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Mechanized Inventory Control for a Rubber Footwear Manufacturing Concern

BOSTON UNIVERSITY

College of Business Administration

THESIS

MECHANIZED INVENTORY CONTROL FOR A RUBBER FOOTWEAR MANUFACTURING CONCERN

(The B. F. Goodrich Footwear and Flooring Company)

(A Division of The B. F. Goodrich Company)

by

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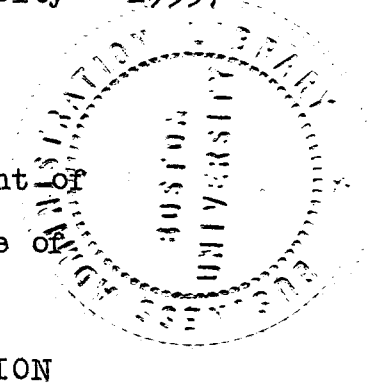

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INTRODUCTION

A. History of the Company

This thesis concerns an inventory control problem at the B.F. Goodrich Footwear and Flooring Company, a Division of the B.F. Goodrich Company of Akron, Ohio. The company was originally founded as the Hood Rubber Company in October, 1896, in Watertown, Massachusetts, as a producer of rubber footwear. At the end of 1896, production was approximately 3,000 pairs of footwear per day. Today, the factory has a capacity of 100,000 pairs of rubber and canvas footwear per day. In addition, the company now produces large quantities of flooring tile, industrial work gloves, hard rubber products, and coated materials. In 1929, Hood Rubber Company became a division of the B.F. Goodrich Company and it operates today under both names--B.F. Goodrich Footwear and Flooring Company and the Hood Rubber Company. The footwear produced today includes those made for the following usage:

1. Protective rubber footwear for all ages such as rubbers, rainboots and snowboots.
2. Heavy-duty footwear for farming, mining, hunting, and fishing.
3. Canvas, rubber-soled shoes for use in athletics and general sportswear.

4. Women's casual shoes for spring and summer styles.
5. Insulated winter boots for the Armed Forces sub-zero usage.

The Watertown plant is the second largest manufacturer of rubber and canvas footwear in the nation and is also one of the largest manufacturing plants in the Boston area, employing over 5,000 people. In addition to the Watertown plant, there is a small footwear plant in Greenville, Kentucky and footwear is also produced in Deerfield, Massachusetts. The company has a large finished goods warehouse located in Lawrence, Massachusetts and merchandise is also stocked at Watertown. In addition, the company has footwear sales offices located in fifteen major cities throughout the country which are Boston, New York, Philadelphia, Pittsburgh, Baltimore, Cleveland, Detroit, Chicago, Minneapolis, Atlanta, St. Louis, Dallas, Los Angeles, San Francisco, and Seattle. This gives the company complete sales coverage of the United States and also sales are made to outlets located in foreign countries. Aside from the footwear operations, the company has several flooring sales offices and warehouses located in strategic locations throughout the country to aid in marketing their flooring products.

B. Statement of the Problem

As of 1954, the B.F. Goodrich Footwear and Flooring Company had been exploring for over ten years the possibility of trying to mechanize many of their order, production, and inventory operations. To that date, the attempts had been rather unsuccessful. A list of the avenues of mechanization which had been examined during these years is not necessary; it is simply necessary to realize that a workable solution had not been found during these ten years. Therefore, in March of 1954, an outside engineering consulting firm was employed to make a survey of the present procedures and to submit a report showing recommendations for improving and mechanizing the above-mentioned operations. The real purpose was to improve the merchandising function through improvement of the order, production, and inventory operations. The previous system of inventory control and its inadequacies is discussed in detail in Chapter II.

Within a month, the consultant submitted a brief report of his findings and an appraisal of the benefits which would be obtained by mechanization of many of the manual operations found in the order, production, and inventory functions. Functional charts were developed in this study and discussed with representatives, both management and employee, of the B.F. Goodrich Footwear and Flooring Company. The proposed system was to be developed around one key piece of equipment--an electronic data

processing machine which would allow, among other things, continuous processing and storage of inventory data. It was decided to go ahead with the recommendation of the consultant and to accept proposals from various manufacturers of data processing machines. Also, proposals were to be accepted for regular supplementary tabulating machines. The consultant was to be retained throughout the selection process to aid in the evaluation of the proposals received for the one principal unit--a special purpose electronic computer. Also, a study group was chosen to work with the consultant.

C. Scope of this Thesis

This thesis is intended to cover the following aspects:

1. Recognizance of a management problem in inventory control.
2. Adaptation of mechanized methods to solve this problem.
3. The problems involved in this adaptation.
4. The costs and savings resulting from this adaptation.
5. The capabilities of the principal unit of mechanization--a special purpose electronic computer.

Since this special purpose electronic computer and the mechanized inventory control system discussed here have been in operation for less than a year, as of the inception of this thesis project, it will not be possible to render a clear-cut conclusion as to how much value this system has been or is going to be to the company. The results are only beginning to take effect. The future will hold the answer to those questions concerning efficiency, value, and adaptability. This study will recognize the trend to mechanization of accounting methods and the steps which this particular company has taken to be up-to-date in this age of mechanized electronic accounting. The company realizes that it is not enough to be able to produce and get orders for their quality footwear--they must also be able to deliver the items when desired by the customer and maintain adequate control over their inventories. It is for the improvement and control of merchandising that this new inventory mechanization system was developed. This thesis, therefore, is based on that phase. Its scope will not cover the intricate mechanisms of electronics as would be found in an engineering thesis. However, the various component units which make up the special purpose computer will be defined and explained. Tabulating machines have been mentioned, but not in any detail, since this study is based mainly on the special purpose computer.

D. Selection of Proper Type of Mechanization

Before proceeding into the body of the thesis, a few words must be written on the importance of the use of caution in the selection of the type of mechanization to be used. This one factor is of extreme importance in the purchase of any type of machinery. In the hasty change-over from manual to mechanized accounting, careful treading sometimes is discarded in favor of speed.

This one factor of caution was stressed to me by men with whom I have talked concerning the use of mechanized methods. These men had the wisdom to foresee into the future. They were not satisfied to choose a method and then see how it worked out. They wanted to be sure they had a workable method and they did not hesitate to question all phases of the selection process. Our management knew that even though they must solve their inventory problems through the use of electronic equipment, haste in solving their problem might hinder the selection of the best type of electronic equipment.

There should be no way of escaping the simple fact that electronic equipment is expensive. In the long run, costs of maintaining records and speed of receiving these records will be the results. During the years before these savings take effect, the costs are higher whether 1) there is an initial outlay for the purchase of the machines plus additional outlays through the years for maintenance and

repair, or 2) the machines are taken on a rental basis which would mean fixed rental payments for the life of the contract.

Even though the simple fact of costs is apparently obvious, some companies have jumped into the buying of electronic accounting machinery without due thought. They knew that they must have some system of electronic accounting but they failed to proceed cautiously in their selection. Consequently, within a few years the costs have been exorbitant as compared to the value of the results or the system is outdated as the future needs of the company were not anticipated.

> "In brief, the problem that faces company management, after they first become interested in electronic data processing, is to investigate and then to select a course of action. Should the company install electronic data processing or should it not? What will the costs be and what will the savings be? What risks will be involved? What equipment should be chosen? Should the equipment be rented or purchased? All of these factors and others enter into the selection of a course of action."*

* 4, P.29

With this viewpoint of caution in mind, it is not difficult to appreciate why management should proceed slowly in their changeover to mechanization. Before they would commit themselves, they must be satisfied as to the following points:

1. Mechanization is necessary.
2. Mechanization will provide the desired results and will also reduce the cost of inventory control.
3. The machine to be used must be adaptable to the needs of their system.
4. Future requirements of the system have been anticipated with the adaptability of the electronic machine in mind.

In the case of the B.F. Goodrich Footwear and Flooring Company, a study group was formed and they proceeded cautiously, step-by-step, through the entire selection process. They did not hesitate to make issue or raise questions when some phase was vague or not suited to their requirements. This was fortunate as it would have been easy to have let some issues pass by without clarification and without adhering to the rigid specifications which were necessary to obtain the best mechanized system possible.

E. A Word About Electronic Data Processing

Since the field of electronic data processing is so new, many businessmen have only a faint conception of the value and scope of this type of processing. Only a few businessmen, outside of those whose job it was to learn more about this new trend, showed genuine interest in this phase. At first I wondered exactly how electronic data processing worked but I never did anything more than wonder about it. So many of us were of the mistaken impression that you had to know electronics to be able to understand this new system. Now, many of us know we were wrong in our beliefs concerning data processing. How did data processing come to be?

> "The field of electronic data processing has grown rapidly. It had its beginning, from a practical point of view, in 1946 when the first electronic digital computer was completed; a complete history of the field, however, would go back to the early ideas of Babbage# in the nineteenth century.

Charles Babbage, professor of Mathematics at Cambridge, became interested in the construction of a calculating machine. His idea was to produce a mechanism to reproduce memory and foresight and to eliminate as much of the drudgery of calculation as possible.

