tional preventive means adopted by the Company has been the use of the Inert Air Type Conservator, OC– or FT–Type. A far more effective method will be to use a construction with sealed-in nitrogen; in that case, however, meticulous care should be taken not to allow nitrogen leakage at gasket joints. So, in the nitrogen sealed type transformer, use of packings is limited to unavoidable places only and joints are made mostly by welding, followed by a strict air-tightness test on them to prove the perfectness of weld.

A second point calling for special attention with this type of transformer is that the oil expands or contracts with temperature variation and the dielectric strength of the insulating oil depends in a large measure upon the pressure distribution of the nitrogen in solution and above the oil, the pressure of which fluctuates with the change of oil volume mentioned. Accordingly, the range of pressure variation of the sealed nitrogen must be selected with extreme caution. It is assured that the transformer of the Company's production is given due consideration in this respect. On the other hand, the tank is subjected to repeated load application on account of this kind of pressure change. Therefore, the tank should have a construction mechanically sturdy enough to withstand this load; the transformer is then built with due consideration on this point.

Main windings are cylindrical layer ones and tap layer windings are divided into two parts, i.e., rough and fine; the fine one is cylindrical tap layer winding, whose axial mechanical force becomes infinitesimal in time of short-circuit at the lowest tap and whose abnormal voltage between taps on the arrival of impulse voltage wave is also extremely small.

For tap changing, a Jansen type under-load tap-changing switch unique product of the Company is employed, assuring rapid and reliable operation; the change-over time is 0.04 sec, which is made possible by using a strong spring and taking advantage of the dead point of its link motion. Also by this, any possibility of the movable contacts coming to a neutral state in the middle of changing is avoided. This switch is normally electrically operated by an apparatus attached to the transformer, but it can be converted to manual operation by the change-over. No matter which system of operation is resorted to, electrical or manual, the mentioned feature of the change-over switch, dependent on the spring, is fully ensured. Moreover, as this switch is placed in a separate room entirely isolated from the main body, there is no fear of the pure oil in the main body being mixed with the contaminated oil by the arc generated at tap changing; this room is provided with a window through which the contamination of oil can be watched all the time.

The mechanism of the nitrogen sealed type transformer does not permit effective use of a Buchholz Protecting Device against internal accidents, so that in this transformer the bursting tube is fitted with trip contacts against emergencies. When the buffer plate is broken by some internal accident, the contacts attached to the plate quickly work tripping the power source and cutting off the transformer; thus the accident can be prevented from spreading.

(Transformer Dev. Eng'g. Dept. by S. Kunieda)

CORELATION BETWEEN GASES GENERATED IN BUCHHOLZ RELAYS AND TRANSFORMER FAILURE

By

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I. INTRODUCTION

Seeing that various kinds of gases always generate by the decomposition of insulation oil or other insulating materials whenever oil immersed transformers fail by short-circuit or discharge occurred in them. Max Buchholz conceived an idea that if the generated gases were detected at the very beginning of troubles and alarms were given automatically, necessary steps would be taken before it became too late. The device thus invented is termed a Buchholz relay which is extensively applied to transformers for detection of troubles.

However, constant watch of the Buchholz relay often reveals that it will not operate only by a simple electrical action. It is considered necessary to make study of the cause of gas generation as well as the analysis of gases accumulated in the relay by building a model transformer. Brief account of this study with respect to oil immersed given herein.

II. CONSTRUCTION OF MOUNTING POSITION OF BUCHHOLZ RELAY

The Buchholz relay, as shown in Fig. 1, consists of large and small floats and gas meter. The large float operates when oil gushes into a conservator from the tranformer body by sudden generation of decomposed gases caused by powerful accident inside of the apparatus. The small one functions when decomposed or other gases due to slow outbreak of troubles accumulate in the gas meter, ringing an alarm.

In the former case, the operation takes place before the gases accumulate in the gas meter, and much quantity of gases gushes out after the function (the bursting tube of the transformer is liable to break on this occasion) to indicate the seriousness of the trouble. In the latter, the trouble proceeds gradually so that investigation is deemed necessary to find the cause and to set up a countermeasure immediately.

