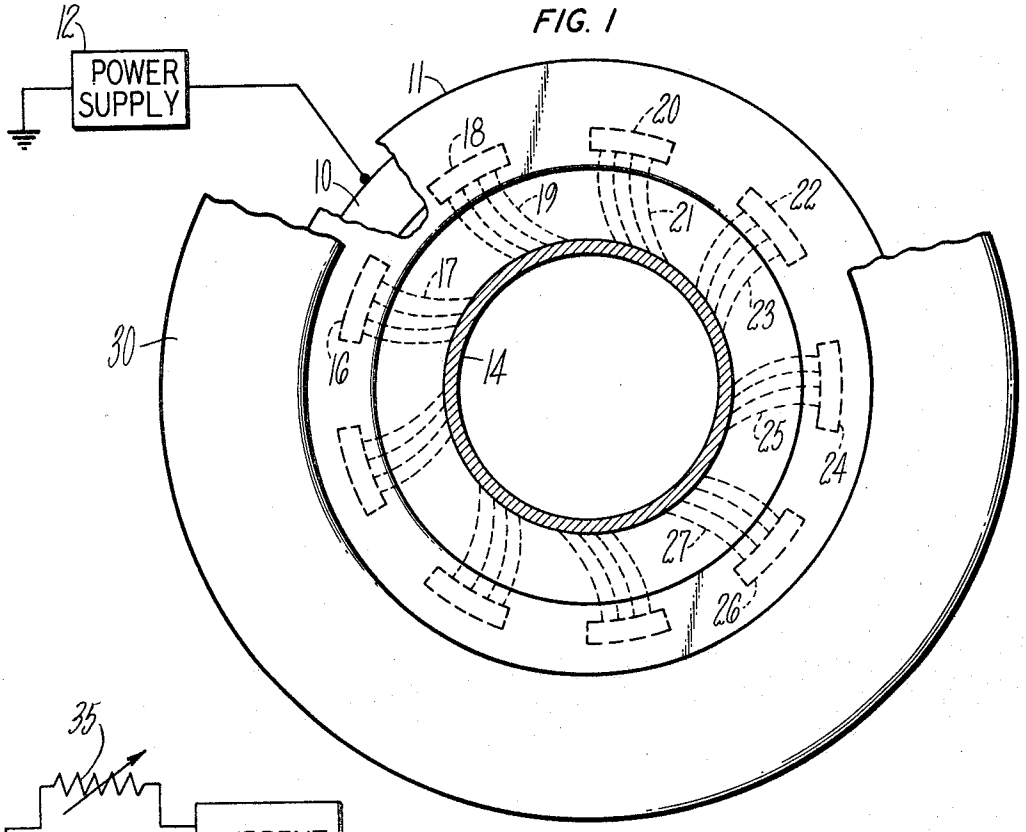
June 30, 1970 E. A. PINSLEY 3,518,479

APPARATUS FOR TRAVERSING A COLD CATHODE DISCHARGE

Filed Feb. 27, 1968

FIG. 1



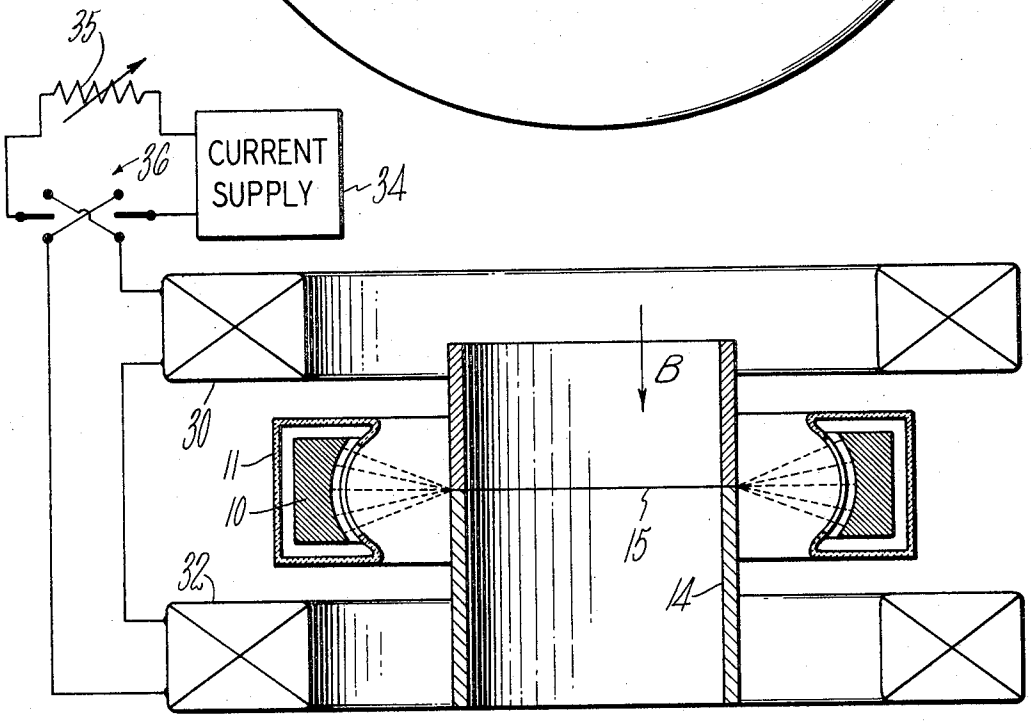


FIG. 2

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APPARATUS FOR TRAVERSING A COLD CATHODE DISCHARGE

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Int. Cl. H01j 1/50
U.S. Cl. 313—161 7 Claims

