

Jan. 2, 1940.

G. PETERSON

2,185,355

REACTANCE DEVICE

Filed May 7, 1936

3 Sheets-Sheet 1

FIG. 1.

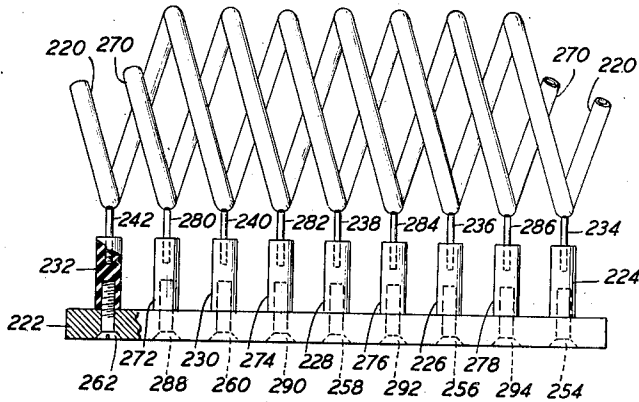


FIG. 2.

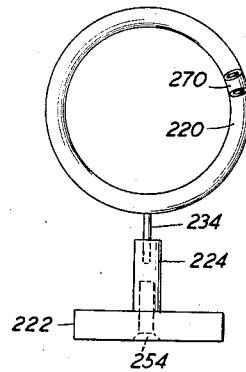


FIG. 3.

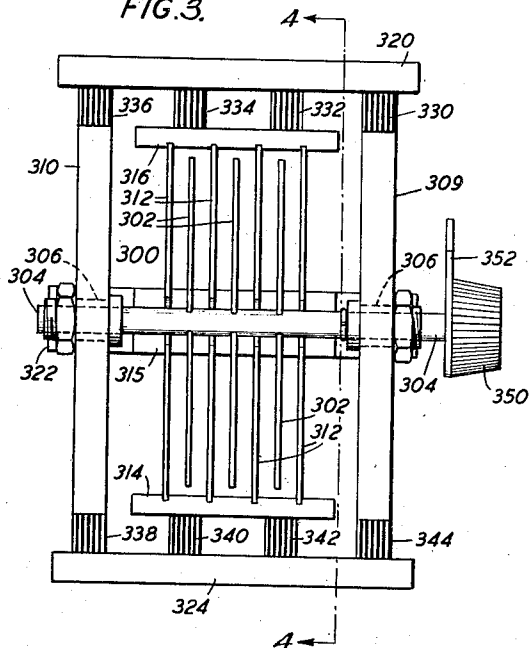
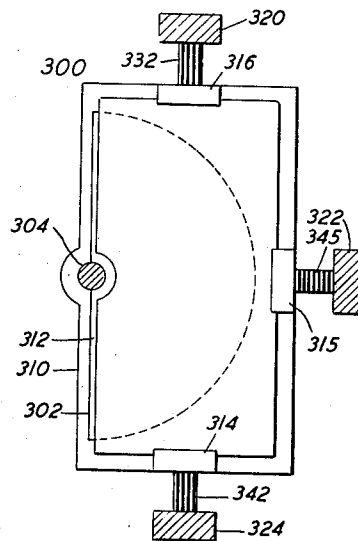


FIG. 4.



