

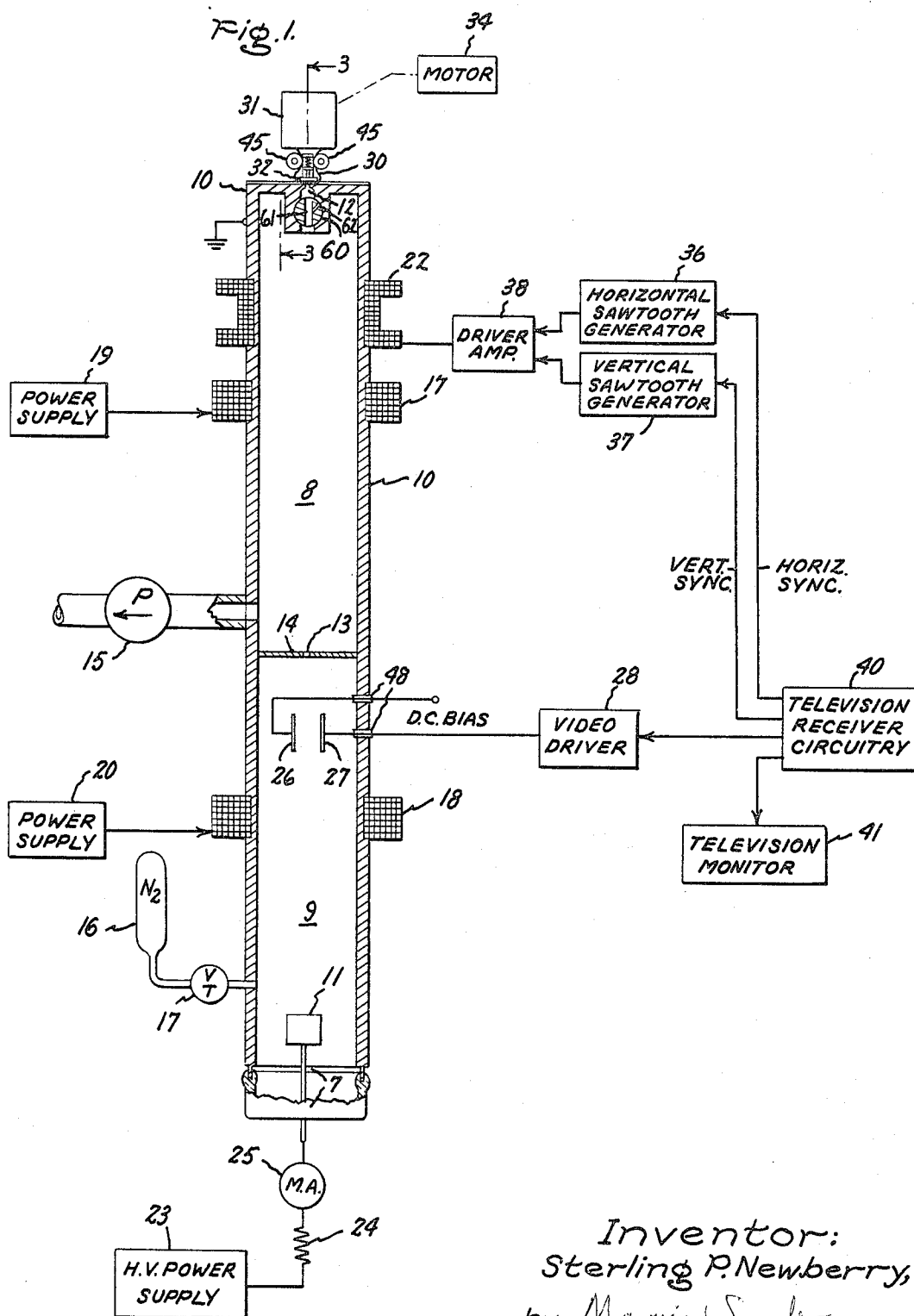
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ELECTRON BEAM RECORDING SYSTEM WITH
RECORDING MEDIUM AS VACUUM SEAL

3,384,901

Filed Jan. 3, 1967

2 Sheets-Sheet 1



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His Attorney.

