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FUJI T-TYPE MINIMUM-OIL-VOLUME CIRCUIT BREAKER (3/6 KV AC CIRCUIT BREAKER)

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I. FOREWORD

With the recent increase in the demand for electric power, there have been growing requirements for reliability in power system usage, increases of power transmission capacity, and higher quality electricity. One of the measures that can be taken to meet these requirements is to increase the number and capabilities of the power distributing facilities. Although the above measures are necessary, they will not be completely satisfactory unless they are rationalized to prevent an increase in costs. However, rationalization has been difficult to realize with the circuit breakers in use up to now due to the fact that the demand for electric power has been so densely centered in urban areas that the number of power substations required exceeded the number that could be built with the existing old type circuit breakers. Another factor making rationalization difficult is the high cost of the installation site itself. These difficulties have naturally given rise to the necessity of making the power distributing facilities as small and economical as possible and so excellent that they will meet today's various technological requirements. In view of this trend, Fuji Electric has begun the manufacture of T-type (minimum-oil-volume) circuit breakers which satisfy the high technological and economical requirements of today's customers. The type now being produced is a 3.6/7.2 kv power distribution circuit breaker with 150 and 250 Mva breaking capacities at 7.2 kv available. Two arc-quenching systems are finely combined in this circuit breaker. One, called the " ring nozzle blast system " based on the oil flow relative to the breaking arc, and the other, called the " volume equilibrium principle " for volume compensation of the downward moving contact. The use of these new ideas has made the performance of these circuit breakers higher than ever. This T-type circuit breaker has the following features:

(1) Revolutionary high performance.

Because the " volume equilibrium " and " ring nozzle blast " systems are used, the arcing energy during breaking is reduced to a minium. Moreover, the arcing time for breakings of all currents,

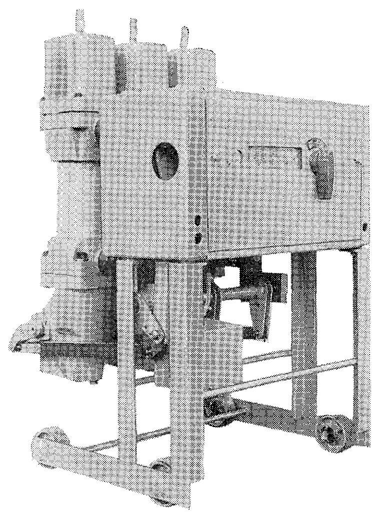


Fig. 1 Exterior view of Fuji T-type circuit breaker

from small currents to large current faults, is shorter than one cycle. Capacitive currents are interrupted without restrike and no overvoltages are generated during breaking of exciting currents. Breaking of double phase-to-ground and out of step faults are also possible. The fears generally associated with air type breakers under contaminated conditions has been eliminated. Isolating characteristics are excellent.

(2) Fire hazard eliminated by the use of a small amount of oil.

Since the amount of insulating oil used to extinguish arcs is extremely small and the gas exhausted during interruption of short-circuits is heated to no more than 100°C, explosive vapors will not ignite, thereby eliminating any fire hazard. Moreover, the amount of oil per circuit breaker is only 6.5 liters, and therefore, is not subject to fire laws. In this regard, this T-type circuit breaker can stand comparison with magnetic blowout circuit breakers.

(3) Extremely small.

Since this truck type unit is extremely small, one unit can be housed on top of the other in one distribution panel, thereby reducing the floor space required by one half.

(4) Spring operated closing mechanism for high safety factor.

Closing energies are charged into a spring, either manually or by motor, and, when the latch is released, the spring functions to drive the closing mechanism. Thus, the closing speed remains constant. If the operating voltage is too low, either the closing may not be effected at all or the charging of closing-spring may merely be prolonged. Thus, high reliability is assured in closing short circuits.

(5) Light weight and ease of maintenance.

Since a unit weighs only 120 kg, units can be transferred easily. Inspection and maintenance time has been considerably reduced by the convenient arrangement of the components in the arc extinguishing chamber. Though not in a drawer assembly, the parts can be replaced without the need of disconnecting the leads from the main conductor. The work time required per phase is only three minutes.

II. HISTORY OF MINIMUM-OIL-VOLUME CIRCUIT BREAKERS AND PRESENT STAGE OF DEVELOPEMENT

In the 1930's, it was thought that reduction of substation installation costs could be attained by reducing the size of the substation. During that time, minimum-oil-volume circuit breakers began to appear in the market. Twenty years later the " air-blast circuit breaker" became popular and replaced older minimum-oil-volume circuit breaker. This was primarily because the minimum-oil-volume breakers, in those days, had a structural disadvantage in that they were designed for capacitive current interrupting and were of multi-breaking construction, while the air blast circuit breakers were comparatively easy to produce. These disadvantages were attributed to the oil used as the arc extinguishing medium, which limits the breaking capacity. However, this has been proven incorrect by the fact that a multi-breaking breaker with a capacity of 760 kv and incorporating some of the features of the air types has been successfully built. None of the above problems are found in this breaker, indicating that it is actually superior to the air types. Oil, which was used in the old breakers, still maintains its superiority as the arc extinguishing medium. Moreover, breakers for medium voltages need not necessarily be of multi-breaking construction, but may be of single-breaking construction if they have an appropriate arc extinguishing chamber to give the desired performance. Maintenance and construction have been made extremely simple by recent solving of the problems in small current breaking characteristics and by reducing the oil volume to much less than that used in the old types of oil breakers. At present, air type breakers seem to have been relegated to second place as far as medium voltage breaking is concerned. Maintenance of the air compressor is appearing as an unnecessary trouble in these days when unattended substations are in general use.

