United States Patent

Fabricius

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[54] **VARIABLE CAPACITOR NETWORK**

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[73] Assignee: **Sprague Electric Company**, North Adams, Mass.

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 880,529, Nov. 28, 1969, Pat. No. 3,588,640.

[52] **U.S. Cl.** ....**317/101 A,** 323/74, 333/70, 317/249

[51] **Int. Cl.** **H01l 19/00**

[58] **Field of Search**...............317/101 A, 249 R, 249 D, 256; 323/74; 333/70

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Attorney—Connolly and Hutz, Vincent H. Sweeney, James Paul O'Sullivan and David R. Thornton

[57] **ABSTRACT**

A continuous electrode and two discontinuous electrodes, made up of a plurality of isolated islands, are arranged over at least a pair of lower electrodes with an intervening film of dielectric material. Terminal connection is provided to the lower electrodes and to the upper continuous electrode. A slidable contact member provides bridging contact between the continuous upper electrode and selected island areas of either of the adjacent discontinuous electrodes to provide a network having two variable capacitors and a fixed capacitor. Additionally, deposited resistors are disposed alongside the electrodes in connection to at least one of the terminals to provide fixed and variable resistors of the network.

15 Claims, 14 Drawing Figures

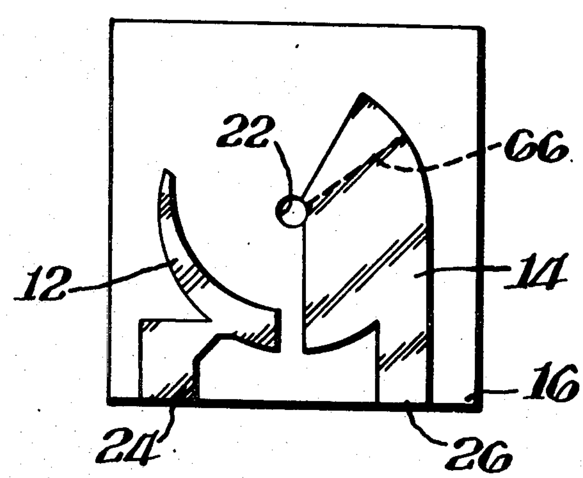


Fig. 1.

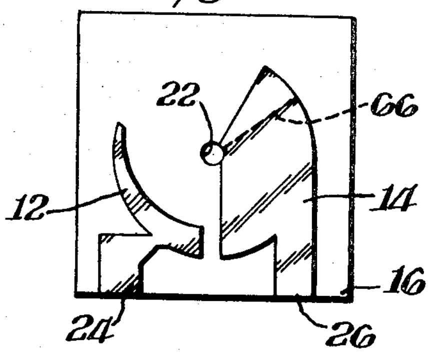


Fig. 2.

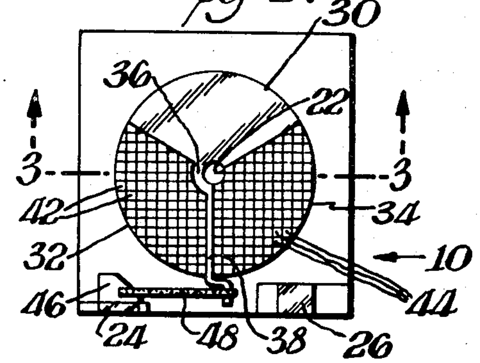


Fig. 3.

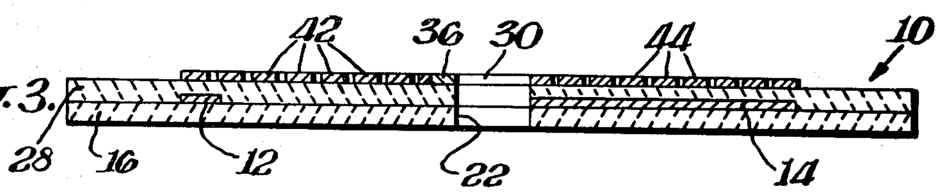


Fig. 7.

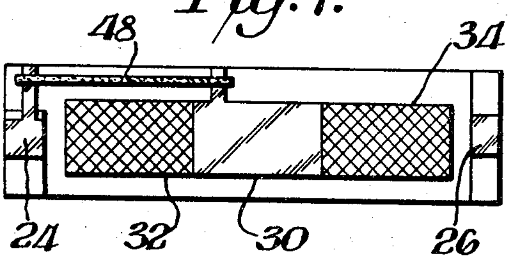


Fig. 5.

