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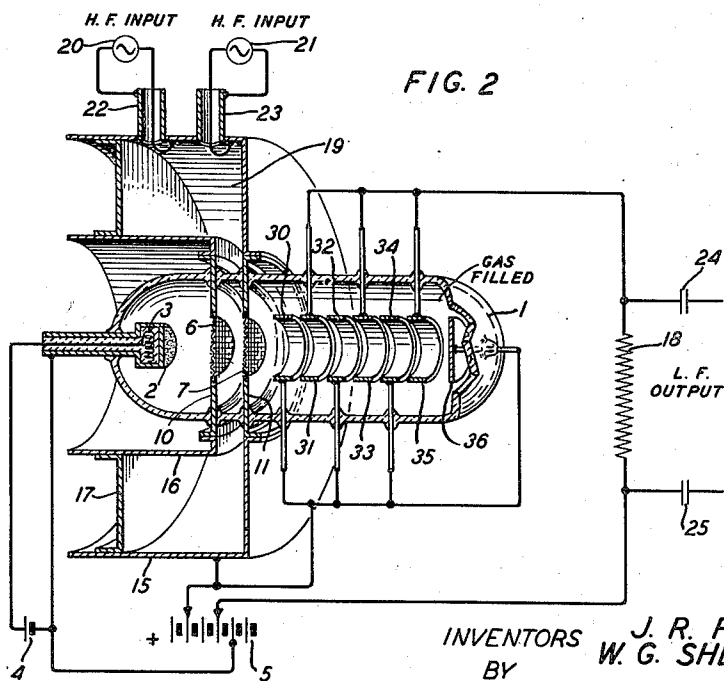
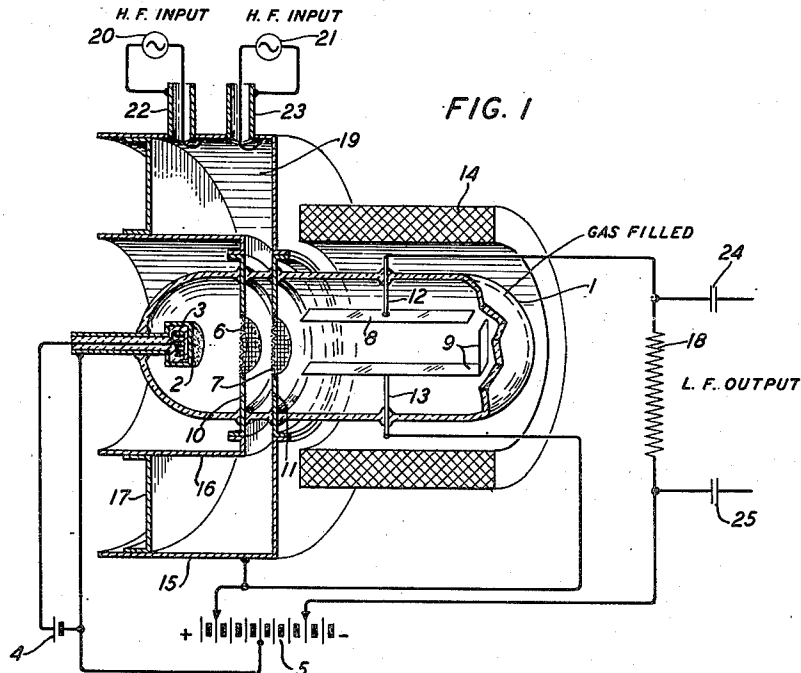
J. R. PIERCE ET AL

2,538,267

GASEOUS ELECTRON DISCHARGE DEVICE

Filed May 19, 1945

6 Sheets-Sheet 1



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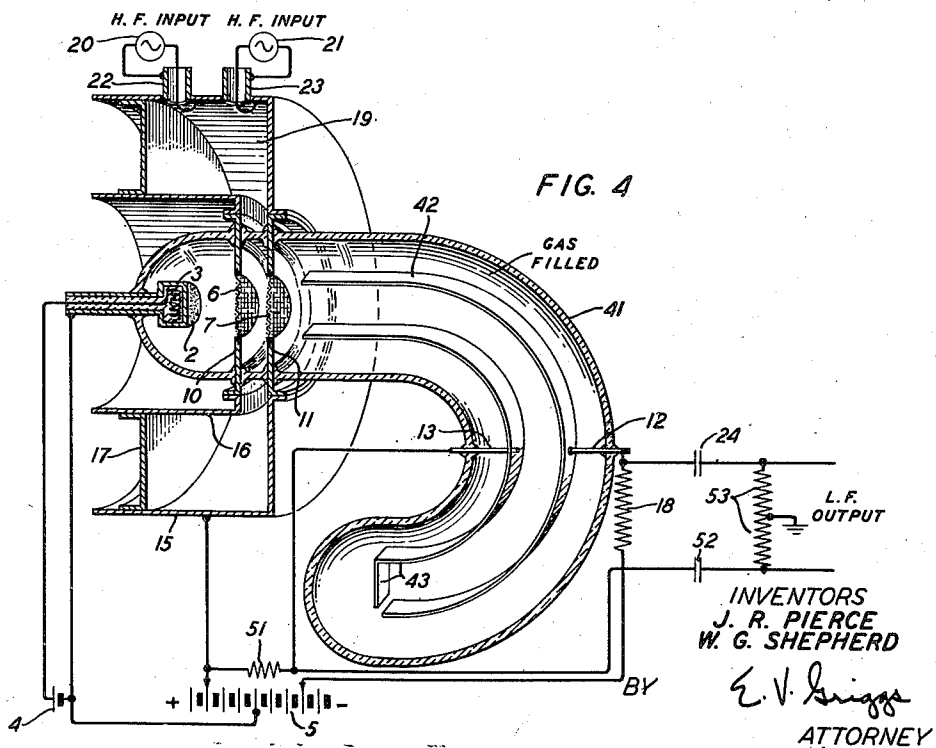
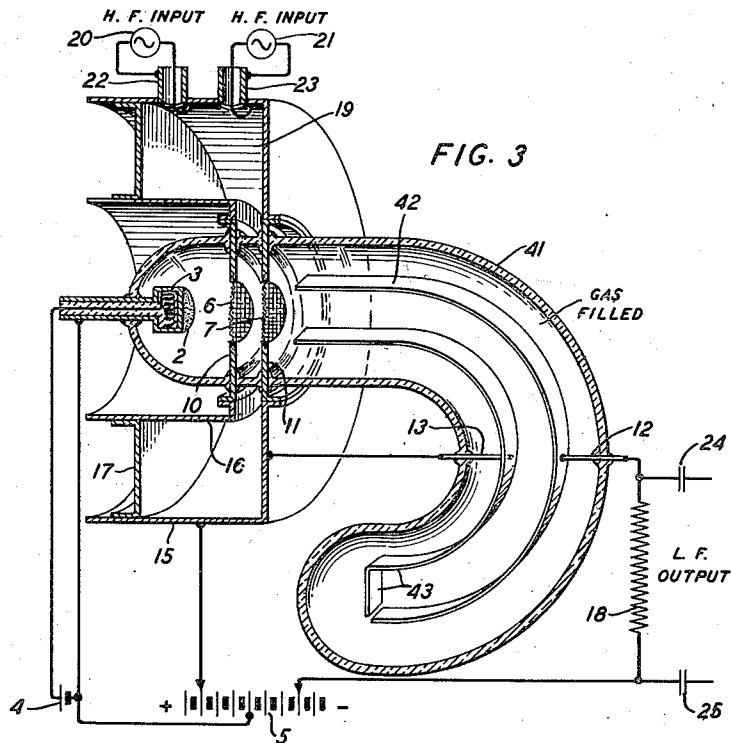
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GASEOUS ELECTRON DISCHARGE DEVICE

