United States Patent [19]

Mann

[11] **3,721,920**

[45] **March 20, 1973**

[54] **SELF-EXCITED COMPOSITE CAPACITANCE AND INTERLOCKING INDUCTANCE OSCILLATOR**

[76] Inventor: **Julius W. Mann,** 9132 De Koven Drive, S.W., Tacoma, Wash. 98499

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[21] Appl. No.: **148,578**

[52] **U.S. Cl.** **331/168,** 219/10.77, 219/10.81, 331/102

[51] **Int. Cl.**.....**H03b 5/18**

[58] **Field of Search**.....331/114, 110, 102, 168; 219/10.75, 10.77, 10.79, 10.81

[56] **References Cited**

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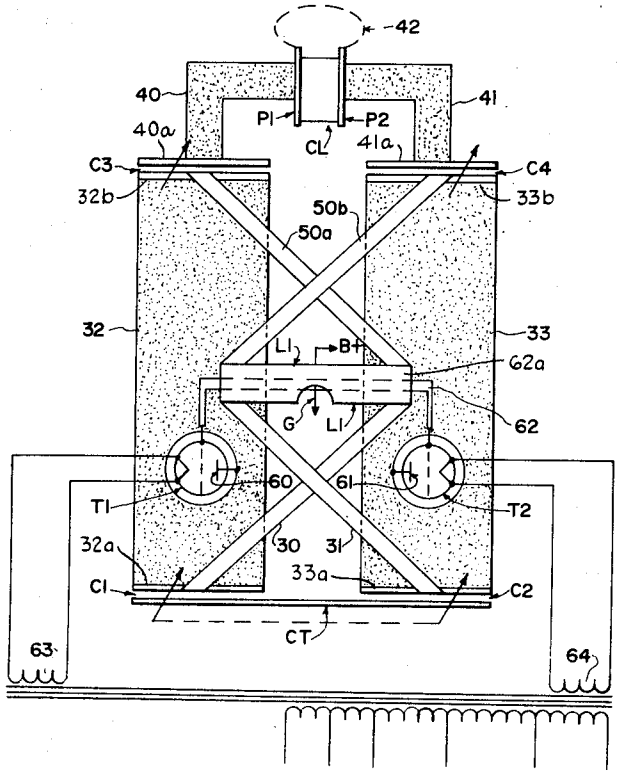
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Primary Examiner—John Kominski
Attorney—William R. Piper

[57] **ABSTRACT**

A self-excited, self-tuning and self-loading generator in which the load electrode is an inherent part of the capacity and inductance of the generator tank circuit. The generator is automatically, instantly and steplessly self-tuning with respect to wide variations in load characteristics. A maximum power input to the load is maintained by the generator and this is in proportion to changes in the loss factor of the load. A composite or interlocked inductance is used for the load electrode and the tank circuit. Series coupling condensers are used in the load circuit and leads from these coupling condensers are crossed and their terminals are connected to the composite inductance thus interlocking the composite inductance with the load circuit. This is why I term the composite inductance an interlocked inductance.

