INDUSTRIAL DATA PROCESSING APPLICATIONS REPORT

Applications	Integrated Information System
Type of Industry	Steel
Name of User	Richard Thomas & Baldwins, Ltd. Spencer Works Llanwern, Wales

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Equipment Used	One GE-412 Process Computer Three Elliott 803 Computers Friden Flexowriters Nine Creed 75/5W Printers 42 Plant Keyboards Creed Paper Tape Punches and Verifiers I. C. T. Unit Record Equipment Elliott Unit Record Equipment

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Synopsis

Richard Thomas & Baldwins, Ltd. is well on its way to implementing a total system at its Spencer Works in Llanwern, Great Britain. The integrated information and control system uses three Elliott 803 computers for the data handling portion of the system and a GE-412 to control a hot-strip mill.

Automated and automatic control systems now in operation at the Spencer Works control production, provide for an information handling system and operate the continuous hot-strip mill.

The four computer systems make up a hierarchy system. At the top of the hierarchy structure is the advanced scheduling and plant optimization computer system which schedules the operations of the plant for future shifts.

Richard Thomas & Baldwins, Ltd. has undertaken the development of a system to control a complete industrial plant at its Spencer Works. The integrated data handling and control system does not make the 1,700-acre Works fully automated but is applied to particular links in the production chain. In the present stage of operation, the systems are regarded as "island developments." Automation at the Spencer Works of Richard Thomas & Baldwins is, in effect, the linking of these islands with a high-level control device such as a computer so that integrated control of the production processes is achieved.

The automated and automatic control systems now in operation at Spencer Works are designed to:

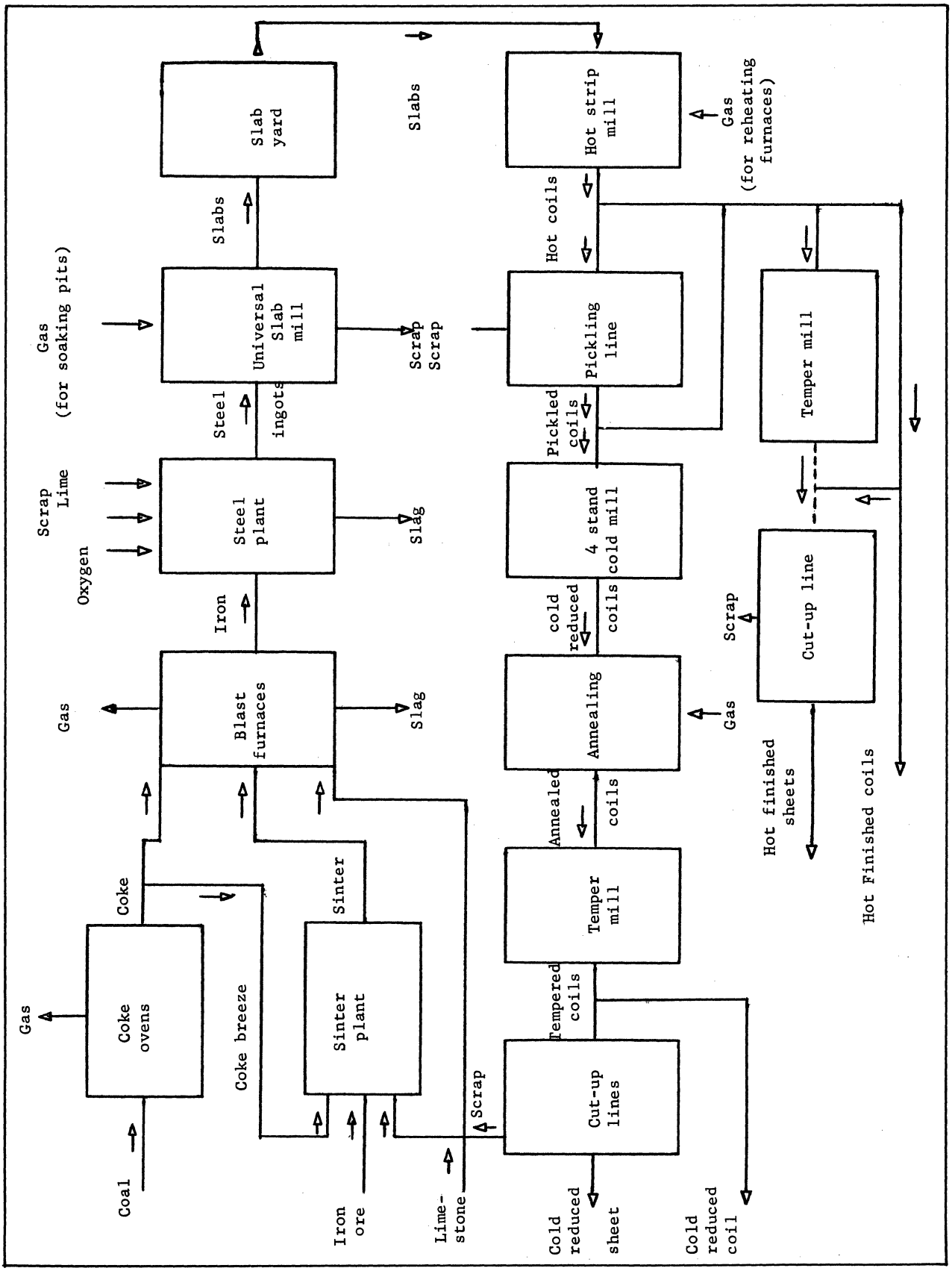
1. Control production from the scheduling of customers' orders so that standards of quality, delivery, commitments and customers' technical requirements are set.