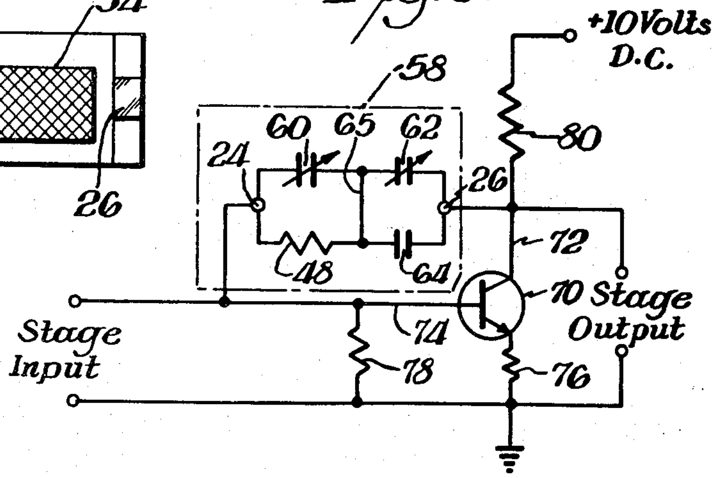


Fig. 4.

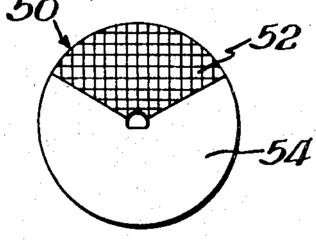


Fig. 6.

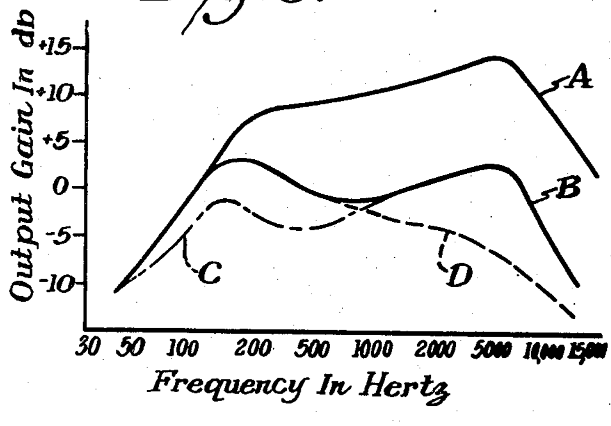


Fig.8.

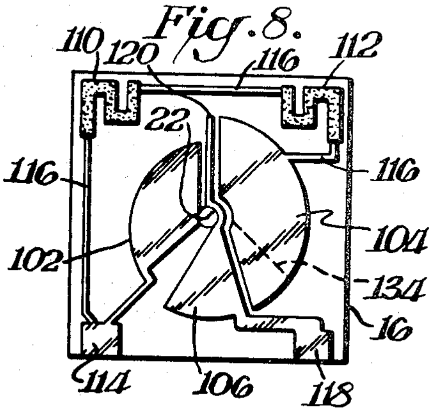


Fig.9.

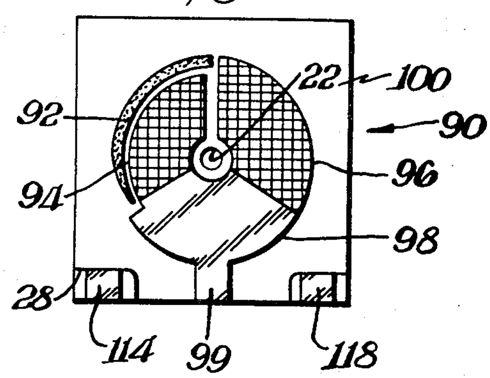


Fig.11.

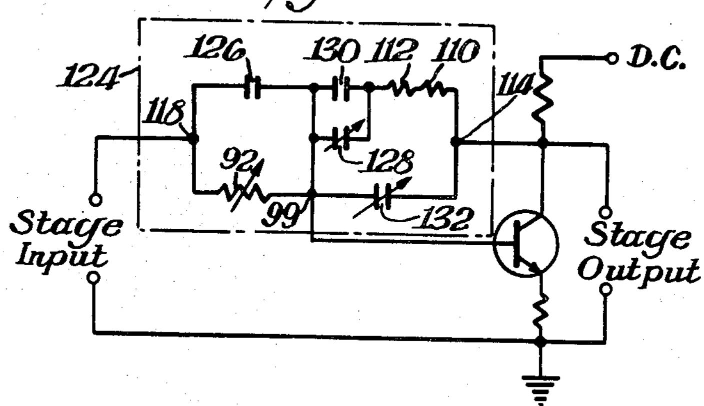


Fig.10.

