May 21, 1946. O. M. WOODWARD 2,400,619

CAPACITY SWITCH

Filed Feb. 27, 1943 2 Sheets-Sheet 1

Fig. 3.

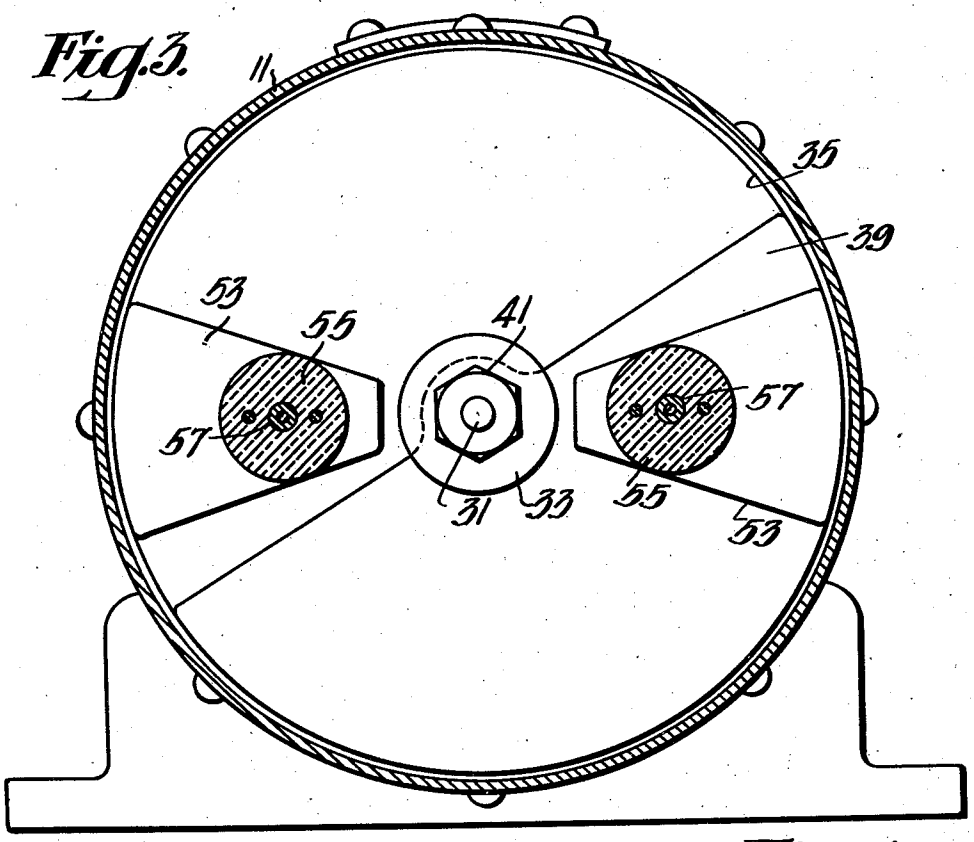


Fig. 1.

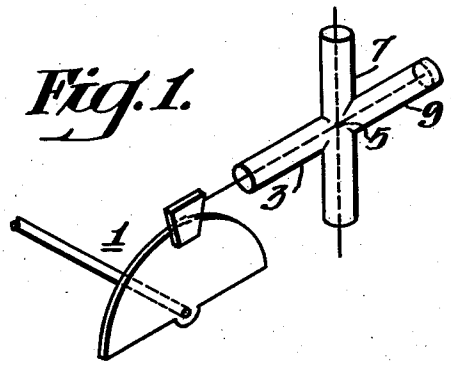
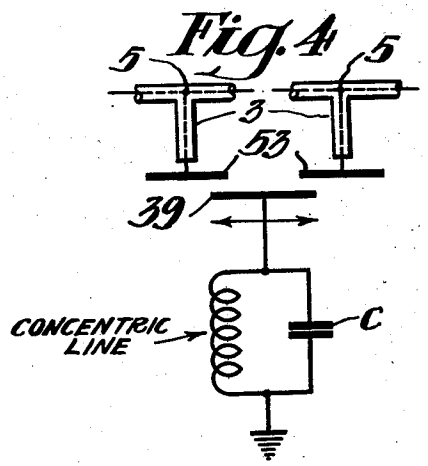


Fig. 4.



