32 to 63 AF Compact Low-Voltage Circuit Breakers

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ABSTRACT

In order to meet diversifying market needs, Fuji Electric has developed 32 to 63 AF compact low-voltage circuit breakers as the new line-up of the global G-TWIN Series. The installation footprint was reduced to 72% of that of previous products, so that the circuit breakers can help reduce the size of panels and machines. In addition, breaking performance has been increased 1.5 times, thus they both provide industry-best compactness and breaking performance. Features of this product include the adoption of a new type of link mechanism and a thermal-electromagnetic over current tripping mechanism as miniaturized technology and the adoption of a unique one-contact arc commutation breaking method as advanced breaking technology. Furthermore, this production is highly extensible breakers designed to improve user interfaces through the expansion of the accessory line-up.

1. Introduction

In order to protect wiring, facilities, human bodies and the like from electric accidents such as overcurrent to the load, a short circuit, ground fault or earth leakage of an electrical line, low-voltage circuit breakers, as typified by molded case circuit breakers (MCCB) and earth leakage circuit breakers (ELCB), are installed in every type of machine, equipment, facility and building that uses electricity.

In 1990, Fuji Electric released its "TWIN Breaker" series that, for the first time in the world, featured MCCBs and ELCBs with common external dimensions. In 2001, Fuji Electric launched the "α-TWIN Breaker" series of 32 to 100 AF products in the industry's smallest size. These features contribute to the miniaturization and the design standardization of panel equipment and machines, Fuji Electric has, therefore, received the support of many customers. In response to the globalization of the market, in 2009, Fuji Electric launched the "G-TWIN Series" that conforms to international standards including IEC and UL[1].

This paper describes the features, miniaturization technology and breaking technology of 32 to 63 AF compact MCCBs and ELCBs that have been developed as a new lineup for the G-TWIN Series.

2. Development Goals

In recent years, the specifications of MCCB and ELCB products have become more diversified. Stable product pricing that is unaffected by procurement market conditions (the rising of material prices), improved breaking performance and sharing of various types of accessories are common requests; however, different specifications are required in each field.

One such requirement is for miniaturization of the devices that are necessary in order to realize smaller and lighter weight in machinery and control panel applications. Additionally, improved safety and compliance with international standards are also required. On the other hand, for power distribution panel applications, in order to simplify the panel design, unified external dimensions and compatibility with existing equipment, as well as an upgraded current rating to handle larger loads are requested. Furthermore, for power supply equipment and power generation facili-

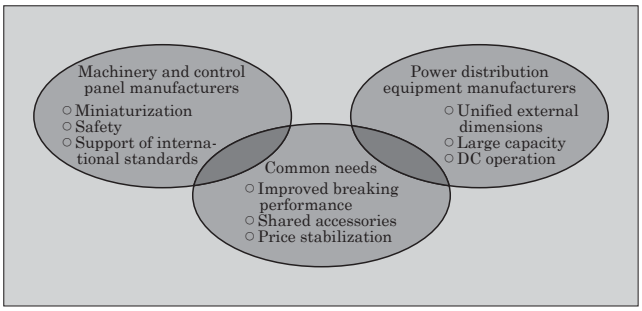

Fig.1 Market needs for MCCBs and ELCBs

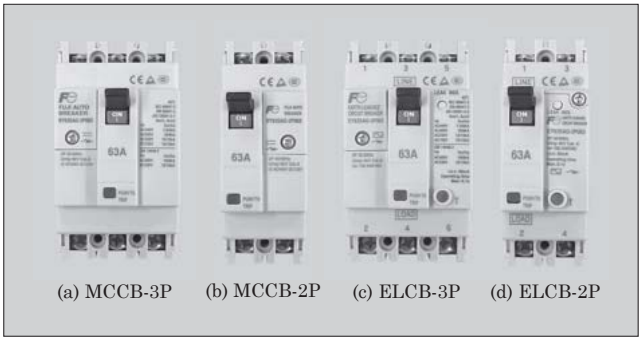

Fig.2 Product lineup

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ties concerning recently increasing renewable energy applications, the ability to handle high DC voltage is necessary. In this manner, there has been a clear trend to use the optimal device for each industry and application (see Fig. 1).