The electronic digital computer completed in 1946 was designed to solve certain types of ballistics problems, and the machines that followed it in the next few years were also designed for mathematical and engineering applications. Around 1949, however, the designers of these computers began to see how they might be used in the business world for performing clerical operations. By 1953 electronic data processing for business and industry was a reality with the first few installations in and working. The year 1954 saw the rapid growth of interest among businessmen in the use of these machines; many saw their potential benefits and decided to become informed on the subject. And there were enough pioneers--men who decided to take a chance and order some equipment--to consume the complete output from at least one leading manufacturer for several years." *

* 4, p.2

Now, what is electronic data processing? Very briefly defined, it is the use of electronic computers and data processing machines to give aid in the following business operations:

1. Lower-level management decision-making.
2. Issuing the necessary paperwork to instruct the organization in accordance with these decisions.
3. Measuring the actual progress and feeding it back for management control.*

The one factor about electronic data processing that is the easiest to understand is the speed. People realize that the work is processed in a much shorter period of time. Now, ask yourself, do you have any idea of how much speedier electronic processing is? The following paragraph will give an example of what speed means.

> "The full impact of electronic speed was felt most quickly in the large scientific calculator. Some idea of the productive speed can be obtained by considering the multiplication of two large numbers, say 10-digit numbers, to form their product. If one were to form a thousand such products, the time required by various methods would be roughly as follows:"**

* 4, p.4
** 3, p.2

By hand with pencil and paper	1 week
With the aid of a key-controlled mechanical desk calculator	1 day
By electro-mechanical calculator with automatic reading and writing	1 hour
By small electronic calculator	1 minute
By electronic super calculator	1 second

Of course, we are interested in much more than multiplication calculations and we would never expect to speed up operations, such as inventory control, to that degree. However, it does give you some idea of the speed involved which can be adapted to practically any office procedure should management desire.

I. THE SYSTEM OF INVENTORY CONTROL BEFORE MECHANIZATION

A. The Manual System of Inventory Control in Operation

The system of inventory control was strictly manual--tedious and time-consuming. It was similar to many other inventory control systems. It was a product of development through the years of several variations within the system. However, it had been in operation for years with little actual change to the original system.

It will be necessary to give only a very brief description of the manual system. The system incorporated a stock book which was maintained to show running stock balances of each item by each style and each size. Several times each year certain segments of stock were physically inventoried and the stock books adjusted accordingly. Additions to inventory were made from case checks which were attached to every case of footwear when they were packed into cartons. These case checks were removed when received at the finished goods warehouse and then delivered to the inventory office daily. They were sorted by items and size with the quantities of each size totaled. After this procedure, these totals were then added to the

existing balances in the stock book. Stock balances were then reduced by the shipments which were determined by means of a procedure known as the releasing operation. A separate release clerk kept track of all items released for shipment. These shipments were totaled by item and size and then the totals were subtracted from the balance of their respective page in the stock book. This was the manual operation by which the clerks maintained the running inventory stock balances. The task was made difficult by the existance of approximately 2,700 different styles with an average of ten sizes for every style. It is fairly easy to see how this operation would be time-consuming and difficult to keep up-to-date under the manual system.

B. Inadequacies in the Manual System

As mentioned previously, the manual system was tedious and time-consuming. Also it was found to be ineffective in many ways. By ineffective is meant that, although the work was done every month, the time it took to perform the work and the manner in which it was performed were not satisfactory to management. General dissatisfaction with the manual system was shown by the seven areas listed below. Although improvements and benefits should be derived from these seven areas after mechanization, it must

be remembered that improvement and control of the merchandising and production planning were the important benefits which were to be derived from any mechanization of the system.

1. Report of stock status

A stock status report was issued monthly to show the inventory status of any particular style of footwear produced. This report, under the manual inventory system, took approximately three weeks to be compiled and issued. This excessive time period meant that the control of factory output was not close enough to the sales requirements. There was an evident deficiency in meeting the current sales requirements. Also obsolescence in inventory was a constant hazard since production schedules were not tied in closely enough to sales needs; any particular style might be overproduced before statistics on sales could point out this fact. Under a proposed system of mechanization, the inventory status of any particular style is much more readily available. The stock status report could be issued at any time and would be less than a day behind the actual inventory. This means that, at any time, a stock status report could be issued within one day's time. Inventory requirements to coordinate with sales needs would be more readily available, and obsolescence would be much less of a hazard since excess inventory over requirements for

sales for any particular style would be ascertained much earlier than under the manual system of inventory control. Under the mechanization system of inventory control, production and inventory would coordinate much closer with sales. The poor selling ability of a particular item would show up in the excess inventory after a month had gone by. Production on this item would be curtailed until sales were increasing enough so that additional production would be warranted.

2. Cut-off of order releases

At the end of each month when the books were closed to determine the inventory status, all releasing of orders to the warehouse were automatically cut off for four days. This meant that the order pickers at the warehouse whose job it is to fill orders released for shipment were assigned to other duties while awaiting the releasing of the orders. Then when the orders were released for shipment, the order pickers were rushed to catch up on any backlog which may have piled up during the cut-off period. These uneven work loads were unfortunate but inevitable under the manual system. As a result of the efficiency and speed of the mechanized system, order releases would not be cut off at the end of the month. The inventory status would be determined without the need to delay the releasing of orders for shipments.

3. Releasing by line items

Many orders were not filled in their entirety. They were subject to partial releasing and back-ordering which became a fairly common occurance. When the inventory was posted manually, book shortages often occurred in the releasing of orders. Although the inventory may have been physically in the warehouse, the books had not reflected the increases. Therefore, many orders were released by line items which was any style listed on an order. Unfavorable results of this partial releasing were:

1. Increased paper work became involved and burdensome.
2. Fewer pairs were shipped on an average order.
3. More shipments meant shipping, billing, accounting, and other related costs were high.

With the practically instantaneous knowledge of inventory status, stock availability can be a known factor and all orders could be released for which the stock is available. The up-to-date inventory figures would result in much fewer deficiencies in any particular style. Partial releases would be greatly reduced with more pairs being shipped per order than previously. Obviously, this would reduce the overall cost of billing, shipping, and other functions. It is not meant to give the impression that all orders

under the new system would be released in their entirety and that partial releases would be rare. Partial releases would still be necessary although their frequency would be diminished and as production is coordinated more closely with sales, the partial releases would be reduced more.

4. Delay of warehouse receipts

Merchandise received at the warehouse from the factory remained idle for approximately five days before it could be used to fill shipments. This happened because of the time period, usually a week, necessary to complete the inventory stock book postings. In times of rush and low inventory, the warehouse situation became distressing. Customer service and relations, two most important items, were hindered in these times. With the up-to-date inventory records, it would be possible to use merchandise for shipments the day following its receipt at the warehouse. Release of stock for shipments the day following its receipt, would greatly improve customer service and relations in times of low inventory and during rush seasons. Also inventory would show a much greater turnover.

5. Releasing by geographical location

Merchandise was held at the warehouse prior to shipment pending an accumulation of a carload of stock awaiting shipment to some specific geographical location.

Sometimes release of carloads for shipment were slow as orders were not released in their entirety but instead were released by separate line items (a particular type and style of footwear) for each order. This slow releasing was due fundamentally to the inability to keep record postings of available stock-on-hand up-to-date. With the practically instantaneous access to up-to-date inventory availability as is normal under a mechanized system of inventory control, many more orders could be released in their entirety and not by line item. Consequently, geographical groupings for carloading would be accumulated much faster and the orders would be on their way to the customers with considerably less delay.

6. Improvement of merchandising control

Merchandising control is one of the main benefits which would be received from any changeover to mechanized methods. For in merchandising control, timing is a most important factor. When the facts and figures to be used are constantly late, even experts in merchandising are very limited in their scope. Under the manual system of inventory control, accurate sales and inventory figures were available but usually so late that they lost their important timely significance. Trends in sales and inventory were recognized but not in time to do the most good in correcting inventory conditions. Under an adequate mechanized system of inventory control, the necessary inventory figures would be

available much earlier. They could be more closely watched so as to detect more easily and earlier the overages and shortages in inventory which are due to the shifts in sales trends. The need to coordinate production with these sales changes would be recognized and production, which is easily changeable, would be scheduled as needed to coordinate more closely with sales and current inventory in order to maintain adequate stocks of the right styles and sizes. When merchandise control data is late, overages and shortages in particular styles will be the result. Overages will lead to losses due to obsolescence and shortages will lead to delays in service which will automatically strain relations with the customers. As there is so much competition in the footwear industry, customer relations must be maintained in the best possible way. Failure to supply a customer with the requested footwear at the desired time could easily result in the loss of that customer to one of their competitors of which there are many in the footwear industry. Therefore, it can be seen that the merchandising function is extremely important and improvements in this area should come about as a result of mechanization.

7. Scheduling of footwear production

Tied in with the merchandising control factor is the production of the footwear. Production can fluctuate quite a bit causing layoffs in some parts of the year and

additional hiring at other times of the year. When merchandise and inventory control data are late, then production is more apt to fluctuate throughout the year resulting in sporadic layoffs. With adequate inventory and sales figures available, production can be geared in a better manner to merchandising requirements. Factory production facilities can be utilized in an even flow of workload throughout the entire year to reduce the peaks and valleys of past production. This is done through adequate planning and scheduling of the production facilities available.

C. Benefits Expected from Mechanized System

In summarizing the benefits which are hoped to be the result of mechanization of the inventory control functions, it must be remembered that proper coordination of the three functions of inventory, merchandising and production under favorable business conditions can do a great deal towards improving the business picture. Some of the main results will be the following:

1. Improved customer service - By having such control of the above three functions that merchandise is usually available in the style and size desired and shipments are made promptly, your customers learn they can depend on you and want to do business

with you. Improved customer service frequently will lead to increased sales. Of course, the price level of your products and other business factors play an important role in this entire picture.

