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SOLID STATE CORONA GENERATOR FOR CHEMICAL-ELECTRICAL
DISCHARGE PROCESSES
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Fig. 1.

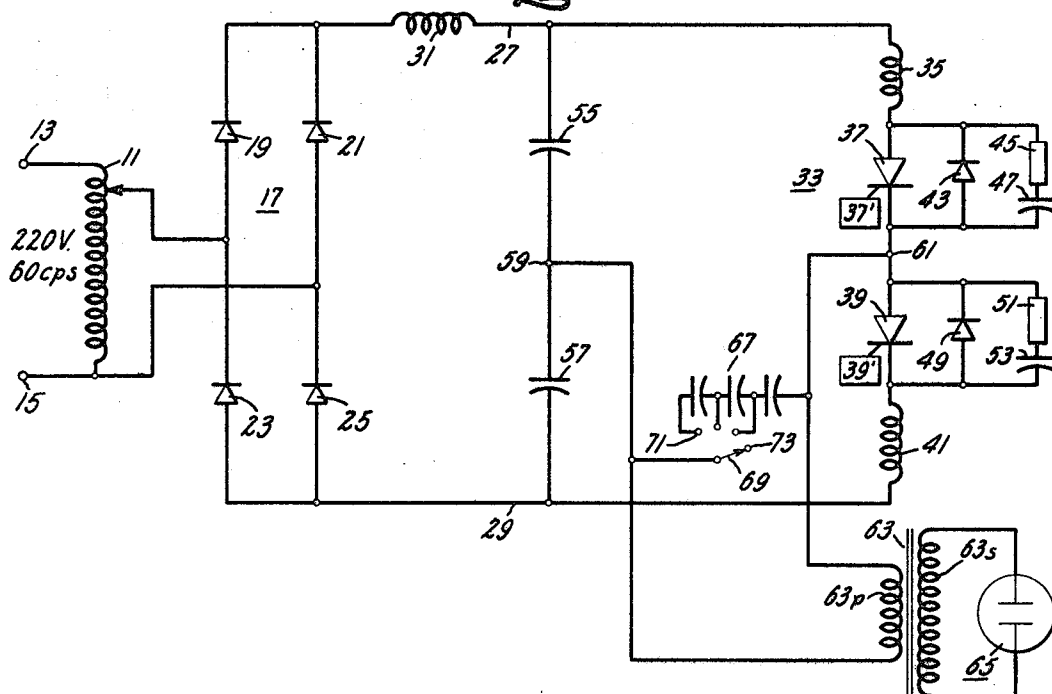


Fig. 2.

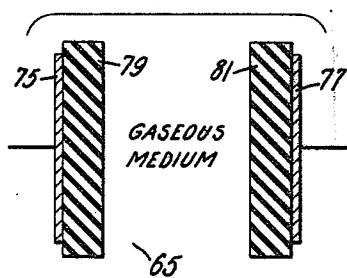
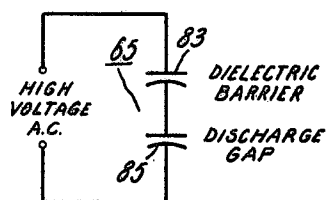


Fig. 3.



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SOLID STATE CORONA GENERATOR FOR CHEMICAL - ELECTRICAL DISCHARGE PROCESSES

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7 Claims

ABSTRACT OF THE DISCLOSURE

A solid state corona generator energized from a commercially available low voltage source comprises an auto-transformer and full wave diode bridge rectifier for supplying controllable D-C potential to a high frequency series capacitor commutated inverter in the center-tapped supply circuit configuration employing SCR thyristors. In the load circuit is a high voltage transformer applying 10,000 to 15,000 volts to a corona reactor connected across the secondary winding which provides a substantial portion or all of the commutating capacitance and is the load during corona discharge. The commutating capacitance is tunable by means of a bank of tuning capacitors connected across the transformer primary winding.

This invention relates to a solid state corona generator for high voltage, high frequency chemical-electrical discharge processes such as a corona-type discharge process. More particularly, the invention relates to an inexpensive solid state corona generator comprising an inverter circuit for generating audio frequency power and including as an integral part of the inverter a step-up high voltage transformer and the corona reactor in which the corona processing is performed.

