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HIGH MODULARITY TWIN BREAKERS

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1. FOREWORD

The importance of electric conversation was the foundation which supports modern living and industry is increasing. Moreover, as seen in the intelligent buildings and FA, many industrial systems are being made more complex and diverse for higher efficiency by informationalization. We feel that it is natural that this be accompanied by a stable supply of electricity at all times as an energy resource that drives systems, like air and water.

On the other hand, viewed from the electric facilities side, to meet such conditions, technological development or proposals that contribute to total cost reduction of more complex facilities aimed at improvement of reliability and ease of use by the consumer were made. Especially, to the customer, these proposals are remarkable for low voltage distribution systems which are closest to him and many of which are used. For example, the molded circuit breakers (MCCB) and earth leakage circuit breaker (ELCB) which are the main components of low voltage switchgear are being improved as shown in *Fig. 1*.

Following this trend, Fuji Electric has completed technology accumulated through long years of experience and has developed a new series of Fuji Auto Breakers (FAB) and Fuji Earth Leakage Breakers (ELB) on new concepts. This new series is a full model change of all models of up to 225A frame and was given the name "twin breaker" to express this new concept positively.

The features, specifications, construction, etc. of the TWIN breakers are outlined.

2. AIM AND FEATURES OF TWIN BREAKERS

2.1 Current state of MCCB and ELCB

Fig. 2 shows the differences between the new series and the current MCCB and ELCB generally used in the Japanese market. From the experience gained in development of the ELCB as a circuit breaker with an earth leakage interrupting function added to the MCCB, the ELCB was designed by adding an earth leakage detector (zero phase transformer + electronic circuit) at the load side of the MCCB.

Therefore, when installed to distribution panel, the installation center line and the window frame of the operating handle of the ELCB do not match, only the ELCB is

Fig. 1 MCCB and ELCB product improvement trend

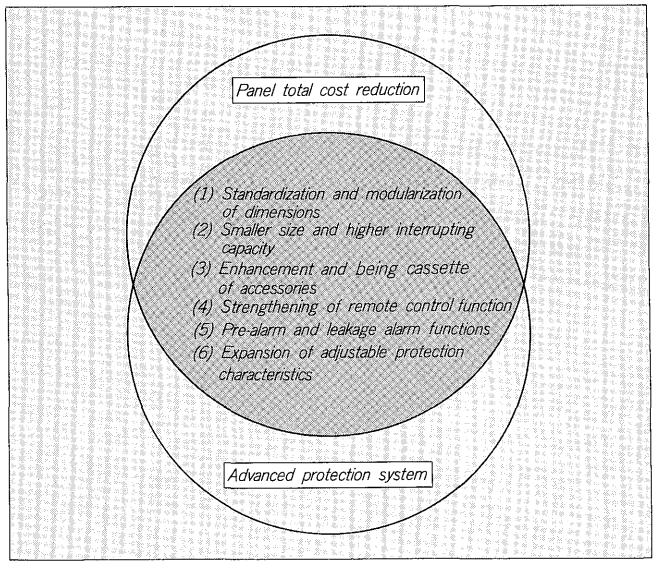


Fig. 2 Differences from current MCCB and ELCB

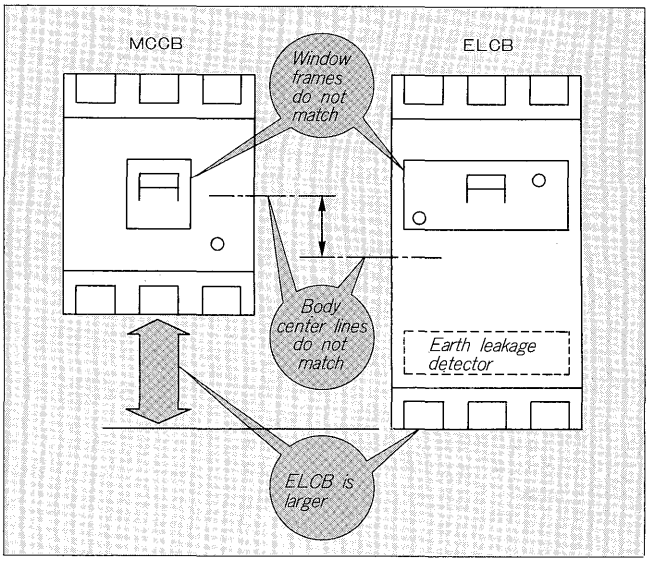


Fig. 3 TWIN BREAKER development concept

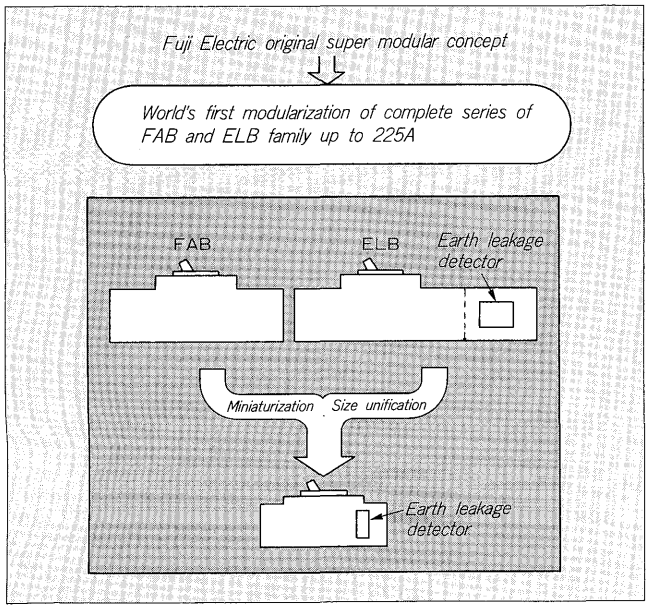


Fig. 4 TWIN BREAKER series

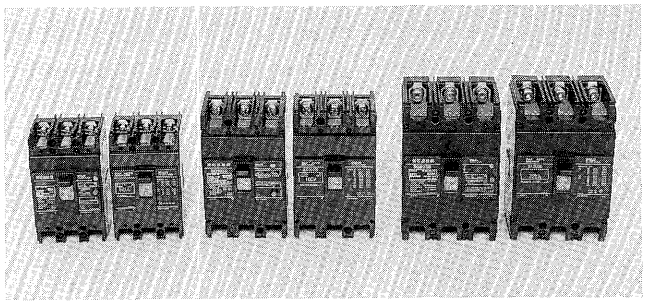
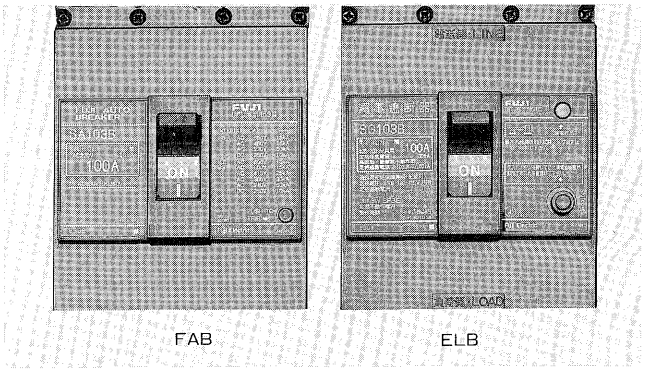


Fig. 5 Front design of TWIN BREAKER



large, and other distribution panel configuration problems are encountered.

Recently, the number of cases in which ELCB are installed has increased because of the demand for improvement of the safety of increasingly complex facilities and the use of both MCCB and ELCB in the same distribution panel has become popular. In such cases, the problems mentioned above make panel design, manufacture, and modification complex and solution of these problems is being important as "replacement needs" for circuit breaker manufacturer's for each consumer from the standpoint of promoting total cost reduction of facilities also.

2.2 High modularity TWIN BREAKER

TWIN BREAKER are a new type of low voltage overcurrent circuit breakers that revolutionize the concept of existing MCCB and ELCB. Their design concept is shown in *Fig. 3*.

For the first time in the worlds, the outside dimensions of FAB and ELB from 30A frame to 225A frame have been standardized and made more compact and "high modularity" has been realized. This concept continues the "height from panel standardized at 60mm" feature that give the initiative to modularization of low voltage circuit breakers are the depth 60 series by Fuji Electric's original concept at the beginning of the 1980's.

Since FAB and ELB with the same dimensions, ratings, and interrupting capacity are available as perfectly matched pairs from an economical series to a high performance type series, the twin breakers were given the name "TWIN", the English word for twins.

2.3 Features of TWIN BREAKER

As shown in *Fig. 4* and *Fig. 5*, the man-machine interface was improved by display of the switching status by color, use of a functional design that concentrates the nameplates, test and earth leakage indication button, etc. at the window frame section at the front of the circuit breaker, etc. The main features of the twin breaker are described below.

(1) Standardization of FAB and ELB dimensions specifications

For the entire series of Fuji Electric FAB and ELB from 30A frame to 25A frame, the number of frames with different outside dimensions has been substantially reduced from the old 15 frames to 7 frames. Moreover, since a high performance series has been added to the ELB, wider circuit breaker application while reducing the distribution panel design and manufacture control man-hours is possible.

