UNIT CONTROL SYSTEMS ENGINEERING

Raymond Davis
Senior Systems Engineer
Librascope, Incorporated
Glendale, California

There are many areas in retailing in which electronic information processing systems may be applied. The areas of application given consideration for this discussion were the following: accounts receivable, including credit authorization; accounts payable; and unit control. To coordinate all of these functions into one system would have been an ambitious undertaking for this session. Accounts receivable and accounts payable are mechanized to a degree at the present time with electromechanical machines. Unit control, on the other hand, in this store is performed entirely by hand. The volume of data to be processed in the 31 departments is large enough so that one can expect an electronic system to produce a more efficient, reliable, and economical operation.

Before we discuss the proposed unit control system, let us briefly review some of the early work in department store record mechanization. One of the earliest attempts to mechanize department store records was the Central Records System. This system was installed at Kaufmann's Department Store, in Pittsburgh, Pennsylvania, in 1929. It was designed to coordinate the paper work in the major departments of the store in one central records system. A point of sale recorder was employed at the cash station to transmit sales data directly from a punched garment tag to a central recorder. The central recorder punched the data into a standard tabulating card. In addition, as a check feature, the information was listed on an adding machine paper tape. The punched cards were run through standard sorting and tabulating machines in order to prepare the various reports. The main areas covered by the system were unit control, sales statistics, and accounts receivable. Thus, we see that Babbage's Calculating Engine has its counterpart in the Central Records System for the retail field. It was withdrawn from Kaufmann's after a few years of difficult operation. It has been stated that the main reason for failure was that the system was 25 years ahead of its time. With this brief introduction, we are now ready to describe a proposed system.

It is generally agreed by people working on department store mechanization that sales data should be captured at the point of sale. At this point, all of the necessary factors for making the sale are together: the customer, the merchandise, and the sales clerk. This philosophy is subscribed to, and the proposed unit control system will include a point of sale recorder. The input media that has been selected for the system is magnetic. Therefore, the point of sales recorder will record the sales data on magnetic tape. From Mr. Shaffer's statement of the problem, it is evident that sorting and
tabulating are the major operations to be performed. The system will include an electronic sorter with magnetic tape inputs and outputs. In addition to the four tape drive mechanisms associated with this type of sorter, a fifth tape unit will be included. The reason for this will be cleared up later on. Sorters of this general type should be available in the near future from a number of manufacturers. The data will be tabulated by an electronic computer which is flexible enough so that many other operations can be performed. The computer will have a magnetic tape input-output system. In addition to the magnetic tape output, it will be tied to a summary punch for punched card output. The additional punched card output was included to take economic advantage of present tabulating equipment for use as an output printer. A keyboard-to-magnetic-tape recorder is included in the system for the preparation of special tapes. The time schedule requires that all daily sales activity reports be delivered to the buyers the next morning following the date of sale. The volume of sales, 20,000 per day on the average, to be processed is such that a punched card printer capable of printing 150 lines per minute is adequate. As the volume of sales increases, and the system is expanded to perform additional operations, one of the high-speed printers could be used without the necessity of a complete system overhaul. Obviously at this time, the punched cards would be replaced by a magnetic tape output for all listing requirements.

The present cost of unit control, at this store, indicates that the cost target to shoot at is in the neighborhood of a quarter of a million dollars for an electronic system. If this can be depreciated over a five-year period, the cost would be $50,000 per year plus operator and maintenance costs. It is felt that a system of this size could be produced (not necessarily developed) for this order of magnitude of price. The task of estimating the savings a store may achieve by obtaining faster and more reliable unit control data is well beyond the scope of this paper. Certainly there is no historical data to serve as a guide in making such an analysis. The systems engineer must be cautious in accepting general statements by controllers that this will be considerable until these statements can be supported with factual data. Thus, the systems engineer must use as a guide to determine economic feasibility known present-day operating costs and not rely on conjecture. It was on this basis that the quarter of a million figure was arrived at as our cost target.