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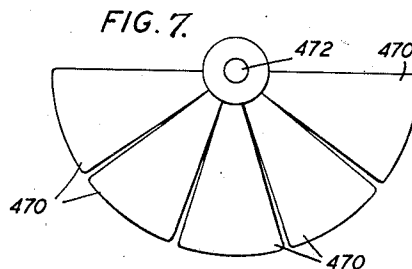
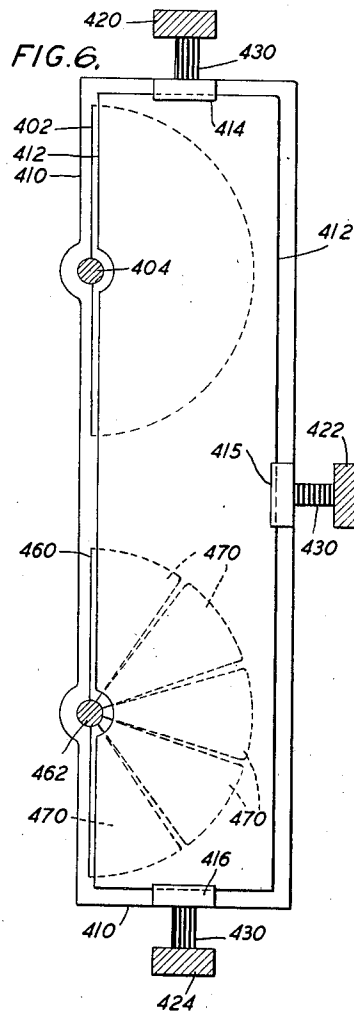
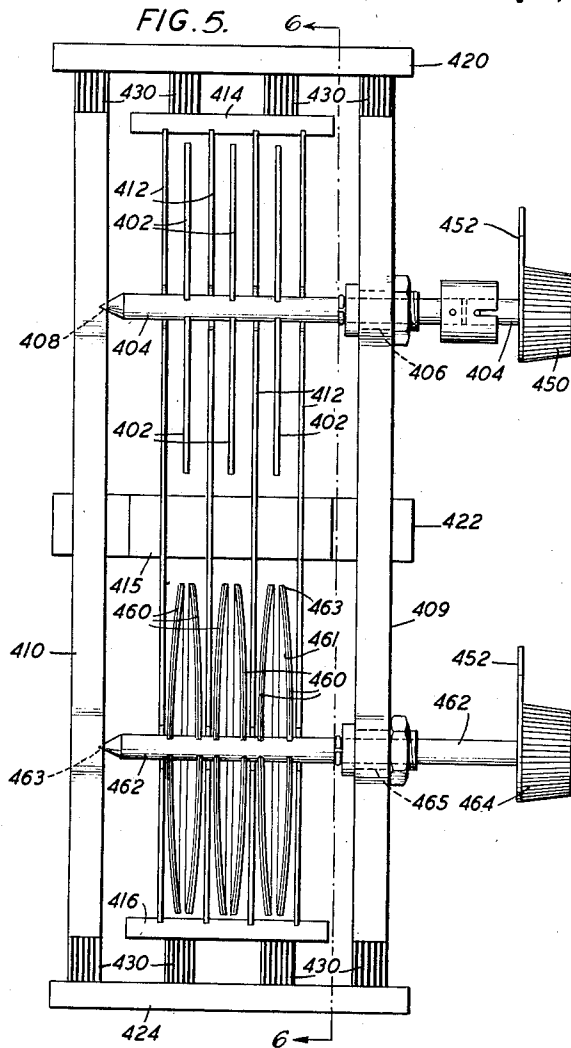
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3 Sheets-Sheet 2



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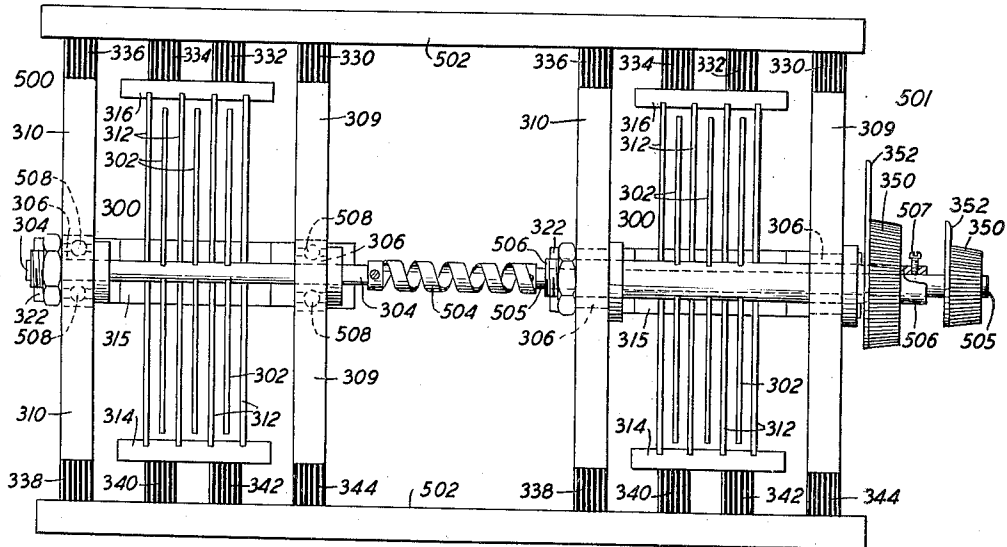
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3 Sheets-Sheet 3

