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LARGE CAPACITY TRANSISTORIZED UNINTERRUPTIBLE POWER SUPPLY

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1 FOREWORD

Uninterruptible power supplies are mainly used with computers. Their generational transition have been shifted from the rotary type to the static type and from the thyristor type to the transistor type even in the static type.

This transition has substantially improved the efficiency and capacity of the equipment as shown in *Table 1*. Since 1977, it has provided a transistorized uninterruptible power supply. Fuji Electric has increased the capacity of the transistor element and has increased the equipment capacity by developing new technology and has already completed serialization up to 600kVA. On the recent market, the demand for very low capacity (1kVA or less) has suddenly increased. On the other hand, the sophisticated information age has been entered and the demand for large capacity uninterruptible power for comparatively large scale online systems, such as for VAN (value added communication network) center machine, finance online, news and publishing industry CTS system, etc., for example, is also tending to increase.

From the above background, a large scale online system will also increase in the future and an increase in the demand for large capacity uninterruptible power supplies is expected to accompany this.

Table 1 Transition of uninterruptible power supply for computer

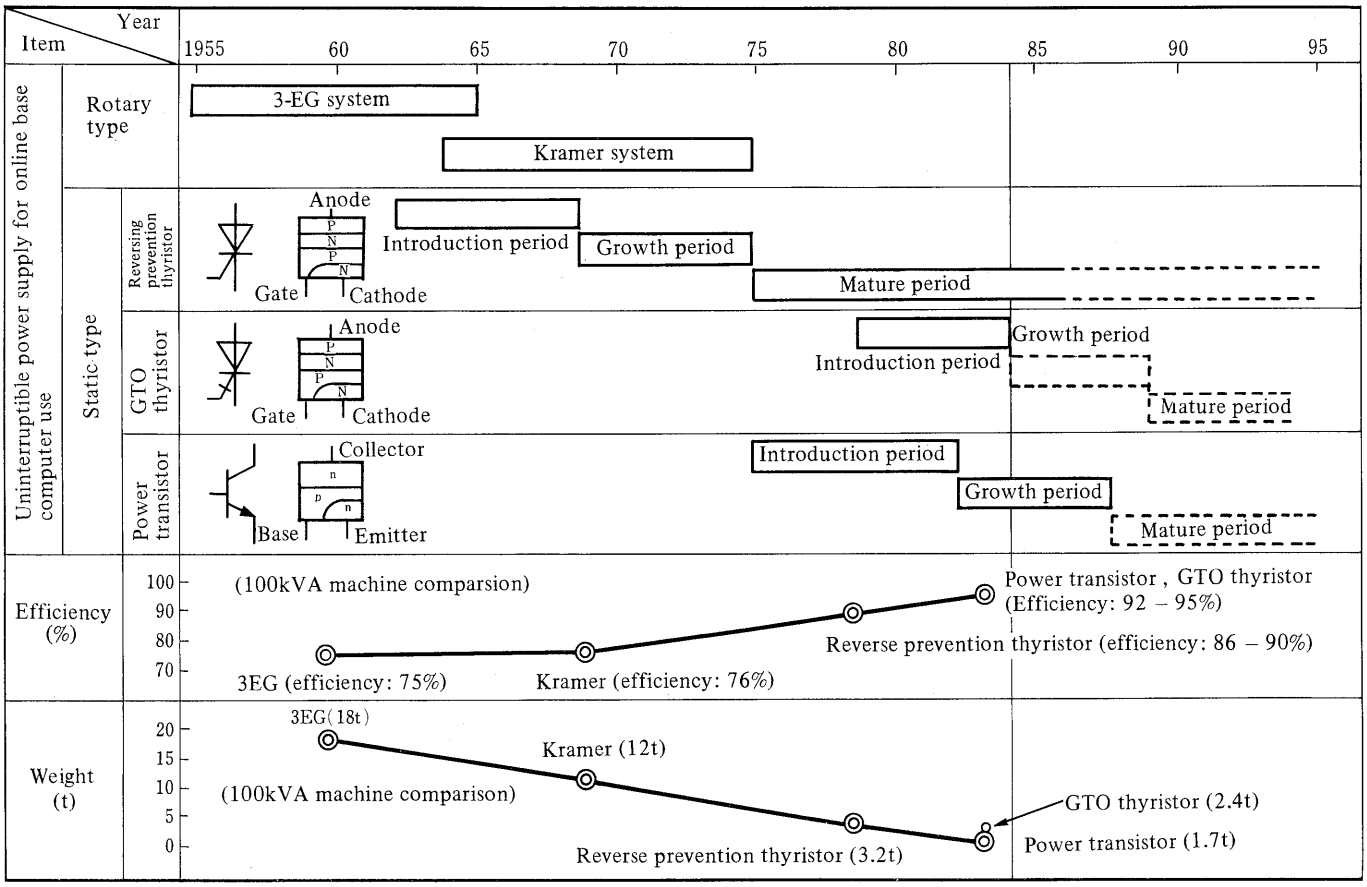
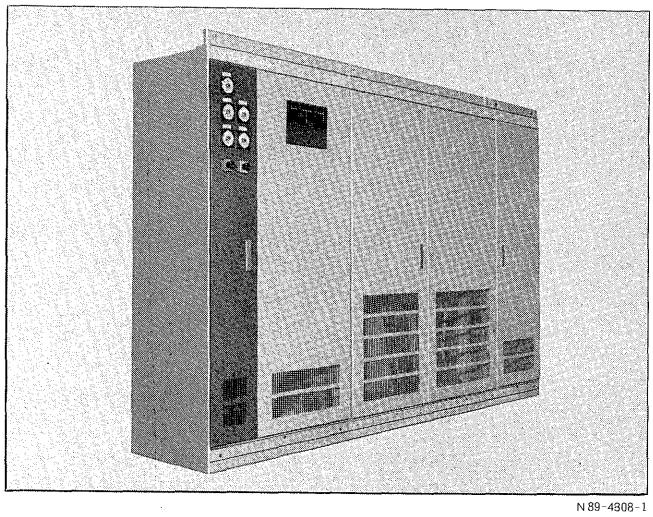


