

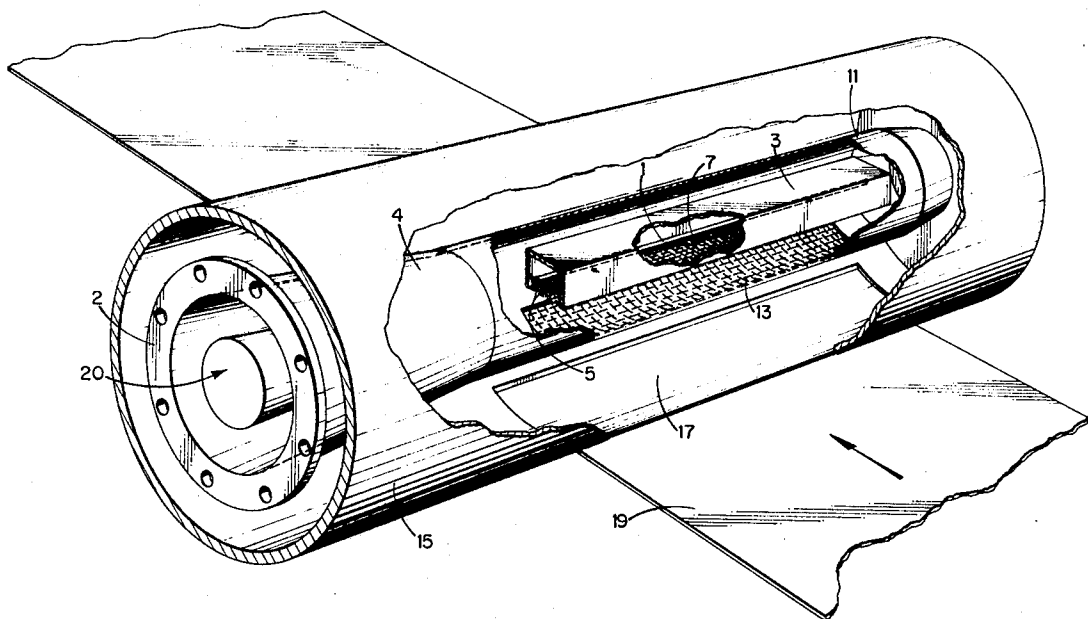
- [54] **APPARATUS FOR AND METHOD OF PRODUCING AN ENERGETIC ELECTRON CURTAIN**
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- [58] Field of Search**315/39; 313/82 NC, 83, 74, 313/299; 328/233**

- [56] **References Cited**
- UNITED STATES PATENTS**
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|-----------|--------|------------|--------|
| 2,887,599 | 5/1959 | Trump..... | 313/74 |
| 3,099,762 | 7/1963 | Hertz..... | 313/74 |
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[57] **ABSTRACT**

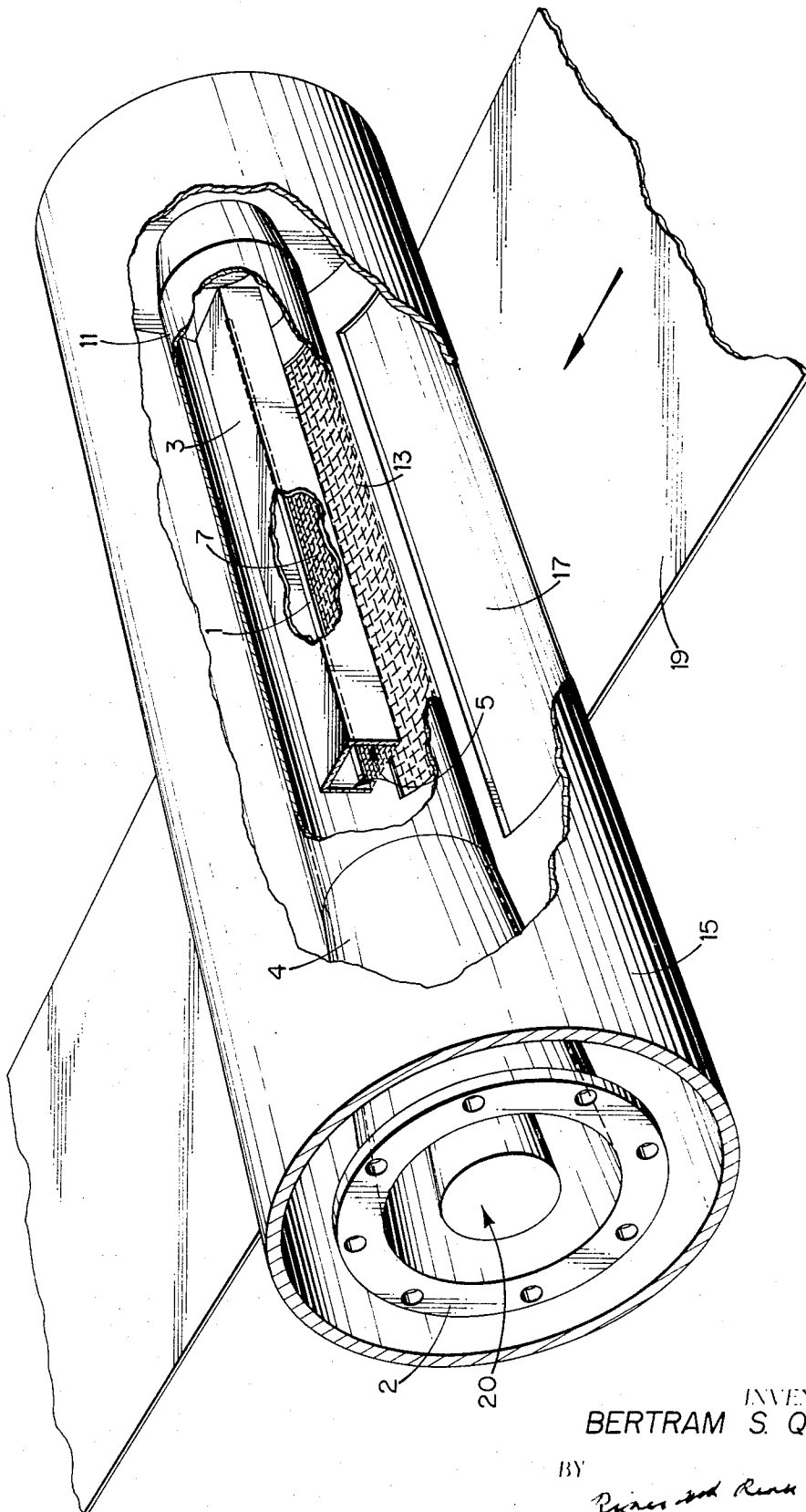
This disclosure deals with the shaping of a longitudinal space-charge-limited line of electrons into a substantially uniform electron density curtain, accelerating the same along field lines that expand the curtain, and then passing the expanded curtain through a longitudinal window for irradiation purposes and the like.

