by a cold sea for a long time, probably throughout the Tertiary Period".

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[3] Roughton, F. J. W., and Scholander, P. F., *J. Biol. Chem.*, **148**, 541 (1943).
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PROF. H. MUNRO FOX, Bedford College, London, writes the following comment on the foregoing article: Prof. Johan T. Ruud's study of the fishes with colourless blood will be a most interesting surprise to most zoologists, although a few knew of their existence[1]. The fact that there are fishes lacking hæmoglobin is not, however, quite so astonishing as appears at first sight, for the following reason. More than thirty years ago Maurice Nicloux[2] showed experimentally that carp, pike and eels remained alive for four hours, "*pas très incommodés*", in water through which a mixture of air with 2 per cent carbon monoxide was bubbled. Such a gas mixture would quickly kill a man. The hæmoglobin in the fishes' blood was found to be about 90 per cent in the state of carboxyhæmoglobin, that is, incapable of transporting oxygen. The conclusion, although not drawn by Nicloux, is that many fishes when swimming quietly get enough oxygen for their needs in solution in the blood plasma, and they probably only require an additional supply with the aid of hæmoglobin when they are moving actively. Their hæmoglobin is an emergency precaution and the 'ice fish' do without this luxury. Doubtless, however, hæmoglobin is not a luxury but a necessity in the blood of such fishes as mackerel, which cannot get enough oxygen without swimming rapidly through the water[3].

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NEW SURGE GENERATOR AT THE NATIONAL PHYSICAL LABORATORY

By R. S. J. SPILSBURY

ON April 21 a ceremony was held at the National Physical Laboratory to inaugurate the new surge generator installed by H.M. Ministry of Works for the use of the Electricity Division of the Laboratory. The equipment was put into action by Sir Edward Bullard, director of the Laboratory, and caused to discharge across a chain of forty-five glass suspension insulators, the total length between end fittings being 20 ft. Thanks to the courtesy of the main contractors for the equipment, Messrs. Ferranti, of Hollinwood, the inauguration was followed by a luncheon, at which Sir Edward made a short speech, and Sir Vincent Z. de Ferranti replied.

The need for surge generators arises, of course, from the hazards to which overhead electricity transmission lines, and the transformers, cables, etc., connected to them, are subjected when lightning strikes the conductors or their supporting towers. The effect is to raise the voltage of the line, in a time of the order of a millionth of a second, to a value limited in practice only by the breakdown voltage of some of the insulation, such as air gaps or strings of porcelain insulators: this voltage may be of the order of a million volts for 275-kV. lines. Similar effects occur when switches are operated, though these surges are usually less serious. The voltage step imposed travels along the line without much attenuation, and in due course reaches a transformer or cable. The effect on transformers is particularly serious, since the steep front of the travelling voltage wave causes most of the voltage to appear across the first few turns of the winding, and so to place a stress on the inter-turn insulation many times that which it has to withstand in normal service.

The increasing use of overhead transmission lines and the occurrence of breakdowns due to the causes mentioned above produced, many years ago, a demand for tests designed to simulate the effects of natural lightning, and the surge generator, in conjunction with a high-speed cathode-ray oscillograph, provided the necessary tool. Briefly, such a generator consists of a series of high-voltage condensers which are charged, through fairly high resistances, by a direct-current source of suitable polarity—the effects of positive and negative surges are not, in general, the same—and are then connected in series by the breakdown of air-gaps. The breakdown is initiated by applying a controlled voltage surge to one of the gaps. In this way a voltage impulse, reaching its peak in perhaps a millionth of a second, and decreasing to half this value in about 50 millionths of a second—values which have been internationally agreed as reasonably representative of those which occur in practice—can be applied to a test object.

The National Physical Laboratory has possessed apparatus of this type, built by its own staff, for many years, the open-circuit voltage of the generator being 2 million, and the energy stored in the condensers 20 kilowatt seconds, and, until recently, this has been adequate. Some little while ago, however, it became clear that new equipment was needed; partly because transmission voltages are rising—275 kV. is in use in Great Britain and 380 kV. on the Continent—and partly because the condensers that form the heart of the generator, and are heavily stressed in service, were showing signs of deterioration. It was therefore decided to install new plant, and to design this for the highest voltage that the size of the building allowed—3·2 million volts—so that it would be adequate for the foreseeable future. The dimensions of the main high-voltage laboratory are 120 ft. × 60 ft. × 45 ft. clear height; even so, it was necessary, in order to obtain adequate clearance, to excavate a large pit 8 ft. deep, in which the generator stands.

The apparatus has eight stages, each charged to a voltage of up to 400 kV. by a transformer and metal rectifier: the stored energy is 77 kWs. Each stage consists of two condensers in separate housings, the stage capacitance being 0·12 microfarad. The circular ribbed porcelain housings, with empty porcelains to act as stage insulators, are assembled into a strong four-column structure, which also supports the 50-cm. diameter spheres that form the electrodes of the various air-gaps, and resistors for controlling the shape of the voltage impulse. A condenser is provided to form the high-voltage section of a capacitance voltage-divider, from which