Nov. 28, 1933. T. W. SUKUMLYN 1,936,922

ELECTRON EMISSION DEVICE

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Fig. 1.

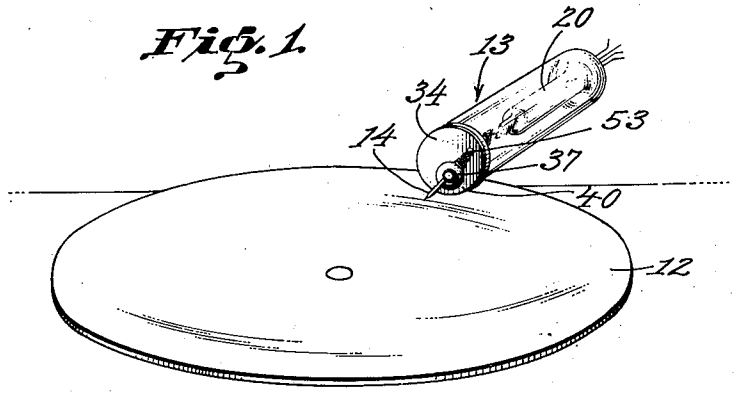


Fig. 6.

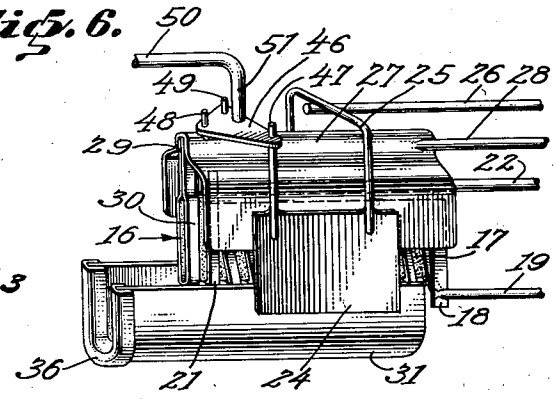


Fig. 7.

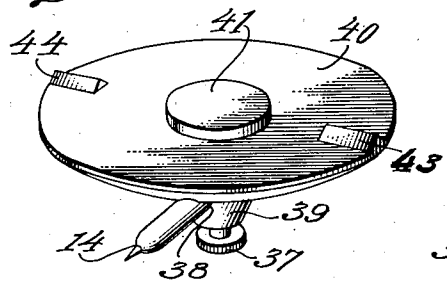


Fig. 11.

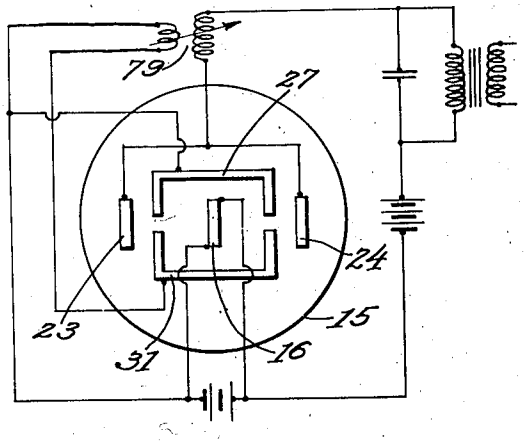
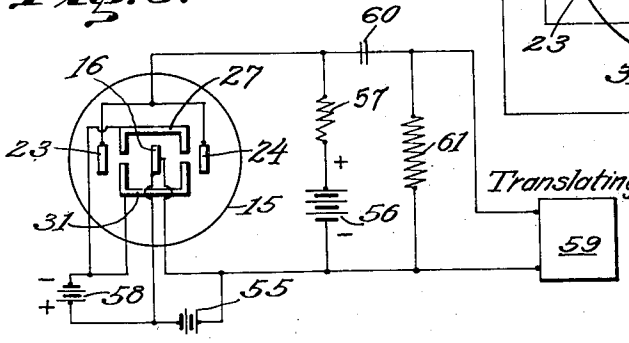


Fig. 8.