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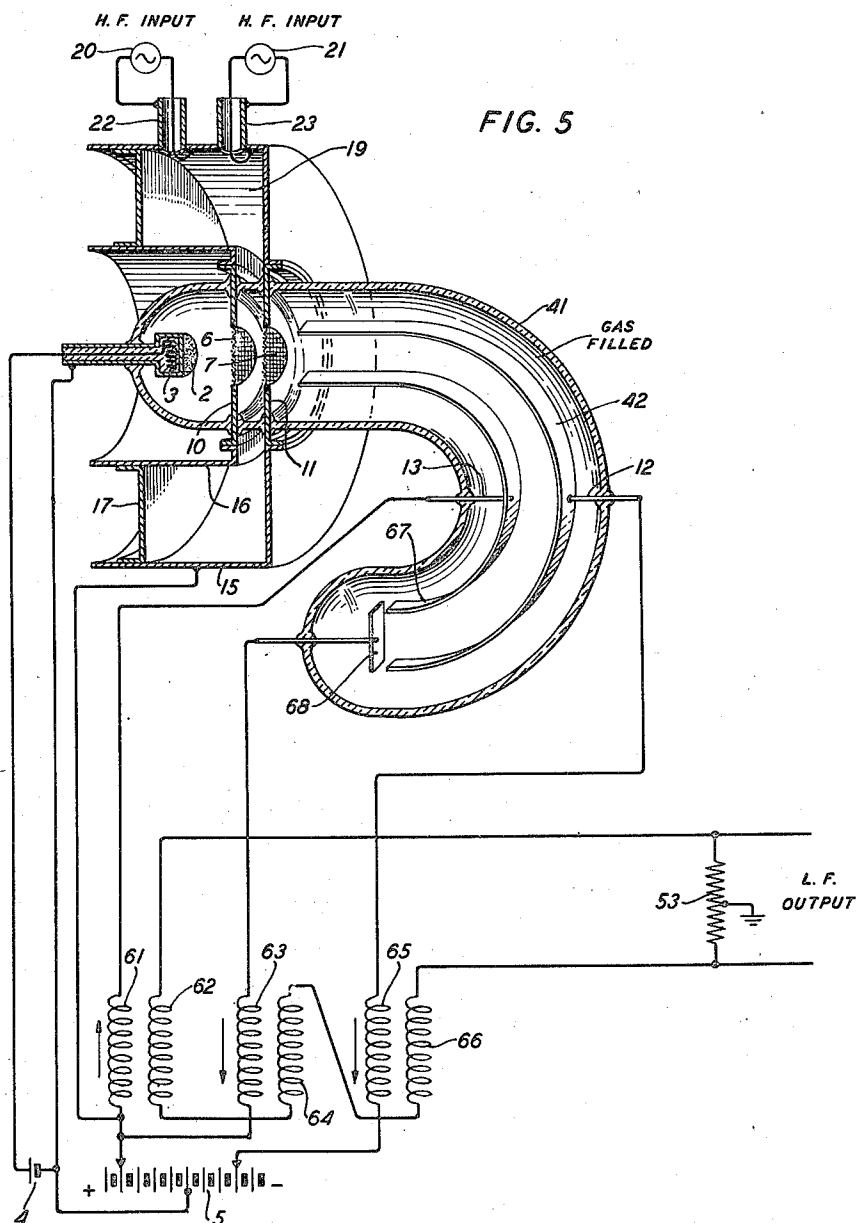
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GASEOUS ELECTRON DISCHARGE DEVICE

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GASEOUS ELECTRON DISCHARGE DEVICE

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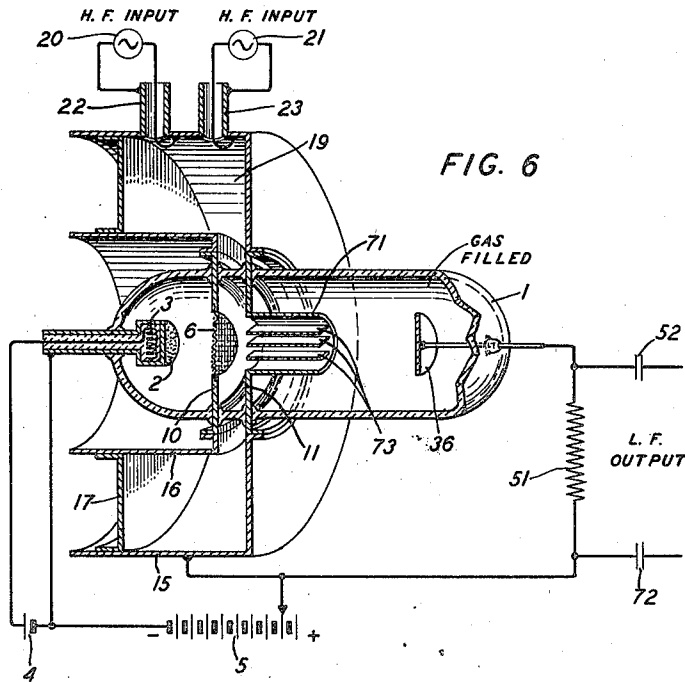