2. Increased merchandise turnover and reduced obsolescences - By having adequate, yet not excessive, inventories, the available storage space is used to best advantage.
3. Reduced costs - This is found in so many phases of the operation of the company:
   a. Production - Even workloads will reduce overtime pay, separation payments in lay-off periods, and additional cost of training new workers in busy periods.
   b. Inventory - Decreased obsolescences will produce fewer losses and more stable inventories will reduce warehouse costs. Also, capital investments in inventories will be reduced.
   c. Labor - Perhaps not immediately, but within a short period of time, overall cost of the order and inventory functions will be reduced by the changeover from manual to mechanized methods.
   d. Shipping - Entire orders will be released

at a time for geographical grouping to cut down delays and reduce costs.

4. Time saved - Not only is manual labor reduced a great deal but the time taken to make up and issue reports is also reduced through the use of mechanized methods. The mechanized components are so efficient that the necessary information and reports will be available to management much earlier. This results in the making of decisions for merchandising and production planning easier, earlier, and more accurately.

II. DESIRE OF MANAGEMENT: MECHANIZATION OF INVENTORY, ORDER, AND RELEASING FUNCTIONS

A. Specific Requirements for Management

Management stated several functions which any proposed system must be able to accomplish or else the system would not be accepted. If a system involving the use of electronic data processing could produce the required results, then it probably would be acceptable providing, of course, other factors such as costs were acceptable.

1. Maintain accurate and up-to-date Watertown inventory figures.

Fundamentally, management wanted to maintain an accurate and continuing description of a variety of footwear styles which would be consistently up-to-date. This should be maintained so that daily figures could be obtained regarding:

Physical inventories in Watertown warehouse.

Committed orders for future shipments.

2. Provide for release of committed orders.

Sometimes the releasing of committed orders at the warehouse fell a little behind the scheduled shipping date. This procedure was to be improved by:

Modifying the inventory and committed order data.

Preparing shipping, billing, and releasing instructions for the warehouse.

3. Present differences between inventories and committed orders.

It was difficult under a manual system of inventory record keeping to present up-to-date information on the numerical differences between the quantities on hand and the committed orders by size for any or all styles. Management wanted to have this information available when required and also to be able to produce it on demand.

4. Produce durable records of all transactions.

Durable records of all individual and routine transactions passing through the inventory system must be maintained and be available for the purpose of:

Verifying the accuracy of all clerical activity.

Preparing punched card summaries of all transactions for subsequent data analysis such as used in the production forecast function.

5. Provide for volumes of activity.

It was found necessary that in any new system of inventory control there must be provision for certain definite volumes of activity as follows:

Warehouse acquisitions	- 6,000 line entries per day
Orders received	- 3,000 line entries per day
Orders released	- 3,000 line entries per day

A line entry is a particular style listed on an order. There would be a separate line entry for every different style and size combination.

In a proposed changeover from manual to mechanized methods, it would be necessary to make adequate provision for the above five factors. Without provision for all five of the above, the system would not accomplish what management specifically wanted it to do.

B. Definite Capacity for Storage

It was determined that the storage capacity of the computer to be used must be adequate enough to handle the following four requirements. Any storage capacity not able to accommodate these four needs would not be satisfactory.

1. Number of styles.

The computer definitely must be able to accommodate approximately 3,000 separate styles. A style is characterized by a single combination of description, color, last, width, and gender and each style will be represented by a code number.

2. Range of sizes.

The range of footwear produced extends over 28 numerical sizes from 1 to 15 including half-sizes for every size except 14 and 15. Any one style may include as many as 17 sizes. The average style is represented as containing 10 sizes. Hence the capacity of total storage must provide for 3,000 styles times 10 sizes or approximately 30,000 style-size combinations for finished goods inventory and approximately 30,000 combinations for unfilled orders making a total of approximately 60,000.

3. Pairs in inventory.

Individual inventories of each style-size combination must be maintained. The computer must be able to register up to 9,999 pairs of any combination as the inventories, meaning pairs on hand, may vary from zero to 9,999 pairs. Total inventory of all the sizes in any particular style may run into, but not exceed, five decimal digits.

4. Pairs in unfilled orders.

The total quantity of unfilled orders must be maintained for each style-size combination. The quantities may range from zero to 9,999. As in the inventories above, the total of committed orders for any style may extend to, but not exceed, five digits. Deductions from unfilled orders in storage must be limited to any three digit number.

C. Normal Operations to be Handled

There were three basic procedures which would have to be converted from manual to mechanized methods. Their conversion to an electronic system would greatly speed up the time necessary to process the figures and to make up the necessary reports.

1. Warehouse acquisitions.

Receipt of footwear from factory is determined by examination of slips bearing style number, size, and quantity data. These numerical items should be recorded on punched tape by clerical personnel for subsequent verification and transmittal at hourly intervals to the central storing equipment. Typical daily activity may involve 5,000-6,000 line entries which have to be reported.

2. Order receipts.

In an auditing process prior to clerical action on processing of orders received, the style descriptions will be translated into the appropriate code numbers and manually included on the standard order form. The order receiving clerk will make a typed copy of each order, filing it for future reference such as shipping instructions to the warehouse. At the same time a punched tape or equivalent record must be prepared for verifying purposes and later conversion to perforated card form. Specified quantities in each order are to be added to corresponding accumulations of orders received for each style-size combination.

3. Order releases.

Release operations will be performed by reference to the typewritten copy of the orders filed by the order clerk. Operator action shall normally result in decreasing the inventory and the count of committed orders by an amount equal to the quantity ordered. When insufficient quantities are on hand, back order instructions must be prepared by the release operator for filing until quantities for outstanding orders are available. Lasting coded records of all release transactions must be automatically prepared.

III. STUDY OF SEVERAL PROPOSALS FOR MECHANIZATION

A. Decision to Seek Proposals for Mechanization

> "The field of electronic data processing has grown so rapidly that many management people find they are unfamiliar with it. Businessmen in general are interested, but somewhat vague, about the subject. They are interested because they need something like this; since the turn of the century, overhead costs have risen four times as fast as direct production costs, and the situation is getting worse."*

When should the investigation into mechanization procedures be made? Realistically, it should not be postponed until a period of crisis. It may take a year or more to develop the plans for an electronic data processing system to the point where management can see the costs, the savings, and the other advantages of the system. Since the equipment should not be purchased until the system has been engineered, this means that the order will not be placed until a year or more after the investigation has begun. Delivery of the equipment may require another twelve to eighteen months. Installation, testing and conversion of the past system will require another six to

*4, p.2

twelve months. All in all, it is not difficult to imagine that the entire investigation, selecting, ordering, installing, testing, and conversion procedures will take two to four years before a new system is operating effectively.*

Management hired an outside engineering consulting firm to make a survey of the possible avenues of mechanization. After the survey had been completed and a report of the findings had been submitted, the consultant was retained and asked to join a study group which would be selected by management.

B. Choice of Personnel to Study the Proposals

> "Care should be exercised in selecting the person or persons who will make the study, since the quality of the planning is directly related to the caliber of the people doing the planning. The final responsibility for deciding on a course of action lies with the management of a company."**

It is not necessary that a person must know electronics before he can evaluate and understand data processing systems. In a number of cases this belief has led to selecting men with amateur radio experience to work on a

* 4, p.32
** 4, p.32

committee to choose an electronic processing system. In these cases, these particular men became so involved in the details of the electronic equipment that they lost sight of the overall system.*

In the Goodrich case, a study group was formed consisting of three supervisory members and the outside consultant was retained as the fourth member of the group. Later, additional supervisors sat in with the group and helped in the analysis and evaluation of the data processing system and the electronic computer. The group's original function was threefold:

1. Study various electronic data processing systems.
2. Visit several demonstrations of electronics processors in action.
3. Contact vendors for proposals on the desired processing equipment.

The group learned much about the various electronic computers and the companies which make the equipment. They watched several demonstrations and then they were ready to judge the proposals.

* 4, p.27

C. Proposals for a Special Purpose Electronic Computer

With the arrival of electronic data procsssing, company management or any appointed study group is faced with a difficult task when selecting the proper equipment. The selection should be based upon an evaluation of the competitive equipment for the particular application under consideration. This evaluation should include estimates of savings in time and money for each. This means that the company's requirements must be predetermined quite accurately, and then each competitive system compared against those requirements.*

In punched card equipment, two companies dominated the field; this is certainly not the same in electronic data processing. Many companies are entering into this field; some with considerable experience in business machines, others with little or no experience. The newer data processing machines will tend to combine many different functions into one piece of equipment so that the process of trial-and-error selection of combinations is made considerably more difficult. The scope of these installations will be much greater than in the case of punched cards. This is because the electronic machines are capable of greater scope, and because their cost usually demands a much wider scope to make them economically feasible.

*4, p.28

Seven manufacturers of electronic processing machines were contacted to submit proposals for supplying the electronic computer. Of the seven companies, three were eliminated in a pre-analysis. An active study was made of the proposals received from the other four companies. The four companies were rated by the study group on six basic group factors. Point scores were assigned to each group factor and to each sub-factor. The evaluation, which is shown on the following page, is the one made up by the members of the study group. They assigned 50% of the points to factors concerning the vendor and the other 50% to the factors concerning B.F. Goodrich. All of the factors and sub-factors are self-explanatory so that a further explanation is not given.

