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APPLICATION OF PROGRAMMABLE CONTROLLER IN THE FIELD OF MECHANICAL EQUIPMENT

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1. FOREWORD

The programmable controller (PC) is incorporated in facilities for automation, flexible manufacturing system (FMS), and factory automation (FA) of general industry and is becoming indispensable as the nucleus of control. For example, at Fuji Electric, the PC is used with special machines and robots which form the production lines of controllers, vendors, electronic parts, motors, etc. As outside facilities, they have been incorporated into the machines of manufacturers of cookies, medicines, machine tools, coating, parts work, etc.

The background of these is their excellent reliability and environmental resistance. A line of products serialized according to the scale of the control structure is also available. From the standpoint of performance, their scanning time is fast and besides basic commands, expanded commands can be used as required. Therefore, sequence control from individual machines to FA system components, of course, and also data processing and communication are possible.

Some applications of the Fuji Electric general-purpose PC MICREX-F incorporated into machines in all fields inside and outside Fuji Electric are introduced.

2. APPLICATION EXAMPLES

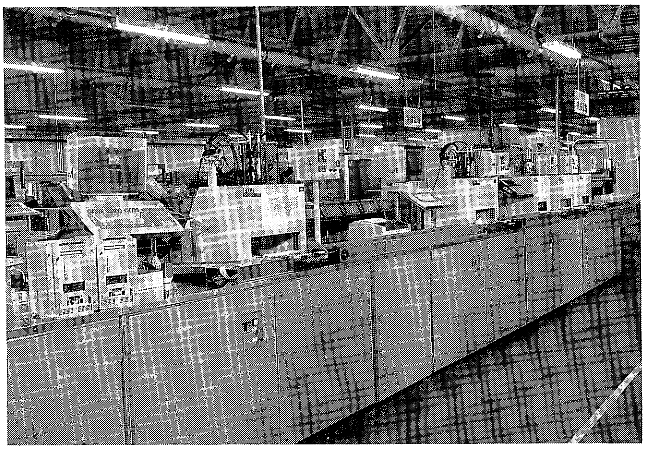
The role of the PC in the past was individual and general sequence control of parts feeding, transfer, working, assembly, testing, and packaging, which are units which form facilities. However, recently, their application to data processing and communication has increased. Equipment using the merits of the PC is outlined below.

2.1 MICREX-F testing equipment of finished product

2.1.1 Aim of equipment

Shortening of the test conditions setting, connecting work, and other setup times is planned with economization of the steps in testing work as the purpose. Further, to round out the functions and improve productivity, the test equipment is distributed among three unit and capacity is increased.

Fig. 1 General view of testing equipment of finished product



2.1.2 General view

A general view of the equipment is shown in *Fig. 2*. This equipment consists of three testers. An I/O tester, CPU tester, and withstand voltage and noise tester are installed in a line, from left to right.

2.1.3 Main test contents

Tests are performed according to the objective product. The I/O tester performs input characteristic and output characteristic tests and performs operation checks and current and voltage measurements, etc. The CPU tester performs CPU software, loader, and power supply operation checks and consumed current, etc. measurements. The withstand voltage and noise tester performs withstand voltages checks according to impressed time and tests using a noise simulator.

2.1.4 Control system hardware configuration

This equipment is made up of independent machines. The I/O tester is described here as an example. The I/O test control system consists of a personal computer, MICREX, measuring instruments, power supply, input test circuit, and output test circuit as shown in *Fig. 2*. The personal computer and measuring instruments are connected by GP-IB bus and the personal computer and MICREX-F100 are connected by a T-link using an RS-232-C interface. The other units are connected by a parallel connecting method.