(2) Modularization of basic dimensions between frames

Since the height of the circuit breaker from the panel surface, window frame dimensions, and terminal height have been standardized, panel design and manufacture can be rationalized. Furthermore, demands for FAB and ELB modification and replacement even after facility operation can be met flexible.

(3) Compact, high interrupting capacity

High speed, high current limiting interrupting was realized and interrupting capacity per unit volume was substantially increased by the development and use of Fuji Electric original AD technique (Active-arc Driving technique). This allows more economical use even for increased power source capacity. An example of expansion of the range of application by the TWIN BREAKER is shown in *Fig. 6*.

(4) Product internationalization

Standard FAB products conform to IEC, BS, VDE, and other international standards and foreign standards.

Fig. 6 Expansion of TWIN BREAKER application range (ELB)

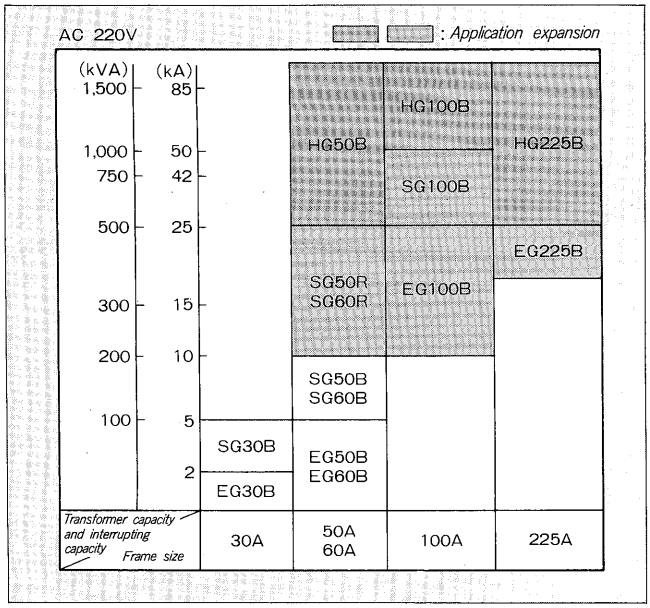
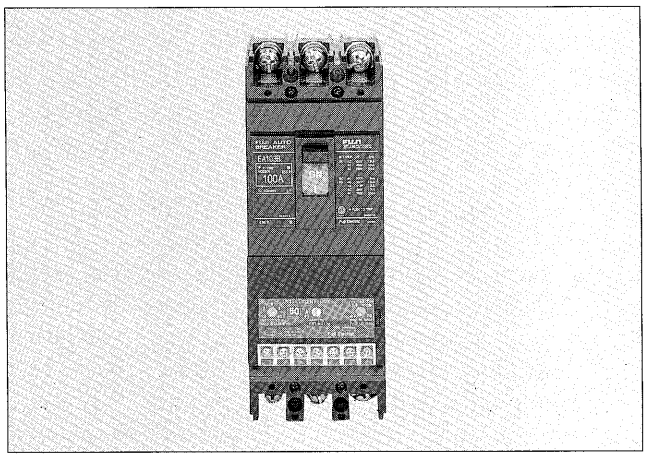


Fig. 7 Example of electronic type TWIN BREAKER



This is entered on the main nameplate. Switching indication conforming to IEC standards is also used. Rated current adjustable type FAB, connection system variation, and other foreign oriented enhancements are planned.

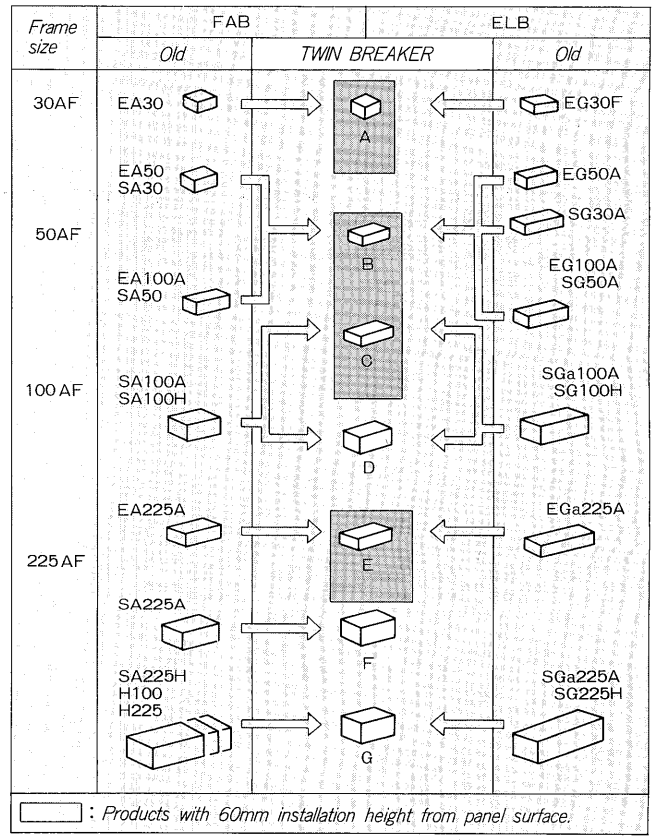
(5) Abundant variations and options

A full line of options aimed at increasing the affect of modularization of the TWIN BREAKER and improving operability, safety, and other user interfaces is available. Especially, their strong points are in wiring internal accessories, remote operating devices, external operation handle, and insulation covers.

An option with an electronic relay integrated at the TWIN BREAKER load side as shown in *Fig. 7* can also be manufactured.

This unit can also be used as an electronic FAB and ELB with an overload protection characteristic adjustment function, pre-alarm output function, etc.

Fig. 8 Model standardization at new series



3. OUTSIDE DIMENSIONS STANDARDIZATION AND MODULARIZATION

3.1 Model standardization TWIN BREAKER

Besides the different interrupting capacity and rated current, the ELB of the current FAB and ELB series from 30A frame to 225A frame has different outside dimensions and, therefore, there are a total of 15 frames of different installation sizes.

The TWIN BREAKER are standardized into only seven models for FAB and ELB combined. *Fig. 8* shows unification of frames from the old series to the TWIN BREAKER series. In particular, the old FAB and ELB series corresponding to the frames indicated by B is were made up of five frames in all. The TWIN BREAKER standardized this to one frame. Therefore, the effect of functions standardization is most remarkable in the frames indicated by B. This is one of the big features of the TWIN BREAKER.

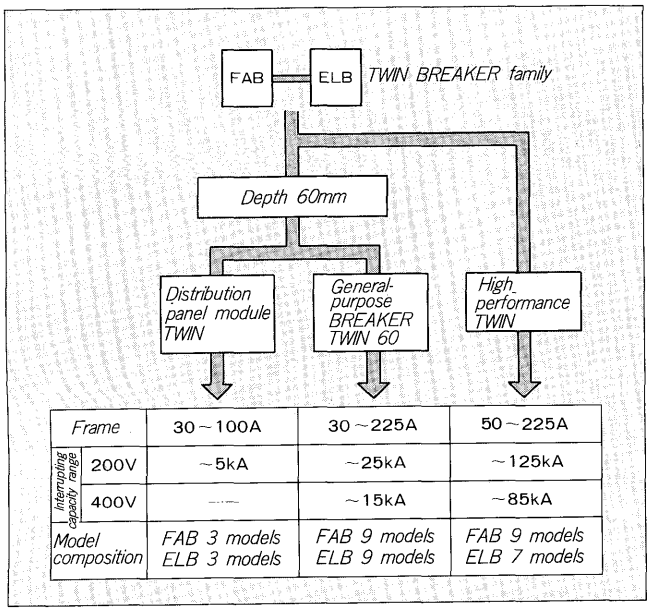
3.2 TWIN BREAKER model configuration

TWIN BREAKERs are grouped into three types by application and specifications as shown *Fig. 9*: distribution panel TWIN BREAKER, general-purpose TWIN 60 BREAKER, and high performance TWIN BREAKER.

(1) Distribution panel TWIN BREAKER (frame indicated by A in *Fig. 8*)

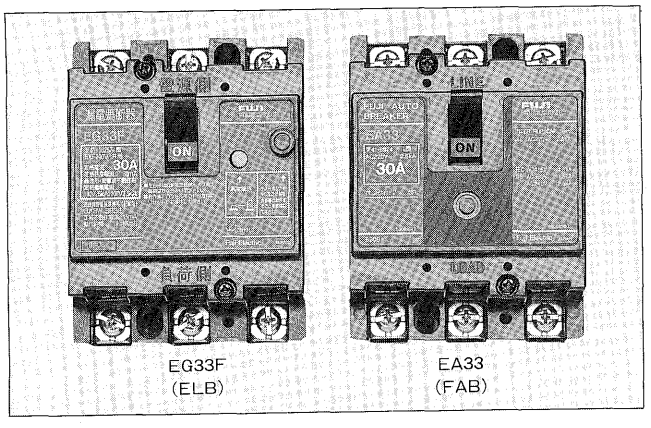
This TWIN BREAKER has main dimensions matched to the contract type molded case circuit breaker of JIS C 8370. This type consists of six models from 30A to 100A

Fig. 9 TWIN BREAKER composition



Frame		30~100A	30~225A	50~225A
Interrupting capacity range	200V	~5kA	~25kA	~125kA
	400V	—	~15kA	~85kA
Model composition		FAB 3 models ELB 3 models	FAB 9 models ELB 9 models	FAB 9 models ELB 7 models

Fig. 10 Distribution panel TWIN BREAKER



and is used mainly with 100V and 200V lighting distribution panels and power distribution panels. One-touch installation to a connecting plate or installation to IEC 35 mm rails is featured. It is shown in *Fig. 10*.

