UDC 621.316.545.06.06 (047.3)

FUJI V TYPE DISCONNECTING SWITCH

By Toyoaki Ohmori

Electric Power Apparatus Sect.,
Design Dep't., Kawasaki Factory

I. INTRODUCTION

With recent increasing of the electric power demand, large capacity power stations, substations and switchyards are now to be installed in many places and then the gigantic site area is required for these. In Europe, the developing of a new type disconnecting switch is considered to minimize the site area. In Japan, we developed pantograph type disconnecting switch in 1958 which is remarkable in this field. Now we further developed 60～140 kV class V type disconnecting switch and delivered 63 phases for Furukawa Electric Co., Ltd. Chiba Works Substation, our Chiba Factory Substation which are a part of 60 kV Goi-Ichihara loop of the Tokyo Electric Power Co., Ltd. and our Kawasaki Factory Substation which is receiving power from Ushioda Thermal Power Station of the Tokyo Electrice Power Co., Ltd. and all of them are now being in operation. The results of switching test of this V type disconnecting switch are described in the following, however, the disconnecting switch is originally not to be used for current switching, and it is question to standardize a switching ability because the ability varies largely by circumstance conditions such as construction of a disconnecting switch, fitting method, wind velocity and wind direction etc. Considering of these points, the Circuit Breaker Committee of the Institute of Electrical Engineers of Japan who is discussing about revision of JEC-125, standard of disconnecting switch, is now going to decide that the item of switching ability is to be struck out from the rating items of JEC-125 and to be described on the appendix as only a reference. On the other hand in Europe Standard, for example, VDE standard does not standardize the switching ability from the view of disconnecting switch being not to switch the current. Therefore, our test results are to be considered only as reference.

II. RATING AND TYPE

Types and ratings of the V type disconnecting switches are shown in the *Table 1*. 5 kg/cm^2 pressure is adopted for rated operating pressure as a standard now, but 15 kg/cm^2 pressure and annual operation can be adopted at customers's requests.

III. CONSTRUCTION AND OPERATION

Fig. 1 shows switchyard in Chiba Factory of our Company which started to receive power on September 1961. As seen in *Fig. 1*, in the power station, substation and switchyard the necessary structure is only for support in and out conductors and others are not. *Fig. 2* shows a skeleton diagram of the Chiba Factory's switchyard.

Fig. 3 shows an indoor substation in Kawasaki Factory of our Company which started on December 1961. In case of indoor power station, substation and switchyard, complete structureless one can be adopted and pipe bus system is favourable from the view of mechanical strength.

Two applications, normal one and another one of V type disconnecting switches are shown in *Fig. 4*

Table 1 **List of ratings and types of V type disconnecting switches**

Body	Type	HF 256/60 / 800 1200 2000	HF 265/70 / 800 1200 2000	HF 265/100 / 800 1200 2000	HF 265/140 / 800 1200 2000
	Rated Voltage (kV)	72	84	120	168
	Rated Current (A)	800, 1,200, 2,000			
Operating device	Type	R 288/1,325			
	Operating pressure (kg/cm^2)	4.5, 5			
	Control voltage (V)	DC 100, 110			