EVALUATION OF ELECTRONIC DATA PROCESSING EQUIPMENT *

Item No.	Item	Maximum Points	Assigned Points A	B	C	D
VENDOR FACTORS 50%						
I	MANUFACTURERS FACILITIES	10				
	A. Completeness of Facilities	2	1	1	2	2
	B. Research Availability	3	1	1	3	2
	C. Service & Maintenance	5	5	4	2	3
II	MANUFACTURERS RELIABILITY	20				
	A. Length of Life	4	2	1	4	4
	B. Credit Rating	6	2	3	6	5
	C. Total Assets of Company	4	1	1	4	3
	D. General Reputation & Proof of Quality	6	5	4	6	6
III	MANUFACTURERS EXPERIENCE	20				
	A. Experience in Computers	5	3	3	5	4
	B. Experience in our Type of Problem	10	6	10	3	4
	C. Experience in Commercial Problems	5	4	2	5	5
GOODRICH FACTORS 50%						
IV	MANUFACTURERS ADAPTABILITY	30				
	A. Ability to Meet our Detailed Requirements	10	7	9	5	10
	B. Concept of our Problem	15	11	15	9	14
	C. Coordination with Tabulating Equipment	5	3	3	5	3
V	COST	10	10	8	4	6
VI	DELIVERY	10	8	6	4	10
	TOTAL POINTS	100	69	71	67	81

*20

TABLE I

D. Ratings of the Several Proposals

The combined rating of Companies A and B would have the best total rating and would contain the best features provided in the equipment of both companies. Theoretically, the combination of the machines of Company A and B would result in the most desirable system. However, both Companies A and B were comparatively small manufacturers and it was believed that it would be difficult to coordinate the efforts of the two firms. Therefore, it was decided to deal with only one firm for this special purpose computer and to award the acceptance of the proposals to Company D.

E. Study of the Regular Tabulating Equipment

In the procurement of punched card equipment, management's problem has not been very difficult. First of all, two major companies have dominated the punched card field so that the selection has been limited. Secondly, the machines have been small and somewhat specialized in purpose, so that if the wrong combination of machines were chosen, some could be exchanged so as to get the necessary combination. The practice of renting this equipment has facilitated the exchanging of machines. Thirdly, the use of punched card equipment within any company has been quite limited in scope--at least, as compared to the newer electronic data

processing system.*

Studies were made of three companies as possible suppliers of the regular tabulating and punched card equipment. One of these companies was eliminated in the preliminary analysis as not having the capacity to meet the requirements which had been set up by management and the study group. The other two companies were evaluated for eleven factors and the results are shown on the evaluation sheet on the next page. The ratings were very close and, although Company B was rated higher, it was decided to select Company A because very satisfactory business dealings had been carried on with this particular company in the past.

The method of assigning point values used in rating the tabulating equipment is different from the method used for rating the four companies involved in the computer evaluation. Since only two companies were rated in the tabulating evaluation, the 100 total points were assigned between the two companies so that the total of both companies would add up to the 100 point total.

*4, p.28

TABLE II

EVALUATION OF TABULATING PROPOSALS *

NO.	FACTOR	WEIGHT	POINTS CO.A	POINTS CO.B
1.	Experience thru Vendors local offices. (available to us.)	10	4	6
2.	Concept of our problems.	10	4	6
3.	Goodrich experience with tabulating equipment.	10	7	3
4.	Coordination with other Goodrich tabulating units.	5	3	2
5.	Shortness of method.	5	2	3
6.	Service and maintenance.	20	11	9
7.	Desirability of competition.	10	3	7
8.	Card capacity.	5	2	3
9.	Future expansion.	5	2	3
10.	Training services.	10	6	4
11.	Price per proposals.	10	3	7
	TOTALS -	100	47	53

*20

IV. STEPS TO SECURE THE SPECIAL PURPOSE ELECTRONIC COMPUTER

A. Choice of the Computer

As stated in Chapter III, the selection of the computer was awarded to Company D. The selection was made not only on the basis of the factors evaluated and rated but also on the past experience of the company in the electronic computer field and their willingness to help solve the existing inventory problem. Only a couple years previously, this same company had built a computer to handle an inventory problem for American Airlines. A brief examination of this somewhat similar problem is now given. The computer and new inventory system for American Airlines were designed to handle reservations and to answer the customer's questions concerning:

1. Can the airlines provide the desired number of seats on the flight requested?
2. Can the airlines provide the seats on an alternative flight on the same day?
3. Can the airlines provide the seats within the next couple days if the answers are 'no' to questions 1 and 2?*

The above-mentioned system has been most successful in handling the growing volume of business in a reliable

*4, p.8

manner for American Airlines. At the present time, the peak volume of inquiries average around 600 per hour, or one every six seconds. This volume would seriously overload a manual system. Their electronic system has shown one of the best operating histories on record -- over 99% effective performance of scheduled "up time", which is 22 hours each day for 7 days each week. Even though the system was designed to handle the reservation problem, a new function is now handled at a slight additional cost. Now the computer can provide up-to-the-minute data on the departure time of outbound flights, as well as the arrival time of inbound flights. There is only one central inventory component for the entire airline. However, several availability machines may be located in important centers throughout the nation.* This is an example of a system handling the inventory problem of a major airline. It is certainly not the same system as was designed for Goodrich but both problems are similar and the manufacturer of the special purpose computer is the same in both cases.

B. Steps Prior to Installation

Now that the decisions have been made as to which companies would provide the electronic data processor and the regular tabulating equipment, the next goal was to set

*4, p.11

up a step-by-step schedule which would lead to the installation and effective use of the new inventory system. Some of the steps which had to be taken are as follows:

1. Receive approval of the B.F. Goodrich Company management.
2. Process the appropriation of the necessary funds for the specific pieces of equipment.
3. Work out contract details and officially place the orders for the various machines and pieces of equipment.
4. Work out and demonstrate some of the more difficult calculations which the computer and the tabulating machines must be able to perform.
5. Give about two months of concentrated effort with the electronic computer manufacturer in order to perfect the methods and the system to be used.
6. Install and put into use the tabulating equipment.
7. Test the components of the electronic data processor as it is produced.
8. Run tests on the data processor after it is completed.
9. Install the processor at Watertown.
10. Run final detailed tests of the entire system.

C. Production of the Electronic Computer

Most of the steps mentioned in section B were completed approximately as scheduled with the exception of the steps concerning the production, testing, and installation of the data processor. Production of the principal unit fell quite a bit behind schedule due to several lags and difficulties encountered in production. Members of the study group made monthly trips to the manufacturer's plant to check on the progress made and to attempt to speed up the overall production. Various mechanical defects occurred from time to time which slowed down the production schedule. Testing of the principal unit and its components was spasmodic as one part or another would fail to function. Whenever some mechanical defect occurred it was remedied and production continued. Finally, after many delays, production was completed and the installation was made. After the various components had been gone over very carefully, the stage was ready for the final testing.

D. Testing of the Electronic Computer

In order to provide an adequate test of the validity, capacity, and dependability of the computer, fourteen tests were selected which would be run through the computer and the system in its entirety. The purpose of each of the fourteen tests is listed below:

1. Enter and remove style numbers successively in same address and random addresses.
2. Check size entries, pairs entries, total pairs, and selected size entry.
3. Check computer's ability to process inventory and order adjustments and to convert these adjustments to punched cards.
4. Change an incorrect style number without affecting order and inventory data.
5. Correct transposition of size detail on inventory and orders.
6. Add and subtract inventory and orders with both stock and orders registered on drum.
7. Check the reading in of a succession of warehouse receipt tapes and check the computer's ability to recognize errors.
8. Check the reading in of inventory to four digits for size, and five digits for total pairs and check the reaction of the computer when sizes and total pairs are entered to exceed these limitations.
9. Check the loading of the computer with initial inventories of finished goods and committed orders.
10. Check the typing and verification of in-

coming orders. Check the creation of two by-product tapes; one for releasing purposes, the other for entry into the computer and conversion to punched cards. Check the accumulation of committed order entries into the computer storage.

11. Check the computer's ability to read out on punched tape complete inventories by style number, size detail, and total pairs of finished goods and committed orders. These tapes would be converted to punched cards for stock status requirements.

12. Test the computer's ability to read out on punched tape a conditions report on a style or a succession of styles showing total pairs of inventory and committed orders on hand and the amount by which inventory exceeds or is less than committed orders.

13. Check the computer's ability to release orders for shipment automatically. This test will cover favorable releasing conditions and will also point out certain conditions which are not conducive to

automatic releasing. Checks will be made on subtraction from inventory and committed orders recorded at the time of releasing.

14. Check the computer's ability to make partial releases of orders, items, and sizes at the operator's discretion. Check all subtractions from inventory and committed orders.

Testing commenced on the computer on November 20, 1956. Nine days were spent running the fourteen tests. Several adjustments to the computer were made and the tests were run again. After that, the tests were run during the day and any minor adjustments were made after hours. On December 17 and for the next eight working days, the inventory figures were loaded into the storage drum and then these figures were checked. By January 4, 1957, testing had been completed and the computer was ready for application to the inventory situation.

