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DEVELOPMENT OF A FUSED SWITCH FOR 20 KV OVERHEAD DISTRIBUTION LINES

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I. INTRODUCTION

In Japan, high voltage distribution lines had always been of the 3-phase 3-wire type for 3300 v. However, after the war, the power requirements increased so sharply that from 1960, a 3-phase 3-wire 6000 v system was adopted. As a result, about 80 to 90% of the former lines have now been converted to the 6000 v system.

However, recently power requirements have again risen tremendously due to domestic electrification. The 6600 v systems have already proven to be insufficient in some places, and voltage increases have become necessary.

22 kv distribution shows excellent reliability and economy when compared with the 6600 v system. Therefore, various power companies including the Central Power Research Insutitute are now conducting research into 22 kv distribution. The Kansai Electric Power Co. started such research several years ago and in April, 1969, they put into operation the first 22 kv actual load distribution system in Japan.

This article will describe a load switch with current limiting fuse developed for protection of the primary side of transformer used with 22 kv overhead distribution lines.

II. APPLICATION OF THE LOAD SWITCH WITH CURRENT LIMITING FUSE

The transformers used on the poles at present for 22 kv overhead distribution lines are 22 kv/200 v with capacities of 50～100 kva. A power current limiting fuse is suitable for protection against short circuit in the primary side of the transformer and a load switch can be used for ordinary load switching.

The main feature of this system is the rapid interruption by the power current limiting fuse when there is an internal short circuit fault in the transformer or a short circuit fault between the phases of the primary bushing of the transformer. This rapid breaking prevents the fault from spreading to the main distribution line.

Short circuit protection of the primary side of the pole top transformers in the former 6.6 kv system accomplished by expulsion fuses, but these fuses have the following disadvantages:

1) An arc is emitted.
2) Deterioration of the element occurs due to corona and environmental conditions.
3) The breaking capacity is small.

For these reasons, power current limiting fuses are used for 22 kv distribution. Also open air type high voltage load switches are employed in the place of the cutouts used in the 6.6 kv systems.

When choosing the current ratings of the power current limiting fuses, fuse deterioration or breakdowns due to lightning surge currents were taken into consideration as will be explained below.

If the heat characteristics $\int i^2\,dt$ which arise in the fuse link due to lightning shock currents are less than the permissible heat characteristics $\int i_a^2\,dt$ of the fuse link, the main fusible wire of the fuse will not deteriorate and the fuse will not be blown. Therefore, the heat characteristics of the fuses and the lightning were compared and the fuses were constructed to the lightning proof.

Since there is no detailed statistical data concerning the magnitude of lightning shock currents and their frequency of occurance in Japan, data from the United States for lightning current peak values was used as follows: the occurance rate for 10 ka or below is 99%, for 5 ka or below: 94%, for 2.5 ka or below: 85% and for 1 ka or below: 70%. When the lightning current wave form is shown in a standard form, the maximum peak value falls to 90% after 8 μs and after 20 μs, it is only about half the maximum peak value.

The heat chracteristics $\int i^2\,dt$ were calculated from the above lightning current waveform peak values, time etc., this was compared with the permissible heat characteristcs of the fuse link and the rated current for the fuse link was chosen.

For short circuit faults on the secondary side, operation of the primary and secondary fuses were coordinated so that the secondary fuse will operate properly.

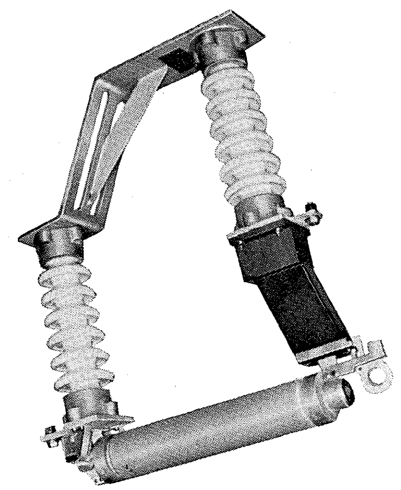


Fig. 1 Load break switch with fuse

***Table 1* Ratings of Load Break Switch with Fuse**

Type	LBF I 20/20
Rated Voltage (kv)	24
Rated Current (amp)	10, 20
Rated Frequency (Hz)	50/60
Insulation Class	150 kv
Fuse Breaking Current (amp)	1000
Others	Outdoor type

III. RATINGS AND FEATURES

An external view of this fused load break switch is shown in *Fig. 1* and its ratings are shown in *Table 1*. The features are as follows:

(1) The arc quenching chamber is made of a special resin so that the switch can be used out of doors. This results in excellent arc quenching capabilities.