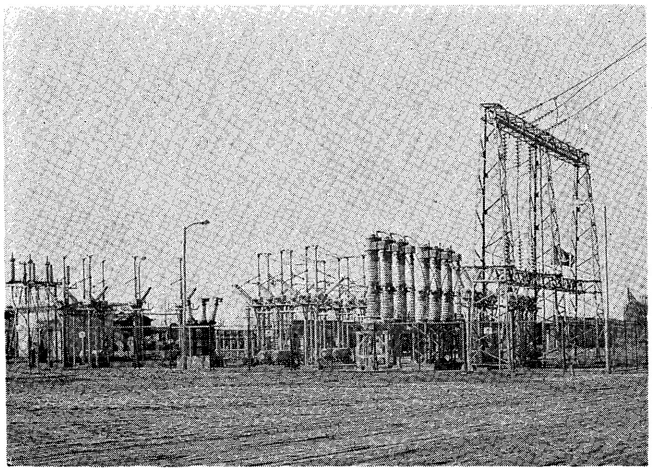


Fig. 1 60 kV outdoor switchyard in Chiba Factry of our Company

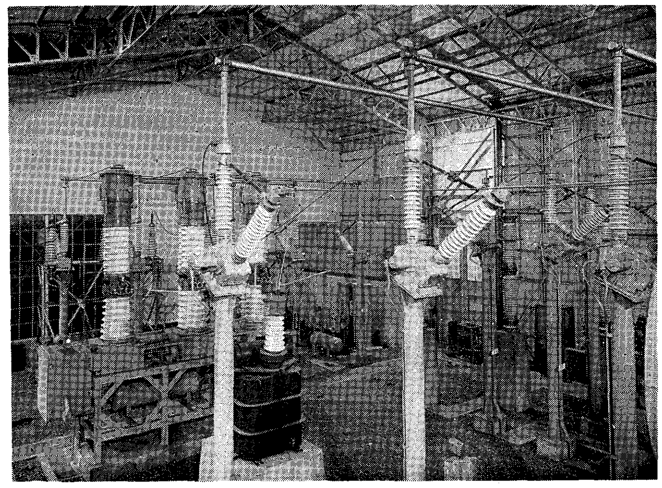


Fig. 3 60 kV indoor substation in Kawasaki Factory of our Company

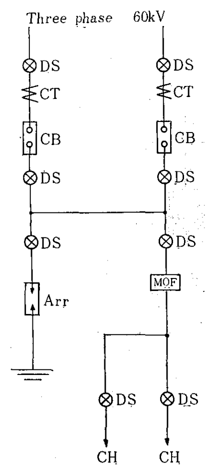


Fig. 2 Skelton diagram of Chiba switchyard of our Company

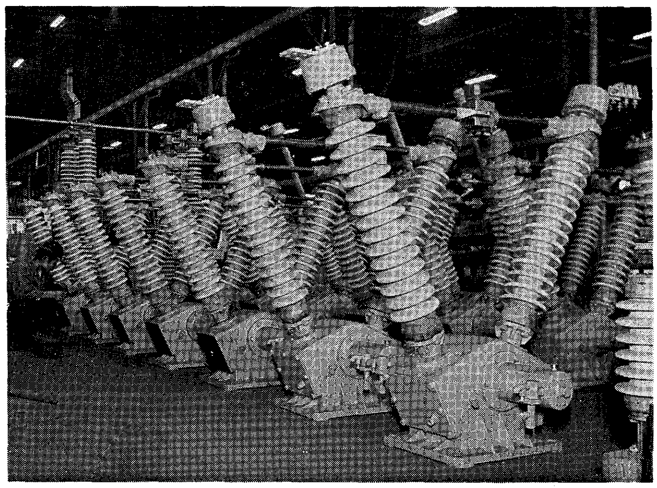


Fig. 4 V type disconnecting switches (one example)

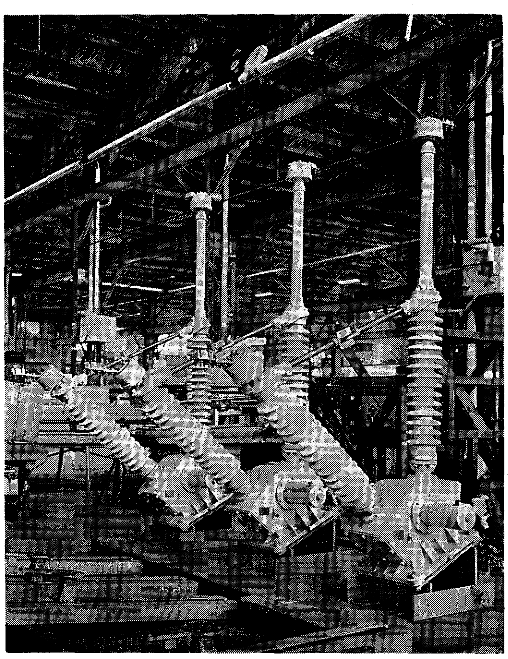


Fig. 5 V type disconnecting switches (another example)

and *5* respectively.