III. T-TYPE CIRCUIT BREAKER CONSTRUCTION

The special construction of the T-type circuit breaker differs from that of other types of " extremely small oil volume circuit breakers ". The breaking tube (*1*) (*Fig. 2*) containing the arc extinguishing device is attached to the mechanism housing (*3*) by two insulating supports (*2*) made of epoxy resin. There are three breaking tubes, one for each phase of the three-phase circuit breaker. The insulating rod (*4*) transmit the operating force from the drive box to the moving parts of the breaking tubes. Phase barriers (*5*) are used between the phases. The extremely small dimensions [1000 mm (high) × 535 mm (wide) × 637 mm (deep)] of this circuit breaker make it advantageous for installation in a distribution panel or cubicle. All the controls, driving motor, free-trip coupling, tripping device, control switch, etc. are placed within one housing. These components become immediately accessible by simply removing the front cover (*6*) during inspection. The making and breaking operations are accomplished by energy stored in the individual springs (making and breaking). These springs are expanded prior to the making and breaking operations.

The spring chargings are made with either the manual drive handle or a motor equipped with a gear train. Motor drive takes approximately three seconds. When the making latch device is released, the making spring contracts and performs breaker closing. Meanwhile, the breaking spring remains expanded until the breaking latch is released and then contracts to break the circuit. This mechanism is detailed in VII. Although the drive box can be readily disassembled if necessary, maintenance is seldom required. A drive by compressed air can also be used with

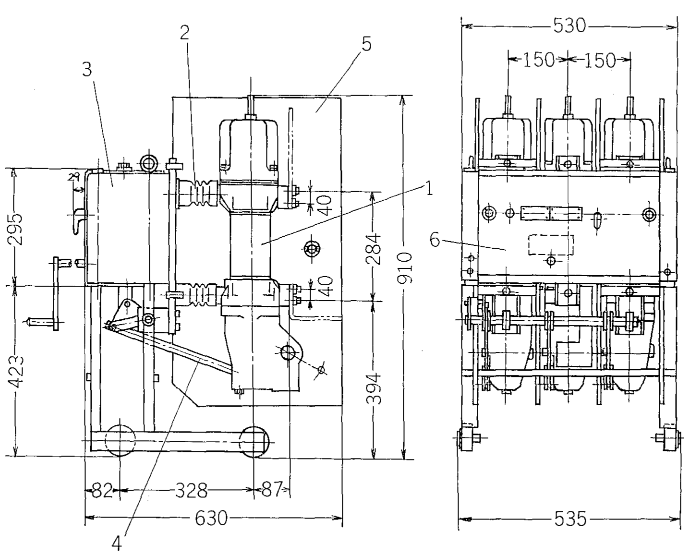


Fig. 2 Outline of T-type 7.2 kv, 250 Mva circuit breaker

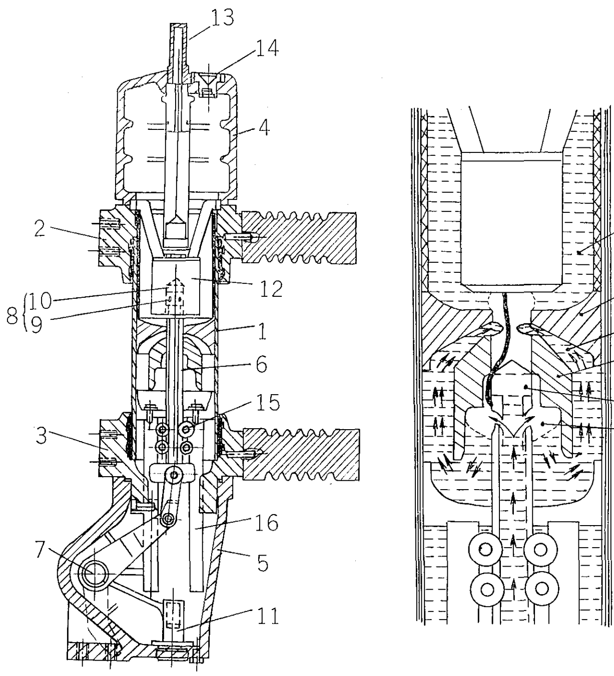


Fig. 3 T-type circuit breaker breaking tube

this breaker.

The breaking tube (*1*) (*Fig. 3*) is made of high capability insulating material, and has flanges (*2*) and terminals (*3*) at both end for lead connections. The breaking tube is sealed at the bottom by the crank case (*5*) and at the top by the top cover (*4*). The crank case has a shaft (*7*) which moves the cylindrical rod (*6*). This rod is driven by *A* and crank has a contact rod tip (*8*) consisting of a tungsten-copper element (*9*) and plastic cap (*10*) at the end. The contact rod is accelerated with the breaking spring immediately after opening and quickly moves away from the fixed contact and reaches the position where the arcing is minimum in 10 msec., at this point the ring nozzle C is opened.

After a little further displacement, the contact rod is stopped by the damper (*11*). This action prevents the arc from becoming unnecessarily long. The fixed contact (*12*) consists of the contact finger and an arcproof ring which protects the contact finger from the arcs, thereby insuring their long service life. The level of the oil is indicated by a float in a glass gauge (*13*). Near the glass gauge is the gas vent (*14*). The length and number of the conductor components are kept to a minimum.

The conductor components are the top terminals, fixed contact, contact rod, current transfer rollers (*15*), guide rod (*16*), and bottom terminal. The guide rod is bolted to the bottom terminal flange. To avoid generation of eddy currents, iron pieces are kept away from the current path. The breaking tubes have a large cooling area and are in direct contact with the open air. The cooling capacity allows for a continuous duty of 1200 amp. Special consideration has been to applied maintenance and inspection of the interior components so that they can be performed without the need of removing the main conductor.

