March 22, 1932. L. L. JONES 1,850,754

SELECTOR SYSTEM FOR RADIO RECEIVING APPARATUS

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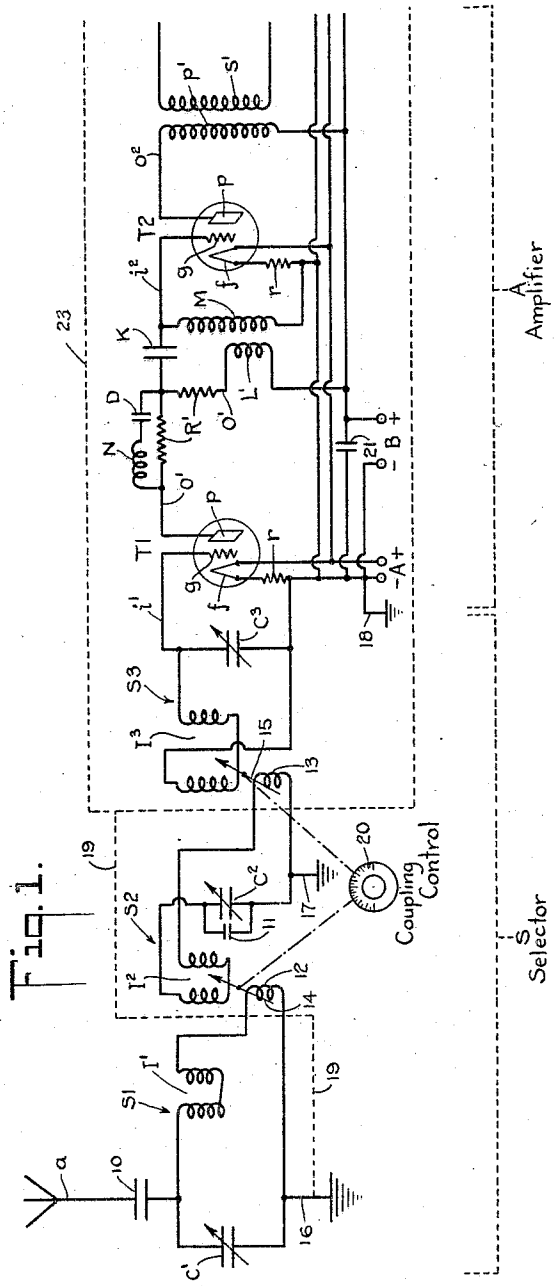


Fig. 1.

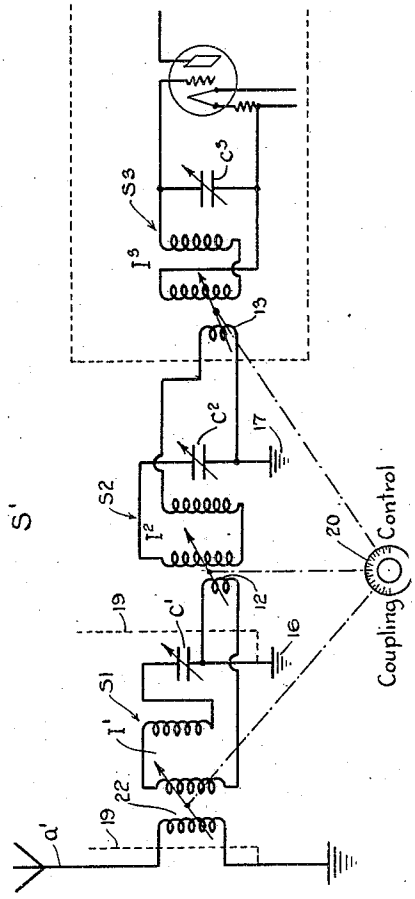


Fig. 2.

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UNITED STATES PATENT OFFICE

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SELECTOR SYSTEM FOR RADIO RECEIVING APPARATUS

Application filed July 15, 1927. Serial No. 205,935.

