concentration, productivity, competition, and monopoly received intensive attention. A great deal of text material is available in all of these areas to provide the broad background for the research. Survey of current appropriate periodicals also reflected a lively continuing interest in these subjects in business and economic journals.

An additional source of secondary data relating to the research was the body of legal and regulatory cases and findings having to do with the activities of the Western Electric Company, the American Telephone and Telegraph Company, the other associated Bell Companies, and other communications companies. There have been a number of court actions involving the structural relationships and practices of the Bell Companies. The established framework of government regulation deals continuously with matters of significance to this study. Consequently, it was necessary to review pertinent legal and regulatory references to make certain that their influence was appropriately included.
The primary research included surveys of operations and performance which were made to obtain data for analysis and comparison. It also included data obtained by interview and discussion with corporate officials and executives. The author's employment with Western Electric was helpful in obtaining relevant data. Another source of data was a series of personal interviews with a group of authorities from the fields of economics and regulation. Included in this group were Dr. John W. Kendrick of George Washington University, Dr. J. Fred Weston of the University of California at Los Angeles, Dr. A. R. Tebbutt of Northwestern University and Dr. Ewan Clague, retired United States Commissioner of Labor Statistics. The results and information obtained from these discussions were identified in the appropriate sections of the research.

The analysis and evaluation work in the body of the dissertation was done against a base of documented data. However, it is appropriate to recognize that some aspects of the research relate to matters of current national import where day-to-day events are still shaping the course of the future. The subject of relationships between AT&T and Western Electric is a collateral part of the current inquiries in Washington before the Federal Communications Commission into the prices and profits of the AT&T Company. The President's Task Force on Communications Policy is expected to complete its report toward the latter part of 1968.
The F.C.C. special study and compilation of data on "computers and data processing" is expected to be completed during 1969. The matter of satellite and international communications is current and controversial. These proceedings may deal with some of the subject matter of this dissertation and may have an impact on some of the important considerations. Wherever circumstances and current knowledge permitted, these considerations are mentioned in the dissertation.

Definitions and identification of fundamental factors

Although most of the terms and concepts that are used in this research follow normal and accepted definitions, it is appropriate in this introductory discussion to identify and define a few of the key terms that occur frequently and are vital in the development of the dissertation.

Vertical integration.--This term describes a situation in which two companies are linked together so that successive stages of the business process are combined under a single controlling management. The key concepts are: (1) complete companies rather than parts of processes, (2) single controlling management, and (3) stages of the total business process rather than the combining of manufacturing processes that may be found within a factory. Vertically integrated structures may be found in either consumer or durable goods industries. In the context of this definition, vertical integration occurs when a manufacturer of men's suits
integrates forward into retailing by acquiring a men's retailing chain or backward into its raw material supply by acquiring a textile mill. It does not occur if the manufacturer rearranges his factory to place successive internal operations under central supervision on a progressive assembly line, thereby replacing the earlier method which employed functional specialization. Vertical integration, then, combines major stages of the total supply process such as raw material, assembly or distribution under a single central management control. Western Electric is a durable goods supplier which is vertically integrated within the Bell System, a service industry.

Performance.--This term will be used in the study to reflect the economic and productive outcome of corporate conduct and behavior. Although it is recognized that the social consequences of corporate action are also important, this aspect is not emphasized other than to recognize that situations that improve telecommunications can have important social and political benefits. The treatment of performance in this study includes identification and research into economic data such as efficiency, cost, price, volume, and analysis and evaluation of these data. In order to interpret and measure, use has been made of comparisons with the data of other firms, evaluation of trends over appropriate time spans, and comparison of data with accepted criteria from the fields of economics and business. Technological performance is
measured on the basis of demonstrated achievements that reduce costs or add new useful products.

Productivity.—As used in this study, the term "productivity" is a measure of corporate efficiency, i.e., a ratio of output to input. This is not the same as the efficiency of classical economics which is primarily concerned with the efficient allocation of resources and distribution of proceeds. Recently, there has been growing interest in various aspects of productivity: output per man hour, value added ratios, and total factor productivity. This study makes use of these measurements of productivity. Total factor productivity which combines the productive effects of labor and capital is particularly emphasized since it is the most recently developed measurement instrument and one that appears to have the greatest applicability and validity.¹

Innovation.—The term "innovation" is used to describe the variety of technological activities that are carried on by American corporations to help improve their products, services, and operations. Economists appear to have great difficulty in defining this concept and have tried to define it across a wide

¹One of the foremost proponents of the use of total factor productivity as a measure of productive efficiency is Dr. John W. Kendrick of George Washington University. His brochure, Productivity Trends in the United States (Princeton, N. J.: Princeton University Press, 1961), a study by the National Bureau of Economic Research, is a lucid explanation of the total factor productivity rationale.
spectrum from the narrow definition of "applied engineering" to the broad concept of "an attitude of progressiveness.\textsuperscript{2}

This investigation does not place major emphasis on managerial improvements in procedures and organization which are frequently included in the broad definition of innovation. Consideration of innovation has been limited to the more technological areas which include research and development, applied engineering, product design and development, process improvement, engineering cost reduction, and value engineering. The study is interested in the engineering impact and the technological output—and measures both against available standards.

Service to the customer.—This is a phrase which can have a double meaning from the standpoint of the Western Electric Company. In the strict sense of the phrase, it means service to the Operating Telephone Companies who are the principal direct customers for manufactured goods. But in a broader sense, Western Electric's ultimate customers are the telecommunications using public which uses the services provided by its manufactured products after they are made operational by the Telephone Companies. Where used in this dissertation, the principal usage is in the context of Western Electric's relationship to its industrial customers, the Telephone Companies. Where used in the broader sense of service to the public, it is so identified.

 Derived demand.—This concept is used in its usual economic sense to describe the fact that a durable goods producer serving the industrial market really operates in a secondary market which is dependent on the primary consumer market. Derived demand has different characteristics from primary demand and tends to influence the behavior and performance of the durable goods manufacturer by its greater volatility and the problem it presents for forecasting and planning. Western Electric responds to the demands of the Telephone Companies which in turn are sensitive to the needs and requests of the telephone using public.

Regulation.—In this study, the term "regulation" will denote supervision of some aspect of the business process by a governmental commission or agency. The entire telecommunications industry operates in a climate of regulation. The principal regulators are the Federal Communications Commission which has jurisdiction over interstate communications and the numerous Public Utilities Commissions which regulate within individual states. In addition, the body of antitrust law (Sherman, Clayton, F.T.C., Robinson-Patman, etc.) and its interpretation through the courts is a significant factor in regulating Bell System conduct and relationships. Western Electric, since it is a manufacturer and not a utility, is not directly regulated. However, it must be

mindful of the regulation applied to its affiliated Telephone Companies and the parent AT&T, and it is deeply involved in the judgments on the capital investment rate bases used in regulation. Consequently, it is considered to be indirectly regulated with its prices, profits, and practices under surveillance by the various Commissions. Throughout the research, wherever applicable, reference is made to the presence and impact of regulation as it affects the substance of the research. In the body of the research, the influence of regulation is an ever present factor which must inevitably enter into considerations of performance.

Plan of the dissertation and major subject matter

The basic structure of this research is relatively straightforward, consisting of: (1) performance of the manufacturer, (2) the significance of the vertically integrated structure, and (3) the effect of indirect regulation.

Subsequent to this introductory section, the initial consideration of the dissertation is the vertically integrated structure of the Bell System and examination of Western Electric's position within it. Western Electric's vertical integration and relationships within the System are compared with vertical integration as it is practiced in industry. Particular attention is given to the objectives and goals of integration to determine if the Bell System integration is aimed at the same objectives. To the extent that there are differences, these are analyzed and eval-
uated for substance. Two obvious points of difference are that: (1) Western Electric is a vertically integrated durable goods manufacturer owned by a public utility, and (2) the Bell System telecommunications network is unique and presents unusual organizational and operational problems.

Subsequent to the consideration of vertical integration effects, the next several chapters deal with an evaluation of Western Electric's performance which is considered from the standpoints of: (1) productivity and productive efficiency, (2) innovation, and (3) service to its customers. This is the major substance of the dissertation, for, in the final analysis, performance must be the determinant of value and must have an important influence upon the national economic structure. Outstanding performance tends to satisfy the goals of the most efficient use of resources and provides proceeds that can be distributed to the factors in a pattern designed to satisfy national economic objectives.

Intensive research investigation has been made of the efficiency of corporate operations with emphasis on productivity and comparative costs and prices. Intensive investigation, too, has been made of technological behavior to measure performance on innovation and technological progressiveness. Related to this and to gain insight into volume effects and related economies of scale and how these affect productivity, the research probes into volume/cost relationships.
The final sections of the dissertation deal with interpretation of the research findings to identify any universals of practice or relationship which characterize the research findings and which point the way to new business understandings. The results of vertically integrated performance are compared with the competitive model postulated by classical economists and the differences are rationalized and interpreted. The data and related analyses are examined for any concepts or principles that may be extended to vertically integrated structures outside the Bell System or beyond that to industry in general.

As reflected in the hypothesis, one of the key questions explored in this research is if superior economic performance can be achieved outside the competitive model of the classical economist by a combination of regulation, ingenious corporate organization, and unusual management techniques. The following sections are an inquiry into performance and organization structure to shed additional light on this thesis and to generate new knowledge for business management.
CHAPTER II

VERTICAL INTEGRATION

The hypothesis of this study refers to organizational structural balance and alludes to matters of corporate organization. The organization structure of an institution is the framework about which activities are carried on and the work of the firm is accomplished. Organization structure can have a significant effect on the character of the institution and on its efficiency and performance.

This chapter deals with vertically integrated organization structures. The objectives of these considerations are: (1) to identify the common characteristics of all vertical integration, (2) to examine Western Electric's vertical integration in the Bell System, (3) to identify any unusual features or differences in Western Electric's situation as compared to general practice, and (4) to evaluate the significance of any differences for consideration with respect to corporate behavior and performance.

Scope of vertical integration in the economy

Vertical integration involves the exercise of unified managerial control over a succession of stages in the production
and distribution of goods and services to the ultimate consumer.\footnote{Vernon A. Mund, Government and Business (New York, N. Y.: Harper and Row, 1955), p. 121.} Conceptually, it includes the full range of business activities from the supply of raw materials through the transactions that place the goods and services in the hands of ultimate consumers. The structure of vertical integration is reflected in Chart I. If any single firm exercises managerial control over two or more of the five successive stages shown on the chart for a related group of final products, it would be considered to be a vertically integrated structure. It is not necessary that the vertically integrated structure include all five stages or that it control stages in strict succession. The present concept of vertical integration applies to control over two or more of the stages, which may even be separated by a stage which is non-integrated. For example, a vertically integrated firm may wish to control the raw material supply and subcontract the manufacture of components and parts which will later be assembled by the firm into the final product which it sells to the ultimate consumer through its own distribution channels. This might occur with the subcontracting of metal plating or metal fabricating operations which the vertically integrated company may choose not to perform in-house for a variety of reasons, such as the need for specialized equipment or concern over a productive capacity mismatch. At any rate, it is
VERTICAL INTEGRATION IN INDUSTRY

SALE TO ULTIMATE CONSUMER

WHOLESALE DISTRIBUTION

MANUFACTURE OR ASSEMBLY OF END PRODUCT

MANUFACTURE OF COMPONENTS OR PARTS

RAW MATERIALS
clear that industrial usage of the concept of vertical integration is relatively well defined and follows the pattern outlined in Chart I.

Vertical integration has been practiced in American industry for a long time. Descriptions of the Colonial textile, iron, and shipbuilding industries include examples of vertical integration which were aimed at achieving economic or marketing advantages. The merger flurries of the late 19th Century and the 1920s included a large number of vertical consolidations, again for the purpose of cost advantages or market position improvement. Along with this, many companies became vertically integrated by internal growth and expansion. More recently, because of concern with government attitudes and action on vertical mergers, there has been much less of a tendency toward either vertical or horizontal consolidations, and the emphasis has been on developing the conglomerate form of consolidated structure.²

But the lessening of recent activity in vertical mergers does not mean that vertical integration is any less important in the structure of the American economy. As a result of the action

taken in earlier periods of economic history and as a result of new activities initiated within the firm which represent the addition of another stage of production, the vertically integrated type of operation is widely prevalent in the economy. Industries such as petroleum, automobiles, tires, steel, and paper represent situations where a vertically integrated structure tends to be the norm rather than the exception.

**Objectives of vertical integration**

The principal objectives of vertical integration are as follows:3

1. Reduction of costs.—This can be accomplished by the elimination or scaling down of functions such as selling, advertising, and market promotion. Cost advantages may also develop out of the greater specialization that integration may establish. Another area of cost reduction may derive from the economies of combined functions that can now be carried on on a larger scale such as financing, marketing, and personnel development.

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2. Improved coordination of successive stages of the total productive process.—The unity of command and purpose brought about by vertical integration will generally provide more effective managerial performance. Some of the ways in which this becomes evident is in faster and more sensitive market response and in better scheduling of processes and action across several stages of production.

3. Assured source of raw material and required supplies.—This can be particularly important where critically needed materials are involved or where the cost of raw materials is a large proportion of selling price.

4. Reduction of inventories and raw material stockpiles.—An assured source of supply will generate more confidence that required materials will be made available when demanded so that raw material inventories in the assembly plant can be held to a minimum.

5. Better quality control.—Unified managerial control can apply and police quality standards throughout the integrated enterprise. This should permit closer adherence to standards and maximum assurance of attainment of quality goals.

6. Increased functional specialization for the total organization.—Larger size and volume should provide a broader base for research and development, financing,
training, and development of personnel. In fact, integration should provide a larger total base of resources to support corporate goals and activities and help toward attaining the economies and opportunities of scale.

7. Improved market sensitivity.---Forward integration toward the firm's markets should provide more knowledge of the markets with increased opportunities for response in meeting customer's needs. Designs and products can be modified and adjusted quickly, when required, to strengthen any aspect of marketing posture.

8. Protection against mistakes of others.---This can be particularly important in highly technological businesses where the nature of the products and services involve a high degree of technical knowledge and worker skills. The computer business and other types of advanced electronic services demand special organization structure or other provisions to provide optimum service to the ultimate consumer.

Problems encountered with vertical integration

As with any institution, practice has reflected numerous problems and disadvantages that tend to make a firm cautious when contemplating action toward an integrated structure. Some of the most prevalent problems that have been observed are:
1. Not all vertical integrations are economical.—Successful integration depends upon the characteristics of product and process. There are numerous examples of vertical integration that have not worked out and many industries where it has not been attempted because of the obvious problems of combining diverse technologies, processes, or capabilities.4

2. Output capacities of successive stages can be out of balance.—This results in problems of disposing of the unbalanced capacity by finding outlets away from the integrated firm, or in operating uneconomically below full capacity. This is the principal reason that tin can manufacturers do not integrate backwards into steel production or breakfast food manufacturers forward into grocery wholesaling or retailing.

3. Lack of diversification and intensification of business risks.—This occurs because more intensive investment is made in the same basic industry rather than using the alternative investment opportunities to broaden and diversify into a variety of products, markets, and industries.

4. Must still earn appropriately on money invested to achieve vertical integration.—Integrating for process

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control or the other objectives outlined does not relieve
the firm of the requirement of earning a reasonable rate
of return on the additional investment.

5. Dilution of managerial experience and know-how.--The
need for management to become involved in the details
and mechanics of the new stage added for purposes of
vertical integration may result in insufficient atten­
tion to either business. In a highly technological
business, where management's knowledge of the technology
becomes strained by the additional requirements of
integration, this may become a significant weakness.

6. Marketing and selling problems that may arise out of
integration.--Other firms in the same business may be
reluctant to continue purchasing relationships with a
supplier who is merged into a competitor. Consequently,
vertical integration may limit selling opportunities.

7. Concern with antitrust legislation and other government
regulation.--Any combination of firms is subject to
scrutiny under antitrust law and practice. There is an
uncertainty and liability related to government reaction
to the merger and associated integrated structure and
subsequent operations and impact on competition in the
industry.
Present status

After reviewing the pros and cons of vertical integration, there is much to be said on both sides. There are no generalizations that apply across the wide spectrum of business situations. Integration is effective and achieves its ends and reflects business values in many long-established situations. Ford in automobiles, Standard Oil in petroleum, du Pont and Celanese in chemicals and plastics, Georgia Pacific in wood products, and General Tire in automobile tires are but a few of many successful vertically integrated companies. Conversely, its practice is not universal. Vertical integration is practiced on a selective basis in situations where the benefits substantially outweigh the potential disadvantages and risks. While vertical integration historically has been subject to criticism, the significant increase in understanding of how it functions which has taken place in recent years has subjected the criticisms to re-examination. In many cases, increased understanding has led to recognition that historical arguments against vertical integration and its presumptively undesirable consequences are not valid.5

One of the concepts that develops out of studying vertical integration is that the price paid for the potential of greater efficiency is increased risk.6 Some of these risks were broadly


6Weston, California Testimony.
covered in the earlier paragraphs on the problems of vertical integration. Inclusion under the umbrella of the vertically integrated firm does not remove the need for each segment to perform efficiently to meet the test of outside competition, nor does it eliminate the requirement to earn an appropriate return.

Western Electric's integration in the Bell System

Western Electric has been part of the Bell System since 1882 when a controlling stock interest was purchased by the American Bell Telephone Company, the ancestor and forerunner of the present AT&T Company. The purpose of the acquisition, as stated in the American Bell Company annual report for that year, was to "insure the highest standards in the manufacture of telephones and apparatus." Today the Western Electric Company is 100 per cent owned by the AT&T Company and serves as principal supplier of telephone equipment to the associated Operating Telephone Companies. In 1967, its revenues for sales and services were over $3.5 billion of which over $3.0 billion was for sales to the Bell Telephone Companies and about $.5 billion for sales to the U. S. Government. This highlights the fact that Western Electric has

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only two significant customers, the Operating Telephone Companies and the U. S. Government. Although some small amount of sales are transacted with a few other customers, these are not sought after and are only nominal in amount. Western Electric is essentially a manufacturing and supply company in the business of providing technologically complex telecommunications equipment. It employs approximately 165,000 people in 15 major manufacturing plants, 35 distribution centers, and 25 installation areas throughout the United States.

Since it is 100 per cent owned by AT&T, and since together with its affiliated Operating Telephone Companies and the Bell Telephone Laboratories, it is under the unified managerial ownership and control of the AT&T, it is a company within a vertically integrated structure. It performs the manufacturing and distribution functions and stages in the model of vertical integration, Chart I. The Operating Telephone Companies perform the function of supplying service to the telephone using public. In general, raw material supply is not integrated in the structure so that the Bell integration includes four of the five stages of vertical integration.

Relationships between Western Electric, its parent company, the AT&T, and its affiliated Telephone Companies are governed by two important sets of documents. One set is the Standard Supply
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Contract between Western Electric and each of the Telephone Companies. Two important provisions included in each Supply Contract are:

1. Manufacture and Purchase of Materials

The Electric Company will manufacture or purchase materials which the Telephone Company may reasonably require for its business and which it may order from the Electric Company; provided, however, that nothing herein contained obligated the Telephone Company to purchase any materials from the Electric Company.

2. Delivery of Materials

The Electric Company will deliver said materials to the Telephone Company upon its written orders, in such quantities, in such manner, and at such times as the Telephone Company may reasonably designate.

The second important set of documents are the Western Electric corporate instructions which set forth basic corporate policy and which cover the ultimate statement of managerial purpose and responsibilities.

The substance of these documents that is germane for the research is the statement that Western Electric exists solely for the purpose of serving the Telephone Companies and the Bell System. It is committed to providing the equipment that the System needs, when it needs it, in the quantities required, and at the lowest cost consistent with required quality and reliability. There is nothing in these documents that makes it mandatory for the Telephone Companies to buy from Western Electric. They may do so if it suits their purposes and they are also free to purchase required goods and services elsewhere. In a sense the integrated
relationship for Western Electric serves to make Western Electric a captive who must be responsive to Bell System needs for survival, and dedicated to superior performance for its continued existence.

Chart II is a graphic presentation of the structure of Bell System integration. Across the top of the structure is AT&T which provides the overall coordination, planning, and financing through ownership and management of the entire enterprise. Along the bottom are the Operating Telephone Companies and the Long Lines Department of AT&T, which operate the telephone network and provide telephone services to the public. Supporting and serving are the Western Electric Company and the Bell Telephone Laboratories (BTL) which together serve to design and manufacture the products required by the Telephone Companies. Although Western Electric's general position in the integrated structure tends to be consistent with the usual model of integrated structures previously examined in Chart I, its relationships with the Bell Telephone Laboratories and the Bell Laboratories' relationship with the AT&T and the Telephone Companies are most unusual and warrant detailed examination. On the chart, there is almost a circular relationship among Western Electric, BTL and either the Telephone Companies or AT&T. This is different from the straight line pattern which characterizes the usual kind of vertical integration examined on Chart I.
CHART II

CORPORATE INTEGRATION IN THE BELL SYSTEM

AT & T COMPANY

OVERALL INTEGRATION, COORDINATION, PLANNING, FINANCING

WESTERN ELECTRIC
MANUFACTURE
INSTALLATION
DISTRIBUTION

OWNERSHIP & FUNDS

BELL TEL. LABS
PRODUCT & SYSTEM R & D
PRODUCT DESIGN

OWNERSHIP & FUNDS

OPERATING TELEPHONE COMPANIES
OPERATION OF THE NETWORK, SERVICE TO THE TELEPHONE PUBLIC

AT & T LONG LINES

OWNERSHIP & FUNDS

RESEARCH
SYSTEMS DESIGN

STANDARDS
QUALITY RELIABILITY
MAINTENANCE

EQUIPMENT SUPPLY

OWNERSHIP & FUNDS
The "systems approach"—key to the Bell System

Western Electric is totally owned by AT&T. Western and AT&T jointly own the Bell Telephone Laboratories and provide funds for the Laboratories' expenditures. This makes the BTL a most unusual organization. It is jointly owned by Western Electric and AT&T and, if the input and output arrows on Chart II are examined, one finds that it develops designs for Western Electric, it does systems design work and research for the AT&T, and it works with the Operating Telephone Companies to perform engineering and planning on the quality, reliability, and maintenance of the telephone plant.

The Bell System emphasizes that it uses the "systems approach" as a vehicle to achieve performance from all organization entities. Western Electric is thus free to specialize in manufacture and production. The Telephone Companies can concentrate on customer liaison and service. Systems planning, research, and development in communications, product designs connecting both of these, and quality, reliability, and maintenance control are all concentrated in the Bell Telephone Laboratories which can then be a powerful planning and engineering resource. And in practice,

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this is precisely what has developed, a central planning and research organization with a formidable array of engineering and technical talent and skills with prowess in communications, electronics, and related technologies.

No one organizational element is free to pursue its interests without consideration for the interests of the other entities, and the objectives of the entire integrated enterprise ultimately govern all actions. The objectives of the total structure are the controlling objectives and the individual interests of individual companies must be subordinated to the interests of the whole, which is oriented to the needs of the customers it serves. This structure establishes a dynamic balance among the companies in the System because it synthesizes the respective objectives of the constituent members. The overall goal of the systems approach is the coordination of each segment of the enterprise with a view toward achieving the best results for the enterprise as a whole.

From the standpoint of Western Electric, although integration affords the Bell System many advantages, the unusual set of relationships with the BTL creates some unique situations. Western Electric is a multibillion dollar manufacturer whose product research and development and product design is performed in a separate company, BTL, and the BTL's principal function is to serve the interests of AT&T and the Telephone Companies. As
will be seen later, this situation where the customer rather than the manufacturer has primary control over product designs and product innovation leads to an unusual set of corporate relationships which has a significant impact on manufacturing performance.

The network

If one reflects on why "the systems approach" in the Bell System, the realization is reached that the Bell System is fundamentally a communications network rather than a conglomerate assembly of equipment products. In order to provide instant telecommunications among approximately 100,000,000 subscribers, the network has been designed and constructed so that every piece must be compatible with, must work with, and must be sensitive to every other piece. This is a technical achievement when one considers that there are hundreds of millions of intricate electrical and electronic devices and billions of conductor feet of wire and cable and that the network is continuously growing and changing.

The design, the development, and the maintenance of this intricate network require a special kind of organizational structure to assure that the knowledge, technical competence, and specialized skills are available to support continued growth and greater usefulness. The Bell System structure has been conceived as the organizational supporting structure that can accomplish this.
Western Electric organization

Even though Western Electric does not do its own product design, but must rely on the Bell Telephone Laboratories for the design of the products it manufactures, it requires technological competence to support its technical manufactures and processes. The requirements for the manufacture of modern telecommunications equipment demand knowledge across the entire spectrum of engineering and technology. In order to understand the intricate, complex products, and to develop appropriate manufacturing processes, scientists and engineers must be available with a wide range of skills from basic material science through and including all of the applied sciences and engineering disciplines. Chart III shows the formal Western Electric organization at the executive level, identifying the major functional areas of the business. In the lower area of the chart the several organizations which are concerned with engineering and technical aspects of the business are depicted. Although no attempt will be made here to explore the detailed functioning of each of these organizations, it is worthwhile to note the relatively large number of organizations with a strong engineering or technical component. The number and substance of these organizations reflect the heavy engineering and technological orientation of the Company. Such major engineering groups as equipment engineering, information systems engineering, the engineer of manufacture organization, quality assurance, and the Princeton Research Center emphasize the technical nature of
The Formal Organization

The Formal Organization

CHART III

WESTERN ELECTRIC
ORGANIZATION

... in doing ____________________________

- MANUFACTURING  SUPPLY & REPAIR
- PURCHASING  NETWORK ENGINEERING  INSTALLATION

... requires unique & special organizational units: ______________________

- Engineer of Manufacture  Quality Assurance  Eng. Research Center

... all of which have a strong engineering or technical component...
the business and Western Electric's dependence on the performance of its engineering organizations. The significance of this is discussed in the later section on innovation, Chapter V.

The impact of vertical integration on Western Electric

One important purpose of all integration, including Western Electric's, is the objective of reducing costs. This is usually sought by economies in selling, distribution, marketing, advertising, and credit extension; or by lower purchase costs; and through the economies and opportunities of expanded scale. In Western Electric's case, its position as an integrated manufacturer has several other pertinent aspects:

1. The requirements of the telecommunications network.—The network is tremendously complex and technical. Western Electric has and maintains a competent technical force to do its manufacturing job and to support the System's requirements for quality, reliability, and compatibility. Western Electric must also stand ready to replace parts of older equipments and to make single or small quantities of items of obsolete vintage.

2. The impact of indirect regulation.—Because of its affiliation with the Bell System, Western Electric
is subject to review of the reasonableness of its prices and profits by the Federal Communications Commission and the State Regulatory Bodies. This is one of the factors that leads to the productivity and cost performance dealt with in detail in Chapter III.

3. It has no product research or design organization.--This is very different from most other integrated companies which still retain their own product design function. The flow of new and changed product designs stems from the Bell Laboratories and the Telephone Companies rather than from within the Western Electric.

4. Number of customers.--Even though the Telephone Companies are grouped together for discussion purposes and are frequently shown as one entity on a chart, they in reality are twenty-three different customers each with its own goals, each subject to varying influences in its area, and each with a significant amount of independence in conducting its own business and deciding what, when, and where it will purchase.

5. The Telephone Companies do not have to purchase from Western Electric.--They purchase from Western Electric only when they feel that it serves their interests to do so. They can and do purchase a substantial amount of telecommunications equipment and supplies from
other non-Bell manufacturing companies, such as switchboards and microwave systems.