2. Provide an information handling system covering operations from the teeming bay in the steel plant to the down-coilers in the hot mill.

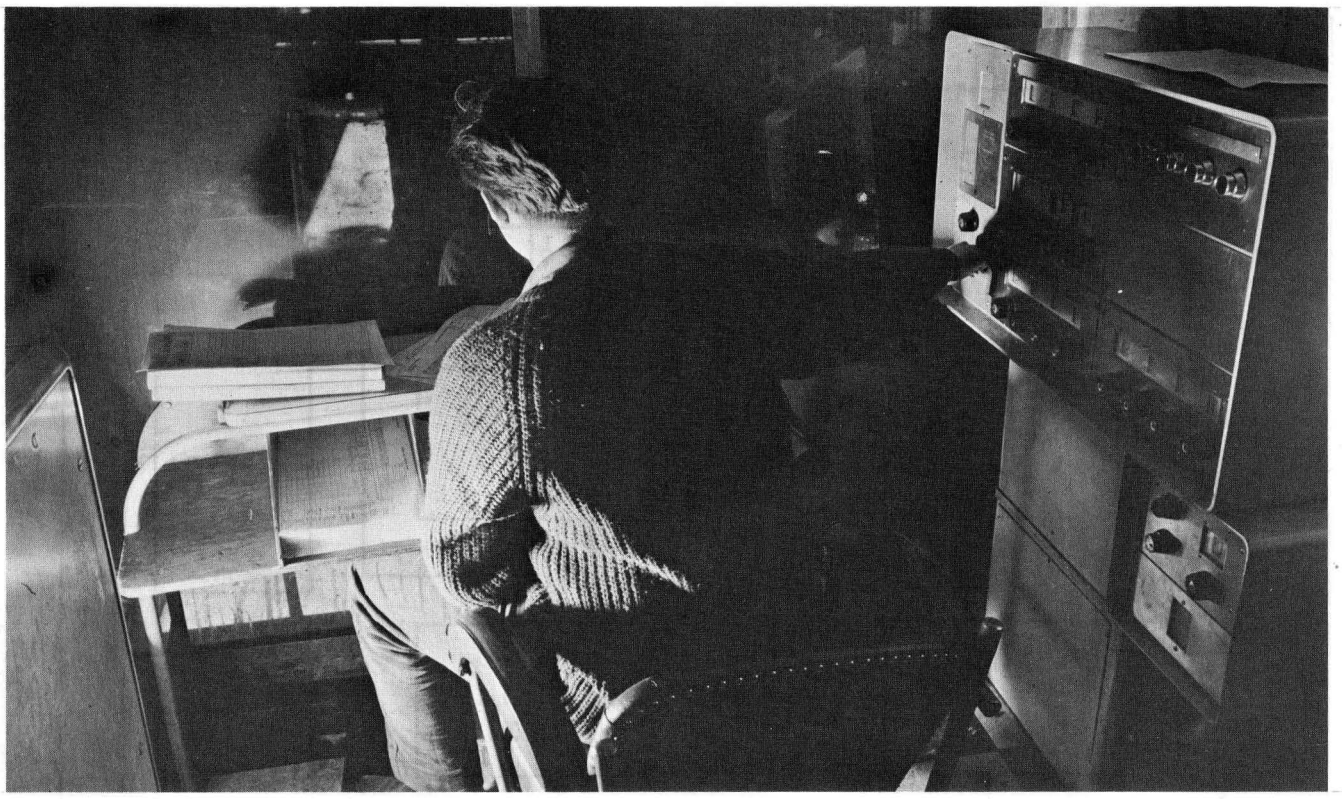
3. Achieve maximum efficiency in the application of certain plant processes.