This invention relates to a radio receiving apparatus and relates more particularly to radio receiving apparatus embodying separate selective and amplifying systems whereby the selection of the electrical oscillations of a desired frequency is accomplished prior to amplification thereof, and has special reference to the provision of an improved system for effecting geometric selectivity of the electrical oscillations of the desired frequency.

A prime desideratum of my present invention centers about the provision of a radio receiving apparatus in which the selection of the desired frequency is accomplished in geometric progression by means of three or more tuned circuits arranged in cascade, said circuits being devoid of separate energy sources so that the selection of the oscillations of the desired frequency is accomplished without energy amplification or relay action, this selective system being so organized that the full geometric selectivity of the system is realized or effectuated.

A further prime desideratum of my present invention relates to the provision of a system for geometrically selecting the electrical oscillations of a given frequency from oscillations differing therefrom in frequency embodying three or more tuned or selective circuits arranged in cascade and adapted for association with an electron discharge device amplifying system, the selector system being organized and constructed to secure a maximum selectivity of the system with a minimum loss of energy in transmitting the selected energy through the system.

As is well known the most common type of radio receiving apparatus employed in commerce is the socalled tuned radio frequency system which comprises a series of tuned cascaded circuits, each circuit of the series embodying an audion or electron discharge device, the audion stages being coupled together and to the energy receptor (antenna) by means of a tuning element. In these tuned radio frequency systems, each stage of the circuit series functions as a frequency selector and energy amplifier of the signal impressed upon the energy receptor or antenna. The building or constructing of a tuned radio frequency receiver, throughout the development of the art, has been beset with numerous difficulties requiring scientific and engineering development; and such difficulties have increased from time to time as the art progressed as it became necessary to build radio receivers of exceedingly high selectivity and sensitivity. The difficulties encountered have multiplied geometrically with the number of tuned stages required so that the physical limitations of tuned radio frequency receivers imposed a limit to the selectivity and sensitivity achievable.

By my present invention I propose to deviate from this prior practice of cascading tuned radio frequency audion stages wherein the selectivity and amplification of the energy are simultaneously accomplished, and I propose to utilize separate instrumentalities or systems for accomplishing the selection of the frequency and the amplification of the energy, these separate selector and amplifying systems functioning to produce a high-powered receiver of great selectivity.

To accomplish this object I have found that the selector system, devoid of electron discharge devices or separate energy sources, should be organized so as to constrain the flow of the energy through each of the cascaded circuits of the selective system, the said circuits being furthermore so interrelated as to prevent any but the first circuit of the series to receive energy from an extraneous source. I have further discovered that these circuits of the selective system may be so operated as to effect a maximum transfer of energy with a minimum energy loss in the transmission of the energy; and that when so organized a maximum and full geometric selection of the energy is effected. A selective system embodying organized circuit instrumentalities for accomplishing these results forms the subject matter of the present application.

I have further discovered that to produce a successful radio receiver in which the frequency selecting equipment or system is separated from the energy amplifying system, the amplifier (of the audion or electron discharge tube type) must be designed so as to prevent

any disturbing reactions from reaching the selector system, such disturbing reactions having the effect of destroying the selective functioning of the selector system, and that such an amplifier must be associated with the selective system to operate upon only the selected energy coming from the selector system. This interrelation between the selective system and the amplifying system is described generally in the present application, but is more specifically described and broadly claimed in my copending application filed herewith, Serial No. 205,934 of July 15, 1927.

To the accomplishment of the foregoing and such other objects as will hereinafter appear, my invention consists in the elements and their relation one to the other, as hereinafter more particularly described and sought to be defined in the claims; reference being had to the accompanying drawings which show the preferred embodiment of my invention, and in which:

Fig. 1 is a wiring diagrammatic view showing the combination of the selector and amplifying systems forming a radio frequency receiver, and

Fig. 2 is a diagrammatic view of a modification thereof.

Referring now more in detail to the drawings and having reference first to Fig. 1 thereof, the radio receiving system of my invention comprises a selective system generally designated as S and also by the legend "Selector" and an audion amplifying system generally designated as A also designated by the legend "Amplifier", the selector system S comprising at least three circuits in cascade tunable to effect geometric selectivity, and the amplifier A comprising untuned audion or electron discharge tube stages coupled to the last selective circuit of the selector system S.