Fig. 1 Exterior view of 400kVA uninterruptible power supply



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An outline of the 400kVA output unit is introduced here.

2 FEATURES

The Fuji Electric transistorized uninterruptible power supply was provided with the following features by the use of a circuit system employing the superior performance of the power transistor and the development of various new technologies.

2.1 High efficiency

Because a commutation compensation circuit is unnecessary and the saturation voltage of the transistor is small. Conversion efficiency is improved and efficiency is high. Compared to the thyristor system, efficiency is improved approximately 3%.

2.2 Small and light weight

Because a commutation circuit is unnecessary and the snubber circuit can be made small because dv/dt suppression is unnecessary, it is small and light weight. The volume of the 400kVA unit is approximately 50% that of the thyristor system and its weight has been reduced to about 60%.

2.3 Low noise

Since the commutation reactor, which was a source of noise in the past, is unnecessary, it is low noise. Noise is reduced 5 – 10dB compared to conventional units.

2.3 High reliability

Since the transistor has a self-quenching ability, even when erroneously triggered by noise, when the noise disappears, self-quenching is possible and operation reliability is very high. Because the Fuji power transistor with excellent dielectric strength, switching characteristics, breakdown resistance, and other characteristics is used as the main circuit element and a digital circuit with a small number of parts is used at the control section, reliability is high.

