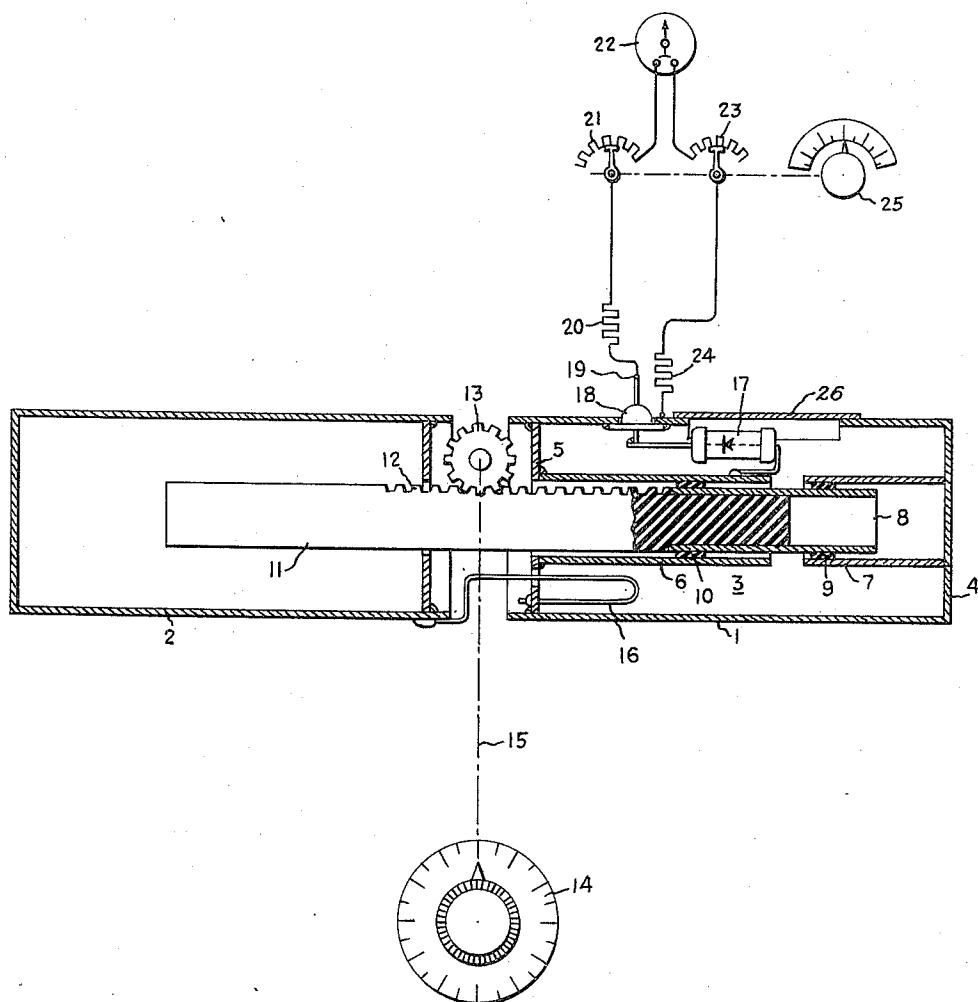


April 3, 1951

P. C. GARDINER ET AL
HIGH-FREQUENCY ANTENNA STRUCTURE

2,547,637

Filed June 30, 1948



Inventors:
Paul C Gardiner,
Charles W. Frick,
by *Merton D. Moore*
Their Attorney.

UNITED STATES PATENT OFFICE

2,547,637

HIGH-FREQUENCY ANTENNA STRUCTURE

Paul C. Gardiner, Scotia, and Charles W. Frick,
Schenectady, N. Y., assignors to General Elec-
tric Company, a corporation of New York

Application June 30, 1948, Serial No. 36,016

2 Claims. (Cl. 250—39)

1

This invention relates to an antenna structure, and more particularly to an antenna structure for high radio frequency waves comprising a short, thick, wide-band pick-up element forming an internal tunable re-entrant cavity resonator.

An object of the invention is to provide a small and compact tunable antenna which is readily portable and well adapted to use in a wavemeter of simple and effective design, or to use in other radio apparatus.

A further object is to provide an antenna structure comprising a pick-up element and tuning means for the antenna which may be housed entirely within a pick-up element of the antenna. An additional object is to improve the sensitivity, efficiency, and sharpness of tuning of high frequency antennas.

The novel features which we believe to be characteristic of our invention are set forth with particularity in the appended claims. Our invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing, in the single figure of which is shown in partially sectional view an antenna structure in accord with the invention, together with elements which may be associated therewith to provide a complete sensitive wavemeter.

Referring now to the drawing, a dipole antenna is shown comprising two oppositely extending arms or pick-up elements 1, 2. Each arm comprises a hollow cylindrical member with a high diameter-to-length ratio. Such an element provides broad-band characteristics and is usually termed a cylindrical antenna element. It will be understood that the cylindrical shape of the arms is preferred but not necessary, and that other shapes will provide, obviously, an operative antenna element. In a particular operative embodiment, the arms 1 and 2 are each a little less than 4 inches long, providing an overall length for the dipole of approximately 8 inches, and are 1 1/4 inches in diameter. A dipole of these dimensions is effective to pick up signals in a band between 700 and 1100 megacycles.