The selector system S comprises more specifically three or more tuned or selective circuits S1, S2 and S3 coupled together preferably inductively by variable coupling means referred to more in detail hereinafter, the first selector circuit S1 being coupled to an energy receptor such as the antenna *a* and the last selector circuit S3 being coupled to the filament grid circuit of the first tube of the amplifier A.

I have found that in order to realize the full geometric selectivity of the selector system S, the selective circuits S1, S2 and S3 thereof must be so interrelated that the first and third circuits S1 and S3 must be capacitively decoupled and inductively decoupled so that the energy transferred from the first to the third selective circuits of the series is constrained to flow through the second or intermediate circuit S2 of the series. The three or more cascaded selective circuits should be capacitively shielded and inductively shielded from each other except for the preferably inductive means which couple the circuits, and this shielding also insures that the second and third selective circuits S2 and S3 are prevented from receiving any extraneous energy. This intercircuit shielding or decoupling except for the energy coupling means between the circuits is very important in order to realize the full selectivity of the system, this being evident when it is considered that if it were possible for circuit S1 to induce a part of its energy directly into circuit S3, the selectivity of the circuit S2 would be eliminated as a factor in the selectivity of the system. This condition is more severe than in ordinary tuned radio frequency circuits since there are no separate sources of energy in the selector system S and therefore the energy received by the circuit S3 is of the same order of magnitude as that transmitted from the selective circuit S1.

The selector circuits S1, S2 and S3 each comprises a tuning element preferably in the form of a condenser designated as C with an exponent corresponding to the circuit of which it forms a part, and an inductance designated as I also with an exponent corresponding to the circuit of which it forms a part, the capacitive and inductive components of each of the circuits being arranged in series, as clearly shown in the drawings. The antenna *a* is coupled capacitively by means of the condenser 10 to the first tuned circuit S1; and where the tuning condensers C', C^2 and C^3 are desired to be simultaneously adjusted for unicontrol, the additional capacity added by the antenna *a* and its coupling condenser 10 is made equal to the tube input capacity effective on the selective circuit S3, and a small fixed condenser 11 equal to this capacity is placed in shunt with the variable condenser C^2 of the circuit S2.

The circuits of the selector system are preferably coupled to each other inductively and adjustably, this being accomplished by means of the coils 12 and 13 which are adjustably coupled to the inductance coils I^2 and I^3 respectively, the adjustment of the coupling being indicated by the arrowed lines 14 and 15 respectively. These coupling means are so constructed as to permit a coupling range from zero coupling to a maximum coupling which is nevertheless a loose coupling, i. e., to a coupling value just short of what will produce coupling waves in the circuits, that is, double resonance peaks. As is well known, a single resonant circuit has a single resonance peak. If two such similar circuits are inductively coupled together with a very slight coupling, their combination also has a single resonance peak. If the coupling is increased or "tightened", the single resonance peak first broadens and then divides into two distinct and separated resonance peaks, corresponding to frequencies higher and lower than the resonance frequency of the single circuits, which condition is obviously very undesirable

in a selector. In ordinary technical parlance couplings permitting the retention of a single resonance peak are considered to be loose couplings, while couplings resulting in a double resonance peak are considered to be close couplings. In the present selector the maximum coupling is less than a close coupling, and does not produce a double resonance peak. This double resonance phenomenon, and the energies of different frequencies tending to result therefrom, are frequently referred to as coupling waves.

To capacitively and inductively shield or decouple the circuits except for the adjustable energy coupling means 12—I^2 and 13—I^3, the main inductances I', I^2 and I^3 are made astatic, these inductances being either of the binocular type or of the concentric astatic type described and claimed in my patent to a coil system, 1,608,560 of November 30, 1926, the construction being such that there is freedom from magnetic and electrostatic coupling between these inductances. The condensers of the circuit are preferably of the grounded rotor type so that there is freedom from inter-capacitive coupling between these elements. The low potential side of each selective circuit is grounded as at 16, 17 and 18 respectively, and each of the circuits is made highly efficient by the use of Litz wire coils and dielectric mountings of low loss. I have found this construction sufficient to accomplish the desired end, but if desired each circuit may be arranged in a separate metal compartment.

