Present State and Trends of Standard Distribution Apparatus

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1. Introduction

Electric energy is convenient, clean, easily controlled, and important for the remarkable economic development of today. Equipment for supplying and distributing electric energy, ie. distribution and control systems, are necessary for factories and buildings to be functional.

With the progress of our information-oriented society and the increased sophistication and complexity of distribution and control systems, demand for stable and reliable electric power supplies has become so critical that even an instantaneous power failure is not tolerated.

Therefore, there is strong demand for the following:

(1) Improvement in the reliability of electric power supply
(2) Improvement in electric power quality (no high harmonics or noise)
(3) Saving of space, energy, and materials
(4) Improved maintenance with reduced labor
(5) Component equipment which has advanced functions and is system compatible

Most standard distribution equipment that comprise distribution and control systems are generally used in circuits of 6 kV or less, that is, ordinary high voltage and low voltage of 600 V or less. Typical functions include switching circuits on and off, transforming voltage and current, protecting the human body and equipment, and conserving power. In concrete terms, they are high-voltage switches, disconnecting switches, high and low-voltage circuit breakers, transformers, various protective relays, etc.

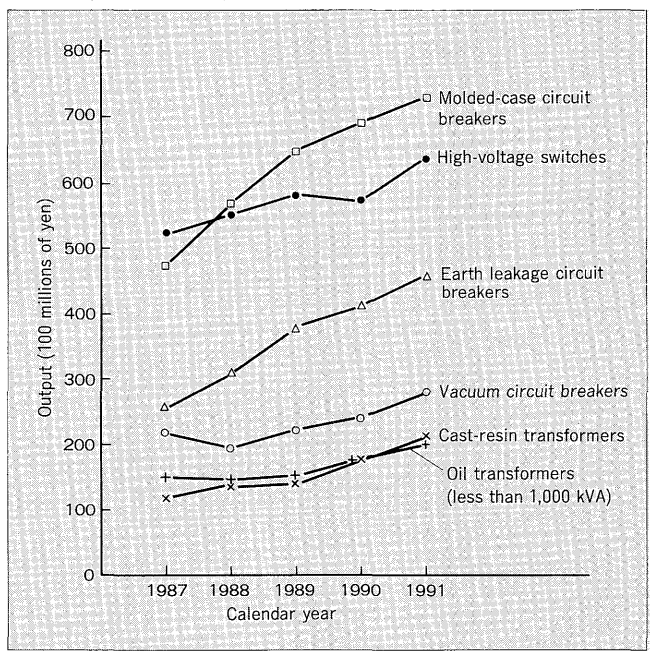
Having realized the above changing trends, Fuji Electric has made efforts to develop products which will contribute to improvement in total economical efficiency, and meet diversified needs in the field of distribution equipment.

This article introduces several new products, including high and low-voltage circuit breakers, high-voltage switches, automatic power factor regulators, transformers, and FI-Net equipment for combining these components into a system network.

2. Distribution Apparatus Market Trends

Figure 1 shows the domestic output of typical distribution equipment, that is, high-voltage circuit breakers, high-voltage switches, molded-case circuit breakers, earth leakage circuit breakers, cast-resin transformers, and oil transformers, over the last five years.

Fig. 1 Transition of domestic output of standard distribution equipment in Japan



The data shows that while high-voltage switches grew only at rates nearly equal to Japan's net GNP, other devises increased at high annual rates averaging 8 to 16%. Although influenced by prosperous economic times in Japan through 1991, the following is also believed to be reflected in the results:

(a) The needs for bigger apparatus and improved maintenance ease enlarged the market for new and replacement equipment.
(b) The shift from the oil type to the cast-resin type transformers was accelerated.
(c) Equipment investment continued actively, particularly with low-voltage circuit breakers which increased with double-digit average annual rates.
(d) The shift from molded-case circuit breakers to earth leakage circuit breakers was advanced.

The following technical comments concern the above mentioned problems of distribution and control systems.

(1) Stable supply of high quality electric power

Consideration is given to eliminating power failure and to improving the protective characteristics and reliability of equipment, and to coordinating system components so as to minimize the spread of faults in case of a short-circuit or the like. To prevent trouble, the development of equipment with preventive maintenance and duplex system capability is planned. Regulations and devices to limit noise and surge interference are also under development.

(2) Savings of space, energy, and materials

Reducing the space required to install distribution apparatus is desired due to high land prices, the technical development of suitable devices for thin cubicles and recent downsizing trends. A limited supply of power will continue to pose problems, creating intense needs for the development of energy-saving equipment. These goals are shared by both future economic policies as well as movements to protect the global environment. Apparatus functions or construction may be combined to meet these needs.

