United States Patent

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[54] MAGNETRON RAPID FREQUENCY CHANGER

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[73] Assignee: **The United States of America as represented by the Secretary of the Navy**

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[51] **Int. Cl.** **H01j 25/50**

[58] **Field of Search** 315/39.55, 39.59, 38.61; 331/90

[56] **References Cited**

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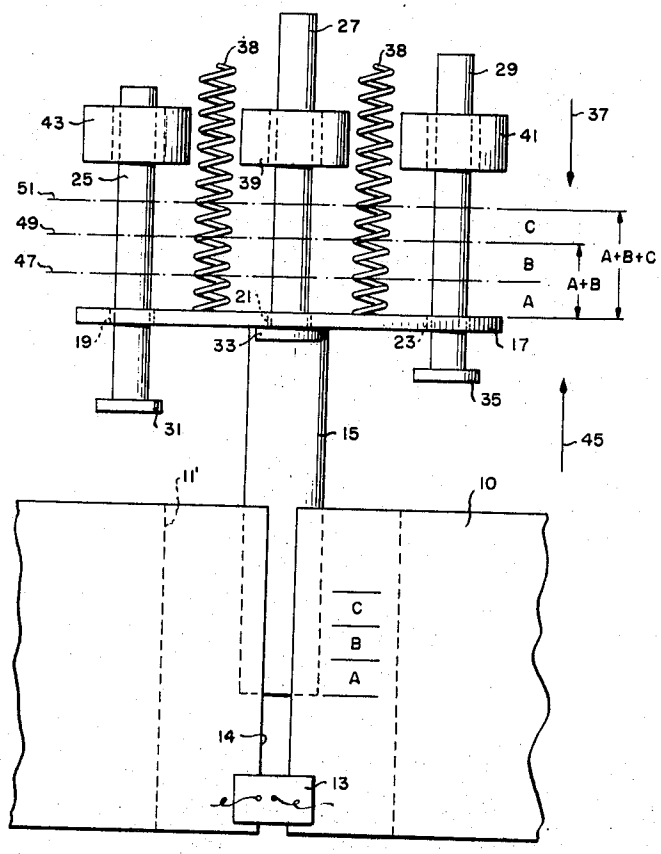
[57] **ABSTRACT**

A magnetron is rapidly tuned over a wide bandwidth by inserting and withdrawing a conductive tuning element in an anode cavity. The conductive element is mounted on a plate which is moved in increments by a plurality of solenoids. A stop is mounted on the solenoids and each solenoid when actuated pulls the plate an incremental distance. The plate, when actuated by a single solenoid slides along the other solenoid rods in the solenoid array. A spring pushes the plate against the force of the solenoids and returns the plate to position of maximum element insertion, when the solenoids are de-energized.

6 Claims, 3 Drawing Figures



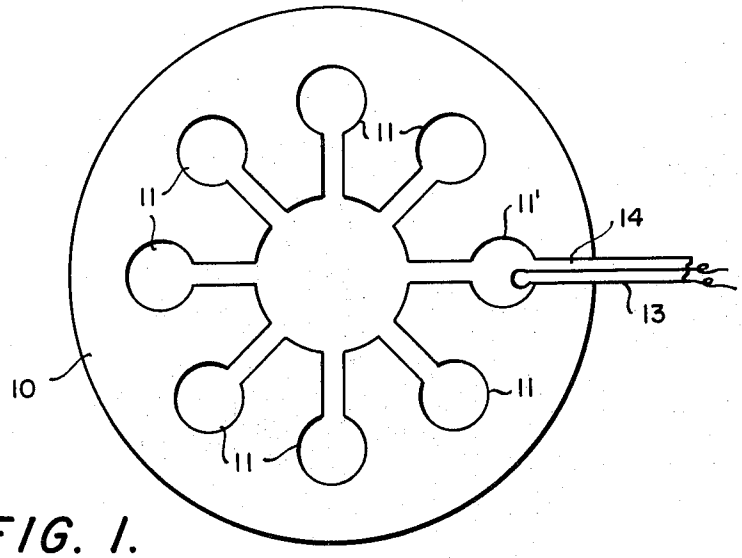


FIG. 1.