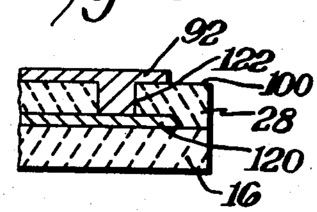


Fig.12.

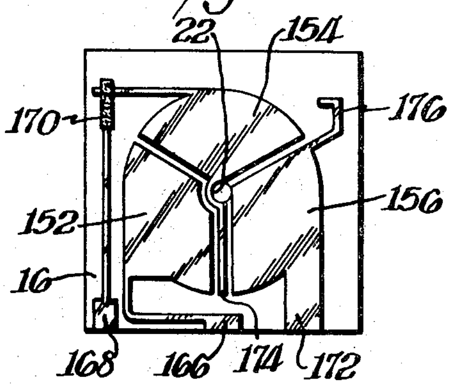


Fig.13.

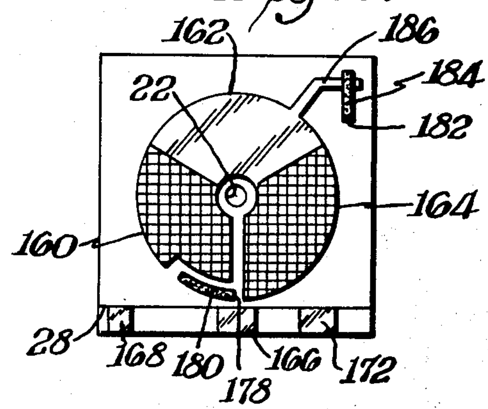
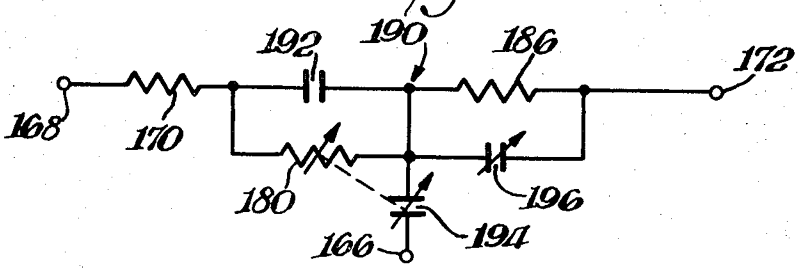


Fig.14.



VARIABLE CAPACITOR NETWORK

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part of application Ser. No. 880,529 filed Nov. 28, 1969, and issued as U.S. Pat. No. 3,588,640 on June 28, 1971.

BACKGROUND OF THE INVENTION

This invention relates to variable capacitor networks and more particularly to variable R–C networks suitable for use as tone controls.

In the prior art, variable resistive or capacitive devices are usually restricted to single element components which severely limits the component functions. Moreover, although variable resistor tone controls are available, their range is generally limited and they also cause an objectional variation in gain at mid-frequencies.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a variable capacitor network having high capacitance and a high degree of stability.

It is another object of this invention to provide a variable R–C network.

It is still another object of this invention to provide a laminated monolithic R–C network having variable resistive or capacitive elements or both.

It is a still further object to provide a compact tone control network having broad range and minimum mid-frequency variation.

These and other objects of the invention will become apparent from the specification and claims taken in conjunction with the drawing.

Broadly, a variable capacitance network provided in accordance with the invention comprises a plurality of upper electrodes disposed in capacitive relation to a plurality of lower electrodes with an intervening thin layer of dielectric material. A plurality of terminals are in connection to the lower electrodes. One of the upper electrodes is a continuous conductive film while another upper electrode is a discontinuous electrode having a plurality of isolated island segments. A contact member having a conductive surface portion is urged into contact with the upper electrodes and adapted for bridging connection between selected island segments of the discontinuous electrodes and the upper continuous electrode so as to provide a network having a fixed and a variable capacitor.

In an alternative embodiment, a resistive strip is also deposited on the upper surface adjacent to one of the electrodes. Fixed connection is provided between one end of the resistive strip and a terminal of the unit, and the conductive portion of said contact member extends to said resistive strip and provides a slidable bridging contact therefrom to a second terminal.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a plan view of a stator substrate of a rotary network showing its lower electrode and terminal configuration;

FIG. 2 is a plan view of the completed stator of FIG. 1;

FIG. 3 is a cross-sectional view of the stator taken along line 3—3 of FIG. 2;

FIG. 4 is a plan view of the rotor utilized in the preferred embodiments;

FIG. 5 is a schematic diagram of an audio stage utilizing the R–C network provided by the structure of FIG. 2 as a tone control.

