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VOLTAGE MULTIPLICATION SYSTEMS

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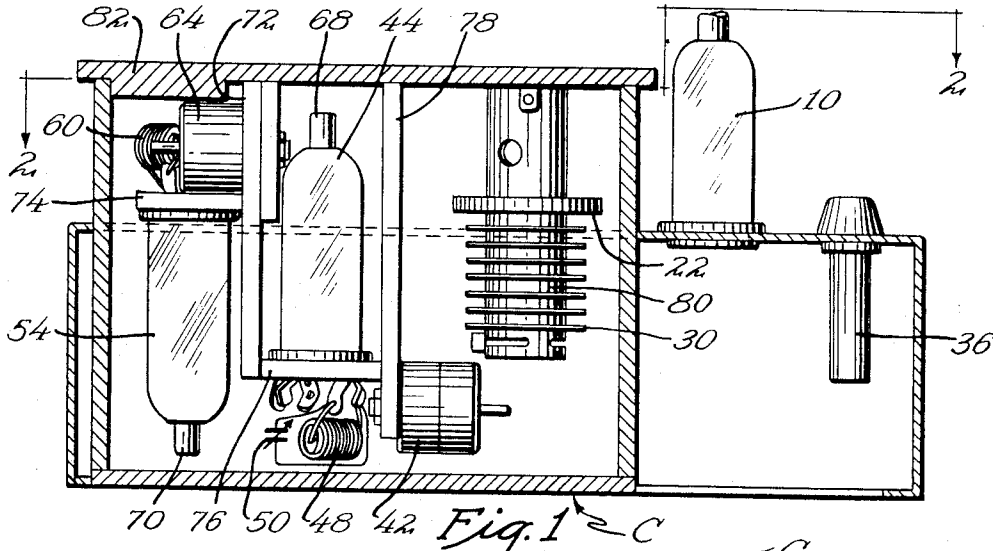


