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HIGH-VOLTAGE ELECTROSTATIC DC GENERATORS: A SURVEY

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[Note: The material below represents the 10th and last section of an article, with the above title, which appeared in Zhurnal Tekhnicheskoy Fiziki Vol. X No. 4 (1940), pages 177-198. The other nine section headings are:

1. Introduction
2. Concept of Van de Graaf's Generator
3. Discussion of the Operating Cycle of Electrostatic Generators
4. Scheme for High-Voltage Accelerating Tubes
5. Belt Generators Operating at Atmospheric Pressure
    - A. Small Generators up to 1000 kV
    - B. Generators with Voltages from 1000 to 2000 kV
    - C. Giant Generators
6. Belt Generators Operating in Compressed Gas
7. Generators with Gas Jet
8. Generators with Rigid Rotor
9. Generators with Cylindrical Rotor
10. Application of Electrostatic Generators (given below).]

10. APPLICATION OF ELECTROSTATIC GENERATORS.

a) The most important application of electrostatic generators is at the present time in physical research. We may mention the following investigations: 1) fast electrons; 2) scattering and absorption of gamma-rays;

3) protons and deuterons; 4) artificial radioactivity and nuclear reaction during bombardment with protons and deuterons; 5) action of neutrons, originating from bombardments by deuterons; 6) scattering of protons by protons etc. We cannot enter into the details of this research (many works are devoted to this topic) because it would be too long for this survey.

b) Recently electrostatic generators have been more and more employed in medicine. Some generators are constructed especially for medical purposes and are installed in hospitals. We may mention the Trump and Van der Graaf, generator installed in Huntington Memorial Hospital. This generator, which started operation in 1937, was used for considerable clinical work; up to now 10,000 separate x-ray sessions and 700 full radiations of patients have been recorded.

In 1939 Trump and Van der Graaf constructed a room-size 1250-kV generator operating in compressed gas, and also intended for use in medical institutions.

We have information that General Electric Company constructs several generators for medical purposes.

The production and investigating of hard X-rays (800 to 2000 kV) also for clinical application were studied with the reconstructed Van der Graaf giant generator [redacted]titute of Technology.

The [redacted]itted by electrostatic generators ensure wide therapeutic possibilities. Thus, 340 roentgens/minute is the intensity of X-rays emitted by the compact Trump and Van der Graaf generator for V = 1250 kV and anti-cathode current of 1 mA and with a filter equivalent to lead 5 mm thick and distance of 50 cm from the anti-cathode.

c) The application of electrostatic generators in other fields is much less important. For example not much application is found in high-voltage research. Here we may merely mention a series of tests by Anderson to test high-voltage vacuum input leads, and also some investigations of charge transmission and corona effects only of interest in general laboratory work.

Data on electrostatic generators used to study defects in metals by means of hard X-rays are lacking, although some time ago much research was devoted in this connection to gamma-rays from natural radioactive sources.

d) Until recently the electrostatic generator had some deficiencies as sources of electric energy; namely, low efficiency and small specific power W per unit volume.

Compared with the small power of generators, their size is rather bulky.

The Van der Graaf generator in Round-Hill, for $V_2 = 4$ MV and I = 2 mA, produces $W = 8.10^{-4}$ kW/m^3 and has a volume of 10^4 m^3.

The Trump and Van der Graaf generator in Huntington hospital has a volume of 300 m^3 and an output of $W = 3.10^{-3}$ kW/m^3 at $V = 10^6$ volts and I = 1 mA.

The LFTI generator (Note: LFTI is the Leningrad Physico-Technical Institute) with a rigid 2-meter rotor in kerosene gives for $V = 10^6$ V and I = 0.1 mA and a volume of 20 m^3 a specific power equal to $W = 5.10^{-3}$ kW/m^3

The giant generator operating in compressed gas and designed for a potential of 5 MV and current of 2 mA occupies a volume of 100 m^3; i.e. W = 0.1 kW/M^3.

The compact Trump and Van der Graaf generator operating in compressed gas at V = 1.5 MV and I = 1 mA and with a volume of 1.5 m^3 gives a specific output equal to W = 1 kW/m^3.

The small LFTI multi-disc model designed for 700 kV and 3 mA has a volume of 0.5 m^3; i.e. W = 4 kW/m^3.

The big multi-disc generators operating in a compressed dielectric gas will probably be able to yield specific power of the order of 100 kW/m^3.

The coefficients of efficiency for most generators are less than unity. The efficiency is extremely small in electrostatic generators with gas jets, where the efficiency is of the order of 0.03. In the belt generators of the

Van der Graaf type the efficiency is around 0.5, while for increasing belt speeds aerodynamic losses (windage) increase much faster than the output of electric energy. The efficiency of rotor and multi-disc rotor generators could be considerably increased with improved streamlining.

Of future interest are generators operating in vacuo; the possibility of creating strong potential gradients in vacuo and the absence of friction are advantageous in the design of electrostatic generators in vacuo with high specific power and with efficiency near unity.

Vacuum construction, however, involves great difficulties such as insulation of the necessary hermetical materials. The construction of electrostatic generators operating in vacuo was attempted in Van der Graaf's laboratory. A model, put in a steel tank at a pressure of 10^{-6} mm/Hg gave an output potential of the order of 200 kV. (Thereafter this model was used for operation in compressed gas, and then gave a potential of 1000 kV).

The unsuccessful attempt to construct an electrostatic generator operating in vacuo does not dismiss the problem; and probably in the future this problem will still be developed, because one is attracted by the idea of a compact high-voltage electrostatic generator with high specific power and efficiency near unity.

A trend to vacuum generators is indicated in multi-disc generators, where a good distribution of potential can be effected. If we could depend on a careful distribution of potential of 50 - 60 kV per sectional unit, we could in the future construct vacuum models (even without particular requirements of a vacuum) that possess increased specific power and efficiency.

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