

CIRCUIT BREAKER

BACKGROUND OF THE INVENTION

The present invention relates to circuit breakers used to protect electric circuit lines and more particularly, to controlling of a delayed-action
5 characteristic of a circuit breaker.

Conventional circuit breakers are disclosed in, for example, JP-A-5-236633 and JP-A-1-270722.

The former JP-A-5-236633 discloses a circuit breaker with a tripping device which is actuated in
10 response to an accident current flowing through an electric circuit line. This circuit breaker has multiple stages of accident current level discriminating means and time delay generating means adapted to perform delayed-action operation of the tripping device in correspondence to a
15 discriminating level of the level discriminating means, which makes protective cooperation easier by increasing electivity of setting of a delayed-action operation characteristic.

More specifically, analog signals corresponding
20 to values of currents flowing through respective phases of a main circuit or an analog signal corresponding to an average value of the currents is detected by current detecting means and fetched by a microcomputer through an A/D converter. The microcomputer controls the delayed-

action characteristic in accordance with the level of the analog signal.

The latter JP-A-1-270722 discloses a technique using a signal processing circuit which executes the trip operation on the basis of a maximum one of load current values, converted through A/D converters, of respective phases of a main circuit. This signal processing circuit is constructed of digital operation means using a microcomputer so as to have the function of a square product operation circuit which takes thermal protection into consideration. With this prior art, the construction of the signal processing circuit can be simplified and troublesome output level adjusting work required for analog output can be eliminated, thereby improving accuracy of the current operation result value and the tripping.

Problems encountered in a conventional circuit breaker having a delayed-action characteristic of three tripping regions (short time-delay region, long time-delay region and instantaneous tripping region) will be described with reference to Figs. 1 to 7.

Fig. 1 is a sectional view of the conventional circuit breaker, Fig. 2 is a schematic circuit diagram of the Fig. 1 circuit breaker, Fig. 3 is a detailed schematic circuit diagram of the Fig. 2 circuit breaker, Fig. 4 is a graph showing characteristics cooperative with an overcurrent delayed-action characteristic of the conventional circuit breaker, Fig. 5 is a front view of the conventional circuit breaker, Fig. 6 is a graph for

explaining an overcurrent delayed-action characteristic of the conventional circuit breaker, and Fig. 7 is a graph showing overcurrent delayed-action characteristics of the conventional circuit breaker.

5 The circuit breaker, as designated by reference numeral 30, has a make-and-break mechanism including a CT unit 1 for detecting currents in electric circuit lines, an overcurrent relay unit 2 operated by the currents detected by the CT unit 1, a tripping device 3 to be tripped in
10 response to the operation of the overcurrent relay unit 2, an operating handle 4 for effecting switching/breaking of the electric circuit lines and contacts 5, and an arc-extinguishing device 6 for extinguishing an arc generated at the contacts during switching/breaking. These members
15 are accommodated in a cabinet comprised of a mold case 7 and a mold cover 8. The mold cover 8 is detachably mounted to the mold case 7 and has a hole for mount of the operating handle 4.

 The function of the circuit breaker 30 will be
20 described with reference to Figs. 2 and 3. Analog current signals of respective phases detected by the CT unit 1 are rectified, then amplified by an amplifier circuit and supplied, in the form of analog current signals, to the overcurrent relay unit 2. In the overcurrent relay unit 2,
25 the analog currents of the respective phases are converted by A/D converters into digital signals and a maximum one of load currents of the respective phases which are represented by the converted digital signals is detected by

a built-in CPU. A characteristic setting unit 10 applies rated current setting, short time-delay setting and long time-delay operation time setting to the CPU. When the load current exceeds a rated current, the CPU operates, on the basis of a set delayed-action characteristic, a trigger circuit which in turn drives a trip coil (not shown) to trip the make-and-break mechanism.

In the conventional example, an over current delayed-action characteristic of the circuit breaker is arranged so as to be brought into protective cooperation with respective load characteristics of appliances connected its upstream and downstream as shown in Fig. 4.

If the upstream appliance is a fuse, the characteristic of the circuit breaker is arranged to perform protective cooperation with thermal characteristic, e.g. fusing characteristic of the fuse.

In order to provide easy controlling of the delayed-action characteristic in the protective cooperation as above, characteristic parameters for individual regions of the delayed-action characteristic are arranged adjustably or controllably so as to enable desirable setting by the microcomputer.

The characteristic setting is carried out by the characteristic setting unit 10 shown in Fig. 3 which includes, as shown in Fig. 5, independent setters (rated current setter 12, short time-delay setter 13 and long time-delay setter 14) provided for the individual characteristic parameters to be adjusted.