FIG. 8.



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UNITED STATES PATENT OFFICE

2,185,355

REACTANCE DEVICE

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Application May 7, 1936, Serial No. 78,365

5 Claims. (Cl. 175—41.5)

This invention relates to radio apparatus such as radio frequency electric wave oscillation generators and amplifiers and particularly to the construction and assembly of the component parts associated therewith, such as inductance coils and condensers.

One of the objects of this invention is to stabilize and maintain constant over considerable periods of time the frequency of oscillations produced by a source of radio frequency energy, such as an electric oscillator.

Another object of this invention is to stabilize and render of great permanency of value the electrical impedance characteristics of devices such as electric condensers and inductance coils.

Another object of this invention is to balance positive and negative temperature-frequency characteristics in radio systems.

Another object of this invention is to render impedance devices more readily responsive to temperature change.

In general, temperature variation, mechanical vibration and power changes or fluctuations influence the frequency stability of radio oscillatory apparatus such as radio frequency electric oscillators the frequency of which may be directly dependent upon the electrical impedance constants or characteristics of inductance coil and condenser apparatus associated therewith.

Temperature changes may cause expansion and contraction of the several parts of the apparatus and corresponding changes in the inductance and capacity thereof with resulting frequency variations. Vibrations from many sources may shake the parts thereof, likewise changing the inductance and capacity of the system and of the parts thereof. Power changes issuing from sources such as, for example, the vacuum tube plate supply, the tube filament supply, modulation, and the load, may change the operating characteristics of the space discharge devices such as the vacuum tubes which may be associated with the apparatus.

As indicated by F. B. Llewellyn in an article entitled "Constant frequency oscillators", Proceedings of the Institute of Radio Engineers, vol. 19, pp. 2063-2094, December 1931; also Bell System Technical Journal, vol. 11, pp. 67-100, January 1932, the frequency of any vacuum tube oscillator may be completely determined by the following quantities:

L, the self-inductance in the network

M, the mutual inductance in the network

C, the capacity in the network

R, the resistance in the network

r_p , the plate resistance of the vacuum tube

r_g , the grid resistance of the vacuum tube

μ , the amplification factor of the vacuum tube

Of these quantities, power changes affect the quantities r_p , r_g and μ , while the temperature

changes and vibration affect the quantities L, M, C and R. As Llewellyn has shown, circuits may be employed which may render the frequency sensibly independent of these tube factors and hence practically independent of any customary changes in the supply and dissipation of power. There remain, then, the effects of temperature and vibration upon any element that contributes to the total L, M, C and R anywhere in the circuit.

