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2,697,206

GAS TUBE CONVERTER

Filed Dec. 20, 1951

FIG. 1.

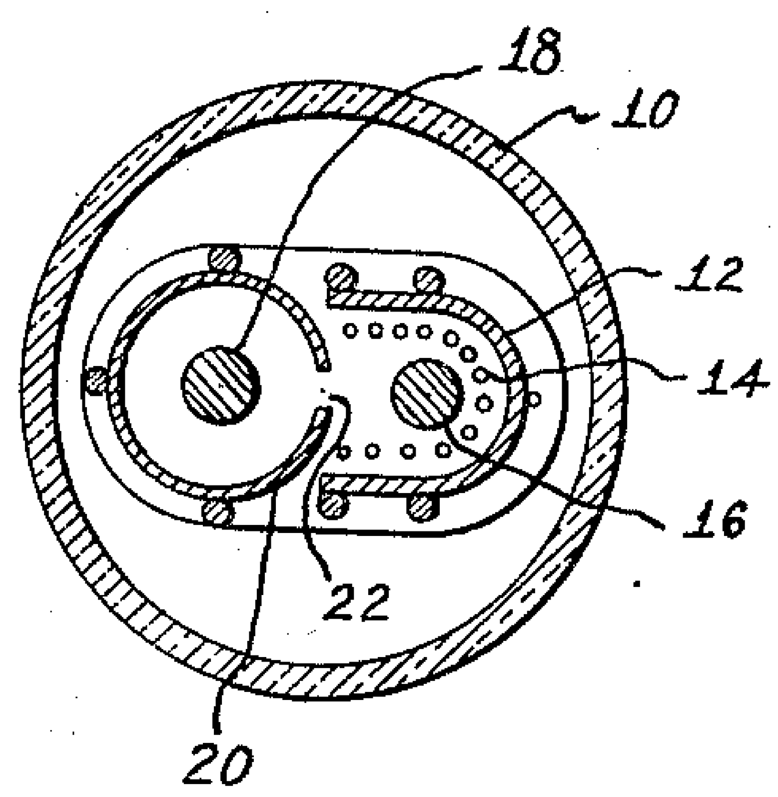
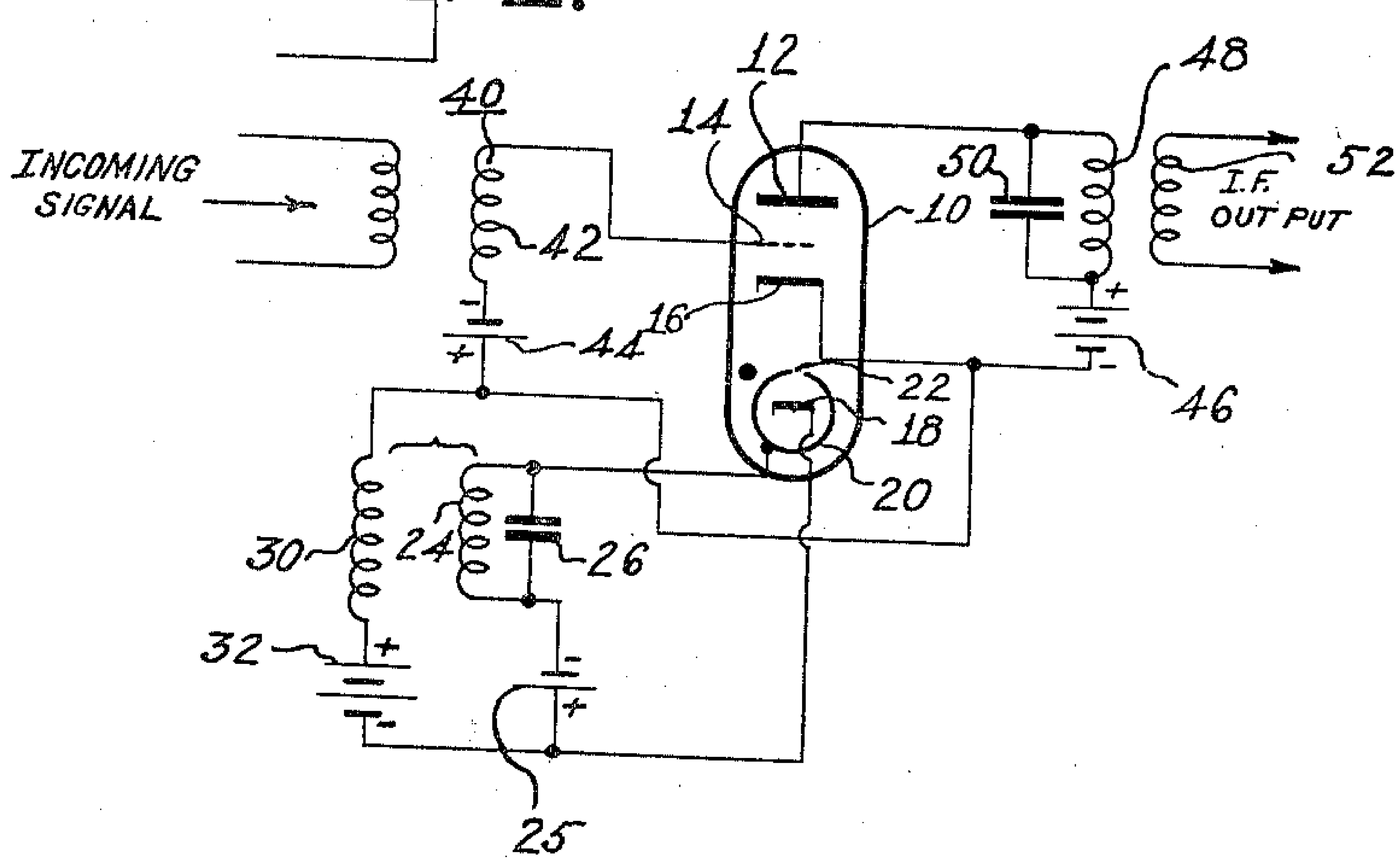


