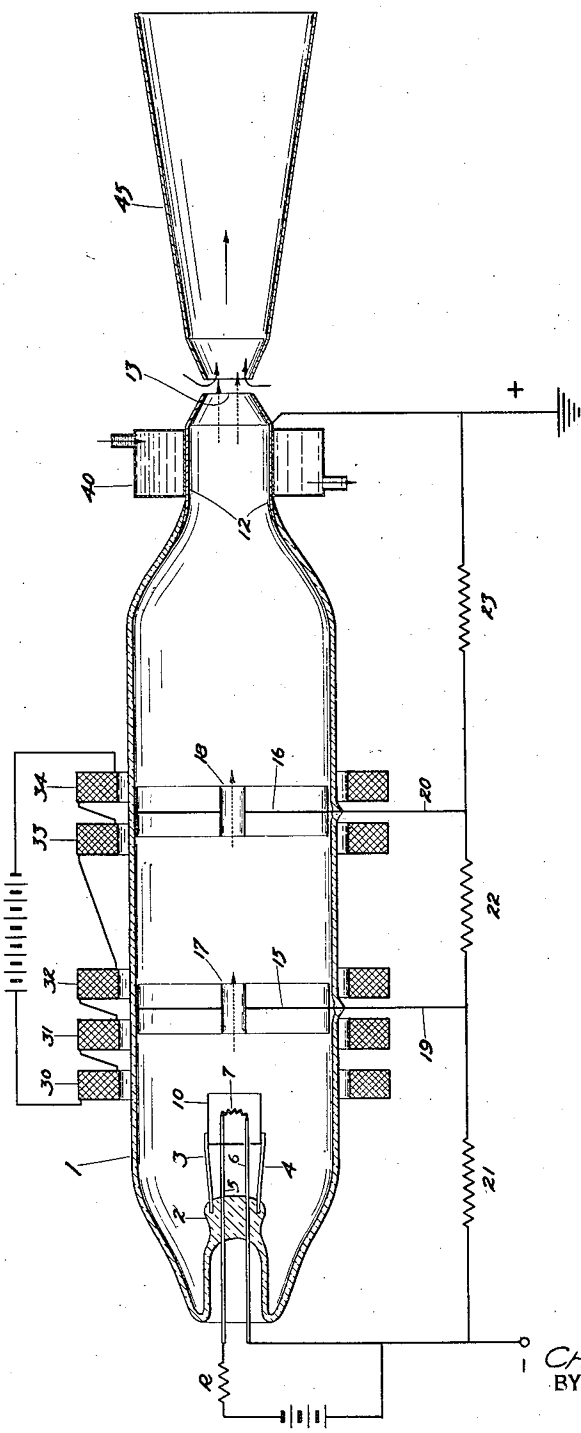
Dec. 26, 1933. C. G. SMITH 1,941,157

ELECTRON DISCHARGE APPARATUS

Original Filed Dec. 5, 1928



INVENTOR
CHARLES G. SMITH
BY
ATTORNEY

UNITED STATES PATENT OFFICE

1,941,157

ELECTRON DISCHARGE APPARATUS

Charles G. Smith, Medford, Mass., assignor, by mesne assignments, to Raytheon Manufacturing Company, Newton, Mass., a corporation of Delaware

Application December 5, 1928, Serial No. 323,902
Renewed March 3, 1931

3 Claims. (Cl. 250—27.5)

This invention relates to an electron discharge apparatus and especially to a device capable of causing electrons to be thrown out into the atmosphere at great speeds.

In the classical experiments of Lenard, a vessel having a thin metal wall, and having cooperating electrodes therein, was used to obtain the discharge of electrons into the air. While the potential between the electrodes was quite high, the number of electrons so obtained and the distance of penetration in the air were both disappointing. Recent investigations in this field have clearly indicated that voltages in the hundreds of thousands are necessary to obtain a stream of electrons which will go through the metal wall of the tube and penetrate for any considerable distance in the air. The uses to which such a device may be put are manifold. Thus, by shooting a beam of electrons into a stream of air so as to ionize the air, it is possible to fix the nitrogen therein. Many other startling results are easily obtainable by such a device providing electrons may be obtained at a sufficiently high speed.

As is well known, the difference in potential between two electrodes is the accelerating force for electrons going from one to the other. In order to obtain a device of this character which will yield a stream of electrons travelling at such speed that when they strike the thin metal wall of the tube, they will pass through, it is necessary to have a voltage of at least 150,000. The exact voltage varies with the thickness and nature of the metal wall. Under such conditions, the electrons in going through the wall will penetrate for several inches before being stopped. If great penetration is desired, it is necessary to increase the potential. When potentials are around a quarter of a million and over are to be used, defects inherent in the construction of ordinary tubes appear which give rise to undesirable phenomena and result in short circuits.