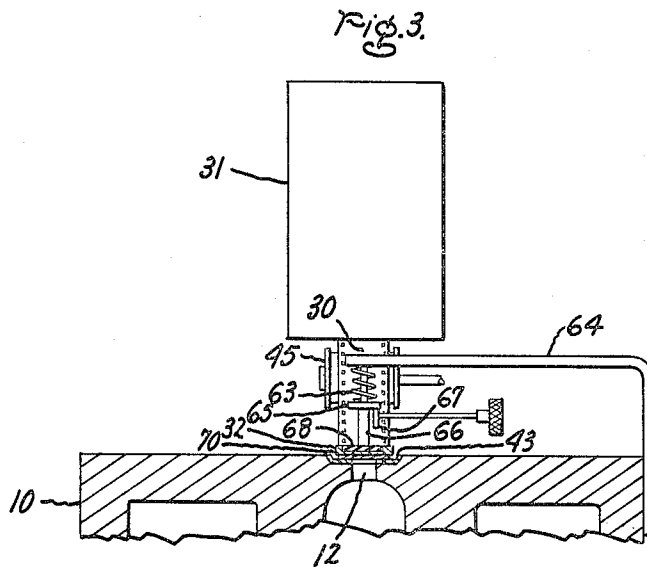
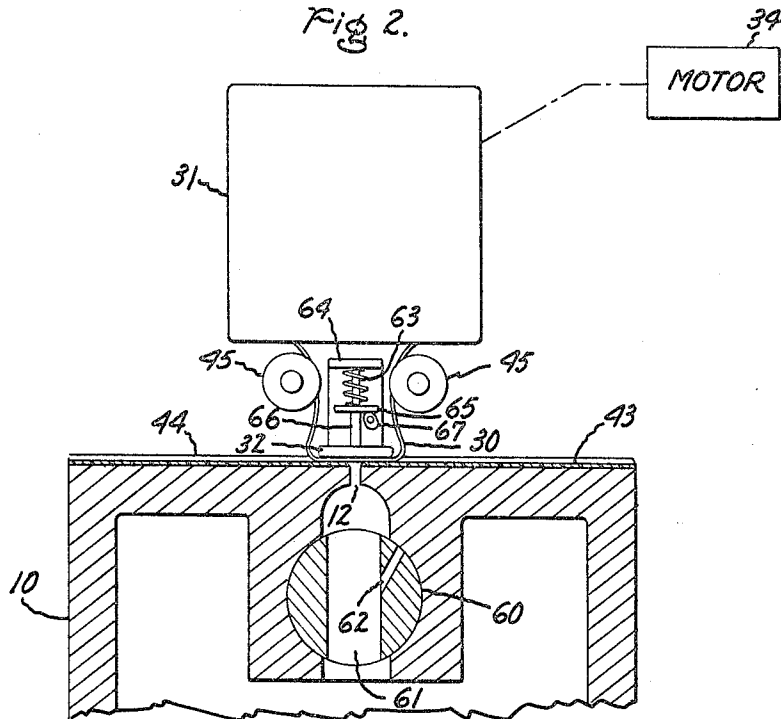
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**ELECTRON BEAM RECORDING SYSTEM WITH
RECORDING MEDIUM AS VACUUM SEAL**
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ABSTRACT OF THE DISCLOSURE

A system for recording information by impinging a controllable electron beam on the surface of a recording medium. The beam is contained in a vacuum, while the medium, situated outside the vacuum, is moved past a slot through which the beam passes to impinge on the medium. By applying pressure to the medium, a gas-tight seal is maintained around the periphery of the slot, thereby retaining the required vacuum.

BACKGROUND OF THE INVENTION

This invention relates to electron beam recording and more particularly to a high resolution system for electron beam recording wherein the recording medium is situated outside a vacuum containing the beam and itself acts as a gas pressure seal for the system.