Under these circumstances, Fuji Electric decided to develop a more compact lineup of 63 A and lower products (see Fig. 2), which are often used at the ends of branch circuits, for the market where miniaturization of device is strongly requested.

3. Product Features

Main features of the developed 32 to 63 AF MCCB and ELCB products are as follows.

(1) 3-pole products are designed with the industry's smallest body size of 54 mm width (2-pole products have a width of 36 mm), reducing the installation footprint to 72% of that of existing products (see Fig. 3 and Fig. 4).

(2) The breaking capacity has been increased 1.5 times comparing to existing products, achieving the industry's highest level of breaking performance in the same body size. In particular, for the 200 VAC lineup, the breaking performance is improved significantly with I_{cs} (rated service short-circuit breaking capacity) = 100%×I_{cu} (rated ultimate short-circuit breaking capacity) (see Table 1).

(3) In response to requests for electrical safety of devices, the terminal block incorporates safety design concepts that conform to IP20 (see Fig. 5).

(4) As shown in Fig. 6, the use of cassette-type internal accessories installable by the customer and the lead routing along the side of the main unit enable close-contact body mounting. Additionally, with Fuji Electric's proprietary product accessary layout, combination variations (see Table 2) are provided, and the functions with accessories are enhanced.

(5) Standard support of IEC 35 mm mounting rails enables two types of installation, either by mount-

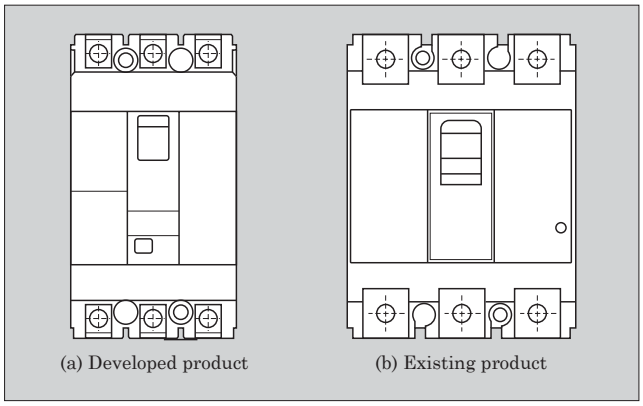

Fig.3 Comparison of external dimensions with those of existing products

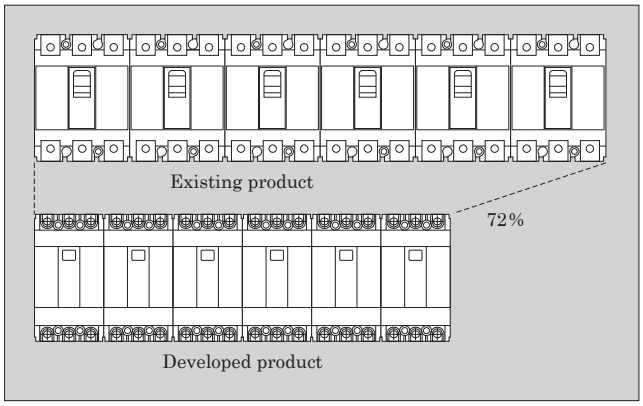

Fig.4 Miniaturization image on parallel installation

Table 1 Comparison of breaking capacity (IEC condition I_{cu} / I_{cs})

		Economy type	General type
Existing product (BW50EAG, SAG)	AC230 V	5/3 kA	10/5 kA
	AC440 V	2.5/2 kA	7.5/4 kA
Developed product	AC230 V	7.5/7.5 kA	15/15 kA
	AC440 V	2.5/2 kA	7.5/6 kA

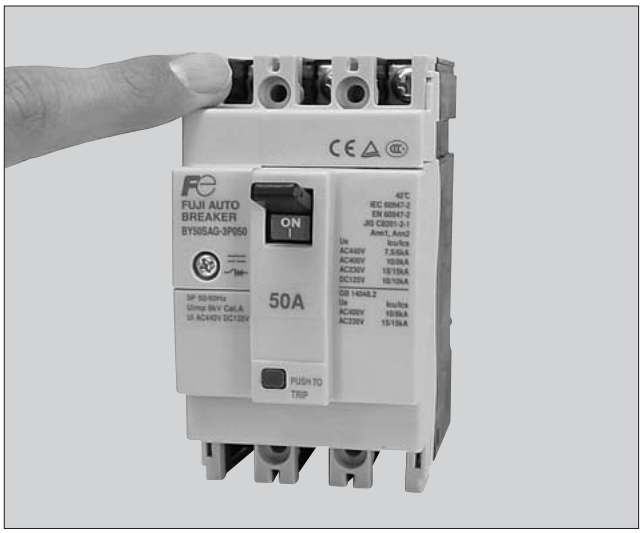

Fig.5 Terminal block safety (finger protection)

