

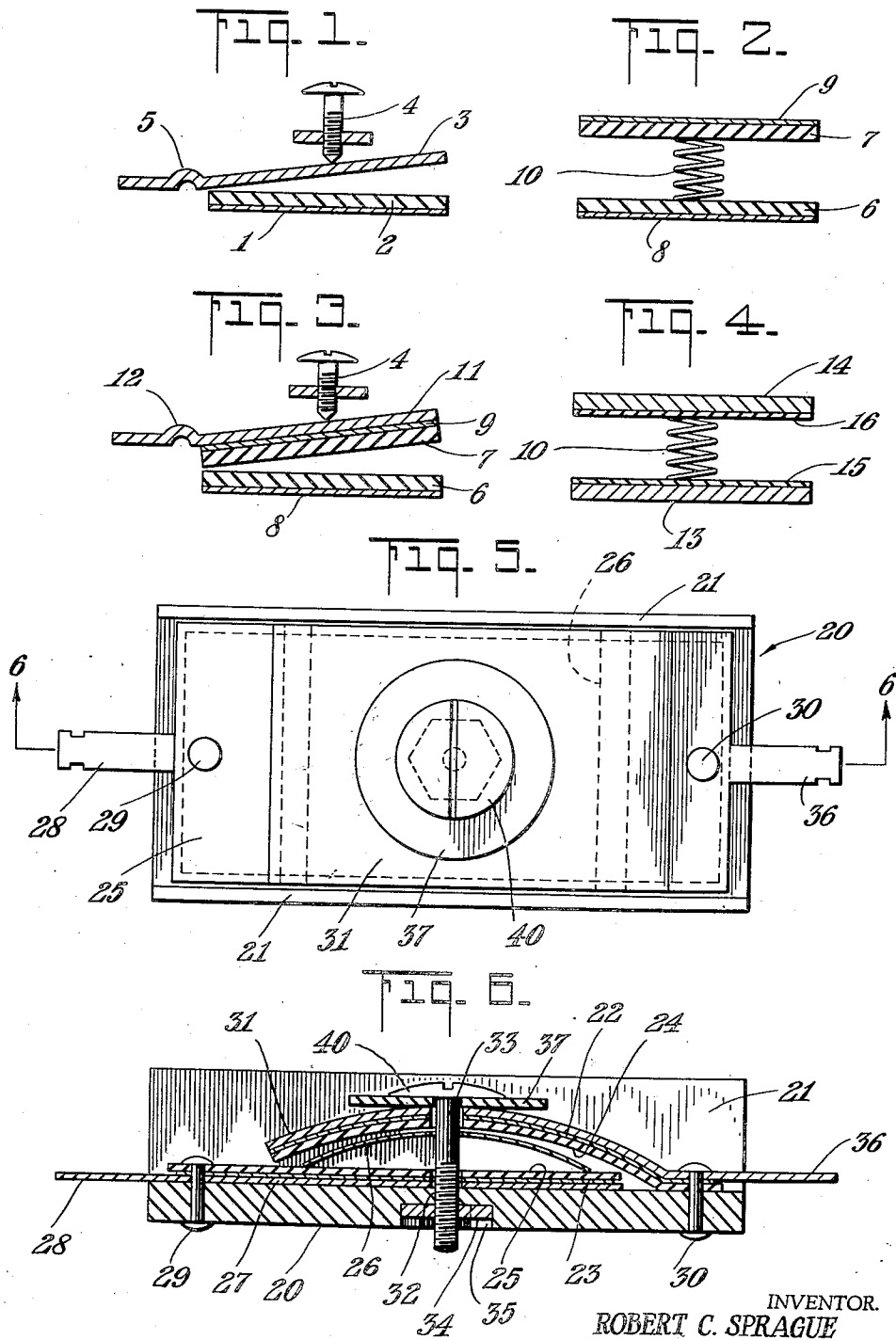
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VARIABLE CONDENSER

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VARIABLE CONDENSER

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The present invention relates to variable condensers, and will be described in connection with the type commonly known as trimmer or padding condensers which find their chief application as semi-adjustable means for tuning the resonant circuits of radio receivers to fixed selected frequencies.