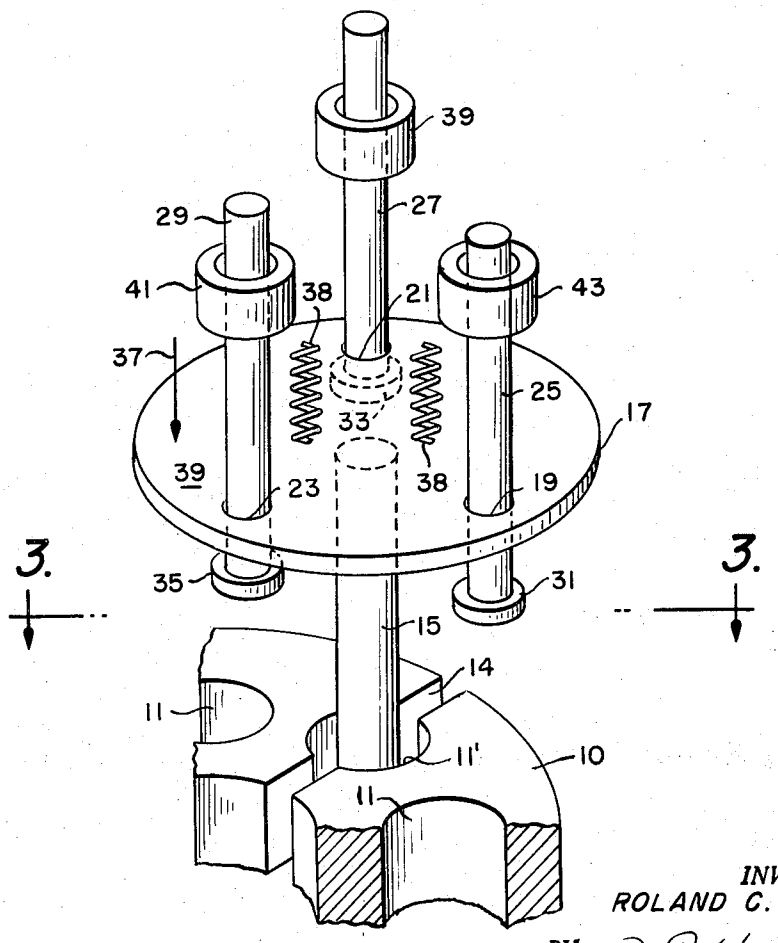


FIG. 2.