To control the effects of vibration upon the frequency stability of an electric oscillator, the following measures may be adopted. The oscillatory apparatus may be preferably situated where vibrational disturbance is at a minimum. The several parts that constitute the oscillator assembly may be so intimately fastened together as to cause the assembly to respond as a single unit when placed in a region of such vibrational disturbances. For securing such single unit response, the several parts and particularly the vacuum tube and the impedance devices, such as the inductance coils, tuning condensers and resistances that control the inductance, capacity and resistance of the oscillatory circuit, may all be rigidly mounted on a single panel and the mounting of the several parts may be by supports at not more than three points to avoid the introduction of stresses with resulting frequency deviations. Also, the several parts of the system may be, wherever possible, constructed of such materials and of such dimensions as to limit the degree of response to vibration and the degree of conduction of vibration. On the matter of dimensions, the thickness of parts such as the panel and metal plates of the condensers may be such as substantially to eliminate response to vibration. On the matter of kind of materials used, materials less responsive to and less conductive of vibrations may be utilized in constructing the oscillator panel. The frequency of an oscillator assembled on a single thick soft wood panel, for example, has been found to be relatively free from following a mechanical vibrational wave applied thereto.

To provide for the attenuation of vibration where the vibration comes from some source exterior to the oscillator apparatus itself, a non-conducting or vibration attenuating medium such as one or more sponge rubber mats supporting the oscillator panel or other form of vibrationless suspension may be interposed between the source of vibration and the oscillator assembly to prevent conduction of vibration therebetween and to damp out the vibrations before they reach the oscillator assembly.

Most materials, the common metals and insulators, expand upon heating and contract upon cooling. Such expansion usually increases the inductance or capacity in the network, thereby decreasing the frequency of the oscillatory appa-

ratus. The temperature coefficients of the several parts accumulate to form a sum which is the overall temperature coefficient. As the term is used herein, the temperature coefficient may be regarded as positive when the inductance or capacity increases or the frequency decreases as the temperature increases, and vice versa.

To control the effect of temperature change upon the frequency stability of the system, the several parts thereof such as, for example, the inductance devices and condensers in circuit therewith may each be constructed in such manner that the apparatus returns to its original dimensions at a given temperature after being heated or cooled and therefore has a constant electrical impedance characteristic at a given value of temperature. For this purpose, the apparatus may have component insulating and metallic parts composed of such materials and so disposed or interconnected with reference to temperature coefficients of expansion of the parts as to permit free expansion and contraction thereof in all directions without producing stresses therein or slippage therebetween. Such construction contemplates that the expansion along any one axis be the same as that along any other equal length axis parallel thereto, that members connected by transverse parallel members shall have the same overall temperature coefficients of expansion measured axially between their ends, that before and after a temperature change, all angles between the parts remain the same and that each part that is homogeneous maintains its volume symmetry. With such construction, substantially no stresses in or slippage between the component parts are introduced when the temperature changes.

A suitable housing or oven consisting of alternate layers of conductive and insulating materials may enclose the several parts of the entire oscillatory apparatus to provide thermal symmetry or relative uniformity of temperature for the several parts thereof. The conductive parts of the housing may electrically shield the apparatus housed therein. To eliminate frequency deviations due to the inherent positive temperature coefficient of the apparatus, the temperature of the oven may be controlled or temperature compensating means may be introduced in the form of one or more negative temperature coefficient devices to compensate for the normal positive temperature coefficient of impedance or frequency in the system.

The negative temperature coefficient device may be in the form of a variable air condenser having bimetallic condenser plates of two different metals such as invar and brass closely adhering to each other and which, by bending, change their position relative to another plate thereof when the temperature is increased or decreased. The bimetallic negative coefficient condenser may be connected in parallel circuit relation with and combined in a single unit with a positive coefficient condenser to obtain an adjustable negative coefficient of any desired magnitude. The bimetallic condenser plates may be radially slotted to permit easier bending thereof in response to temperature change.

For a clearer understanding of the nature of this invention and the additional features and objects thereof, reference is made to the following description taken in connection with the accompanying drawings, in which like reference characters indicate like or similar parts and in which

Figs. 1 and 2 are side and end views respec-

tively of an inductance device embodying this invention;

Figs. 3 and 4 are views of a condenser embodying this invention, Fig. 4 being a view taken on the line 4—4 of Fig. 3;

Figs. 5, 6, and 7 are views of another form of a condenser embodying this invention, Fig. 6 being a view taken on the line 6—6 of Fig. 5, and Fig. 7 being a view of a condenser plate of Figs. 5 and 6; and

Fig. 8 is a view of another form of condenser apparatus embodying this invention.