FIG. 6 is a graph of frequency response from a typical audio amplifier employing the audio stage of FIG. 6 under different network variations;

FIG. 7 is a plan view of the network of FIG. 2 arranged in rectilinear form;

FIG. 8 is a plan view of a stator substrate of another embodiment;

FIG. 9 is a plan view of the completed stator of FIG. 8;

FIG. 10 is a view in section of a vertical conductive path employed in the stator of FIG. 9;

FIG. 11 is a schematic diagram of an audio stage employing the R–C network resulting from the stator of FIG. 9;

FIG. 12 is a plan view of a stator substrate of another embodiment;

FIG. 13 is a plan view of a stator employing the substrate of FIG. 12; and

FIG. 14 is a schematic diagram of the R–C network resulting from the stator of FIG. 13.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1, 2 and 3 illustrate a stator member 10 wherein thin (approximately 0.2 mil) film electrodes of conductive material such as silver or the like are deposited as two generally semicircular annular segments 12 and 14 on a portion of a major surface of an insulating substrate 16. Segments 12 and 14 provide a pair of continuous lower electrodes. Substrate 16, which operates as the support layer of the laminated stator 10, has an aperture 22 therethrough, substantially located at its center. Substrate 16 is of sufficient rigidity and thickness, for example, 0.030 inch in the preferred embodiment, to fixedly support the overlying layers. Terminals 24 and 26, which are formed with and of the same material as electrodes 12 and 14 extend from their respective perimeters to provide terminal pads to which circuit leads can later be soldered.

A layer 28 of a ceramic dielectric is deposited over the surface of lower electrodes 12, 14 and surrounding portions of substrate 16; the thickness of layer 28 overlying electrodes 12 and 14 being approximately 1 mil. For the present embodiment, aluminum oxide has been used for substrate 16 and a barium titanate glass mixture having a dielectric constant of approximately 400 for dielectric layer 28. For example, the barium titanate mixture as described in U.S. Pat. application No. 767,046 filed by Galeb H. Maher on Sept. 26, 1968 is suitable. A thin film (approximately 0.7 mil thick) of conductive material such as silver or the like, is then deposited over the outer surface of layer 28 to provide upper electrodes 30, 32 and 34.

All electrodes are arranged around aperture 22 such that all, or portions, of upper electrodes 30, 32 and 34 overlie lower electrodes 12 and 14. Electrode 30 is a continuous conductive film which overlies a portion of electrode 14 and form a capacitance therewith. Electrode 30 also extends around aperture 22, as at 36, to provide an extended conductive path 38. Electrodes 32 and 34, on the other hand, are formed in an island pattern, having a plurality of isolated islands 42 and 44, respectively, which cooperate with underlying electrodes 12 and 14 to form a capacitance.

A terminal area 46 of silver or the like, is also deposited on dielectric 28 and extended vertically to contact lower terminal 24 as shown, and, dielectric film 28 is deposited so as to leave end portions of terminals 24 and 26 exposed for external connection. Finally, stator 10 is completed by deposition of a film of resistive material to form resistor 48 which extends from path 38 to terminal pad 46.

As noted in the parent application, various methods of deposition for formation of the continuous and discontinuous or island electrodes and contact areas etc. can be used, such as spraying, sputtering, dipping, vacuum deposition and silk screening. Of course, the isolated electrode areas can be formed during film deposition or may be formed from a completed continuous film by photolithographic etching techniques or the like. Some of the appropriate materials for these conductive films are tantalum, gold, silver, platinum, rhodium, iridium, copper, molybdenum, or combinations thereof. Resistor 48 is constructed in a conventional manner by deposition of a film (0.3 to 1 mil thick) of Pd–Ag cermet or carbon filled varnish or the like.

Stator 10 is designed such that when a rotor element, as described in the parent application, is urged into contact with its upper surface a selective bridging contact between islands

42 or 44 and the adjoining electrode 30 is provided during rotation. Preferably, a rotor element 50 as shown in FIG. 4 is utilized for the rotary embodiments. Rotor 50 includes a conductive web or mesh 52 of phosphor-bronze or the like, secured in a substantially coplanar arrangement with low friction material 54 such as polytetrafluoroethylene or the like.

As in the parent application, rotor 50 is urged into contact with the upper surface of stator 10 by a resilient pressure washer (not shown herein). Mesh 52 is exposed over approximately 120° of arc, and a stop is provided in the package (not shown herein) such that the rotor is permitted to rotate mesh 52 from electrode 32 to electrode 34. Hence, the center position lies over electrode 30. Electrode 30 is made slightly in excess of 120° of arc such that when wiper mesh 52 is rotated into contact with all islands of either discontinuous electrode, a portion of wiper mesh 52 remains in contact with the adjoining edge area of electrode 30 and through it to termination 24.