Fig. 2 I/O test system configuration

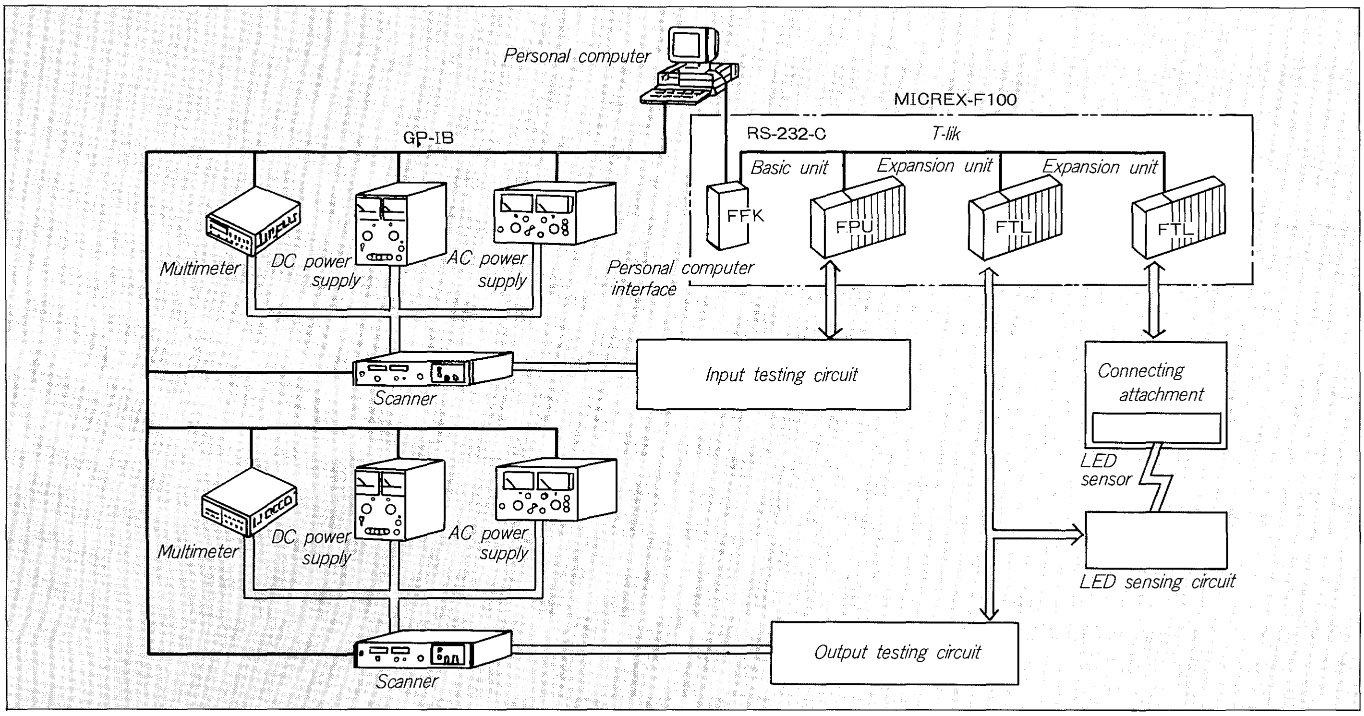


Fig. 3 Test process basic flow

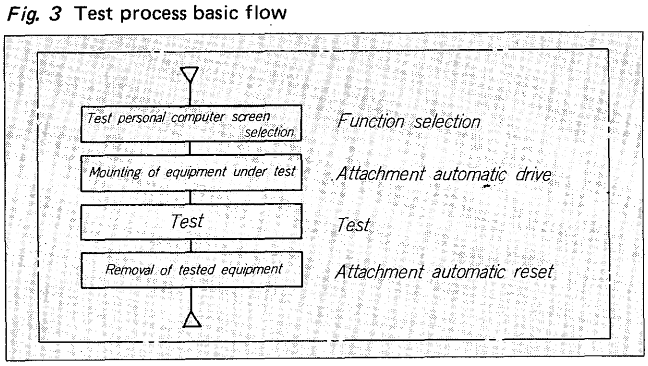
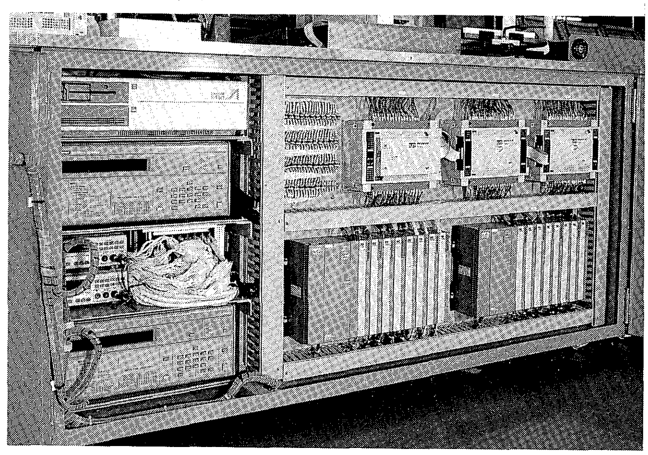