A high diameter-to-length ratio of the antenna elements provides reception over a wide fre-

2

quency band, with the dimensions mentioned above, the ratio will be 1:3, which has proved satisfactory in the practical embodiment herein described. For an antenna consisting of a wire element, the ratio would be one-to-many thousands. The antenna elements here under consideration, for example, may have a ratio of between about 1:10 and 1:1, although the invention may be applied to elements with a greater or less ratio. It will be apparent from the remainder of the description as set forth herein that the limits of the ratio are dependent only upon practical mechanical design considerations, upon the desired requirements of the cavity resonator within one arm of the dipole, and upon the band width to be received by the antenna.

The arm 1 of the dipole antenna of the figure houses a cavity resonator indicated generally at 3. The outer walls of the resonator, as shown, comprise the cylindrical pick-up arm itself, including the cylindrical wall and an end wall 4. An additional wall 5, provided with suitable openings, closes the other end of the cylinder.

The resonator 3 has two re-entrant elements 6 and 7, each in the form, preferably, of hollow cylinders, element 6 extending from wall 5 into the cavity preferably coaxially therewith and element 7 extending toward element 6 from wall 4 in a similar manner. It will be understood that all of the members described, including cylindrical arms 1 and 2, end walls 4 and 5, and re-entrant elements 6 and 7 are conductive and are conveniently made of copper or other conductive metal.

Cooperating with elements 6 and 7 is a conductive, tubular, tuning member 8 arranged in longitudinal sliding relationship with respect to members 6 and 7 for varying the capacitive coupling therebetween. Tuning member 8 is insulated from elements 6 and 7 by insulating bands 9 and 10 which form bearing surfaces to permit sliding of member 8 within elements 6 and 7. The bands may be attached either to the tuning member or to the respective elements 6, 7 as desired. Longitudinal sliding of tuning member 8 is controlled by a rod 11 of insulating material, secured by glue, by a pin, by a pressed fit, by a threaded stub, or in like manner, to member 8, and having a toothed portion 12 for

cooperation with a rotatable gear wheel 13. The gear wheel is arranged for rotation by a calibrated dial 14 through a suitable shaft 15.

Tuning of the resonator is accordingly accomplished by varying the capacitance between the ends of the two re-entrant elements. The capacitance increases with movement of member 8 into element 7 and decreases with movement into element 6 from the position shown in the drawing. The capacitive coupling between the re-entrant elements is a maximum when member 8 is in a mid position with its center aligned with the center of the gap separating elements 6 and 7 and the coupling is decreased by any displacement of member 8 from this mid position. It will be apparent to those skilled in the art that the resonant frequency will decrease with an increase in the capacitive coupling between the elements and that the mid positioning of element 8 corresponds, accordingly, to the minimum resonant frequency to which the resonator may be tuned.

A small loop 16 is interposed between the adjacent ends of arms 1 and 2 of the dipole, the loop ends being connected respectively to the arms as by soldering. The signal picked up by the dipole elements is thus coupled to excite the resonator.

In the complete wavemeter shown in the figure, a crystal diode 17 is connected between a point on re-entrant element 6 remote from end wall 5 and the center conductor of a feedthrough bypass capacitor 18. The outer conductor of capacitor 18 is connected to the wall of arm 1 to complete a pick-up or exciting loop for radio frequency energy exciting the resonator, and this loop extends from the point of connection of the diode through a portion of re-entrant element 6, through a portion of end wall 5 and a portion of the outer wall of arm 1 of the resonator to the outer terminal of the bypass capacitor, and thence to the center conductor and through the diode back to the connection on re-entrant element 6. When the resonator is excited, a direct current voltage appears across the terminals of capacitor 18.

The center conductor of capacitor 18 protrudes outside arm 1 and a connection is made near the end 19 thereof to an external circuit comprising an isolating resistor 20, an adjustable resistor 21, a galvanometer 22, a second adjustable resistor 23 and a second isolating resistor 24. The isolating resistor 24 returns this external circuit to the outer wall of arm 1 at a point adjacent the outer terminal of capacitor 18. It is desirable that capacitor 18 and the return through resistor 24 should be close to the end wall 5 whereby the external circuit as a whole does not act as a part of the antenna.

The external circuit as described provides on meter 22 an indication of the direct current voltage on capacitor 18, and thus indicates the field strength of radio energy received by the dipole antenna at a frequency at which the resonator is resonant. To enable adjustments and a desirable means of calibration of the sensitivity of the wavemeter, a calibrated dial 25 is arranged to adjust the resistance presented by resistors 21 and 23. In addition, suitable calibration of meter 22 is desirable. The resistors 21 and 23 may be continuously variable, or they may be step attenuators, and only one may be found necessary. The resistance of the whole external voltage measuring circuit is preferably in the order of megohms. The meter may have a full scale deflection,

for example, of one microampere, and if so, the sensitivity of the wavemeter will be of the order of a few hundred microvolts per meter at a frequency of about 1000 megacycles.