3 Claims, 14 Drawing Figures



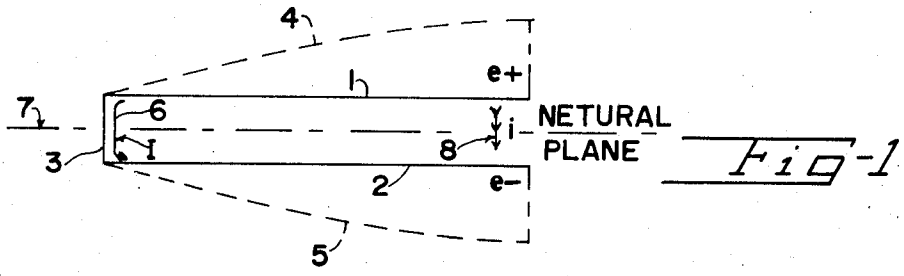


Fig-1

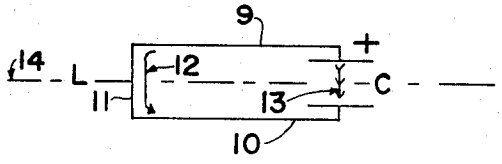


Fig-2

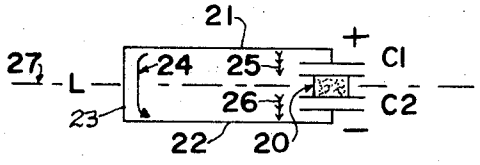


Fig-3

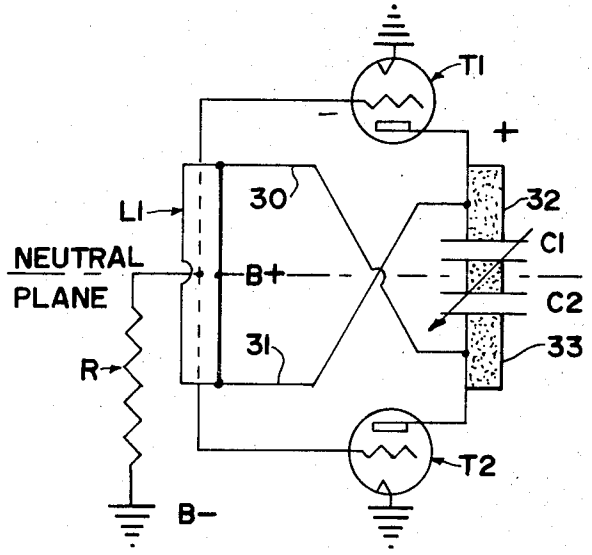


Fig-4

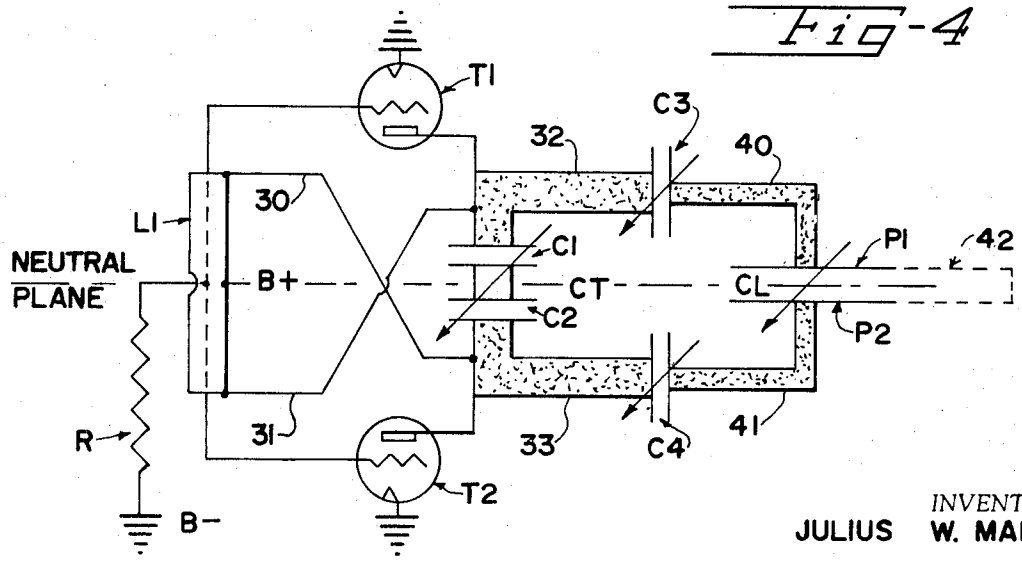


Fig-5

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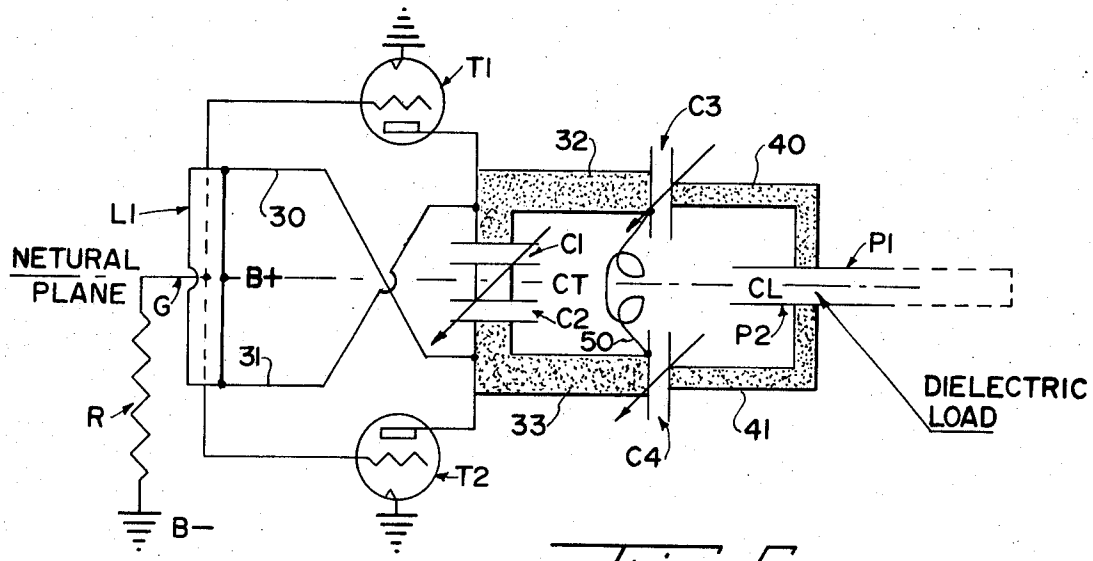