Fig. 4 I/O test equipment control board



2.1.5 Test process and control contents

The test process is shown in *Fig. 3*. The personal computer mainly displays the test procedure and test results and controls measuring instruments, power supply, and scanner range switching and function switching and reads the measured result.

The role of the MICREX-F100 is control of the connecting attachment mechanism, circuit switching according to personal computer side circuit setting, and input and/or output operation check and judgement of tested unit by input and output test circuits and data transmission of the result to the personal computer.

2.1.6 MICREX-F100 selection and merits

(1) 672 I/O points and 2,000 application program steps are possible.
(2) Input of the circuit set conditions data and reporting of the results of the input and output tests are possible by data communication with the personal computer by personal computer interface.
(3) Number and appearance of wiring work with the personal computer are made better by using a T-link.
(4) Since control adjustment, modification, etc. can be performed easily without the participation of the personal computer by controlling mechanical units by PC, maintainability is good.

2.1.7 Control board

The board housing the MICREX-F100 and controller is incorporated into the equipment for effective use of space. The control panel is shown in *Fig. 4*.

2.2 Magazine transfer machine

2.2.1 Aim of equipment

This equipment automatically transfers magazines filled with parts between making-up machine, drying

Fig. 5 Overall structure

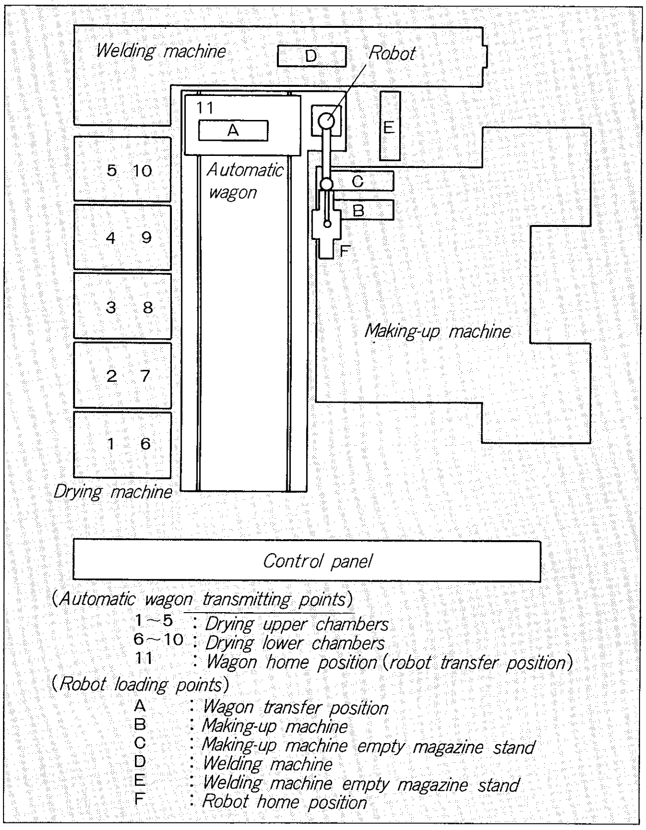
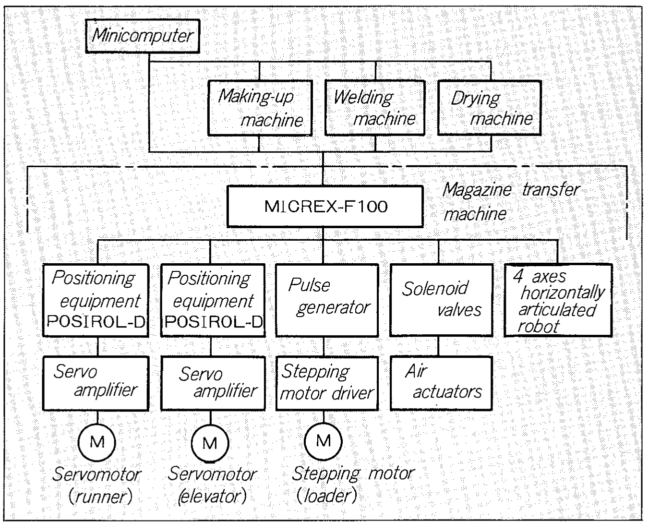


