# INDUSTRIAL DATA PROCESSING APPLICATIONS REPORT

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| **Applications** | Order Processing and Inventory Control |
| **Type of Industry** | Suppliers of Industrial and Utility Equipment |
| **Name of User** | Westinghouse Electric Corp.<br>Pittsburgh, Pa. |

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| **Equipment Used** | Univac 494 Computer Systems (2) |

## Synopsis

The Westinghouse Teletype Order Processing System (TOPS) is a completely automated, nationwide system for the centralized processing of Teletyped customer orders for industrial and utility equipment stocked in plants and warehouses across the nation. Utilizing a large private Teletype network and two Univac 494 computers, which also perform Teletype message switching and many other real time and batch data gathering and processing functions, the system also provides scientific inventory control and automatic reordering of stocks. A high speed stock inquiry service gives immediate, automatic replies to sales offices on the availability of stock of a given item at any warehouse in the country.

The Westinghouse Teletype network is one of the largest private industrial communications systems in the world. Over 500 Teletype stations located throughout the U.S. and Canada are served by 61 American Telephone & Telegraph Co. leased lines or circuits, which terminate at the Tele-Computer Center. These circuits are directly connected to 61 communication control units, integral components of the computer system. There are approximately 500 persons employed at the Tele-Computer Center. About 280 are in the financial and accounting functions and 220 are in the computing, communications and technical support functions.

Introduction to the system

For 12 hours each day, one of the Univac computers performs the real time functions at the Westinghouse Tele-Computer Center, while the other is used for large scale batch processing work. The latter machine is always available to take over the real time chores in case of trouble with the first.

The real time Univac 494 has a 65K random access work core memory capacity and operates as the switching facility for the corporation's private Teletype communications system. All Teletype traffic, over 50 percent of which consists of data messages, flows into the computer for processing or for forwarding to another destination. Reception and retransmission of normal traffic is entirely electronic, no hard copies or paper tape is required in any part of the storing and forwarding process. The computer identifies and intercepts various kinds of data which it processes automatically, answering inquiries, handling customer orders and generating financial and statistical information for the divisions and for higher management.

The other system, which will not be examined in this report, is called the Tele-Order system. It processes dealer orders for major appliances from 50 appliance sales offices throughout the country.

A normal day's traffic on the system assigned to real time work handles about 24,000 incoming messages and about 26,000 outgoing messages. Although the messages are variable in length, the average message contains about 55 words or 3,330 characters of information. There are two reasons why output volume is greater than the input. First, "book message" transmission (a single input message with multiple addresses) represents about 10 percent of incoming traffic. A book message creates a multiple output message. Second, the repeat message capability permits messages transmitted over the last running 24-hour period to be stored in random access memory, and subject to recall by any addressee location in the field. This recall capability allows for repeat transmission in case the receiving station has equipment or line trouble.

A given message may be either an administrative message to be forwarded or data to be processed. Appropriate action is taken by the programs, dependent upon analysis of the message heading format. Volume statistics are kept by station and by circuit, and at the end of the month billing distribution is automatically prepared on a computer batch run for distribution to the various user locations.

Service messages, which in effect constitute commands to the message switching program, are identified in the Teletype input analysis and are given preferential processing treatment; for example, by a coded service message addressed directly to the computer, any station can be placed on or off "skip" condition, under which the computer does not attempt to pick up traffic from that point, or an intercept condition, under which it does not send traffic to that point but stores it for later release. In all, there are over a dozen types of service messages.

Provisions are made in the program for automatic network emergency stop in case the executive system detects a program or hardware malfunction, and for real time recovery in case of serious trouble. The program is also set up to detect open-line conditions and remote equipment problems as evidenced by lack of response or incorrect response to invitations to transmit. These conditions are reported by the computer to the communications system operators in a separate communications room.

## TELETYPE ORDER PROCESSING SYSTEM (TOPS)

The TOPS system controls the inventories and processes orders for the products of 23 Westinghouse divisions which manufacture industrial, electric utility and construction products. The products involved are stocked in some 65 warehouses, including the factories themselves.

