From the collection of the Computer History Museum (www.computerhistory.org)

The RCA BIZMAC System Central

J. L. OWINGS

THE RCA BIZMAC system is a product line of fully-integrated electronic data-processing machines, which has been designed to meet the large volume requirements of commercial applications. A typical large installation may have about 200 separate RCA BIZMAC units. To operate such a large assemblage of machines, a means must be provided for integrating them into an operating unity and for controlling their operation at all times. For the RCA BIZMAC system the "system central" is the integrating element and the focus of all operating activity.

The design of a system central was based on the concept of centralized control of all elements in the system. This concept is well known in other fields for obtaining optimum performance from assemblages of equipments and operators, and is well suited to the field of electronic data-processing machines. A review of the design of the system central that was provided for the RCA BIZMAC system which was supplied to the Ordnance Tank and Automotive Command (OTAC) will show how it is made and how it is used to control the operation of the system.

The RCA BIZMAC Machines

Before looking into the data-processing task itself, a knowledge of the function of the machines in the system and what system central has to do to operate them is necessary. Fig. 1 shows the RCA BIZMAC equipments. They consist of input machines for transcribing data into the system, a magnetic-tape storage file for both long-term and short-term storage of data in the system, processing machines for computing on and rearranging data, output machines for transcribing data from the system after processing, and auxiliary machines which fulfill special system functions.

System Central Functions

To transcribe data into the system it is necessary to select one of the input machines and one of the magnetic-tape-storage units, connect them together, set up the input machine, and operate the two machines. To reduce both operating and equipment costs, the tape units have been designed for automatic operation under the control of the data-processing machine to which they are connected. This is an important system feature, because it means that there need be no occasion for an operator to attend any one of the tape stations during periods of normal operation. This considerably reduces the cost of operating an RCA BIZMAC system.

To process data on one of the major machines in the system, it is necessary to select the proper kind of machine for the job and the particular tape stations which contain either the data to be processed or the reels of magnetic tape which will be used to carry the processed data to the next operation, connect the tape stations to the correct input and output trunks of the data-processing machine, instruct the machine, and proceed with the operation. During the operation it may be necessary to supply more than one reel of data (on magnetic tape) to one or several information trunks of the machine. When one tape is exhausted, the major machine automatically initiates rewind of the tape and requests the next tape. It is then necessary to select the proper tape station from the storage file and the machine trunk which needs the tape, connect the two, and continue with the operation.

To transcribe data from the system it is necessary to select an output machine and the tape station which contains the data to be transcribed, connect the two, set up the output machine, and transcribe the data.

These functions, i.e., selecting, connecting, instructing, and operating, are fundamental in the operation of an RCA BIZMAC system and, as such, must be provided in the design of system central. Another essential function is over-all control of the operation of the system. The principal areas for control which system central is responsible for are: the orderly execution of data-processing operations, the location of all data which are on magnetic tape, the setup and operation of all machines in the system, and the work which operators do. With these functions in mind, a typical example of a particular job is given, and the resulting design of a system central is presented.

Owings—The RCA BIZMAC System Central
As mentioned previously, data are processed through the system in batches. Each batch may be released to the system as soon as the detailed plans for operation have been completed. Therefore, there may be more than one batch of data in process on the equipment at one time. Fig. 5 shows how, in a typical operating situation, cycles may overlap during normal system operation. Cycles are introduced into the system at irregular times. The time needed to complete a cycle is only roughly known at the outset and may be radically changed by unforeseen or unanticipated operating conditions. This means that detailed scheduling of the use of data-processing machines and tape stations is not practical or desirable. The most desirable situation is to use the machines and tape stations when they are available, and control the order in which things are done instead of the time at which they are done. This then, is the situation which system central was designed to accomplish.

The System Central

Fig. 6 is a diagram of the system central which was designed for this system. This diagram shows system operation under control of system central. The lightning strokes show the system operator's control over both the operating team and the system machines. The broad arrows show the flow of operating instructions from the operating team into the system, and the feedback from the system to the operators. In addition to these operators there is another group of operators located at the various input and output machines which require manual setup and operation. The work of these operators is strictly controlled and co-ordinated with the activity in the system central control room through procedures and the use of the operation cards.

To assist the operators in performing the functions of selection, connection, instruction, and operation, system central contains a switching unit, an operation control unit, and a set of consoles and control panels for the operators. The switching unit consists of electromagnetic relays of a special design to provide reliable operation for long periods of time. Fig. 7 is an example of the kind of relay which was the basic element used in the switching unit to connect tape stations to machine trunks for operation. The operation control unit supplies the checking, lockout, transfer, and other functions needed to set up elements of the system for operation, guard the system against improper operating routines and operator mistakes, and return the monitoring information needed by the system operators. The consoles, as shown in Figs. 8 through 10, provide the work space and control panels needed by the system central operators to perform their duties. These consoles were human-engineered to make operation simple and straightforward for the operators, and to be comfortable to work at for long periods of time. The operating functions of direction, setup, and monitoring were separated and provided on separate consoles on the basis of the amount of operating load which was required for each of these functions in this system.