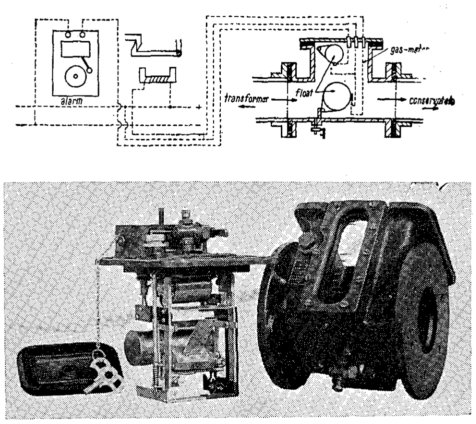

Fig. 1. Construction of Buchhalz relay

In the Buchholz relay, it is necessary to accumulate even a small quantity of generated gases without fail, as it is liable to cause serious troubles. The relay is usually connected in the middle of a pipe connecting the top of transformer and the conservator, but one more relay is sometimes provided at a plate convenient to collect gases depending on the capacity of transformers.

III. ABNORMAL GAS GENERATED IN TRANSFORMERS

Abnormal gases generated in the nitrogen sealed transformer are roughly divided into those generated by thermal decomposition of insulation oil, insulation paper or organic material and nitrogen gas dissolved in the oil. This report deals principally with the thermal decomposition of insulation oil and insulation paper experimented with the model transformer, only slight mention is being made with nitrogen dissolved in oil.

IV. THERMALLY DECOMPOSED GASES OF INSULATION OIL AND INSULATION PAPER

As a cause of thermal decomposition of oil in the transformer, local heating electrically and mechanically comes in mind. The former is produced by such phenomena as short-circuit, discharge or magnetic unbalance. The latter is mostly caused by the wear and damage of the bearings of pump for forced oil circulation. There is a wide difference between the locally heated temperatures of above two types. The former is recorded as high as above 2,000°C, while the latter is guessed to be below 1,000°C.

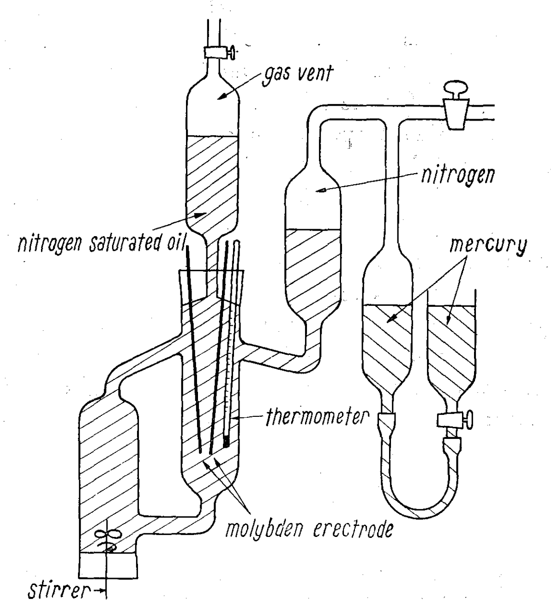

Fig. 2. Model nitrogen sealed transformer

A model nitrogen sealed transformer shown in Fig. 2 was employed to experiment how the insulation oil would decompose.

First of all, two pieces of molybdenum wires were immersed in oil as electrodes for the study of electrically local heating. With the gap of electrodes set apart 0.25 mm, make and break discharge of 1/4 second current-on and 1/4 second current-off was kept on. Sample oil was prepared by degassing and saturating with nitrogen at a normal temperature. The working voltage was 12,000 volts, but, the terminal voltage being about 2,000 volts, the discharge was supposed to be between glow and corona discharge. The results, as shown in Table 1, reveal that major portion of the gases is hydrogen, and unsaturated hydrocarbon gas including acetylene and ethylene

Table 1.

H_2	72.3~86.0
Unsaturated H.C	2.3~9.5
CO	0.4~1.0
CO_2	0~0.2
O_2	0.1~0.3

Table 2.

