finished cassette. Sensors detect the correct positioning of each part before the next is added. Tape length is determined according to the duration of the cassette currently being produced. Obviously the large number of operations and controls calls for many status and control signals to be handled by FACT. There are over 280 inputs and 220 output signals for FACT to cope with.

Each operation station, with different inputs and outputs, is connected to FACT's modular input-output system (MIOS). Signals to and from each winding station and the electrical supply to each station are fed via commutating contacts on a number of copper tracks along the line-machine. To keep the number of tracks to a minimum and in order to correctly identify each station, a system of coding the inputs and outputs is used. Standard input filters in the MIOS input units eliminate the effects of contact bounce that would otherwise give rise to misleading or erroneous indications being fed to the controlling computer.

The *very first* application of the then newly developed FACT program was used at this factory in August 1973 to control the packing machine only. This packs each completed cassette together with an index card into its plastic case. That initial system was implemented by Philips personnel from the Industrial Data Systems department of S & I, working in close collaboration with local factory staff. However, the new FACT system has been implemented solely by the local E.B.M. department. The team soon became very familiar with the FACT language and procedures after the first cassette packing machine was running in the factory. It illustrates the simplicity and the ease with which FACT can be learnt and applied locally.

Implementation of FACT control itself in this complex application never presented any problems. Changes in the program that became necessary during the development phase were quickly implemented using a teletypewriter as an input device. For current control purposes and for fault or status reporting a small display is located at each machine. This complex FACT application together with service programs for one whole automatic assembly line is administrated by a Philips P855 minicomputer using 8 k memory. Management information is shown on a central Video Display Unit. Status reports on the automatic lines are displayed and are generated on a conversational basis without interrupting any machine operation.

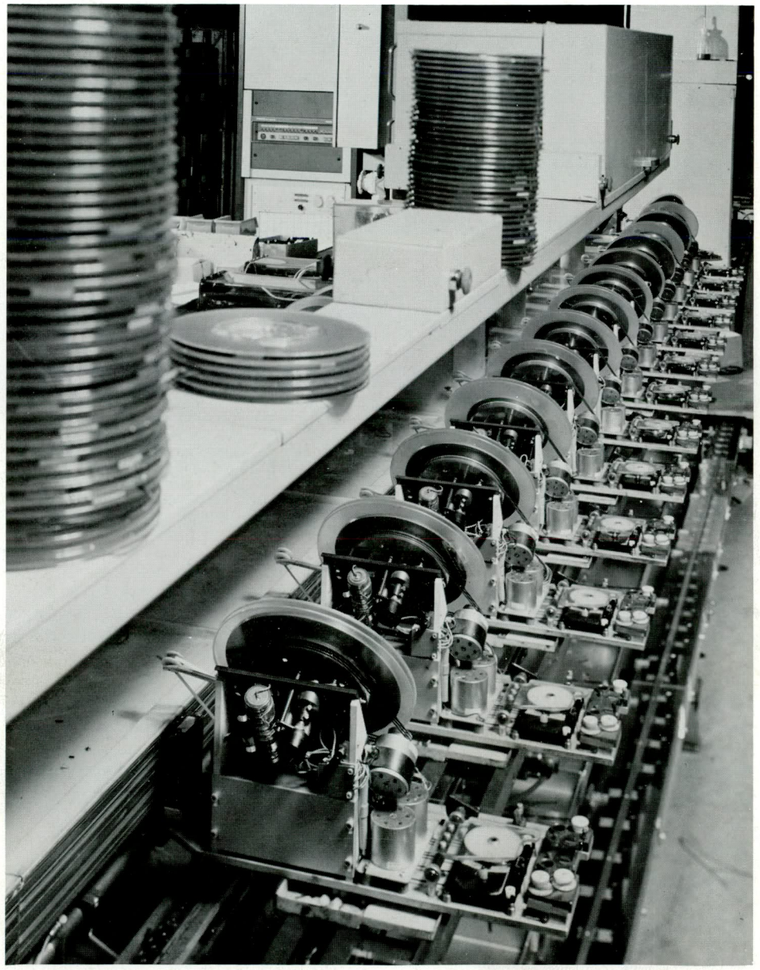

Fig. 3. FACT in sequence control.

