INDUSTRIAL DATA PROCESSING APPLICATIONS REPORT

Applications	Process Control and Management Information Systems
Type of Industry	Paper and Packaging Manufacturer
Name of User	The Mead Corp. Dayton, Ohio
Equipment Used	IBM 1710 Process Control Systems IBM 1050 Data Communication System IBM 1401, 1410 and 1440 Data Processing Systems

Synopsis

The Mead Corp. is currently involved in efforts aimed at creating a fully integrated, company-wide management information system. The company's application of an IBM 1710 control system to papermaking is considered an essential element in the total information system.

The process control system encompasses most of 175 important variable control factors connected with operation of the papermaking machine. Several factors are under closed-loop computer control, that is, are continuously controlled with the use of the 1710 computer. This ensures minimum variation in the basis weight of paper produced.

The IBM 1710 control system, installed first on the number four paper machine at Mead's Chillicothe (Ohio) Paper Co. Division and now used also for process control on an adjoining machine contributes to more uniformity in terms of quality and to increased production efficiency.

The Mead Corp. is well on its way toward a total information system. Computer-based operating and information systems are operative in order entry and status reporting, production scheduling, requirements planning and inventory management, manufacturing control, forecasting, marketing and accounting.

Management of Mead Corp. (annual sales over $500 million and ranked sixth in the industry) has been involved in a continuous program to implement a comprehensive computer-based systems concept embracing every phase of corporate and line operation. The logic design alone for this program, called Project SCOPE (System to Control and Optimize Planning Effort), is valued at a quarter of a million dollars.

The approach, from the start, has been to establish the management information system concept as the dominant, overriding goal and every job-oriented computer installation that has gone into a Mead facility -- mills, packaging plants, research laboratory, sales offices or subsidiary company -- has been dovetailed to the basic information pattern. Further assurance of systems compatibility, in equipment, programing and procedures, is provided by a project team. The information program also enjoys the unqualified backing of top Mead management.

Mead is now better than half way along in accomplishing this program. Computer-based operating and information systems are operative in order entry and status reporting, production scheduling, requirements planning and inventory management, manufacturing control, forecasting, marketing and accounting.

Linear programing and mathematical model techniques are in use to project product demand, taking into consideration market trends and seasonal factors; to allocate forecasted production to all 24 of the company's papermaking machines; to provide a master schedule showing when, how often and in which sequence (run frequency and cycles) the various products should be run; and to provide a production schedule starting with the final trimming operation on the paper machine through finishing operations to the warehouse.

Work-in-process, stores and raw materials and finished product inventory control is fully automated. Accounting has become more dynamic, with the establishment of exception reporting to spotlight cost and profit contribution on a level-by-level basis. The information system produces a margin statement to show profit per ton and profit per hour, per machine and per manufactured item.

Currently, an IBM System/360, Model 50 is functioning at Dayton headquarters and IBM System/360, Model 20s are installed at the paper mills in Chillicothe and Kingsport, Tenn. Two IBM 1710 Control Systems are functioning in process control and these are slated for replacement by IBM 1800 Process Control Systems. Additional IBM System/360s, Model 30s and a variety of data communications devices are also on order.