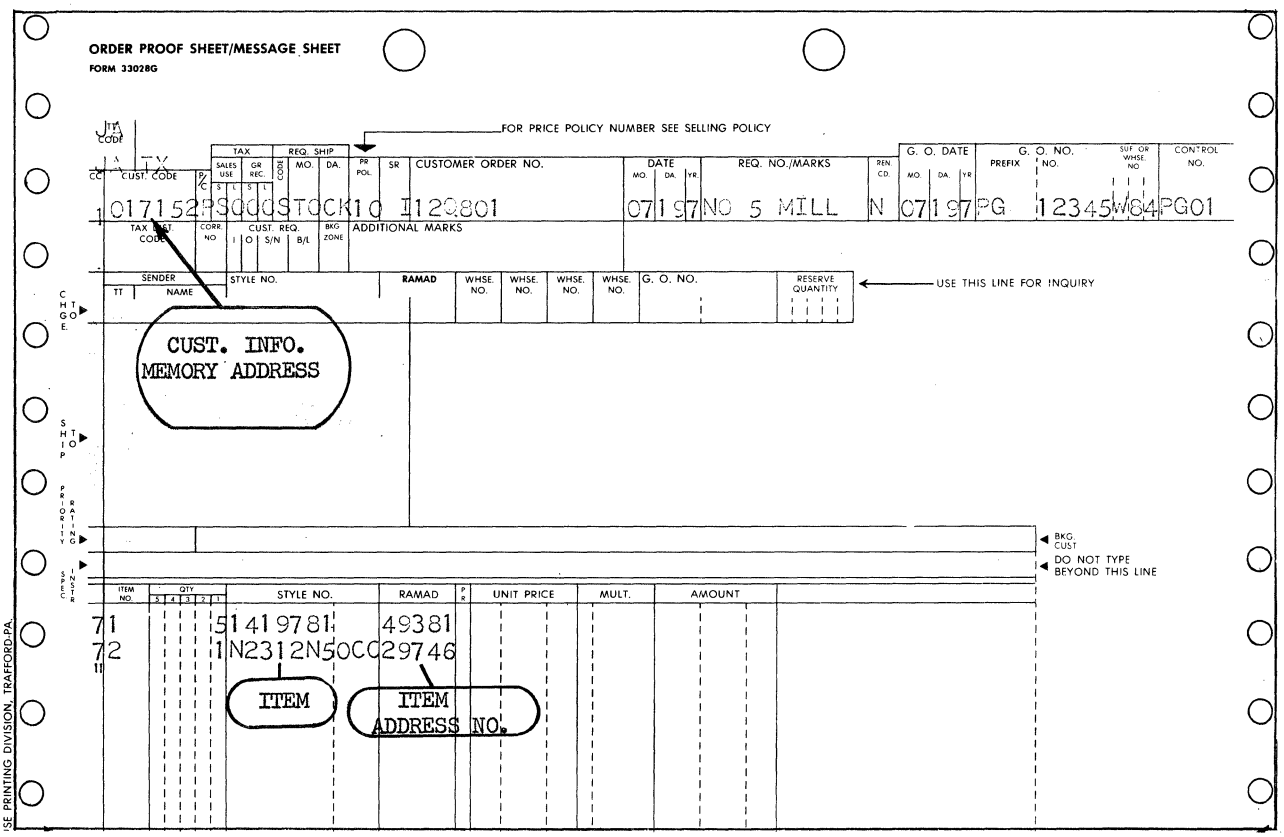
This report will cover specifically the operation of the TOPS system. Although there are many detailed differences, the basic elements of both systems are the same, and volumes are comparable. Nearly 90 percent of all Westinghouse customer orders for industrial and electric utility equipment are entered by Teletype through the TOPS system. Over 125 Westinghouse sales offices, located throughout the country, type each day either on Flexowriters or Model 28 Teletype equipment a total of nearly 3,000 such orders. These orders are for items in finished goods stock and for those non-stock items that have a short manufacturing lead time. The handling of orders for non-stock items will be described later.

The orders are prepared in a highly compressed, encoded format. Five-channel Teletype tape is a by-product of this typing of a hard copy of the order. The order format begins with the Teletype address code "JA," which identifies the message to the order processing system, and the sending station address code. The next line contains a six-digit customer identification, a code indicating whether partial shipment is acceptable, codes indicating applicability of sales taxes, required shipping date, pricing policy, the original customer order number and date, special marks required, the date and number assigned to the order by Westinghouse, the preferred warehouse number, and a serial control number assigned by the sales office.

If the customer is previously "registered," the customer number defines the billing and shipping addresses carried in computer memory. Otherwise, either or both must be typed on the order. The item lines of the order contain item number, the quantity, the style number (part number) of the product, and the random access memory address at which product information is stored in the computer system.