The use of corona-type electrical discharges for chemical processing is well known, and has historically been employed to synthesize ozone from air or oxygen. Recent advances in corona chemistry and a greater understanding of the mechanisms of corona reactions has increased the potential applications of the process, as for instance to lay down a thin film of polymer as a coating on sheets of metal, plastic, or cloth, and to convert coal to liquid and gaseous hydrocarbon fuels and chemicals. For the simplest and most common situation in which both the starting material and the products are gaseous, a corona-type discharge is characterized by a low current carrying column at a voltage gradient in the order of the electrical break-down strength of the gas. The gas is only slightly or incompletely ionized and a diffused soft bluish glow results. A corona-type discharge is different from an arc discharge which is characterized by a highly ionized current accompanied by a high current density and a low voltage gradient. In general, an arc is localized and produces high temperature and a bright white light. Corona discharge is thus a high voltage, low current phenomenon with voltages typically being measured in kilovolts and currents in milliamperes. Chemical changes occur in corona processing due to the fact that the corona energy serves as a chemical catalyst or activator, and is briefly explained in that when corona starts, stray electrons present in the gas strike a gas molecule creating ions and possibly knocking out orbital electrons to produce "excited" molecules which decompose spontaneously into free radicals while simultaneously producing heat and light—in other words, corona. The synthesis of ozone from oxygen is a typical three-step corona reaction: impacting electrons create positive ions and excited molecules of oxygen; excited molecules dissociate to form free radicals or oxygen atoms; and

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the highly reactive oxygen atoms combine with the remaining oxygen molecules to form the desired product, ozone (O_3).

A corona-type discharge is produced by capacitively exciting a gaseous starting material lying between two spaced electrodes, at least one of which is insulated from the gaseous medium by a dielectric barrier. The spaced electrodes have the form of flat plates or concentric tubes connected across a source of high voltage alternating current electric potential, and the dielectric barrier interrupts the conductive path when the voltage is high enough to produce corona so that there is only an incomplete breakdown of the gas and the formation of arcs is prevented. As will be developed later, the corona reactor primarily represents a capacitive load to the power supply equipment up to the time of initiation of corona, since both the barrier and the gas are good insulators, but after the start of corona, there is additionally some conductance across the gaseous gap. Although a corona discharge may be maintained over wide ranges of pressure and frequency, it is desirable to perform the corona process at atmospheric pressure, and the frequency of the applied high voltage A-C potential should be much above conventional power transmission frequencies since it is well established that the corona power generated, and thus the efficiency of the process, is directly proportional to the frequency.

The power supply requirements of a corona reactor for a number of applications emphasize the need for a small compact, static, trouble-free corona generator for the production of ozone and for other chemical-electrical discharge processing. A solid state inverter operating in the 3,000 to 10,000 c.p.s. range provides a desirable compromise between operating voltages, reactor voltage, and economy of operation.

Accordingly, an object of the invention is to provide a new and improved static solid state corona generator comprising an inverter circuit for producing high voltage, audio frequency power suitable for chemical-electrical discharge processing.

Another object of the invention is to provide a new improved inverter power supply for corona processing using thyristors as the current switching devices wherein the corona reaction in which the processing takes place provides at least a portion of the commutating capacitance for the inverter as well as being the load, and the commutating capacitance is tunable so that the power supply can be used with corona reactors having different physical dimensions.

Yet another object is the provision of an inexpensive solid state inverter power supply for corona-type discharge processes operating in conjunction with a rectifier link from a commercially available source of electric potential and including a step-up, high voltage transformer and a capacitive corona reactor forming an integral part of the inverter.

In accordance with the invention, a solid state corona generator inverter circuit comprises a source of D-C potential and at least a pair of thyristor devices connected in series circuit relationship with commutating inductance means and commutating capacitance means across the source of D-C potential. The thyristor devices are preferably silicon controlled rectifiers. Means are provided for alternately rendering conductive the thyristors at a relatively high operating frequency determined by the series resonant frequency of the series connected commutating inductance and capacitance means. The load circuit means includes a high voltage transformer having inductively coupled primary and secondary windings with a turns ratio capable of developing 10,000 to 15,000 volts in the secondary winding. The corona re-

actor is connected across the secondary winding and provides at least a substantial portion of the commutating capacitance means, and has a conductance path during each high frequency half cycle serving as the load for the inverter circuit. A bank of tuning capacitors is adapted to be connected across the transformer primary winding for tuning the commutating capacitance.