Fig-6

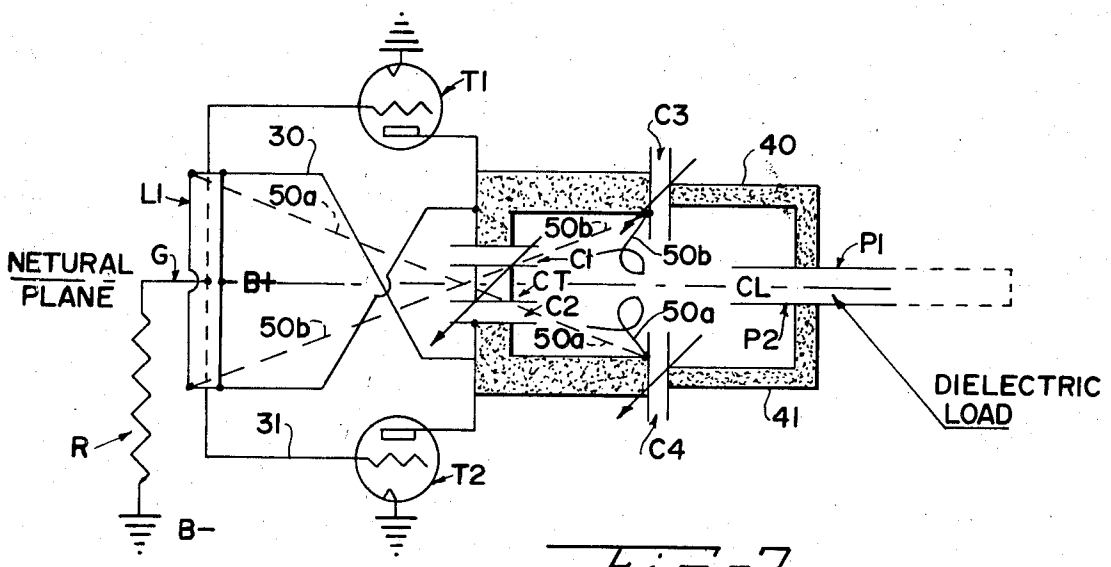


Fig-7

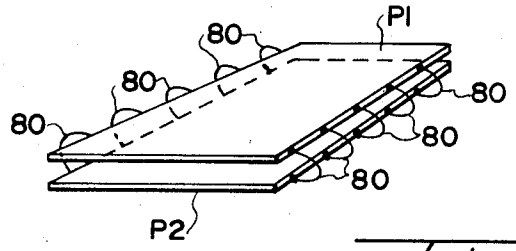


Fig-14

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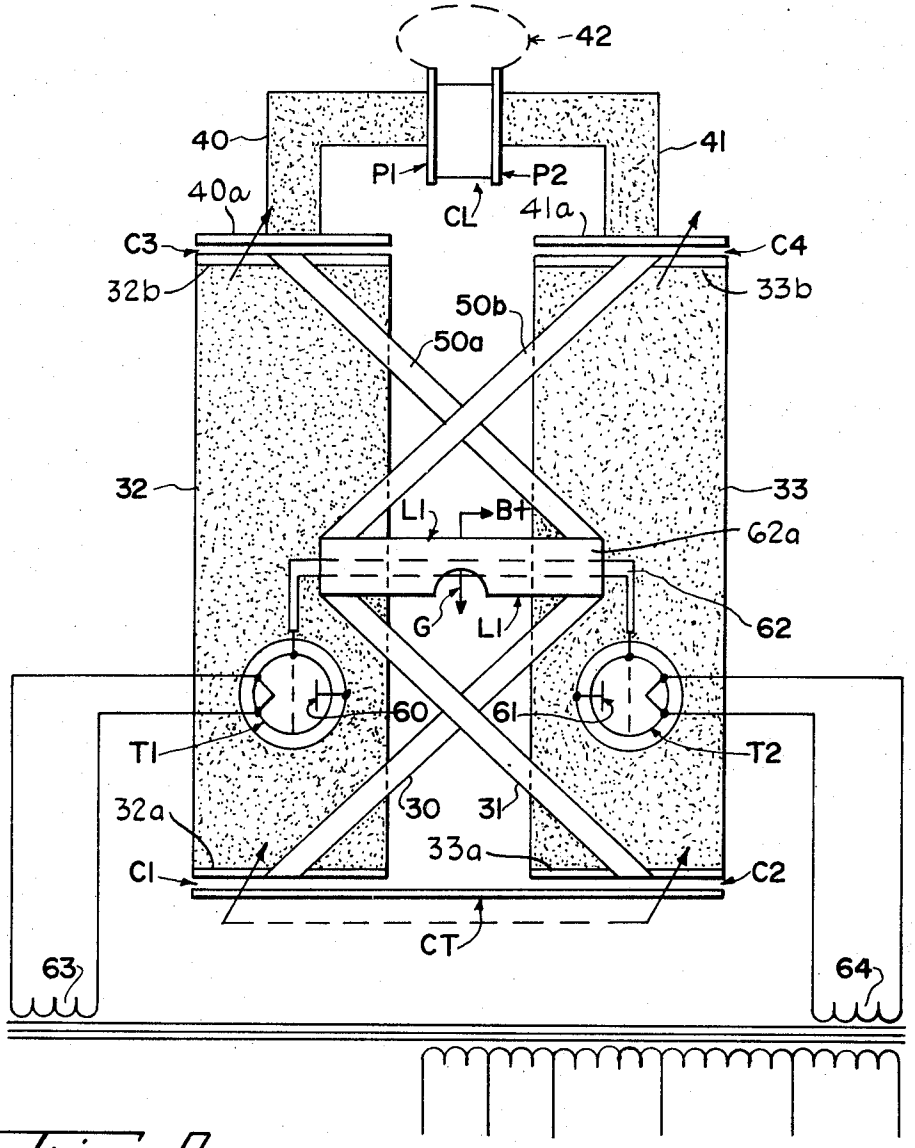


Fig-8

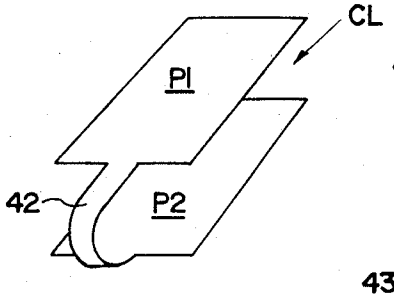


Fig-11

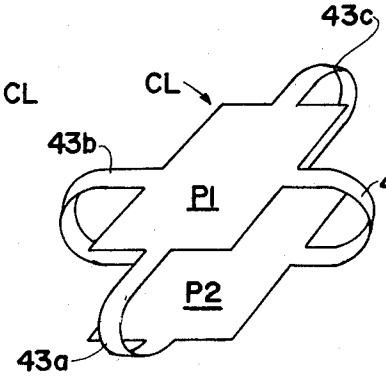


Fig-12

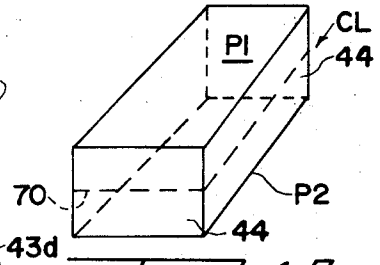


Fig-13

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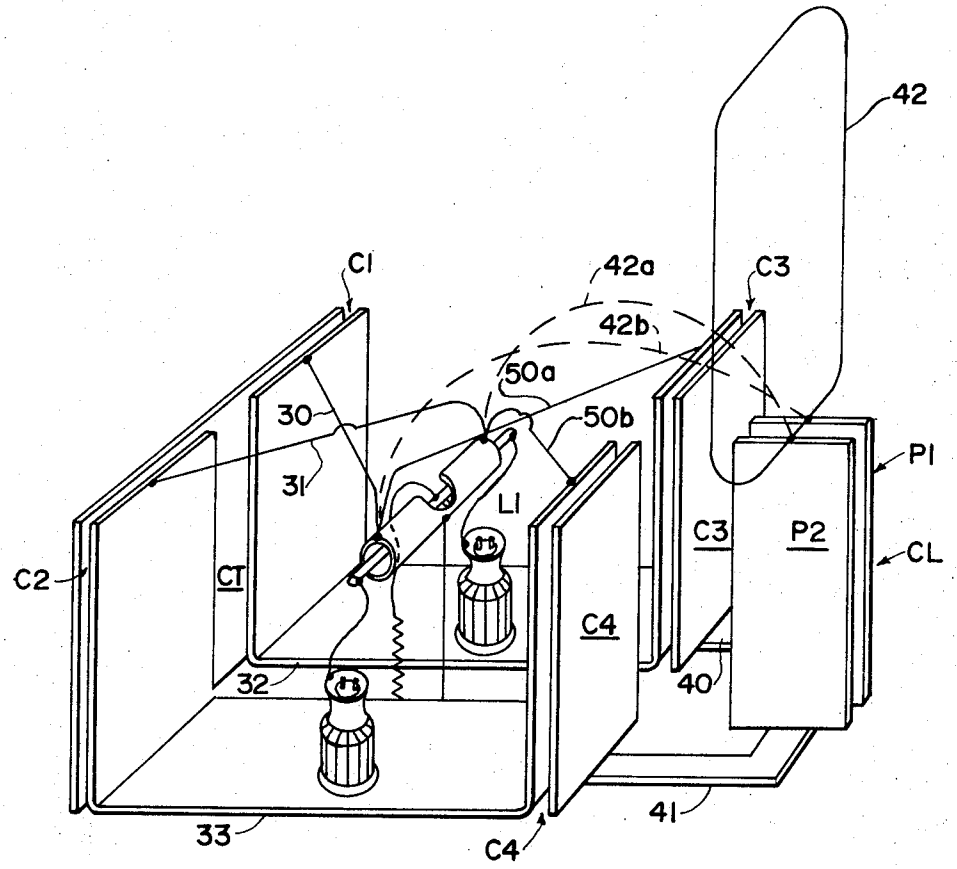