Fig. 6 Control system hardware configuration



machine, and welding machine, which are the peripheral devices, and mounts and dismounts the magazines at the machines for the purpose of rationalization.

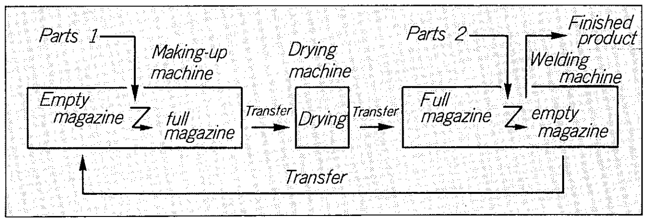
2.2.2 Overall structure

A plan view of the overall equipment is shown in *Fig. 5*. Each equipment is installed around the transfer machine.

2.2.3 Main specifications

(1) work weight: 50kg

Fig. 7 Basic processes of magazine transfer machine



(2) Wagon moving speed: 1m/s
(3) Wagon moving distance: 2.5m
(4) Transfer points: 17 points
(5) Wagon motion: X, Y, Z operation
(6) When moving, ID number of magazine handled is read and posted to host computer

2.2.4 Control system hardware configuration

Fig. 6 shows the system configuration. The system consists of drive object servomotors, stepping motor, air actuators, and 4 axes horizontally articulated robot, centered about the MICREX-F100.

The related facilities consist of host computer, making-up machine, drying machine, and welding machine.

2.2.5 Control contents

The basic processes of the magazine transfer machine are shown in *Fig. 7*. The transfer robot performs making-up machine and automatic wagon and automatic wagon and welding machine handling and transfer after transfer to the drying machine is performed by a handling unit on the automatic wagon.

The transfer points are the 17 points shown in *Fig. 5*. A transfer request from the position of each machine supplies or ejects an empty magazine and supplies or ejects a full magazine. Requests from the making-up machine and welding machine are raised at an arbitrary timing. This uses the robot and transfers the automatic wagon while considering the priority order. When empty magazines cannot be returned to the making-up machine, to increase welding machine working efficiency, the empty magazines are placed on the empty magazine stand of the welding machine or an empty chamber of the drying machine is used as a temporary magazine stand.

The drying machine has 10 chambers in two stages, one at the top and one at the bottom. The order of insertion into these chambers is on the principle of first-in, first-out. Magazine ID number and presence/absence are controlled simultaneously.