In the FASTRAND random access drum files associated with the central processor, information is stored on 15,000 regular customers and some 45,000 different products. Over 60,000 inventory accounts are maintained for 65 warehouses located throughout the United States. In addition to the name and the billing and shipping addresses of each customer, information necessary for determining the discount applicable to each customer for any item on file is carried as part of the customer record.

Each product record contains the information necessary for complete identification, pricing, and costing, and the lead time in manufacturing. Each warehouse inventory record contains quantity on hand, quantity back ordered or held for deferred shipment, quantity on order for replenishment, current month actual issues and demands, 30-day forecasted issues and demands, date of last activity, inventory review codes, the replenishment review point, and a number of other fields necessary for complete order processing and inventory control.



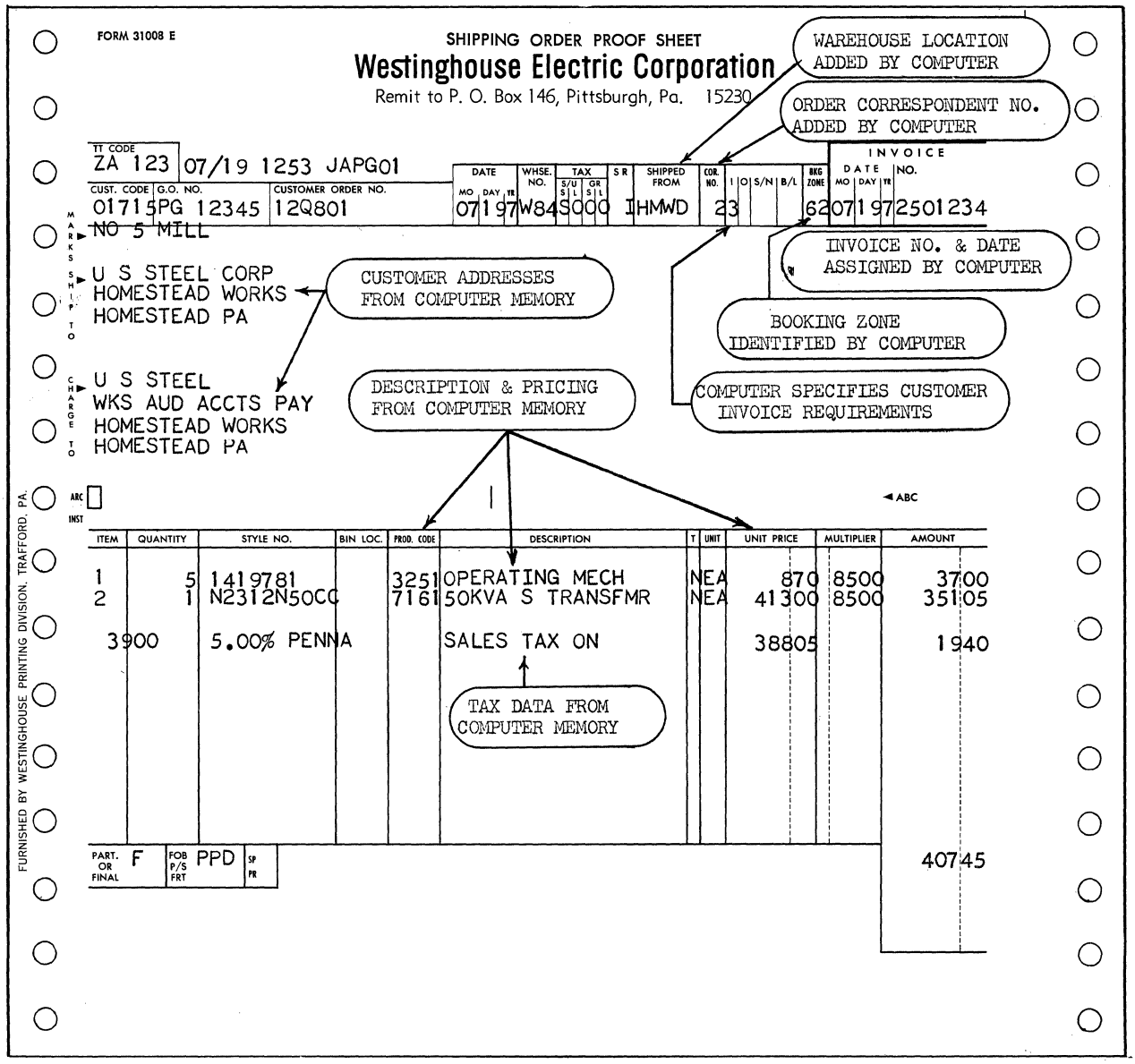

TYPICAL TOPS ORDER (TWO ITEMS) AS TYPED BY SALES OFFICE IN STANDARD FORMAT.

