

Nov. 19, 1946.

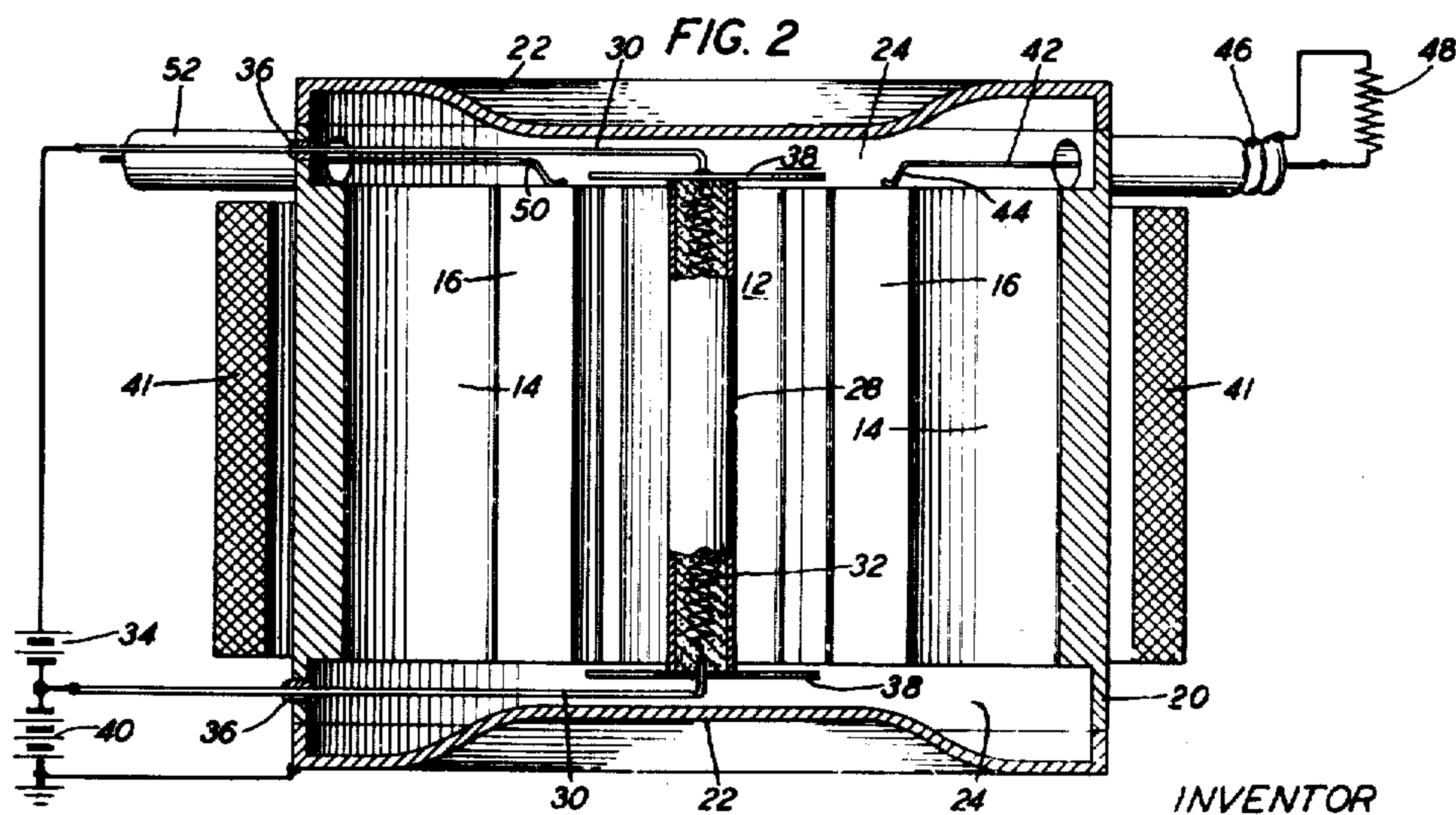
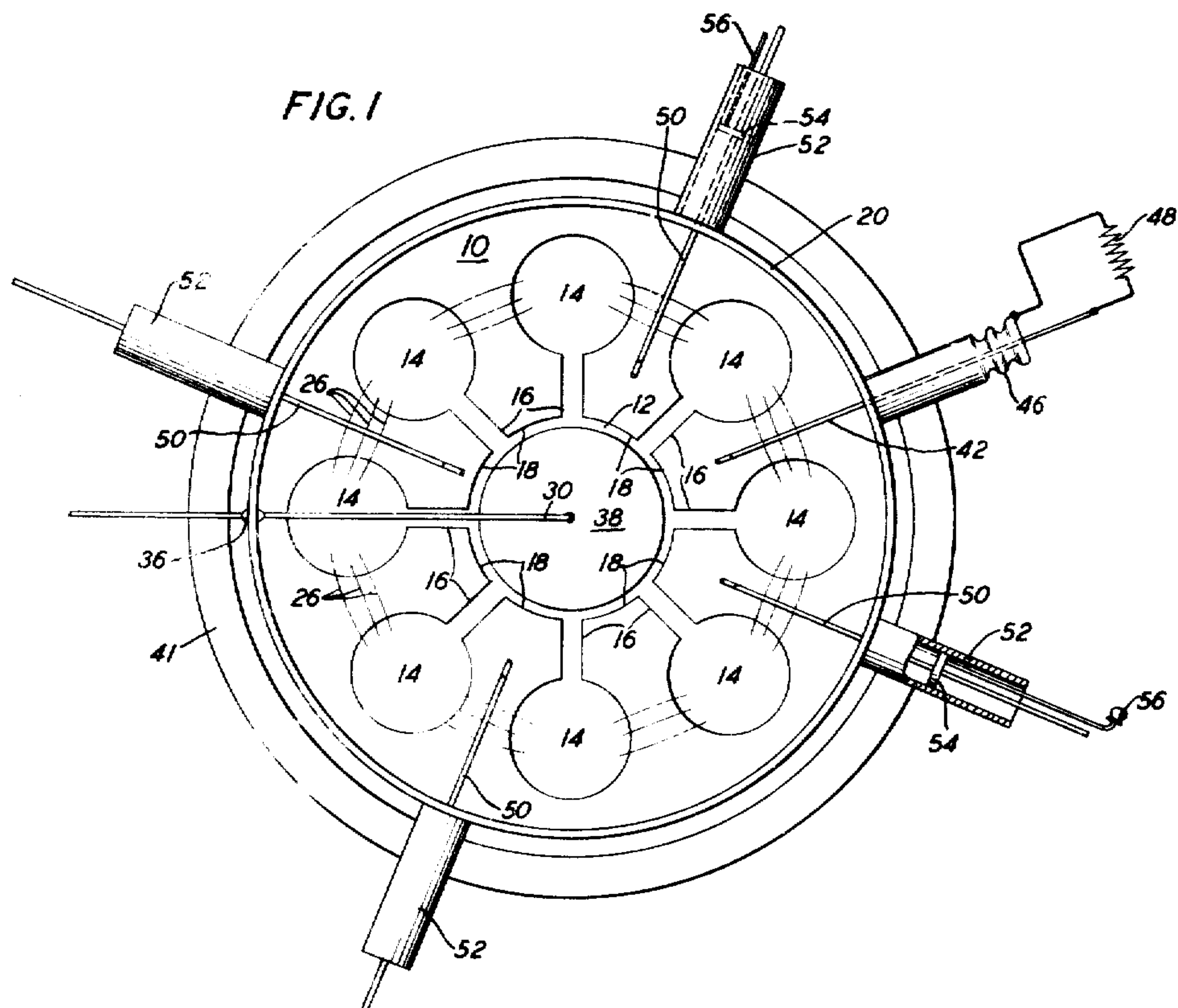
J. B. FISK

2,411,151

OUTPUT COUPLING FOR HIGH FREQUENCY OSCILLATORS

Filed May 1, 1942

3 Sheets-Sheet 1



INVENTOR
J.B.FISK
BY
Harry C. Hart

ATTORNEY

Nov. 19, 1946.