Electron beam recording of information on moving storage media is well-known in the art, as evidenced, for example, by W. E. Glenn, Jr., et al. Patent No. 3,116,962, issued Jan. 7, 1964, and assigned to the instant assignee. In systems of this nature, maintenance of a vacuum through which the beam passes is essential in order to avoid dissipation of the electron beam energy due to an unduly large number of electron collisions with gas molecules. This necessitates either a complex system of seals to permit the recording medium to pass into the vacuum chamber and out again after impingement of the beam thereon has taken place, or else placement of the recording medium within the vacuum, which requires a large volume vacuum chamber and attendant lengthy intervals during which pumping down of the system takes place. In the latter system, the vacuum chamber must be opened in order to replace the storage medium, thereby requiring pumping down of the chamber after each change of medium has taken place. These problems are avoided in another form of electron beam recording system wherein a window of material which is gas-impermeable but electron-permeable is utilized, so as to permit the electron beam to pass therethrough and impinge upon the recording medium which may be situated outside the high vacuum chamber. However, any window which is gas-impermeable introduces many molecules in the path of the electron beam and, unless it is so thin as to defy handling without causing damage thereto, produces some dispersion of the electron beam, resulting in degraded resolution. To minimize this resolution degradation, the moving film must be pressed into intimate contact with the window, giving rise to window and film wear because the coefficient of friction is dominated by the window and film characteristics. The system of the instant invention obviates the limitations of the aforementioned systems by utilizing a window which is entirely open; that is, no gas-impermeable material is present therein.

Still another technique for electron beam recording involves passage of the electron beam through a series of small, differentially-pumped apertures within the enclosure containing the beam, to permit placement of the electron gun in a high vacuum and the recording medium

in a weak vacuum. However, this technique involves complex construction of the chamber in which the electron beam is confined, and precise alignment of the minute apertures therein, and a complex and large pumping system. On the other hand, the instant invention requires no series of differentially pumped apertures since the recording medium is placed outside the vacuum chamber over a beam exit slot in the chamber. With sufficient pressure applied to the recording medium, the medium itself, being gas-impermeable, seals the vacuum chamber. If the medium is in the form of a strip, as herein disclosed, it may be continuously moved over the slot without breaking vacuum. Moreover, by utilizing a valve within the vacuum chamber, vacuum need not be broken in order to replace the recording medium, since the chamber may be sealed by the valve prior to removal of the recording medium and not be reopened to the beam exit slot until the recording medium has been replaced. Furthermore, the amount of focusing apparatus required by the instant invention is advantageously far less than that required by electron beam systems utilizing differentially pumped apertures, since each section of the vacuum enclosure normally requires focusing apparatus to facilitate passage of the beam through the entrance aperture of the next section. Hence the simplicity of the electron beam system of the instant invention is readily apparent.

SUMMARY OF THE INVENTION

One object of this invention is to provide a simple, high-resolution system for impinging an electron beam upon a medium situated outside a vacuum surrounding the electron beam source without passing the beam through any gas-impermeable material.

Another object is to provide an electron beam recording system in which the recording medium itself serves as a gas-tight seal for an electron beam exit slot of the system.

Another object is to provide an electron beam recording system in which it is unnecessary to break vacuum when replacing recording media.

Briefly, in accordance with a preferred embodiment of the invention, a system for recording data on an information storage medium by impingement of an electron beam thereon is provided. This system comprises a gas-tight chamber having at least one open slot therein. The chamber includes a source of electrons positioned so as to direct the electrons through the slot. Means are provided for evacuating gas from the chamber, and resilient means are bonded to the outer surface of the chamber around the periphery of the slot with capability of forming a hermetic seal around the slot. When recording, a gas-impermeable recording medium covers the slot in sealable contact with the resilient means. In addition, means are provided for applying pressure to the recording medium so as to force the recording medium tightly against the resilient means.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the invention believed to be novel are set forth with particularity in the appended claims. The invention itself, however, both as to organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a schematic diagram of the vacuum chamber showing the relationship among the components therein and the recording medium, along with a block diagram of circuitry for achieving control of beam parameters with television signals;