The result of these influences on Western Electric is to establish a climate of uncertainty and pressure within the Company because of its liabilities as a specialized manufacturing unit which does not have full control over the design of the products it must produce, the timing of the introduction of new products, or the volume of demand at any specific time. Both the Telephone Company customers and the BTL designers can generate pressure on Western Electric and can cause responses that require unusual performance to accomplish Bell System objectives within a limited time span. Many of the situations generated by the customer or designer, which are developed without too much concern for the impact on Western Electric, have a substantial effect on its costs, orderly processes, or other current plans. All of this suggests that there can be no complacency in Western Electric and that the Company has to be flexible, resourceful, and quick in reaction to accomplish its purpose. The emphasis is on what is best for the Bell System rather than what is convenient for Western Electric.

The specialization allowed by the vertical integration with BTL doing the product design and systems planning, with Western Electric a specialized manufacturer and with the Telephone Companies furnishing service to the public, together with the "systems approach" described previously, establishes a structure
of checks and balances, a sort of "dynamic tensioning" that tends to make the total system sensitive, responsive, and efficient. The Bell Telephone Laboratories can design new things and improve the network without too much concern for the impact on current manufactures. The Telephone Companies can demand new features and designs from the BTL and Western Electric, again, without too much concern with the effect on the manufacturer. Western Electric has the responsibility for pointing out how designs can be modified to minimize manufacturing costs and for assuring that new designs can be manufactured at a cost that will make them attractive. It also is in a good position to work closely with the Telephone Companies to improve forecasting procedures and to point out the cost of unreasonably tight or seasonal delivery requirements. The BTL, in addition to affecting its partners by its research and new designs, can have an impact through its quality and reliability standards and through its position in setting maintenance requirements for the network.

These aspects of Western Electric's environment present both advantages and disadvantages. It has no product research and development function and does no product design. The products it makes are prescribed by a separate company which is under the principal influence of Western Electric's customers. It has no sales, product promotion, or credit extension functions. The absence of these functions is economical and leads to reduced costs and reduced prices to the customers. But the absence of these functions can
also be a liability. There are no alternative markets to the sales to the Telephone Companies. If the Telephone Companies for any reason decide to reduce orders, Western Electric has no alternative markets and no sales force to try to stimulate orders or to try to turn in other directions. Added to this, the regulatory influence with surveillance over efficiency, prices, and profits tends to apply further pressure for performance so that the total climate is one that requires a high level of performance to satisfy the various demands on the manufacturer.

From this discussion, the picture of Western Electric emerges as a specialized manufacturer of highly complex technical durable goods, operating in the secondary industrial market. It is a relatively large company, but only one organization in the much larger Bell System. Its assets and profits amount to a small percentage of those of its parent, AT&T Company, and consequently its goals and objectives are subordinate to those of the System. Western Electric's organizational structure has been arranged so that it can specialize on production with no distractions with product design and no need to dissipate its energies in marketing and selling activities. Its task is sharply focused from a functional point of view. It need be concerned only with doing the best possible job of production from the standpoint of efficiency, cost, quality, reliability, and on-time delivery. While it is carrying out its intensely specialized function, it is subject to surveillance, check, and stimulation from its Bell System partners.
and, at a little greater distance, the Commissions through indirect regulation and their interest in prices and profit. All of this suggests a situation for the Western Electric very different from most other manufacturing companies and one that is conducive to production specialization and efficiency. The specific effects of the integrated relationships and the indirect regulatory constraints are reflected in the next chapter which deals with productivity performance.
CHAPTER III

PRODUCTIVITY, COST CONTROL, AND PRICES

The productivity of a manufacturing enterprise is important because it identifies the efficiency with which resources are being used. It tends to reflect the adequacy of the management, organization, and direction of the enterprise. The productivity level is a major determinant of costs. Productivity trends tend to indicate the quality of management performance over a period of time. Productivity, also, influences prices and profits.

There is a circular relationship among the three aspects of performance—productivity, innovation and customer service—that are being explored in this study. Research into the elements of productivity indicates that productive efficiency is heavily dependent on innovation and technological progress. Improved performance in the area of customer service is dependent upon increasing usefulness of the products and services offered to the public which is also influenced by the innovative processes. The improved products and services must, of course, be made available at a reasonable and marketable price. Innovation leads to improved productivity and products which in turn support innovation and make possible further innovation.
This chapter deals with Western Electric's productive performance. Since productivity is reflected in costs, the study is also concerned with costs, particularly those aspects that can provide insights into performance and how performance is accomplished. Examination of the data on productivity, cost, price, and profit should provide a basis for evaluating the behavior and conduct of the vertically integrated, indirectly regulated subject.

Productivity and productive efficiency

Through the years, economists and business experts have evolved a number of concepts which are useful for evaluating the productivity of the firm. Each of the several concepts has value for its own purposes, but "total factor productivity" is now accepted as the best productivity measure. Adam Smith gave classic expression to the role of productivity advance in national economic growth when he wrote:

... The annual produce of the land and labour of any nation can be increased in its value by no other means, but by increasing either the number of its productive labourers, or the productive powers of those labourers who had before been employed ... in consequence either of some addition and improvement to those machines and instruments which facilitate and abridge labour; or of a more proper division and distribution of employment.  

One of the simplest measures of productivity is the ratio of output in some standard measure to input of labor measured in 

hours worked. This ratio can be computed for an individual, for a group of employees, for the firm, or for the economy. It can become less valid as it is applied to the output of larger groups of workers. If variations in the labor skills with related differences in hourly wages develop, specific adjustments must be made. This ratio can be misleading as a measure of efficiency since a large part of the increase in output comes from increased capital per worker. Differences in the production processes and the level of integration makes its use in comparing companies difficult.

Output can be measured in either gross or net terms. The net or value added concept is one that has received growing attention as a more appropriate measure for comparing productive efficiency among firms. Value added is the total output of the firm in dollars less the value of purchased raw material, component parts, and services. The value added concept is used extensively by manufacturing firms and is gaining growing acceptance in the marketing field to measure the effectiveness of wholesaling and retailing establishments.²

The most recent development for efficiency measurement is the concept of "total factor productivity." This index goes beyond the measurement of labor productivity and provides considera-

tion for the effective use of capital. One of the leading proponents of this method is Dr. John W. Kendrick, Professor of Economics at George Washington University, who developed his concept of "total factor productivity" in the late 1950s and has since published several books and treatises on the subject. Total factor productivity is defined as a measure of net output per unit of combined labor and capital inputs based on accounting data, all restated in base year prices.  

Concept of total factor productivity

The concept of "total factor productivity" is comprehensive and applicable to efficiency measurement in both the short and long run. As Dr. Kendrick says:

In the short run, improvement in productivity may merely reflect changes in the rate of utilization of capacity in a given plant. Over the longer period, productivity indexes, as measured between years of comparable rates of operation in two or more business cycles reflect primarily changes in the technology and organization of production. At the company level it may mean (1) more and better machinery and equipment per worker, (2) more economical use of improved materials, (3) altered plant layout and work flow, (4) improved organization, (5) relinquishing of certain activities or acquiring of new activities, (6) expanded training programs, (7) improved labor relations, and (8) generally reorganized management procedures.

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And then significantly Dr. Kendrick goes on to say:

How fast a company's productivity advances thus depends on the relative effectiveness of management in discovering and adopting ways and means of reducing unit costs.\(^5\)

Solomon Fabricant, of the National Bureau of Economic Research, lends support to the thought of Dr. Kendrick when he says:

Productivity is a measure of the efficiency with which resources are converted into the commodities and services that men want. Higher productivity is a means to better levels of economic well-being and greater national strength. Higher productivity is a major source of the increment in income over which men bargain and sometimes quarrel. And higher—or lower—productivity affects costs, prices, profits, output, employment and investment, and thus plays a part in business fluctuations, in inflation, and in the rise and decline of industries.\(^6\)

While the arithmetic computation of total factor productivity has been reduced to a relatively simple series of mathematical steps, it should be recognized that there are complexities included in the input and output factors which can represent measurement problems. On the input side, some of the problems that should be kept in mind are: (1) the nature of both labor and capital inputs tend to be diverse and change with time, and (2) the process requires aggregation of heterogeneous units of input. There are similar problems on the output side since outputs, too, tend to change over a period of time and must combine dissimilar units of output.

\(^5\) Ibid., p. 12.

An example of how the change in total factor productivity is computed is reflected in Table I.

Productivity performance

As has been indicated, productivity measurement attempts to identify the efficiency of the firm. It relates output to input, over a period of time, to get an efficiency index. The simplest form of measurement is one that relates the total "real" output of the firm to labor hours, and is expressed in terms of dollars of output per labor hour. This overly simple criteria is infrequently used because of the many variables included in dollars of output and hours of labor. It has been largely replaced by other indexes which have more meaning and which have achieved more universal acceptance because of their greater validity.

Chart IV reflects Western Electric's labor output on the basis of value added per man hour worked over the period 1948-1967. It relates these data to a similar measure for all U.S. manufacturing industries. It can be readily seen that labor output measured in this fashion has increased for both sets of data over this time period. It can also be observed that Western Electric's value added per man hour worked improved by 215 percent while all U.S. industry increased by 73 percent.

Even though output is expressed in terms of dollars per man hour, most of the productivity performance in both curves is
TABLE 1

Computation of Total Factor Productivity
(Dollar and man-hour data in millions)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gross output (sales + manufactured plant + change in inventory)</td>
<td>$200.0</td>
<td>$220.0</td>
<td>$235.0</td>
</tr>
<tr>
<td>2</td>
<td>Intermediate materials and services (including depreciation and taxes other than Social Security and income)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Value-added (output for the productivity measure)</td>
<td>100.0</td>
<td>110.0</td>
<td>117.5</td>
</tr>
<tr>
<td>4</td>
<td>Labor input</td>
<td>26 man-hours at $2.80 per hour</td>
<td>72.8</td>
<td>27 man-hours at $2.80 per hour</td>
</tr>
<tr>
<td>5</td>
<td>Capital</td>
<td>20% x average investment of $150.0</td>
<td>32.5</td>
<td>20% x average investment of $163.5</td>
</tr>
<tr>
<td>6</td>
<td>Total input (line 4 + line 5)</td>
<td>$100.0</td>
<td>$105.3</td>
<td>$109.8</td>
</tr>
<tr>
<td>7</td>
<td>Productivity increase (line 3 — line 6) (cumulative)</td>
<td></td>
<td>$4.7</td>
<td>$7.7</td>
</tr>
<tr>
<td>8</td>
<td>Total factor productivity</td>
<td>100.0</td>
<td>104.5</td>
<td>107.0</td>
</tr>
<tr>
<td>9</td>
<td>Partial productivity measures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Output per unit of labor input</td>
<td>1.429</td>
<td>1.511</td>
<td>1.554</td>
</tr>
<tr>
<td>10</td>
<td>Index (1961 = 100)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Output per unit of capital input</td>
<td>100.0</td>
<td>105.7</td>
<td>108.8</td>
</tr>
<tr>
<td>12</td>
<td>Index (1961 = 100)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*1961 rate of return on average investment before income taxes.

CHART IV

WESTERN ELECTRIC OUTPUT
PER UNIT OF LABOR INPUT *

INDEX: 1948 = 100

WESTERN ELECTRIC

ALL U.S. MANUFACTURING INDUSTRIES

VALUE ADDED BASIS

Source: Western Electric Company
due to technological improvements, innovation, the judicious application of capital, and management effectiveness. Since the value added per man hour measurement fails to take into account the substitution of capital for labor, total factor productivity is a better measure of performance and provides additional insights into the operation of the firm.

**Measurement of total factor productivity**

The various productivity measures have different uses for internal management, such as analyzing the effects of new investments, projecting requirements for inputs, budgeting for future periods, or for promoting efficiency. For purpose of this study, productivity indexes are used as a prime measure of the degree of success achieved by management in the reduction of "real" costs per unit of output and to compare these results with those of other industries and the economy as a whole.

In 1962, a basic study was conducted by Western Electric following the methodology developed by Dr. Kendrick, which provided a total factor productivity measure for the Company. The year 1961 was chosen as a base since it was a recent year in which Western Electric's volume was relatively high, and in which the rate of return on investment was relatively normal. This insures that there is no distortion of the relative importance of capital and labor in the input measure for total factor productivity. Subsequently, total factor productivity has been calculated each year and is one of the indexes upon which evaluation of Company performance is based.
A review of the concept and methods followed for computing Western Electric's productivity is outlined in the following paragraphs.

**Output measure.**—The concept of output used in the study is "real value-added" or "income created within the firm," expressed in constant dollars. "Real value added," or net output, refers to that portion of the production which is the direct result of the Company's contribution to the market value of its production.

**Input measures.**—As the labor input measure, the Company used the total man hours worked by all employees on Bell business in each year. Since these data were already available in physical volume form, no adjustment or deflation was required. The capital input measure is based on the Company's average annual net investment expressed in constant dollars derived from price indexes for each major asset component.

**Combining labor and capital inputs.**—The labor and capital input series were combined by using the base year (1961) payments to and on behalf of employees per man hour worked as a weight for the labor input series, and the year's pre-tax rate of return as the weight for the average net investment series. In the base year the combined factor inputs are equal to value added. In all other years, however, they differ from value added and this difference is a measure of productivity change.

The productivity measure developed from the basic study can be directly compared with the productivity series for the
private domestic economy and other industries developed under the supervision of Dr. Kendrick. The same methodology is followed as is used in Western Electric's studies with the necessary component values derived from various accepted sources, such as publications of the Department of Commerce organizations, the Office of Business Economics and the Census Bureau. The "Employment and Earning Statistics" from the Bureau of Labor Statistics, Department of Labor, help to provide input information.

Chart V reflects the trend rate of growth of total factor productivity for Western Electric and various sectors of the economy during the period 1948-67. Western Electric's average annual improvement in productivity during the period has been approximately 5.4 per cent or over one and one-half times the annual improvement for the electrical equipment industry, and more than twice that of the private domestic economy and the manufacturing sector.

The primary data used in computing Western Electric's productivity indexes reveal a greater proportional increase in value added and capital input than in labor input. This indicates that some portion of the increase in output per man hour was gained through the substitution of capital for labor. This suggests that Western Electric, like most other companies, is achieving productivity increases by increasing the amount of capital per employee and by utilizing the benefits of technological progress.
CHART V

TOTAL FACTOR PRODUCTIVITY TREND
INDUSTRY COMPARISON
(AVERAGE ANNUAL RATE OF CHANGE 1948-1967)

<table>
<thead>
<tr>
<th>Industry</th>
<th>Rate of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>W.E. Bell Business</td>
<td>5.4%</td>
</tr>
<tr>
<td>Private Domestic Economy</td>
<td>2.3%</td>
</tr>
<tr>
<td>Manufacturing Industries</td>
<td>2.5%</td>
</tr>
<tr>
<td>Electrical Machinery and Equipment</td>
<td>3.5%</td>
</tr>
</tbody>
</table>

Source: Western Electric Company
Chart VI shows that Western Electric's net investment per employee, over the time span 1948-1966, has increased three times, and at a compound rate of growth of 6.3 per cent per year. The greatest increases have occurred in the past ten years.

Firms with higher productivity improvement rates enjoy a competitive advantage over their peers. Distribution of the gains achieved through productivity increases can provide insights into the characteristics and mode of operation of a company. Under competitive conditions, firms that increase productivity and, thus, cut unit costs, should enjoy larger than average rates of return. In unregulated industries, profit, the rate of return on capital, and the growth rate, should reflect the competitive advantage of better than average productivity growth. But in an industry whose rate of return is constrained through indirect regulation, direct efficiency measures, of which the productivity index is one of the most effective, are of special relevance in appraising the performance of the firm.

In contrast to the normal competitive behavior, which would be to retain a portion of the increased earnings, approximately 60 per cent of Western Electric's improvement in productivity has gone to labor in the form of higher wages; the remainder has gone to suppliers in the form of higher raw material and component prices, and to the Operating Companies in the form of lower prices for Western Electric products.
WESTERN ELECTRIC NET INVESTMENT PER EMPLOYEE

Note: Bell business only. Net investment consists of equity, and long-and short-term borrowings.

Source: Western Electric Company
The AT&T statement to the President's Task Force on Communications Policy makes an interesting observation about this productivity performance. This statement postulated that if Western Electric had achieved only the average annual improvement in productivity realized by other electrical equipment suppliers, the Bell Operating Companies would have paid several billion dollars more for the equipment they purchased in the postwar period. An alternative result of the postulated higher prices might have been a commensurate reduction in the amount of equipment purchased from Western Electric by the Telephone Companies.

Prices

Prices provide an important measurement of performance as well as serving as an indicator of other corporate characteristics. Professor Weston says:

Economists generally apply two kinds of price tests. One is the trend in relative prices in relationship to the economy as a whole and the second is a comparison of prices charged by a given firm to prices charged for similar products by firms in the same general line of business. Western Electric's price performance is evaluated by comparing the relationship of its prices to prices in the economy over

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8Weston, California Testimony.
a period of time, and by comparison with competitive manufacturers' prices on similar products. In addition to the general level of overall prices, the major components of: (1) apparatus and equipment, (2) cable and wire, and (3) supplies are each individually reviewed. Interest in profit will be limited to the extent of helping to understand the position of prices as they evolve out of the comparative study of prices with the economy, and the comparison of product prices with general trade manufacturers.

Western Electric develops its prices principally from estimates of future costs. Standard or predetermined manufacturing costs are established for all manufactured items. Increments are added to these standard costs to recover estimated research and development expense, general administrative expense, merchandising expense, forecasted manufacturing variation, Federal income taxes, and a return on investment.

The primary objective of the Western Electric pricing policy is to set prices at the lowest level which will recover costs and provide a reasonable return on the investment involved. It should be noted that since profit maximization is not a primary objective, benefits accrue to the Bell System customers in the form of prices that are lower than if the objective was to return a maximum profit. Consequently, evaluation of price performance, measured against input cost, should prove a valid
measure of manufacturing performance, and will help to reflect Western Electric's operational and managerial effectiveness.

As one measure of price performance, Western Electric maintains price and cost indexes based on internal accounting and statistical data. Review of the methods of compilation, illustrates that a conservative approach is used in developing these indexes. The indexes of raw material purchase prices are based upon the delivered cost, i.e., prices less any discounts plus freight. These (average monthly) prices are taken directly from invoices and purchase contracts. Changes in the prices for each commodity are computed monthly and combined into indexes by means of appropriate weighting. The wage index is based on changes in job rates, as specified in the collective bargaining contracts, for all hourly rated employees in Western Electric's factories.

The Western Electric manufactured products price indexes have several interesting features. First, Western's price indexes reflect an evaluation of the price changes of all significant items

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9Dr. Ewan Clague, retired Commissioner, Bureau of Labor Statistics, was retained to review Western Electric's price indexes and found "that the procedures followed in their construction are statistically sound and that the indexes are reasonably accurate measures of the changes in the price levels of the products the company manufactures and sells to the Bell Operating Companies." "Report of NARUC-FCC Telephone Staff Subcommittee on Manufacturing and Service Affiliates to the Staff Committee on Communications Problems," (Transmittal letter for the "Report on Operating Results, Western Electric Company, Incorporated, Years 1958 to 1967, Inclusive"), p. 2.
in every category and are not developed on a sampling basis. Second, they do not reflect substantial savings which frequently accrue to the Telephone Companies from changes in design of the product which increase its service-providing capacity, improve its quality, or extend its life. Only the interaction of changes in cost elements and efficiency are reflected. Correspondingly, the introduction of new or changed designs at price levels lower than the products they replace are not reflected in Western Electric's price indexes. Third, the price indexes do not have the downward bias which could occur if new products were introduced at relatively high prices and subsequently reduced to more normal levels, and these reductions were reflected in the price indexes. Generally, new products are introduced at prices based on costs which are expected to prevail at efficient production levels.

Chart VII compares the current level of cost and price indexes (July 1, 1968) with January 1, 1950 indexes. (Appendixes I and II reflect these indexes in detail.) The chart shows three sets of cost and price change data over this period of time: Bureau of Labor Statistics general prices; the most important Western Electric cost element inputs; and Western Electric prices to the Bell Telephone Companies. The Bureau of Labor Statistics data show that over this time period, wholesale prices for industrial commodities have gone up 37 per cent, for durable manufactures 54 per cent, for electrical machinery and
### Chart VII

**Manufacturing Cost and Price Comparisons**

**July 1, 1968 with January 1, 1950 Levels**

<table>
<thead>
<tr>
<th>% Decrease</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0</td>
</tr>
</tbody>
</table>

**General Prices - Bureau of Labor Statistics (June 1968)**

<table>
<thead>
<tr>
<th>Industrial Commodities</th>
<th>5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durable Manufactures</td>
<td>7%</td>
</tr>
<tr>
<td>Electrical Machinery and Equipment</td>
<td>5%</td>
</tr>
<tr>
<td>Wire and Cable</td>
<td>9%</td>
</tr>
</tbody>
</table>

**Important Western Electric Cost Elements**

<table>
<thead>
<tr>
<th>Description</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Materials for Apparatus and Equipment (June 1968)</td>
<td>46%</td>
</tr>
<tr>
<td>Raw Materials for Cable and Wire (June 1968)</td>
<td>56%</td>
</tr>
<tr>
<td>Wages (July 1, 1968)</td>
<td>13%</td>
</tr>
</tbody>
</table>

**Western Electric Prices to Bell Companies**

<table>
<thead>
<tr>
<th>Description</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Products of W.E. Manufacture</td>
<td>5%</td>
</tr>
<tr>
<td>Apparatus and Equipment</td>
<td>11%</td>
</tr>
<tr>
<td>Cable and Wire</td>
<td>19%</td>
</tr>
<tr>
<td>Supplies</td>
<td>12%</td>
</tr>
</tbody>
</table>

Source: Western Electric Company
equipment 54 per cent, and for wire and cable 98 per cent. These categories have been charted because they seem to be most comparable to Western Electric's manufacturing and product line.

Examination of Western Electric's cost element inputs shows that the changes over this time period have been 46 per cent for raw material for apparatus and equipment, 56 per cent for raw material for cable and wire, and 120 per cent for wages paid to Western Electric employees. The increase in cable and wire raw material prices, which is larger than the increase in raw material for the other product lines, is significantly influenced by the large increases in copper prices that have been experienced over recent years. The combined raw material costs index of 50 per cent correlates reasonably well, on an average basis, with the increases shown for the Bureau of Labor Statistics wholesale prices.

From the lowest section of the chart, which shows Western Electric prices to the telephone companies, it can be seen that despite these increases in the level of wages and material prices of 120 per cent and 50 per cent, respectively, Western's prices for its total line of products has been reduced by 5 per cent on a weighted average basis over the 1950-1968 period, and has been reduced 11 per cent for the apparatus and equipment product lines. Included within the 5 per cent reduction and averaged with the 11 per cent reduction is a 19 per cent increase in cable and wire
prices. Since the copper raw material cost represents a relatively large percentage of the selling price of wire and cable, it is more difficult to offset the increases in copper prices by more efficient production methods.

Not only has Western Electric been able to offset, in a large measure, substantial increases in material and wage costs, but it has been able to do this more successfully than industry generally, as reflected in Bureau of Labor Statistics Wholesale Price Indexes (WPI). While Western's prices for Apparatus and Equipment went down 11 per cent, the WPI for both Durable Manufactures and Electrical Equipment increased 54 per cent. Even more strikingly, Western Electric held its increases in cable and wire to 19 per cent, while the WPI for such products increased by 98 per cent.

In summary, though burdened with substantial increases in the cost inputs of raw material and labor, and despite rising price levels in general, Western Electric productivity has provided a base which has made it possible to reduce prices. Although cable and wire prices increased moderately, apparatus and equipment prices declined, for a combined manufacture price level at 5 per cent below the January 1, 1950, prices.

Western Electric's price performance is also reflected in the price trends of individual products which become significant items of Telephone Company plant. Chart VIII shows the price
WESTERN ELECTRIC MANUFACTURING
COST AND SELLING PRICE TRENDS
(ANNUAL AVERAGES, 1948 - 1967)
1-1-50 = 100

W.E. RAW MATERIAL COSTS

W.E. WAGE COSTS

TRANSMISSION EQUIPMENT PRICES

SWITCHING EQUIPMENT PRICES

EXCHANGE & TOLL CABLE PRICES

STATION APPARATUS PRICES

Sources: Western Electric Company
trends of four major product lines along with the trend of raw material and wage costs. (Appendix III is an index summary of the four major product lines.) These figures indicate that Western Electric's ability to offset rising costs is not confined to one particular area of the business, but is distributed across most product lines.

Studies comparing Western Electric prices for telecommunications products with independent manufacturers' prices for equivalent equipment have been made regularly by AT&T for a number of years. These studies, supervised by the AT&T's Engineering Economics Department, are made to furnish the Bell Telephone Companies with a gauge of the reasonableness of Western Electric's prices and to submit as testimony in rate cases. Price comparisons, among general trade manufacturers, seem to be a reasonably valid test since the independent manufacturers are competitive in their respective fields of communications equipment and the comparisons can be made on equivalent equipment. Equivalent equipments are those items which perform the same function and are similar in design and construction. This is ascertained by a review of general trade catalogs, manufacturers' drawings, and examinations and tests of the items. Telecommunications products are separated into three product groupings: telephone apparatus, cable, and outside plant material. Telephone apparatus consists of items used principally on or about the telephone subscribers'
premises, such as telephone instruments, insulated wire, and other products used for maintenance or minor additions to private branch exchanges, such as relays and repeating coils. Cable covers the various types used in exchange and toll applications. Outside plant material includes such items as wire, strand, poles, and hardware. These groupings reflect aggregate results obtained from the broad assortment of telecommunications products included in the annual studies. Western Electric's price level is then shown as a per cent of the lowest general trade prices for equivalent products.

Charts IX through XI show the overall results of the annual studies. For 1967, Western Electric's telephone apparatus is priced at approximately 50 per cent of the lowest general trade prices. Cable, including exchange and toll cable, is priced at 60 per cent of the lowest general trade price. Outside plant, most of which is manufactured by others and which is handled by Western Electric as a middleman in its role as a supplier, has the least difference at 76 per cent of the lowest trade price.

Periodically, in addition to these annual studies, extensive detailed studies are conducted to provide an overall measure of price comparison between central office and private exchange equipment assemblies. Another, still broader study, is made of an independent telephone company's complete purchases of telecommunications products for a period of one year. This study provides an
CHART IX

Telephone Apparatus
Western Electric Bell Prices as a Per Cent
of the Lowest General Trade Prices

Note: 1967 and 1968 are results of preliminary studies. 1968 prices are latest available as of July 1.

Source: American Telephone and Telegraph Company
CHART X

Cable

Western Electric Bell Prices as a Per Cent of the Lowest* and Average General Trade Prices

*Prior to 1958 average prices were used.

Note: 1967 and 1968 are results of preliminary studies. 1968 prices are latest available as of July 1.

Source: American Telephone and Telegraph Company.
Outside plant material
Western Electric Bell Prices as a Per Cent of the Lowest General Trade Prices

Source: American Telephone and Telegraph Company
evaluation of Western Electric's price relationship over a total spectrum since it considers the product mix and quantities actually purchased by the Independent Telephone Company. The results of these studies are similar to the annual studies, and show Western Electric's overall price level at approximately 65 per cent of that charged to an Independent Telephone Company by its supplier. Chart XII reflects the results of these studies.