(2) Since it also functions as a disconnecting switch, it can serve this purpose in addition to its regular functions.

(3) When combined with a power fuse, it can be used in place of a breaker.

Since interruption of load and exciting currents are possible, usual currents are switched by the load switch and since the fuse serves as a breaker for fault currents, there is no need to use an actual breaker.

(4) Compact

Since the power fuse link also serves as a load switch blade, the size is about half of that of usual units of this type.

(5) After the power fuse performs interruption, it is possible to change the fuse without coming near charged parts.

The rear contact part of the fuse is constructed in a special way so that fuse replacement can be accomplished remotely by means of a special tool.

(6) Due to the simple construction, maintenance is simple.

(7) No oil is used.

(8) The price is lower.

IV. CONSTRUCTION AND OPERATION

Fig. 2 shows the construction of this switch. The charged part is supported by 2 porcelain insulators. In oder to make this part compact, the levels of the two insulators are different. Since a fuse link is employed instead of a blade, space above and below is economized. A special type of hook is provided with the fuse link so that the contacts will not be opened by earthqukes or other such vibrations. The key on the top of this hook prevents operation of the arc quenching chamber as long as point P is not released and the lock is not opened by the hook rod. When fualt currents such as short circuit currents are flowing the fuses are cut off. Since the fuse is an easily removed type, it can be easily changed without getting near live parts by using a special fuse puller.

When this switch is attached to an electric pole, it gives an attractive appearance since the insulators and fuses are long and narrow just like the poles and wires.

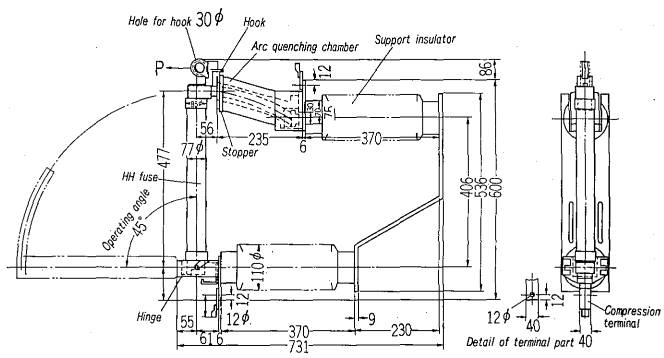


Fig. 2 Dimensions of load break switch with fuse

V. TEST RESULTS

The tests were carried out on the basis of standards JEM 1219 " Ac Load Switches " and JEC 175 " Power Fuse ". The most important points from the test results are as follows.

1) Temperature test

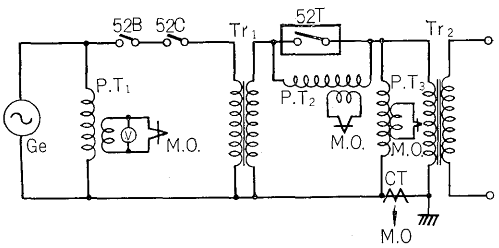
The temperature test was conducted on a single fused load switch with a 3-phase parallel test circuit and a single-phase power source. As a result, the temperature rise in each part did not exceed the specified values.

2) Load current interruption test

(1) *Fig. 3* shows the test circut.

(2) Test results.

Load current breaking was conducted up to 10 amp at rated voltages of 24 kv. The results showed that if the arc time is constant, no matter what the amount of opening (proportional to the arc time



Ge : Short-circuit generator
52 *B* : Back protecting breaker
52 *C* : Closing switch
52 *T* : Test model (load switch with fuse)
Tr_1 : Transformer for power source 3300 kva
Tr_2 : Transformer for exciting load 3300 kva & 20 Mva
CT. : Current transformer for current measurement
PT_1 : Transformer for measuring generator voltage
PT_2 : Transformer for measuring voltage between poles test model
PT_3 : Transformer for measuring load side voltage to ground
M.O. : Electromagnetic oscilloscope