FIG. 6

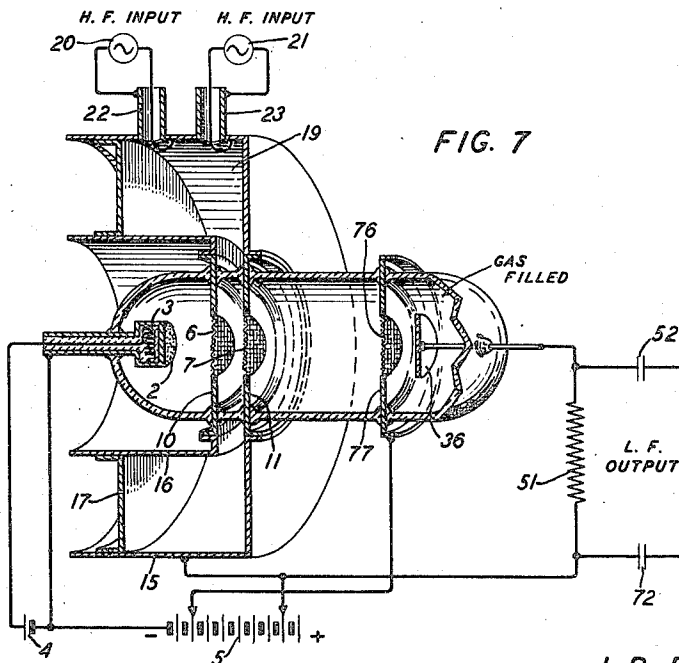


FIG. 7

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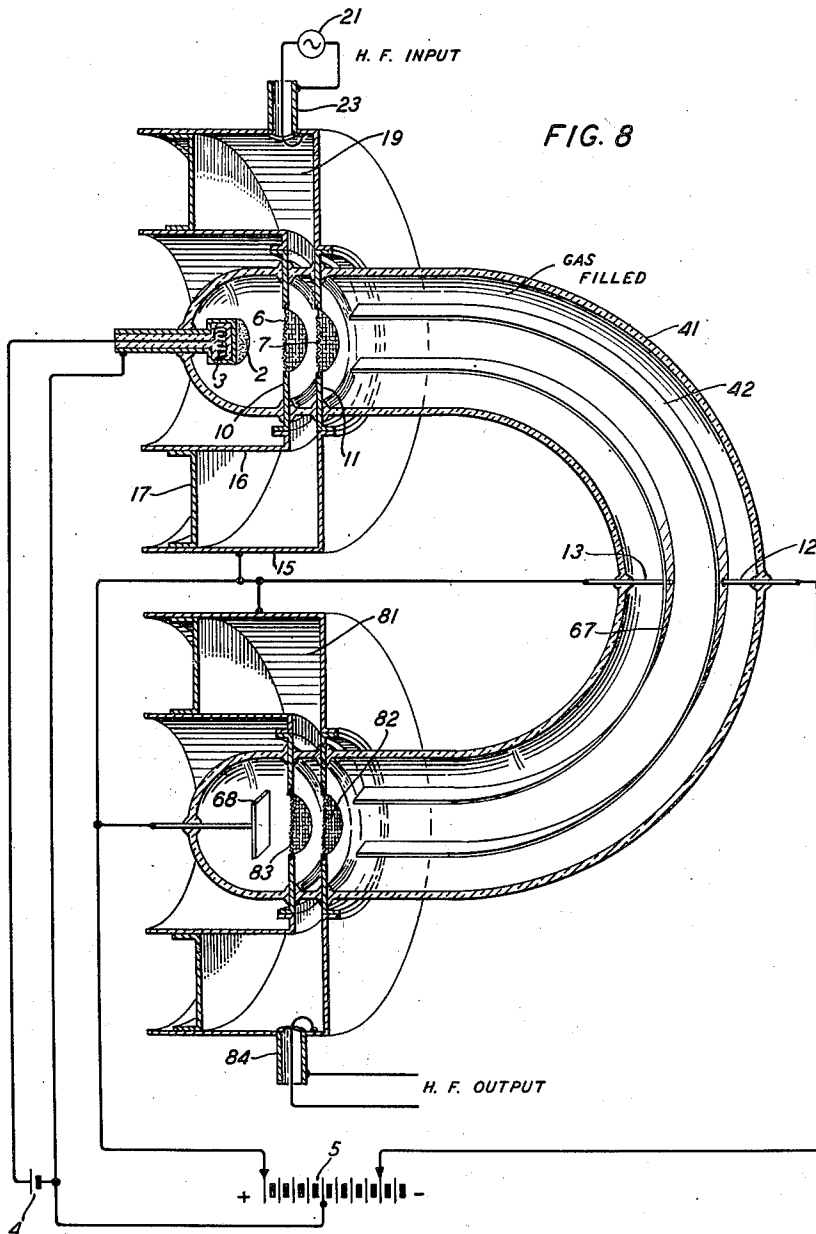
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GASEOUS ELECTRON DISCHARGE DEVICE

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6 Sheets-Sheet 5



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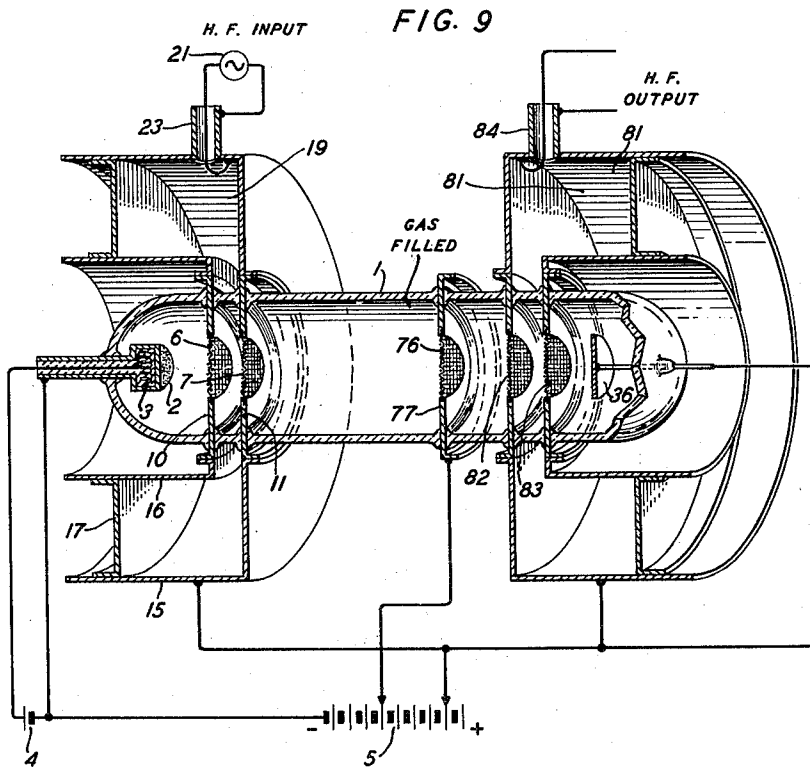
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GASEOUS ELECTRON DISCHARGE DEVICE

Filed May 19, 1945

6 Sheets-Sheet 6



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UNITED STATES PATENT OFFICE

2,538,267

GASEOUS ELECTRON DISCHARGE DEVICE

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Application May 19, 1945, Serial No. 594,630

19 Claims. (Cl. 315-5)

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This invention relates to electron discharge devices such as detectors, frequency converters and amplifiers and more particularly to those employing an electron tube which contains an ionizable gaseous atmosphere and of which the operation is characterized by variable ionization.

A principal object of the invention is to provide such devices of good sensitivity and better efficiency than heretofore available.

This and subsidiary objectives are attained by taking advantage of the rapid changes in gas ionization which may occur with changes in the ionizing agency, and of the benefits of relatively high tube potentials and well-adapted circuits.

