May 18, 1965 J. CHRISTOFFERSON 3,184,621

HIGH VOLTAGE TERMINAL FOR TANDEM-TYPE CHARGED-PARTICLE ACCELERATOR

Filed March 20, 1962 2 Sheets-Sheet 1

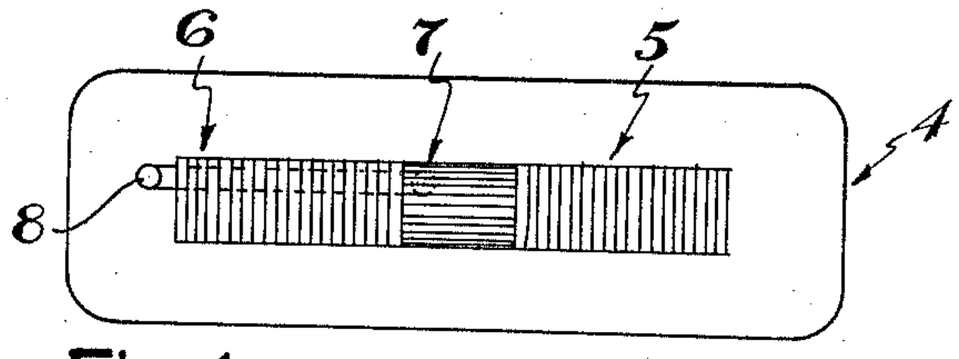

Fig. 1

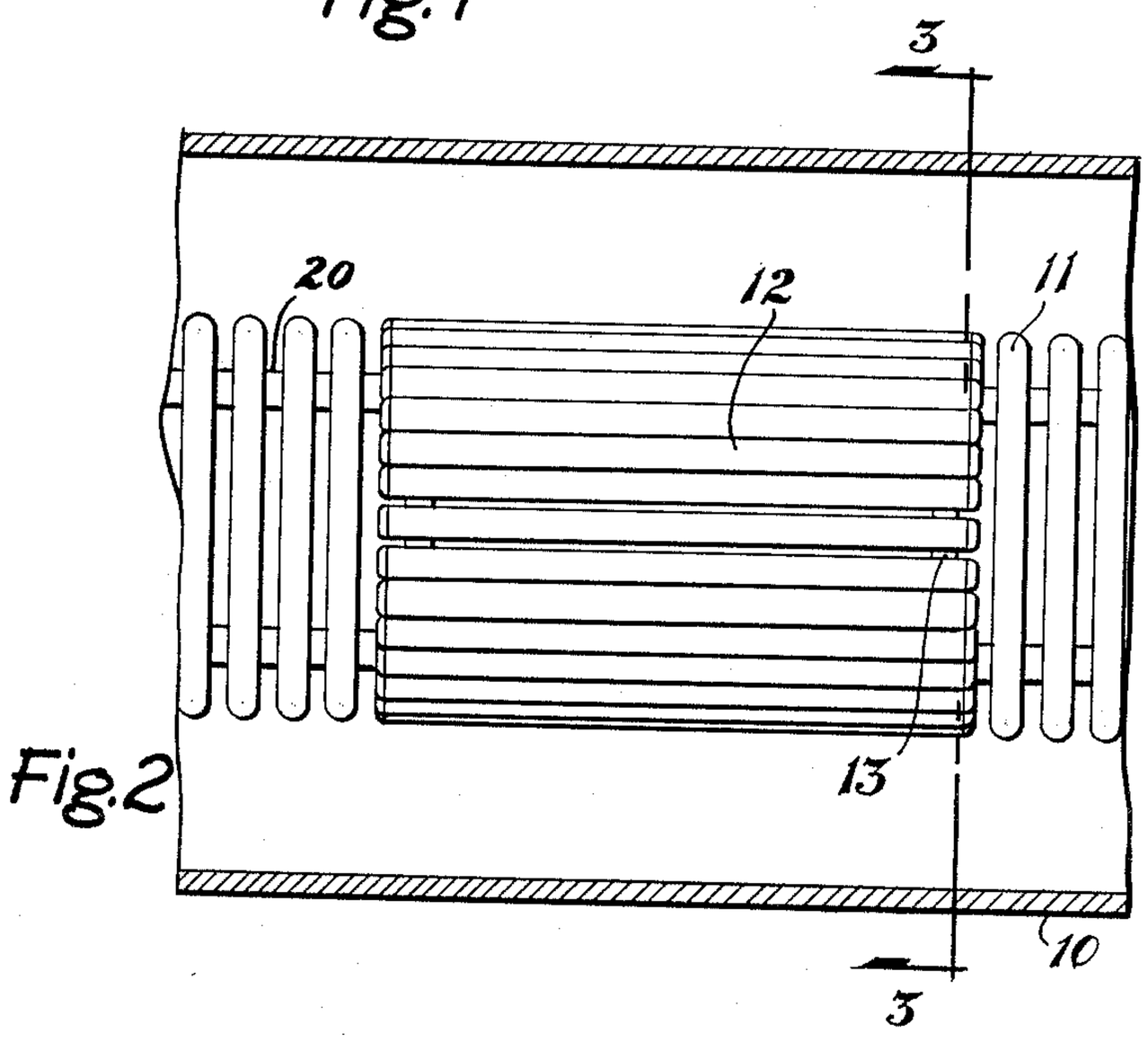

Fig. 2

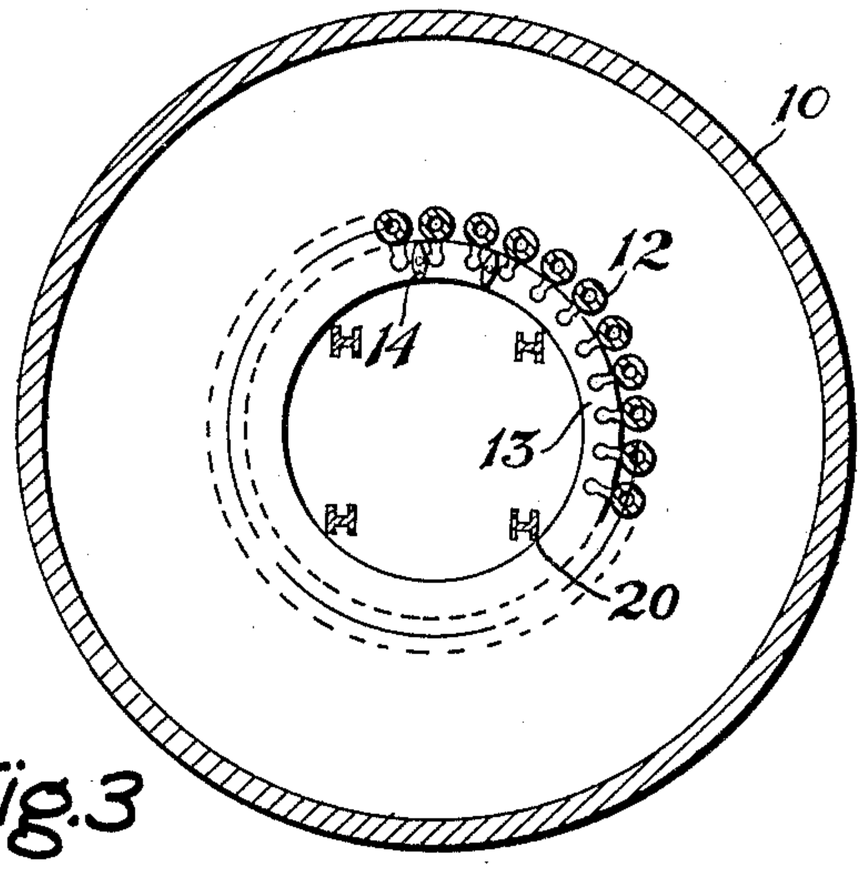

Fig. 3

May 18, 1965 J. CHRISTOFFERSON 3,184,621