The first problem to be solved is the input problem. The systems engineer is inevitably faced with a difficult input problem when he seeks the solution to a business procedure. The difficulty arises, strange as it seems, because the data which must be utilized is recorded on a document in digital form. Our colleagues in the control session generally obtain their input data from instruments. It may be in voltage or shaft position form, which of course is not digital. However, a great deal of progress has been made in converting analog data into a useful digital form for data processing. The way in which this analog to digital transformation is accomplished is not biased by tradition or legal reasons. Tradition and legality are important factors which must be kept in mind in selecting an input media for a business system.
It was decided to use a tag similar to the one now in use. The present string tag is a three-part tag, while the pin tag is a two-part tag. When the merchandise is sold, one part of the tag is detached. If it should be returned, it is not necessary to retag the garment, in the case of a string tag. Thus, when it is sold again the second detachment is made. In case of a second return, the item must be retagged. These garment tags are generally printed either with a Dennison or Kimball Tag Machine in the marking department of the store. The tag proposed for this system is a single tag. That is to say, no section of the tag can be detached. The same tag will serve as a string or pin tag. In addition to the Arabic numerals printed on the tag by these machines, it is proposed that the marking machines be modified to print a binary coded decimal representation of the data. Thus, the tag is divided in half; one part has the figures printed on it, while the other part contains the binary coded decimal information. The coded portion will be printed with an ink containing a magnetic oxide. This portion of the tag is capable of being magnetized when placed in a magnetic field. In the case of a returned item, the tag may be re-used provided it is in good condition. The tag contains all of the necessary information for sales and receiving records. Figure 1 shows the proposed tag. It is realized that a tag of this type does not lend itself to a hand-marking machine. Mr. Shaffer is agreeable to the issuing of a new tag for marked-down items.

When the garment is sold, the transaction will be recorded by a point of sale recorder. The recorder will be placed adjacent to the cash register. No attempt is made to replace the cash register or its function. The recorder will contain a magnetic tape on which the sales data will be recorded. This tape is called the Sales Activity Tape. The tag is placed in a holder and inserted in the recorder. As it enters the recorder, the coded portion of the
tag is magnetized. When it is fully inserted, the coded portion is under the magnetic tape. A lever is depressed which places the tag and tape in contact. An alternating magnetic field is applied perpendicular to the tag and the tape, and the contact printing is made. When the lever is released, the magnetic field is withdrawn, the tag holder is retracted, and the tape is indexed for the next recording. It would be desirable to use a magnetic ink of a higher remanence than the oxide used on the tape. The so-called 3M "Green oxide" should be a desirable material for this purpose when it is available in dispersion form. Interlocks would be designed in the recorder to insure foolproof operation. If we wish to record the sales clerk's number, another tag with the sales clerk's number in coded form would be required. Each clerk would be issued a clerk's tag, and both tags would be used in the point of sale recorder. In this case, if only one tag was in its holder an interlock would prevent a recording. This method of duplicating magnetically recorded information by contact printing was described in 1949 by Camras and Hess. It is felt that this method will give a reliable and economical sales recording. To my knowledge, recorders of this type are not being manufactured at the present time.

![Magnetic Field Diagram](image1)

Figure 2 shows a tag in contact with a section of the magnetic tape.

![Artist Conception of Point of Sale Recorder](image2)

Figure 3 is an artist's conception of a point of sale recorder.

At an increase in the cost of the point of sale recorder, a keyboard could be added. The keyboard would be used to add additional information to the sales record. The linear density of digits with this type of recording is extremely low. However, this eases the mechanical registration of the tags in the recorder and allows a practical tolerance on the size of the tags. One-inch magnetic tape is proposed for the point of sale recorder. The amount of tape required for each recorder would, of course, vary with the volume of sales. Two hundred feet of tape would handle approximately six hundred
sales per cash register. This should be adequate by a factor of 3 to 1 for most cash register stations in the stores used for this case study.

The linear density of recording by the contact recording method is too low to use for extensive data processing. In the interest of saving tape, it is necessary to compress this recording. Rather than construct a special tape compressor, the electronic sorter has a special input designed for these tapes. This tape drive is in addition to the four associated with the sorting process. All contact recorded tapes will be placed on this tape drive. The first pass in the sorting process will receive input data from this unit. As the data is recorded on the sorter tapes, it is compressed to 100 bits per inch. From this point on, all tapes have a density of 100 bits per inch. Clearly, the order of fields to be sorted must be capable of being programmed into the sorter. This could be accomplished by setting a group of switches or by having a plug board for this purpose.

We are now ready to follow the flow of information for the preparation of the daily selling report. The merchandise is received by the receiving department, and a receiving report is prepared. A copy of the report is sent to the buyer. He sets the retail price and sends the report to the marker. The required number of tags for each report is run off with the modified tag machine. The tags are first used to prepare the Receiving Tape. This is accomplished with a recorder similar to the point of sale recorder. However, this recorder is provided with an automatic feed mechanism. Thus, the tags are fed automatically, and the information is contact recorded on the receiving tape. After the tags have been recorded on the receiving tape, they are placed on the merchandise and delivered to the selling floor.