The system works smoothly with extremely low error rates, good reliability and high production rates. The opinion at Hasselt is: "It would have been impossible to implement control of this nature if we had been restricted to using only a hard-wired controller".

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APPLICATIONDATA

industrial data processing systems

IDS-PROJECT SALES DEPARTMENT,
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FACT Facility for Automation, Control and Test.

Three applications of FACT are described, these illustrate the complete versatility of FACT; both in the uses to which FACT can be put in the manner in which FACT can be used. The first application is control of an industrial process, the second is in an establishment of advanced education and the third, automatic sequence control of parts assembly.

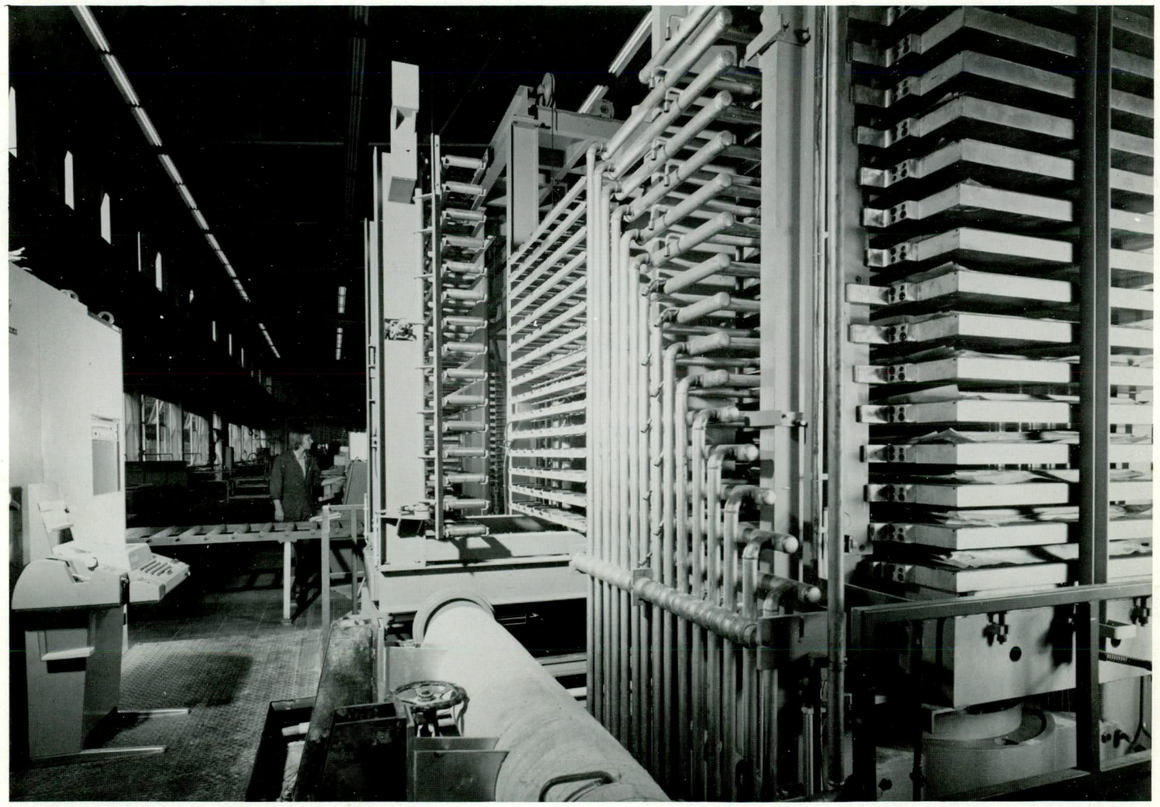

Fig. 1. FACT in process control.

PHILIPS

FACT — Facility for Automation, Control and Testing — combines three elements to provide versatile solid-state software programmable control that is flexible in application, simple to implement and easy to change at any time. The basic elements of FACT are:

- A mini-computer from the established range of Philips mini-computers.

- A completely modular input output system.

- A simple software instruction set.