Such condensers usually comprise as their main elements at least one fixed and at least one flexible and/or adjustable metal plate or armature, between which metal plates is disposed a layer of dielectric material, for example, of mica, the assembly being mounted on a suitable base of low-loss insulating material. To obtain a continuous variation of the capacity, the flexible plate is made of a resilient material having a high degree of elasticity, and its capacitative relationship to the fixed plate is varied by flexing it towards or away from the fixed plate by means of an adjustment screw or the like.

The main difficulty heretofore encountered in prior art condensers was that they were incapable of maintaining their adjusted capacity value, mainly because of the temperature changes and vibration to which the condensers are normally subjected in operation.

Such influences, as just stated, affect the capacity of the condenser by changing the effective area of the plates, the effective distance between the plates, and the effective dielectric constant of the dielectric.

There have been various suggestions to overcome these difficulties either by constructions preventing changes in the adjusted capacity of the condenser or by auxiliary means which would compensate for such changes. Such solutions were only partly successful, i. e., only to the extent that they eliminated or compensated for capacity changes which were of a regular and predictable nature.

I have found, however, that in practice capacity changes take place in the operation of such condensers which are highly irregular and of an erratic and unpredictable nature and the influence of which has not been and could not be overcome in prior art constructions.

My invention, therefore, relates to adjustable condensers particularly of the so-called trimmer type, in which the possibility of such unpredictable capacity changes is eliminated. The occurrence of such unpredictable capacity changes can be explained as follows:

In the assembled condenser the fixed electrode plate is intended to contact with its entire effective surface with the dielectric layer, whereas

the flexible or adjustable plate contacts therewith with a smaller or larger surface depending upon the adjustment of the condenser.

An air gap defined by the flexible plate and the dielectric layer—normally consisting of a mica sheet—forms a second dielectric in series with the mica, and the adjustment of the condenser takes place by varying the average thickness of the air gap.

That the condenser for a given adjustment assumes a definite capacity value and that after passing through a heat cycle returns to such value, is predicated among other things on the assumptions that the contact between the electrode plates and the dielectric layer is perfect and that the air gap for a given setting is reliably defined by the flexible plate and the dielectric layer.

With the prior art constructions these assumptions are found not to be correct. While the adjusting means tends to press the dielectric layer against the fixed plate, the contact between the two is far from perfect. This is due to the facts that the fixed condenser plate and the dielectric layer consist of materials which are not plastic at ordinary temperatures, and that the surfaces of these elements and particularly that of the metal plate are microscopically rough. One result thereof is that an air film of indefinite and non-uniform thickness is formed between the fixed plate and the contacting dielectric layer.

In operation this air film changes its effective area and average thickness for various reasons. For example, when the condenser heats up in operation, the electrode plate and the dielectric layer, because of their different expansions, are relatively displaced.

Again when cooling down, these elements contract and tend to assume their former relative position; however, the friction between their contacting surfaces interferes with this.

Furthermore, at the higher operating temperatures the materials of the condenser elements become increasingly plastic, and have a tendency to flow into each other, and as a rule the condensers after having passed a number of heat cycles are found to have increased in capacity.

From the above it will be noted that the imperfect contact between the dielectric layer and the fixed electrode plate, and the variations in the extent and effective thickness of the air film between same, cause capacity variations of the condenser, which are of an erratic nature and which have not been taken care of in prior art constructions.

To eliminate the capacity variations due to the imperfect contact and the air film between the dielectric layer and the fixed condenser electrode, I provide between the two a perfect molecular contact either by applying to the fixed plate a thin firmly-adhering dielectric layer, or preferably by forming the fixed condenser plate as a thin metallic layer firmly adhering to the dielectric layer. The latter may be achieved by various well-known methods, for example, by electroplating, painting or spraying the metal—in a finely divided state and held by a suitable binder—onto the dielectric layer.

While the above measure removes partly the causes responsible for the erratic capacity variations found in such condensers, it did not eliminate them altogether.

More particularly, I found that a condenser in which the fixed electrode was formed as a metallic layer adhering to the dielectric gave satisfactory results as long as the percentage capacity adjustment was small; i. e., as long as the flexible electrode contacted only with a small portion of the dielectric layer. However, at large percentage capacity adjustments the behavior of the condenser was not much more satisfactory than that of condensers of the prior art.

I found that this was due to an imperfect contact also occurring between the flexible plate and the dielectric layer and an air film also forming between their contacting surfaces, the effect of which, however, manifests itself only with large percentage capacity setting.

This can be explained as follows: As long as the capacity adjustment is small, the flexible electrode plate contacts with the dielectric layer over a very small surface. Consequently the pressure of the adjusting means is distributed over a small contact area, and the resulting high specific pressure insures a good contact. Furthermore, even if an air film is formed between the contacting surfaces of the flexible electrode and the dielectric layer, its extent and average thickness variations are small and thus any variations thereof have but a negligible influence on the condenser. However, for larger capacity settings the contacting surface of the flexible electrode increases, with a corresponding decrease of the specific pressure; this results in a poorer contact and produces an air film the variations of which, because of its greater extent and greater average thickness variations, have an important influence on the condenser capacity.

I have found that a trimmer condenser which at any capacity setting is free from erratic capacity variations, can be obtained if in accordance with the invention I use a construction in which the dielectric is divided into two layers. The two dielectric layers, for example two mica plates, are each provided with an outer adhering metallic coating, which coatings form the electrodes of the condenser.

To adjust the capacity of such a condenser various means may be used. For example, the two composite elements (each comprising a dielectric layer with an adhering metallic layer) may be adjustably spaced from each other by the interposition of a spring member of metal or of insulating material, or the composite elements may be biased externally, for example, by attaching to one of them a flexible spring member.

In the preferred embodiment the composite elements are adjustably biased by an interposed metal spring which may be either a leaf spring or a spiral spring. It should be well understood

that such metal springs, whatever their shape may be, do not electrically affect the condenser.

The condenser of the invention thus consists of two dielectric layers, for example of two mica plates interposed between two outer metal coatings adhering to them. As the metal coatings have a perfect molecular contact with their respective mica plates, and the variable air gap is defined by the two mica plates, changes in pressure of the adjusting means merely vary the average thickness of this air gap and no erratic capacity variations occur.

It should be noted that irrespective of the capacity setting and the extent of pressure by the adjustment means, the mica layers because of their smooth surface and identical hardness, neither scratch each other nor are they molecularly pressed into each other. It is important however to avoid sharp edges of the spring member and it is preferable that the contact area of the spring member with the mica plates remains substantially constant irrespective of the capacity setting.

In the drawing forming part of the specification:

Figure 1 is an enlarged schematic representation of a trimmer condenser in which the fixed plate is formed as a metallic layer coated on the dielectric layer;

Fig. 2 is a schematic representation of a trimmer condenser, comprising two composite elements each consisting of a dielectric layer and an outer adhering metal coating, and an interposed coil spring which serves as the capacity adjusting means;

Fig. 3 is a schematic representation of a condenser similar to that of Fig. 2, but with an outer leaf spring serving as the adjusting means;

Fig. 4 is a schematic representation of a trimmer condenser similar to that of Fig. 2, but with the composite elements consisting of dielectric layers deposited on solid electrode plates;

Fig. 5 is an enlarged plan view of a condenser similar to that of Fig. 2, but with a leaf spring used as the adjusting means;

Fig. 6 is a cross-sectional elevation along the line 6—6 of the condenser of Fig. 5.

Referring to the drawing, Fig. 1 represents schematically a trimmer condenser of the compression type in which a metallic layer 1 which firmly adheres to a dielectric layer 2, preferably of mica, serves as the fixed electrode of the condenser. The metallic layer 1 may consist of a thin layer of silver, gold, platinum, zinc, copper, or the like deposited by various known methods on the mica layer 2. As a rule I prefer to use for the metallic layer silver and deposit same by the process described in the copending application of William M. Allison and Mathew Nazzewski, Ser. No. 153,824, filed July 15, 1937. This process also provides for a clean insulating border on the mica, which eliminates any possibility of electrical leakage at the edges.

A flexible metallic plate 3 of phosphor bronze, or other similar resilient metal, serves as the adjustable electrode of the condenser. The capacity of the condenser may be varied by flexing the plate 3 towards or away from the armature 1 by a suitable adjusting means shown as a screw 4. By distorting a portion of the plate, for example, by forming a pintle 5, plate 3 is mechanically biased to press against the adjustment screw 4.

As stated before, a condenser of a construction as shown in Fig. 1 will perform satisfactorily only for small percentage capacity settings. How-

ever, the condensers hereafter described in connection with Figs. 2 to 6 perform satisfactorily at any adjustment within their capacity range.

The condenser of Fig. 2 comprises two dielectric layers 6 and 7, preferably two mica plates, the outer faces of which are provided with adhering metallic layers 8 and 9 respectively, which form the electrodes of the condenser. The metallic layers 8 and 9 are preferably formed in the same manner as has been stated in connection with layer 1 of Fig. 1. The mica plates 6 and 7 are distanced from each other by an interposed helical metal spring 10, which for the adjustment of the capacity of the condenser is compressed by external adjusting means (not shown) to the desired extent.

The condenser of Fig. 3 is similar to that of Fig. 2, except that the mechanical biasing means are formed by an external resilient metal plate 11 attached to the armature 9 and provided with a distorted pintle section 12. The capacity of the condenser is adjusted by varying the average distance between the composite elements, for example by the adjustment screw 4.

The condenser illustrated in Fig. 4 comprises two metallic plates 13 and 14 serving as the condenser electrodes, each plate being provided on its inner surface with an adhering thin dielectric layer 15 and 16 respectively. The layers 15 and 16 consist of a low-loss dielectric material and may be applied to the plates by various well-known methods, for example, they may be formed by painting or spraying on the metal plates 13 and 14 a thin film of a solution of "Victron" or of a suitable resin, whereby after the coating, the solvent may be volatilized by heating the plates. A very good dielectric layer for this purpose can be obtained by cataphoretically depositing on the surface of the plates a flexible insulating material such as hard rubber. By curing, the deposited insulating material forms a thin layer firmly adhering to the plate.

The condenser shown in Figs. 5 and 6 comprises a base 20 of an insulating material having low dielectric losses such as "Bakelite", porcelain or the like. The base 20 is provided on its top face with side walls 21—21 between which is disposed the condenser assembly, comprising two mica plates 24 and 25, the respective outer faces of which are provided with firmly adhering silver layers 22 and 23 respectively, the layers 22 and 23 forming the condenser electrodes.

The silver layers are preferably deposited by the above-mentioned process whereby to prevent electrical leakage, the edges of the mica plates 24 and 25 are left unsilvered. The composite element composed of the mica plate 25 and its silver backing layer 23 is flat and is secured to the base 20 by means of a rivet 29 together with a plate 27 interposed between the layer 23 and the base 20. The plate 27 is preferably of soft copper or other highly conducting metal and serves as a low-resistant electrical connection for the electrode layer 23. The plate 27 is provided with an extending lug portion 28 forming one of the outside terminals of the condenser.

Interposed between the mica plates 24 and 25 and pressing against the mica plate 24 is a curved rectangular spring plate 26 made of phosphor bronze or similar highly resilient material. On top of the composite element 22—24 is a curved resilient rectangular metallic plate 31 which serves as a low resistant contact for the electrode layer 22. The plate 31 is provided with an extending lug 36 which serves as the second ex-

ternal terminal of the condenser. The plate 31, and the composite element 22—24 are secured to the base 20 by a rivet 30.

The base 20 is provided with a central hole 32 adapted to receive a screw 33, which screw passes through corresponding apertures of the plate 27, composite element 23—25, spring 26, composite element 22—24, and plate 31, the respective apertures of these parts being sufficiently large to prevent contact between same and the screw. The screw 33 with its nut 34 disposed in an hexangular recess 35 of base 20, forms the adjustment means of the condenser.

Interposed between the head 40 of the screw 33 and the plate 31 is an insulating washer 37 of mica, porcelain, "Bakelite", or the like.

As will be noted from the drawing, the composite element 22—24 is sufficiently flexible to assume under the pressure of curved spring plate 26 substantially the same shape as has the curved plate 31; this holds for any position which the plates 31 and 26 may assume due to the different settings of the adjustment screw 33. The arrangement also provides for sufficient elasticity of composite element 22—24 to permit a smooth continuous variation of the capacity setting.

The side walls 21—21 of the base serve to prevent rotation of the parts about the rivets 29 and 30.

I have found that the wearing qualities of the metallic layers 22 and 23 are much improved by either providing on top of the same a coating of a hard metal as copper electrolytically deposited thereon or by making the metallic layer as such a harder and thicker coating.

The insulating base 20 can also be replaced by a metal base which may at the same time serve as the conducting plate 27, whereby no side walls are required as the riveting of the condenser elements to a metal base insures them from displacement. In this case the rivet 30 is to be insulated from the base.

I have found that condensers made in accordance with my invention, show remarkable stability in capacity, irrespective of the number of heat cycles or the temperature ranges to which they are subjected.

For instance, when condensers made in accordance with the invention are placed in an electric oven and passed through three consecutive heat cycles, from 25° C. to 65° C. and back, no appreciable change in their capacity can be detected, while condensers of the prior art subjected to the same test, show permanent capacity changes of several percent, whereby the higher the initial capacity of the condenser, the greater the change. I have found that even the best of present day condensers have capacity drifts three or four times as great as the condensers of my invention.

Furthermore, the temperature coefficient of capacity of the condensers of the invention because of their high stability can be made positive or negative, or substantially zero, as it may be desired.

A further important advantage is that with trimmer condensers made in accordance with the invention, maximum capacity settings can be obtained which are about 50% greater than those of prior art condensers having the same dimensions and total thickness of the dielectric layer.

While I have described my invention in connection with specific embodiments and examples, I do not wish to be limited thereto, but desire the appended claims to be construed as broadly as permissible in view of the prior art.

What I claim is:

1. In an adjustable condenser, a condenser electrode, a flexible composite element consisting of a metal layer and a dielectric layer, said layers being in molecular contact with each other, said element adapted to be flexed relative to the electrode to vary the capacity of the condenser.
2. In an adjustable condenser, a condenser electrode, a flexible composite element consisting of a thin dielectric layer and a thin metallic layer disposed on one face of said dielectric layer and in molecular contact therewith, said element adapted to be flexed relative to the electrode to vary the capacity of the condenser.
3. In an adjustable condenser, two mica plates and two metallic layers serving as electrodes, one metallic layer forming a strongly adhering outer coating on one mica plate and the other metallic layer forming a similar layer on the other mica plate, said mica plates facing each other and means to vary the capacity of said condenser by flexing one of said layers towards the other.
4. In a trimmer condenser, a stationary electrode and a flexible electrode, and a dielectric layer interposed between said electrodes, said dielectric layer comprising a thin flexible mica plate, said flexible electrode consisting of a me-

tallic layer adhering to the outer face of said plate, a resilient metallic backing member in electrical contact with said flexible electrode, resilient distancing means contacting with the inner face of the mica plate, and adjusting means to vary the shape of the mica plate and its average distance from the stationary electrode, said mica plate assuming substantially the shape of said backing member.

5. An adjustable condenser comprising a composite element consisting of a mica layer and a metallic layer adhering to the outer face thereof, said metallic layer forming the stationary electrode of the condenser, a second composite element consisting of a flexible mica plate and a metallic coating adhering to the outer face thereof and forming the adjustable electrode of the condenser, a resilient metallic backing member in electrical contact with said coating, a concave spring member interposed between the two mica plates, and adjustment means to vary the shape of the flexible mica plate and its average distance from the stationary electrode, said mica plate assuming substantially the shape of said backing member.

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