V. COMPONENTS OF THE ELECTRONIC COMPUTER SYSTEM

A. Input Devices

1. Tape perforator.

A keyset machine called a Soroban Puncher is used to convert the inventory data onto punched tapes. Later, these punched tapes are used to feed the inventory information into the computer. The keyboard of this perforator resembles a 10-key adding machine. The case checks received at the warehouse on the incoming stock are sent twice daily to the inventory office. The information on these case checks are converted onto these tapes. The information which is transferred onto the tapes is as follows:

1. A one digit punch, the start key punch, which indicates the beginning of a series of punches.
2. A four digit number which represents the code number.
3. A three digit number which represents the size.
4. A two digit number which represents the number of pairs, whether the pairs involved are 24 or only 01.
5. A one digit punch, the end key punch, which indicates the end of the series of punches.

Therefore, for every entry on the tape from the case checks there is a series of eleven punches. When a digit key is pressed, the tape is automatically perforated in the proper position on the tape which corresponds with the number punched on the keyboard. The operator will convert all the case checks she has onto the tape. Then she will give these same case checks and the corresponding tapes to another operator who has a similar Soroban Puncher which is equipped with an additional unit known as a verifier unit. Operator #2 will punch the same data from the same source, the case checks, onto another tape. At the same time, the original tape is fed through the verifier unit. If Operator #2 does not punch the exact same figures as were punched by Operator #1 on the original tape, the machine will automatically lock and stop, The operator then will check to see whether tape #1 or tape #2 is correct. Through this procedure, there is a ppsitive check that the correct figures have been punched and the second tape is a verified tape which is used to enter the inventory data into the memory storage drum of the computer. Approximately 6,000 case checks are handled daily by these two machine operators.

2. Tape Reader.

The tape reader is designed to read and understand the perforated tapes which have been punched. The tape reader is connected to the computer and information is

entered into the computer automatically as the punched tape passes through the tape reader. The additions to inventory from the case checks and the deductions from inventory from the selective or automatic releases all pass through the tape readers as they are entered into the computer. The tape reader is the main source of entry into the computer and the only one outside of the control console.

3. Flexowriter.

The flexowriter is a special purpose electric typewriter. It has the regular typewriter keyboard plus additional keys as required by the operation for which it is specially designed. It is hooked up electronically to a tape reader and to two tape perforators. This flexowriter performs several functions which are enumerated below:

a. Typing of the order from the original customer order and simultaneously, the preparation of the master programmatic tape for each order.

b. Typing of the combined invoice and shipping order form from the master programmatic tape and, simultaneously, the preparation of the edited order tape containing the data necessary for the computer and for the conversion to punched cards, and the order tape containing all the order in-

formation necessary for later release of the order.

c. Releasing of the selective committed orders by using the previously prepared order tapes.

d. Preparing of several reports such as the ones listed below:

(1) The committed orders of each size in any specified list of styles.

(2) The inventory of each size in any specified list of styles.

(3) The inventory minus committed orders for each size in any specified list of styles.

(4) The number of sizes in which the inventory minus the committed orders results in a positive, zero, or negative balance by each style in any specified list and also the accumulated total of the differences.

4. Control Console.

This is the supervisor's control station where he can control all of the operations of the computer. He has a console which consists of lights to signal what operation is going on, 2 panels which show the style number and size

for which the computer is giving information and eight rows of keys to indicate certain operations, or to enter data into the computer.

Some of the regular operations are the following:

a. Change priority by cutting off certain stations using the computer and thereby altering the sequence of computer operations.

b. Change data on inventory and orders which previously had been entered into the computer.

c. Call out on the display panel by size and pairs the inventory or orders for any style number included in the storage drum of the computer. This information is shown in seconds and is called instantaneous random access.

d. Punch out on tapes reports such as inventory or orders by sizes and total pairs and number of pairs by which inventory exceeds or is less than the pairs required for unfilled orders.

B. Computer Storage

The central storage of all data is in a magnetic memory drum which was designed specially to handle a large volume of units. The drum is not located with the other units previously described but is located in a separate computer machine room where the maze of wiring and electrical attachments are all set.

The internal memory of the computer refers to the registers for storing digits within the processing machine. It is the place where the machine programs are stored. Also the particular transaction and unit records being processed are stored there. Part of the internal memory unit may be used to collect statistical data during the processing of unit records.* The major characteristics of internal memory are:

1. Relatively low volume of storage.
2. Relatively high speed of access.

C. Output Displays

1. Flexowriter.

The flexowriter, although its use is primarily for input procedures, is also used for output. With a program

*4, p.88

tape inserted in the tape reader of the computer, the computer will read out information in the form of the punched tape, for many types of reports. This punched tape is punched so that it can be inserted in the tape reader of the flexowriter. Then, the flexowriter will type out the information on a report in readable form. This procedure is used to make up the following reports:

a. Inventory by size in any specified list of styles, plus style total.

b. Committed orders of each size in any specified list of styles, plus style totals.

c. A report or listing showing:

Column 1 Inventory by style total.

Column 2 Committed orders by style total.

Column 3 Number of pairs by which the inventory exceeds the committed orders.

Column 4 Number of pairs by which the inventory is less than the committed orders.

2. Inventory display board.

The inventory status of any particular style and size of footwear can readily be obtained by the use of the console controls and the inventory display board. The operator asks the computer how many pairs of any particular style

are in inventory. The computer dictates and shows the answer by size on the inventory display board. This operation can be performed at any time by the operator. Through this method, it is possible to learn whether there is enough inventory of any particular style to permit an order to be released. There is also an insufficient inventory signal which indicates whenever the inventory of any particular style and size is insufficient to meet the needs of an order pending release.

D. Tapes

> "One of the most common forms of recording input data in machine language has been by the use of paper tape, with the character codes either punched into or printed on the tape. Computers have made use of the Flexowriter typewriter, which can be operated at a top speed of 10 characters per second, and which punches a paper tape in addition to preparing the normal typed copy."*

The punched tapes provide the common language between the machines and the personnel within the data processing system. The personnel convert the data onto the punched tapes and the tapes bring the data into the computer, then the computer gives back the required information to the people who began the search for information.

*4, p.248

VI. EXPLANATION OF SYSTEM OPERATION

A. Warehouse Transactions

All inventory received at the warehouse is entered into the inventory kept by the special purpose computer in the manner described below.

The case checks, which accompany every case of footwear, are removed from the cases. These case checks show the code number, size, and quantity in addition to other information not used in the computer. All of the case checks are sent to the inventory control office twice daily for processing. This means that the merchandise has been physically transferred from production to inventory. Upon receipt of the case checks at the inventory control office, they are processed and converted onto reeled perforated paper tapes. The original conversion of the code number, size, and number of pairs onto the tapes is verified by a second conversion to tapes. This procedure has already been described in the explanation of the Tape Perforator machine. This gives a positive check on the accuracy of drawing off the information from the case checks.

The verified tape is run through a tape reader which is electrically connected to the computer. The actual units added into inventory are transmitted from this tape into the computer and are added to the appropriate stock number and size in the central storage unit of the computer.

After the units have been entered into the computer, the tapes are available for use by the tabulating section for conversion of the data from tapes to punched cards. This is for the purpose of statistical reports and also so that the inventories on hand could be reproduced by punched card methods in the event the computer should fail to operate for any sizeable period of time.

B. Orders Received

As orders are received, they are completely audited and separated by brands and branches, which are classifications for sales and accounting purposes. A code number is assigned to each item on the orders. The order is typed onto a master programmatic tape. This special tape is used in a later procedure for typing the combined shipping order and invoice. Orders are filled and shipped through a releasing operation, either automatically or selectively. This releasing operation will be described in detail in the next section.

When the orders are ready to be processed, this master programmatic tape is fed through a tape reading device which is installed on a Flexowriter programmatic electric typewriter. This tape automatically controls the operation of the typewriter in most phases of the billing process. The operator of the typewriter will start the tape through the reader and the tape automatically causes the typewriter

to start typing billing information onto the combined shipping order and invoice form. When the typewriter gets to the customer's name, address and shipping information section of the invoice, the operator cuts in and stops the master tape. The operator then manually types in the necessary information. When she has finished, she starts the master tape again. Then automatically the typewriter continues typing information such as order number, style number, total pairs ordered, and number of pairs by each size.

As the master programmatic tape is fed through the tape reader and as the invoice is being filled out, two other tapes are punched simultaneously. One is called the edited order tape which contains the data needed to be entered into the computer and other data which is necessary for conversion to IBM punched cards. The other tape is the order tape for releasing the orders whether automatically or selectively. This tape contains all the information on the original order and therefore contains more information than is needed for the operation of the computer or conversion of the data to punched cards. The edited order tape is usually continuous for all orders and is stored on a tape reel until such time as it is decided to apply the order data into the central storage. The order tape is attached to the corresponding typed order form and filed for future reference in chronological order of releasing.

C. Orders Released Automatically

The supervisor will have pulled from the order file all orders which he wants released at any time. The operator at the automatic release station is equipped with a tape reader and an insufficient inventory monitor. She takes the tape attached to the first order and feeds it into the tape reader which is electrically connected up to the computer. The computer reads the entire tape into the buffer storage drum before making any reductions from the drum. If the quantities in inventory are sufficient to fill the order, the computer will automatically make the deductions from orders and inventory. In cases where there is insufficient inventory to take care of the order, at the first size which reflects this condition, the insufficient inventory monitor lights will indicate the stock number and size and simultaneously the tape reader will stop. The operator will remove this tape from the tape reader, set it aside, and enter a new tape into the reader. After each tape is run through the tape reader, it is returned to the typed copy of the order with which it had been originally filed pending the releasing operation. The operator goes through the above operation on all orders and she divides the orders into two separate batches, the first for complete releases and the second for non-releases. On the completed releases, the tapes are sent to the tabulation room supervisor for conversion of the necessary data to punched cards. Orders not released are re-

turned to the file for a subsequent release. One copy of the release is sent to the warehouse, 1 copy goes to the branch or other originating office, and 1 copy is retained at the order section.