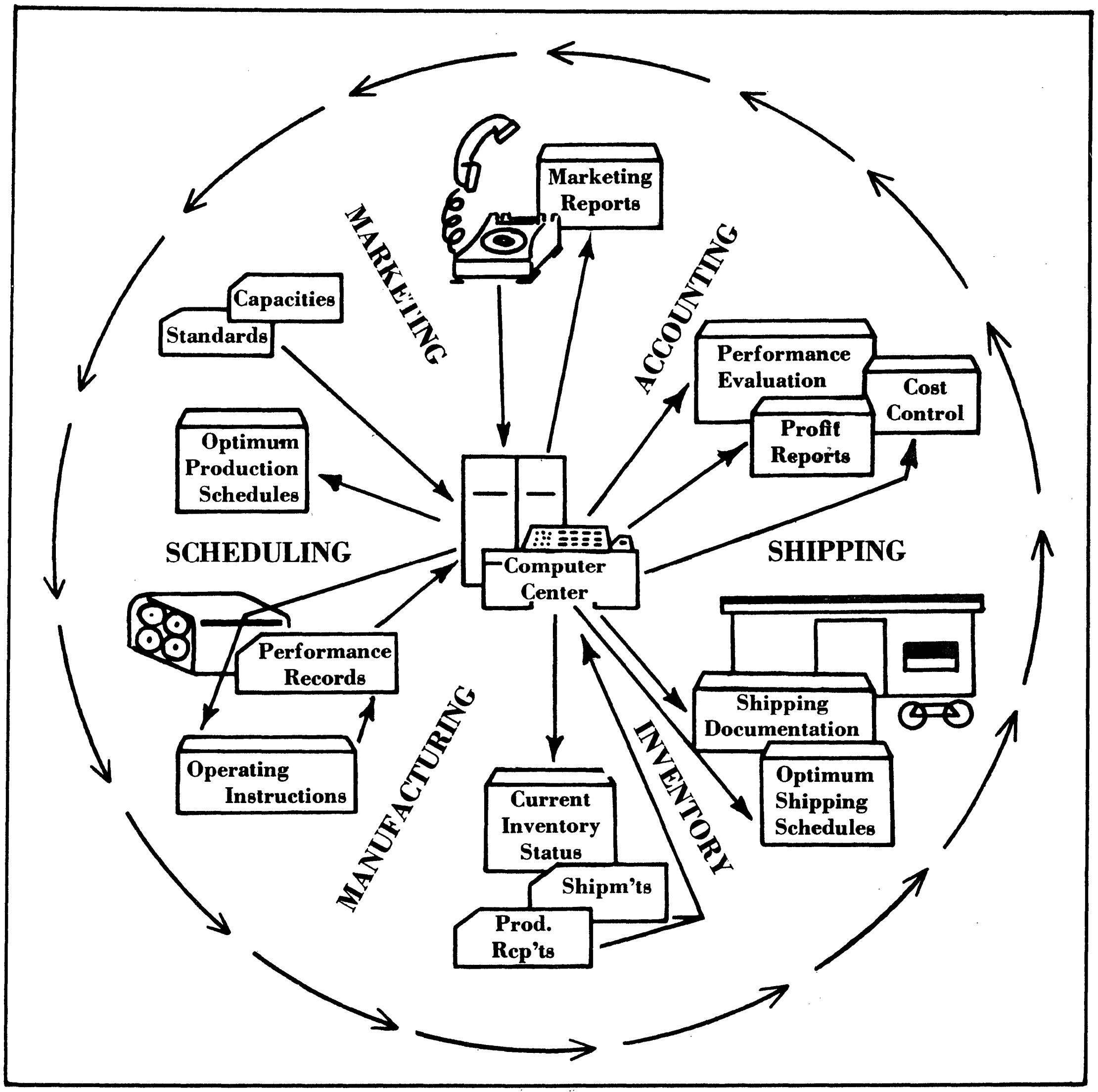
"We expect," says Vice President R.A. Gilbert, "to develop a computer-based information system whereby corporate management, which determines the overall direction of the company and sets the goals, will have the dynamic data it needs to guide the business on its most profitable course. Operating management, responsible for implementing corporate aims, will get the performance reports it needs on a real-time basis to help capitalize on opportunity while it exists or avoid trouble buildups before they can become serious. Progress will be continually measured against objectives and, for the most part, on an exception basis."

Mead's management information system concept originated a few years ago with a decision to automate the White Papers Group. Initial objectives were three-fold:

1. To improve customer service, through more effective scheduling of production machines and more current inventory and work-in-process status information.

2. To improve the quality of products, through implementation of higher performance standards and the application of computer capabilities to production equipment.

3. To improve cost performance, through more responsive scheduling and sequencing in production cycles. This, of course, would include more effective control of the papermaking machines by means of feedback control -- sensitive instruments, interrogated by the computer on a pre-set schedule.