The receiving tape is sent to the Unit Control Center. It is sorted by manufacture number, style number, color code, size, and store number. On completion of the sort, the Master Inventory Tape must be brought up to date. It is assumed that the master inventory tape has been initially prepared on the keyboard-to-magnetic-tape recorder. The master inventory will be required to store approximately 200,000 items. In addition to the information that is sorted on the receiving tape, the master inventory tape will contain the current price of the item, the number on hand at the beginning of the month, the number received during the month, the number sold, and the net number on hand. These last four fields will contain three digits each. The total digits per master record is 32. The receiving tape is run against the master tape in the computer. Each item is totaled and added to the number received. The net balance is calculated and brought up to date on the master tape. This completes the receiving operation.

When the merchandise is sold, the tag is removed and the transaction is recorded by the point of sale recorder. At the end of the day, the sales activity tapes are collected and delivered to the Unit Control Center. It is proposed to process these tapes by department number wherever possible. Since some cash registers are shared by more than one department, a physical
Merchandise received and receiving report prepared.

One copy of receiving report used to prepare string or pin tags.

Information on tags contact recorded on magnetic receiving tape.

Tags

Receiving Tape

Merchandise is tagged and distributed to selling floor.

Tag removed from merchandise at time of sale. Transaction contact recorded on sales activity tape by point of sale recorder.

Sales activity tapes delivered to unit control center.

Sales activity tape sorted by mfg., style, color, size, and store.

Master inventory tape brought up to date on number of items received.

Sales activity tape sorted by dept., class, and price.

Sales activity totalized and summary card punched.

Daily sales report listed from summary cards.

Daily sales report delivered to buyer next morning.

Receiving tape delivered to unit control center.

Receiving tape sorted by mfg., style, color, size, and store.

Master inventory tape brought up to date on number of items received.

Unit Control Flow Diagram
Figure 4

breakdown by departments is not always possible. Assuming that all sales activity for department X are on separate tapes, these tapes would be fed into the sorter and sorted by manufacture number, style number, color code, size, and store. The record length will be expanded so that the net on hand may be recorded on the sales activity tape. The sales activity tape is then run against the master inventory tape, and the sales data and net on hand are brought up to date by the computer.

Unfortunately, it is necessary to sort the sales activity tape twice, since the desired sort from the buyer's point of view in this store is by department number, class, and price line. Thus, the next sort is by department number, classification, and price. The sales tape is now ready to be totalized by the computer and summary cards punched. The summary cards are listed, and the report is delivered the next morning to the buyer. This process is outlined in Figure 4.
The daily selling report contains information which is not available in the present system. Size has been incorporated in this report, and the net on-hand for each store has been included, as well as the total on-hand for all stores. This figure should be of value to the buyer, particularly when an item is moving in one store and not in the others. A glance at the report will tell him from what store to transfer stock without requiring a physical inventory of the stock in all stores. This additional information is obtained at relatively low cost by an electronic system of this type. The format of the daily sales report is illustrated in Figure 5.

**DAILY SALES REPORT**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>11</td>
<td>295</td>
<td>310</td>
<td>2464</td>
<td>5</td>
<td>32</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>2</td>
<td>8</td>
<td>2</td>
<td>38</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>299</td>
<td>64</td>
<td>3911</td>
<td>1</td>
<td>36.5</td>
<td>1</td>
<td>25</td>
<td>2</td>
<td>20</td>
<td>15</td>
<td>20</td>
<td>3</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>310</td>
<td>2476</td>
<td>1</td>
<td>38</td>
<td>1</td>
<td>18</td>
<td>3</td>
<td>16</td>
<td>2</td>
<td>20</td>
<td>1</td>
<td>19</td>
<td>7</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>399</td>
<td>74</td>
<td>118</td>
<td>10</td>
<td>32</td>
<td>1</td>
<td>12</td>
<td>13</td>
<td>13</td>
<td>14</td>
<td>1</td>
<td>14</td>
<td>52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1*</td>
<td></td>
<td>2*</td>
<td></td>
<td>1*</td>
<td>11*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4**</td>
<td></td>
<td>5**</td>
<td></td>
<td>2**</td>
<td>3**</td>
<td>14**</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Subtotal  ** Total

Figure 5

There are several other required reports to be prepared. The monthly price line sales report will be prepared from the daily sales activity tapes. A monthly sales activity tape would be generated in this process and these would be used for the six months' price line report. The master inventory tape replaces the so-called "Black Books" at this store.

Time has not permitted a detailed analysis of the department store problem. Certainly there is much rethinking to be done on present methods in terms of new concepts and possible systems. The department store controllers and store operations managers must join forces with the digital computer systems engineers if electronics is to be successfully applied in this field.

**Bibliographical Reference**