By the provision of this construction I have determined that each of the selective circuits is coupled to the other only through the adjustable energy coupling means therebetween, this being diagrammatically represented by the broken dotted line 19 in Fig. 1 of the drawings. When the circuits are so constructed each of the three or more tuned circuits of the series contributes its share to and forms a full component in the selectivity of the system since that coupling between a circuit and a non-adjacent circuit which results in virtually eliminating an intermediate circuit of the series as a selector component is effectively prevented.

For effecting a coupling variation over an extremely wide range and for producing that coupling variation between the circuits which secures the maximum system selectivity with the minimum energy loss in the transmission of the energy through the selector system, the coupling instrumentalities 12—I^2 and 13—I^3 are adjustable so as to equalize the selectivity of all of the circuits of the series, this being accomplished by constructing the adjustable coupling instrumentalities for simultaneous and similar operation. This is diagrammatically represesented by the single dial element 20 which is shown diagrammatically connected to the coupling inductances 12 and 13 to effect the simultaneous operation of the latter.

By similarly adjusting the coupling instrumentalities there is prevented a difference in degree of coupling between the circuits S1, S2 and the circuits S2, S3, such difference in degree resulting in a loss of selectivity of the system. This will be seen when it is appreciated that when a pair of the circuits are more tightly coupled than another pair, the loss in selectivity of the system due to the tightly coupled pair is greater than the gain in selectivity which is due to the weakly coupled pair, so that for a given energy transmission the selectivity of the system as a whole is less than it would be where both pairs of circuits are coupled with equal degrees of coupling. Moreover, by utilizing a plurality of coupling instrumentalities and by effecting the simultaneous adjustment of such coupling instrumentalities, I produce an exceedingly wide coupling range of the circuits.

I have found that this non-audion selector system embodying three or more tuned circuits in which only the energy impressed upon the receptor or antenna is transmitted through the circuits of the series, and in which such energy is constrained to flow through and be progressively acted upon by each of the circuits of the series and in which similar and preferably simultaneous adjustment is made of the energy coupling means therebetween, provides a successful solution of the problem of building a selector system which is adapted to produce true geometric selectivity and which is adapted for circuit attachment to a separate audion amplifier of the untuned type.

In order to make this selective system S functionable in a radio receiving system, I have discovered that it must be associated with an amplifier of proper characteristics, the amplifier being designed so as to inhibit any reactions upon the selector system which tend to destroy the selectivity thereof, and so as to prevent the picking up of any energy except that fed to the amplifier through the selector system. Such an amplifier should also desirably be sufficiently powerful to increase the signal to a volume suitable for operating the audio system even though the couplings in the selector system be made quite loose so as to permit said loose couplings to be used and realize the full geometric selectivity of the system.

To accomplish these results my invention is directed to the provision of an amplifier embodying a series of electron discharge tubes and having a pair of tubes first in the series which are so organized as to eliminate all damping reactions and oscillating creating tendencies at the input terminals of the first tube of the series. I have discovered that in the prior art amplifying systems there ex-

isted a transition from an unstable oscillatory condition at the input terminals of the first tube which created distortions of tone to a damping reaction at such input terminals which distinctly destroyed the selectivity of the selector system; and therefore to eliminate these reactions and the transition from an oscillatory condition to a damping reaction, the cascade audion amplifier A is equipped with a pair of tubes T1 and T2 respectively of the triode or three-electrode type coupled together and to subsequent circuits in such a way as to eliminate or balance all of the reactions at the input terminals of the tube T1.

The specific functional interrelation of the parts of this amplifier system is more particularly described and claimed in my aforementioned copending application filed concurrently herewith, Serial No. 205,934; and in the present application I will confine the description of this amplifier to the structural features and broad functional interrelation of the pair of coupling amplifier tubes T1 and T2.

