Oct. 4, 1949. F. C. EVERETT 2,483,893

TUNABLE UNIT FOR HIGH-FREQUENCY CIRCUIT

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Fig. 1.

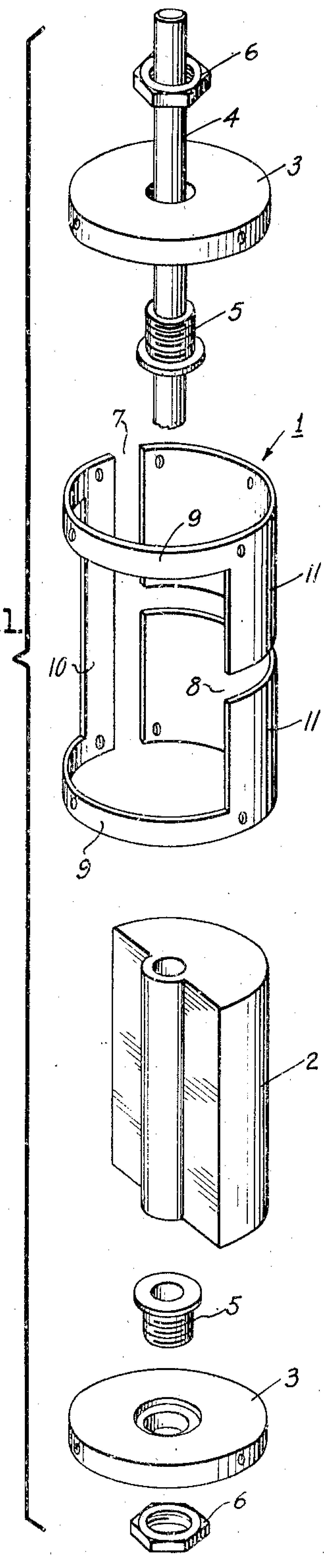


Fig. 2.

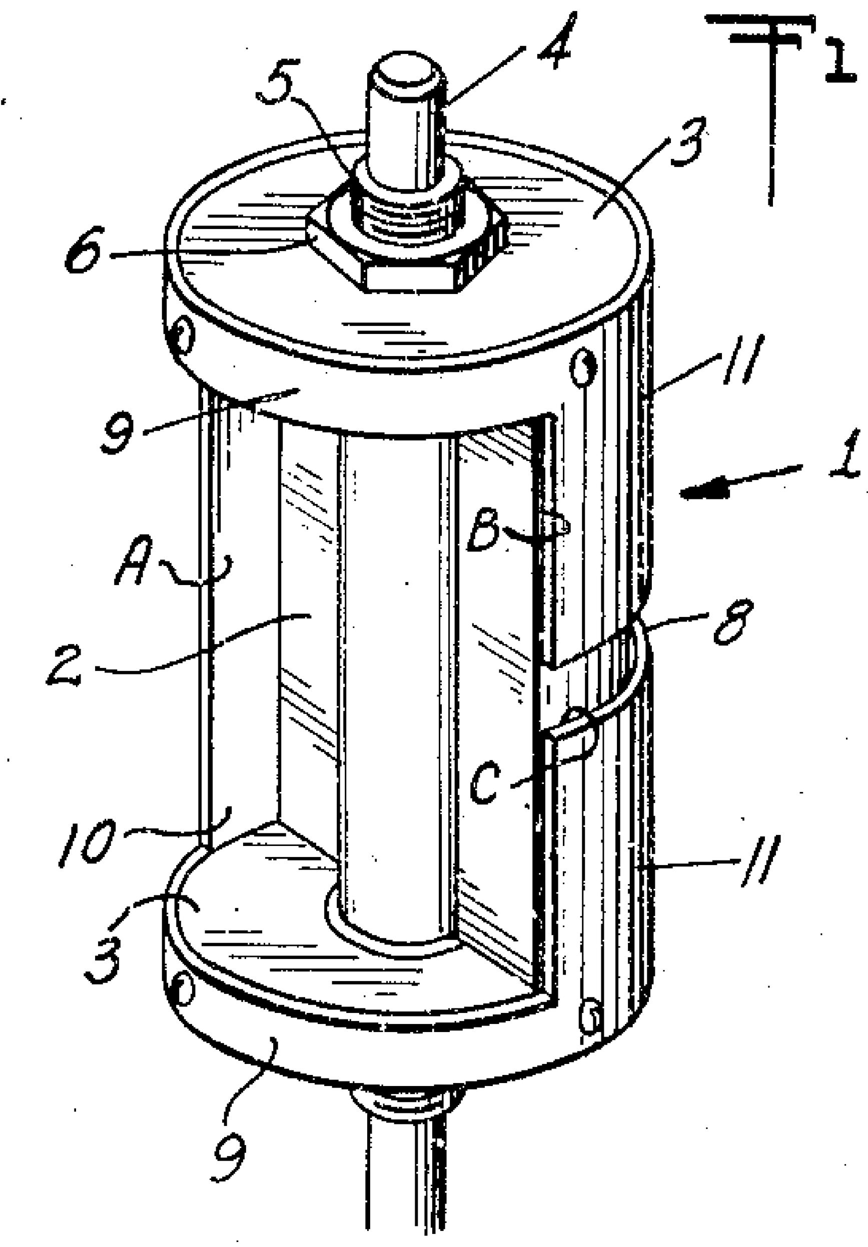


Fig. 3.

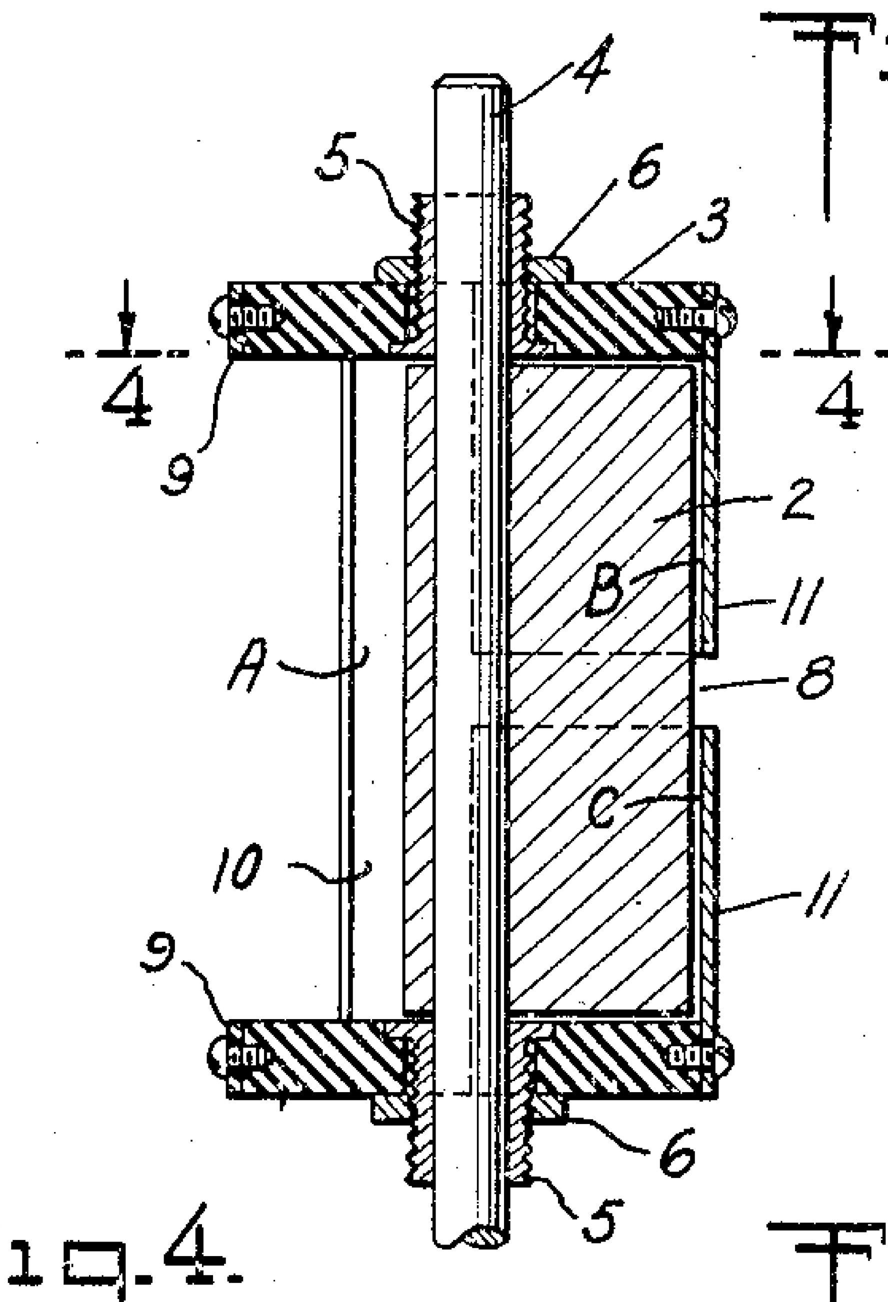


Fig. 4.

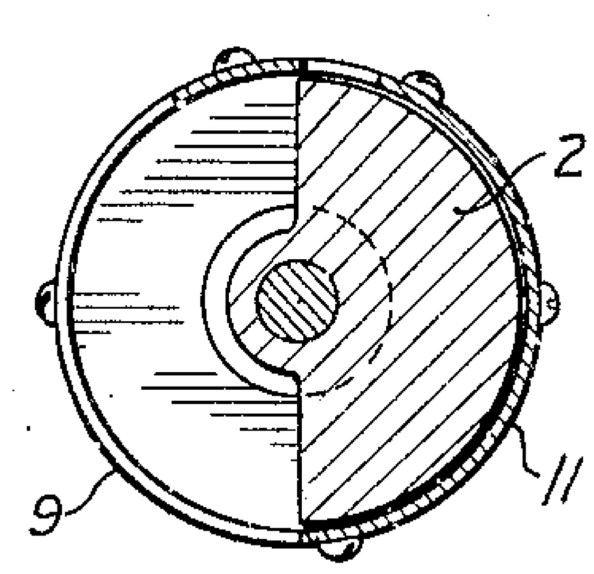
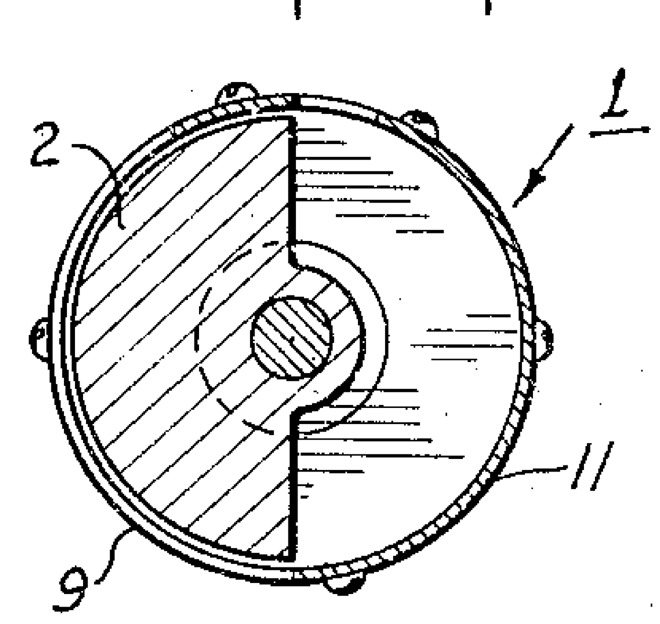


Fig. 5.



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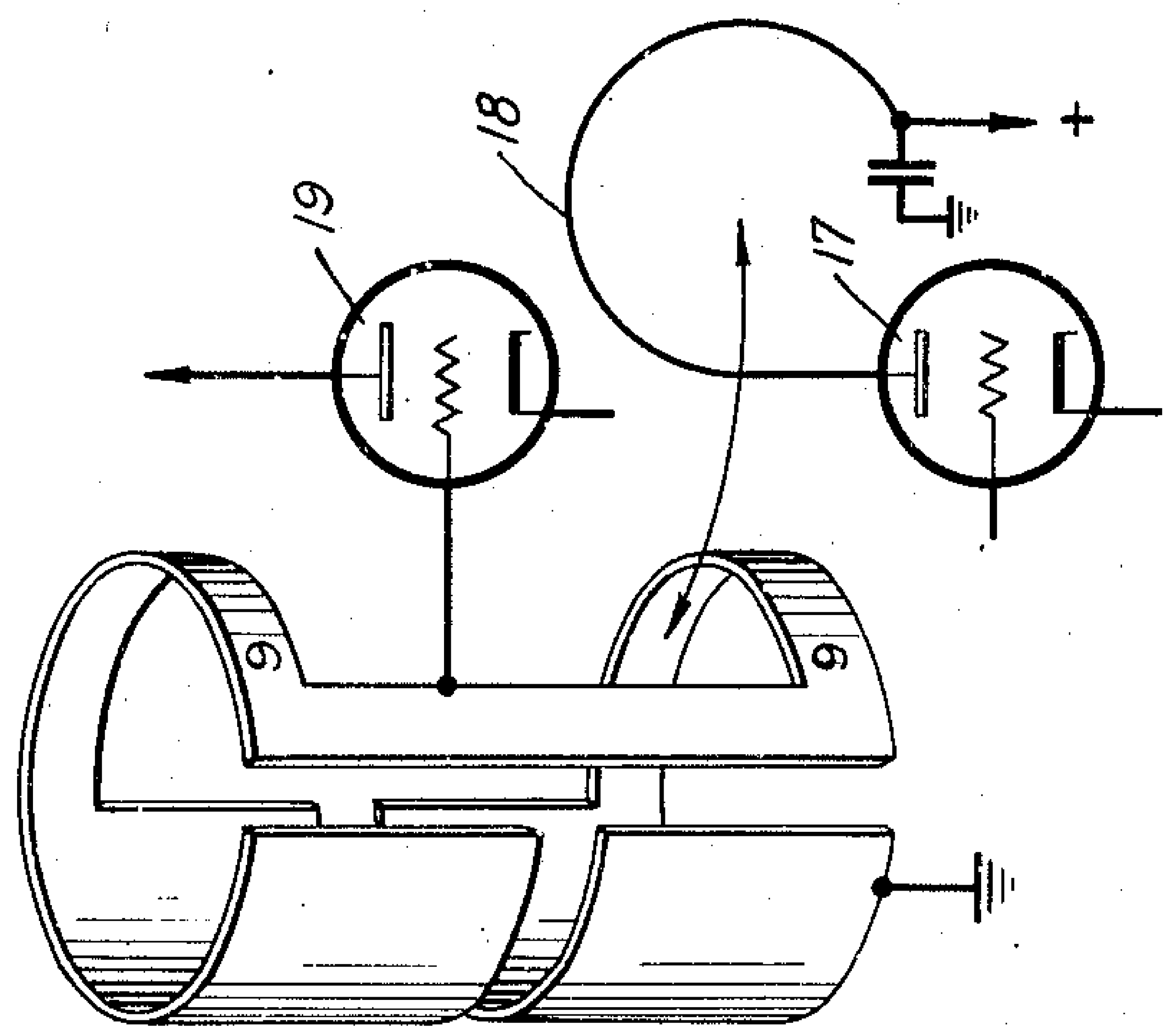

Fig. 7.

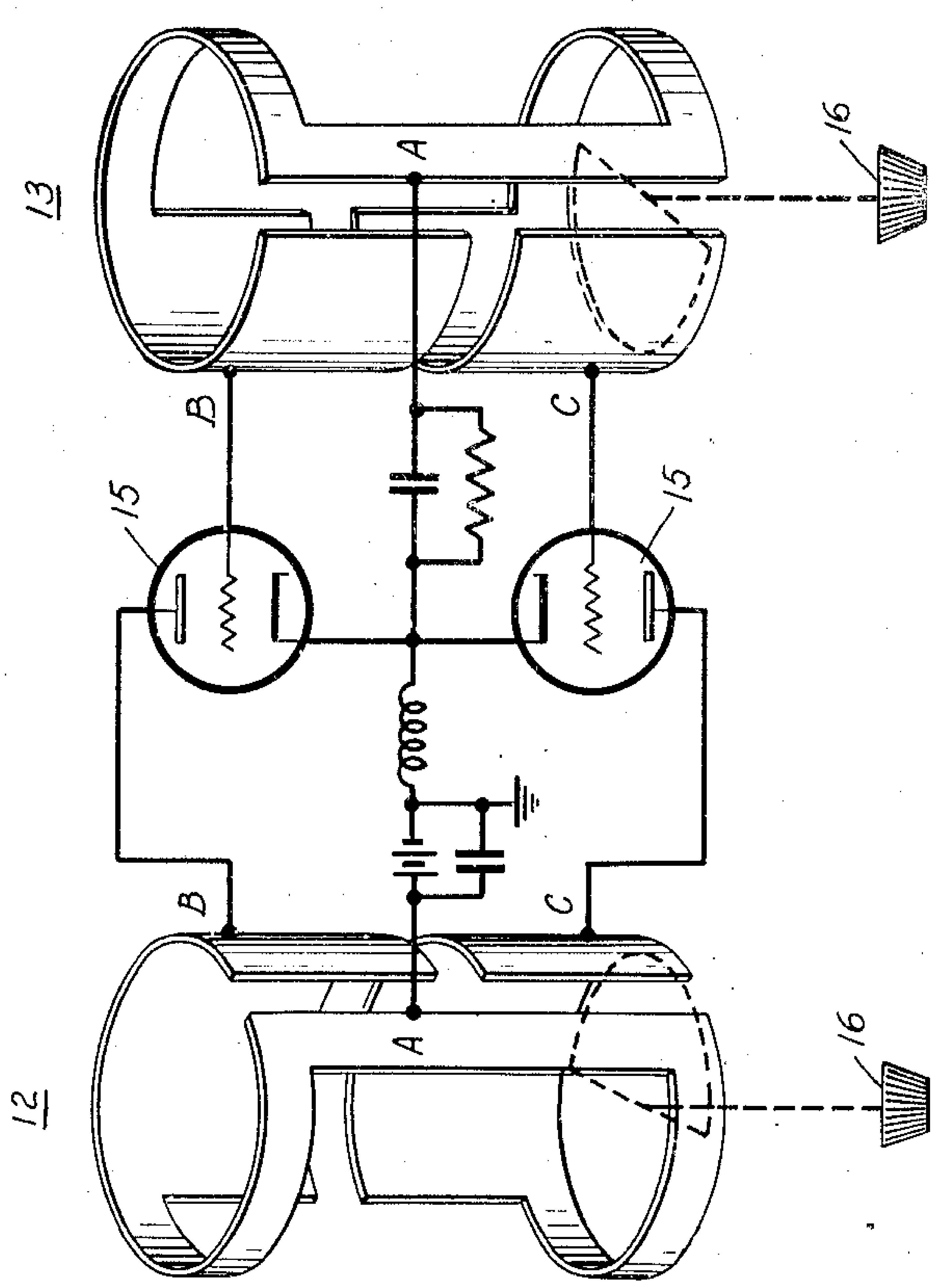

Fig. 6.

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TUNABLE UNIT FOR HIGH-FREQUENCY CIRCUIT

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Application November 19, 1945, Serial No. 629,664

8 Claims. (Cl. 178—44)

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This invention relates to tunable high frequency resonant circuits, particularly useful in the frequency range above 100 megacyles.

An object of the present invention is to provide a tunable resonant circuit suitable for use in the ultra high frequency range and having a center point which is always electrically balanced with respect to the output terminals for all tuning positions.

Another object is to provide a relatively high Q tuned circuit having appreciable surface area for the flow of radio frequency currents, and in which there are three connecting terminals one of which is always electrically balanced with respect to the other two.

A further object is to provide a novel mechanical construction of a tuned circuit which is tunable over a relatively wide radio frequency range and which eliminates the need for sliding contacts between movable elements.

A more detailed description of the invention follows in conjunction with drawings, wherein:

Fig. 1 is an exploded view of the tuned circuit of the invention showing the different parts which go to make up the mechanical construction;

Fig. 2 is a perspective view of the tuned circuit of the invention with the parts assembled into a unit ready for use with an ultra high frequency system;

Fig. 3 is a vertical cross-sectional view of Fig. 2;

Fig. 4 is a section of Fig. 3 along the line **4—4**;

Fig. 5 is a view similar to Fig. 4 with the rotor turned 180° relative to the showing of Fig. 4; and

Figs. 6 and 7 show uses of the tuned circuit of the invention in high frequency vacuum tube circuits.

The high frequency tunable circuit of the invention includes a hollow metallic stator **1** and a metallic rotor **2** positioned within and rotatable with respect to the stator. When completely assembled, the ends of the hollow stator are closed by insulating discs **3**. Rotor **2** may be either solid or hollow and is rotated by means of a shaft **4**. This shaft may be made of metal or insulating material and is held in position on the tuned circuit by means of threaded bushings **5** in which the shaft moves. These bushings are, in turn, locked by threaded lock nuts **6**.

The stator **1** consists of an open ended hollow metallic cylinder about half of which is removed. The remaining portion of the hollow cylinder is provided with a slot **7** cut parallel to the longitudinal axis and another slot **8** cut in the center at right angles to the longitudinal axis. As a re-

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sult of this construction, the stator **1** comprises two incomplete circular strips or ribbons of metal **9** joined together by another metallic strip or ribbon **10**, and two substantially half cylindrical sheets **11**. The strips or bands **9** can be considered to be single turn inductances, while the sheets **11** can be considered to be condenser plates. The half-cylindrical condenser plates **11** are arranged end-to-end on the same arc of a circle and are rigidly connected to the ends of the metal strips **9**, as shown, to constitute therewith a single integral unit.

Considered from another viewpoint, the two strips **9** can be viewed as the two conductors of a transmission line which is short-circuited at one end by metallic strap **10**.

The rotor **2** is substantially half of a metallic cylinder supported on insulated bearings or insulated end pieces **3**. This half cylinder is freely rotatable within the stator and forms a very small gap with the stator.

When the rotor **2** is in the position shown in Figs. 2, 3 and 4, its half cylinder will be closely spaced from plates **11**. In this position, the capacitance and the inductance of the tuned circuit is a maximum while the resonant frequency of the tuned circuit is a minimum. In other words, Figs. 2, 3 and 4 show the lowest frequency position of the tuned circuit. When the rotor is turned 180° from the showing of Figs. 2, 3 and 4 so as to assume the position of Fig. 5, the capacitance and the inductance of the tuned circuit is a minimum while the resonant frequency of the tuned circuit is a maximum. Stated otherwise, Fig. 5 shows the highest frequency position. In the position of Fig. 5, the rotor fills up the opening of the inductance loop and the lines of magnetic flux are restricted to the small gap between rotor and stator.

For intermediate positions of the rotor between those shown in Figs. 4 and 5, the capacitance and inductance (as well as the frequency of the tuned circuit) assume values intermediate the maximum and minimum.

By suitable design of the dimensions (diameter and length) of the stator and rotor elements, and proper choice of the gap or separation between rotor and stator, the tuned circuit can be made to tune to a wide range of frequencies of the order of hundreds of megacycles.

Moreover, by changing the shape of that portion cut out of the stator, a control can be had of the rate of variation of capacitance and inductance.

An important advantage of the present invention lies in the symmetrical change in capacitance and inductance about a center point. Thus, considering the center of strip 10 at point A (note Figs. 2 and 3) as the center point, and points B and C as output terminals, it will be observed that point A is always electrically balanced with respect to terminals B and C. This advantage is particularly useful when using the tuned circuit of the invention in a push-pull circuit.

Another advantage of the tuned circuit of the present invention is the fact that sliding contacts and pig tails which are present in conventional tuned circuits are eliminated. Further, there is no flow of radio frequency current through the shaft bearings.

A further advantage lies in the fact that the connection to the strip 10 is a tap on the inductance which prevents loss of Q in the tuned circuit due to the low impedance of vacuum tubes at very high frequencies.

If desired, the metallic strip 10 can be broken intermediate its ends, and various inductors bridged across the open ends of strip 10 to change the frequency range of the tuned circuit.

Fig. 6 illustrates how two tuned circuits of the invention designated 12 and 13 can be used as input and output circuits in a push-pull oscillator or amplifier. The cathodes of the two vacuum tubes 15 are connected to the center points A of the tuned circuits. The anodes are connected to points B and C on one tuned circuit 12, while the grids are connected to the points B and C on the other tuned circuit 13. The rotors have been incompletely shown by dotted lines in order not to detract from the simplicity of the drawing. These rotors are similar to the arrangements shown in Figs. 1, 2 and 3 and may be turned by knobs 16 individually, or ganged together.

Fig. 7 shows the tuned circuit of the invention used as a frequency determining interstage coupling network in a single ended high frequency vacuum tube system. The rotor has not been shown in order not to detract from the simplicity of the drawing. The tuned circuit is coupled to the anode vacuum tube electrode of one stage 17 by means of a coupling loop 18 which is magnetically coupled to one of the single turn inductors 9, and to the grid of another vacuum stage 19.

The invention is useful for ultra high frequency applications wherein circuits are used which are resonant to frequencies extending approximately from 100 to 1000 megacycles per second.

In one embodiment of the invention successfully tried out in practice, the stator was a copper cylinder having a thickness of about one-sixteenth inch, an inside diameter of about one and one-half inches, and a length of about two and one-half inches. The strips or bands 9 were about one-quarter inch wide. The slot 7 was about one-quarter inch wide, and the horizontal slot was about three-sixteenths inch wide. The tuning range extended from about 160 megacycles to 450 megacycles.

What is claimed is:

1. An ultra high frequency tuning unit comprising a pair of arcuate-shaped condenser stator plates positioned end to end on the arc of a circle and parallel to and on one side of the longitudinal axis of said tuning unit, individual incomplete annular metallic bands respectively connected at one end to and integral with said stator plates and forming parallel inductive paths, a metallic connection electrically joining said bands at their other ends, and a metallic rotor in capacitive relation to said stator plates and movable to vary both the capacitance and inductance of the unit.

2. An ultra high frequency tuning unit comprising a pair of arcuate-shaped condenser stator plates positioned end to end on the arc of a circle and parallel to and on one side of the longitudinal axis of said tuning unit, individual incomplete annular metallic bands respectively connected at one end to and integral with said plates and forming parallel inductive paths, said bands lying on a circle having the same dimensions as said first circle, a metallic connection electrically joining said bands at their other ends, and a metallic rotor in capacitive relation to said stator plates and movable to vary both the capacitance and inductance of the unit.

3. A high frequency tuning unit comprising a stator and a rotor, said stator comprising a hollow incomplete metallic cylinder having an appreciable portion removed from one side between the ends thereof, the other side of said cylinder being cut along a line at an angle to the longitudinal axis to form a pair of plates arranged end-to-end and located on one side of the longitudinal axis of the tuning unit, said rotor comprising an arcuate-shaped section of a metallic cylinder whose diameter is sufficiently different from the diameter of said stator to form a small gap therebetween as the rotor is turned, both ends of said stator forming incomplete annular bands constituting the major portion of the inductance of said tuned circuit, said plates forming the stationary plates of a variable condenser, the arcuate-shaped section of said rotor forming the variable plate of said variable condenser.

4. A high frequency tuning unit comprising a stator and a rotor, said stator comprising a hollow incomplete metallic cylinder having an appreciable portion removed from one side between the ends thereof, the other side of said cylinder being cut along a line substantially at right angles to the longitudinal axis to form a pair of plates arranged end-to-end and on one side of the longitudinal axis of said tuning unit, said rotor comprising an arcuate-shaped section of a metallic cylinder whose diameter is smaller than the inside diameter of said stator to form a small gap therebetween as the rotor is turned, both ends of said stator forming incomplete annular bands directly connected together at only one end and constituting the major portion of the inductance of said tuned circuit, said plates forming the stationary plates of a variable condenser, the arcuate-shaped section of said rotor forming the variable plate of said variable condenser.

5. A high frequency tuning unit comprising a stator and a rotor, said stator comprising a hollow incomplete metallic cylinder having about half its area removed from one side in such manner to leave incomplete annular bands at both ends of the cylinder, the other side of said cylinder being cut along a line substantially at right angles to the longitudinal axis to form a pair of condenser plates arranged end-to-end and on one side of the longitudinal axis of said tuning unit, said rotor being located within said stator and comprising about half of a metallic cylinder whose length is approximately coextensive with the length of said stator and whose diameter is smaller than the inside diameter of said stator to form a small gap therebetween, said plates forming the stationary plates of a variable condenser, said rotor forming the variable plate of said variable condenser, whereby the capacitance and inductance of said tuning unit

is a maximum when the maximum area of said pair of condenser plates is adjacent the maximum area of said rotor.

6. An ultra high frequency tuning unit comprising a pair of condenser plates of generally arcuate shape and positioned end to end on the arc of a circle, an incomplete curved metallic band joined at one end to one of said plates, another incomplete curved metallic band joined at one end to the other of said plates, said bands having substantially the same dimensions and the same curve, a metallic conductor electrically connecting said bands together at their other ends, said plates, bands and conductor forming an integral unit and being made of highly electrical conducting material, and an arcuate-shaped metallic element in capacitive and movable relation to said plates, whereby both the capacitance and inductance of the tuning unit are simultaneously variable.

7. A high frequency tuning unit comprising a stator and a rotor, said stator comprising a hollow incomplete metallic cylinder having an appreciable portion removed from one side between the ends thereof, the other side of said cylinder being cut along a line at an angle to the longitudinal axis to form a pair of plates arranged end-to-end and located on one side of the longitudinal axis of the tuning unit, said rotor comprising an arcuate-shaped section of a metallic cylinder whose diameter is sufficiently different from the diameter of said stator to form a small gap therebetween as the rotor is turned, both ends of said stator forming incomplete annular bands constituting the major portion of the inductance of said tuned circuit, said plates forming the stationary plates of a variable condenser and being connected to said bands, the arcuate-shaped section of said rotor forming the variable plate of said variable condenser, insulation plates secured to both ends of said stator for mounting said rotor, said rotor being located within said stator and mounted at both ends on said insulating plates, said rotor in one position having the arcuate-shaped section thereof adjacent to the end-to-end plates of said stator, whereby the capacitance and the inductance of the tuning unit is a maximum, and in an opposed position having the arcuate-shaped section adjacent said bands, whereby the capacitance and the inductance of the tuning unit is a minimum.

8. An ultra high frequency tuning unit comprising a pair of arcuate-shaped condenser stator plates positioned end-to-end on the arc of a circle and parallel to and on one side of the longitudinal axis of said tuning unit, individual incomplete annular metallic bands respectively connected at one end to the opposite ends of said plates and forming parallel inductive paths, said bands lying on a circle having the same dimensions as said first circle, a metallic connection electrically joining said bands at their other ends, and a metallic rotor in capacitive relation to said stator plates and movable to vary both the capacitance and inductance of the unit.

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