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention, as illustrated in the accompanying drawings wherein:

FIG. 1 is a detailed circuit diagram of a solid state corona generator comprising a full wave single phase rectifier and an inverter constructed in accordance with the principles of the invention;

FIG. 2 is a schematic cross-sectional diagram of an illustrative plate-type corona reactor; and

FIG. 3 is an equivalent circuit diagram of the corona reactor shown in FIG. 2.

The equipment shown in FIG. 1 for use in high voltage, high frequency chemical-electrical discharge processing is especially designed to be employed in corona processing, and will be referred to as a solid state corona generator. The solid state corona generator is adapted to operate from a commercially available low frequency A-C source of electric potential, such as a single phase 220 volt, 60 c.p.s. source. To make provision for a variable input supply, the equipment comprises an auto-transformer 11 having a primary winding connected across a pair of input supply terminals 13 and 15 which in turn are adapted to be connected across the source of A-C potential. The secondary winding of the auto-transformer 11 is connected between the input terminals of a single phase solid state full wave rectifier 17 for rectifying the A-C potential and providing a variable source of D-C potential. The full wave rectifier 17 is preferably a diode bridge rectifier comprising four solid state diodes 19, 21, 23, and 25 connected in the usual manner to provide a positive D-C supply terminal 27 and a negative D-C supply terminal 29. A filter inductor 31 is connected in series in the positive D-C supply terminal 27 in order to reduce the ripple. The solid state corona generator further includes an inverter circuit connected across the D-C supply terminals 27 and 29 and indicated generally at 33 for converting the D-C potential into a high frequency A-C potential having a frequency in the audio range from about 3,000 c.p.s. to approximately 10,000 c.p.s. The inverter has the center-tapped supply circuit configuration and employs series capacitor type commutation for the thyristor devices. The inverter circuit 33 comprises a first commutating inductor 35 and silicon controlled rectifier 37, and a second silicon controlled rectifier 39 and commutating inductor 41 all connected in series circuit relationship across the D-C supply terminals 27 and 29. The silicon controlled rectifier (SCR) is a unidirectional conducting thyristor solid state switching device which can be operated at high frequency rates. Conduction through the SCR from the anode to the cathode is initiated by the application of a gating signal to the gating control electrode of the device, but thereafter the gating electrode loses control over conduction through the device and the anode potential must be made negative relative to the cathode potential in order to turn off the device and return it to its nonconducting condition. The gating circuits for the SCR's 37 and 39 are represented here diagrammatically by the respective boxes 37' and 39', since the details of the construction of such gating circuits having the desired firing or gating sequence is conventional as taught for example in the SCR Manual, 4th edition, published by the Semiconductor Products Department, General Electric Company, Syracuse, N.Y., copyright 1967. In order to protect the SCR 37 from excessive reverse voltages, a feedback diode 43 is connected in inverse-parallel relationship across the load terminals

of the device, and the series circuit comprising a resistor 45 and a capacitor 47 is also connected across the load terminals of the SCR to reduce the rate of rise of forward voltage and prevent an undesired turning on of the SCR to switch it into its low impedance forward conducting stage. In similar manner, there is coupled across the load terminals of the SCR 39 a feedback diode 49 and the series circuit comprising a resistor 51 and a capacitor 53.