The literally thousands of apparatus codes used in telecommunications make the cost of examining each specific item prohibitive. However, price comparisons can be made of a few specific items which are typical of the major elements used in the operation of the telecommunications system, and provide further insight into the price differentials. Appendix IV includes illustrations of the following summary. The basic telephone set, the standard 500 type telephone, is currently priced at $11.76, including the connector block, to the Bell System Operating Companies. A comparable set manufactured by an independent telecommunications manufacturer sells for over $18.00 to an Independent Telephone Company. Western Electric's price for another popular set, the Princess, is currently $25.76 compared to over $37.00 for an Independent's equivalent set. The total dollar savings to the Bell Telephone Companies in purchasing telephone sets from Western Electric are substantial when one considers the more than 86 million telephones in the Bell System, and current annual sales of approximately 8 million sets.
CHART XII

Independent Telephone Companies Total Purchases of Telecommunications Products

Western Electric Bell Prices as a Per Cent of the Actual General Trade Prices

Source: American Telephone and Telegraph Company
Although central office switching equipment is custom made, and consequently difficult to compare on any basis other than on a total office comparison, apparatus within the office provides a basis for valid price comparisons. The 120C impedance matching repeater coil commonly used in the central office is currently priced at $6.55 by Western Electric, as compared to over $8.80 by the lowest price Independent. The 300 B2C, 100 pair, 20 foot stub type connector block used to connect incoming lines to the central office is manufactured and currently sold for $118.00 by Western Electric. The Independent Companies' equivalent is priced at over $270.00, a substantial difference. Two of Western Electric's cable products, the 900 pair feeder distribution STALPETH CABLE and the "C" rural wire, are priced at $230 per 100 feet and $20.80 per 1000 feet, respectively. The Independent's equivalent of these cables are priced at $465 per 100 feet for feeder cable, and $33.00 per 1000 feet for rural cable.

The items selected are representative products, reflecting typical differences between Western Electric's prices and those of the lowest price competitor in the Independent telecommunications industry. These items are specific examples of the many that contributed to the broad category or class comparisons noted earlier. The data indicate the scope of Western Electric's performance in minimizing the price levels of its Bell System sales items. Prices have been reduced from the 1950 base, while Western Electric has been subject to constantly increasing wage rates and
purchased material costs. Further, Western Electric's price level is significantly lower than the lowest price general trade manufacturer.

In summary, these preceding examples give strong indication, based upon price comparisons, that Western Electric has achieved and maintained a high level of manufacturing performance.

Profit

A brief consideration of Western Electric's position on profit is in order at this stage to provide further background for consideration of Western Electric's productivity and price performance. Attention is given to the level of Western Electric's profits relative to those of other comparable firms in the economy, to determine if Western Electric is obtaining unusual profits as a result of its good productivity performance.

As part of the testimony in the recent Pacific Telephone and Telegraph—California Rate Case, Dr. J. F. Weston, Professor of Economics at the University of California at Los Angeles, testified regarding a study he had made of Western Electric's profit and rate of return on investment. He studied the earnings and capital structure of 91 manufacturing companies, and then compared Western Electric's performance against them. He selected the companies for comparison out of an analysis of 1000 companies

10 Weston, California Testimony.
listed as suppliers to Operating Telephone Companies in the "Telephone Engineer and Management Directory." Out of his analysis and evaluation, he identified 91 as being appropriately comparable to Western Electric on the basis of the nature of the business, product line, size, or operational characteristics. The principal criteria was product line within the telecommunications or communications market and the pattern of relationships with major companies.

Chart XIII shows the 91 companies used for comparison. Group I includes suppliers of specialized communications products. They include component and instrument companies which are listed as suppliers in the "Telephone Engineer and Management Directory."

Group II companies include three categories. One segment consists of suppliers of telecommunications products and services with some breadth of product line, and for which communication equipment is a substantial portion of their total sales. A second category is represented by large non-regulated companies, the operations of which include formerly independent telecommunications supplier companies. The third type of companies in Group II are large, with a wide range of electrical, electromechanical, electronic, and electrochemical products, known to include one or more types of telecommunications products. They overlap in only a segment of Western Electric's product output, but are continuously

### IDENTIFICATION OF THREE GROUPS OF COMPANIES

**COMPARABLE TO WESTERN ELECTRIC**

#### GROUP I

Suppliers of one or more communications products.

<table>
<thead>
<tr>
<th>Product</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amp(Aircraft-Marine Products)</td>
<td>General Instrument</td>
</tr>
<tr>
<td>Amphenol</td>
<td>General Signal Co.</td>
</tr>
<tr>
<td>Beckman Instruments, Inc.</td>
<td>Gould National Batteries</td>
</tr>
<tr>
<td>Bourns, Inc.</td>
<td>Hewlett-Packard</td>
</tr>
<tr>
<td>Burndy, Corp.</td>
<td>IRC, Inc. (International Resistance Co.)</td>
</tr>
<tr>
<td>Century Electric Co.</td>
<td>ITE Circuit Breaker</td>
</tr>
<tr>
<td>Continental Connector</td>
<td>Jerrold Corp.</td>
</tr>
<tr>
<td>CTS Corp.</td>
<td>Joslyn Mfg. &amp; Supply</td>
</tr>
<tr>
<td>Dielectric Products Engineering Co., Inc.</td>
<td>Lynch Communications</td>
</tr>
<tr>
<td>ESB, Inc. (Electric Storage &amp; Battery)</td>
<td>Microwave Associates, Inc.</td>
</tr>
<tr>
<td>General Cable</td>
<td>P. R. Mallory Co.</td>
</tr>
<tr>
<td></td>
<td>Plymouth Rubber Co., Inc.</td>
</tr>
<tr>
<td></td>
<td>Reliance Electric</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Suppliers that are a segment of a larger firm; telecommunications products may not be the largest portion of company sales.

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admiral Corp.</td>
<td>Gulton Industries, Inc.</td>
</tr>
<tr>
<td>American Bosch Arma</td>
<td>Kellogg Switchboard &amp; Supply</td>
</tr>
<tr>
<td>Anaconda Company</td>
<td>Kennebec Copper</td>
</tr>
<tr>
<td>Avnet</td>
<td>Keystone Steel &amp; Wire Co.</td>
</tr>
<tr>
<td>Collins Radio</td>
<td>Magnavox</td>
</tr>
<tr>
<td>Cook Electric</td>
<td>McGraw Edison</td>
</tr>
<tr>
<td>Dynamics Corp.</td>
<td>Motorola</td>
</tr>
<tr>
<td>Emerson Electric</td>
<td>North Electric Co.</td>
</tr>
<tr>
<td>Essex Wire Co.</td>
<td>Okonite Co.</td>
</tr>
<tr>
<td>General Electric</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### GROUP II

Diversified and advance technology firms seeking to extend penetration in the telecommunications market.

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Chain &amp; Cable</td>
<td>Ford Motor</td>
</tr>
<tr>
<td>Avco</td>
<td>General Precision</td>
</tr>
<tr>
<td>Bell &amp; Howell Co.</td>
<td>Equipment</td>
</tr>
<tr>
<td>Bandix</td>
<td>Hazeltine</td>
</tr>
<tr>
<td>Corning Glass</td>
<td>IBM Corp.</td>
</tr>
<tr>
<td>E.G. &amp; G., Inc.(Edgerton, Germeshausen &amp; Grier)</td>
<td>Intl. Tel. &amp; Tel. Co.</td>
</tr>
<tr>
<td>Fairchild Camera &amp; Instrument</td>
<td>Lear Siegler, Inc.</td>
</tr>
<tr>
<td></td>
<td>Litton Industries</td>
</tr>
<tr>
<td></td>
<td>Narco Scientific Co.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Testimony filed by Dr. J. Fred Weston with the California Public Utility Commission, Case Numbers 8608 and 8609, December, 1967.
seeking to widen and extend their penetration of the telecommunications market.

Group III companies include advanced technology firms now supplying some types of telecommunications or communications products. Included also are widely diversified companies with one or more electronics communications divisions. Both types of companies are partially in the telecommunications market, seeking to broaden their penetration and to develop new products for this purpose.

Chart XIV tabulates the earnings and capital structures of the study companies in three time span groupings. The return on equity and the per cent of total capital in debt and in equity were calculated for these companies over the postwar period and segments thereof. One time period is the full postwar period, 1946-1966. A second time segment eliminates the immediate postwar adjustment period and the higher-than-average industry profits of 1950 and 1951 and hence begins with 1952, ending with 1966. The third time span covered is the most recent eight-year period, 1959-1966. The data present a remarkable consistency and narrow range of results. The returns on equity fall between 11.3 per cent and 13.7 per cent.

In his study, Dr. Weston commented:

The observed returns on capital and equity for business firms can be influenced by at least three elements that would account for differential returns. These three elements are monopoly, risk, and efficiency. Because we are
## Chart XIV

### Return on Equity and Capital Structure Proportions of Ninety-One Companies

**In the Western Electric Product Market, 1946-1966**

<table>
<thead>
<tr>
<th>Years</th>
<th>Group</th>
<th>Companies</th>
<th>Percent Return on Equity</th>
<th>Percent of Total Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Debt</td>
</tr>
<tr>
<td>1946-66</td>
<td>I</td>
<td>21</td>
<td>12.0</td>
<td>15.3</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>20</td>
<td>13.6</td>
<td>14.8</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>15</td>
<td>12.7</td>
<td>18.6</td>
</tr>
<tr>
<td>1952-66</td>
<td>I</td>
<td>31</td>
<td>11.3</td>
<td>18.7</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>21</td>
<td>12.2</td>
<td>15.6</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>17</td>
<td>12.6</td>
<td>19.9</td>
</tr>
<tr>
<td>1959-66</td>
<td>I</td>
<td>42</td>
<td>12.9</td>
<td>17.8</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>25</td>
<td>12.6</td>
<td>15.6</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>22</td>
<td>13.7</td>
<td>22.3</td>
</tr>
</tbody>
</table>

*Source: Weston, California Testimony.*
dealing with a large number of firms in a dynamic environment, we may rule out the influence of monopoly returns. The returns, therefore, reflect primarily the impact of risk and efficiency. Other things being equal, an industry in which risk is higher on the average than in other industries should tend toward higher rates of return. In addition, if individual firms are more efficient on a consistent basis over a period of time, their returns would also tend to be higher on the average.

The data provide guidelines indicating that an appropriate range of return on equity for Western Electric would be 11.3 to 13.7 per cent based on an appropriate debt ratio for Western Electric of 14.8 to 22.3 per cent of total capitalization. Within these boundaries, the establishment of a return on capital for Western Electric would meet the standards of regulatory and economic equity. This equates to a return on total capital of between 10.1 to 12.1 per cent based upon an average debt ratio of 18.6 per cent and a cost of debt of 5.0 per cent.12

Compared to these standards developed by Dr. Weston, Western Electric's actual rate of return has been as shown in Table 2. Table 2 shows that Western Electric's return on net investment and return on equity tends to be slightly below the norms developed by the Weston study. The Western Electric return on equity for the 1946-1966 period was 11.3 per cent for the total Company and 10.6 per cent for Bell business. This compares to the 11.3 to 13.7 per cent range postulated by the study of 91 companies. These data suggest that Western Electric's prices tend to be set on the low side to yield a low rate of return relative to other comparable companies. To the extent that Western Electric is

12Weston, California Testimony.
<table>
<thead>
<tr>
<th>Year or Period</th>
<th>% Return Total Co.</th>
<th>% Return Bell Business</th>
<th>% Return Total Co.</th>
<th>% Return Bell Business</th>
</tr>
</thead>
<tbody>
<tr>
<td>1958</td>
<td>9.5</td>
<td>9.1</td>
<td>10.1</td>
<td>9.7</td>
</tr>
<tr>
<td>1959</td>
<td>10.6</td>
<td>8.0</td>
<td>11.4</td>
<td>8.5</td>
</tr>
<tr>
<td>1960</td>
<td>10.1</td>
<td>9.7</td>
<td>10.9</td>
<td>10.5</td>
</tr>
<tr>
<td>1961</td>
<td>9.7</td>
<td>9.3</td>
<td>10.5</td>
<td>10.0</td>
</tr>
<tr>
<td>1962</td>
<td>9.6</td>
<td>9.2</td>
<td>10.4</td>
<td>10.0</td>
</tr>
<tr>
<td>1963</td>
<td>9.7</td>
<td>9.5</td>
<td>10.7</td>
<td>10.4</td>
</tr>
<tr>
<td>1964</td>
<td>10.3</td>
<td>9.7</td>
<td>11.1</td>
<td>10.4</td>
</tr>
<tr>
<td>1965</td>
<td>10.5</td>
<td>9.7</td>
<td>11.5</td>
<td>10.6</td>
</tr>
<tr>
<td>1966</td>
<td>9.6</td>
<td>8.8</td>
<td>10.8</td>
<td>9.8</td>
</tr>
<tr>
<td>1967</td>
<td>8.5</td>
<td>8.0</td>
<td>9.4</td>
<td>8.8</td>
</tr>
<tr>
<td>Total</td>
<td>9.8</td>
<td>9.1</td>
<td>10.7</td>
<td>9.9</td>
</tr>
<tr>
<td>1946-1966</td>
<td>10.1</td>
<td>9.4</td>
<td>11.3</td>
<td>10.6</td>
</tr>
</tbody>
</table>

Source: Western Electric Company.
willing to accept a lower rate of return than other manufacturers, this should be reflected in and be a partial explanation of lower prices. But since Western Electric's return in terms of profit per sales dollar is relatively small, in the order of 5 per cent, this can hardly be a significant explanation of the approximately 40 per cent spread between the prices of Western Electric products and comparable items from other companies. This study also supports the earlier evidence that the returns from productivity gains are not used to increase earnings, but rather are used to offset rising costs, with the remainder applied to reduce prices.

This, then, leads to consideration of cost control and cost reduction as a major explanation of the price performance.

Cost control and the standard cost system

Effective cost control methods are a necessary element in achieving and maintaining reasonable price performance. Standard costs provide a framework for gauging performance, for building useful budgets, for guiding pricing, and for meaningful product costing.\(^{13}\) The systems utilized within Western Electric are

oriented to controlling costs, creating internal competition, and providing a means for reporting and evaluating operating results.

Western Electric has implemented a manufacturing cost system, based upon good general accounting practice, which facilitates assignment of portions of the total cost incurred in manufacture to each item of output on an appropriate and consistent basis. Under this system the costs of manufacturing individual products are periodically predetermined on the basis of anticipated material, labor, and other cost elements. The results of operations are then compared to the standards and any variations are analyzed by the various cost elements and are evaluated to provide a guide for managerial control. Standard shop costs are established for each apparatus and equipment in addition to the costs for thousands of constituent piece parts.

Some of the important factors considered in establishing standard costs for a "bulletin period" are reflected in the following paragraphs.

The estimated level of production for the period is derived from forecasts of sales for the period, which usually extends for approximately two years. "Cost centers" are established to facilitate assignment of common costs to groups of related operations for similar products. A manufacturing "layout" is a specification, prepared and maintained by the responsible manufacturing engineer, which details the facilities and methods of manufacture to be used. These are supplemented by engineering
controlled drawings specifying dimensional and material requirements. Wage incentive rates are determined through detailed analysis of labor effort required by using elemental time standards developed by Western Electric or other industrial engineers. Where wage incentive rates are not available, engineering estimates are used as a standard base for labor cost and associated overhead expense applicable to a particular item.

Labor costs consist of direct labor, which is the labor hours that are necessary to perform the manufacturing operations, and indirect labor, which includes such things as wage incentive allowances, night shift bonus, vacation and holiday pay, pension accrual, paid for absence, and payments on behalf of direct labor employees for pensions, social security, etc.

Material in the standard cost consists of raw material or components, either manufactured within Western Electric or purchased from outside suppliers. The price per unit of measure of any material or component, times the required amount specified in the layout or drawings, plus a dropout or scrap allowance, less the reclaimable scrap value, equals the "material" portion of the standard cost being computed.

14 The present wage incentive plan is based on output of work groups rather than individuals. To determine the group aggregate "should take" hours, each operation is analyzed and its "should take" hours added to all other jobs performed by the group. The group efficiency is ascertained by comparing the "should take" hours to the actual hours taken and base pay is supplemented according to the scale of the plan if the incentive goals have been met.
Overhead expense is quite varied and generally includes those expenses that are associated with the manufacture of product other than labor and material. This includes such things as administrative expense, electricity, rent, supplies, maintenance, process scrap, etc. The expense of these items is allocated to the product's standard cost by an appropriate means of distribution to each cost center.

The standard cost system is utilized within Western Electric to serve these purposes:

1. As a basis for managerial control of costs.
2. For use in current accounting transactions and evaluation of inventories.
3. As a basis for estimating cost of new and changed items.
4. As a basis for establishing selling prices.
5. As a foundation for preparing the Company's financial reports.\(^{15}\)

The use of a standard cost system, then, provides a base for reporting accounting and financial transactions and serves as the foundation for setting prices. A most important value of the use of the Western Electric standard cost system is the basis it establishes for managerial control of costs.

Control of a manufacturing operation of the size, complexity, and diversity of Western Electric's requires a highly developed system for the collection and evaluation of data, with emphasis on the following:

1. Knowing what parameters and what variables of the business are most significant;
2. Being able to obtain quantification of these variables regularly, reliably, and rapidly;
3. Being able to relate a cause to each important effect—that is, to explain why a particular result came about; and
4. Being able to assign clearly, to individual managers at all levels, responsibility for each important element of results under their jurisdiction.

The standard cost system provides the basis for filling these requirements by contributing to the development of a system for analysis of operating results and control of costs. The analysis is based on a three-way comparison of actual current costs by elements:

1. with the recent past to indicate trends,
2. with the expected or standard costs, and
3. with the periodic forecasts of objectives.

The "Operating Results Statistics," commonly referred to as the 2.15A Report, is one of the important results and control
reports prepared each month. It is a collection of the monthly results and statistics which experience has shown to be most useful in an overall appraisal of current operations. Appendix V includes the format of a typical report.

The results are derived from standard cost accounting data generated during the month. The difference between actual costs experienced and standard expectancies results in "standard cost variance," or in Western Electric terminology, "variation." Analysis of variation and follow-up action is the key to managerial cost control under the standard cost system. Variations are accumulated and published periodically for every shop or department under local Works control. The direct expenses of each costing center and the indirect expense of services received by that costing center from the Works are summarized, as are the costs of materials and direct labor. These reports are then summarized for each General Manager's review and are later totaled for review by the executives of the Manufacturing Divisions.

These reports form a sound and consistent basis for managerial cost control, since they analyze variations by cause. They deal principally with those items that most significantly affect manufacturing costs and operating efficiency: direct labor, direct material, overhead expenses, and capital usage.

Examination of Appendix V shows that the statistics reported provide a great amount of detail on the results of operations and should facilitate effective cost control. The important cost
elements are covered and sufficient detail is given for each to pinpoint areas requiring further study and action. Sections 1 through 5 provide nearly 50 different measures of performance with respect to labor and labor cost; Section II provides an analysis of materials expense and variation; Sections 9 and 10 provide over 20 analyses of overhead expenses; Section 8 provides half a dozen different figures for measuring the efficiency with which inventory is being managed.

Study of Western Electric's manufacturing cost control methods reveals a standard cost system consistent with good industrial practice. The attention given to the details of cost and the arrangement of reports suggests that managerial action is closely coupled with the results of operations. The nature of the cost system and the breadth of reporting suggests a results-oriented management.

The engineering cost reduction program

Cost reduction is the formal engineering program that is directed towards reducing product cost after it is "shaken down" and a standard cost is established. The program is based on the theory that improvement in manufacturing processes is always possible, and is necessary to improve performance. Western Electric's program is not a sporadic effort to reduce costs, but a continuous program in keeping with the responsibility of providing product at the lowest possible price. It, therefore,
applies to the total line of products regardless of the immediate competitive situation faced by any individual product. Savings goals are set in correlation with annual budgets for manpower, investment, and related expenditures. Forecasts are made by each engineering organization having product engineering responsibility. These are reviewed for appropriateness at executive levels. The concern and support of management coincides with the interests of the engineers and facilitates cost reduction efforts.

Cost reduction cases are prepared on a written, formal basis and the participating engineers are given recognition for individual accomplishments on the merits of their cases by a dollars and cents savings valuation. This individual recognition for participation creates strong motivation in the engineering staff, and often is used as a measuring standard for individual accomplishments.

The formal cost reduction plan is detailed in its structure. Before any significant expenditures are committed to a case, the originating engineer must present for approval the data specifying the cost to conduct the investigation and the net savings to an engineering cost reduction committee. Each case is reviewed by standard methods of measure to assure proper dispersal of available funds. It is relevant to note that the accounting organization audits and computes critical dollar value portions of each case, from a carefully defined guide that stresses con-
servatism in evaluation of results, thereby eliminating bias or
distortion and insuring realistic valuations.

A cost reduction may be achieved in many ways. The general
qualification is that it must reduce the expense of labor effort,
material content, facilities, or any expense factor, and thereby
achieve a lower cost product to the Bell System. However, quality
and service must also be maintained or improved.

An example of sustained cost reduction is the program which
has been carried on for the widely used 500 General Purpose Dial
Telephone Set. Through intensive effort over a period of years,
more than one hundred labor and material savings have been insti-
tuted. The labor cases have resulted in a reduction of labor
effort from 1.19 hours to produce the 500 set and its components
in 1955, to .73 hours, or almost 40 per cent less, at present.
As mentioned in the pricing section, even after years of constantly
increasing costs, labor savings plus substantial material savings
have kept the 500 set priced significantly below the introductory
price of $13.90. The savings are substantial when applied against
the volume of more than 2 million 500 sets produced per year.

Cost reduction contributes to Western Electric's produc-
tivity record. The first-year savings for the period 1957-1967
totaled about $215 million. During this same period $126 million
was spent for engineering development time and equipment needed
to implement cost reduction cases. Although these results indi-
cate a substantial return on the money invested, they do not
reflect the total return. The cost reductions instituted this year will have savings value for some period to come.

During 1967, the engineering cost reduction program closed 3,180 cases, with individual case savings ranging from a few thousand dollars to more than a half million annually. This established a record high of about $40 million savings which will be credited to the 1968 base as the first year for full savings. The annual effect, in 1967, of the engineering cost reductions introduced during the past ten years was over $243 million. Chart XV reflects the cost reduction savings for the past twenty years. The striped bars indicate the total dollar value of first full year's savings of cases made effective in each prior year. The solid bars represent the dollar value of savings realized each year as a carry-over from previous years.

Advancing technologies and the continued emphasis on cost reduction effort stimulate an increasing trend of cases each year, which expands the carry-over to following years. These extensive manufacturing cost savings flow to the telephone companies in the form of lower prices.

Engineering cost avoidance on new products

Cost reduction applies to products already in production. To assure that new products are introduced into manufacture in the best configuration for lowest possible cost, an active "cost avoidance" effort is also carried on. This is a
WESTERN ELECTRIC COST REDUCTION SAVINGS
(IN MILLIONS OF DOLLARS)

KEY

- New Cost Reduction - Annual Savings
- Savings Realized in Year Shown From Cases
- Made Effective in Previous Years

Source: Western Electric Company
separate and supplementary program to the formal cost reduction program.

"Cost avoidance" is the term applied to the joint efforts of Western Electric's and Bell Telephone Laboratories' engineers, during design stages, to reduce a product's initial cost. This design/manufacture interface is of considerable importance and calls for close collaboration to achieve the most effective transition from design to production.

The Bell Telephone Laboratories' engineers, who have the functional design responsibility, and the Western Electric engineers, who have the manufacturing responsibility, each highly trained and competent in their respective areas, work in harmony during the product's transition from preliminary design, through the model shop prototypes, and pilot manufacturing runs, to the final design. The benefit of this relationship is that simultaneous concentrated effort of engineering specialities, and free exchange of ideas, experience, and know-how, assure the earliest possible introduction of the most desirable design, consistent with System objectives of high quality, low cost products.

A more intensive and formal approach to the team concept was organized at the Indianapolis Works of Western Electric, in 1966. Advance product design (APD) groups made up of Bell Labs designers and Western Electric product engineers, whose responsibilities range from materials to aesthetics, are generally as-
signed to view products while still in the early design stage."

An APD group, utilizing a value engineering approach, acts as an independent and objective team that endeavors to apply their specialized talents and knowledge toward lowering product costs and improving quality.

A typical example is the 10/20 Button Key Telephone Set APD project, which began April 1, 1966, fifteen months prior to the estimated time that the design drawings would be released to Western Electric by the BTL. The team effort was supplemented by twenty-six formal sessions during which the team members consulted with Western Electric engineers, BTL engineers, members of the purchasing and accounting organizations, as well as representatives of outside companies. Various design alternatives were explored and recommendations were made that reduced manufacturing costs $250,000. Modified design features also increased the quality and service potential of the instrument.

Another example, now under development in the station apparatus field, is the Picturephone set. The size and importance of this task is highlighted by the exciting future potential of the Picturephone development and its broad possible applications.

16"Flexibility to Innovate," Bell Telephone Magazine (January/February, 1968), pp. 16-21.
At the "device manufacturing plants," where the major product lines are devices such as transistors, diodes, tubes, and microelectronic circuits, considerable benefit has been obtained from engineering cost avoidance work prior to standard production. The nature of semiconductor technology is such that the transition from laboratory design to production capability is difficult because of the critical nature of the product and the need to exercise extremely close control over both the product and the environment during manufacture. Consequently, the design specifications for the manufacture of semiconductor devices include the processes to be used as well as the final requirements to be satisfied.

Probably, the most important of the many steps taken to facilitate the ability to manufacture critical semiconductor devices was the establishment of the design capability line (DCL). The DCL is a special complement of facilities on which new designs can be proven capable of economical manufacture. This step in design development promotes the training of personnel and provides a more realistic view of the device parameters and the manufacturing process than is possible in the laboratory. This method also provides sufficient production of new devices for models and equipment prove-in. The device design is not final until it has been "shaken down" to the satisfaction of both the Bell Laboratories and Western Electric engineers.
Cost avoidance accomplishments are not measured and documented as accurately as engineering cost reduction cases, so the savings are not included in the formal cost reduction program or reports of savings. However, cost avoidance activities make a significant contribution to the goals of Western Electric and the Bell System by introducing new products into manufacture at the lowest possible cost.

Summary

This section has reviewed the productivity performance of Western Electric and compared it with the performance of other companies, industries, and the economy. Western Electric's prices and profits were examined and were compared with other companies and industries. Western Electric's productivity tends to be higher and its prices and profits lower than comparable firms in either the telecommunications field or general industry. The benefits of superior performance were passed on to the Telephone Company customers in the form of lower prices.

In exploring the reasons for this performance, cost control, cost reduction, and cost avoidance, coupled with quick and effective managerial control and corrective action, appear to be the principal factors that support the performance data. With the passage of time, there has been an increasing tendency to substitute capital for labor on the resource input side of production and to take advantage of technological progress through
engineering cost reduction and value analysis which have resulted in improved production processes and better product designs.

The question of volume, too, must be given consideration. Expanding volume, according to classical economic theory, should provide a base for the economies of scale, and this may be a factor in the productivity and price performance that has been identified.

The following, Chapter IV, is devoted to consideration of volume and the inferences and understandings that it may bring to the analysis of performance.
CHAPTER IV

THE EFFECT OF VOLUME AND DEMAND FLUCTUATIONS

It is an accepted business belief that increasing volume leads to lower unit costs. This is the result of the economies of scale and specialization. Mass production and mass marketing yield scale economies which have over the years reduced the real costs of most manufactured goods and improved our standard of living by bringing more goods within the reach of more people.¹

A question which must be considered in this study is the role of volume and, on a broader basis, Western Electric's market position as part of the Bell System. It has been pointed out many times by critics of the Bell System that Western Electric's affiliation within the System affords advantages which should be reflected in lower product costs.² As has been mentioned previously, the absence of selling, advertising, and credit costs certainly are tangible advantages in achieving lower unit costs.

¹Samuelson, Economics; Bain, Industrial Organization.
It has been mentioned, too, that even though the Telephone Companies are free to obtain the equipment they need from any supply source, they choose to purchase the largest part of their requirements from Western Electric because of the lower prices, the superiority in product quality, and delivery interval. Because of this, it could be expected that Western Electric would enjoy a favorable situation from the standpoint of large volume and stability of orders. It might also be postulated that by reason of its associations with the Telephone Companies, Western Electric could even out any irregularities in demand input, and obtain the advantages of early forecasts from the Telephone Companies, which would serve as a sound base for manufacturing planning and help avoid fluctuations which lead to inefficiencies and excess costs.

