Jan. 14, 1947. A. E. BOWEN 2,414,084

TUNABLE RESONATOR AND OSCILLATOR

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FIG. 2

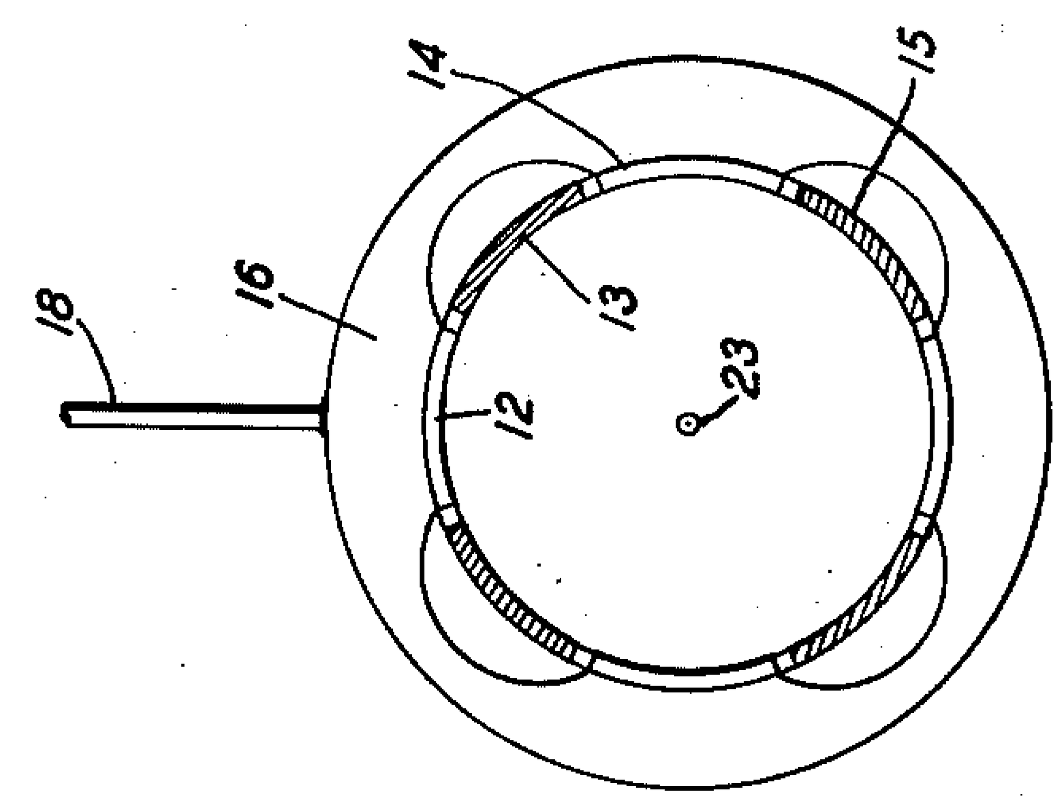
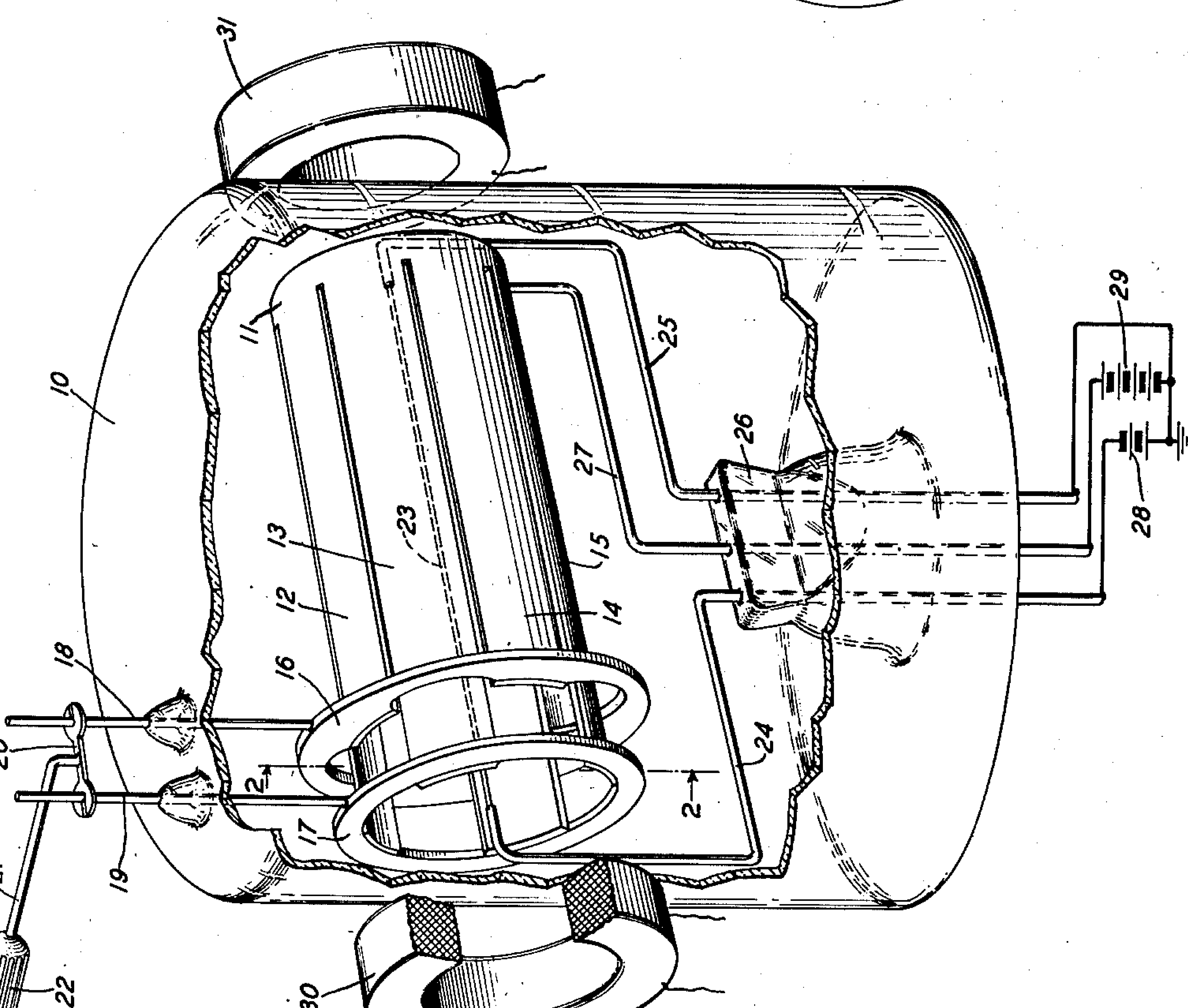


