Introduction of Products

63 kV ON-LOAD TAP-CHANGING TRANSFORMER WITH DIRECTLY CONNECTED CABLE

I. INTRODUCTION

Recently, with increase in power demand, the method is being adopted in many places of the country, so that the large substations are constructed on the centers of load, and connected with under ground high voltage cable. In this case, the use of the elephant transformer (the name "elephant transformer" is derived from the fact that the shape of the cable terminal chamber resembles to an elephant's head), in which the cable is directly inserted into the transformer tank, and connected with the transformer winding, has much merits.

Our company recently completed and installed 63 kV, 4,500 kVA transformer with directly connected cable, the first industrial transformer of this kind to be manufactured in Japan, for Furukawa Chemical Industry Co., Ltd.

In this report we shall introduce a brief outline of our new product.

II. FEATURES OF ELEPHANT TRANSFORMER

1. Economization of space

The outline dimensions of this transformer are small, because it is not provided with bushings, and the transformer can be installed near a building. This means a great saving in space.

2. Easy maintenance

Since the transformer has no bushing, it is not affected by atmospheric agents such as dust, smoke and salty deposits. Also, the trouble of taking care of the bushing is eliminated.

3. Safety

There is absolutely no danger of electric shocks, since there are no uncovered live part. In the large power plants ohmic loss due to low voltage lead wire and synchronous reactance can be decreased, because the transformer can be installed near the generator.

III. SPECIFICATIONS, WEIGHT AND DIMENSIONS

1. Transformer

Type :	3-phase, core type, outdoor use, oil immersed self-cooled, on-load tap changing.	
Capacity :	4,500 kVA	
Frequency :	50 c/s	
Voltage :	Primary	69–67.5–66–64.5–63^{R} –61.5–60–58.5–57^{F} kV
	Secondary	3.45 kV
BIL :	Primary	No. 60 (full wave 350 kV)
	Secondary	No. 3 (full wave 45 kV)
Rated current :	Primary	41.3 A
	Secondary	753 A
Transportation :	In complete unit	