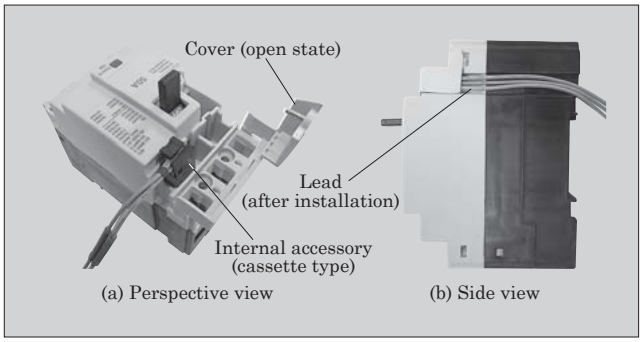

Fig.6 Installation example of internal accessory of developed product

Table 2 Examples of representative accessory combinations

●: Auxiliary contact ▲: Alarm contact		MCCB		ELCB	
No. of poles		2P	3P	2P	3P
Auxiliary contact	W	○	○	○	○
	W2	–	○	–	○
Alarm contact	K	○	○	○	○
Auxiliary/ Alarm	WK	○	○	○	○
Voltage tripping	F	○	○	–	○

ing screws or by mounting rails.

(6) Two types of products lineuped according to the application to accommodate the various international standards.
- ○ Standard: Japan Industrial Standard (JIS), IEC, CCC
- ○ Global: JIS, IEC, CCC, UL489

(7) Compliance with various environmental regulations including the RoHS directive*1 contributes to a reduction in the environmental load.

4. Product Miniaturization Technologies

In the newly developed products, each functional unit was miniaturized and made more efficient in order to realize a compact size and high performance, and the design was devised to optimize the quantities of the main conducting materials used, such as of copper and silver, in order to lessen the effect of the recent increase in material prices on the product price.

Moreover, in general, with MCCBs and ELCBs, their parts differ according to the rated current and the rated breaking capacity. Therefore, a modular structure (see Fig. 7) for each function was adopted to reduce the number of assembly steps for the product.

(1) Opening and closing mechanism

Because main components of the opening and closing mechanism in existing products were made of resin, miniaturization had been difficult due to subjects with dimensional accuracy and strength. Fuji Electric's newly developed breakers utilize an integrated structure with a new link mechanism and an outer frame using metal parts (see Fig. 8), and realize an opening and closing mechanism that has been miniaturized to 75% of the existing size, and a 20% improvement in contact opening speed with lighter weight parts (see Fig. 9).

*1: RoHS directive: European Union (EU) directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment

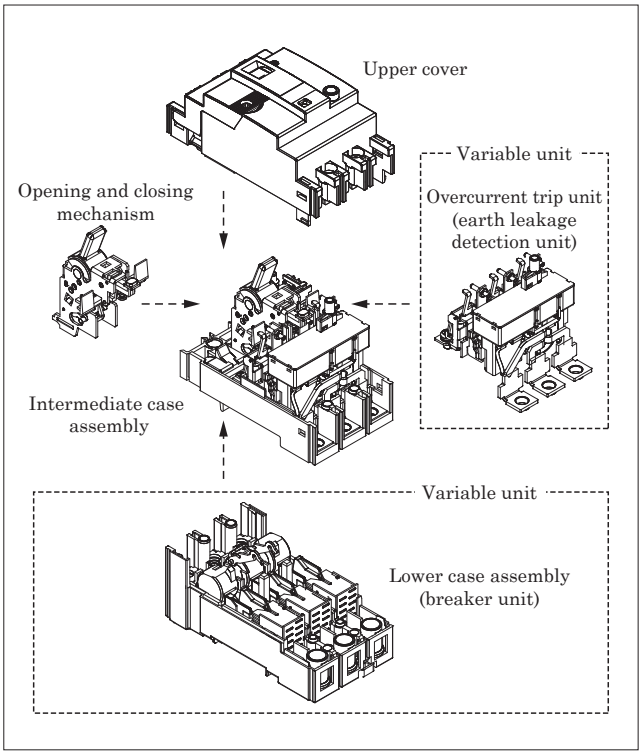

Fig.7 Modular structure of each functional unit

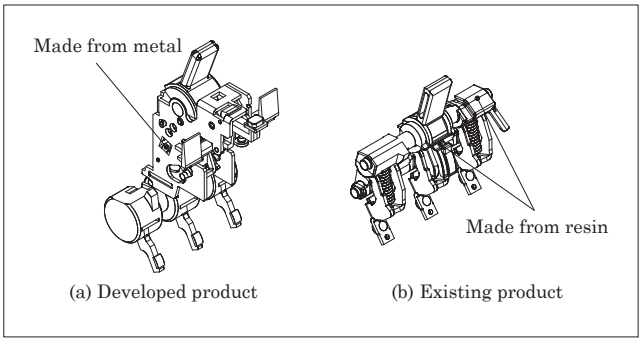

Fig.8 Opening and closing mechanism

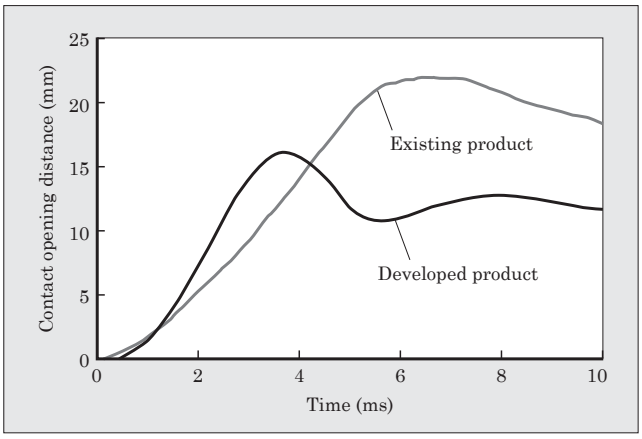

Fig.9 Comparison of contact opening characteristics

(2) Overcurrent tripping unit

As shown in Fig. 10, the attractive force of the elec-

tromagnetic tripping mechanism was examined using magnetic field analysis, the mechanism was miniaturized and the overcurrent tripping mechanism was changed from the existing fully electromagnetic method to a thermal-electromagnetic method. As a result, the size was reduced to 70% less than that of the existing overcurrent tripping unit, and overcurrent protection characteristics covering up to 10 times the rated value (fluctuation by differences in the mounting orientation and AC or DC operation) could be commoditized, thereby enhancing versatility.

Moreover, as efforts to reduce silver and copper usage in order to stabilize product prices, thermal analysis was performed to examine the temperature rise of a conducting element and the design was optimized (see Fig. 11). At the maximum rating products, copper and silver usage was reduced more than 30% compared to existing products.

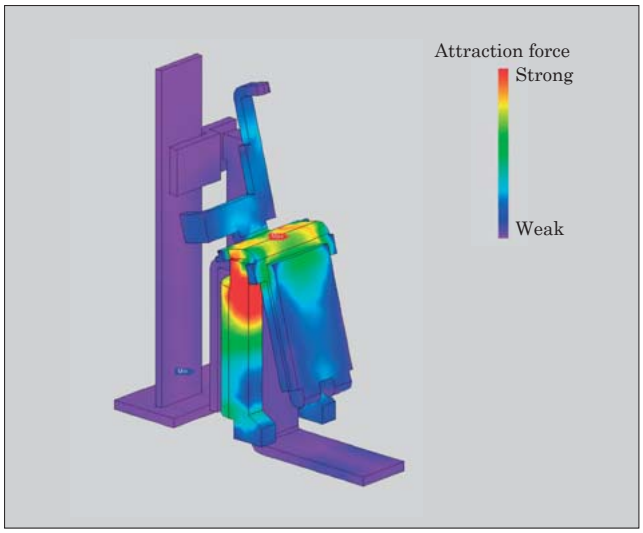

Fig.10 Examination of attraction force of electromagnetic tripping mechanism by magnetic field analysis