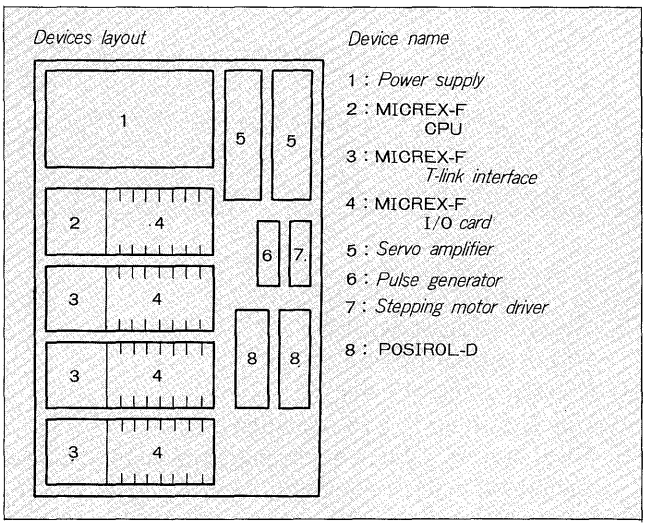
2.2.6 MICREX-F100 selection and merits

(1) Memory size, small space, data transfer, operation and storage functions were demanded. 512 I/O points and 6,000 application program steps are possible.
(2) DC servomotors are used in automatic wagon movement and lowering and the transfer numeric data is set by MICREX-F and data is transferred to the POSIROL servo controller. This also applied to the stepping motor.

2.2.7 Control board

The control board is the separate type. The power

Fig. 8 Layout of devices in control board



supply and servosystem modules are arranged around the MICREX as shown in *Fig. 8*.

2.3 Powder coating machine

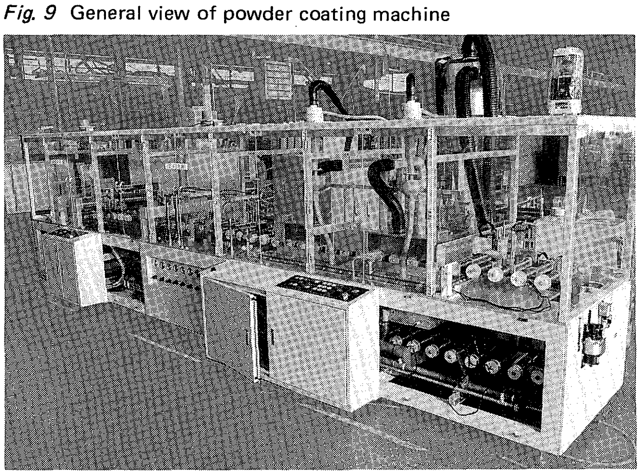
2.3.1 Aim of machine

All operations from work loading to ejection after the end of the coating process are automated for the purpose of rationalization and product stabilization.

2.3.2 General view

A general view of the equipment is shown in *Fig. 9*. The work is automatically loaded from the right end and the powder coated part is ejected from the left end. HF oscillators for heating and drying are installed at the rear.

Fig. 9 General view of powder coating machine



2.3.3 Main specifications

(1) Transfer method: Tact chain transfer
(2) Transfer time: 2 seconds/transfer
(3) Tact time: 10 seconds/tact
(4) Driving method: Indexing drives
(5) Full automatic

2.3.4 System hardware configuration

This system consists of a work loader which is the control objective, ejector, coating unit, and HF oscillators, centered about a MICREX-F100 as shown in *Fig. 10*.

Fig. 10 System hardware configuration

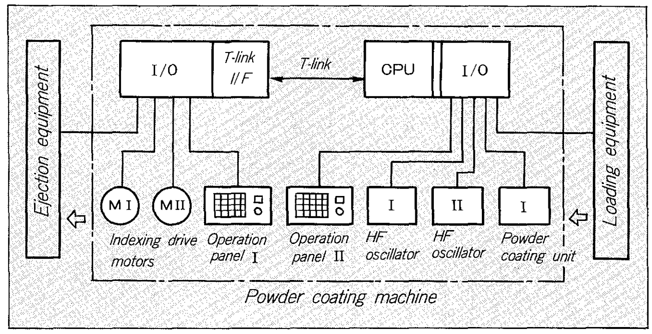
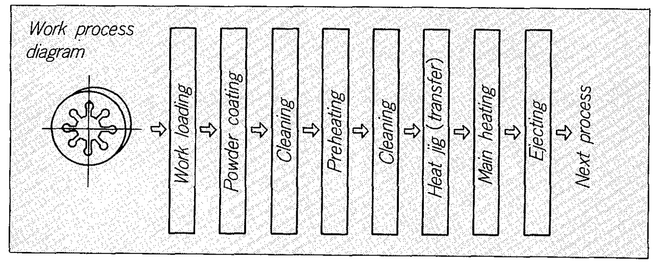


Fig. 11 Work process



2.3.5 Work processes and control contents

The work processes are shown in *Fig. 11*. The MICREX-F100 controls machine transfer drive and the peripheral facilities operation processes while taking the timing. There are management points at each process. When abnormal, the abnormal contents can be learned at a 2-digit LED display on the operation panel.