FIG. 1



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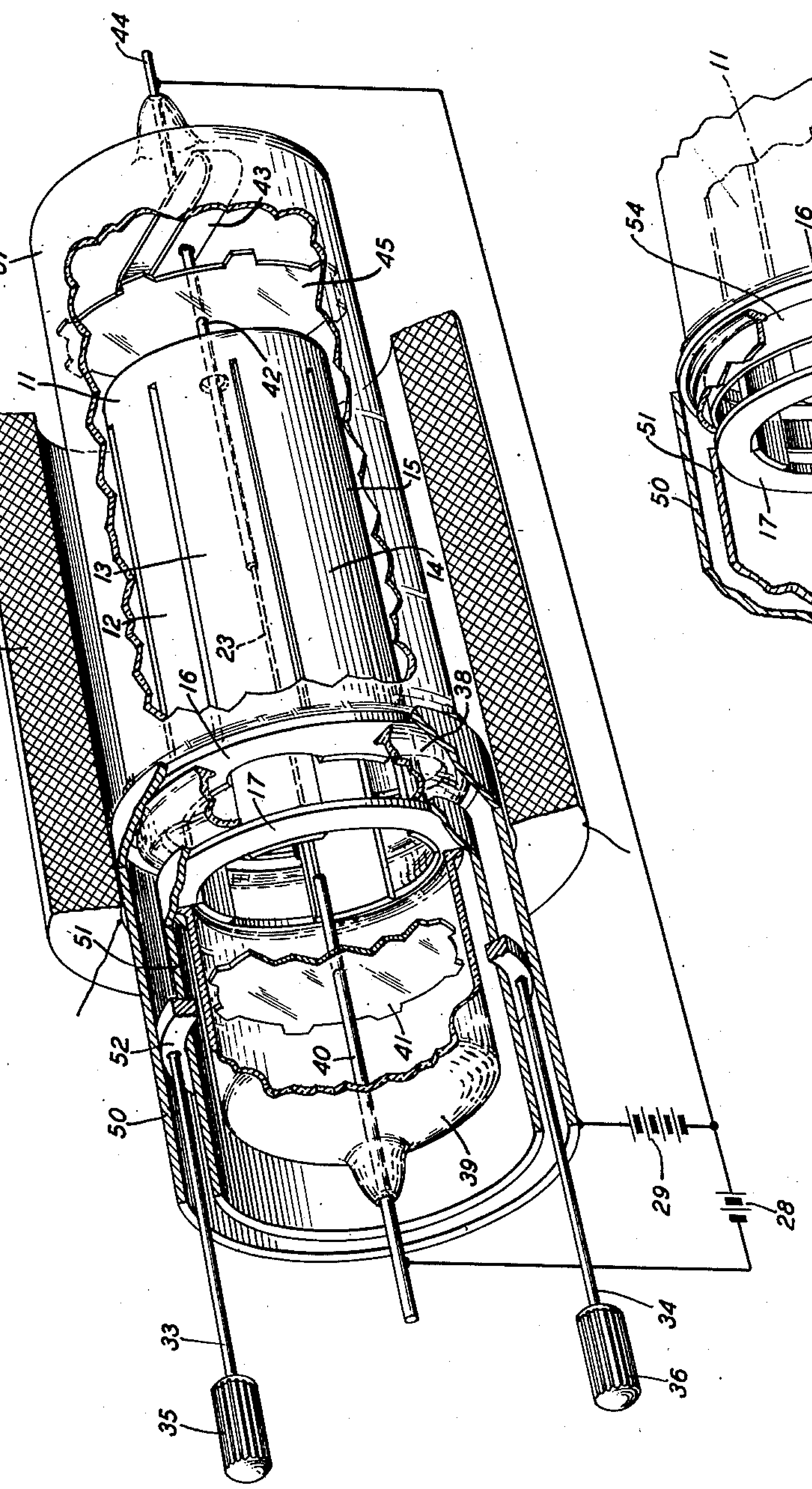

