

July 1, 1958

W. C. WILEY

2,841,729

MAGNETIC ELECTRON MULTIPLIER

Filed Sept. 1. 1955

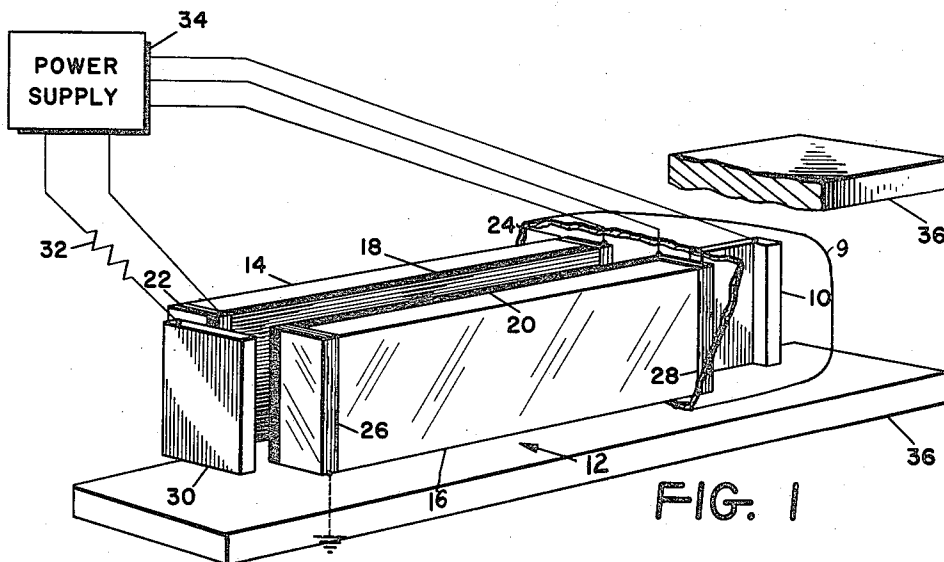


FIG. 1

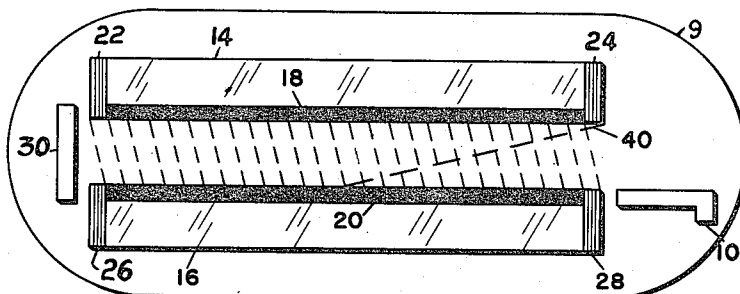


FIG. 2

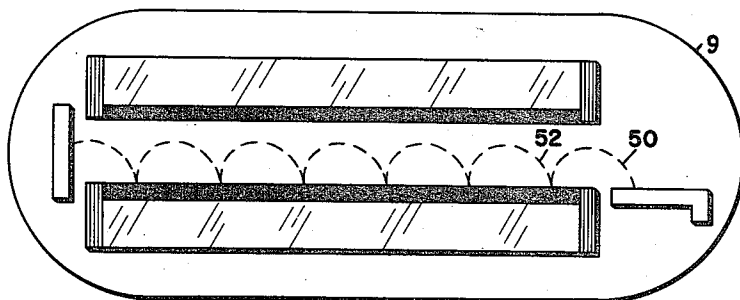


FIG. 3

INVENTOR.

WILLIAM C. WILEY

BY

Wett Parsigian

ATTORNEY

1

2,841,729

MAGNETIC ELECTRON MULTIPLIER

William C. Wiley, Detroit, Mich., assignor to Bendix Aviation Corporation, Detroit, Mich., a corporation of Delaware

Application September 1, 1955, Serial No. 531,878

4 Claims. (Cl. 313—104)

This invention relates to magnetic electron multipliers. Magnetic electron multipliers in present use include a plurality of plates which are spaced from one another in a plane or in a stepped relationship. These multipliers are disadvantageous in that the cost of mounting and supplying power for a large number of separate plates is very high and it is difficult to provide a uniform electric field without appreciable distortion. Furthermore, the structure of both the plane and stepped arrangements occupy an excessive volume.

This invention provides a magnetic electron multiplier which is inexpensive to construct and operate and is reliable in its operation. The multiplier includes a pair of plates, each plate being provided with a conductive surface. The plates are disposed in substantially parallel relationship with the conductive surfaces facing each other and a current is passed through each conductive surface to provide a uniform electric field in the region between the plates. Electrons introduced to the region between the plates travel in cycloidal paths and become multiplied as they successively strike the conductive surface of one of the plates.

