Jan. 14, 1947. P. L. HARTMAN 2,414,085

OSCILLATOR

Filed Dec. 14, 1944 2 Sheets-Sheet 1

FIG. 1.

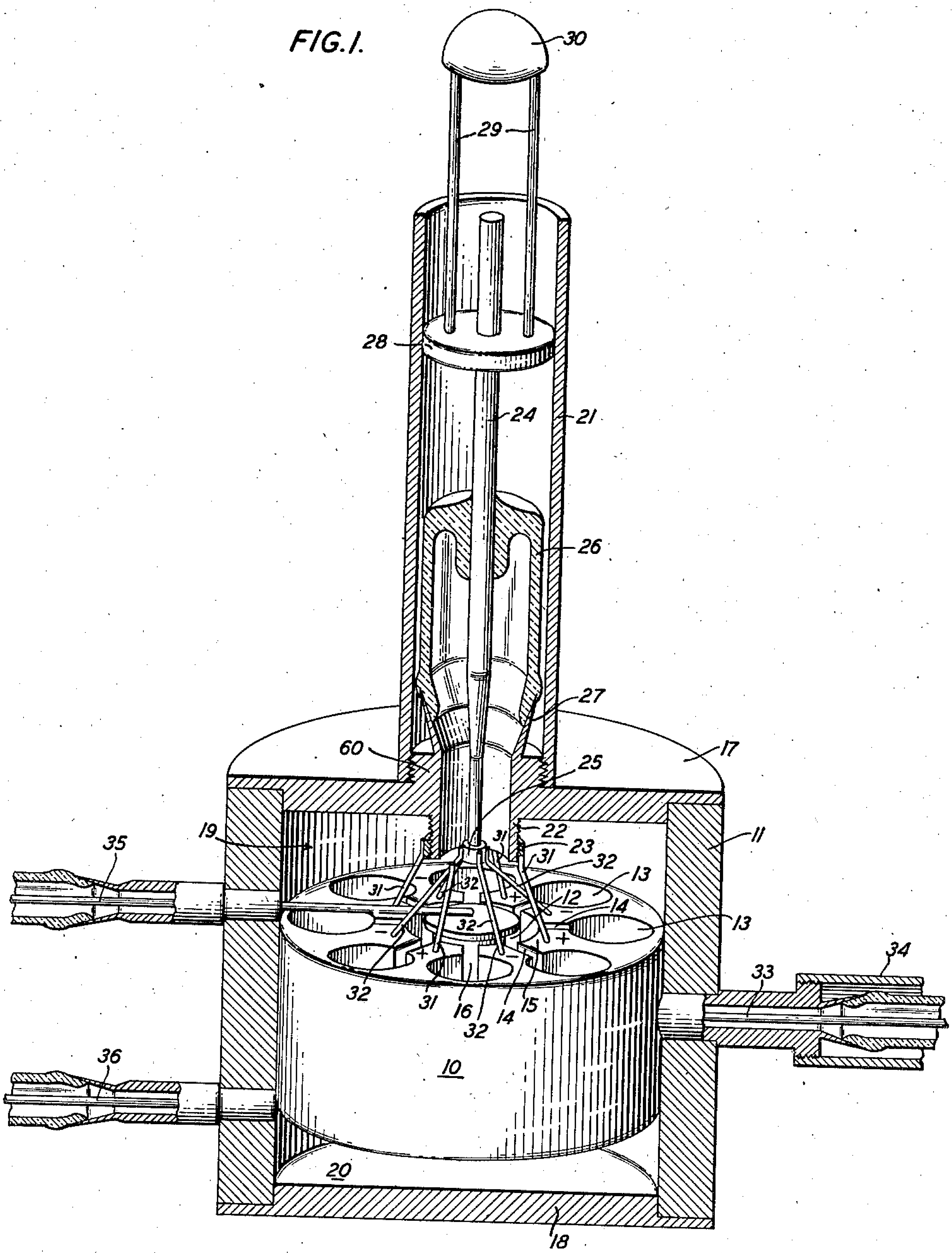

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FIG. 2.