TOTALLY INTEGRATED SYSTEM EMBRACES ALL ASPECTS OF THE COMPANY'S OPERATIONS. INCOMING ORDER IS CHECKED FOR CREDIT AGAINST MASTER A/R FILE, CHECKED FOR REQUIREMENTS AVAILABILITY AGAINST FINISHED STOCK INVENTORY SYSTEM. IF MAKE ITEM IS CALLED FOR, CONTROL COMPUTER SCANS OPTIMUM PRODUCTION SCHEDULE FILES, ASSIGNS A MANUFACTURING DATE AND RECORDS THAT DATE WITH SHIPPING COMPUTER. THE COMPUTER RELEASES OPERATING INSTRUCTIONS TO MILLS, GETS BACK PERFORMANCE DATA TO UPDATE STATUS RECORDS AND BREAK OUT VARIOUS MARKETING, PRODUCTION AND MANAGEMENT CONTROL REPORTS. ALL ALONG THE LINE PERFORMANCE EVALUATION AGAINST OPTIMUM SCHEDULES AND AGAINST STANDARDS ARE PULLED OUT FOR CONTROL OF COST AND PINPOINTING PROFIT CONTRIBUTION.

Because the papermaking process is the key to all these objectives, it was decided to concentrate attention on automating the paper making machines. Lending impetus to this decision was a rapid expansion of Mead's paper line (some 600 grades and basis weights) and growing customer demand for a more uniform product, run-to-run, at competitive prices.

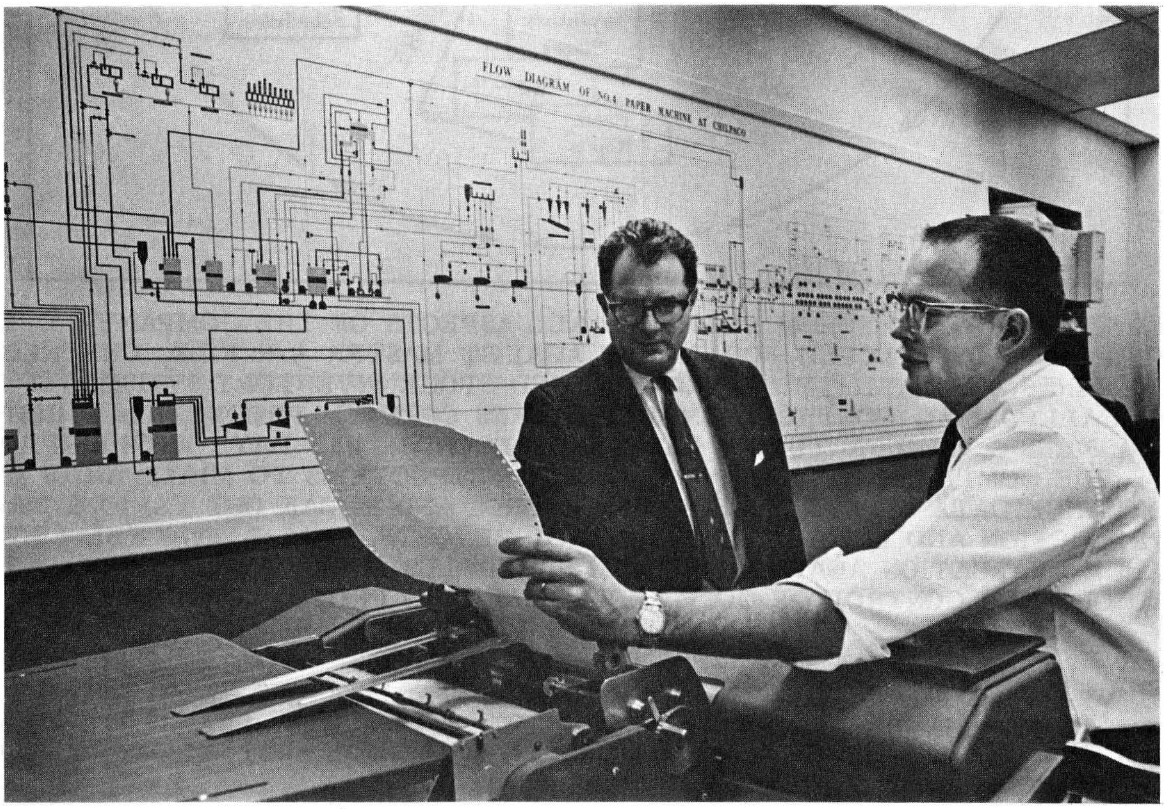
Research and development aimed at designing a control system got underway in 1962 and a task force was formed made up of research engineers, a division process engineer and computer programer, a corporate engineering department instrument engineer and systems and engineering support from the corporate information systems department, and from IBM.

Critical path scheduling techniques were used in designing the physical setup for computer equipment, in analyzing the papermaking process and in the specification and installation of instrumentation. After intensive review of available computer equipment and programing support, the 1710 system was installed.