4. Operate automatically the 68-inch wide continuous hot-strip mill from its slab-reheating furnace to its coilers.

HOT STRIP MILL COMPUTER ROOM WITH PERIPHERAL EQUIPMENT USED WITH GE-412 COMPUTER.



MAIN PROCESSES OF THE WORKS.



A QUALITY CONTROL OBSERVER FEEDING INFORMATION BASED ON VISUAL INFORMATION INTO AN ELLIOTT 803 COMPUTER SYSTEM. THIS INFORMATION DEALS WITH SURFACE QUALITY OF THE SLAB AS IT IS BEING ROLLED.

The information and data handling systems installed at the Spencer Works of Richard Thomas & Baldwins are comprised of:

1. An ingot and slab controller involving 42 keyboards, nine digital displays and eight printers designed to give control information to operatives between the steel plant and the output weigh-bridge of the hot mill and to received back and evaluate their reports.
2. A scheduler to handle all orders and prepare schedules to govern production and material flow from the steel plant to the hot-strip mill.
3. An off-line data processing unit, largely used to analyze the results of quality control operations and to help in pinpointing the causes of any defects in the products. It is also used by service departments such as operational research when investigating particular problems.

These three systems are respectively centered on three Elliott 803 computers housed in a specially designed building in the middle of the Works.

A General Electric 412 digital computer installed in the hot-strip will undertakes six main on-line functions:

1. Slab-tracking.
2. Mill-pacing.
3. Set-up and width control.
4. Temperature control.
5. Production logging.
6. Engineering logging.

Richard Thomas & Baldwins, Ltd. and its subsidiary companies -- known collectively as the RTB Group -- today form one of the largest iron and steel manufacturing organizations in the United Kingdom.

The Group has at present a production capacity of more than 3 million ingot tons of steel a year -- the larger part being rolled into steel sheet or tinplate. These represent RTB's principal products.

RTB also has substantial interests in other high quality products, the chief of which are steel billets. These are either rolled into sections in the Group's own Works or sold to independent re-rollers.

The RTB Group also manufactures narrow steel strip, alloy and stainless steels. It is one of the few makers in the United Kingdom of silicon sheets for the electrical industry. Its range of products further includes cable tape, wire, refractory bricks for the steel industry and various types of bricks for the building trade. In addition, RTB engages in sheet metal fabrication, general engineering and foundry work. All told, the RTB Group now employs some 33,500 people in 26 Works in England and South Wales.

Spencer Works, part of the Flat Rolled Products Division of the company employs some 8,000 persons; finished products include hot rolled and cold reduced coils and sheets and light plates.

