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THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO
RESEARCH DIVISION REPORT

To Mr. J.H. Waghorne
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METERING OF LINE LOADINGS IN HIGH-VOLTAGE STATIONS

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Improved metering performance is one of the advantages of using separate metering current transformer cores for metering the line loadings in a high-voltage station. A circuit is presented which allows the meterings of line loadings to be performed with the aid of one set of current transformers per circuit breaker, and without the use of auxiliary current transformers.

INTRODUCTION

An Ontario Hydro standard practice is to place all circuit breakers, and therefore current transformers, in the bus of a high-voltage station. This means that to obtain the loading on a line, the output of two current transformers must be added. Because most of the current transformers on Ontario Hydro's 230-kv and 500-kv systems are primarily specified and used for relaying purposes, the metering circuits are usually isolated from the relaying circuits by means of auxiliary, saturating-type current transformers. All of the above practices have the effect of increasing the effective burden on the primary current transformer and of reducing its metering accuracy.

With the advent of the Ontario Hydro Data Aquisition and Computer System (DACS), more emphasis has been placed on obtaining improved accuracy for the various circuit loadings. This emphasis may result in the future purchase of HV current transformer assemblies which will contain a core exhibiting high metering accuracy, and for use exclusively for metering purposes.

This report outlines some of the advantages of using a separate core for metering purposes only, and presents a circuit which allows the metering of line loadings without the use of auxiliary current transformers.

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PRESENT PRACTICE

Figure 1 illustrates a typical situation. The outputs of two sets of current transformers are added after passing through some relays. The sum of the currents is then applied to more relays, as well as to metering equipment through an auxiliary, saturating-type current transformer. The typical range of current-transformer ratios, their relaying and metering accuracies, and an estimate of burdens allow one to calculate a range of possible errors. Figure 1 shows that the range of errors starts at about 1 per cent, where modern current transformers are used on high ratios (1600 to 5); up to about 5 per cent, where older current transformers are used on low ratios (500 to 5). The above values apply for instances where the output of two current transformers is used to obtain the line current. The errors are expected to be larger if more than two current transformers must be used to obtain the desired current.

SEPARATE CORES FOR METERING

There are a number of advantages to be gained by separating the metering and relaying functions performed by a current transformer assembly. The advantages are:

1. Improved metering accuracy due to the separate metering core and its low burden (metering equipment only).

2. Improved performance of the relaying current transformer due to the reduction of burden.

3. Elimination of the auxiliary, saturating-type current transformer from the circuit.

4. The possible use of air gaps in the relaying current transformers.

5. Simplification of design, specifications, and diagrams due to the separation of metering and relaying functions.

The chief disadvantages of the separate core are first, its additional cost which may be in the range of $300 to $600 per unit for 230- or 550-kv units, and second, the possibility that some manuracturers may have to increase the size of their assemblies to accommodate the extra core. Other disadvantages may be the extra number of leads and wiring required, and the non-interchangeability of the metering core with the relaying cores.

Research Division Report No 71-44-K, entitled Metering Accuracy of Relaying Current Transformers, suggests that if the metering core were to have an accuracy of 0.3B1.8, its cross-section area would have to be between 0.5 to 16 square inches. The area of core depends on the type of material used and on the voltage rating of the assembly. This indicates that the volume of the assembly would have to be increased less than 5 per cent if the metering core was made of extra-high permeability material; or about 35 per cent if the metering core was made of grain-oriented silicon steel. The above-mentioned figures apply to a three-core free-standing assembly. The manufacturers, therefore, have a choice of either increasing the size of their assemblies to accommodate the metering core, or to use special materials for the metering core.

METERING CONNECTIONS

A single-phase diagram showing the connections used to meter three lines emerging from a bus is shown in Figure 2. Ontario Hydro standard practices are applied in Figure 2 with respect to grounding each set of current transformers, and thus auxiliary current transformers must be used for isolation. The auxiliary current transformer's metering accuracy should be as good as the primary current transformer's metering accuracy, and its short circuit impedance must be low. This will prevent the auxiliary transformer from spoiling the accuracy of the metering system by either adding its own large errors, or by overburdening the main current transformer. Suggested values for accuracy and short-circuit impedance for the auxiliary current transformer are given in Figure 2. Using the connections in Figure 2 the error in the current at the meters is expected to be within 1 per cent, at rated current, if current transformers of suggested accuracy are used.