Basic objectives, according to J.D. Maloney, associate director of Mead's central research laboratories, were to utilize the computer as a key tool in increasing product uniformity and to improve operating efficiency by cutting down waste, broke, machine downtime for grade changes and the percentage of time the machine operated at less than potential. Equally important was the opportunity the computer would afford to apply a systems engineering approach to learn more about the many imponderables inherent in papermaking. The importance of coordinated process engineering, systems engineering and research engineering in a project of this nature cannot be overemphasized.

The 1710 project team concluded that two steps had to be taken before computer control could become feasible. First, operations had to be stabilized as much as possible and, second, some measure of standardization for producing each grade of paper had to be established.

Stabilization of the papermaking process was no easy task. It involved an extensive engineering reappraisal, from one end of the machine to the other. Instrumentation had to be checked very carefully to make certain that all sensors were properly placed and calibrated and that all control elements were adequate and in good working order. New instrumentation was added for additional



OPERATING INSTRUCTION AND PRODUCTION REPORTS ARE PRINTED IN THE COMPUTER ROOM AT CHILLICOTHE PAPER CO. FLOW CHART OF PAPER MACHINE IS IN BACKGROUND.

measurements of temperatures and pressures at various points along the materials flow, especially in the stock preparation and Fourdrinier areas. In certain machine areas, process piping was redesigned and in others the procedures were modified to assure maximum feedback of control data.

Standardization of machine operations was even more of a problem. Traditionally, the papermachine operator is the key man in production. He learned his trade after a long apprenticeship and developed his own ways of doing things and, as a result, there was a good deal of variance in control techniques and procedures from operator to operator and even from run to run. The standardization problems faced by the project team was not simply a case of enforcing a set of production standards established by management directive.

Rather, the standards procedure at Mead has been a dynamic one from the very beginning. It involves careful data collection and analysis; the isolation and description of "good" control techniques under varying circumstances; the setting of preliminary standards; and the never ending checking, revising and adopting of operable standards which permit the right measure of operator discretion within acceptable product tolerances. Mead officials point out that the machine operator is an essential part of the process control system of papermaking and will remain so.

The procedure involves use of the 1710 computer for data collection, analysis and evaluation, as well as to provide data supervision and operator guidance. In the earliest phase of the project, some 36 of the most important wet end variables on the machine were logged on a computer print-out every fifteen minutes and readings made available to supervisors and operators. This logging method proved unwieldy and was replaced with a program in which the computer triggered an operator alarm when control factors approached off-standard conditions based on preset limits.

The first loops were closed for complete computer control. These were on the stock valve, dilution valve, machine speed and Jordan flow affecting basis weight. Closed loop control of grade change was accomplished and the system now operates in both closed loop and operator guide capacities.

Results of using the combination of systems engineering techniques and computer control on the No. 4 paper machine at Chillicothe were successful to the extent that management decided to utilize the 1710 to establish basis weight control and standard operation of the wet end of the adjacent No. 3 paper machine. Necessary instrumentation was added to No. 3 and the 1710 control system now functions in closed loop and operator guide capacities with both the No. 3 and No. 4 machines.

An additional 1710 is operative on Mead's newest paper machine at the Kingsport mill. The initial function is to provide data for establishing standard operation as soon as possible and for complete production information reporting.