There are a number of other automatic control systems at the Spencer Works of Richard Thomas & Baldwins. In the sinter plant there is automatic proportioning of raw materials, water addition and burn-through control. In the blast furnaces there is automatic blending of raw materials. In the universal slabbing mill, rolling of an ingot to the finished slab is controlled automatically, and finally, in the cold mill, there is automatic gage control in the four-stand cold-reduction mill.

As the methods of control were contemplated concurrently with the design of the Spencer Works, the recruitment of personnel was conditioned accordingly and no redundancy of personnel was brought about by the application of automatic controls. The initial cost of the computer equipment was just under $5.6 million.

THE SYSTEM

The Spencer Works of Richard Thomas & Baldwins at Newport, Monmouthshire, was "designed to be the most advanced steelworks in the world." In order to solve the problems associated with industrial automation, a control hierarchy system was set up. Within this hierarchy control and information system there are four computers -- three Elliott 803 computers and a General Electric 412 computer. The Elliott 803 computers control the information and data handling part of the system and the GE-412 computer controls the hot-strip mill.

THE INFORMATION AND DATA HANDLING SYSTEM

The purpose of the information and data handling system is to schedule the operations of the various parts of the plant so that the production requirements, as specified by the various customer orders, can be met in the most efficient and economical manner. In order to achieve this, it is necessary to have up-to-date information concerning the operations on the plant floor so that correct instructions can be prepared and presented to the operators.

In order to implement the above, the problems were reduced to four requirements:

1. Collecting of shop floor operating data.

2. Provision of customer order data, company policy data (for example, level of production for the current period) and similar information.

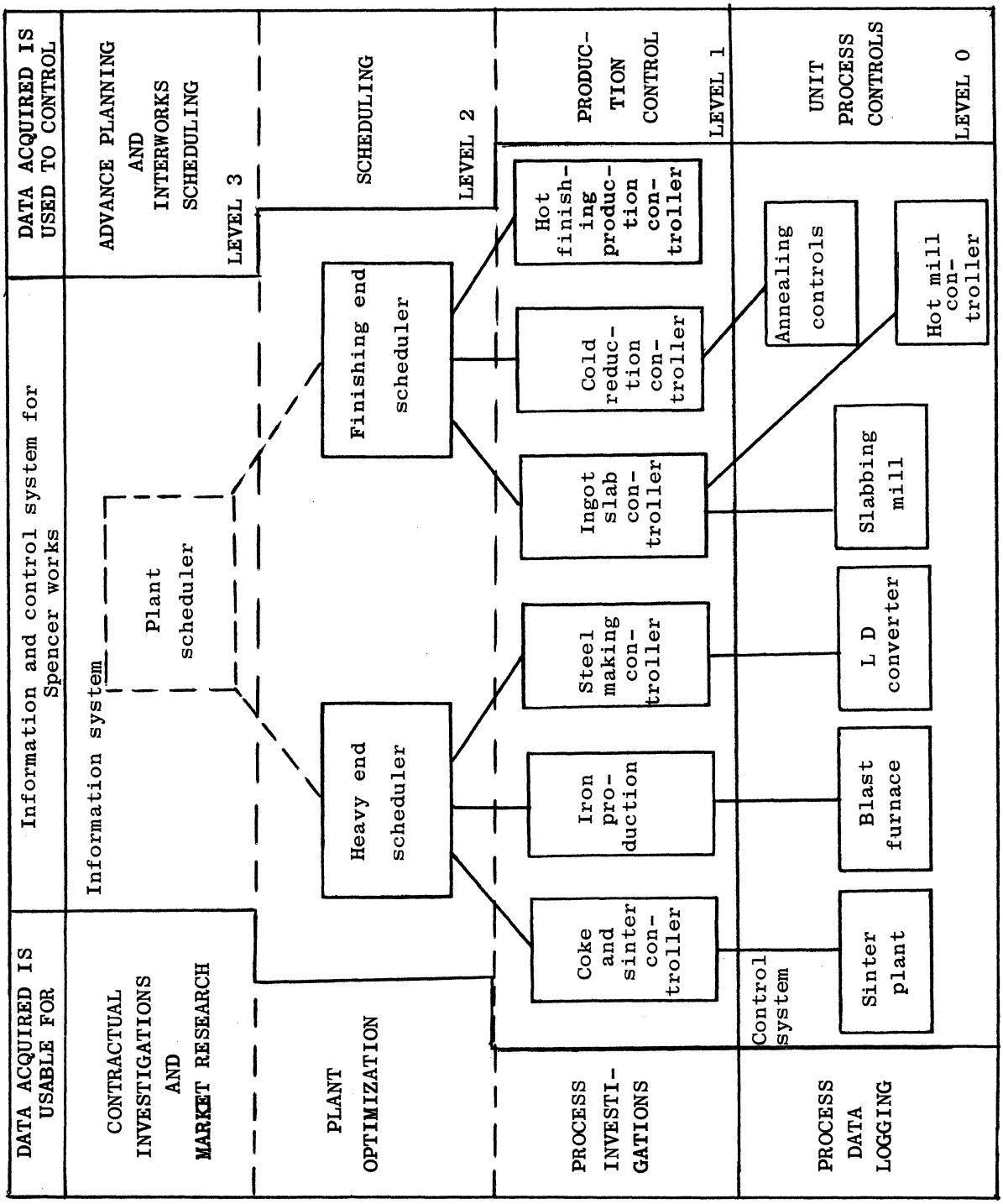
3. Coordination of the first two items to provide production control and action data.