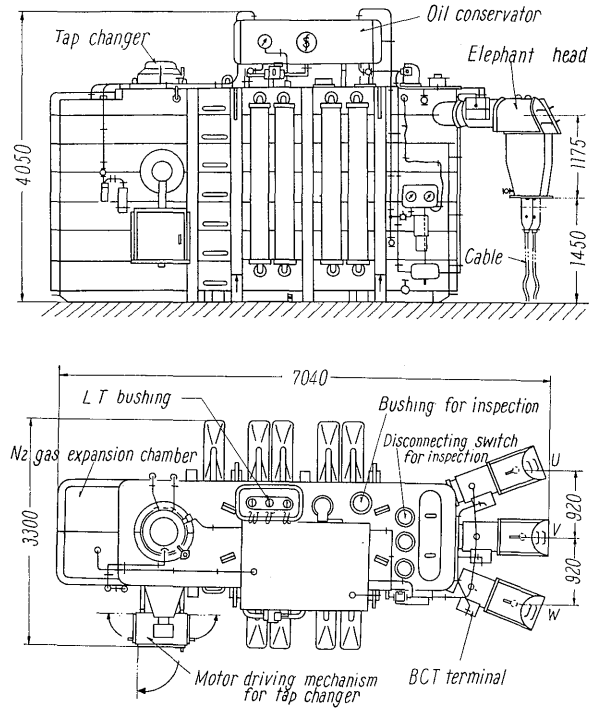

Fig 1. 4,500 kVA completely transportable transformer

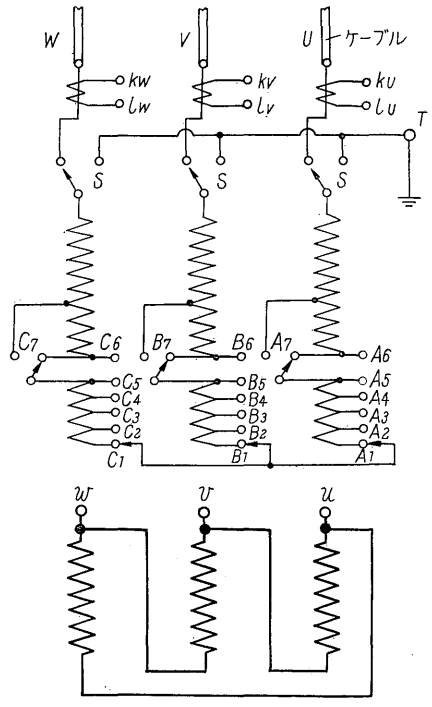

Fig. 2. Connection diagram

Total weight : 38,200 kg
Total oil : 17,500 *l*

Fig. 1 shows sketch of transformer and outer dimensions. Fig. 2 is connection diagram of transformer.

2. Cable

Kind : Oil filled cable of three conductors
Voltage : 66 kV
Conductor cross section : 100 mm^2
Length : 200 m

IV. CONSTRUCTION

This transformer is an on-load tap changing N_2 gas sealed type transformer. The outer view is shown in Fig. 3. The on-load tap changing equipment has a " Yansen " switch fitted inside the transformer tank and the oil in the switch chamber is exchanged under operating condition without service interruption. Also, there is no need to replace the switch contacts since it has a service life more than that of the transformer.

Low voltage conductors between the low tension bushings and the switchboard are covered with a metal bus duct ; there is absolutely no danger of electric shocks since there are no exposed live parts. Furthermore, there is no damage due to atmospheric agents such as dust and salty deposits, although the transformer is installed in a factory located near the seashore.

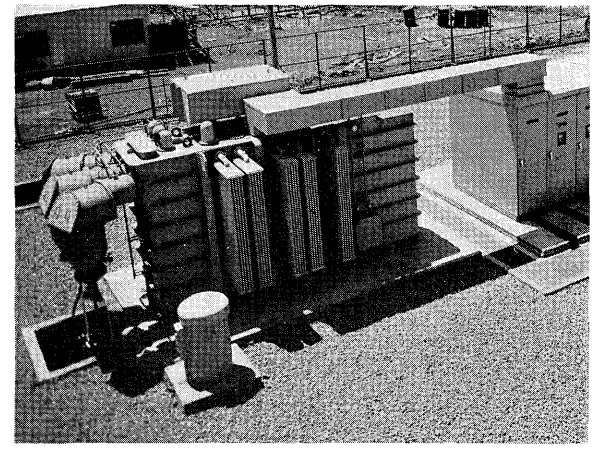

Fig. 3. Outer View

The H.T. terminals are connected to a 100 mm^2 three-conductor OF cable by using the phase separator case and B.C.T. are installed midway.

As can be seen by Fig. 2, the disconnecting switchs and bushings for inspection are installed between the B.C.T. and windings. These apparatus are used to cut off the cable from the transformer when measuring the tan δ or insulation resistance of the transformer. When a trouble occurs in the installation, it can be used to determine whether the trouble is on the side of the transformer or the cable. Also, it can be used to cut off the transformer from the cable when DC Voltage is impressed on the cable by the government inspection team. This switch is, therefore, designed to withstand the DC test voltage. The inspection bushing is used only for inspection purposes ; therefore, the insulation class is No. 10 and the bushing is ordinarily grounded and covered with a metal cover.

Fig. 4 shows the interior construction of the " Elephant's head ". The oil in the transformer body and the oil in the elephant's head are partitioned off, so it is not necessary to drain off the transformer oil when connecting the cable and transformer at site. The oil of the elephant's head is joined with the conservator through the " Buch-Holz " relay and this prevents damages in the elephant's head.

V. TEST

Special consideration is necessary since the live parts are not exposed as is the case of the standard type transformers.