HIGH VOLTAGE TERMINAL FOR TANDEM-TYPE CHARGED-PARTICLE ACCELERATOR

Filed March 20, 1962 2 Sheets-Sheet 2

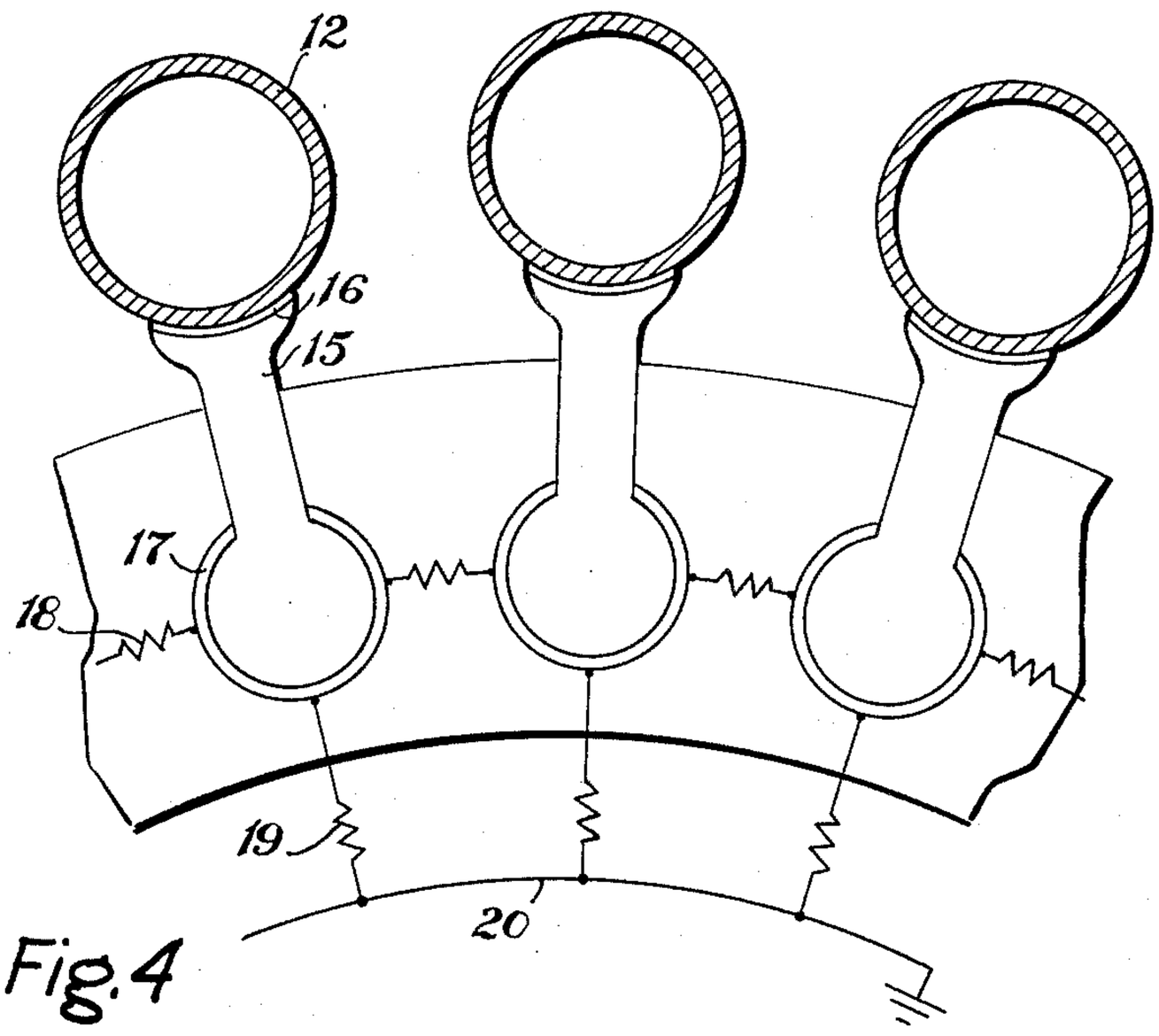

Fig. 4

United States Patent Office

3,184,621

Patented May 18, 1965

3,184,621

HIGH VOLTAGE TERMINAL FOR TANDEM-TYPE CHARGED-PARTICLE ACCELERATOR

James Christofferson, West Newbury, Mass., assignor to High Voltage Engineering Corporation, Burlington, Mass., a corporation of Massachusetts

Filed Mar. 20, 1962, Ser. No. 181,049
2 Claims. (Cl. 310—6)

This invention relates to charged particle accelerators and more particularly to high energy tandem electrostatic belt generators of the so-called Van de Graaff type, and to novel high voltage terminal structures therefor.