For convenience in construction and in later servicing, small conductive access plate 26 forms a portion of the outer wall of arm 1. The plate may be held in place by screws (not shown). The capacitor 18 and diode 17 are conveniently mounted adjacent the plate, or may be mounted on the plate if desired.

The arms 1 and 2 are effective to receive or intercept radio waves within the band of frequencies determined by the dimensions of the dipole elements, and in the presence of energy at the frequency to which the resonator 3 is tuned, to excite the resonator. The combination of the dipole antenna receiving arms 1, 2 and the resonator 3 accordingly coact to transfer radio frequency energy of the frequency to which the resonator is tuned between the external field surrounding the antenna to the circuit connected to the output coupling loop for the resonator, as represented by the diode 17, capacitor 18 and the portions of element 6, end wall 5 and the outer wall of arm 1 as hereinbefore described. It will be apparent that the diode 17 and capacitor 18 may be physically located outside of the resonator, though the positioning described is more desirable since it eliminates radio frequency conductors external to the antenna structure. In applications wherein the antenna and resonator are used other than as a part of a simple wavemeter, the resonator may be coupled to provide radio frequency energy through a coaxial cable, or the like, to other types of equipment located externally of the antenna. It would be feasible, also, to provide additional apparatus in the resonator if desired, or additional apparatus could be placed inside arm 2.

The impedance of the dipole pick-up elements is low, and the dipole operates to receive signals throughout a wide frequency range, whereas the impedance of the cavity resonator is relatively high and tunes sharply to the selected frequency. An impedance match is obtained between the resonator and the crystal diode by proper selection of the coupling loops which couple the antenna arm to the resonator and the resonator to the diode. The crystal diode circuit represents an impedance several times greater than that of the dipole if a low-current meter circuit is employed. The coupling loop for the diode circuit should be, accordingly, several times as large as the coupling loop from the dipole for the best impedance matching.

Since the device is adapted particularly to high frequencies, the value of capacitor 18 should be of the order of a few micromicrofarads and the resistance of the external meter circuit, including resistors 20, 21, 23 and 24, may be of the order of several megohms.

Prior art wavemeters of comparable size and complexity to that of the present design exhibit sensitivities of thousands or tens of thousands of microvolts per meter in the neighborhood of 1,000 megacycles, whereas a wavemeter incorporating this invention exhibits a sensitivity of only a few hundred microvolts per meter. The greatly improved results for the very compact equipment described are in large part due to the excellent impedance match between the antenna and the sensitive meter circuit of the wavemeter made possible by the novel arrangement. Although attempts have been made heretofore to obtain high

5

efficiency and corresponding high sensitivity in small portable wavemeters, results comparable to those obtained with the device described have been provided only by much larger and more expensive equipment utilizing amplifier tubes.

The cavity resonator according to the invention has a high Q, and provides sharp and accurate tuning. While this is characteristic of tuned re-entrant cavities, the use of a separate device coupled to be fed by a remote antenna leaves much to be desired in the way, for example, of portability, size, simplicity and accuracy of calibration.

While the antenna housing the cavity resonator in accord with this invention has been described as useful in a wavemeter, it is also adaptable for use as a sharply tunable antenna for other receiving applications at high radio frequencies, and may be used also in connection with the transmission of high frequency waves. The characteristics of a high-Q tuned circuit cooperating with a wide band dipole antenna are of particular utility in many types of applications, and the present invention makes possible such an arrangement with the advantages of simplicity, high efficiency, compactness and the other advantages mentioned heretofore.

While we have shown only certain preferred embodiments of our invention by way of illustration, many modifications will occur to those skilled in the art and we therefore wish to have it understood that we intend, in the appended claims, to cover all such modifications as fall within the true spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

6

1. High frequency apparatus comprising a wide band dipole antenna with two elongated cylindrical pick-up elements, one of said elements forming an internal cavity resonator, tuning means for said resonator comprising therein a re-entrant member and a movable coupling member, and exciting means coupling said elements to said resonator, a rectifier and capacitor disposed within said resonator in circuit with said re-entrant member for detecting the voltage thereon, indicating means for measuring the detected voltage.

2. High frequency apparatus comprising a wide band dipole antenna with two extended portions, one of said portions comprising internally a cavity resonator, means to excite said resonator with a wave received by said antenna, and means for measuring the strength of oscillations in said resonator.

PAUL C. GARDINER.
CHARLES W. FRICK.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,218,923	Newhouse	Oct. 22, 1940
2,235,521	Higgins	Mar. 18, 1941
2,261,879	Higgins	Nov. 4, 1941
2,313,513	Brown	Mar. 9, 1943
2,327,418	Goldman	Aug. 24, 1943
2,344,171	Rote	Mar. 14, 1944