Human Engineering

The system central provisions for selecting, connecting, instructing, and operating machines have been reviewed. Now the provisions for controlling the proces-
The system central design leaned heavily upon know-how in the field of human engineering, because it was very important that the system be easy to operate and at the same time protected from mistakes which the operators might make. It is easy to see that a wrong connection, or a wrong machine setup, or an operation done out of order, might cause destruction of valuable data and great loss in time. To avoid these things, tight control was provided for all operator activity. Fig. 11 shows the flow of operating instructions among the system operators, and the checks used to guard the system against operator mistakes. This is a closed-loop type of operation, and is based upon a scheduling technique which was developed specifically for this job. It permits the use of both data-processing machines and tape stations on essentially an availability basis, yet provides tight control over the flow of data through the system. It also permits the processing of several batches of data through the system at the same time.

**Schedulers**

The schedulers receive, from the planning group, sets of detailed instructions for processing batches of data, and, from the operating group, both status indications on the progress of work already in process on the machines, and indications of tape stations which were available for handling new data. With this information, they complete the preparation of operation cards for all the operators. To avoid the consequences of human error in doing this work, two schedulers are used. They work independently at filling out identical decks of operation cards and the correctness of their work is checked by the interim scheduler, who inspects completed cards for identity and rejects cards containing errors. This procedure, called verification through independent duplication, is a powerful tool for checking the accuracy of operator performance. It enables the operators to work quickly at simple tasks and is quite effective for spotting errors made by either of the two people who do identical work.

**Interim Scheduler**

The interim scheduler controls the distribution of operation cards to all operators. He has to make sure that the system is ready for each operation before he releases the cards. To do this he receives operation cards for completed operations from the operators and checks them off against a list of prerequisite operations. Each operation card has a list of prerequisite operations which must be completed before it can be released. This list is prepared by the planning group and
forwarded to the control room as part of the operating instructions. The purpose of the list is to provide a routine procedure for controlling the order in which operation cards are released to the operators, and thereby control the order of processing data through the system. When the cards are delivered to the system operators, the system is ready to handle the data as soon as machines are free. The work described thus far requires judgment and decision-making by the schedulers. In this system also, there is a considerable time lag between the release of operation cards and the actual setup and operation of the machines. This time lag is a very important factor in allowing enough time for judgment in filling out the cards, checking them, and determining when to release each card.

System Operators

The actual setup and operation of machines is done by the system operators. These people consist of a system operator who selects machines for operation and directs all operation, a monitor who keeps track of the progress of operations in the system as well as the operating status of machines, two teams of operator-verifiers who set up machines and connect tape stations to machines for operation, and a group of input, output, and auxiliary machine operators who set up and operate the machines which are not directly operated from the control room. All the operators work from operation cards.

The monitor receives operation cards from the interim scheduler and checks to make sure that the prerequisites have been met for each operation before he releases the card to the system operator for action. This checking procedure, called double checking, is useful for finding errors in very simple tasks. It is not so effective as verification through independent duplication, but it is faster.

The system operator receives cards from the monitor, selects machines for operation, and releases the setup to an available operator-verifier team. The selected operator-verifier team refers to its operation cards, and then each one proceeds independently to make identical setups on different consoles. The system central operation-control unit checks the identity of the setups, rejects errors, and transfers correct setups to the machines in the system. This is another form of verification through independent duplication, only, this time, a machine is used to check the identity of the work of the operators. This not only checks the operator and verifier but also pro-

From the collection of the Computer History Museum (www.computerhistory.org)
vides a second check on the identity of the work of the schedulers. When the setups are complete, the monitor checks his displays to make sure that the equipment functions properly, then signals the system operator that the operation is ready to proceed. The system operator starts the machine and then goes on to other work. At times of peak activity in the system, the system operator has both operator-verifier teams busy making setups for different operations at the same time.

The activities of the operators at the consoles are co-ordinated with the control room through the handling of the operation cards. The operation cards contain detailed instructions for machine setups, and each operator has to supply a written record of certain critical information with regard to how he did his work. This is checked by a floor supervisor before other dependent operations are permitted to go ahead.

All these operating procedures described were reduced to simple routine actions, and the procedures were made similar for all operations. This made them easy to learn, and easy to do. The operators at the consoles had very simple decisions to make, and could work fast to keep machines busy. The procedures used and equipment checks provided the necessary safeguards to protect the system against the consequences of mistakes by both the schedulers and the operators. Thus, human engineering provided the know-how for operating the equipments and controlling the processing of data through the system in a manner which was easy for operators to learn and do.