Electrostatic generators of the type comprehended by this invention usually include a cylindrical metallic terminal that is insulated from ground for high voltages by two voltage gradient structures. An electric charge is conveyed to the terminal by means of a rapidly moving belt of insulating material. In operation, a positive-ion beam from an external ion source is passed into an electron-adding canal wherein a flow of hydrogen causes the successive attachment of two electrons to a limited number of positive ions, transforming these into negative ions. The negative ion beam is deflected by a magnetic analyzing system so that negative ions of the correct mass and energy will be injected into an acceleration tube which is disposed within one of said voltage gradient structures. These negative ions are accelerated to the terminal which is kept at a high positive voltage by the charging belt system. Inside the terminal, the negative-ion beam passes into a stripping canal where the presence of gas causes it to be stripped of its electrons. Emerging as a positive-ion beam, it is given a second acceleration through the other voltage gradient structure, this time to ground potential. The positive ion beam is then deflected through a 90° magnetic analyzing system before proceeding to a switching system where it can be directed to any one of a number of targets.

The increasing demands of physics research has led to the design of generators of this type that are capable of producing charged particles having extremely high energy. Currently, machines adapted to operate at fifteen and twenty million volts and larger are being designed and produced. This increase in electrical capacity is accompanied by a commensurate increase in physical size and it is toward the solution of the various problems introduced by such increased physical size that the present invention is directed.

With the smaller, lower energy device, it is possible to remove the apparatus from the pressure tank within which it is housed if adjustment or maintenance of components is required. Access to parts residing within the high voltage terminal, which terminal generally consists of a polished cylindrical metal member, in these smaller generators is readily accomplished by the removal thereof. Larger generators have been designed having a high voltage terminal comprising a plurality of hoop members whereby access to the interior of the terminal may be accomplished by removal of a group of the hoops. Such access methods become impracticable, however, with respect to the larger electrostatic generators now being designed and produced. A cylindrical metal high voltage terminal that is greater than eight feet in length cannot readily be removed or easily handled.

Accordingly, it is a principal object of this invention to provide, in a charged particle accelerator, a new and improved high voltage terminal.

It is another object of this invention to provide, in a tandem electrostatic generator, a high voltage terminal adapted to permit access to the interior thereof without removal or displacement of the entire terminal.

It is another object of this invention to provide, in a tandem electrostatic generator, a high voltage terminal that comprises a plurality of tubular members arranged to form a cylindrical member that has greater flexibility than currently available devices.

It is another object of this invention to provide, in a tandem electrostatic generator, a high voltage terminal comprising a plurality of tubular members, said tubular members being characterized by ease of fabrication and assembly.

These, together with other objects and features of this invention will be more clearly understood from the following detailed description of one presently preferred embodiment thereof taken in conjunction with the accompanying drawing wherein

FIGURE 1 illustrates a tandem electrostatic generator of the type comprehended by this invention;

FIGURE 2 is an enlarged detail of the high voltage terminal thereof;

FIGURE 3 is a section through FIGURE 2 at 3—3; and

FIGURE 4 is a detail illustrating a method of inserting the component parts of said high voltage terminal.

Referring now to FIGURE 1, there is illustrated a tandem electrostatic generator of the type comprehended by this invention. Voltage gradient structures **5** and **6** support high voltage terminal **7** within pressure tank **4**. Terminal **7** is maintained at its high voltage by means of charge belt system **8**. An ion source (not shown) generates and directs charged particles through this apparatus as described above.

FIGURE 2 illustrates in detail the novel high voltage terminal structure of this invention. Instead of the conventional cylindrical metal terminal member, a plurality of tubular members **12** have been arranged to form a cage-like structure. These tubular members **12** are attached to two ring shaped members **13**. Members **13** are fabricated of insulating material, preferably Micarta. The high voltage terminal abuts grading rings **11** of voltage gradient structures **5**, **6** and is spaced apart from pressure tank wall **10** as shown. This novel high voltage terminal has several distinct advantages and is particularly suited to the very large machines now being produced. The tubular members **12** may be individually removed, as will hereinafter be described in detail, thereby giving ready access to any area within the terminal. This, of course, obviates the problem of completely dismantling the machine and removing the entire terminal to perform routine adjustments, and the like within the terminal itself. Also, the cage-like construction of the subject terminal provides for the ready passage of coolant fluid therethrough. Another important advantage of this invention is that members **12**, having a straight tubular geometry may be readily fabricated to close tolerances, thereby reducing the possibility of any voltage breakdowns to pressure tank wall **10** that might be initiated by an irregular surface. It is pointed out that members **12** are preferably, but not necessarily, tubular in form. Although solid rods could be used, the improved electrical characteristics associated with the larger diameter tube, together with the reduction in weight of a hollow member make the tubular embodiment most desirable.