D. Orders Released Selectively

The decision to release an order selectively will be made on the basis of two courses of action:

1. Orders that had been previously sent through automatic releasing and were not released due to insufficient inventory.
2. Certain selected orders which, after analysis, show a call for items which are currently in limited supply and therefore would not go through automatic releasing.

The supervisor has pulled from the file orders which he wants released at any time. The operator at the selective release station is equipped with a programmatic flexowriter, a display indicator, and a tape reader to perform this task. These three items are all connected electrically to the computer. The operator removes the tape from the order to be released and inserts this tape into the tape reader attached to the programmatic flexowriter. She starts the flexowriter which operates automatically from the programmatic tape passing through the tape reader. While the flexowriter is automatically typing the heading

information, the tape perforator is punching that information which will be used in the computer and for tape-to-card conversion. Typing ceases just prior to the first style number. The tape reader will call up the stock number at which time the digital display will indicate the style number and the number of pairs of inventory in each size. As soon as the call out is finished, control of the operation returns to the tape reader.

There are three releasing procedures dependent upon the situation involved:

1. When operator elects to release nothing of that item - she presses a skip key and the tape reader advances through this item to the next item.
2. When operator elects to release an entire item:
    a. Types the code number called for on the order.
    b. Depresses start-read key which:
        (1) Causes tape reader to program flexowriter and to type automatically and in turn to activate the tape-punch.
        (2) Causes tape reader when it comes to tab stops to stop the flexowriter at which time the operator will depress the start-read button again.

3. When operator elects to release part of an item:
   a. Types code number called for on the order.
   b. Depresses start-read key which will move the flexowriter and reader over to the first tab stop.
   c. Depresses code-delete key and switches on the accumulating machine if the first size to be released differs from the quantity in the order tape.
   d. Depresses start-read key and types in the amount she wishes to release. She must strike three keys for each size. The tape reader will move along with the typing as long as the start-read and code-delete keys are depressed. Whenever the quantity of this size being released agrees with that appearing on the order, the operator can switch off the code-delete key and the tape reader will automatically type in the quantity and program the flexowriter.

e. Completes the size run, at which time the tape reader, which is synchronized with the flexowriter, will automatically skip one line space and return to the tab stop at the total pairs ordered column of the item being released. With the start-read and code-delete keys depressed, the operator types in the total pairs. She then switches off the code-delete key and the tape reader will automatically program the flexowriter to the next item.

The tape created in the tape-punch of the Flexowriter will be run onto a second tape reader which is electrically connected to the computer. This tape reader will make the necessary deductions from the drum and this tape will be the tape used for tape-tO-card conversion. As the operator completes action on each item, she makes a record of this action by marking the hard copy of the billing. Upon completion of the selective release action on any order, the operator will remove the order tape from the tape reader and return it to the original order. She removes the release from the flexowriter, one copy of which she clips to the original order. After the batch of orders have gone through the selective release procedure, she removes the reel of tape

representing the released item from the second tape reader. She marks the accumulated total on the tape. Orders which have not been completed are filed in the pending order file awaiting final release at a later date.

In passing an order through the selective release procedure a second time, the operator will use the original order tape to program and type the additional release. Variable amounts to be entered on the new release will be determined by the record made on the original hard copy of the order. The reel of tape is then turned over to the computer supervisor for the tape-tO-card conversion procedure. The released orders are distributed according to a predetermined distribution.

E. Supervisory Position

In order to maintain adequate control of all operations handled by the computer, a supervisory position is necessary. At this position, the chief operator or the supervisor is able to control the operations, to change the sequence of operations, and to change figures which have already been entered into the computer. This supervisory position utilizes the master control keyboard and a flexowriter equipped with an auxiliary tape reader and tape perforator.

Several functions will be performed by this position:

1. Add, delete, or change style numbers in central storage. This is done by depressing the necessary keys on the master control keyboard.
2. Add to or subtract from any style-size inventory. This is done by using keys on the master control keyboard. Any changes will be recorded in a log book and punched on a tape.
3. Add to or subtract from any style-size committed orders accumulation. This is handled in the manner as number 2 above.
4. Assign computer priority to the routine operating positions. The normal priority in the system can be changed by deleting functions through the master control stations or by manually deactivating input devices. The normal priority is as follows:
   a. Supervisory functions.
   b. Selective releases.
   c. Automatic releases.
   d. Warehouse acquisitions or committed orders accumulation.

5. Produce a perforated tape properly coded to make punched cards for any transaction at the supervisory station which results in a change of stored inventory or committed order data.
6. Read out any style-size inventory.
7. Read out any style-size committed orders accumulation.
8. Originate automatically typed inventory and committed order reports.
9. Originate any reports whose source is the computer. The reports will be read out of the computer in the form of punched tape, which, when run through the Flexowriter, will type out the reports in the proper format. The reports are as follows:
   a. Inventory by size in any specified list of styles, plus style total.
   b. Committed orders of each size in any specified list of styles, plus style total.
   c. Number of pairs by which inventory exceeds or is less than committed orders.
10. Cancel all orders which have already been entered into the computer.

F. Control of Input Errors

Errors are bound to accur on the input tapes and they must be recognized and corrected. The computer will spot any errors and will automatically signal the operator. Errors likely to occur are of the following types:

1. Unassigned style-size combination.
2. Impossible style number.
3. Impossible size.
4. Impossible quantity.

Errors can be corrected by the master control station, by the electric flexowriter, or by invalidating the tape.

G. Verification

The method of verifying the input information should be analyzed. If the wrong information is put into the machines, the result is simply the wrong information faster. The only way to insure accuracy in any data processing system is to build the proper verification procedures into the system. Any part of the system, whether it measures, transmits, or stores information, can be expected to make some errors. Some means must be established for the detecting and correcting of these errors. The problem of verifying the accuracy of the input information is difficult. It involves both the people who record the in-

formation and the equipment that does the recording.*

There is little general agreement on how much automatic checking or verification should be built into a computer. There is poor logic in asking for a perfect machine since a machine is only as good as the people who operate it. There are bound to be some errors and these are understandable. The experienced operator tries to check the information before it is entered into the computer and he plans overall checks.

In the procedure of recording the information from the warehouse case checks onto the tape, it was previously mentioned that the information is verified before it is entered into the computer. This is done by punching the same information onto two different tapes with the second tape acting as a verifier of the first. If the two tapes are not identical, the tape-punch machine locks. This is an example of positive verification. A method of negative verification is built into the computer. The computer will automatically reject an impossible style number, size, or quantity which is fed into the computer by an input tape.

Verification is always performed in a visual manner. Original documents are visually compared with data which has been automatically typed by tapes which were prepared using the original documents.

*4, p.187

H. Tape to Card Conversion

Although punched cards are not a function of the computer, they play an integral part of the entire system. The tapes containing inventory and sales data are so prepared that they can be used to convert the inventory data to punched cards. The conversion to punched cards is very important for several reasons.

1. With the data on punched cards the inventory figures could be obtained through the use of these cards in the event the computer should fail to operate for any period of time.
2. Reports for statistical and planning use are prepared from these cards.
3. The cards will be used to prepare production orders and in other ways will facilitate the control of production.

Punched cards accounting is a field by itself. Although this field is much older than the newer, highly specialized field of electronic data processing, it is by no means outmoded. Few firms at present can afford to buy the specialized machines but they can afford and are in a better position to utilize punched cards machines which are smaller and much less specialized. Furthermore, the punched card machine supplements the newer electronic data machines.

A great deal more could be said about punched cards, their methods and their use. In the B.F. Goodrich installation, punched cards are used mainly in the areas of production planning and scheduling. Since these areas are not within the scope of this study, only passing attention has been given to punched cards. However, it must be remembered, in other installations, that the use of punched cards would be much more greatly emphasized.

VII. COSTS AND SAVINGS

A. Comparison of Costs and Savings

Although the cost of any particular program may not be the most important consideration in determining whether to go ahead with a program, it must be remembered that initial cost may be accepted easily enough by management whether or not recurring costs are assigned their importance. The necessity of initiating a program may justify the changeover costs and the benefits to be derived may be worth more than the additional costs. However, in any future planning, future costs must be anticipated for and reckoned with, otherwise, the proposed benefits may not be worth the additional expenses each year and the system may have to be eliminated, modified, or changed in order to effect a reduction in the overall costs. With the elimination or modification of the system, there would probably follow a lessening of the material benefits derived from the program.

In the B.F. Goodrich plan of conversion of their manual methods to mechanized means and the utilization of a special purpose electronic computer, costs and savings played an important part in selection of the proposed changeovers. The company, in addition to increasing the speed, accuracy, and importance of their data, wanted to be able to show specific reductions in costs which would

more than justify the changeover and the initial costs of mechanization. It is not necessary to go into the mechanics of figuring what the possible future savings will be for each phase of the operation. However, the possible savings will be shown in brief form so as to lend emphasis to the fact that savings are expected, both directly and indirectly, through the conversion of manual to mechanized methods.

