United States Patent

Newman et al.

[15] **3,679,940**

[45] **July 25, 1972**

[54] TRIMMER CAPACITOR

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[73] Assignee: **Voltronics Corporation**, Hanover, N.J.

[22] Filed: **Jan. 21, 1971**

[21] Appl. No.: **108,294**

[52] **U.S. Cl.** .....**317/101 C**, 317/249 T, 317/251

[51] **Int. Cl.** **H01g 5/14**

[58] **Field of Search** .....317/249 R, 249 T, 251, 101 C, 317/101 CC

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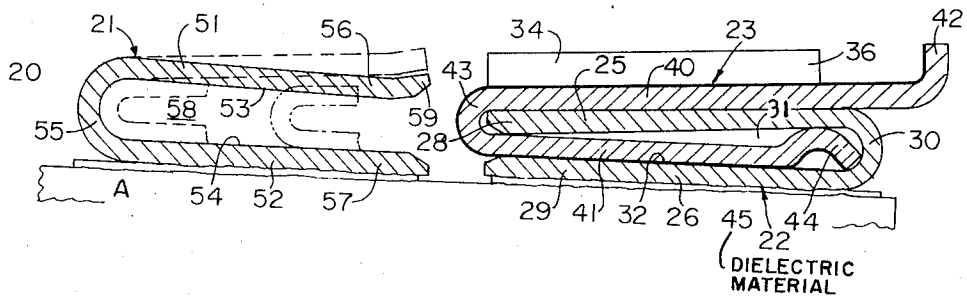
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[57] **ABSTRACT**

A variable electronic component having a plurality of unmounted coacting elements adaptable in particular for attachment in sub-miniature electronic circuits on a supporting substrate includes, at least one conductive contact means connected to one side of the circuit and adjustable means independent of and in spaced relation to said contact means for operative coaction therewith. The adjustable means has at least one support member of conductive material connected to the other side of the circuit and at least one movable means in current conducting relation with and slidably or rotatably disposed on the support member for guided movement into and out of engagement with the contact means. Means are provided to maintain the movable means in adjusted position of engagement with the contact means, and means disposed between the contact means and the movable means is provided to establish a desired impedance characteristic for said electronic component.

20 Claims, 24 Drawing Figures



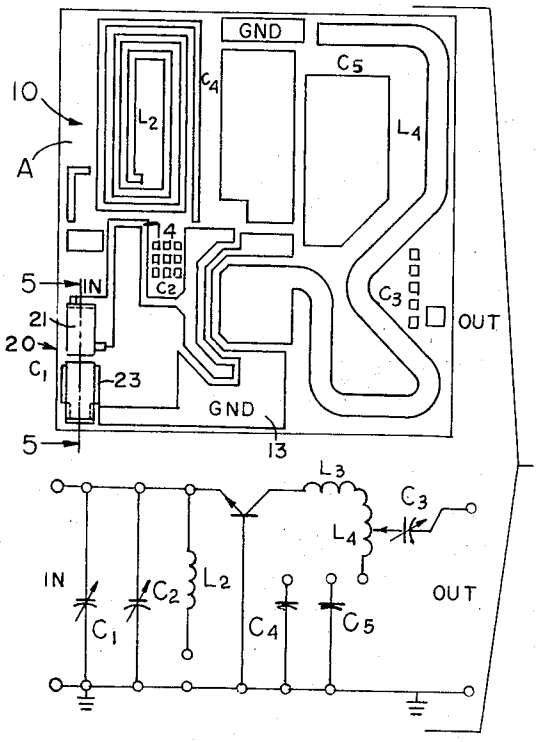


FIG. 1

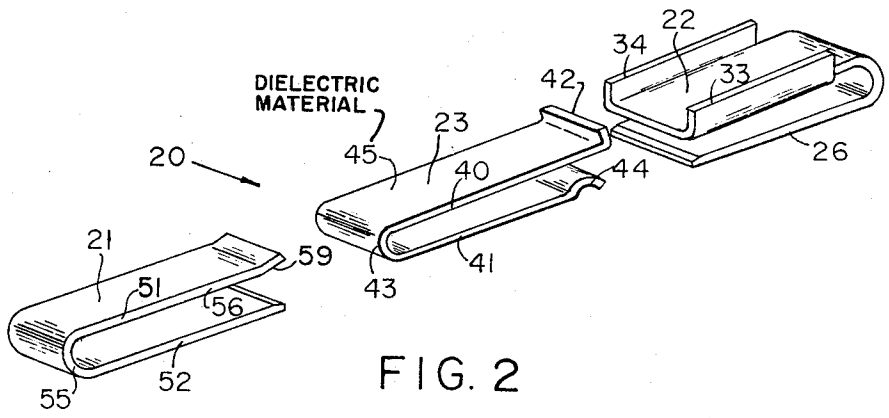


FIG. 2

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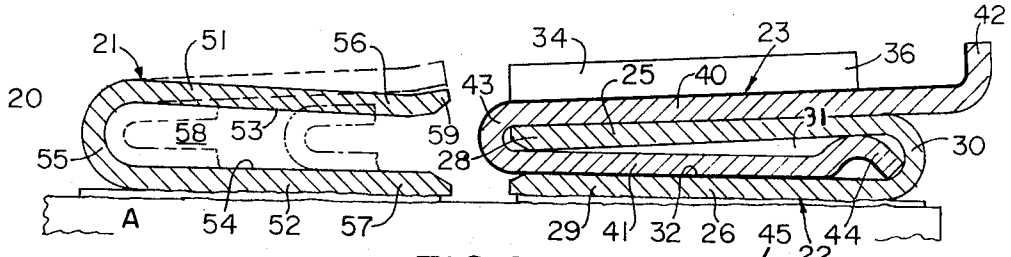