The Philips range of mini-computers is well established in many fields of application including education, commerce and industry. All mini-computers in the range have been designed to function without error under the most arduous environmental conditions. The modular input output system (MIOS) ensures complete operational flexibility since all types and combinations of digital and analogue, input and output signals can be accommodated. Also, different interface units can be plugged-in after installation, this facility allows changes in system design to be rapidly incorporated. The simple software instruction set can be readily learnt and programs written, even by those unfamiliar with software languages and techniques. And system implementation is simplified since it is possible to directly render Boolean algebraic expressions into FACT program instructions.

FACT APPLICATIONS

FACT in process control

Becker von Hüellen, the German manufacturers of industrial presses have recently applied a FACT control system to one of their high temperature presses. The press is used in the manufacture of Synthetic Resin Bonded Paper (SRBP) laminate, which is used as an inexpensive insulator or as a substrate for printed circuit boards. Different thicknesses of laminate can be produced on the press, ranging from 0,1 - 30 mm. The laminate can be copper coated on one side or both sides or it can be uncoated. The maximum size of sheet that can be produced is 900 x 1300 mm. This type of laminate is used extensively in consumer electronics equipment.

The press has 15 pressing layers and is water heated to a maximum of 180°C, pressure at each layer is 85 kg/cm^2. The loading magazines are charged alternately with 15 pallets, each pallet containing material for 9 separate laminate sheets. Two operatives manually load the copper/paper/resin sheets onto the pallets according to the thickness of laminate required. The pallets are then transported via a conveyor belt and loaded into the waiting magazine.

This is where FACT takes control. It is used to control and supervise the cycle times of the different stages. These comprise lifting, magazine filling, pre-heating, heating, pre-cooling and cooling of the press. In order to exercise this control all valves etc for the water heating and water cooling are solenoid operated. In order to control and to determine the exact status of each valve, 80 inputs and 64 outputs are handled by FACT. These are all routed via MIOS, its modular input output system.

Different types and thicknesses of laminate require different cycle times and temperatures. Using FACT these could be software controlled but in this sytem the user opted for thumbweel setting mainly because the press operators were unfamiliar with the teletypewriter, which normally provides FACT's man/machine interface. The average overall cycle time for 15 pallets is $1^1/_2$ hours.

An indication of FACT's flexibility is that the paper feed, conveyors and magazine charging will shortly be brought under FACT control. An extension of this nature would be virtually impossible if a hard-wired process controller had been installed. In use, the FACT control system has been proved to be realiable and simple both to operate and maintain. And Philips delivered the complete FACT system, mini-computer, modular input-output system, thumbwheel units and software exactly on time.

FACT in education

In Holland, institutions of higher education often cooperate in Research and Development with engineering and manufacturing companies. One such institution is the Delft University of Technology (D.U.T.) The Mechanisation of Production section of the Mechanical Engineering Department in particular cooperates with companies in the fields of automation and machine handling.

In order to simplify their tasks and to improve the service offered, the Mechanisation of Production section of the D.U.T. use a process controller. Before choosing FACT they evaluated systems from different manufacturers. PLC type controllers were ruled out since they lack flexibility and also need special translators to convert Boolean expressions into controller functions. Other computer controlled systems suffer the disadvantage that the use of a higher powered computer is necessary in order to produce the control programs. In contrast to this, FACT contains all necessary program development facilities. Also, since the students are required to generate their own control programs the simple and easy to learn instruction set available with FACT was a strong point in favour. A further attractive feature of FACT is the direct relationship between Boolean expressions and FACT instructions.
These factors, together with FACT's flexibility and reliability led to it being selected as the most suitable control system.

The very first task for which the Mechanisation of Production section of the D.U.T. used FACT, was to establish ways of achieving more effective operation of an item of automatic handling equipment.