7 Claims, 1 Drawing Figure



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APPARATUS FOR AND METHOD OF PRODUCING AN ENERGETIC ELECTRON CURTAIN

The present invention relates to apparatus for and methods of producing an energetic electron curtain, being more particularly, though not exclusively, directed to the electron irradiating of relatively long articles.

In order to enable the electron beam irradiation of articles of substantial dimensions, resort has been had to scanning a focused beam along such dimensions as described, for example, in "The Industrial Electron Processing System," High Voltage Engineering Corporation Catalogue — 5/69. Such techniques not only require scanning or deflection apparatus and driving circuits therefor, but require collimating or focusing structures, as well, to produce a defined beam that can be scanned. In addition, though scanning may be effected rapidly, all parts of the objects are not actually simultaneously irradiated, and differences in electron density are produced in different positions of the scan in view of different path lengths of the beam. It has also been proposed, accordingly, to produce a strip or line of electrons to enable simultaneity of irradiation, as, for example, in U.S. Pat. No. 2,887,599 to Trump; but such proposals have not proven practical because of variation of electron emission at different points of the long cathode, in view of inherently different points of the long cathode, in view of inherently different temperatures therealong, and in view of wide variation in current density along the line of electrons.

It is to the solution of the problem of providing a substantially uniform density, longitudinally extending, high energy electron curtain, not subject to the above disadvantages, that the present invention is accordingly primarily directed.

A further object of the invention is to provide a novel apparatus for and method of producing energetic electrons of more general utility, as well.

Other and further objects will be explained hereinafter and are more particularly delineated in the appended claims. In summary, the invention contemplates, in one of its broad aspects, the shaping of a longitudinal space-charge-limited line of electrons into a substantially uniform electron density curtain, accelerating the same along field lines that expand the curtain, and then passing the expanded curtain through a longitudinal window for irradiation purposes and the like.

The invention will now be described with reference to the accompanying drawing, the single FIGURE of which is an isometric view of a preferred apparatus operating in accordance with the method of the invention, with regions partly broken away to illustrate details of construction.

Referring to the drawing, a longitudinal cathode is shown at 1 in the form of a tungsten or other electron-emitting line filament or indirectly heated strip or the like, suspended from a gun structure or channel 3 provided with heat shielding walls 5, as of, for example, multifoil thermal barrier as made by Thermoelectron Corporation, Waltham, Massachusetts, and described in their 1970 catalogue, "Multi-Foil Thermal Insulation." The channel 3 is provided at the bottom with a control grid 7 extending longitudinally parallel to and coextensively with the cathode 1 and transversely thereof to the walls of the channel structure 3. By con-

trolling the potential applied between the control grid 7 and the cathode 1, which can be achieved easily via low voltage control connections which pass within the high voltage connection tube 20, such that the former is negative with respect to the latter, the electrons leaving the different-temperature portions of the cathode 1 become space-charge limited such that a substantially longitudinally uniform charge-density beam is emitted through the grid 7, but usually with a non-uniform transverse charge density of greater density centrally under the cathode 1 than transversely at the sides thereof near the walls 5 of the channel structure 3.