IV. THEORY OF ARC SUPPRESSING PERFORMANCE

The outstanding breaking performance of the T-type circuit breaker is attributed to the unique method used for arc extinguishing. During break operations, the contact rod is inserted into the oil in the lower chamber which is fully isolated from the atmosphere. The oil expelled during this action passes through the path in the cylindrical contact rod and is applied to the arc. This application of oil enables non restriking in capacitive current breakings. In this method, an amount of oil adequate enough to fill the cavity produced by displacement of the contact rod in the arc extinguishing chamber can be supplied in response to, but not exceeding, the speed of the displacement.

Thus, the generation of low-pressure foam, which causes restriking, is prevented. This is called the "volume equilibrium principle". In this method, the length of the arcing is minimized and the generation of overvoltages minimized when breaking exciting currents of several amperes to several hundred amperes.

The structure is simple: No moving components are used in the arc extinguishing chamber and the arc extinguishing device is located below the fixed contact in the breaking tube (Refer to *Fig. 3*). The arc extinguishing device is divided into portions A and B by the ring nozzle, which consists of two parts. In the ring nozzle blast system, the chamber cover (*17*) and chamber insert (*18*) form ring-nozzle C, whose diameter is a few milimeters at the narrowest point. During break operations, the contact rod is moved downward to extend the arc between portion A and portion B. Gas produced in portion A is discharged, from the top, through the path next to the fixed contact. In portion B, the gas is prevented from escaping by the plastic insulating cap (*10*) and the arc, and is maintained at a high pressure. The difference in pressure produced between portion A and portion B moves the gas and oil mixture (chiefly oil) through the ring nozzle and the mixture is blown from the nozzle which has been opened by the downward movement of the contact rod. The oil flow continues until the pressures are balanced. The blown oil cools the arc, and the arc is then extinguished at the zero current point immediately after the opening of the ring nozzle (by the tip of the moving contact).

The space where the arc existed is completely de-ionized to prevent any possible restriking. The determination of an appropriate nozzle shape was of prime importance during development of the circuit breaker. The breaking fluid is applied to the arc radialy so that the arc is effectively suppressed and maintained straight while it exists. That is, the length and existing time of the arc is minimized.