A pair of voltage dividing capacitors 55 and 57 are connected in series circuit relationship across the D-C supply terminals 27 and 29. Thus, when the potential between the supply terminals 27 and 29 is considered to be E_d , then the average voltage at the junction point 59 between the two voltage dividing capacitors 55 and 57 is $E_d/2$. A load circuit is connected between their junction point 59 and the junction point 61 between the two SCR's 37 and 39. The load circuit comprises a step-up, high voltage transformer 63 having a turns ratio in the order of about 100:1 in order to produce at its secondary winding 63s a voltage of about 10,000 to 15,000 volts. The primary winding 63p of the step-up transformer 63 is connected between the junction points 59 and 61, and a corona reactor 65 in which the corona processing is to take place is connected between the ends of the secondary windings 63s of the transformer. As will be explained in greater detail later the commutating capacitance can be tuned by means of a bank of tuning capacitors 67 comprising several individual capacitors connected in series circuit relationship with one another which can be connected in different combinations across the primary winding 63p. For this purpose, one of the tuning capacitors 67 is connected to one end of the primary winding 63p while the other end of the primary winding is connected to a movable contact 69 which can be engaged with a selected one of the terminals 71 each connected to the junction of the individual tuning capacitors 67 or to the end plate of the final capacitor in the series. It is not necessary, however, that the tuning capacitors 67 be in the load circuit, and thus the contact 69 is movable to a position 73 for removing all of the tuning capacitors 67 from the circuit.

The physical construction of the corona reactor or cell 65 is shown diagrammatically to an enlarged scale in FIG. 2. The corona reactor 65 comprises a pair of substantially parallel electrodes in the form of flat plates 75 and 77 each having a relatively long area as compared to their spacing. Solid dielectric barriers 79 and 81 are attached in opposing relation to the insides of the respective electrodes 75 and 77 and are typically made of good insulators such as fused quartz, alumina, and mica mat, and possibly of glass, the material used historically. It is more common for the electrodes and dielectric barriers to be in the shape of insulated concentric cylinders, however, the physical configuration of corona reactors takes various forms and the invention is not dependent on the particular corona reactor that is selected. A suitable gaseous medium providing the starting material for the corona process is passed between the two insulated electrodes 75 and 77. Corona is purely a gas-phase phenomenon and it produces free radicals only in a gas or mixture of gases. The product which is produced as a result of chemical change is ordinarily a gas such as the production of ozone from air or oxygen. In addition to reacting in the gas phase, however, the radicals can interact with molecules of a liquid or of a finely divided solid that is subsequently exposed to them. Thus, the product produced as the result of corona processing, in addition to being another gas, can also be a liquid or a solid.

In order to obtain a corona discharge, a high voltage of about 10,000 to 15,000 volts at a current level in the order of milliamperes, is applied across the electrodes 75 and 77 to produce a strong electric field having a voltage gradient near the electrical breakdown strength of the gaseous medium. The solid dielectric barriers 79 and 81 (only one is absolutely required) interrupt the conductive

path and allow only an incomplete breakdown of the gaseous medium, so that there is a relatively cool, diffuse, bluish discharge at or near atmospheric pressure called corona. As has been briefly explained, the strong electric field accelerates electrons toward the positive electrode, striking gas molecules in their path, and forming highly reactive free radicals. A radical is a molecular fragment that functions as a unit, such as a single hydrogen atom or a methyl group (CH_3). These free radicals readily combine with other atoms or group of atoms, thereby producing the desired product.

Referring to FIG. 3, the equivalent electrical circuit diagram for the corona reactor or cell 65 comprises two capacitors 83 and 85 connected in series circuit relationship across the high voltage A-C source. The capacitor 83 represents the capacitance of the dielectric barrier, while the capacitor 85 represents the capacitance of the discharge gap containing the gaseous medium. It will be noted that the dielectric barrier in the corona reactor serves as a built-in current limiting device or ballast in the event of a short circuit or arc between the cell electrodes, so that the stored energy is dissipated in the barrier at breakdown. The maximum power density at which a corona reactor can be operated without puncturing the barrier is a function of the dielectric strength of the barrier material, the total thickness of the barrier, the ambient temperature at which it is operated, and the gap spacing between barriers. The dielectric constant of the barrier affects both the voltage gradient across the barrier, and the corona power which can be dissipated in the reactor. The dissipation factor is a measure of the electric losses which produce heating of the barrier. The voltage at which breakdown will occur between a set of electrodes in a corona reactor depends upon the gaseous atmosphere present, the density (pressure, temperature) of the gas between the electrodes, and the gap length.