(2) General-purpose TWIN 60 BREAKER (Frames indicated by B, C, and E in *Fig. 8*)

This type has an interrupting capacity applicable to the maximum short time current class of JIS C 8480 Cabinet Type Distribution Panel. The installation height from the panel surface is standardized at 60 mm. It consists of 18 models from 30 A to 225 A.

This series makes the most of the features of the TWIN BREAKER. Typical models are shown in *Fig. 11*.

(3) High performance TWIN BREAKER (Frames indicated by D, F, and G in *Fig. 8*)

This series are high performance current limiting circuit breakers that cover the high interrupting capacities up to 220 V 125 kA and 460 V 85 kA. It is made up of 16 models from 50 A to 225 A. The addition of a high interrupting capacity impossible with the old type to the series makes a high capacity facility distribution board configuration easy.

Fig. 11 General-purpose TWIN 60 BREAKER

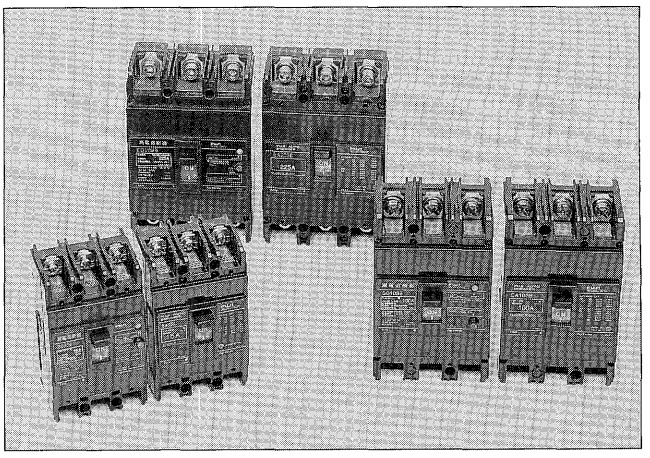
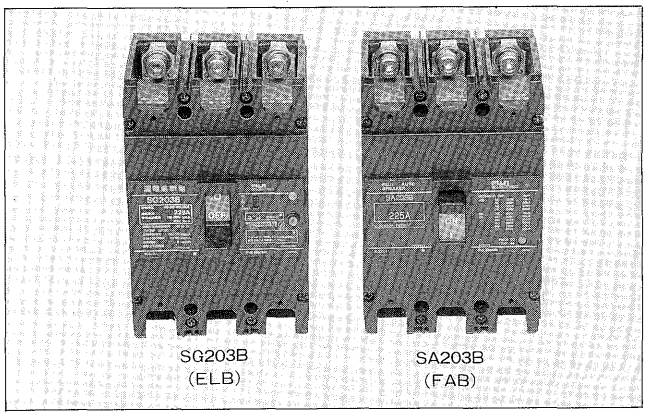


Fig. 12 High performance TWIN BREAKER



This series was made compact so that the installation projection area to the panel surface is the same as that of the general-purpose TWIN 60 BREAKER.

The installation height from the panel was made higher than that of the TWIN 60 BREAKER to realize a high interrupting capacity. The 225 A frame FAB and ELB are shown in *Fig. 12*.

3.3 Standardization of main dimensions

Standardization of the main dimensions of the FAB and ELB has a large affect on panel design, manufacture, and appearance. Therefore, the main dimensions of the TWIN BREAKER were standardized thoroughly.

The standardized main dimensions of the general-purpose TWIN 60 BREAKER are shown in *Fig. 13*.

Besides the basic standardization which made the outside dimensions of the FAB and ELB the same, 60 mm height from panel surface, 50 mm handle window frame width, 24 mm terminal height, and other standardizations were planned.

The handle window frame shape of the TWIN BREAKER was standardized to a large window frame from which the handle and nameplate protrude, the same as the old ELB. However, the window frame was made a 2-stage construction so that the system used with the old FAB in which only the handle protrudes from the panel is also possible.

Fig. 13 Standardization of main dimensions

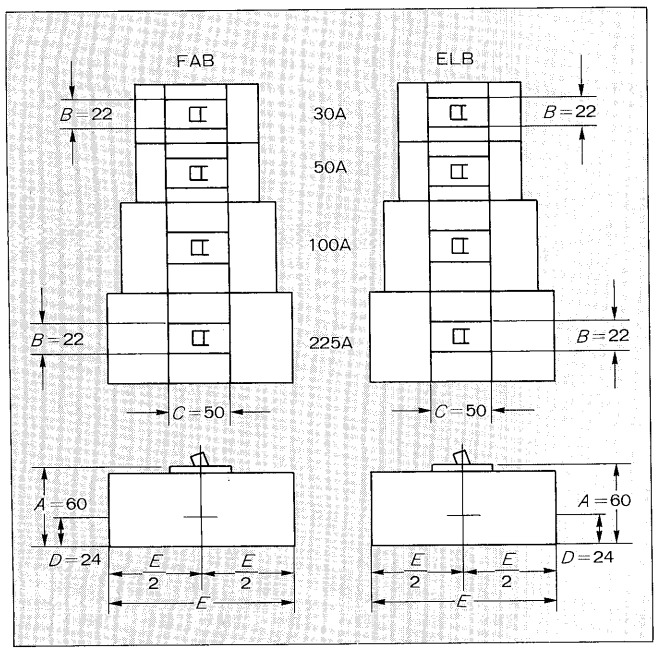
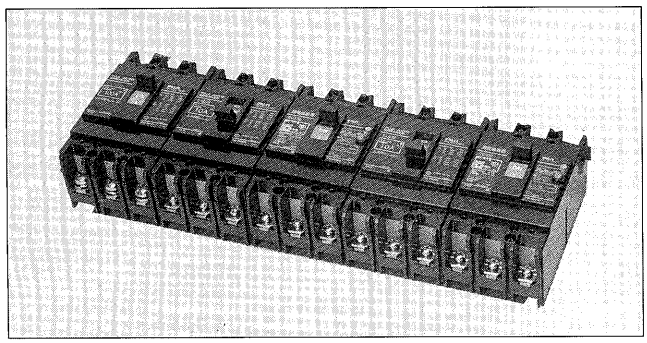


Fig. 14 Modularization of outside dimensions (economy type up to 100A frame)



3.4 Modularization of outside dimensions

For economy type 100A frame and lower distribution TWIN BREAKER and general-purpose TWIN 60 BREAKER, modularization that made the width 25 mm per pole was realized, in addition to the same main dimensions mentioned previously. Therefore, an extremely rational configuration even when performing wiring is possible, not to mention panel machining. The existing board construction of distribution boards that use both FAB and ELB, in particular, can be fundamentally simplified. Densely arranged general-purpose TWIN 60 BREAKER (called economy type 100A frame hereinafter) is shown in *Fig. 14*.

3.5 Compacting

The TWIN BREAKER is more compact than the old series. Substantial miniaturization was realized with the ELB, in particular, by standardization of the outside dimensions with the FAB. *Fig. 15* is a comparison the economy type 100A frame TWIN BREAKER and old product. *Fig. 16* is a comparison of the general-purpose type 225A frame TWIN BREAKER and old product.

Fig. 15 Comparison of size of TWIN BREAKER and old series (100A frame)

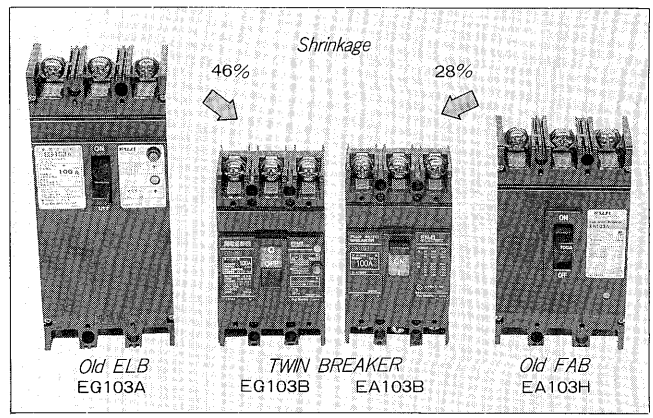
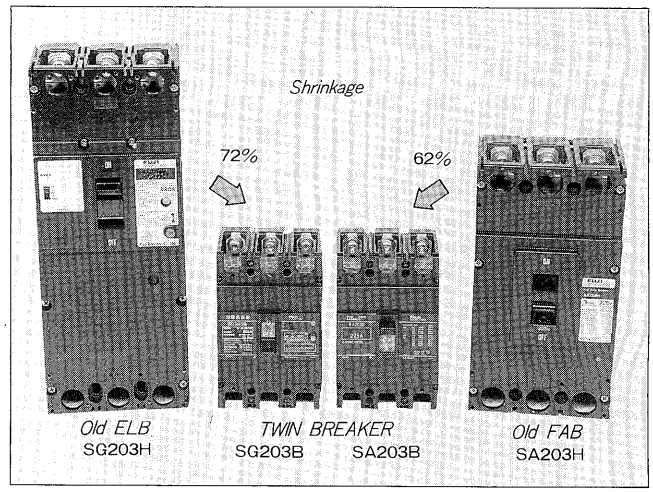


Fig. 16 Comparison of size of TWIN BREAKER and old series (225A frame)



4. EFFECT OF MAIN DIMENSIONS STANDARDIZATION AND MODULARIZATION

4.1 Simplification of panel design and manufacture

Realization of standardization of the outside dimensions of FAB and ELB is expected to bring about large changes in manufacture. That is, if the TWIN BREAKER is used, once the interrupting capacity, rated current, and number of circuits are decided, panel design and manufacturer can proceed and selection of FAB and ELB or both based on the detailed specifications is possible. Therefore, it can contribute to panel standardization and quick delivery and promotes CAD design and automatic manufacture of panels. A concrete example is shown in *Fig. 17*. The shape, mounting hole, and number of handle window frame shape patterns of the old series are each standardized to 1/3 less with the TWIN BREAKER.