Translating Device

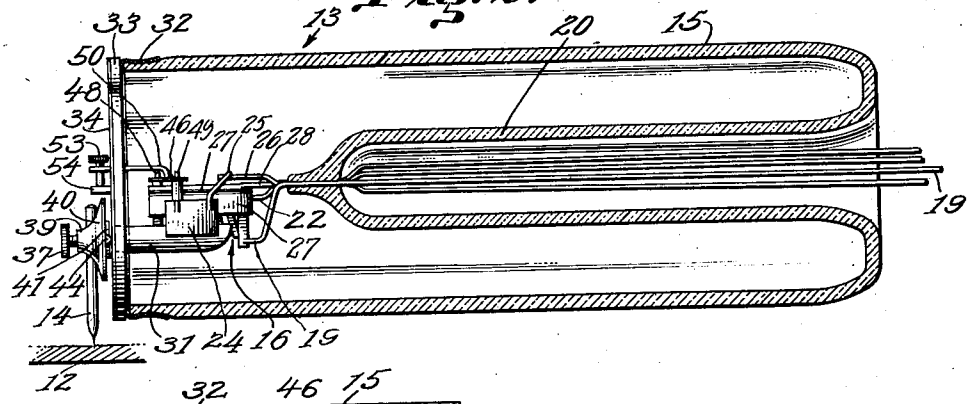
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ELECTRON EMISSION DEVICE

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Fig. 2.



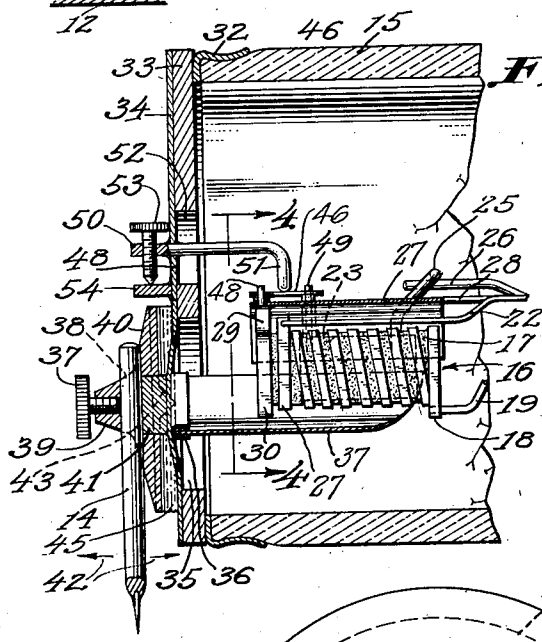


Fig. 3.

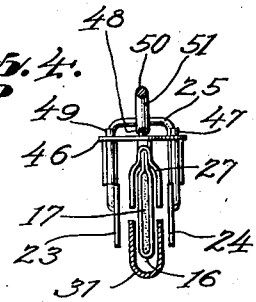


Fig. 4.

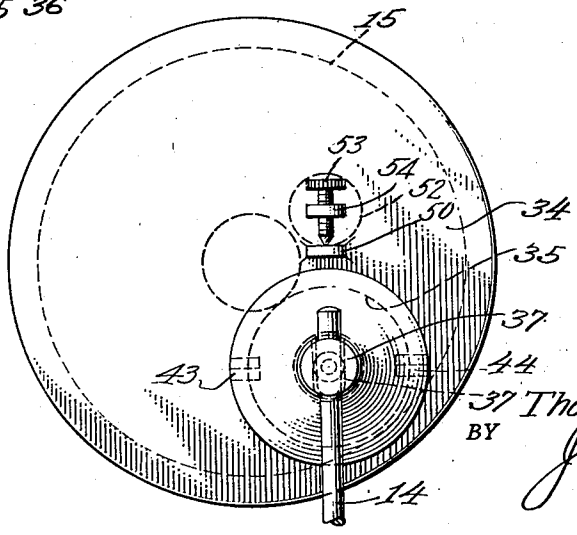


Fig. 5.

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Fig. 9.