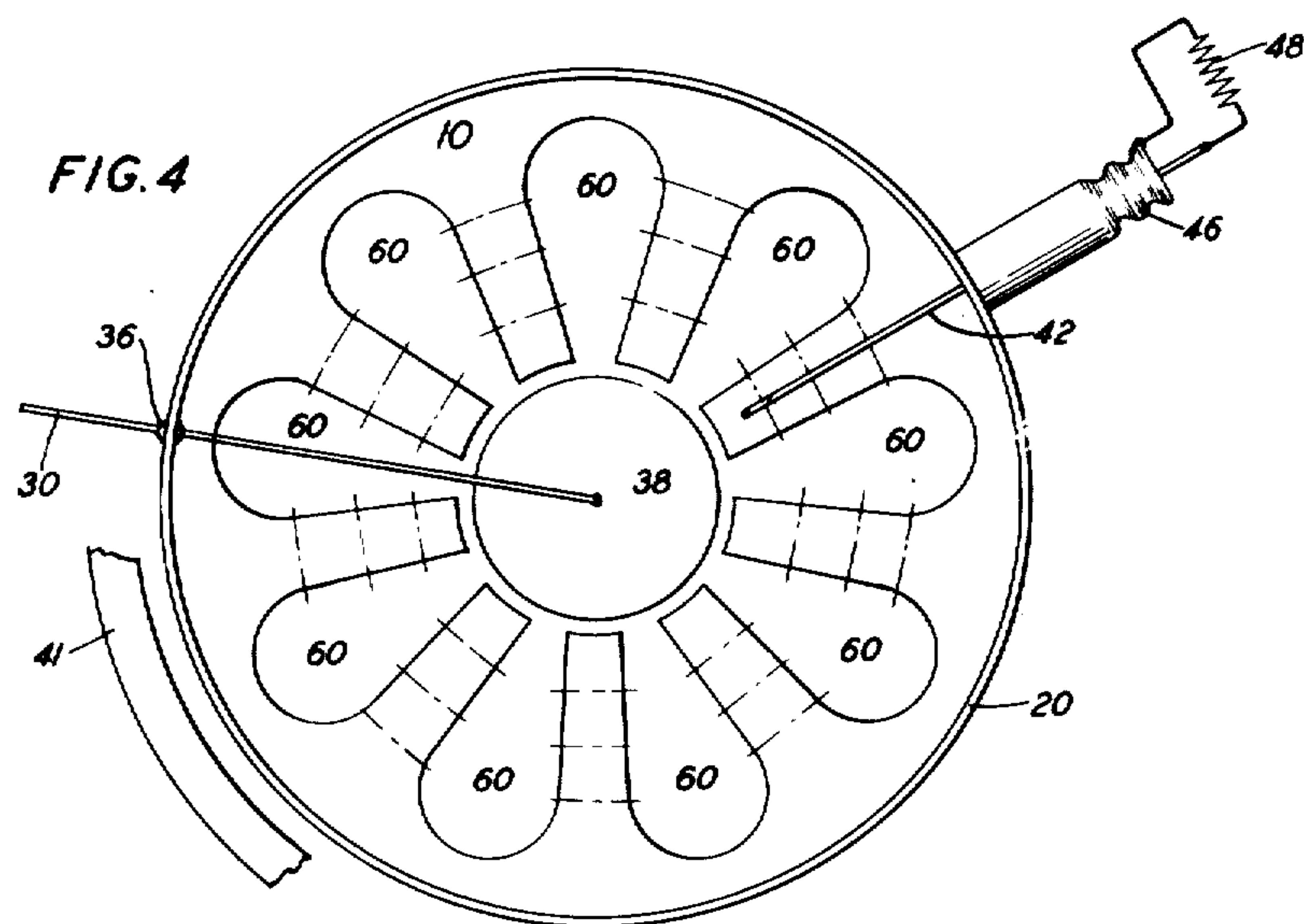