B. Direct Savings

Clerical savings would be the main source of direct savings. These savings were based on the reduction of employees through the use of machines in place of people. These people would not be laid off but would be absorbed into other operations. An estimated annual savings figure of $34,000. was set as a result of using machines to replace people in this particular area.

C. Indirect Savings

Indirect savings would result in several ways--through decreased obsolescence, decreased number of odd lot shipments, reduced factory training costs, and decreased shipping, billing, and accounting costs. Examples of possible savings are shown below and are based on a one-year period.

1. By decreasing obsolescence, an annual savings of $20,000. could be the result.
2. By decreasing the number of odd lot shipments, $5,000. annual savings could be attained.
3. By decreasing shipping, billing, and accounting expenses, a yearly savings of $90,000 could be obtained if individual shipments were reduced 10%.
4. By reducing training costs, an additional $50,000 would be the resultant savings.

The above four examples of indirect savings show a possible $164,000 reduction in costs. Savings can be effected in other ways as the manual system is improved upon.

D. Actual Savings

We have just considered the costs and estimated savings to be realized. These savings were not to be realized immediately but would be realized after the system had been in effect for three or more years. At the time of writing this thesis, the new inventory system and the special purpose electronic data processor had been in use for less than a year. Therefore, it is impossible at this time to quote current figures on actual savings. It would be most interesting to know how closely the estimates were attained, but savings are not the prime consideration in reviewing

the results of the system. Therefore, it is possible to move right into the final stages of this thesis.

CONCLUSION

The future will hold the answer to how successful the electronic computer has been in the mechanization of inventory and order control methods. The mechanized system at the B.F. Goodrich installation has been in use for less than a year. The computer has been adapted to the uses for which it was produced and it has been performing the manual operations with such speed and accuracy that was never thought possible only a few years back. Since the computer is a special purpose one, its uses are limited and further applications of this computer to other areas is extremely doubtful. However, the data which is compiled by the computer will be used in other areas such as production planning and scheduling.

It was a known fact, when the purchase of a computer was in the planning stage, that a special purpose computer could be used for limited applications only. Therefore, it is not possible to use the present computer to adapt to such other types of work as would be possible with a general purpose computer. Was this a shortcoming of the purchase of this particular computer? A definite limit of possible applications is a disadvantage when purchasing a special purpose computer. However, in this particular case, the limits of the computer were known before the purchase so that this particular computer was

not purchased with the intention of applying it to manual tasks other than those concerned with the inventory and order control functions. Therefore, the limited applications do not constitute a shortcoming of this computer.

The management of the B.F. Goodrich Footwear and Flooring Company will be able to get first-hand information on what a computer can do and how efficiently it performs the special tasks for which it was designed. In this way they will be in such a position that they will be more adept at analyzing the possible mechanization of other areas of manual labor.

At this time it is only conjecture as to how many more types of operations will be adapted to mechanized means and when any future changeovers would take place. Also it is not known whether a special purpose or a general purpose computer would be chosen for any further conversion to mechanized methods. Furthermore, with the progress which has been made in the invention and production of electronic data processors during the past few years, there is no telling what type of computers will be available during the next few years.

So great is the importance which is being attached to electronic data processing that practically every business publication contains at least one article about the subject. Libraries are buying the latest publications on the subject. One of the best publications concerning

present and future data processing appears to be "Systems" magazine. In recent issues there were several articles which would interest businessmen who might be faced with a decision regarding mechanization. Businessmen now have several avenues through which they are able to obtain information about new machines and methods. They should not hesitate to read up on the subject or to attend meetings where such topics are exhibited and discussed.

From all apparent indications, the mechanization of the inventory system is a success. The computer which was designed to handle a special job has done just that. Inventory requirements are now kept much closer to the sales needs. The mechanized system gives the information in detail whenever needed to coordinate fully with the merchandising function; thereby, improving greatly the previous slow manual system. Through the use of the mechanized system, the problems encountered in merchandising will be largely solved. It must be remembered that, as amazing as a machine can be, its success still depends on the "human" element. Without intelligent and capable personnel to perform the duties, whether they may be purchasing of new materials or selling the ultimate product, the merchandising system would be inefficient regardless of what machines might be available.

As mentioned previously, the future holds the answer as to how successful the new system will continue

to be. As long as the system continues to operate as efficiently as it has been and as long as costs are reduced and the projected savings are realized, the system will be considered a success. Should the computer fail to function properly for any period of time, should costs be much higher than expected with a resultant decrease in savings, or should the volume of work become too much for the computer, then the "successful" decision might have to be changed. However, these possibilities are not expected to happen and, for this reason, indications are that the new mechanized system and its main unit, the special purpose computer, will continue to function in an efficient, time-saving, and cost-reducing manner. Thus, another step will have been attained in keeping the B.F. Goodrich Company at the top of the rubber footwear industry.

APPENDIX

PROCESSING OF SALES ORDERS

INVENTORY & RELEASES

EXHIBIT NO. I

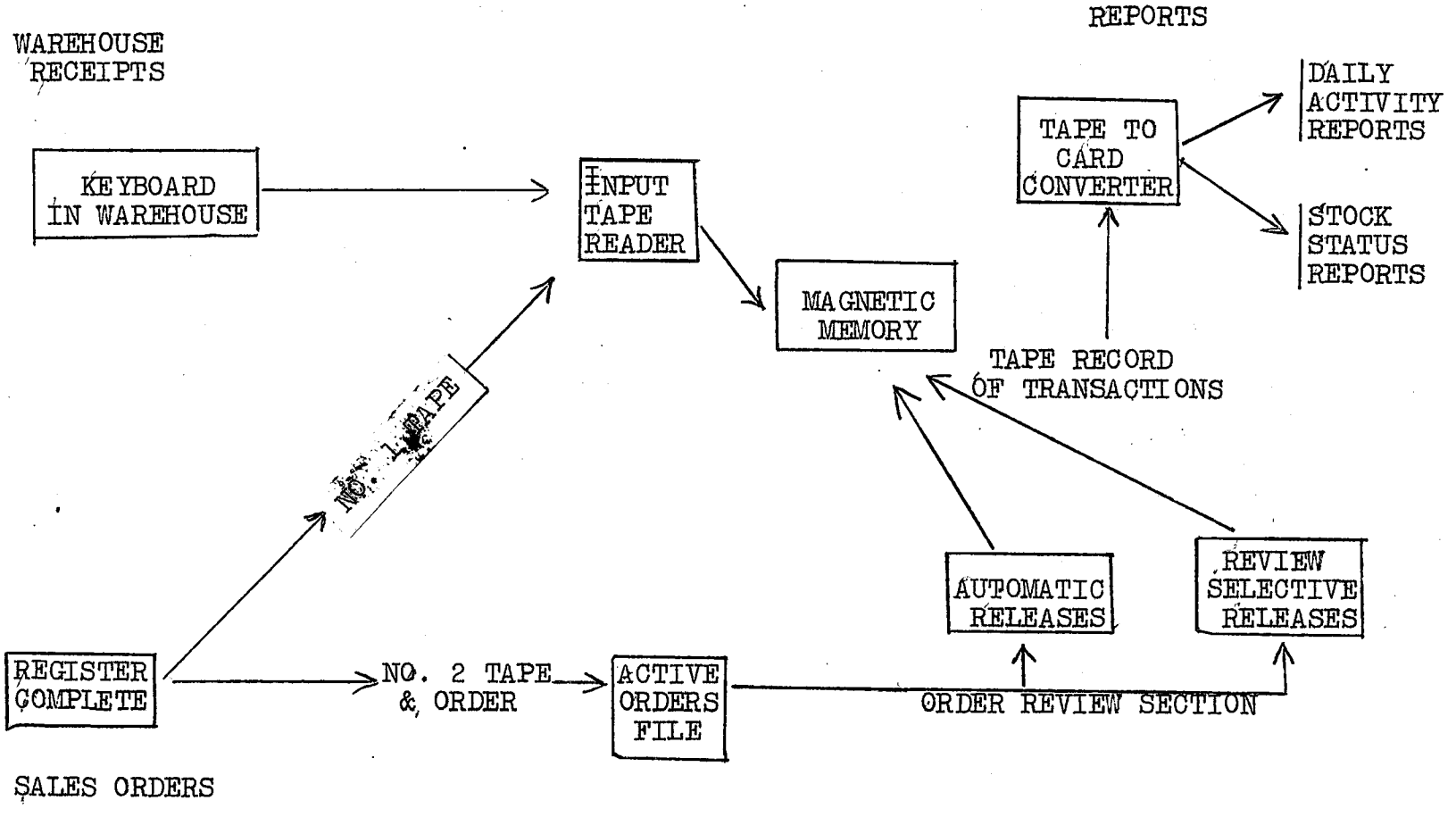


EXHIBIT II

Shipping and Billing Form

B.F.Goodrich Footwear Company
a Division of The B.F.Goodrich Company

TOMER/BRANCH NO.	STORE NO.	HOUSE REGISTER NO.	F.M.U. %	INVOICE NO.
TO	DEPT. NO.	SALESMAN	INVOICE DATE	
	COUNTY NO.	B/L NO.	TERMS	
TO	DEPT. NO.	ROUTING		
	COUNTY NO.			