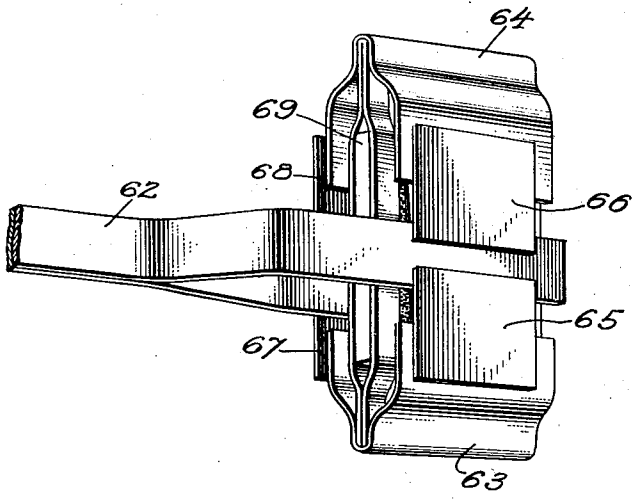
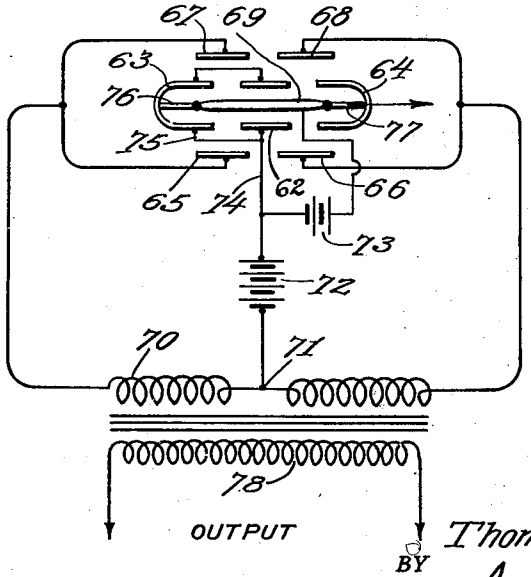


Fig. 10.



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UNITED STATES PATENT OFFICE

1,936,922

ELECTRON EMISSION DEVICE

Thomas W. Sukumlyn, Los Angeles, Calif.

Application January 25, 1930. Serial No. 423,416

13 Claims. (Cl. 250—27.5)

This invention relates to a device that operates to translate weak impulses either electrical or mechanical, into impulses of a different kind. For example, my device can be used to produce variations in current flow in a circuit, said variations corresponding to mechanical movement of a stylus as actuated by a record.

Such an apparatus in general is disclosed in my prior patent application, Serial No. 391,560, filed September 10, 1929, and entitled "Electronic device". My present application is directed to a modified form of such electronic devices and can be used in general for the same purposes as outlined in my said prior application.

One of the adaptations of the device forming my invention is as a pick-up device for phonographic records. Electromagnetic pick-up devices of this character are well known. However, such electromagnetic devices depend upon the vibrations of a coil or an armature in a magnetic field. The movable parts possessing considerable inertia serve to introduce some distortion in the final reproduction of the sound record. Furthermore, in these prior devices the variation in the current flow produced by the mechanical movement of moving parts is usually not in proportion to the degree of movement. This obviously introduces another source of error, whereby the current fluctuations do not exactly correspond to the movement of the stylus on the record.

It is one of the objects of my invention to obviate these difficulties and to make it possible for the pick-up device to follow much more closely the mechanical impulses imparted to it from the record.

I attain these objects by mechanically controlling the electronic emission between a filament and a plate as by a movable gate mechanism; and furthermore by so designing the parts that they are small and close together whereby the effects of inertia are minimized to such a degree as to form no appreciable factor in the operation thereof.

It is another object of my invention generally to improve all structures of this character.

My invention possesses many other advantages, and has other objects which may be made more easily apparent from a consideration of several embodiments of my invention. For this purpose I have shown a few forms in the drawings accompanying and forming part of the present specification. I shall now proceed to describe these forms in detail, which illustrate the general principles of my invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of my invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a perspective view showing in a general way my electronic device in use on a flat disc record;

Fig. 2 is a longitudinal sectional view of an electronic emission device embodying my invention, said device being shown on a greatly enlarged scale for the sake of clarity;

Fig. 3 is a detail section of the left-hand portion of the device as shown in Fig. 2, said detail section being still more enlarged than the section of Fig. 2;

Fig. 4 is a detail section taken along plane 4—4 of Fig. 3;

Fig. 5 is an enlarged end view of an electronic emission device illustrated in Fig. 2;

Fig. 6 is a perspective view of the electrodes and the manner in which they are supported;

Fig. 7 is a detail perspective view of a portion of the mechanism, illustrating particularly the means utilized for producing rocking motion of the gate electrode;

Fig. 8 is a wiring diagram showing how the electronic emission device can be utilized in a repeater circuit;

Fig. 9 is a perspective view of a double gate arrangement, whereby a push-pull effect can be obtained;

Fig. 10 is a wiring diagram showing how this push-pull arrangement can be utilized; and

Fig. 11 is a wiring diagram of a modified system utilizing the electronic emission device.