(3) Improvement in maintenance ease and handling

Distribution equipment has had new functions of monitoring, warning, and communication added to its original function of electric circuit protection and has evolved into intelligent equipment that can perform preventive maintenance. On the other hand, difficulty in securing enough maintenance personnel has resulted in trends towards simplification of handling for installation, system enlargement, and part/device replacement.

(4) Equipment with advanced functions and system compatibility

The sophistication of equipment has progressed rapidly through application of FA and CIM to plant facilities and the use of intelligent buildings. With this increase in sophistication, distribution and control equipment has been changing, utilizing technical achievements in electronics and key sensor technologies.

For example, using communication and transmission technology, an easy to build network for the exchange of signals between equipment and system operating conditions is currently under development. Wider application of the equipment is expected.

3. Present State and Trends of High-Voltage Distribution Equipment

Main circuit breaking devices for high-voltage distribution apparatus include high-voltage circuit breakers, high-voltage current-limiting fuses, high-voltage air load break switches, etc.

Market needs of these devices were formerly: improvement in safety, improvement in reliability, reduction in size and weight, and economical efficiency, but now new requirements of intelligent functions, laborsaving maintenance, and internationalization have been added.

The standards relating to distribution equipment reflected issues of safety, reliability, and internationalization and were revised successively.

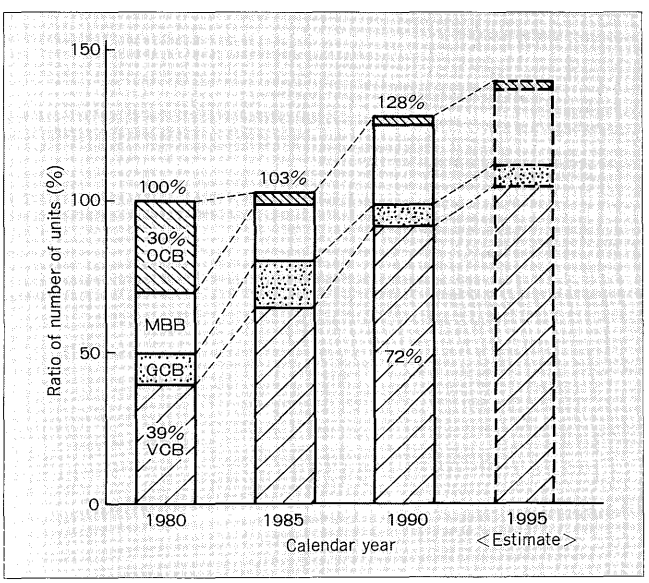
Table 1 shows an outline of the revision of their major standards. The main points of the revisions are safety during handling, trouble prevention, improvement in the reliability of protective coordination, and adjustments according to international standards.

We are confident that the equipment introduced in this paper satisfies these latest standards and is compatible with market trends.

Table 1 Outline of the revision of standards related to high-voltage distribution apparatus

Name	Standard	Outline of revision
Cubicle type high-voltage power receiving units	JIS C 4620–1992	Revision was made to meet the requirements of the actual conditions of cubicle manufacturing, the revision of related standards, and safety precautions. (1) High-voltage AC load-break switches shall be provided with an insulation barrier. (Safety) (2) CT current-carrying capacity, guaranteed current duration, and overcurrent constant n>10 are specified. (Protective coordination)
AC metal-enclosed switchgear and controlgear for rated voltages from 3.6 to 36 kV	JEM 1425–1990	JEM 1153 replaced JEM 1425 (High-voltage metal-enclosed switchgear from 3.3 to 33 kV), which was abolished in 1990. (1) Adjustments to IEC 298. (Internationalization and safety improvement)
AC circuit breakers for 3.3 or 6.6 kV	JIS C 4603–1990	An overall revision was made because the source standard JEC-181 was revised to JEC-2300, IEC 56 was revised, and many VCBs were used. (1) Addition of 3-cycle circuit breakers. (2) Adjustments to IEC standards (Internationalization)

Fig. 2 Transition of circuit breaker output in Japan (3.6 kV and more)



3.1 MULTI-VCB

Figure 2 shows the transition of production of circuit breakers in Japan. It is clear that the vacuum circuit breaker (VCB) is the mainstream high-voltage circuit breaker because of market needs for small size, light weight, long life, and laborsaving maintenance.

The MULTI-VCB was developed with Fuji Electric's VCB technology to provide VCBs which give people a sense of security.

The MULTI-VCB series consists of three models: standard VCB, AUTO-V (OCR-incorporated VCB), and intelligent VCB.

Its main features are as follows:

(1) Ease to use
(2) Improved safety and reliability
(3) Multiple functions
  (a) Equipped with various preventive maintenance (Intelligent VCB)
  (b) Equipped with protective functions (AUTO-V and intelligent VCB)

3.2 Air load-break switches with fuse

The air load-break switch with fuse combines a high-voltage current-limiting fuse and an air load-break switch into one unit. This device aims for optimum operation by using the current-limiting fuse to break short-circuit current and the load switch to switch load current on and off.