Each of the tubes T1 and T2 comprises the usual grid, plate and filament, g, p, and f respectively, the filaments of the tubes being connected by means of filament circuits to the A battery designated $-A+$. Both filament circuits may be suitably provided with fixed resistors such as r, r. The B battery designated $-B+$ is connected in the usual way to the A battery and to the output circuits of each of the tubes T1 and T2, a blocking condenser 21 being employed connecting the plus side of the B battery to the minus side of the A battery. The input and output circuits i', o', i^2, o^2 of the tube stages T1 and T2 are connected as clearly shown in the drawings.

To balance the reactions at the input terminals of the input circuit i', the circuit network of the amplifying tubes T1 and T2 are, generically speaking, so organized as to cause such network to act or behave as a pure reactance, either capacitive or inductive. To permit of uni-control for the selective system S, this amplifier circuit network should further be so designed as to produce a constant reactance at the input terminals of the first input circuit i'. In the construction exemplified in Fig. 1 of the drawings, this reactance is capacitive. When the circuit network of the amplifier A is made to react as a pure capacitance (all positive and negative resistances effective on the input circuit i' being elminiated for the whole wave length range), I have found that the selectivity of the selector system S is unimpaired and is capable of optimum operating results; and when such a capacitance is maintained constant, uni-control of the selector system S may be accomplished.

To attain this balance at the input terminals of the first tube T1, I first fix the constants of the output circuit o' in accordance with the principles described and claimed in my copending application, Serial No. 51,569, August 21, 1925, or in my Patent 1,620,661, March 15, 1927, the natural frequency of this output circuit in connected circuit being greater than the highest frequency of the whole frequency range through which the input circuit i' is tunable. With this characteristic, feedback reactions from the output circuit o' to the input circuit i' are produced for the whole frequency range, which feedback reactions are neutralized by means of a resistance R′ located in this output circuit and preferably between the plate and the inductive component of the output circuit. This resistance may be of the order of 1600 ohms and is selected in accordance with the laws or rules described, for example, in my aforementioned Patent 1,620,661.

The output circuit o' with these determined characteristics is then coupled to the input circuit i^2 by means of a coupling condenser K and an inductance M, the condenser K being tapped at a mid-point of the resistance R′, the capacity K and inductance M when taken in series having preferably a natural frequency lower than the lowest frequency of the frequency band to be transmitted through the amplifier. Preferably also, the plate side of the resistance R′ is shunted by means of an inductance N and a condenser D. The inductance M may be loosely coupled to the plate inductance L′, but preferably is closely coupled thereto.

As an example of suitable magnitude of these constants, the section of resistance R′ between the plate and the intermediate tap may be 921 ohms, the remainder of the resistance R′ about 707 ohms, the coupling condenser K, 250 micromicrofarads, the inductance N, 22 microhenrys, and the capacity D, 150 micromicrofarads. The inductance M is preferably divided into two sections, one transformer coupled to the inductance L′ and the other a free section, the free section being about 480 microhenrys and the coupled section about 150 microhenrys. The transformer coupled parts are preferably bifilarly wound after the manner described and claimed in my copending application, Serial No. 195,631 of June 1, 1927, for transformer and coil system.

To balance the aforesaid reactions over the whole wave length range, I have found that the effective input capacity at the input terminals of the circuit i^2 should rise in a predetermined way with increase of wave length. This I accomplish by predetermining the characteristics of the transformer p', s' in the output circuit o^2 of the tube T^2. I have found that this transformer should be given a natural frequency lower than the lowest frequency of the range of the receiver,

and that such a natural frequency of the transformer has the effect of producing a rising input capacity characteristic at the input terminals of the second circuit i^2. This transformer p', s' is also preferably of the bifilarly wound type, the natural frequency of which is selected to be about 625 meters.

