THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO
RESEARCH DIVISION REPORT

To Mr. J.H. Waghorne
Director of Research

COMPARISON OF NEUTRALIZING TRANSFORMER PERFORMANCE

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Measurements on a neutralizing transformer of recent manufacture indicate that the manufacturer is increasing the capability of transformers for the same nominal voltage. Indications are that these transformers will be able to withstand, without saturation, the sudden application of nominal voltage, without transient component.

Neutralizing transformers are rated according to the number of pairs, nominal primary voltage, remanent voltage and external impedance of the primary circuit. The nominal primary voltage is approximately the voltage that, when applied to the primary winding, results in a magnetizing current that when multiplied by the total impedance of the primary circuit, gives the remanent voltage. The above calculation applies to steady state conditions.

If remanent voltage is not to be exceeded, the transformer is capable of handling only about one-half of the nominal voltage when it is abruptly applied. Its capability is much less than one-half if the applied voltage contains a transient component. Residual flux, if present in the transformer, with the appropriate polarity, may further reduce the voltage handling capability of the transformer by a factor of approximately two.

As a result of the above information, contained in Research Division Report 71-153-H*, Osborne Electric modified the design of their transformer so that it could more readily handle the sudden application of the nominal primary voltage. This report gives the results of tests on three different neutralizing transformers and comments on their expected performance.

* O.W. Iwanusiw. Performance of Neutralizing Transformers. Research Division Report No 71-153-H. May 4, 1971.

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Neutralizing Transformers and Tests

The complete nameplate data of the three neutralizing transformers is given in Appendix A. They include a transformer rated at 6 kV of conventional design (Ser No 70-35), a transformer also rated at 6 kV but of modified design, and a transformer rated at 4.5 kV with further modifications. The modifications to the design were reported by the manufacturer to be larger core dimensions and the insertion of air gaps.

The tests that were conducted on the transformers included the determination of the excitation curves and the measurement of residual flux.

Test Results and Discussions

Appendix A lists the residual flux as a percentage of the induction for the current shown. The figures indicate almost no difference in the percentage of residual flux between the three transformers tested. It can be stated that the modifications in the construction of the transformers, which included the insertion of an air gap, did not effectively interrupt the magnetic circuit.

Figure 1, appended, shows the excitation characteristics for the three transformers. The figure indicates that there was a sizeable increase in the core or winding of transformer Serial No 70-169 as compared to Serial No 70-35. This increase resulted in a capacity of about 35 volt-seconds for the modified transformer (70-169) as compared to 21 volt-seconds for the original (70-35), at an exciting current of 1 ampere. The same figure indicates that there was a further increase in core or windings for transformer 73-77 associated with a modification of the excitation characteristics. The change of the excitation characteristics suggests that a different grade of iron or a partial air gap has been used in the assembly of the core. Only a partial air gap is indicated because of the high residual flux that has been measured on that transformer. A complete air gap would have reduced the residual flux to a much lower percentage than shown in Appendix A.

The transient factor is defined as the ratio of maximum capacity (volt-seconds) to the nominal capacity for the transformer, and is useful in assessing the performance of a transformer under transient conditions. The transient factors have been computed for the three transformers and are shown below:

Serial No	Transient Factor	Transient Factor Accounting for Residual Flux
70-35	1.1	0.65
70-169	1.9	1.1
73-77	3.0	1.8

The values in the table indicate that the manufacturer is allowing extra capacity in the transformer to cope with the sudden application of voltage. The second transformer could almost stand the sudden application of the nominal voltage (requires a transient factor of 2), without saturation, if there was little remanence present.

The third transformer, with a transient factor of 3 and remanence of 38 per cent, could almost stand the sudden application of the nominal voltage even with maximum residual flux present.

As can be readily seen, the performance of neutralizing transformers depends on the residual flux and on the transient factor. It is therefore important that these values be known and specified on the nameplate if accurate prediction of transformer performance is to be made.

Conclusions

Transformer Serial No 73-77 will not fail, functionally, under the sudden application of rated voltage (4.5 kV), even with maximum residual flux present in the core. Additional data on the nameplate, namely transient factor and residual flux, is desirable if accurate prediction of a neutralizing transformer's performance is to be made.

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APPENDIX A

NAMEPLATE DATA AND RESIDUAL FLUX FOR NEUTRALIZING TRANSFORMERS

All transformers manufactured by Osborne Electric Co Ltd.

No 1

Type 190-019-B	Serial No 70-35
Primary Voltage	6000, 60 Hz
No of Pairs	25 - 22 ga
Max Remanent Volts	150 at 35 ohms ext Z

Magnetizing Current	Residual Flux (%)
10.2	39
2.0	46
0.3	55
0.1	60

No 2

Type 190-017-B	Serial No 70-169
Primary Voltage	6000, 60 Hz
No of Pairs	16 - 22 ga
Max Remanent Volts	150 at 30 ohms ext Z.