FIG. 5

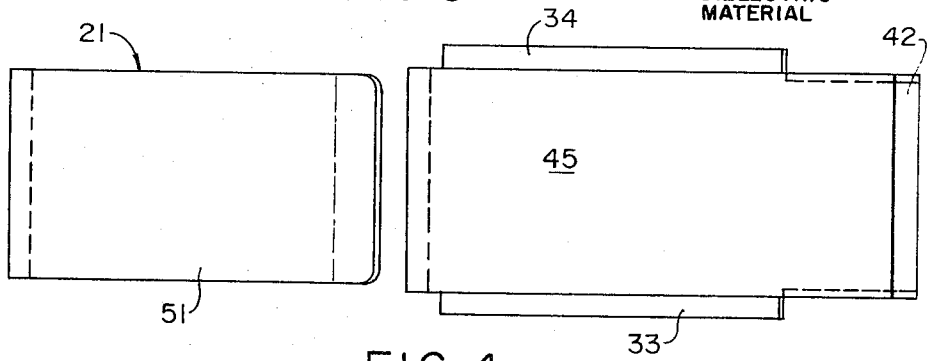


FIG. 4

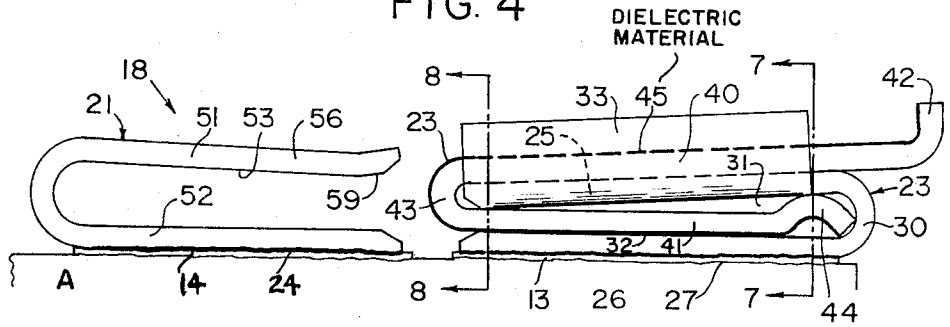


FIG. 3

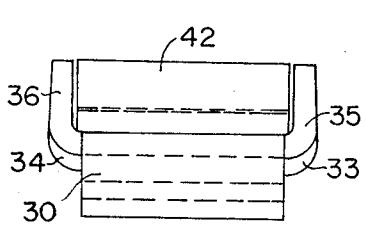


FIG. 6

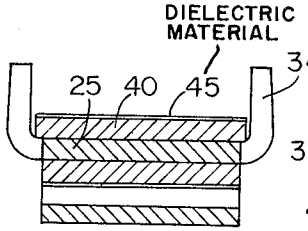


FIG. 7

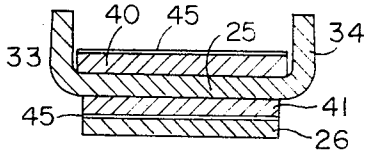


FIG. 8

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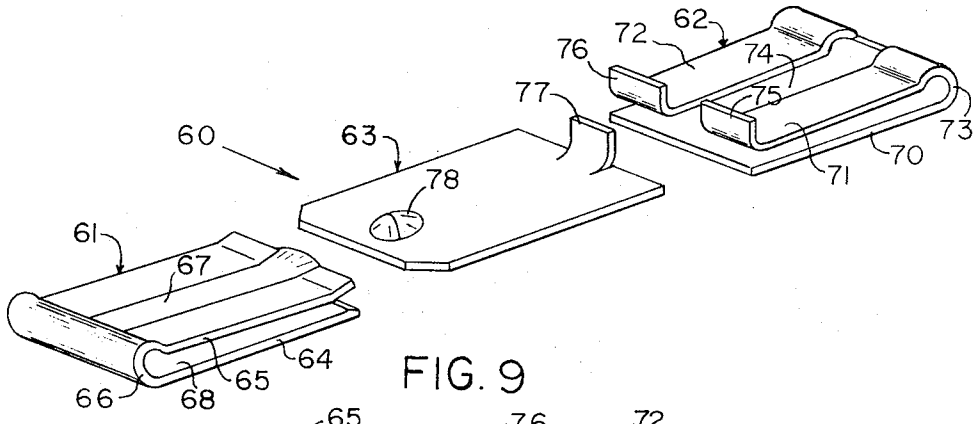


FIG. 9

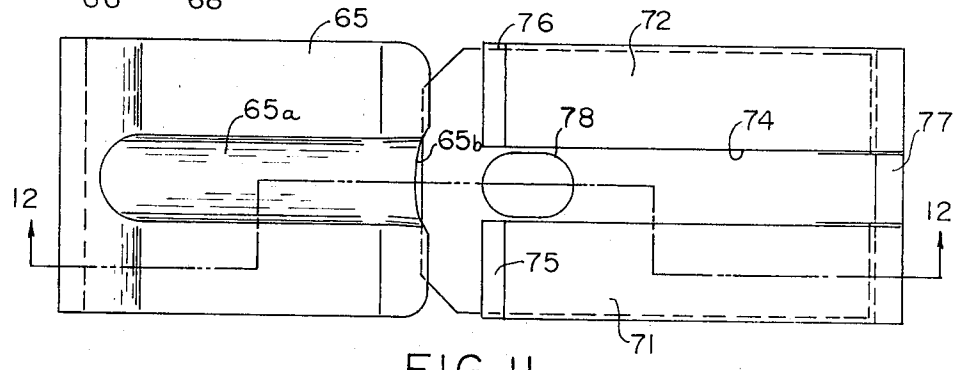


FIG. 11

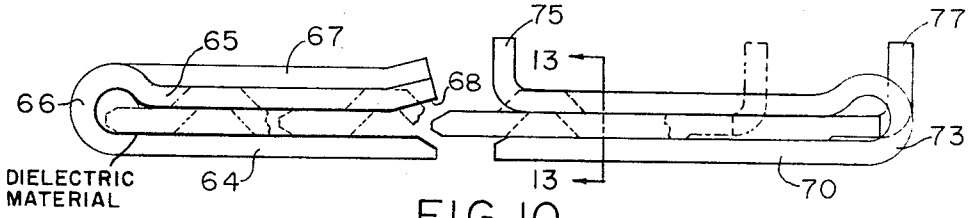


FIG. 10

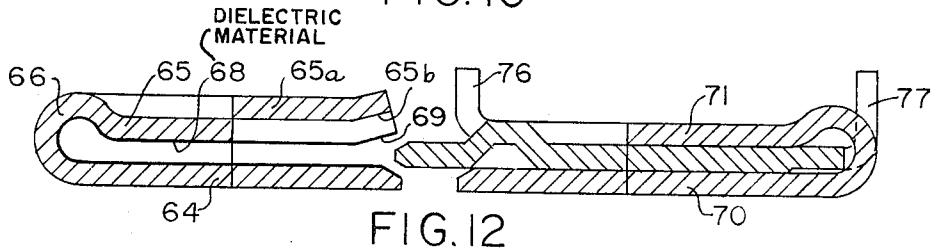


FIG. 12

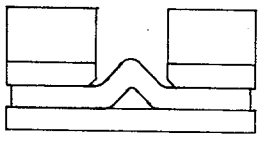


FIG. 13

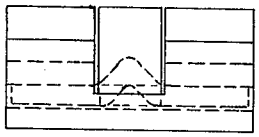


FIG. 14

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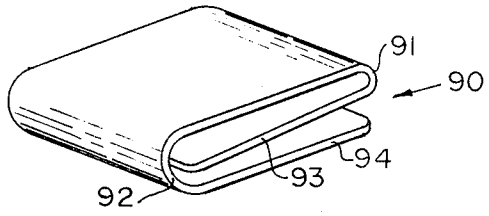