Fig. 3 Test circuit for load currennt interruption

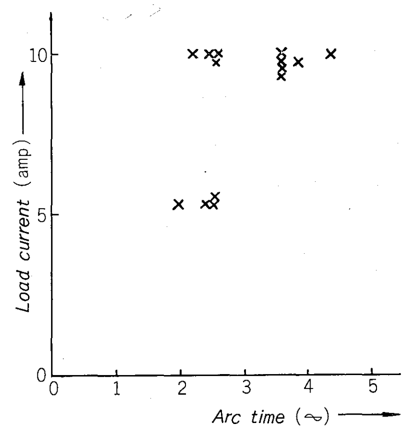


Fig. 5 Current arc time characteristics of load current (at 24 kv 50 Hz)

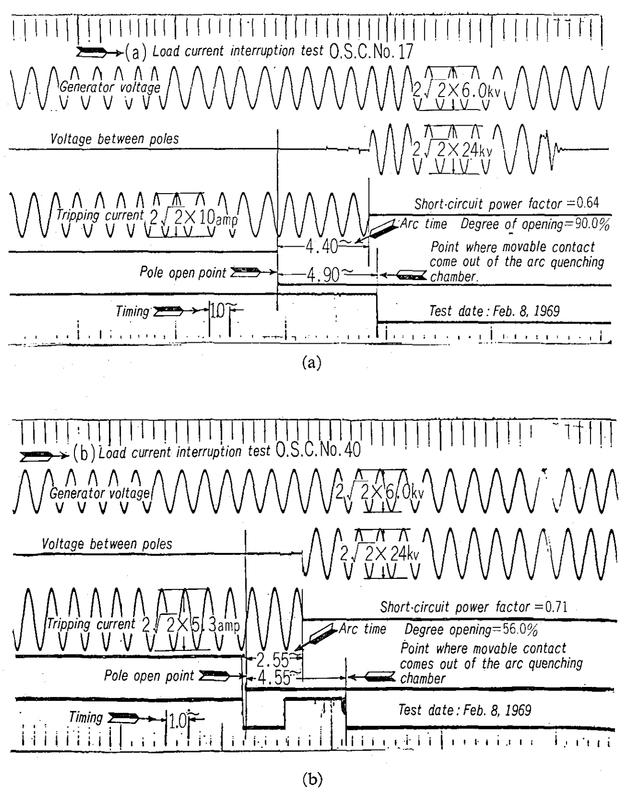


Fig. 4 Typical oscillograms of load current interruption

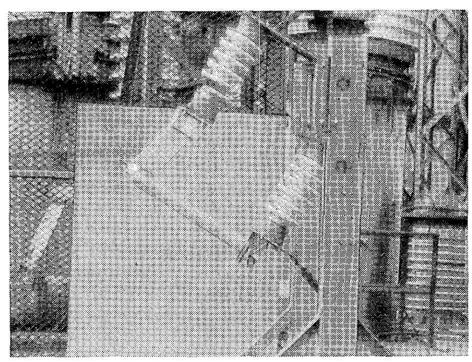


Fig. 6 Load current interruption (at load current 10 amp)

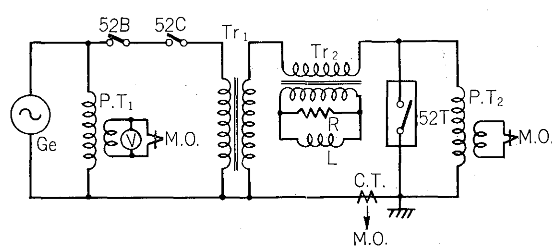


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Fig. 7 Test ciscuit fos exciting current interruption

vs the time it takes the arc to escape to the exterior of the arc quenching chamber right after the moveable contacts open), there is no special problem since it is still within 100%. *Fig. 4* shows a typical oscillogram, while *Fig. 5* shows a graph of relation between the load current and the arc time. *Fig. 6* shows the actual conditions during the test.