4.2 Specification changes are easy to meet

Since the TWIN BREAKER has the ELB of the same outside dimensions corresponding to the FAB of certain specifications, specified changes during panel manufacture and demands for modification from FAB to ELB created

Fig. 17 Reduction of dimensions patterns by standardization of dimensions

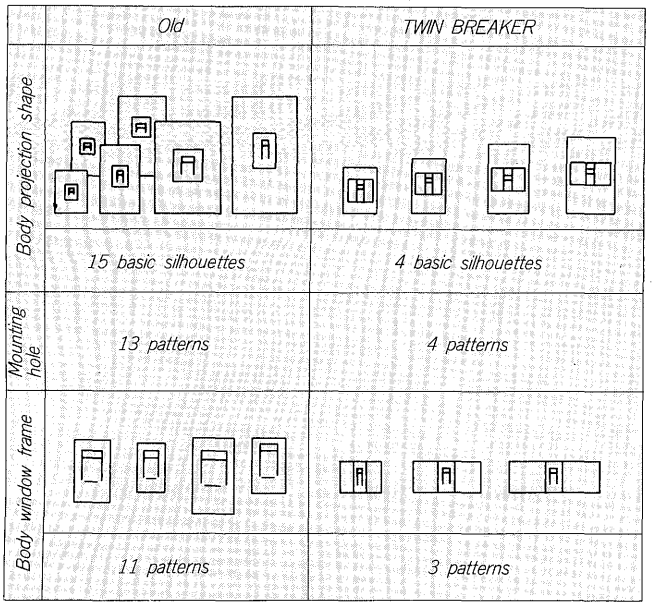
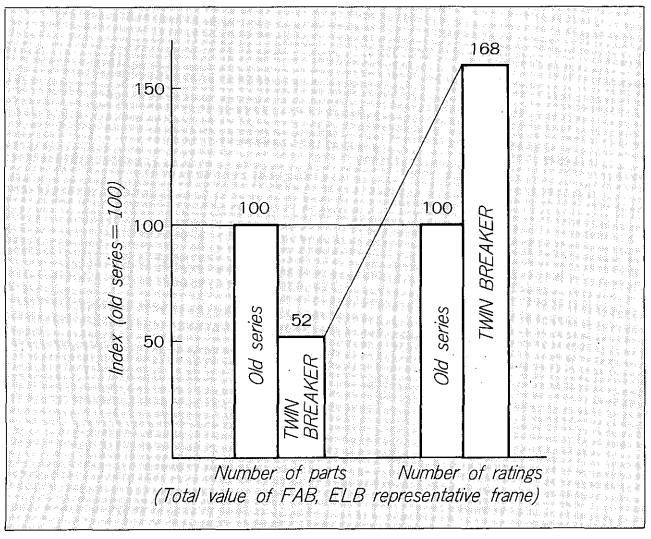


Fig. 18 Comparison of number of parts and ratings of TWIN BREAKER and old series



by relocation of the load, etc. after installation and vice versa are very easy to deal with. Especially, since distribution TWIN BREAKER and general-purpose TWIN 60 BREAKER economy type frames up to 100A are standardized to the same shape, coping with specifications changes is easier and maintainability is also improved.

4.3 Quick delivery

(1) Common accessories

FAB and ELB accessories consist of auxiliary switches, alarm switches, and other internal accessories which are installed inside the body and external operating handle, encloser, and other external accessories which are installed outside the body.

With the TWIN BREAKER, the FAB and ELB can use the same accessories. Therefore, not only is selection easy,

Fig. 19 Easy-to-assemble product construction

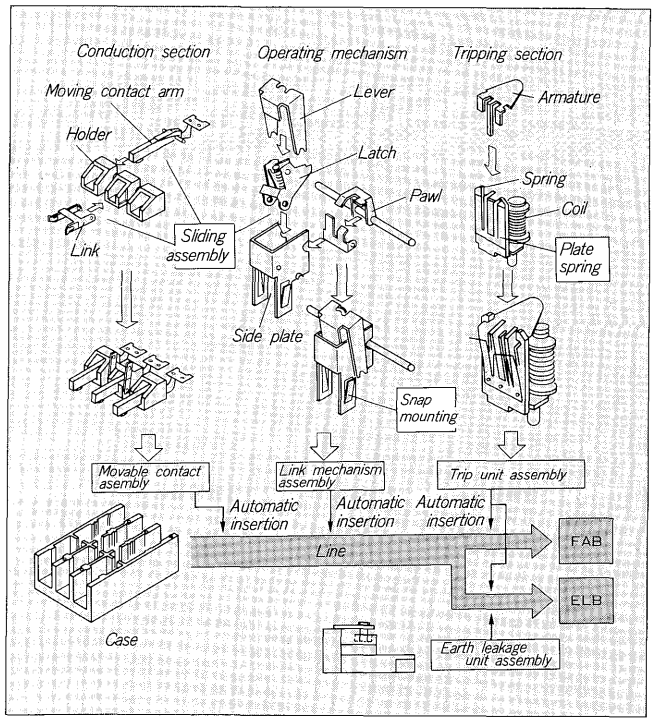
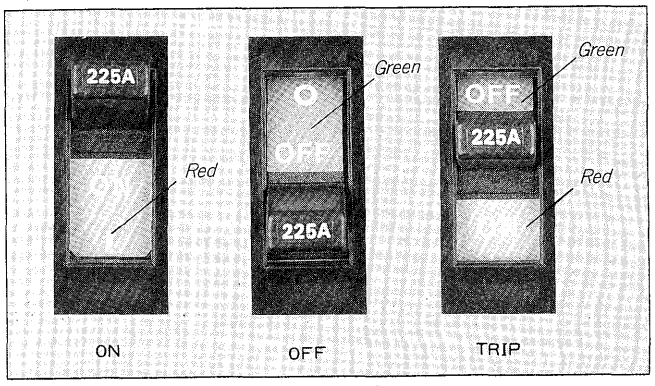


Fig. 20 Handle switching display



but it also contributes to reduction of the delivery time and inventory.

(2) Common parts

With the TWIN BREAKER, common FAB and ELB parts was pursued exhaustively. *Fig. 18* is a comparison of the number of parts and number of product ratings with the old series with one frame of the TWIN BREAKER series as an example. As can be seen from the figure, the smaller the number of parts, the large the number of product ratings. Also, it was made a product that can handle new CIM production systems while equalizing quality at a high level by pursuing the ease-of-use of automatic assembly as shown in *Fig. 19*. We feel that it can amply respond to the increasingly severe demand for quick delivery.

5. IMPROVEMENT OF DISPLAY

With the TWIN BREAKER series, switching display is performed by color so that the switching state of the

Table 1 FAB ratings and specifications (3-pole product)