Fig. 1

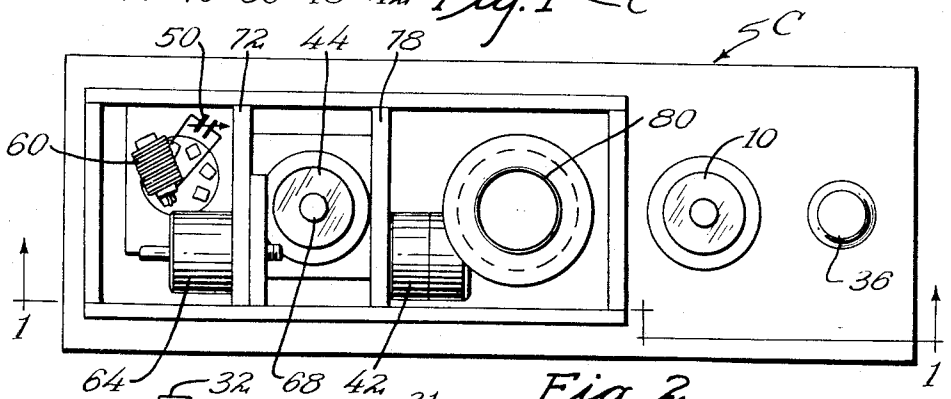


Fig. 2

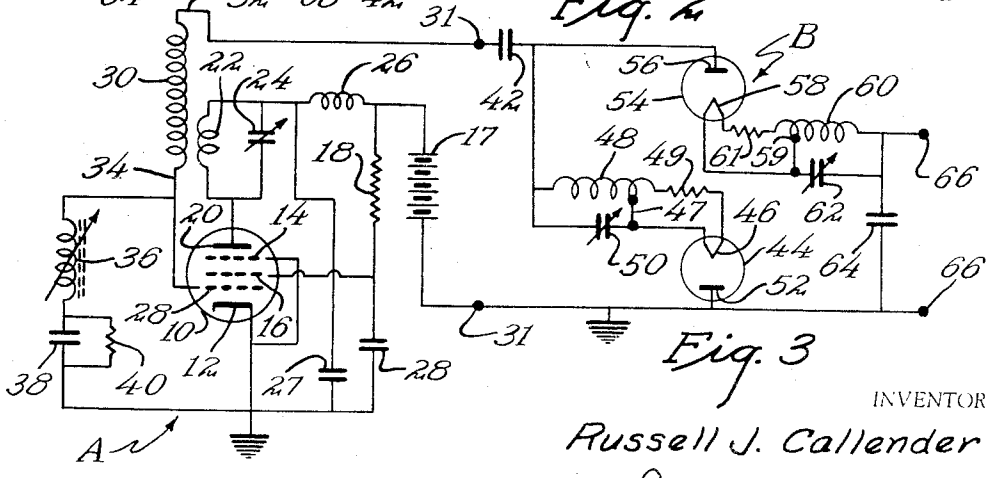


Fig. 3

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VOLTAGE MULTIPLICATION SYSTEMS

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6 Claims. (Cl. 321—2)

This invention relates to voltage multiplication systems, and pertains more particularly to an improved system of this general character having a high degree of voltage regulation for various load conditions.

In a number of electronic circuit applications it is necessary to provide a relatively high voltage output from a given lower voltage source over a range of different load conditions. In conventional oscillator-multiplier systems of this type a high output voltage carries with it the concomitant disadvantage of having large swings in output voltage for the various load changes to which the now employed systems are subjected. In some instances such swings are intolerable, for obviously relatively large swings in output voltage cause corresponding swings in output current. One example where large voltage and current changes are exceedingly detrimental is in television receivers, for in such installations picture tube voltages of the order of 30,000 volts are encountered and deviations in this picture voltage will of course adversely affect the picture tube beam current and consequently the focusing of the picture itself.

Accordingly, an object of the instant invention is to provide a voltage multiplier system that will be extremely stable in voltage output for various load conditions.

Another object of the invention is to provide a system, as above mentioned, that will have a relatively high output current at the high operating voltages for which it is designed.

Another object of this invention is to eliminate the tickler or feed back coil of conventional generator systems of this general character, thereby eliminating any danger of arcing between the high voltage output coil and the prior art tickler coil or the circuitry associated therewith, these latter elements being generally low voltage components.

Another object of the invention is to provide a novel grid shunt arrangement, adjustable to keep grid to ground voltage within controlled limits and to prevent effectually insulation break downs between the various parts comprising the oscillator tube.

A further feature of the invention resides in the physical positioning and arrangement of the component parts of my system whereby any corona discharge effect is effectively minimized for the high voltages involved.

Still another feature of the instant invention resides in the attainment of a high output voltage at the general magnitude ordinarily obtained with a tripler circuit, the invention employing only a doubler circuit.

Yet another purpose of the invention is to provide tunable means for heating the cathodes of the diodes used in the doubler portion of my overall system.

For a more complete understanding of the nature and scope of my invention, reference can be had to the following detailed description, taken together with the accompanying drawing, in which:

Figure 1 is an elevational view in section of the chassis and the physical arrangement of the salient parts of my

invention in relation thereto, the view being taken in the direction of line 1—1 of Figure 2;

Figure 2 is a view taken in the direction of line 2—2 of Figure 1 with the chassis cover removed; and

Figure 3 is diagrammatically illustrative of the circuitry used in carrying out the concepts of my invention.

For a more facile understanding of the invention, it is thought desirable to first describe the circuit pictured in Figure 3. In this figure there is shown a power amplifier tube **10**, in which the cathode **12** and the suppressor grid **14** are grounded in conventional manner. Whereas, I have shown only one tube **10**, it will of course be understood that more than one tube may be utilized when desired, the tubes then being connected in parallel with suitable resistors therebetween for operational stabilization. For instance, I have successfully operated my system when using two 6BQ6–GT tubes. The screen grid **16** is connected to a voltage supply of approximately 150 volts D.C.; as shown, this grid **16** is connected to the high side of the "B" power supply source **17** having a resistance **18** of about 8,500 ohms in circuit therewith to provide the 150 volts screen voltage when the source **18** is a potential of roughly 400 volts D.C. or less.