ABSTRACT OF THE DISCLOSURE

An annular cathode structure with a magnetic beam deflection mechanism is described. A plurality of radial electron beams are generated by an annular glow discharge cathode, and a uniform magnetic field generated by a pair of coils is directed perpendicular to the electron beams. The direction of the magnetic field may be reversed and the magnitude of the magnetic field may be varied to control the direction and amount of deflection of the beams of electrons.

BACKGROUND OF THE INVENTION

In the use of annular cold cathode discharges for welding purposes, a problem is encountered in performing welds when the orientation of the weld plane is off the horizontal. Under such circumstances, molten material in the circular weld can flow around the periphery of the joint and run out of the joint at its lowest point due to the action of gravity. This is a particularly serious problem in performing annular welds in a large pipe because of the relatively large hydrostatic pressures which can build up with joints that are even slightly skewed to the horizontal plane. In order to avoid this weld run out, it has been proposed to provide a spoked electron beam using an annular cathode having a series of circumferential segments operating in a glow discharge, as for instance as described and claimed in the copending application filed by Allen P. Walch and Albert W. Angelbeck entitled "Annular Multiple Beam Cathode," Ser. No. 646,730, filed June 16, 1967 and assigned to the same assignee. To perform a complete axisymmetric weld with such a spoked beam, it is necessary to circumferentially traverse the spokes which lie in a plane substantially transverse to the axis. One means for accomplishing this traversal is to index the segmented cathode mechanically, or alternately to index the workpiece mechanically in a circumferential direction. To simplify the construction of the cathode apparatus, it is desirable to provide essentially non-mechanical traversing means.

SUMMARY OF INVENTION

It is therefore an object of this invention to accomplish the circumferential traverse of the individual plurality of beams of electrons distributed about the axis by use of a time-varying magnetic field directed parallel to the axis and transverse to the plane containing the plurality of spoked beams.

BRIEF DESCRIPTION OF THE DRAWINGS

The object is accomplished as hereinafter described and shown in the figures wherein

FIG. 1 is a schematic axial view of the cathode and its associated magnetic field coils.

FIG. 2 is a schematic cross-sectional view of the cathode and magnetic field coils of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1, an annular contoured cathode structure **10** is shown which is operated in an evacuated chamber (not shown). The chamber is evacuated to a pressure conducive for establishing a glow discharge to obtain an electron beam mode operation from the cathode structure **10**. A power supply **12** is coupled to the cathode structure **10** for establishing the potential drop and electric field necessary for extracting the electrons from the cathode by secondary emission. The power supply **12** is preferably positioned external to the chamber and connected therethrough by any known means and a ground return is provided in the chamber. The ground may be either the workpiece **14** represented as a metal pipe or some other convenient metallic portion of the apparatus such as a supporting mechanism for the workpiece.

Electron beams have been produced from narrow-apertured cold hollow cathode devices as a result of the volume production of electrons substantially trapped within a hollow chamber enclosed by the cathode. See for example the patent to Allen, et al., 3,262,013. In these glow discharge devices, various operating modes may be encountered by varying the potential difference between the cathode and the anode as well as the gas density of the environment. One of these modes produces the well-defined electron beam as described in the Allen patent and this beam may be advantageously used to work materials. Operation in other modes such as the arc mode, which produces a copious supply of electrons, in general does not produce a high-energy collimated electron beam.

Other glow discharge cathode devices have been developed such as described in U.S. Pat. 3,430,091. In this contoured cathode, a highly focused electron beam is produced under moderately high pressures and high voltages. This cathode can operate in a pressure region up to a thousand microns and produces the electron beam with a different mechanism than that relied upon in the hollow cathode. The electrons in the contoured cathode are essentially produced as a result of secondary emission processes such as from ions striking the surface. The contoured cathode is essentially a surface emitter. Focusing is accomplished by suitably contouring the surface of the cathode.

As may be seen by reference to copending application Ser. No. 646,730, a plurality of discrete electron beams may be produced in a number of ways. For example, the cathode may be a single annular contoured cathode having a plurality of inscribed identical contoured sections circumferentially positioned around the internal surface of the cathode, each of the plurality of contoured sections being curved both axially and circumferentially and producing an electron beam which is focused at or near the center of the annulus. Alternatively, the cathode may consist of a plurality of separate contoured cathode sections, each of which are shielded and individually supplied with power. Another possibility using contoured cathodes is a single annular contoured cathode surrounded by an apertured shield through which individual beams emanate.