	Frame		30	50		60		100		225	
E	Basic name		EA30	EA50A	EA50B	EA60B		EA100F	EA100B	EA225B	
	Number of poles		3	3	3	3		3	3	3	
	Rated current (A)		3, 5, 10, 15, 20, 30	5, 10, 15, 20, 30, 40, 50	5, 10, 15, 20, 30, 40, 50	60		60, 75, 100	50, 60, 75, 100	125, 150, 175, 200, 225	
	Rated insulation voltage (V)	AC	415	415	660	660		415	660	660	
		DC	–	–	250	250		–	250	250	
	Rated interrupting capacity (kA) JIS (sym)	AC550V	–	–	1.5	1.5		–	7.5	10	
		AC460V	–	–	2.5	2.5		–	10	15	
		AC220V	2.5	2.5	5	5		5	25	25	
		DC250V	–	–	2.5	2.5		–	5	10	
	Outside dimensions (mm)	Width	75	75	75	75		75	75	105	
		Height	96	96	130	130		130	165	165	
		Depth	60	60	60	60		60	60	60	
S	Basic name		SA30B	SA50B	SA50R	SA60B	SA60R	SA100B	SA100R	SA225B	SA225R
	Number of poles		3	3	3	3	3	3	3	3	3
	Rated current (A)		3, 5, 10, 15, 20, 30	5, 10, 15, 20, 30, 40, 50	5, 10, 15, 20, 30, 40, 50	60	60	15, 20, 30, 40, 50, 60, 75, 100	15, 20, 30, 40, 50, 60, 75, 100	125, 150, 175, 200, 225	125, 150, 175, 200, 225
	Rated insulation voltage (V)	AC	660	660	660	660	660	660	660	660	660
		DC	250	250	250	250	250	250	250	250	250
	Rated interrupting capacity (kA) JIS (sym)	AC550V	1.5	5	7.5	5	7.5	15	35	18	35
		AC460V	2.5	7.5	10	7.5	10	25	42	25	42
		AC220V	5	10	25	10	25	50	85	50	85
		DC250V	2.5	5	5	5	5	10	40	20	40
	Outside dimensions (mm)	Width	75	75	75	75	75	90	90	105	105
		Height	130	130	130	130	130	155	155	165	165
		Depth	60	60	60	60	60	60	82	82.5	82.5
H	Basic name			H50B				H100B	H100R	H225B	H225R
	Number of poles			3				3	3	3	3
	Rated current (A)			15, 20, 30, 40, 50				15, 20, 30, 40, 50, 60, 75, 100	40, 50, 60, 75, 100	125, 150, 175, 200, 225	125, 150, 175, 200, 225
	Rated insulation voltage (V)	AC		660				660	660	660	660
		DC		250				250	250	250	250
	Rated interrupting capacity (kA) JIS (sym)	AC550V		42				42	65	42	65
		AC460V		65				65	85	65	85
		AC220V		100				100	125	100	125
		DC250V		40				40	40	40	40
	Outside dimensions (mm)	Width		90				90	105	105	105
		Height		155				155	165	165	165
		Depth		82				82	99	99	99

handle can be verified with one glance even from a distance. As shown in *Fig. 20*, at the handle, red indicates the ON state and green indicates the OFF state (complies with IEC). When the breaker was tripped by an overcurrent or earth leakage, red and green are displayed simultaneously. Furthermore, the conventional ON-OFF characters and I-O characters conforming to IEC standards are also displayed simultaneously with display by color.

Since the nameplate of the TWIN BREAKER body was changed to a new design based on the color orange, the panel image is improved. The type designation and specifications and the rated interrupting capacity are displayed separately. The type designation is also color coded by FAB and ELB series. The type designation characters are green for the economy series, yellow for the general-purpose series, gray for the general-purpose high interrupting capacity series, and red for the high performance series.

Since the nameplate that shows the specifications of the accessories that require a control circuit power supply is color coded by control circuit voltage, applicable voltage check is easy.

Table 2 ELB ratings and specifications (3-pole product)

	Frame		30		50		60		100		225	
E G	Basic name	High-speed type	EG30F	EG30B	EG50F	EG50B	EG60B		EG100F	EG100B	EG225B	
		Time-delay	–	–	–	–	–		–	EG100BD	EG225BD	
	Number of poles		3	3	3	3	3		3	3	3	
	Rated current (A)		5, 10, 15, 20, 30	5, 10, 15, 20, 30	5, 10, 15, 20, 30, 40, 50	5, 10, 15, 20, 30, 40, 50	60		60, 75, 100	60, 75, 100	125, 150, 175, 200, 225	
	Rated voltage*1 (V)	AC	100-200 common	100-200-415 common	100-200 common	100-200-415 common	100-200-415 common		100-200 common	100-200-415 common	100-200-415 common	
	Rated sensitivity current (mA)	High-speed type	15, 30	15, 30, 100	15, 30	15, 30, 100/200	15, 30, 100/200		30, 100/200	30, 100/200 /500	30, 100/200 /500	
		Time-delay	–	–	–	–	–		–	100/200 500	100/200 500	
	Rated interrupting current (kA) JIS (sym)	AC415V	–	1.5	–	2.5	2.5		–	10	15	
		AC200V	2.5	2.5	2.5	5	5		5	25	25	
		AC100V	5	5	5	5	5		5	25	25	
	Outside dimensions (mm)	Width	75	75	75	75	75		75	75	105	
		Height	96	130	96	130	130		96	130	165	
		Depth	60	60	60	60	60		60	60	60	
S G	Basic name	High-speed type	SG30B		SG50B	SG50R	SG60B	SG60R	SG100B	SG100R	SG225B	SG225R
		Time-delay	–		–	–	–	–	SG100BD	SG100RD	SG225BD	SG225RD
	Number of poles	3	3		3	3	3	3	3	3	3	3
	Rated current (A)		5, 10, 20, 30		5, 10, 15, 20, 30, 40, 50	5, 10, 15, 20, 30, 40, 50	60	60	15, 20, 30, 40, 50, 60, 75, 100	15, 20, 30, 40, 50, 60, 75, 100	125, 150, 175, 200, 225	125, 150, 175, 200, 225
	Rated voltage*1 (V)	AC	100-200-415		100-200-415 common	100-200-415 common	100-200-415 common	100-200-415 common	100-200-415 common	100-200-415 common	100-200-415 common	100-200-415 common
	Rated sensitivity current (mA)	High-speed type	30, 100/200 /500		30, 100/200 /500	30, 100/200 /500	30, 100/200 /500	30, 100 /200 /500	30, 100/200 /500	30, 100/200 /500	30, 100/200 /500	30, 100/200 /500
		Time-delay	–		–	–	–	–	100/200 /500	100/200 /500	100/200 /500	100/200 /500
	Rated interrupting current (kA) JIS (sym)	AC415V	2.5		7.5	10	7.5	10	25	42	25	42
		AC200V	5		10	25	10	25	50	85	50	85
		AC100V	5		10	25	10	25	50	85	50	85
	Outside dimensions (mm)	Width	75		75	75	75	75	90	90	105	105
		Height	130		130	130	130	130	155	155	165	165
		Depth	60		60	60	60	60	60	82	82.5	82.5
H G	Basic name	High-speed type			HG50B				HG100B		HG225B	
		Time-delay			HG50BD				HG100BD		HG225BD	
	Number of poles				3				3		3	
	Rated current (A)				15, 20, 30, 40, 50				15, 20, 30, 40, 60, 75, 100		125, 150, 175, 200, 225	
	Rated voltage*1 (V)	AC			100-200-415 common				100-200-415 common		100-200-415 common	
	Rated sensitivity current (mA)	High-speed type			30, 100/200 /500				30, 100/200 /500		30, 100/200 /500	
		Time-delay				100/200 /500				100/200 /500		100/200 /500
	Rated interrupting current (kA) JIS (sym)	AC415V			65				65		65	
		AC200V			100				100		100	
		AC100V			100				100		100	
	Outside dimensions (mm)	Width			90				90		105	
		Height			155				155		165	
		Depth			83				82		99	

*1 : Time-delay type voltage: 200-415 common

6. RATINGS AND SPECIFICATIONS OF TWIN BREAKER SERIES

The TWIN BREAKER series is available in numerous variations for the most economical application matched to the capacity of the power supply facility. Both the FAB and ELB consist of an economy type (E series), general purpose type (S series), and high performance type (H

series). Since abundant ratings and specifications are available in each series, a wide range of applications and exact selection are possible even though the dimensions are standardized. The ratings and specifications of the basic type of TWIN BREAKER are shown in *Table 1* and *Table 2*.

7. TWIN BREAKER CONSTRUCTION AND PERFORMANCE

Development of the TWIN BREAKER was aimed at the arrangement of switchgear standardization conditions on one hand and arrangement of the product composition conditions for the optimum production system architecture capable of coping with multiple types and quick delivery at Fuji Electric, the supply side. Therefore, construction selection was aimed at placing the functions of an ELB into the physical construction of the most compact and modularized FAB from the beginning. For instance, as the most extreme example, ultra-compacting which reduced the volume to 30% that of the old ELB was necessary.

Therefore, simulation that minimized the main components of the circuit breaker, backed by CAD and partial experimentation, was performed. A comparison of the volume of the TWIN BREAKER and old Fuji Electric FAB and ELB is shown in *Fig. 21*.

The points given particular care and the target policy at TWIN BREAKER construction selection are given below.

(1) Optimization of space distribution of each function element

Since it was clarified that miniaturization of the earth leakage detection section, ample operating force is obtained even with a high space saving switching mechanism, etc. as a result of miniaturization simulation, reducing the volume ratio occupied by the arc chute that is connected directly to circuit breaker performance was made the policy.

(2) Unitization of each function element

If each component element of the FAB and ELB, including the options are unitized and assembled according to the order specifications, design of the final product advanced.

(3) Introduction of new material and new technology

Positive development of new material and new technology was advanced toward the realization of ultracompact design. Especially, development of high strength molding materia, development of a high speed current limiting breaking mechanism, development of a transformerless earth leakage detection circuit, and development of a sliding contact mechanism with the lead wire from the conduction part removed (225 A frame) became the basic technology of compacting.