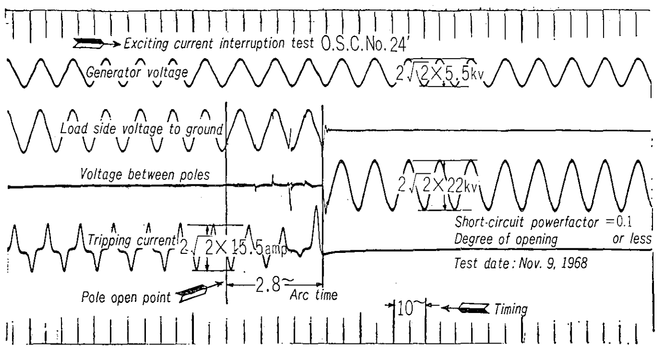
3) Exciting current interruption test

(1) *Fig. 7* shows the test circuit.

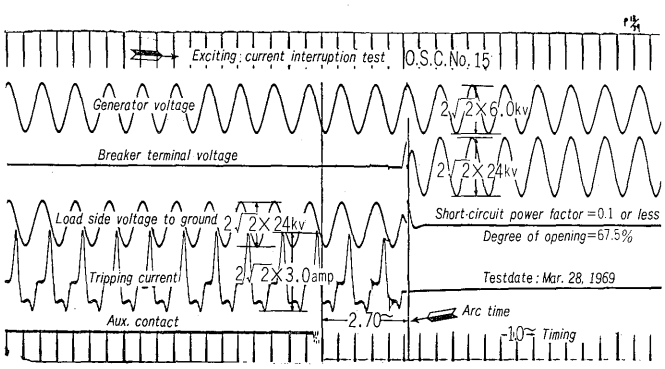
(2) Test results.

The exciting current interruption was conducted up to 15.5 amp at rated voltage of 24 kv. When the breaking current was about 7.2 amp the degree of opening was 40 to 53%, when it was about 15 amp it was 120% ; and when one cycle had finished, it was about 26 to 37%.

The test voltage for 15 amp interruption was 22 kv



(a)



(b)

Fig. 8 Typical oscillograms of exciting current

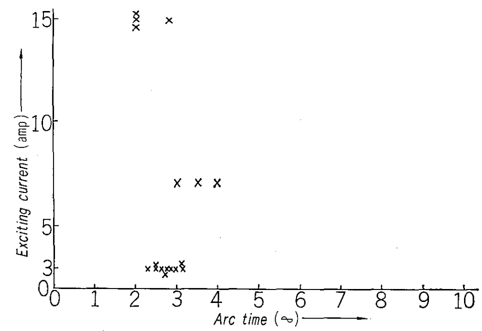


Fig. 9 Current-arc time characteristic of exciting current (24 kv 50 Hz)

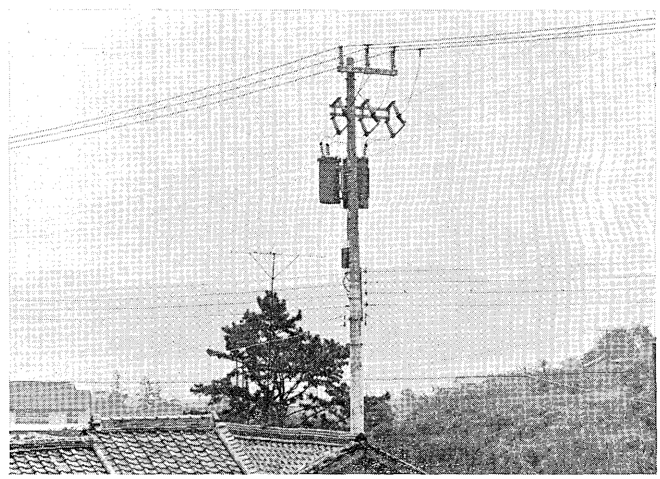


Fig. 10 Practical condition of the fused switches

or over because of the load switch transformer conditions.

Co-operation was carried out 3 amp but no irregularities in the contact part could be detected. *Fig. 8* (a) shows a typical oscillogram of test while *Fig. 8* (b) is a typical oscillogram of the closing test. *Fig. 9* shows the current arc-time characteristics during breaking and closing.

VI. CONCLUSION

This article has described the ratings, features and test results of the 24 kv fused load switch. Actual installation in the Naruto power distribution line in the Seto Inland Sea coast area where salt contamination is a problem is shown in *Fig.* 10. Since the demands for fused load switches seems to have increased in the last few years, the authors would be very pleased if this article proves to be of use in this field.

References:

(1) Actual conditions and recent progress in lightning arresters for power lines, Technical Report (No. 33) of the Institute of Electrical Engineers of Japan.