If hollow cathodes of the type disclosed in U.S. Pat. 3,381,157 are preferred, the cathode configuration may also be a plurality of circumferentially spaced individual cathodes, separately shielded and powered or a single annular hollow cathode with an apertured shield.

In FIG. 1 there is shown as a preferred embodiment a single homogeneous contoured cathode **10** having a plurality of circumferentially spaced contoured surfaces inscribed thereon, each separate surface producing an electron beam **17, 19, 21, 23, 25, 27** which is emitted toward workpiece **14** through apertures **16, 18, 20, 22, 24, 26** in shield **11**. However, any other embodiment producing a plurality of circumferential electron beams produced by a glow discharge and focused at a workpiece

may be used. The beams may be used, for example, to weld or fuse two annular pipes as shown in FIG. 2.

In either event the annular cathode structure **10** produces plurality of beams of electrons around the periphery and radiates them radially inwardly towards the axis of the annular structure. It is, of course, possible to radiate the beams outwardly.

The cathode structure **10** is provided with a shield **11** to improve the efficiency of the glow discharge cathode. The shield may be made of a conductor material or an insulator. The shield suppresses the emission of the electrons from those surfaces on the cathode where the electrons would not contribute to the main beam, and is selectively spaced from the cathode so that the glow discharge is suppressed within this space.

In FIG. 2 current producing solenoid coils **30** and **32** are shown positioned on opposite sides of the cathode structure **10**. The coils **30** and **32** produce a magnetic field in a direction shown by the vector B. The magnetic field deflects the electron beams in a circumferential direction. The aiding fields from the coils **30** and **32** produce a uniform magnetic field in a manner similar to a set of Helmholtz coils. Current is supplied from a supply **34** which is continuously variable by means of variable resistor **35** and reversible in polarity by means of switch **36**.

The windings of the coils **30** and **32** are connected in series such that they produce aiding magnetic fields and when the current is reversed the entire field vector B is reversed to point upward instead of downward. Reversing the field vector will reverse the direction of deflection of the electron beams.

The field from the coils **30** and **32** is of relative low field strengths and may be varied typically between zero and 50 gauss. The magnitude of the field determines the amount of deflection of the electron beams. It is important that the field strength not be made so high that the plurality of beams are too strongly deflected to become practically tangential relative to the workpiece **14**. On the other hand, sufficient deflection is needed to produce a continuous fusion zone for a continuous weld along the seam **15**.

The magnetic field passes essentially parallel to the workpiece **14**, and therefore the workpiece cannot be magnetic material for otherwise the weak magnetic field would be essentially contained within the material.

Although this invention has been shown and described with respect to the preferred embodiment thereof, it should be understood by those skilled in the art that the foregoing and various other changes and omissions in the form and detail thereof may be made without departing from the scope of the invention, which is to be limited and defined only as set forth in the following claims.

Having thus described a preferred embodiment of my invention what I claim as new and desire to secure by Letters Patent of the United States is:

1. Apparatus for working non-magnetic materials with a plurality of beams of charged particles comprising,

glow discharge cathode means for generating a plurality of discrete beams of electrons spaced circumferentially about an axis and radiating radially inwardly, said plurality of beams being focused by said cathode means on a workpiece positioned in the path of said beams,

first and second coils axially displaced on opposite sides of said cathode means and coincident with said axis,

and means for actuating said first and second coils to generate a substantially uniform magnetic field coaxial with said axis and intersecting said electron beams to deflect said beams in a circumferential direction.

2. A device as in claim **1** and further comprising,

means for varying the strength of said magetic field to thereby vary the amount of deflection of said beams of electrons.

3. A device as in claim **1** and including means for reversing the direction of said magnetic field to reverse the direction of deflection of said beams of electrons about said axis.

4. A device as in claim **1** wherein said cathode means comprises a shielded single annular cathode structure having a plurality of contoured electron beam emitting surfaces peripherally distributed about said axis.

5. A device as in claim **1** wherein said cathode means comprises a plurality of individually shielded cathode structures distributed peripherally about said axis.

6. A device as in claim **1** wherein said cathode means comprises a cathode structure having an annular peripheral beam radiating surface coaxial with said axis,

and shield means having a plurality of apertures therein positioned adjacent said cathode.

7. A method for working non-magnetic materials with a beam of charged particles comprising the steps of,

generating a plurality of beams of charged particles about an axis,

radially directing said plurality of beams toward a non-magnetic workpiece,

generating a uniform magnetic field in a direction substantially transverse to and intersecting said beams of charged particles to deflect said beams about said axis,

varying the strength of said magnetic field to control the magnitude of the deflection of the plurality of beams about said axis,

and controlling the axial direction of the magnetic field to control the direction of deflection of said plurality of beams.

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RAYMOND F. HOSSFELD, Primary Examiner

U.S. Cl. X.R.

219—121; 250—49.5; 313—69