United States Patent 2,288,256, issued to co-applicant William G. Shepherd June 30, 1942, discloses circuits utilizing the effects of collisions between electrons and gas molecules in an electron tube as the velocity of the electrons is varied. It is particularly concerned with the probability of collision and the electron scattering occasioned thereby. The present invention pertains to the effects of such collisions occurring under conditions of ionization and is concerned with variations in ionization resulting from variations in the velocity of electrons projected into the gaseous atmosphere. Under such a condition the products of ionization (positive ions and electrons) may be utilized as well as the effects of the scattering of the projected electrons which are velocity varied by an input electrical signal so as to be instrumental in producing and varying the ionization. By the employment of high potentials (exceeding the ionization potential of the gas) high electron current is possible permitting relatively high output power and efficiency to be obtained. For a discussion of the efficiency of ionization by electron impact and curves showing the variation with changes in electron energy, reference may be made to an article, "The ionization of helium, neon, and argon by electron impact," by Philip T. Smith, published in the Physical Review, volume 36, page 1293 (October 15, 1930).

A more complete understanding of the invention may be had from the following description and the accompanying figures, of which:

Fig. 1 shows an arrangement particularly suitable as a detector or frequency converter according to the invention in which the electron path is essentially straight and an axial magnetic field is employed to prevent excessive divergence of the electron beam;

Fig. 2 shows a detector or frequency converter

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arrangement similar to Fig. 1 but without the magnetic field and employing a series of aligned annular electrodes;

Fig. 3 shows a detector or frequency converter arrangement employing curved electrodes to permit the use of a long electron path and facilitate the collection of positive ions;

Fig. 4 is an arrangement similar to that of Fig. 3 except that push-pull operation is obtained through the utilization of both electrons and positive ions;

Fig. 5 is another push-pull arrangement but utilizing a three-section transformer and a split electron collecting electrode to attain higher efficiency;

Fig. 6 shows a detector or frequency converter arrangement in which electrons scattered or deflected as a result of ionizing collisions with gas molecules are collected by a slat-like grid electrode before they reach the output electrode;

Fig. 7 shows a detector or frequency converter arrangement wherein electrons whose forward velocities are retarded by ionizing collisions with gas molecules are retarded and collected by a low potential grid and so prevented from reaching the output electrode;

Fig. 8 shows an amplifier arrangement utilizing curved electrodes to collect positive ions and scattered and slowed electrons, the output signal being produced by other electrons having sufficient velocity to reach the output electrodes; and

Fig. 9 shows an amplifier arrangement which utilizes a retarding grid to prevent scattered and slowed electrons from reaching the output electrodes, the output signal being produced by the electrons not so affected by ionizing collisions.

Consider now the embodiment of the invention illustrated in Fig. 1. An electron tube comprises the generally cylindrical air-tight envelope 1 (which may be of glass or other suitable material) enclosing in an ionizable gaseous atmosphere the electrodes 2, 6, 7, 8 and 9. Electrode 2 is an electron-emitting cathode which may be of any suitable type either heated or cold. For an example it is shown in the figure as being indirectly heated from the energy source 4 by the heater 3. Electron permeable grids 6 and 7 are supported by annular metallic rings 10 and 11 which pass through the envelope to permit external connection to the grid electrodes. These grid electrodes are maintained at a potential positive with respect to the cathode by connection through the cavity resonator member 15 to energy source 5. By this means a stream of electrons is projected from the cathode through the grid electrodes and

along the axis of the envelope 1 into the space between the electrodes 8 and 9. The electrodes 8 and 9 may be in the form of plates extending along the electron stream as shown and may be supported by rods such as 12 and 13 which pass through the envelope 1 and provide for external electrical connections. The end portion of the electrode 9 farthest from the cathode is bent at a right angle to the rest of the electrode and to the axis of the envelope 1 to intercept the electrons reaching that point. As an alternative a separate positively charged electrode such as is shown in Fig. 2 may be used to terminate the electron path. Electrode 9 is given a potential positive with respect to the cathode through the connection to the direct current potential source 5 and serves to collect electrons from the space between it and electrode 8. The potential applied to electrode 9 may or may not be the same as that applied to electrodes 6 and 7. The electrode 8 is maintained at a potential negative with respect to the electrode 9 by the connection through the resistor 18 to the direct current potential source 5 and serves to collect positive ions produced in the space between electrodes 8 and 9. In Fig. 1 the electrode 8 is shown connected to the source 5 so as to be negative with respect to the cathode. It is essential only that electrode 8 be negative with respect to electrode 9 and it may be either positive or negative with respect to the cathode.

An axial magnetic field may be employed to reduce divergence of the electron stream. This may be provided by means of a direct current coil surrounding the tube envelope as the representation designated 14 or in any other suitable manner.

Attached to the grid electrodes 6 and 7 through the rings 10 and 11 is a cavity resonator 19 comprising the cylindrical members 15 and 16 and the annular member 17. The member 17 connects members 15 and 16 and is slidable axially therebetween to alter the size and thereby the resonant frequency of the cavity. The cavity is bounded by the members 17, 16 and 15, the rings 11 and 10 and the grid electrodes 7 and 6. Input excitation of the cavity at high frequency may be in any suitable manner such as from the input sources 20 and 21 through the coaxial lines 22 and 23 which terminate in coupling loops within the cavity. Excitation may be at a single frequency as for simple detection or at a plurality of frequencies as shown for the case of a frequency converter. With excitation of the cavity resonator, a high frequency alternating potential is produced between the electrodes 6 and 7, and the resulting electric field therebetween impresses corresponding variations in the velocity of the electrons in the passing stream as is usual in devices of the velocity variation type.

The gas included in the envelope of the tube is preferably one having a relatively high ionization potential such as helium and the potentials applied to the electrodes may be such that the constant electron velocity component due to the direct current potentials is maintained below the ionization potential of the gas. The high frequency excitation of the cavity resonator by the input signal would then vary the energy of the electrons above and below the ionization potential of the gas. On the other hand, the potentials may be such that the constant electron velocity component due to the direct current potentials is maintained above the ionization potential of the gas preferably at a point where the ionization

changes are relatively great with variation in electron energy. Then the excitation of the resonator would vary the degree of ionization of the gas. Either of these modes of operation may be used according to the invention, and it is evident that in either case the gas may be variably ionized in accordance with the signal input. Different effects of the ionizing collisions between the velocity varied electrons and the gas molecules may be utilized for desirably translating the signal. One of these is the variable production of positive ions and electrons from the breakdown of gas molecules. Others are the effects upon the electron stream from the cathode due to reactions upon the colliding electrons whereby they are scattered and deflected from their normal axial paths and lose forward velocity. In the Fig. 1 arrangement the variably produced positive ions are utilized in deriving the output signal in the following manner. Without input excitation of the cavity resonator 19 the steady electron stream from the cathode 2 passes through the electrodes 6 and 7 into the region between the electrodes 8 and 9 and the electrons are collected on various portions of the positively charged electrode 9. If the steady electron velocity is below the ionization potential of the gas in the tube, no positive ions are produced and no current flows to electrode 8 or through the resistor 18. If the steady velocity is above the ionization potential of the gas, there will be a steady production of positive ions which will be drawn to the negatively charged electrode 8 resulting in a steady flow of current through the resistor 18 which however will not affect a signal output circuit which may be connected through the stopping capacitors 24 and 25 to the resistor 18. The steady no input electron velocity may be adjusted suitably to either of these conditions. Then if the input cavity resonator 19 is excited, the varying potential occurring between the electrodes 6 and 7 will vary the velocities of the electrons in the passing electron stream alternately above and below the ionization potential if the no input adjustment has been below that or will vary the electron velocities to vary the magnitude of the ionizing potential if the no input adjustment has been above it. In either case there is a variable production of positive ions which flow to the negative electrode 8 and produce a variable current through the resistor 18 in accord with the input excitation. The signal voltage thus produced across the resistor 18 may be applied to any desired output circuit through the capacitors 24 and 25.

