which stud the high plateau of Abyssinia. He first visited Mounts Kaka and Chillalo, south-east of Addis Ababa, finding well-developed moraine ridges extending in the latter case almost 800 metres below the 4,100-metre summit, and he then travelled northwards across the Hawash valley to the Highlands of Semien, which lie on the northern edges of the Abyssinian plateau. On the highest three peaks of the worn-down volcano forming these highlands he again discovered extensive moraines and fresh-looking cirques, and shorter moraine ridges formed during the later stages of declining glaciation. Correlation of new data from Abyssinia with the results obtained on Kilimanjaro in Tanganyika, Mounts Kenya and Elgon in Kenya, leads Nilsson to the conclusion that the maximum extension and stages of recession of the mountain glaciers were simultaneous throughout East Africa.

Nilsson's second expedition is hence notable for the great area covered and for the further demonstration that the climatic history of East Africa is not purely local. Thus parallel phenomena are found over a very wide area, and there is a considerable degree of agreement with the standard successions of the Nile Valley and Mediterranean.

[1] "Ancient Changes of Climate in British East Africa and Abyssinia", *Geografiska Annaler*, **22**, Haft 1–2, 1–79 (Stockholm, 1940).
[2] Wayland, E. J., *Compt. Rend. XV Int. Geol. Cong.*, **2**, 323–53 (South Africa, 1929).
[3] Kent, P. E., *Geol. Mag.*, **78**, 173–84 (1941).
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THERMAL BREAKDOWN IN SUPER-TENSION CABLES

An article by E. A. Beavis (Eng. Supp. *Siemens Magazine*, Nos. 202 and 203, March and April, 1942) considers the various factors contributing to cable failures in the sphere of dielectric heating. For any type of high-voltage cable installation there is a definite limit to the heat which can be dissipated, and above which the condition of the cable insulation becomes thermally unstable. The chief factor governing instability is the dielectric loss, which has a certain critical value dependent partly upon the thermal constants of the cable but chiefly upon the external thermal conditions. When this value is exceeded, cable breakdown becomes inevitable in course of time, provided such conditions continue unchanged. This maximum value of dielectric loss, which denotes the commencement of instability, remains constant for a given set of thermal values, and the higher the applied voltage the lower is the critical temperature at which this loss occurs, since it increases as the square of the voltage. For the same conditions, therefore, the higher the voltage the shorter the time required for thermal breakdown to occur. Failure will normally take place when the temperature of the insulation has reached the point at which the existing potential gradient exceeds the dielectric strength, and in most cases will occur shortly after passing the critical value.

For very high voltages, failure in some cases precedes the actual approach of instability by reason of reduced dielectric strength consequent upon the high cable temperature attained, and conversely with comparatively low voltages the time to breakdown may occasionally be much prolonged on account of a flat dielectric loss/temperature characteristic reducing the rate of temperature rise. Should the thermal conditions change in such a way that the temperature tends to fall again below the critical point before breakdown takes place, then thermal failure will in general be avoided. In the case of super-tension cables of special design where ionization is suppressed, no permanent deterioration may take place under the above conditions, but with the normal solid-type cables distortion of the lead sheath will occur due to excessive expansion of the cable oil, tending to produce ionization on cooling which will probably render the cable unfit for service in course of time.

On account of the increase in dielectric loss, the higher the applied voltage the less the thermal factor of safety for the same maximum conductor temperature. As it is often necessary for economical reasons to run the highest voltage cables at their maximum permissible temperature, it becomes essential to study carefully the thermal conditions for such installations in order to ascertain the limiting current-carrying capacity of the cable. Although it is now possible to calculate the thermal characteristics for any cable reasonably accurately from published data, it is customary to carry out special testing operations on short lengths of about thirty yards of various types of super-tension cable in the high-voltage laboratory. Such tests, usually denoted as stability tests, consist in running a series of loading cycles on the cable conductors with superimposed voltage, so as to simulate so far as possible the conditions in practice. Extending these tests by gradually increasing current and voltage on periodic cycles until thermal breakdown ensues enables the limits of thermal stability to be ascertained for the given conditions. Such tests are usually carried out in air with the cable laid out on the test house floor, the ends being properly terminated in porcelain insulators. From the results it is possible to calculate the critical temperature for any particular thermal condition, thus providing an indication of the thermal factor of safety in the given circumstances.

For the purpose of calculating the thermal breakdown phenomena the author shows the development of some of the heating formulæ which have been published earlier. These are dealt with under the headings of cable heating due to load current, and dielectric loss heating. Test results are given for various sizes and types of single- and three-core cables from 33 kv. to 132 kv. The examples show that, with accurate thermal data, it is possible to calculate the time/temperature effect reasonably closely and to predict the minimum probable time for thermal breakdown, since this practically approximates to the attainment of the critical temperature. Although in theory the cable may be thermally stable up to this point, the actual value of the dielectric loss is of no real practical significance, as it would be impossible for the cable to withstand such high temperature for long. However, the importance of the dielectric loss temperature coefficient and of the thermal resistance—mainly the external part, since the cable itself remains more or less constant—is definitely established with regard to thermal stability under working conditions. Since the critical temperature depends primarily upon these two characteristics, the ratio of critical temperature to working temperature can be looked upon as the thermal safety factor. It is evident that with high-voltage cables the relation between dielectric loss and temperature needs to be studied carefully in order that full allowance can be made for all the thermal factors of the installation.