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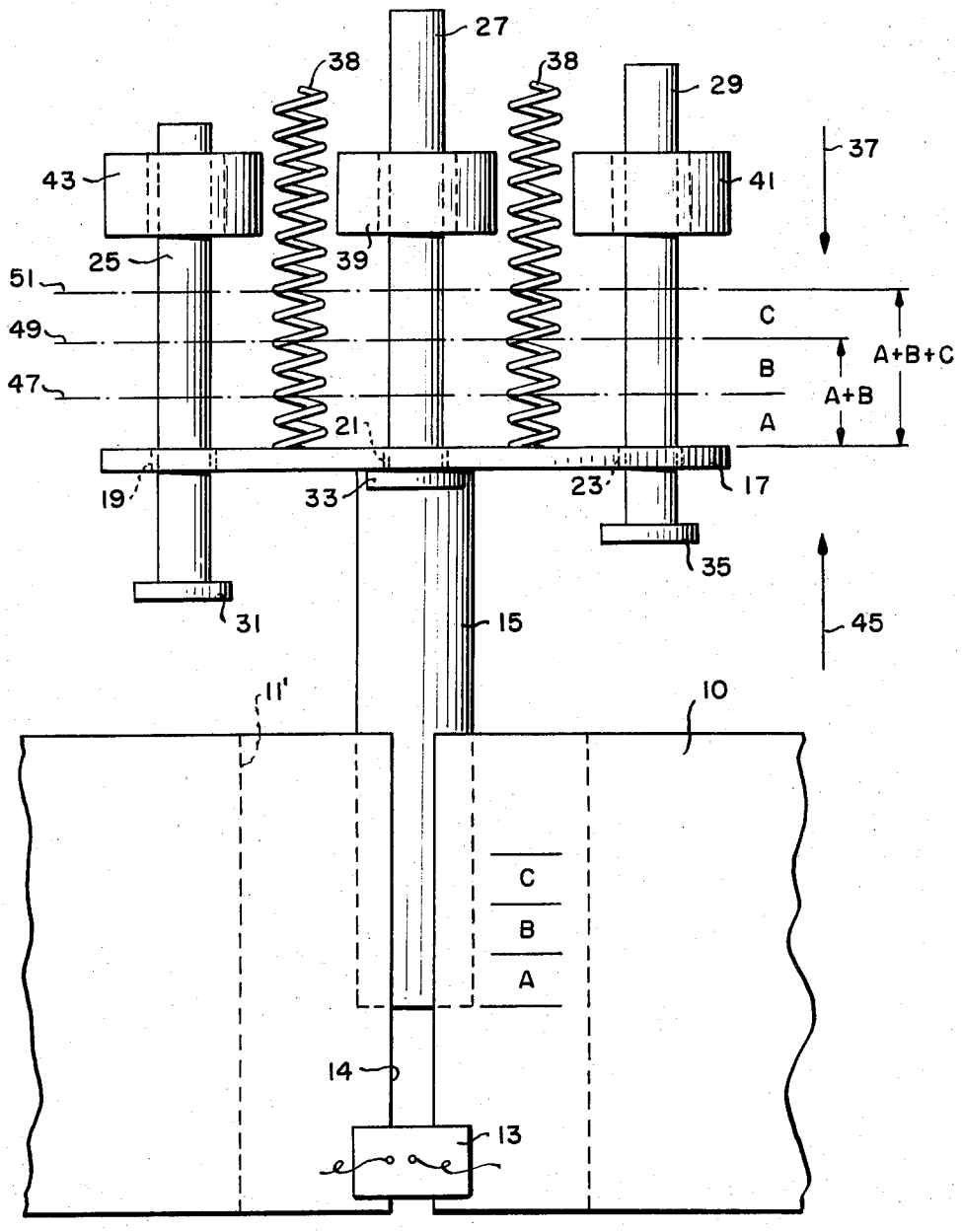

FIG. 3.

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MAGNETRON RAPID FREQUENCY CHANGER

This invention relates to magnetrons and more particularly to a magnetron structure having electrically actuated parts for tuning the magnetron rapidly over a wide range of frequencies.

In some applications of magnetrons, it is required to rapidly tune the magnetron over a wide frequency band. In the past, tuning of the magnetron has been accomplished in a variety of ways. For example, the "pulling effect" is all often employed to tune a magnetron over a fraction of a percent bandwidth by mismatching the load coupled to the output of a magnetron. The "pushing effect" is also employed by varying anode voltage, although generally this effect is undesirable and is eliminated whenever possible even through tuning over a somewhat wider bandwidth (about 1 percent) can be obtained.

Recently, conductive tuning elements have been employed in magnetrons, which are movable in and out of the anode cavity spaces, to accomplish tuning. A cylindrical element is usually employed which has the same general conformation as the cavity but is somewhat smaller so that it may fit within the cavity without touching the sides. The magnetron tube is sometimes equipped with a diaphragm arrangement which can be flexed externally to thereby move the plunges in and out of the cavities, tuning the magnetron over a relatively wide frequency band. For example, in some structures of this type, 50 percent bandwidth tuning has been accomplished. However, such plunger tuned magnetrons have not been readily tuned at high rates but are usually adjusted manually by an operator to produce a given frequency and once this frequency is established it is not changed again for sometime.