The plate **20** has in circuit with it a parallel resonant L-C circuit comprising a low inductance coil **22** and a variable high capacitance condenser **24**. As a suggested frequency, the coil **22** and condenser **24** should be tunable to a resonant frequency in the neighborhood of 200 kilocycles. In circuit with the plate **20** and the L-C circuit **22**, **24** is a choke coil **26** of approximately 2.5 millihenries for the purpose of choking out A.C. pulsations in this D.C. plate circuit. In order to rid the plate circuit of undesired A.C. components, a condenser **27** in the neighborhood of 0.1 mf. is connected so as to pass these A.C. currents to ground. Similarly, a condenser **28** having a suggestive capacitance of 0.01 mf. is placed in the screen circuit.

Up to this point it will be seen that the plate circuit connections resemble the plate circuit arrangements of the well-known Hartley and Colpitts oscillators. However, as will be presently described, the circuitry involving the control grid **29** is radically different from known oscillator circuits. It will be noted that a high inductance coil **30** is inductively coupled with the coil **22**. This coil **30** has a low distributive capacitance and of course influences to a certain extent the setting of the condenser **24**, for there is a mutual inductive effect between the two coils **22** and **30**. It is not believed necessary to separate or classify the effects of the resonance producing components **22**, **24** and **30**, it only being necessary to appreciate that these elements are tunable to a particular resonant frequency, assumed to be 200 kilocycles in this discussion. However, it should probably be stated at this point that with a primary voltage of 250 volts A.C. impressed upon the coil **22**, the coil **30** should be so designed to produce a secondary voltage of approximately 15,000 volts A.C. of a pair of terminals **31**. In other words, the coils **22** and **30** serve as a step-up transformer, and in order to produce the proper phase relation in generating the desired oscillations, these coils are oppositely wound as denoted in the drawing.

One end **32** of the coil **30** leads directly to the doubler portion of the system (yet to be described), and the other end **34** is connected to the grid **29** of the tube **10**. Also connected to the end **34** of the coil **30** is a variable powdered iron core coil **36** having an inductance ranging from 1.0 millihenry to 5.0 millihenries, and between the coil **36** and ground is a grid condenser **38** having a capacitance of 2200 mmf. Paralleling the condenser **38** is a grid resistance **40** having a value of from 150,000 to 175,000 ohms. The iron core coil **36**, the capacitor **38** and the resistor **40** serve as a shunt for adjusting the

amount of bias on the control grid 29, as will hereinafter be made clearer in connection with the operational sequence of the system. The condenser 38 also serves as a by-pass condenser for the grid 28 to ground through the variable reactance of the coil 36.

The circuitry thus far described may be referred to as the oscillator circuit and for convenience of reference this circuit is given the letter A. As will be seen from a continued reference to Figure 3, the doubler portion of the multiplier system bears the letter B, and will now be described in detail. The ungrounded side of the doubler B is in circuit with the coil 30 and has contained therein a condenser 42 in the order of 1500 $\mu\mu$mfd.

In circuit with the condenser 42 and ground is a half-wave rectifier 44, such as a diode 1B3–GT tube. The cathode 46 of the tube 44 is heated by an auxiliary circuit comprising an inductance 48 and capacitance 50 adjustable over a frequency range in the neighborhood of the 200 kilocycles suggested as the operating frequency or whatever system frequency is selected. The inductance 48 is tapped at 47 and desirably there is placed a small current limiting resistor 49 in circuit with the tapped portion of the inductance 48 and the cathode 46. It will be observed that it is the plate 52 of this tube that is connected to ground.

A similar diode 54 has its plate 56 connected to the condenser 42 and its cathode 58 is heated in the same fashion employed for the rectifier tube 44, there being a similar inductance 60 with a tap 59, a resistor 61 and capacitance 62 in circuit with the cathode 12. The juncture of the inductance 60 and capacitance 62 opposite the cathode 58 is connected with a condenser 64 of approximately 500 $\mu\mu$mfd. which is in turn connected to ground.