A single-phase diagram showing an alternate method for connecting metering current transformers is shown in Figure 3. This method of connection avoids the use of auxiliary current transformers, thereby maintaining the highest possible accuracy. It should be pointed out that the current transformers may not be grounded individually in this method, but are grounded through the metering burdens which may elevate them by a few volts above ground.

The advantages of the connection without the auxiliary current transformers are the improved accuracy due to the reduction of burden on the main current transformers and the elimination of the inherent errors of the auxiliary current transformers.

Figure 4 gives the connections for metering all lines in a large station without the use of auxiliary current transformers. The error in current at the meters is expected to be within 0.6 per cent for lines where the output of two current transformers is used (Figure 4, lines 2, 3, 5, 6, 7, 8, 10, 11), increasing to within 0.9 per cent for lines where the output of three current transformers is used (Figure 4, lines 1, 4, 9, 12).

CONCLUSIONS

The separation of relaying metering functions, by using separate current transformer cores for metering and relaying, will result in a large improvement in the accuracy of currents in the metering circuits, and in some improvement in the performance of relaying current transformers. Circuits are presented that avoid the use of auxiliary current transformers when metering large numbers of lines thereby allowing the highest possible accuracy to be obtained in the metering circuits.

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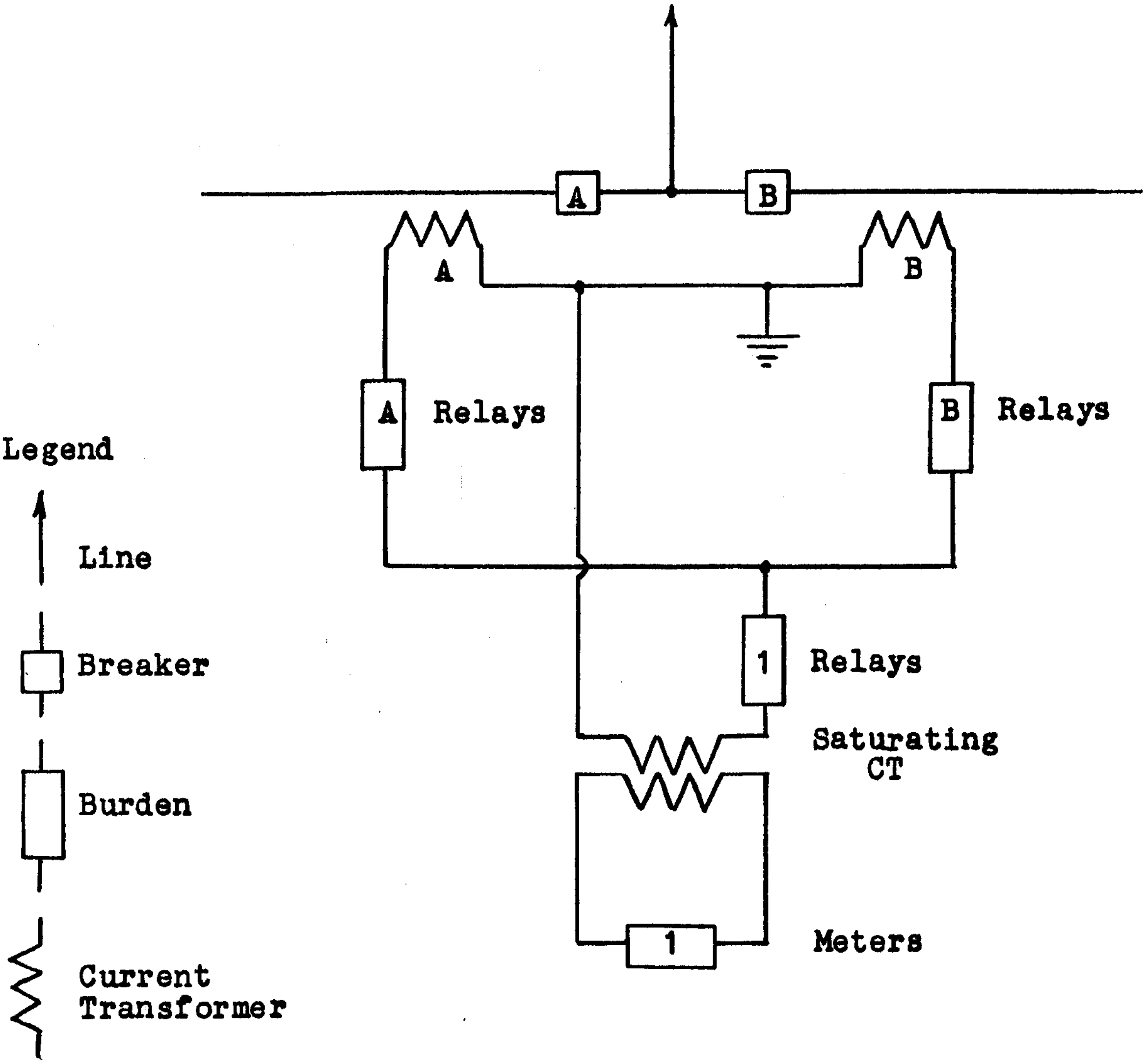
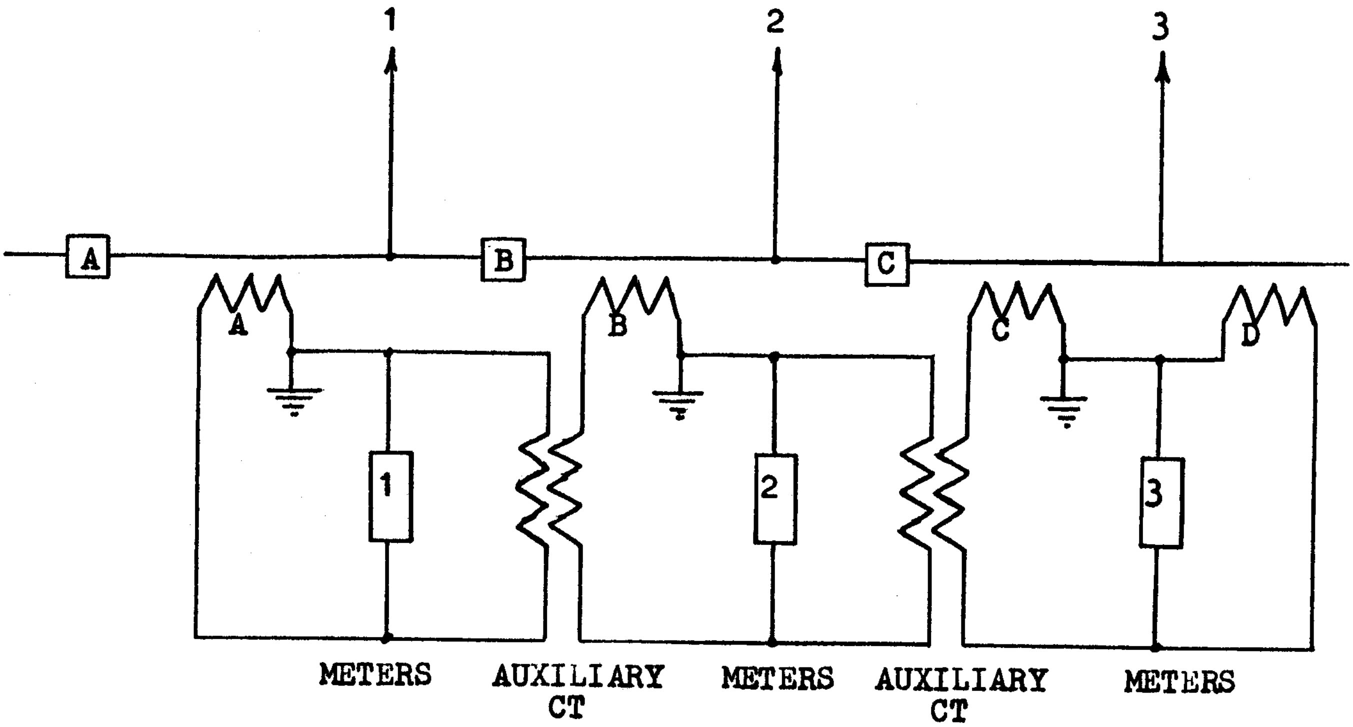


Main CT Ratio	Typical Rel Acc'y	Typical Met Acc'y	Expected Error in Current at Meters: At Rated Current	Expected Error in Current at Meters: At 10% Rated Current
1600/5	2.5 L 1000	0.6 B-1.8	1.5%	3%
1200/5	2.5 L 800	1.2 B-1.8	2%	4%
800/5	2.5 L 400	1.2 B-0.9	3%	6%
600/5	2.5 L 200	1.2 B-0.5	5%	10%