After typing the order and cutting its by-product paper tape in the sales office, the hard copy is visually reviewed by the operator for obvious errors. If none are detected, the paper tape is placed in the Teletype transmitter and the order is transmitted into the 494 computer.

The message switching program examines the order and determines that it is data for the order processing system. The information is then written on a specialized area of the mass storage FASTRAND file, and control is turned over to the order editing and processing routine. The order is processed concurrently with the collecting, queuing and switching or processing of all other messages that are coming into the Teletype system.

The order entry program passes the order through an input edit routine, which looks for obvious errors in format. If this type of error is found, a message identifying the error is generated and transmitted to an error control clerk at the Tele-Computer Center, who notifies the sender and requests retransmission of the order. Once the order has passed the initial editing checks, control is turned over to another routine which does the main processing required to fill the order. The customer's record is looked up in the FASTRAND file and validated, the product identifications are checked and validated, and then determination is made as to whether or not sufficient stock is available at the preferred warehouse, normally the warehouse nearest the customer. If sufficient stock is available, the stock record is updated, the order review point checked for a possible break, and the item is priced and costed. If stock is not available at the preferred warehouse, the program automatically calls in an alternate warehouse procedure, which searches up to six additional warehouses between the preferred warehouse and the manufacturing division.

After the order has satisfied all of the conditions of the main processing run, another routine immediately generates complete shipping instructions in Teletype message format and transfers this information into the message switching program, which in turn queues it with other messages for the circuit servicing the designated warehouse. The complete processing of an average order requires only two to three seconds.




SHIPPING ORDER AS TRANSMITTED TO WAREHOUSE AFTER PROCESSING BY COMPUTER.

On a typical outgoing shipping order, corresponding to the customer order, it can be seen that the computer has located the stock at a suitable warehouse, translated the customer number to the actual billing and shipping names and addresses, assigned an invoice number,

identified and priced the product, calculated the applicable sales tax, and totaled the billing. Thus, a substantial amount of information is added to the incoming data to complete a shipment notice for transmission. An incoming order averages about 50 Teletype words. By comparison, the average outgoing shipment notice requires about 100 words.

Shipping notices are received at the warehouses on six-part forms, which provide a shipping order/invoice copy, a packing list, three bills of lading, and a tear-out shipping label. The shipping order/invoice copy is sent to the entering sales office with a copy of the bill of lading as confirmation of shipment. The remaining two copies of the bill of lading are given to the carrier. The warehouse retains none of the paperwork, maintaining only a one-line shipping log.

Error Control

Conventional Teletype transmission by five-level Baudot Code provides no error-checking means inherent in the transmission system itself. Therefore, insurance against transmission errors is provided for critical data items in the format of the order message. Customer identification is transmitted as a six-digit number, of which the last digit is a check digit derived from the previous five digits. This is not a completely secure system, since it is possible for two or more digits to be altered in transmission in such a way that the check digit still indicates a valid number. In the history of the TOPS system, during which over three million orders have been processed, this has occurred twice.

Product identification is transmitted redundantly. In addition to the standard "style number" identification of a product, the message also includes the random access memory address of the file location where product information for that item is stored. The program compares the stored product identification at that address and the transmitted number. If the two do not agree, the order is rejected to the control clerk, who takes appropriate action with the sender. Because the majority of errors are operator errors rather than transmission errors, these control features would have to be provided in the format even if the transmission system had error-checking provisions. They serve the dual purpose of checking for both human mistakes and transmission system faults.

There has been no occurrence of an incorrect shipment resulting from an error in the actual transmission of product identification. Unfortunately, an operator occasionally types an incorrect style number and the memory address associated with that incorrect number, and there is nothing the system can do to detect such an error. Errors of this kind occur once or twice a month at the current level of 45,000 to 50,000 orders handled monthly.

Inventory Control

Scientific methods of control are used to maintain inventory levels in the system and to determine the frequency of reordering and proper order quantities for replenishment of both field and factory warehouse stocks. Detailed descriptions of the mathematical techniques employed, formulas for which are an inherent part of the computer programs, will not be documented here. However, these methods are not unique to the system and do not differ materially from the methods of scientific inventory control presented in modern texts on the subject.