Fig-9

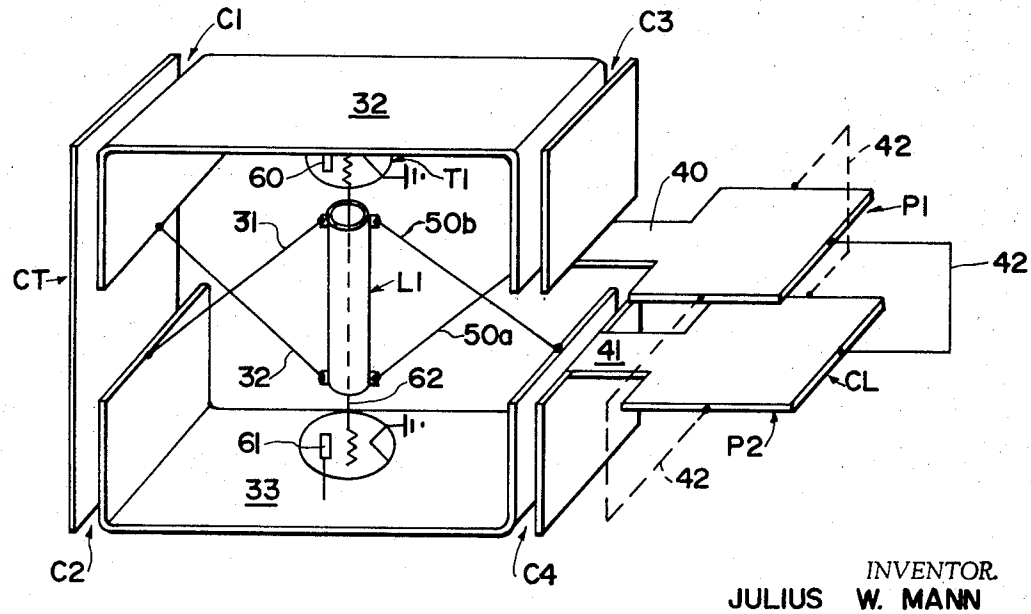


Fig-10

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SELF-EXCITED COMPOSITE CAPACITANCE AND INTERLOCKING INDUCTANCE OSCILLATOR

BACKGROUND OF THE INVENTION

Field of the Invention. My copending patent application on a self-excited, self-tuning and self-loading generator in which the load is an inherent part of the tank circuit capacitance and inductance, Ser. No. 848,656, filed Aug. 8, 1969, when commercialized and put to work in industrial environments exhibited several instabilities in certain installations which were under certain circumstances, objectionable. Although of quite rare occurance, certain load characteristics apparently shift the oscillator's stationary wave pattern to a position which more or less favors the parallel inductance loop that interconnected the variable series condensers in the work circuit, to take over as the dominant current antinode which normally resides on the composite inductance. Thus the parallel inductance tends to rob the magnetic field of force centered on the composite inductance, since the grid line length is also centered on the composite inductance and far removed from the influence of the parallel inductance. Excessive drop in grid excitation results even to a degree insufficient to maintain oscillation. Also, excessive heat development in the parallel inductance and undue loss of grid excitation together with a marked drop in plate efficiency is evidence of the above-described instability. The circuit diagram of FIG. 6 of the drawing in Ser. No. 848,656, clearly reveals the isolation of the parallel inductance with respect to the composite inductance L1. Other differences between the circuitry shown in my copending application and my new circuitry will be shown after I have described the new circuitry.

SUMMARY OF THE INVENTION

An object of my invention is to provide a high frequency circuitry configuration in which the load electrode is an inherent part of the inductance and capacity of the generator tank circuit. A further object is to provide a generator that will automatically, instantly and steplessly be self-tuning with respect to wide variations in the load characteristics, and which will maintain maximum power input to the load in proportion to changes in the loss factor of the load. The inductances for the load and tank circuits are interlocked and this vital improvement of the present case over my copending application gives the present circuitry a great advantage over the circuitry of my application, Ser. No. 848,656, as will hereinafter be set forth.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a circuit diagram of a pair of Lecher wires terminating in an open circuit and conventionally termed a quarter wave line. This is the first step in a series of evolutionary steps for arriving at the present circuit.

FIGS. 2 and 3 show an oscillatory inductance-capacitance system of an equivalent electrical line length to that shown in FIG. 1.

FIG. 4 illustrates the use of conventional high vacuum triode oscillators in the inductance-capacitance circuitry of FIGS. 2 and 3 for the self excitation of the oscillator and illustrates the second evolutionary step.

FIG. 5 is a schematic showing of the completed circuitry with the work load connected to the output terminals of the series condensers which in turn function so as to make the work load an inherent part of the tank circuit capacitance and inductance.

FIG. 6 illustrates a parallel inductance loop spanning the series condensers shown in the circuitry configuration of FIG. 5.

FIG. 7 illustrates the evolutionary step from the circuitry of FIG. 6 to that of FIG. 8. FIG. 7 shows the severance of the parallel inductance interconnecting the series condensers at its current antinodes. The severed terminals are then crossed as indicated by the dash lines and are connected to the opposite extremities of the composite inductance as shown.

FIG. 8 illustrates the final "interlocked" circuitry, which is a remarkable improvement in simplicity and symmetry over that shown in FIG. 6. It is obvious that this simple revision in circuitry, because of the physical electrical line lengths involved, required a radical change in the disposition of the component parts and circuit configuration from that of FIG. 6.

FIG. 9 is a perspective view of the components illustrated in FIG. 8, and shows a loop in full lines connected to the two plates of the work condenser. FIG. 9 further shows by dash lines, the loop severed at its current antinode and the two terminals crossed and connected at opposite extremities to the composite inductance to prove that the loop could be interlocked with crossed inductances that connect the series condensers with the composite inductance and with the crossed inductances that connect the series condensers of the tank circuit with the composite inductance.

FIG. 10 shows the circuitry and components of the oscillator of FIG. 9 folded to a perspective fantasy to illustrate the apparent equivalence of the composite capacitance and interlocked inductance oscillator to a resonant cavity.

FIGS. 11, 12 and 13 depict the progression of an LC circuit spanned by one inductance path, as shown in FIG. 11; spanned by four parallel inductances, as shown in FIG. 12; and, finally, to the ultimate form of FIG. 13, where an infinite number of inductances are used and forms a closed box.