FIGURE 2 is a detailed showing of the top portion of the vacuum chamber containing a beam exit slot over which the film passes; and

FIGURE 3 is a sectional view along line 3—3 in FIGURE 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIGURE 1, an electrically conductive electron optical column or tube 10 comprising the vacuum chamber is illustrated in section. A source of electrons 11 is secured by electrically insulating support means 7 at one end of the tube, and an open slot 12 is situated at the opposite end of the tube. The electron source preferably comprises a non-thermionic hollow cathode structure adapted to formation of plasma electron beams, such as described in L. H. Stauffer Patent No. 3,218,431, issued Nov. 16, 1965, and assigned to the instant assignee. Chamber 10 is divided into upper and lower sections 8 and 9 respectively by a plate 14 containing an aperture 13. Aperture 13 may conveniently be 0.002" in diameter.

The upper section of chamber 10 is pumped, preferably by a mechanical pump 15, down to a pressure of approximately 10^{-4} to 10^{-5} torr, although pressures as high as 10^{-2} torr may be utilized if desired. The lower section of chamber 10 is exhausted by pump 15 through aperture 13 to a pressure which varies from 60 to 40 microns of mercury depending upon beam current requirements. A plasma gas, such as nitrogen, is supplied from a gas reservoir 16 maintained at constant pressure by a conventional diaphragm-type regulator (not shown). Gas pressure in the lower section is controlled by a throttle valve 17, so that electron beam current can be adjusted since, as is well-known in the art, the beam current is proportional to plasma gas pressure.

A pair of magnetic lenses 17 and 18 are positioned about the upper and lower sections of tube 10 respectively, and are energized from power supplies 19 and 20 respectively. Lenses 17 and 18 serve to focus the beam of electrons to a diameter of approximately 0.004" at its arrival at aperture 13 and to a diameter of approximately 0.002" at its arrival at slot 12, respectively. A deflection coil 22 is disposed about the upper section of tube 10 between magnetic lens 17 and exit slot 12. This coil is capable of deflecting the beam through a raster over the entire area of exit slot 12. High voltage negative potential is supplied to cathode 11 from a high voltage power supply 23 through a series-connected current limiting resistance 24 and milliammeter 25. The conductive casing of tube 10 is grounded, so as to establish a high anode-to-cathode potential through the entire length of the tube. In addition, a D.C. bias is applied to one modulation deflection plate 26 of a pair of electrostatic deflection plates in lower section 9 of tube 10, while a video signal is supplied to the other one 27 of this pair of deflection plates from a video driver circuit or amplifier 28. Deflection plates 26 and 27 are energized from conductors passed through insulators 48. The D.C. bias on plate 26 serves to establish an operating reference point required by the modulating signal.

Exit slot 12 in the upper section of tube 10 is sealed by a recording medium 30 which passes over the exit slot in sealable engagement therewith. This medium, which may comprise photographic film, is supplied from a film cartridge or cassette 31, such as that commercially available from Eastman Kodak Company, Rochester, N.Y., over a flat, resilient pressure pad 32, having a low coefficient of friction. The pressure pad may comprise, for example, a flat inner region of rubber to which is bonded a coating of polytetrafluoroethylene, sold by E. I. du Pont de Nemours & Co., Wilmington, Del., under the trademark Teflon. The pressure pad bears against film 30 so as to force the film into a sealable relationship with exit slot 12. Cassette 31 is preferably driven by a constant speed motor 34 to maintain a constant linear speed for film 30.

When medium 30 comprises 16 millimeter film, for example, the dimensions of exit slot 12 are preferably 0.125" wide by 0.300" long. It is to be understood, however, that recording medium 30 may, if desired, comprise a form other than film, such as a disc, for example, in which case a narrow diameter turntable might be required instead of a cassette, with a border of Teflon bonded to the recording end of tube 10 around slot 12 and raised above the surface of tube 10 thereat. The seal would be accomplished by urging the disc against the Teflon border. Moreover, recording media other than photographic may also be utilized, such as thermoplastic, for example.

