Oct. 31, 1950 E. G. LINDER 2,527,946

TUNABLE MICROWAVE DEVICE

Filed Aug. 23, 1946

Fig. 1

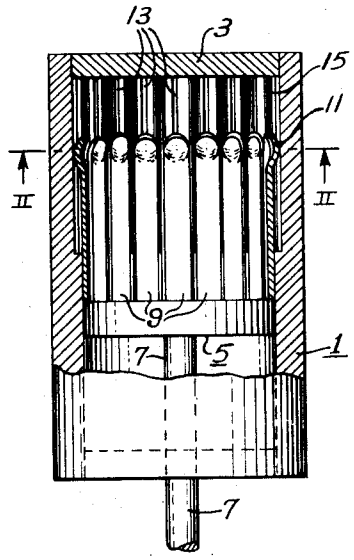
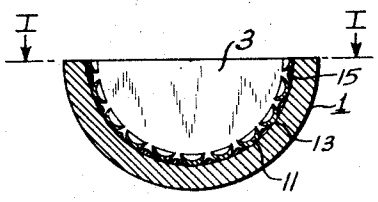


Fig. 2



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Patented Oct. 31, 1950 2,527,946

UNITED STATES PATENT OFFICE

2,527,946

TUNABLE MICROWAVE DEVICE

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Application August 23, 1946, Serial No. 692,535

7 Claims. (Cl. 178—44)

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This invention relates generally to super-high-frequency apparatus and more particularly to an improved tunable microwave device of the type utilizing an adjustable tuning piston in a microwaveguide or cavity resonator.

Heretofore various types of tuning pistons for waveguides and cavity resonators have been employed to vary the effective length of resonant microwave cavities. However, many such slidable pistons have introduced serious power losses and undesirable wave reflections due to faulty electrical contact between the piston and the interior faces of the waveguide or cavity resonator. The terminating piston in such devices carries considerable circulating current and it is highly desirable that the contact resistance between the piston and the adjacent waveguide or resonator walls remain substantially constant.

It is well known that relatively movable surfaces disposed within evacuated chambers have relatively larger coefficients of friction than is the case with the same materials in air. Furthermore, materials having relatively low coefficients of friction either in air or in vacuo frequently have poor electrical conductivity and vice versa.

The instant invention contemplates the use of relatively hard materials having relatively low coefficients of friction for the inner walls and the piston contacts of an adjustable cavity resonator, wherein the inner resonator walls are coated or plated with relatively soft, high conductivity material to provide a low resistance surface for the relatively high circulating microwave currents. However since high conductivity materials, such as silver or copper, have relatively high coefficients of friction, the inner walls of the cavity resonator include channels through the thin high conductivity layer thereon which permit the piston contacts to engage directly with the low friction base substance under the high conductivity layer. Preferably, the channels should be arranged parallel to the direction of current flow in the resonator walls. Since the major portion of the inner surface of the cavity resonator still comprises the layer of high electrical conductivity material, the resistance thereof to circulating microwave currents is substantially unaffected by the channels which pass therethrough. Also, since low coefficient-of-friction materials only are in contact between the movable piston and the resonator walls, the resultant device is especially efficient for rapid, mechanically frequency-modulated systems wherein the piston position is rapidly and continuously changed.

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Among the objects of the invention are to provide an improved method of and means for tuning microwave resonators and waveguide systems. Another object is to provide an improved microwave tuning piston and cavity resonator having the advantages of high electrical conductivity, low coefficient of friction, and long operating life. A further object is to provide an improved microwave tunable device comprising a cavity resonator or waveguide structure consisting of low coefficient-of-friction material upon which is plated or deposited a layer of high conductivity material, and wherein channels are provided through said layer for contact with a movable element. An additional object is to provide an improved tunable microwave device for use in vacuo. A further object is to provide an improved tunable microwave device having long operating life and substantially uniform electrical characteristics.

The invention will be described in further detail by reference to the accompanying drawing of which Figure 1 is a partially cross-sectional elevational view of a preferred embodiment thereof taken along the section line I—I of Figure 2; and Figure 2 is a cross-sectional bottom view taken along the section line II—II of Figure 1. Similar reference characters are applied to similar elements throughout the drawing.

Referring to the drawing, a typical embodiment of the invention comprises a cylindrical cavity resonator 1 closed at one end by a plug 3 and having disposed therein a longitudinally adjustable tuning piston 5 including an actuating shaft 7. The walls of the cavity resonator 1 preferably are of some very hard material such as chromium plated or hardened steel, tungsten, or boron carbide. The inner surfaces of the cavity resonator are plated or coated with a layer of high electrical conductivity material, such as silver, to a depth at least equal to the skin thickness at the microwave frequency employed.

