Limitations of High-Voltage Insulation

DR. WHITEHEAD, of Johns Hopkins University, communicates an interesting paper to the *Journal of the Franklin Institute* of September on the limitations of high voltage. Fifty years ago, it was thought that electrical transmission distances in America would never go much beyond 150 miles and that the economical voltage would not rise much above 110 kilovolts. The grounds for this opinion seem to have been that the distances between available sources of power, whether hydraulic or steam, were never greater than about 300 miles. At the present time, there are not many transmission systems for distances greater than 150 miles, but there are several working at 220 kilovolts. A conspicuous example is the Boulder Dam—Los Angeles transmission line over a distance of 300 miles at 287 kilovolts.

Calculation has shown the economic advantage of power development and transmission to greater distance at a higher voltage. Dr. Whitehead discusses the limitations placed on a further increase of transmission voltage by the insulating properties of the materials which are at present available. Those most commonly used are the atmospheric air, ceramic materials such as glass and porcelain, petroleum oils and various composite fibrous materials such as impregnated paper. The important electrical properties of the materials used for the insulation of high-voltage circuits are conductivity and electric strength. The conductivity measures the ability of the material to withstand slow leakage, and the electric strength measures its ability to withstand breakdown or actual failure and short circuit. All materials, including liquids and gases, have some electrical conductivity, but they vary over a very wide range, the conductivity of copper being 10^{20} times greater than that of a good mineral oil. Those with high insulating properties may vary a million times between themselves, but they are all classified as available for high-voltage insulation.

All the materials used for insulating high voltage must have high electric strength. Usually the overhead high-voltage transmission line depends on the atmospheric air for its insulation. The conductivity of the air is so small initially that it can be neglected. As there are always a few ions present, they move backwards and forwards under the forces exerted by alternating high voltage, and when they move fast enough they have collisions with neutral ions, thus creating new ions and increasing the conductivity of the air between the lines. This causes the well-known corona or brush discharge surrounding the conductors. The discharge increases the conductivity and energy loss in the air and is thus a limitation to its insulating properties. Up to the present, it has been found possible—notwithstanding the great increases in voltage values—by separating the conductors sufficiently and increasing their diameter, to prevent coronas from forming. In the Boulder Dam line the main conductors are hollow and 1·4 inch in diameter; they work at 285 kv. To get a corona the voltage would have to be increased to 450 kv.

It appears that the saving effected in conducting material at higher transmission voltages is partly offset by the increased cost of the insulation. The higher the voltage the greater the cost of the insulation and the construction of the line, as the minimum total cost must always determine the most economical value of voltage. We have reached a stage in raising voltage values where the physical dimensions of the line are so great as to be practically prohibitive. To meet these limitations, special forms of construction of the conductor system and special auxiliaries to the insulation system have become necessary, and these impose further limitations to increasing the voltage.

For these reasons, engineers are studying the use of underground cables for high voltages. There are now several installations at 132 kv. and a few at 220 kv. Some of these systems using 'oil-filled' cables have given satisfaction for more than seven years, and credit is due to the engineers in the experimental laboratories where they were developed.

Building Research*

A SPECIAL feature of the report of the Building Research Board for the year 1936 is the retrospect prepared by the Director, Dr. R. E. Stradling, reviewing the progress made during the eleven years since the Station was established in its present laboratory at Garston, Herts. For four years previously the organization was taking shape, and the value of the experience then gained may be judged from the progress made since 1925. The work of the Station goes ahead continuously and, in knowledge of materials and methods and in experience, considerable progress has been made, but it is seldom possible in any one year to chronicle any definite advance. Over the longer period the work can be seen in better perspective, the import of it becomes more evident and lines of future development are more clearly indicated.

For example, the Library begun primarily for internal service with a stock of two thousand items, has increased fully tenfold in size and has become a focal point for world-wide information regarding all matters appertaining to building. Its functions are not merely to stock all this material, but also to include its study and documentation for the promotion of research and assistance in inquiries. The fact that this work of the Library, its resources, and the kind of service it can provide are insufficiently well known outside, justifies special mention of them in detail, for, as the Director notes, there is no reason why

* Department of Scientific and Industrial Research. Report of the Building Research Board, with a Report of the Director of Building Research for the Year 1936. Pp. vi + 210 + 25 plates. (London: H.M. Stationery Office, 1937). 4s. net.

these services should not be equally available for the assistance of outside bodies as are those of the experimental and other facilities of the Station.