FIG. 3

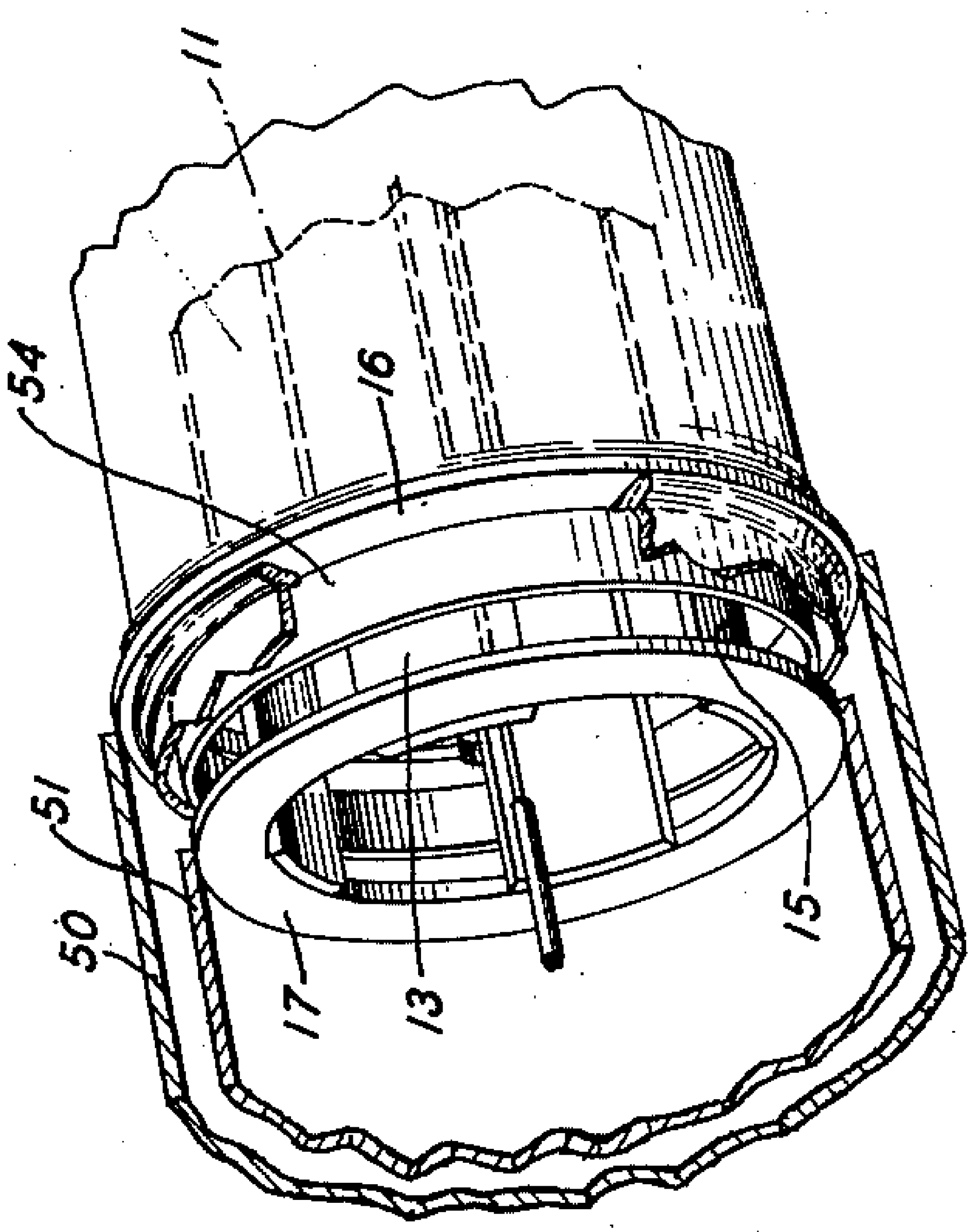

FIG. 3A