Many proximity switched unaffected by dust are used as operation confirmation sensors.

2.3.6 MICREX-F100 selection and merits

(1) 190 I/O points and 2,000 application program steps made possible by abundant instruction words.

(2) Control board could be changed from old separate type to integrated type.

Since the I/O capsules can be distributed at the positions of the machine drive sources by using a T-link, the board can be made small and integrated into the machine.

(3) Wiring work reduction

Wiring can be reduced by using a T-link.

(4) Improved appearance

Since the large separate type board is discontinued and the board is a small distributed type, overall appearance is better.

(5) Maintenance is easy

Since the wiring is short, addition and modification of specifications can be easily dealt with.

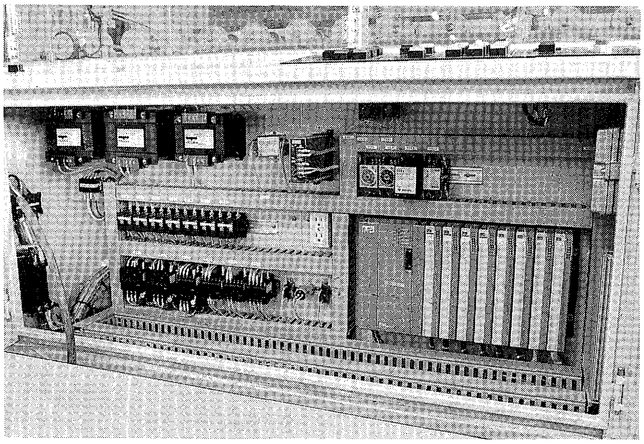
(6) Error display using LED is easy.

Since data can be handled, abnormal state signals can be easily displayed on an LED display as error number. Two-digit display makes it possible to display up to 99 kinds of errors.

2.3.7 Control board

The layout of the PC and devices is shown in *Fig. 12*. The boards are distributed at the left and right ends.

Fig. 12 Powder coating machine control boards



2.4 Automatic checker of vials

2.4.1 Aim of equipment

Inspection of the cap of vials is automated with rationalization and stable quality as the purpose.

2.4.2 General view

A general view of the equipment is shown in *Fig. 13*. There is a rotary-index-table at the left side. Testing process stations are installed on this table. The test circuits and monitor are at the top right and a control board housing a MICREX-F50 at the bottom right.

2.4.3 Main specifications

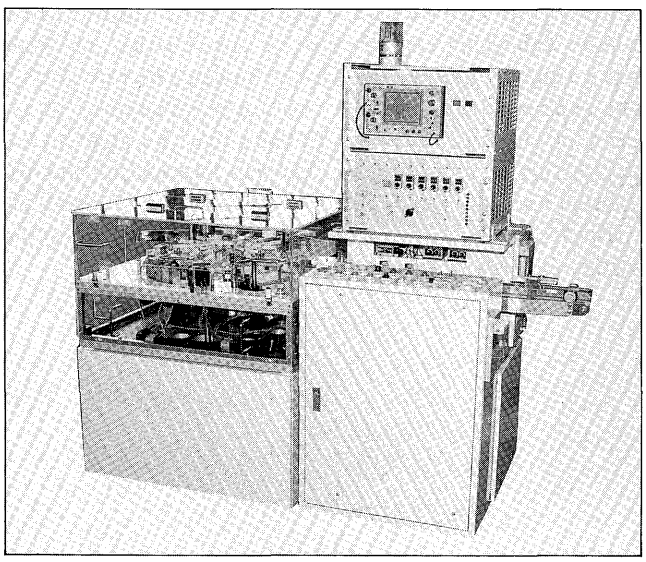
The main specifications are shown in *Fig. 14*.