Referring to the drawing, Figs. 1 and 2 are, respectively, side and end views, partly in section, of an inductance device having stable inductance characteristics. An inductance element comprising a solenoidal coil 220 constructed of copper conductor such as quarter inch diameter hollow copper tubing of suitable dimensions and a suitable number of equal diameter turns is supported from a flat plate 222 of the same material, namely copper, by a suitable number of equal length insulating pillars 224, 226, 228, 230, and 232 of hard rubber or preferably quartz or "Isolantite" or other suitable dielectric preferably relatively free of cold flow and aging qualities. Small prongs 234, 236, 238, 240, and 242 of copper or other suitable material and of equal length may be suitably fastened as by screw threads, for example, to the insulating pillars 224, 226, 228, 230, and 232, respectively. The extreme bottom portions of the turns of the copper tubing 220 are suitably fastened as by soldering, for example, to the vertical prongs 234, 236, 238, 240, and 242. The insulating pillars 224, 226, 228, 230, and 232 are fastened to the copper plate 222 by suitable means such as copper screws 254, 256, 258, 260, and 262, respectively.

While the coil 220 and the plate 222 are preferably wholly constructed of copper of the same temperature coefficient of expansion, it will be understood that other suitable material such as aluminum may be utilized to provide the same overall expansion as measured between ends connected by any two of the transverse parallel members 224, 226, 228, 230, and 232.

The coil 220 so constructed and mounted is free to expand and contract in every direction. The length and also the diameter of the coil 220 is wholly determined by copper. The spacing between the coil 220 and the plate 222 is wholly determined by the supporting members therebetween, each having the same overall temperature coefficient of expansion. Accordingly, all of the parts are so connected with respect to each other that when the temperature changes, no stresses are introduced into the component parts, no frictional slippage is introduced between the component parts, all angles between all of the component parts remain the same before and after a temperature change, each part that is homogeneous maintains its volume symmetry, and any two members connected by transverse parallel members have the same overall temperature coefficients of expansion as measured between their ends whereby the expansion along any one axis is the same as that along any other equal length axis parallel thereto.

Another copper coil 270, similar to the coil 220, may if desired, be inductively coupled with the coil 220 by disposing the turns of the coil 270 in spaced relation between those of the coil 220 and supporting the turns of coil 270 from the copper plate 222 by equal length insulating pillars 272, 274, 276, and 278, by screws 280, 282, 284, and 286, 75

and by screws 288, 290, 292, and 294 in the same manner as the coil 220 is supported. The subject-matter of Figs. 1 and 2 is disclosed and claimed in my copending divisional application Serial No. 286,515 filed July 26, 1939 (Case 2).

Figs. 3 and 4 are respectively a front view and a sectional top view of a variable air condenser of stable electrical characteristics, wherein the insulating and metallic portions of the condenser are constructed in accordance with principles similar to those of the inductance coil structure shown and described in connection with Figs. 1 and 2. More particularly, Figs. 3 and 4 show a variable capacitance element 300 in the form of an air condenser comprising spaced metallic rotor plates 302 of suitable number, shape and dimensions mounted on a metallic shaft 304 which is supported by suitable bearings 306 and 308 in end plates 309 and 310, respectively. The condenser 300 also comprises spaced metallic stator plates 312 of suitable number, shape and dimensions mounted in three metallic stator frames 314, 315, and 316. The stator frames 314, 315 and 316 and the end plates 309 and 310 are disposed equidistantly from three metallic supporting rods or plates 320, 322, and 324 and are fastened thereto by a suitable number of equal length insulating pillars such as the four pillars 330 to 336, the group of pillars 338 to 344, and a third group of four pillars designed as 345 in Fig. 4 all of which are composed of the same material such as for example hard rubber or preferably quartz or "Isolantite" or other dielectric, preferably itself relatively free from cold flow and aging. Also all metal parts are constructed of the same kind of material to obtain the same temperature coefficient of expansion therein. Thus the stator plates 312, the stator frames 314, 315, and 316, the end plates 309 and 310, the supporting rods 320, 322, and 324, the shaft 304 and the rotor plates 302 may all be constructed of aluminum or other suitable metallic material. Accordingly, the condenser structure 300 may expand and contract fully without introducing stresses in the component parts thereof or slippage between such component parts.