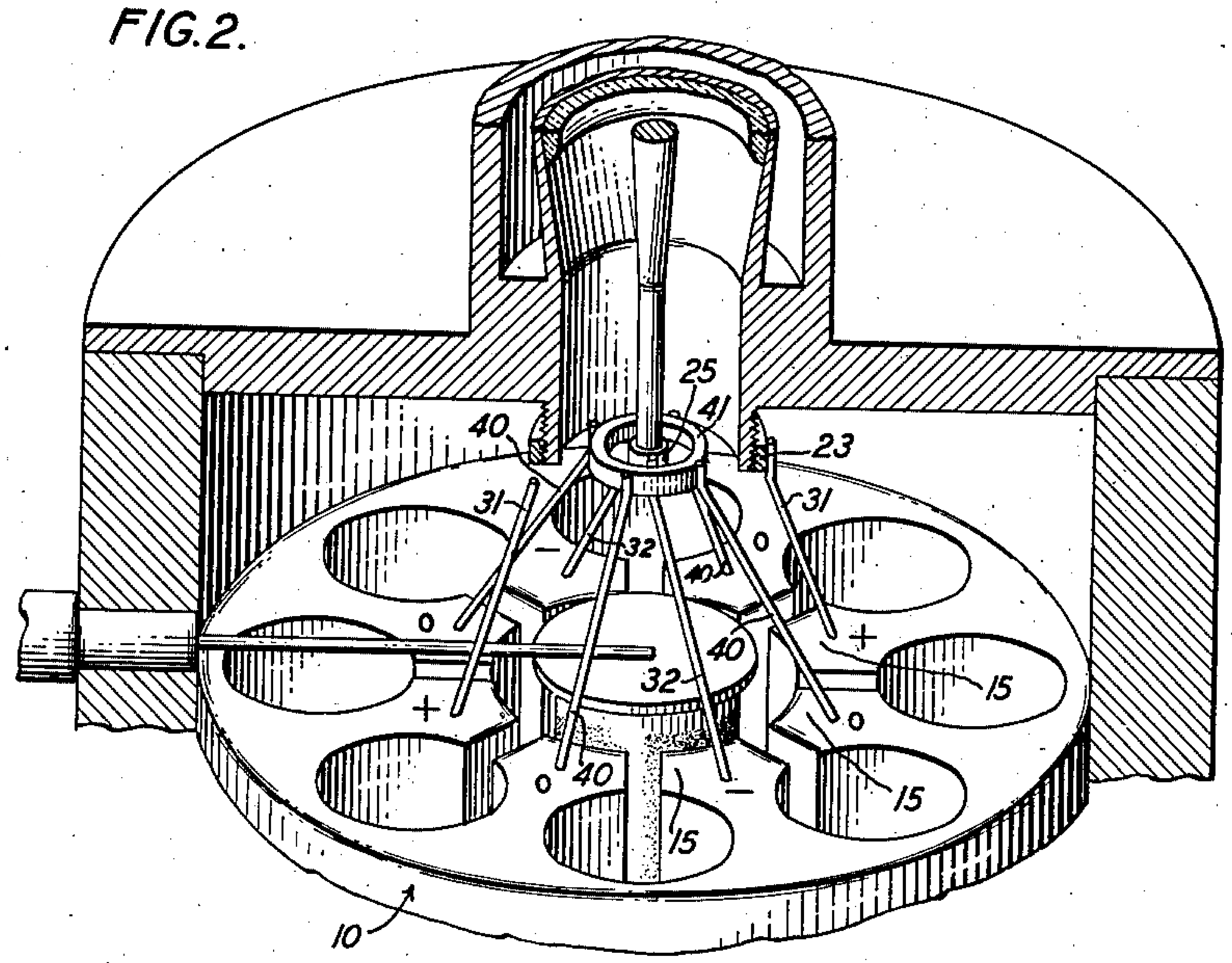