Tube 10 in FIGURE 1 is illustrated in combination with circuitry for reproducing television signals on recording medium 30. This is accomplished by supplying horizontal and vertical sawtooth signals from a horizontal sawtooth generator 36 and a vertical sawtooth generator 37 through a driver amplifier 38 to deflection coil 22. The horizontal and vertical signals are algebraically added by amplifier 38. Television receiver circuitry, indicated generally at 40, furnishes horizontal sync signals to horizontal sawtooth generator 36 and vertical sync signals to vertical sawtooth generator 37. In addition, the video signal is supplied to video driver 28 for modulating the electron beam. A television monitor 41 may be driven by television receiver circuitry 40 so as to provide visual indication of the signal being recorded on recording medium 30.

Tube 10 is equipped with a rotary valve 60 containing a major passageway 61 and a minor passageway 62 communicating with the major passageway at an angle therewith. Valve 60 is illustrated in the fully open position. To close the valve, it is rotated 90° counterclockwise. Passageway 62 eases the application of load on the vacuum pump when valve 60 is opened for exhausting gas between medium 30 and the valve by first bleeding some of this gas to diminish the volume of gas suddenly withdrawn through passageway 61. The valve may be manually operated by means of a shaft (not shown) extended through the wall of chamber 10.

In operation, tube 10 is evacuated by pump 15, and plasma gas, preferably nitrogen, is introduced into the lower section 9 of tube 10. A beam of electrons is produced by cathode 11 and focused by magnetic lens 18 to a diameter larger than that of aperture 13, which constitutes the focal point. Assuming a 0.002" diameter for aperture 13, the diameter of the focused beam arriving at aperture 13 is preferably about 0.004", with essentially Gaussian distribution. This aperture then acts as though it were a new source of electrons, emitting a beam which is initially 0.002" in diameter. The beam emerging from aperture 13 is focused by magnetic lens 17 to a final 0.002" diameter at exit slot 12, valve 60 being in the fully open position. The sawtooth voltage waveforms supplied to deflection coil 22 cause the beam to scan a television raster pattern at exit slot 12 when the recording medium is at least momentarily at rest. For continuously moving recording media, however, vertical sawtooth generator 37 is de-energized, since only the horizontal sweep of the electron beam is desired in such case.

Modulation of the electron beam may be accomplished by deflecting the beam across the edge of aperture 13 by control of the voltage between electrostatic deflection plates 26 and 27; that is, the beam emitted by cathode 11, when fully unmodulated, is substantially undeflected by plates 26 and 27 so as to occupy a position whereby a maximum number of electrons are admitted through aperture 13, while, as modulation is increased, the beam is deflected by plates 26 and 27 onto plate 14 progressively farther from aperture 13, so as to progressively admit less and less electrons through aperture 13. Hence, as modulation is increased, the beam emerging from aperture 13 becomes increasingly weaker, and vice-versa. Throughout recording operation, sufficient pressure is supplied by pressure pad 32 against recording medium 30

to seal slot 12, thereby preventing loss of vacuum within tube 10.

In FIGURES 2 and 3, details of the seal at exit slot 12 are shown. A resilient surface 43 having a low coefficient of friction to promote smooth sliding contact therewith, which is preferably comprised of Teflon, is shown bonded or otherwise adhered to a groove in the upper surface of metallic tube 10. The Teflon is cut at exit slot 12 so as to coincide with the slot. The Teflon is also provided with sidewalls 44 which serve as guides to maintain recording medium 30 in the proper position with respect to slot 12 for suitable recording on medium 30 and sealing of tube 10. A pair of guides, such as rimmed rollers 45 insure proper shape and positioning of the loops formed by film 30.

A downward force is supplied to pressure pad 32 from a compression spring 63 anchored against an L-shaped bracket 64 which is preferably welded to tube 10. Spring 63 bears against a plate 65 which is rigidly connected to pressure pad 32 through a stem 66. Both plate 65 and stem 66 are preferably metallic. The pressure pad may be lifted from the surface of recording medium 30 by rotation of a cam 67 so as to apply an upward-directed force against plate 65 whenever it is desired to remove or replace recording medium 30.