The cost and price performance under these postulated conditions should be excellent. Questions then arise and are frequently asked by critics as to the real measure of productive performance, and the validity of comparisons when Western Electric has more volume than the general trade manufacturers in the telephone equipment business, and when Western Electric enjoys the close liaison that it does with the AT&T and the Telephone Companies. These are valid questions and deserve consideration in a study such as this, where there is concern with the evaluation of performance.
Demand study

In order to determine the nature of Western Electric's demand and volume, a study was made of the characteristics of total demand and demand by product line. Data were obtained on total sales volume going back to 1925 to cover a period of over 40 years. In addition, detailed data were accumulated on sales by major product lines going back to 1946. There are several interesting points that develop out of this analysis.

Chart XVI shows total Western Electric sales from 1925 to the present. It indicates, as might be expected, that sales have grown—from about $300 million in 1925 to over $3.5 billion in the most recent years, which reflects an annual growth rate of 6 per cent for the total period and a rate of 5 per cent for the most recent ten years. It can be noted that Western Electric's sales are preponderantly to the Bell Telephone Companies which represent about 85 per cent of the total. The remaining 15 per cent are sales to the United States Government, principally of military and defense systems, and a small amount of sales to the commercial market. The sharp acceleration in sales since 1950 can also be noted.

Chart XVII has been prepared to show Western Electric's Bell sales charted against total Bell System revenues over the same period on a base of percentage deviation from trend. The purpose of this chart is to compare the fluctuations in Western Electric's sales with fluctuations in total Bell System revenues.
CHART XVI

WESTERN ELECTRIC ANNUAL SALES

$4000

TOTAL

BELL

NON-BELL

Source: Western Electric Company
CHART XVII

WESTERN ELECTRIC SALES VS BELL SYSTEM REVENUES
1925-1967

Percentage Deviations From Trend

Source: Western Electric Company
Appendix VI lists the revenues and deviation percentages.

Chart XVIII is a summary of a detailed examination of Western Electric's sales by major product lines to determine if the total sales mask component variations which may be significant.

Derived demand

It has been mentioned previously that Western Electric is a durable goods producer serving an industrial market. As a result of this, it satisfies a secondary or "derived" demand which swings off the primary demand which is satisfied by the industrial customer. Western Electric sells equipment to the Telephone Companies which is used by the Telephone Companies to sell telecommunications services to its customers. Western Electric's link with the ultimate telephone user is through the Telephone Companies.

CHART XVIII

WESTERN ELECTRIC SALES VOLUME
MAJOR PRODUCT LINES
(Millions of Dollars)
1945 - 1966

Source: Western Electric Company
primary supplier, who deals with the ultimate consumer. The principal reason for this is that the industrial producer's sales are the result of his customer's decisions on capital goods acquisitions, capital investment, and capacity, while the consumer goods producer's sales are geared directly to market conditions in the economy. Consequently, it can be expected that the industrial goods producer's sales would fluctuate not only more widely, but not even necessarily in phase with those of the producer of consumer goods. In other words, the supplier of consumer goods can have a good or moderate year while his industrial supplier is having an extremely poor year and, at the other end of the spectrum, the industrial producer can have a boom year while his consumer goods customer is having only a moderately good year.

This relationship applies to Western Electric and its Telephone Company customers, and is reflected in Chart XVII which relates Western Electric's Bell sales to Bell System total operating revenues. It can be seen that the deviations from trend for Western Electric are much greater than the deviations for Bell System revenues. In fact, the Bell System deviation curve tends to be smooth while Western Electric's, on the other hand, fluctuates erratically with extremely wide swings. In recent years, unaffected by any major cyclical recessions in the economy, the fluctuations in the Western Electric curve seem to be flattening and are less than in earlier years, but they still
exceed the Bell System revenue variations.

To examine this relationship more closely, a detailed study was made of the 1957-58 recession's effect on Western Electric and AT&T revenues. The sharp dip in the business of Western Electric was compared with changes in AT&T revenues and general economic indicators. The results of this study are reflected in Chart XIX. From peak to trough, Telephone Company new orders on Western Electric were cut back nearly 40 per cent, Western Electric's Bell sales were down almost 30 per cent, and Western Electric employment was down 20 per cent. During the same time, Telephone Company revenues were up 4 per cent and the Gross National Product for the total economy was down about 3 per cent over the same period. This illustration serves to highlight the fact that derived demand creates much wider sales and volume fluctuations for Western Electric than its customers experience or than are experienced by many manufacturing companies in the economy. Western Electric's experience parallels that of other durable goods machinery producers.

Demand by product line

Analysis of Chart XVIII shows that total statistics sometimes mask significant component data. This chart covers major product lines and represents approximately 45 per cent of total sales. Consideration of the individual sales curves with respect to the total sales curve that was examined previously, shows that the individual product lines swing much more widely
SALES VOLUME CHANGE 1957-1958 RECESSION

% Decline from Peak to Trough
-40 -30 -20 -10 0 10

WESTERN ELECTRIC - NEW ORDERS

WESTERN ELECTRIC - DELL SALES

WESTERN ELECTRIC - EMPLOYMENT

NATIONAL ECONOMY GDP

BELL SYSTEM OPERATING REVENUES

Source: Western Electric Company
than the total curve, and that the relative narrowness of the total curve fluctuations over the past ten years has been the result of offsets rather than a true stability. Examination of the individual demand curves shows substantial drops in Broadband, Microwave, and 740 PBX business during the past several years, which when integrated with the sharp growth in Step-by-Step and the several Cable product lines, provides a total sales curve which is relatively smooth with moderate growth. It is hazardous to generalize about the nature of the group without knowing more about the ranges, deviations from norm, and specific characteristics of the individual components making up the groups. Since Western Electric operates its production in decentralized factories by product line, it is obvious that the fluctuations in individual product lines are much more significant from a manufacturing point of view than the year-to-year variation in total sales. In 1966, for example, severe cutbacks were experienced in the Broadband and Microwave factories, while the Cable and Data Set factories were on an all-out production basis and were working all possible overtime.

Problems with forecasting

In view of the preceding discussion, an important question that develops is that of why Western Electric encounters these kinds of problems and why it is not able to extract the benefits of stability and firm programs from its relationship with the AT&T and the Telephone Companies. There are two kinds of
major order-fill problems that Western Electric encounters in satisfying customer demand. One is the instability of the demand input which fluctuates widely because of the "derived" nature of the demand. The second is the problem of accurately forecasting customer requirements so that plans can be made for production.

As might be expected, Western Electric makes every possible effort to develop accurate forecasts of the Bell System's demand for its products and services. Available knowledge and information is brought to bear, including the forecasts received from the Telephone Companies, as well as the most modern business techniques of statistical analysis and the new computer technology. However, the uncertainties and imponderables of consumer economics and preference—the thousand and one things that influence people, including the Telephone Companies, to do what they do as purchasers—seem to make the job of forecasting demand for specific products a difficult one. Because of the long engineering and material procurement intervals which are associated with most of its products, Western Electric must initiate manufacturing activities in advance of receipt of hard orders in order to meet the relatively short order-fill intervals that are involved in its commitments to the Telephone Companies.

While Western Electric's affiliation in the Bell System provides opportunities for obtaining information and knowledge in
advance of Telephone Company orders, this relationship obligates Western Electric to produce in advance of the receipt of hard orders to a greater extent than might be expected of an unaffiliated supplier. The various telephone companies each ultimately do what they must to react to their markets and environments—the forces that operate on them—and do not buy equipment merely because of a prior indication of possible requirements.

Some of the chief factors that contribute to the wide demand fluctuations, the difficulties in forecasting, and the problem of maintaining a reasonably level production program are:

1. The volatility and instability of derived demand;
2. The problem of having each telephone equipment installation designed expressly for its particular application;
3. The tailor-made character of most of the equipment products sold to the telephone companies;
4. The telephone company requirement for short delivery intervals on items that have long production intervals, such as complex telecommunications systems;
5. The absence of an order back-log to serve as a cushion ahead of Western Electric production; and
6. The absence of diversification in customers and market outlets.
Analysis of variation between forecasts and actual production

Charts XX and XXI summarize the data obtained from a study of ten major product lines, which compares annual production for the product line with the forecast made at the mid-point of the prior year. The data go back to 1946, or to the year of initial production of the line in those cases where production was initiated subsequent to 1946.

Examination of the data reveals a widely varying set of experiences for the various product lines, which shows that actual production tends to differ in almost all instances from the prior mid-year forecast, and, in many cases, by a very substantial percentage. In numerous cases this percentage of deviation is in excess of 100 per cent. One could generalize that the earlier fourteen-year period from 1946 to about 1960 seems to be characterized by overestimates of the actual production, while the more recent six years or so seem to reflect a general underestimating of actual production.

In analyzing the patterns of the last six years' production, from 1961 through 1966, it is found that the average underestimate of the major products tabulated came to 12.78 per cent, while the average overestimate was 15.05 per cent. It should be recognized that during this time period, the number of specific overestimates tended to be very few so that the 15.05 per cent does not have as much statistical support as the 12.78 per cent. In any case, it would seem valid to conclude that the
CHART XX

WESTERN ELECTRIC SALES VOLUME VS. PRIOR MID-YEAR FORECAST

MAJOR PRODUCT LINES

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Source: Western Electric Company
Western Electric Sales Volume vs. Prior Mid-Year Forecast

Major Product Lines

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Source: Western Electric Company
level of forecasting error seems to be somewhat over 10 per
cent. The 1966 sales of the ten products analyzed totaled
$803,700,000 or 44 per cent of the total apparatus, equipment
sales to the Telephone Companies for that year.

The forecasts against which actual shipments are compared
are prepared by Western Electric's Customer Planning Department,
which is a specialized organization dedicated to developing
forecasts and projections. This organization is in continuous
contact with many organizations in the Telephone Companies and
AT&T, as well as the Bell Telephone Laboratories and many Western
Electric departments and plants, to obtain all useful information
on the total business situation, trends, and specific factors
that may influence demand. In addition to customer contact,
market surveys, and economic evaluations, use is made of
statistical, operations research, and computer techniques in the
attempt to develop the most accurate and useful forecasts.
Despite these substantial efforts, as has been indicated
previously, significant problems are encountered. This suggests
the need for a more detailed examination of the forecasting
procedure.

The forecasting procedure

The limitations on Western Electric's forecasting
procedure can probably be best understood by examining the supply
and information interfaces between Western Electric and the
Telephone Companies. Identification of the kind of information
that is available and how it flows can also be helpful, as can examination of the mechanics involved in developing forecasts and processing hard orders.

Western Electric is able to obtain preliminary information on possible Telephone Company requirements one to two years in advance of expected delivery dates. This information tends to be in bulk outline, it is sketchy and is subject to change and modification as the lead time interval closes. In most instances, because requirements tend to be vague and in general terms, the information can be used by Western only for broad planning purposes, and for order of magnitude approximations of the level of sales for the major product lines. Using these as a base, estimates and predictions are made on the required production volume of equipments and thousands of component sub-assemblies of purchased and Western Electric parts. These approximations are used to plan material purchases and the probable level of activity in the many Western Electric manufacturing and service division locations throughout the country. The forecasts which Western Electric calls CPE's (Customer Production Estimates), and sometimes "the program" or the "production program", are revised every three months. Appendix VII shows a typical CPE for Merrimack Valley products for the year 1967 as projected in CPE-671 (the issue number of the forecast). The products listed line by line are frequently called "key items." There are about 80 key items used for forecasting in the CPE.
It should be understood that the forecasting procedure is based upon predictions of probable demand rather than firm Telephone Company orders, and is carried on to gain time for production planning and preparation to meet the tight published delivery intervals when orders are actually received. The CPE is only a summary of the best early information on customer requirements. Firm orders for specific products come later, and may or may not support and confirm the predictions which have been made earlier, which are the basis for many important production commitments.

A single item or line in the CPE encompasses hundreds of different kinds of equipment packages and thousands of component sub-assemblies and parts. Appendixes VIII-X show the range of items included in three of the key forecast items. The key items selected—Broad Band Terminals, Crossbar Frames, and No. 1 ESS Frames—are typical and reflect the general situation that applies for most of the key items. The significant thing about the exhibit is the wide spectrum of equipment, parts, facilities, skills, and costs that are represented in a single item. For Broad Band, for example, a count of one on the CPE line can mean anything from a frame involving only simple shop facilities and skills, and with a current shop cost of $1500.00 to a highly complex 2-bay frame, weighing 1000 pounds, presenting demanding challenges on skills and facilities, and costing $27,000. Appendix XI shows how the same lack of definition applies to components, too—in this case,
electronic circuit packs.

The CPE is used as a guide for possibilities and trends which can be moderately helpful in preparing for production so long as its limitations are recognized and compensated for, within the boundaries of managerial insight and judgment.

Flow diagram of overall forecasting procedures

Chart XXII outlines the main organizational elements involved in the forecasting procedure, and shows the flow of information originating in the Telephone Companies in the form of proposed Construction Programs in terms of buildings and major types of equipment, such as switching offices or carrier routes expected to be needed for the year. The Telephone Companies forecast their needs in broad terms such as Carrier Systems, Microwave Systems, Crossbar Equipment, ESS Equipment—as they see subscriber requirements in terms of systems and circuits. Information on possible requirements also flows toward the Western Electric producer units from the Service Division Regions and Distributing Houses, which are in close, continuing contact with the Telephone Companies. All of this early information is channeled into Western Electric's central Customer Planning organization where the many information inputs are organized into the broad product categories which are listed in the CPE "key items."

The job of converting the broad CPE data into the specific data required for manufacturing operations rests with the Mer-
FORECASTING WESTERN ELECTRIC DEMAND

SPECULATED NEEDS FOR:
1. RESIDENTIAL DEVELOPMENT
2. COMMERCIAL EXPANSION
3. TRAFFIC INCREASES
4. SERVICE OPTION ADDITIONS
5. MODERNIZATION ACTIVITIES
6. INNOVATIONS IN SYSTEMS & SERVICES
7. SPECIAL PROJECTS

LONG LINES & TELEPHONE COMPANIES

W. E. VIEWS OF ECONOMIC TRENDS

W. E. PROGRAM PLANNING 10 KEY ITEMS

A.T. & T.

W. E. REGIONAL CENTERS

FACTORIES & SUPPLIERS

ANTICIPATED PRODUCTION NEEDS:
1. FACILITIES
   • MACHINES
   • TOOLS
   • BUILDINGS
2. EMPLOYEES
   • PRODUCTION
   • SKILLED
   • PROFESSIONAL
3. MATERIAL
   • RAW MATERIAL
   • PURCHASED COMPONENTS
   • PURCHASED ASSEMBLIES

INPUT INFORMATION: CIRCUIT NEEDS

COLLECTION, COORDINATION, CLASSIFICATION INTO MAJOR EQUIPMENT ELEMENTS

CONVERSION INTO MEANINGFUL INFORMATION FOR MANUFACTURING
chandise and Service organization and the Production Control Units at the several factories. One measure of the scope and complexity of the information conversion job is that about 2000 specialized production control employees are involved in identifying specific items, ordering and scheduling Telephone Company jobs, placing orders for parts, and maintaining records of the status of various jobs. The estimated cost of carrying on these activities is approximately $20,000,000 per year. In addition to converting forecast information into production data, the Merchandise and Service units coordinate the various elements required for one Telephone Company job which may involve production from several factories. In doing this, they work closely with the Service Division regional centers, as well as the factories.

A substantial information conversion job must be done to convert the broad classifications into the thousands of specific equipment varieties (as has been indicated, one line in the CPE may encompass hundreds of equipment varieties, having widely varying materials, components, labor hours, etc.) and beyond this into the hundreds of thousands of Western Electric manufactured components and myriad purchased items that go into the manufactured equipment.

The supply pipeline

The supply chain is a long and involved series of transactions which may link through several factories which have supply
inter-relationships. It also involves outside supply sources at several stages of the supply process. For example, an order on the Columbus Works for a #1 Electronic Switching Office will include a requirement for several Line Switching Frames. These will require, among many other sub-assemblies and components, some of which are purchased, several hundred ferreed switches which are manufactured at Columbus.

These will require a wide range of components and materials which come from many different sources, including outside purchase. If one of the more important of these is followed back into the supply line, the complexity can be seen more clearly. The 237B Sealed Contact, which is the most important element of the switch, is obtained either from the Allentown or the North Carolina factory, both of which make this device. To make the 237B, Allentown and North Carolina fabricate some of the parts and purchase the glass, iron-nickel alloy, gold, and other raw materials that are required. This sequence of activities is schematically diagrammed in Chart XXIII.

From this relatively simple example of the supply sequence, an insight can be gained into the interdependence of Western Electric's supply arrangements among its factories and with vendors. The relationship is one of considerable complexity because of the hundreds of thousands of items that Western Electric must procure through its several factories and tens of thousands of suppliers,
CHART XXIII

WESTERN ELECTRIC DELIVERY INTERVAL COMPARED TO PROCUREMENT AND PRODUCTION INTERVAL

Interval To Fill Order:

- TELCO SERVICE NEEDS
- TRANSMISSION SYSTEMS
- TELCO ORDERS
- EQUIP. ENGR. TRANSUTES SERVICE NEEDS INTO PRODUCT NEEDS
- FACTORY COMMITMENT TO DELIVER

11 TO 15 WEEKS

Interval For Procurement & Production:

- RAW MATERIALS & PURCHASED COMPONENTS - 10,500 ITEMS
- NORMAL INTERVALS RANGE FROM 4 TO 15 WEEKS

- TOTAL: 44 WEEKS

Risk And Uncertainty:

- 29 WEEKS
- PRODUCTION COMMITMENTS ARE MADE IN ADVANCE

- 11 TO 15 WEEKS
and because of the effective coordination and timing that is re-
quired to have all transactions and operations result in having
the right piece at the right place at the right time.

**Time problems and delivery intervals**

Some interesting time relationships become apparent when
data on Western Electric's delivery commitments to the Telephone
Companies are compared with how long it takes to engineer, prepare
for, and produce the products required to fill a Telephone Company
order. Chart XXIII shows typical order-fill interval commitments
for Carrier and Crossbar products, and compares them with the time
Western Electric needs to produce the equipment required. It is
evident that the supply interval commitment to the Telephone Com-
panies of eleven to fifteen weeks, in the case of these complex
equipments, is much shorter than the average forty-four week time
span required to obtain raw material and produce the equipment.
The Western Electric planning for production, and the start of part
fabrication, are initiated well in advance of receipt of customer
orders.

**Summary of forecasting and demand fluctuations**

It is apparent from this discussion that Western Electric
tends to experience the same kinds of problems as other durable
goods producers even though it is vertically integrated in the Bell
System. Examination of the statistical data reveals that there are
substantial variations between forecasts of demand and the realization reflected in sales by product line. Further, rather substantial volume variations are experienced from year to year, and even from quarter to quarter in some of the extremely volatile product lines. The variations seem to be due to the characteristics of the business with Western Electric as a durable goods producer supplying an industrial customer on a secondary demand basis being subject to all the volatility and accelerator effects of derived demand. Since the factories are set up by product line, there is very little cushioning for the factories as demand fluctuates. They tend to have to adjust directly and immediately to the volume changes in order to continue to operate efficiently.

Some of the significant points which are apparent in the detailed study of demand relate to the vertically integrated structure which has been discussed previously. A brief summary of these points is outlined below.

1. Western Electric does not have much choice about its responsiveness to its Telephone Company customers. The "supply contracts" oblige Western Electric to serve the Telephone Companies. There is no obligation under the contracts for the Telephone Companies to buy goods or services from Western Electric. As a consequence, Western Electric is "obligation oriented" and must remain dedicated to its Bell System customers since
its welfare and continued existence is dependent on how well it serves the Telephone Companies, and, beyond this, in how successful the Telephone Companies are in serving the public.

2. Western Electric's sales are determined largely by additions to and expansions of the Bell System network. If for any reason, the network did not grow for a period of time, Western Electric's business would substantially disappear. Replacement business is only a relatively small portion, about 20 per cent of total sales.

3. Western Electric does not have the cushion of diversification, and is subject to the risk of serving only one specialized market. The absence of a sales force and the limited scope of marketing, advertising, and sales promotion activities, although yielding cost advantages, also operates as a liability since Western Electric has no mechanism for trying to obtain additional business in slack time.

4. Western Electric must take substantial risks in ordering material and authorizing production of items before firm orders from the Telephone Companies are in hand. This must be done because Western Electric's delivery intervals
to the Telephone Companies in most cases are shorter than the time span for Western Electric to engineer, obtain material, and set up and produce particular items of equipment.

5. Western Electric has fifteen major factories which are specialized in machinery, skills, and techniques, and which are oriented toward particular products and the production operations necessary to make those products. Since Telephone Company orders are placed on the basis of circuit requirements or traffic needs, there is a massive conversion job required to translate Telephone Company requirements into production information. Further, the wide fluctuations in demand for specific product lines, and the variations which are experienced between forecast and actual demand tend to have an adverse effect on orderly shop operations and impact on all aspects of the productive process at the factories.

From the data examined in this section of the research, questions develop with respect to the degree of advantage that Western Electric obtains as a result of its affiliation in the Bell System, and to what extent its production is maintained at an assured, stable high level. The following part of this section describes a special survey that was made to determine how the production people at the manufacturing plants see this question of
demand, order entry, and volume.

**Survey of manufacturing problems**

In order to obtain more data on volume effects and the characteristics of derived demand, contact was made with each of the major manufacturing plants to explore the nature of their manufacturing problems, and through this, to trace the impact of customer demand into the shop. A survey was made to identify the most troublesome problems that the manufacturing plants experience. The thought behind the survey was that the problems of the factories can be studied against the overall corporate performance data examined previously, to see if any additional insights could be developed or any knowledge obtained that would help explain the performance.

A letter was written to each plant general manager asking him to identify the most troublesome manufacturing problems he had experienced over the past several years, including any current problems. Each of the plants responded identifying from one to five situations that they considered to be major problems. The responses have been analyzed and are tabulated in Chart XXIV.

In order to fully interpret the tabulated data, it will be helpful to have some background on the factories and how they are organized.

Western Electric's Manufacturing Division includes four
### CHART XXIV

#### SURVEY RESULTS

**MAJOR PROBLEMS OF WESTERN ELECTRIC WORKS LOCATIONS**

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Note: The chart includes various problems associated with different locations, such as equipment issues, efficiency, and cost management. Each problem is marked with an 'x' to indicate its presence at the respective location.
manufacturing vice presidents, each in charge of a division comprising several manufacturing plants devoted to a major product line. The four divisions are Switching, Carrier and Transmission, Cable and Wire, and Station Equipment and Electronic Devices. These are the manufacturing "line" divisions of the corporation, which are relatively autonomous in their internal operations with the vice presidents being delegated considerable executive freedom. Control is through performance accountability and the continued centralization of decisions on capital expenditures, corporate expansion, and research and development budgets. The "line" organizations are supported and assisted in their operations by local staff support and by the corporate staff divisions which are centralized at corporate headquarters. The corporate staff functions include personnel, public relations, and finance activities. There are also strong corporate staff organizations for engineering, information systems, and quality assurance.

Each of the Manufacturing Divisions carries on its work at its plants in a roughly similar framework of delegations and accountabilities. Even though there is a variety of product manufactured at the factories and the specific factory organization for production of its product must be tailored to that product, there is a broad similarity in functional organization and relationships due to the influence of corporate method guides and common tradition and experience. Each factory develops operational forecasts
and budgets which are guides and objectives for operations. The objectives of cost control, schedule attainment, and meeting of quality and reliability standards is common and pervasive because they are established as major goals by the corporation and are followed and measured as an indication of performance. The rewards of performance—commendations, salary increases, and promotions—are related to performance, and there is, naturally, a competition among the plants to receive greater rewards than the other plants.

Since the plants are manufacturing plants carrying on manufacturing operations and since there is a competition for results, it would be reasonable to expect that inquiries about major problems should yield responses that are related to factors that have a strong impact on operations. It would further be anticipated that since these are manufacturing organizations, they would respond most often with situations that disturb or have an adverse effect on operations. It would be expected that labor problems, or efficiency, or machine yields or down time, or defective raw material would be mentioned frequently.

In this context, it is interesting to evaluate the results of the survey. As can be seen on Chart XXIV, five broad groupings of difficulties have been used and are arranged horizontally. These are forecasting problems, order-schedule problems, operating problems, cost and price problems, and engineering and research and development problems. Along the vertical axis appear the plants and a brief identification of the specific case. A check mark is
placed under each type of mentioned difficulty for the particular cases submitted by the plant managers. The total grid then reflects the density of types of problems which are most troublesome to the factories. The surprising outcome of this survey which can be observed by scanning Chart XXIV is that the greatest intensity of response is not in the "operating" or "cost" categories, which might have been expected by advance preliminary thinking about what might be the major problems of factories, but rather in the forecasting, scheduling, and engineering areas.

The results of the questionnaire are a measure of how practicing manufacturing people in the Western Electric feel about their job and how they see their problems. In the context of our interests in this study, it is particularly significant to note how intensely the manufacturing people react to the demand forecasting, order scheduling, and engineering problems which they consider to be the areas of greatest difficulty to them. The results of the study seem to say that they feel they can better cope with and resolve the problems of production and cost than they can those of forecasting, scheduling, and engineering. This is particularly interesting in view of the frequently expressed conjectures that (1) Western Electric's demand is assured and can be arranged to suit the wishes of the Company, presumably at a stable, unvarying level that optimizes production costs, and (2) that Bell System innovation is introduced carefully to minimize Western Electric's manufacturing and service problems. The data in this study seem to
refute these allegations and can be related to the data in Charts XX and XXI which show the fluctuations in demand and order input and which highlight the inaccuracies of forecasts. The concern with engineering and innovation is developed further in the following, Chapter V. This information covers the physical impact of demand fluctuations and forecast variations on the manufacturing shops, and reflects how these procedural problems are felt by the shops as they attempt to achieve their objectives of reasonable cost, high quality, and on-time delivery.

The significance of the data developed in the survey is further considered and related to other data in this study in Chapter VII, which is devoted to evaluation of the data and interpretation of the findings.

**Summary of volume, forecasting and order entry**

Evaluation of the data included in this section indicates that Western Electric's large volume, by itself, is not the principal cause of the productive performance identified in Chapter III. The volume provides opportunities that must be recognized and capitalized upon by management. Certainly, $3 billion in sales of goods and services, which is the current level of Western Electric's sales to Telephone Companies, is substantial. The size of the dollars involved suggests that economies of scale are at work assisting in reducing costs, and should be a factor in the productive performance identified in Chapter III. The size of the company,
its financial strength, and its access to various kinds of resources must be factors in Western Electric's performance. They make it possible to support a large, competent force of managers and engineers who use their skills to draw upon the Company's financial strength for cost reducing machinery and facilities and for innovating methods that contribute to performance.

But there are many factors that have been identified in this section that suggest that the size of Western Electric's sales volume does not reflect the full story, and that the total volume masks many diverse factors. Some of these aspects and situations are:

1. The fluctuations in volume by product line with consequent impact on the efficiency of the factories,
2. The persistent problems with forecasts which tend to be inaccurate even with Western Electric's close liaison with the AT&T and Telephone Companies,
3. The volatility in demand that is associated with Western Electric's position as a durable goods producer in the secondary, industrial market with all the problems of derived demand and its captive position with the Bell System, and
4. The factories' experiences as they cope with the problems of forecasting, changes, demand fluctuations, and continuing Bell System innovation.
Although it is difficult to give specific weight to these factors, it is valid to conclude that their impact is substantial, and they tend to impair Western Electric's ability to extract the full, undiluted benefits of the economies of scale.