Magnetizing Current	Residual Flux (%)
9.5	39
2.2	45
0.3	57
0.1	61

No 3

Type 190-026-B	Serial No 73-77
Nominal Primary Volts	4500, 60 Hz
No of Pairs	75 - 22 ga
Max Remanent Volts	150 at 35 ohms ext Z
Max Primary Volts	8000

Magnetizing Current	Residual Flux (%)
10.0	38
2.5	44
0.3	50
0.16	60

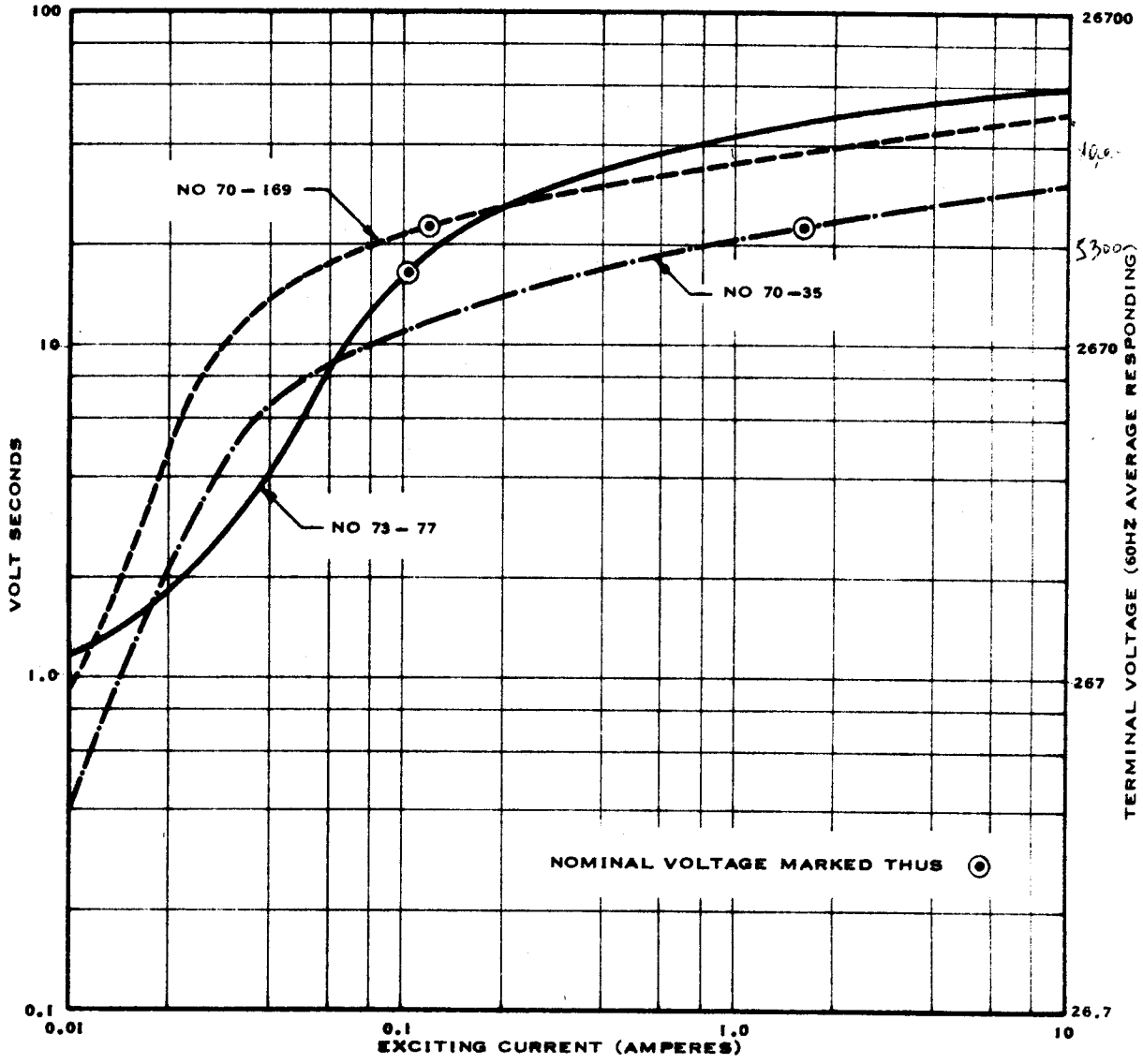

FIGURE 1

EXCITING CHARACTERISTICS FOR NEUTRALIZING TRANSFORMERS

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