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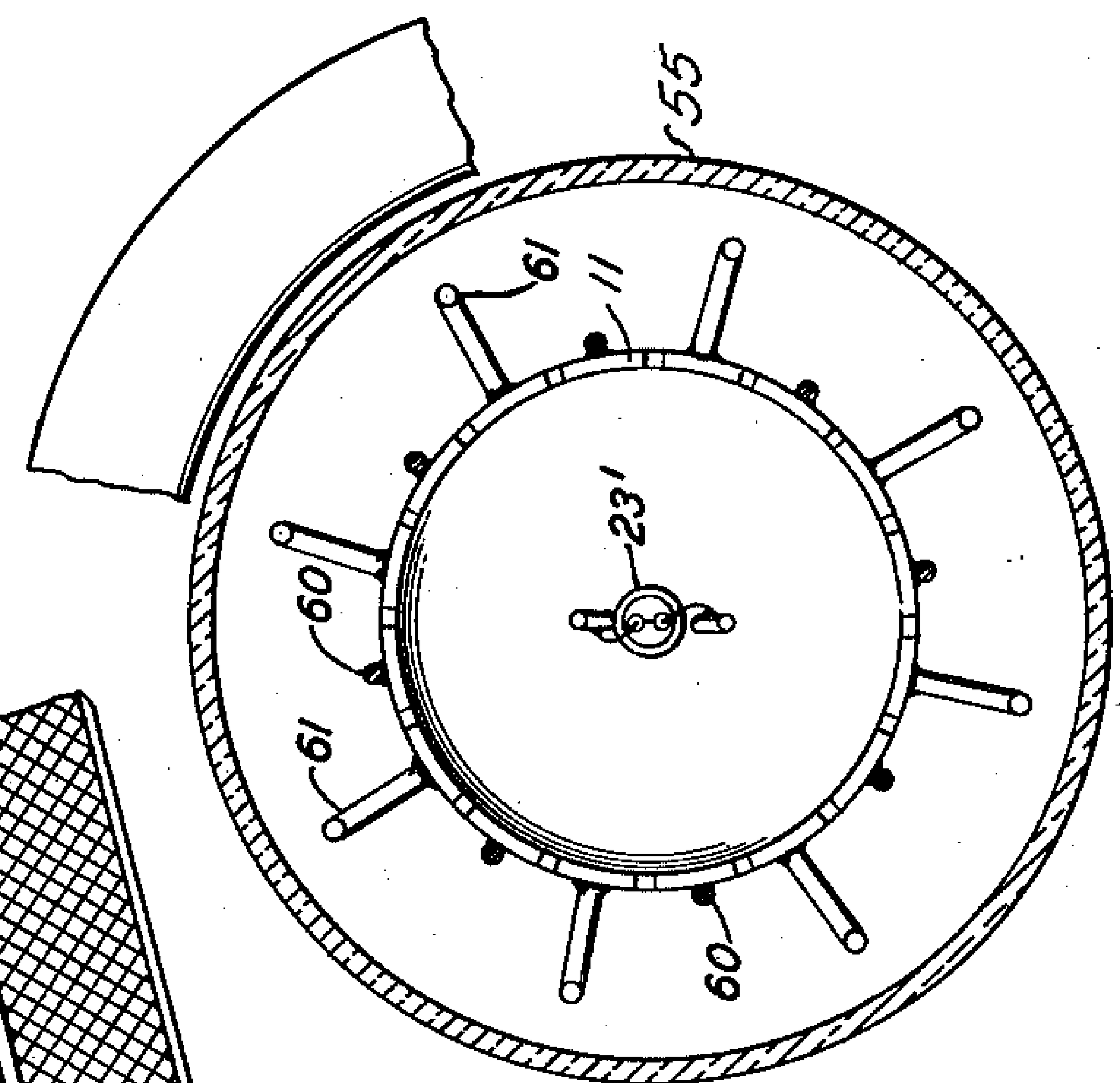