Inventor

Oakley M. Woodward

By C. D. Tuska

Attorney

May 21, 1946. O. M. WOODWARD 2,400,619

CAPACITY SWITCH

Filed Feb. 27, 1943 2 Sheets-Sheet 2

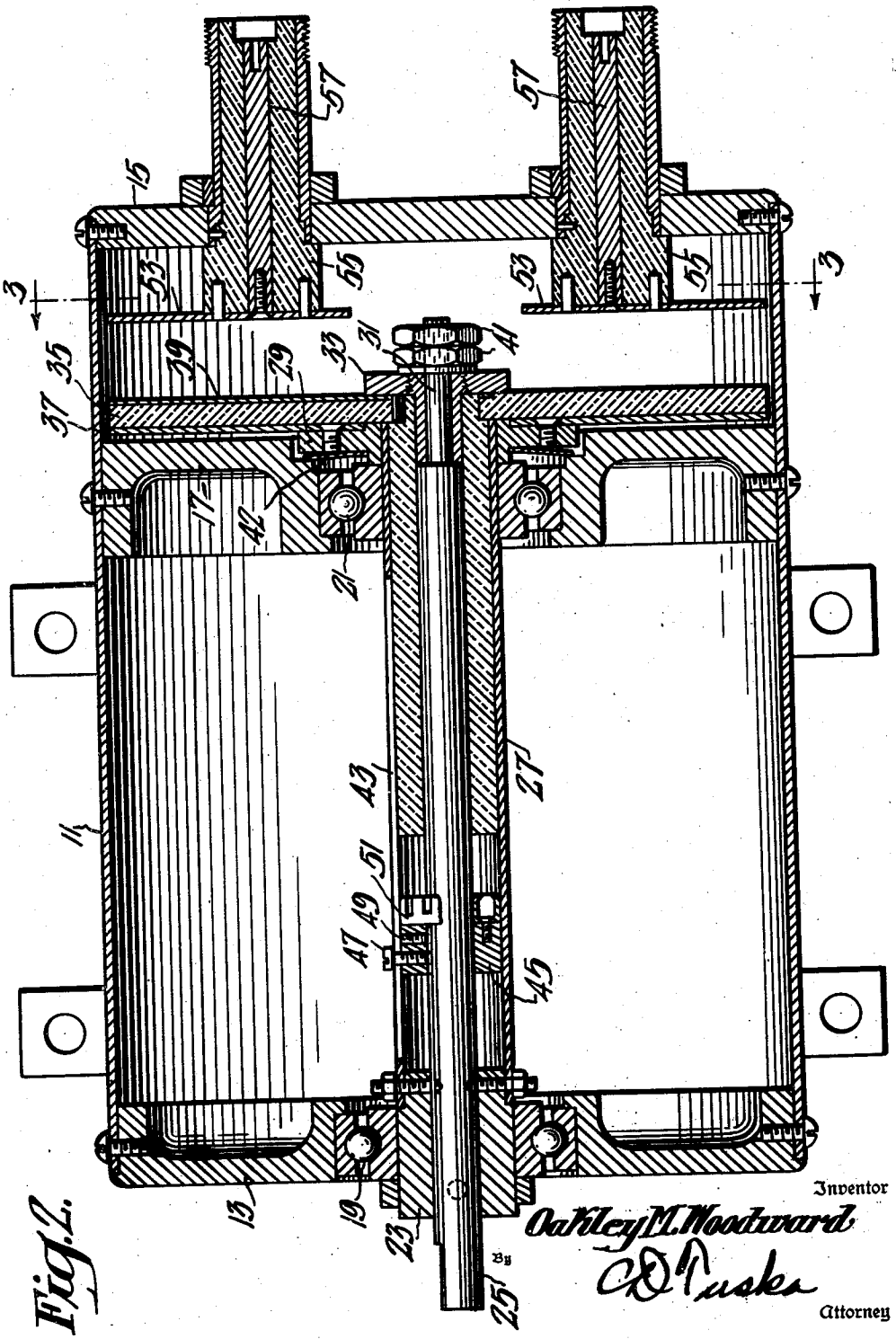


Fig. 2.