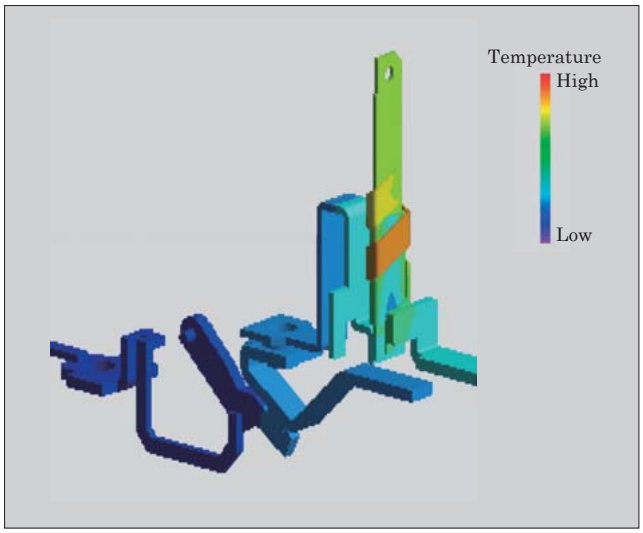

Fig.11 Examination of conductor temperature rise by thermal analysis

5. Arc Commutation Breaking Technology Realizing High Breaking Performance

To attain the small size and high breaking performance that are features of these products, the developed products use a proprietary single-contact arc commutation breaking method. With a typical MCCB, a commutation breaking method as shown in Fig. 12 is used. The structure is able to suppress short-circuit current by opening the contacts at high-speed, driving the arc to the arc-extinguishing unit, and increasing the arc resistance between contacts so as to instantaneously increase the circuit impedance.