Formerly when fuses were used, sometimes one-phase breaking, in other words, an open-phase condition was caused. However, the use of a mechanical striker-trip device solved this problem and greatly improved reliability. The reliability and safety of the load switch used as a main breaker was further improved by providing a standard insulating barrier.

3.3 Cast-resin transformers

Transformers installed in public facilities, buildings, and underground markets are required to be flame-resistant in order to prevent potential disaster. Cast-resin transformers are the most common transformers at present. The cast-resin transformer has superior fire resistance, small size and light weight, low loss, low noise, easy maintenance, moisture resistance, and economical efficiency. Remarkable progress in cast-resin insulation technology has raised the characteristics, particularly of 6 kV class cast-resin transformers, equivalent to or higher than those of oil transformers. As a result, cast-resin transformers are being used even more widely.

3.4 Automatic power factor regulators

An energy conservation policy in Japan provides for a system where customers will receive a discount on their electric bill if they maintain a high power factor. The automatic power factor regulator is a device that automatically maintains and controls the power factor above a preset value. The new models are equipped with a microcomputer and have the following features:

(1) The power factor can be controlled at a proper value by simply inputting the capacitor capacity, PT ratio, CT ratio, and the target power factor.
(2) The same power source and input voltage can be used for 100 V and 200 V.
(3) The unit automatically can diagnose an input signal wiring error and will issue an alarm.
(4) A control system is available to minimize the total number of capacitor switching operations and further equalize switching operations among equal capacity units.

4. Present State and Trends of Low-Voltage Distribution Equipment

Low-voltage distribution equipment includes molded-case circuit breakers (MCCB), earth leakage circuit breakers (ELCB), fuses, and circuit protectors. These products have a long history, and their basic principles of operation have not changed. However, with newly developed materials and technical innovation, they are continuously adapting to meet the needs of the times and to change in the environment. The latest trends are towards downsizing, modularization, electronics application, and system compatibility. The major points are outlined below.

4.1 Twin breakers, realization of the ultimate modularization

The twin breakers are an MCCB and an ELCB with 800 A frames or less. For the first time in the world, main specifications and external dimensions have been made the same, and a great reduction in size has been realized.

This concept has been developed from the merits of the Depth 60 series which Fuji Electric took the initiative to modularize about ten years ago. Twin breakers make the design and fabrication of switchboards more efficient and permit flexible changes in specifications. The Super twin breakers with 400 A frames and above are constructed to allow easy mounting of internal accessories.

4.2 Electronic twin breakers which match the improvement in power supply reliability

About ten years have passed since the molded-case circuit breaker with electronic overcurrent relay (OCR) was put on the market. Now there is a shift to second generation circuit breakers which use a custom IC in place of a discrete circuit.

Electronic OCRs are used to replace mechanical OCR, and to meet new distribution and control systems needs through the combination of peripheral functions. The electronic Twin breaker has an OCR section designed to be compact and is able to realize more effective current control than was possible with the former discrete circuit. Since it is euqipped with a prealarm function and functions to monitor load current and control a load simply and properly, new applications may be possible.

4.3 Power supply system capable of increasing load terminals

At a construction site, for example, there is a need to freely increase or decrease distribution panel units for power supply in accordance with the work under progress. Fuji Electric has developed a new type of power supply system for this purpose, which can meet such conditions as tall buildings, large construction machines, and man power shortages in the field as well. The system consists of an operating panel unit and local panel units that can be distributed at work sites. The system construction allows these units to communicate with each other through the FI-Net. Centralized monitoring of the local panels distributed at work sites can be performed from an operating panel installed in an office. Up to 120 local panels can be monitored and controlled.

4.4 Thin type circuit protectors

Circuit protectors are low-voltage circuit breakers for the control circuitry of machines. Taking the place of fuses which require element replacement after fault breaking, circuit protectors have come into wide use to improve maintenance efficiency. The number of components has increased due to highly complex control systems which accompany sophisticated machinery. On the other hand, control panels are required to be small-sized. Fuji Electric's newly developed series is 30% thinner than former models.

5. Conclusion

New distribution apparatus is expected to raise system integrity with functions of monitoring, warning, and communication in addition to its original function of system protection. Various changes such as protection of the global environment and mutual interaction between man and systems are beginning to be noticed. This is an indication of system safety and reliability being regarded as more and more important, and will result in great potential for distribution apparatus in the future. We expect that market research, individual product technology as well as progress in fundamental and peripheral technologies such as new materials, electronics, sensor technology, optical system technology, and information transmission technology will spur on this change.