The tuning piston 5 is loosely fitted inside of the cavity resonator 1, and includes a plurality of finger contacts 9. The ends of the contacts remote from the piston 5 are curved or rounded to provide relatively small contact surfaces 11 which engage the hard steel or alloy resonator walls through narrow longitudinal channels 13 which are cut through the high electrical conductivity coating 15 on the inner resonator walls. Since the area of the actual contact points of the contact fingers 9 is very small, the area of the

hard resonator wall base material which must be exposed through the channels 13 also is small, and the circulating currents in the walls of the resonator flow almost entirely in the high conductivity layer 15. However, since the high conductivity layer 15 is not in direct contact with the edges of the piston or the piston contacts, there is relatively little wear or scratching of the relatively soft high conductivity surface.

Thus the invention disclosed comprises a novel tunable microwave waveguide or cavity resonator device including a tuning piston wherein the relatively movable elements are constructed of hard, low coefficient-of-friction materials where in contact, and the non-contacting portions thereof are plated or coated with high electrical conductivity material to provide low resistance paths for circulating microwave currents, and long operating life with uniform operating characteristics.

I claim as my invention:

1. In a tunable microwave device including a conductive microwave chamber of hard material having a low coefficient of friction with a movable tuning element disposed therein, the improvement comprising at least one contact finger on said element for contacting the inner walls of said chamber, and a thin layer of high electrical conductivity material disposed upon the inner walls of said chamber for carrying circulating currents thereon, said layer having a plurality of narrow longitudinal channels extending through said layer in registry with said contact fingers for permitting said fingers to slide upon and contact directly with the underlying chamber walls having low coefficient of friction therewith.

2. In a tunable microwave device including a conductive microwave chamber of hard material having a low coefficient of friction with a movable tuning element disposed therein, the improvement comprising at least one contact finger on said element for contacting the inner walls of said chamber, and a thin layer of high electrical conductivity material disposed upon the inner walls of said chamber for carrying circulating currents thereon, said layer having a plurality of narrow longitudinal channels extending through said layer parallel to the direction of current flow in the inner walls of said chamber and in registry with said contact fingers for permitting said fingers to slide upon and contact directly with the underlying chamber walls having low coefficient of friction therewith.

3. In a tunable microwave device including a microwave cavity resonator of hard conductive material having a low coefficient of friction with a movable tuning piston disposed therein, the improvement comprising a plurality of contact fingers on said piston for contacting the inner walls of said resonator, and a thin layer of high electrical conductivity material disposed upon the inner walls of said resonator for carrying circulating currents thereon, said layer having a plurality of narrow longitudinal channels extending through said layer in registry with said contact fingers for permitting said fingers to slide upon and contact directly with the underlying resonator walls having low coefficient of friction therewith.

4. In a tunable microwave device including a conductive waveguide of hard material having a low coefficient of friction with a movable tuning piston disposed therein, the improvement comprising a plurality of contact fingers on said piston for contacting the inner walls of said waveguide, and a thin layer of high electrical conductivity material disposed upon the inner walls of said waveguide for carrying circulating currents thereon, said layer having a plurality of narrow longitudinal channels extending through said layer in registry with said contact fingers for permitting said fingers to slide upon and contact directly with the underlying waveguide walls having low coefficient of friction therewith.

5. In a tunable microwave device including a conductive evacuated microwave chamber of hard material having a low coefficient of friction with a movable tuning element disposed therein, the improvement comprising a plurality of contact fingers on said element for contacting the inner walls of said chamber, and a thin layer of high electrical conductivity material disposed upon the inner walls of said chamber for carrying circulating currents thereon, said layer having a plurality of narrow longitudinal channels extending through said layer in registry with said contact fingers for permitting said fingers to slide upon and contact directly with the underlying chamber walls having low coefficient of friction therewith.

6. In a tunable microwave device including a conductive microwave chamber of hard material having a low coefficient of friction with a movable tuning element disposed therein, the improvement comprising a plurality of contact fingers on said element each having rounded projecting ends for contacting the inner walls of said chamber, and a thin layer of high electrical conductivity material disposed upon the inner walls of said chamber for carrying circulating currents thereon, said layer having a plurality of narrow longitudinal channels extending through said layer in registry with said ends of said contact fingers for permitting said ends of said fingers to slide upon and contact directly with the underlying chamber walls having low coefficient of friction therewith.

7. In a tunable microwave device including a microwave chamber of hard material having poor electrical conductivity and a low coefficient of friction with a movable tuning element disposed therein, the improvement comprising a plurality of contact fingers on said element each having rounded projecting ends for contacting the inner walls of said chamber, and a thin layer of high electrical conductivity material disposed upon the inner walls of said chamber and having a thickness at least equal to the skin-thickness for microwave currents at the operating frequncy for carrying circulating microwave currents thereon, said layer having a plurality of narrow longitudinal channels extending through said layer in registry with said ends of said contact fingers for permitting said ends of fingers to slide upon and contact directly with the underlying chamber walls having low coefficient of friction therewith.

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