For proper operation, valve 60 must be closed prior to lifting pressure pad 32, in order to preserve the vacuum in tube 10. After recording medium 30 has been replaced and pressure pad 32 again lowered onto the surface of medium 30, valve 60 may again be opened. Preferably, the valve is maintained in the position whereby passage-way 62 allows exhausting of the volume between the valve and medium 30 at a slow rate for approximately 5 seconds before being fully opened.

FIGURE 3 illustrates the relative positions of pressure pad 32, exit slot 12, and sides 44 and bottom 43 of the Teflon track through which recording medium 30 is slidably passed. In this view, pressure pad 32 is shown as having flattened itself against medium 30; however, when lifted off of medium 30, the lower surface of pad 32 assumes a concave shape. This shape assures a tight seal by causing the pad to bear with greater pressure against the edges of recording medium 30 than against the inner area thereof. Pad 32 may be seen to comprise a rubber core 68 adhered to stem 66 and having a Teflon coating 70 bonded thereto. Rubber core 68 furnishes added resilience to the pressure pad.

While the Teflon track is shown in FIGURE 3 as being recessed within the upper portion of tube 10, this is for convenience only; it is also feasible to mount the Teflon channel directly upon the upper surface of the top of tube 10 without necessity for a grooved recess to hold the channel. Additionally, the source of electrons need not be of the plasma gun type, but alternatively may be of the thermionic type. In such case, the plasma gas is absent from tube section 9 which is pumped to a vacuum equal to that of tube section 8. However, the plasma type cathode not only has an inherent long life capability, but also has the advantage of not being susceptible to damage in case of accidental loss of vacuum, as well as having an inherent long-life capability.

The foregoing describes a simple, high-resolution system for impinging an electron beam upon a medium situated outside a vacuum surrounding the electron beam source, without the necessity for passage of the beam through any intervening gas-impermeable material. The recording medium itself serves as a gas-tight seal for the

beam exit slot of the system. Moreover, by utilizing a valve within the vacuum chamber, it is unnecessary to break vacuum when changing recording media since the vacuum chamber may remain sealed by the valve throughout the entire recording medium changing procedure.

While only certain preferred features of the invention have been shown by way of illustration, many modifications and changes will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. In a system for recording data on an information storage medium by impingement of an electron beam thereon, the combination comprising: a gas-tight chamber having at least one open slot therein, said chamber including a source of electrons positioned so as to direct said electrons through said slot; means communicating with said chamber for evacuating gas therefrom; and resilient means bonded to the outer surface of said chamber around the periphery of said slot capable of forming a hermetic seal around said slot.

2. The system of claim 1 including a gas-impermeable recording medium covering said slot in sealable contact with said resilient means; and means bearing against said recording medium with pressure so as to force said recording medium tightly against said resilient means.

3. The system of claim 1 including a groove in the outer surface of said chamber directed over said slot, said resilient means being bonded to the outer surface of said chamber around the periphery of said slot within said groove.

4. The system of claim 2 including a groove in the outer surface of said chamber directed over said slot, said resilient means having a low coefficient of friction and being adhered to the outer surface of said chamber around the periphery of said slot within said groove.

5. The system of claim 2 wherein said resilient means has a low coefficient of friction.

6. The system of claim 4 wherein said means bearing against said recording medium comprises a resilient pressure pad having a low coefficient of friction.

7. The system of claim 5 wherein said means bearing against said recording medium comprises a resilient pressure pad having a low coefficient of friction.

8. The system of claim 1 wherein said slot is positioned at one end of said chamber, said source of electrons is positioned at the opposite end of said chamber, and said chamber includes means situated intermediate said ends of said chamber for establishing a controllable field to deflect said beam by predetermined amounts.

9. The system of claim 6 wherein said resilient means and said pressure pad each comprises polytetrafluoroethylene.

10. The system of claim 7 wherein said resilient means and said pressure pad each comprises polytetrafluoroethylene.

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