Then, in an ordinary method, changes in setting of the individual characteristic parameters are effected in correspondence to a change in setting of the rated current by switching the individual setters, as shown in Fig. 7.

5 In this case, the change of setting of the delayed-action characteristic parameters is carried out using a coefficient δ . The coefficient δ has, however, the same value for any rated current values set within the adjustment range and suitable protection against
10 overcurrents is not always achieved.

The independent setters 13 and 14 provided for the individual parameters can permit the fine change of delayed-action characteristic but many setting points of all of the setters must be set even when strict
15 characteristic setting is not required, giving rise to troublesome setting operations on the other hand.

Further, setting work carried out by a setting operator who does not sufficiently recognize the characteristic will bring about a dangerous condition due
20 to erroneous performance caused by careless mistake in setting.

SUMMARY OF THE INVENTION

The present invention contemplates elimination of the above problems and it is an object of the present
25 invention to provide a circuit breaker which can afford to provide a trade-off among the setting function of delayed-

action characteristic, the easiness of setting in practical use and the suitable overcurrent protection.

To accomplish the above object, according to a first circuit breaker construction of the present invention, in a circuit breaker having an analog signal processing unit for detecting and amplifying load currents flowing through electric circuit lines of a plurality of phases, A/D converters for converting the detected analog signals into digital signals and a digital signal processing unit for causing a tripping device to trip on the basis of the digital signals so as to obtain a predetermined delayed-action characteristic and set controllable parameters of the delayed-action characteristic, the circuit breaker comprises setting means for variably setting only one parameter representative of a rated load current value upon operation start of the controllable parameters of the delayed-action characteristic and precedently fixing other controllable parameters of the delayed-action characteristic to corresponding predetermined values in accordance with the rated load current value.

According to a second circuit breaker construction of the present invention, in a circuit breaker having an analog signal processing unit for detecting and amplifying load currents flowing through electric circuit lines of a plurality of phases, A/D converters for converting the detected analog signals into digital signals, a digital signal processing unit for

causing a tripping device to trip on the basis of the digital signals so as to obtain a predetermined delayed-action characteristic and setting means for setting controllable parameters of the delayed-action characteristic, the circuit breaker comprises a switching unit for performing switching between first and second modes, the setting means has the delayed-action characteristic setting function for variably setting only one parameter representative of a rated load current value upon operation start and fixing other controllable parameters of the delayed-action characteristic in advance to corresponding predetermined values in accordance with the rated load current value when the mode is switched to the first mode and for resetting at least of one of the fixed values of the other controllable parameters of the delayed-action characteristic set through the delayed-action characteristic setting function when the mode is switched to the second mode.

According to a third circuit breaker construction of the present invention, in a circuit breaker having an analog signal processing unit for detecting and amplifying load currents flowing through electric circuit lines of a plurality of phases, A/D converters for converting the detected analog signals into digital signals and a digital processing unit for causing a tripping device to trip on the basis of the digital signals so as to obtain a predetermined delayed-action characteristic and set controllable parameters of the delayed-action

characteristic, the circuit breaker comprises short-circuit means, and setting means having the delayed-action characteristic setting function for variably setting only one parameter representative of a rated load current value upon operation start and fixing other controllable parameters of the delayed-action characteristic in advance to corresponding predetermined values in accordance with the rated load current value when the short-circuit means is turned on and for variably setting the rated load current value upon operation start and the other controllable parameters of the delayed-action characteristic when the short-circuit means is turned off.

With the above constructions of the present invention, switching between the simple delayed-action characteristic setting function and the fine delayed-action characteristic setting function can be effected in accordance with a use state of the circuit breaker and therefore, the merit brought about by the characteristic parameter adjustable function, on the one hand, can be utilized and on the other hand, the complicated and troublesome adjusting function can be short-circuited, thereby providing a simple and easy-to-use circuit breaker in which the possibility of erroneous setting is decreased.

Further, by providing two kinds of delayed-action characteristic modes meeting a greatest common measure like general load while limiting the settable characteristic parameter to only the rated current, the general load can

be dealt with within a sufficiently practicable range, thereby providing a simple and easy-to-use circuit breaker.

Further, the settable characteristic parameter is limited to only the rated current, thereby providing an
5 inexpensive circuit breaker in which the complicated setting switch can be dispensed with when the circuit breaker is applied to the greatest common measure like general load and the possibility of erroneous setting can be decreased.