Operations of the V type disconnecting switch are described in the following lines. *Fig. 6 (a)* shows normal use one, two rotating support insulator ***d*** are mounted on the pneumatic operating device ***e*** and the support insulator ***d*** is directly connected to the crank fitting shaft in the operating device. On the support insulator ***d***, two current carrying blades ***b***, a lead connecting part ***a*** and a contact ***c*** are

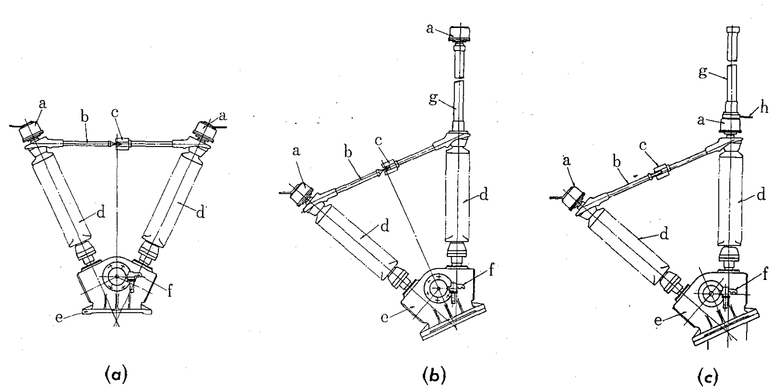


Fig. 6 V type disconnecting switches

mounted. A lead connecting part ***a*** provides a bearing and a shunt for current conducting, then the outer lead are not to be moved even when the disconnecting switch operates. *Fig. 6* (*b*) and (*c*) show the V type disconnecting switch to be used for connecting with another circuit which has a construction so as to connect with another circuit by adjusting the height of current conducting pipe ***g***. *Fig. 6* (*c*) is especially provides a internal terminal ***h*** and is so constructed as to connect with another equipment with this terminal.

Fig. 7 shows the construction of operating devices of these V type disconnecting switches. The pneumatic operating device is consisting of a case ***n***, two cylinders ***o***, a double piston ***j*** and two cranks ***i***. The double piston ***j*** is driven by the pneumatic operation device to rotate the shaft ***m*** and the support insulator ***d*** through the crank ***i*** which is engaging with the roller ***l***, and then the two current conducting blades are to be switched. The crank ***i*** is stopped with the stopper ***k*** at the both end not to rotate over limitation, then any contacting trouble does not occur. Furthermore, the crank ***i*** is so completely locked with the roller ***l*** of double piston that it is not moved even by external forces, for example electromagnetic force, pressed on the switch. This construction is a feature of pneumatic operating device of our disconnecting switch. Further to say, at emergency, the pneumatic operating device can be operated with manual handle to switch the disconnecting switch.

Fig. 8 shows contact part of V type disconnecting switch. As arcing contact is adopted for the main contact, the contact is not worn out with arc at current switching, and the temperature rise does not vary before and after current switching test.

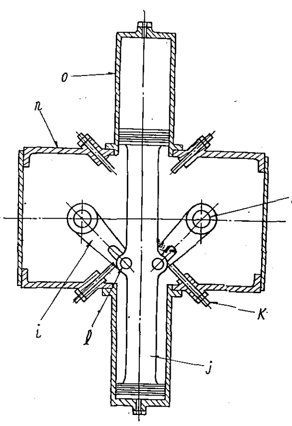


Fig. 7 Pneumatic operating device

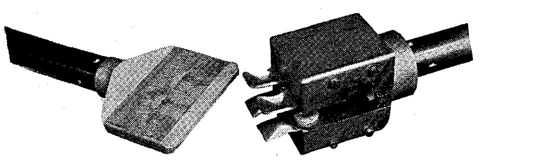


Fig. 8 Contact part of V type disconnecting switch

Next, *Fig. 9* shows connection diagram of operating device of the V type disconnecting switch. Each phase of V type disconnecting switch has a pneumatic operating device, the compressed air is pressed into the cylinder of each phase when pushing a button of valve rod of double electromagnetic valve manually or electrically and each phase of the switch is operated to be interlocked each other. As speed regulating valves are attached on the both sides of a cylinder of each phase operating dervice, closing and breaking speed of each phase can be adjusted independently and continuously with ease. Then irregularity among three phases can be adjusted. (This mechanism belongs to a pattent of our Company, Patent No. Showa 35–11714) Further in case of any one phase being not finishing it's operation, a indicating lamp is not to be switched in or off. In other words, limit switches are provided on the both sides of the crank to be operated at the end point of closing and breaking, and these limit switches are connected in series and to a kip relay.