It is well known that even with the highest vacuum obtainable there are a certain number of free gas particles in the space. With the ordinary tube, the electrons travelling at such tremendous speeds strike and ionize these few particles and thus finally cause a stream of positive ions to be drawn to the cathode. In it there may be enough ions so that a flashover between the electrodes occurs with the establishment of a destructive arc.

In order to overcome this serious disadvantage and use extreme potentials, it has been proposed to dispose two or more of such tubes in series and have the electrodes very close to each other. Hence, electrons from the first one would go through the two walls of the adjacent tubes as well as any intervening space and then down to the other electrode and to the final anode. In this way, it has been possible to use much greater voltages. However, the benefits of this were greatly reduced by the losses due to extra walls.

An object of my invention is to devise a tube which will permit the use of extremely high potential without the danger of flashovers from ionization.

Another object of my invention is to devise such a structure so that the final speed of the electrons will be substantially and entirely due to the difference of potential and will not be substantially lessened by obstructions.

In general my invention comprises a tube of glass, quartz or other suitable insulating material at one end of which is a cathode which may be of the cold or thermionic type At the other end of this tube is a metal wall which forms the anode. This metal wall is just thick enough to withstand the atmospheric pressure. It may be made in various shapes, as spherical, or may be of very thin metal supported on a fine strong grid or gauze. The metal is preferably nickel, although beryllium and other metals may be used if desired.

Under ordinary conditions with such a tube the high speed electrons would ionize some of the few gas particles left after exhausting and cause the ions to travel toward the cathode. In order to prevent the ions from traveling the entire length of a tube bombarding the cathode and initiating an arc, I dispose metallic barriers or obstructions between the cathode and anode. These metallic obstructions are suitably connected so as to be at an intermediate potential between the cathode and anode. Thus, the cathode and anode may be connected by a high resistance of several hundred megohms. The obstructions are connected to intermediate portions of the resistance. Ions attracted toward the cathode will impinge on the metallic obstructions, be neutralized and become ordinary gas particles. In many cases, these are buried in the metal as by clean-up.

In order, however, to prevent the stream of electrons from having to go through the walls of the obstructions themselves, I dispose the obstructions in such manner that the channels therethrough are along the axis of the tube and in line between the cathode and anode. Around the tube I dispose one or more solenoids by which an intense magnetc field may be created. Ordinarily without the field, the electrons emerging from the cathode would go off in all directions because of their mutual repulsion. By providing an intense magnetic field whose axis coincides with the axis of the tube, the electrons emerging from the cathode are prevented from diverging and caused to travel in a concentrated compact beam. The electrons are thus influenced by the magnetic field in spite of their tremendous speed because of their very small mass.

The ions, however, are substantially unaffected by the magnetic field because of their relatively great mass. Hence, the ions formed will travel at will in space between obstructions to be finally disposed of by the obstruction. The electrons are thus allowed to go through the entire length of the tube and impinge on the metal wall and there to go through and strike the air particles in the atmosphere. A tube of this character may have impressed upon it potentials considerably in excess of a quarter of a million of volts.

The single figure in the drawing is a sectional view of a tube involving my invention.

The tube comprises an insulating container 1 of glass, quartz or any suitable material. At one end is an inwardly directed press 2 in which are sealed wires 3, 4, 5 and 6. Wires 3 and 4 support a cylindrical shield 10. Within this shield and connected to wires 5 and 6 is a filamentary cathode 7 of tungsten or any other suitable material. If desired, an oxide coated cathode may be used, although I prefer tungsten because of its greater purity and freedom from gases. The shield is slightly negative to the cathode and therefore tends to cause the electrons to leave in a beam because of repulsion. Battery A through a resistor R is suitably connected to energize cathode 7.

At the other end of the tube is sealed a metallic member 12 which tapers to a comparatively small circle. The end wall of metal member 12 is a thin member 13 of nickel suitably supported to withstand atmospheric pressure and constitutes the anode. Within the tube are metallic obstructions 15 and 16 which have centrally disposed channels 17 and 18. It will be noted that cathode 7, channels 17 and 18, and nickel member 13 are all in line and symmetrically disposed with respect to the axis of tube 1.

The tube is exhausted to as high a vacuum as possible and is thoroughly freed of all occluded gases in accordance with approved practice. Metal member 12 of the tube and cathode 7 are connected to the positive and negative terminals (+) and (−), respectively of a source of extremely high unidirectional potential. Thus a potential of 500,000 volts would be satisfactory. Between the anode and cathode are resistances 21, 22 and 23, which are one or two hundred megohms. Leads 19 and 20 connect obstruction 15 and 16 respectively to either side of resistance 22. Disposed around the tube are a plurality of coils 30, 31, 32, 33 and 34. These coils while shown as separate, may be in whatever units desired and might either be a long continuous coil or lumped coils. A battery energizes the coils and forms an intense longitudinal, magnetic field, especially around the obstructions.