10 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of a conventional circuit breaker.

Fig. 2 is a schematic circuit diagram of the conventional circuit breaker.

15 Fig. 3 is a detailed schematic circuit diagram of the conventional circuit breaker.

Fig. 4 is a graph showing an overcurrent delayed-action characteristic and cooperative characteristics in the conventional circuit breaker.

20 Fig. 5 is a front view of the conventional circuit breaker.

Fig. 6 is a graph for explaining the overcurrent time-limit characteristic of the conventional circuit breaker.

25 Fig. 7 is a graph showing overcurrent delayed-action characteristics of the conventional circuit breaker.

Fig. 8 is a front view of a circuit breaker according to a first embodiment of the present invention.

Fig. 9 is a detailed schematic circuit diagram of the circuit breaker according to the first embodiment of
5 the present invention.

Fig. 10 is a graph showing overcurrent delayed-action characteristics of the circuit breaker according to the first embodiment of the present invention.

Fig. 11 is a graph showing load current
10 characteristics of a general motor.

Fig. 12 is a diagram for explaining an overcurrent delayed-action characteristic of the circuit breaker according to the first embodiment of the present invention which is applicable to load currents of a small-
15 capacity motor.

Fig. 13 is a diagram for explaining an overcurrent delayed-action characteristic of the circuit breaker according to the first embodiment of the present invention which is applicable to load currents of a large-
20 capacity motor.

Fig. 14 is a graph showing overcurrent delayed-action characteristics of a modification of the circuit breaker according to the first embodiment of the present invention..

25 Fig. 15 is a front view of a circuit breaker according to a second embodiment of the present invention.

Fig. 16 is a graph showing delayed-action

characteristics in the second embodiment of the present invention.

Fig. 17 is a front view of a circuit breaker according to a third embodiment of the present invention.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will now be described with reference to Fig. 1 and Figs. 8 to 17.

First Embodiment

10 Referring now to Fig. 1 and Figs. 8 to 14, a first embodiment of the present invention will be described.

Fig. 8 is a front view of a circuit breaker according to the first embodiment of the present invention,
15 Fig. 9 is a circuit diagram of the circuit breaker according to the present embodiment, Fig. 10 is a graph showing overcurrent delayed-action characteristics of the circuit breaker according to the present embodiment, Fig. 11 is a graph showing characteristics of motor load
20 current, Fig. 12 is a graph useful to explain an overcurrent delayed-action characteristic of the circuit breaker of the present embodiment for small-capacity motor load currents, Fig. 13 is a graph useful to explain an overcurrent delayed-action characteristic of the circuit
25 breaker of the present embodiment for large-capacity motor load currents, and Fig. 14 is graph showing overcurrent

delayed-action characteristics of a circuit breaker according to a modification of the present embodiment.

Reference is also made to Fig. 1 to describe a circuit breaker of the present invention. As shown in Fig. 1 and Figs. 8 and 9, the circuit breaker, designated by reference numeral 40, of the present invention comprises a make-and-break mechanism including the CT unit 1 for detecting currents in electric circuit lines, the overcurrent relay unit 2 operated by the currents detected by the CT unit 1, the tripping device 3 to be tripped in response to the operation of the overcurrent relay unit 2, the operating handle 4 for effecting switching/breaking of the electric circuit lines, and the make-and-break contacts 5, and the arc-extinguishing device 6 for extinguishing an arc generated at the contacts during switching/breaking. These members are accommodated in the cabinet comprised of the mold case 7 and the mold cover 8. The mold cover 8 is detachably mounted to the mold case 7 and has a hole for mount of the operating handle 4.

The function of the circuit breaker 40 will be described with reference to Figs. 9 and 10. Analog current signals of respective phases detected by the CT unit 1 are rectified phase by phase by means of rectifier circuits and then converted into voltages by means of resistors. The converted voltages are partly supplied to a power source circuit which in turn supplies power to individual components and partly supplied, in the form of analog

current signals, to the overcurrent relay unit 2. In the overcurrent relay unit 2, the analog current signals are supplied to an amplifier circuit so as to be amplified and then supplied to A/D converters phase by phase so as to be converted into digital signals. A CPU connected to the A/D converters detects a maximum one of load currents of the respective phases which are represented by the digital signals. The CPU is coupled to a characteristic setting unit 10 and an internal characteristic setting unit 9 through I/O units. The characteristic setting unit 10 is provided with only a rated current setter 12 (see Fig. 8). The present embodiment does not include the short time-delay setter 13 and the long time-delay setter 14 which are provided conventionally and parameters for regions of a characteristic which are to be obtained through these setters are set by the internal characteristic setting unit 9 provided in the overcurrent relay unit 2.