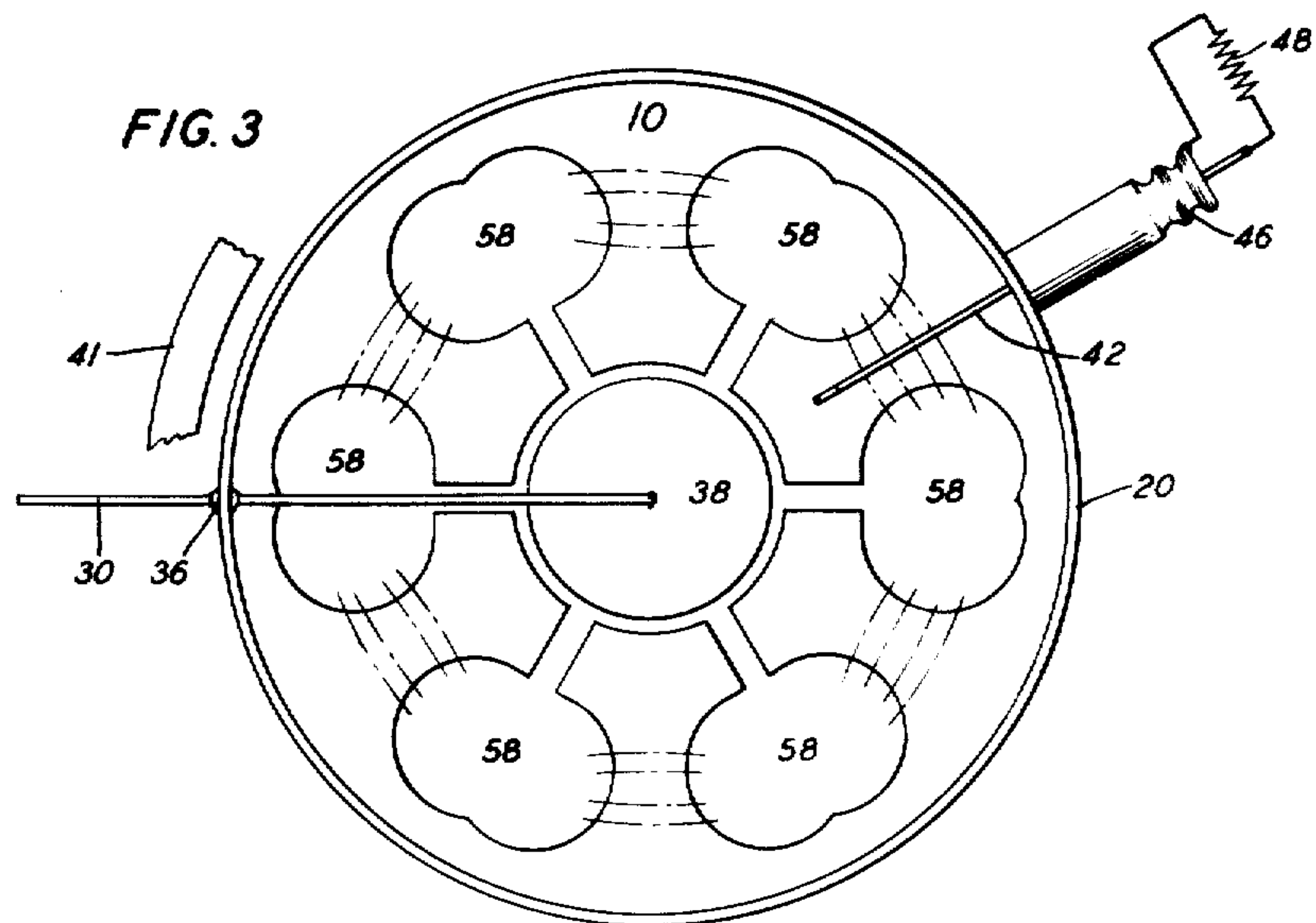
J. B. FISK

2,411,151

OUTPUT COUPLING FOR HIGH FREQUENCY OSCILLATORS

Filed May 1, 1942

3 Sheets-Sheet 2



INVENTOR
J. B. FISK
BY Harry C. Hart

ATTORNEY

Nov. 19, 1946.

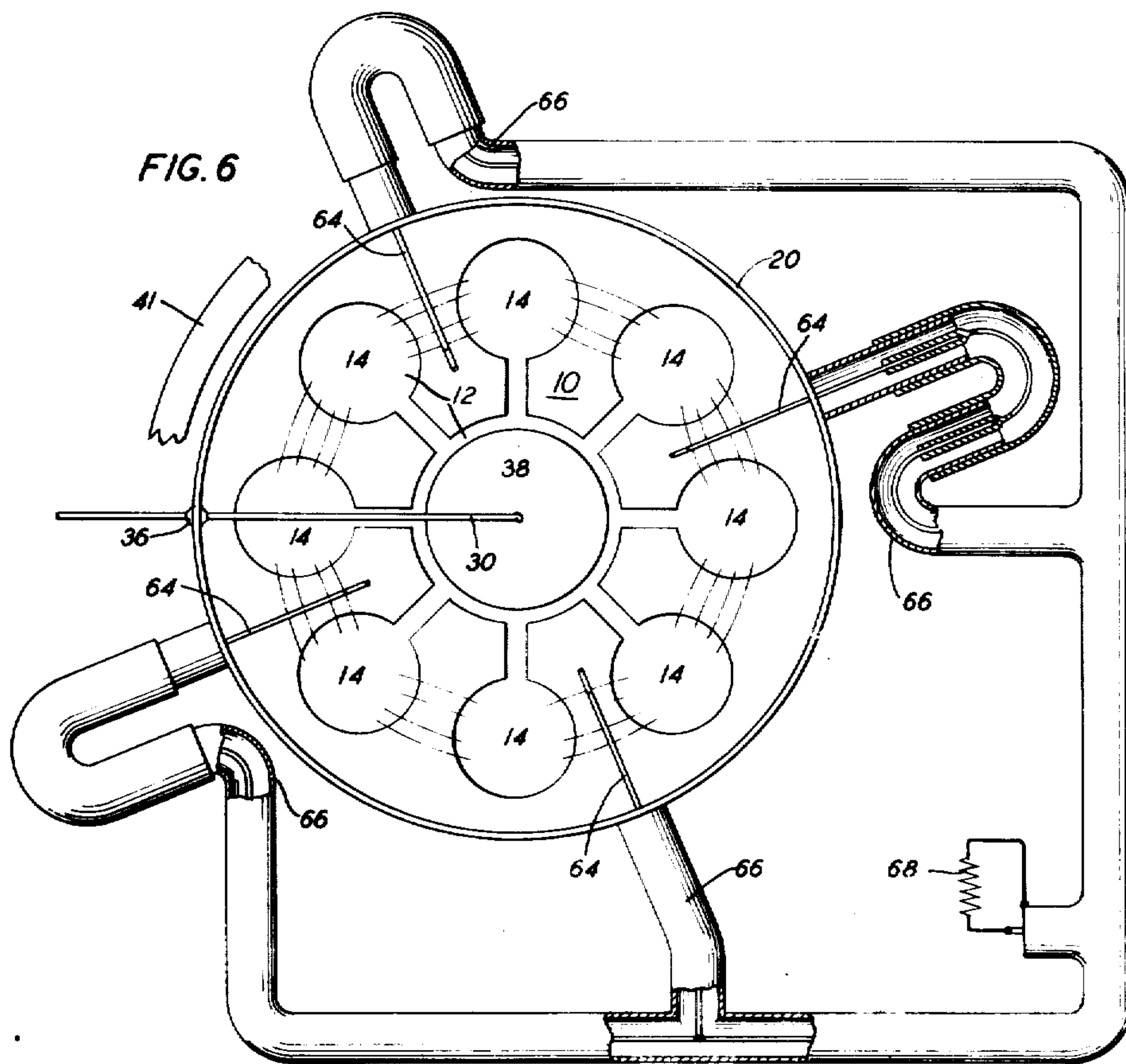
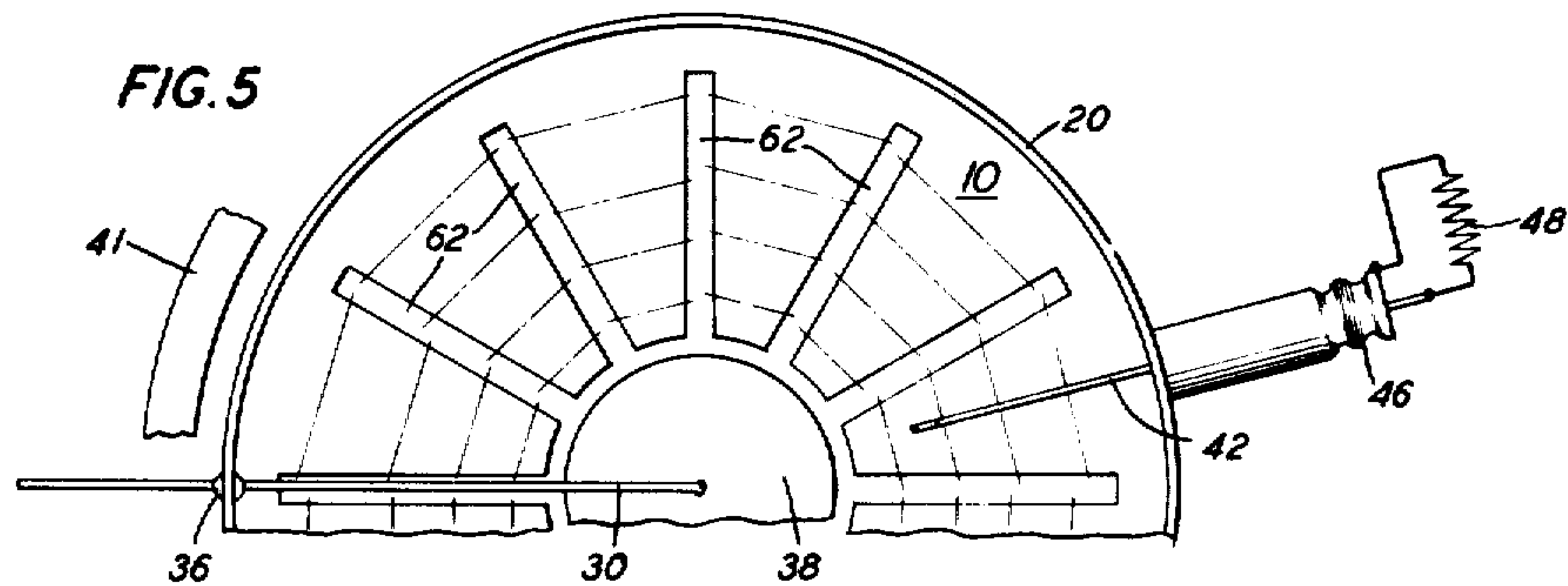
J. B. FISK

2,411,151

OUTPUT COUPLING FOR HIGH FREQUENCY OSCILLATORS

Filed May 1, 1942

3 Sheets-Sheet 3



INVENTOR
J. B. FISK
BY
Harry C. Hart
ATTORNEY

UNITED STATES PATENT OFFICE

2,411,151

OUTPUT COUPLING FOR HIGH-FREQUENCY
OSCILLATORSJames B. Fisk, Madison, N. J., assignor to Bell
Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

Application May 1, 1942, Serial No. 441,406

15 Claims. (Cl. 250—36)

1

This invention relates to electron discharge devices and particularly to those devices termed "magnetrons" in which high frequency oscillations are produced by the curvilinear orbital motions of electric charges under the joint influence of electric and magnetic fields.