The corona reactor represents a capacitive load to the inverter power supply equipment up to the time of initiation of the electrical discharge. The total reactor capacitance consists of the series combination of the dielectric barrier and gaseous gap capacitance, and the voltages appearing across the barrier and the gap divide inversely as their capacitance. Before corona starts, the corona reactor current consists of the charging or displacement current which is proportional to the applied voltage, the frequency, and the cell capacitance. This charging current, of course, leads the applied voltage by 90° .

As the applied A-C voltage rises sinusoidally on each half cycle from zero to its maximum, a point is reached at which a burst of corona activity begins. While usually being a good insulator, the dielectric barrier now supports a conducting path, but the amount of conductance is small and the dielectric barrier is still essentially capacitive in character after the start of the corona. There is also a conducting path through the gaseous medium, but the conductance across the gaseous gap is significant in relation to the capacitance of the gap, and the result is that after the start of corona the cell acts as an impedance load to the inverter circuit. The conductance currents essentially are in phase with the applied voltage, and as to this characteristic or like resistive currents. Thus, the total current drawn by the corona reactor after the start of corona is the vector sum of the charging and the resistive-type conductance currents. When the corona discharge takes place, there is a hump in the current waveform whose height and width is related to the applied voltage, and the ending of the discharge coincides with the maximum of the applied voltage. The time of the beginning of the discharge depends on the interior surface charges accumulated during previous discharges. As the electrons and positive ions which are created during corona become concentrated at the opposite electrodes, they build up a space charge that neutralizes the electric field and chokes off the corona. When the field

is reversed, the space charge is dissipated and another corona burst can occur.

Accordingly, there is a corona discharge during each half cycle of the applied voltage producing a characteristic bluish glow, alternating with periods when the corona reactor is dark. As the frequency of the applied voltage increases, the efficiency of the corona process taking place within the corona reactor increases also. The number of bursts or discharges, the current drawn, the power level, and the rate of chemical reaction are all approximately proportional to the frequency. In particular, the corona power dissipated in a gaseous gap in series with one or more dielectric barriers can be determined from a well-known formula and is directly proportional to the frequency. Although the amount of chemical product does increase with frequency, higher frequencies are more expensive to generate. A reasonable compromise between low productivity and high cost is in the medium audio range, from about 3,000 to 10,000 c.p.s. Thyristors having a frequency rating of 3,000 c.p.s. are presently available commercially, and there is promise in the immediate future of increasing this to 10,000 c.p.s.

Having explained the electrical characteristics of the corona reactor 65 before the production of corona and during the corona discharge, its effect as a circuit component of the inverter circuit 33 will now be analyzed. Assuming that the movable contact 69 is at the position 73 so that the entire bank of tuning capacitors 67 is out of the circuit, then the corona reactor 65 provides all of the commutating capacitance for the inverter circuit 33 in addition to being the load for the inverter. The commutating inductance for the converter is provided by the inductor 35, or the inductor 41, in combination with the effective commutating inductance of the high frequency transformer 63, depending on the half cycle of inverter operation. All of the charging current for the corona reactor 65 appears in the secondary winding 63s of the high voltage transformer, and if desired the commutating capacitance provided by the reactor 65 can be thought of as being reflected into the circuit of the primary winding 63p according to the n^2 ratio, and appears connected across the ends of the primary winding 63p. Thus, if there is an effective commutating capacitance of 1400 picofarads in the secondary winding, then the reflected value in the primary winding circuit is about 9.28 microfarads for a transformer turns ratio of about 80:1.

In the operation of the inverter circuit 33, during the positive half cycle of the high frequency wave, the SCR 37 is turned on by means of an appropriate gating signal from its gating circuit 37', and a half sinusoid of current is produced by the series resonant circuit comprising the effective commutating inductance of the inductor 35 and the high frequency transformer 63, and the effective commutating capacitance of the reactor 65. At the end of this half sine wave of current, the potential at the junction point 61 exceeds the potential of the positive D-C supply terminal 27, and the load current through the SCR 37 is reduced to zero for a period of time at least equal to the turn-off time, and any excess current flows through the feedback diode 43, tending to reverse bias the SCR 37. In this manner, the SCR 37 is commutated off at the end of the high frequency half cycle. The other SCR 39 is now turned, on and current flows from the juncture point 59 of the voltage dividing capacitors 55 and 57 through the load circuit including the corona reactor 65, and through the SCR 39 to the negative D-C supply terminal 29. A negative half sine wave of current is produced by the series resonant circuit comprising the effective commutating inductance of the inductor 41 and the high frequency transformer 63, and the effective commutating capacitance of the corona reactor 65. The potential at the junction point 61 now becomes more negative than that of the negative D-C supply terminal 29, and the SCR 39 is commutated off in the same manner as was described for the SCR 37. The corona reactor 65,