2.4.4 System hardware configuration

This system consists of a MICREX-F50, driving gear, operating panel, and judgement unit.

The outline configuration is shown in *Fig. 15*.

Fig. 13 General view of automatic checker



2.4.5 Work process and control contents

The work processes and station names are shown in *Fig. 16*. The inspection stations and inspection method are shown in *Table 1*.

The PC drives a feed conveyor to supply the vials to be inspected from the preceding process. At this time, vial tilt detection and no viasl detection are performed and an operation order is sent to the preceding process.

The end of the feed conveyor is connected to the index table and insertion into the index pockets is sensed and the index table is driven.

The number produced is counted by the PC.

Fig. 14 Main specifications

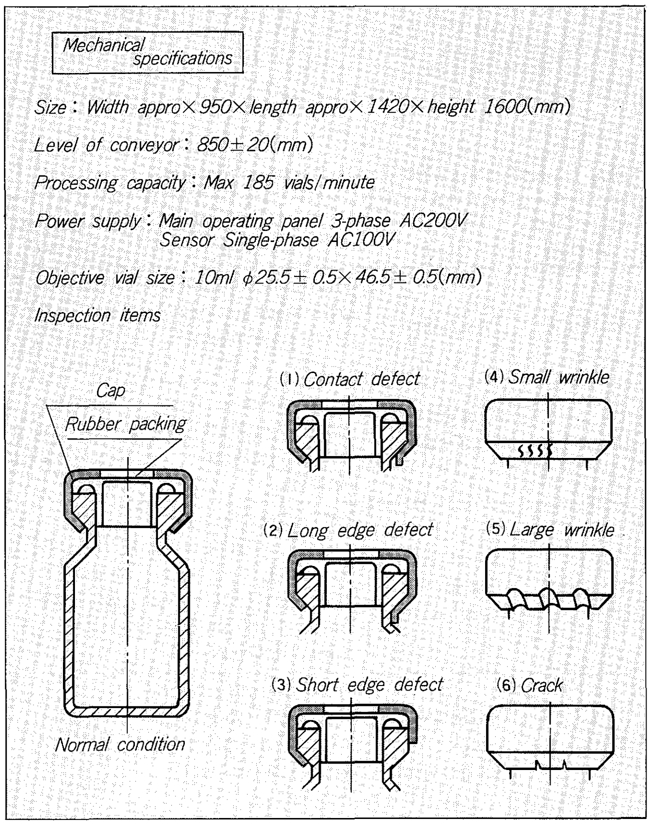


Fig. 15 System hardware configuration

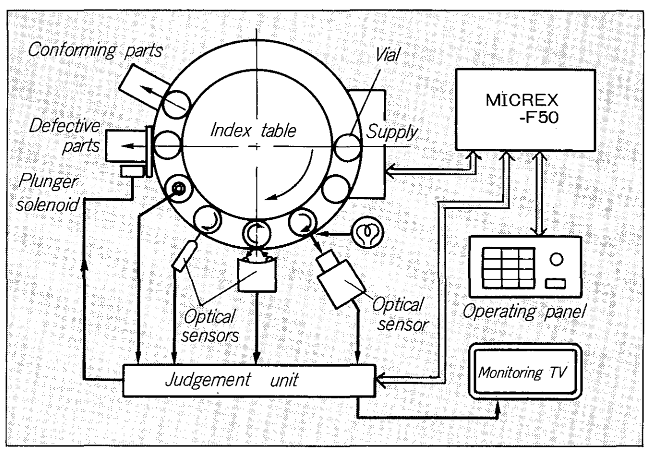


Fig. 16 Work process and station

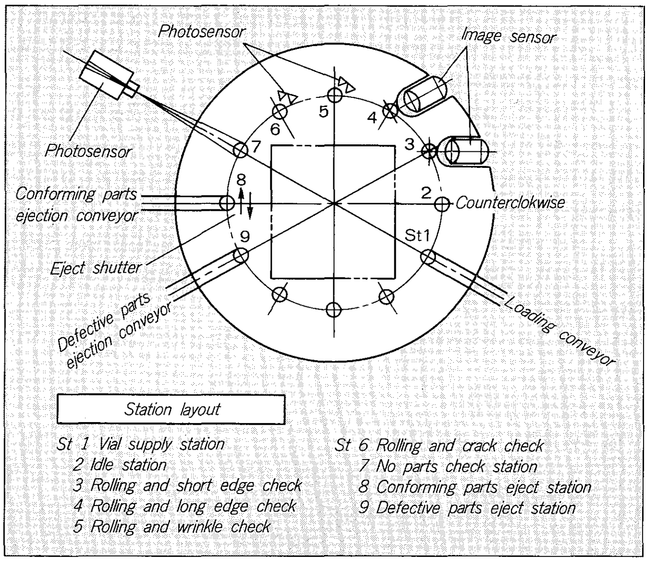


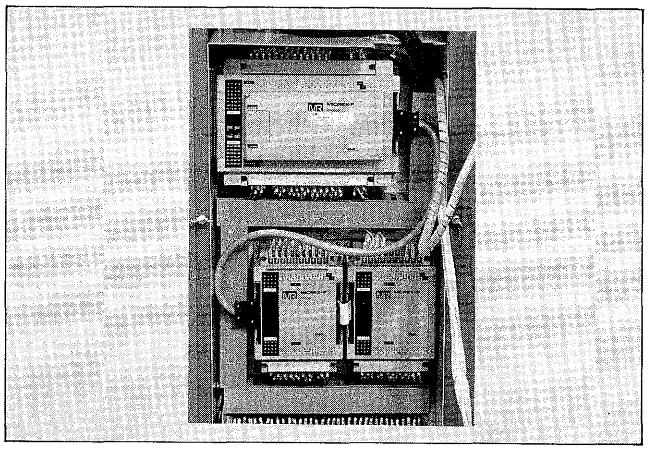
Table 1 Inspection stations and inspection method

Inspection station	Defective item	Linear image sensor	Judgement method
Station 3	Short edge	One dimension solid type image sensor (1) (MOS type image sensor)	Width of reflected light wave-form
Station 4	Contact Long edge	One dimension solid type image sensor (2) (MOS type image sensor)	Width of wavelength of reflected light
Station 5	Small wrinkle Crack Large wrinkle	Reflection type photo-sensor (1) (from down-ward tilt) Reflection type photo-sensor (2) (from hori-zontal direction)	Variable value Variable value