Study of production technology reveals that efficient manufacture usually involves blocks of capacity which provide the most economical unit cost for a given product and a given process. Additional volume over that handled by one block of capacity has to be achieved with an additional block of capacity. Any economies that develop out of providing a second unit of identical capacity would be managerial or overhead economies rather than increased output efficiency. For example, if the balanced capacity of one of the telephone assembly lines at the Indianapolis Works is 1,000,000 sets per year, another assembly line would be needed if volume goes to 1,500,000 or 2,000,000 sets a year. There is no automatic productive increase merely because another assembly line has been added. But, the growth that leads to the need for additional capacity provides opportunities for innovation and improvement in the production process. The new assembly line could include improvements over the first line, which have become technologically and economically feasible, and the efficiency with respect to output would be higher. Any associated reduction in production costs is due principally to capitalizing on the

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opportunity provided by additional volume, rather than automatically accruing as the result of more units made the same way. Moreover, many substantial cost reduction cases mentioned in Chapter III, involved innovation at current production levels so that it is evident that cost reduction is not dependent only on growth. Kenneth Boulding, in making the point that frequently increasing returns to scale are only apparent says:

Thus the problem of "diminishing returns," in the sense of diminishing marginal physical productivity, essentially relates to the problem of the proportions of the inputs used. The problem of increasing, decreasing, or constant returns to scale has nothing to do with the change in the proportions of the input quantities. Frequently, however, what appears to be variable returns to scale turns out to be nothing but a subtle example of variable marginal physical productivity. For instance, it is often the case that doubling the size of a factory, the number of machines in it, and the number of men and the quantities of materials employed more than doubles the output. We may be tempted to regard this immediately as an example of increasing returns to scale, or as it is often called, "the economies of large-scale production." However, we have overlooked one kind of input: management. What we have really been doing is to hold constant the quantity of one input, management, and to vary the quantities of all the others. It is possible that the proportion of management to the other inputs was better in the larger factory and that management was being "underworked" in the smaller factory, just as land might be underworked when it had only a small quantity of labor employed on it.5

The relevant data suggests that some part of the productivity performance is due to the size of the Company, its substantial resources, and the economies of scale as applicable to

overhead and total Company financing and engineering. Freedom from significant selling, promotion, advertising, and credit extension expenses also contribute to price performance. But the impressive performance in efficiency and reduction in labor costs is not the result only of volume, but also reflects effective managerial cost control supported by the use of standards and a system of continual measurement against these standards. Good engineering, a formal cost reduction program, and the introduction of new and improved manufacturing processes, which are discussed more fully in the following chapter, have also been of great assistance in improving manufacturing cost performance and productivity.
CHAPTER V

INNOVATION—PERFORMANCE ON NEW PRODUCTS AND PROCESSES

This chapter deals with Western Electric's performance on innovation. The principal area of interest as indicated earlier in Chapter I is technological innovation. Innovation at Western Electric consists of two major parts: (1) the manufacture of new products for the telephone system, and (2) the design and application of new production processes. Western Electric is responsible for carrying on process development within its own engineering organization and manufacturing the products designed and developed by the Bell Telephone Laboratories.

Constraints imposed by the telecommunications network

It is appropriate to consider at an early stage the discipline, constraints and opportunities imposed on all technological matters in the Bell System by the telecommunications network.

The telephone industry sells a service. It offers to provide a communication path between two points. This service has developed beyond its original use for oral conversations and is now used to transmit radio and television programs to distant points, to transfer information between computers, and to carry written
and printed data electronically. The telecommunications network is what makes point-to-point communication possible. It is the network that provides both the means for selecting a distant point and the pathway to communicate with it. The network is a combination of subscriber premises gear, transmission media, and switching facilities assembled to provide an economical communication link between any two users. Its value obtains from its ability to interconnect selected points at any selected time.

The network must be ready at all times to make any of trillions of possible connections between each of the 103 million telephones in the country today. During a typical day it must handle between 300 and 400 million calls. Tens of thousands of connections must be set up and taken down every minute. More than 3 million people may be using their telephones simultaneously at a particular time. Minutes later a new pattern of 3 million different people may be using the network. The faint electrical impulses generated when the voice falls on the telephone transmitter must be amplified countless times before reaching their destination.

By any standard, the equipment necessary to accomplish this complex task is imposing. The Bell System telephone plant represents a gross investment of over $40,000,000,000. Its web extends into every geographical part of this country. Over six hundred thousand employees are required to furnish the service. Billions of separate electrical contacts are required to function on a daily
basis and hundreds of millions of miles of voice channels have been provided.

The telecommunications network, then, must be the prime consideration of Western Electric and the Bell System. The efforts of the total organization are utilized to keep the network operational. The network places constraints and opportunities on innovation.

With a large plant in existence, new techniques must be capable of operating with that which already exists to be economically feasible. Not only must product innovations be measured economically, but the operation of the network must also be considered when and as they are being introduced. The systems designer must take into consideration the operation of the various kinds of switching systems in the network, the different transmission systems and the many kinds of terminal equipment located on subscribers' premises.

For the network to have full value, every person must be able to reach every other in the system. Every new person added to the system also affects in some way the services to every other person in the system. This is different from most other final consumer service industries. In the power industry, a new customer will require more output from the power plant. If the system is not large enough, some degradation in the service to the other customer may occur, but normally there is no change in the characteristics of the service received by other customers.
casting, the addition of a few more receivers will not affect in any way the receivers currently in operation. Yet in the telephone system, as the system becomes larger, there is an increasing requirement for more interconnections between the customers. When two people are connected to a line, only one inter-connection is required. To interconnect ten phones, forty-five interconnections are required. This number continues to expand rapidly. To interconnect the 103,000,000 telephones in this country, 500 million billion lines would be required. Obviously, no one would attempt to build such a system. This led to the development of switching systems. The same problems obtain when the various switching centers are interconnected. This leads to switching offices for switching offices, which are called tandem offices within the telephone industry. This tendency towards dis-economy of scale can be reduced, but never eliminated.

Constraints overcome become opportunities. A critical factor behind many innovative opportunities of the telephone network is that the vast plant standing behind the customer gear is of little interest to the user if the quality and integrity of the service is maintained. Very few consumer services are so situated. When an airline provides transportation, one is usually interested not only in getting to the destination, but also in the accommodations along the way. In a restaurant, not only the food but the atmosphere counts. In the telephone industry, the means or plant facilities behind the scene are of little concern to the sub-
scriber, provided the quality and integrity of the communication is maintained.

Innovation policies and purposes

Bell System innovation is directed towards improving the utility and reducing the cost of telephone service. An organization's actions and achievements better express its attitude towards innovation than words which could well describe a desirable situation that does not exist. Examination of corporate actions reflects a positive and constructive attitude toward innovation. A series of decisions, designed to provide an innovative organization, has been implemented. Some of the most significant of these were:

1. Establishment of the Bell Telephone Laboratories as a separate corporation to carry on research and product development and design functions previously performed by Western Electric engineering. This established a climate more conducive to research and development by providing long-run continuity, opportunity to concentrate, and protection against expedient action which might develop out of the pressures of everyday operations.

2. Investing in a specialized Engineer of Manufacture organization to provide highly developed professional skills for designing machines, tools, and other productive facilities, for planning manufacturing processes, and for innovating
new methods of production.

3. Participating with the Bell Telephone Laboratories in the establishment of Branch Laboratories at the manufacturing locations. These bring the designer and manufacturer close together at the point of manufacture and stimulate interchange of technical ideas, which leads to improvements in design and better manufacturing methods.

4. Pioneering in manufacturing research through the establishment of the Engineering Research Center at Princeton, New Jersey. The Center is dedicated to research in advanced manufacturing techniques, and capitalizes upon the new findings of science to harness them for Western Electric's production needs.

5. Establishment of Production Engineering Control Centers (PECC) which combine and integrate the previously organizationally separated functions of manufacturing engineering, network engineering, installation engineering, and repair engineering for a single major product line under one management at an appropriate manufacturing location. This has resulted in PECC's for Electronic Switching at Hawthorne, Crossbar at Columbus, Station Sets at Indianapolis, Transmission at Merrimack Valley, and Manual at Kearny, where all Western Electric engineering for that product line is concentrated organizationally and geographically at one point.
6. Development and maintenance of educational programs
designed to expand engineering and technical competence
and effectiveness, such as the Graduate Engineering and
the Lehigh Masters Degree Program, the Tuition Refund
program, and a host of other local programs to assure
maximum technical proficiency in the business.

This continuum reflects a concern with innovation and a
desire to improve engineering performance by appropriate organization that reaches back into the early history and operations of the corporation. Western Electric's current wide interest in innovation is not a recent infatuation brought about by the dramatization of the possibilities of high science.

Organization for Innovation

Analysis of organization reveals that within the Bell System not only is each Bell Company committed to innovation in its statement of purposes and goals, but each company has organizations with a definite commitment to innovative goals. These goals are formulated to concentrate on the organizations' functional responsibilities. As a member of the Bell System, each organization has ancillary responsibilities to interact with the other companies in the System to respond to total System needs. Each organization is asked to accomplish its primary functions within System constraints.
Among the Telephone Companies' main innovative responsibilities are the effective use of the plant facilities. They are responsible for anticipating the needs of the telephone users and having the equipment available when it is needed. Refinements or changes that would either improve the service or reduce the cost are suggested to Western Electric, Bell Telephone Laboratories, or AT&T depending on the nature and scope of the suggestion.

One of AT&T's main innovative responsibilities is to evaluate the System's operation. In doing this, AT&T makes general studies looking forward to the broad development of the telephone network. Overall planning of technical requirements, design, and styling for new and improved instrumentalities and systems also fall under their purview. They must establish operation and performance objectives which are used for guidance of the development work of Bell Telephone Laboratories. AT&T reviews and approves proposed authorizations for work to be performed by the Bell Telephone Laboratories on behalf of the Telephone Companies.

Bell Telephone Laboratories has three main innovative responsibilities. First, they perform the research and development work that provides the technological base for the telephone industry. Their second responsibility is to act as systems engineers for the vast telephone network. Their systems engineering group makes continuous studies of evolving technologies to determine when and where new technologies can be applied with the most economic value. Systems Engineering is a current buzz word; but the
principles are not new to the Bell System. An article in the 1926 issue of the Bell Lab Record defines the systems engineering concept in terms that would be relevant in the discussions of the concept today. The third major responsibility of the Laboratories is to develop and design telephone gear. This responsibility includes setting quality and performance characteristics for the device or system.

Western Electric has several major innovative responsibilities. The first, related to its function as manufacturing and supply arm of the System, is to furnish the manufacturing and distribution capability of the System. It must assure the System that the products which are manufactured or purchased will be of high quality and of low cost and will meet the design intent of the Laboratories. Western Electric works closely with Bell Telephone Laboratories to assure that new technologies fully exploit the advantages of quantity manufacture. The responsibility for manufacturing process innovation is vested with Western Electric. Not only must improvements in existing processes be made, but capability to handle new technologies must also be developed. Western Electric also funds the product development work of BTL. Another responsibility of Western Electric is to maintain the integrity of the System through maintenance of the System records. The Systems Equipment Engineering organization is charged with the responsibility

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for keeping records of the switching system up to date, for only then can the system operate with the assurance that the 150,000 annual additions to central office equipment can be made with the minimum of operational difficulties.

Each organization within the System has well defined prime responsibilities to itself and the System. To optimize total System performance each of these organizations must interact with the others. This interaction occurs at all levels and all times. These activities are sometimes formalized into inter-company task forces, but the bulk of the communication inter-company takes place outside of a formal committee structure. The structure and location of intra-company organizations are usually arranged to facilitate inter-company communications. When a Bell Laboratories engineer needs to be in frequent contact with his Western Electric peer to collaborate on design development, he is usually located at a branch laboratory which is housed in the same physical facilities as his Western Electric peer. The systems equipment engineers within Western Electric that must have frequent communication with members of the Operating Companies are usually located at regional engineering centers. Their job is organized on a geographical basis. Bonds of individuals within the companies are strengthened not only by exposure through work situations but by a continuing program of rotation and mixed participation in training courses. When individuals have common interests, but are
not located in the same physical area, meetings and symposia are set up to aid the flow of information. These symposia are usually attended by members of more than one of the Bell System Companies.

Expenditures for research and development

The high rate of innovation is necessary for Western Electric and the Bell System to meet their responsibilities to the telephone user. Research and development permits the system to explore and exploit the developing technology in the whole spectrum of activities which may be useful to telephony.

Rapid product innovation requires a large investment in research and development. Data made available by the National Science Foundation show research and development expenditures by industry. These data are summarized in Table 3 along with data submitted by Western Electric to the National Science Foundation. Western Electric's research and development expenditures as a percent of net sales to the telephone companies exceed those of any other industry group. Even the drug industry which has a reputation for being research oriented does not exceed Western Electric's expenditures. The aircraft and missile industry has the highest rate of product innovation, but only average company financed expenditures for research and development. This is caused by the nature of the industry. Most research and development within the aerospace industry is government supported by direct grants and the amount indicated is that which is company sponsored. A high
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* Not Separately Available but Included in Totals

** Western Electric percentages restated to reflect NSF definitions of

Source: National Science Foundation 67-12; Western R&D, Electric Company.
rate of research and development expenditures by Western Electric accompanies the high rate of product innovation.

The engineering work force

Western Electric employs approximately 15,000 people in its engineering organizations of whom about 7,000 are classified as professional engineers by the Company. The engineers represent virtually every scientific and engineering discipline with electrical, mechanical, and industrial engineers being the largest groups because of the nature of the work. Over 350 of the engineers or about five per cent presently hold advanced degrees. In order to improve and upgrade the qualifications of its engineering staff, beyond the high entry credentials required for employment, Western Electric operates several engineering training programs. One of these, called the Graduate Engineering Training Program, which is mandatory for all college graduates in the engineering department, has been operating for ten years and has processed over 4,000 engineers through the special curriculum designed to expand engineering skills and relate them to Western Electric's needs and objectives. Another training activity, the Lehigh Masters Degree Program, which has been in operation for seven years, has graduated over 140 Western Electric engineers from Lehigh University with masters degrees. The present Western Electric class at Lehigh numbers approximately fifty. The cost of these programs to Western Electric is about $3,000,000 per year. It is estimated that
Western Electric has invested about $28,000,000 in the programs over the years, expanding the knowledge and improving the skills of its engineers.

The discussion so far has been concerned with organization, effort, and expense. To gauge the innovative effectiveness, it is necessary to identify what was achieved in terms of values, new products, new systems, and new processes. The evidence obtained from corporate records and interviews regarding a variety of new products and services that have derived out of engineering invention and application is covered in the following sections starting with the new developments in the network as a whole and then dealing with each major product line.

Product Innovation—technical evolution of the network

The history of telephony reveals a succession of innovations that have been tiered one upon another to yield the existing telephone network. Not only has the network been expanded to meet the rising demand for service but the quality of service rendered has also improved substantially.

In 1915, when the original transcontinental transmission line was placed in service, the transmission quality was considered to be equivalent to shouting 400 feet across a grass field. By 1930 transcontinental transmission was considered equivalent to talking at thirty-five feet. Now the standard effectiveness of transmission both for long distance and local calls is considered
to be conversation at ten feet. In the early days of switching, a considerable amount of time was taken as the operator made necessary connections. On long distance calls, connection time could extend to twenty minutes as a series of operators made the necessary interconnections. Today the connection procedure in an electronic office is virtually instantaneous. Another indicator of improving quality is the transmission channel frequency of telecommunications. The first transcontinental line had a frequency band of 900 hertz. Today, transmission frequency is 3500 hertz for voice communications and up to 4 megahertz to accommodate color television transmission.

The vast telephone network in the United States is composed of 103,000,000 telephones, thousands of switching centers and millions of miles of voice channel circuits. Its development has kept pace with the successive stages of technology, substantially pioneered by the telephone industry itself. It is a large and extremely complex mechanism. Its size and diversity might have restrained growth and inhibited technology; yet, through the combined innovative efforts of the Bell System, the network has demonstrated the capability to grow and improve by taking advantage of new technologies.

Station sets

Telephone communications began with Alexander Graham Bell's invention of the telephone transmitter and receiver. Terminal
equipment or station apparatus has continued to be a critical element in communications technology. The evolution of the telephone set from its early days to the 500 General Purpose Dial Set in common use today is a history of technological improvement. The 500 Set introduced in 1950 represented a culmination of acoustical and electrical design principles which evolved after painstaking development efforts by the Bell Telephone Laboratories and Western Electric. This set included a new transmitter with greatly improved stability and a new receiver giving an extremely flat frequency response over the voice band with a three-fold improvement in transmission efficiency. It also included an application of solid state technology, varistor voltage protection, which resulted in more uniform performance in spite of large variations in subscriber loop length. It became the standard of the industry in this country; its features were adopted by other manufacturers. Design of the set incorporated many ideas that would facilitate manufacture. As shown in the price comparisons, many innovations continue to be made in the production process to make this set the standard of cost and quality.

During the '60s, a new line of telephones, the Trimline series, offered new styling without compromising the quality of the network. Special sets have been developed for use in Touch-Tone calling service. Special purpose gear has also been designed and manufactured. This includes key telephone equipment which
permits the customer to do a small amount of localized switching at his own discretion; Call Director telephone for more complex switching functions; Speakerphone to convert the telephone into a hands-free device or conference instrument; a wide variety of coin telephones; automatic dialing telephones; and many others. Some measure of the level of innovative development in this area can be gained by looking at the spectrum of products produced at the Indianapolis Works. In 1955, Indianapolis produced approximately 475 different codes of telephone station apparatus, including color varieties. In 1968, this number has grown to over 1,500.

Looking to the future, two principal trends are anticipated. First, a continually expanding variety of station apparatus to serve the requirements of an increasingly demanding telephone customer. Second, and perhaps of even greater importance, is the growing complexity in the station apparatus itself. In particular, the new technology of integrated circuitry will permit the inclusion of a large number of complex electronic functions within the station set which will make the typical home telephone a much more versatile and flexible instrument. Picturephone service for video telephony (which is now on the horizon) is an example of both these trends. Greater complexity and diffusion of this type must not sacrifice the ability of the ubiquitous station set to survive the tremendous variety of environments to which it is exposed. The
costs of providing and maintaining more complex apparatus on the customers' premises must remain consistent with the value of the services offered. At the same time, the telephone station set will become a still more convenient and useful instrument for the telephone customer to use in calling to his service the remarkable machinery of the nationwide and international telephone network.

Transmission systems

The first telephone transmission systems consisted of open wires carrying voice frequency signals. They were limited in both band width and length by the electrical characteristics of resistive metallic circuits. The invention of the audion (electron tube amplifier) by DeForest in 1907 provided the missing element that had limited the growth of long-distance telephony. This was quickly recognized by Bell System engineers, who developed long life tubes and voice frequency amplifying circuits which led to the opening of the first transcontinental line in 1915 connecting California to the East Coast.

In addition to long-distance telephony, electronic empli- fiers stimulated the development of carrier systems. Carrier systems permit many conversations to be transmitted over a single electrical path; they, in effect, give the operating company a more efficient use of copper wire as a transmission medium. Carrier systems have been the major factor in reducing long and short haul transmission costs experienced over the past several decades.
Bell Laboratories has designed and Western Electric has manufactured and supplied a broad spectrum of these carrier systems to the Telephone Companies.

Carrier transmission equipment places several telephone conversations over a single pair of wires. The early basis for carrier transmission systems was frequency division multiplexing. Frequency division multiplexing can be thought of as a group of radio transmitters at the sending end and a group of receivers at the receiving end. The outputs of the transmitters are combined and carried over wire, cable or airway to a distant point, where the receiving terminal separates the signals. The first carrier system was introduced in 1918. Progressive developments in radio transmitter and receiver technology, backed by increasingly sophisticated devices, led to the introduction of new carrier systems. Between 1918 and 1950, sixteen different carrier systems were introduced. In 1950, N Carrier, which placed twelve voice grade circuits on a single pair of wires, was introduced for use in transmission from 20 to 200 miles. In close succession came 0 Carrier for long haul and the 0/N system to utilize the virtues of both the 0 and N systems. N-2 was introduced in the mid-'50s and N-3, which utilized the growing capability of the transistor, followed in 1962. Each succeeding system represented an improvement in either quality or cost, and usually both.

Prior to World War II, significant developments were made in electrical wave filters utilizing quartz crystals. This develop-
ment produced a channel filter with flat frequency characteristics. The individual channel response is approximately 400 cycles wider than the normal voice band of other carrier telephone systems using other filter circuits. Another development of the period, coaxial cable, led to the development of the L Carrier Systems. The first trial installation utilizing crystal filters on coaxial cable was prior to the war and the first commercial system with large coaxial conductor was placed into service in 1946. The L Carrier multiplexing equipment was later adapted to the microwave systems. The L-1 Carrier system had a capacity of 600 voice channels or one black and white television channel. L-3 was designed in 1953 and provided 1800 channels or a four megahertz bandwidth color television grade channel. Further improvements in technology led to the redesign of coaxial repeaters to widen their bandwidth to approximately twenty megahertz and double the capacity of the system. L-4 was introduced in 1967 utilizing solid state technology and represents a significant advance in the areas of linear amplification and channel capacity. L-5, a system with much higher message carrying capacity, is now under development.

While the network was attempting to utilize improvements in wire and cable carrier systems, work was also going on in radio microwave transmission. By 1940, sufficient exploratory research and development work had been completed by Bell Laboratories to point toward the utilization of the microwave frequencies (two to twelve gigahertz) as an attractive transmission media. Initial
studies disclosed large available frequency allocations and that transmission disturbances and noise were relatively minor when compared to lower frequency systems. In January of 1941, a report signifying the opportunities was submitted with some pieces of an experimental system.

During World War II, microwave was perfected further and BTL designed and Western Electric produced a system (AN/TR-6) that was used successfully in forward combat areas. After the war, this same system was used in limited applications by the Bell Telephone Companies. By May of 1946, a field trial between 463 West Street in New York and Murray Hill, New Jersey, was in operation. The development proceeded and equipment was installed for a Boston to New York City route. Experimental television transmission began on November 13, 1947, and on May 1, 1948, commercial television transmission between these points was inaugurated. In 1946, it was decided, after studying the comparative costs of microwave and coaxial cable, that the microwave system appeared attractive if it could be developed to meet the required technical performance characteristics. The New York-Chicago TD-2 Microwave System was placed in service on September 1, 1950, and on August 17, 1951, a transcontinental system, New York to San Francisco, was completed. Only twelve days after the opening of the New York-Chicago link, the BTL issued their initial report recommending improvements to the TD-2 System and some twenty-three improvements were authorized by October, 1950. The TD-2 System was originally conceived to
handle six two-way, broadband transmission channels, each capable of transmitting one black and white television signal or 480 voice channels. The system since has been significantly improved and its usage expanded. Currently, the TD-2 System will handle twelve two-way broadband transmission channels, counting protection and interstitial channels; each channel can handle one color television video signal or as many as 1200 voice conversations.

In 1962, development of a solid state replacement system for TD-2 was authorized. The principal objectives of this replacing system were improved performance, greater system stability and a lower maintenance cost. The TD-3 System was conceived to be completely interchangeable with the TD-2 System. After the development of this system was well underway, it was realized that many of the components developed for TD-3 could also be used to upgrade the service on the TD-2 System. TD-2A was designed to upgrade all of the TD-2 systems then in the field. This upgrading started in 1966 and had a large impact on all of Western Electric's planned microwave production programs, including the newly developed TD-3, for now the operating companies could at low cost increase their existing capability by fifty per cent by simply modifying existing equipment.

Other microwave systems have been designed and produced for special purposes. The TH system was designed in 1952 to utilize the six gigahertz frequency allocations. It is a long haul system that has the capability of eight microwave channels, each microwave
channel carrying up to 1800 voice channels or one color television video signal. This system utilized traveling wave tubes which have low operating and maintenance features. TJ Microwave, an eleven gigahertz short haul system, was developed in 1959. TL was designed as a solid state replacement for TJ. TM is another short haul system in the six gigahertz region. Presently, TH-3 Microwave is under development. TH-3 is a blend of TD-3, TM, and TH with long haul capabilities. This new system is planned to be available by 1970.

In the mid-'50s a new system of multiplexing reached the stage of practicability in the development laboratories. Time division multiplexing and pulse code modulation had been used during the War to code telephone conversations. In use, though, it had a very high first cost and maintenance of the system was very expensive. The transistor and the steady improvement in the reliability and speed capabilities of devices and circuits made a carrier system utilizing pulse code modulation look practical. The system was designed and built as a trial installation in 1957. The reliable standard transistor of the period fell short of the system requirements. New devices had to be designed that could meet the stringent requirements. In 1962, T-1 Carrier was introduced into production and has in the subsequent years become the primary exchange carrier system. This economical system made it practical to use carrier systems for transmission of distances down to ten miles. Time
division multiplexing is being considered for use in other transmission systems and has been incorporated into private branch exchange switching networks.

The development of transmission systems has been varied and at times characterized by projects in parallel as well as tandem. Each system has borrowed the good features of the others to reduce the overall cost of transmission systems and each has an economic part to play in the development of the switching network. Transmission systems have become larger as demand for their services expanded. Economies of scale benefiting the Telephone Companies show very clearly, for the largest systems offer the lowest channel mile cost, if they can be utilized close to their capacity. Satellites represent a natural development from the Bell System Carrier development. Without the wide development of switching and multiplexing gear that can utilize a satellite's large transmission capacity, it would be difficult to justify a satellite communication medium. As the satellite becomes a commercial reality, Bell System technology will have a large part to play in making it a successful commercial venture.

**Switching Systems**

Switching has been one of the most demanding and challenging areas of telecommunications development. This has been especially true for large urban areas where service needs have created some of the most complex switching requirements.
It was apparent in the earliest days of the telephone that manual switching could not possibly keep pace with the increased demand for telephone services. Strowger's invention of the step-by-step switch provided one of the earliest practical solutions to this problem. This has been a very durable solution for smaller switching offices and Western Electric continues to manufacture a substantial quantity of step-by-step equipment that represents a highly developed and refined derivative of these early switching arrangements.

However, even in the early years of its use, it was clear that step-by-step switching had fundamental limitations, particularly in large urban areas, where the interconnection of large numbers of lines was required. In 1921, the Bell System provided a new generalized approach to the switching problem with the introduction of common control switching. The first embodiment of common control principles was in the panel switching office. This office included digit registers and translators which were used to set up a call, then released to set up another call as soon as the desired connection was established. This technique provided important equipment economies in large offices. In addition to these economies, however, common control switching brought with it a degree of flexibility in switching arrangements which has made this design philosophy the fundamental framework of modern switching systems.

The original panel equipment version of common control was
succeeded in 1938 by crossbar common control switching systems. In this development the crossbar switch replaced the panel switch, but more significantly an additional feature to the common control principle, the marker, was introduced. The marker is an electro-mechanical computer specialized to deal with the logic of telephone interconnection. It increases the efficiency of the switching arrangement and also aids system maintenance. No. 1 Crossbar also introduced line number translation and the number group concept which increased the ease with which a large central office could be engineered.

In 1948, No. 5 Crossbar was introduced and represented a massive refinement and improvement in common control crossbar principles. Today, it represents one of the most sophisticated and efficient of the electro-mechanical switching offices in use throughout the world. Its principal features are now coming into increasing use by independent telephone companies in the United States and the world.

A principal characteristic of the development of switching systems is the very high degree of intensive and continued development effort that is required in order to make a major step in switching system improvement. Bell System problems of switching in highly concentrated urban areas stimulated the development of common control principles. Over the past forty years, these principles have continued to be the keystone of switching system evolution.
Another milestone in the development of switching technology was recently reached with the introduction of the new generation of electronic switching systems. These systems continue to build upon the general principles of common control, but add the innovation of stored program control which promises to be as fundamental to switching as was common control itself.

A major part of the telephone switching problem is that of processing information. The switching system accepts data from the telephone customer in the form of dial pulses or tones. From this coded message, it identifies one out of the tens of millions of other telephone lines and makes a unique connection between the calling and the called parties. Thus the telephone switching network is a type of powerful, although highly specialized, computer. Indeed, some of the earliest principles of today's general purpose digital computers came directly out of the technology of telephone switching engineers, and some of the first digital computers were built by Bell Laboratories' switching engineers.