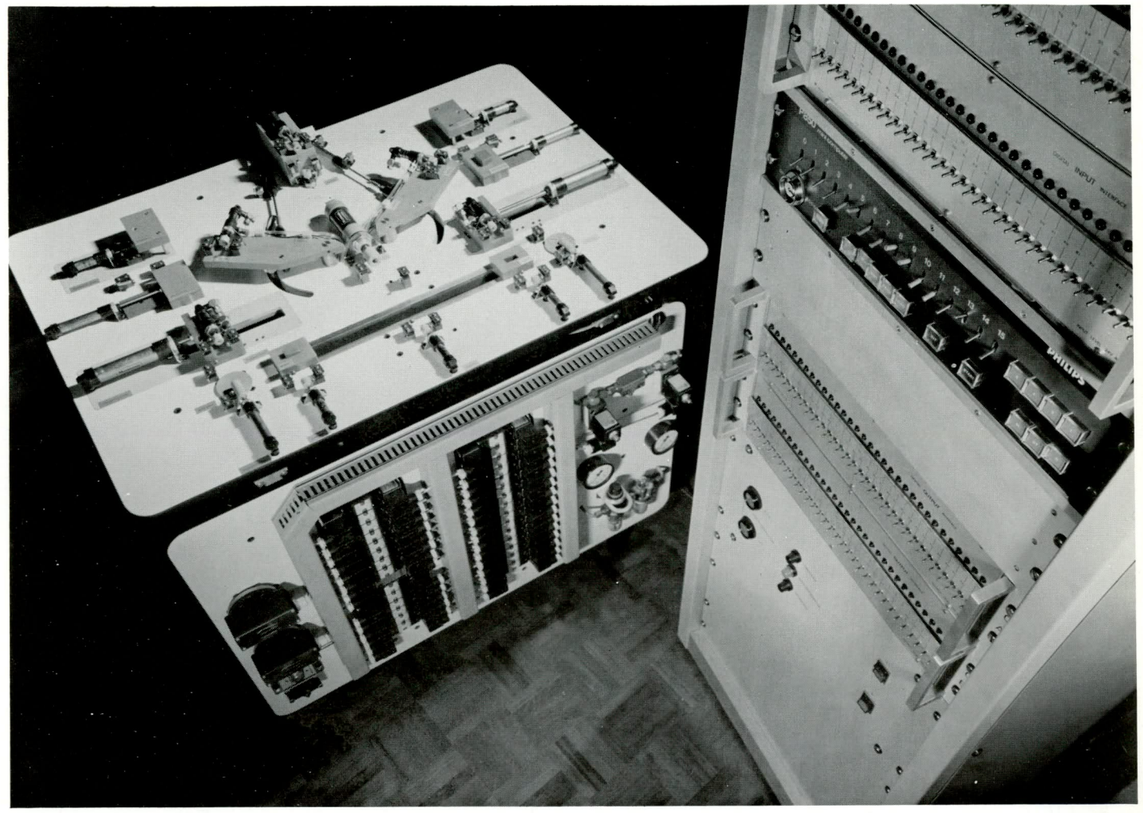

Fig. 2. FACT in education.

In order to do this it was decided to make a working model of the equipment, this was termed a visualisation unit and can be seen in figure . As the name implies the unit allows all parts of the control cycle to be inspected visually. This has advantages over a purely mathematical model since it is necessary to control the special procedure for emergency-stop or initial switch on. The visualisation unit allows all control and timing signals to be accurately determined.

The machine comprises two inter-related and parallel systems which work simultaneously. The various stations utilize different forms of movement such as linear and rotary. The stations are actuated by 28 pneumatic cylinders. Operation of the cylinders is controlled by FACT. The status of the cylinders is constantly monitored together with the position of the various moving parts. Over 128 input and 64 output signals are generated, and full control is effected through over 150 Boolean expressions. A teletypewriter is used to implement program changes.

One important functional aspect that has been resolved is the "emergency stop", this obviously has very important implications for personnel safety and damage to the mechanism itself. It was quickly established that in some critical situations when the machine is in motion, the best emergency stop procedure is to apply full reverse power so that all moving parts are returned to their start positions. Use of FACT control has resulted in many improvements to the mechanism being recommended. These have led to increased safety together with greater reliability and more effective operation.

FACT in sequence control — PHILIPS uses FACT itself

The Philips factory at Hasselt in Belgium has recently completed the task of automating the assembly of magnetic tape cassettes. The fully automated assembly lines which are controlled by FACT were designed, developed and built at this factory.

One line consists of a combination of four interconnected automatic machines:
- a preparing caroussel with 16 work stations.
- a line-machine with 36 assembly stations and 67 moving winding stations.
- a labeling machine.
- a packing machine.

Cassettes of different duration, C 60, C 90 and C 120 can all be assembled on the machine.

This combination of four machines prepares both cassette halves, assembles the rollers and other piece parts, winds on the correct amount of tape, finishes the cassette with fixing screws, executes the necessary controls, labels and packs the