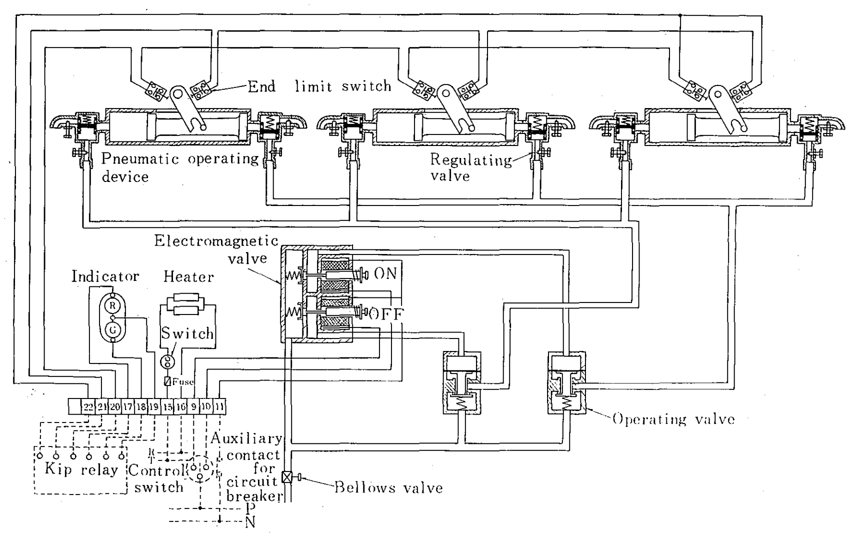


Fig. 9 Operation control system of V type disconnecting switch

IV. TEST RESULT

No load operating test, exciting current switching test, charging current switching test and loop current switching test were conducted under 100% (5.0 kg/cm₂), 110% (5.5 kg/cm²) and 75% (3.75 kg/cm²) of rated operating air pressure, and all current switching tests were executed in order to find out the limit of interrupting capacity. In the following sections, test results of the V type disconnecting switch were introduced and the all tests were applied on 1 ϕ.

1. Test of No Load Operation

This test was exercised to know the variations of

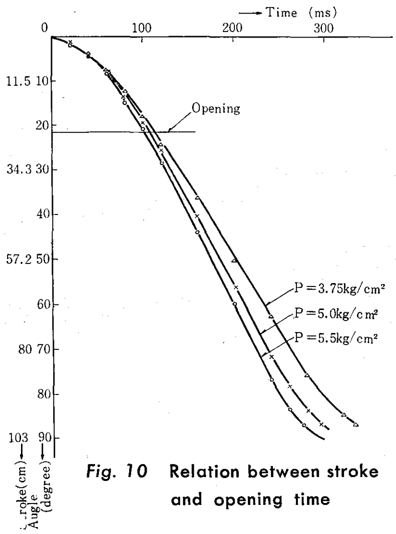


Fig. 10 **Relation between stroke and opening time**

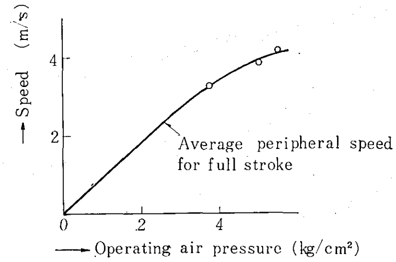


Fig. 11 **Characteristics of opening speed**

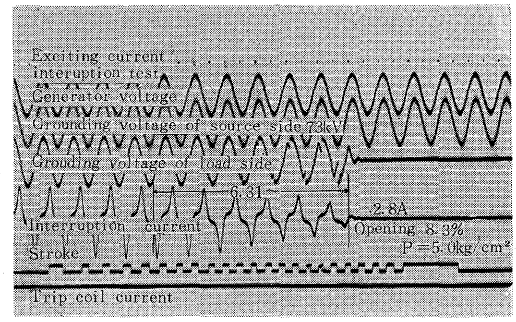
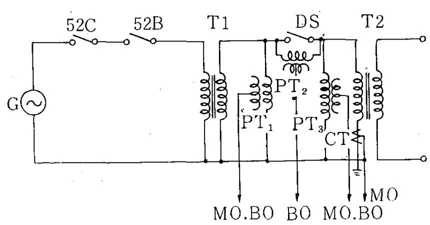


Fig. 14 **Typical oscillogram of exciting current interruption**

stroke and interrupting speed under the pressures such as 100 %, 110 % and 75 % of rated operating air pressure.