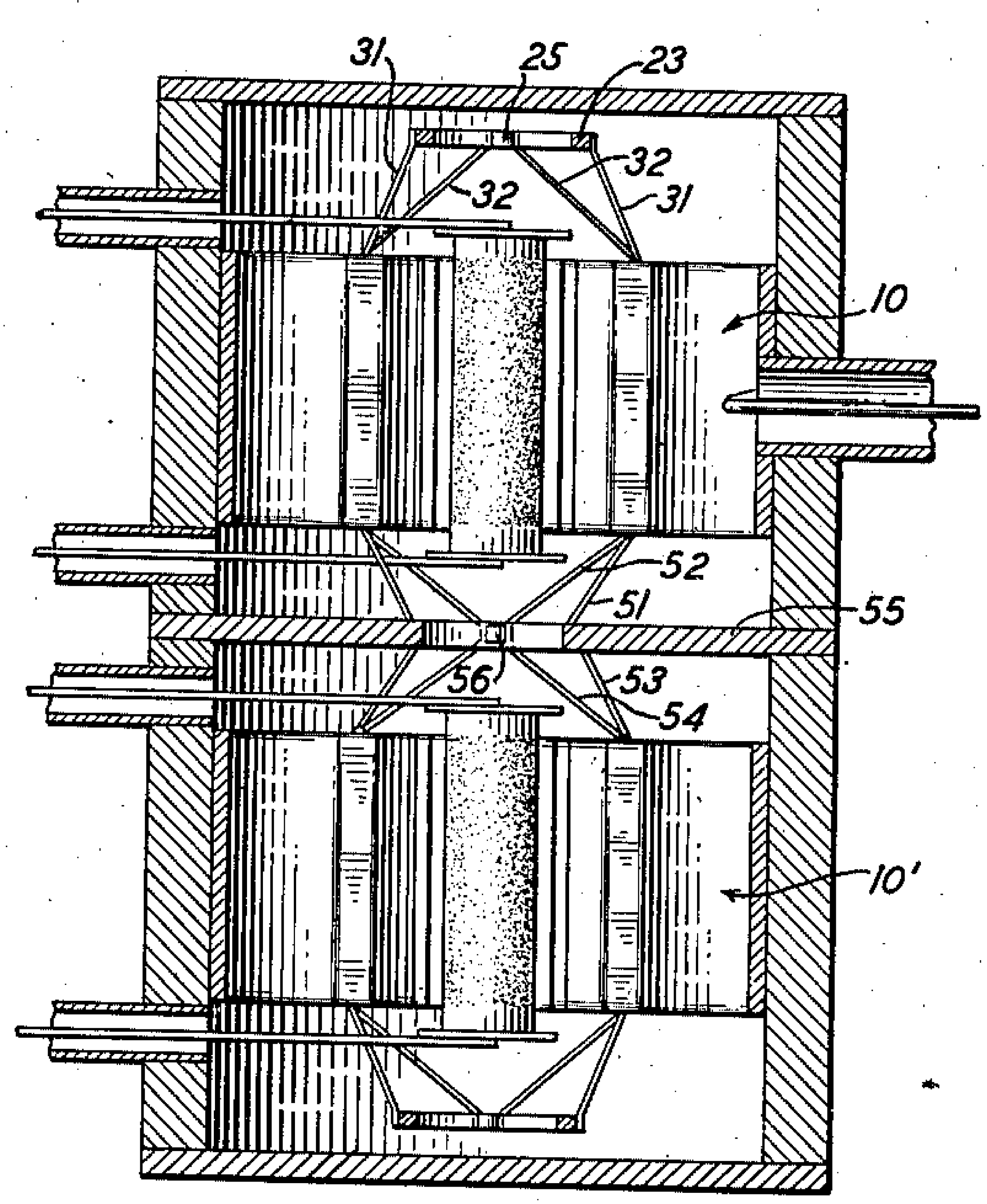