Inventor

Oakley M. Woodward

By C. D. Ruske

Attorney

Patented May 21, 1946 2,400,619

UNITED STATES PATENT OFFICE

2,400,619

CAPACITY SWITCH

Oakley M. Woodward, Princeton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application February 27, 1943, Serial No. 477,482

3 Claims. (Cl. 178—44)

This invention relates to switches for controlling radio frequency energy and more particularly to capacitor switches of the type which are combined with resonant transmission line sections to provide an open circuit or short circuit at a predetermined point in a radio frequency distribution system.

It is the principal object of the present invention to provide an improved method of and means for producing a short circuit or open circuit at a point on a transmission line.

A further object is to provide a capacitor having a very high ratio of maximum reactance to minimum reactance.

Another object is to provide an improved capacitor type radio frequency switch.

The foregoing and other objects will become apparent to those skilled in the art upon consideration of the following description with reference to the accompanying drawings, of which Fig. 1 is a schematic diagram of a capacitor switch constructed according to prior art practice, Fig. 2 is a sectional view of a variable capacitor constructed according to the instant invention, Fig. 3 is an elevation taken along the section 3—3 of Fig. 2, and Fig. 4 is a schematic diagram of the equivalent circuit of the device of Fig. 2.

Referring to Fig. 1, a known type of radio frequency switch comprises a variable capacitor 1 connected through a transmission line section 3 to a point 5 on a transmission line 7. A short circuited stub line 9 is also connected to the point 5. The length of the line section 3 is such that the maximum capacitance of the device 1 is transformed to a short circuit at the point 5. The stub 9 is designed to provide the proper amount of inductive reactance at the point 5 to resonate with the transformed minimum capacitance of the device 1. This parallel resonant combination acts substantially like an open circuit across the line 7 at the point 5. Thus as the capacitor 1 is varied between its minimum and maximum values, the point 5 is alternately open circuited and short circuited. It is to be noted that this type of operation will occur only at the frequency which the line sections 3 and 9 are correctly proportioned with respect to the characteristics of the capacitor 1.

It is found in practice that if the ratio of maximum to minimum capacitance is low, the adjustments of the lengths of the line sections 3 and 9 are very critical. This ratio is governed by the physical dimensions and the spacings of the capacitor plates, and there is a fairly low practical limit to which the ratio can be increased by employing large plates or close spacing.

According to the present invention, a parallel resonant circuit is connected in series with the capacitor. The tuning of this circuit is adjusted to provide inductive reactance at the frequency of the energy to be controlled. The total effective reactance of the parallel resonant circuit and the capacitor may be adjusted to any desired value by tuning the parallel circuit. Thus the maximum effective capacitance may be made very large without requiring large plate areas or close spacing. At the same time the minimum capacitance is substantially unchanged.

Referring to Fig. 2, a preferred embodiment of the invention comprises a cylindrical housing 11, provided with circular end plates 13 and 15, and an internal supporting plate 17. The plates 13 and 15 are provided with central apertures for bearings 19 and 21 respectively. A plug 23 is supported in the bearing 19 and carries a shaft 25. The plug 23 also supports a tubular member 27 at one end. The other end of the member 27 is supported by the bearing 21. A clamping ring 29 is supported at the end of the tubular member 27 near the bearing 21. The shaft 25 extends through the tube 27 and terminates in a reduced portion 31 which is threaded. A clamping disc 33 is provided upon the reduced portion 31 for engagement with a disc 35 of insulating material. A metal disc 37 is supported between the insulating disc 35 and the clamping ring 29. One-half of the disc 35 is coated with a layer 39 of conductive material, as more clearly shown in Fig. 2. The disc assembly is held together rigidly by means of nuts 41 on the threaded portion 31 of the shaft 25. A distorted washer 42 of spring material is provided to insure connection between the clamping ring 29 and the plate 17. The tubular member 27 is provided with a longitudinal slot 43. A shorting plug 45 is supported on the shaft 25 and is provided with set screws 47 and 49, adapted to engage the tube 27 and the shaft 25 respectively. A cage-like structure 51 of spring material is