Stator 10 in conjunction with rotor 50 provides a two terminal R–C circuit 58 as shown in FIG. 5, wherein two variable capacitances 60 and 62 are connected in parallel with fixed resistor 48 and fixed capacitor 64.

Capacitor 60 is made up of electrode 12 and overlying islands 32. Capacitor 62 is made up of that portion of electrode 14 which underlies islands 34, whereas capacitor 64 is formed by electrode 30 and the underlying portion of electrode 14 bordered by dotted line 66. The interconnection of resistor 48 and capacitor 60 to terminal 24 is formed by the vertical interconnection between lower terminal 24 and upper terminal 46. The interconnection of capacitor 62 and 64 to terminal 26 is provided by lower electrode 14 which provides joined electrodes for both capacitor 62 and 64. Whereas the bridging interconnection 65 between capacitor 60 and capacitor 64, or capacitor 62 and resistor 48, etc. is provided by rotor 50.

Network 58 is highly suitable for a tone control when it is utilized as a variable feedback around the driver stage of an audio amplifier as shown in FIG. 5. Herein, network 58 is connected between the collector 72 and base 74 of transistor 70 which is operated in the common emitter mode such that negative feedback occurs through the R–C network.

The values of resistor 48 and capacitance 64 are chosen to give a one kilohertz crossover; that is, with capacitance 60 and 62 equal to zero (center position of the rotor), the capacitive reactance of capacitor 64 is equal to the resistance of resistor 48 at that frequency.

With capacitor 60 and 62 at zero, the feedback circuit modifies the inherent frequency response of the amplifier stage to provide a suitable frequency response. Then turning of the variable network to introduce capacitor 60 or 62 will swing the response curve around the crossover point. That is, the low or high frequencies can be controlled without significant change in gain (loudness) at the crossover frequency.

In a specific example, the circuit of FIG. 5 was designed as follows:

Stage Input	4 KΩ
Transistor 70	No. 3N3393
Resistor 48	20 KΩ
Capacitor 60	0–015 μf
Capacitor 62	0–.045 μf
Capacitor 64	.02 μf
Resistor 76	100Ω
Resistor 78	6.8 KΩ
Resistor 80	4.7 KΩ

This circuit arrangement in conjunction with its output stage not shown produced the frequency response curves as shown in FIG. 6. Herein, curve A is the response without feedback network 58. Curve B is the response with network 58 but with the capacitance of both capacitor 60 and 62 equal to zero. That is, when mesh 52 is positioned wholly on electrode 30 such that only the fixed elements (resistor 48 and capacitor 64) appear across terminals 24 and 26. Curve C represents the low frequency modification of curve B (bass cut) when rotor 50 is rotated approximately 120 ccw to introduce the maximum capacitance of capacitor 60, and curve D represents the high end modification (Treble Cut) of curve B when rotor 50 is rotated 120° cw to introduce the maximum capacitance of capacitor 62. Of course, since capacitors 60 and 62 are incrementally variable, a variety of curves intermediate between curves B and C or B and D are possible.

The stator capacitances given in the specific example are provided by lower electrode 12 which is roughly an annular segment of 110° length having an inner radius of approximately 0.200 inch, and an outer radius which tapers from approximately 0.340 inch at its terminal end to 0.240 inch at its open end; and lower electrode 14 which is an annular segment, approximately 160° in length, and having an inner and outer radius of 0.087 inch and 0.280 inch, respectively. Lower electrodes 12 and 14 are covered by an approximately 0.001 inch thick coating of barium titanate glass having a dielectric constant of 2,000. Upper electrodes 30, 32 and 34 have the same radii as electrode 14 and are arranged in a full circle with upper electrode 32 over electrode 12, electrode 30 over approximately a 40° arc of electrode 14, and electrode 34 over the remainder of electrode 14.

As indicated above electrode 12 is tapered such that it varies in width along its length, and produces a rate of change of capacitor 60 which is not equal to the percentage overlap of rotor 50. Hence, in contrast to lower electrodes of uniform width for which the capacitance is directly proportional to the arc length of contacted islands, capacitor 60 increases at an accelerated rate during ccw rotation. This introduces a nonlinear change of capacitance in network 58.