The operation of the devices is as follows: Upon cathode 7 being suitably energized, a quantity of electrons is emitted therefrom. Shield 10 compels the electrons to be emitted outwardly along the axis of the tube. The intense magnetic field due to the solenoids, prevents a dispersion of the electron stream and causes them to go through passages 17 and 18 of the obstructions. Any ions formed in the region between obstruction 15 and the anode, will be, practically without any exception, trapped on the obstructions 15 or 16. The electron stream impinging on wall 13 has sufficient velocity to go through the wall and strike the particles of air outside. In order to prevent metal member 12 from being heated unduly, a water jacket 40 may be provided.

If the fixation of nitrogen into its oxides is to be accomplished, a blast of air shown by the full arrows may be provided from the outside region to the inside region of a conical member 45. The dotted line arrows indicating the electrons, strike a large number of air particles and ionize them, and cause the chemical union between the nitrogen and other element. With air, one or more oxides of nitrogen would be formed from which compound nitrates are obtainable by well known chemical methods.

While I have disclosed my invention as being applied to the fixation of nitrogen, I do not limit the scope of usefulness of my invention to that field alone. In fact it is not even necessary for the electrons to leave the tube. Instead of the thin wall through which the electrons are to pass, it is possible to substitute a target for the generation of X-rays. Other uses and modifications will occur to those skilled in the art.

I claim:

1. An electron discharge device for projecting high-speed electrons, comprising a highly-evacuated, longitudinally-extending vessel, an electron-emitting cathode and an anode disposed at the ends of said vessel and separated by a discharge path over which electrons from the cathode are driven toward said anode under the action of a high potential, one or more conducting partition walls extending transversely across the vessel, subdividing the vessel into a plurality of serially-arranged sections, said partition walls having aligned openings providing a narrow channel between said cathode and anode through said discharge path, means for producing a magnetic field through each of said openings in the direction of the discharge for confining the path of the electrons flowing from said cathode to said anode to said narrow channel and for preventing impingement of electrons on parts lying outside said channel, and means including said partition walls adapted to impress upon the individual sections successive fractions of a source of a high-voltage driving potential to cause progressive acceleration of the electrons from section to section along said channel toward said anode, said conducting partition walls having an extensive surface sufficient to trap positive ions in the space within said sections, tending to flow toward said cathode.

2. A cathode-ray tube comprising a highly-evacuated, longitudinally-extending vessel, an electron-emitting cathode and an anode disposed at the ends of said vessel and separated by a discharge path over which electrons from the cathode are driven toward said anode under the action of a high potential, said anode forming a portion of the enclosed wall of said vessel and having a thickness permitting passage of high velocity electrons therefrom, one or more conducting partition walls extending transversely across the vessel, subdividing the vessel into a plurality of serially-arranged sections, said partition walls having aligned openings providing a

narrow channel between said cathode and anode through said discharge path, means for producing a magnetic field through each of said openings in the direction of the discharge for confining the path of the electrons flowing from said cathode to said anode to said narrow channel and for preventing impingement of electrons on parts lying outside said channel, and means including said partition walls adapted to impress upon the individual sections successive fractions of a source of a high-voltage driving potential sufficient to cause substantially uniform progressive acceleration of the electrons from section to section along said channel toward said anode to a velocity at which they penetrate said anode, said conducting partition walls having an extensive surface sufficient to trap positive ions in the space within said sections tending to flow toward said cathode.

3. An electron discharge device for projecting high-speed electrons, comprising a highly-evacuated, longitudinally-extending vessel, an electron-emitting cathode and an anode disposed at the ends of said vessel and separated by a discharge path over which electrons from the cathode are driven toward said anode under the action of a high potential, a conducting partition wall extending transversely across the vessel, subdividing the vessel into a plurality of serially-arranged sections, said partition wall having an aligned opening providing a narrow channel between said cathode and anode through said discharge path, means for producing a magnetic field through said opening in the direction of the discharge for confining the path of the electrons flowing from said cathode to said anode to said narrow channel and for preventing impingement of electrons on parts lying outside said channel, and means including said partition wall adapted to impress upon the individual sections successive fractions of a source of a high-voltage driving potential to cause progressive acceleration of the electrons from section to section along said channel toward said anode, said conducting partition wall having an extensive surface sufficient to trap positive ions in the space within said sections, tending to flow toward said cathode.

CHARLES G. SMITH.