This beam is shaped by a preferably coaxially surrounding cylindrical electrostatic shield or Faraday cage structure 11 substantially axially containing the cathode 1 and having a further longitudinal grid structure 13 aligned with the cathode 1 and control grid 7. This cage structure 11 is supported by a dielectric structure such as the vacuum feed through bushing. With an appropriate positive potential applied at 11 with respect to the control grid 7, the non-uniform transverse charge density become converted into a substantially uniform electron curtain. An anode-cylinder 15 coaxially surrounds the cage 11, with the whole system vacuum-sealed at 2, and the anode cylinder contains a longitudinal electron-pervious window 17, as of aluminum, aligned with the control and further grid structures 7 and 13. The anode structure 15-17 is maintained at an accelerating potential above the cage 11, though grounded to avoid shock hazard. The radial lines of the voltage gradient or field thus set up between the cylinders 11 and 15 (or other geometrical configurations, if used) will cause the electron curtain at the further grid 13 to expand in the gap or space between 11 and 15 along the radial lines of force, broadening the electron curtain so as uniformly and simultaneously to irradiate, through the window 17, all parts of corresponding longitudinal or long-dimension objects-to-be-treated (not shown), carried transversely past the window 17 by a conveyor or other mechanism 19, in the direction of the arrow. With this structure wherein the longitudinal dimension of the electron curtain is very large compared with the cathode-to-window separation, and with appropriate potentials, as later illustrated, the uniform current density of the expanded energetic electron curtain at the window 17 will be determined substantially by the electron distribution at the beam-shaping grid 13, and substantially independent of the accelerating potential, the large field of which only serves to expand and accelerate the electron curtain.

As an example of practical apparatus of this design, energetic electron curtains of uniform current density of from 200 to 2,000 μ amperes/cm.² may be obtained with a control grid-to-cathode potential of about -20 volts, a beam-shaping grid potential of from about +800 to 1,000 volts, and an accelerating potential between the grounded anode and window structure 15-17 (about 8 inches in diameter) of about 150 kilovolts. With a 6-inch long tungsten filament cathode 1, very long compared to the approximately 0.010 inch width thereof, a 6-inch long control grid 7 about one-fourth inch wide, a 6-inch long beam-forming grid 13 about one-half inch wide, a 6-inch long wider window 17 (about 1-inch in width) for receiving the expanded

curtain, current density uniformity of ± 10 percent and better has been obtained over about a 6-inch beam width.

Further modifications will occur to those skilled in this art, and all such are considered to fall within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. Apparatus for producing a curtain of energetic electrons having, in combination, a longitudinally extending electron-emitting cathode, a control grid structure positioned on one side of the cathode and extending longitudinally therealong and transversely thereacross, means for applying a space-charge limiting potential between the cathode and control grid to generate at the egress of the control grid a longitudinally extending electron beam substantially uniform in density longitudinally but non-uniform transversely with substantially greater density centrally than transversely to the sides, a Faraday cage structure surrounding the cathode and control grid and provided with a further grid substantially aligned with the cathode and control grid for shaping the non-uniform transverse electron beam density into a substantially uniform density curtain, an anode structure surrounding the Faraday cage structure and having an electron-pervious window substantially aligned with the control and further grids, and means for establishing an accelerating-voltage gradient field between the further grid and the window such that the substantially uniform density electron curtain may expand along the lines of the field and pass through the window with a current density distribution at the window determined substantially by the electron distribution at the further grid.

2. Apparatus as claimed in claim 1 and in which the said potential applying means maintains the said con-

trol grid negative with respect to the cathode and the said anode structure is grounded but at positive potential with respect to the said further grid.

3. Apparatus as claimed in claim 1 and in which the said Faraday cage structure and the surrounding anode structure are cylindrically substantially coaxially disposed.

4. Apparatus as claimed in claim 1 and in which means is provided for carrying objects with longitudinal dimensions corresponding to that of the window past the same in order to permit substantially uniform and simultaneous longitudinal energetic electron irradiation by the electron curtain.

5. Apparatus as claimed in claim 1 and in which the longitudinal dimension of said curtain is large compared with the distance between the control grid and anode structure.

6. A method of energetic electron beam irradiation, that comprises, simultaneously emitting electrons along a longitudinal line, space-charge limiting the emitted electrons to produce a longitudinally extending electron beam substantially uniform in density longitudinally, but non-uniform transversely, shaping the longitudinal electron beam to convert the non-uniform transverse beam density thereof into a substantially uniform density electron curtain, directing said curtain into an accelerating electric field to expand the electron curtain along the lines of said field, and ejecting the expanded electron curtain with a current density distribution determined substantially by the electron distribution just prior to expansion.

7. A method as claimed in claim 6 and in which said accelerating electric field lines are set up in the pattern of radial lines between cylindrical surfaces such that the electron curtain expands along said radial lines.

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