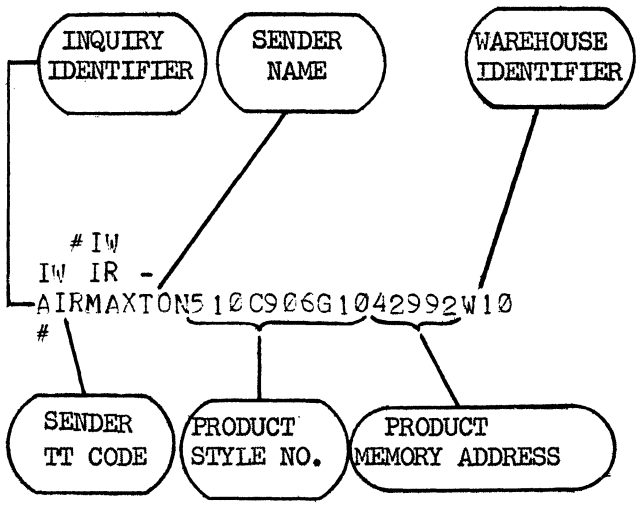
For each item at each warehouse, an order review point is calculated and recorded in the file for that particular item location. Actual as well as exponentially forecasted monthly demands (orders) and monthly issues (total quantity) are also maintained. As each order for the item is processed, the program determines whether the previously calculated order review quantity has been reached. When this occurs, the inventory account is earmarked by the program for the nightly inventory control run. The first step in this routine is a recalculation of the order review point, based on the now more up-to-date activity information and any new information on lead time. If the new order review point continues to indicate need for replenishment of the stock, an economic order quantity (EOQ) is calculated. The EOQ calculation determines the quantity to be ordered which will minimize the cost of ordering and carrying the inventory, taking also into account the cost of set-up for production in the factory if factory stock is to be replenished by new production.

The output of the inventory control run is a series of requisitions on the producing plants, which are automatically fed to the message switching program for immediate transmission to the plants the next morning. When a warehouse receives a replenishment shipment, it enters a receipt notice, similar in form to an order, by Teletype to the Tele-Computer Center. This notice is processed automatically and the inventory account is immediately updated to show the new quantity on hand and the corresponding reduction in quantity on order.

Certain constants in the inventory control formulas are subject to variation at the discretion of the producing divisions. For each class of product, the sensitivity of the formulas to short versus long term fluctuations in activity, desired frequency of stockouts, and other factors of a policy nature can be decided by each division to fit the characteristics of its particular product or products. The system includes a superseding procedure for items which are salable but which are to be superseded by a similar product carrying a new style number. Even though the new identification may be used in the order, the new stock is automatically "blocked" or reserved until the previous inventory is exhausted. Activity information on the old item is then automatically carried forward to the new record. Meanwhile, identifying symbols in the old record prevent reordering of the superseded item by the automatic requisitioning system.

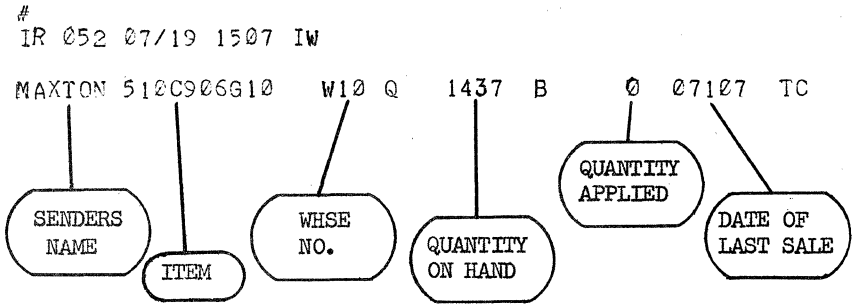
Inquiry Services

An important feature of the TOPS system is the high speed stock inquiry service it provides. Any sales office can transmit an inquiry message into the system, using the address code "IW," which the programs recognize as an inquiry to be answered. The format shown for a typical inquiry message is that for an inquiry requesting the stock status of an item at one warehouse only. For this type of inquiry, the sender address code, his name, the style number and memory address of the product in question, and the warehouse identification are the only items of data required.




TYPICAL SINGLE-WAREHOUSE STOCK INQUIRY.

Processing of inquiries and transmission of replies are given top priority in both the order processing and message switching systems. Inquiry replies are queued ahead of all waiting administrative traffic on outgoing lines. Inquiries are processed in less than 2 seconds after receipt. The only delay in transmitting the reply is the time required for an outgoing message already in progress on the line to be completed, normally only a few additional seconds. A typical answer to a simple inquiry contains the inquirer's name, the product identification, the warehouse number repeated, followed by the physical quantity on hand, the quantity applied for deferred shipment and the date of last activity.