Fig. 2 shows an arrangement electrically equivalent to Fig. 1 in so far as signal translation is concerned. Instead of the axial magnetic field and the plate electrodes 8 and 9 of Fig. 1, Fig. 2 shows the use of a series of aligned annular electrodes, alternate ones being positive and negative with respect to those adjacent. These alternately positive and negative electrodes serve to selectively collect electrons and positive ions and at the same time due to a focusing effect tend to prevent divergence of the electron stream. The elements of Fig. 2 which are the same as in Fig. 1 are correspondingly designated and similarly function. The path of the electron stream from the cathode 2 follows the axis of the cylindrical tube envelope 1 and terminates at the collector 36. The series of annular electrodes axially aligned with the electron path are disposed along that path between the velocity varying electrodes 6 and 7 and the collector 36. Alternate ones of

these annular electrodes 30, 32 and 34 are connected to the direct current potential source 5 so as to be maintained at a positive potential with respect to the cathode 2. The other alternate annular electrodes 31, 33 and 35 are connected through the resistor 18 to the potential source 5 so as to be maintained at a potential negative with respect to the electrodes 30, 32 and 34. This potential of the more negative electrodes 31, 33 and 35 is not critical but must not be so low as to stop the electron stream. The operation of this circuit is the same as that of the Fig. 1 arrangement. The electrons are collected by the positive electrodes 30, 32, 34 and 36. The positive ions which are variably produced by the velocity variations imposed upon the electron stream by the input signal are collected by the more negative electrodes 31, 33 and 35 causing variable current corresponding to the signal input to flow in resistor 18. The output signal voltage thereby appearing across the resistor 18 may be applied to any desired load circuit through the blocking condensers 24 and 25.

Fig. 3 illustrates a variation of Fig. 1 in which the straight flat electrodes 8 and 9 of Fig. 1 are replaced by longer curved electrodes 42 and 43, the tube envelope 41 is made curved to accommodate the curved electrodes and the direct current magnet coil is omitted. The elements of Fig. 3 which are the same as in Fig. 1 are similarly designated and their functioning is the same. The inner curved electrode 43 corresponds to the electrode 9 of Fig. 1 and is similarly connected to the potential source 5 so as to be maintained at a positive potential with respect to the cathode 2. The outer curved electrode 42 corresponds to the electrode 8 of Fig. 1 and is similarly connected to the potential source 5 through the resistor 18 so as to be at a negative potential with respect to the electrode 43. An advantage of the curved electrodes such as 42 and 43 is that they permit the use of a longer electron path. This is because the direct electric field maintained between the long positive and negative electrodes deflects the electron stream causing it to follow a path which curves toward the more positive electrode. The operation of the Fig. 3 arrangement is the same as that of Fig. 1. Electrons are collected by the electrode 43. The variably produced positive ions go to the more negative electrode 42, causing an output signal voltage to be developed across the resistor 18 which may be applied to an output load circuit through the coupling and blocking capacitors 24 and 25.

Fig. 4 illustrates a modification of Fig. 3 in which push-pull type of operation is secured. In the arrangements of Figs. 1, 2 and 3 only the positive ions have been utilized to produce the output signal. In the arrangement of Fig. 4 the electrons produced by ionization are also used to that end. In Fig. 4 the elements which correspond to those in Fig. 3 and perform similarly are similarly designated. The curved electrodes 42 and 43 collect positive ions and electrons respectively just as in the Fig. 3 arrangement. However, electrode 43 instead of being connected directly to the direct current source is connected through the resistor 51. Thus, the collection by the electrode 43 of electrons variably produced, as the input signal causes variable ionization, will produce corresponding variations of voltage across the resistor 51 which may be transmitted to an output load circuit through the capacitor 52 just as the output signal voltage variations produced across the resistor 18 by the collection

of positive ions is transmitted through the capacitor 24. The resistor 53 is shown with a grounded center tap to balance the output load circuit. The resistor 53 may be considered to represent a balanced load circuit or it may be considered a balancing means to the terminals of which a load circuit may be connected. It may be seen that the voltages developed across the resistors 18 and 51 by the collection of positive ions and electrons respectively are complementary in producing output voltage across the resistor 53.

Fig. 5 is a variation of Fig. 4 to improve the translating efficiency of the device by utilizing not only the collection of positive ions and electrons variably produced by gas ionization but also the variations in the distribution of the collection of electrons from the cathode as the ionization of the gas is varied. As before, the similar elements of Fig. 5 are designated as in the preceding figure and their functions are similar. In Fig. 5 the inner curved (positive) electrode of Fig. 4 is divided into two parts. In effect the end portion corresponding to that shown bent at a right angle in Fig. 4 (as also in Figs. 1 and 3) is (in Fig. 5) detached from the curved portion 67, is designated 68 and is separately connected through the transformer winding 63 to the direct current source 5. The curved portion 67 is connected to the source 5 through the transformer winding 61. The outer curved electrode 42 is connected to the source 5 through the transformer winding 65. Secondary windings 62, 64 and 66 of the transformer are coupled to windings 61, 63 and 65 respectively and may be connected to an output load circuit. As in the Fig. 4 arrangement, when signal input voltage is applied to the grid electrodes 6 and 7, the velocity of the electrons in the stream from the cathode is varied causing variable ionization of the gas between the electrodes 42 and 67 in accord with the signal input. Positive ions produced will be collected by the more negative electrode 42 and electrons will be collected by the more positive electrodes 67 and 68. The transformer comprising windings 61 to 66 is arranged to utilize cumulatively in the output circuit the variable currents flowing to and from these electrodes as a result of the variable collection of positive ions and electrons. To illustrate, consider the input voltage to be changing to increase the electron velocity thus increasing the gas ionization. This will increase the number of positive ions collected at the negative electrode 42 which is the same as increasing the current from that electrode to the source 5 through the winding 65. This current change (an increase) is represented by the arrow adjacent to the winding 65 pointing toward the negative pole of source 5 in the direction of current flow. The increased ionization will also produce an increased number of electrons as a result of ionizing collisions and at the same time will cause a greater number of the electrons from the cathode to be scattered and lose forward velocity as a result of these collisions. Both of these effects will cause a greater number of electrons to be collected by the positive electrode 67 which is the same as increasing the current to that electrode from the source 5 through the winding 61. This current change (an increase) is represented by the arrow adjacent to the winding 61 pointing away from the positive pole of source 5 in the direction of current flow. Since the increase in electron velocity and ionization causes more of the electrons from

