NOTES ON THE USE OF INSTRUMENTS ON SWITCH- BOARDS.

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The object of this paper is to invite discussion on what seems to be the more important features of instrument engineering, and its value to the INSTITUTE should be found in the discussion rather than in the paper itself.

In selecting instruments for any particular class of service the conditions under which they are to be used must be given careful consideration. It is evident that the conditions on a central-station switchboard will not permit of the same accuracy as could readily be obtained in a laboratory, and the information to be derived from the instrument readings does not require so exact a determination of values. For example, consider a shunt ammeter: an instrument best adapted for laboratory conditions would have a shunt loss too great for switchboard service, and one designed for switchboards would have temperature errors so great that its use in the laboratory could not be contemplated. It is the author's intention to confine these notes to the conditions which are found on switchboards in central stations.

One of the most important considerations is in connection with the capacity of instruments to be used, and present needs cannot be altogether overshadowed by possibility of future growth. An ammeter whose needle constantly hovers around zero position is of comparatively little use, and an integrating wattmeter, which normally operates at ten per cent., and frequently at less than one per cent. of its rated capacity, may give a false impression of the operating efficiency of the station.

Under such conditions agreement is difficult to obtain where totality meters are used and an effort is made to check them up with the sum of the individual feeders. Better results would be obtained by metering each generator, for under these conditions the meters would not be required to operate upon as low loads as they would if placed upon the feeders.

The friction of a jewel-bearing is generally considered so small that it may be neglected; but it must not be forgotten that a torque of 25 millimetre grammes is a little less than one five-thousandth of a foot-pound, and friction must be very small indeed if it is negligible as compared with this torque. Under normal working conditions, integrating instruments frequently operate at much lower torque, and even at full scale indicating instruments never approach this value.

It must also be remembered that the vibration of the board tends to impair the perfect polish of both jewel and pivot, and thus affect the accuracy of the readings. Other things being equal, it is apparent that these errors will be minimized by high torque, but they must not be altogether overlooked even under the most favorable conditions

In deciding upon the capacity of an instrument it is necessary to take into consideration the relations between the smallest load, which it is desired to read, and the peak. It is generally considered advisable on railway circuits to have considerable overload capacity, and but little attention is paid to the light-load period. On lighting circuits, however, the overload is not considered to be as important as on railway circuits, and the light load is given more attention. It is usually good practice to select instruments of such capacity that under normal working conditions the needle of an indicating instrument will rest between half- and two-thirds scale. This allows a reasonable capacity for growth and for overloads, and at the same time permits of sufficient accuracy during the light-load period.

Integrating instruments should be fully loaded under normal conditions, for they have an inherent overload capacity not possessed by indicating instruments; such practice insures not only low-load accuracy but also a reasonable dial registration over comparatively short periods of time. Where hourly or even daily readings of the dial are recorded, it is not necessary that the registering train should have a capacity sufficient to care for several months' output. A rapidly-moving dial-train permits full advantage to be taken of the meter's accuracy,

and a change of one or two figures should be recorded for each observation period.

Accurate records necessitate occasional calibration and adjustment of switchboard instruments, and suitable arrangements should be made for conveniently doing this work. Too little attention has been given to this feature in the past. It is frequently very difficult and sometimes impossible to introduce standards in circuits for calibration purposes. Perhaps this is a matter which should come under switchboard design rather than under instruments, but it is one of great importance and should be very thoroughly discussed.

Stray fields are always present in central stations and are frequently so strong that they cause marked instrument errors. In locating instruments on the board it is not sufficient to allow for position of bus-bars in relation to the instruments themselves, but the location of the iron framework of the board must also be taken into consideration. Magnetic fields have been carried by such iron frames and have introduced errors in instruments located many feet from the bus-bar itself. Such errors may be almost entirely eliminated by properly shielding the instrument, and no error need be introduced on account of residual magnetism or hysteresis of the iron shield. Properly designed instruments of this class show no appreciable difference between ascending and descending scales, or between alternating and direct currents, and they are entirely unaffected by fields which would influence the readings of unshielded instruments as much as 10 or 15 per cent.

The use of series transformers, even on circuits of comparatively low pressure, seems to be increasing; the added convenience in removing or in cutting out instruments for recalibration, and the added security for the operators, more than compensate for the slight errors introduced by their use. This practice is particularly to be recommended in those cases where both sides of the line are brought into the same instrument; such for example as the polyphase, integrating, or indicating instruments. It is also a good practice to interconnect the stationary and moving circuits and case of indicating instruments, and very often this would hardly be practicable unless series and pressure transformers are used.

Commutator meters are the only ones available for measurement of direct current; properly equipped with cupped diamond jewels, and occasionally corrected for commutator friction,

they give excellent results. But induction meters with light moving element and no commutator are to be preferred wherever their use is possible.

Balanced three-phase circuits may be accurately measured by a single-phase wattmeter with a Y box. An instrument of this character records three times the energy of the phase in which the current coils are connected; therefore, it should be used only in those cases where there is no possible question as to the circuits being exactly balanced.

Polyphase instruments, both integrating and indicating, are to be preferred even for balanced circuits, and for unbalanced circuits they become a necessity. Professor Nies advocates the use of three independent single-phase meters. Of course the resulting records of the different phases are interesting, and on a balanced circuit any material difference in the readings of the three instruments would indicate an error in one of them, and serve as a warning that recalibration is necessary, or that the circuit has become accidentally unbalanced. In any case, it indicates a necessity for investigation. Still it is very doubtful if these advantages are sufficient to offset the added expense of three instruments and the space required on the switchboard for their installation.

In the measurement of polyphase circuits, the greatest care should be taken to see that the instruments are installed exactly in accordance with instructions received from the manufacturer. Sometimes a slight deviation from the connection shown on the diagram to connections which seem to be equivalent introduces considerable error, due to the instrument coils being in wrong phases; instruments are not infrequently charged with errors which should properly be attributed to incorrect connections.