4. Issue of production schedules and operating instructions to the shop floor.

To accomplish the above, three Elliott 803 computers are used and each performs a number of functions. The scheduler -- the first computer -- handles order entries, maintains an outstanding order file, an ingot stock file, an ingot-mold history file, and produces schedule-data input tapes for the on-line GE-412 computer in the hot-strip mill. It also prepares schedules for the steel plant and slabbing mill, maintains a slab-stock file and produces a variety of reports for management using information passed to it by the ingot and slab controller.

The second computer -- the ingot and slab controller -- deals with production factors in the steel plant area. Nearly 20 miles of cable link the ingot-slab controller to four scanners housed in a room under the universal slabbing mill. The scanners distribute data and instructions to, and collect information from, operators in the area between the steel plant and the slab yards. Keyboards, teleprinters and visual displays are used. Data includes production factors such as the width and thickness of the slab required from each ingot, the degree of automatic scarfing to apply, the slabs to obtain for rolling in the hot-strip mill, etc.

OPERATORS CHECKING INFORMATION INCLUDED ON PAPER TAPES WHICH IS TO RELAYED TO THE GE-412 COMPUTER.



HIERARCHY COMPUTER SYSTEM.

The automatic scarfing machine consists of a number of oxy/propane nozzles of special design which scarfs simultaneously the four sides of hot slabs or which can be set to scarf the top and bottom or sides only. The speed of scarfing is 65 to 195 feet a minute, with cuts ranging from 1/32 of an inch to 1/8 of an inch depending upon the amount of metal to be removed.

Operators communicate with the computer by means of the keyboard sets, indicating whether instructions have been followed or whether deviations have occurred.

The third Elliott 803 computer operates off-line in that its tasks are not directly coupled to the actions in the plant as they occur. A weekly analysis of all quality control observers' reports and test results is performed by this computer. These reports are processed statistically and compared with previous values to enable trends in quality to be detected quickly. The computer is also used to pin-point the cause of quality difficulties, again by statistical techniques.

Sales are analyzed and personnel statistics are reviewed regularly. In addition, efficiency reports for most of the production departments are prepared monthly.

Ingot and Slab Controller

Many of the operations in a steel plant are unsuitable for the application of automatic measuring techniques. For example, a reference number is cast on the outside of each mold. Each time it is used, this number is recorded so that a mold usage register can be maintained. No means exists for automatically reading this number and, therefore, it must be manually transferred to the system. It is, therefore, necessary to rely on the operator as an essential link for inserting much of the essential data.

Data prepared by the operators form a message describing a particular operation or the state of a unit in the plant. In order for messages to be recognized by the information handling system, they contain a unique label and the computer then acts on each message accordingly. Messages occur completely at random and have to be dealt with immediately.