2. Test of Exciting Current Interruption

1) Test Circuit



G: 10 MVA short-circuit generator
52C: Switch for closing
T_2: 1ϕ, 3,333 kVA transformer
PT_1 PT_2 PT_3: Potential transformer
MO: Electromagnetic oscillogram
52B: Circuit breaker
T_1: 3-phase, 16.5 MVA transformer
DS: V type disconnecting switch
CT: Current transformer
BO: Brown tube oscillogram

Fig. 12 **Test circuit for exciting current interruption**

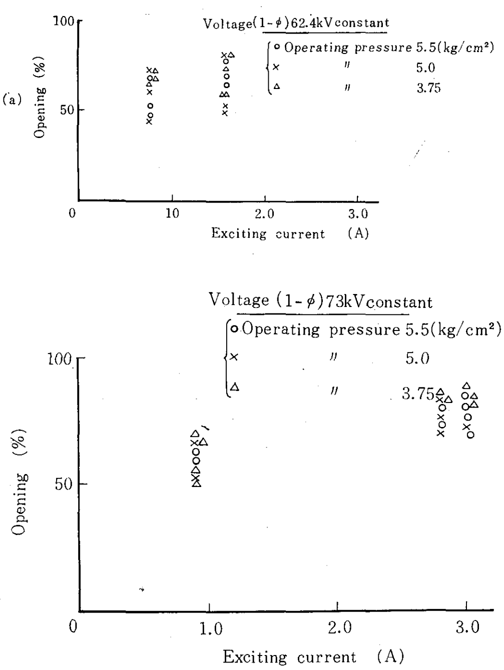


Fig. 13 **Characteristics of rupturing capacity of transformer exciting**

2) Test Results

This test was conducted upto 3 A at the testing voltage of 1–ϕ 62.4 kV (equivalent with 3 phase 72 kV) and 1–ϕ 73 kV (equivalent with 3 phase 84 kV), however, in this range any variation of interupting ability was not found out. As known from *Fig. 13 (a)* and *(b)*, 3 A at 3 phase 84 kV is considered to be a limit of interupting capacity. The abnormal voltage at interuption was low, max. 1.55 times. A typical oscillogram and a view of testing are shown in *Fig. 14* and *Fig. 15* respectably, and conditions of oscillogram are 1–ϕ 73 kV, 2.8 A, 83 % opening and rated operating air pressure, and *Fig. 15* is under conditions of 1–ϕ 62.4 kV

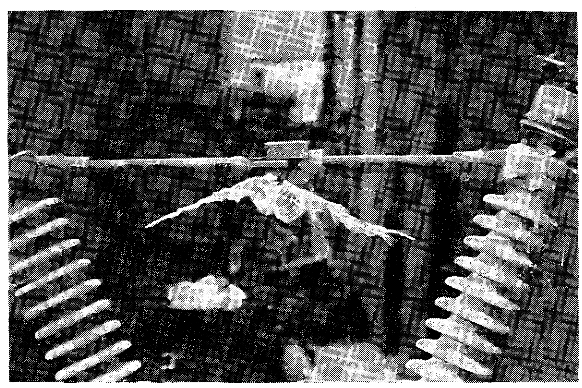


Fig. 15 **View of exciting current interruption test**

1.55 A, 77 % opening and 110 % of rated air pressure.

3. Test of Charging Current Interruption

1) Test Circuit

Fig 16 shows test circuit of charging current interruption.