FIG. 15

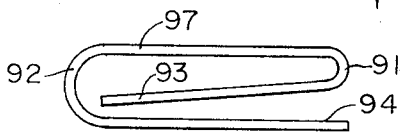


FIG. 16



FIG. 17

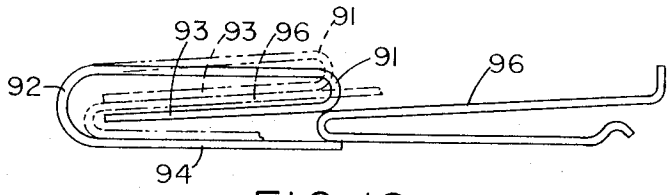


FIG. 18

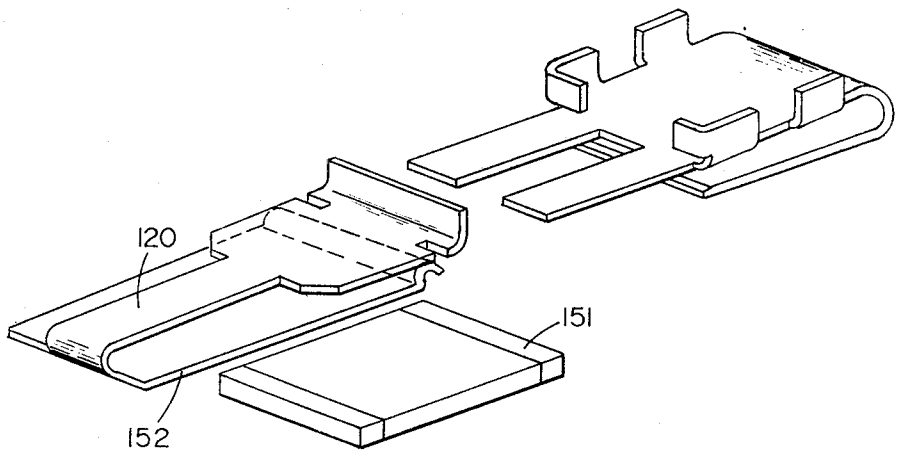


FIG. 24

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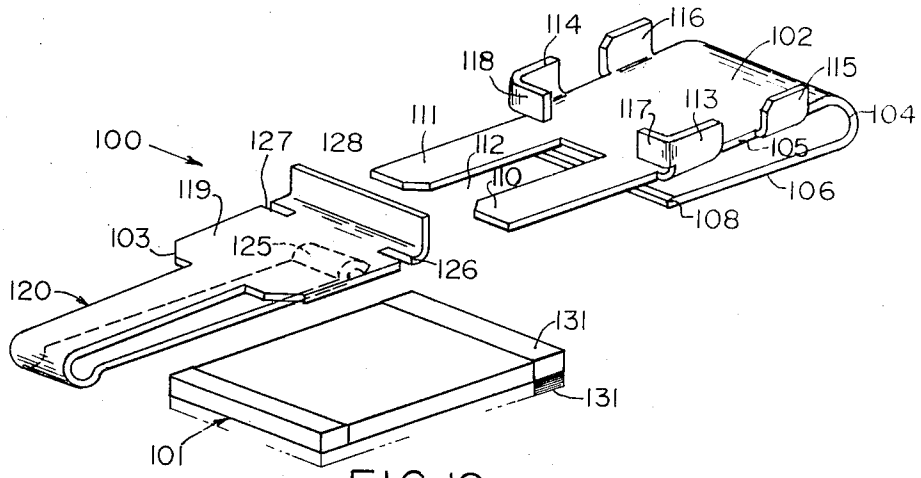


FIG. 19

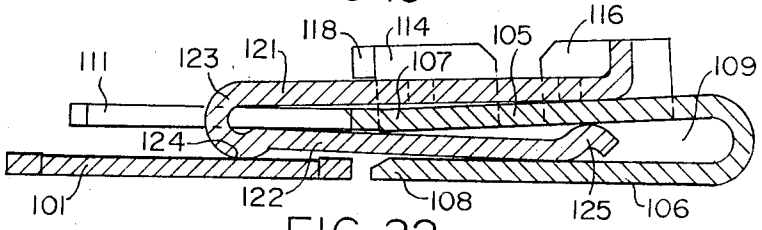


FIG. 22

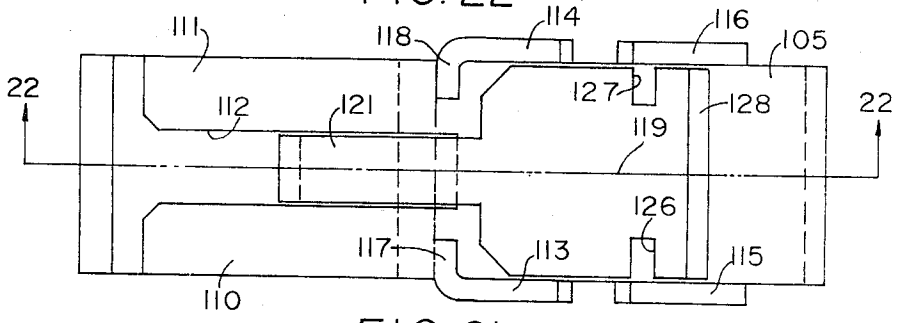


FIG. 21

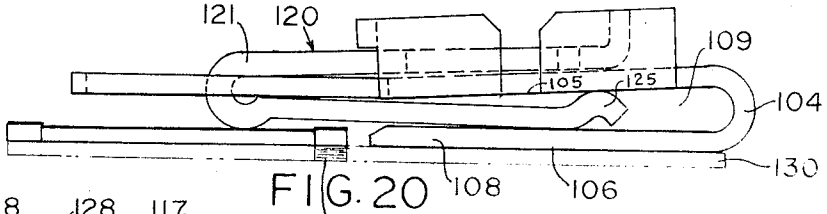


FIG. 20

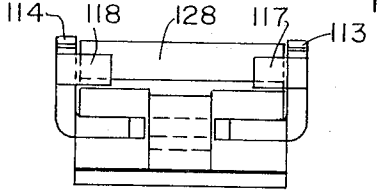


FIG. 23

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TRIMMER CAPACITOR

BACKGROUND OF THE INVENTION

In the advancing technologies of computers, testing equipment, appliances and other fields various types of hybrid electronic circuits, integrated electronic circuits, micro strip amplifiers, micro electronic systems and other electronic devices are being developed which are made on increasingly smaller scales and sizes than has been known theretofore.

In accomplishing this end, the enumerated devices and systems are generally mounted on small flat insulating bases known as substrates and these various systems or devices incorporate or have formed therein or coact with various types of electronic components such as inductors, capacitors, resistors, potentiometers, etc., which in turn must be as small as possible to meet the demands of the reduced scale or size of these systems and devices.

The known prior art miniature components have about reached their functional limit even with the best precision manufacturing techniques because certain elements of such devices cannot be reduced further at reasonable costs for commercially acceptable regularly usable components.

For example, the present known prior art variable trimmer capacitors heretofore used in miniature electronic circuits require a mounting frame and a tuning mechanism and there is a limit as to how these elements can be miniaturized and still provide effective and proper function.

Further, the mounting elements and tuning mechanisms, when connected in miniature electronic circuit handling high frequencies create unwanted inductance and capacitance in the systems and devices in which they are used because they form stray current paths when placed in close proximity to each other; as may be required in miniature systems or small electronic designs; they produce unwanted circuit interaction such as excessive coupling.

The present invention provides a variable electronic component which is particularly adapted to meet and overcome the problems of these prior art devices and accomplishes this by eliminating the area and mass of conventional mounting frames, tuning mechanisms and other elements heretofore used; and instead integrates the elements of the variable electronic component into the circuit.

The present device is primarily designed as a low profile structure exceedingly small in size, simple in construction, easily adjustable, reliable in operation, easily replaceable and reproducible in quantity without sacrificing uniformity of performance.

SUMMARY OF THE INVENTION

Thus, the present invention covers a variable electronic component having a plurality of unmounted coacting elements adaptable for use in sub-miniature electronic circuits on a supporting substrate which comprises, a conductive contact means connected to one side of said circuit, a support member or holder of conductive material independent of said contact means connected to the other side of said circuit and disposed in predetermined spaced relation to said conductive means, means movably mounted in said support member or holder and adjustable for guided movement into and out of engagement with said contact means, means to hold said movable means in any given adjusted position of engagement or non-engagement with said contact means, and means between said conductive and said movable means to provide a desired range of impedance characteristics to said electronic component.

OBJECTS AND ADVANTAGES

Accordingly, it is the primary object of the present invention to produce a variable electrical component in which the part or parts thereof are independently mountable in current conducting circuit disposed on an associate substrate.

It is another object of the present invention to provide a variable electronic component which is relatively small and cheap to build wherein the area and mass of conventional mounting means and tuning means of the known prior art devices are substantially eliminated.

It is another object of the present invention to provide a variable electronic component particularly adapted for use in high frequency sub-miniature electronic systems and devices.

It is another object of the present invention to provide a variable electronic component which is relatively easy to adjust to provide fine tuning for the electronic circuit in which it will be used.

With the above considerations and objects in mind, the invention itself will now be described in connection with several preferred embodiments thereof given by way of example and not by way of limitation and with reference to the accompanying drawings in which:

FIG. 1 is a highly enlarged plan view of a micro-lumped thin film circuit having a variable trimmer capacitor thereon in accordance with the present invention.

FIG. 2 is an enlarged exploded view of the variable trimmer capacitor shown in FIG. 1.

FIG. 3 is an enlarged side elevational view of the variable trimmer capacitor shown in FIG. 1 in assembled relation showing a fragmentary portion of the circuit and the substrate on which the trimmer is mounted.

FIG. 4 is a top plan view of the assembled variable trimmer capacitor shown in FIG. 3.

FIG. 5 is a vertical section taken along line 5—5 of FIG. 1 illustrating the movable member phantomized in various positions of engagement with the contact means.

FIG. 6 is a view from the right end of the variable trimmer capacitor shown in FIG. 3.

FIG. 7 is a vertical section taken along line 7—7 of the variable trimmer capacitor shown in FIG. 3.

FIG. 8 is a vertical section taken along line 8—8 of the variable trimmer capacitor shown in FIG. 3.

FIG. 9 is an enlarged exploded view of another form of variable trimmer capacitor in accordance with the invention.

FIG. 10 is an enlarged side elevational view of the form of variable trimmer capacitor shown in FIG. 9 in assembled relation with the movable member or shuttle phantomized in various positions of engagement with the contact means.

FIG. 11 is a top plan view of the assembled variable trimmer capacitor shown in FIG. 10.

FIG. 12 is a vertical section taken on line 12—12 of FIG. 11.

FIG. 13 is a vertical section taken on line 13—13 of FIG. 10.

FIG. 14 is a right end view of the variable trimmer capacitor support shown in FIG. 10.

FIG. 15 is an enlarged perspective view of another form of contact means for the form of the invention shown in FIGS. 3–9 of the drawings.

FIG. 16 is a side view of the contact means shown in FIG. 15.

FIG. 17 is an end view of the end of the contact means shown in FIG. 15 which faces and is engaged by the movable member of the variable trimmer capacitor shown in FIGS. 3–8 of the drawings.

FIG. 18 shows a movable member in engagement with the contact means shown in FIG. 16 in various positions as shown by the solid and the dotted lines.

FIG. 19 is an enlarged exploded view of a variable resistor in accordance with the present invention.

FIG. 20 is an enlarged side elevational view of an assembled variable resistor as shown in FIG. 19.

FIG. 21 is a top plan view of the assembled variable resistor shown in FIG. 20.

FIG. 22 is a vertical section taken on line 22—22 of the assembled variable resistor shown in FIG. 21.

FIG. 23 is an end view taken from the left-hand side of the variable resistor shown in FIG. 20.

FIG. 24 has elements similar to the device shown in FIGS. 19 to 24 but shows an enlarged exploded view of the movable member modified to provide a variable trimmer capacitor having a chip from the circuit converted into an element of the trimmer capacitor.

ONE FORM OF VARIABLE TRIMMER CAPACITOR

Referring to the drawings, FIG. 1 illustrates a variable trimmer capacitor generally designated 20 in accordance with the present invention applied to a subminiature electronic circuit of the micro-lumped thin film construction generally designated 10 which is used for example in 2 GHz 5 watt power amplifier. The electronic circuit is illustrated in highly enlarged form as its actual dimensions are about one square inch.

The variable trimmer capacitor 20 illustrated will have actual approximate dimensions and sizes as follows — Height 0.04 inch, Width 0.07 inch and Length 0.200 inch. A variable trimmer capacitor with these dimensions will have a capacitance range from 0.1 pf to above 2.5 pf (pico farads); minimum voltage ratings will be 100 volts D.C. and a "Q" over 1,000 at 100 GHZ.

It is noted that in all the other forms of the present invention illustrated in the various figures to be described hereinafter that the elements are also shown in highly enlarged form to more clearly illustrate the construction and arrangement of the parts. It will be understood that these forms of the invention may also have dimensions similar to those above indicated for the variable trimmer capacitor illustrated in FIGS. 3 to 8 of the drawings.

The micro-lumped thin film construction shown in FIGS. 1 and 2 comprises a substantially planar member having an alumina substrate generally designated A which is metalized and etched on at least one side to form current carrying sections as at 13 and strips 14 to provide an electronic circuit.

One of the current carrying section 13 is maintained intact as the ground plane and the current carrying strip 14 and other strips in spaced relation to provide a plurality of patterns which form the functional components of the circuit indicated by the letters "C" for capacitors and "L" for inductors. Such forms of circuitry are well known in the prior art and must be made with great precision. FIGS. 1 and 2 further show that the variable trimmer capacitor includes a conductive contact means 21 connected to the current carrying strip 14 of the electronic circuit disposed on the substrate A and spaced therefrom is a support member or shuttle holder 22 also made of conductive material and connected to the side of the circuit elements 13 forming the ground plane GND opposite in the circuit from that to which the conductive contact means 21 is connected.

The support member is so spaced that a movable member or shuttle 23 mounted on the support member 22 can be moved into and out of engagement with the contact means or clasp 21. The coaction between the movable member and the contact means will perform the operative function of the variable trimmer capacitor as is explained more fully hereinafter.

The variable trimmer capacitor is affixed in properly adjusted position for the desired interrelation between the movable member or shuttle 23 and the contact means or clasp 21 as by solder means 24 for affixing the elements to the electronic circuit parts. Alternatively the elements of the variable trimmer capacitor can be affixed directly to the substrate and connected by suitable lead lines, not shown, to the current conducting section 13 and the current conducting strip 14 of the electronic circuit formed on the substrate A. Thus, there is no independent mounting frame or other means provided for the elements 21, 22 and 23 of the variable trimmer capacitor. The elements 21, 22 and 23 are integrated directly into the electronic circuit as a component thereof.

The contact means or clasp 21 and the support member or shuttle holder 22 may be made of substantially similar materials. One such material particularly adapted for this purpose is a beryllium copper alloy. This material is desirable for this purpose in that it is a fine grained metals which conducts current well. It can be easily shaped, can be hardened into and will retain a shape or configuration such as the U-shape or bobby-pin shape of the respective contact means or clasp 21 and the support member 22 as shown in side elevation in FIGS. 3 and 5 of the drawings. Alternatively other materials such as nickel-chromium-steel alloys or phosphor bronze alloys may be used.

Additionally, the contact means or clasp 21 and support member 22 can be gold plated or silver plated by any suitable means because this will make the elements non-corrodable, give them high electrical conductivity and facilitate soldering them to the electronic circuit in which the variable trimmer capacitor will be used.

The movable member or shuttle 23 is preferably made of stainless steel alloy 304. This is a nickel-chromium alloy which is commercially available on the open market. It is spring-like, non-corrodable and non-solderable by the conventional techniques applicable to the contact means 21 and the support member or shuttle holder 22. Thus, when the variable trimmer capacitor is affixed in assembled position in the electronic circuit the movable member a shuttle 23 will not be affected by the soldering action required for such assembly.

It is thought clear from FIGS. 1 to 8 that the elements of the variable trimmer capacitor are shown to have no independent mounting means and that the elements are independently and directly connected into the circuit itself hence they are supported by the same substrate that supports the circuit. The only requirement to get effective operation is to so space the contact means 21 and the shuttle holder 22 that the movable member or shuttle 23 can be brought into and out of full engagement with the contact means or clasp 21 as is shown by the phantomized lines in FIG. 5 of the drawings. This is best understood by now describing the construction of the support member or shuttle holder 22 and the movable member or shuttle 23 mounted therein and their relation to the contact means 21.

Thus, referring to FIGS. 3 to 8 of the drawings, the support member or shuttle holders 22 is shown to be substantially U-shaped or bobby pin shaped in side elevation. It can be stamped, formed or shaped from a relatively thin flat member of conductive material such as beryllium copper alloy for the reasons above set forth.

The support member 22 has an upper leg 25 and a horizontal lower leg 26, and continuous with one end of the legs 25 and 26 is a rounded base or connecting section 30. The lower face of the lower leg 26 is soldered to the current conducting section 13 as at 27. The free ends 28 and 29 respectively of the upper leg 25 and lower leg 26 are closer together than the portions of the respective legs remote from the free ends which are continuous with the rounded connecting section 30. The upper leg 25 is thus in compression or stress with respect to the lower leg 26 and the arrangement forms a wedge shaped space 31 wherein the upper surface 32 of the lower leg 26 provides a horizontal or flat planar engaging surface.

Additionally the upper leg 25 is provided with a pair of shuttle guides 33 and 34 which are connected on opposite side normal to the upper leg 25 as shown in FIGS. 3, 4 and 5 of the drawings. The shuttle guides act fundamentally to prevent sidewise movement or slippage of the shuttle 23 during movement or when it is in adjusted position.

The movable member or shuttle 23 is also a substantially U-shaped member having an offset upper leg 40 and a horizontal lower leg 41. The upper leg 40 will be disposed at substantially the same angle as the upper leg 25 of the shuttle holder 22 and will at the free end thereof have an upturned gripping tab or element 42. The upper leg 40 and lower leg 41 are connected by the rounded base on connecting portion 43.

The horizontal lower leg 41 has a contact shoe or arcuate section 44 formed adjacent the free end of the lower leg.

To provide the desired function as a capacitor in the circuit the entire outer face 45 i.e., the surface facing and to be brought into engagement with the contact means 21 will be coated to the desired thickness with a suitable dielectric material such as polytetrafluoroethylene. It will be understood that other dielectric materials such as the ceramic coatings presently in use on piston type variable trimmer capacitors could also be applied to the outer surface of the shuttle to accomplish the same result.

Alternatively, the inner surface of the contact means **21** could be coated with such dielectric material or other techniques could be used to establish the desired capacitance without departing from the spirit or scope of this invention.

The movable member or shuttle **23** will be assembled to the support member or shuttle holder **22** by passing the horizontal lower leg **41** of the shuttle **23** into the wedge shaped space **31** between the upper leg **25** and horizontal lower leg **26** of the shuttle holder **23** as by springing the upper leg **25** away from the lower leg **26**. The free end **28** of the upper leg **25** will return to its normally stressed position and bring the face of the horizontal leg **41** of the shuttle **23** into initimate engagement with the upper face or surface **32** of the horizontal lower leg **26** of the shuttle holder **22**. At the same time this will act to bring the contact shoe or arcuate section **44** of the lower leg **41** into engagement with the underside or lower face of the upper leg **25** of the shuttle holder **22**.

Since the movable member or shuttle **23** can be suitably sized, the width thereof can be adjusted to permit the shuttle **23** in assembled position to be in frictional engagement with the inner faces of the shuttle guides **33** and **34**, as is shown in FIGS. **3** and **4** of the drawings.

The contact means **21** is made of a relatively thin, flat, conductive member which may be formed, stamped or bent into a U-shape. Thus the contact means **21** will also have an upper leg **51** and a horizontal lower leg **52**. The lower leg **52** is connected to current conducting strip **14** of the electronic circuit by solder **24** or other suitable means. In assembled position the horizontal lower leg **52** provides a substantially flat planar inner surface **54**. The upper leg **51** is spaced from the lower leg **52** by the rounded end section **55** which connects leg members **51** and **52** to each other.

By reference to FIGS. **3**, **4** and **5** when the movable member **23** is not in engagement with the contact means **21** the free end **56** of the upper leg **51** will be disposed closer to the free end **57** of the lower leg **52** to provide a wedge shaped space **58** therebetween. In other words, the upper leg **51** will be prestressed or in compression relative the lower leg **52**. As a result, when the movable member **23** is forced into engagement with the inner surface of the contact means **21** the movable member **23** will be held in firm engagement with the inner surface **53** and flat planar surface **54** of the contact means **21**.

The free end of the upper leg **51** is turned or bent slightly outward as at **59** to provide an abutting surface which will initially guide the rounded connecting end **43** of the movable member or shuttle **23** as this member is moved into engagement with the contact means.

The compressive forces and frictional engagement between the shuttle holder **22** and the shuttle or movable member **23** and between the movable member **23** and the contact means or clasp **21** will act to keep the respective adjacent and contacting surfaces of the movable member **23**, the inner surface **32** of the support member and the inner surface **54** of the contact means in close and intimate engagement. This will insure both proper electrical contact and proper function of the variable trimmer capacitor.

FIGS. **3**, **4** and **5** further show that by acting on the upstanding gripping tab **42** as with any suitable adjusting tool for example, a tweezer, the movable member or shuttle **23** can be moved forward and back between a minimum and a maximum position. The minimum position is identified at FIG. **3** where the contact shoe or arcuate section **44** at the free end of the lower leg **41** is in engagement with the rounded connecting section **30**. This is the minimum capacitance position for the capacitance range of this form of the invention.

As is illustrated in FIG. **5**, by the phantomized lines the shuttle **23** can be moved to various positions of engagement with the contact means **21** and the maximum capacitance position for the capacitance range of this form of the invention is illustrated by the engagement of the rounded connecting section **43** of the shuttle **23** with the inner surface of the rounded connecting section **55** of the contact means **21**.

This construction makes is impossible to overdrive the respective parts of the disclosed variable trimmer capacitor **20** shown in FIGS. **3** to **8** and the shuttle guides **33** and **34** will prevent sidewise movement. Accordingly, disassembly of the elements of the variable trimmer capacitor **20** cannot occur in the form of the invention shown in FIGS. **3** to **8** of the drawings above described.

The prestressed condition of the contact means **21** will act to force the respective outside or coated face **45** of the movable member or shuttle **23** into intimate engagement with the inner face **53** of the contact means or clasp **21** and since the respective members **21** and **23** are conductive and are separated by a dielectric they form a relative simple adjustable capacitor.

Additionally, the compressive forces and the frictional engagement between the elements of the variable trimmer capacitor **20** above described will normally be sufficient to maintain the shuttle or movable member **23** in any given adjusted position because the mass of the shuttle **23** is so small that it has little tendency to shift position. It is however relatively simple to provide positive means to prevent such movement as by ears, not shown, which may be struck inwardly on the shuttle guides **33** and **34** or detent means not shown can be provided to coact with the movable member or shuttle **23** as will be understood by those skilled in the electro-mechanical arts.

ANOTHER FORM OF VARIABLE TRIMMER CAPACITOR

FIGS. **9** to **14** show another form of variable trimmer capacitor in accordance with the present invention in which the fundamental elements perform the same functions in substantially the same way.

In enlarged perspective form therefor FIG. **9** shows a variable trimmer capacitor generally designated **60** having a contact means or clasp **61**, a support member or shuttle holder **62**, and a movable member or shuttle **63**.

The contact means or clasp **61** and the shuttle holder **62** are made of conductive materials and are substantially U-shaped inside view as is clear from FIGS. **10**, **11**, and **13**. The materials used are thin, flat members of beryllium copper, nickel-chrome steel alloy and phosphor bronze and are gold or silver plated as above mentioned for the variable trimmer capacitor shown in FIGS. **3** to **8**. They are made by shaping, forming or stamping those or any other materials which are conductive and can hold the desired engagement with the movable member or shuttle **63**.

The contact means or clasp **61** includes a horizontal lower leg **64** and an upper leg **65** which are connected at one respective end by a rounded end section **66** so constructed that the legs **64** and **65** respectively act as resilient or spring like members. The upper leg **65** has a groove **65*a*** struck along the axial or longitudinal line which extends to and flare slightly as at **65*b*** at the free end of the upper leg **65**. The free end is bent outwardly or upwardly as at **68**. This will open the space between the adjacent free ends of the respective lower leg **64** and upper leg **65** to facilitate entry of the end of the movable member or shuttle **63** into the contact means or clasp **61** as is hereinafter described.

The contact means or clasp **61** will be affixed to the electronic circuit as by solder or other suitable technique in the same manner above described for the contact means **21** of the form of this invention shown In FIGS. **3** to **8** of the drawings.

Since this form of the invention is to act as a capacitor it is necessary to provide a suitable dielectric between the coacting plates. For this purpose the entire inner surface of the contact means or clasp **61** will be coated as at **68** with polytetfluoroethylene or a suitable dielectric. Thus when the shuttle **63** is moved into engagement with the clasp **61**, the conductive portion of the clasp **61** acts as one plate and the shuttle **63** as the other, the dielectric coating **68** being disposed between these plates in the required manner to provide the desired capacitance.

The support member or shuttle holder **62** also includes a horizontal lower leg **70** which provides means to permit the shuttle holder **62** to be connected into the circuit as was above described for the shuttle holder **22** of the form of the invention shown in FIGS. **3** to **8** of the drawings.

Coacting with the horizontal lower leg **70** are a pair of upper legs **71** and **72** which are connected in spaced relationship to a rounded end section **73** to provide a longitudinal channel guide **74** therebetween. The rounded end section **73** is so formed that the upper legs **71** and **72** act as resilient or spring elements or leafs with respect to the lower leg **70**.

At the free end remote from the end connected to the rounded end section **73** the legs **71** and **72** have adjusting tabs **75** and **76** which provide means for engagement by a suitable tool not shown for adjusting this form of variable trimmer capacitor.

The movable member or shuttle **63** which coacts with the shuttle holder for this form of the invention is a flat member having an upstanding guiding tab **77** and one end which may be used above or in association with adjusting tabs **75** and **76** to move the shuttle **63** so as to adjust its longitudinal position with respect to the contact means or clasp **61**.

The guiding tab **77** will be sized so that the width thereof will permit it to fit snugly in the guiding channel **74**.

In alignment with the guiding tab **77** is a center guide **78** which may be formed on the shuttle **63** by any suitable means such as by striking the same from the under-surface of this member.

The center guide **78** will engage the centrally extending groove **65a** in the contact means or clasp **61** when the movable member or shuttle **63** is moved to engage said clasp **61**, as is illustrated in FIG. **10** and will prevent lateral movement of the shuttle during adjustment or when the shuttle **63** is in either assembled position, or adjusted position.

The elements are assembled or connected to the circuit in predetermined space relation to each other, as a function of the length of the shuttle **63** such that when the shuttle **63** is in the maximum capacitance position of engagement that is with its forward edge in abutment with the coated inner wall of the rounded end section **66** of the clasp **61** a sufficient length of the shuttle **63** will still remain in the shuttle holder **62** so that the guiding tab **77** will still be engaged in the guiding channel **74**.

FIG. **11** shows that the movable member or shuttle **63** may be moved to a minimum capacitance position that is when the shuttle **63** is not in engagement with the stator clasp **61** and the back end thereof is in abutment with the inner wall of the rounded end section **73** of the shuttle holder **62**.

Those skilled in the art will recognize that each variable trimmer capacitor in accordance with the present invention will have a range of capacitance as a function of the area of the plates and the thickness of the dielectric, and that the capacitance can be infinitely varied within the minimum and maximum limits of that range.

Rough tuning of the electronic circuit in which the trimmer capacitor is mounted can be accomplished by manual movement of the movable members or shuttles **23** or **63** respectively. Fine tuning of the electronic circuit is more easily accomplished by using an adjusting tool in association with suitable test instruments, also not shown, to move the movable members or shuttles **23** or **63** respectively in incremental steps until optimum operating conditions are obtained.

ALTERNATE FORM OF CONTACT MEANS OR CLASP

FIGS. **15**, **16** and **17** show an alternate form of the contact means or clasp device adaptable for use in the form of the invention shown for example in FIGS. **3** to **8** of the drawings.

This contact means or clasp would replace the element **21** and will provide an improved functional interrelationship between the movable means and the contact means in that it will increase surface-to-surface contact between the inner surface of the contact means and the outer surface of the movable means in the adjusted position.

Thus, referring to FIGS. **15**, **16** and **17** the contact means is designated generally **90** and consists of a relatively thin conductive strip of material such as has been described above for the contact means **21** and **61**. The strip is folded on itself to provide the convoluted shape shown in which two spaced and rounded end portions as at **91** and **92** provide means to permit an upper member **93** to pivot relative a lower member **94** suitably spaced therefrom when the movable means **96** is moved into operative position with said contact means as is illustrated by the various phantomized positions of the movable member in FIG. **18** of the drawings.

The lower member **94** is connected to one of the end portions **92** and a connecting member **97** connects to the end portion **92** remote from the lower member **94** at one end and at the other end to the end portion **91** which is continuous at its other end with the upper member **93** all of which is clearly shown in FIGS. **15** and **16** of the drawings.

During operation of a variable trimmer capacitor which includes this alternate form of contact member as the movable member **96** enters into engagement with the end portion **91** snug engagement will occur between the respective coacting faces of the upper member **93**, the lower member **94** and the outer face of the movable member **96**.

When the movable member **96** extends inwardly for engagement of the respective contacting surfaces of the upper member **93** and the lower member **94**, the upper member **93** will initially pivot about the end portion **92**. As the movable member **96** extends inwardly further and further in order to accommodate engagement, the force being exerted by the movable member will be transmitted to both the upper member **93** and the connecting member **97** and the combination of the upper member **93**, the end portion **91** and the connecting member **97** will then pivot about the respective end portions **91** and **92** so as to maintain firm and operative connection with the outer surface of the movable member **96**.

VARIABLE RESISTOR

The forms of the invention above described illustrate the use of a contact means or clasp in association with an adjustable means for providing a capacitor.

The nature of the present invention is such that the contact means can be a simple flat impedance means which is affixed directly into one side of the circuit and a suitable coacting adjustable means made to coact therewith can provide a variety of sub-miniature electrical components. This form of the present invention are illustrated in FIGS. **19** to **24** and will now be described.

Thus, referring to FIGS. **19** to **23** a variable resistor component generally designated **100** is illustrated as including resistor means **101** support means **102** and movable means **103**.

The flat resistor means **101** may be any suitable type of resistor. This is in electrical connection with one side of an electronic circuit which is disposed on a substrate.

While a resistor **101** is shown it is thought clear that instead of a single resistor that a plurality of spaced resistance elements or a plurality of switch contacts could also be used in place of the resistor element **101** without departing from the scope of the present invention as will be understood by those skilled in the art.

The adjustable means which coacts with the resistor element **101** includes a support member or shuttle holder **102** which is made of the same type of conductive materials above described for the forms of the invention shown in FIGS. **2** and **9** of the drawings, and thus can be formed into a U-shaped member substantially similar in cross-section to the U-shape of the support members or shuttle holders shown in these forms of the inventions. It differs therefrom in that it includes additional structure to permit a cantilevered or overhung arrangement for the movable means **103** with respect to the resistor pad or element **101**.

Thus the support member of shuttle holder **102** includes a rounded end portion as at **104** to which is connected an upper

leg **105** and a lower leg **106** so mounted that they are in stressed or compression relation to each other to thus bring the central portions **107** of upper leg **105** and the free end portion **108** of the lower leg **106** remote from the end portion **104** closer to each other to form a wedge shaped space **109** all of which is clearly shown in FIGS. **20** and **22** of the drawings.

The lower leg **106** provides means for affixing the support member **101** to the conductive portion of the electrical circuit on the side thereof remote from the side of the circuit to which the resistor or impedance element **101** will be connected.

From the central portion **107** of the upper leg **105** there are a pair of longitudinally extending arms **110** and **111** which form between them a guide groove or space as at **112**. Additionally, the upper leg **105** includes pairs of side guides in spaced relation to each other as indicated by elements **113**, **114**, **115** and **116**. Elements **113** and **115** are in spaced relation to each other and are connected to one side of upper leg **105** and guides **114** and **116** are in spaced relationship to each other and are connected to the opposite side of upper leg **105**. These members will act to hold the movable member **103** from slipping sideways when the movable member **103** is mounted for operation on the support member or shuttle holder **101**.

Additionally, elements **113** and **114** have front stops as at **117** and **118** which coact with the movable means to limit the forward movement thereof.

The movable member or shuttle includes a slide portion **119** and a finger portion generally designated **120**. Finger portion **120** is in the form of a U-shaped element having an upper arm **121** and a lower arm **122** connected respectively to a rounded end portion **123** which forms a contact means as at **124** at the lowermost side thereof for contact with the resistor means or impedance element **101** when the movable means **103** is moved for operative engagement therewith.

The upper arm **121** of the finger member **120** is connected at the end remote from the rounded end portion **123** to the slide element **119** of the movable member **103**. The lower arm **122** of the finger member **120** extends along the longitudinal line of the movable member **103** in spaced relation to the upper arm **121** and as indicated in FIGS. **19**, **20** and **22** is slightly longer than upper arm **121** so that it extends for a portion of its length under the slide element **119** of the movable member **103**.

At the end of the lower arm **122** remote from the rounded end portion **123** a contact shoe **125** is formed.

It will be noted that the lower arm **122** of the finger member **120** is disposed so that in assembled position the end adjacent the contact means **124** is maintained above the surface of the resistor means **101**. Stated another way the lower leg **122** forms an acute angle with the horizontal and slopes upwardly in assembled position from the contact shoe **125** to the contact means **124** so that the movable member is limited to line contact with the resistor means or impedance element **101**.

The slide element **119** of the movable member **103** is also shown with a pair of spaced grooves **126** and **127** struck transversely in the side edges of the slide element **119** and inwardly from a gripping or adjusting tab **128** formed at the end of the slide element **119** remote from the end connected to the finger member **120**. The grooves **126** and **127** are sufficiently wide so that during assembly the slide element **119** and finger member **120** may be sprung outwardly and slipped over the front stops **117** and **118** until the slide element **119** is brought into engagement with the upper surface of the upper leg **105** on the support member or shuttle **103**.

When the movable member **103** is thus assembled the finger member **120** will be disposed in the guide groove or space **112** between the arms **110** and **111** formed on the support member **102**. The lower arm **122** of the finger member **120** will be held snugly between the upper leg **105** and the lower leg **106** of the support member **102** so that the contact shoe **125** will be in the wedge-shaped space **109**. The compressive relationship between the upper leg **105** and the lower leg **106** will force the contact shoe **125** into engagement with the inner surface of the support member **102** as is clearly shown in FIGS. **20** and **22** of the drawings.

FIG. **21** further shows that the slide guides **113**, **114**, **115** and **116** act to prevent sidewise movement of the movable member **103** and coact with the guide groove or space **112** to permit or maintain the movement of the movable member **103** substantially along the longitudinal line of the resistor means or impedance element **101**.

It will be noted that the lower face of the upper leg **105** and the contact shoe **125** stay in electrical connection in all adjusted positions of the movable member **103** and that the movable member can move between certain limits either to non-engagement as where the end of the lower arm **122** is in engagement with the inner surface of the rounded end portion **104** of the support member **102** or on outward movement for engagement with the resistor means or impedance element **101** until the adjusting tab **128** engages the front stops **117** and **118**.

CANTILEVERED VARIABLE TRIMMER CAPACITOR WITH CHIP TYPE IMPEDANCE MEANS

FIG. **24** shows that the cantilevered or overhung form of adjusting means is equally applicable for use as a Variable Trimmer type capacitor.

This is accomplished by replacing the resistor pad **101** with a chip element as at **151** connected into the electronic circuit by any suitable means so as to provide a suitable impedance means having a ceramic coating and modifying the finger element **120** to eliminate the contact means **124** and to widen the lower leg as shown at **152** to provide when brought into operative position with the chip the upper or other plate of the capacitor.