Station 6	Small wrinkle Crack Large wrinkle	Reflection type photo-sensor (1) (from tilt) Reflection type photo-sensor (2) (vertical installation)	Variable value Variable value
Station 7	No parts	Reflection type photosensor	Variable value

2.4.6 MICREX-F50 selection and merits

(1) Small scale 100 I/O points and 1,000 application program steps can be satisfied.
(2) An inexpensive system suitable for small scale control can be built.
(3) Production capacity is 185 vials/minutes and life is long.
(4) Speed, response, and reliability are clearly better than a relay sequence.

Fig. 17 Automatic checker control board



2.4.7 Control board

As shown in *Fig. 13*, the control board is compactly installed at the right bottom of the machine. The devices in the control board are shown in *Fig. 17*.

3. CONCLUSION

A usage record of the following items was obtained at the above:

(1) Data communication to personal computer
(2) Data processing using a large size memory
(3) Distribution of control boards by T-link
(4) Fast scan time and reliability

In the future, the range of applications of the PC are is expected to steadily expand into the personal computer and microcomputer control area. This is because that entrusting the range which can be covered by the capabilities of the PCshortens the period from program generation to debugging and response to specification additions and maintainability are good and a human structure is easy. The application topic is the creation of a bar-code system using PC in FA, FMS and is being incorporated in the architecture of integrated management information and distributed control. Finally, the authors which to express their gratitude to all those concerned who cooperated in the writing of this article.