1. Test at factory

1) Test voltage

A test voltage higher than that of the transformer is specified for the transformer bushing, because it

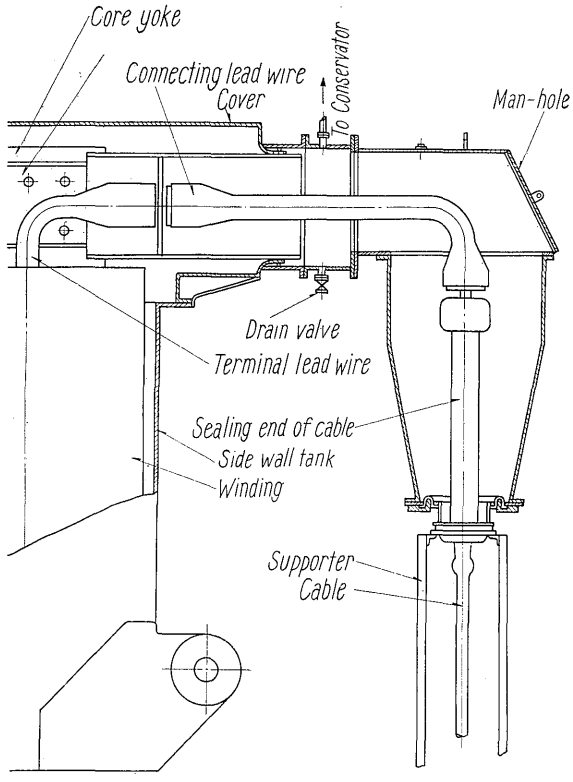

Fig. 4. Internal connection of "Elephant" head

may become soiled or affected by moisture. But the test voltage for the sealing end of the cable is the same as that of the transformer since this section is immersed in oil and regarded as being a part of the transformers.

2) Test method.

The following test methods may be taken when conducting electric tests at factory.

a. Method of testing by replacing bushings with conventional bushings.
b. Method of using a temporary test cable set, several meters long.
c. Method of using special test bushings.

The elephant's head is so designed that it can be replaced with a standard type bushing and make it possible to use the (a) test method. However, it is difficult to ascertain the insulation inside of the elephant's head with this method.

With method (b), the test can be conducted without making any changes in the completed state inside of the elephant's head, however, this method requires a complicated cable system and it is necessary to ask the help of the cable manufacturer. Furthermore, this test method requires a spacious testing shop. Also, the characteristics of the cable will influence the characteristics of the transformer.

Method (c) is a unique method used by Fuji Denki. As shown in Fig. 5, a special test bushing is used. The exposed sections are the same as the

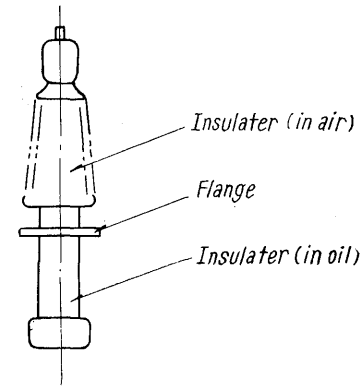

Fig. 5. Test bushing

conventional bushing, while the section immersed in oil is of the same construction as that in the elephant's head. For the test, the elephant's head is turned about 180 degrees in order to connect this test bushing. (See Fig. 6). By this method, there