FIG. 14 is a perspective view of a pair of work electrodes interconnected by a plurality of short loop inductances.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In carrying out my invention it is best to set forth the same evolutionary steps for arriving at the circuitry of FIG. 6 as was set forth in my copending application, Ser. No. 848,656, and then illustrate in FIG. 7, the vital improvement made in the present case over the copending case and follow this by setting forth the remarkable advantages derived by such a change.

FIG. 1 is a circuit diagram of a pair of Lecher wires terminating in an open circuit and conventionally termed a quarter wave line. However, it should be kept in mind that, actually, fractional wave lengths cannot be propagated as such. The Lecher wires 1 and 2 parallel each other and are short circuited by a wire 3. The arcuate dotted lines 4 and 5 represent the sine wave distribution of voltage which "sit" at the instant on the

lines 1 and 2 in the form of a stationary wave propagated by some source of high frequency energy, such as a dip meter adjusted to match the fundamental resonant frequency of the Lecher line. I have indicated the state of the charge at the instant shown by the $e+$ on the line 1 and by the $e-$ on the line 2. An instant later the charges displace.

The solid arrow 6 represents an actual conduction current shown in the conventional manner, i.e., from plus to minus. The current antinode "I" centers on the axis 7 of the neutral plane, and so designated in FIG. 1. The feathered arrow 8 indicates a virtual Maxwell current with its virtual antinode *i* also centered on the axis 7 of the neutral plane. This virtual current displacement current exhibits all of the properties of a real galvanic current. Note that the charge displaces from the positive side to the negative side by means of the metallic lines 1, 2 and 3 and also spacially in the gap between $e+$ and $e-$. The above may be verified by means of a dip meter and standing wave on the line or wire 1 and the sine wave 5 is likewise a one-fourth full standing wave. A half standing wave spans the gap $e+$ to $e-$ thus completing a full standing wave.

In carrying out step one of the various evolutionary steps to arrive at my present novel electronic configuration, I replaced the open ended termination of the Lecher line, shown in FIG. 1, with a lumped capacity equivalent to the stray capacity which, in a manner, had been amputated from the showing in FIG. 1. The result was an oscillatory inductance-capacitance system of equivalent electrical line length as shown in FIGS. 2 and 3. The oscillatory LC system of equivalent electrical line length to the Lecher wire shown in FIG. 1, is shown in FIG. 2. Here the parallel lines or wires 9 and 10 are short circuited by the wire 11 and form the inductance portion L of the oscillatory LC system of FIG. 2. The lumped capacity is shown at C in this Figure. The arrow 12 represents an actual conduction current from the line 9 to the line 10 and the feathered arrow 13 indicates a virtual Maxwell current in the capacitance C. The current antinodes of the actual and virtual currents will center on the axis 14 of the neutral plane that lies between the two parallel lines 9 and 10.

In case the capacitance is to be variable, the series capacity shown at C1 and C2 in FIG. 3 is preferable to the single capacitance shown at C in FIG. 2 for the reason that a control linkage, not shown, may be attached to the stippled neutral portion of the metallic connector 20 between the series capacities C1 and C2, which connection point will be at or near ground potential. The parallel wires 21 and 22 of FIG. 3 are glavanically short circuited by the wire 23 and these three wires form the inductance portion L of the electronic configuration. The arrow 24 represents an actual conduction current from the line 21 to the line 22 while the feathered arrows 25 and 26 indicate the Maxwell currents in the series condensers C1 and C2. A neutral plane 27 lies midway between the parallel wires 21 and 22 and the current antinode of the actual current between the two wires will center on this plane.

The second step was the addition of means for self-exciting the circuit of FIG. 3. This is accomplished in the electronic configuration shown in FIG. 4. I incorporate two conventional high vacuum triode oscillators T1 and T2 in the LC circuitry of FIG. 3, see FIG. 4. It is understood that other types of oscillatory devices can be substituted for the vacuum tube triodes, such as solid state or field effect tubes. The parallel wires 21 and 22 of FIG. 3 are crossed, as shown by the wires 30 and 31 of FIG. 4 and this is done to properly phase the grids with respect to the anodes in the triods T1 and T2. The particular type of inductance L1 illustrated in FIG. 4 is that on which a U.S. Pat. was granted, No. 2,453,241, on a composite radio frequency inductance, of which I was a joint inventor with George F. Russell. The rectangularly-shaped stippled areas 32 and 33 that are connected to the wires leading from the anodes of the vacuum tubes T1 and T2, are also connected to the series condensers C1 and C2 and represent low inductance connections in the condenser circuitry. It is well known that high frequency displacement currents do not penetrate the surface of a conductor more than a small fraction of an inch. Hence, a low impedance connection in the circuitry should expose a large area with respect to its cross section. A ribbon or strap of copper or aluminum is far superior to the same cross section in the form of a wire that is circular in cross section. In FIG. 4 the rectangular stippled areas 32 and 33 represent a ribbon or a plate of copper or aluminum in lieu of a round wire. The ribbon form, besides minimizing the I^2R losses, also minimizes the inductance residing in the connections involved in the network of lumped capacities, the latter as a whole comprising the tank capacity of the oscillator. Wires can be used under certain conditions, but the preferred structure makes use of ribbons or plates 32 and 33.

The system thusfar developed, as shown in FIG. 4, will oscillate at a frequency *f*, conforming to the formula $f=1/2\pi\sqrt{LC}$, where *L* is the inductance and *C* the capacitance. It would be possible to treat dielectrics in the series condensers C1 and C2 of the electronic configuration shown in FIG. 4, but from a practical standpoint, it would not be acceptable for industrial purposes because of the lack of means to control the power input to the load and, further, because of the physical restrictions in coupling to a more or less remote load. Hence, something must be added to satisfy these requirements.

Step three. I found that a pair of condensers, commonly designated as series coupling capacities, fulfills the need. The work load, whether dielectric, inductive or radiative, may then be connected to the output terminals of the series condensers which also isolate the work from the high d.c. potentials. I have added these features to the high frequency circuitry configuration of the generator which is schematically shown in FIG. 5 and represents the essential circuitry. Note in FIG. 5 that a capacity of the LC circuit is composed of three condensers, i.e., the series coupling condensers C3 and C4, and the dielectric load condensers CL. The condenser C3 and C4 are variable condensers, while the condenser effect of the load condenser CL will vary according to the type of dielectric load received between the two plates P1 and P2 of this condenser. All of these condensers C3, C4 and CL are connected in series and, in turn, this series of condensers is in parallel with the variable capacity CT. Also note that the crossed inductances 30 and 31 and the composite inductance L1 which span the capacity Ct are dominant factors for controlling the frequency and the frequency spread of the generator.