SUMMARY OF THE INVENTION

In accordance with the present invention a tunable element is positioned within a cavity of a magnetron anode. The tuning element is attached to a plate, the plate being mounted on a number of solenoid rods. The solenoid rods are each of a unique length and each rod has a stop on its end. All rods are of a finite length and each rod is moved by its respective solenoid, a finite distance.

At the position of maximum tuning element insertion, the plate is held against one of the solenoid stops by a spring. As the first solenoid is actuated, the force of the solenoid applied to the stop lifts the plate and the element away from the magnetron anode, the plate sliding along the other solenoid rods inserted through the plate. When it is desired to remove the tuning element, an additional increment from the anode cavity, a second solenoid is operated applying a force to the plate through its respective stop element and sliding the plate along the inactivated solenoids.

Accordingly, it is one object of this invention to provide a magnetron with a capability for rapid tuning over a wide frequency band.

Other features and object of the invention will be more apparent from the following specific description taken in conjunction with the drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a conventional solenoid anode block in top view and with a coupling in one of the resonant cavities.

FIG. 2 shows in perspective a portion of the anode block of FIG. 1 with a conductive element inserted within the resident cavity and fitted on a movable plate.

FIG. 3 shows in side view of an invention, shown in FIG. 2, taken along view line 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, the anode block **10**, within a magnetron is shown as having cavity resonators **11**, one of the cavity resonators designated **11'**, having a coupling loop **13** inserted therein for extracting RF energy.

The block structure shown in FIG. 1, shown in section in FIG. 2, with the cylindrically shaped tuning rod **15** inserted

therein. Tuning rod **15** is mounted on plate **17**. Plate **17** is shown as having a plurality of holes **19, 21** and **23**, and in each hole a solenoid rod **25, 27** and **29**, respectively, is slidely fitted. At the end of each solenoid rod is a fixed stop, stop **31** on rod **25**, stop **33** on rod **27**, and stop **35** on rod **29**. A solenoid coil is mounted on each solenoid rod, coil **43** on rod **25**, coil **39** on rod **27** and coil **41** on rod **29**.

A spring means **38**, has a force in the direction of arrow **37** on surface **39** of plate **17**, forcing plate **17** down against stop **33** of solenoid rod **27**.

Referring now to FIG. **3**, a side view along sections **3—3** of FIG. **2**, is shown and wherein like numerals designate like and similarly operating parts. In FIG. **3**, cavity resonator **11'** is shown partly in phantom. Conductive tuning element **15** is extended down in the cavity **11'** and can be partially seen through slot **14** in block **10**, the hidden portion of tuning element **15** within cavity resonator **11'** being shown in phantom. The tuning element as shown in FIG. **2** and FIG. **3**, is at its position of maximum insertion into cavity **11'** and under spring force **37** is held in this position by stop **33** on rod **27**.

OPERATION OF THE DEVICE

Operation of the device will now be described with reference to the solenoid actuators solenoid **39** on rod **27**, solenoids **41** on rod **29** and solenoid **43** on rod **25**. Actuation of these solenoids causes its respective rod to move in the direction as shown by arrow **45** in FIG. **3**. Under spring force **37** the plate **17** is held against stop **33** on rod **27** and the tuning element is at its maximum insertion in cavity **11'**.

To change the frequency of this device a first increment solenoid **43** is energized displacing solenoid rod **25** in the upward and vertical direction **45** and forcing stop **31** on rod **25** against plate **17**. The continued upward movement of rod **25** to its point of maximum vertical displacement forces stop **31** to lift the plate **17** through a distance A and holds the plate at line **47**.

As can be seen and is well known in the art, the retraction of tuning element **15** of cavity **11'** for the distance A changes the frequency of the magnetron. In moving from its fully inserted position shown in FIG. **3**, upward to level **47**, the plate **17** slides along rod **27** and rod **29**.