In any computer, a program is required which instructs the computing equipment how to solve the various problems for which it was designed. In electro-mechanical switching systems, this program is provided by wired interconnections between the various relays that perform logical operations. In the Bell System's stored program electronic switching systems such as No. 1 ESS and No. 101 ESS, the program is stored in magnetic memory devices. This pro-
vides a tremendous increase in the flexibility of the switching equipment. It is possible to build a single type of switching system controller which can manage principal types of central offices such as a local two-wire office, a four-wire toll office, or a tandem office without significant change in its wired connections. This is accomplished by electronically writing a different stored program into the magnetic memory. The stored program also makes possible a variety of new custom services which can be assigned to a specific circuit and changed at will without changing wired connections.

Electronic switching has raised this area of telephone technology to a new level of complexity and challenge. Western Electric has been required to make an expenditure in effort and dollars unmatched by any previous single undertaking. The combination of Bell Laboratories' design effort and Western Electric's preparation for manufacture, distribution, and installation required an expenditure of over $200 million by the end of 1966. Electronic switching is also an example of Western Electric applying what it learned from a new product to the old to keep it competitive. "Appliques" for No. 5 Crossbar are being considered to help this system offer some of the same new services made possible by ESS.

The Telephone Companies need and have obtained increasingly versatile switching equipment capable of providing new services while simultaneously obtaining economic advantages. The dis-
economies of scale inherent in any expanding switching system have been minimized by the evolution in switching organization concepts. The field of switching development is an example of aggressive and successful technical effort both in product design and in manufac­turing techniques. Each successive type of system development has progressively reduced maintenance expenses, and new features have helped the Telephone Companies to offset further their rising traffic and accounting costs.

Components

Traditionally, components have been the basic elements which the engineer considers in planning and developing a new tele­communications system. The component is the basic building block. The discovery of a new principle and the invention of a new com­ponent can have a revolutionary effect throughout communications technology.

A new era in components began with the invention of the electron tube amplifier. This device made possible the development of long distance telephony and transmission carrier systems. Over the years, the Bell System has continued to make substantial con­tributions to the design and manufacture of electron tube devices. Among the results of this continuing research and development pro­gram was the design and manufacture of the ultra-high reliability electron tube amplifiers which made possible the first trans­oceanic telephone cables.
In the early 1960s, the Bell System made another major contribution to electron tube technology by developing a process for producing a synthetic nickel alloy for electron tube cathodes. The introduction of this new alloy increased the average life of electron tubes from approximately 75,000 hours to over 100,000 hours, resulting in estimated annual savings to the Bell System of more than $4 million.

The invention of the transistor at Bell Telephone Laboratories signalled a new era of challenge in the manufacture of components at Western Electric. Production of semiconductor devices required the development of a completely new repertoire of manufacturing techniques. Material structure and composition had to be controlled to laboratory conditions. The evolution of transistor production techniques was marked by an extremely close interlocking of Bell Laboratories' design functions and Western Electric's manufacturing process development. The invention of crystal growing techniques, zone refining and diffusion processes by the Bell Telephone Laboratories were essential keys which were followed by Western Electric's conversion of these discoveries into economic, large scale manufacturing processes.

The decade following the discovery of the transistor was a period of rapid change in both device capabilities and manufacturing techniques. First generation transistors were called point contact transistors after the junction forming process. Two wires were
placed in contact with the semiconductor material and given a large pulse of current to form the semiconductor junction. The process produced devices which were fragile and difficult to reproduce. By 1954 the grown junction transistor had been developed. This device was produced by alternating the semiconductor material type during the crystal growing process. The leads were then attached to the different zones in the crystal. Devices made by the grown junction process had better electrical characteristics and were easier to produce than point contact devices, but required new production facilities. By 1955 the alloy transistor was under development. This device diffused the semiconductor junction from metal pellets that were attached to each side of the semiconductor material. The production process was again completely new, but again the change produced devices with better operating characteristics.

The mesa diffused transistor represented another major step in semiconductor manufacturing procedure. Bulk processing and high tolerance control led to devices of vastly improved electrical characteristics. The mesa device junction was grown by diffusing the impurities into the semiconductor material surface. After the junction was formed, part of the surface was chemically etched away leaving an island of active semiconductor material, the mesa. Again new production techniques were required.

By the end of the '50s, planar transistors had been
developed. These devices diffuse the junction into the semiconductor material in much the same way as mesa devices, but did not require surface etching to provide isolation of the active electrical area of the device. Surface passivation techniques were used to isolate the junction. Planar technology has been modified by better junction sealing techniques and the epitaxial material growing process, but remains the dominant production technique.

Transistor development depended on production technology, so much so that the manufacturing technique gave each succeeding generation of devices their generic name.

A new era of component technology has been generated with the development of integrated circuitry which is a feature of micro-electronic technology. This new technology permits the manufacture simultaneously of large numbers of transistors, resistors, capacitors, and all their interconnections. It holds the promise of greatly reduced cost, increased reliability and speed, better long-term performance, and substantially more compact equipment and systems. It makes possible the most profound revolution in communications equipment ever experienced. Consequently, Western Electric and the Bell Telephone Laboratories have been early and active in developing and applying this technology to the design and manufacture of new products and to the redesign of existing products. To take advantage of integrated circuitry's size, new
physical mounting procedures had to be devised. A termination
technique utilizing plated precious metal interconnections, generi-
cally called "beam leads," was developed by Bell System technolo-
gists. Thin film circuitry was also converted to a production
process to enhance the capabilities of these tiny devices. This
effort is requiring a substantial commitment of research and
development forces with the associated risks that attend such
commitment. The final result should be the ability to design and
manufacture a more useful and powerful complement of communica-
tions equipment which will permit the Telephone Companies to con-
tinue to improve their ability to serve the public's communications
needs.

Wire and cable

In addition to the telephone receiver and transmitter, the
second principal component of the earliest telephone system was
the wire and cable which connected the station sets together. This
has been another area of continuing innovation in design and manu-
facture.

During the early years of the Twentieth Century, telephone
cable consisted principally of copper wires insulated by wrappings
of paper ribbon, bundled together and protected by a thick sheath-
ing of lead. In 1928, Western Electric's engineers introduced a
process innovation for producing paper insulated copper wire. In-
stead of applying ribbons of processed paper to the wire, they
developed a process to apply pulp directly, producing a paper coated wire in a single operation. This paper pulp insulated wire has been an important item of commerce ever since. It is currently manufactured according to Western Electric processes by major manufacturers in this country and abroad.

In the late 1940s and early 1950s, there was a second revolutionary change in the manufacture of wire and cable. The discovery and manufacture of low cost, quality synthetic polymers by the chemical industry presented the attractive possibility of using these new materials to replace lead in telephone cable sheathing. During this same period, the telephone network was expanding rapidly and required large amounts of telephone cable. Periodic lead shortages and increasing lead prices made it imperative that a substitute be found for the lead protective sheath.

After several years of engineering development by Western Electric and the Bell Telephone Laboratories, the Alpeth and the Stalpeth families of telephone communications cable were brought into manufacture. These cable structures replace lead with a composite of thin corrugated sheets of steel and/or aluminum combined with extruded layers of specially compounded and stabilized polyethylene. These structures have since become the world-wide standards for telephone cable.

Growing complexity of the network and products

As described, the Bell System product innovation has con-
sistently pressed the frontiers of technology to offer new and improved products to the Telephone Companies. Not only must the new products be produced, but manufacturing capability must be maintained for the older products. Western Electric has to stand ready to deliver to the Telephone Companies whatever they order. The System then has the opportunity to choose among the newer products of innovation and the products of the past, and can make a cost effective decision on which product to procure.

The descriptive story of product innovation in the Bell System is extensive, yet it gives only a flavor of the impact of innovation. As shown in Table 4, in 1966 48 per cent of Western Electric's sales of manufactured products to the Telephone Companies were derived from products introduced since 1960. In the ten year period from 1950 to 1960, new products introduced during the decade provided 34 per cent of Western's sales revenue in 1960. It is expected that 65 per cent of Western Electric's sales of manufactured product in 1970 will come from products introduced during the '60s. Two things should be noted: first, the percentage is large and Western Electric's manufactured product is constantly being changed. Second, the rate of innovation is increasing—more sales from new products in the '60s than in the '50s. Chart XXV compares Western Electric's estimated sales from products introduced since 1965 with other industries. In 1969, it is estimated that new products introduced in the four year period from 1966 to
TABLE 4

NEW DESIGN SALES
(ESTIMATED PORTION OF TOTAL BELL SALES)

<table>
<thead>
<tr>
<th>BASE YEAR</th>
<th>SPAN OF YEARS</th>
<th>END OF PERIOD</th>
<th>PERCENTAGE OF SALES OF NEW DESIGN SINCE BASE YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>10</td>
<td>1960</td>
<td>34%</td>
</tr>
<tr>
<td>1960</td>
<td>6</td>
<td>1966</td>
<td>48%</td>
</tr>
<tr>
<td>1960</td>
<td>10</td>
<td>1970</td>
<td>65%</td>
</tr>
</tbody>
</table>

* W.E. MANUFACTURED PRODUCTS

Source: Western Electric Company
SALES DERIVED FROM PRODUCT INNOVATION
INDUSTRY COMPARISON

New Products Since 1965
as a Percentage of 1969 Sales

CHART XXV

1969 will comprise 25 per cent of Western Electric's sales.
Western Electric ranks higher than all industries except aerospace, where the government finances research and development to meet the nation's defense requirements.

Process innovation

Process innovation is usually an internal phenomena for the firm and its results are demonstrated by the price and productivity performance. The productivity performance delineated previously appears to demonstrate good process innovation performance on the part of Western Electric.

Each production shop within Western Electric is assigned to a product engineering group whose sole responsibility is to examine the productive processes within that shop and manage them in an engineering sense. The history of process development within Western Electric extends back to the beginnings of the telephone industry. Proper application of manufacturing engineering skills has produced such achievements as a telephone which contains over 400 parts and sells for less than $12.00. Over 100 separate and distinct cost reduction cases have been processed on the 500 Type telephone. Dr. D. A. Thompson of the Stanford University Industrial Engineering Department testified before the California Public Utilities Commission in 1967 and stated "Western's cost performance in the case of 500 Type telephone sets is attributable primarily to Western Electric's efficiencies and is not attributable
in any substantial degree to the volume of Western Electric's production of the sets.\textsuperscript{2} Summation of many small innovations in the productive process offset rising wage rates.

At the Baltimore Works, a building was constructed and is dedicated to the production of copper plated drop wire. The entire process from start to finish is continuous and allows wire to be produced at increased quality and lower cost than other available methods. Tandemized cable production facilities, which join together the machines that produce the cable, were conceived at the Hawthorne Works in the mid-'50s and have been introduced at the other cable plants. Improvements in control equipment and machine operating characteristics were made to reduce the processing cost and inventory requirements. As a large user of copper, Western Electric participated in the development of continuous casting techniques and jointly with Southwire Company developed the first continuous casting facility in this country for copper rod.

Wire spring molding techniques which mold multi-insert plastic parts were developed at the Hawthorne Works in the early '50s and are now used at other plants in the System. This manufacturing development made feasible the production of low cost relays which freed the designer from contact limitations during

\textsuperscript{2}D. A. Thompson, Testimony filed with California Public Utility Commission, Case Numbers 8608 and 8609 (November, 1967).
circuit design. By 1960 wire spring molding techniques were applied to the production of apparatus designed for use in Electronic Switching Systems. By then the engineers felt that considerable improvement could be made on the productive system by combining several of the operations in a different manner. Recombination was accomplished building on past developments while taking advantage of the improvement opportunities presented.

At North Carolina product engineers designed and developed a resistor production line completely under the control of a computer. Resistors produced on this line have their quality constantly monitored and the production facilities are adjusted frequently to optimize the balance between quality and cost. Process engineers at the Columbus Works have combined the computer, a tape controlled wiring assist device, and a wiring operator to take advantage of the unique skills of each of the parties. The skills and ability of the operator are combined with the speed and infallibility of the computer to reduce substantially the time required to wire a unit and increase the quality level to perfection.

Even an item such as the telephone jack, which has been produced by Western Electric for the past seventy years, is still an object of process innovation. The transistor and integrated circuit are the newest products to come under the persistent product engineering scrutiny at Western Electric. Their cost, in fact their very existence, depended on the ability of the proces
engineer to develop processes to take advantage of the known physical capabilities of the device.

Dispersion and general use of telephone innovation

Bell Telephone invention and innovation has spawned a large number of improvements outside of the telephone industry. The most dramatic is the rapid development of the transistor device industry. In less than twenty years the transistor was conceived, produced and diffused to industry. Solid state technology now provides the base for the production of over a billion dollars of devices. The advances in other industries, such as the computer, instrumentation, and missile rest solidly on the base provided by low cost, highly reliable solid state devices. Although the impact of this one technological breakthrough on the national economy is difficult to ascertain, it is given credit for siring what is commonly called the age of the computer. This device brings the cost of machine logic down to a point where its application depends only on the inventiveness of man.

The transistor currently receives more attention than many of the Bell System's past contributions to science and the economy. But the record reveals many inventions and innovations that have been significant and which have had a broad and pervasive effect.

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3C. D. Hanscom; Dates in American Telephone Technology (Bell Telephone Laboratories, 1961).
The negative feedback principle perfected by H. S. Black of Bell Laboratories, in 1927, was placed in use within Bell System Carrier Systems but was also used widely in the broadcast communications industry. Within the entertainment industry, the method of recording sound on film was made possible by H. C. Wente's development of a practical light valve in 1922.

Stereophonic sound, the private entertainment media of the '50s, was first demonstrated in Washington in 1933, and at Carnegie Hall in 1940, by Bell System personnel. Information on the crystal phonograph pick-up was published by A. M. Nicolson of BTL in 1919. Many of the microphones in use today had their genesis at Bell Laboratories. The hearing aid for the deaf and the artificial larynx for the dumb were developed within the Bell System. The radio altimeter was demonstrated in 1939. Much of the early work associated with aircraft and ship navigational aids was done by members of the Bell System. The cathode ray tube receiver, patented by A. M. Nicolson of BTL in 1923, was the first of many contributions to the television industry. Early computer technology was fostered within the Laboratories and Hamming error correction for use in digital information was conceived by a member of Bell Telephone Laboratories. In September, 1968, a patent for a new vidicon camera was granted that reduces substantially the light required to pick up a television picture. W. A. Shewhart applied statistical theory to manufacturing quality problems and founded statistical quality control as it is practiced throughout industry.
Even wood has not escaped improvement by Bell System technologists, and many of the treatments first developed for protection of telephone poles have found wide application in industry.

This list is neither definitive or all-inclusive, but it gives the flavor of the substantial contribution that Bell System technology has made to the economy. Its major contributions have been in the electrical transmission field, but occasionally the effect has gone far beyond industry boundaries.

Summary of innovation

In this section, many aspects of Western Electric and Bell System innovation and technological behavior have been examined. A number of specific innovative accomplishments have been identified and the development of several major product lines has been outlined. The continual refinement and upgrading of each product line has enabled the telecommunications network to expand and improve in terms of its range, usefulness, and adaptability.

Introduction of new product technology has had a large effect on the productivity of the Telephone Companies. This is illustrated by a study recently completed by Dr. John Kendrick of George Washington University. According to Dr. Kendrick's study, the average annual improvement in total factor productivity

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in the telecommunications sector from 1948-1966 has been 3.8 per cent, or slightly greater than that of the electric and gas utility industries. This is well in excess of the national average of 2.4 per cent found by Dr. Kendrick for the private domestic economy for the same period. But this does not tell the whole story, since during this period of time a steady flow of new and better products and upgraded services was offered to the public which is not reflected in the improved productivity index. Process innovation has also been a contributor to the demonstrated price and productivity performance of Western Electric. Process development has also had an integral part to play in the ability of Western to manufacture the newly conceived products of the Laboratories.

A common test of a company's or an industry's ability to innovate is to notice the source of innovation within that industry. It was not the traditional producers of locomotive equipment in the railroad industry who saw the opportunity of the diesel engine. This development was sponsored in large part by the automotive industry. The textile industry did not develop synthetic fibers; but rather the chemical industry. The intrusion of one industry on another tends to take place when an industry does not take into account all of the possibilities or tries to stabilize or reduce innovation. In the Bell System the opposite effect has been noticed. The dispersion of innovation has normally been from the
telephone industry to others. The new vidicon tube, mentioned earlier as a recent Bell System development, was not introduced by the television equipment suppliers but by the Bell System trying to overcome the limitations of present technology. The transistor, crystal filters, negative feedback, statistical quality control, mathematical approaches to business problems, the systems engineering concept, have all had their birth in the telephone system and now find wide application in other industries, often after a considerable time lag.

This innovative ability of the Bell System depends on more than size. In the solid state device industry, Bell System production represents less than 10 per cent of the industry's output and several companies within the industry have a greater production than Western Electric. Yet the system continues to spawn significant innovations. The epitaxial-base integrated circuit utilizing an extremely thin epitaxial layer is one of the most advanced devices of the day. Beam lead technology was developed to overcome the problem which confronted designers attempting to utilize the fantastically small integrated circuit devices. Most of the industry set up overseas plants in areas where the labor cost to interconnect these devices was very low. This solution seemed inappropriate for the Bell System. Some other technique had to be developed to overcome the high cost of assembly. The beam lead connection technique has been developed by the Bell Telephone Laboratories for use in the
Bell System to cope with this problem. It has been selected for use in the Sentinel anti-missile defense project because of its high reliability and low cost. The Bell System remains on the forefront of the extremely complex and competitive solid state industry, not only because of its size, but also because of its dedication to the principal goal of utilizing technology to provide the telephone network with better performing, lower-cost gear.

The organization of the Bell System is designed to implement innovation. Basic research is pursued by a separate group in the Bell Laboratories. Efforts are made not to intrude on the basic research organization. Rather, as promising findings appear, another organization is assigned the task of evaluating its importance and incorporating the concept into the operating system. A well-structured means of innovation through cost reduction activity on the part of Western Electric is in evidence. The multi-company structure assures that each organization will maintain its identity and the integrity of its goals. Each organization is constrained by the others around it to optimize not its performance but the performance of the system. The structure of each organization can be fitted to its tasks. Optimum advantage of organization opportunities can be taken by each organization. In manufacturing, for example, where a high degree of structure is necessary for satisfactory performance, this can be accomplished without interfering with the structure of the other affiliates in the System. The
System organization is formed to allow transfer of the innovative activity through discrete steps to maximize the opportunity for successful communication and effective collaborative effort. The ability to suggest innovative changes is highly diffused, but the decision-making apparatus for accepting an innovative change is centralized. Each area has its own management which must recognize and take into account the impact on the total organization of the decisions it makes in its functional area.

Western Electric's management has demonstrated a willingness to accept the expense associated with supporting a competent engineering organization. The hazards associated with major innovative projects have been accepted as a necessary challenge to effective management and as a necessary step to optimum Systems performance. The pace of internal innovation has allowed the System to progress without being dependent upon unaffiliated suppliers whose innovative goals may be different from those of the Bell System. The hazards of such dependence are reflected in the experience of the electric utilities which often are required to wait up to six years for delivery of generators, and which are dependent for innovation on a manufacturing industry which has not displayed much initiative in recent years. Dr. Phillip Sporn, Chairman of the System Development Committee, American Electric Power Company, said recently in "the Citrine lecture" at London:
In fact the record of the utilities on the whole is that they have done very little in application development. They have influenced manufacturers to some degree and to some extent with positive results, but altogether too frequently, with negative results . . . . Sometimes the negative results have been the result of obtuseness or ineffectiveness of manufacturers.5

The Bell System organization and its activities seem to comply with the behavior expected of an innovative organization. Economic performance substantiates product and process innovation. The innovative performance of Western Electric is stimulated by its membership in the Bell System.

CHAPTER VI

THE IMPACT OF GOVERNMENT AND INDIRECT REGULATION

One of the consequences of the great growth in the American economy over the past one hundred years has been the expanding influence of government and government policy in the business area as well as in all other aspects of American life. The technological advances that have converted America from an agrarian to an industrial society, with all the attendant changes in modes of living and upgrading of material standards, have demanded that public policy be continually readjusted to be compatible with rapidly changing factors in the economic and social environment. The growth of new industries to supply new commodities to an ever-expanding population, the growth in importance of the service sector of the economy, the continuing shift of population towards the centers of urban concentration, and the emerging influence of American leadership on world affairs have presented problems that have required reconsideration and adjustment of government's role in all areas of society.

The fact that emerges out of consideration of present relationships among major institutions is that big government is here to stay as a necessary corollary to big business, big labor, a big economy, and a big place for the United States on the
international scene. And with big government comes the expectancy that government will inevitably have more impact and exercise more influence on all aspects of American life.

This section of the study is concerned with government and regulatory influences on the performance and operations of a manufacturer subject to regulatory constraints. The objective is to identify factors that develop out of government and regulatory relationships that have an influence on the operations of the Western Electric Company. The principal interest will relate to the area of main inquiry—the effect of indirect regulation on the performance of Western Electric as the integrated manufacturer of the Bell System. In this connection, it is interesting to note the remarks of H. I. Romnes, Chairman of the Board of Directors of AT&T, at a recent share owners' meeting. He said:

Now, what of the future, and the motivations of today and tomorrow?

First, we have the everlasting incentive to generate efficiencies that will sustain Bell System earnings and command regulatory approval for good and improving earnings performance.

Second, communications today is a highly competitive field. So, we have that motive for innovation in ever-increasing measure.

Third, and most important of all, we know we must produce superb service to continue to be entrusted with the pace-setting role for this nation's integrated communications system. This is just as true in 1968 as it was in Mr. Vail's time.

From Mr. Romnes' remarks, it can be seen that the Bell System recognizes its responsibilities for performance and service to the public.

Public policy and regulatory policy

The main line of government policy with respect to competition and monopoly has been clear for many years. The backbone of legislative and judicial policy is structured upon the dual objectives of achieving workable competition on the one hand while inhibiting tendencies toward monopoly on the other. Although there is considerable margin for debate on exactly how these objectives may be best achieved, most authorities are agreed that these dual objectives must be vigorously supported for a capitalistic free market system to function effectively. The concept of "workable competition" has been developed and has had most substantial consideration by a host of distinguished British and American economists and scholars. Since the purpose of this study is the specific examination of the performance of one company, it is not appropriate to enter into a deep analysis of competitive and monopolistic characteristics. However, as a base to facilitate understanding of Western Electric's position in the Bell System, it is worthwhile to briefly identify the accepted criteria for measuring the performance of workable competition.

Joe S. Bain outlines his interpretation of the market performance goals which should be promoted by public policy.  

1. Efficiency in scale and rate of utilization of plants and firms within an industry.

2. Absence both of monopolistic (chronic) excess profits and of chronic net losses. Industry profits in the long run should tend toward equality with basic interest returns on investment. There should be margin to deviate from this for acceptable reasons such as windfalls, for rewards for innovation, and for differences among individual firms.

3. Adequate progressiveness in the development and innovation of improved or new techniques and products.

4. Absence of excess selling costs.

5. Desirable level and variety of product qualities and designs.

Bain, in another discussion, makes the point that American public policy is made up of two parts: the first expressed in the federal legislation which maintains competition by prohibiting private restrictions of it and preventing the development of monopoly; and the second, expressed in both federal and state laws,

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the policy of restricting or preventing competition and imposing
direct governmental regulation as a substitute. The first part,
the maintenance of competition, rests on three principal federal
antitrust laws: The Sherman Act passed in 1890; the Clayton Act
passed in 1914 and amended in 1936 and 1950; and the Federal Trade
Commission Act passed in 1914 and amended in 1937. The second
aspect is made up of a series of unusual and special departures
from the general pro-competitive policy. These departures in-
clude the regulatory treatment established for public utilities,
which in most cases involve "so-called" natural monopolies for
electric power, natural or manufactured gas, public transportation,
and telephone and telegraph communications, and beyond this for
several relatively atomistic industries in which unregulated com-
petition tends to result in untoward consequences (agriculture,
distributive trades, coal mining, petroleum production).

**Government attitude toward bigness in business**

Interest in this study in the attitudes toward big business
stems from the fact that AT&T is one of the largest businesses in
the land and that Western Electric, as part of the Bell System,
will tend to be affected by whatever affects the Bell System.

Bigness in and of itself seems to be able to conjure up
spectres of fear and apprehension in many quarters. This is

\[4\] Ibid., p. 477.
apparent from a review of the literature in the field. Scarcely a year passes that the business best seller list does not contain several inclusions that in some fashion deplore the size, power, concentration, and threat of large businesses. And in many cases, after identifying the fact that there are large corporate structures, that they do indeed have substantial real or potential economic power and that power can corrupt and lead to abuses, the authors suggest that government action be taken to reduce the size of the large businesses or even to eliminate them completely.\(^5\)

Sober reflection will indicate that in most cases it would be unrealistic to level the large corporations because the efficiency they provide is needed, and because they occupy a balanced position in an established market structure. Although, occasionally some major abuse of corporate power is detected, as in the 1960 electrical machinery price fixing case, the number of such cases tends to be relatively few compared to the possibilities conjured up by critics and alarmists. This is not to say or imply that bigness in and of itself is good, either. The test of bigness should be whether it serves the interests of national policy and functions in the best interests of the public. As has been pointed out previously, the expansion of technology, the large amount of capital required for complex, specialized machinery and plants, \(^5\)

and the problems of satisfying large mass markets, all tend to demand large firms to satisfy the requirement of sufficient substance and efficiency to function in the public's best interest. Beyond these requirements, the incentives of competition should be encouraged to apply a discipline to the productive process and to avoid the pitfalls of unregulated monopoly.

It is interesting to trace the legislative and judicial attitudes toward bigness. The public alarm that accompanied prosecution of the trusts in the period of 1890-1910 indicated grave concern with concentration of market power and apprehension over the size of large firms. The U.S. Steel Case in 1920 established the concept that "mere size is not an offense nor unexerted power."\(^6\) Justice Learned Hand in his decision in 1945 in the Alcoa Case tended to modify this position by identifying share of the market as an indicator of monopolistic position and as a significant factor in judging restraint of trade.\(^7\) Since that time, mergers and consolidations have tended to be evaluated by the share of the relevant market involved.

During the past several years, the size of many American corporations was increased not only by internal growth but also by merger. There were 1479 mergers in 1963; 1797 in 1964; 1893 in

\(^6\)United States v. United States Steel Corporation, 251 US 417 (1920).

\(^7\)United States v. Aluminum Company of America, 148 F.2d 416 (2d Cir. 1945).
1965; 1746 in 1966; and 2384 in 1967. This compares with an average of 1162 for the years 1955-1959. More significant, perhaps, than the growing number of mergers is the size of the companies involved. This too has been growing. The Federal Trade Commission's 1967 report on corporate mergers revealed that merger activity in the United States experienced the sharpest increase in modern history, up 37 per cent from 1966 to a record total of 2384. *U.S. News & World Report* recently reported that the trend toward mergers is stepping up again, and that mergers of United States companies could reach 4,000 this year, according to W. T. Grimm & Co., a Chicago consulting firm. There were 155 mergers during 1967 in mining and manufacturing that involved companies with more than $10 million in assets, which are classified as "large" merger activity. Of particular interest is the fact that six companies with assets of more than $250 million were acquired during 1967— one more than was acquired during the entire period from 1948 through 1966. Another interesting aspect of the merger trend is the tendency toward conglomerate mergers rather than horizontal or vertical. The statistics clearly high-


light the fact that the concentration of American "big" industry is increasing.