(4) Exhaustive verification of reliability and safety versus miniaturization

The temperature rise of each part of the circuit breaker given special attention by miniaturization, connection wire

Fig. 21 TWIN BREAKER and old series volume comparison

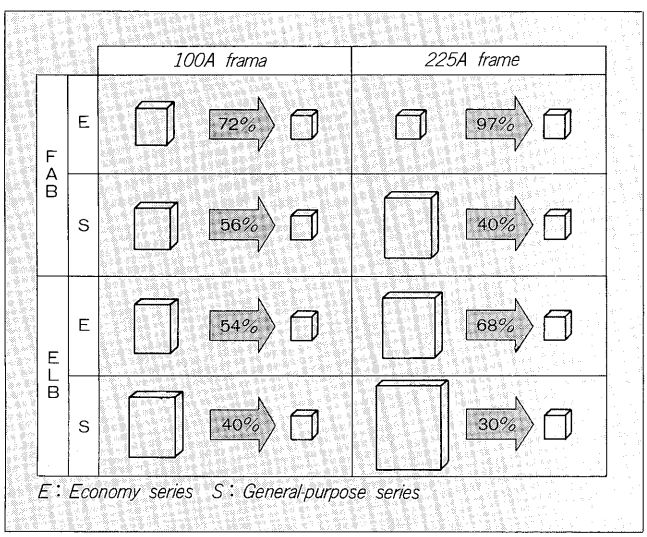


Fig. 22 TWIN BREAKER minimum frame section and old series comparison

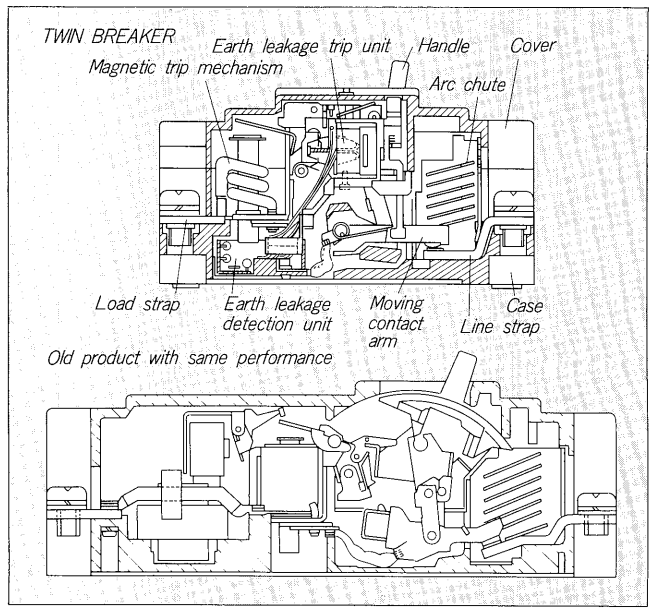
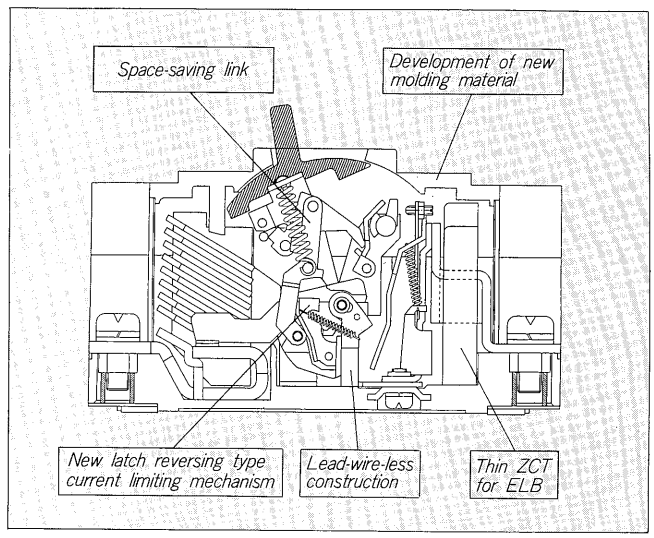


Fig. 23 TWIN BREAKER maximum frame section and compacting technology



range, terminal section insulation processing, etc. were amply certified by using the actual product.

7.1 Overall Structure

The construction sectional view of the minimum frame TWIN BREAKER is shown in *Fig. 22* and that of the maximum frame size TWIN BREAKER is shown in *Fig. 23*.

For the minimum frame size, the earth leakage detection unit is located directly beneath the overload protection magnetic tripping mechanism and for the maximum frame size, the earth leakage detection unit is located between the protection bimetal and the load strap.

An earth leakage detection unit is provided at each frame because the minimum frame can be made a cassette that is integrated with the magnet unit. By only removing the earth leakage detection unit of this part as shown in *Fig. 24*, the ELB becomes the FAB. This is because with the maximum frame primary conductor can be installed with the smallest effect on the balance characteristic of the ZCT. for earth leakage detection. In any case, it is known that the arc chute secures ample space.

7.2 Switching mechanism

The principle of the switching mechanism is a 4-joint toggle link mechanism. This movement changes complexly with the relationship between the rotation supporting point of the part that becomes the joint of the link and the supporting point position combination. Therefore, to decide the link mechanism, (1) position analysis of the link joint, (2) calculation of the transmission load of the main spring force that moves the link mechanism, study of the balance of the contact load that opposes the spring force and the magnetic repulsion force by current, and many other calculations are necessary.

In TWIN BREAKER design, a CAD program capable of link mechanism operation simulation and analysis of the closing load synchronized with it was developed and calculations were performed. *Fig. 25* shows the results of analysis of operation from off to on of the link mechanism of the TWIN BREAKER and analysis of the closing load characteristic at the contacts contact position synchronized with it when space was saved vertically. *Fig. 26* is the result of movement analysis from on to trip operation.

The TWIN BREAKER switching link mechanism has a contact closing force about 30% greater and contact opening time about 15% faster than the old series and contact switching with a margin is possible even though its exclusive area relative to the overall construction was reduced 20 to 30%.

The position of the link dead point was modified and was made the switching mechanism was made a fail safe positive ON mechanism that tentatively corresponds the main contacts position and handle position display in all cases.

Since the first uncharged switching link mechanism of MCCB and ELCB of this class was realized by the method shown in *Fig. 27*, safety was improved substantially.