FIG. 2.



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GAS TUBE CONVERTER

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Application December 20, 1951, Serial No. 262,580

5 Claims. (Cl. 332—57)

This invention relates to improvements in gaseous electron tube systems and more particularly to converter systems employing gaseous electron tubes.

In a conventional vacuum tube a control grid, placed between the cathode and the anode, provides a very effective means of controlling the tube current. A very small change in the control grid potential will have a relatively large effect on tube current, it being possible to vary the tube current smoothly and continuously within relatively wide limits by varying the control grid potential.

Vacuum tubes, however, are subject to current limitations due to space charge and usually require high operating potential. It has been found that these limitations can be overcome by adding a small quantity of gas to the tube and ionizing the gas. If a sufficiently high potential is applied between the emitting and the collecting electrodes in the tube, the gas becomes ionized by electron bombardment of the gas molecules, thereby developing positive ions which neutralize the negative space charge consisting of electrons. The combined cloud of ions and electrons acts as an excellent conductor.

In the case of the conventional gas tube, however, it is found that the control electrode has only a trigger type of control action. Potentials on the control electrode below some predetermined level prevent tube current from flowing. The tube current flow is started by a suitable change in this control electrode potential. However, once the conventional gas tube begins to conduct, the control electrode loses control and the tube current becomes independent of the control electrode potential.

In addition to the loss of control by the control electrode, the conventional gas tube presents a further problem. In general, a certain amount of energy must be given to an atom or molecule in order to cause an electron to be liberated from the energy confines of the atomic structure. In the case of a gas tube, this means that the bombarding electrons must be given a certain minimum velocity in order to provide this minimum amount of energy and thus sustain ionization. To give the ionizing electrons this minimum velocity, a minimum potential or arc drop must be maintained between the electron emitting electrode and an electron collecting electrode immersed in the gas. In a conventional gas tube this arc drop represents a minimum wasted potential where the principal objective is to key on a load current with an input signal with the least possible loss.

Because of the trigger type of control which the conventional gas tube has, it has not found favor as a tube to be employed in a converter or signal mixing circuit. There are advantages, however, in being able to employ a gas tube for such an application. A gas tube provides a high current output, which can eliminate the requirement for subsequent amplification prior to detection. Also, the output is at a low impedance, thus reducing pickup noise and eliminating the requirement for an impedance matching transformer when coupling to a detector.

In a copending application of E. O. Johnson, Serial No. 185,745, filed September 20, 1950 and assigned to the assignee of the present invention, there is described and claimed a gaseous electron tube in which the functions of supplying energy to provide a space charge neutralizing plasma and providing a field to draw work current are separated. It was found that by having separate work and ionization paths and by energizing the work circuit at a low potential, the function of providing

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plasma would not be taken over by the work circuit. Since the work current is incapable of causing ionization, an auxiliary source of ionizing current is provided to fill the need, and since only this source is energized with a potential large enough to produce ions, it is unaffected by signal variations in the form of either changes in the potential of the control grid or changes in the work current which are produced thereby.

In such a tube structure it is found that a very high current can be passed between the main emitter electrode and the collector electrode at potentials far below those normally required to ionize the gas. It is also found that the current flow between the main emitter electrode and the collector electrode can be controlled in various ways, one of which is by means of varying the control electrode potential as in a conventional vacuum tube. Accordingly, the tube may be made to operate as an oscillation generator by applying positve feedback between the collector or anode and control grid or between the main emitter or main cathode and control grid.

It is an object of the present invention to provide a novel converter circuit employing a gas tube of the type described.