In Fig. 1, I indicate a record 12, which, it is understood, is rotatable by any desired source of motion, such as a spring motor. The electronic emission device 13 is shown as coacting with this record. It includes a stylus bar 14, which is intended to rest in the grooves of the record 12 and can be vibrated laterally in accordance with the groove modulations.

Referring particularly now to Figs. 2 and 3, the movement of the stylus bar 14 transversely to its axis is caused to affect the space current flow between a filament structure and a plate structure. I shall now describe the electrode structure whereby these effects are secured.

I show a tube or vessel 15 (Figs. 2 and 3) preferably made from glass, in which the electrodes are accommodated. In order to make it possible to employ a device large enough to manipulate without difficulty, in spite of the small size of the electrodes, this tube 15 is preferably made

long, and with a long reentrant stem 20 upon which the electrodes are supported near the left hand end of the tube 15.

The electron emitting electrode or filament 16 is made from a flat ribbon preferably coated with a material adapted to facilitate electron emission (Figs. 2, 3 and 6). The flat ribbon form is advantageous because there is a more uniform distribution of electron flow than from a circular filament. It can be wound on an insulation strip 17 such as mica, appropriately notched to receive the flat ribbon. At metal band 18 is connected to the lower end of the filament 16 and is supported on a bar or lead-in rod 19. This rod passes through the stem 20 to form one terminal of the filament 16.

A similar connecting band 21 serves to conduct current to the upper end of the filament 16, and is also connected to a rod 22 that passes through stem 20.

Spaced on each side of the filament structure just described are a pair of plate or anode structures 23, 24. A strut bar 25 connects the two plates. A rod 26 fastened to the strut 25 passes through stem 20 and serves as a terminal as well as a support for both plates. This rod 26 is made purposely rigid enough to provide a sufficient support for the plates.

In order to provide a variable gate or opening through which electrons can pass from filament 16 to plates 23, 24, there is both a stationary and a movable gate electrode, interposed between the filament or cathode 16 and the anodes 23, 24. Thus the stationary electrode 27 is of general U-shaped configuration, being supported at one end on a rod 28. At the other end, it is held in spaced relation to filament 16 by the aid of a band 30 encompassing strip 17 and insulated from the filament 16. This band has extensions 29 (Fig. 6) entering into a groove formed at the bottom of the U in the electrode 27 and can be welded thereto. Rod 28 can also pass through stem 20 and also forms a terminal for the electrode.

The movable gate member is opposed to electrode 27, and is designated as 31. It also is of general U contour, and forms with electrode 27 an interrupted hollow shell between the cathode and anode structures. This electrode is preferably made from very light material, such as aluminum. It is mounted in such a manner that the lateral movement of stylus 14 will tilt it about an axis spaced from the stem 20 and adjacent the left hand end of the tube 15. I shall now describe in greater detail, the mechanical parts included in the mounting of the stylus 14. The U-shaped structure 31 has extreme lightness and strength. The natural period of vibration can thereby be kept beyond the range of audibility even for a comparatively long structure 31.

The left hand end of tube 15 has welded over it, a ring 32 of copper or other similar metal. This ring is preferably tinned on both sides. To facilitate manufacture, the ring 32 is first placed over the tube 15 as a solid diaphragm which is later cut through to form the ring. Flux and solder is placed on the outside surface before it is cut down, to make it possible to connect the other elements to this ring by soldering.

Fastened as by the solder to this ring is a comparatively heavy closure plate 33 which is apertured to permit the passage of parts into the tube 15, as explained hereinafter. This plate is preferably made of steel. It in turn serves as a support for a thin diaphragm 34 also made of steel and soldered to plate 33. This diaphragm is continuous and extends completely over a comparatively large aperture 35 in plate 33, thereby forming a flexible cover for this aperture. The left hand end of structure 31 is soldered to the inner surface of this diaphragm so as to be rigid therewith. To facilitate this soldering, I preferably provide a band 36 crimped over the end of electrode 31, and made of copper.