A pair of terminals 66 is made available for the connection to any appropriate load. Since my system is particularly designed for supplying the beam current for television picture tubes, a load of approximately 88 megohms will be involved. With the various voltages, inductances, capacitances and resistances mentioned an output voltage of 31,000 volts D.C. is to be expected of the terminals 66 when connected to the type of load referred to. Interestingly enough, the output voltage will not vary over 3,000 volts between full load (88 megohms) and no load (open circuit), whereas circuits now employed will jump to as much as 50,000 volts no load, or even more, when previously delivering a full load voltage of 31,000 volts. Also, a relatively large output current (in the neighborhod of 200–800 micro ampere) is to be expected under the above referred to full load conditions. It should of course be understood that the various values mentioned in the course of this description are representative and that persons skilled in the art may wish to vary the constants and variables herein mentioned to suit the particular design of installation involved.

The operation of my system will now be briefly reviewed. The particular source 17 is selected so as to deliver 180 milliamperes at 325 volts. Then the condenser 24 is adjusted so that resonance is produced in the plate circuit, such resonant condition being observable when the voltage at 31 is a maximum. After this, the iron core coil 36 is adjusted for the proper grid voltage at the control grid 29. Such a grid voltage should be approximately negative 325 volts, plus or minus 50 volts as measured from the grid 29 to ground. However, it is not necessary actually to measure this grid voltage, as during the adjustment thereof the voltage at the terminals 31 will vary slightly, usually only about 100 volts or so, but it is here again the maximum voltage we are looking for. Therefore, even though the variation at 31 might be slight compared to the actual A.C. voltage existing at these terminals (about 15,000). While the grid voltage has been mentioned as negative 325 plus or minus 50 volts, this represents an optimum value which is susceptible to considerable variation. It is believed that the elements 36, 38 and 40 act as a shunt which not only serves as a means for initially setting the grid voltage for the proper value but thereafter during the functioning of the system cooperates in the stabilizing of the output voltage at the terminals 66 for the various encountered load conditions.

The doubler circuit B requires that the condensers 50 and 62 be adjusted to produce a tuning condition with the respective coils 48 and 60 that will result in the requisite heat in the cathodes 46 and 48. This is all that need be done, for the cathodes 46 and 58 will upon becoming heated, emit the necessary electrons to produce electron flow to the plate when the plate is alternately positive. When the plate 52 is positive there will be current flow to the cathode 46 and condenser 42 will become charged. On the next half cycle, when the plate 52 becomes negative, the tube 44 will be non-conducting but the plate 56 will be positive and there will be impressed on the terminals 66 the voltage of the condenser 42 from the previous half cycle plus the voltage of the instant half cycle which is rendering the plate 56 positive. This results in a voltage at 66 which is literally double that at the terminals 31, this voltage charging the condenser 64. During the next half cycle, corresponding to the first referred half cycle, the tube 44 is again conductive to charge the condenser 42, whereas the condenser 64 bolsters the voltage at 66 by then discharging into the load connected thereto. In this manner a pulsating D.C. voltage of approximately twice the voltage at 31 is sustained at 66.

In view of the fact that various parts of my system are subjected to extremely high electrical tensions by virtue of the operating voltages involved, it becomes essential to minimize the corona effect that would otherwise exist. With this aim in mind, I mount the system diagrammed in Figure 3 on a Lucite or Plexiglas chassis pictured in Figures 1 and 2, this chassis being designated generally by the letter C. Not all of the elements of Figure 3 are included, only the salient ones being indicated, in Figures 1 and 2 in order to keep these two views as simple as possible.

The tubes 44 and 54 are shown with plate terminals 68 and 70, respectively, and since these terminals 68 and 70 are alternately at widely different potentials, the tubes 44 and 54 are inverted with respect to each other. A partition 72 of Lucite or Plexiglas is interposed between the tubes 44, 54 and this partition is provided with oppositely extending lateral shelves 74 and 76 upon which the bases of the tubes 44 and 54 are affixed. Another partition 78 effectively separates the nearest tube, which is 54, from the high potential coil 30 which is inductively coupled to the plate coil 22, the two coils being circumscribed about an insulating cylindrical form 80 which depends from the top 82 of the chassis C. Inasmuch as the tube 10 and the iron core coil 36 are at relatively low potentials, they may be exposed externally of the chassis in the manner shown.