ORDER NUMBER	CODE NUMBER	TOTAL PAIRS ORDERED	DESCRIPTION	BACK ORDER	PAIRS SHIPPED	SELLING PRICE
TOTAL			TOTAL			

MAIL CHECK TO WATERTOWN 72, MASS.

ereby certify that these goods were produced in compliance with all applicable requirements
ions 6, 7 and 12 of the Fair Labor Standards Act of 1938, as amended, and of regulations and
of the Administrator of the Wage and Hour Division issued under Section 14 thereof.

AMOUNT DUE

TYPE OF ORDER	CREDIT CODE	SALESMAN NO.	SHIPPING DATE
DATE SOLD	CREDIT STAMP	PULLED BY	CASES / WEIGHT
		CASE NO.	
SPECIAL INSTRUCTIONS		DATE	
		TOTAL CASES	

1 XS		2 S	—	3 M		4 L		5 XL		6		7		8		9		10		11		12	—	13	—	14	15

STAMPS

EXHIBIT III

"Thanks for the Memory"

These office workers are not being replaced by a machine, but they're somewhat envious of its capabilities when it comes to memorizing details. They're looking at the memory drum which stores information on thousands of style-size-color combinations of boots and shoes produced by the B.F. Goodrich Footwear Company and Hood Rubber Company. "Memorizer" is drum 20 inches in diameter and 30 inches long which spins at 1300 RPMs. (In photo, it is partially hidden beneath wires leading to the "reader" heads). It is the heart of a Teleregister magnetronic inventory control system, first in the rubber industry, which speeds order processing and production planning. Owners of the non-magnetic type memories are (left to right) Gertrude Connors, Mary George and Ann Donahue.

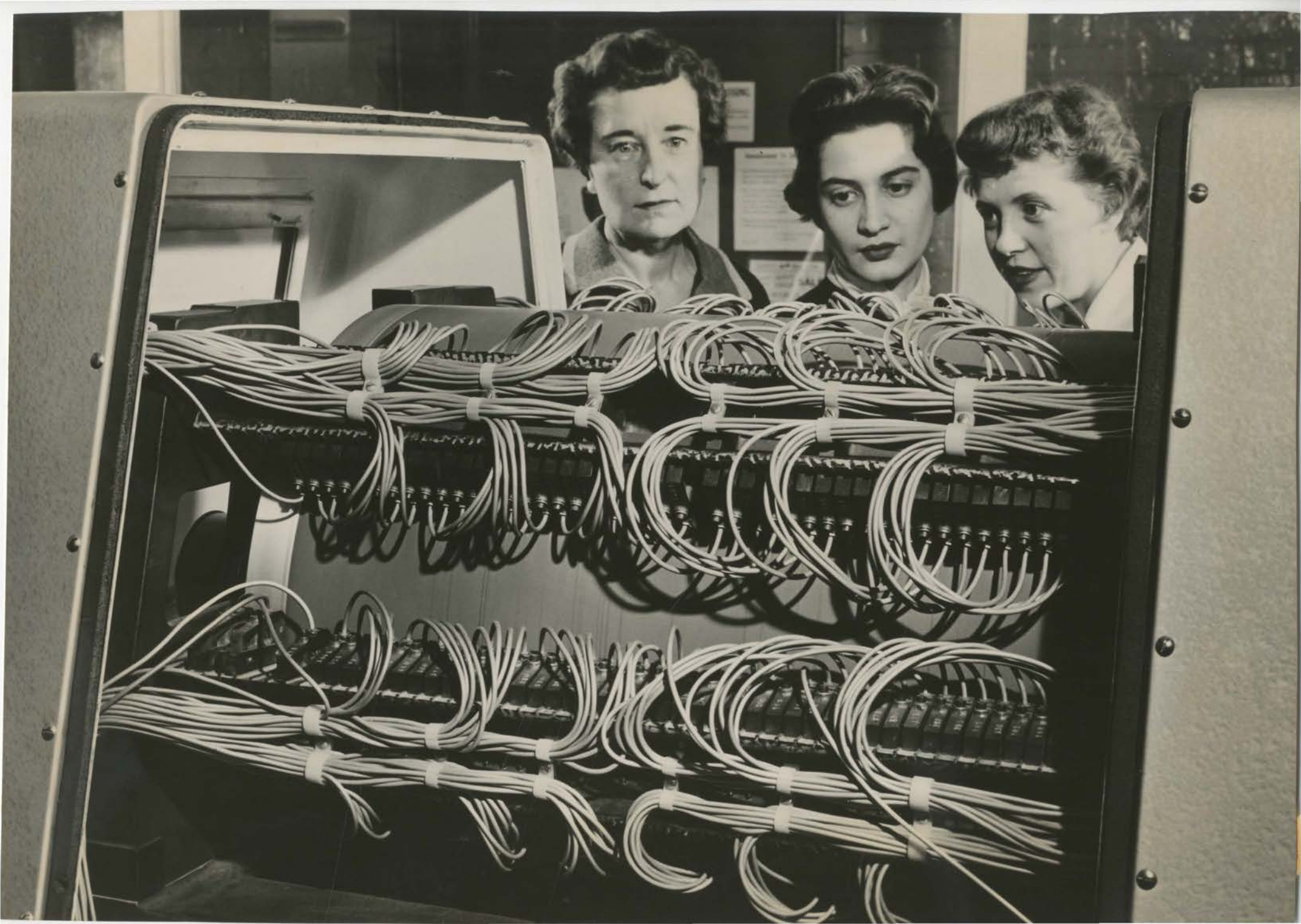


EXHIBIT IV

"Asking the 'Brain'"

By the touch of a button on this Teleregister keyset, Operator Mary George can ascertain the warehouse inventory on any of the items appearing on the shipping order she holds in her hand. The information is flashed to her instantaneously on the indicator board in the background. She can also add or delete style numbers by keying in new codes on the console. This is part of Magnetronic Inventory Control System at B.F. Goodrich-Hood Rubber Plant in Watertown, Mass. In providing almost instantaneous information on unshipped orders and stock in factory warehouse at Lawrence, Mass., the system provides speedy processing.


XS - S - M - L - XL
1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 - 11 - 12 - 13 - 14 15
CODE NO

EXHIBIT V

"Tape Tells the Story"

Punched tape containing code numbers--one for each of 3,156 different styles and colors of footwear--is prepared for electronic memory drum at B.F. Goodrich Footwear-Hood Rubber, divisions of B.F. Goodrich at Watertown, Mass. Tape replaces volumes of hand-written and typed records formerly used to keep track of thousands of pairs of shoes going into inventory daily. Once taped information is on memory drum, it becomes instantaneously available to order department, and production planners--who previously had to wait four to six days to determine warehouse inventory. Keypunch operator Doris Miller here records a warehouse receipt on tape.

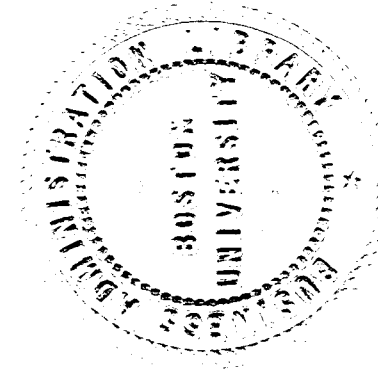
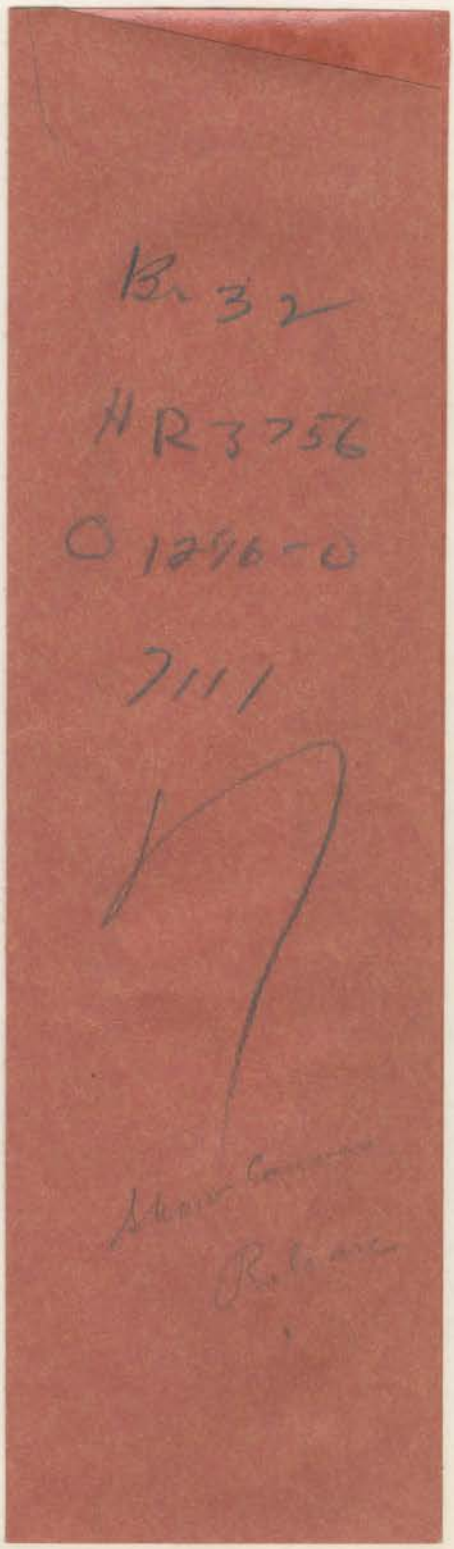


EXHIBIT VI

TAPE



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