INQUIRY ANSWER AS TRANSMITTED BY COMPUTER.

Other inquiry formats provide for determining available quantities of an item at up to four warehouses by means of a single inquiry message, as well as for automatic reservation for a limited time of specified quantity of stock of an item, if available, for a follow-up order. Inquiry volume for the TOPS system averages approximately 1,000 inquiries received and answered daily.

## Invoicing

It has been stated that the shipping order/invoice copy of the multi-part form generated at the warehouse is sent to the originating sales office. This serves only as confirmation of receipt of the order and of shipment. Actual invoicing is done from the Tele-Computer Center for all stock orders processed. The invoices are generated by a batch routine run several times daily. This and many other batch processing jobs are run concurrently with real time operation on the 494. The invoices are held until the next morning. This allows time for warehouses to notify the TOPS staff of inability to ship an item for any reason, such as an out-of-stock situation which the file records did not disclose. Such situations are relatively quite rare, however, and this exception reporting approach has proved to be quite satisfactory.

## Non-Stock Orders

A substantial number of the orders entered into the system is for standard items not normally stocked, or for near-standard items made up by special modification of stocked items before shipment. These items are available only from the factory responsible for the product line. Such orders are entered in the same format as orders for stock. The warehouse identifiers in these cases actually identify special order sections in the plants, which are set up to handle such orders effectively. Provision is made in the order format for free-form notes describing any special modifications necessary, and such notes are transmitted unchanged after reformatting of the order by the programs.

Prices are usually negotiated in advance for special items, and the price is typed in the order by the sales office in such cases and extended and totalled in the reformatting process. At the factory, the reformatted order is received on a 12-part form on a Teletype printer usually located in the short-order shop section itself. The acknowledgment, packing list, and bill of lading copies are used as previously described for warehouse shipments. The additional copies are the actual invoice copies, which are dated and mailed by the factory when shipment is made.

## Batch Processing and Periodic Reports

All real time systems of any complexity involve substantial amounts of batch processing and the generation of periodic reports. In the TOPS system, a variety of batch processing routines are required, some repeated several times a day, others ranging to as infrequently as once a year. Among the more important of these, in addition to the invoicing and inventory control runs already described, are:

(1) The Disposition List and Unfilled Orders (generated several times daily) is a journal of transactions that have occurred since the previous listing, showing exactly how each order was processed, which warehouses were directed to make shipment of which items, and a listing of warehouse receipts. In the case of orders which are not filled because of unavailability of stock, the entire order is reproduced in punched card format and delivered to an order clerk, who may elect to re-enter the order on a warehouse outside of the normal chain or to hold it for later release when stock availability is reported.

(2) The Billing and Cost Distribution (weekly, with monthly summary) advises each division of the billing and associated costs on its products sold through the system for each period, for entry into its accounting system.

(3) Stock Bulletins to the field (weekly) is a report of the stock status of selected active items, for sales office use.

(4) Ledger Abstracts to Divisions (monthly) is a complete listing of stock status by manufacturing divisions, covering all accounts that are the responsibility of each division.

(5) Inactive and Excess Stock Reports (quarterly) are generated for each division. They are an analysis of the stock of its products which show no activity for a predetermined period, or for which analysis indicates that inventory is excessive in comparison to the activity.

(6) Reconciliation of Physical and Financial Inventories is an annual run associated with the taking of annual physical inventory in the warehouses.

Many other specialized reports are run for individual divisions, depending on their particular requirements.

## RESULTS AND FUTURE PLANS

The cost of the TOPS system, including the communications and computer expense, have been more than offset by direct savings in clerical functions in sales offices, warehouses, divisions, and field and plant accounting activities. However, the greatest benefits of the system cannot be measured because it is impossible to assess the value of the improvement in customer service that the system has brought about. The ability of any sales office in the country to quickly locate a desired item, to enter an order, and within a few minutes have the shipping order in the hands of a shipper at the warehouse, has without doubt led to greater sales.

Centralized scientific inventory control has brought about a 50 percent reduction in total inventory levels since the system began operation. During the same period, the volume of business processed against these stocks has almost doubled. Many auxiliary benefits could be cited. For example, an audit of the manual system of pricing previously used disclosed an average of 0.45 percent underbilling due to clerical errors. (Customers seemed to have sharper eyes for errors in the other direction.) With prices carefully loaded in computer memory and reviewed by the responsible marketing departments, accuracy of pricing and price extensions is assured.