FIGURE 1

TYPICAL LINE METERING INSTALLATION



Accuracy of Main CT	Recommended Acc'y of Auxiliary CT	Recommended SC Impedance of Aux CT
0.3 B-1.8	0.3 B-0.9	<0.5 ohm
0.3 B-0.9	0.3 B-0.5	<0.25 ohm

FIGURE 2

METERING OF LINES WITH METERING CT'S AND AUXILIARY CT'S

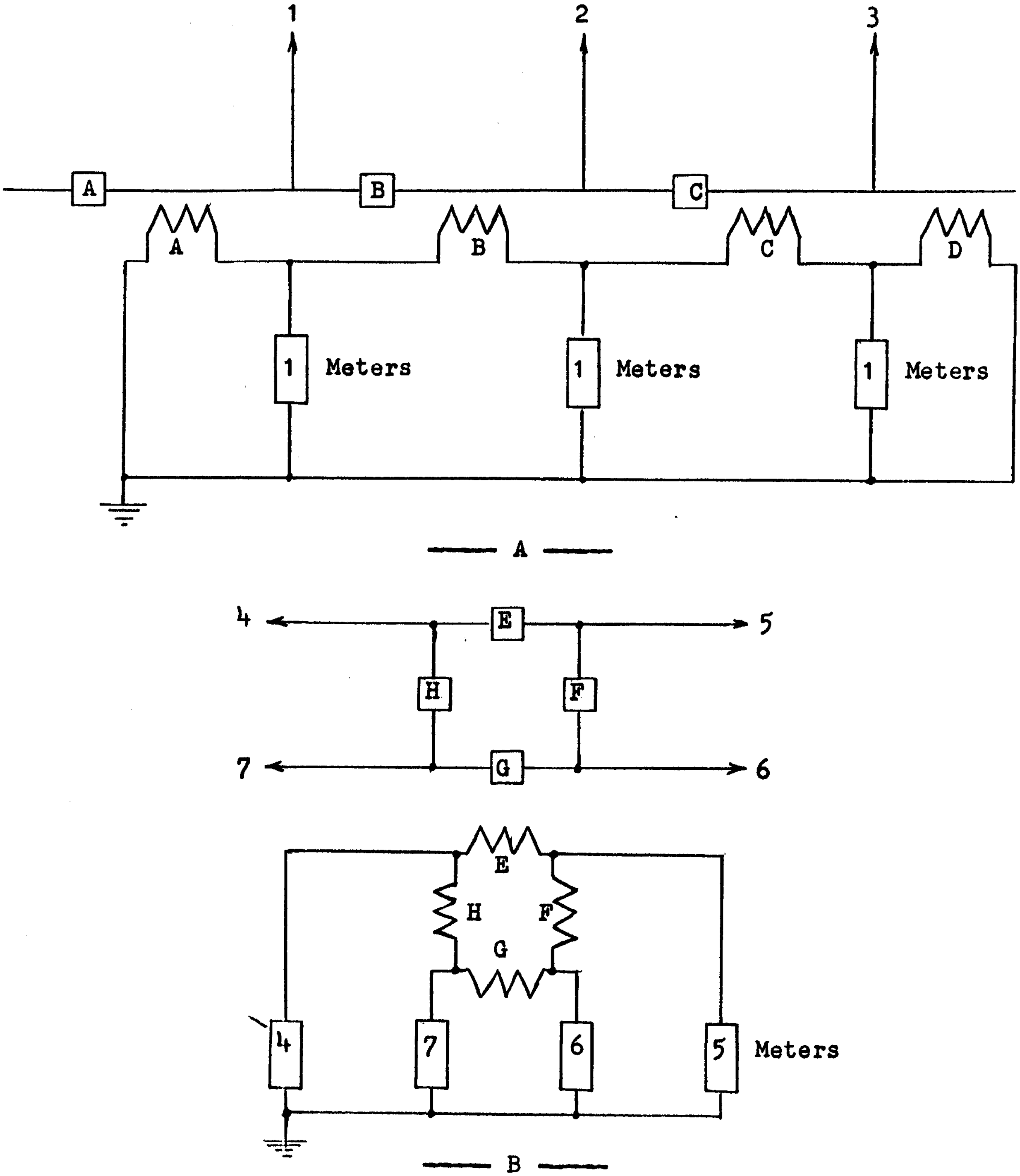


FIGURE 3

METERING OF LINES WITHOUT THE USE OF AUXILIARY CT'S

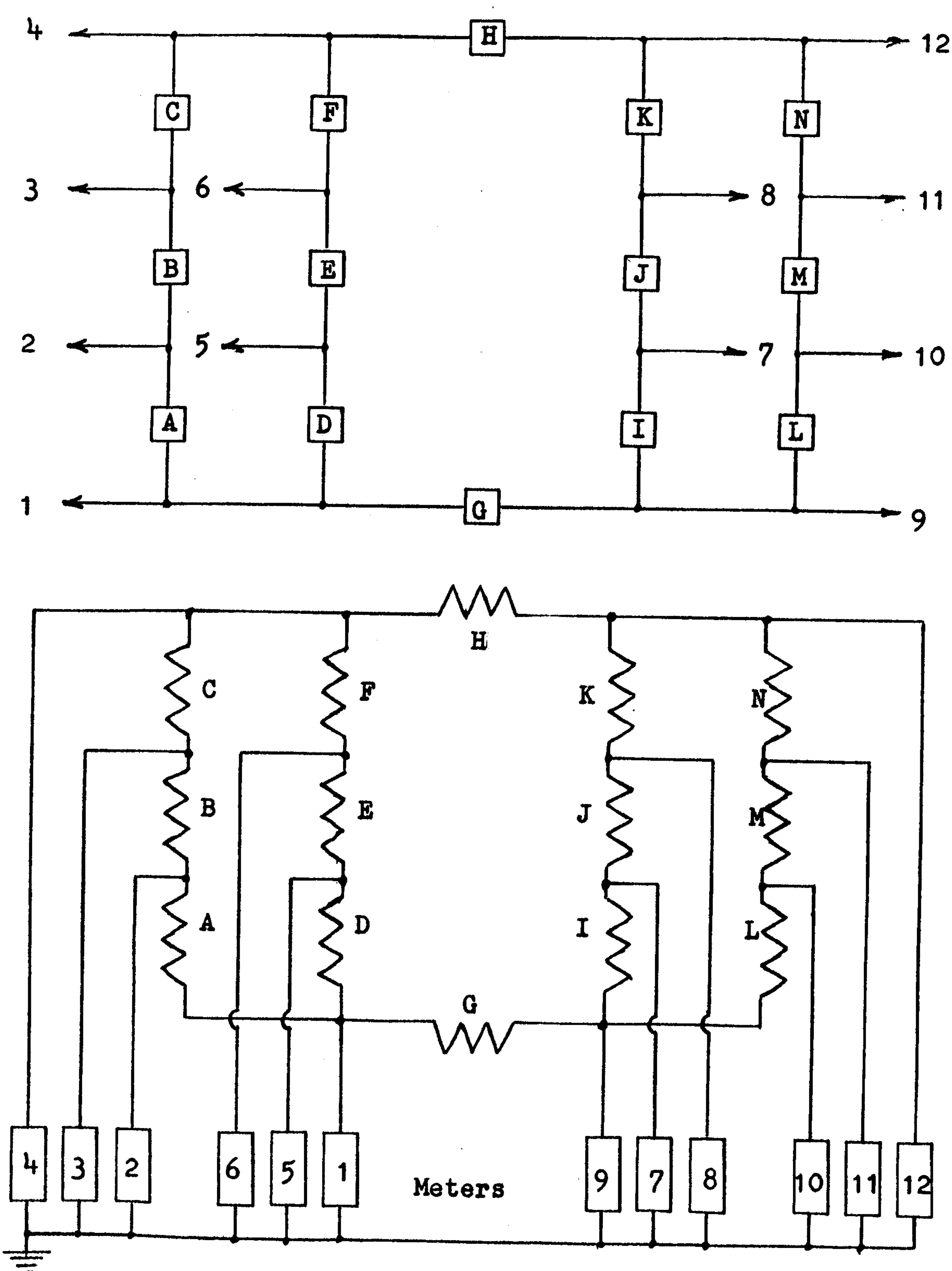


FIGURE 4

METERING OF LINES IN A LARGE STATION
WITHOUT THE USE OF AUXILIARY CT'S