2) Test Results

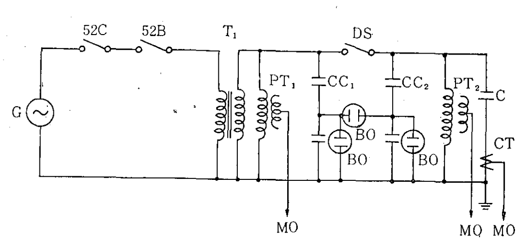


Fig. 16 **Test circuit for charging current interruption**

Charging current interruption test was conducted upto 2.9 A at 1-ϕ 52 kV (3 phase 72 kV $\times \frac{1}{\sqrt{3}} \times 1.25$) and at 1-$\phi$ 61 kV (3 phase 84 kV $\times \frac{1}{\sqrt{3}} \times 1.25$). As known from *Fig. 17 (a)* and *(b)* 1.5 A at equivalent 3 phase 84 kV is considered to be a limit of interupting capacity, and the abnormal voltage at interuption was max. 2.4 times. As shown in *Fig. 18* in spite of frequent reignition of arc the abnormal voltage is not so high. The reason of this is that the reignition current is not quenched in a short time after reignition, but low frequency quenching is seen.

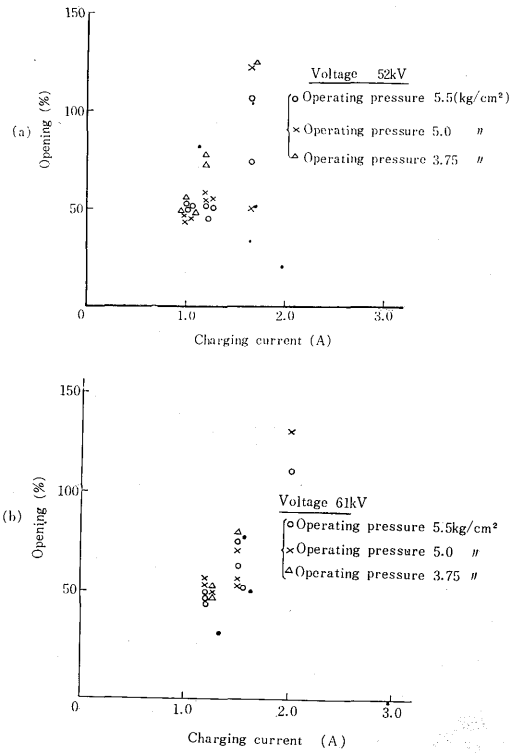


Fig. 17 **Characteristics of rupturing capacity of charging current**

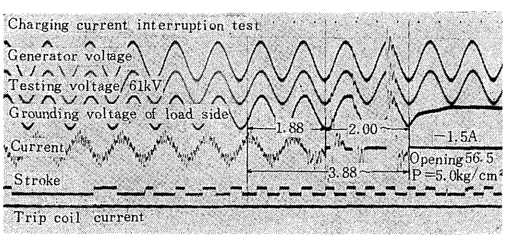


Fig. 18 **Typical oscillogram of charging current interruption**

There is a many opinions what times voltage of the phase voltage is necessary for one phase interuption aginst charging current interuption, but our test was conducted at 1.25 times. A typical oscillogram and a view of testing are shown in *Fig. 18* and *Fig. 19* which were conducted under 1-ϕ 61 kV 1.5 A, 56.5 % opening, rated operating pressure and 1-ϕ 61 kV 2.9 A,

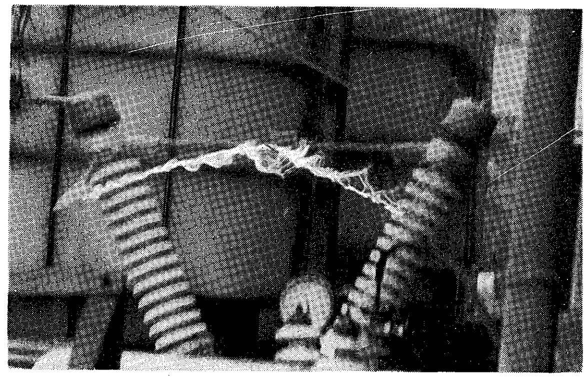


Fig. 19 **View of charging current interruption test**

112 % opening, 110 % of rated air pressure respectively.