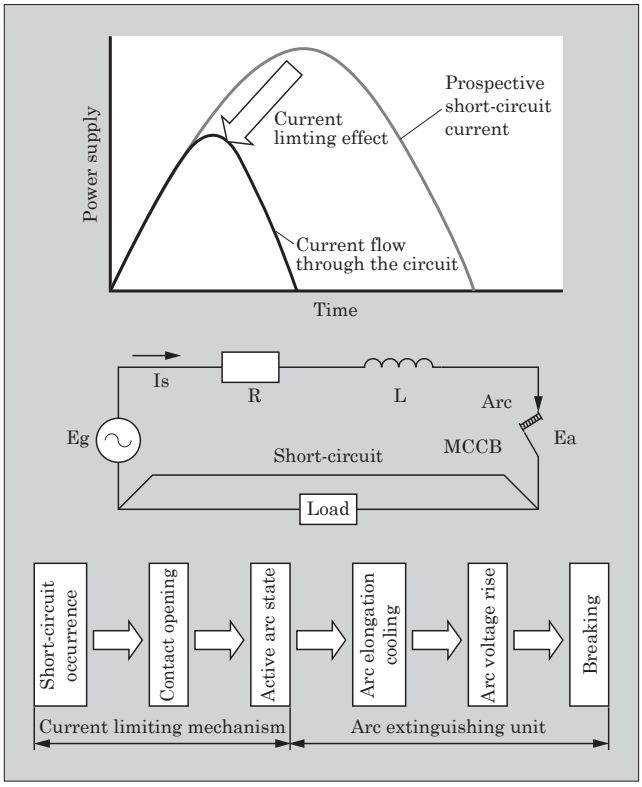

Fig.12 Current limiting breaking method

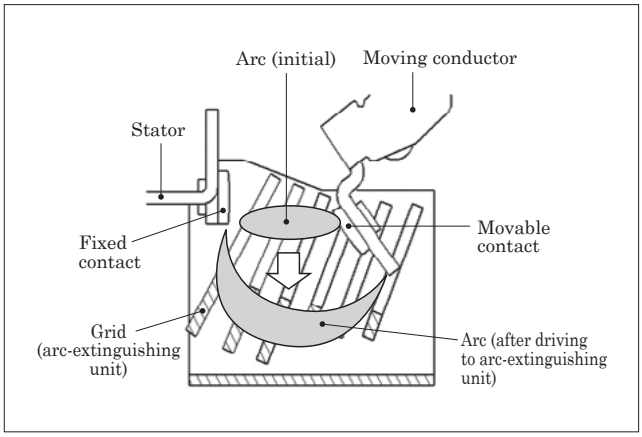

Fig.13 Schematic diagram of the breaking structure in an existing product

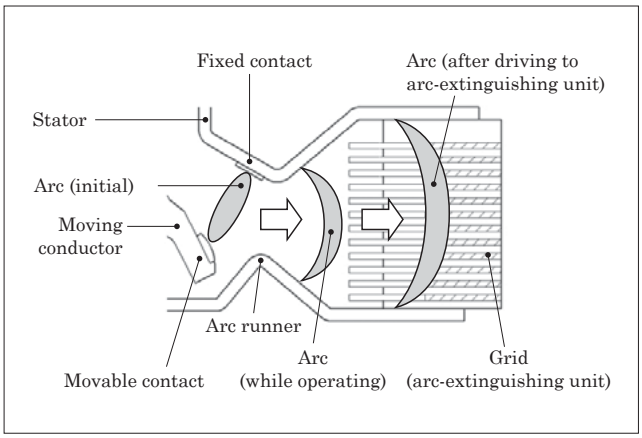

Fig.14 Schematic diagram of breaking structure in developed product

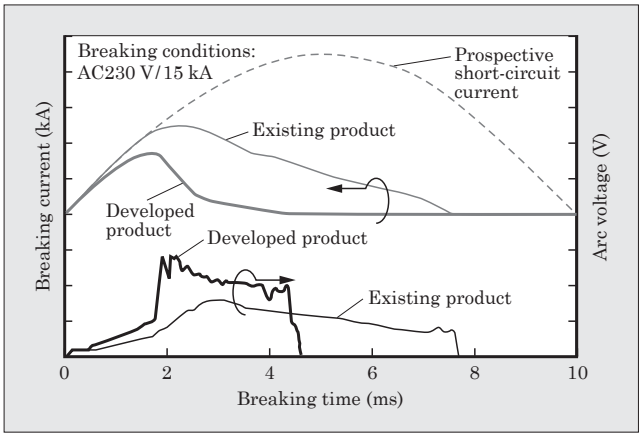

Fig.15 Breaking oscillograms of existing product and developed product

The breaking structure of an existing product (see Fig. 13) utilizes the electromagnetic force or rise in internal pressure to drive an arc, having been generated between the contacts, along the edges of the moving conductor and stator to an arc-extinguishing unit configured with a laminated magnetic metal body (grid). For this purpose, a large arc-extinguishing unit was needed to enhance the current limiting effect. Because the arc-extinguishing unit was constrained in size in proportion to the contact opening distance (contact gap) of the moving conductor, it was difficult to enlarge only the arc-extinguishing unit in small products. Additionally, because arcs at the current breaking time are always generated in the vicinity of the contacts, there is the problem of greater wear of the contacts.

The breaking structure (see Fig. 14) of the developed product uses a breaking method in which an arc generated between contacts is commutated to a conductor known as an arc runner, and is driven at high-speed to an arc-extinguishing unit located a distance from the contacts. This method enables the arc-extinguishing unit to be made large even if the contact opening distance (contact gap) is small, and the contact wear to be reduced since the final position of the arc is far away from the vicinity of the contacts.

With this new technology, in the developed products, the time until reaching the maximum value of arc voltage can be reduced compared to existing products and, the pass-through energy (time integration of square product of the pass-through current: $\int i^2 dt$) at the time of breaking can be suppressed to less than half by increasing the arc voltage (see Fig. 15).

6. Postscript

The featuring miniaturization technology and breaking technology of Fuji Electric's 32 to 63 AF compact low-voltage circuit breakers have been introduced. For electrical equipment used in Japan and overseas, a product lineup that supports diversifying market needs is expected to become even more important in the future. Fuji Electric intends to promptly embrace the requests of customers and to expand the lineup of products that meet market needs.

References

(1) Okamoto, Y. et al. New Technology of the Global Twin Breaker "G-TWIN Series." FUJI ELECTRIC REVIEW. 2010, vol.56 no.3, p.97-102.