secured to the plug 45 to provide contact to the shaft and the inner wall of the tube 27. A pair of stationary plates 53 are supported on insulating bushings 55 which extend through and are supported by the end plate 15. Connections to the plates 53 are made through conductors 57 extending through the bushings 55.

The tubular member 27 and the shaft 25 function as a concentric line, short circuited by the plug 45. The reactance of a short circuited line is:

$$X=jZ_0 \tan \frac{2\pi l}{\lambda}$$

where Z_0 is the characteristic impedance of the line, l is the length of the line, and λ is the wavelength. This reactance is shunted by the capacitive reactance between the semicircular rotor plate 39 and the disc 37. With proper adjustment of the position of the shorting plug 45, the line, shunted by the capacitance C between the plates 35 and 37, may be caused to present a reactance at its open end which is of the proper value to series resonate the capacitance between the semicircular rotor plate 39 and one of the fixed plates 53. This provides a very low impedance path for the flow of radio frequency current between the fixed plate 53 and the supporting plate 17. Inasmuch as the plate 17 is grounded through the housing 11, the plate 53 is effectively grounded for currents of the frequency for which the plug 45 is adjusted. As the plate 39 is rotated, the reactance between the plate 53 and the plate 17 varies between a relatively high value corresponding to the stray capacitance between the plate 53 and the remainder of the device and a very low value equal to the series resonant impedance of the variable capacitance and the concentric line.

Thus the invention has been described as an improved radio frequency switch of the variable capacitor type. In order to provide a high ratio of maximum reactance to minimum reactance, an inductance is connected in series with the variable capacitor. This inductance is adjusted to the proper value to provide series resonance with the maximum capacitance at the frequency of the energy with which the switch is to be used. An important advantage of this arrangement arises from the fact that relatively small capacitor plates may be employed. This decreases the length of the periods when the reactance is neither maximum nor minimum, but at some intermediate value. It should be noted also that the stub 9 of Fig. 1 may be omitted, as shown in Fig. 4, by choosing the lengths of the lines 3 to provide open circuits across the junctions 5 with the minimum capacitances between plates 39 and 53, and adjusting the inductance of the line to provide short circuits at the points 5 with the maximum capacitances between plates 39 and 53. The described embodiment of the invention comprises a rotary capacitor with a short circuited concentric line employed as the inductor means. This arrangement provides a relatively simple structure having good mechanical strength and a minimum of rotating contacts.

The invention covered herein may be manufactured and used by or for the Government of the United States for governmental, military, naval and national defense purposes without payment to me or assigns of any royalty thereon.

I claim as my invention:

1. A radio frequency switch comprising a substantially cylindrical housing provided with conductive end plates and an internal suporting plate, a pair of conductive sectors supported on insulating bushings extending through one of said end plates, a rotatable shaft extending through the other of said end plates and through said internal supporting plate, a tubular member of conductive material surrounding said shaft and electrically connected to said housing, a semi-circular plate of conductive material secured at one end of said shaft in proximity to said conductive sectors, and a plug of conductive material adjustably supported on said shaft within and in contact with said tubular member.

2. The invention as set forth in claim 1 wherein said plug is adjusted to such a position longitudinally of said shaft as to provide an inductive reactance substantially equal in magnitude, at a predetermined frequency, to the minimum capacitive reactance between said semi-circular plate and one of said sectors.

3. The invention as set forth in claim 1 wherein a tubular body of insulating material is included in the space between said shaft and said conductive tube and between said plug and said semicircular plate.

OAKLEY M. WOODWARD.