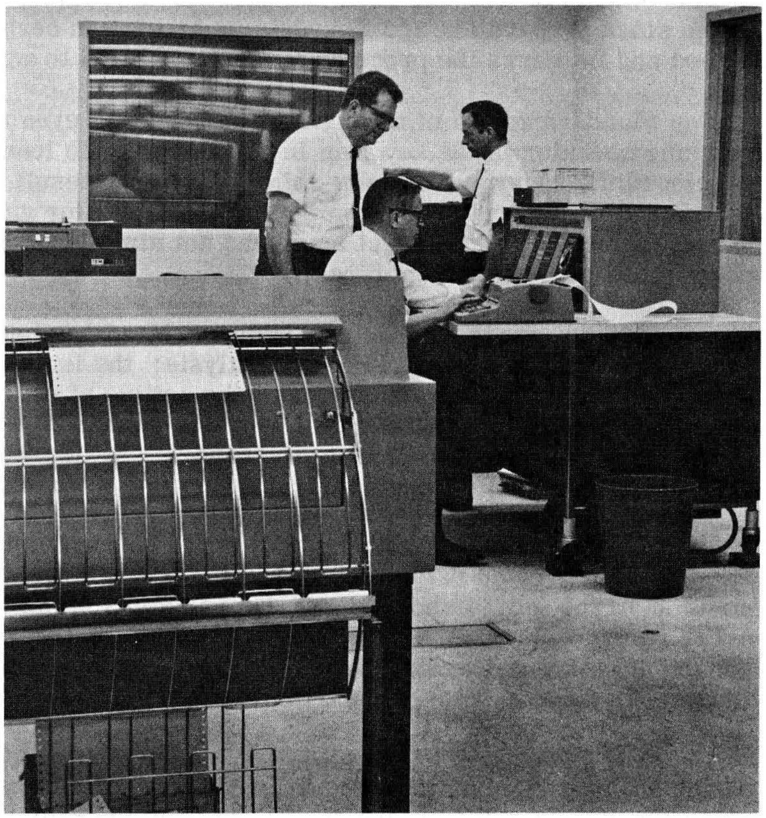
THE PROCESS CONTROL SYSTEM

The 1710 control system at Chillicothe is housed in an air-conditioned room built over the wet end of the No. 4 paper machine. The system configuration is built around a 1620 processor with 40K storage and includes a sorter, keypunch, printer and two IBM 1311 magnetic disc drives, each capable of storing up to two million characters of information on interchangeable disc packs. The disc packs greatly expand data storage capacity for on-line processing, including linkage to the instrument sensors. Conversion of analog signal readings is handled by a 1712 multiplexer and 1711 data converter. The 1711 feeds analog signals directly to the 1620 processor without off-line conversion. All messages (impulses) between the processor and instrument sensors or manual entry units are channeled through the multiplexer.

Instruments on the paper machine are connected to one of three trend recorders or a plotter linked to the computer via a special terminal connected to the multiplexer. Use of the trend record-

COMPUTER CONTROLLROOM

AT KINGSPORT PLANT.



ers is, however, more valuable at the outset of a process control project and, now that the program is established, they are not used as extensively.

A 1053 logging typewriter and manual entry unit is located at the dry (exit) end of the paper-machine for use by the backtender. A print-out typewriter at the wet end provides the operator with guidance messages from the computer. The stock proportioning operator also has a manual entry unit and typewriter at his disposal and another is located in the stock preparation area. The control laboratory has a manual entry unit which permits input into the on-line computer system which are off-line to direct process control but real-time in data collection. A second 1710 control system is located at Mead's central research laboratory. This is employed in research into the basics of the papermaking process and allows development of computer programs without interfering with on-line control.

About 200 sensing and control points along the length of the paper machine are monitored by the on-line system to provide some 170 analog inputs. These include 51 temperature inputs, 48 flows, 32 pressures and vacuums, 7 consistencies, 9 power inputs, 9 levels and 14 miscellaneous inputs. Speeds of the rotating shafts on the machine are brought in by a digital channel and some 75 contacts are recorded for on-off position.

On-line outputs from the computer include set point control of the Jordan flows, speed of the paper machine and water flow to the headbox. This set-point control over the stock flow is based on on-line measurements from the dry end of the machine to control basis weight and is a true, closed-loop control in the conventional sense. Closed loop control of moisture and Jordan flows has also been implemented.

In the operator guide aspects of the program, the computer works with about 25 of the more important of the 175 variable factors, A set of limits has been established for these variables and deviation triggers a message print-out at the operator's typewriter station. The print-out shows the time of the deviation, the variable factor and the measurement. A signal light comes on when such a deviation printout is made to flag the operator's attention. If the deviation persists a repeat message is typed out and the warning light at the logging station remains on until the operator pushes an acknowledge button.

This operator guide deviation routine has been integrated with the evolving standards program so that the standards will always provide the base values to which acceptable deviation limits are applied. So far, about 15 variables -- such as headbox pressure, stock flow to headbox, speeds, pH and temperatures -- have been standardized on all grade runs. The operator guide aspects of the program are accomplished by processing standards data and suitable control strategy data involving the size of the run order and the time of the variable change.