In conclusion, it will be appreciated that this invention takes cognizance of all of the important details which are necessary to produce a workable system of the class described. It should be reiterated, however, that the various values specified throughout this specification are only suggestive and that others may be substituted in lieu thereof, although the ones mentioned have proved very satisfactory in actual tests. Therefore, any limitations imposed upon the scope of this invention should be governed solely by the breadth of the appended claims and the reasonable equivalents thereof.

I claim:

1. A voltage multiplier system comprising an electronic tube including a plate circuit, cathode circuit and at least one grid element circuit, means in circuit with said plate and cathode for producing a plate voltage having a resonant frequency, said means including in circuit therewith a low inductance parallel resonant coil,

battery means connected to said low inductance coil, an oppositely wound high inductance resonant coil inductably coupled electromagnetically and electrostatically to said low inductance coil and having one end thereof connected to said one grid element circuit, combined inductive, capacitive and resistive means connected with the said one end of the high inductance resonant coil and decoupling the alternating oscillation of the grid, a condenser connected to the other end of said high inductance resonant coil, and parallel output circuit means connecting with said condenser, said parallel circuit means including a rectifier in one leg thereof, and an oppositely disposed rectifier and condenser in the other leg.

2. The system described in claim 1 in which said high inductance coil produces a secondary voltage in the approximate ratio of 75:1 to said low inductance coil.

3. In an alternating oscillator circuit for use in a voltage multiplier system, an electronic tube including a plate circuit, cathode circuit and at least one grid circuit element, a direct current potential means in circuit with said plate for producing an alternating oscillatory plate voltage frequency, said means including in circuit therewith a low inductance resonant coil, a high inductance resonant coil inductively coupled to said low inductance resonant coil and having one end thereof connected to said one grid element, and shunt reactance means including a coil equipped with a powdered iron core in circuit with said high inductance coil, said one grid element and said cathode circuit.

4. In a voltage multiplication system the method of obtaining stable voltage value and producing a uniformly usable current comprising the steps of changing the impedance of grid and controlling grid bias by regulation of amplitude of alternating oscillation, adjusting a resonant plate circuit, inductively feeding back the resonant adjusted plate circuit into an output circuit, and adjusting the excitation voltage of the feed back to maintain a bias relationship to plate circuit which halves the current on doubling the voltage.

5. In a voltage multiplication system the method of obtaining stable voltage value and producing a uniformly usable current comprising the steps of changing the impedance of grid and controlling grid bias by regulation of the alternating oscillation of amplitude at the control grid, adjusting a resonant plate circuit, inductively feeding back the resonant adjusted plate circuit into an output circuit, and adjusting the excitation voltage of the feed back to maintain a bias relationship to plate circuit which halves the current on doubling the voltage.

6. In a voltage multipler system for supplying stabilized output direct current voltage from a source of alternating current a circuit comprising a pair of input alternating current terminals, an oscillator circuit including an electronic tube having a plate and plate circuit, a cathode and cathode circuit, screen grid and screen grid circuit and control grid and grid circuit, B-battery circuit means having a negative side connected to a common ground of the multipler and the cathode of the alternating current generator and the positive side connected to said screen grid circuit and to said plate circuit, a resonant circuit connecting said battery with said plate including a decoupling component, a plate coil and a variable high capacitance condenser in parallel with said plate coil, the said screen grid element by-passed through a condenser to ground and connected to the positive side of said direct current voltage supply circuit, a resistor in the connection between said screen grid and the said positive side of said direct current supply circuit, a plate return lead through a condenser to ground, and an oppositely wound step up transformer coil and transformer coil circuit inductively coupled to said plate coil having one end connected to said control grid and the opposite high impedance end connected to one of said alternating current terminals, a control grid circuit including a variable inductance, grid leak and grid condenser connected to cathode having no tuning frequency relationship and said variable inductive coil uncoupled electromagnetically and electrostatically to said plate coil and said oppositely wound step-up transformer coil.

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