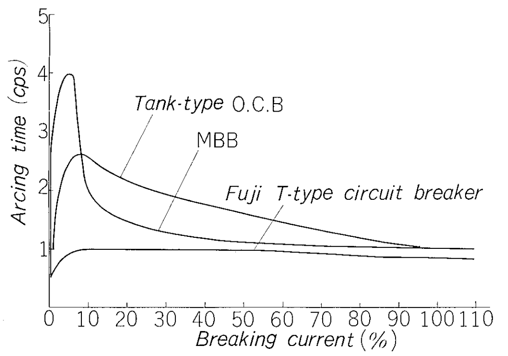


Fig. 4 Arcing-time characteristics of T-type and other circuit breaker

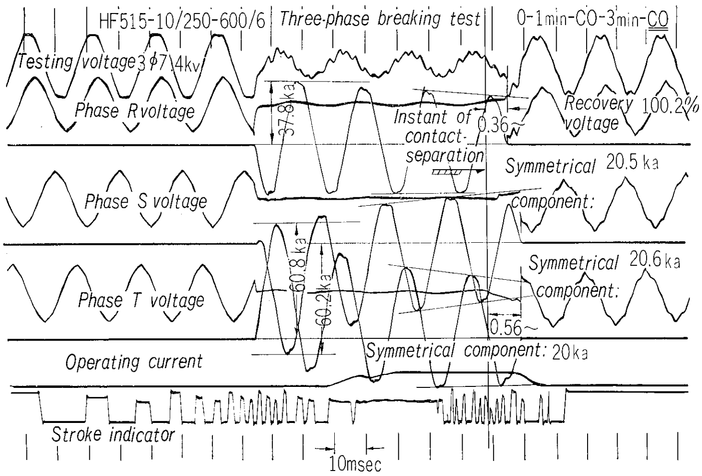


Fig. 5 Oscillogram of CO breaking test 250 Mva at 7.2 kv

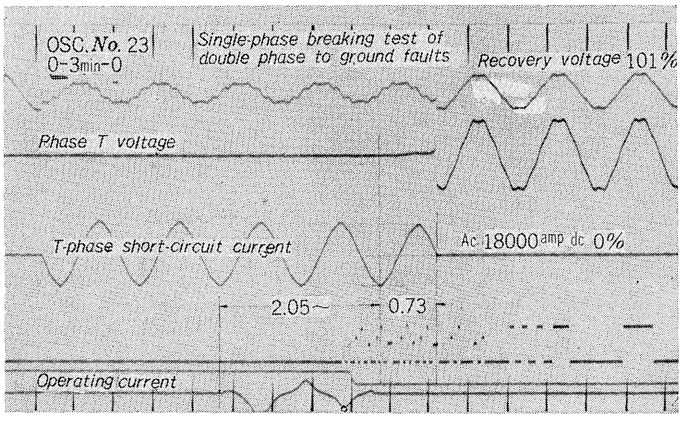


Fig. 6 Single-phase breaking test of double phase-to-ground faults

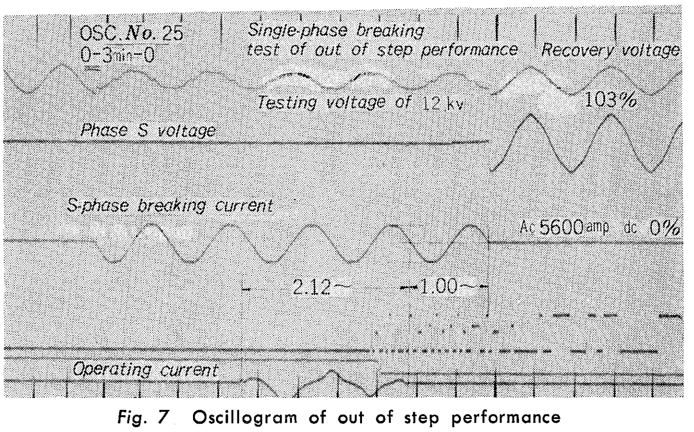


Fig. 7 Oscillogram of out of step performance

(This helps to reduce arc energy and the gas pressure it produces.) To attain this, the direction in which the oil flow is applied by the ring nozzle is extremely important. The oil stream must not only flow parallel to the axis but must also be focused toward the axis at an appropriate angle. The oil flow tends to be automatically controlled by the contact rod. When the insulating strength, between the contacts, is not very strong immediately after contact opening, the oil pressure and oil flow is small; but when the contacts reach the point where arc spu pression is greatest, the oil blow over the arc suddenly increases. How small the arc voltages are during breakings is shown in the oscillograph representations in *Figs. 5* thru *7*. The test data described in the following indicates the ideal breaking performance of the T-type circuit breaker.

V. TEST DATA

Prior to production, the T-type circuit breaker was thoroughly examined mechanically and electrically. The breaker was verified through various tests to exhibit reliable performance under every possible condition, including normal conditions and in an emergency during use in the power system. These tests are described in the following. These circuit breakers are based on speci fications JEC-145 (1959) and specifications B–112 for electric power distribution prescribed by the Institute of Electrical Engineers of Japan.

This circuit breaker has achieved 10,000 noloaded operations without replacement of parts. The making and breaking springs showed no changes in characteristics after 50,000 operations. In spite of the small size, the breaker showed excellent strength against commercial frequency and impulse voltages, as specified by JEC–145.

The short-time current capacity was also verified as excellent: 2 seconds at 24.1 ka and 1.3 seconds at 30 ka were insured. Under conditions where a dc component was involved during the short-circuit period, maximum value was safely extended to 75 ka.

The breaker was found reliable over the entire breaking current range. Average arc time over the short-circuit current range was 0.75 cycles.

Fig. 4 shows the arc time characteristics of this circuit breaker compared to those of bulk-oil circuit breaker and magnetic circuit breakers.

Fig. 5 shows an oscillogram record of operation at the rated voltage of 7.2 kv and interrupting capacity 250 Mva. The breaker performed interruption of a maximum of 300 Mva during an experimental test. It also showed excellent performance in double phase-to-ground and out of step performance interruption. These are shown in *Figs. 6* and *7*. The arc length in breakings of exciting current is short and the overvoltage coefficient is always less than 2. In capacitive current breakings, the maximum voltage of the line is below twice that of the rated voltage, verifying that the breakings based on the volume equilibrium system are superior.

Figs. 8 and *9* show the contacts and parts of the arc extinguishing device after being subjected to short-circuit currents. Wear was light, and the rated current test subsequently conducted on the same test pieces detected no greater increased temperature under the rated current than that before the interruption test.

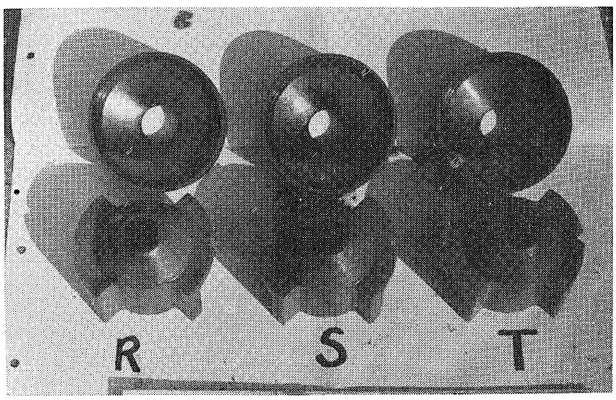


Fig. 8 Arc suppressing device components after breaking tests (Total current of approx. 70,000 amp)

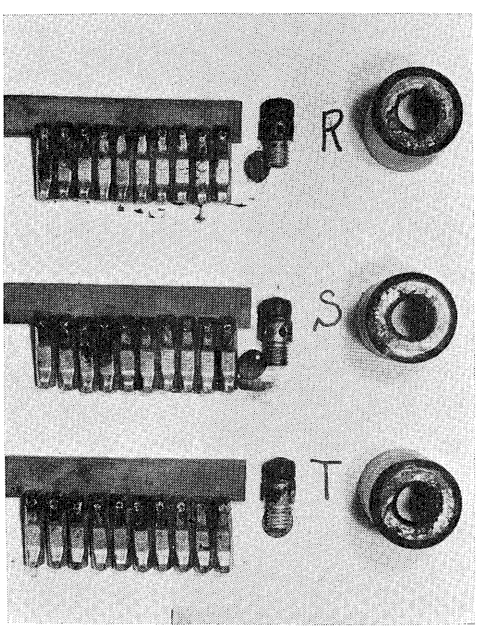


Fig. 9 Contacts after breaking tests (Total current of approx. 70,000 amp)

VI. RATINGS AND TYPES OF T-TYPE CIRCUIT BREAKER

Table 1 shows the standard specifications of the Fuji T-type circuit breakers.