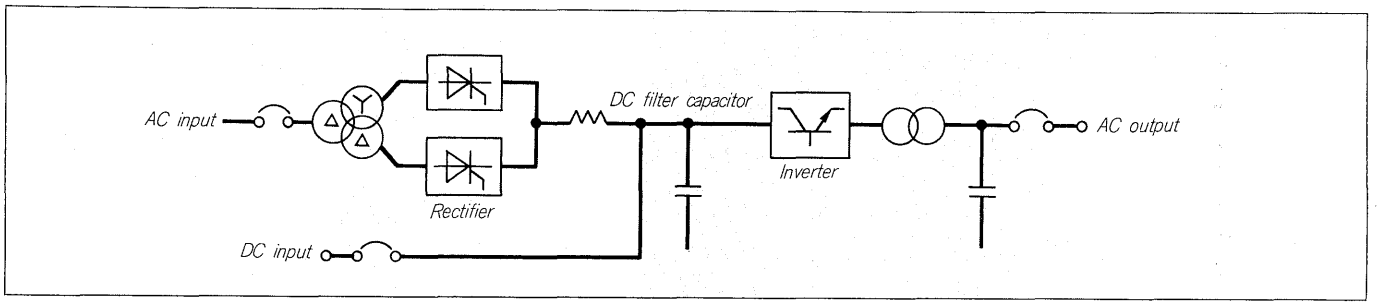
3 STANDARD SPECIFICATIONS

The standard specifications of the large capacity transistorized uninterruptible power supply are listed in *Table 2.*

Table 2 Standard specifications of Fuji power transistor type three-phase uninterruptible power supply

Item \ Model		175/200	175/250	175/300	175/400	175/500	175/600
Input	Voltage	200 V ±10%					
	Frequency	50 Hz or 60 Hz ±5%					
	Number of phases and number of wires	3 phases, 3 wires					
Output conditions	Rated capacity (kVA/kW)	200/160	250/200	300/240	400/320	500/400	600/480
	Voltage	200 V, 208 V, 220 V, 230 V / 380 V 440 V					
	Frequency	50 Hz or 60 Hz					
	Number of phases and number of wires	3 phases, 3 wires or 3 phases, 4 wires					
	Load power factory	0.7 (lagging) ~ 1.0 rating 0.8					
	Voltage accuracy (integer constant)	±1.5%					
	Transient voltage fluctuation	±8% Conditions (1) 40% sudden load change (2) Input voltage ±10% sudden change (3) Mains power interruption and recovery (4) One unit selective tripping (5) CVCF bypass switching					
	Response time	100 ms					
	Waveform distortion	5% (All harmonics square average value at linear load 100%) 3% (Sine harmonic maximum value at linear load 100%) 10% (at rectifier load 50%)					
	Interphase voltage unbalance	±3% (when ratio of maximum and minimum phase current is 1.3)					
	Frequency stability	±0.1% (internal oscillation)					
	External synchronization range	±1%					
	Overload resistance	125% for 10 min, 150% for 10 secs. (operation guaranteed value)					
	Overcurrent limit value	150%					
	Output phase error	120° ± 1° (balanced load) 120° ± 3° (30% unbalanced load)					
	Voltage setting range	±5% (rated load)					
Others	Ambient temperature	−10 ~ +40°C (operating), −20 ~ +70°C (storage)					
	Relative humidity	30 ~ 95%					
	Noise	Approx 70 dB					
	Dielectric strength	2,000 V for 1 min (main circuit)					
	Insulation resistance	3 MΩ or greater (500 V megger)					

Fig. 2 Main circuit block diagram



4 CIRCUIT CONFIGURATION

The main circuit block diagram is shown in *Fig. 2*. Internally, it consists of a DC power supply with storage battery charger function and inverter which converts DC to AC.

Fuji adopts a twelve pulse rectifier/charger as shown on the above *Fig. 2* to suppress the input harmonic current of not more than 10%. The inverter uses three-phase bridge inverter using power transistors and 15 times modulation carrier frequency is used for the power transistors.

As a result, the lowest harmonic included in the waveform immediately is made. The waveshaping AC filter becomes very small due to the above reason.