An object of this invention is to provide a magnetic electron multiplier.

Another object of this invention is to provide a magnetic electron multiplier including a pair of continuous plates arranged in substantially parallel relationship.

A further object of this invention is to provide a multiplier of the above character in which each plate is provided with a conductive inner surface for the passage of current through each surface to produce an electric field in the region between the plates.

Other objects and advantages will become apparent from the following detailed description and from the appended claims and drawings.

In the drawings:

Figure 1 is a perspective view, partly in block form, schematically illustrating a magnetic electron multiplier constituting one embodiment of this invention.

Figure 2 is a plan view illustrating the electric field produced in the multiplier shown in Figure 1.

Figure 3 is a plan view illustrating the operation of the multiplier shown in Figure 1.

In one embodiment of the invention a vacuum tube 9 encloses a source for emitting electrons, such as a cathode 10, which is positioned to introduce electrons to a magnetic electron multiplier generally indicated at 12. The multiplier 12 includes a pair of substantially parallel plates 14 and 16 which are spaced from each other a distance such as $\frac{1}{4}$ inch. The plates 14 and 16 are made of an insulating material such as glass or Bakelite.

The plate 14 is provided with a conductive coating on strip 18 on its inner surface and a similar conductive strip 20 is provided on the inner surface of the plate 16. The conductive strips 18 and 20 are made of a secondary electron emissive material having a relatively high resistance such as a tin oxide or carbon compound. Since the secondary emissive properties of the strip 18 are

2

not utilized, if manufacturing economies may be achieved thereby, the strip 18 may be made from a material which has a relatively high resistance but which does not have outstanding secondary emissive properties.

Terminals 22 and 24 are provided on the opposite ends of the plate 14 in contact with the conductive strip 18. Similarly, terminals 26 and 28 are provided on the opposite ends of the plate 16 in contact with the conductive strip 20. The terminals 22, 24, 26 and 28 are made of a conductive material having a very low resistance, such as silver.

An anode plate 30 is disposed in substantially perpendicular relationship to the plates 14 and 16 to receive any electrons passed between the plates. The anode 30 is connected through a resistance 32 to a power supply 34 which applies a direct voltage such as +1500 volts to the anode.

Direct voltages, such as +1500 volts and +1500 volts are applied respectively to the terminals 22 and 24 from the power supply 26. A direct voltage, such as -3000 volts, is applied to the terminal 28 from the power supply and the terminal 26 is grounded. A direct voltage, such as -3200 volts, is also applied to the cathode 10 from the power supply.

A pair of pole pieces 36 are disposed above and below the plates 14 and 16 to provide a magnetic field in the region between the plates in a vertical direction and substantially parallel to the face of the plates. For example, a magnetic field of 300 Gauss may be provided by the pole pieces.

The application of the direct voltages to the terminals 22 and 24 produces a flow of current through the conductive strip 18. The amount of current flow is relatively small because of the high resistance of the strip 18. For example, a current of one milliampere may be produced in the strip 18. This current flow results in a uniform voltage drop across the conductive strip 18 between the terminals 22 and 24. A similar current flow and uniform voltage drop results across the conductive strip 20 between the terminals 26 and 28.

Although the magnitude of the voltage drop across the strips 18 and 20 is substantially the same, the drop in each strip occurs between different potential levels. This causes the equipotential lines between the strips 18 and 20 to be slanting. For example, equipotential line -1500 volts is represented by the slanting line 40 (Figure 2) which is drawn between the terminal 24 and an intermediate position in the strip 20. Since the electric field in a region is disposed in a direction perpendicular to the equipotential lines in the region, the electric field shown in Figure 2 is produced in the region between the strips 18 and 20 in a direction perpendicular to the equipotential line 40. This field has a component substantially perpendicular to the plates 14 and 16 in a direction for causing any electrons in the region to move towards the plate 14. The field also has a component substantially parallel to the plates 14 and 16 in a direction to cause any electrons in the region to acquire energy in their travel to the anode 22. In this way the electrons acquire sufficient energy to cause secondary emission at a ratio greater than 1:1 when they impinge upon a surface of the plates.

Electrons emitted by the cathode 10 are subjected to the combined action of the magnetic field and electric field in the region between the plates 14 and 16. This causes the electrons to travel in a cycloidal path 50 and to strike the surface of the strip 20 which emits a proportionately increased number of electrons. The electrons emitted by the strip 20 travel in a cycloidal path 52 and impinge upon another part of the strip 20 to again emit a proportionately increased number of electrons for cycloidal travel to another part of the strip

18. In this way, successively emitted electrons travel across the surface of the strip 20 in successive cycloidal paths as shown in Figure 2 to multiply the number of electrons initially emitted by the cathode 10. Finally, the electrons emitted by the strip 20 at its extreme left impinge upon the anode 30 for detection.