Consoles

The design of the consoles for the operators who work in the control room was an important factor in making the work easy for the operators and enabling them to work quickly and accurately. Fig. 12 is a close-up view of the system operator's console. On the left side of the vertical section are status indications for the most heavily used machines in the system. On the right side of the same panel are control buttons for the most important machine functions. In the center of the sloping panel is a register control for indicating the operation the system operator wants to initiate, and for selecting the machines he wishes to do the work. On the right and left sides of the
same panel are the team-control sections. The controls and indicators on these panels are arranged in the sequence for normal use, and follow the same design principles used in connection with the design of the control panels for the input and output machines.

Fig. 13 shows the control panels for the operator-verifier consoles. The vertical panel contains directions for action and registers for displaying the number of the operation card which is to be used for the machine setup. The sloping panel contains the controls used for connecting tape stations to machines and for setting up the computers and sorters. The controls are arranged for sequential operation from left to right. Color is used to separate the function of tape connection from machine instruction, and indications are provided to tell the operator whether or not his work is in agreement with his partners'. A call button is provided for signaling the system operator if there are operating difficulties. To make the work at these consoles even easier, the operation cards were designed so that the information was displayed on the cards in the same arrangement as the controls on the console. (See Fig. 4.)

Fig. 14 shows the vertical section of the monitor's console. This panel displays the operating status of each tape station in the system. Fig. 15 shows the sloping panel of the same console. This panel displays both the operating status of the sorters and computer, and the status of the data-processing operation which is in progress on each of these machines.

The human engineering of the system was carried beyond the system central control room to include all those areas where operators work with machines and
must be directed and co-ordinated from the system central. This included the design of control panels for operating the input, output, and auxiliary machines in the system. A brief review of the results of this effort will show how human-engineering principles lead to good equipment design.

The controls and indicators needed for the operation and maintenance of each machine were first divided into two classes, i.e., operation and maintenance. Where possible, those needed for operation were grouped on an operating panel, and those needed for maintenance on a maintenance panel.

The operating panel was made easily accessible to the operator and the maintenance panel accessible to the maintenance man. The operating panels, controls were limited to a single design of push-button light which contains a light inside the button. This push-button light was specially designed for the RCA BIZMAC system. Indicators were limited to three colors: green, amber, and red. Throughout the system, green generally means: go, the situation is normal, or, proceed with the operation. Amber indicates normal operation—no operator action required. Red indicates trouble, an operating status which is not normal. The names of similar controls and indicators were made the same on all control panels. Directness of meaning, common usage, and avoiding the use of abbreviations were important considerations in choosing names. Names were chosen for controls to tell the operator what would happen when the control was activated. The indicator names tell the operator what has happened or what was happening.

All control panels were designed with large readable letters and good contrast between letters and the background. Careful attention was paid in the selection of material to avoid glare.

The control panels for the input, output, and auxiliary machines were all similar in design and laid out so that an operator could easily learn to operate any machine. The panels were divided into three sections. The section on the operator's right contains all the controls and indicators which are used for normal operation and which are similar among all machines. The section on the operator's left contains all the controls and indicators associated with abnormal or faulty operation. Wherever possible, the indicators for similar functions on the right and left side are opposite each other to make it easy to notice the cause of trouble. The center section of each panel contains the controls and indicators which are peculiar to the specific machine, or were placed in the center section to focus attention.

The basic pattern for arranging the controls and indicators follows the simple sequence: (1) an indicator to indicate the requirement for operator activity, (2) a control to effect the required action (push button), and (3) a feedback (light inside the push button) to indicate the successful accomplishment of the act. Where possible, the controls and indicators were arranged in sequences from top to bottom or left to right, in the order of normal use, to guide the operator and provide simple habit patterns. This procedure makes machine operation simple, straightforward, and easy to learn. When followed on all machines in the system, each operator can easily learn to operate any machine. Operators are interchangeable. New operators can be quickly trained.

An example of the control panel for the paper tape transcriber will illustrate some of the human-engineering design features which were mentioned. Two panels are shown for this machine to emphasize the value of styling, proper panel layout, and lettering. Fig. 16 shows the panel before human-engineering design. Fig. 17 shows the panel after the studies had been completed. The basic design shown in Fig. 17 was used on all input, output, and auxiliary machines in the system.

Summary

To summarize what has been said, return to Fig. 6. The system central is the focus of all operating activity for an RCA BIZMAC system. Its design includes providing the means for selecting machines for data-processing tasks, and tape stations for working with these machines, for connecting tape stations to machines, for setting up machines for operation, for operating the system, and for controlling all the things which contribute to co-ordinated and integrated system performance. Human engineering played a large part in making the system easy to operate and providing the know-how to protect the system from the effects of operator mistakes.

Through the use of the system central, the task of operating the system has been reduced to the point where a few operators located in a centralized control room can control the operation of about 200 machines, and rapidly process large quantities of data through complicated operating routines in a controlled and orderly fashion. This facility permits high utilization of data-processing equipment, provides effective control over the accuracy and efficiency of all aspects of data processing, makes it easy to accommodate changes in requirements, and does this all for a low investment in provision for operation.