Bell System and Western Electric regulation

As public utilities, the AT&T Company and the various Telephone Companies are regulated by governmental agencies. The Federal Communications Commission jurisdiction over interstate and foreign commerce in communications by telephone, telegraph, and radio was established by the Federal Communications Act of 1934. Each of the various states except Texas has its own public utility commission which regulates utility rates on an intrastate basis. The utility commissions have joint membership in a national federation, the National Association of Regulatory Utility Commissioners (NARUC), which serves as an information exchange and a coordination agency for matters of mutual interest. As might be expected, there is a close community of interest between the FCC and NARUC and frequent exchange of data and views on matters of common concern. Two areas of great interest on a continuing basis between the federal and state commissions are: (1) the question of jurisdiction, and (2) the matter of separations, which involves the procedures for determining how much of the telecommunications plant and expenses are interstate and how much are intrastate.

The universal practice in regulating Telephone Companies is to establish an appropriate rate of return on the rate base which is composed of those assets used and useful in providing
service. This focuses attention not only on the Telephone Companies' revenues and profit, but also on the capital items that are permitted in the rate base. Since the Telephone Companies purchase a considerable amount of the capital equipment they use in providing telecommunications service to the public from Western Electric, the prices they pay Western Electric become part of the rate base. This relationship serves as the basis of what is really indirect regulation of Western Electric, which is a manufacturing company and not a utility. If a question develops about Western Electric's prices to the Telephone Companies or Western Electric's rate of return, the Telephone Companies have the burden of proving that Western Electric's prices are reasonable. In such proceedings, the rate commission can disallow a portion of the rate base and, in this fashion, effectively reduce the earnings that it would allow to the Telephone Companies.

It now is fairly standard practice for the reasonableness of Western Electric's prices and profits to be part of hearings on Telephone Company rates. The initial precedent was established in a ruling in 1922 derived from the City of Houston vs. Southwestern Bell Case in which the court ruled that it had to be shown that Western Electric's prices were as low as or lower than prices charged by other manufacturers for similar equipment. In 1930, the burden was increased. In Smith vs. Illinois Bell, the court

ruled that a comparison of Western Electric's prices with those of other manufacturers was not sufficient. In considering the reasonableness of Western Electric's prices, the court held that it was also necessary to establish the reasonableness of Western Electric's earnings on its Bell System business. Since the Smith case, the Telephone Companies have been called upon to justify their dealings with Western Electric in hundreds of cases, and in all but a few cases the courts and commissions have approved Western Electric's prices and profits. In the fourteen cases that have gone to the highest state courts, thirteen cases found Western Electric's prices and profits to be reasonable for rate making purposes.

The FCC has conducted several major inquiries into the operations of Western Electric and its affiliation with the Bell System. Such an investigation was conducted in the late 1930s. Another was carried on in 1948 by a joint FCC-NARUC Committee. This investigation resulted in the preparation of an extensive report on Western Electric's role in the Bell System, which included great detail on most aspects of Western Electric's financial operations. With this as a base, each year Western Electric submits a similar detailed report on its operations to both the FCC and NARUC. This report is supplemented by monthly and quarterly reports and other special studies that may be required by the

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Commissions. The constant contact and the continuing, close scrutiny by the Commissions of the Telephone Companies and Western Electric has resulted in a regulatory relationship which is known as "constant surveillance" and which seems to be highly effective in providing the Commissions with needed information and control.

The "consent decree"

In 1949 the Justice Department filed an antitrust suit against the Bell System alleging violation of Sections 1 and 2 of the Sherman Act because of the Western Electric-AT&T vertical relationship. The complaint requested that Western Electric be divorced from the Bell System and be split into three companies; that AT&T be compelled to grant licenses to other manufacturers under its patents at reasonable royalties; and that the Bell System be required to purchase equipment under competitive bidding.

After extended negotiations with the Department of Justice, the suit was settled by a consent decree entered on January 24, 1956. Western Electric was enjoined, with a few limited stated exceptions, from engaging in any business not of a character engaged in by it or its subsidiaries for companies of the Bell System; and AT&T was enjoined from engaging in, other than through Western Electric, any business other than furnishing common carrier com-

13United States v. Western Electric Co., and AT&T, #17-49, District Court of N. J. (January 24, 1956).
munications, and a number of specified related activities. Western Electric was ordered to maintain cost accounting methods that conform with accepted principles for determining the cost of equipment sold to AT&T and the Telephone Companies. Western Electric was required to license all Bell System patents at reasonable, non-discriminatory rates and royalty-free with respect to pre-consent decree patents. It was also required to furnish certain defined technical information relating to equipment manufactured by Western Electric for the Bell System, upon payment of reasonable non-discriminatory charges.

From the occasional article that finds its way into print and from some political and academic positions that are taken on the subject, there is evidence that the substance of the consent decree has not been accepted by some economists and politicians. These positions seem to be taken because of: (1) a total and unswerving dedication to the theoretical values of competition, (2) the conceptual attractiveness of attacks on big business and monopoly regardless of the situation, (3) a desire to make political capital out of an accepted economic structure, and (4) a lack of complete information or a misguided sense of mission.¹⁴

The following quotation from a recent law publication typi-

fies the position taken by critics of the results of the consent decree:

The common ownership of public utility and private manufacturing activities has long posed conflicting implications for public policy. Nowhere is this conflict more evident than in the vertical relationship exhibited by the communication equipment industry. The integration of utility and supplier may yield production economies, reduce communication equipment costs, and ultimately lower the price of communication service. On the other hand, vertical integration, in addition to aggravating regulatory problems, may lend itself to market abuse by restricting market entry, squeezing non-integrated rivals and passing cost inefficiencies forward into the common carriers' rate base. The line separating market efficiency and market power is by no means clearly defined.15

Irwin and McKee go on to the conclusion that Western Electric should be separated from the Bell System and suggest that this might be best accomplished under the Clayton Act in view of the fact that the earlier attempt toward divestiture under the Sherman Act was unsuccessful. They conclude:

Among the three policy alternatives for structuring the communication equipment market—competition, vertical integration, and a mixture of the two—competition best serves the public interest. It not only meets the test of economic efficiency, but also marks a return to a unified, consistent policy. Divestiture, then, is but a step to reaching these goals.16

This discussion of the pros and cons of the reaction to the consent decree again highlights the ambivalent nature of vertical

15Irwin and McKee, "Vertical Integration and the Communications Equipment Industry," p. 446.

16Ibid., p. 472.
integration, the strong positions that can be taken on the values of competition, and how the interests of efficiency and performance are best served. Based upon the judicial precedent of the decree, the official acceptance of Western Electric's vertical integration in the Bell System is quite clear. However, the continued attacks by a limited but vociferous group of commentators, and the raising of the same familiar arguments, serve to maintain this issue, which is vital to both Western Electric and the Bell System as a matter of public attention.

The 1965 Interstate Rate Case

On October 27, 1965, the FCC ordered a full scale formal rate case involving the interstate operations of the Bell System. As the proceeding developed the investigation was divided into three parts: Phase IA which deals principally with an appropriate rate of return for the Bell System's interstate operations; Phase IB which is addressing itself to the Bell System's interstate rate structure or pricing system; and Phase 2 which will deal with the reasonableness of the Bell System's interstate rate base and operating expenses and through these the reasonableness of Western Electric's prices and profits.

On July 5, 1967, the Commission issued a 107-page unanimous interim decision with respect to the basic Phase IA issues. 17

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On the important subject of rate of return, the Commission held that the Bell System's rate of return on interstate and foreign communications services should be in the range of 7 to 7-1/2 per cent. The Commission took the position that this finding involved no drastic change in the standards previously applied to interstate rates and earnings. In response to an AT&T motion for reconsideration on August 30, 1967, the Commission issued a 24-page unanimous interim decision and order which in addition to reaffirming the 7 to 7-1/2 per cent range of earnings allowed in the interim order stated further, "It is not to be construed to mean that any future level of earnings which exceeds 7-1/2 per cent will warrant immediate action looking toward rate adjustments."

On the matter of separations, the Commission decided to stay until December 1, 1967, the effectiveness of the separations change specified in the interim order and requested the Chief of the Common Carrier Bureau to convene the technical experts group to examine the prescribed separations plan. The Commission, later, instituted a separate proceeding to resolve this issue. The Commission, while deferring $20 million of the required rate reduction, insisted on an immediate $100 million rate reduction.\(^8\)

Although the Commission's interim findings were unanimous, it is interesting to note the concurring statements of Commis-
sioners L. Loevinger and N. Johnson. Commissioner Loevinger in his statement said:

The interim order does not get to the heart of the matter. In my view, that lies in devising an approach that will provide the maximum incentives to the regulated company to achieve efficiency and economy in operation. ... Rather, it seems to me, that regulated companies, like those in the unregulated segment of the economy, should be encouraged to strive for improved products and services to the public by the hope of thereby earning reward in the form of greater profit.19

Commissioner Loevinger suggested that the Commission should establish a reasonable rate base, but permit the rate of return to increase within a wide range so long as the actual rates charged to users decreased or did not increase and the service continued to improve.

In his 4-page concurring statement, Commissioner Johnson referred to what he called the archaic principles of public utility regulation. He said he thought the Commission had applied them well, but that it should begin to consider seriously and in depth the creation of new principles better suited to the perfection of a national communication system for tomorrow's America. He said that the procedures followed by the Commission in this case, while legal, had proved to be unwise in serving the interest of the public, the Commission, other participants, and even the Bell

System itself.\textsuperscript{20}

The public and professional reaction and comment upon the interim order have run the gamut of criticism from applause to severe disappointment. Typical of the comments was the view expressed by Dr. Charles F. Phillips, Jr., who said that the interim order contained few surprises and was disappointing.\textsuperscript{21} He felt that there was little that was accomplished that could not have been done under the process of continuing or constant surveillance. He reiterated some of the comments made by Commissioners Loevinger and Johnson and, in addition, noted that little attention had been given to future investment conditions and observed that the Commissioners had relied almost exclusively on the history of past Bell System performance. He noted, too, that insufficient attention was given to the effect of the decision, particularly the rate of return upon incentives to efficiency. He felt that the Phase IA decision, therefore, was traditional and did not blaze any new trails.

Professor Prendegast comments upon the decision to the effect that it is significant that for the first time the FCC has

\footnotesize{\textsuperscript{20}Concurring Opinion of Commissioner Johnson, Interim Order, 70 PUR 3d, 234.}

explicitly introduced the concept of a rate of return range rather than specify a specific figure.²² He says that it is also noteworthy that, although the decision was unanimous, two of the commissioners wrote concurring opinions that contained statements that are progressive and forward looking in the view of most students of public utility regulation. He goes on to say that on the other hand, the level of the rate range, 7 to 7-1/2 per cent, would seem from a number of points of view to be too low. Professor Prendergast supports this position regarding the inordinately low level of allowed earnings by referring to: (1) the increasing technological risks of the Bell System, and (2) the comparable earnings of other firms in the American economy.

The interstate rate case is still in process with hearings currently being conducted on Phase IB at the time of this writing, during the Summer of 1968. As has been mentioned previously, Western Electric's direct involvement will occur in Phase 2, which will be directed toward consideration of Western Electric's prices and profits. However, interest for the purposes of this study in the Phase I aspects of the case is more than superficial. Any impact on AT&T, the parent company, can have significant effects on Western Electric as the principal equipment suppliers, particularly when the sensitivity and critical interdependence between

parent and supplier are considered. The concept of a rate of return range, when coupled with regulatory lag, creates incentives toward efficiency for public utilities that are particularly interesting in the context of this research, because, to the extent that they so affect the Bell Telephone Companies, they also explain, in part, Western Electric's efficiency, productivity, and innovation. The concern of regulators and students of regulation with public utility efficiency, then, lies in with some of the aims of this study. On an increasing basis, the literature of public utility regulation is becoming concerned with the problem of providing incentives that will assure the most efficient performance of public utilities under regulation. The comments of Commissioner Loevinger summarized the viewpoints of a great many experts in the field.

Another important question that derives out of the interstate rate case is the consideration of the proper relationship between the allowed AT&T rate of return and that which might be appropriate for its Western Electric manufacturing subsidiary. What is an appropriate rate of return for Western Electric, con-

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sidering that as a manufacturing company its problems are quite
different from a utility, and that it probably is exposed to
greater technological, competitive, and operational risks than
the utilities? This question will be considered by the FCC in
Phase 2 of the interstate rate case.

Other current government influences

The new developments of technology, as they combine with
the changing social, political, and economic trends, are serving
to place the entire area of communications services in the fore­
front of government consciousness. At no time in history have
there been so many significant problems and questions that must
be resolved by government policy on communications. These problems
are not only in the area of domestic policy, but also affect inter­
national relationships. The accelerating advance in technology
is serving as a spur to highlight the problems and as a catalyst
that may help in resolving them. The advent of satellite technology
has served to place added emphasis on the need to work out adequate
understandings for the future of international telecommunications.
The tremendous accomplishments in the field of computer and data
processing science have created imposing needs for establishing
a sound base for the future growth of data transmission. The
question of the use of the frequency spectrum for radio, microwave,
and tele-picture transmission continues to plague regulation and
is compounded by considerations of satellites and Community Antenna
Television (CATV) type operations.

It is obvious that the surge forward of technology which is accentuating communications policy considerations will not come to a sudden halt, but rather will probably gain momentum. This suggests that the mounting problems of communications policy will tend to become more complex in the future and emphasizes the need for the establishment of a solid framework of policy, soon, that will be capable of accommodating the requirements of the future.

In response to some of these problems, President Johnson in August of 1967 established a blue ribbon investigation group in the area of international telecommunications, under Undersecretary of State Eugene G. Rostow, to look into all aspects of international telecommunications and to develop recommendations for future policy. The group is known as the President's Task Force on Communications Policy. It includes fourteen distinguished Americans, public officials who have an interest in communications. The Task Force has been working for approximately one year. It is expected that the final report of the Task Force which will reflect its recommendations for action will be rendered in the latter part of 1968.

Another significant recent government undertaking has been the "computer inquiry," which has been underway for approxi-
mately two years and which is being conducted by the Common Car-
rier Bureau of the FCC's staff. In a recent paper, Bernard
Strassburg, Chief of the Common Carrier Bureau of the FCC, summed
up the reasons for the inquiry in his conclusion. He said:

These, in summary, are some of the issues that have
at their base a persistent driving technology—a tech­
nology that has blurred a once comfortable distinction
between communication and data processing; a technology
that is altering institutional structures and conventions;
a technology that is putting to the test of contemporary
reasonableness long-standing carrier and commission
policies and practices; but above all, a technology with
unmatched potential for social and economic betterment.

Communications satellites, which are really specialized
forms of microwave stations, have added still another dimension to
communications development. They are providing an alternative mode
of international communications and, because of the number of
channels they provide, they make possible the transmission not only
of voice, but radio and television signals. The future development
of satellites and cable technology gives promise of abundant
 economical international communications. Satellites, of course,
will find a place in the domestic communications picture.

With respect to the several cases and proceedings which are
currently in process, we have previously discussed in detail the

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The formal title of the project is: "The Inquiry into the
Regulatory and Policy Problems Presented by the Interdependence of
Computer and Communication Services and Facilities," Docket Number
16979.

B. Strassburg, "Communications and Computers: How Shall
the Twain Meet?", Public Utilities Fortnightly, (September 12, 1968).
interstate rate case and its significance. Of equal significance is the Carterphone Case and the Microwave Communications Incorporated Case, which involve the principles of Bell System control over attachments to the Bell network, nationwide rate uniformity, and the quality of messages transmitted over the telecommunications network. The question of attachments on a broad basis gets into interfacing the Bell network with all types of input and output systems, including not only telephone sets but more complex attachments, such as computer systems, microwave systems, private communications networks, and private branch exchanges.

The substance of the preceding paragraphs reflects the aura of uncertainty that overhangs many aspects of the telecommunications business. For the purposes of the study, this uncertainty becomes part of the environment in which Western Electric operates and must have some influence on the operations of the Company.

**Summary of government and indirect regulation**

This chapter has been concerned with governmental and regulatory influences that impact on the performance of Western Electric. The main elements of public policy with respect to market and efficiency objectives have been identified, so that consideration could be given to how Western Electric measures up
to these standards, even though it is integrated in a public utility. Beyond this, the study considered the history of the development of regulatory examination of the operations of Western Electric. The continuing interest in Western Electric's prices and profits as they enter the Telephone Company's rate base has been noted, as well as the impact of the consent decree, and the overhanging concerns of the Interstate rate case with its implications for Western Electric.

The question of public and governmental considerations with respect to sheer size, the "bigness" of the firm, have been alluded to. This study has briefly identified some of the major problems in the communications area that require updating and expansion of government policy to provide a framework that will encourage orderly growth and efficient operation in the future. Not only has technology and innovation created problems for government policy, but the advance of technology creates new spurs to Western Electric to maintain its position among the technological leaders of industry.

All of this bears on the environment in which the Western Electric job is done. The research has previously studied the data on productivity and innovative performance. As it continues to evaluate the data and search for the factors that underlie and explain performance, it should be recognized that the environmental factors identified in this chapter are part of the performance
story. They enter into the motivations, incentives, and objectives that surround the job.

When the question is asked about why Western Electric performs as it does and this is related to the considerations of this research, Western Electric is found in a crossfire between the Bell Telephone Laboratories on one side and the Telephone Companies on the other. The BTL, with its commitment to the highest technological standards, is constantly developing new products and improving and changing older ones. The Telephone Companies are constantly clamoring for high quality, more useful products at a low price, and immediately, as they need them in order to satisfy their customers and discharge their responsibility as regulated utilities. In this position of stress, between the designer and customer, Western Electric must do its productive job effectively, and with sufficient flexibility to adjust to and make use of the rapidly advancing technology.

Now, if one adds to this the increasing weight of government surveillance which comes through both regulation and increasing government concern with bigness, and if beyond this adds the growing spur of rapid technological change, one can begin to appreciate the real pressures on the firm and the factors which undergird its performance.

The production environment is characterized by overtones of urgency and pressure which develop from the factors discussed
above. On a short term basis, the pressure builds out of the demands of the Telephone Companies for deliveries on extremely short schedules and a continuing stream of design changes that flow on a daily basis from the BTL and Western Electric's own process engineers and which must be incorporated in the ongoing production process. The longer term pressures, which add to and build upon the short run stresses, are those of the need to respond to government and regulatory pressures by continued outstanding performance in productivity and prices and by major new product innovation that will achieve a good performance rating in this regard from both the Telephone Companies and the regulatory commissions.

The products continue to become more complex. The technology continues to be more complicated. The undiversified customer continues to be extremely demanding in order to meet his expanding communications needs. The uncertainty of new government policies and practices is ever present. There is uncertainty about the future in many respects.

These factors tend to add to the total picture of Western Electric. Committed to the Bell System and no other alternatives, the encouragement to action is inevitable. Western Electric must perform because it has no other alternatives. It must respond quickly to survive, and it must find its outlets in service to
the Bell System as part of the systems concept in which each of
the members must subordinate any individual objectives to the
goals of the total enterprise for the benefit of the telecommunications user.

The key to the performance which was documented in Chapters III, IV, and V may be found in these considerations.
CHAPTER VII

EVALUATION AND ANALYSIS OF RESEARCH DATA

The preceding chapters of this study have presented data on productivity and innovative performance, the structure and relationships of the Western Electric to its integrated affiliates, and the environment in which the Company operates. This chapter is concerned with an evaluation of the data to identify its significance, and with considerations of how the data can be interpreted from the standpoint of performance and value to the economy. In the final analysis, the test of performance is the utility of the goods and services provided, and the cost relative to other costs.

Productivity and prices

Chapter III examined in detail the data on Western Electric's productivity and prices. It was found that by cost control, cost reduction, and managerial efficiencies, Western Electric was able to achieve high productivity and prices lower than any of the general trade manufacturers for comparable products. The data indicated, too, that Western Electric was able to offset and compensate for the increases it had to accept in purchasing raw material and components, and in meeting an ever higher labor bill.

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The most significant aspects of productivity and price performance are as follows:

1. The average annual improvement in total factor productivity during the period 1948-1967 has been 5.4 percent or about one and one half times the annual improvement for the electrical machinery industry, and over two times that of the private domestic economy and the total manufacturing sector.¹

2. Approximately sixty per cent of this improvement in productivity has gone to labor in the form of higher wages. The remainder has gone to: (1) suppliers in the form of higher raw material and component prices, and (2) the Telephone Companies as lower prices for Western Electric products,

3. The formal engineering cost reduction program for the one year, 1967, yielded first-year direct savings in production of $40 million.² Each year's savings are added to the savings of earlier years so that in any current year the economies derived from the cost reduction program are far greater than the amount of the cases made effective in that year. In 1967, for example, the one-year effect of the engineering cost reductions introduced during the preceding

¹ Using the total factor productivity method of Dr. Kendrick outlined in Chapter III.

² For details, see Chapter III.
ten years was about $240 million, or more than ten per cent of the total value of manufactured output.

4. During the period January 1950 to July 1968, Western Electric's prices for its total manufactures were down 5 per cent while its wage rates increased 120 per cent, and purchased material costs increased by 50 per cent.

5. During this same period, Western Electric's prices for the apparatus and equipment portion of its manufactures decreased by 11 per cent as compared with an increase of 54 per cent in the Bureau of Labor Statistics index for electrical equipment prices, generally.

6. In this same period, its prices for cable and wire increased by 19 per cent as compared to a 98 per cent increase in the BLS index for cable and wire.

7. Prices for its manufactured products are, on the average, about 60 per cent of those available elsewhere.

8. In checking against a comparable large electrical equipment manufacturer, Western Electric's prices were down 14 per cent while the level of General Electric's prices were up 13 per cent in the period 1950-65 after which General Electric's price information is no longer available.
Profits

An evaluation of productivity, costs, and prices must be accompanied by a review of profits to provide the full picture, and reflect information on what the producer does with the values that develop out of high productivity and low costs. Some of the key Western Electric profit data follows:

1. Return on investment on Bell business during the 1946-1967 period has averaged 9.3 per cent compared with 12.3 per cent for the 50 largest manufacturers in the economy.

2. Profit per dollar of sales has averaged 4.7¢ compared to 6.1¢ for the 50 largest manufacturers.

3. Western Electric's rate of return on invested equity capital in 1967 ranked 341st on Fortune magazine's list of the 500 largest United States industrial corporations.3

4. Western Electric contributes less than 10 per cent of AT&T's total earnings.

Innovation

Some measure of the attention devoted to innovation by Western Electric is reflected by the size of the research and development expenditure. In 1967 Western Electric funded over $200 million for development and related engineering. This includes that part of Bell Telephone Laboratories' research, development and design that is related to new and improved products that will

be manufactured or purchased by Western Electric. The data presented in Chapter III demonstrated that Western Electric's expenditures for research and development exceeded those of other industries. These figures exclude research and development on government work, as well as the basic research and related activities funded directly by AT&T.

Some of the major systems and products that have resulted from this development and design activity, and which are now in production are tabulated below:\(^4\)

**In carrier transmission.**—New short haul carrier systems since 1950 include the N1, ON1, ON/K, N2, N3 and the T1 digital system. The T2 and other advanced digital systems are currently under development. In the long haul carrier field, the complex L3 and L4 coaxial systems have been introduced since 1953 and the L5 system is now under development.

**In microwave transmission.**—In the short haul microwave field, new systems since 1955 are TJ, TL-1, TL-2 and TM. In long haul microwave since 1955 new introductions have been interstitial TD-2, TH, TD-3, TD-2A, TD-2B and TH-3.

**In switching.**—New switching systems introduced since 1950 have been DDD (Direct Distance Dialing), CAMA (Centralized

Automatic Message Accounting, LAMA, Touchtone Calling, Centrex Service, ESS (Electronic Switching, both 2 wire and 4 wire), Custom Calling Services, the 1AI Concentrator, the TSP (Traffic Service Position), a wide range of new PBX's (756, 757, 758, the 800 Electronic and 101 Time Division Switching). ESS #2, TSPS, electronic appliques for crossbar and other advanced switching systems are now under development.

In station equipment.—Some of the new products since 1955 have been the Call Director Telephone, the Princess Telephone, Repertory Dialing, the Picturephone set (undergoing trial), and the Trimline Telephone. The Picturephone set and a new Electronic Telephone set are presently under development for production. Touchtone calling and the Picturephone development go far beyond the design of new station equipment and involve major additions to and changes in the network.

In cable and wire.—Since 1950 the major developments in cable and wire include PIC cable (polyethylene insulated), electro-formed wire, self-supporting cable, PVC (polyvinylchloride) central office cable, ready-access terminals, the B-wire connector, D-wire, and Unigage. The new Corax cable is now almost ready for production. During this same period there have been several generations of submarine cable; SA, SB, SD, SF transistorized, and TASI.
In data transmission - In addition to the digital systems that have been mentioned under Carrier Transmission, Dataphone service was introduced in 1958. Several hundred different data sets have been developed with a wide range of speeds, signal formats, and coupling and auxiliary features. Many new models are currently being introduced to cover still wider applications with substantially increased speeds.

This summary is only a scan over the multitude of new projects that have been introduced in recent years. The corporate records are replete with many other examples and, of course, numerous examples from earlier years, too. Two additional items that warrant mention are the extensive device and component developments that underlie the systems developments that have been mentioned, and also the Bell System work with space and satellites such as Echo and Telstar, which are extensions of microwave technology.

The names of the developments have been recorded as they are known in the telecommunications business recognizing that the jargon, in some instances, may not be clear to someone from another industry. But, probably more important than precise expression of the name of every project is the feeling of action and thrust that comes with the large number of major projects in each product area, all within a relatively recent time frame. If the dollar expenditure for engineering and development is considered together with the evidence of numerous systems projects, it appears that there is an
innovative thrust which makes its presence felt in all aspects of the business -- in the manufacturing area through planning for new processes, new methods, new machinery, and new skills for the new products and systems, as well as for the conception and design of new products.

Because of the requirements of the network, one of the constraints on new system design and manufacture is that all new systems must work with existing installations. The compatibility that must be achieved must further satisfy or upgrade standards of quality and reliability.

Some additional overall data that develop out of examination of Western Electric's performance on innovation are:

1. 43 per cent of Western Electric's 1966 sales consisted of products of new design since 1961. A recent National Industrial Conference Board survey of 223 manufacturers indicated that 20 per cent of their 1966 sales consisted of products that did not exist five years earlier.5

2. Western Electric estimates that 65 per cent of its 1970 sales will be made up of new products introduced during the 1960-70 period. During 1960, 35 per cent of sales were made up of products introduced during the 1950-60 period.

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3. During the period 1960-66, Western Electric spent 5.2 per cent of its annual sales on research and development. Similar comparative statistics are 2 per cent of sales for all manufacturing industries, and 3.5 per cent for the communications and electronic equipment industry excluding Western Electric. These data are developed on the basis of National Science Foundation studies using the Foundation's definitions of research and development.

4. Western Electric follows a broad patent licensing policy which makes licenses available, under Bell System patents, to all interested parties at reasonable non-discriminatory royalties, and royalty-free with respect to patents predating the "consent decree." This policy has made available to others, licenses for inventions underlying present day electronics such as the transistor and the sealed reed switch. In return, the Bell System gains access to inventions and technology that originates elsewhere, but which can be incorporated with advantage into telecommunications science.

Customer service

A manufacturer of durable goods for the industrial market must be concerned about two levels of service. It must be vitally interested in its immediate customer, who, in the case of Western Electric, is the Telephone Company. Beyond this, it must also be
interested in the customer's customers who in the Telephone Company's case is the telecommunications-using public who is the ultimate consumer and user of Western Electric's manufactured products. In the final analysis, Western Electric's reputation and future will depend on how good the telephone plant is and how well it serves the public.

In considering customer service in terms of the Telephone Company primary customer, Western Electric can quickly identify a battery of factors that will be extremely important to the Telephone Company. The Telephone Company would like to have:

1. Excellent equipment at the lowest possible cost. A good price is important, but the thing that is really important to the Telephone Company is not so much first cost, as cost over the life of the equipment. This means that quality, reliability, and durability are extremely important.

2. Equipment and systems that will require minimum maintenance.

3. Equipment and systems that are as automatic as possible in operation to be economical in labor requirements, and that will be efficient to operate from a cost standpoint.