By the provision of this construction I therefore first stabilize the adjacent stage reactions of the tube T1, then neutralize the feedback reactions between these stages and finally impose a varying input capacity characteristic on the input of the second tube T2 by predetermining the characteristic of the output circuit of the tube T2; and by this combination of means I balance over the whole wave length range the feedback and feed-forward reactions at the terminals of the first tube T1.

The amplifying system A is desirably shielded as by an enclosing shield 23 so that the same is prevented from picking up any energy except that received from the selector system S.

In Fig. 2 of the drawings I show a modified form of the selector system of the radio frequency apparatus wherein three instead of two adjustable coupling means is employed. Otherwise, the circuits are substantially similar to those shown in Fig. 1 of the drawings. In this modification the selector system S' comprises the three selective circuits S1, S2 and S3, similar to those heretofore described, the circuit S1 including a third adjustable coupling instrumentality generally designated as 22 which couples the circuit S1 inductively to the receptor or antenna a'. This adjustable coupling means 22 is connected to the other adjustable elements 12 and 13 so that all are simultaneously adjustable by means of the single dial 20. The remaining parts of the selector system S1 of Fig. 2 are substantially similar to those shown in Fig. 1 and are indicated by similar reference numerals.

The operation of the radio apparatus and the selector system therefor of my present invention, and the many advantages thereof, will, in the main, be fully apparent from the above detailed description thereof. It will also be apparent that while I have shown and described my invention in the preferred form, many changes and modifications may be made in the structure disclosed without departing from the spirit of the invention, defined in the following claims.

I claim:

1. A system for geometrically selecting electrical oscillations of a given frequency from oscillations differing therefrom in frequency comprising at least three efficient circuits each including capacitive and inductive reactances and being adjustably tunable to the frequency of the oscillations to be selected and arranged in cascade or series, a first coupling means linking the first circuit of the series to the second circuit for the transfer to the second circuit of energy selected by the first circuit, a second coupling means linking the second circuit of the series to the third circuit for the transfer to the third circuit of energy selected by the second circuit, the coupling being less than that producing coupling waves, means for grounding one side of each of said circuits between the capacitive and inductive reactances thereof, and means for capacitively and inductively decoupling the first and third circuits of the series from each other whereby the energy transferred from the first to the third circuits of the series is constrained to flow through the second or intermediate circuit of the series.

2. A system for geometrically selecting without energy amplification electrical oscillations of a given frequency from oscillations differing therefrom in frequency comprising at least three efficient circuits resonant to the frequency of the oscillations to be selected and arranged in cascade or series, variable capacitive means in each of the circuits for tuning the same to resonance, a first inductive coupling means linking the first circuit of the series to the second circuit for the transfer to the second circuit of energy selected by the first circuit, a second inductive coupling means linking the second circuit of the series to the third circuit for the transfer to the third circuit of energy selected by the second circuit, the coupling being less than that producing coupling waves, means for grounding one side of each of said circuits between the capacitive and inductive reactances thereof, and means for capacitively and inductively decoupling the first and third circuits of the series from each other to a high degree whereby the energy transferred from the first to the third circuits of the series is contrained to flow through and be selected by the second or intermediate circuit of the series.

3. A system for geometrically selecting electrical oscillations of a given frequency from oscillations differing therefrom in frequency comprising at least three efficient circuits each including capacitive and inductive reactances and being adjustably tunable to the frequency of the oscillations to be selected and arranged in cascade or series, a first coupling means linking the first circuit of the series to the second circuit for the transfer to the second circuit of energy selected by the first circuit, a second coupling means linking the second circuit of the series to the third circuit for the transfer to the third circuit of energy selected by the second circuit, the couplings being equal and less than that producing coupling waves, means for grounding one side of each of said circuits between the capacitive and inductive reactances thereof, and means for capacitively and inductively

decoupling to a high degree any one of the circuits of the series from each of the other two and from its surroundings, except for the heretofore mentioned coupling means, whereby the energy transferred through the three circuits of the series is constrained to flow solely from a circuit to its next adjacent circuit and only through said coupling means.

