Dec. 21, 1965 R. R. THOMPSON 3,225,239

ELECTRON MULTIPLIER

Filed Nov. 15, 1960

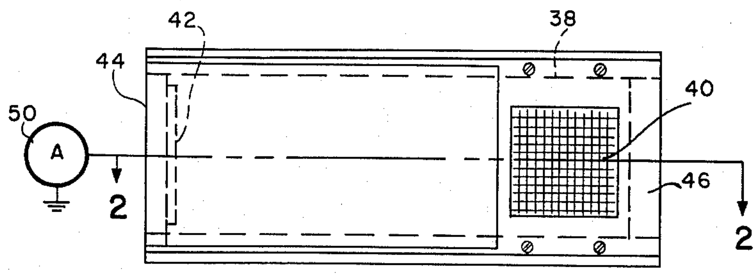

FIG. 1

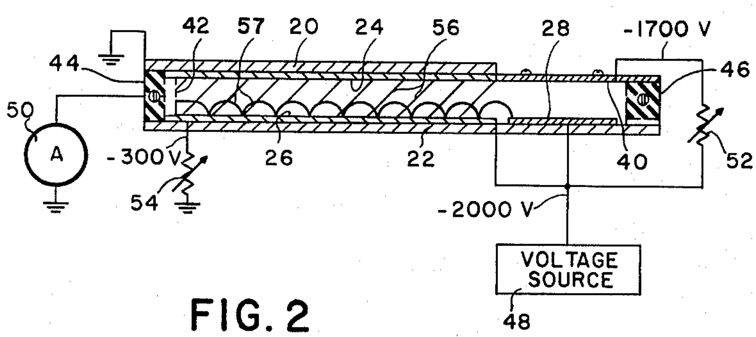

FIG. 2

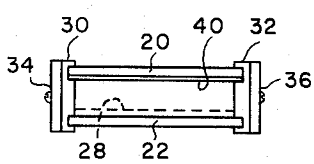

FIG. 3

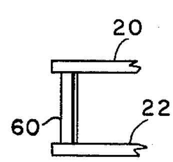

FIG. 4

INVENTOR.
ROBERT R. THOMPSON

BY

ATTORNEY

United States Patent Office

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ELECTRON MULTIPLIER

Robert R. Thompson, Livonia, Mich., assignor to The Bendix Corporation, Southfield, Mich., a corporation of Delaware

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This invention pertains to an electron multiplier of the kind where electrons are caused to cycloid by magnetic and electric fields against a secondary emissive surface, wherein the means for establishing the magnetic field are used to establish the electric field, making unnecessary separate electric field strips and dynode strips.

It is an object of this invention to provide such an electron multiplier having a pair of closely spaced permanent magnets having their north poles aligned and their south poles aligned to provide magnetic lines of force between the plates and between the north and south poles. The magnets may be coated with a resistive material and a voltage source may be connected to the coatings to establish electric currents in the coatings transverse to the magnetic lines of force. Charged particles, then may be introduced between the magnetic plates and caused to cycloid against one of the resistive surfaces, resulting in a multiplying action.

This and other objects will become more apparent when preferred embodiments are considered in connection with the drawings wherein:

FIGURE 1 is a plan view of a preferred embodiment of this invention;

FIGURE 2 is a section taken at 2—2 of FIGURE 1;

FIGURE 3 is an end view of FIGURE 2; and

FIGURE 4 is an end view of an embodiment wherein the magnetic plates are separated by spaced posts instead of a continuous strip of insulation.

Looking at the drawings, and especially FIGURES 1, 2 and 3, is seen a pair of magnets **20**, **22**, which may be of a ferrite material such as $BaO \cdot 6Fe_2O_3$, each of which has a coating **24**, **26** of antimony tin on their inner sides. A further coating is formed on the lower magnet **22** and provides a cathode **28**. This coating may also be antimony tin but for ultra violet photon detection, for which this embodiment is particularly adapted to, tungsten, nickel, or platinum is preferable.

Permanent magnets **20**, **22** have their north and south poles aligned as indicated in FIGURE 3, with the two north poles at the left side of the magnets and the two south poles at the right side of the magnets, so that a magnetic field is created between the magnets from the north pole side to the south pole side.

Separating the magnets **20**, **22** a distance of .2″ are longitudinal strips **30**, **32** made of a polymer of trifluorochloroethylene, each having a pair of longitudinal grooves formed therein to receive the north and south pole sides of magnets **20**, **22**. Bolted or otherwise connected to each strip **30**, **32** is a polepiece **34**, **36**, of soft iron or other magnetic material. The polepieces **34**, **36** form part of the magnetic circuit and reduce the reluctance of the path of magnetic lines of force. Bolted to insulation strips **30** and **32** on the upper surface of the multiplier and approximately horizontally aligned with upper magnet **20**, is a grid frame **38** which contains at the center part thereof a nickel mesh **40** which is substantially above and vertically in line with cathode **28**. Located at the opposite end of the multiplier is an anode **42** which is bolted or otherwise fixed to an end section **44** of insulative material. Also, there is an end section **46** of insulative material between the right ends of the multiplier. Connected through insulation **44** to anode **42** is a micro ammeter **50**.