and to a less extent the high frequency transformer 63, are an integral part of the inverter circuit 33 and their capacitance and inductance values determining the operating frequency of the inverter, the period being approximately $2\pi\sqrt{LC}$. During each high frequency half cycle there is a corona discharge in the corona reactor 65 in the manner previously explained. The conductance of the gaseous gap between the dielectric barriers, and to a much lesser extent the conductance through the dielectric barriers themselves, constitute the load for the inverter, or in other words, the corona power dissipated. Since this is an untuned high voltage circuit, the inverter and the transformer are designed to carry the power factor loss current. The total power available for chemical processing is the product of supply volt-amperes times the power factor of the load, and in this case, the transformer secondary winding 63s must carry the fully reactor impedance current.

The complete inverter circuit 33 is designed for a preselected corona reactor capacitance load in the secondary of the high voltage transformer 63. When the physical dimensions of the reactor being used for corona processing is changed, or when a different type of reactor is substituted, there will also be a change in the reactor capacitance. This in turn will change the commutating capacitance in the inverter series resonant circuits, and for this purpose the bank of tuning capacitors 67 is provided to tune the commutating capacitance. Any reactor capacitance value below this preselected value can be compensated for by inserting the capacitance difference in series with the transformer primary winding 63p, after making due allowance for the transformer turns-ratio reflected value. To this end, the movable pointer 69 is engaged with the proper terminal 71 to connect one or more of the tuning capacitors 67 across the transformer primary winding 63p. This is preferable to tuning in the secondary circuit of the high voltage transformer 63 by inserting the capacitance difference across the ends of the transformer secondary winding 63s for two reasons. The first is the cost advantage gained since a much smaller capacitor can be used in the primary winding circuit by the factor n^2 . Furthermore, a smaller high voltage transformer 63 can be used, i.e., the transformer k.v.a. is less. When the tuning of the commutating capacitance is done in the secondary winding circuit the transformer must carry a larger charging current to charge both the corona reactor 65 and the tuning capacitor. The higher the value of the capacitance in the secondary winding, the bigger is the price that is paid for the charging current. When, on the other hand, the tuning capacitors are located in the primary winding circuit of the transformer 63, the transformer windings need not carry the charging current for the tuning capacitance since it is now furnished by the inverter circuit itself. The transformer windings now need conduct only the current required to sustain the conductance when there is a corona discharge, in addition of course to the charging current for the corona reactor 65. In this manner the power factor loss current in the transformer itself is reduced or minimized.

In a practical working example of the invention, the single phase A-C supply was 220 volts, 60 c.p.s. as shown in FIG. 1. The output of the autotransformer 11 was 208 volts, 60 c.p.s., and the value of the D-C voltage across the D-C supply terminals 27 and 29 was 187 volts. Because of the losses in the inverter circuit, the voltage generated by the inverter circuit 33 was 150 volts at a frequency of 3,000 kilocycles. For this example, the turns ratio of the high voltage transformer 63 was about 90:1, and the capacitance of the corona reactor 65 was about 1400 picofarads. The rating of the transformer 63 was 3 k.v.a.