	300°C~400°C	400°C~500°C
H_2	20~40%	40~50%
Unsaturated H.C	10~20%	20~40%
CO	0~0.6%	0.8~8.2%
CO_2	0	0

come next. Very little quantity of Carbon dioxide was in it, the remaining being mostly nitrogen. This nitrogen was released from the oil when the above mentioned gases such as hydrogen was released and balance of pressure was broken.

In this experiment, currents of 10~30 mA were used. As the current was reduced, the discharge became small, decomposed gas decreased and bubbles also became small. As a result, a trend of decreasing the amount of hydrogen formation was noticed.

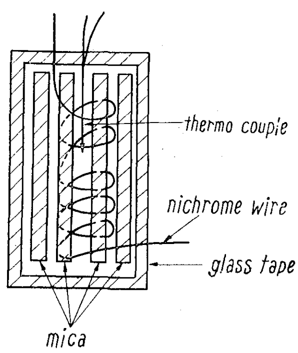

Fig. 3. Meating element

Next, experiment of mechanically local heating was conducted. On the assumption that this is a case of low temperature local heating, a heating element made of nichrome wire wound on mica frame and covered by glass tape was employed. The specimen of oil was the same as the one used for the former experiment. In this experiment, however, the heating element had a larger heating area for the oil than the previous experiment and oil temperature was liable to rise higher than required. This was prevented by cooling the apparatus from outside with water. The oil temperature was thus kept below 60°C. With the progress of heating the oil by passing current through the heating element, decomposed gases were noticed to start rising as foams at the temperature of 250~270°C. When the temperature reached 300°C the phenomena were becoming active, and at above 500°C the gases generated so vigorously that explosive combustion occurred from time to time. The composition of the generated gases is as shown in Table 2. Difference noticed from that of discharge is the reduction of hydrogen and slight increase of unsaturated hydro-carbon gas and carbon mono-oxide.

Among those subjected to the effect of local heating in the transformer is the insulation paper. It consists of cellulose $(C_6H_{10}O_5)n$. Unlike the oil, oxidized substance such as carbon dioxide or carbon mono-oxide is supposed to exist in the decomposed gases. A device shown in Fig. 4 was worked out. The heating

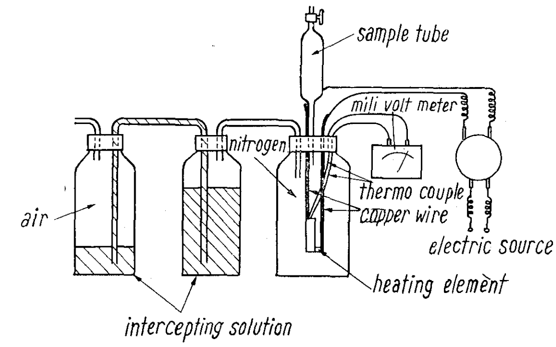

Fig. 4. Sampling apparatus of decomposed gas in nitrogen chamber

element used was of pressboard and kraft paper in the core in place of mica and glass tape to examine what effect these kinds of paper would be observed on them when the element was hung in a nitrogen sealed container and the nichrome wire was heated. At the heating temperature of the nichrome wire of (temperature at the contact with the paper) 250°C an experiment was conducted. The composition of the gases is as shown in Table 3. A part of insulation paper in contact with the nichrome wire was somewhat carbonized, the rest being burned brown. As will be seen in Table 3, carbon dioxide occupies a major portion of generated gases as expected.

Table 3.

Gas	Compose
CO_2	4.4
CO	0.3
H_2	0.2
N_2	95.1

In many cases, nitrogen gas is found in the gases accumulated in the Buchholz relay. This is considered to be chiefly on account of partial pressure balance of nitrogen made between two phase of liquid-gas, that is the relation of the change of solubility of nitrogen into oil with other gases (e.g. hydrogen, carbon dioxide generated in the oil). The solubility of nitrogen in the oil is as shown in Fig. 5. Unlike other gases, the solubility decreases with the drop of temperature, so nitrogen saturated oil becomes over-