The stylus 14 is fastened as by thumb screw 37 in a transverse aperture 38 of a boss 39 (Figs. 3 and 7) formed on a disc 40. The central portion of this disc can be made from steel; but I prefer to make the skirt portion from light material such as aluminum or magnesium. This disc has thus formed a central boss or projection 41 soldered to the diaphragm 34 immediately opposite band 36. In order that transverse motion of the stylus 14 in the direction of arrows 42 be translated into an up and down motion of electrode 31, I provide a pair of knife edge pivots 43, 44 fastened to the bottom of disc 40 and resting on the diaphragm 34. The depth of these knife edges is substantially greater than the thickness of the boss 41. The spacing between the lower surface of disc 40 and the diaphragm 34, due to the provision of boss 41, permits this rocking to follow quite faithfully the motions imparted to the stylus 14 by the record 12. Thus there is a definite, fixed axis represented by the alined knife edges, about which the oscillation occurs. Without this fixed axis, the diaphragm 34 would permit such a degree of freedom to the motion as to produce a distorting effect on the reproduction.

In order to damp the oscillations, a film of oil 45 can be provided in the narrow space between the disc 40 and the diaphragm 34. This film is held in place by capillarity or by surface tension.

As shown most clearly in Fig. 5, the aperture 35 is not in alinement with a vertical diameter of the tube 15. Due to this arrangement, it is possible so to turn the tube 15 on its axis as to slant the stylus with respect to record 12, as to maintain the stylus 14 short while the desirable slanting position is yet procured.

The free gate opening between electrodes 27 and 31 should preferably be adjustable. By making this opening adjustable, the characteristic of the operation can be varied, somewhat analogously to the adjustment of the negative bias on the control electrode of an ordinary three-electrode device. Thus a steep linear characteristic may be secured.

To accomplish this result, an insulation member 46 such as mica is supported on three pins 47, 48, 49. The pins 47, 49 are fastened respectively near the free edges of plates 24, 23 as indicated more particularly in Fig. 4. The pin 48 is fastened to the back of electrode 27. A member 50 has an extension 51 that contacts with the member 46. By moving member 50 downwardly, the electrode structure 16, 23, 24, 27 will be moved closer to the movable gate member 31, this structure being flexed about the ends of the supporting rods 19, 22, 26, 28.

Similarly, the resilience of these rods will return the structure upwardly against extension 51 as this extension is moved upwardly. A resilient damping effect against extraneous vibrations of the electrode structure is secured. The control of member 50 is obtained in a manner now to be described.

Member 50 extends through the aperture 52 in plate 33, as well as through the diaphragm 34. At its external end, a set screw 53 is threaded therein. This screw has a tip engaging a sta-

tionary abutment 54 and against which it resiliently bears. By turning screw 53 in and out, the position of member 50 can be adjusted.

A true linear characteristic for sound reproduction is well assured in the device as described. The weight of all moving parts is kept at as low a value as feasible. The inside of tube 15 being evacuated or carrying only a small amount of inert gases, the diaphragm 34 over aperture 35 will resiliently damp the stylus movements by a force quite closely proportional to the amplitude of vibration. This is true especially because of the use of the fixed axis provided by knife-edges 43—44.

It may be preferable to use such an inert gaseous filling, as argon, for I find that it increases the space current flow.

It is thus possible to reproduce faithfully, records cut on the so-called "constant amplitude" basis. In other words, there is no necessity to vary the amplitude of the vibrations inversely to the frequency, as is now needed in connection with electromagnetic pick-up devices.

Furthermore, the provision of two anodes 23, 24, one on each side of the filament 16, and of two gates, is useful to compensate for any deleterious effects of vibrations. Thus, if due to any cause, one plate 24 vibrates laterally toward and from filament 16, the other plate 23, being joined thereto, will vibrate in a sense exactly 180° out of phase with the plate 24. Therefore, any tendency toward increase in space current due to the reduction in the distance between one plate and the filament will be compensated for by the tendency toward decrease in space current due to the increase in the distance between the other plate and the filament.

There is also a greater output current due to the two plates, since the two plates are in parallel.

Although various ways of connecting the device into a circuit could be adopted, I show one form in Fig. 8. The filament 16 is shown as energized from a battery 55. The output circuit is formed between plates 23, 24 and filament 16 through a battery 56 which supplies the positive potential for the plates. A resistance 57 can also be used. The movable gate electrode 31 as well as the stationary gate electrode 27 are connected to the filament circuit so that these electrodes have a definite potential with respect to the filament. In this instance, a battery 58 is included in this circuit to provide a negative bias to these electrodes 27, 31; but obviously this battery could be omitted, especially if the flexing member 50 is used to adjust the mean opening of the gate for the electrons between filament 16 and plates 24.

