steel) and its upper and lower liners (13% stainess steel). Accordingly, a model test is immediately performed with a spare guide vane. From the results, we observed that the clinging phenomena would not occur provided the gap between the moving and fixed materials exceeds 0.1 mm.

Since the actual machine had this gap of 0.2–0.25 mm when measured at installed site, we believe that no clinging phenomena would occur.

In the foregoing, we disclosed and explained the outline of the water turbine unit delivered to Utsubo Power Station and the results of its model test. At the final of this discription, we must express our sincere gratitude for the kind advices of Kansai Electric Power Co. in manufacturing and installing the present water turbine.

# Introduction of Products

## 30,000 kVA FURNACE TRANSFORMER WITH ON LOAD TAP SWITCH

(Produced for Messrs. Electro Chemical Industries, Ltd.)

Fuji Denki Seizo K. K. is outstanding in our country for excellency of engineering techniques, and is proud of the Fuji Furnace Transformer, the performance of which eclipses any produced before. Recently we have completed a 30,000kVA capacity Furnace Transformer for our client, the Electro-Chemical Industry Co., Ltd. and is a record breaking achievement for us in the post-war period. The new Siemens techniques, and our many years of experience were applied in manufacturing this transformer. It is of the same type as the three phase 40,000 kVA transformer ordered by the Manchurian Electro Chemical Industry Co., Ltd. which construction was unfortunately suspended before completion because of the war's end. The indirect voltage method, in which the series transformer is inserted in the secondary side for adjusting of load voltages in the secondary side, has been adopted.

We introduce herewith an outline of Specifications.

Oil circulating water cooled type, with on load tap changer.

Single phase 60 C Three sets of 10,000kVA transformers.

(comprising series transformer)

| | |
|---|---|
| Primary Voltage | 60,000 V |
| Secondary Voltage | 255 V–145 V (5 V step, 23 stages) |
| Secondary Current | 47,600 A (Furnace current 82,300 A) |
| Bank Connection | △—人／／／ |
| Total weight | 42tons Net weight 22.5tons Oil capacity 11,200 L |

Core and Coil

The core is of the core type, with both the main and series transformer having a rectangular section same as the shell type. The silicon steel sheets used are those which have undergone severe testing and have passed sheet testing by sheet-measuring instruments.

In order to improve cooling efficiency such construction technique have been adopted as installing an oil way at right angle to the steel sheet pile, and another oil way paulled to the pile as a passage to the coil line under a coil yoke, considering the thickness of the silicon steel sheet pile.

The primary voltage of ordinary type furnace transformers are limited to 30 kV at the most, and we have adopted the disk type copper sheet coil made of copper sheet cut out in a circular shape and arranged high and low voltage winding in sandwitch type. However, in this case when the voltage is 60 kV, the above method cannot be applied as the thickness of insulating material between the high and low voltage increased to

such an extent, fatally diminishing mechanical strength. Such being the case, we have been using the following construction since 1925.

1. Use of bare copper sheet and single one turn for the low voltage coil.
2. The high and low voltage windings are arranged to the same center.
3. The high voltage winding is inside, and low voltage winding outside.

As a result of using a copper sheet, naturally the high voltage winding is placed inside and the low voltage coil outside, in other words in the main transformer the tertiary tap winding, primary and secondary winding are arranged in order from inside, while in the series transformer the exciting and series winding are arranged in that order, each of them being screwed in by a press ring with strong bolts. The construction of the low voltage coil is worthy of note. The secondary winding of the main transformer and the series winding of the series transformer are wound continuously without jointing with a copper sheet, this being possible by standing the two together in one room. Ordinarily in the limited space between the main and series transformer, extraordinary difficulty is encountered at the secondary side connection through which tens of thousands of amperes pass through.

This difficulty does not arise when a pipe type copper sheet coil connecting the two transformers is used and furthermore this fantastic innovation enhances the electric and mechanical dependability of the transformers. Specially selected electric copper with a high degree of purity is used for the copper sheet, and two more thin copper sheets are put together and used for diminishing eddy current loss. The gaps between them are insulated by a press board.

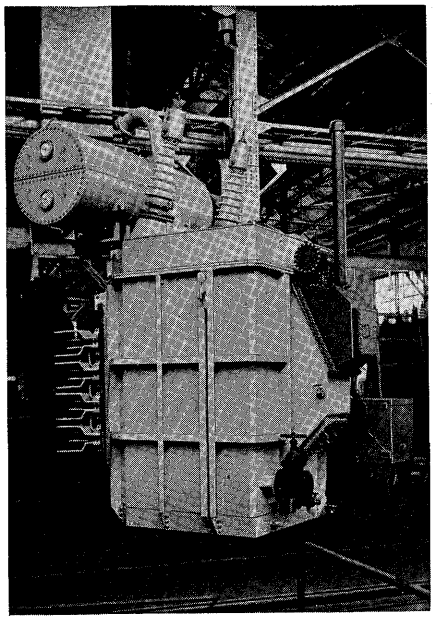

Fig. 1. Outside View of Transformer

The beginning and the end of the copper sheet coil are connected directly to the water cooling pipe terminals as the U & V terminal. The pipe terminals pass through transformer tank and are connected to the leads of electric furnace. Thus the secondary side of the large current is connected directly from the secondary coil to the leads of the electric furnace omitting all intermediate leads. This construction makes possible a simpler and more compact unit despite the fact that it contains a series transformer inside because it omits all wasteful space.