Network 58 may also be provided in other than a circular configuration, for example, in a rectilinear form as shown in FIG. 7. Herein, the unit is constructed in essentially the same manner as the rotary device of FIGS. 1–3, with, however, all electrodes formed as rectangular strips, rather than annular segments.

As in the rotary unit, the upper continuous electrode 30 is disposed between the island electrode such that the latter border on two of its opposing edges. The slide contact (not shown) includes a rectangular metal mesh of approximately the same size as the continuous electrode. The contact is adapted for rectilinear motion along a path from electrode 32 to electrode 34.

The island electrodes 32, 34 are made slightly shorter than electrode 30 such that when all islands of one electrode are contacted, the contact mesh extends over one end portion of, and remains in contact with, electrode 30.

In an alternative embodiment which is constructed in a similar manner and by the same techniques as the previously described units, a three terminal stator 90, as shown in FIGS. 8 and 9 is made to also include a variable resistor 92. Resistor 92 is deposited on upper surface 100 along with island electrode 94, island electrode 96 and continuous electrode 98 which is in connection to terminal pad 99. The upper electrodes 94, 96 and 98 are arranged in a circular configuration overlying lower electrodes 102, 104 and 106, respectively, and are separated therefrom by thin dielectric material 28. As in the first described embodiment, the lower electrodes are disposed on an insulative substrate 16.

A pair of deposited resistors 110 and 112 are also disposed on substrate 16 and interconnected between electrode 104 and a terminal pad 114 by deposited conductive paths 116. Terminal 114 is also a common connection to electrode 102. Another terminal pad 118 is in connection to electrode 106 and through it to a conductive path 120 which extends to a point adjacent the opposite edge of stator 90. At the end of path 120, a vertical conductive path 122 extends through dielectric 28 to its upper surface 100 where it connects to one end of resistor 92, as shown in FIG. 10. Vertical conductor 122 is formed by any conventional means such as by providing a small opening or hole in layer 28, which is then filled with conductive material such as silver or the like during formation of the upper electrodes.

Stator 90 is employed in conjunction with a 120° wiper mesh, and provides an R–C network 124 as shown in FIG. 11. Rotor 50 is arranged such that in its center position, wiper 52 is positioned over electrode 98, and is permitted to rotate 120° to either side of this position. Herein, variable resistor 92 and fixed capacitor 126 (provided by electrodes 98 and 106) are connected in parallel between terminals 118 and 99. A variable capacitor 128 (provided by electrodes 96 and 104) is connected in parallel with fixed capacitor 130 (from electrode 99 and a portion of electrode 104) and in series with resistors 110 and 112 (capacitors 128 and 130 are connected through resistors 110 and 112) to make a first branch between terminals 99 and 114. Finally, variable capacitor 132 (from electrodes 94 and 102) is connected between terminals 99 and 114, in parallel to the first branch.

Fixed capacitor 126 is provided by a portion of electrode 98 in conjunction with its underlying electrode 106, and fixed capacitor 130 is provided by electrode 98 and that portion of electrode 104 bounded by dotted line 134. Hence, capacitors 126 and 130 are interconnected by common electrode 98 while capacitor 130 and capacitor 128 are interconnected through common electrode 104.

Network 124 is a three terminal network which operates on both the forward gain and the inverse feedback of the audio stage shown in FIG. 11 to provide wider tone adjustment with increased gain at the low end. That is, it provides increased "-bass" as the high frequency response is attenuated.

As shown in FIG. 11 the unit is included in a grounded emitter stage, similar to that of FIG. 6. Herein, terminal 114 is connected to the collector and terminal 99 to the base of the amplifying transistor, while terminal 118 is connected to the output of the preceding stage. Hence, the components between terminals 118 and 99 (variable resistance 92 and fixed capacitor 126) are in series with the transistor base, and control forward gain while the network portion between terminals 99 and 114 control inverse feedback.

The feedback portion differs from the prior embodiment, inasmuch as capacitor 132 bypasses the entire feedback. Hence, there is no fixed crossover, and consequently, mid-frequency response tends to increase as the capacitance of capacitor 132 decreases. However, this is compensated for, by a decrease in forward gain due to the increase in resistor 92. That is, as rotor mesh 52 contact is reduced with respect to electrode 94 (rotation ccw from stop position) capacitor 132 is decreased while at the same time the resistor mesh contact to resistor 92 moves towards its free end which increases the length of resistor 92 introduced into the circuit.