Operators prepare the messages on keyboards which are placed at convenient locations on the production floor. Each keyboard can originate up to six types of messages and for each type has provision for a maximum of 24 decimal digits of information. A message is a block of information that uniquely defines a single operation in the plant.

The type of message is selected by means of a control on the keyboard, and a series of switches are set with the data to be sent. The actual collection of the messages is organized by scanners which are informed that a message is to be read when the operator presses an action button. A key switch allows only authorized personnel to insert messages.

When a message is read and passed by the scanner to the ingot and slab controller (an Elliott 803 computer), it is checked for errors. If no error is detected, an OK sign is displayed. If an error is indicated, the operator can either re-insert a corrected message or, if he feels that he is correct, he can re-insert the original message. This will produce an alarm in the system control room and a system supervisor will then deal with the situation.

A number of items are suitable for automatic recording. For example, the cross-section of the slab as it leaves the slabbing mill is automatically recorded by a direct pick-off from the edger (width) and screwdown (thickness) settings during the last pass of the slab through the mill. Another example is at the soaking pits where the temperature of the 20 pits is recorded every 10 minutes. A thermocouple is used to measure the temperature, which is indicated on a conventional chart recorder.

Scheduler

When a customer's order is received at the Spencer Works from the Richard Thomas & Baldwins' sales organization, it includes information such as the purpose for which the sheets are required, the size, the tonnage, the price, the delivery date, the packing requirements, etc. At the Spencer Works the order is examined and routed through the plant by the quality control department. Routing means describing what grade of steel is to be used and how the material is to be processed, specifying rolling temperature, anealing cycles, and the like.

Data derived from the detailed contract is then punched on to paper tape (the input to the computer). Accuracy is critical at this stage since all subsequent operations of the computers will depend upon this data. To check that the tape is correct a second tape is punched and the two tapes are automatically verified against each other. Any errors are corrected and the tape is ready to be fed into the scheduler computer.

The scheduler computer stores this information and produces a paper tape output used for the printing of work cards. These are printed by Friden Flexowriters and provide processing information for the production areas in the cold mill and act as packing documents and progress cards. The cards are also used internally for scheduling (arranging the order in which material is to be worked).

The original data on paper tape is transferred to magnetic tape which acts as an order file. Twice a day the file is updated.

At any time there may be material in the pipeline that is not suited for its original use; it may have been downgraded by the quality inspectors or may be a tonnage in excess of the amount required. The computer can allocated these stocks against incoming orders and print out suggested allocations.

COMPUTER CENTER. OPERATOR IN FOREGROUND AT CONSOLE OF INGOT AND SLAB CONTROLLER CAN INTERROGATE ELLIOTT 803 COMPUTER TO OBTAIN AN UP-TO-DATE STATUS OF THE PLANT.

The computer also calculates factors such as hot-rolled width, ingot sizes and the number of ingots to be produced against the original orders. It also allocates what should be rolled according to delivery promises; a file of orders ready for production is also produced.

The computer also selects orders every week for the hot mill for the following week. At the beginning of each shift the steel plant work shift's schedule is produced and factors such as restrictions on the availability of ingot-molds or the nominal production rates of the converters are taken into account.

The schedule is produced on paper tape and passes to the ingot and slab controller which monitors information about the material being produced in the area from the ingot mold preparation bay to the slabbing mill. For example, if a cast of steel has been downgraded for quality reasons, information about the situation is fed via the ingot and slab controller into the scheduler for decisions concerning the allocation of such material, taking into account grade and order priorities. Details of the required slab widths and thicknesses are then transmitted back to the ingot and slab controller.

The final rolling schedule for the hot-strip mill is produced by the scheduler along with the input paper tape for the GE-412 computer.

HOT-STRIP MILL PROCESS CONTROL

In the hot-strip mill a GE-412 computer performs the main mill control functions: slab tracking, roughing mill set-up, width control, finishing mill set-up, temperature control, mill pacing and production logging.

These functions, conventionally performed by human operators, are achieved automatically. The operators now serve as monitors of the process and act under emergency conditions.