Assuming that the electrode 31 is unenergized, the gate remains of uniform size; and consequently electrons flow from filament 16 to plates 23, 24 in a uniform stream. There is no fluctuation in the flow. Consequently, a translating device 59, such as a loud speaker, remains unenergized. As soon as the gate opening varies, due to the stylus movement, there are fluctuations in the output circuit connecting plates 23, 24 with filament 16, and these fluctuations affect the translating device in accordance with the current variations.

It may sometimes be desired to emphasize some of the frequencies to be reproduced. This can be effected by choosing a filter in the output circuit, of suitable design. For example, in Fig. 8, there are shown the condenser 60 and resistance 61, bridging the circuit 56—57. For effective operation, resistance 57 should be made to match that of the tube; or in the neighborhood of one or two hundred thousand ohms; the impedance of condenser 60 at the upper limit of frequency in the reproduction should be less than the resistance 61; but at the lower limit of frequency, it should be more than the resistance 61. Furthermore, the combined impedance of condenser 60 and resistance 61 should be greater than that of resistance 57, when circuit 60—61 is considered as parallel to resistance 57.

In some instances there may be some undesired harmonics formed in the output circuit. These may result from a departure from a strict linear characteristic graph that is plotted on abscissae chosen as electrode movements, against which plate currents are plotted as ordinates. These may be largely cancelled out by a push-pull arrangement whereby a single yoke-shaped armature is made to open one pair of electron gates while simultaneously closing another pair. Thus separate anodes can be provided for each gate and connected to the ends of a split-primary transformer so that the fundamental vibration is transmitted and the harmonics generated within the device cancel out.

Such an arrangement is diagrammatically illustrated in Figs. 9 and 10. The movable electrode 62 operates in connection with a pair of stationary U-shaped electrodes 63, 64 to form a pair of electron gates, one of which is increased in size and the other decreased in size as electrode 62 swings in the space between the opposite edges of electrodes 63, 64. Anodes 65, 66, 67, 68 receive the electrons through the gates. A filament structure 69 can be supported between the electrodes 63, 64.

Anodes 65, 67 are both connected to one end of a transformer primary 70; and anodes 66, 68 are both connected to the other end of the primary. At a neutral point 71, the connections are made through a plate battery 72 to the filament structure, as well as to the other electrodes 62, 63, 64. The filament heating battery 73 is connected to the filament structure via connections 74, 75, 76, 77. The secondary coil 78 can connect to an output circuit.

The operation of this push-pull system is substantially analogous with that in which stationary grids are used in place of movable screens; and a further detailed operation thereof is not essential.

Where the swing of the screen electrode such as 31, 62 is minute, it may sometimes be desirable to obtain some regenerative effect to increase the response. It has been found that this can be secured by introducing a small amount of output energy back into the input, as by a variable inductive coupling 9 (Fig. 11). The degree of coupling is adjusted nearly to the point of oscillation for maximum sensitivity. The system of Fig. 11 is otherwise similar to that of Fig. 8.

I claim:

1. A pick-up device for translating mechanical into electrical impulses comprising an electrode assembly, an evacuated vessel supporting said assembly from one end of the vessel with the assembly close to the other end of the vessel, said assembly including an anode and a cathode, a cover for the said other end, said cover including a flexible portion, and a U-shaped movable gate electrode fastened to said portion and cooperating with the cathode and anode to provide a variation in the electron flow by a movement of the gate electrode transversely to the path of the electrons and transversely to a longitudinal axis of said U-shaped gate electrode.

2. A pick-up device for translating mechanical into electrical impulses comprising an electrode assembly, an evacuated vessel supporting said assembly from one end of the vessel with the assembly close to the other end of the vessel, said assembly including an anode and a cathode, a cover for the said other end, said cover including a flexible portion, a U-shaped movable gate electrode fastened to said portion and cooperating with the cathode and anode to provide a variation in the electron flow by a movement of the gate electrode transversely to the path of the electrons and transversely to a longitudinal axis of said U-shaped gate electrode, and a stationary gate electrode rigidly supported with respect to the anode and cathode, and cooperating with the movable electrode to define a gate.