The on-line control program is invaluable as a research tool to unlock some of the mysteries in the papermaking process and for planning and developing future applications of computer control to the paper machine. A material balance program, for example, yields extensive on-line data useful in predicting retention factors on the paper machine wire, which is one of the long standing imponderables in papermaking.

The material balance program is a mathematical model for determining water content, fibre, filler and flow rates of the process streams and then calculating a balance. Using the balance data, statistical models have been developed for the basis weight, headbox ash, retention, drainage and formation on the wire. These models are not currently being used in the process control routine, but will be and the computer's ability to work with such statistical models promises a major breakthrough in feed-forward control of the entire papermaking process, from wet end to final product.

The process data gathered and evaluated on-line furnishes a basis, also, for a dynamic analysis program. Mead officials believe this program will open up potential for assessing the stability of systems and permit faster machine startups (an aspect already being implemented on the new Kingsport machine), grade changes and run interrupt recovery.

RESULTS AND FUTURE PLANS

The IBM 1710 Control System, improved instrumentation, better standards and the cooperative efforts of research, systems and process engineers are credited with substantial contributions in papermaking. Measurement of results on the No. 4 machine showed a 20 percent decrease in grade change time; a 15 percent increase in operating speed; a two percent increase in machine efficiency and a 19 percent increase in production. The production improvement implications alone are important because of the cost of the paper machines. The payout from even a fractional increase in yield is considerable.

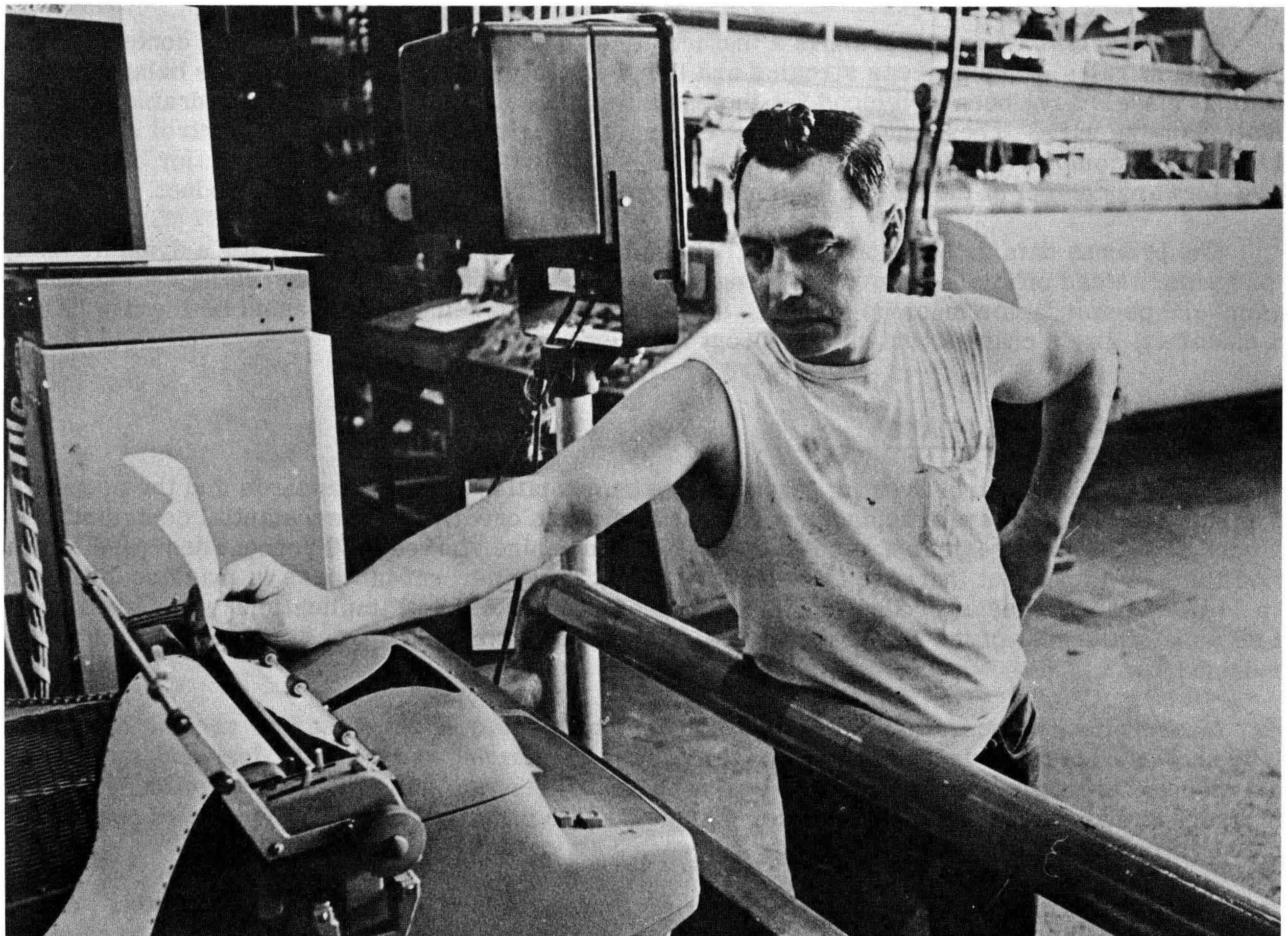
Measurement of operating results on the No. 4 machine over the first four accounting periods of 1966 show a 28 percent in broke (interrupted run), 25 percent reduction in lost and down time, a four percent improvement in machine speed and a 12 percent increase in production. These later figures relate to operations of the No. 4 machine with paper of substantially altered grade structure and differeing quality requirements.