the cathode to be diverted to the electrode 67, fewer will reach the terminal electrode 68 resulting in a decrease in the current to that electrode from source 5 through the winding 63. This current change (a decrease) is represented by an arrow adjacent to the winding 63 pointing toward the positive pole of source 5 opposite to the direction of current flow. The secondary windings 62, 64 and 66 are connected in series aiding with respect to the directions of the arrows referred to, thus taking cumulative advantage of the current changes in the windings 61, 63 and 65. The secondary windings are shown connected to the balancing resistor 53 and may be connected to any suitable output signal load circuit. The circuit of Fig. 5 thus offers the advantages of relatively high output and efficiency. Contrasted with the circuit of Fig. 4 for instance it takes advantage of the changing distribution of electrons between the two positive collecting electrodes whereas in a circuit such as Fig. 4 there is a single positive electron-collecting electrode connected to the output circuit and only the variation in the total number of electrons reaching it due to electrons produced by gas ionization can contribute to the output of the device.

Figs. 6, 7, 8 and 9 illustrate arrangements having features shown in the previous figures but which rely entirely upon the variable collection of electrons to produce output energy. The effects utilized are those of scattering and the resultant slowing of the electrons due to collision with gas molecules, which effects are enhanced by the employment of relatively high electron energy exceeding the ionizing potential of the gas.

Fig. 6 shows a device in which electrons losing forward axial velocity through being scattered or deflected from their normal path by ionizing collisions with gas molecules are intercepted while other electrons not so deflected continue to an output electrode and produce output signal energy. In this figure many of the elements are the same as shown in earlier figures and already described. These are similarly designated in Fig. 6. An input cavity resonator is employed. However, the second input velocity variation grid supported by the ring 11 is different from the grid 7 shown in previous figures in that it is what may be termed a slat grid. It comprises a number of spaced parallel plates 73 extending parallel to and along a portion of the path of the electron stream after it emerges from the region within the cavity resonator where the electric field varies the electron velocities according to the signal input. In operation, as the velocity-varied electrons pass through the spaces of the slat grid, they ionize the gas to a greater or less extent depending upon their velocities and in this process the electrons themselves are scattered and deflected from their paths in varying degrees so that, depending upon the input voltage, portions of the electrons no longer follow their original axial path and are collected by the slat grid. The remainder of the electrons continue on and are collected at the positive electrode 36 causing current to flow through and a signal voltage to occur across resistor 51. This output signal voltage developed across the resistor 51 may be connected to any desired load circuit as through the capacitors 52 and 72.

Fig. 7 is similar to Fig. 6 except that instead of employing a slat grid to intercept scattered electrons it employs two similar velocity-variation

grids 6 and 7 as shown in all the figures except Fig. 6, and a retarding grid 76 supported in the annular ring 77 is utilized to intercept electrons which have lost forward velocity due to scattering by gas collisions. Other electrons continuing past the grid 76 go to electrode 36 and may produce a signal output voltage across the resistor 51 in the same manner as described in connection with Fig. 6. The output signal will correspond to the input as the number of electrons intercepted by the grid 76 will vary as the ionization varies in accordance with the input signal voltage. The grid 76 may be maintained at any suitable potential below that of the preceding grid 7. However, with respect to the cathode that potential should be lower than the ionization potential of the gas but not so low as to prevent all electron flow to the electrode 36.

It may be remarked here that an output transformer may be substituted for the output resistors such as 18, 51 and 53 in Figs. 1 to 4 and 6 and 7.

Fig. 8 shows an arrangement to operate on the same general principle as the arrangement of Fig. 6 but designed particularly as an amplifier. As such it employs cavity resonator input and output circuits. Also, it uses three collecting electrodes (of which two are curved) as in Fig. 5. The curved envelope 41 and curved strip electrodes 42 and 67 give the advantages of a long electron path as explained in connection with the description of Fig. 3. To obtain high frequency output energy from the electron stream an output cavity resonator 81 is employed. This resonator (as illustrated) may be the same as the input resonator 19 the details of which have been described. The electron permeable grids 82 and 83 permit electrons to pass through the field of the output cavity resonator and deliver energy to it in the usual manner. Electrons from the cathode 2 pass through the input resonator between the grids 6 and 7, between the curved electrodes 42 and 67, through the output resonator between grids 82 and 83 and are collected at electrode 68. In the region between the input grid 7 and the output grid 82 ionizing collisions occur between electrons and the gas molecules. Positive ions produced go to the more negative electrode 42. Electrons produced by ionization and those from the cathode which are sufficiently scattered and deprived of forward velocity by the collisions go to the more positive electrode 67 and are so removed from the stream before it reaches the output resonator. The electrons which have not been so intercepted continue through the grids 82 and 83 of the output resonator and may transfer energy to it before being collected at the electrode 68. Thus, as in Fig. 6 the electrons not intercepted produce the output energy, but by exciting a resonator rather than by developing a voltage across a resistor as in Fig. 6. In Fig. 8 the electron stream excites the output resonator in accordance with the input signal because it is density modulated due to the variable interception of electrons from the original steady electron stream from the cathode as the ionization varies in accordance with the electron velocity variations impressed by the input signal. As in the previously described arrangements, the electrode potentials are made such that the variable velocity of the electron stream produces variable ionization of the gas in the tube with resulting reaction upon the electron stream. It may be noted that since Fig. 8 illustrates an amplifier, only one input source 21 is shown coupled to the

input resonator. This is not, however, a necessary limitation. A coaxial line 84 is shown coupled to the output resonator. This line may be connected to any desired output load.

Fig. 9 shows an arrangement to operate on the same general principle as the arrangement of Fig. 7 in that slowed electrons are prevented from reaching the output region of the tube by a retarding grid. However, as this Fig. 9 illustrates particularly an amplifier, it shows only one input source and differs from Fig. 7 in other respects. Like Fig. 8 it includes both input and output cavity resonators (19 and 81 respectively), and the processes of varying the electron velocities between the input grid electrodes 6 and 7 and of deriving signal output from the density modulated electron stream between the output grid electrodes 82 and 83 are the same in both Fig. 8 and Fig. 9. Also, as in Fig. 8 and all of the other figures, the potentials applied to the tube electrodes are such that the gas is variably ionized as the electron velocities are varied by the applied input signal voltages. The retarding grid electrode 76 as in Fig. 7 may be adjusted to a suitable potential below that of the input grid 7 such that electrons which have been scattered and slowed in the ionizing process are further retarded, collected and so removed from the electron stream before it reaches the output electrodes 82 and 83. Thus, the stream continuing past electrode 76 to the collector 36 is density modulated and produces signal energy in the output resonator 81 to which any desired load circuit may be coupled as through the coaxial line 84.