Table 1 **Standard Specifications of T-type Circuit Breakers**

Type	HF 515-10/600-150	HF 515-10/600-250 HF515-10/1200-250
Rated Voltage (kv)	7.2	7.2
Insulation Class	6	6
Rated Current (amp)	600	600/1200
Rated Frequency (cps)	50/60	50/60
Rated Breaking Capacity (Mva)	150	250 (150 at 3.6 kv)
Rated Breaking Current (ka)	12	20 (24.1 at 3.6 kv)
Rated Making Current (ka)	32.8	54.8 (65.5 at 3.6 kv)
Rated Short-Time Current (ka)	12	20 (24.1 at 3.6 kv)
Rated Opening Time (sec)	0.04	
Rated Breaking Time (cycle)	5 (or 3 cycles for 50 cps)	
Rated Closing Time (sec)	3—electrically driven/spring 0.3—electrically driven/spring (quick close type) 0.1—directly operated by compressed air	
Oil Volume (liters)	6.5	
Approx. Weight (kg)	120—Board type, 160—Drawer type	
Applicable Specification	JEC—145 (1959)	

Wiring for Fuji T-type circuit breaker nomenclature

HF515-10 M / 600—250 / 6 M f
(1) (2) (3) (4) (5) (6) (7)

(1) Standard type
(2) Installation mode
  - B: Board type
  - W: Wall type
  - P: Portable type
  - PB: Portable type (with leads)
  - M: Drawer type
  - N: Simplified drawer type

(3) Rated current (amp)
(4) Rated breaking capacity (Mva at 7.2 kv)
(5) Rated voltage (6 : 7.2 kv)
(6) Type of closing mechanism
  - HR: Manual spring-operated closing
  - M: Motor spring-operated closing
  - MS: Motor spring-operated closing (Quick close type)
  - D: Directly driven by compressed air

(7) Tripping method
  - f: Voltage tripping
  - r: Low voltage tripping
  - c: Capacitor tripping
  - wf: Current and voltage tripping
  - w: Current tripping

The rating of this circuit breaker can be increased to 12 kv, 350 Mva if the supporting insulator and certain insulating parts are replaced. The installation shown in *Fig. 10* is available to choose from so as to best suit the planned distribution panel. Board type B may be installed on an open panel. The circuit breaker has an operating switch (or a handle for manual operation) and an indicator in front of the drive box. There is no need to equip them on the panel if the drive box is made accessible through

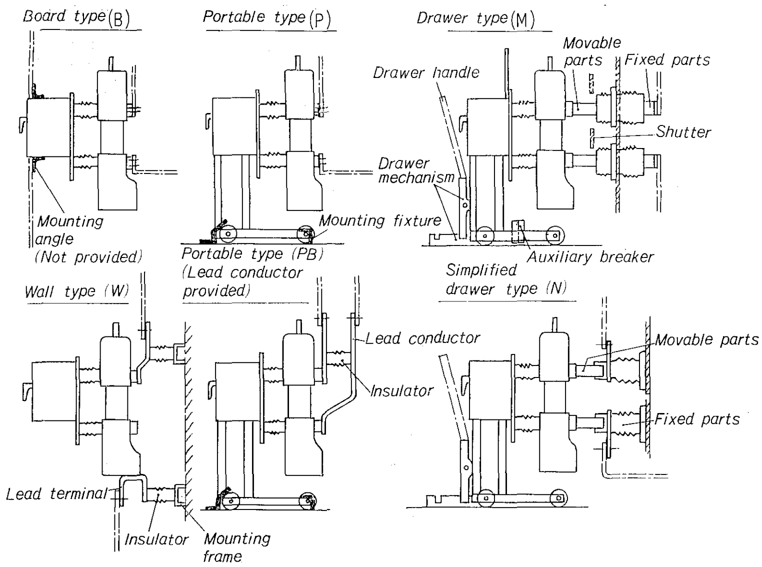


Fig. 10 Installation modes of T-type circuit breaker

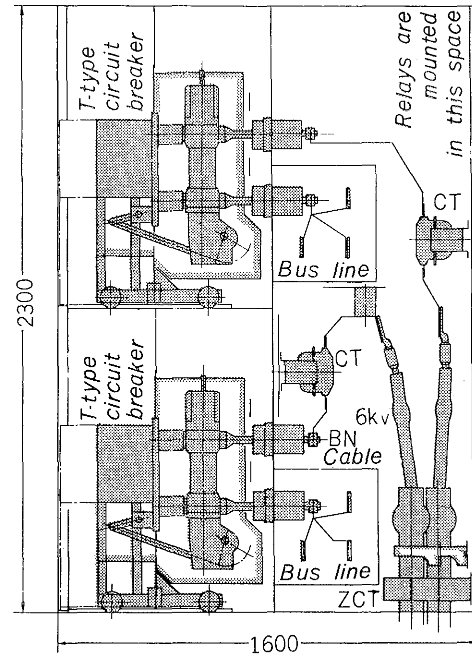


Fig. 11 Two breaker compartments of T-type circuit breaker

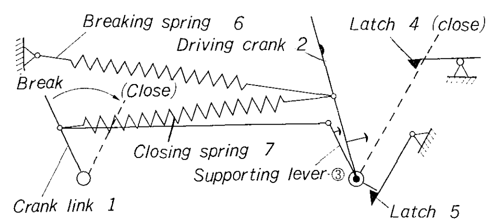
the panel.

Wall type W is convenient for wiring the bus line in the upper portion of the room to the breaker and cable, or in the reverse direction. Portable type PB is equipped with conductors, and may become a convenient replacement with the existing bulk-oil circuit breaker. Either M or simplified drawer N are designed so that one unit can be installed on top of the other in a cubicle. Applicable cubicle dimensions are 650 mm w, 2300 mm (h), and 1600 mm (d) as shown in *Fig. 11.*

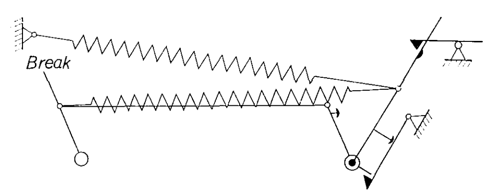
VII. TYPES OF T-TYPE CIRCUIT BREAKER OPERATION INCLUDING TRIPPING CONTROL

Prior to proceeding to an explanation of the types of operation and tripping, the switching and trip-free mechanisms are described. *Fig. 12* illustrates the spring-driven closing and breaking mechanisms used in this circuit breaker. Shown at (a) is the circuit breaker at its break position, where both breaking and making springs are de-energized. The preliminary step for the subsequent closing action is to extend the making spring, with the breaker moving section remaining at the open position, to charge energy to the spring. The making and breaking springs are simultaneously energized in this action. *Fig. 12* (b) shows the making and breaking springs charged with operating energy and ready for closing.