On the other hand, the capacity variation of any one of the series group of condensers C3, C4 and CL, produces comparatively little change in frequency. In this case, within certain limits, frequency may be restored to some desired constant value by means of varying the terminating capacity Ct up or down as the case may be. Frequency control is arrived at in this manner. The relatively narrow width of the stippled conducting straps **40** and **41** between the series output condensers C3 and C4 and the load receiving condenser CL, indicate that longer leads or connections to the load may be tolerated, yet the inductance should be kept to a minimum for optimum performance. The termination dielectric load receiving condenser CL in FIG. **5** is especially adaptable for loads such as solid, liquid or gaseous dielectrics, or a mixture of these substances.

Load control. The power input to the load may be controlled by varying the impedance of the series condensers C3 and C4 in FIG. **5**. For instance, enlarging the spacing of the series condenser plates reduces their capacitance which results in a relative increase in impedance and this in turn curtails the energy input to the load. Vice versa, energy input to the load may be increased by reducing the spacing between the plates in the series condensers C3 and C4. It is obvious that the gaps between the plates of the condensers C3 and C4 can be increased to a degree which would reduce the energy input to the load condenser CL to practically zero. The voltage gradient in the load condenser approaches zero as the series condensers C3 and C4 approach zero capacity.

The introduction of parallel inductance in a given LC oscillatory system increases the fundamental frequency thereof. Inductances whose magnetic fields do not interact when connected in parallel result in an inductance value less than the least one in the group. Fundamentally, an oscillator, whether mechanical or electronic, involves two states of energy, potential and kinetic. Inductance, i.e., the magnetic field is the "-kinetic" sink of energy and the capacitance, the "-potential" sink of energy. The formula $f=1/2\pi \sqrt{LC}$ involves the inductance L composing the kinetic sink of the oscillator. Since L is under the square root radical in the above-mentioned formula, linear changes in L do not result in linear changes in frequency. Assume C in the above formula to remain constant, then doubling L changes the ratio of L to C, and will result in slowing the frequency F by a factor of one over the square root of two, namely 1/1.41 . Conversely, cutting the inductance to one-half will increase the frequency by a factor of 1.41. Thus, the introduction of parallel inductance **50** in FIG. **6**, which parallels the inductances **32** and **33**, provides a means for widening substantially the frequency range of the given oscillator of FIG. **5**, changing the L, C ratio up or down.

In the circuitry of FIG. **5**, the necessary connections between the various condensers introduced considerable inductance and this sets a ceiling on the frequency of the oscillator. The band spread is controlled by means of the variable capacities. Hence, a reduction of L in effect increases the dominance of C. This change in the L, C ratio broadens the control band spread. FIG. **6** is similar to FIG. **5** and as stated above shows the addition of the parallel inductance **50** schematically in the form of a series of loops. The inductance **50** of FIG. **6** makes it possible to broaden the frequency response and the frequency control.

Balance. In FIGS. **1** to **5** inclusive, a neutral plane is indicated by dot-dash lines extending between charges of opposite polarity "sitting" as it were in stationary wave configuration. If the oscillatory circuitry is symmetrical, the field intensity on each side of the neutral plane will be in balance. Any unbalance will show on the plate current meters, not shown in FIG. **5**, of the vacuum tubes T1 and T2. The balance of the electronic circuitry may be controlled by adjusting the relative spacing of the plates in the variable condensers Ct, C3 and C4.

Current Antinodes. Current antinodes may exist in one of two forms, real or virtual. A real current antinode is associated with a galvanic conductor and is more or less fixed with respect to an established wave length. A virtual current antinode exists in space and may drift more or less to suit changes in the stationary wave patterns. A virtual current, i.e., a Maxwell displacement current in space exhibits all of the characteristics of a real current. A drifting current antinode is essential with respect to the automatic and stepless self-tuning operation of the generator.

FIG. **6** indicates where the positive and negative terminals of a power supply, not shown, should be connected in this special case and this is regarded as a sufficient disclosure that some form of power supply is used. FIG. **5** shows by dotted lines a parallel inductive loop **42** connecting the plates P1 and P2 of the load receiving condenser CL. This loop may be added to raise the frequency of the load and also effects the frequency of the whole to some extent.

FIG. **7** shows the important transition step involved from FIG. **6** to the interlocked inductance of FIG. **8**. The parallel inductance **50** that interconnects the series condensers C3 and C4, has been severed at its current antinodes and this leaves the inductances **50***a* and **50***b*. The severed terminals **50***a* and **50***b* are then crossed and have their ends connected to the opposite extremities of the composite inductance L1, as indicated by the dash lines **50***a* and **50***b*. In all other respects the circuitry of FIG. **7** is the same as FIG. **6** and like reference characters are applied to similar components.

In FIG. **8**, I schematically show the circuitry of my improved self-excited composite capacitance and interlocked inductance oscillator. A pair of oppositely charged base plates **32** and **33** are shown, each of which terminates in the form of stator plates **32***a* and **33***a* in the variable series condensers C1 C2, respectively. The purpose of the variable capacity member CT is to add or subtract capacity, as the case may be, with respect to the composite capacity of the whole. Hence, I will designate CT as a frequency control. The opposite ends of the base plates **32** and **33** each terminate in the form of stator plates **32***b* and **33***b* in series variable condensers C3 and C4, respectively which function as load controls and also for balancing the load on the oscillator tubes T1 and T2, whose anodes **60** and **61** are connected galvanically, respectively, to the base plates **32** and **33**. Since as above stated the base plates **32** and **33** are oppositely charged, there will be a capacitance between the plates.

The leads **40** and **41** are preferably fabricated from sheet copper and connect the output terminals **40***a* and

41*a* of the series condensers C2 and C4, respectively to the work electrode CL. The leads **40** and **41**, plus the work electrode CL compose an integral portion of the inductance and capacitance of the oscillator as a whole. The electrical line lengths of the leads **40** and **41** are not critical with respect to resonance as is the case for inductively coupled resonant circuits. The inductive loop **42** or a multiplicity of such loops, shown in dotted form may or may not be necessary for adjusting the electrical line length of the load electrode CL to enhance the absorption of energy in the load. The loop **42**, or a multiplicity of loops, also tend to bring about a more uniform distribution of electric flux between the oppositely charged electrodes P1 and P2. A number of inductive loops, not shown, and properly distributed, as shown in FIG. 5A of my copending application, Ser. No. 848,656, may be required, dependent upon the relative dimensions and characteristics of the load electrode CL, such as area, spacing of the opposing electrodes P1 and P2, and the dielectric constant involved. The loop **42** and any additional similar loops, not shown, are not critical with respect to the resonant electrical line length as compared to the so-called tuning stubs commonly used for tuning loads inductively coupled to conventional oscillators, such as Hartley, Colpitts, tuned plate-tuned grid, etc.