3. A pick-up device for translating mechanical into electrical impulses comprising an electrode assembly, an evacuated vessel supporting said assembly from one end of the vessel with the assembly close to the other end of the vessel, said assembly including an anode and a cathode, a cover for the said other end, said cover including a flexible portion, a U-shaped movable gate electrode fastened to said portion and cooperating with the cathode and anode to provide a variation in the electron flow by a movement of the gate electrode transversely to the path of the electrons and transversely to a longitudinal axis of said U-shaped gate electrode, a stationary gate electrode rigidly supported with respect to the anode and cathode, and cooperating with the movable electrode to define a gate, and means for adjusting the mean opening of the gate.

4. An electron discharge tube having an evacuated vessel, an electrode assembly in said vessel, a flexible cover for the vessel, an electrode mounted on said cover to be mechanically actuated, and to cooperate with the electrode assembly, and means confining the movement of said electrode about a fixed transverse axis.

5. An electric discharge tube having an evacuated vessel, an electrode assembly in said vessel, a flexible cover for the vessel, an electrode mounted on said cover to be mechanically actuated, and to cooperate with the electrode assembly, and means confining the movement of said electrode about a fixed transverse axis, including a rigid support for the flexible cover, knife edges resting over said support to rock thereon, and an actuator capable of rocking on said knife edges and fastened between the knife edges to the flexible support.

6. An electric discharge tube having an evacuated vessel, an electrode assembly in said vessel, a flexible cover for the vessel, an electrode mounted on said cover to be mechanically actuated, and to cooperate with the electrode assembly, and means confining the movement of said electrode about a fixed transverse axis, including a rigid support for the flexible cover, knife edges resting over said support to rock thereon, an actuator capable of rocking on said knife edges and fastened between the knife edges to the flexible support, and a projection extending from the actuator and spaced close to the outer surface of the flexible cover, for accommodating a thin film of damping fluid between it and the flexible cover.

7. An electric discharge tube having an evacuated vessel, an electrode assembly supported therein, said assembly including a cathode, a stationary U-shaped electrode having the edges of the legs opposite the cathode and a pair of plates each at opposite sides of the cathode and spaced from the stationary U-shaped electrode, and a movable U-shaped electrode cooperating with the stationary U-shaped electrode to define an interrupted shell around the cathode, there being formed gates between the opposite edges of said two U-shaped electrodes, said movable electrode being tiltable about an axis transverse to all the electrodes to vary the gate openings.

8. An electric discharge tube having an evacuated vessel, an electrode assembly supported therein, said assembly including a cathode, a stationary U-shaped electrode having the edges of the legs opposite the cathode and a pair of plates each at opposite sides of the cathode and spaced from the stationary U-shaped electrode, a movable U-shaped electrode cooperating with the stationary U-shaped electrode to define an interrupted shell around the cathode, there being formed gates between the opposite edges of said two U-shaped electrodes, said movable electrode being tiltable about an axis transverse to all the electrodes to vary the gate openings, and a flexible cover supporting said movable electrode and mounted to be flexed about said transverse axis only by an externally applied force.

9. An electrode discharge device comprising a pair of U-shaped members, a cathode encompassed between said members, said members being spaced apart with their legs in opposed relation, a gate electrode movable in the space between the members, to define a pair of variable gates at each side of the device, and an anode opposite each of the four gates thus formed.

10. The combination as set forth in claim 1, in which the cathode is in the form of a flat ribbon, the flat surfaces being parallel to the sides of the shell.

11. An electric discharge tube comprising a cathode, an electrode partially surrounding the cathode to form a tubular structure within which the cathode extends longitudinally, said electrode having a stationary part and a movable part, said two parts defining a gate opening extending longitudinally of the electrode, and an anode opposite the opening.

12. The combination as set forth in claim 11, with the addition of means for moving the movable part in an axis transverse to the tubular structure for varying the gate opening.

13. A pick-up device for translating mechanical into electrical impulses comprising an evacuated vessel, an electrode assembly, said assembly including an anode and a cathode, resilient supports for the anode and the cathode, connected to form a rigid assembly resiliently supported from one end of the vessel with the assembly close to the other end of the vessel, a cover for the said other end, said cover including a flexible portion, means supported on the cover for flexing the assembly on its supports for adjusting the mean portion of the electrodes, and a movable gate electrode fastened to said portion and cooperating with the cathode and anode to provide a variation in the electron flow by a movement of the gate electrode transversely to the path of the electrons.

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