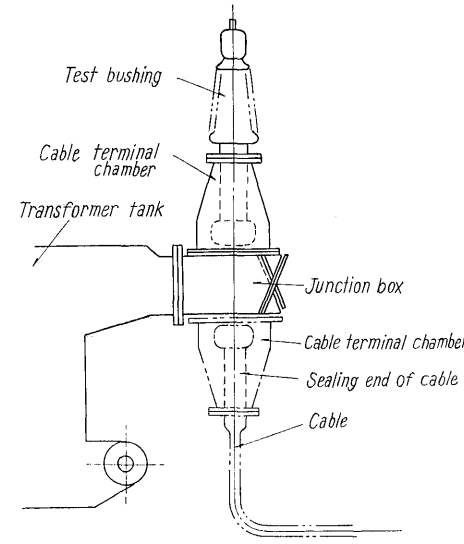

Fig. 6. Test method

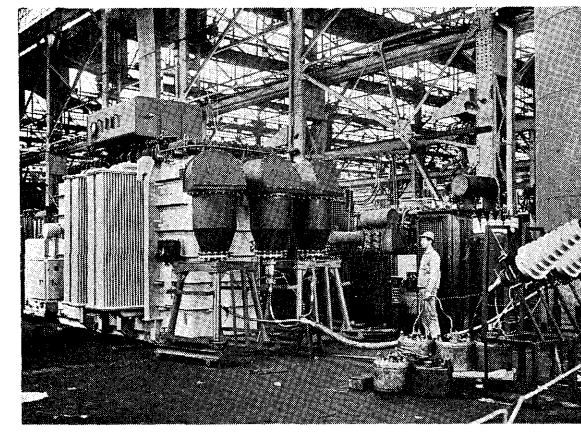

Fig. 7. Elephant transformer in testing at factory

is ample insulation distance between the bushings and the tank, and the condition inside of the elephant's head is the same as that when it is in operation. Fig. 7 is a photograph in testing at factory.

The test of the sealing end of the cable cannot be conducted by using methods (a)-(c); therefore, this part will be made sure by type test.

2. Test at site

1) When cable is short:

Cable and transformer are simultaneously impressed for ten minutes with AC voltage of 1.1 times the maximum operating voltage prescribed in National Electrical Code of Japan.

2) When cable is long:

In this case, a large leading capacity is necessary; therefore, a DC voltage of 2.2 times the maximum operating voltage is impressed on the cable. Since it is not advisable to impress direct current on the transformer, the aforementioned switch is turned to separate the transformer and cable. (When there is no switch, the connecting lead wires are removed from the transformer.) The interior of the elephant's head is designed to withstand this DC voltage.

Normally, those places where the cable is long are geographically located where transportation of assembled units is possible; therefore, the official test of the transformer is conducted at factory. This is because the insulation condition at time of assembly is preserved at site.

In this transformer, the cable length was approximately 200 m; therefore, the AC 72.6 kV was impressed on the transformer at factory, and DC 145 kV was impressed on the cable at site. Needless to say, when the DC voltage test was conducted, the transformer was cut off from the cable by using the disconnecting switch.

3. Test results

1) Dielectric test

The results of AC high voltage test (140 kV, one minute) of JEC 120 and impulse voltage test (1×40 μs full-wave 350 kV, chopped wave 400 kV) of JEC-110 were very satisfactory.

2) Temperature test

The temperature of the oil in the elephant's head under condition of full loss is lower by 22°C than the temperature of the oil in the tsansformer body. This is because the transformer body and elephant's head is completely partitioned. Therefore, though the JEC rule prescribes that the maximum temperature of the transformer oil is 90°C, and that of the cable oil is 80°C, there is absolutely no damage on the cable.

3) Vibration test

The maximum amplitude of the elephant's head is 0.05 μ and there is absolutely no fear of fatigue on the cable. The maximum amplitude of the transformer tank is 5.5 μ.

VI. CONCLUSION

The foregoing is a brief outline of the first elephant transformer manufactured in our country. This elephant transformer has the following advantages:

1. The transformer can be installed in the factory located near the seashore, because there is absolutely no fear of damage from atmospheric agents.
2. Power loss can be decreased, because the substation can be installed at the center of load.
3. The transformer can be installed in the center of the plant at a distance from switching station near residences; consequently, there is no claims against troublesome noise from neighbours. The installation has been in satisfactory service condition ever since April, 1958.

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