4. A system for geometrically selecting electrical oscillations of a given frequency from oscillations differing therefrom in frequency comprising at least three efficient circuits each including capacitive and inductive reactances and being adjustably tunable to the frequency of the oscillations to be selected and arranged in cascade or series, a first adjustable coupling means linking the first circuit of the series to the second circuit for the transfer to the second circuit of energy selected by the first circuit, a second adjustable coupling means linking the second circuit of the series to the third circuit for the transfer to the third circuit of energy selected by the second circuit, the maximum coupling being less than that producing coupling waves, means for grounding one side of each of said circuits between the capacitive and inductive reactances thereof, means for capacitively and inductively decoupling the first and third circuits of the series from each other so that the energy transferred from the first to the third circuits of the series is constrained to flow through the second or intermediate circuit, and means for varying both of the adjustable coupling means to produce substantially like degrees of coupling therein.

5. A system for geometrically selecting without energy amplification electrical oscillations of a given frequency from oscillations differing therefrom in frequency comprising at least three efficient circuits resonant to the frequency of the oscillations to be selected and arranged in cascade or series, variable capacitive means in each of the circuits for tuning the same to resonance, a first variable inductive coupling means linking the first circuit of the series to the second circuit for the transfer to the second circuit of energy selected by the first circuit, a second variable inductive coupling means linking the second circuit of the series to the third circuit for a transfer to the third circuit of energy selected by the second circuit, the maximum coupling being less than that producing coupling waves, means for grounding one side of each of said circuits between the capacitive and inductive reactances thereof, means for capacitively and inductively decoupling the first and third circuits of the series from each other to a high degree so that the energy transferred from the first to the third circuits of the series is constrained to flow through the second or intermediate circuit, and means for simultaneously adjusting both of said coupling means to produce substantially like degrees of coupling therein.

6. A system for geometrically selecting electrical oscillations of a given frequency from oscillations differing therefrom in frequency comprising at least three efficient circuits adjustably tunable to the frequency of the oscillations to be selected and arranged in cascade or series, a first coupling means linking the first circuit of the series to the second circuit for the transfer to the second circuit of energy selected by the first circuit, a second coupling means linking the second circuit of the series to the third circuit for the transfer to the third circuit of energy selected by the second circuit, the maximum coupling being less than that producing coupling waves, and means for adjusting both of said coupling means to equalize the selectivity of all of the circuits of the series.

7. A system for geometrically selecting electrical oscillations of a given frequency from oscillations differing therefrom in frequency comprising at least three efficient circuits arranged in cascade or series, tuning means for each of the circuits to render the same resonant to the frequency of the oscillations to be selected, a first adjustable coupling means linking the first circuit of the series to the second circuit for the transfer to the second circuit of energy selected by the first circuit, a second adjustable coupling means linking the second circuit of the series to the third circuit for the transfer to the third circuit of energy selected by the second circuit, the maximum coupling being less than that producing coupling waves, and means for simultaneously varying both of said coupling means to produce substantially like degrees of coupling therein.

8. A system for geometrically selecting electrical oscillations of a given frequency from oscillations differing therefrom in frequency comprising at least three efficient circuits resonant to the frequency of the oscillations to be selected and arranged in cascade or series, a first adjustable coupling means linking the first circuit of the series to the second circuit for the transfer to the second circuit of energy selected by the first circuit, a second adjustable coupling means linking the second circuit of the series to the third circuit for the transfer to the third circuit of energy selected by the second circuit, the maximum coupling being less than that producing couplings waves, and means for simultaneously and similarly adjusting both of said coupling means.

9. A system for geometrically selecting electrical oscillations of a given frequency from oscillations differing therefrom in frequency comprising a plurality of efficient circuits each adjustably tunable to the frequency of the oscillations to be selected and arranged

in cascade or series, a plurality of coupling means linking the said circuits together, the maximum coupling being less than that producing coupling waves, energy receptor, means loosely coupling the same to the first of said circuits, shielding for said circuits, the circuits and shielding and coupling means being such that solely each of the said coupling means is effective for transferring energy selected by one circuit to a circuit next adjacent thereto, and means for varying at least two of said coupling means to produce substantially like degrees of coupling therein.