It is a further object of the present invention to provide an improved converter circuit employing a gas tube of the type described.

It is still a further object of the present invention to provide a useful and inexpensive converter circuit employing a gas tube of the type described.

These and further objects of the invention are achieved by employing a gaseous discharge tube having separate work function and ionization function electrodes. The ionization function electrodes are coupled to one of the work function electrodes in a manner to establish oscillations in the plasma at a first frequency. A signal is applied to the control grid at a second frequency. The anode has a tuned circuit connected thereto. The frequency of the tuned circuit is determined by the frequencies of the oscillation in the plasma, and the signal being applied to the control grid. The third frequency or frequency of the tuned circuit connected to the anode may be the sum or difference of the first and second frequencies. The novel features of the invention as well as the invention itself, both as to its organization and method of operation will best be understood from the following description when taken in connection with the accompanying drawings, in which

Figure 1 is a cross-sectional view of a gaseous electron tube utilized in the embodiments of the invention, and

Figure 2 is a circuit diagram of a converter system which is an embodiment of the present invention.

Reference is now made to Figure 1 wherein there is shown in cross-section a view of the gaseous electron tube which is utilized in this invention. A tube envelope **10** contains a U-shaped anode **12** of sheet metal which is disposed external to and in juxtaposed position with a control grid **14** having relatively coarse spacing. A main cathode **16** is maintained within and is partially surrounded by the control grid **14** as well as the anode **12**. An auxiliary cathode **18** is maintained coaxially with respect to a slotted cylindrical constricting electrode **20**.

The elongated narrow slot **22** in the electrode **20** is positioned with its center extending along a plane base through the axes of the auxiliary and main cathodes. This permits the desired degree of ionization to be obtained between the auxiliary and main cathodes with a considerable minimization of power required to sustain ionization. The anode **12** and the main cathode **16** of the tube provide the load circuit through which load currents can be passed in the manner of conventional tubes. These currents may be controlled by the potential applied to the control grid **14**. The auxiliary cathode **18** is an additional electrode for cooperation with the main anode **12** and main cathode **16** to provide for the ionization of the tube. In the usual operation of the tube, a source of potential (not shown) which has a value less than that required for ionization, is connected between the main cathode and the anode, and a second source of potential (not shown) which has a value sufficient to provide ionization, is connected between the main cathode and the auxiliary cathode. This latter potential may, for example, be on the order of 50 volts for helium filled tubes.

This gaseous electron tube is completely shown, described and claimed in the above identified copending application by E. O. Johnson. Ionization or breakdown of gas occurs between the auxiliary cathode and the main cathode and/or anode of the tube. There is thus provided within the tube envelope, a plasma which acts as an excellent conductor to provide, in effect, a low resistance connection between the main cathode and the anode of the tube. The density of the plasma generated in the tube is controlled at least in part by the amount of current flowing through the ionization circuit. Accordingly, the effect of resistance between main cathode **16** and the anode **12** may be controlled effectively by controlling the current flow in the ionization circuit. Alternatively, the load current may be controlled by the potential applied to the control grid **14** interposed between the main cathode and the anode. The characteristics of the type of gaseous electron tube utilized are such that a relatively small change in the ionization current is effective to produce in the load circuit a relatively large current change.

Referring now to Fig. 2 of the drawings, there may be seen a circuit diagram of a converter system which is an embodiment of the invention. A gaseous electron tube, such as has been described above, is employed.

A tuned circuit, consisting of a parallel connected inductance **24** and capacitance **26** is connected between the constricting electrode **20** through a bias source **25** to the auxiliary cathode **18**. An inductance **30** is connected between the main cathode **16** through a source of ionizing potential **32** to the auxiliary cathode **18**. The inductance **30** is inductively coupled to the tuned circuit inductance **24** which is connected to the ionization function electrodes. As is well-known to the art, these two coils may be included in transformer having a tuned primary. The values of the capacitance **26** and inductance **24** of the tuned circuit are selected to provide resonance at a first desired frequency.

In view of these connections, which establish feedback between main and auxiliary cathode and constricting electrode, oscillations are set up in the plasma generating section of the tube which have the effect of modulating the plasma generated at the frequency of the tuned circuit. An input transformer **40** is used to apply a signal at a second frequency between the control grid **14** and the main cathode **16**. The secondary **42** of the signal input transformer is connected to the main cathode through a source of bias potential **44**. The input signal may also be applied to the control grid in any of the other well-known methods. The present system is shown merely by way of illustration.