Similar results have been recorded for operation of the No. 3 machine at Chillicothe, controlled by the same 1710 system. And expectations are high for even better results from process control applications on the new machine at Kingsport, one of the largest and fastest in existence.

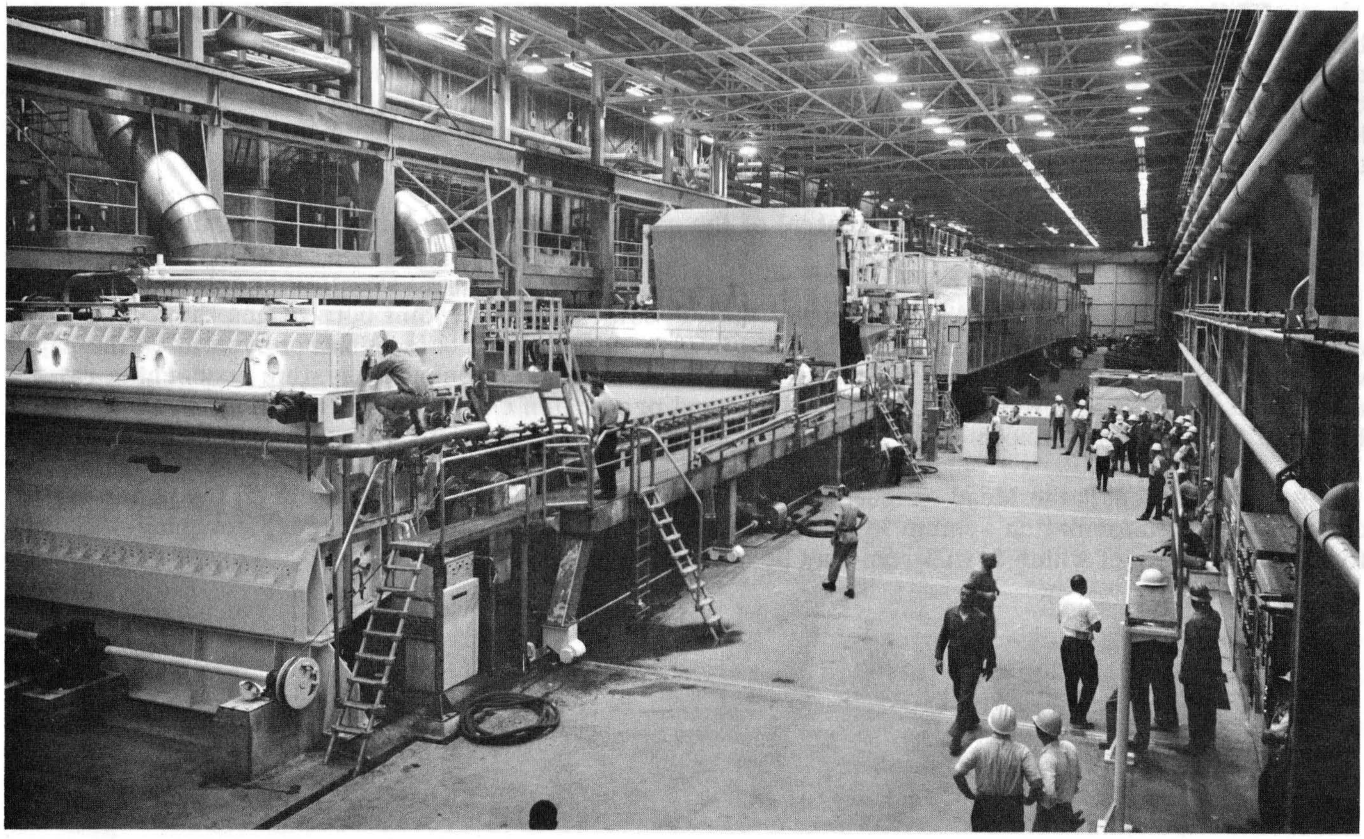
In addition to production payout, the process control system makes a real contribution to the company's marketing effort. This is because the many variables on the paper machine can be held to closer tolerances, resulting in a more uniform product run to run. The ability to guarantee such uniformity is an increasingly important facet in customer satisfaction.