The shaft 304 of the condenser 300 may be variably controlled if desired by any suitable means such as for example a control knob 350 fastened thereto. A dial 352 may be provided to rotate with the shaft 304 and the control knob 350 to indicate the setting of the rotor plates 302.

Figs. 5 and 6 are, respectively, a front view and a sectional top view of an air condenser structure of stable electrical characteristics wherein the insulating and metallic portions thereof are constructed in accordance with principles similar to those shown and described in connection with the condenser illustrated in Figs. 3 and 4.

More particularly, Figs. 5 and 6 show a variable air condenser having two separately variable rotors and a common stator combined in a single unit to obtain adjustable negative and positive condensers. One of the rotors may comprise semi-circular metallic rotor plates 402 which may be constructed of aluminum or other suitable metal. The rotor plates 402 may be mounted upon a metallic shaft 404 which is supported by suitable bearings 406 and 408 arranged in end plates 409 and 410, respectively. Metallic stator plates 412 of suitable number, spacing and dimensions are mounted in metallic stator frames 414, 415, and 416. The stator frames 414, 415, and 416, and also the end plates 409 and 410, are disposed equidistantly from supporting rods or

plates 420, 422, and 424, and are fastened thereto by a suitable number of equal length insulating pillars 430, all of which are composed of the same material, such as for example hard rubber or, preferably, quartz or "Isolantite" or other dielectric which, preferably, is itself free from cold flow and aging. The shaft 404, the rotor plates 402, stator plates 412, the stator frames 414, 415, and 416, the end plates 409, 410, and the supporting rods 420, 422, and 424 are constructed of the same metal, such as aluminum or other suitable material. The aluminum shaft 404 carrying the rotor plates 402 may be rotatably controlled by suitable means, such as a control knob 450 fastened thereto to obtain an adjustable capacity of a desired magnitude. A dial 452 may be provided to rotate with the shaft 404 to indicate the position of the rotor plates 402. If desired, a suitable clutch (not shown) may disconnect the control knob 450 from the rotor plates 402 in order to avoid possible disturbance to the setting of the rotor plates 402 after once setting them to a proper position. Such clutch may be of a known form and may be utilized in connection with this or other condenser rotor shafts disclosed herein.

The other rotor of the condenser apparatus shown in Figs. 5 and 6 may comprise a plurality of semi-circular bimetallic rotor plates 460, each composed of a plate 461 of Invar closely adhering to a plate 463 of brass, or other suitable bimetallic materials to cause them to change their space position by bending with respect to the stator plates 412 to vary the capacitance therebetween negatively in response to temperature change. The bimetallic rotor plates 460 are mounted upon an aluminum shaft 462 which may be controlled by a control knob 464 in the same manner as previously described in connection with the rotor shaft 404. Suitable aluminum bearings 463 and 465 may be provided to support the shaft 462. While the rotor plates 460 are indicated as composed of bimetallic material, it will be understood that if desired they may be composed of a unimetallic material, as in the case of the aluminum rotor plates 402.

It will be noted that the condenser illustrated in Figs. 5 and 6 differs from that illustrated in Figs. 3 and 4 in having a plurality of rotor shafts 404 and 462 operatively disposed in the same or common stator frame 412, an arrangement which may be used, for example, where it is desired to employ two condensers connected in parallel circuit relation, one being adapted to balance the other, as, for example, to give an electric oscillator an overall zero temperature-frequency coefficient. One of the advantages of employing a common stator 412 for the two rotors 404 and 462 is that it is easier to balance the positive and negative temperature coefficients of capacity of two condenser elements in view of the substantially equal stator temperature provided by the heat conducting connection in the common stator 412.