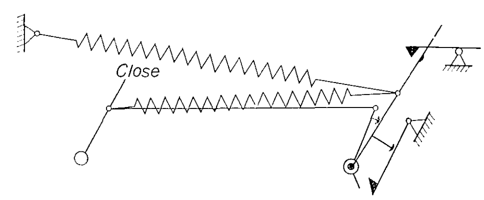
The crank link (*1*), which is connected to the moving section, still remains in the break position at this stage of action. It is prevented from turning because the energy [which has been produced by the clockwise pivoting of the driving crank (*2*)] is held by latch (*5*) through lever (*3*). When the driving crank reaches the end of its pivoting range, the latch is released and ceases to lock the crank link. The crank link, as a result, turns and moves the moving contact to the close position shown at (c) in the figure.



(a) Mechanism at its break position



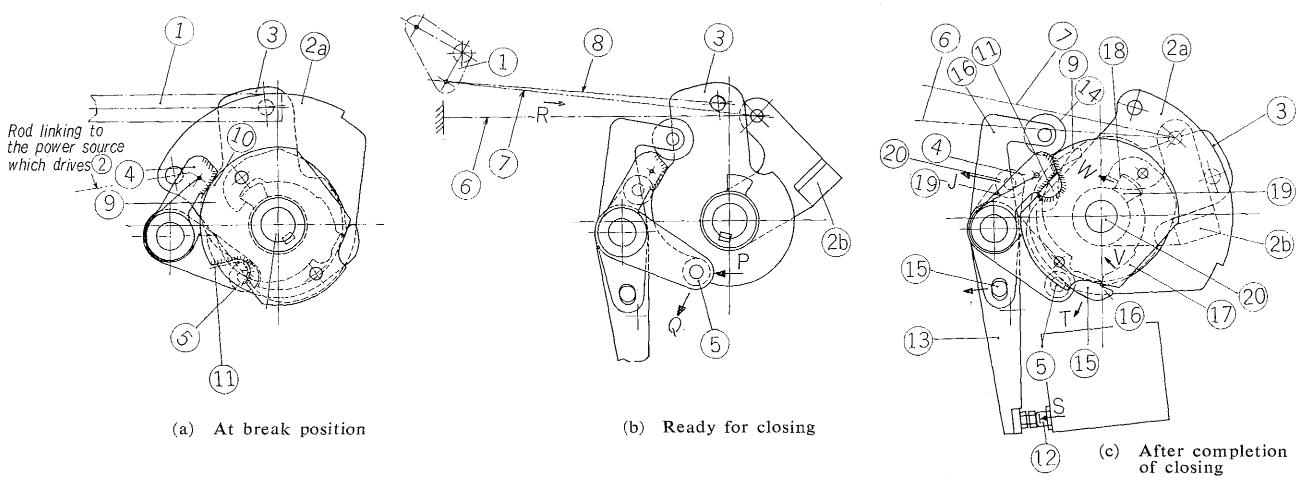
(b) Mechanism ready for closing



(c) Mechanism at the close position

Fig. 12 Operating mechanism

At this stage, the breaking spring is still in the expanded condition. Triggering of the breaking spring is similarly effected by removal of latch (*4*). The driving crank is turned, by spring force, in the counterclockwise direction. It, by this action,



(a) At break position

(b) Ready for closing

(c) After completion of closing

Fig. 13 Operating mechanism

gives a counterclockwise turn to the crank link by way of the supporting lever, and moves the moving section to the break position.

This circuit breaker has a special feature in that the making and breaking springs are set by an independent force. With a usual operating mechanism, the making spring must have enough power to expand the breaking spring in addition to that necessary for the primary making action. This requires the making spring to be bulky, and the spring produces an unnecessarily large shock in operation. In this mechanism, the breaking spring is set by a power other than the making spring. This allows the making spring to be small. *Fig. 13* shows the trip-free mechanism. Study will be made by reference to *Fig. 12*. The mechanism shown at (a) is at the break position. The numbers refer to *Fig. 13* (a, b, c). The preliminary action for closing is a clockwise pivoting of the drive crank (*2a*). The supporting lever (*3*), however, is still maintained at the break position by latching roller (*5*). *Fig. 13* (b) shows the mechanism ready for closing. Under this condition, (*2a*) in *Fig. 13* (a), (*2b*) in *Fig. 13* (b), and front plate (*9*) (a) all together have turned and, making spring (*7*) is pulled by driving crank (*2b*) and is at work against crank link (*1*) so as to turn the crank. This movement, however, will not take place, because supporting lever (*3*) is locked by latching roller (*5*) by way of link lever (*8*). The force of this movement is against the latching roller in the direction shown by arrow *P*, and will move it in the direction of arrow *Q* when it is released from the edge (*10*) of the front plate. When ready for closing [shown at (b)], the front plate notch (*11*) has turned clockwise and is about to engage with latch (*4*). When drive crank (*2a*) turns, so does the front plate, and roller rotation in the direction *Q* is effected because of the presence of notch (*11*). Latch (*5*) is released; supporting lever (*3*) turns in the direction of *P*; and crank link (*1*) is moved, by the force of the making spring in the direction of R, to the close position.