Fig. 24 ELB unitized construction

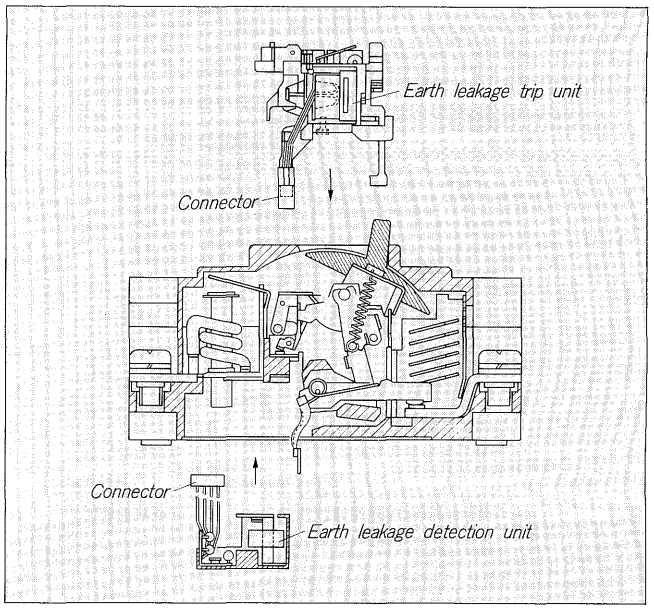


Fig. 25 ON-OFF operation analysis and load closing example

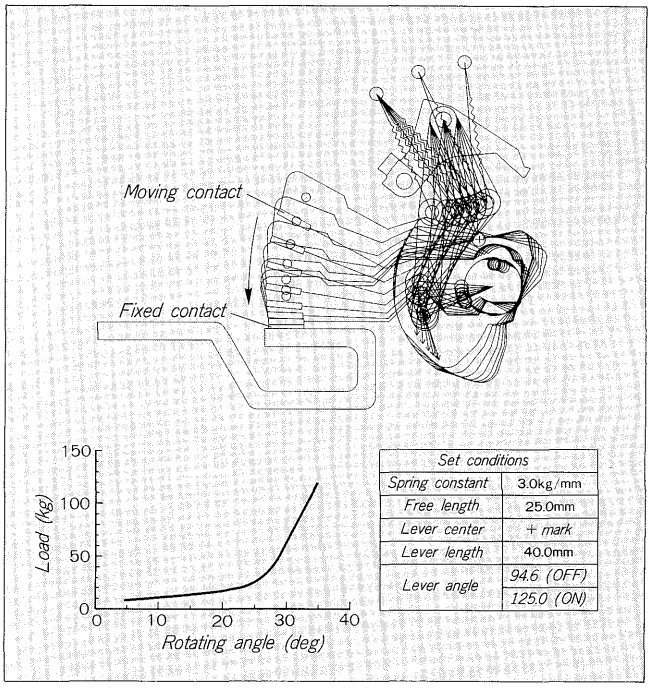


Fig. 26 ON-OFF link operation analysis example

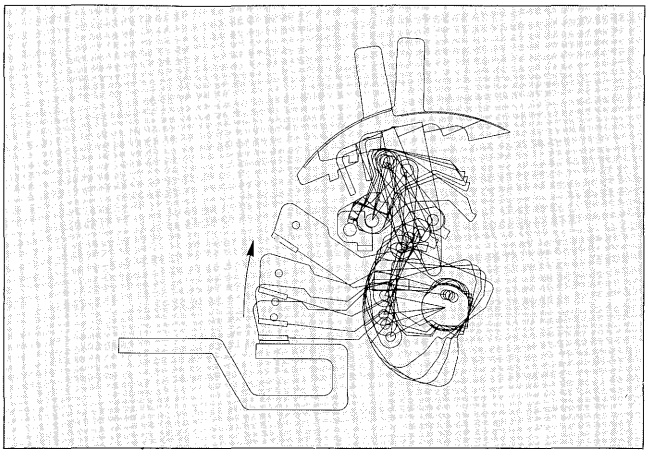


Fig. 27 Switching link mechanism unchanged construction

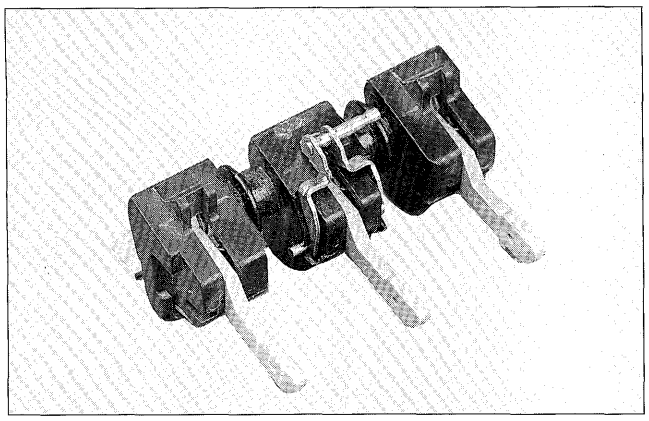
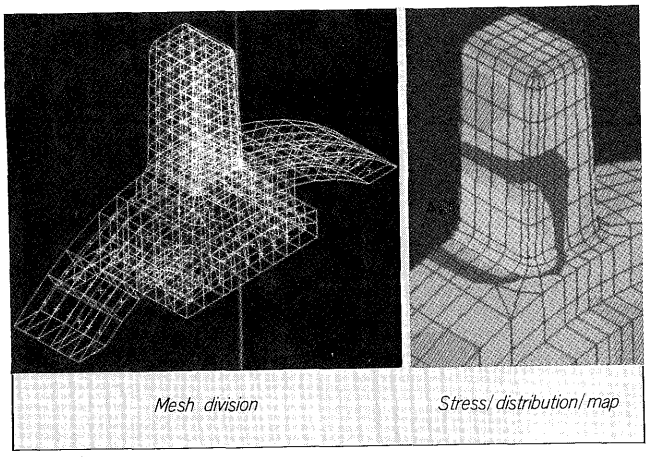


Fig. 28 Handle stress analysis



Since the circuit breaker handle has a man-machine interface function, a design that withstands the energy of the internal switching mechanism and the large operating force at external operation is necessary. Since the shape of the handle of the TWIN BREAKER has also been made compact, a shape capable of withstanding the large operating force was studied in detail. As an example, the three dimensional infinite elements method was also applied to molded parts and the stress applied to arc part shown at the handle A part of *Fig. 28* was analyzed. Since quantitative evaluation based on wire frame graphic was possible by means of this, a handle that is slim and sufficiently strong was realized.

7.3 Current limiting mechanism and interrupting part

The interrupting ability of a molded case low voltage circuit breaker is determined by the processing limit of the stress due to the arc energy generated at interruption. This stress causes destruction of the molded case by a sudden increase of the internal pressure and a lowering of the insulation strength due to melting and scattering of the conduction material and insulation material.

Since ultra compact design was the target of the TWIN BREAKER, it was assumed that the problems caused by stress previously mentioned could not be solved with existing interrupting technology. Therefore, a new current limiting mechanism was pursued and a high strength molding material was developed in development of the TWIN BREAKER.

Fig. 29 Principle of current limiting interruption

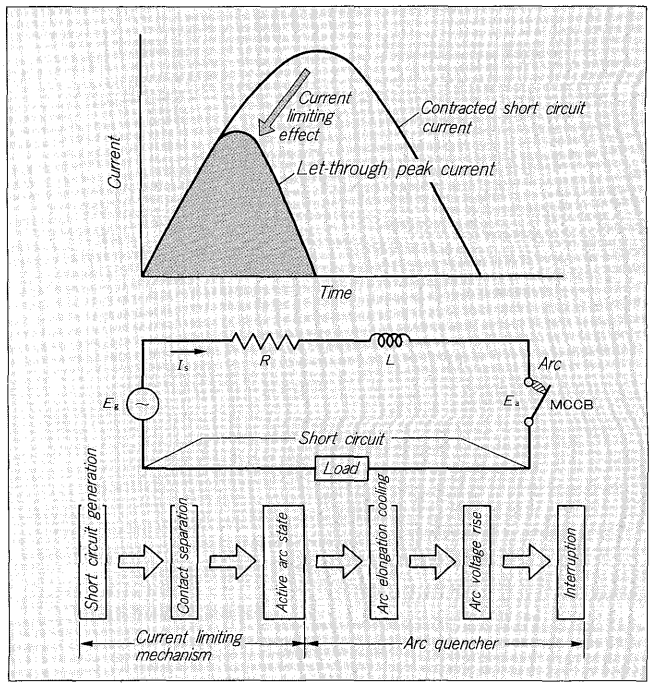
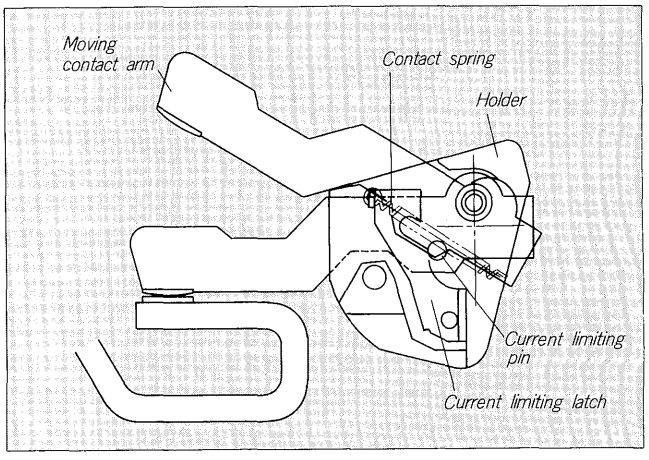


Fig. 30 TWIN BREAKER current limiting mechanism



The principle of current limiting interruption is shown in *Fig. 29*. Current interruption cools the arc generated between the interrupting contacts at short circuit interruption and increases the arc resistance and reduces the short circuit current itself. Most exiwting MCCB use the pinch effect of the vaporized gas generated from the organic matter provided at the arc chute to cool the arc. However, to make the MCCB more compact, interruption that suppresses the arc energy farther is necessary.

From the standpoint that shorting the time between generation of the short circuit and shifting to a coolable arc is the most effective method of suppressing the arc energy, Fuji Electric concentrated on development of a mechanism that realizes this.

Fig. 30 shows the current limiting interrupting mecha-

Fig. 31 Current limiting operation process

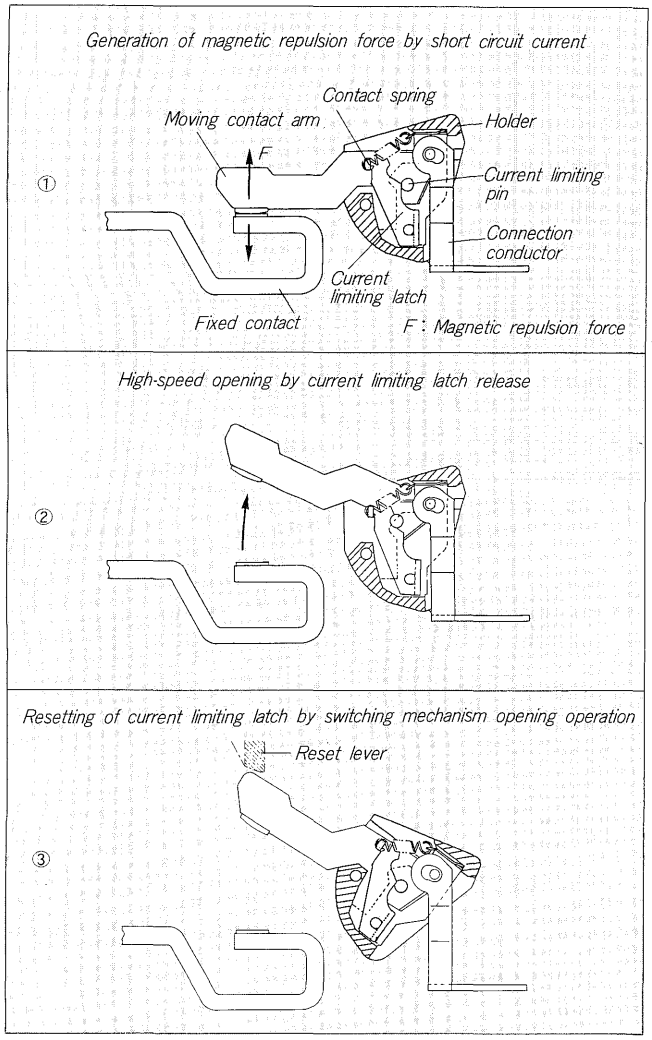
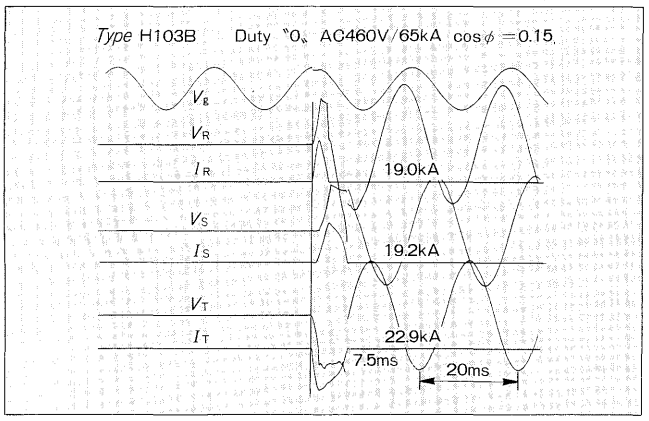
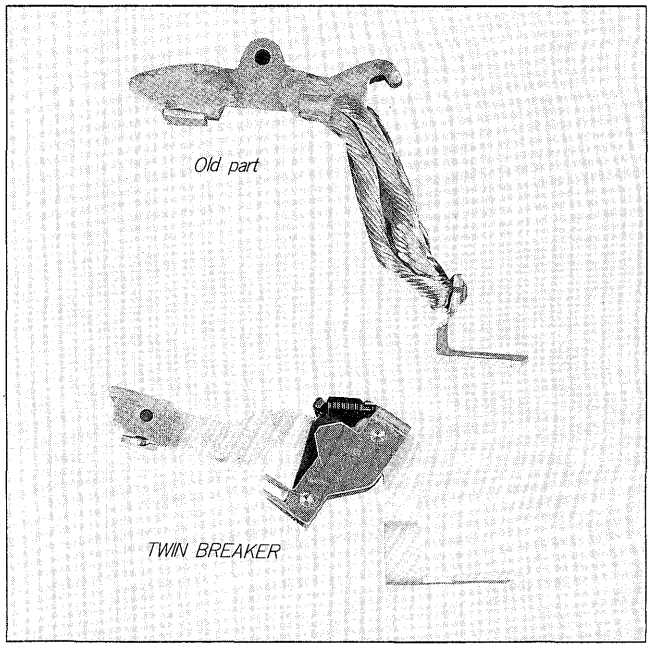