Fig. 7 illustrates a radially slotted form of condenser rotor plate which may, if desired, be used as the rotor plate of any of the condensers disclosed herein. The plate is slotted radially, as shown, to form a suitable number of portions which may be easily bent in a direction toward or away from its associated stator plate to vary the capacitance of the condenser. The rotor plate may consist of a suitable number of sections such as for example the five sections 470, each of which may be composed of suitable bimetallic material as in the case of the bimetal-

lic rotor plate 460 of Figs. 5 and 6, to provide a condenser with a negative temperature coefficient of capacitance to decrease the capacitance thereof with rising temperature. The radially slotted portions 470, in response to temperature change, freely bend or curl substantially in the direction of the axis of the shaft 472. As the temperature rises, the plate portions 470 may bend or curl away from the associated stator plate adjacent thereto to decrease the capacitance of the condenser. It will be understood that the condenser apparatus illustrated in Figs. 5 and 6 may have its bimetallic rotor plates 460 radially slotted as illustrated in Figs. 6 and 7 and that the spacing between the bimetallic rotor plates 460 and the aluminum stator plates 412 may be such that the rotor plates 460 of one section form capacitances of relatively small magnitude with the stator plates in sections not directly related thereto in order that capacitance variation may not be nullified.

Fig. 8 illustrates another form of negative coefficient condenser in combination with a positive coefficient condenser. The arrangement may consist of two variable air condensers 500 and 501 both individually constructed substantially like the condenser 300 of Figs. 3 and 4 and of suitable capacitances. The condensers 500 and 501 may be provided with common supporting rods 502 corresponding to and of the same construction as the rods 320, 322 and 324 of Figs. 3 and 4. The negative temperature coefficient of capacitance may be obtained for one of the condensers as the condenser 500, by connecting together the rotor shafts of the two condensers 500 and 501 with a bimetallic helix 504 disposed therebetween so that as the temperature varies, the capacitance of one condenser, as the condenser 500, varies with respect to the other condenser 501. In the embodiment illustrated in Fig. 8, one end of the bimetallic helix 504 is secured to the rotor shaft 304 of the condenser 500 and the opposite end of the helix 504 is secured to a shaft 505 disposed within a hollow rotor shaft 506 supporting the rotor plates 302 of the condenser 501. A set screw 507 may adjustably interconnect the shafts 505 and 506. The bimetallic helix 504 may be constructed of a bimetallic strip composed of two metals having different temperature coefficients of expansion such as, for example, strips of Invar and brass closely adhering to each other and wound together in the form of a helix as illustrated by the helix 504 in Fig. 8.

The bearings 306 for the rotor shaft 304 of the condenser 500 may include relatively frictionless aluminum roller or ball bearings 508 in order that the rotor shaft 304 may be free to rotate and adjust its relative position in response to rotary movements imparted thereto by the bimetallic helix 504 as a result of temperature change.

Control knobs 350 and dials 352 secured to the shafts 505 and 506 may be utilized to adjust the capacitance of the condenser 500 until its negative coefficient balances that of the positive coefficient condenser 501. The adjustment of the control knobs 350 changes the coefficient of the combination of the condensers 500 and 501 when connected in parallel or series circuit relation.

When the desired balance between the temperature coefficients of capacitance of the condensers 500 and 501 has been obtained, the set screw 507 may be fixed and thereafter the capacitance of the combination comprising the condensers 500 and 501 may be varied without disturbing the temperature balance therebetween to obtain the

desired frequency for the oscillator for example which may be connected in circuit therewith. The balance of the temperature coefficients of capacitance of the condensers 500 and 501 may be made to extend over a substantial range of capacitance values when utilizing the semi-circular rotor plates 302 illustrated. Where the condenser plate 302 are shaped in the form of logarithmic spirals or as disclosed in application Serial No. 104,192, filed October 6, 1936, by F. B. Llewellyn (Case 18), the capacitance may be varied substantially over the entire range of the condensers 500 and 501 and the balance between the positive and negative temperature coefficients of capacitance maintained substantially over such entire capacitance range of the condensers 500 and 501.