To change the frequency of the magnetron a second increment, solenoid **41** is actuated displacing rod **29** in a vertically upward direction **45**, and bringing stop **35** against plate **17**. As rod **25** continues its upward travel to its point of maximum vertical displacement, it drives plate **17** a distance B, from level **47** to lever **49**, sliding plate **17** along solenoid rods **25** and **27**. At level **49** plate **17** has moved an increment B or a total incremental distance A + B, by the operation of solenoids **43** and **41**.

To change the frequency of the magnetron a third increment, solenoid **39** is operated drawing solenoid rod **27** in the upward vertical direction **45** and forcing plate **17**, by stop **31**, through the distance C, between level **49** and **51**. In this position, plate **17** has traveled a total distance of A + B + C. As is well known to those skilled in the art, the frequency of the magnetron will be unique for each of the levels **47, 49** and **51**.

In a similar manner the frequency of the magnetron may be changed by de-energizing sequentially each of the solenoids **39, 41** and **43**. This may be done as follows: To drive plate **17** from level **51** to level **49**, solenoid **39** would be de-energized and plate **17** under spring force **37** would be forced down against stop **35** on solenoid rod **29**, stop **35** being at level approximately at level **49**. Similarly to change the magnetron frequency to that when the plate **17** is at level **47**, solenoid **41** would be de-energized and spring force **37** would similarly force plate **17** down against stop **31** of solenoid rod **25** to level **47**. Finally, to bring the operating frequency of the magnetron back to its point where the tuning element **15** has its maximum insertion into cavity **11'**, solenoid **43** would be de-energized and spring force **37** would similarly force plate **17** down against stop **33** of tuning element **27**.

By operating solenoids **43**, **41** and **39** in sequence, or by operating each of the solenoids individually, the frequency of the magnetron can be rapidly changed over wide band limits.

Although the preferred embodiment shows solenoid actuated rods, the invention is not limited by the specific type of actuator used. Obviously many other various means of actuation could be used such as hydraulic, or pneumatic or any other actuator which permits a mechanical force to be rapidly applied to the rods **25**, **27** and **29**.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A magnetron rapid frequency changer, comprising:
a tuning element for insertion into a magnetron cavity resonator;
a plate;
said tuning rod being affixed to said plate;
said plate having a plurality of holes;
a plurality of rods;
each of said rods being inserted through a respective hole in said plate;
said plate being slidably mounted on said rods;
each said rod having a stop mounted on its end; means biasing said plate toward said stops; and
means to move each of said rods through its said respective holes thereby forcing its respective stop against said plate, and moving said plate.

2. The apparatus of claim **1**, wherein:
each of said stop is disposed on the same side of said plate; and
each said stop being mounted on its respective rod at a unique distance from said plate, when said tuning element is at its point of maximum insertion.

3. The apparatus of claim **2**, wherein:
said means to move separately moves each rod through its respective hole a discrete distance; and
including a spring to force said plate towards said stops.

4. The apparatus of claim **3**, wherein:
said plurality of rods includes first, second and third rods;
said spring forcing said plate against the stop on said first rod;
said means to move displacing said second rod a finite distance to slide said plate along said first and third rods, against the force of said spring, moving said tuning element an increment away from said cavity;
said means to move displacing said third rod a finite distance to slide said plate along said first and second rods against the force of said spring and moving said tuning element an increment away from said cavity; and
said means to move displacing said first rod a finite distance to slide said plate along said second and third rods and against the force of said spring, moving said tuning element an increment away from said cavity.

5. The apparatus of claim **1**, wherein:
said means to move is a plurality of solenoids; and
each said rod is a solenoid rod, inserted within a respective solenoid.

6. The apparatus of claim **4**, wherein:
said means to move is a plurality of solenoids; and
each said rod is a solenoid rod, inserted within a respective solenoid.

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