The mill incorporates three re-heating furnaces in which slabs up to 30 feet in length and 10 inches in thickness are heated prior to the continuous rolling process. The rolling plant includes two scale breaker stands and five roughing mills through which the slab is reduced to about one inch in thickness. The two scalebreakers in the roughing train consist of a vertical and horizontal scalebreaker. The purpose of the two units is to remove the oxidized scale on the surface of the slab. The front and tail ends of the flat bar produced are automatically cropped before passing through a six-stand finishing mill to reduce the final thickness to between 0.500 inch and 0.048 inch. Finally, the strip is coiled alternately in two down-coilers. The final product can be dimensionally accurate to ± 0.002 inch from head to tail end with temperature control to ± 20 degrees Fahrenheit at the coiler. This accuracy is achieved under control of the GE-412 computer.

In order to roll steel to these close tolerances, the variety of equipment that controls the roll gaps, guides, main stand speeds, etc., must be set to extreme accuracies. The requirements of customers include various combinations of finished width, thickness and temperature, and the computer is continuously making changes to accommodate these variations.

In the past, operators have achieved a high degree of manual control only after acquiring great skill as a result of years of experience. The computer achieves these standards by having a program that simulates these qualities and by continual reference to devices which measure the various parameters during the rolling process.

It is essential that the exact position of all slabs in the mill is known at all times. This is a function -- known as tracking -- that ties the computer to the mill in real-time and allows the speed of the computer to be synchronized to the speed of the material being processed.

Upon receiving this information, the computer sends instructions to the various drives throughout the 2,778-foot length of the mill which set them to the positions or speeds necessary to roll the

OPERATOR AT GE-412 COMPUTER CONTROL CONSOLE.

product. Along the length of the mill, measuring devices enable the computer to control gage and width.

Temperature measuring sensors feed back information to the computer, enabling it to control the final temperatures of the product. These requirements are of great metallurgical importance. The computer achieves them by controlling the speed of the strip through the finishing stands and by distribution of the amount of water on the run-out table.

The GE-412 also controls the distance between consecutive slabs entering the finishing mills -- the gap time between the tail of one slab and the head of the next can be as little as three seconds.

Another function performed by the computer is the logging of production and engineering data. This means that the amount of strip rolled within various tolerance bands can be accurately measured, the information being supplied almost without delay. It also produces such information as a record of the power used at any time on the finishing stands.

A sub-function vital to the success of the system is the automatic gage control on the finishing stands. Inevitably, temperature differences along the length of the slab result in differences in strip hardness which lead to inaccuracies in the out-going gage. Automatic gage control irons out these differences, achieving closest possible tolerance and supplementing the computer mills set-up which obtains the best possible head-end gage. Similarly, the rotary crop shears has an automatic sheared feature. Here, optimum lengths are cut from the front and tail ends of the bar.

RESULTS AND FUTURE PLANS

The off-line computer is now operating on a continuous basis and is providing a valuable service to a number of departments, particularly to Quality Control, who have much more comprehensive statistics available than would be possible on a manual basis.

The ingot and slab controller is operating in an area as large as is possible with the existing computer capacity; that is, from steelmaking and mold preparation to the slabbing mill. It allows much closer control by management of operations in this area. Plans are well advanced for increasing computer capacity so that the systems can be extended to cover the slabyard and hot-strip mill.

The benefits obtained thus far from the scheduler are in increased accuracy of information on hot-strip mill schedules and in taking account -- on order input -- of more factors than could be handled efficiently when working manually. This latter gives a tangible gain in terms of increased material yield. The most important gain is expected to come from the optimization involved in allocating ingots to orders. This is still in the process of implementation.

The hot strip mill control computer has given the benefits anticipated in terms of improved dimensional tolerances and improved control of temperatures.

For the future, computers have been ordered for carrying out all accounting work and for scheduling and stock control throughout the finishing departments of the Works. Further developments will follow in on-line data collection in these departments, in computer control of the four-stand cold reduction mill and in computer control of the steelmaking process.