In the foregoing a number of embodiments of the invention have been described in each of which signal translation is accomplished utilizing the effect of variable ionization produced by varying the velocity of a stream of electrons projected through an ionizable gaseous atmosphere. Other embodiments will be obvious and it is not intended that the scope of the invention be limited to the illustrative embodiments shown but rather that it be defined according to the appended claims.

What is claimed is:

1. An electronic system comprising an envelope containing an ionizable gaseous atmosphere, a cathode and a plurality of other electrodes, means comprising appropriate direct current potential sources connected between the cathode and other electrodes for projecting a steady stream of electrons from the cathode into the said gaseous atmosphere, without causing ionization thereof and for maintaining desired potential differences between electrodes, means comprising a signal input circuit connected to electrodes of the tube for varying the velocities of the electrons in the said stream without substantially varying the rate of emission of electrons from the cathode whereby electrons having their velocities increased cause ionization in the said gaseous atmosphere, one of said other electrodes being maintained at a negative potential with respect to the cathode to collect positive ions so produced and a signal output circuit connected to the positive ion collecting electrode.

2. An electronic system comprising an envelope containing an ionizable gaseous atmosphere, a cathode and a plurality of other electrodes, means comprising appropriate direct current potential sources connected between the cathode and other electrodes for projecting a steady stream of electrons from the cathode into the said gaseous at-

mosphere at a velocity exceeding the ionizing potential of the gas whereby a certain steady ionization of the gas is produced and for maintaining desired potential differences between electrodes, means comprising a signal input circuit connected to electrodes of the tube for varying in accordance with an input signal the velocities of the electrons in the said stream without substantially varying the rate of emission of electrons from the cathode whereby the ionization of the gas is varied in accord with the input signal and the number of positive ions resulting from gas ionization is varied correspondingly, one of the said other electrodes being maintained at a negative potential with respect to the cathode to collect the positive ions and a signal output circuit connected to the positive ion collecting electrode.

3. A signal translating system comprising an envelope containing an ionizable gaseous atmosphere, a cathode and a plurality of other electrodes, means comprising direct current potential sources connected to the cathode and other electrodes for projecting a steady stream of electrons from the cathode into said gaseous atmosphere and for maintaining desired potential differences between electrodes, means comprising a signal input circuit connected to a pair of electron permeable electrodes within the envelope for varying the velocities of the electrons in said stream without substantially varying the rate of emission of electrons from the cathode to cause variable ionization in said gaseous atmosphere, means comprising one of said other electrodes maintained at a suitably low potential for collecting variably produced positive ions and a signal output circuit connected to said positive ion collecting electrode.

4. A signal translating system comprising an electron discharge tube containing an ionizable gaseous atmosphere, a cathode, a plurality of electron permeable electrodes and an electron collecting electrode, means comprising direct current potential sources connected to said cathode and other electrodes of the tube for producing a steady stream of electrons from the cathode through the said permeable electrodes and the gaseous atmosphere, said potential sources being of a magnitude to make the energy of said stream in electron volts near to but below the ionizing potential of the gaseous atmosphere, means comprising a signal input circuit connected to two of said permeable electrodes for impressing velocity variations upon said stream whereby the energy of the electrons in said stream is caused to exceed the gas ionizing potential variably according to the signal and produce through variable ionization of the gas similarly variable quantities of electrons and positive ions and variably scattered beam electrons, means comprising a suitably biased electrode for intercepting one of said products of variable ionization and means comprising an output circuit operatively connected to said tube for extracting signal energy from one of said products of variable ionization.

5. A signal translating system comprising an electron discharge tube containing an ionizable gaseous atmosphere, a cathode, a plurality of electron permeable electrodes and an electron collecting electrode, means comprising direct current potential sources connected to said cathode and other electrodes of the tube for producing a steady stream of electrons from the cathode through the said permeable electrodes and the gaseous atmosphere, said potential sources being

of a magnitude to make the energy of said stream in electron volts above the ionizing potential of the gaseous atmosphere and at a value where variations in electron energy are accompanied by relatively large changes in the resulting ionization of the gas, means comprising a signal input circuit connected to two of said permeable electrodes for impressing velocity variations upon said stream whereby the energy of the electrons in said stream is caused to exceed the gas ionizing potential variably according to the signal and produce through variable ionization of the gas similarly variable quantities of electrons and positive ions and variably scattered beam electrons, means comprising a suitably biased electrode for intercepting one of said products of variable ionization and means comprising an output circuit operatively connected to said tube for extracting signal energy from one of said products of variable ionization.

6. A signal translating system comprising an electron discharge tube containing an ionizable gaseous atmosphere, a cathode, a plurality of electron permeable electrodes and an electron collecting electrode, means comprising direct current potential sources connected to said cathode and other electrodes of the tube for producing a steady stream of electrons from the cathode through the said permeable electrodes and the gaseous atmosphere, means comprising a signal input circuit connected to two of said permeable electrodes for impressing velocity variations upon said stream without substantially varying the number of electrons in the stream from the cathode whereby the energy of the electrons in said stream is caused to exceed the gas ionizing potential variably according to the signal and produce through variable ionization of the gas similarly variable quantities of electrons and positive ions and variably scattered beam electrons, means comprising a suitably biased electrode for intercepting one of said products of variable ionization and means comprising an output circuit operatively connected to said tube for extracting signal energy from one of said products of variable ionization.

7. A system according to claim 6 in which the means for varying the velocity of the electrons comprises a cavity resonator connected to the said two permeable electrodes.

8. A system according to claim 6 in which the means for varying the velocity of the electrons comprises a cavity resonator connected to the said two permeable electrodes and the means to produce a translated signal output comprises a cavity resonator connected to two other permeable electrodes farther from the cathode.

9. A signal translating system comprising an electron discharge tube containing an ionizable gaseous atmosphere, a cathode, a pair of electron permeable electrodes, an electron collecting electrode and a positive ion collecting electrode, means comprising direct current potential sources connected between the cathode and other electrodes of the tube for projecting an electron stream from the cathode along a path through the said electron permeable electrodes and the gaseous atmosphere and for maintaining the electron collecting electrode at a positive potential with respect to the cathode and the positive ion collecting electrode at a negative potential with respect to the electron collecting electrode, means comprising a signal input circuit connected to the said pair of permeable electrodes for varying the velocity of the electrons in the said stream in

accord with an input signal whereby the energy of the electrons in electron volts is varied over a range which extends above the ionization potential of the gaseous atmosphere and from the resulting variable gas ionization positive ions are variably produced and collected by the said positive ion collecting electrode, and a signal output circuit connected to said positive ion collecting electrode responsive to said variable collection of positive ions for producing a translated signal output.