A voltage source **48** supplies a large negative voltage, such as a —2000 volts, to one end of coating **26**, cathode **28**, and potentiometer **52**. The other end of potentiometer **52** is connected to grid **40** and the potentiometer is set so that the potential applied at grid **40** is a —1700 volts. Grid **40** is in electrical connection with resistive coating **24** and, hence, a potential of approximately —1700 volts exists at the right end of coating **24** and the other end of coating **24** may be grounded so that its potential is zero. The coating **26** on the lower magnet **22** is connected at one end to the —2000 volt potential source **48** and at the other end to a potentiometer **54** which is set so that the voltage at the other end is approximately a —300 volts. This provides an electric field having equipotential lines which are slanted from top to bottom as shown by lines **56** and which combine with the transverse magnetic field to cause electrons to travel in a cycloidal path **57** against coating **26**. Each cycloid results in secondary emission, or freeing of electrons from the surface of coating **26**, thereby multiplying the number of electrons according to the characteristics of the cycloid and the coating **26**. The above voltage values are, of course, only representative.

Operation

In the operation of this embodiment charged particles such as positive ions or ultra violet photons are introduced to grid **40** and are accelerated to cathode **28** since it is at a lower potential. This causes secondary emission from cathode **28** of electrons which are attracted between the magnets **20** and **22**, and due to the electric and magnetic fields existing between the plates, are caused to cycloid along the lower surface coating **26**. Each cycloid causes a multiplication of electrons. The electrons impinge upon anode **42** where the current may be read by ammeter **50** or used in another manner.

If desired, the magnets **20** and **22** could be used without any resistive coating, utilizing the current carrying and secondary emissive properties of the magnet material itself.

An end view of a second embodiment is shown in FIGURE 4 wherein spaced insulative posts **60** are used to separate magnets **20** and **22** on each side. Posts **60** replace the continuous insulative strips **30** and **32** and pole pieces **34**, **36** but otherwise the multiplier shown in FIGURE 4 is the same as that shown in FIGURE 3. This provides a magnetic field which may be desired for certain applications.

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.

Having thus described my invention, I claim:

1. A multiplier apparatus for receiving and multiplying charged particles comprising
   - at least one magnet means having a north pole and a south pole with lines of magnetic force extending between said poles,
   - a secondary emissive resistive coating being on a surface of said one magnet means,
   - the material of said one magnet means on which said secondary emissive resistive coating is formed having a resistance greater than said resistive coating,
   - a voltage source connected across said secondary resistive surface in a direction substantially perpendicular to a line between said north pole and said south pole,
   - said voltage source causing current to flow through said resistive secondary emissive coating,

said voltage source supplying an electric field having a component perpendicular to the surface of said one magnet means to cause charged particles including electrons to cycloid into the surface of said magnet means,

and means for collecting the charged particles.

2. The apparatus of claim **1** with a second magnet means having a north and south pole aligned, respectively, with the north and south pole of said one magnet means and being closely spaced to the secondary emissive resistive surface of said one magnet means,

the north pole of said second magnet means being adjacent the north pole of said one magnet means and the south pole of said second magnet means being adjacent the south pole of said one magnet means with the magnetic lines of force being between and substantially parallel to said one and said second magnet means,

a secondary emissive resistive coating being on the surface of said second magnet means which is facing the secondary resistive surface of said one magnet means,

said voltage source being connected across said secondary emissive resistive surface of said second magnet means in a direction substantially perpendicular to a line between said north pole and said south pole.

3. The apparatus of claim **2** with the potentials applied by said voltage source to said secondary emissive resistive surfaces establishing an electric field which is inclined to the surface of said one magnet means,

the planes formed by said lines of force of said electric field and the projections of said lines on said one magnet means surface being substantially perpendicular to the magnetic lines of force.

4. The apparatus of claim **2** with grid means being coplanar with said second magnet means,

means for placing said grid at a potential relative to said one magnet means to accelerate said charged particles towards said one magnet means.

5. The apparatus of claim **4** with cathode means being placed adjacent said one magnet means and opposite said grid means so that it is in the path of said charged particles,

said cathode means emitting electrons when struck by said charged particles.

6. The apparatus of claim **2** with a magnetic pole piece

being adjacent and between the north poles of each of said magnet means and a magnetic pole piece being adjacent and between the south poles of each of said magnet means,

insulation being between each of said magnet means and said pole pieces.

7. A multiplier apparatus for receiving and multiplying charged particles comprising

at least one magnet means having a north and south pole with lines of magnetic forces extending between said poles,

a voltage source connected across said magnet means in a direction having a substantial perpendicular component to a line between said north pole and said south pole,

said magnet means having a secondary emissive resistive surface,

said voltage source causing current to flow through said secondary emissive resistive surface,

said voltage source supplying an electric field having a component perpendicular to the secondary emissive surface of said magnet means to cause charged particles including electrons to strike the secondary emissive surface of said magnet means in a plurality of successive multiplication stages,

and means for collecting the charged particles.

8. The multiplier of claim **7** with

a second magnet means having a secondary emissive resistive surface and a north and south pole being aligned, respectively with the north and south poles of said first magnet means,

said voltage source connected across said second magnet means in a direction having a substantial component to a line between said north and south pole of said second magnet means,

said voltage source causing an electric field to be formed between said magnet means.

References Cited by the Examiner

UNITED STATES PATENTS

2,983,845 5/1961 Damoth et al. ---- 313—103 X

JOHN W. HUCKERT, *Primary Examiner.*

RALPH G. NILSON, ARTHUR GAUSS, *Examiners.*