The solid state corona generator including the inverter circuit holds considerable promise for future applications. Among the advantages are that the voltage and current capabilities can be extended in an almost un-

limited fashion by stacking together module units. As was mentioned, high frequency silicon controlled rectifiers or other equivalent thyristors capable of operating at 10,000 c.p.s. or even beyond are expected to be available. A coordinated integrated design has enabled the reduction of the inverter size, and in particular the reduction of the size of the high voltage transformer for a given rating. Moreover, the tests indicate that this type of corona generator appears to have an improved k.v.a. to kw. efficiency as compared to that of other systems for producing high frequency, high voltage power for corona applications, such as an inductor-alternator equipment, or resonant tuned generator equipment using vacuum-tube amplifiers.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A solid state corona generator inverter circuit for chemical electrical discharge processes comprising
 - a source of D-C potential,
 - at least a pair of alternately conductive thyristor devices each connected in series circuit relationship with commutating inductance means and commutating capacitance means across said source of D-C potential,
 - means for alternately rendering conductive said thyristor devices at a preselected relatively high operating frequency determined by the series of resonant frequency of said series connected commutating inductance and capacitance means, and
 - load circuit means including a step-up, high voltage transformer having inductively coupled primary and secondary windings with a turns ratio capable of developing a voltage in the range of 10,000 to 15,000 volts in said secondary winding, and further including a corona reactor comprising two spaced electrodes, one of which is insulated with a dielectric barrier, connected across said high voltage secondary winding,
 - wherein said corona reactor provides at least a substantial portion of the commutating capacitance means and additionally has a conductance path during each high frequency half cycle serving as the load for the inverter circuit.
2. A circuit as defined in claim 1 further including
 - a bank of tuning capacitors, and
 - means for connecting none or a selected number of said tuning capacitors across the high voltage transformer primary winding, to thereby tune the commutating capacitance means to a predetermined value.
3. A circuit as defined in claim 1 wherein said thyristor devices are silicon controlled rectifiers, and the relatively high operating frequency of the inverter circuit is in the range from 3,000 to 10,000 c.p.s., and further including
 - a bank of tuning capacitors, and
 - means for connecting none or a selected number of said tuning capacitors across the high voltage transformer primary winding, to thereby tune the commutating capacitance means to a predetermined value.
4. A circuit as defined in claim 1 wherein said thyristor devices are silicon controlled rectifiers and the relatively high operating frequency of the inverter circuit is in the range from 3,000 to 10,000 c.p.s., and
 - all of the commutating capacitance means is provided by said corona reactor.
5. A circuit as defined in claim 1 wherein
 - said inverter circuit has the center-tapped supply cir-

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cuit configuration and includes a pair of voltage dividing capacitors connected across the source of D-C potential,

said thyristor devices are silicon controlled rectifiers, and the relatively high operating frequency of the inverter circuit is about 3,000 to 10,000 c.p.s., and said load circuit means is connected between the junction of said voltage dividing capacitors and a junction point located between the alternately conductive silicon controlled rectifiers, and further includes a bank of tuning capacitors and means for connecting none or a selected number of said tuning capacitors across the primary winding of said high voltage transformer, to thereby tune the commutating capacitance to the predetermined value.

6. A circuit as defined in claim 1 wherein said source of D-C potential as a variable source and comprises a solid state single phase full wave bridge rectifier having its input terminals connected across the secondary winding of an autotransformer whose primary winding is in turn adapted to be connected across a source of commercially available relatively low voltage, low frequency A-C electric potential, and wherein

said thyristor devices are silicon controlled rectifiers, and the relatively high operating frequency of the inverter circuit is in the range of 3,000 to 10,000 c.p.s.

7. A circuit as defined in claim 1 wherein said source of D-C potential is a variable source and comprises a full wave single phase diode bridge rectifier having its input terminals connected across the secondary winding of an autotransformer whose primary winding is adapted to be connected across a commercially available relatively low voltage, low frequency A-C potential, and

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said inverter circuit has the center-tapped supply circuit configuration and includes a pair of voltage dividing capacitors connected across the source of D-C potential,

said thyristor devices are silicon controlled rectifiers, and the relatively high operating frequency of the inverter circuit is about 3,000 to 10,000 c.p.s., and said load circuit means is connected between the junction of said voltage dividing capacitors and a junction point located between the alternately conductive silicon controlled rectifiers, and further includes a bank of tuning capacitors and means for connecting none or a selected number of said tuning capacitors across the primary winding of said high voltage transformer, to thereby tune the commutating capacitance to the predetermined value.

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