A source of potential, **46**, having a value less than that required to ionize the gas in the tube, is connected between the anode **12** of the tube and the cathode **16** of the tube through a second tuned circuit. This second tuned circuit, consisting of inductance **48** and capacitance **50** in parallel, is tuned to a third frequency which may be the sum or difference frequency of the frequency of the signal input and the frequency of oscillation in the ionization section of the tube. Output is derived from the inductance **48** in the second tuned circuit by means of an inductively coupled coil **52**. It is to be appreciated that an output transformer may be employed utilizing a tuned primary connected to the anode of the tube.

The voltage fed back from the cathode in the circuit modulates the plasma in the ionization circuit which in turn modulates the current flowing in the work portion of the tube. The incoming signal, which is applied to the control grid further modulates the current flowing between the cathode and anode and thus a mixing or heterodyning action occurs providing sum and difference frequencies in the output circuit. If desired, external oscillations may be applied directly to the constricting electrode and auxiliary cathode in place of connecting these electrodes to form an oscillator, and the sum and difference frequencies of the two applied signals will appear in any output which is derived from the anode **12**.

There has been described above a novel, useful and simple converter system which employs a gas tube and provides a high current, low impedance output.

What is claimed is:

1. A converter system comprising in combination a

gas filled electron tube having work electrodes including an anode, a main cathode and a control grid between said anode and main cathode, and plasma generating electrodes including an auxiliary cathode and a constricting electrode surrounding said auxiliary cathode and having a slot opening therein between said main and auxiliary cathodes, means to feed a voltage at a first frequency from said main cathode across said constricting electrode and said auxiliary cathode to modulate the density of the plasma being generated, means to apply a signal voltage at a second frequency to said control grid electrode, and means to derive a voltage at a third frequency dependent upon the first and second frequencies from said gas tube anode.

2. A converter system comprising in combination a gas-filled electron tube having work electrodes including an anode, a main cathode and a control grid between said anode and main cathode, and plasma generating electrodes including an auxiliary cathode and a constricting electrode surrounding said auxiliary cathode and having a slot opening therein between said main and auxiliary cathodes, a first tuned circuit coupling said constricting electrode and said auxiliary cathode, means to feed energy from said main cathode to said first tuned circuit to modulate the plasma stream generated by said plasma generating electrodes at the frequency of said first tuned circuit, means to apply a signal at a second frequency to said control grid, and means connected to said anode to derive a signal at a third frequency dependent upon said first and second frequencies.

3. A converter system comprising in combination a gas filled electron tube having work electrodes including an anode, a main cathode and a control grid between said anode and main cathode, and plasma generating electrodes including an auxiliary cathode and a constricting electrode surrounding said auxiliary cathode and having a slot opening therein between said main and auxiliary cathodes, a transformer having a tuned primary winding tuned to a first frequency and a secondary winding, said tuned primary being coupled between said constricting electrode and auxiliary cathode, said secondary winding being coupled between said main and auxiliary cathodes, means to apply a signal at a second frequency between said control grid and main cathode, and means connected to said anode to derive a signal at a third frequency dependent upon said first and second frequencies.

4. A converter system comprising in combination a gas filled electron tube having work electrodes including an anode, a main cathode and a control grid between said anode and main cathode, and plasma generating electrodes including an auxiliary cathode and a constricting electrode surrounding said auxiliary cathode and having a slot opening therein between said main and auxiliary cathodes, a transformer having a tuned primary winding tuned to a first frequency and a secondary winding, means to apply a first bias voltage through said tuned primary winding to said constricting electrode and said auxiliary cathode, means to apply a potential having a value in excess of the ionizing potential of said tube gas through said transformer secondary winding to said main cathode and said auxiliary cathode, means to apply a second bias voltage to said control grid, means to apply a signal at a second frequency to said control grid, a second tuned circuit tuned to a third frequency dependent upon said first and second frequencies, and means to apply a potential having a value less than the ionizing value of said tube gas through said tuned circuit to said anode and to said main cathode.

5. A converter system comprising in combination a gas filled electron tube having work electrodes including an anode, a main cathode and a control grid between said anode and main cathode, and plasma generating electrodes including an auxiliary cathode and a constricting electrode surrounding said auxiliary cathode and having a slot opening therein between said main and auxiliary cathodes, a first circuit including a parallel connected inductance and capacitance having their values selected to be parallel resonant at a first frequency, a first bias source, said first circuit and first bias source being connected in series between said constricting electrode and said auxiliary cathode, an inductance positioned to be inductively coupled to the inductance of said tuned circuit and having one end connected to said main cathode, a first source of potential having a value in excess

of the value required for ionization of said tube gas connected between said auxiliary cathode and the other end of said inductance, means to apply a bias to said control grid, means to apply a signal at a second frequency to said control grid, a second circuit including a parallel connected inductance and capacitance having their values selected to be parallel resonant at a third frequency dependent upon said first and second frequencies, and a second source of potential having a value less than that required for ionizing the gas in said tube,

said second circuit and second source of potential being connected between said anode and cathode.

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