FIG. 3.



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OSCILLATOR

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8 Claims. (Cl. 315—39)

1

This invention relates to tuning and coupling devices for microwave systems and more particularly to an arrangement comprising a coaxial type transmission line or resonator symmetrically coupled to all the individual cavities of a circularly symmetrical multicavity resonator.

The resonator of a commonly employed type of magnetron oscillator comprises a cylindrical anode block containing a plurality of axial perforations constituting portions of a multiresonant cavity system having a number of individual cavities, separated by segments of the anode block. Adjustment of the resonant frequency of the oscillator during operation is commonly affected by tuning one or more of the individual cavities.

It is known that those tuning arrangements which affect the individual cavities differently, distort the field pattern of the oscillator as a whole. This distortion may alter the operating conditions of the oscillator as the frequency is changed, thereby introducing undesirable variations in the efficiency of operation, power output, etc. The tuning arrangement in accordance with the present invention is symmetrical with respect to all the individual cavities and hence has a minimum of disturbing effects upon the output of the oscillator as a function of the frequency.

In accordance with the invention, a coaxial line structure is associated with the resonator and a plurality of electrical connectors are provided each joining a different one of the anode segments with one or the other of the conductors of the coaxial line. The anode block in the usual case is surrounded by an electromagnetic shield defining in conjunction with the anode block an end space opening into the individual cavities of the multiresonant system. The electromagnetic shield and the outer conductor of the coaxial line are preferably electrically continuous and integral to prevent energy propagation except within the interior of the system and into the desired load connection. The coaxial line may be tuned in conventional manner thereby adjusting simultaneously the resonant conditions for all the individual cavities to influence the operating frequency of the system as a whole. If desired the coaxial line may serve also as the output coupling for supplying wave energy from the oscillator to a load.

The tuning and coupling arrangements of the invention are adaptable for use with a variety of different modes of oscillation in a multiply

2

resonant system. For example, in magnetron oscillators as ordinarily operated, the anode segments at any given instant are alternately of more positive and more negative polarity in succession around the circumference of the anode block, relatively to the mean potential of the anode block. In another mode of operation, alternate anode segments are at zero potential difference with respect to the mean potential of the anode block, the succession of relative polarities being then positive, zero, negative, zero, positive, etc. To utilize the invention in the latter mode of operation, the relatively positive segments may be connected to one conductor of the coaxial line and the relatively negative segments to the other as before, while the zero segments may be connected together through a short-circuiting conductive ring or otherwise.

The coupling arrangement of the invention is further adapted to coupling a plurality of magnetron oscillators in a pile or stack arrangement in which adjacent magnetrons are connected by a short length of coaxial line or the equivalent.

In the drawings,

Fig. 1 is a perspective view partly in cross-section showing a magnetron oscillator embodying the invention.

Fig. 2 is a fragmentary view of an arrangement similar to that shown in Fig. 1 but with an interconnection of anode segments designed to favor a different mode of oscillation; and

Fig. 3 shows two magnetron oscillators in a pile or stack arrangement with coupling between the oscillators in accordance with the invention.

Referring to Fig. 1, there is shown an anode block 10, as in a magnetron oscillator. The block may constitute an insert in a casing 11 and may be perforated axially with a central hole 12 and a plurality of peripheral holes 13 each joined with the hole 12 by means of a slot 14. Between each pair of slots 14 there is defined an anode segment 15. A cathode 16, which may be cylindrical, is preferably mounted centrally in the hole 12, the space between the cathode 16 and the plurality of anode segments 15, comprising the electron interaction space as in a conventional magnetron oscillator.

The casing 11 may be closed at top and bottom by end plates 17 and 18, respectively forming, together with the end surfaces of the anode block end spaces 19 and 20.

A coaxial line enters the end space 19 as through the plate 17, preferably axially and centrally. The outer conductor of the line may comprise a hollow cylindrical conductor 21 surrounding a central hole in the plate 17, secured as by means of a threaded collar portion 60. An inward extension of the plate 17 may comprise a hollow cylindrical portion 22 and this may be threaded exteriorly to engage a complementary thread within a conductive ring 23 to which are connected a number of rods, wires or other conductors connecting with various segments 15 of the anode block 10. The inner conductor of the coaxial line may comprise a rod or wire 24 extending through the member 22 into the end space 19. The conductor 24 may terminate in an enlarged cylindrical portion 25 to which may be connected a number of conductors going to various segments 15. The conductor 24 may be supported and a vacuum tight closure formed by a seal 26, as of glass, extending between a tapered flaring member 27 and the inner conductor 24. Beyond the sealing member 26 an adjustable conductive short-circuiting bridge 28 may be arranged to slide upon the conductor 24 and in contact with the inner surface of the outer conductor 21. The bridge 28 may be adjusted by any suitable means such as rods 29 and a knob 30.

The conductors which connect the segments 15 with the two sides of the coaxial line 21, 24 may be arranged as shown to connect alternate segments with the ring 23 and the cylinder 25, respectively, thus favoring the customary mode of oscillation, in which alternate segments 15 are positive and negative respectively with respect to the mean potential of the anode. In Fig. 1, the segments 15 are marked alternately positive and negative representing a relative polarity of the segments in the oscillating system at a particular instant. After the lapse of a half cycle of the operating frequency, the polarity of each segment is the reverse of that shown in the figure. For clarity in the drawing, the front half of the ring 23 is cut away. A plurality of connectors 31 are shown connecting the positive segments to the ring 23. Between each two connectors 31 a connector 32 is shown connecting a negative segment with the cylinder 25.