A branch of the work which has expanded rapidly during these years is that of dealing with technical inquiries. In the past year the number of inquiries received from architects for advice on the problem of sound transmission in buildings has been commented upon. On this subject investigation shows that the solution is primarily a matter of planning, as structural precautions can mitigate but not eliminate the discomfort of having noisy and quiet rooms adjacent. The report indicates that the most promising method of dealing with the transmission of noise in buildings is the provision of what is described as a 'floating floor'. The special investigations carried out in this branch also include those which are necessary to resolve difficulties or problems met with in practical operations, and the independent testing carried out for manufacturers of proprietary products. Reference is made to several of the most important or interesting of these in the report.

During the period a vast amount of work has been done on, and in connexion with, building materials —stone, brick, concrete, etc.—and the continuance of these activities is indicated. About those, their properties and limitations, much information has been obtained and made available for use. The investigations on bricks and brickmaking clays having been brought to a stage at which they can usefully be applied, attention is now being given to what is referred to as the efficiency of the brickwork structure as regards such matters as strength, permanency of bond, thermal insulation and exclusion of rain. In the cleaning of the exteriors of buildings the use of chemicals is condemned as destructive, and a process is recommended in which fine jets of water are employed for a period dependent on conditions, and this is followed by brushing. It is held that this gives satisfactory results without causing immediate or ulterior damage to the stone or even to carvings on it.

Among the major investigations made during the year were a series of tests to ascertain the resistance of I-beams of high tensile steel and of mild steel to failure by bend yielding of the flanges, by shear yielding of the web and by buckling of the web. Where necessary the surfaces were scraped and painted with a thin coating of plaster of Paris, the flaking of which indicated local yielding; this is clearly seen in the photographs taken during the tests. On behalf of the Ministry of Transport, tests were made during the year on six bridges; some particulars are given of these, but the data obtained have yet to be completely analysed. Three of the bridges were tested to destruction—a stone arch bridge of 21-ft. span built in 1793 collapsed under a load of 77·6 tons, a brick arch bridge of the same span and date failed at 123 tons, while one constructed in 1870 of cast iron beams and plates, with a span of 13 feet, broke under 74·6 tons, in each case the load being applied by hydraulic jacks at the centre of the span.

The record of work and results as set out here fully justify the Board in its statement that in this short period the Station has become a real factor in the building industry.

Eskimo Origins

THE essay on the origins of the most ancient civilization of the Eskimo, for which a prize was awarded by the Danish Government to Mr. Henry B. Collins, jun., in 1936, is now published under the title "Archæology of St. Lawrence Island, Alaska" (Smithsonian Misc. Collect., **96**, 1).

The essay takes as its starting point a descriptive account of the results achieved by the author and others in excavations on ancient sites in St. Lawrence Island, which established the succession *Old Bering-Punuk-modern Eskimo* in Western Eskimo culture. On the basis of this material it has been possible to make a detailed comparison not only of the elements of the two prehistoric and the modern cultures *inter se*, but also of this Western Eskimo culture, both as a whole and in each of its phases, with the other Eskimo groups, ancient and modern, including the Thule culture of Th. Matthiassen, the Caribou Eskimo of Kaj Birket Smith, and the Eastern Eskimo, as well as the neighbouring aboriginal peoples and cultures of America and north-eastern Asia.

In arriving at a series of general conclusions a number of problems come under consideration.

As regards the relation of the Western Eskimo and the Thule cultures, it has been demonstrated by Matthiassen that the Thule culture must have originated in the west along the Alaskan or Siberian coast, north of Bering Straits. This is now seen to be within the range of the Old Bering Sea and Punuk cultures; and on the basis of the St. Lawrence Island finds, it is shown that the Thule culture is more closely allied to Punuk of a late stage and the modern culture than to the Old Bering Sea culture. The Thule culture has also been shown to be close to the modern Point Barrow Eskimo. There is a close relationship between the Old Bering Sea culture and the prehistoric or Birnirk culture of old Point Barrow sites—the Birnirk culture, in fact, was, in part at least, contemporaneous with the old Bering Sea culture, while the modern Point Barrow is the closest to the Thule, possessing a number of important Thule elements, absent in the Birnirk culture.

This prominence of the Thule elements in modern northern Alaska is explained as due to a late return migration within the past few centuries of Thule Eskimo, after the original eastward spread of the Thule culture, which had developed out of the Birnirk, rather than the Old Bering Sea culture. This inference of a late migration westward is supported by the cultural, linguistic and physical uniformity of modern Eastern and Western Eskimo, while the physical characters of the modern Point Barrow Eskimo are quite distinct from the skeletal material from old Point Barrow sites.

The hypothesis that the north coast of Alaska has been subjected to a relatively late wave of migration from the east would serve to explain the view that the Eskimo had entered as a wedge at Bering Strait, breaking off earlier connexions between the