This transformer was manufactured especially considering impulse voltage, and benefiting by our long years of experience in this field, it was designed and dry-processed in the most logical manner.

It has passed impulse voltage test #60 designated in JEC-120 as the first case of such transformers. It should be noted that cylinder type tapping is used for the third tap winding. Several copper wires are wound in parallel and they are all tap coils wound to the same height as the other windings. Unlike transformers which have been manufactured hitherto, the mechanical force in a vertical direction does not appear. Due to their particular uses, especially electric furnace transformers are often subjected to severe short circuits, but by adopting the cylinder type tap and because of the untapped primary winding this transformer is fully reliable to the mechanical force in the case of short circuit.

Consideration has been given in order that mechanical irregularity and magnet force will not effect operation by not connecting directly the copper sheet coil, water cooling pipe terminals and the eletric furnance leads, and by using a flexible leads composed of a pile of their copper sheets. The oil sealed construction of the pipe terminal is also protected.

## VOLTAGE ADJUSTING METHOD

An equivalent tap is commonly placed in the primary side of an electric furnace transformer to adjust its secondary voltage, but in the case of this transformer where minute adjustment of 5 V steps in loading time for the wide range of 43%, from 225 V to 145 V of secondary voltage is required, more than necessary difficulties will arise when this method is applied, resulting in characteristic unreliability. Satisfactory effects were obtained in this case by not placing a tap on the primary side, but inserting a series transformer in the secondary side as

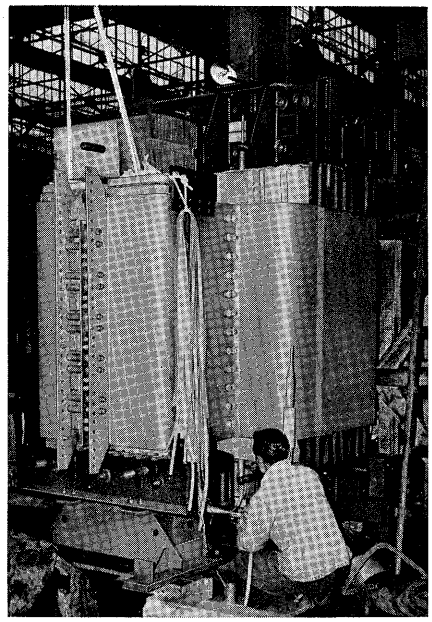

Fig. 2. Core and Coil

stated above with voltage supplied to the exciting winding from the third tap winding which was nstalled in the main transformer. In short, this may be called the indirect voltage adjusting method.

In ordinary construction difficulties are met when inserting a series transformer in the secondary side of the large current, and although the method of inserting adjusting transformer on the primary side may be considered, but when this method is applied to a 60 kV line the adjusting transformer naturally becomes larger than that which is desirable. Therefore from the standpoint of safe insulation it is more advisable to conduct adjustment on the low voltage side.

For the purpose of making possible a 23 stage adjustment in 5 V steps, the tertiary winding is composed of 12 (11 taps) tap coils. A double effect is obtaind by means of a direction changer attached to the tap cnanger.

A combined on toad tap changer is used which is assembled in the switch case placed inside of the transformer tank opposite the secondary terminals. The oil in the switching case is completely separated from the transformer oil, and has a buchholz relay and a conservator for its own use. The tap leads from the third winding pass through the spearating partition between the main body and the switch case, and by using special glass is completely oil sealed, enably simple checking of the switch case without lowering the oil level of the main body. The Jansen type on load switch and no voltage tap changer had ample mechanical and electrical reliability and durability and can be switched in the short time of 0.04 seconds by using a resistance for limiting current in tap changing. The p. f. of this short current is good compared with that using a reactor, and furthermore current breaking can be performed quite easily without damage to the contact parts, with less soiling of the switch case oil. We are sure that the electric furnace transformer which is frequently switched will again prove its usefullness.

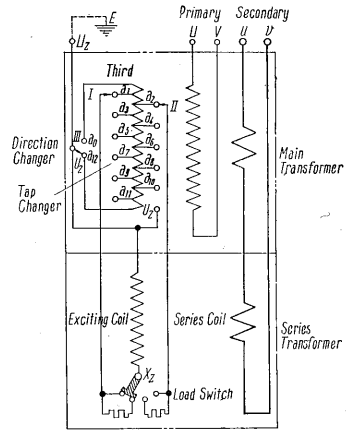


Fig. 3. Connection Diagram

Motor driving mechanism is installed under the switch case. Tap changing can be performed by a control switch from the panel board room separately or simultaneously.

## CONSERVATOR AND COOLING MECHANISM

A conservator with three cells containing nitrogen is used for the protection of insulation oil, and oxygen absorption mechanism is attached.

The cooling mechanism is separated, and each transformer has a water cooled vertical type multi tube system cooler of high cooling efficiency. Motor driven oil pumpes without ground packing, oil separator, oil flow alarming device and water flow alarming device are attached.

Transportation will be done with a temporary cover, with on load tap changer, motor driven mechanism and secondary terminals attached. Therefore upon arrival at destination only the external cover and high voltage terminals need be attached, making possible immediate use without touching the interior of the transformer.