More particularly, while the characteristic setting unit 10 applies only the rated current setting to the CPU, the internal characteristic setting unit 9 applies the setting of parameters for short time-delay region and the setting of parameters for long time-delay region to the CPU. In an alternative, the CPU may fulfil the function of the internal characteristic setting unit 9. When load current exceeds the rated current, the CPU generates a trip signal on the basis of a set delayed-action characteristic. The trip signal is supplied to the tripping device 3

through an I/O unit so that a trip coil (not shown) built in the tripping device 3 may be driven to stop the make - and-break mechanism and open the make-and-break contacts 5.

As shown in Fig. 10, among parameters in the delayed-action characteristic control regions of, only one parameter that is selected so as to be settable during normal use by the user is the one for the rated current. When the setting of the rated current parameter is changed, other parameters of the delayed-action characteristic are so designed as to be determined automatically by multiplying, by means of the internal characteristic setting unit 9, constant coefficients α and β which are determined by the maker in advance.

In the present embodiment, these coefficients α and β have independent specific values for individual set values of rated current. This is for the purpose of presupposing a load characteristic capable of including that of a general load connected (hereinafter called a greatest common measure like load) without specifying an object to be protected and for obtaining a delayed-action characteristic conforming to the presupposed load characteristic.

For simplicity of explanation, an example of a general motor load as shown in Fig. 11 will be described. A load curve of small-capacity motor (a) is compared with a load curve of large-capacity motor (b). On the assumption that the former has a steady load current i_1 and a start

current αi_1 and the latter has a steady load current i_2 and a start current βi_2 , $\alpha > \beta$ holds and a relatively large current flows through the small-capacity motor.

Accordingly, gathering from a comparison of
 5 delayed-action characteristics when such general motor loads are presupposed, that is, a comparison of a delayed-action characteristic for the small-capacity motor load curve (a) as shown in Fig. 12 with a delayed-action characteristic for the large-capacity motor load curve (b)
 10 as shown in Fig. 13, it will be seen that a more excellent protective characteristic can be obtained when the operation start current value for the short time-delay region to be determined for the rated current set in accordance with the motor capacity is so changed as to
 15 meet the start current characteristic and start currents αi_1 and βi_2 of the general motor than when the operation start current value for the short time-delay region to be determined for the rated current has constant ratios to the respective rated current values.

20 In the embodiment as described in connection with Fig. 10, the setting ratio is changed only for the setting of the short time-delay detection start current value in accordance with the rated current value but in a modification of the present embodiment, the setting ratio
 25 may be changed for other characteristic parameters as shown in Fig. 14.

In other words, when the setting of the rated current is changed from I_1 to I_2 , the setting of the long

time-delay characteristic value is changed from mI_1 to nI_2 by using coefficients n and m , and the setting of the short time-delay characteristic value is changed from αI_1 to βI_2 and from lI_1 to kI_2 by using coefficients α , β , k and l .

5 In the present embodiment, the parameter to be set by the user is limited to only the rated current and parameters of other characteristic regions are set in relation to the respective set values of rated current in accordance with independent specific coefficients.

10 In the present embodiment, the delayed-action characteristic for the greatest common measure like general load can be set easily with the simplest construction and it is not intended to meet a special load characteristic or very fine characteristic setting. According to the present
15 embodiment, when the rated current is changed on the basis of an increase or decrease in the connected load without exchanging the circuit breaker itself, complicated and troublesome operation of the setting switch can be eliminated and a circuit breaker capable of preventing
20 erroneous setting can be provided at low costs.

Second Embodiment

Referring now to Figs. 15 and 16, a second embodiment of the present invention will be described. Fig. 15 is a front view of a circuit breaker according to
25 the second embodiment of the present invention. Fig. 16 is a graph showing delayed-action characteristics of the Fig. 15 circuit breaker.

In the present embodiment, there are provided two kinds of setting modes. In a first mode, the setting function by only a rated current setter 12 is allowed for the user and in a second mode, setting values of other parameters of a delayed-action characteristic which are set through that setting function can be reset. In the present embodiment, a setting mode switching unit 17 for switching the setting mode is provided on the front surface of a cabinet. When the mode is switched to the first mode, the setting function allowed for the user is limited to only the rated current setter 12, and as for other parameters of the delayed-action characteristic, setting values at these parameters corresponding to a set rated current are limited to values for a greatest common measure like general load, which allows the values to be changed in accordance with independent specific coefficients as in the case of the first embodiment.