In a specific example resistor network 124 when designed for use with the circuit of FIG. 6 had the following parameters:

Resistor 92	0–20 KΩ
Resistor 110	12.5 KΩ
Resistor 112	12.5 KΩ
Capacitor 126	.02 μf
Capacitor 128	0–.015 μf
Capacitor 130	.005 μf
Capacitor 132	0–.008 μf

In addition both resistor 92 and capacitor 132 are tapered to provide a non-linear response with respect to rotor position and are coordinated with each other to vary in approximate accordance with the following:

Resistor 92	Capacitor 132
0	0
20 KΩ	0 μf
10 KΩ	.001 μf
5 KΩ	.002 μf
3KΩ	.003 μf
1.3KΩ	.004 μf
.3 KΩ	.005 μf
0	.006 μf
0	.008 μf

The results achieved in an audio circuit employing the circuit of FIG. 11 approximate those shown by curves B, C and D of FIG. 7, with, however, curve D showing an increase of approximately 8db at 180 Hertz. Hence, this provides a single control with a broad dynamic range while keeping the gain at center frequency substantially contact.

In another embodiment, a stator 150 as shown in FIGS. 12 and 13 is designed to provide an R–C network suitable as a tone control which operates on negative series voltage feedback from an amplifier output. Herein, lower electrodes 152, 154 and 156 are disposed on substrate 16 with overlying dielectric layer 28 and upper surface electrodes 160, 162 and 164. Electrodes 152 and 156 are in direct connection to terminals 166 and 172 respectively. Electrode 154 is in connection to terminal 168 through a deposited resistor 170.

Electrodes 154 and 156 are also connected to the upper surface through extended conductive strips 174 and 176, respectively, and vertical conductors similar to that shown in FIG. 10. Hence, electrode 154 is connected by conductor 174 to one end 178 of variable resistor 180, and electrode 156 is connected through path 176 to one end 182 of fixed resistor 184. The other end of resistor 184 is in connection to upper electrode 162 by conductive path 186.

Stator 150 is constructed with a 120° conductive mesh in a manner similar to that of the other embodiments. Upper electrodes 160 and 164 are made discontinuous to provide variable capacitors, and resistor 180 is included within the radius of rotor 50 with a fixed connection at one end such that its circuit resistance varies in accordance with wiper contact.

As in the other embodiments, rotor mesh 52 is allowed to rotate from one discontinuous electrode to the other, and at its center position is wholly over electrode 154.

This provides a three terminal network 190 as shown in FIG. 14 wherein fixed capacitor 192 is provided by electrodes 154 and 162, variable capacitor 194 results from electrodes 152 and 160, and variable capacitor 196 is formed by electrodes 156 and 164.

In a specific example, the electrical parameters were as follows:

Resistor 170	6 KΩ
Resistor 180	0–150 KΩ
Resistor 186	21 KΩ
Capacitor 192	.022 μf
Capacitor 194	0–.018 μf
Capacitor 196	0–.010 μf

As in the prior embodiments, the various components are keyed together; that is, capacitor 194 is zero when capacitor 196 is in the circuit and vice versa. Resistor 180 is not connected in the circuit until rotor mesh 52 has rotated approximately 80° over electrode 160. At this point, resistor 180 decreases from its maximum (150K) to zero as capacitor 194 reaches its maximum.

Network 190 is designed to feed back voltage from the output transformer in an audio circuit so as to vary the gain versus frequency. In operation, terminal 168 is connected to the emitter of a grounded emitter stage, terminal 172 is connected to the output of the audio circuit, and terminal 166 is grounded. Network 190 varies the transfer impedance with frequency is accordance with rotor position to achieve the desired frequency shaping. The impedance at mid-range frequencies is substantially determined by the fixed elements, that is, resistors 170, and 186 and capacitor 192.

In operation, as rotor mesh 52 is rotated ccw from center position over electrode 162 to discontinuous electrode 160, the gain is increased at the high frequency end of the range without effecting the low frequencies. However, as ccw rotation continues, resistor 180 is decreased (from infinity) by mesh 52 and low frequency feedback increases thereby reducing low frequency gain while further increasing high frequency gain. This provides treble coloration.

On the other hand, bass coloration is obtained by bypassing resistor 186 with capacitor 196. This occurs as mesh 52 is rotated cw from electrode 162 over electrode 164. During this interval, resistor 180 is infinity and capacitor 194 is zero. The introduction and increase of capacitor **196** provides greater feedback at high frequencies, and thus, less gain thereat. Resistor **170** is included in network **190** is isolate the low impedance of the emitter resistor and allow capacitor **196** to bypass high frequency feedback signals to ground.

Advantageously, network **190** provides broad tuning control with little change in mid frequency (1 Kc) gain. Additionally, it also supplements the gain at the high end during low end attenuation or treble.