10. A system according to claim 9 but comprising also means for maintaining a magnetic field in a region of the path of the projected electron stream and substantially parallel to the path.

11. A system according to claim 9 in which the said electron collecting electrode comprises a plurality of electrically interconnected annular electrodes spaced from each other and aligned axially along the path of the electron stream and the said positive ion collecting electrode comprises a plurality of electrically interconnected annular electrodes spaced from each other, aligned axially along the path of the electron stream and positioned along the path so as to be interleaved with the annular electrodes comprising the said electron collecting electrode.

12. A system according to claim 9 in which the said electron and positive ion collecting electrodes extend along the path of the projected electron stream substantially parallel thereto, on opposite sides thereof and are curved in a plane common to the path and the electrodes so as to follow the path as it curves toward the positively charged electron collecting electrode.

13. A system according to claim 9 but comprising also output circuit means connected to said electron collecting electrode and responsive to a variable collection of electrons by the said electron collecting electrode for producing a translated signal output and circuit means for combining signal outputs derived from the variable collections of positive ions and electrons.

14. A signal translating system comprising an electron discharge tube containing an ionizable gaseous atmosphere, a cathode, a pair of electron permeable electrodes, two electron collecting electrodes and a positive ion collecting electrode, means comprising direct current potential sources connected between the cathode and other electrodes of the tube for projecting an electron stream from the cathode along a path through the said electron permeable electrodes and the gaseous atmosphere and for maintaining each of the electron collecting electrodes at a positive potential with respect to the cathode and the positive ion collecting electrode at a negative potential with respect to the electron collecting electrodes, means comprising a signal input circuit connected to the said pair of permeable electrodes for varying the velocity of the electrons in the said stream in accord with an input signal whereby variable ionization is produced in the said gaseous atmosphere and electrons and positive ions are collected in variable quantities by the said respective collecting electrodes, and a signal output circuit connected to the three said collecting electrodes responsive to the variable collection of electrons and positive ions by those electrodes for producing a translated output signal in which the effects of the variable electron and positive ion collections by the three said collecting electrodes are combined.

15. A system according to claim 14 in which one of the said positively charged electron col-

lecting electrodes and the more negatively charged positive ion collecting electrode are positioned substantially parallel to each other on opposite sides of the electron path, extend along the path and are curved to conform substantially to the path as it curves toward the said one positively charged electron collecting electrode.

16. A signal translating system comprising an electron discharge tube containing an ionizable gaseous atmosphere, a cathode, an anode and two electron permeable control electrodes therebetween, means comprising direct current potential sources connected between the cathode and other electrodes of the tube for projecting a stream of electrons from the cathode through the said permeable electrodes and the gaseous atmosphere toward the anode at such velocity that a variation of it will vary the electron energy in electron volts over a range above the ionization potential of the said gaseous atmosphere, means comprising the said two permeable electrodes and a cavity resonator signal input circuit connected thereto for varying the velocity of the electron stream in accordance with an input signal over a range above the said ionization potential whereby variable ionization of the gaseous atmosphere is produced and a variable number of electrons in the said stream are scattered and deflected from their normal path, the one of the two said permeable grids nearest the anode comprising a plurality of spaced parallel plates extending in the direction of the normal path of the electron stream and being capable of intercepting electrons deflected from their normal path to prevent them from reaching the anode, and an output circuit connected to said anode responsive to a variable arrival of electrons at the anode for producing a translated signal output from the device.

17. A signal translating system comprising an electron discharge tube containing an ionizable gaseous atmosphere, a cathode, an anode, a pair of electron permeable control electrodes therebetween, and an electron permeable retarding electrode between the control electrodes and the anode, means comprising direct current potential sources connected between the cathode and other electrodes of the tube for projecting a stream of electrons from the cathode through the said permeable electrodes and the gaseous atmosphere and maintaining desired potential differences between electrodes, means comprising the said control electrodes and a cavity resonator signal input circuit connected thereto for varying the velocity of the electron stream from the cathode in accordance with an input signal whereby variable ionization of the gaseous atmosphere is produced and a resulting variable number of electrons in the said stream are scattered and deflected from their normal path and lose velocity in the direction of the normal path toward the said retarding electrode and the anode, one of the said potential sources maintaining the said retarding electrode at a potential positive with respect to the cathode but sufficiently low to retard and prevent passage through the retarding electrode to the anode of electrons having lost velocity in that direction due to said scattering, and an output circuit connected to said anode responsive to a variable arrival of electrons at the anode for producing a translated signal output from the device.

18. A signal translating system comprising an electron discharge tube containing an ionizable gaseous atmosphere, a cathode, a pair of elec-

tron permeable input electrodes, a pair of electron permeable output electrodes remote from the said input electrodes, a positive electron collecting electrode and an ion collecting electrode each extending longitudinally between the region of the input electrodes and the region of the output electrodes and a second electron collecting electrode on the opposite side of the region of the output electrodes, means comprising direct current potential sources connected between the cathode and other electrodes of the tube for projecting a stream of electrons from the cathode through the said permeable electrodes and the gaseous atmosphere to the said second electron collecting electrode and for maintaining each of the electron collecting electrodes at a potential positive with respect to the cathode and the positive ion collecting electrode at a negative potential with respect to the electron collecting electrodes, means comprising the said pair of input electrodes and a cavity resonator signal input circuit connected thereto for varying the velocity of the electrons in the said stream in accord with an input signal whereby variable ionization is produced in the said gaseous atmosphere and electrons and ions are collected in variable quantities by the said respective collecting electrodes, and means comprising the said permeable output electrodes and a cavity resonator connected thereto, responsive to the variations in number of electrons passing through the output electrodes to be collected by the said second electron collecting electrode, for producing a translated signal output from the device.

19. A signal translating system comprising an electron discharge tube containing an ionizable gaseous atmosphere, a cathode, a pair of electron permeable input electrodes, a pair of electron permeable output electrodes remote from the said input electrodes, an electron permeable retarding electrode between the region of the input electrodes and the region of the output electrodes and an anode on the opposite side of the region of the output electrodes, means comprising direct current potential sources connected between the cathode and other electrodes of the tube for projecting a stream of electrons from the cathode through the said permeable electrodes and the gaseous atmosphere toward the anode and maintaining desired potential differences between electrodes, means comprising the said input electrodes and a cavity resonator signal input circuit connected thereto for varying the velocity of the electron stream from the cathode in accordance with an input signal whereby variable ionization of the gaseous atmosphere is produced and a resulting variable number of electrons in the said stream are scattered and deflected from their normal path and lose velocity in the direction of the normal path toward the said anode, one of the said potential sources maintaining the said retarding electrode at a potential positive with respect to the cathode but sufficiently low to retard and prevent passage through the output electrodes to the anode of electrons having lost velocity in that direction due to said scattering, and means comprising the said output electrodes and a cavity resonator connected thereto, responsive to the variations in number of electrons passing through the output electrodes to be collected by the anode, for producing a translated signal output from the device.

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