In assembling the device of Fig. 1, the connectors 31 may be secured to the block 10 and ring 23 and the connectors 32 to the block 10 and cylinder 25 before the block is inserted in place in the casing 11. The inner coaxial conductor 24 may be fastened to the cylinder 25, either before or after inserting the block in the casing. Next the end plate 17 may be installed, the extension 22 meshing with the internal thread on the ring 23. The seal 26 may then be applied and thereafter the hollow cylindrical conductor 21 may be screwed down over the collar 60.

A conventional output connection comprising an inner conductor 33 and an outer conductor 34 may be introduced in known manner into one of the cavities 13. Rods 35 and 36 may be introduced in known manner to support the cathode 16.

The basic operation of the device of Fig. 1 as a magnetron oscillator is conventional and being well known in the art need not be particularly described herein. The conductors 31 and 32, however, take the place of the intersegmental connectors sometimes called mode-locking straps usually employed with magnetron oscillators of this type for insuring operation at one predetermined mode only. By connecting alternate anode segments to the ring 23 and cylinder 25, the anode segments of like plurality are conductively connected by electrically short conductors to insure the operation of the device in a mode of oscillations in which alternate anode segments are always of opposite polarity. In addition each adjacent pair of conductors 31, 32 forms, with adjacent anode segments 15 and the periphery of the intermediate cavity 13, an inductive circuit coupling the individual cavity across the terminal of the coaxial line 21, 24 in parallel with all the other circuits similarly formed involving the remaining cavities. The system comprising the anode block 10, the conductors 31, 32 and the transmission line 21, 24 may be given a high degree of circular symmetry, thereby insuring uniform coupling of the individual cavities 13 to the transmission line 21, 24. The line 21, 24 may be tuned as by means of the bridge 28, the tuning adjustment evidently affecting the individual cavities 13 substantially uniformly. The output may be derived from one of the cavities 13, as shown, in which case the tuning adjustment will have little disturbing effect upon the wave pattern in any cavity, including the cavity to which the output lead is connected. If still greater degree of symmetry is desired, the output may be taken from the transmission line 21, 24 in any suitable manner without interference with the tuning function.

Fig. 2 shows how the anode interconnections, or strapping, may be made to favor the type of wave pattern in which the segments 15 at any given instant may be either positive, negative or at zero relative potential. For example, the segments may show a succession of relative polarity such as: positive, zero, negative, zero, positive, etc. Each segment that is positive at a given instant may be connected by a conductor 31 to the ring 23, the same as in the arrangement of Fig. 1, and each negative segment may be connected by a conductor 32 to the cylinder 25 as before. The zero potential segments, however, are in this case preferably connected to a short-circuiting ring 41 located intermediate the ring 23 and the cylinder 25, as shown in Fig. 2.

The operation of the system of Fig. 2 is similar to that of Fig. 1, the principal difference being that a different wave pattern and different relative potentials of the anode segments are favored. In general, with the same dimensions of the resonator, the operating frequency as well as the field pattern in the resonator will be different in the two systems, Figs. 1 and 2, respectively.

It may be desirable in some cases to employ the ring 23 and cylinder 25, or their counterparts, together with strapping conductors 31 and 32 without any connection to an outgoing transmission line. Such an arrangement is shown in the upper part of Fig. 3 where the elements 23, 25, 31, 32 serve as a mode-locking device without any provision for tuning or for coupling through an external system.

The arrangements of Fig. 3 also shows the utility of the arrangement of the invention in connecting a plurality of magnetrons together by end to end connection as in a pile or stack. In Fig. 3, two anode inserts 10 and 10′ have their respective anode segments interconnected by means of four sets of connectors 51, 52, 53, 54. An end plate 55 common to both anodes is shown inserted between them, the plate 55 having a central hole in which may be centrally located a small conductive member 56, corresponding to the cylinder 25 of the previous figures. The connectors 51 may connect alternate segments of the anode 10 to the plate 55, the connection at the plate being made preferably near the edge of the central opening. The connectors 52 may connect the remaining segments of the anode 10 with the member 56. Alternate segments of the anode 10′ may be connected to the underside of the plate 55 by the connectors 53 which may make contact with the plate near the periphery of the central opening. The remaining anode segments of the anode 10′ may be connected to the member 56 by the connectors 54. It will be evident that the system of connectors 52 and 54 and the element 56 may be replaced if desired by a system of connectors running from an element of the upper anode to a diametrically opposite element of the lower anode. In the arrangement of Fig. 3 each anode with its associated cathode works as a unit with only a certain small phase difference between one unit and the next. The magnetic flux in each of the two units is practically limited to its own unit. This arrangement has certain advantages over the use of a longer anode block, such as reducing any tendency of the oscillating system to establish a mode of oscillations in which there are considerable phase differences or phase reversals along the axis of the oscillator.

While the invention is illustrated herein as applied to a magnetron oscillator having eight cavities, it will be evident that the invention is not limited to an oscillator nor to a magnetron and that the number of cavities may be increased or decreased as desired, without going beyond the scope of the invention as defined in the appended claims.

What is claimed is:

1. An oscillator comprising a cylindrical anode block containing a plurality of axial perforations constituting a multi-resonant system having a number of individual cavities separated by segments of said anode block, an electromagnetic shield surrounding said anode block and defining therewith an end space opening into said multi-resonant system, said end space being bounded in part by end surfaces of said anode block, a coaxial line extending into said end space, and a plurality of electrical conductors each joining a different one of said anode segments with one or the other of the conductors constituting said coaxial line, the said electromagnetic shield and the outer conductor of said coaxial line being electrically continuous and integral whereby energy propagation is confined within the system.

2. An oscillator comprising a multi-resonant structure having a plurality of coupled circuits connected by intermediate conductive elements, means for constraining said multi-resonant structure to operate in a particular mode of oscillation wherein a succession of potentials relative to the mean anode potential occurs at any given instant upon said intermediate conductive elements in the order positive, zero, negative, zero, positive, etc., said constraining means comprising electrically short interconnectors connecting together respectively the elements of positive relative potential in one group, those of negative relative potential in a second group and those of zero relative potential in a third group.

3. An oscillator comprising a multi-resonant structure having a plurality of coupled circuits connected by intermediate conductive elements, means for constraining said multi-resonant structure to operate in a particular one of its possible modes of oscillation, namely a mode wherein a succession of relative potentials occurs at any given instant upon said intermediate conductive elements in the order positive, zero, negative, zero, positive, etc., said constraining means comprising three concentric conductors and a plurality of connectors joining the positive elements to one of said concentric conductors, the negative elements to a second of said concentric conductors, and the zero elements to the third of said concentric conductors.

4. An oscillator in accordance with claim 3, in which the intermediate conductive elements of zero relative potential are connected to the middle one of said concentric conductors.

5. An oscillator in accordance with claim 3, in which the intermediate conductive elements of zero relative potential are connected to the middle one of said concentric conductors, and in which tuning means are connected between the innermost and outermost of said concentric conductors.

6. An oscillator in accordance with claim 3, in which the innermost and outermost of said concentric conductors are of extended length to constitute a transmission line, the middle one of said concentric conductors comprises a conductive ring, and in which the said intermediate conductive elements of zero relative potential are connected to said ring.

7. An oscillator comprising a plurality of multi-resonant anode blocks mutually spaced apart and mounted end to end, said anode blocks each having a plurality of anode segments, an apertured shielding member interposed between adjacent anode blocks, a plurality of electrically short conductors connecting a group of anode segments in one of said anode blocks to said shielding member, and another plurality of electrically short conductors connecting another group of anode segments of the same anode block to a common conductor located within and spaced from the edge of the aperture in said shielding member.

8. A plurality of multiresonant anode blocks mutually spaced apart and mounted end to end, said anode blocks each having a plurality of anode segments, an apertured shielding member interposed between adjacent anode blocks, a plurality of electrically short conductors connecting a group of anode segments in one of said adjacent anode blocks to said shielding member, and another plurality of electrically short conductors respectively connecting together anode segments in two other groups of anode segments, said latter two groups being located respectively in adjacent anode blocks on opposite sides of said shielding member.

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