FIG. 5

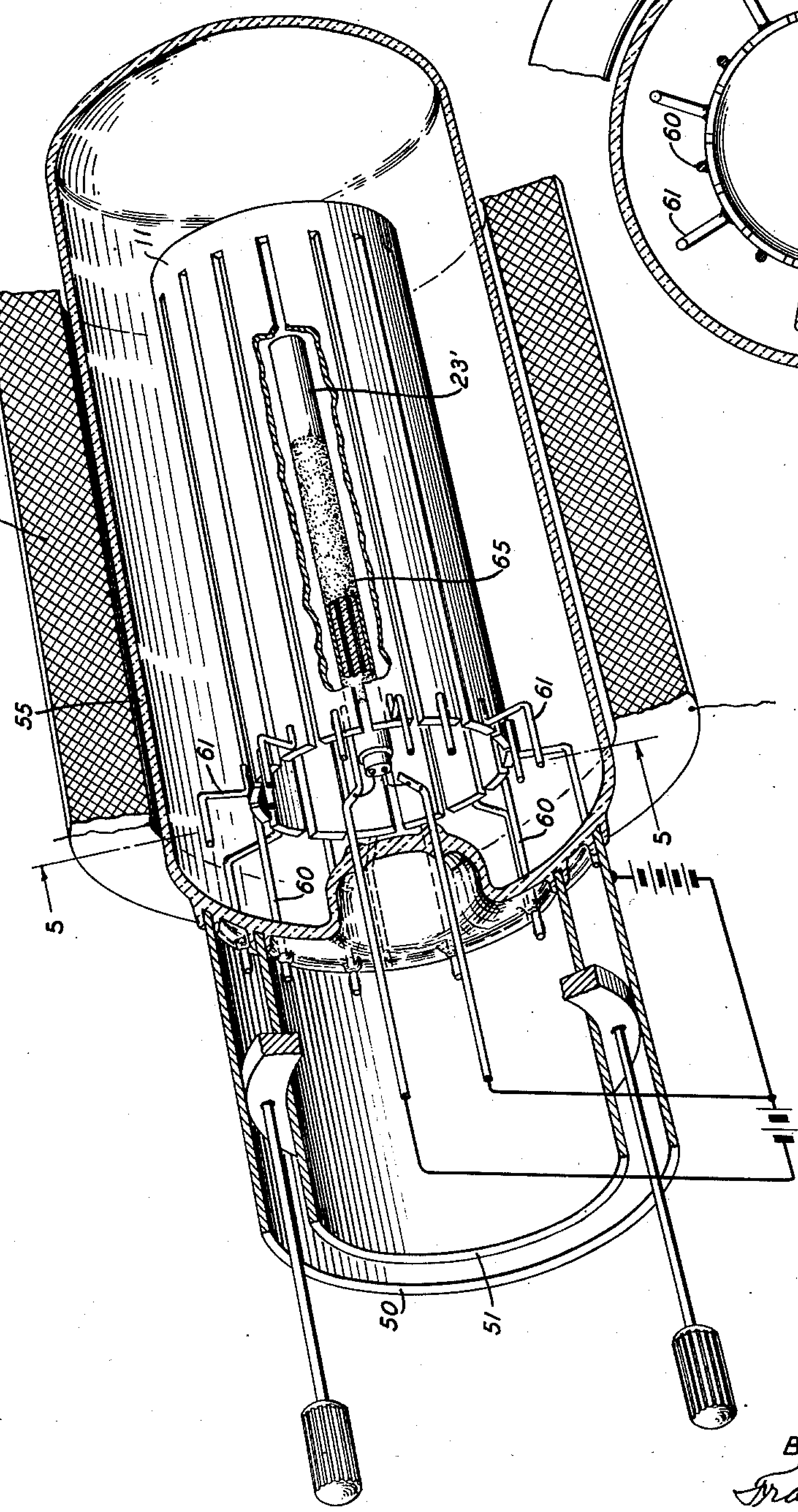

FIG. 4

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Patented Jan. 14, 1947

2,414,084

UNITED STATES PATENT OFFICE

2,414,084

TUNABLE RESONATOR AND OSCILLATOR

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Application May 11, 1943, Serial No. 486,579

2 Claims. (Cl. 250—27.5)

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This invention relates to resonators and oscillators and, as to oscillators, particularly those of the magnetron variety with a segmented anode.

An object of the invention is to provide adjustable tuning for a resonator or oscillator.

Another object is to minimize losses by uncontrolled radiation from a high frequency oscillator particularly where the oscillator has adjustable tuning.

A feature of the invention resides in the manner of merging a segmented anode with a concentric transmission line structure.

Another feature is a combination of a segmented anode inside a vacuum envelope with a tuning adjustment outside the envelope.

A further feature of the invention is a half-wave resonator formed of a combination of a segmented anode with a concentric line tuner, the resonator having short-circuited ends to prevent undesired radiations.

The invention is described in detail hereinafter with reference to the accompanying drawings in which:

Fig. 1 is a perspective view, partly broken away, showing one form of magnetron oscillator embodying the invention;

Fig. 2 is a cross-sectional view in a vertical plane through the line 2—2 in Fig. 1;

Fig. 3 shows another embodiment of the invention;

Fig. 3A is a fragmentary view showing a modification of the structure of Fig. 3;

Fig. 4 shows still another embodiment of the invention; and

Fig. 5 is a cross-sectional view of the structure of Fig. 4 in a vertical plane through the line 5—5 in Fig. 4.

In Fig. 1 there is shown within a vacuum-tight envelope 10, a conductive cylindrical anode 11 which is slotted from one end to form a plurality of segments, such as 12, 13, 14 and 15. All the segments are conductively connected together or short-circuited at one end by the body of the anode 11. In Fig. 1 the short-circuited end appears at the right. At the open end, which is at the left in the figure, alternate segments including 12 and 14 are cut shorter than the others and are conductively joined together by a ring or yoke 16 which may be shaped as shown, somewhat in the physical form of an internal gear with cut-away portions providing clearance for the remaining anode segments including the segments 13 and 15, as appears in cross-sectional view in Fig. 2. The latter group of segments are conductively connected together by a second

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ring 17, spaced apart from the ring 16, as shown. The ring 17 requires no clearance spaces as the group of segments including 12 and 14 do not extend as far as the ring 17. A Lecher pair 18, 19 is shown connected to the rings 16 and 17. The individual wires 18 and 19 of the Lecher pair may be sealed through the envelope 10 and the pair may be provided with a short-circuiting movable bridge 20 and any suitable mechanical adjusting means, represented here by a bent rod 21 with an insulating handle 22.

The cathode may be an axial filament 23 attached to supports 24 and 25. The envelope 10 may include a suitable press 26 for mounting the supports 24 and 25 as well as an anode support 27. In well-known manner the supports 24, 25 and 27 may serve as leading-out conductors for the respective filament and anode terminals.

Any suitable cathode heating means, such as a battery 28, may be provided, together with a source of anode potential such as a battery 29. Windings 30 and 31 may be provided, preferably external to the envelope 10, to set up a suitable magnetic field inside the anode 11. As is customary in this art, the axis of the magnetic field may be slightly tilted with respect to the axis of the anode 11 in order to impart a helical motion to electrons within the anode so that the electron motion is progressive along the axis.

In the operation of the arrangement of Figs. 1 and 2, electrons are emitted by the cathode 23 and constrained to circulate in the vicinity of the anode segments in manner well-known in the art, with result that high frequency oscillations are produced in the anode and in the slots between the anode segments. The segmented anode structure is merged physically and electrically into the Lecher pair 18, 19 by means of the rings 16 and 17. The combined system is found to constitute a half-wave resonator having short-circuited ends. The right-hand end portion of the anode 11, which is conductively joined to all the anode segments, constitutes a short-circuiting connection at that end of the anode as shown in Fig. 1. The bridge 20 forms a short-circuiting connection across the Lecher pair to constitute the other end of the half-wave resonator. It is found that electromagnetic waves can form standing wave patterns in the resonator as so constructed, with voltage nodes at the short-circuited ends and with a voltage antinode appearing between adjacent anode segments over a portion of the anode 11 between the ring 16 and the right-hand end of the anode. The resonant frequency of the system may be adjusted by moving the bridge 20 along the wires 18 and 19 by manipulating the handle 22. As brought out in Fig. 1, the electronic portion of the magnetron structure is situated inside the envelope 10 whereas the adjustable portion of the tuning element is located outside the envelope where adjustment is accomplished without the mechanical complication of any linkage extending through the envelope.

In the arrangement of Fig. 3, the anode 11 and the rings 16 and 17 connected to alternate anode segments are the same as in the arrangement of Fig. 1. The Lecher system in this case, however, is in the form of a concentric transmission line having an outer conductor 50 conductively attached to the ring 16 and an inner conductor 51 conductively attached to the ring 17. An annular slidable tuning member 52 is provided in the space between the conductors 50 and 51. The member 52 may be adjusted in position by means of rods 33 and 34 attached thereto and provided with insulating handles 35 and 36. The vacuum-tight envelope may be arranged in any suitable manner so as to enclose the anode 11 and leave the concentric line partially outside the vacuum space to permit the tuning adjustment to be effected outside the envelope as in Fig. 1. Fig. 3 shows the envelope in three sections. The right-hand section 37 is sealed to the right-hand side of the ring 16 in Fig. 3. A middle section 38 is inserted between the rings 16 and 17 and the left-hand section 39 is sealed to the left-hand side of the ring 17. The filament 23, which is axially located as in Fig. 1, may be shorter than the anode 11, as shown in Fig. 3, in order to limit the thermionic emission to the region where the electric field is the strongest, that is, the left-hand half to two-thirds, or so, of the anode, constituting a voltage antinode. One end of the filament is shown attached to a leading-out conductor 40 which is sealed through the envelope section 39. An insulating spacer 41, such as a mica disc, may be employed for centering the conductor 40. The other end of the filament may be attached to a conductor 42 which is in turn conductively connected to a tension maintaining spring 43, which latter is connected to a leading-out conductor 44 that may be sealed through the section 37 of the envelope. A second insulating spacer 45 may be employed between the filament 23 and the spring 43 to center the conductor 42. The filament may be heated by means of the battery 28 as in the arrangement of Fig. 1 and the anode battery 29 may be connected to the outer conductor 50 of the concentric line outside the envelope, which is in conductive connection with the anode 11 through the ring 16. A solenoid 30′ may be provided to set up the desired magnetic field inside the anode 11.

The operation of the system of Fig. 3 is essentially the same as in the case of the arrangement of Figs. 1 and 2, the tuning being accomplished by manipulating the handles 35 and 36 to adjust the position of the annular tuning member 52.

In the arrangements so far described, the anode is preferably designed to be approximately a quarter wave-length long, the Lecher system then comprising an additional quarter wave-length to make up the desired half wave-length for the combined structure. If desired, however, the anode as a unit may be made to operate substantially as a half wave-length resonator. In this case the system may still be tuned by means of the exterior Lecher system, although the range of tuning is generally reduced. Fig. 3A shows a way in which the structure of Fig. 3 may be modified so as to permit the anode to operate substantially as a half-wave resonator. For this purpose there is attached to the left-hand surface of the ring 16 a short length of hollow tubular conductor 54. The conductor 54 has an inner diameter a little greater than the outer diameter of the anode 11 to afford a clearance between the conductor 54 and the segments such as 13 and 15 attached to the ring 17. The conductor 54 partly closes the space between the rings 16 and 17 but leaves an annular gap through which electromagnetic waves reaching the rings 16 and 17 from the anode may enter into the space between the concentric conductors 50 and 51. A considerable capacity is provided between the conductor 54 and the segments such as 13 and 15, this capacity serving as a partial short-circuit between the two sets of anode segments at the left-hand end of the anode 11 in Fig. 3A. The presence of the substantial short-circuit tends to make the anode operate as a half-wave resonator by determining a voltage node at this point. The resonator is coupled to the adjustable tuning device through the annular space above described between the conductor 54 and the ring 17. The annular tuning member 52 will in this case be adjusted to a position approximately a half wave-length distance from the left-hand end of the anode. A certain amount of variation in the resonant frequency of the system as a whole may be obtained by adjusting the position of the element 52 although, as above mentioned, the tuning range will generally not be as great as in the case where the anode serves approximately as a quarter wave-length section as in the arrangement of Figs. 1 and 2.

Fig. 4 shows an alternative construction in which the envelope is in a single section 55. The inner conductor 51 of the concentric transmission line is connected directly to alternate segments of the anode by means of a plurality of straight rods or wires 60 which pass through the envelope 55 and may be soldered to the conductor 51 outside the envelope. The outer conductor 50 is connected to the remaining segments of the anode by bent rods or wires 61 which also pass through the envelope and may be soldered to the conductor 50 outside the envelope. The concentric line is in effect passed through the envelope by means of the plurality of rods or wires 60 and 61. A sectional view of the rods and their attachment to the anode segments is shown in Fig. 5. Instead of the filamentary cathode of Figs. 1 and 3, an indirectly heated cathode 23′ of any suitable known construction is shown in the arrangement of Fig. 4. The indirectly heated cathode may be inserted from one end of the envelope as shown and has the advantage that it is more easily centered than the filament and does not require spring tension. The thermionically active portion of the cathode 23′ may be confined to the region 65 in the strongest portion of the electric field, by applying a suitable coating in that region.

Couplings for picking up the generated electromagnetic waves and means for conveying the waves to an antenna or ay other suitable utilization circuit or device may be provided in conventional manner. For clarity in the drawings, such output coupling means have been omitted, but these will be readily supplied by any one versed in the ultra-high frequency art.

What is claimed is:

1. A resonator comprising a segmented anode, each segment of which has a free end at one and

the same end of the anode and all of which segments are conductively connected together at the other end by the body portion of the anode, a pair of conductive means joining together the free ends of alternate segments into two insulated groups, respectively, and a concentric transmission line, the inner and outer conductors of which are connected respectvIely to said conductive joining means.

2. A magnetron oscillator comprising a vacuum-tight envelope containing working electrodes including a segmented anode, the segments of which anode are all conductively connected to-

gether at one end and free at the other, a concentric line section located outside said envelope and having a closed end adjustable by means of a slidable short-circuiting conductor and having the opposite end open-circuited, means conductively connecting the free ends of the anode segments into two groups, said groups being insulated from each other, and means conductively connecting the said groups of segments with the respective terminals of the open circuited end of said concentric line section.

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