What is claimed is:

1. A variable capacitance network comprising a plurality of spaced apart upper electrodes disposed in at least partially overlying relation to a plurality of spaced apart lower electrodes with an intervening thin layer of dielectric material, one of said upper electrodes being a continuous electrode having a continuous conductive surface area, another of said upper electrodes being a discontinuous electrode having a discontinuous conductive area provided by a plurality of isolated island segments, a pair of terminals in connection to said lower electrodes, means for connecting said upper continuous electrode to a terminal of said network so as to provide a fixed capacitance, and a contact member adapted for relative motion with respect to said upper electrodes, said member having a conductive surface portion urged into contact with said upper continuous electrode and adapted to slidably engage selected island areas of said discontinuous electrode so as to connect said selected islands to said upper continuous electrode and the terminal means thereof.

2. The network of claim **1** including a supporting substrate, and wherein said electrodes are films of conductive material, said lower electrodes being disposed on an upper surface of said substrate with said thin dielectric layer and upper electrodes in a monolithic structure.

3. The network of claim **1** wherein said contact member is adapted for slidable motion in a predetermined path over said upper electrodes; and including a pair of discontinuous upper electrodes disposed along two edges of said continuous upper electrode, said predetermined path extends from a first of said discontinuous upper electrodes across said continuous upper electrode to a second of said discontinuous electrode, and said conductive surface portion of said contact member approximately conforms to the portion of said upper continuous electrode included between said two edges such that said discontinuous upper electrodes are substantially disconnected when said conductive surface portion is centered on said continuous upper electrode.

4. The network of claim **3** wherein said means for connecting said upper continuous electrode to a terminal includes a deposited resistor disposed in fixed connection between said upper continuous electrode and one of said lower electrodes or the terminal thereof.

5. The network of claim **3** wherein said upper continuous electrode is in connection to a third terminal of said network through a fixed conductive member.

6. The network of claim **3** wherein one of said lower electrodes underlies at least portions of both said upper discontinuous electrode and said upper continuous electrode such that said one lower electrode provides a common electrode of a fixed and a variable capacitance.

7. The network of claim **3** wherein a lower electrode which underlies portions of said upper discontinuous electrode is tapered so as to provide a rate of capacitance change which is not equal to the rate of sliding motion of said contact member.

8. The network of claim **3** including a deposited resistor disposed upon the upper surface of said dielectric layer alongside at least one of said upper electrodes, said resistor being an elongated strip disposed generally in the direction of motion of said contact member, terminal means connected to one end of said resistor, and said contact member extended over said resistor and providing connection therefrom to the terminal means of said contact member such that a varying length of said resistor is interconnected in said network in accordance with slide position of said contact member.

9. The network of claim **8** wherein said resistor strip is tapered in width such that the rate of change of resistance is not equal to the rate of sliding motion of said contact member.

10. The network of claim **9** wherein said resistor strip is disposed along-side one of said upper discontinuous electrodes, and at least a portion of the lower electrode underlying said one upper electrode is also tapered such that the rate of change of capacitance is not equal to the rate of sliding motion of said contact member.

11. The network of claim **8** wherein a lower electrode underlies at least a portion of both said upper discontinuous electrode and said upper continuous electrode to provide a common electrode for a variable and a fixed capacitor of said network.

12. The network of claim **8** including a third lower electrode which also underlies at least a portion of said upper continuous electrode so as to provide an additional fixed capacitor of said network.

13. The network of claim **8** wherein said electrodes are arranged in a substantially circular configuration, said contact member is a rotary member centered on said circular configuration and adapted for rotary slidable contact thereto, said resistor element is disposed upon said thin dielectric layer adjacent one of said discontinuous electrodes, said resistor being an elongated strip disposed substantially along a radius within the radius of said rotary element, and said resistor having a fixed connection at its end furthest from said upper continuous electrode such that during rotation of said rotary element said conductive portion thereof interconnects a varying length of said resistor to said upper continuous electrode and provides an R–C network having variable resistance and capacitance.

14. The network of claim **8** wherein said electrodes are aligned in a substantially rectilinear arrangement, and said contact member is adapted for substantially rectilinear motion over said arrangement.

15. The network of claim **14** wherein said resistor element is a substantially rectilinear strip disposed upon said thin dielectric layer adjacent one of said discontinuous electrodes, said resistor having a fixed connection at one end furthest from said upper continuous electrode, said resistor extended in the direction of said path of said contact member, and said contact member extended to said resistor such that during sliding motion of said contact member a varying length of said resistor is connected to said upper continuous electrode to provide a network having variable resistance and capacitance.

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