5 LARGE CAPACITY AND NEW TECHNOLOGY

5.1 Inverter stack

The inverter stack consists of an upper and lower arm set consisting of power transistors, its base drive circuit, and a snubber as shown in *Fig. 3* and is unitized as shown in *Fig. 4* by adding heat sink to this.

To make the equipment high capacity and to select a high DC voltage, the Fuji Electric single transistor IDI480A-055 (VCEO = 550V, Ic = 480A) is used as the transistor used at this stack. Eight transistors are connected in parallel. Generally, high withstand voltage products tend to have a low hFE and high saturation voltage at on. However, a high hFE and low saturation voltage were obtained by employing the three-stage Darlington circuit shown in *Fig. 3* and using each stage with the optimum current value. As a result, a small heat sink was achieved by making the base drive circuit smaller and low loss and it was made a small and light weight and easy to handle unit.

5.2 Base drive circuit

The base drive circuit connection diagram is shown in *Fig. 5*. Since a large drive current must be supplied to the main circuit transistors due to the large capacity of the equipment, it was made a system which uses a special drive circuit power supply separate from the signal source from the control circuit. However, since providing a special power supply for each arm is not feasible from the standpoint of reliability, with this equipment, a system which supplies power to each arm from one special power supply by using a pulse transformer was employed.

Fig. 3 Inverter stack circuit composition

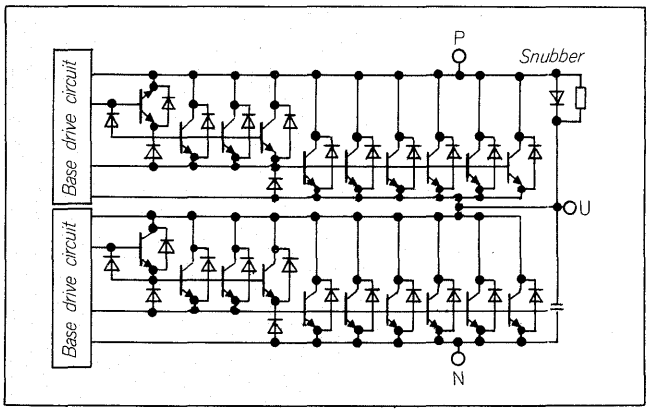


Fig. 4 Exterior view of inverter stack

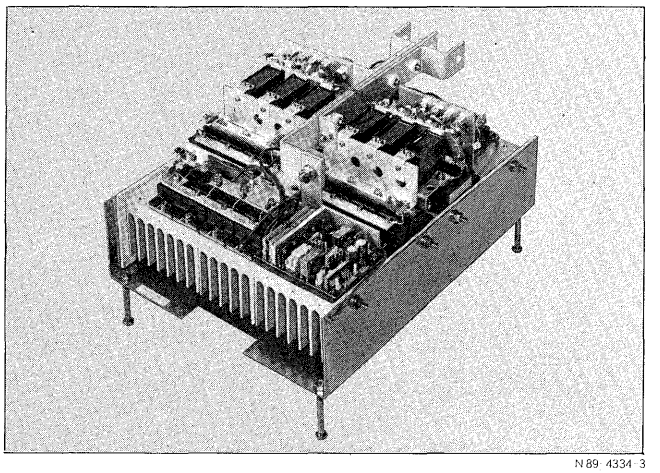
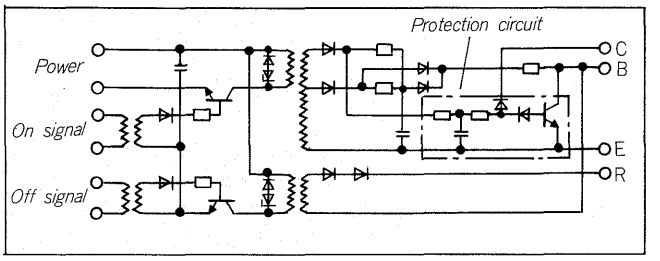