I will now describe my new and unique improvement in FIG. **8** over the circuitry shown in my copending patent application. My unique configuration of inductance provides parallel paths by which the charge on the composite capacitance of the tank may disperse and converge to form one common current antinode on the composite or center interlocked inductance L1, in FIG. **8**. This composite radio frequency inductance was covered by a joint U.S. Pat. No. 2,453,241, of which I was a joint inventor with George F. Russell. The parallel inductance **50**, shown in FIG. **6**, was severed at its midpoint and the two resulting line lengths **50***a* and **50***b* were crossed with respect to each other and their terminal ends connected to the ends of an outer cylindrical inductance **62***a* that is concentric to the inner grid line inductance **62** which form the composite or center interlocked inductance L1. This connects the series coupling condensers C3 and C4 with the composite or interlocked inductance L1 and the lines **50***a* and **50***b* are crossed in order to provide the proper phase relationship with the grid radio frequency current. Note in FIG. **8** that the grid line inductance **62** is concentric to the common current antinode, but is isolated therefrom galvanically. It will be seen that the total charge stored in the capacitance of the tank, which includes the load electrode CL and the charge on the grids of the oscillator tubes T1 and T2, all converge in the same phase to substantially form a single common current antinode, i.e., a single magnetic kinetic sink. It is for this reason that I term this particular circuitry as "interlocked inductance" and I believe that it is a unique feature in the state of the art. The composite inductance L1 could be termed "interlocked inductance" and it is composed of the inner grid line inductance **62** and the outer cylindrical concentric inductance **62***a*.

FIG. **8** also indicates the filament power supply for the tubes T1 and T2 as being provided by transformers **63** and **64**, together with terminals B+ and G. The B+ terminal is connected to the high voltage terminal of the power supply and G, in the case of a self-excited oscillator, to a grid leak resistance as a negative bias. The ends of the grid line length **62** of the composite or interlocked inductance L1, are connected to the grids of the tubes T1 and T2. Any type of power supply may be used which satisfies the characteristics of the oscillators used to power the generator. It should be noted that the connecting points for B+ and G, in FIG. **8**, are located at the voltage node of the single stationary wave which, so to speak, "sits" on the circuitry.

Terman in his text, "Radio Engineering" calls attention to the fact that symmetry in the construction of an oscillator or amplifier is of great importance in favor of stable operation and efficiency plus the suppression of unwanted spurious frequencies. The circuit diagram of FIG. **8** is remarkable for its simplicity and symmetrical structure, including the load. All of the lumped capacities CL, C3, C4 and Ct, and the stray capacity between the base plates **32** and **33**, comprise the total capacity of the single stationary wave oscillator of FIG. **1**. The stray capacity between the base plates **32** and **33** cause these plates to function as a condenser whose end plates **32***a* and **33***a* constitute stator plates for the variable series condensers C1 and C2, respectively, and whose end plates **32***b* and **33***b* constitute stator plates for the series variable condensers C3 and C4, respectively.

The ideal high frequency generator should be capable of satisfying the following requirements imposed by industrial applications and environment.

Frequency stability. To remain within the assigned I.S.M. band widths.

Frequency control. To compensate for changes in load configuration.

Interference. Decreases in proportion to simplicity and symmetry.

Self-excited oscillator. Oscillator should be self-excited.

Load changes. Simple dial settings. No complex resonant matching. Automatic and instant adjustment to changes in load loss factor and in load resonance.

Arc suppression. There should be no arcing.

Efficiency. Important for prolonging vacuum tube life.

Lethal voltages. Isolation of load from high d.c. components.

Structural and physical configuration. Should be symmetrical to neutral plane.

Load linkage to generator. Should constitute a part of the inductance and capacitance of the single stationary wave pattern oscillator.

Stationary wave. One only. No multiplicity of coupled resonant circuits.

Tube balance control. All tubes should be evenly balanced for equal performance.

Load adaptability. The oscillator should tolerate shorting the load control terminals or leaving them open circuited. Between these extremes, the generator should accept the following types of loads: ohmic resistance; induction heating; dielectrics such as liquids, solids, rarefied gases; radiative loads and a load which may approach an open circuit.

My self-excited composite capacitance and interlocked inductance oscillator satisfies all of the above requirements to a degree superior to any oscillator presently available.

An experiment was undertaken to show the distinct advantage of the "interlocked" circuitry shown in FIG. **8** over that shown in FIG. **6**, the latter Figure being the same as FIG. **6**, in my copending application, Ser. No. 848,656. A generator of the circuitry shown in FIG. **6** was connected to a water calorimeter for measuring plate efficiency and was rated at 5KW output. The generator barely put out 5KW at maximum tube rating of 1.2 amperes plate current. The grid current dropped very low at this loading. The plate efficiency calculated to about 45 percent.

The circuitry of FIG. **6** was then rearranged to be like FIG. **8**. The "interlocked" generator was then connected to the calorimeter leaving all else the same as nearly as possible. The plate current was again adjusted to 1.2 amperes and the generator operated on the same frequency as before. The grid during this test dropped but little by comparison. The results were that the output measured 7KW instead of 5KW and at a plate efficiency from 45 percent to above **60** percent.

I have found that the interlocked inductance and composite capacitance oscillator circuit configuration of FIG. **8** is not only new and different from other oscillators as already explained, but it has a resonant cavity equivalence. Reference to FIGS. **9** to **13** inclusive illustrates in perspective the circuitry used in an experiment which is the same circuitry as shown in FIG. **8**. The output of the oscillator was 5KW and it operated on a frequency of 27.12MH_2. Like reference characters to similar components in FIGS. **9** and **10** to those in FIG. **8** are used in FIGS. **9** and **10**. A wood dielectric load, not shown, was placed in the work electrode CL.

By means of the series load control the input to the load was adjusted to approximately 4KW and set at 27.12MH_2 by means of the frequency control variable condenser Ct. The power was then shut off to the circuitry of FIG. **9**, and without changing any other component or dial setting, the lop **42** was severed at its center point, and the inductances were crossed with respect to each other and connected to the ends of the composite or interlocked inductance L1 as shown by the dash lines **42***a* and **42***b* in the Figure. Then upon again applying the electrical power to the oscillator very little change in the load or frequency was observed.