4. A flow of attractive and marketable new features and services that can be more useful to telecommunications subscribers, and will expand revenues.

5. Timely delivery whenever and wherever required.

If customer service is considered in terms of the ultimate consumer, it can quickly be established that he, too, has a set of
requirements that must be satisfied before he would acknowledge good performance. Some of the important things that the subscriber wants are the lowest possible bill from the Telephone Company, reliability and dependability in the operation of the equipment, the widest possible range of convenience and utility and, finally, an ever expanding choice of new features and services.

If Western Electric provides reliable, high-quality, low maintenance equipment at the lowest possible cost, on short delivery schedules, it will be satisfying the needs of both the Telephone Companies and the communications using public. If in addition to this, through innovation, it can furnish a continuing stream of newer, more useful products that will permit the Telephone Companies to minimize their unit labor costs, with constantly reducing equipment cost, with the potential for even less maintenance, and that will make it possible to provide new features and services to the public, then Western Electric will be functioning in a manner consistent with its and the Bell System's objectives.

In the final analysis, performance must be measured by how well the producer serves the market in terms of the utility, variety, quality, and cost of goods and services. These criteria are applicable in our study and the true test of Western Electric's productive and innovative performance is the range of values that have been studied in the research.
If one looks toward the ultimate consumer in the context of the values that may have been projected forward out of Western Electric's performance, one finds that there are evidences that the consumer is being given a widening choice of reasonably-priced offerings.

The following quotation from documents prepared by the AT&T Company for the President's Task Force on Communications Policy outlines the trend of telephone rates over the past thirty years.

Interstate telephone rates have come down steadily. Thirty years ago, the charge for a weekday, three-minute, coast-to-coast call was $6.50. Today the same call may be made for $1.75 weekdays and for $1.00 nights and weekends. In the aggregate, interstate rates are down by 24% from pre-World War II levels (1940-67), compared with a 142% increase in the cost of living, while average hourly earnings have gone up by 300%. In the past five years alone there have been major interstate rate reductions of $79 million in 1963, $159 million in 1965, $100 million in 1967, and $20 million in 1968. These reductions equate to even greater amounts at today's volumes of business.

Overall telephone rates (local and long distance) have gone up about 10% over pre-war levels, only a small fraction of the increase in the cost of living. At the same time, substantial service improvements have been introduced and the usefulness of the service has been greatly enhanced. Calling areas have been expanded, direct distance dialing has been introduced and the speed and quality of service improved. The hours of work by factory employees, required to pay for one month's local residence service with 100 local calls, has declined from six hours to less than two hours. The relative cost of telephone service in terms of the required
work hours in the 56 major cities of this country is substantially less than in other countries, with only Stockholm and Ottawa approaching the U. S. figures.6

The telephone subscriber gets more for his money today, not only in absolute dollars, but in terms of the range that his telephone commands, his access to many more stations, the quality of transmission, and the reliability which he may expect of his instrument and the network. Chart XXVI indicates how the 10 per cent increase in telephone rates over the past 25 years compares with the much greater general wholesale and retail price increases, and with the very substantial increases in manufacturing hourly earnings. It also shows that the purchase of telephone service is a good buy as compared with the trend of other costs and prices. Direct distance dialing, Touch-Tone calling, centrex services with in-dialing features, new PBX's, custom calling services, and the wide and growing range of instruments and customer premise attachments are making the service more useful to both residential and business customers, and are providing flexibility in the choice of service. Options for features such as abbreviated dialing, automatic dialing, card dialing and speakerphones, are providing variety, versatility, and convenience to the telephone subscriber.

TELEPHONE SERVICE PRICE CHANGE COMPARISON

Source: American Telephone and Telegraph Company
The choice of colors and telephone set styles has introduced a note of fashion and esthetics into telephone set selection. Increasing attention is being given to making sure that all the potentialities of the telephone are used in the interests of public security and safety. The new systems that will permit no-coin calling of the operator and the Dial 911 for emergency plan are examples of how the telephone network can be used to tie in with important unsatisfied community needs. The Picturephone development, which is presently in the product trial stages of development, appears to be an innovation which will have many important new, useful applications for both residential and business customers.

If one considers what Western Electric's performance has meant to the Telephone Companies, one finds that the productivity economies that have been conveyed to the Telephone Companies in the form of reduced prices, and the extensive roster of new systems and products that has been made available by the BTL-WE collaboration have served to provide the Telephone Companies with a telecommunication network that is versatile, flexible, and economical to operate, making possible the improvements that have been described for telephone subscribers.

Some of the specific new systems and products that have enabled the Telephone Companies to cope with operational cost problems and to provide new services are: direct distance dialing; automatic message accounting; automatic number identification;
person-to-person calling assists; new multiple message carrier and transmission systems; faster, higher capacity, lower maintenance switching systems such as Crossbar and #1 ESS with automatic trouble identification features; and many labor saving features such as quick connect terminals, B-wire connectors to reduce splicing effort, even-count PIC cable, and self-supporting cable.

The beneficial impact of these innovations and other similar developments together with the effects of Western Electric's price performance are reflected in the following two important Telephone Company operational factors which underlie the price and service performance of the Telephone Companies to their customers, the ultimate telephone consumer.

1. The average AT&T Long Lines book cost per circuit mile has been reduced from $150 in 1940 to about $20 today. Chart XXVII shows how the reduction has occurred over this time span.

2. The average annual improvement in total factor productivity in the telecommunications sector from 1948 to 1966 has been 3.8 per cent. This is considerably higher than the national average of 2.4 per cent per year for the private domestic economy over this same period of time.\(^7\)

INVESTMENT PER LONG DISTANCE CIRCUIT MILE

AT&T Long Lines Department

Source: American Telephone and Telegraph Company
At this point, it may be well to reflect on where the considerations have led. The research and the data have established on a rather solid basis that Western Electric is an efficient producer and that it has done a good job on productivity and innovation. Checks on customer service indicate that Western Electric's performance is finding its way forward in terms of values to both the Telephone Companies and the ultimate consumer, and is reflected in an expanding spectrum of systems, products, and services which appear to be attractive to the communications user. The question that still remains is why Western Electric performs as well as it does: and related to this the question of whether it performs as well as it does because of the integrated structure and other related factors.

Comparison of Bell System vertical integration with foreign telecommunication systems

A brief review of foreign telecommunications systems reveals a variety of structures with government ownership and operation or coordination being the most prevalent arrangement. The only structures similar to the U.S.-Bell System arrangement exists in part of Canada and in Sweden where the equipment manufacturers are integrated with the telephone company. Interestingly, these countries appear to have the best performance in terms of availability of telephones, quality of service, and real cost of service, and of all the systems are the ones that are closest to U.S. standards of
performance. It appears that, in this industry, the integration of the manufacturer and the institution that furnishes service to the public works out better than other types of arrangements.

Recently, the Select Committee of the British Parliament criticized the existing division of responsibility for research and development efforts between the British Post Office and its telephone equipment suppliers. The Select Committee emphasized the importance of associating research work as closely as possible with the operation of the equipment developed. It also commented:

They (the Committee) note the advantages obtained within the Bell System in America, where the research work of Bell Laboratories is closely coordinated with the production requirements of the Western Electric manufacturing company but where both are completely under the same ownership and control as the operating companies.

A major problem in foreign countries with respect to providing telecommunications service is the difficulty of obtaining required equipment on time. In Great Britain, for example, standard procurement intervals for complex switching equipment are between two and four times as long as comparable Western Electric order-fill intervals. And even with these longer intervals, suppliers tend to

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8 The World's Telephones, American Telephone and Telegraph, 1967; Arne Angerby, "Manufacturing Activities of the Swedish Telephone Administration During the Past 25 Years," Telle, Number 2, 1965.

be unreliable. British Postmaster General Edward Short recently pointed out that "1350 out of 1700 major contracts have fallen behind agreed delivery dates."\(^{10}\)

U. S. NEWS & WORLD REPORT in an article on the interstate rate case commented on the status of foreign communications:

At a time when a telephone investigation is making news in the United States, telephones abroad are making news for a different reason - delays, breakdowns, inadequate equipment. This report from 11 countries shows what foreign phone users put up with.\(^{11}\)

It appears that Bell System is significantly better in many respects to that available in almost all foreign countries, and charges on a real cost basis are lower. The tendency for the independent telephone companies in the United States to emulate the vertically integrated structure of the Bell System may be significant, too. The values of Western Electric's vertically integrated position within the Bell System seem to be confirmed by the experiences of foreign telecommunications systems.

The theory of competition

The advocates of "competition without compromise" are convinced that the only assurance for the most efficient allocation of resources, and the distribution of earnings in the best public in-

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\(^{10}\) Electronic Weekly (British: February 14, 1968).

terest comes from competition as pure as possible. They have a horror of monopoly, a fright for oligopoly, and a skepticism of any structure that involves government regulation as a substitute for competition.

This viewpoint looks at the Bell System and the Western Electric Company and is gravely concerned that Western Electric, in its affiliated position, may not perform as effectively as possible and lacks the disciplines and constraints of the competitive model. Some of the possible economic distortions that have been postulated are prices unresponsive to cost, discriminatory pricing abuses, restriction of output, controlled obsolescence of products and facilities, restriction of innovation and invention, and unfair conduct toward potential rivals.

The evidence of this research would seem to indicate that none of these concerns and allegations actually have merit. In fact, the research is revealing a vertically integrated, regulated enterprise, which because of a number of factors, seems to perform as well as the competitive ideal. The study has examined performance on productivity and price and has found that the record shows Western Electric to be more productive than the closest comparable manufacturers. Its prices are only 60 per cent of the lowest prices for similar items available elsewhere. Examination of profits and rate of return indicates reasonable profits which contribute to a set of favorable prices to the Telephone Company's customers. There
is absolutely no evidence of output restriction for purposes of controlling the market and establishing artificially inflated prices, nor evidence of high prices to discourage demand. The opposite appears to obtain, with Western Electric passing on to the customer the benefits of higher production, and extending every effort, frequently under difficult circumstances, to make what the Telephone Companies want, when they want it. This point was highlighted in the findings of the survey of the factories where the chief complaints were the unreasonable fluctuations and volatility of demand and order input, and the impact of innovation.

The study of innovative behavior reflects a record of a continuing, expanding stream of inventions, innovations, and new and improved products and processes. In fact, rather than resisting the impact of change and innovation, the WE/BTL team is adding to it, and accelerating it. This is evidenced in the increasing proportion of new products in Western Electric's sales, the many new and improved products and services made available to the Telephone Companies and subscribers, and beyond this, in the contributions to the broader American technological and economic scene, which have helped to create new businesses and even entire new industries.

It is possible to be critical of anything if one so wishes, and to argue that no matter what the demonstrated performance, it could or should be better. And it is true too, that arguments can be advanced that the values and results that have been identified
above are due to the integrated structure and the advantages of being a manufacturing affiliate of a natural monopoly, even if it is regulated. And as has been indicated previously, it is true that some of Western Electric's performance is due to the benefits that develop out of its integrated position within the Bell System. But the studies have gone sufficiently deep to demonstrate that a large part of the performance story goes far beyond the natural advantages of integration and must be due to motivational and behavioral incentives beyond those that are normally identified. In fact, the above-average performance of Western Electric suggests the kind of efficiency and progressive management that economists expect ideally from a perfectly structured market which is rarely, if ever, encountered in industrial practice.

The thread in the study that reveals the key to the puzzle is the one that identifies how Western Electric is integrated in the Bell System and the planned organizational structure which establishes a delicate and critical balance that results in the above-average performance that has been identified. The systems planning that structures Western Electric without a market arm toward the customer and without a product design organization to do the primary work on the product lines it will produce was not accidental, but was calculated and intended to permit intense manufacturing specialization, and to avoid distraction and dilution of purpose. Further, the direct linkage between the BTL product designer and
the AT&T customer by recognized channels, and the subordination of Western Electric's interests in Systems decisions on the development of new products and design improvements, delineates an unusual role for Western Electric.

Western Electric is stimulated to perform because it has no other alternatives and serves no other purposes than those of its AT&T parent and the associated Telephone Companies. There are no other strategies it can employ and no other distracting influences. Its goals are sharply focused. Further, there is a set of objectives that develops when an organization becomes intensely specialized and single-purposed to excel for no other reason than to demonstrate excellence. It springs out of the pressures and tensions and frustrations of not being able to generate offsetting and countervailing strategies and tactics that will absorb energy and neutralize pressures.

This then appears to be the unusual and somewhat startling key to Western Electric's performance. It is the unique, planned organizational structure within a framework that can be mistaken for the usual kind of vertical integration. This is a special kind of integration, planned to achieve superior results with a record that matches this purpose.

In a sense, the study might conclude that through this unique organization and the influences that develop out of it, the Bell System has managed to achieve the results which are postulated
as the benefits of competition but which are seldom accomplished in a real world of compromise and adjustment. It is ironic that a regulated public utility should have been able to organize in a way that achieves the competitive results that so-called competitive industry has difficulty in matching. If one conjectures about what might happen if Western Electric were separated from the Bell System, the other side of the situation can be seen, and some insights can be generated on what a so-called competitive structure might accomplish.

If Western Electric were separated from the Bell System, one might expect the following:

1. Production for the express benefit of the Bell Telephone Companies and its customers would be replaced by production for the long run maximization of the manufacturers' profit.

2. The standardization of equipment and systems design made possible by integration would become much more difficult.

3. The proliferation of designs encouraged by uncoordinated rivals would probably increase costs, delay innovation, and create serious compatibility and coordination problems.

4. The advantages of the productivity and price performance of Western Electric would be lost to the Bell System.
5. The Bell Telephone Laboratories would not be able to collaborate on research and development with competing manufacturers as it now does with Western Electric. Consequently, the rate of innovation would probably be slower and the time span required for the introduction of new equipment and systems would probably be lengthened.

6. Separating Western Electric and the BTL would result in the loss of cost avoidance and manufacturing economies which are now generated by the close liaison between the two companies.

7. The ability of the Bell System to respond rapidly to meet growth and change in service needs might be seriously impaired because unaffiliated suppliers could not be expected to be as subservient to System's interests as an integrated supplier.

These are some of the major postulated effects of the separation of Western Electric from the Bell System. While they are hypothetical, they serve to identify some of the penalties that might be anticipated if divestiture was arranged for any reason. The potential losses in efficiency and coordination serve to reaffirm the values of the integrated systems structure. These factors, together with Western Electric's proven record of performance, seem to suggest that, on balance, there are far more real losses that would be experienced than any gains that could be ex-
pected from an oligopolistically competitive situation, even under the most optimistic conditions.

The matter of potential extensions of what has been identified here as the real key to performance is left to Chapter VIII, the next and concluding chapter. It is interesting to note that monopoly with appropriate regulation and organizational structure can be extremely efficient, and in special cases can be more efficient than competition.
CHAPTER VIII

SUMMARY AND CONCLUSION

In Chapter I, several objectives were outlined as the major goals of this study. In this final section, it is appropriate to determine if the objectives have been satisfied and to identify any related significant findings.

The objectives of the research were:

1. To examine the vertical integration relationships between a manufacturing company and its utility parent, and compare these relationships with other vertically integrated structures;

2. To establish performance standards and evaluate the performance of Western Electric in the areas of productivity, innovation, and customer service;

3. To identify the impact of indirect government regulatory constraints on the integrated manufacturer;

4. To evaluate the behavior and performance of the integrated manufacturer as related to the national economic objectives of full employment, stability of prices, and national growth; and
5. To consider the validity of extending the findings and conclusions of this study to other business situations.

The first objective outlined above was the basis of the material in Chapter II, which dealt with vertically integrated structures in general industry, the Bell System's unusual vertically integrated structure, Western Electric's place in the Bell System, and how vertical integration in the Bell System compares with the vertical integration generally found in industry. The important points established by the study were: (1) the unusual relationship between Western Electric and the BTL, (2) the degree of subordination of Western Electric's interests to those of the Bell System, and (3) the "systems approach" and the power balance that exists among the integrated partners in the Bell System.

Chapter III, IV, and V dealt with Western Electric's performance in the areas of productivity, prices, innovation, and customer service. As has been pointed out previously, Western Electric's performance has been above average as compared with other manufacturing companies. Over the past twenty years, its productivity has been one and one-half times that of the rest of the electrical machinery industry, and twice that of the private domestic economy and the total manufacturing sector. Its prices average about 60 per cent of those of other manufacturers' comparable items. The rate of innovation is high, and a continuing stream of new products and design improvements is made available.
to Telephone Company customers at reasonable prices.

The third objective, dealing with the impact of indirect government regulatory constraints on the integrated manufacturer, was treated principally in Chapter VI. However, the influence of indirect regulation on Western Electric is pervasive and tends to be one of the important factors that guides corporate behavior. The impact of government surveillance is to further stimulate performance in all aspects of the business. As has been pointed out previously, from public statements, Bell System leaders understand the responsibilities that are inherent in a public utility arrangement and are mindful of the fact that they must continue to provide improving service to the public at reasonable costs. This philosophy pervades the Bell System, and is one of the reasons for the thrust toward continuous improvement, innovation, and greater productivity.

Objective four treats with how Western Electric's performance relates to the public interest and to the national economic objectives of full employment, stability of prices, and national growth. Although these questions have, as yet, not been dealt with directly, the basic ingredients for the answers are included in the earlier expositions on performance. The question of whether the type of unique vertical integration that has been studied in this research is in the best interest of the public can
no doubt be debated by those inclined to do so. But, it would seem that the record speaks for itself, and the results of the performance that develops out of this structure, which was delineated in the preceding chapter, should make a convincing case. The values, in terms of reliable, useful service and reasonable price that the public enjoys, would appear to be too valuable to abandon for experimentation with other untested theoretical systems that might not work and that could become an economic burden to the public. Consequently, it would seem valid to conclude that Western Electric's vertical integration in the Bell System seems to operate in the best interests of the public.

The questions regarding full employment, the stability of prices, and national growth are answered by the data on productivity, costs, and prices. Western Electric's above average performance, both on an absolute and on a trend basis, is in the direction of supporting price stability and helping to cope with inflation by offsetting the burgeoning cost of factor inputs through productivity improvements, and so holding the line on sales prices. The expanding sales level over the years with stable prices has contributed to national employment goals, both within the Company and through increasing purchases which create jobs at suppliers' establishments. Increasing productivity and increasing goods output certainly are consistent with national growth objectives.
As has been mentioned previously, despite Western Electric's Bell System affiliation—indeed, largely because of it—the detailed data that have been examined in this study suggest that its performance and behavior closely match what theoretical economists postulate as the norms for their competitive model, rather than what they describe as the possible result of monopoly situations. Western Electric seems to be motivated to serve the Bell System with reasonable prices, modest profits, high output, efficiency, and progressive innovation, rather than to be reaching for maximum profits.

The last objective refers to the validity of extending the findings of this study to other business situations. The results of the study suggest that some of the findings may have broader application, but discussion of this is deferred to later in this chapter.

The hypothesis stated in Chapter I was that the corporate incentives and performance derived from competition in the market place can also be provided by a combination of regulation, structural balance, and unusual management techniques in the situation where a durable goods producer is vertically integrated within a utility system.

The findings of the research support the hypothesis. Western Electric performs like a manufacturer in the competitive market place even though it is vertically integrated in the Bell
System. The key to its behavior is the unique "systems type" organizational structure which when combined with vertical integration achieves optimum specialization in each organizational element, and a power balance that stimulates and motivates each integrated unit to maximum performance. The "systems type" organization concentrates research, development, and product design in a separate and independent organization from the manufacturing line organization.

With the objectives satisfied and the hypothesis tested, there is still the matter of the significance of the research findings for business practice, and the question of broader application to other areas of industry. Consideration of this question indicates that the techniques identified in this study can be extended and can find worthwhile application in other areas. One way that this can develop involves application of the "systems type" of organizational structure as typified by the WE/BTL relationships described in detail in Chapter II. This concept could be used effectively in other large vertically integrated establishments. The research, development, and product design functions can be separated from their conventional places, usually as internal divisions of each unit in the integrated structure, and can be set up as a separate organizational entity with well-defined functional responsibilities, prerogatives, and authorities as a co-equal to the other corporate structural elements. Under
appropriate top level coordination and guidance this establishes a power balance which will tend to give effective, high-incentive performance similar to the results of the WE/BTL partnership.

It is interesting to conjecture if a vertically integrated structure, such as has been examined in this research, would help with achieving better efficiency and performance in the United States Post Office. The postal system seems to be slow to use the output of modern technology and engineering. There seems to be a substantial margin for improvement in the very things that have been explored in this study—cost control, productivity, innovation, and efficiency. Perhaps the application of the kind of structure that has been studied in this research would be helpful in achieving better results. Certainly, the addition of more technical capability to accelerate the pace of innovation could improve efficiency in similar fashion to what innovation has contributed to Bell System productivity.

Problems requiring additional research

One of the characteristics of research is that in the process of resolving one set of questions, the researcher inevitably encounters others that present challenges for future resolution. Such is the case now. Along the way, as the study has followed the path of the initial inquiry, several provocative questions have developed and are left for further study in the future. Some of the most challenging of these are:
1. What will be the impact of the report on President Johnson's Task Force on Communications Policy? The report is expected in the latter part of 1968. The Task Force charge was to review international communications, the 1962 Communications Satellite Act, the use of the frequency spectrum, and other broad-gauged matters of this kind. No doubt, the final report will call for significant action in the communications field. And beyond this, what will be the net effect of all the current, intensive government interests and activities in the communications area?

2. Under present economic conditions, are the concepts of market structure that underlie current antitrust policy valid? How can the apparent incompatibility of the government policy on industrial concentration and the values of economy of scale for encouraging innovation and greater productive efficiency be resolved? What is the optimum size firm, and what variables apply in what manner?

3. What is the present situation in foreign countries with respect to the characteristics that have been examined in detail in this study? What is the total factor productivity in foreign telecommunications plants? What is the relationship of manufacturers and the institutions that provide service to the
public? What is the technological and R&D situation? What are the comparable real costs of equipment and prices for service? What kind of standards of quality, service, and reliability prevail?

4. How does the telecommunications industry compare with other utilities such as electric power, gas transmission, and transportation in structure and performance? What are the similarities; the differences? How do these affect cost, innovation, productivity, reliability?

5. How effective is public utility regulation in achieving its objectives? What other kinds of regulation, other than those now employed, could be used with advantage? Can incentives for regulated companies be improved? What are the differences in regulatory methods and practices for the various regulated industries?

This tabulation of questions that have only been touched on in this study, or that are just beyond the field of interest of the objectives, is interesting for its content and range. It demonstrates the point made earlier, that research leads to more questions to be resolved. Certainly, from the above questions there appears to be margin for additional research in this area to provide more information and better understanding of many situations.
Closing statement

In concluding this study, it is appropriate to summarize the major findings. The most important conclusions are indicated in the following summary:

1. Western Electric achieves results similar to those postulated for the competitive model. Its performance is characterized by increasing productivity, excellent price and market performance, a good record of innovation, and sensitivity to the needs of its Telephone Company customers. It is responsive to its market. Improvements in productivity are passed along to its customers in the form of lower prices. There is no indication of excess profits, market restrictions, or controlled obsolescence.

2. This performance is due principally to three factors: (a) the vertically integrated, "systems organization," which permits specialization in the major functions of the enterprise, and establishes a power balance among the integrated organizations that stimulates performance; (b) the "systems approach," which demands that each organizational element subordinate its individual goals to those of the total enterprise; and (c) the effect of indirect government regulation,
which serves as an additional spur to performance in the best public interest.

3. Western Electric, though a relatively large company, is only a small part of the Bell System. Its assets represent 5 per cent of total Bell System assets. Its profits are less than 10 per cent of System earnings. Consequently, its interests always weigh as a relatively minor factor in total Bell System decisions.

4. Western Electric's record of innovative progressiveness is excellent. This is reflected both in the continuing stream of new products it brings to market, and in the scope of its process improvements, which contribute substantially to the productive performance.

5. Western Electric contributes to the economic and technical progress of society. The impact of the continuous flow of improved products and reasonable prices has been to facilitate the growth and universal availability of telecommunications services in the residence and business areas. Bell System inventions, such as the transistor and the negative feedback amplifier, have diffused broadly into industry and have led to the establishment of new industries.
This, then, is the finding of this study. A manufacturer vertically integrated within a regulated public utility system can and does perform in a manner expected only for the ideal behavior of firms in the competitive market place.
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* Includes Copper Line Wire from 1948 through 1957.

Source: Western Electric Company
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Sources: Western Electric Company and Bureau of Labor Statistics

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**APPENDIX II**
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(Annual Averages, 1948 - 1967)

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Source: Western Electric Company

APPENDIX III
TYPICAL COMPARISONS

PRICES IN EFFECT 10-1-68

500 SET

PRINCESS SET

CONNECTOR

STALPETH CABLE

RURAL WIRE

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MANUFACTURING DIVISION M.V. REPORT M-2 IS A-OPERATING RESULTS STATISTICS YEAR 1977

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**Expense Per $100 of Loading**

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**Objectives**

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## Western Electric Bell Sales vs. Bell System Operating Revenues
### Years 1925-1967

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Average of Annual Deviation* 17.2%
Z - Based on logarithmic trend fitted by method of least squares to annual data for 1925-1967
* - Without regard to direction of sign

Source: Western Electric Company

APPENDIX VI
### THE CPE- CUSTOMER PRODUCTION ESTIMATE

**MERRIMACK VALLEY - CARRIER & MICROWAVE EQUIPMENT**

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CUSTOMER PLANNING DIV.  
PROGRAM PLANNING ORG.  
FIGURES ARE Rounded WHERE APPROPRIATE  
FISCAL BASIS

DATE 10/7/66

PA = PREVIOUS ACCEPTANCE  
E = CURRENT ESTIMATE  
A = CURRENT ACCEPTANCE

APPENDIX VII
A single key item represents a wide spectrum of products with large variations in complexity, production inputs and manufacturing interval.

- Typical Key Item: BROAD BAND TERMINALS

LMX-1 BAY

1967 STANDARD
BULLETIN COST – $1,500

L 60 BAY

1967 STANDARD
BULLETIN COST – $12,700

L 1860 BAY

1967 STANDARD
BULLETIN COST – $27,300

APPENDIX VIII
A SINGLE KEY ITEM REPRESENTS A WIDE SPECTRUM OF PRODUCTS WITH LARGE VARIATIONS IN COMPLEXITY, PRODUCTION INPUTS AND MANUFACTURING INTERVAL.

- Typical Key Item: No. 5 CROSSBAR SWITCHING FRAMES

JUNCTOR GROUPING FRAME

LINE LINK FRAME

COMPLETING MARKER FRAME

1967 STANDARD BULLETIN COST – $450
1967 STANDARD BULLETIN COST – $2150
1967 STANDARD BULLETIN COST – $3450

APPENDIX IX
A single key item represents a wide spectrum of products with large variations in complexity, production inputs and manufacturing interval.

**Typical Key Item: No. 1 ELECTRONIC SWITCHING FRAMES**

- **TRUNK DISTRIBUTING FRAME**
  - 1967 STANDARD BULLETIN COST — $1,300

- **JUNCTOR SWITCH FRAME**
  - 1967 STANDARD BULLETIN COST — $6,600

- **CENTRAL CONTROL FRAME**
  - 1967 STANDARD BULLETIN COST — $21,000
COMPONENTS TOO, INCLUDE A WIDE SPECTRUM OF PRODUCTS WITH LARGE VARIATIONS IN COMPLEXITY, PRODUCTION INPUTS AND MANUFACTURING INTERVAL.

- ELECTRONIC CIRCUIT PACKAGES

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<td>BULLETIN COST – $35</td>
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APPENDIX XI


Articles


"Growing from Within May Pay Off Faster." Business Week, September, 1966, pp. 44-46.


Weintraub, Sidney. "Ratemaking and an Incentive Rate of Return." Public Utilities Fortnightly, April 25, 1968.


Reports