4. Test of Loop Current Interruption

1) Test Circuit

Fig. 20 shows a test circuit of loop current interruption.

2) Test Results

2.1 kV and 3.1 kV were adopted for test voltage, and interrupting capacities at these voltages were researched. Test results are shown in *Fig. 21*, 15 A at 3.1 kV and 35 A at 2.0 kV are considered to be limit of interruption. A typical oscillogram and a view of testing are shown in *Fig. 22* and *Fig. 23* respectively. The oscillogram was taken at 3.1 kV 18 A, 97 % opening and rated operating air pressure

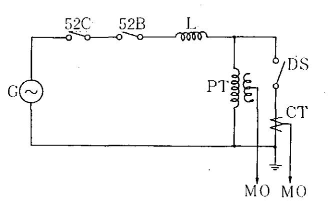


Fig. 20 **Test circuit for loop current interruption**

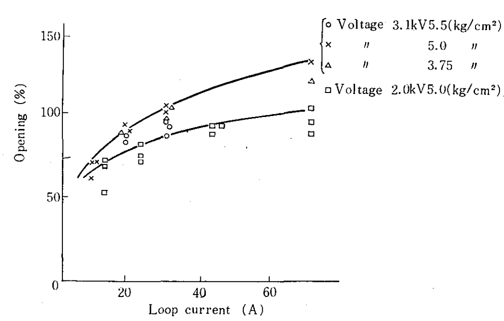


Fig. 21 **Characteristics of rupturing capacity of loop current**

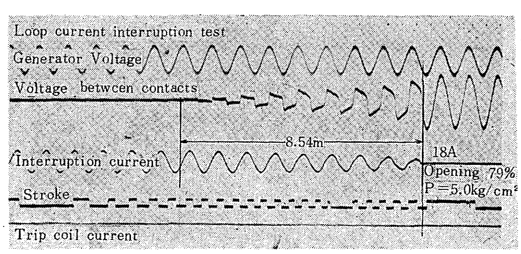


Fig. 22 **Typical oscillogram of loop current interruption**

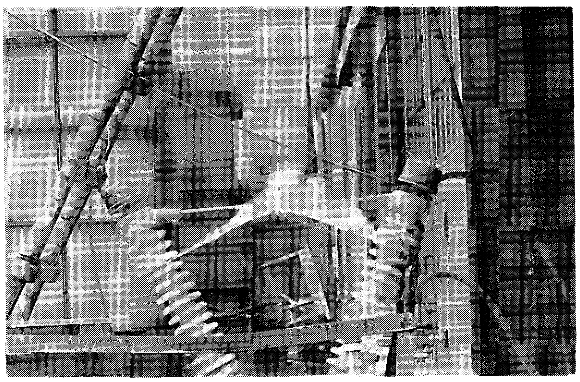


Fig. 23 View of loop current interruption test

and the view of testing was the one conducted under 3.1 kV, 30.6 A, 98% opening and 75% of rated air pressure.

V. FEATURES

Fuji V type disconnecting switch is most suitable one for 60 kV～140 kV line, and has following features:

(1) Site areas of power station and substation and switchyard can be minimized.

(2) Having V type disconnecting switch not only superior switching function, but also functions of structure, the construction cost can be downed.

(3) The arrangement of power station, substation and switchyard are to be stereographic and perspective, and they are convenient for maintenance.

(4) As arcing contact is attached to main contact, the main contact is never worn out by switching.

(5) The support insulator of V type disconnecting switch is two-third of older one in size, and the bus support insulator is unnecessary, then in case of location at salt contamination district the cost of water spray washing system is remarkably downed.

(6) As the support insulator of V type disconnecting switch is reclined, the insulator is cleaned with rain effectively and wet flushover voltage of insulator is to be high remarkably.

(7) Each switch is single pole single throw type, but is able to be used for 3 pole single throw by the compressed air, so the equipment can be arranged freely.

(8) This switch is also most suitable one for recent pipe bus type and underground type of power station and substation and switchyard.

VI. CONCLUSION

In the above sentences, we described the outline and switching test results of recently developed Fuji V type disconnecting switch, and now we believe this type disconnecting switch will be adopted more and more in future, because this is able to make power station and substation and switchyard structureless.