The other parts will be identical with those above described for the form of the invention shown in FIGS. **19** to **23** and the operative relations will be the same as that above described for the forms of the invention shown in FIGS. **2** and **9** of the drawings.

Thus, as has been illustrated above, we have provided a simple variable electronic component of great versatility and with minimum parts adapted to be made in particular for very small size electronic circuits.

The variable electronic component is characterized by the fact that the elements are independently and directly connected to the circuit and have no drive mechanism for operation.

The elements of the variable electronic component further are so constructed that they have good electrical contact at all times and substantial misalign can occur without interferring with this electrical connection between the elements. Thus, in contrast to many miniature prior art devices the variable electronic components herein disclosed produce limited or very little electrical "noise"; have low contact resistance and minimal electrical inductance in use and in assembled relation in the circuit to which they are connected.

It is considered manifest that many variations to the structures described above in detail with respect to the disclosed embodiment can be made without departing from the spirit and scope of this invention.

What is claimed is:

1. A variable electronic component for use in a sub-miniature electronic circuit disposed on a supporting substrate comprising;

a. conductive contact means directly connectible to one side of the electronic circuit and having a portion forming a planar surface,

b. u-shaped, conductive support means directly connectible to the other side of said electronic circuit independent of and in predetermined spaced relation to said contact means,

c. movable means slidably mounted in said support means and adjusted for movement into and out of engagement with the planar surface of said contact means,

d. means on said support means to normally maintain positive engagement with the movable means to hold the movable means in all given positions of adjustment relative the contact means, and

e. means between the planar surface of said contact means and said movable means to provide a desired range of impedance characteristics to said variable electronic components on movement of the movable means.

2. In a variable electronic component as claimed in claim 1 wherein,

a. stop means is formed on said support means to limit the adjustable outward movement of the movable means on disengagement thereof from the contact means,

b. and at least one other stop member disposed to coact with said movable means at full inward movement thereof during engagement with the contact means.

3. In a variable electronic component as claimed in claim 1 including,

a. guide means on the support means,

b. said movable member operatively associated with the guide means to prevent relative sidewise movement of the movable member during adjustment thereof.

4. In a variable electronic component as claimed in claim 1 wherein,

a. the contact means is U-shaped and is stressed to coact with the support means in holding said movable member in adjusted position.

b. said movable means to be forced into engagement with the U-shaped contact means to move it into adjusted position.

5. In a variable electronic component as claimed in claim 1 wherein

a. said contact means is substantially U-shaped having a bent portion and continuous therewith a pair of spaced leg means normally having the free ends thereof in compression relationship to each other.

b. at least one of said leg means connected to the electronic circuit and forming a flat planar surface in assembled position,

c. the other of said leg means of the contact means having an upturned engaging face to permit said movable means to be forced into engagement with said U-shaped contact means,

d. and said U-shaped contact means to maintain at least one face of said movable means in snug engagement with the leg means forming the flat planar surface.

6. In a variable electronic component as claimed in claim 3 wherein the U-shaped contact means is provided with guide means, and said movable means having a guide member disposed to engage the guide means.

7. In a variable electronic component as claimed in claim 1 wherein,

a. guide means are formed on said support means,

b. and said movable means is operatively associated with the guide means to prevent relative sidewise movement of the movable member during adjustment thereof.

8. In a variable electronic component as claimed in claim 7 wherein the guide means comprise spaced side members connected to opposite sides of the support means, and the movable means has a width to just clear the inner walls of the responsive side members.

9. In a variable electronic component as claimed in claim 1 wherein the impedance means characteristic is established by a dielectric coating on the inner surface of the contact means.

10. In a variable electronic component as claimed in claim 1 wherein,

a. the support means is substantially U-shaped having a bent portion and continuous therewith a pair of spaced legs normally having the free ends in compression relation to each other,

b. one of the legs of said U-shaped support means connected to the electronic circuit and forming a flat planar surface,

c. said movable means substantially U-shaped in cross section and having a bent portion and continuous therewith a pair of spaced legs at least one of which forms a flat planar surface disposed in assembled position to fit between legs of said support means and to engage the associate leg of said support means having the flat planar surface,

d. and a contact shoe formed on the end of the leg of said movable means disposed between the legs of said support means to provide continuous electrical contact therewith in all adjusted positions of the movable member.

11. In a variable electronic component as claimed in claim 9 including guide means on said support means, and said movable means disposed to coact with the guide means to prevent sidewise movement of the movable means during adjustment thereof.

12. In a variable electronic component as claimed in claim 11 wherein the guide means include spaced side members connected normal to one of the legs of said U-shaped support means.

13. In a variable electronic component as claimed in claim 11 wherein the guide means include a pair of spaced longitudinally extending arms connected to one of the legs of said U-shaped support means, and a finger means on said movable member disposed to fit into and be guided by the space between said pair of arms.

14. In a variable electronic component as claimed in claim 13 wherein the impedance means characteristic is established by a dielectric coating on the coacting surface of the contact means.

15. In a variable electronic component as claimed in Claim 13 wherein the impedance means characteristic is established by a dielectric coating on the coacting surface of at least one leg of the movable means.

16. In a variable electronic component as claimed in Claim 9 wherein,

a. stop means is formed on said support means to limit the adjustable movement of the movable means out of engagement with the contact means,

b. and at least one other stop means is formed on the support means to coact with said movable means to limit movement thereof into engagement with the contact means.

17. In a variable electronic component as claimed in Claim 13 wherein the finger means on the movable member is substantially U-shaped,

a. said finger means having a bent portion and an upper leg and a lower leg continuous with the bent portions,

b. the lower leg having a contact part at the end adjacent the bent portion and a contact shoe at the end remote from the bent portion,

c. said contact part disposed to operatively engage the contact means,

d. and said contact shoe in continuous conductive connection with the support means.

18. The combination with an electronic circuit on a support substrate of a variable electronic component adaptable for use therein comprising:

a. at least one conductive contact means connected to one side of the electronic circuit and mounted therewith to the substrate, said contact means having a portion forming a planar surface,

b. at least one u-shaped conductive support means connected to the other side of the electronic circuit and mounted therewith to the substrate independent of and in predetermined spaced relation to the contact means,

c. movable means electrically connected to and slidably mounted on said support means for adjustable and operable engagement with the planar surface of the contact means,

d. means on said support means to normally maintain positive engagement with the movable means to hold the movable means in all given positions of adjustment relative the contact means, and

e. means between the planar surface of said contact means and said movable means to provide a desired range of impedance characteristics to said variable electronic component on movement of the movable means.

19. In a variable electronic component as claimed in claim **2** wherein,

a. the movable means is u-shaped and is mounted so as to intermesh with the u-shaped support means,

b. and the u-shaped support means is stressed to provide the means for maintaining positive engagement of the movable means to hold the same in all adjusted positions.

20. In a variable electronic component as claimed in claim **19** wherein,

a. the contact means is u-shaped and is stressed to coact with the support means for holding said movable member in adjusted position,

b. the respective open ends of the u-shaped contact means and the u-shaped support means facing each other, and

c. said movable means is forced into engagement with the u-shaped contact means to move it into adjusted position.

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