Fig. 5 Base drive circuit



5.3 Three-phase bridge circuit

The 3-phase bridge inverter consists of three inverter stacks as shown in *Fig. 6*. With large capacity equipment, since a large current is switched at high speed, the snubber for absorbing the energy stored in the wiring inductance at switching becomes large. To make the snubber small, the wiring length between the DC power supply (DC filter capacitor) and inverter stack must be very short. But there is a limit because of the demand for good maintenance, as well as for large equipment. To solve this, with this equipment, the inverter stack power lines (P, N) and output line (U) use a system in which the output line is led into the DC power supply by using laminated bar sandwiched by the power supply (Patent Pending). This allowed construction of a three-phase bridge circuit with both a small snubber circuit and good maintainability.

5.4 Parallel operation control

When the output capacity of an existing uniterruptible power supply must be increased, a parallel operation system has been used from the past. In this case, even if the parts and technology of the additional unit and existing unit are different, parallel operation with a different type of equipment is required. With the conventional control system, since a common oscillation bus line was necessary, modification to realize it was difficult. With this equipment, parallel operation with different type of equipment can be made easy by using the following technologies:

(1) Upon a parallel operation with different types of equipments, the paralleled UPS are operated by the average value of the mutual basic oscillator frequency. In case different types of equipments are operated in parallel, the oscillation frequency of the additional transistor equipment automatically tracks the frequency of the existing equipment and the additional equipment operates at its own oscillation frequency when the existing equipment is stopped at operation.

(2) The load sharing control system uses a system which controls the output frequency and output voltage of this equipment so that the cross current between inverters becomes "zero". Further, the load transfer between inverters or inverter and mains use was made in a soft switching system.

formed completely.

(3) The faulty machine judgement method uses a system which detected the output frequency, output voltage, and cross current and isolation of the faulty machine is performed completely.

5.5 Monitoring equipment

In recent years, troubleshooting equipment for trouble analysis of power supply equipment has gained much attention. Fuji Electric has standardized troubleshooting equipment (popular name: monitoring system) mounting a microcomputer for an uninterruptible power supply for this purpose. This equipment has functions for operation state monitoring, recording when trouble is generated, and reproduction of the waveform of each part before and after

Fig. 6 Three-phase circuit composition

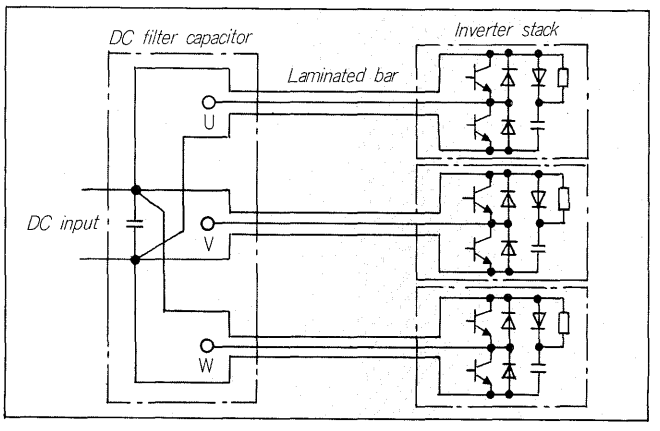
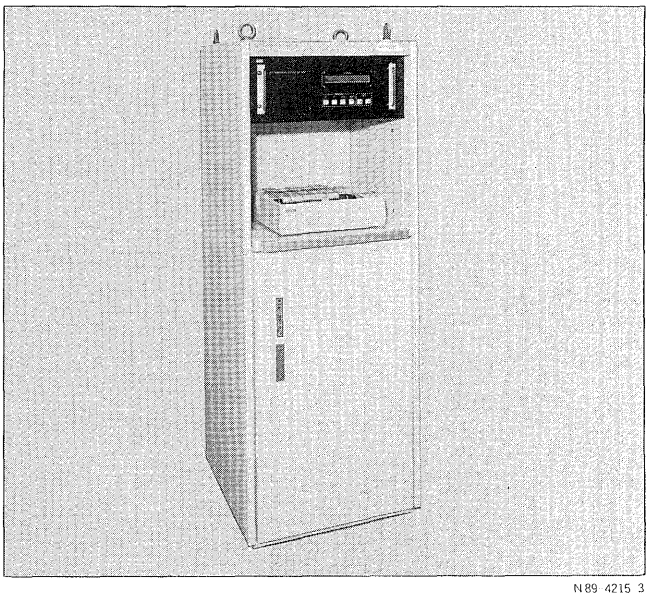