When the mode is switched to the second mode, the setting values of other parameters of the delayed-action characteristic which are set in accordance with the set rated current can be reset.

As shown in Fig. 16, coefficients for the resetting are different from those for the first mode but the resetting is effected with the coefficients fixed to γ . In an alternative, like the first mode, the resetting may be effected with coefficients which are so changed as to have independent specific values.

Since the two setting modes are available, the simple characteristic setting as in the first embodiment can be effected while permitting a general load to be dealt with.

5 Any one of the two setting states can be indicated on a setting mode switching indicator 18 provided on the front surface of the circuit breaker cabinet.

Third Embodiment

Referring now to Fig. 17, a third embodiment of
10 the present invention will be described.

Fig. 17 is a front view of a circuit breaker according to the third embodiment of the present invention. In the present embodiment, conditions which cannot be dealt with by the simple setting function as in the first
15 embodiment can be handled. In the present embodiment, there are provided as shown in Fig. 17 a rated current setter 12, a short time-delay setter 13 and a long time-delay setter 14 and switching between the simple characteristic setting and characteristic setting for
20 individual parameters can be carried out by a short-circuit switching unit 15. In the present embodiment, by operating the short-circuit switching unit 15, other parameters of a delayed-action characteristic (short time-delay setting parameter and long time-delay setting parameter) can be
25 adjusted independently parameter by parameter by means of the setters as in the case of the prior art.

More particularly, when the short-circuit switching unit 15 shown in Fig. 17 is turned off or disconnected, delayed-action characteristic control is carried out by setting values obtained by the short time-delay setter 13 and the long time-delay setter 14.

When the short-circuit switching unit 15 is turned on or connected, the short time-delay setter 13 and long time-delay setter 14 is short-circuited so as to kill these functions, so that the delayed-action characteristic adjustment in which the short time-limit setting and the long time-delay setting are automatically determined in relation to the rated current setting by the rated current setter 12 in accordance with specific coefficients determined by the maker is carried out to fulfil the setting function of the first embodiment.

The on/off state of the short-circuit switching unit 15 can be indicated on a short-circuit state indicator 16.



CLAIMS:

1. A circuit breaker having an analog signal processing unit for detecting and amplifying load analog signals of currents flowing through electric circuit lines of a plurality of phases, analog to digital (A/D) converters for converting the detected analog signals into digital signals and a digital signal processing unit for causing a tripping device to trip on the basis of the converted digital signals so as to obtain a predetermined delayed-action characteristic and so as to set controllable parameters of the delayed-action characteristic, characterized by comprising:
- setting means for variably setting only one parameter representative of a rated load current value upon operation start of the controllable parameters of the delayed-action characteristic and precedently fixing the other controllable parameters of the delayed-action characteristic to corresponding predetermined values in accordance with the rated load current value.
2. A circuit breaker having an analog signal processing unit for detecting and amplifying load currents flowing through electric circuit lines of a plurality of phases, A/D converters for converting the detected analog signals into digital signals, a digital signal processing unit for causing a tripping device to trip on the basis of the digital signals so as to obtain a predetermined delayed-action characteristic and setting means for setting



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controllable parameters of the delayed-action characteristic, characterized by comprising:

a switching unit for performing switching between first and second modes,

5 said setting means having the delayed-action characteristic setting function for variably setting only one parameter representative of a rated load current value upon operation start and fixing other controllable parameters of the delayed-action characteristic in advance
10 to corresponding predetermined values in accordance with the rated load current value when the mode is switched to the first mode and for resetting at least one of the fixed values of the other controllable parameters of the delayed-action characteristic set through the delayed-
15 action characteristic setting function when the mode is switched to the second mode.

3. A circuit breaker having an analog signal processing unit for detecting and amplifying load currents flowing through electric circuit lines of a plurality of
20 phases, A/D converters for converting the detected analog signals into digital signals and a digital signal processing unit for causing a tripping device to trip on the basis of the digital signals so as to obtain a predetermined delayed-action characteristic and set
25 controllable parameters of the delayed-action characteristic, characterized by comprising:

short-circuit means; and



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setting means having the delayed-action characteristic setting function for variably setting only one parameter representative of a rated load current value upon operation start and fixing other controllable

5 delayed-action characteristic in advance to corresponding predetermined values in accordance with the rated load current when said short-circuit means is turned on and for variably setting the rated load current value upon operation start and the other controllable parameters of

10 the delayed-action characteristic when said short-circuit means is not turned-off.

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