With reference to FIGURES 3 and 4, there is illustrated in greater detail the manner in which members **12** are retained in discrete relationship to the adjacent voltage gradient structures. A Micarta ring member **13** is provided at each end of the terminal in fixed relationship to the said voltage gradient structures. Aluminum members **15** are attached to members **12** by a conductive epoxy cement **16** as shown in FIGURE 4. The aluminum members **15** have the same widths as Micarta ring members **13** and fit into the keyhole shaped slots therein. Pivotable lock-

ing members 14 are arranged to secure adjacent members 12 in place. In order to remove any member 12 it is only necessary to rotate member 14 to the position shown in FIGURE 3, shift said member 12 axially until members 15 are free of Micarta rings 13, and remove the said member 12.

An electrically conductive lining 17 is provided in each "key-hole" portion of Micarta ring members 13. Resistances 18 connect each of said keyhole portions together, and resistances 19 connect each of said keyhole portions to terminal support frame 20. In this manner, when the high voltage cage is completely assembled, each member 12 is electrically connected through appropriate resistances to each other and to said support frame. This arrangement has the advantage that if a voltage breakdown should occur between any particular member 12 and pressure tank wall 10, the overall effect on the entire terminal would be less severe. That is, a voltage breakdown or short circuit between any given number 12 and the tank wall would immediately discharge the electrical charge stored thereon. The resistance of the electrical connection between such a member and any adjacent member would oppose or inhibit a simultaneous discharge through said connection and short circuited member of the electrical charge stored on said adjacent member. The values of such resistances, then, are a function of the physical and electrical parameters of the electrostatic generator involved. For example, an electrical connection having a resistance of one thousand ohms would restrict the current that would flow between two such members of a one million volt generator to one hundred amperes in the event that one of the members were shorted to ground. For any given electrostatic generator, however, the permissible current, and the required resistance values and resistor current carrying capacities are determined in accordance with conventional engineering practices.

There has thus been described apparatus whereby the various objects of my invention may be accomplished. It is to be understood that the above-described arrangements are illustrative of the applications of the principles of this invention only. Numerous other arrangements may be devised by those skilled in the art without departing from the scope of the invention.

What is claimed is:

1. A tandem-type electrostatic generator adapted to generate voltages in the order of millions of volts comprising a pressure tank, and disposed therein, a high voltage terminal, a voltage gradient structure adapted to support said high voltage terminal in spaced relationship from said tank, and a charge belt system adapted to maintain a high electrical potential on said high voltage terminal, said high voltage terminal comprising at least two annular support members and a plurality of electrically interconnected tubular metallic members mounted thereon in closely spaced parallel relationship so as to form a cylindrical cage, said tubular metallic members being individually removable from said cage.

2. In a tandem type electrostatic generator having a terminal support frame, a high voltage terminal comprising first and second ring shaped insulating members, a multiplicity of straight tubular metallic members, said metallic members and said insulating members cooperating to establish a cylindrical cage, said metallic members being individually removable from said cage, a resistive electrical connecting member operably engaged between all adjacent metallic members, and a resistive electrical connecting member operably engaged between each metallic member and said terminal support frame.

References Cited in the file of this patent

UNITED STATES PATENTS

2,095,791	Chilton et. al.	Oct. 12, 1937
2,096,072	Spagnola	Oct. 19, 1937
2,295,816	Wilson	Sept. 15, 1942
2,451,987	Sloan	Oct. 19, 1948
2,545,595	Alvarez	Mar. 20, 1961

FOREIGN PATENTS

951,012	France	Apr. 4, 1949

Disclaimer

3,184,621.—*James Christofferson*, West Newbury, Mass. HIGH VOLTAGE TERMINAL FOR TANDEM-TYPE CHARGED-PARTICLE ACCELERATOR. Patent dated May 18, 1965. Disclaimer filed Mar. 8, 1965, by the assignee, *High Voltage Engineering Corporation*.

Hereby enters this disclaimer to the terminal portion of said patent subsequent to Jan. 20, 1982.

[*Official Gazette July 20, 1965.*]