It will be understood that the condensers 500 and 501 may be connected in parallel circuit relation and that one may balance the temperature coefficient of capacitance of the other to provide an over-all zero or other desired temperature-frequency coefficient for the oscillator, for example which may be connected in circuit therewith.

Although the invention has been described and illustrated in relation to specific arrangements of particular inductance coils and condensers associated with a particular circuit arrangement, it is to be understood that it is capable of application in other organizations and is therefore not to be limited to the particular embodiments disclosed, but only by the scope of the appended claims and the state of the prior art.

What is claimed is:

1. A condenser structure including stator plates, rotor plates, a shaft secured substantially axially perpendicular to the planes of said rotor plates, a stator frame secured substantially axially perpendicular to the planes of said stator plates, end plates pivotally supporting said shaft and disposed substantially perpendicular thereto, said end plates and said stator frame having substantially coplanar surfaces disposed substantially equidistant from the axis of said shaft, a supporting plate having a surface disposed substantially parallel to said coplanar surfaces, and substantially equal length and parallel insulating pillars disposed between and secured to said coplanar surfaces and said surface of said supporting plate, said stator plates, stator frame, shaft, end plates and supporting plates being composed of the same metallic material having substantially the same temperature coefficient of expansion, and said insulating pillars having substantially equal overall temperature coefficients of expansion along said equal length dimension thereof.

2. Variable capacitance electric condenser apparatus including a plurality of rotors, and a common stator for said plurality of rotors, one of said rotors having unimetallic condenser plates, and another of said rotors having bimetallic condenser plates, said rotors being separately supported by separate shafts between common end plates, said stator and said end plates being mounted by at least one group of equal length insulating pillars which are connected to and disposed between said stator and end plates at one end of said pillars, and a supporting plate at the opposite end of said pillars, said pillars having substantially equal overall temperature coefficients of expansion as measured axially between said ends thereof at the points of connection to said supporting plate,

stator and end plates, said stator, shafts, end plates and supporting plate being composed of the same metallic material having substantially the same temperature coefficient of expansion.

5 3. A capacitance device including a plurality of condensers having independent rotors, and means including a bimetallic helix interconnecting said rotors for varying the capacitance of one of said condensers with respect to the capacitance of another of said condensers, whereby
10 a desired resultant overall temperature coefficient of capacitance is obtained for said condensers.

4. A reactance device and a mounting there-
15 for, said device including a pair of variable air condensers having independent rotor shafts and a bimetallic helix interconnecting said shafts of said condensers, whereby the capacity of one condenser is varied with respect to the capacity
20 of the other condenser as the temperature changes, said mounting including a support insulated from said condensers by a plurality of parallel insulating members rigidly connected between said support and said condensers, said
25 support and the parts of said condensers that are rigidly connected to said insulating members being of metallic composition having the same

temperature coefficient of expansion and said plurality of insulating members having substantially equal overall temperature coefficients of expansion as measured axially between the points of connection to said condensers and support. 5

5. A reactance device and a mounting there-
for, said device including a pair of variable air
condensers having independent rotors and bi-
metallic means connected to at least one of said
rotors for varying the capacitance of one of said
condensers with respect to the capacity of the
other condenser as the temperature changes, said
mounting including a support insulated from
said condensers by a plurality of parallel insulat-
ing members rigidly connected between said
support and said condensers, said support and
the parts of said condensers that are rigidly
connected to said insulating members being of
metallic composition having the same tempera-
ture coefficient of expansion and said plurality
of insulating members having substantially equal
overall temperature coefficients of expansion as
measured axially between the points of connec-
tion to said condenser and support. 25

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