Table 3 Standard specifications of monitoring system

Item		Contents
Functions		(1) Data logger function (2) Trouble recording function (3) Status monitoring function
Component devices		(1) Microcomputer monitoring function (2) Dot printer (80 columns) (3) Interface unit
Others	Data logger function	Input and output current, output power, room temperature, etc. 20 points
	Trouble recording function	Voltage, current, etc. 8 points
	State change input signal	UPS trouble, battery operation, bypass supply, etc. 13 points

Fig. 7 Exterior view of monitoring system



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trouble occurs. The Fuji Electric transistorized uninterruptible power supply is constructed to be easy to connect to this monitoring system.

The standard specifications of the monitoring system are listed in *Table 3*.

The features of the Fuji Electric monitoring system are described below.

(1) Reproduction of the waveform 240m second before and after trouble occurs is possible.
(2) The date and time are recorded at the printed out data.
(3) Waveform reproduction is performed both automatically and manually.
(4) Report generation is performed in two modes (mode which generates reports with the set time as one unit and mode which generates reports with the time from operation to stopping as one unit).
(5) Commercially available recording paper can be used.

6 TEST RESULTS

The standard specifications of this equipment are shown in *Table 2*. The test results for the typical characteristics are described here after.

(1) Efficiency

The conversion efficiency at the rated input and output was 93.1% at AC/AC conversion and 95.2% at DC/AC conversion.

(2) Fuse short circuit test

The results of the load short circuit test performed through a fuse are shown in *Fig. 8*. Since this equipment uses instantaneous current limiting and instantaneous

Fig. 8 Output voltage and output current waveforms at load short circuit test (AC200V output, 150A fast acting fuse blown)

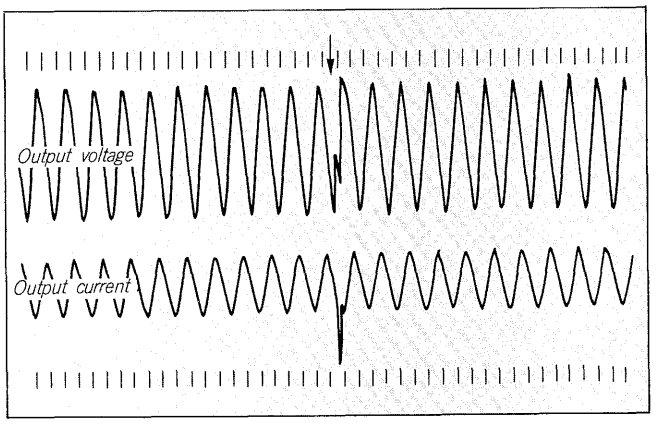
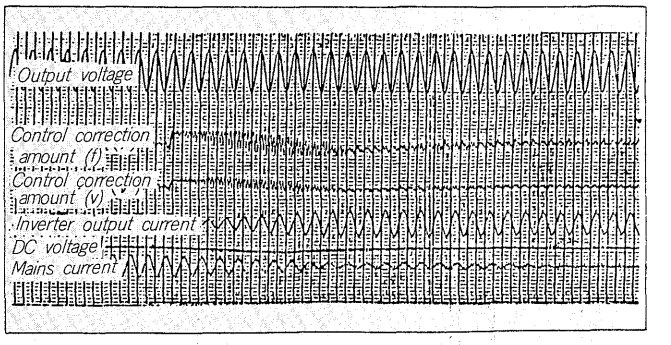


Fig. 9 Output voltage and output current waveforms at load transfer between inverter and mains



recover circuit and a control system which can amply display the capacity of the transistor at overloads, disturbance of the output voltage when the fuse blows and after the fuse blows is show to be a sufficiently small value.