If physically possible, any number of loops, such as **42** in FIG. **9**, could be interlocked as an ideal circuitry. The phenomenon uncovered by this experiment suggested that the interlocked circuitry imitates the properties of a resonant cavity. Accordingly, FIGS. **11**, **12** and **13** depict the progression of an LC circuit, the plates P1 and P2 of the load condenser CL, spanned by one inductance path **42** in FIG. **11**, spanned by four parallel inductances **43***a* – **43***d*, inclusive, in FIG. **12**, to the ultimate in FIG. **13** where an infinite number of inductances, indicated by the four side walls **44**, interconnect the plates P1 and P2 to form a closed box. The top and bottom plates P1 and P2 of the "box" could be thought as made up of an infinite number of condenser plates, each being spanned by an inductance. A "belly band" **70**, drawn around the "box" of FIG. **13**, and midway between the top plate P1 and the bottom plate P2 could be conceived as being a common magnetic *i* field which interlocks the infinite number of inductances represented by the four sides **44** of the "box".

Each inductance that is added, maintaining symmetrical spacing, raises the resonant frequency governed by the law of parallel inductance. For instance, two equal inductances in parallel will result in halving the inductance. How does the addition of parallel inductance affect the increase in frequency? Frequency $F\alpha 1/LC$. Hence, if L is reduced to $\frac{1}{2}L$, substitution reveals that the frequency will increase by the factor $\sqrt{2} = 1.41$. If L is reduced to 1/3, the factor becomes 1.73, etc. A curve plotted against the increase of parallel paths indicates that the rise in frequency tends to level off above approximately eight to 10 parallel paths. The frequency of the resonant cavity is, of course, the limit to which the frequency can rise.

The apparent equivalence of the composite capacitance and interlocked inductance oscillator to a resonant cavity further suggested folding the circuit configuration of the above oscillator shown in FIG. **8** to a perspective fantasy shown in FIG. **10**. Because of the extreme simplicity and symmetry of the composite capacitance and interlocked inductance oscillator, it must be admitted, it does fold to resemble a rectangular box. Folding the *i* loop **42** of the work electrode CL to interlock, as shown in FIG. **9** by the dash lines **42***a* and **42***b*, reveals a configuration apart, as far as I can ascertain, from any known oscillator circuit presently known in the state of the art. Certainly any of the conventional oscillator circuits involving two or more tuned components inductively coupled, one to the other and in turn inductively coupled to a work load or antenna would not simulate the properties of a resonant cavity or to readily fold symmetrically upon themselves. See the Hartley, Colpitts tuned grid-tuned plate, the Tickler circuit, all of which involve two or more resonant electrical line lengths tuned each to the same frequency or a harmonic thereof. The components of the oscillator shown in FIG. **10** are the same as those shown in FIG. **9**, and like parts are given similar reference characters.

The "interlocked" circuitry of FIGS. **8**, **9** and **10**, appears in fact a form of resonant cavity in which all displacement currents in the network of parallel inductances are in the same sense and phase. In the case of a resonant cavity the infinite parallel inductances forming the sides of the cavity have a common magnetic sink in the form of a "belly band" **70** located midway between the top and bottom of the cavity.

An actual problem was faced in the form of a large work condenser composed of two plates each 2½ ft. × 5 ft. encompassing a wood panel one-half inch thick, see FIG. **14**. In order to excite this load when connected to the output terminals of a self-excited composite capacitance and interlocked inductance oscillator designed to operate at 27.12MH_2, 10 parallel inductances were required for optimum performance and efficiency, the load remaining an integral part of the system as a whole. Note the skeletal resemblance to a shallow box the resonant cavity makes with incomplete sides.

The circuitry of FIG. **8** is the one that connects with the plates P1 and P2 of FIG. **14**. It will be further seen from this actual example that my new "interlocked" circuitry of FIG. **8** is different from others as well as unique. FIG. **14** shows the plates P1 and P2 interconnected by 10 symmetrical spaced parallel inductances **80**.

I claim:

1. A self-excited oscillator comprising:

a. a pair of base plates parallely arranged in spaced relation and adapted to be oppositely charged and having an integral stator plate at each end, each stator plate forming a part of a condenser;

b. a first pair of adjustable condenser plates positioned adjacent to the pair of stator plates disposed at the same ends of said base plates and forming a first pair of series variable condensers with said stator plates;

c. a work receiving pair of electrodes, the adjustable plate of one of said series variable condensers being electrically connected to one of said pair of electrodes and the adjustable plate of the other series variable condensers being electrically connected to the other electrode to place said pair of electrodes in series with the two series variable condensers;

d. a third adjustable condenser plate positioned adjacent to the stator plates disposed at the other ends of said base plates and forming a second pair of variable series condensers, said third adjustable condenser plate being movable for controlling the frequency of said oscillator;

e. a pair of three element vacuum tubes, one for each base plate, the anode of one tube being electrically connected to one of said base plates and the anode of the other tube being electrically connected to the other base plate;

f. an interlocked inductance having an inner elongated grid line inductance with one end of said grid line being electrically connected to the grid of one of said vacuum tubes and the other end of said grid line being electrically connected to the grid of the other tube;

g. said interlocked inductance also having an outer cylindrical inductance that is concentric to and insulated from said inner grid line;

h. a first pair of crossed inductances, one of which extends from the stator plate of one of said first pair of said series variable condensers to the end of said outer cylindrical inductance and the other of which extends from the stator plate of the other one of said first pair of said series variable condensers to the opposite end of said outer cylindrical inductance; and

i. a second pair of crossed inductances, one of which extends from the stator plate of one of said second pair of said variable series condensers to an end of the outer cylindrical inductance and the other of the second pair of crossed inductances extending from the stator plate of the other one of said second pair of said variable series condensers to the opposite end of said outer cylindrical inductance.

2. The combination as set forth in claim 1, and in which

a. said first pair of crossed inductances that connect said first pair of series variable condensers with said outer cylinder of said interlocked inductance are in electrical parallel with said second pair of crossed inductances that connect said second pair of variable series condensers with said outer cylinder of said interlocked inductance;

b. whereby these two pairs of crossed inductances and said interlocked inductance are all in the same electronic phase with respect to the current displacement at the mid-portion of said elongated grid line inductance length.

3. The combination as set forth in claim 2 and in which

a. said first pair of series variable condensers and said work receiving pair of electrodes form a series capacitance that parallels the capacitance created between said pair of base plates; and

b. the capacitance of said second pair of variable series condensers parallels the capacitance created between said pair of base plates.

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