The invention disclosed above has several important advantages. Since only two plates are required in the multiplier, the cost of mounting the plates and for supplying power to them is relatively small. Also, the provision of a uniform electric field becomes a simple matter. The provision of a uniform electric field is highly advantageous in that it reduces the transit time spread of the electrons and increases the band width of the multiplier. Furthermore, the volume requirements of the multiplier can be made very small by limiting the thickness of the plates.

It will be recognized by persons skilled in the art, that this invention will be very useful for particle detection, such as in mass spectrometry, and will also be useful for general amplification purposes and for photomultiplication.

Although this invention has been disclosed and illustrated with reference to particular applications, the principles involved are susceptible of numerous other applications which will be apparent to persons skilled in the art. The invention is, therefore, to be limited only as indicated by the scope of the appended claims.

What I claim is:

1. A magnetic electron multiplier, including, a first plate, a second plate disposed a particular distance from the first plate in substantially parallel relationship to the plate to define a first region between the first and second plates, means for producing a uniform voltage drop across the first plate, means for producing a uniform voltage drop across the second plate at a potential relative to the voltage drop across the first plate to provide in the first region an electric field having a component in a direction substantially perpendicular to the plates, and means for providing a magnetic field in the first region in a direction perpendicular to the electric field and parallel to the plates.

2. A magnetic electron multiplier, including, a first plate made of an insulating material, a second plate made of an insulating material, the second plate being disposed a particular distance from the first plate in substantially parallel relationship to the plate to define a first region between the first and second plates, a first conductive coating on a surface of the first plate contiguous to the first region, a second conductive coating on a surface of the second plate contiguous to the first region, means for applying a first voltage across the first conductive coating to produce a current flow through the coating and a uniform voltage drop across the sur-

face of the coating, means for applying a second voltage across the second conductive coating to produce a current flow through the coating and a uniform voltage drop across the surface of the coating, the voltage drop across the second conductive coating being at a potential relative to the voltage drop across the first conductive coating to produce in the first region an electric field having a component in a direction substantially perpendicular to the plates, and means for providing a magnetic field in the first region in a direction perpendicular to the electric field and parallel to the plates.

3. A magnetic electron multiplier, including, a first plate, a second plate disposed a particular distance from the first plate in substantially parallel relationship to the plate to define a first region between the first and second plates, means for producing a voltage drop of uniform gradient across the first plate, means for producing a voltage drop of uniform gradient across the second plate, the gradient across the second plate being the same magnitude as the gradient across the first plate and the potential level of the voltage drop across the second plate being different than the potential level of the voltage drop across the first plate to provide in the first region a uniform electric field having a component in a direction substantially perpendicular to the plates, and means for providing a magnetic field in the first region in a direction substantially perpendicular to the electric field and substantially parallel to the plates.

4. A magnetic electron multiplier, including, a first plate, a second plate disposed a particular distance from the first plate in substantially parallel relationship to the plate to define a first region between the first and second plates, means for producing across the first plate a voltage drop of uniform gradient, means for producing across the second plate a voltage drop of uniform gradient having the same magnitude as the gradient across the first plate, the voltage drop across the second plate being at a potential level relative to the voltage drop across the first plate to produce in the first region a uniform electric field having a first component in a direction substantially perpendicular to the plates and a second component in a direction substantially parallel to the plates, and means for providing a magnetic field in the first region in a direction substantially perpendicular to the electric field and substantially parallel to the plates.

References Cited in the file of this patent

UNITED STATES PATENTS

2,130,152	Perkins	Sept. 13, 1938
2,141,322	Thompson	Dec. 27, 1938
2,143,146	Farnsworth	Jan. 10, 1939

FOREIGN PATENTS

884,059	Germany	July 23, 1953
---------	---------	---------------

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,841,729

July 1, 1958

William C. Wiley

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 66, for "coating on" read ~~on~~ coating or ~~on~~; column 2, line 18, for "~~1500~~", second occurrence, read ~~1500~~; line 20, for "26" read ~~26~~ 34.

Signed and sealed this 21st day of July 1959.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,841,729

July 1, 1958

William C. Wiley

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 66, for "coating on" read ~~on~~ coating or ~~on~~; column 2, line 18, for "~~1500~~", second occurrence, read ~~1500~~; line 20, for "26" read ~~26~~ 34.

Signed and sealed this 21st day of July 1959.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents