

Feb. 18, 1947.

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2,415,850

ULTRA-HIGH FREQUENCY LINE

Filed Dec. 31, 1942

2 Sheets-Sheet 1

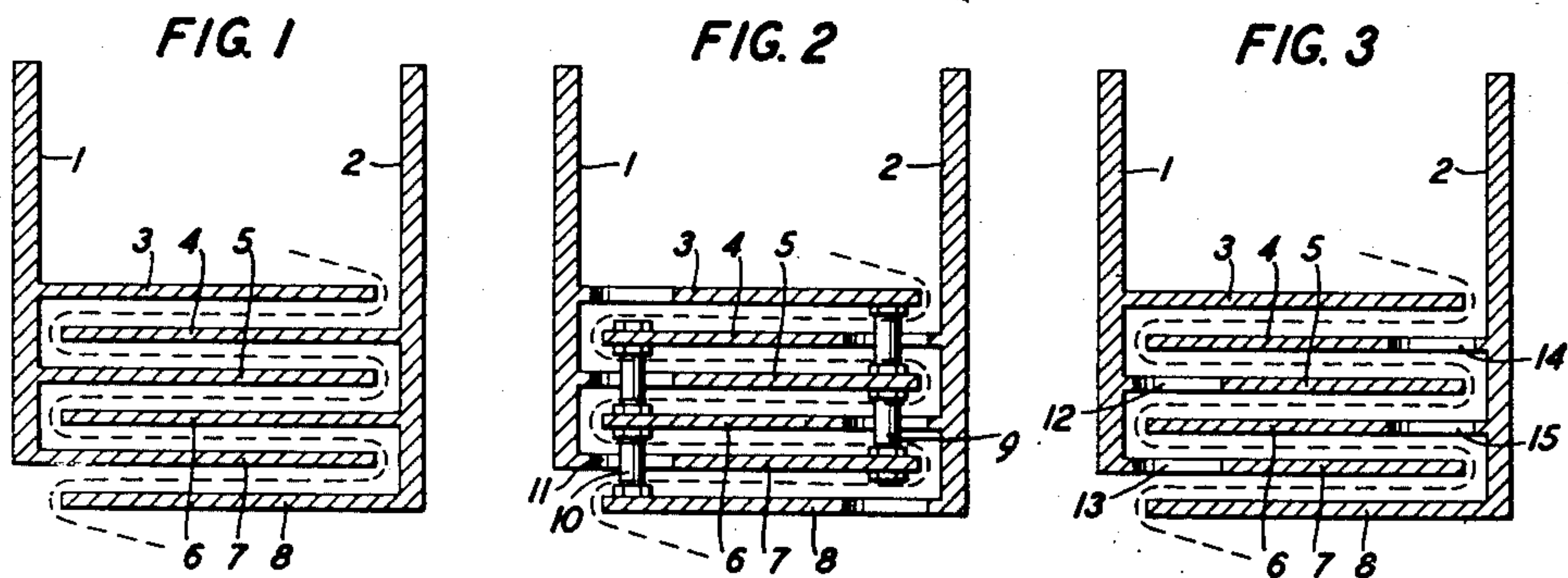


FIG. 6

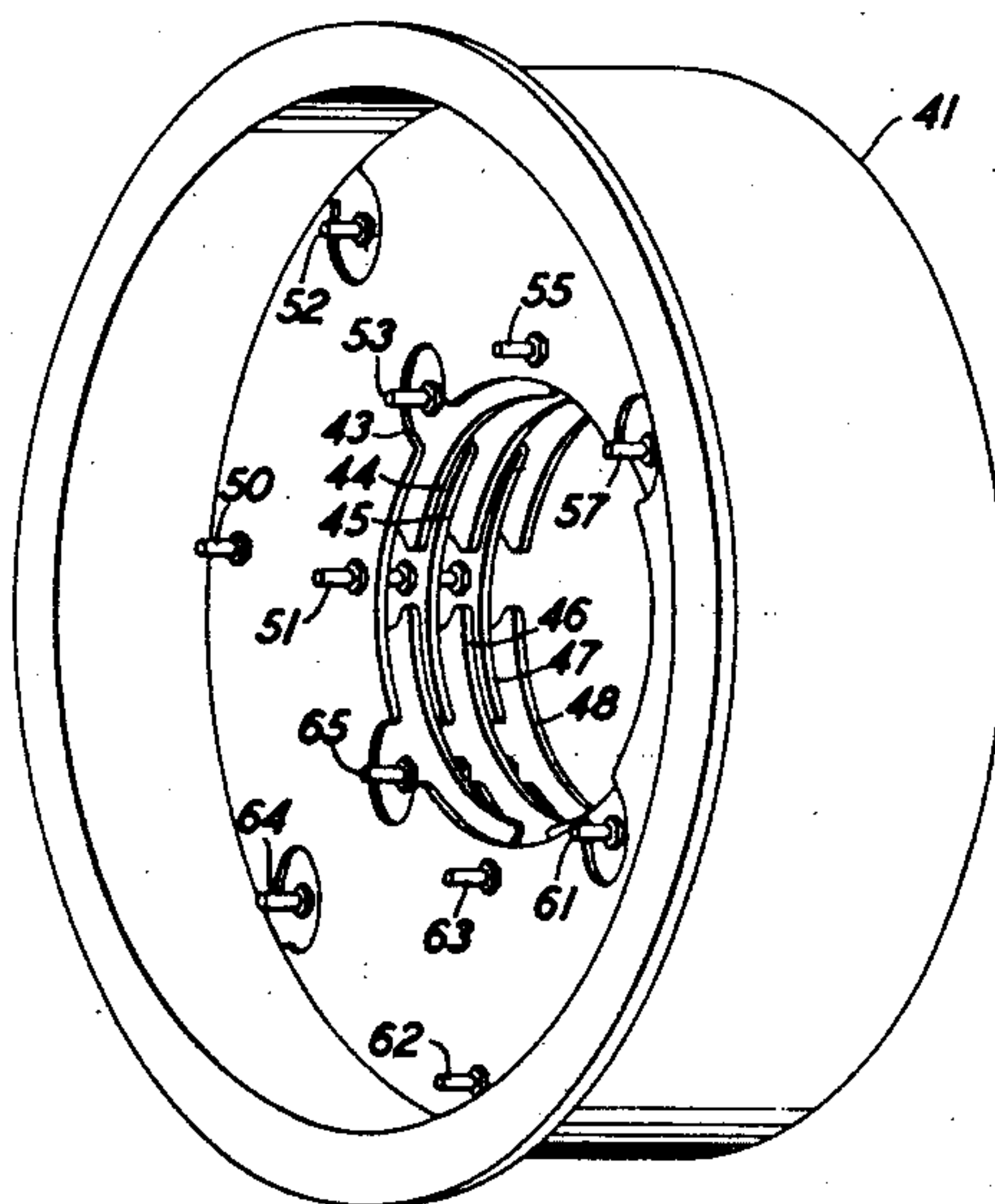
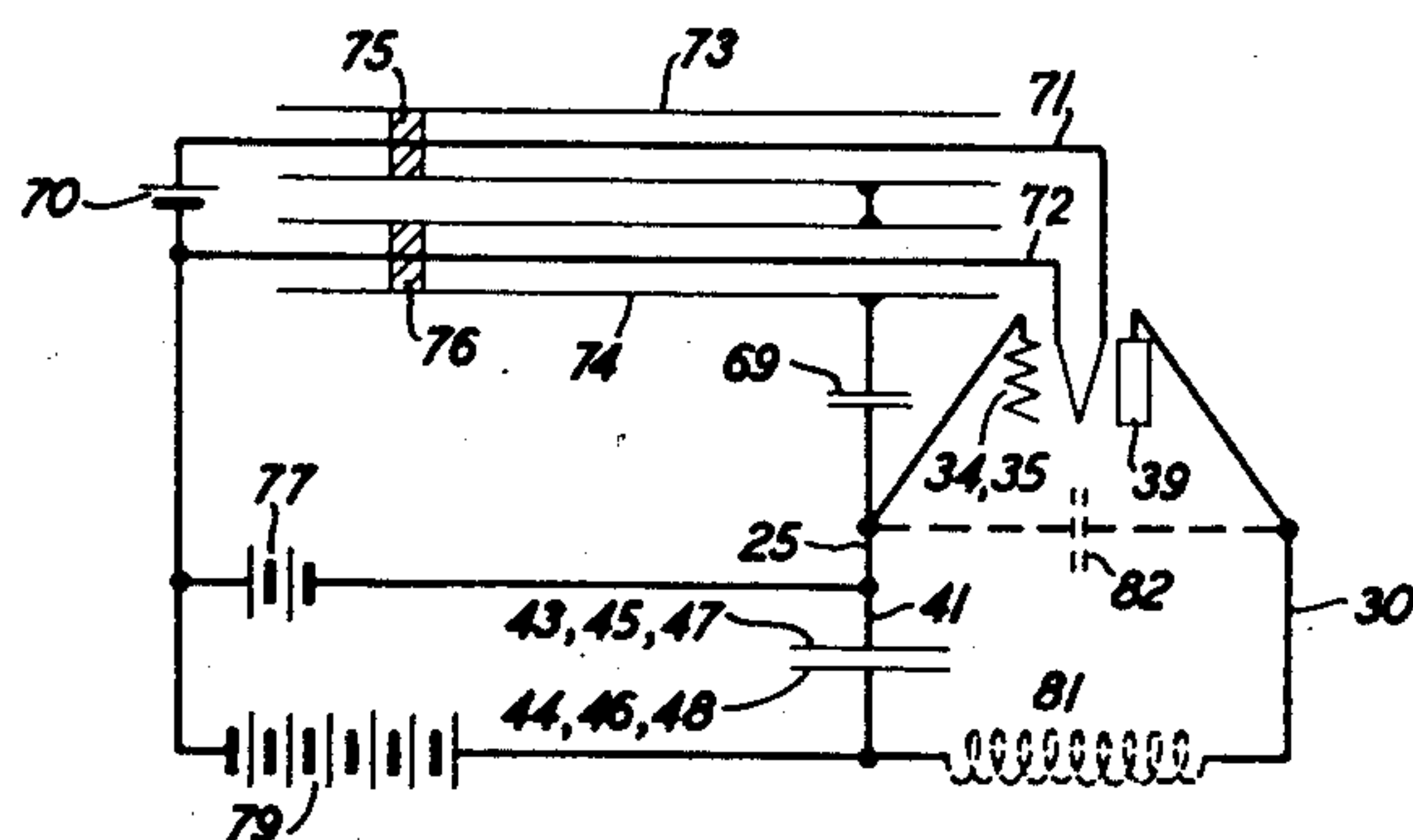


FIG. 7



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FIG. 4

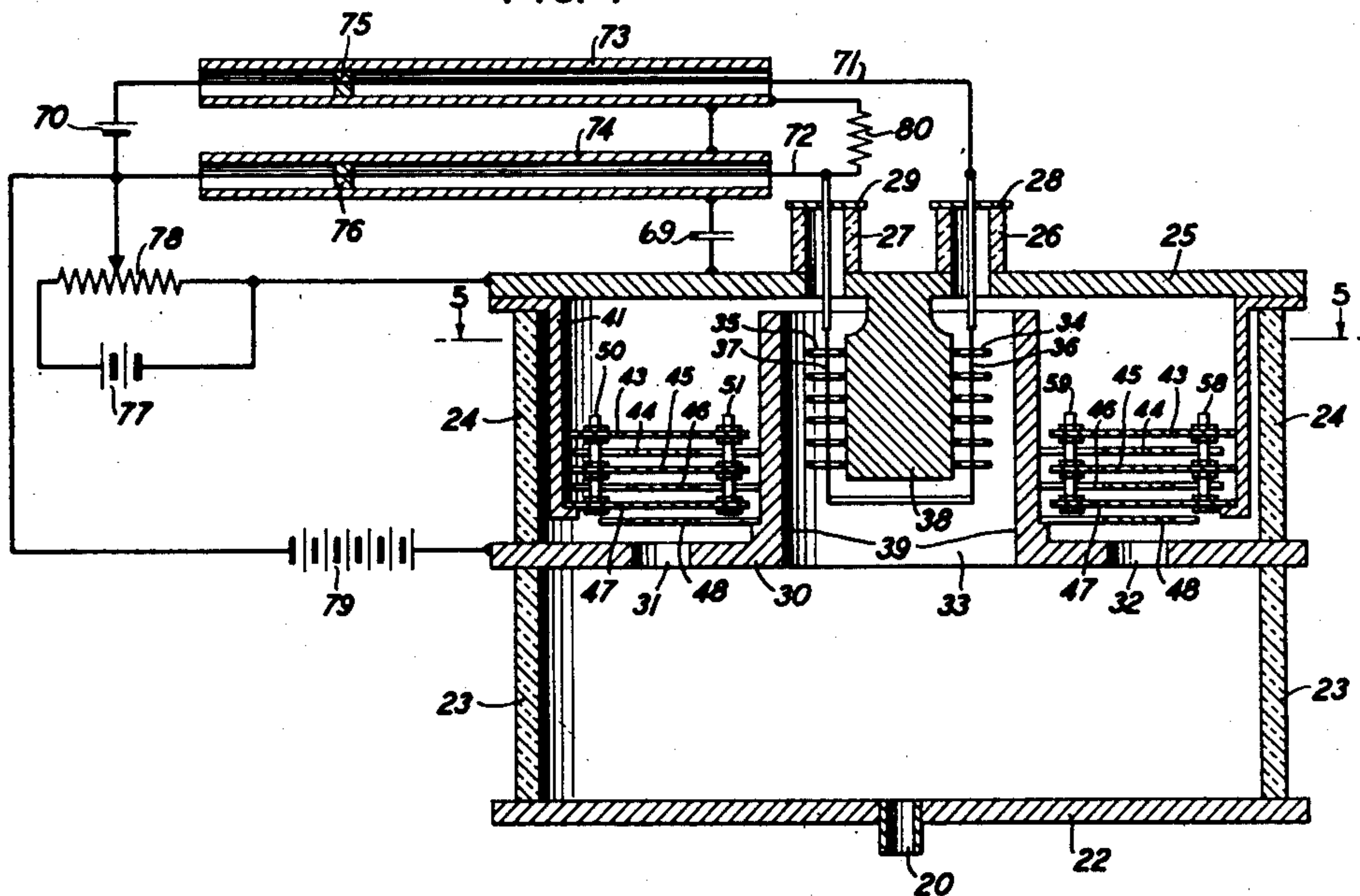
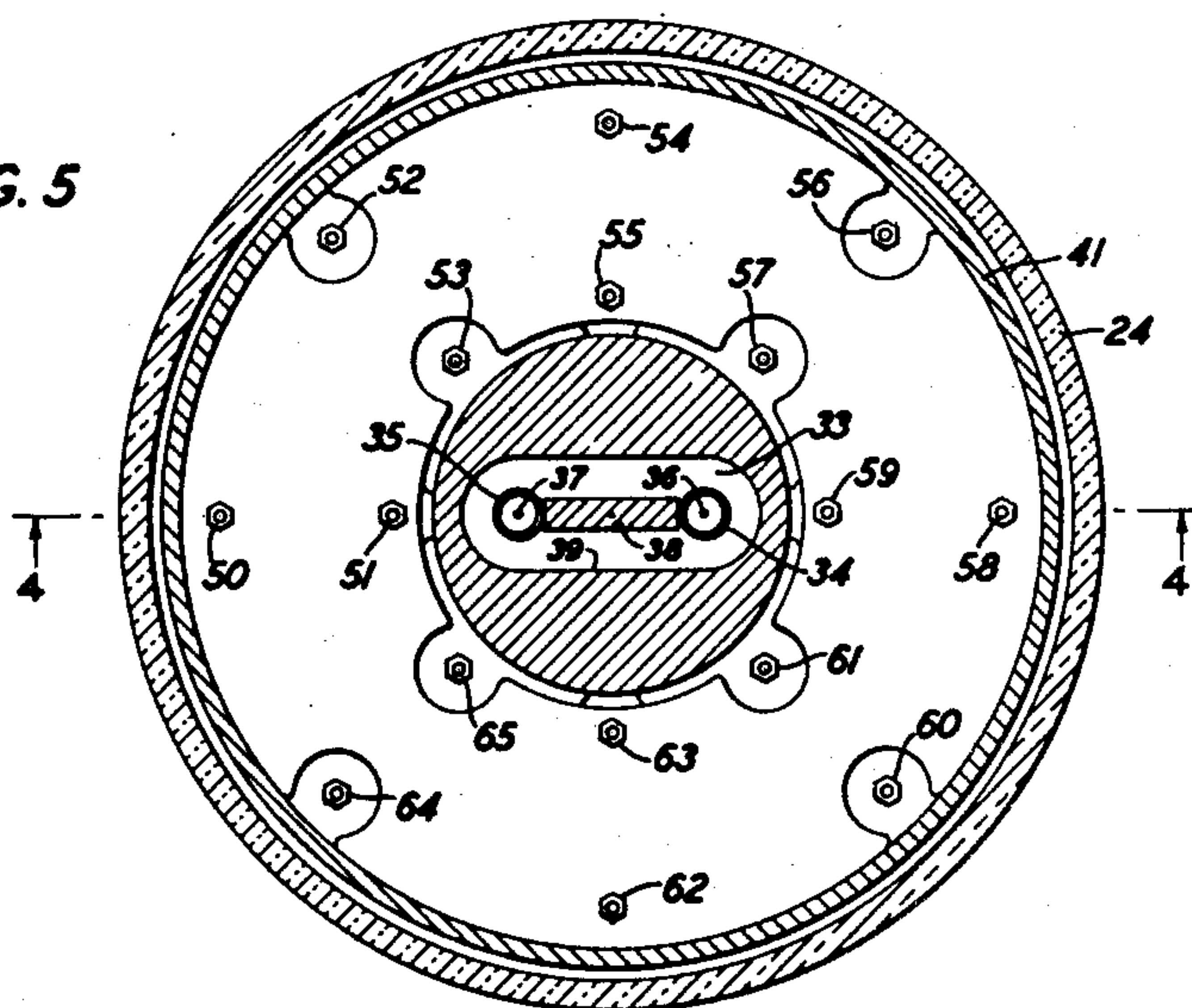


FIG. 5



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ULTRA HIGH FREQUENCY DEVICE

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7 Claims. (Cl. 178—44)

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This invention relates to high frequency circuits and more particularly to such circuits which employ electron tubes and by-pass condensers in connection therewith. However, the principle disclosed is applicable generally to such circuits requiring a condenser with low impedance at high frequency.

A principal object of the invention is to provide a high frequency circuit incorporating a by-pass condenser in which the by-pass condenser has an exceptionally low impedance at the operating frequency of the circuit.

Another object is to provide a cavity resonator type of circuit incorporating conveniently and efficiently a low impedance high frequency by-pass condenser.

Another object of the invention is to provide for high frequency current, a low impedance by-pass between portions of a circuit requiring insulation between them for direct current.

Another object is to provide a by-pass condenser capable of by-passing high frequency current with relatively low voltage between its terminals.

Another object is to provide such a condenser in a form particularly adaptable to use with a cavity resonator type circuit.

Another object is to provide a type of by-pass condenser structure generally applicable in producing low impedance high frequency condensers.

In the use of by-pass condensers in high frequency circuits, difficulty is often encountered due to inadequate by-passing of the high frequency current which results in the impression of unwanted high frequency voltage upon the by-passed circuit with attendant undesired radiation and losses. This occurs particularly at very high frequencies such as where the wave-length is of the order of the physical dimensions of the by-pass condenser and under this condition the difficulty may result from resonance effects which set up standing waves throughout the condenser structure so that regions of high voltage occur at which the condenser is not effective as a low voltage by-pass.

According to this invention, the difficulty arising from these resonance effects is avoided by effectively shortening the lengths of the free transmission paths in the condenser so that they are less than one-quarter wave-length at the operating frequency. In this manner, the paths otherwise long enough to permit resonance are broken up so that the standing waves and resulting regions of high voltage or high impedance are not produced. The transmission paths in a

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multiplate condenser are broken up or effectively shortened so far as resonance effects are concerned by interconnecting at appropriate points the alternate plates or the interplate spaces. The principle will be more clearly understood from the following description and the accompanying illustrations, in which:

Figs. 1, 2 and 3 are explanatory to the construction of the by-pass condenser;

Figs. 4, 5 and 6 illustrate the construction of an electronic tube circuit of which the condenser is a part; and

Fig. 7 is a schematic to make more evident the type of oscillator circuit incorporated in Fig. 4.

Where useful, the figures are partially schematic in order to illustrate circuit as well as mechanical characteristics.

Fig. 1 depicts a conventional form of multiplate condenser having terminals 1 and 2 and plates 3 to 8 spaced from each other and connected alternately to the two terminals. When a high frequency voltage is applied to the terminals, a field is set up between the plates and current is transmitted between the terminals. When such a condenser is used as a by-pass to shunt one portion of a circuit to exclude high frequency energy from it while completing the high frequency path of another portion of the circuit, it is desirable that the high frequency impedance of the condenser be low so that considerable current can be by-passed without any substantial voltage being developed across the condenser and thereby impressed upon the shunted portion of the circuit from which it is desired to exclude high frequency energy.

If the frequency is such that the wave-length is comparable to the distance across the condenser plates, resonance effects prevent a uniformly low voltage and effectively increase the impedance of the condenser thereby decreasing its effectiveness as a by-pass. It may be observed from Fig. 1 that the condenser plates with the space between them form a transmission line open at both ends and folded as indicated by the dotted line depicting the longitudinal path. The line conductors are the plates and the terminal interconnections which together bound the line in two transverse directions and enclose the electric field which is transverse as in one radial direction between the central and outer conductors of a coaxial line. It is evident that if this folded line has sufficient length, it may resonate when energized so that standing waves are set up in the electric field and where voltage loops occur, the

voltage between the condenser plates will be relatively high.

A preferred method of preventing this undesirable resonance, according to this invention, is shown in Fig. 2 illustrating the modification of a condenser of the type shown in Fig. 1. By this method the longitudinal path by which resonance occurs is broken up by additional interconnections between the plates. As shown, the free ends of alternate plates (the ends distant from the terminal interconnections) are additionally interconnected by leads 9 and 10 which pass through clearance holes in the intervening plates. These interconnecting leads short-circuit the folded path loops and thus shorten the free path lengths over which resonance can occur. For instance, it will be seen that the longitudinal path partially bounded by the surfaces of plate 7 and passing around that plate (first between plates 8 and 7, then between plates 7 and 6) is shunted by the short interconnection of the free ends of plates 8 and 6 by lead 10 passing through the clearance hole 11 in plate 7. If the plates should be appreciably greater than one-quarter wavelength in extent, additional intermediate interconnections preferably at random locations will be desirable to adequately break up the longer, otherwise free, path lengths. In any case, interconnections should be provided so that the lengths of free path are less than one-quarter wavelength.

Fig. 3 illustrates an alternative method of breaking up the resonance paths in the condenser. Here, at locations such as those of the interconnections in Fig. 2, the interplate spaces are interconnected by the holes 12, 13, 14 and 15 in the intervening plates. Such holes provide short paths for the current to pass between opposite surface of the plates and as mentioned above in connection with the interconnections of Fig. 2, additional intermediate holes should be provided when the plates extend appreciably greater than one-quarter wave-length.

Fig. 4 illustrates an electronic tube with a cavity resonator form of high frequency circuit arranged to function as an oscillator and incorporating a by-pass condenser such as is typified by Fig. 2. This is shown as an example of a practical application of the invention, it being understood that the condenser is also applicable to an amplifier arrangement or any other high frequency device requiring a condenser having such desirable characteristics. Fig. 5 and 6 show details to further illustrate the structure of Fig. 4. Fig. 5 is a section on 5—5 of Fig. 4 and Fig. 6 is a perspective view from the top of the by-pass condenser removed from the assembly of Fig. 4. Corresponding parts are similarly designated in Figs. 4, 5 and 6. Fig. 7 is a schematic illustrating the type of oscillator circuit incorporated in Fig. 4.

Fig. 4 depicts a continuously pumped vacuum tube which was operated at wave-lengths between 75 and 100 centimeters with plate voltages 3,000 to 5,000 and power outputs up to 200 watts. The tube and cavity structures are generally cylindrical and the figure shows an axial section, the axis being vertical. The tube is evacuated through the opening 20, the evacuated space 21 being bounded by the envelope comprising the flat member 22, the insulating cylindrical glass members 23 and 24, the conducting flat plate 25, the insulating cylindrical glass members 26 and 27 and the cap members 28 and 29. The joints shown where various members come together in

the path of the envelope are, of course, made airtight. The annular plate or anode member 30 with several openings such as 31 and 32 to facilitate evacuation and the central oval-shaped opening 33 surrounding the cathode and grid is clamped around the edges between the insulating glass members 23 and 24. The inner surface 39 of the opening 33 is the anode surface surrounding the grid structures 34 and 35 and the filamentary cathode members 36 and 37. The grid structures are connected to the plate 25 by the metallic grid supporting member 38. The by-pass condenser is made up of the annular plates 43, 44, 45, 46, 47 and 48. Plates 43, 45 and 47 are supported by the conducting member 41 and make contact with member 41 along the outer edges. It will be seen that the upper flange of member 41 is clamped between members 24 and 25 and electrically connected to member 25. The condenser plates 44, 46 and 48 are supported by the anode member 30 and make contact with member 30 around the inner edges of the plates. Plates 43, 45 and 47 are interconnected electrically near both edges and spaced from each other by the pins 50, 51, 54, 55, 58, 59, 62 and 63 which pass through clearance holes in plates 44 and 46. Plates 44, 46 and 48 are interconnected electrically near both edges and spaced from each other by the interconnecting pins 52, 53, 56, 57, 60, 61, 64 and 65 which pass through clearance holes in plates 45 and 47 and the ends of which are cleared by similar holes in plates 43 as indicated in Figs. 5 and 6. It is evident that the plates are interconnected in the manner shown in Fig. 2 with members 41 and 30 in Fig. 4 corresponding to the condenser terminals 1 and 2 in Fig. 2.

The straight filamentary cathode members 36 and 37 are supported from the cap members 28 and 29 and are insulated from the envelope and other tube elements by the tubular members 26 and 27. The grid structures 34 and 35 surround the cathode members as shown in Fig. 5 and are connected through the supporting member 38 to member 25 and thence to the top flange of 41.

The cathode members are heated from source 70 through leads 71 and 72 which are made the central conductors of coaxial lines with outer conductors 73 and 74. These lines are tuned to one-quarter wave-length by the sliders 75 and 76 in the well-known manner to isolate the source 70 from the high frequency voltage at the cathode. In the actual device, members 73 and 74 extend along the cathode leads close to member 25 so that very little of the leads is exposed. The high frequency load indicated by the resistance 80 is connected between a cathode terminal and the outer conductors 73, 74 which are connected through the stopping condenser 69 to member 25. The grid is biased from source 77 through the potentiometer and grid leak resistance 78. The plate, or anode, is energized from source 79 connected to member 30.

The high frequency oscillation circuit has as frequency determining elements the inductance of the resonant cavity and the capacitance between the anode surface 39 and the grid members 34, 35 and 38. The resonant cavity is bounded by the members 25, 41 and 30 and the by-pass condenser (comprising plates 43, 44, 45, 46, 47 and 48) which provides the high frequency path between members 41 and 30 as well as insulation for the anode potential from source 79.

The oscillator circuit is of a conventional type as shown in Fig. 7. The by-pass condenser, de-

scribed above, is designated by the designations of the component plates 43, 44, 45, 46, 47 and 48, the cavity members 25, 41 and 30 are indicated and their combined inductance is depicted as the inductive element of the circuit and 82 represents the capacitance between the anode surface and grid, the capacitive element of the circuit.

It will be noted that the by-pass condenser is essentially a part of the boundary of the resonant cavity and at the same time is enclosed therein so as to be completely shielded. This contributes substantially to making the oscillation circuit non-radiating.

In the arrangement shown, the by-pass condenser effectively confines the high frequency energy and excludes it from the by-passed external circuit by virtue of the low high frequency impedance achieved by the interconnected multiple plate construction despite the large high frequency oscillation current to be by-passed and despite the fact that the condenser plate dimensions are comparable to the wave-length of that current.

While, for illustration, an oscillator arrangement has been shown, obviously, the principles of the invention may equally well be applied to other high frequency devices.

What is claimed is:

1. In combination, a space resonator comprising a substantially closed conducting shell having portions insulated from each other for direct current and electrical condenser means between the said insulated portions, the electrical condenser means comprising a plurality of plates of conducting material arranged substantially parallel and spaced from each other, the plates comprising each set of alternate plates being electrically connected together and to one of the said insulated shell portions near one edge of each said alternate plate and being additionally electrically connected together near the edges opposite those connected to a shell portion.
2. A space resonator comprising a substantially closed conducting shell and means for insulating portions of the shell from each other for direct current, electrical condenser means providing a path for high frequency current across the said direct current insulating means and between the said portions of the shell, the electrical condenser means comprising a plurality of plates of conducting material arranged substantially parallel and spaced from each other, the plates comprising each set of alternate plates being electrically connected to one of the said shell portions by being in contact therewith substantially continuously along one edge of each plate and the plates of each of the said sets of alternate plates being additionally connected together electrically near the edges opposite those in contact with a shell portion.
3. In combination, a space resonator comprising a substantially closed conducting shell having inner and outer coaxial portions insulated from each other for direct current, and electrical condenser means to provide a path for high frequency current between the said insulated portions, the electrical condenser means comprising a plurality of electrically conducting plates arranged substantially parallel, spaced from each other and extending from one insulated shell portion toward the other, one set of alternate plates

being in contact with the outer shell portion and extending toward the inner shell portion while the other set of alternate plates is in contact with the inner shell portion and extends toward the outer shell portion, the plates of each said set of alternate plates being additionally connected together at points distant from the shell portion to which they are connected.

4. A space resonator comprising a substantially closed conducting shell, portions of the shell comprising the elements of an electrical condenser which provides a high frequency path between the shell portions and therefore a closure for the shell but insulates the shell portions from each other for direct current, the condenser comprising a plurality of plates of conducting material arranged in substantially parallel spaced relation and the plates of each set of alternate plates being connected together by direct connections at a plurality of discrete points.

5. In a high frequency device, a path for the passage of high frequency current of a given wave-length, the path comprising an electrical condenser having a plurality of substantially parallel spaced plates of conducting material the plate surfaces extending distances greater than one-quarter of the said wave-length and having openings through from one surface to the other such that high frequency current may be transmitted directly therethrough, the openings being spaced such that the distances over the surface of the plates between direct paths from one side of a plate to the other is less than one-quarter of the said wave-length.

6. In a high frequency device, a path for the passage of high frequency current of a given wave-length, the path comprising an electrical condenser having a plurality of substantially parallel spaced plates of conducting material, the plate surfaces extending distances greater than one-quarter of the said wave-length and alternate plates being interconnected at points spaced such that the distances over the plate surfaces between at least some of the interconnections are less than one-quarter of the said wave-length.

7. Means for completing a high frequency electrical circuit by providing a transmission path for high frequency current of a given wavelength while at the same time preventing the transmission of direct current therethrough, the said means comprising a plurality of substantially parallel spaced plates of conducting material having surface dimensions greater than one-quarter of said wavelength, alternate plates being interconnected at a plurality of points such that the maximum distance over a plate surface from a point on the surface to an interconnection does not exceed substantially one-eighth of said wavelength.

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