The Röntgen: Deficiencies in Present-day Free-Air Chamber Standards

THE röntgen is defined as "that quantity of X- or gamma-radiation such that the associated corpuscular emission per 0·001293 gm. of air produces, in air, ions carrying 1 e.s.u. of charge of either sign". An ionization chamber designed for the realization of this unit must therefore provide sufficient space around the air volume in which the primary ionization occurs to permit the corpuscles from it full range, effectively. In the parallel-plate type of chamber, this involves not only sufficient electrode spacing, but also adequate dimensions at right angles, that is, lateral to the X-ray beam. It was recognized in the design of the typical standards set up more than twenty years ago in Great Britain[1] and the United States[2] that the actual electrode spacing need not be so great as might at first sight be thought necessary on theoretical grounds. Thus for 200-kV. X-rays, a plate spacing approaching 70 cm. (with effectively equal lateral dimensions) is theoretically desirable, whereas, in fact, the ionization losses with dimensions considerably less than these may be negligible. Thus 10 cm. only was adopted as the plate-spacing in the chamber set up at the National Physical Laboratory, Teddington, and 12 cm. in that at the U.S. Bureau of Standards.

We have shown in our experiments that, assuming the chamber geometry to be adequate in other respects, these values of plate-spacing would lead to ionization losses of about 0·5 and 0·1 per cent respectively with 200-kV. medium-filtered radiation. However, critical consideration of the lateral geometry in these two chambers (including electrolytic tank studies to elicit the electrostatic field conditions) reveals the existence of relatively serious deficiencies. Thus the effective lateral dimension of the collecting region in the National Physical Laboratory chamber was found to be a little less than 7 cm., largely as a result of the incorporation of unnecessary and, indeed, undesirable lateral guard plates. The corresponding dimension in the U.S. National Bureau of Standards chamber was estimated to be 8 cm. The resulting lateral losses in both chambers are hence far more serious, and we have concluded that they exceed 2 per cent in the National Physical Laboratory chamber and are almost 1·5 per cent in the National Bureau of Standards chamber at 200-kV.

These deductions were made from a series of experiments, employing a free-air chamber pair in conjunction with a Kemp-type precision X-ray comparator[3], one of the chambers being housed in a pressure-casing so that the effective dimensions of the electrode assembly could be varied by alteration of the air pressure within the chamber. As a check on our conclusions in the case of the National Physical Laboratory chamber, we built an exact geometrical replica of the latter and made a direct comparison of it with our own over a range of X-ray qualities (again using the X-ray comparator). The losses predicted by the pressure-change experiments and those observed by direct comparison are set out in the accompanying table.

kV.	Filter	Losses of N.P.L. chamber due to inadequate geometry	
		From pressure-change experiments	By direct comparison
60	Nil	Nil	Nil
75	1 mm. Al	Nil	Nil
100	1 mm. Al	0·4 per cent	0·4 per cent
145	0·2 mm. Cu + 1 mm. Al	1·9 „	2·3 „
190	0·47 mm. Cu + 1 mm. Al	2·5 „	2·9 „

Thus the existence of the losses was confirmed by the direct comparison, which indicated that if anything the losses had been under-estimated in the original series of experiments.

This investigation is being described in a paper before the International Congress of Radiology at Copenhagen during July; an account of the experiments themselves will be published elsewhere in due course.

L. A. W. KEMP
Physics Laboratory, London Hospital,
London, E.1. May 18.

[1] Kaye, G. W. C., and Binks, W., *Brit. J. Rad.*, **6**, 530 (1933).
[2] Taylor, L. S., and Singer, G., *Radiology*, **15**, 637 (1930).
[3] Kemp, L. A. W., *Brit. J. Rad.*, **18**, 107 (1945); **19**, 233, 301 and 488 (1946); **24**, 211 (1951).

Alternating-Current Energy Losses in Iron Laminations at Magnetic Saturation

A LIMIT to the power output of most rotating electrical machines is set by magnetic saturation in the teeth of the punchings employed. Designers of these machines have, however, never had data available on the specific iron losses of the materials they use for alternating flux densities higher than about 75 per cent of the saturation value. The usual methods of measurement, applied to specimens of the material, fail completely at higher flux densities than this because the power factor becomes very small and the magnetizing current very high. The former introduces difficulties when wattmeters are used, and the latter when thermal methods are contemplated. We have successfully used the following method.

A small four-limbed core of laminations was built up, the specimen under test being a single strip near the centre of one limb. This limb was wound with a magnetizing coil and was of smaller cross-section than the other three. Strips, of the same width as the test piece, of a non-ferromagnetic resistance material were placed above and below the test piece and separated from it by small air spaces. A pair of thermocouple junctions in opposition were placed, one on the test piece and the other on the adjacent surface of a resistance guard strip. This thermocouple circuit was connected to a very sensitive and stable photo-electric galvanometer amplifier which was used only as a null detector. In carrying out a test, the specimen was magnetized from a 50 c./s. supply. At the same time the guard strips were heated by passing a current through them, this being adjusted by trial to give the same rate of rise of temperature. Thus, for a given flux density $B_{max.}$ in the specimen and correct adjustment of the current in the guard strip, simultaneous closing of both circuits would produce no deflexion of the galvanometer. Then, from the specific heats of the two materials and the electrical resistivity of the guard strip, the iron loss in the specimen could be determined. Alternatively, and as a check, a method of direct calibration was also used in which the specimen was first heated by the iron losses and then, secondly, heated by passing a current through it also.

The method has worked well and has a number of advantages. The magnetizing current need not be applied for a period greater than about four seconds for each reading. There is therefore no difficulty due