And, according to Dr. John C. Redd, vice president of research, the system is a powerful research tool. "By collecting data on a real-time basis we can made projections and simulations to show what would happen if we were to alter various machine operations; to show how to get the machine up to paper grades it has never run before; or how to set up higher run speeds than any that have ever been achieved before. As paper machines run faster and faster, we must rely on instruments and new control devices to keep pace with the new technology and with stepped up demands of the market -- volumewise and varietywise."

Mead president George H. Pringle points out that the computer's performance on the No. 3 and No. 4 machines at Chillicothe was a big factor in the company's decision to apply the control system to other paper machines. The four IBM 1800 Data Acquisition and Control Systems on order each are capable of controlling several paper machines simultaneously, broadening the opportunity for process control expansion.



REPORTS ON PROCESS VARIABLES AND INSTRUCTIONS FOR ADJUSTING THE PAPER MACHINE ARE ISSUED BY COMPUTER AND PRINTED OUT.



PAPER MACHINE AT KINGSPORT, TENN. IS CONTROLLED BY COMPUTER.

From the corporate viewpoint, the success with process control is important in Mead's overall plan for a company-wide management information system. As the key production facility, the paper machine is the basis for the ultimate goal of dynamic, real-time operating procedure, which when fully implemented will work like this:

The trigger for the total systems approach is the customer order which is dependent, in the final analysis, on the performance of the paper machine. In a fast computer run, the incoming order will be first checked for credit against master A/R files, checked for requirements against current stock inventory records and, if available from stock, immediately scheduled for shipment through the related computer control shipping system.

If the order calls for a make item, it will enter the schedule control computer system which will scan current production schedules and in-process inventory, assign a manufacturing date and record that date with the shipping control computer. Schedule control, meanwhile, will be constantly monitoring its own system, updating production status and performance and keeping surveillance over set order production, then issuing appropriate order instructions to the producing mill, including operating and raw materials specifications.

As the mill operations go forward, data collection devices will inform the mill computer center of the progress of the order and this data will be distributed by the master control computer at headquarters to the appropriate computer control system. Item withdrawal from stock and materials withdrawal records will be continuously updated, as will the sub-systems for sales analysis, forecasting and economic data and cost analysis, which will incorporate both standards and production run expense.

While all this is going on, three vital sub-systems -- inventory levels calculations, production run frequency calculations and standards determinations -- will use simulation and mathematical model techniques to predict order status and mill requirements in advance and linear programing techniques to minimize costs and maximize profit contribution. All along the line, the sophisticated information system will flag the attention of corporate and operating management to exception situations and also will provide all needed performance and control reports.

Without the tight, responsive control of the papermaking process itself, the ultimate system could not be implemented.

As both Dr. Redd and Administrative Vice President Gilbert point out: "Once the total information system we are working towards is fully implemented, the process control system on the paper machines will be essential to supply information to the corporate computer system concerning raw materials usage, machine and production status and production costs, on a continuing, dynamic basis. Because the paper machine is so basic to company operations, this will allow for true optimization.

"In essence," the Mead executives conclude, "the process control system on the paper machine is a total information system in miniature, functioning much like the larger, company-wide information system of which it will someday be a part."