(3) Transfer test

The oscillogram when transferring from mains power to inverter power is shown in *Fig. 9*. With this equipment, since the output voltage transient fluctuation at switching is suppressed to a small value and since a soft switching control system is employed, it can be seen that there is almost no output voltage change.

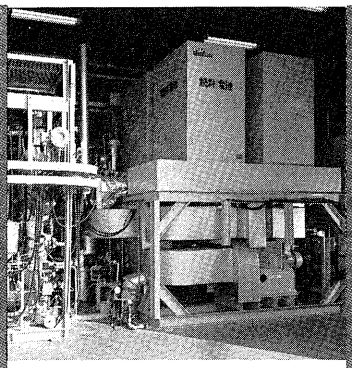
7 CONCLUSION

The power transistorized uninterruptible power supply, centered about the large capacity unit, was introduced here in. We are confident that the equipment will become smaller, more efficient, and more reliable with the application of power transistors and the development of new technology and is a product amply matched to the needs of the current marker.

In the future, computer systems will become larger and multifunctional and the demand for smaller and more reliable power supplies will become strong. To meet this demand, in the future Fuji will make efforts in building power supply equipment with higher cost-performance and reliability with making transformers and reactors smaller by use of higher frequency, development of preventive maintenance and troubleshooting technology as the topic. This requires research on new devices (for example, SI thyristor, power MOS FET, etc.) and the development of higher function LSI.

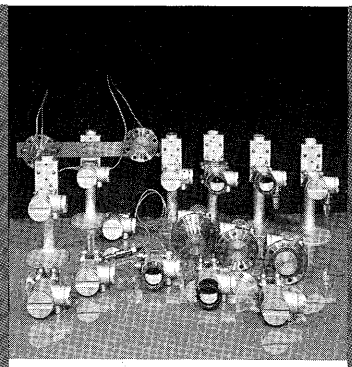
Outline of Products

Power and Industrial Electrical Machinery



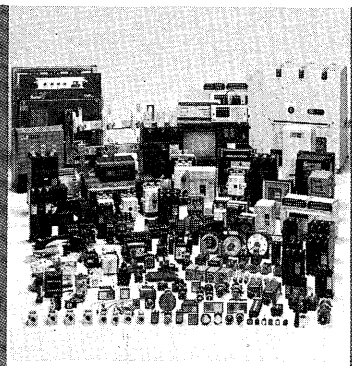
- Nuclear Power
- Power Generation and Distribution
- Transportation
- Environmental Equipment
- Industry
- Electrical Installation
- Mechatronics Equipment

Instrumentation



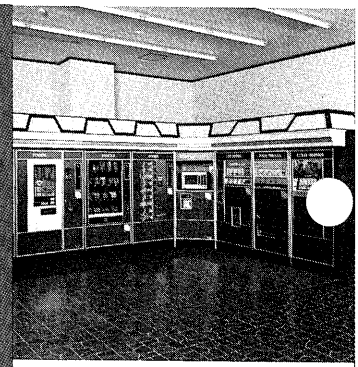
- Industrial Instrumentation
- Water Treatment
- Data Process Engineering

Standard Electrical Products



- IC (Integrated Circuit)
- Semiconductors
- Rotating Machines
- Standard Electrical Equipment

Vending Machines and Specialty Appliances



- Vending Machines
- Freezing & Refrigerating Open Showcases
- P.O.S. for Versatile Purpose Appliances
- Air Conditioning