10. A system for geometrically selecting electrical oscillations of a given frequency from oscillations differing therefrom in frequency comprising a plurality of efficient circuits each resonant to the frequency of the oscillations to be selected and arranged in cascade or series, a plurality of adjustable coupling means linking the said circuits together, the maximum coupling being less than that producing coupling waves, an energy receptor, means loosely coupling the same to the first of said circuits, shielding for said circuits, the circuits and shielding and coupling means being such that solely each of the said coupling means is effective for transferring energy selected by one circuit to a circuit next adjacent thereto, and means for simultaneously and similarly adjusting at least two of said coupling means.

11. A system for geometrically selecting electrical oscillations of a given frequency from oscillations differing therefrom in frequency comprising at least three efficient circuits each including capacitive and inductive reactances and being resonant to the frequency of the oscillations to be selected and arranged in cascade or series, a small portion of the inductance of the first circuit of the series being coupled to the main inductance of the second circuit for the transfer to the second circuit of energy selected by the first circuit, and a small portion of the inductance of the second circuit being coupled to the main inductance of the third circuit of the series for the transfer to the third circuit of energy selected by the second circuit, the coupling being less than that producing coupling waves, means for grounding one side of each of said circuits between the capacitive and inductive reactances thereof, and means for capacitively and inductively shielding the first and third circuits of the series from each other to inhibit any transfer of energy therebetween, whereby the energy transferred from the first to the third circuits of the series is constrained to flow through the second or intermediate circuit of the series.

12. A system for geometrically selecting electrical oscillations of a given frequency from oscillations differing therefrom in frequency comprising at least three efficient circuits each including capacitive and inductive reactances and being resonant to the frequency of the oscillations to be selected and arranged in cascade or series, a small portion of the inductance of the first circuit being coupled to the main inductance of the second circuit of the series for the transfer to the second circuit of energy selected by the first circuit, and a small portion of the inductance of the second circuit being coupled to the main inductance of the third circuit of the series for the transfer to the third circuit of energy selected by the second circuit, the maximum coupling being less than that producing coupling waves, means for grounding one side of each of said circuits between the capacitive and inductive reactances thereof, means for capacitively and inductively shielding the first and third circuits of the series from each other to inhibit to a high degree any transfer of energy therebetween whereby the energy transferred from the first to the third circuits of the series is constrained to flow through the second or intermediate circuit of the series, and means for varying the coupling between the first and second circuits and between the second and third circuits simultaneously.

13. A system for geometrically selecting electrical oscillations of a given frequency from oscillations differing therefrom in frequency comprising at least three efficient circuits adjustably tunable to the frequency of the oscillations to be selected and arranged in cascade or series, a first coupling means linking the first circuit of the series to the second circuit for the transfer to the second circuit of energy selected by the first circuit, a second coupling means linking the second circuit of the series to the third circuit for the transfer to the third circuit of energy selected by the second circuit, the coupling being less than that producing coupling waves, and means for capacitively and inductively decoupling the first and third circuits of the series from each other to a high degree whereby the energy transferred from the first to the third circuits of the series is constrained to flow through the second or intermediate circuit of the series.

14. A system for geometrically selecting electrical oscillations of a given frequency from oscillations differing therefrom in frequency comprising at least three efficient circuits adjustably tunable to the frequency of the oscillations to be selected and arranged in cascade or series, a first coupling means linking the first circuit of the series to the second circuit for the transfer to the second circuit of energy selected by the first circuit, a second coupling means linking the second circuit of the series to the third circuit of energy selected by the second circuit, the coupling being less than that producing

coupling waves, means for independently grounding each of said circuits, and means for capacitively and inductively decoupling the first and third circuits of the series from each other to a high degree whereby the energy transferred from the first to the third circuits of the series is constrained to flow through the second or intermediate circuit of the series.

Signed at New York, in the county of New York and State of New York, this 11th day of July, A. D. 1927.

LESTER L. JONES.