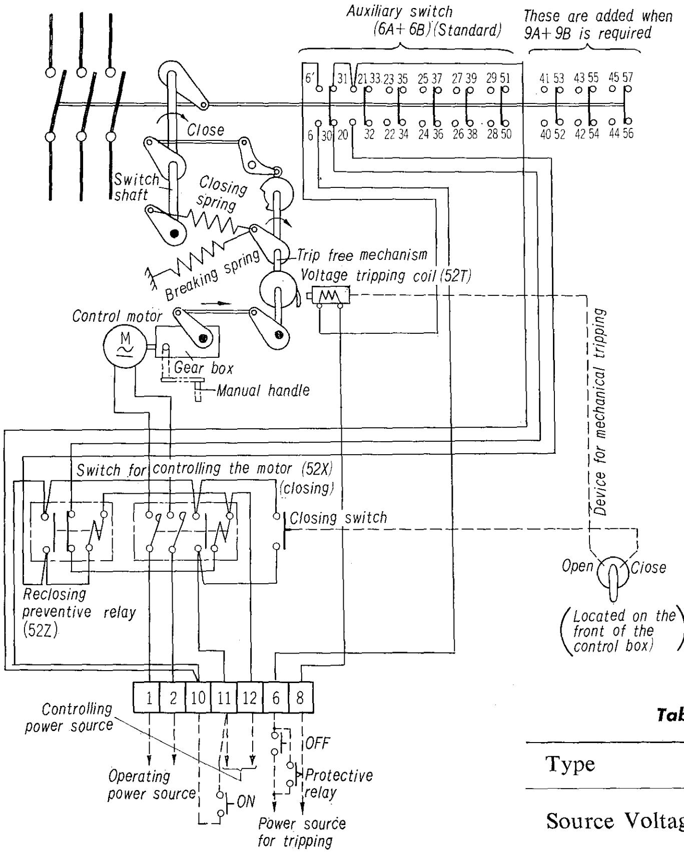
Under this condition, the breaking spring (*6*) is expanded. Breaking is accomplished as follows: The actuator functions to shift plunger (*12*) in the direction shown by S, and lever (*13*) clockwise. (This may be made manually by the lever on the front of the drive box). Roller (*14*) moves, in the direction of T, and the release lever (*15*), which frees latch (*16*). The ratchet lever (*17*) turns in the direction of V, causing release of latch (*18*). Then, cam (*17*) turns toward W (in a direction toward the break position). Cam (*20*) which is fixed to shaft (*20*), and drive crank (*2b*) turn together in the direction of W to move supporting lever (*3*) to the close position.

1. Manual/Spring Drive (Type HR)

This circuit breaker uses manually charged springs, which enable opening and closing of 7.5 kv, 250 Mva. The operating handle is readily removable and the angle is adjustable in 10° graduations. This makes it possible to install this breaker, top of another in cubicle. The pivoting angle is 90° and the maximum driving force 25 kg.

2. Motor Driven/Spring Drive (Type M)

Fig. 14 shows a schematic of this system. As a rule, the closing time is three seconds at the rated voltage. This period, however, may be reduced to 0.1 sec. in effect, since the operating switch (52X) is self-held. When the making spring is charged with energy, and the breaker is ready for the closing, auxiliary contacts B (30 and 31) makes the motor circuit start. A relay is equipped to prevent pumping action. Closing signals applied after the completion of the previous tripping do not effect reclosing. There is a manual handle on the front of drive box. When the handle is turned to "Close", switch S closes the breaker. When set to "Open", the breaker is tripped mechanically. The control switch can be omitted from the distribution panel if this handle if used. *Table 2* shows the ratings of the ac/dc driving motor.



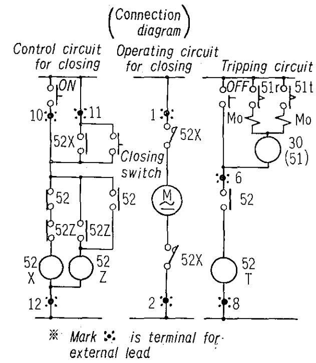


Fig. 14 Connection diagrams of synchronous operation circuit

Table 2 Driving Motor Specifications

Type	SGA 661	HSA 661
Source Voltage	Dc 100/110 v (100/110 v 50/60 cps	200/220 v 50/60 cps (Dc 200/220 v)
Continuous Rating at 800 rpm	200 w (3.8/100 v)	200 w (3.13 amp/ 200 v)
Permissible Operating Time under Maximum Breaker Load	180 sec	180 sec
Speed under Maximum Breaker Load	4500 rpm	4500 rpm
Curent Drawn under Maximum Breaker Load	7 amp	5.2 amp

As can be seen from the table, this driving motor requires less current than the motor of other breakers. Size of the operating circuit wiring can be the same as that for the control circuit and a dc power source with much less capacity can be used. However, a battery need not be used, since changes of the operating voltage will not affect the closing performance of this circuit breaker.

Another feature of this motor drive is that the motor rotates only in one direction, and the direction need not be reversed according to operations, while conventional types must. If the motor circuit should continue working beyond the completion of the closing, the motor will run idle. With the conventional motor drive, the kinetic energy of the rotor at the completion of the closing process presented a problem and often led to accidents. This problem does not exist in this unit. The driving motor is small and rotates in one direction, thus insuring smooth operation—a great feature of this motor drive.

3. Electrically Driven/Spring Drive, Quick Close (Type MS)

Where synchronous closing is required, closing must be instantaneously accomplished, much faster than M type closing which requires 3 sec. The MS type has an additional device over the M type, and reduces its closing time to 0.4 sec. This system is such that the controller, with the circuit breaker remaining at the break position, is automatically set to the position at which the closing is ready, and the closing takes place as soon as a closing signal is given. *Fig. 15* (*a*), (*b*) shows circuit diagrams of the quick close system, and the condition under which the close-controlling circuit is not connected with power source. When power is applied, *52X* immediately closes and the drive motor begins turning to expand the closing spring. When the device eventually reaches the closing ready position, the cam on the drive shaft in the gear box actuates the limit switch (LS). The motor stops at this point. Preparatory action for receiving the start signal is complete.