Fig. 32 Interrupting test oscillogram



nism developed for the TWIN BREAKER. The magnetic repulsion force generated between the contacts by the sudden increase of the short circuit fault current is concentrated at the current limiting latch. When this force exceeds a certain limit, the moving contacts open quickly. When the current limiting latch opens, since the pushing direction of the contact spring is reversed and the moving contacts are driven in the open direction, they stabilize immediately

Fig. 33 Comparison of TWIN BREAKER moving contact arm conduction section construction with old series



and ample current limiting opening speed and distance are obtained. The TWIN BREAKER current limiting operation process is shown in *Fig. 31*.

The "coolable arc" is the active arc, but since the arc can be made an active arc in a short time (1~2 ms) by the technique described above, Fuji Electric has named this system the "AD technique". An oscillogram at 460V 65 kA interruption of a TWIN BREAKER H103B is shown in *Fig. 32*. It can be seen that the current peak is reduced by 20% and I^2t is reduced to 45% with respect the an equivalent old type and that the AD technique is extremely effective. The TWIN BREAKER back-up interruption harmonizing range will be increased by improvement of its current limiting interrupting performance.

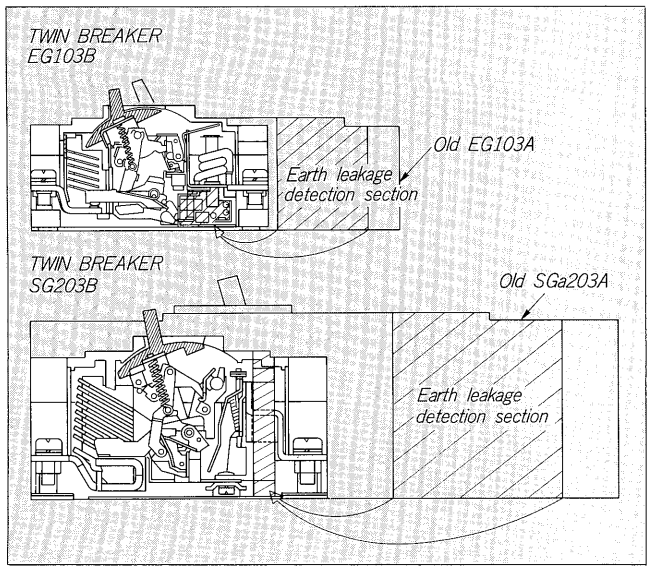
7.4 Conduction part construction

When making a low voltage circuit breaker compact, the conduction part must be designed carefully. Especially with the most compact 225A frame, conduction part sectional area and ample contact pressure were secured. With high interrupting capacity units, compactness and high interrupting capacity were realized while maintaining the existing temperature rise performance by developing a sliding contact system which receives the moving contact arm by parallel conductor from lead system conduction as compared and shown in *Fig. 33* to secure a conduction part sectional area and make high speed current limiting opening of the moving contact easier.

7.5 ELB earth leakage detection section

Besides standardizing the dimensions of the FAB and ELB, how to make the space occupied by the earth leakage detection section that is large with the conventional ELB smaller and secure performance was a big problem. To solve

Fig. 34 Miniaturization of ELB earth leakage detection section



this problem, a zero phase transformer (ZCT) and feedthrough conductor space-saving structure, compact earth leakage detection circuit, and smaller and efficient trip coil were pursued and a substantial size reduction of 10% to 30% compared to the old series was realized as shown in *Fig. 34*.

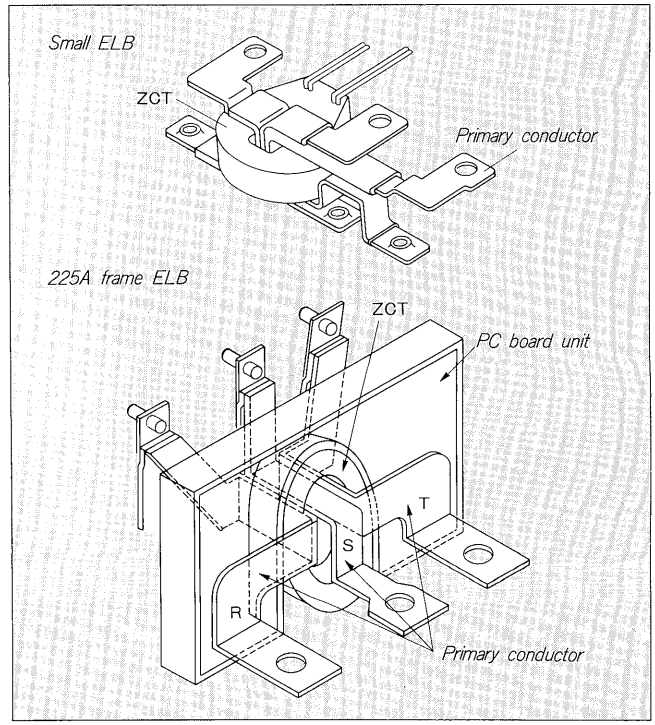
(1) ZCT and feedthrough conductor space-saving structure

Fig. 35 is an example of the structure of the ZCT and its feedthrough conductor. This structure differs with the frame, but the basic design technique is designed to save space by making the unit thinner by improvement of the ZCT manufacturing method, etc. and optimum arrangement of the plate shaped feedthrough conductor. Moreover, while a stable zero phase detection characteristic was secured by using high permeability material at the ZCT core, an ample balance characteristics was obtained by suitable shielding.

(2) Miniaturization of earth leakage detection circuit

The old earth detection circuti was a system which configured the amplitude circuit power supply by using a transformer and drove the trip coil by operation of a built-in relay. For the TWIN BREAKER earth leakage detection circuit, a method that does not use a transformer and relay was developed and the circuit was miniaturized substantially. Since the circuit current drain had to be maintained at a minimum as a condition, Fuji Electric's original current limiting circuit was used and an amplifier capable of operating at low current drain, and other technology was developed. The rated voltage range was also expanded from the conventional 200V-415V to 100V-415V. The electronic circuit was made a high density mounting PC board using surface mounting electronic components and was made compact and highly reliability.

Fig. 35 Example of ACT and feedthrough structure



(3) Small and efficient trip coil

The trip coil of the TWIN BREAKER is a magnetic hold type that can be driven at a low current drain. Backed by finite element analysis, the optimum magnetic circuit structure by which small size, high mechanical output, and minimum drive VA are obtained was pursued in development. A high flux, stable performance rare earth permanent magnetic is used as the permanent magnet.

8. CONCLUSION

Fuji Electric followed the sale of the new series of magnetic switches with the development of the new series of molded case circuit breaker and earth leakage breakers introduced here. Both types are products with a record of use over many years. However, even though they are products that are used familiarly, we will be happy if an understanding that there is room for renovation matched to to the needs of the age through this article. The approach to developing this products follows the development of the new series of magnetic switches. That is, it is a revolution to components that correspond more flexibly to electric facilities that are becoming more advanced and complex. We are confident that the TWIN BREAKER can contribute to the growth of low voltage distribution systems. Farther enhancement based on the comments of consumers is planned.