When the start signal is applied, the breaker closes. After the breaker conducts automatic breaking, the preparatory step is automatically accomplished, and the condition is self-held.

4. Direct-Acting Compressed-Air Mechanism (Type D)

This circuit breaker can also be directly operated by compressed air. The closing spring is not used, but the compressed air directly actuate the mechanism. Closing time is very short 0.08 sec, making this system suitable where high-speed or high switching capability is required. Rated closing pressure required is 5 kg/cm^2.

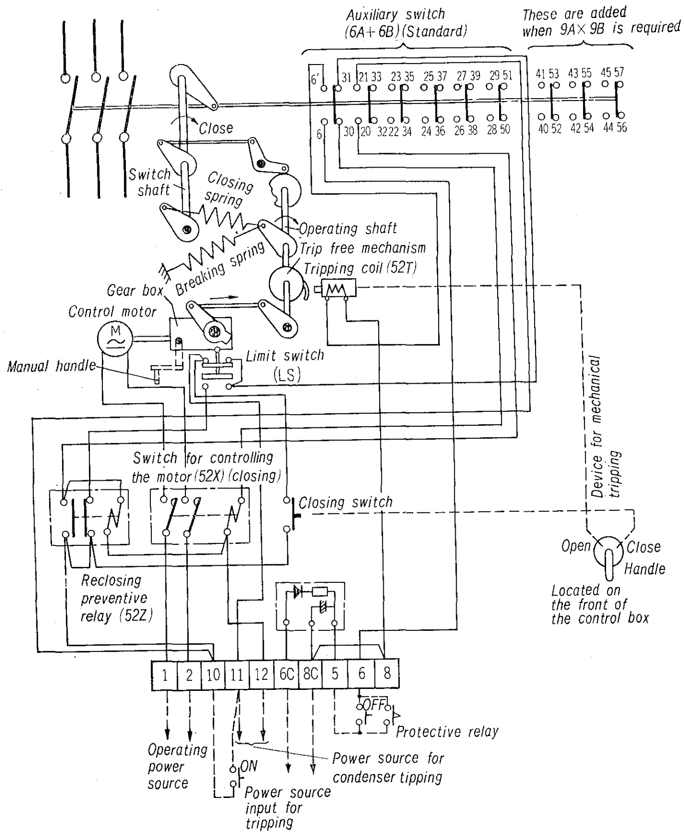


Fig. 15 (a) **Connection diagram of motor spring operation circuit**

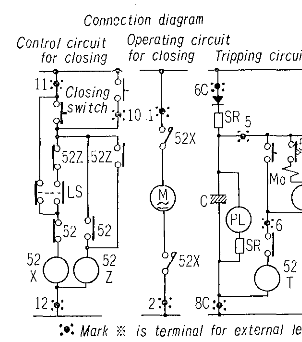


Fig. 15 (b) **Connection diagram of motor spring operation circuit**

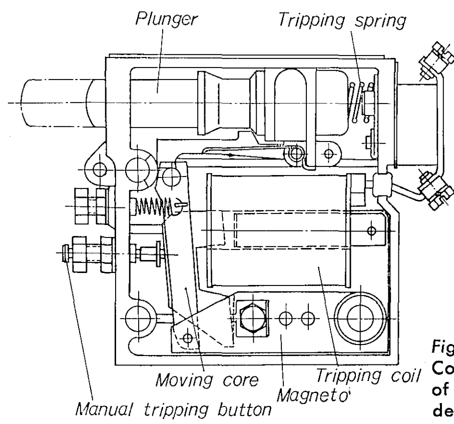


Fig. 16 **Construction of tripping device**

Table 3 **Tripping Systems of T-Type Circuit Breaker**

Type of Tripping (Symbol)	Voltage Tripping (f)	Tripping by Insufficiency of Voltage (r)	Capacitor Tripping (c)	Current Tripping (w)	Voltage/Current Tripping (w/f)
Specifications	(1) Rated tripping voltage Dc 100/110 v Dc 200/220 v Ac 100/110 v 50/60 cps Ac 200/220 v 50/60 cps (2) Tripping current 1 amp	(1) Rated tripping voltage 100/110 v ac (50/60 cps) (2) Rated capacity 30 va	(1) Rated input voltage 100/110 v ac 50/60 cps (2) Rated charged voltage 140 v (3) Rated charging time 0.05 sec (4) Trip-able duration after tripping source eliminates greater than 30 sec	(1) Instantaneously magnetized (2) Standard tripping current 2.5 amp 4 amp (3) Minimum tripping current of 90% of the standard value	Two current tripping coils Specifications identical to those of the voltage tripping One voltage tripping coil Specifications identical to those of the voltage tripping

5. Tripping

This trip-free mechanism requires very little power, and therefore is accordingly small. It does not require adjustment. Since energy for tripping is stored in a spring, the electrical power consumption is extremely small.

A small capacity suffices, making the power supply economical. The construction of the tripping mechanism is shown in *Fig. 16*. Types of mechanisms shown in *Table 3* are available.

VIII. CONCLUSION

The new Fuji T-type Minimum-Oil-Volume Circuit Breaker with many new features is anticipated to contribute to the improvement and economization of substations. It has not been long since this new T-type circuit breaker was first placed in use. We consider that technical improvements will be made in the future in cooperation with the users. Fuji Electric is now concerned with the development of small type of larger capacity circuit breakers—250 Mva/3.6 kv, 350 Mva/7.2 kv, and 500 Mva/12 kv with a rated current of 2500 amp, and 3000 amp.

References

(1) "Ohm" No. 12 (1966) by K. Taketani
(2) Siemens Z. Heft 4 (1965) by H. Bitter and S. Jaehrig
(3) Siemens Z. Heft 4 (1964) by S. Jaehrig and A. Schulz