An object of the invention is to provide simple and effective means for abstracting the power of a magnetron and delivering it to a utilization circuit.

A related object is to effect such withdrawal or power abstraction with a minimum of distortion or perturbation of the high frequency electromagnetic fields which exist within the device during operation.

Another object of the invention is to provide simple and effective means for adjusting the frequency of oscillation of the magnetron.

In the development of the magnetron art, an important step which was taken in an effort to obtain higher oscillation frequencies than were possible with the original continuous anode surface, was to subdivide the anode into two halves and connect tuning elements, for example inductance and capacity elements, between them. This practice was then further extended by subdividing the anode surface into four, six, eight, etc. surfaces, alternate ones being conductively connected together. In all of these arrangements tuning was a comparatively simple matter, being accomplished simply by adjustment of the inductance and capacitance elements which were normally mounted externally of the magnetron proper to desired values.

Further efforts to extend the oscillation frequency of magnetrons to higher values were impeded by the limitations inherent in the lumped tuning elements. Accordingly, the art turned to a modified structure such as shown, for example, in Samuel Patent 2,063,342, December 8, 1936, in which the external lumped tuning elements are replaced by cavity resonators disposed within the envelope and close to the discharge or interaction space itself, being coupled thereto by way of openings or channels. The discharge space and the tuning cavities may indeed be machined from a single solid mass which may be mounted within a cylindrical shell and between flat end plates.

This departure permits a considerable increase in operating frequency. However, it presents difficulties in effecting an external coupling for the abstraction of power. Output power coupling to magnetrons of the solid anode type has heretofore been effected by way of a small coupling loop which passes through the outside wall or

2

casing of the device into one of the tuning cavity resonators and there links a portion of the high frequency magnetic flux which exists therein during operation. When the area of this loop is a substantial fraction of the cross-sectional area of the cavity resonator with which it is so coupled, the latter is overloaded, with the result that severe distortions and perturbations exist in the electromagnetic field pattern within the device. On the other hand, when the coupling loop area is but a small fraction of the cross-sectional area of the cavity resonator, it links but a correspondingly small fraction of the magnetic flux and suffices to abstract only a correspondingly small amount of power. Furthermore, adjustment of the area or orientation of such coupling loop to link more or less of the magnetic flux within the cavity, is beset by such difficulties that it is customary to build the coupling loop as an integral part of the device, with the result that the power abstracted is not subject to change at the will of the operator, but can be altered only by a completely new construction based on a new design.

Devices of this character also suffer from the disadvantage that any minute error in the dimensions of the resonators or the channels which interconnect them with the discharge space causes a corresponding error in the oscillation frequency which can be corrected only by a complete remachining and reconstruction of the anode structure as a whole.

The present invention is based upon the discovery that in a magnetron of the solid anode type the cavity resonators, though geometrically separate, are electromagnetically intercoupled, inasmuch as some of the high frequency magnetic flux lines which link any one cavity bend over at the ends of the structures to link other cavities, thus providing a mutual impedance coupling between the members of each pair of adjacent cavities, and providing, also, regions of relatively dense mutual flux at which desired couplings may be effected, alternating with regions at which the mutual flux density is much reduced, at which regions conductors may be led into the end space without appreciable unwanted coupling. The magnitude of this mutual impedance as compared with the self-impedance of each cavity depends, in a highly complex manner, on all the cavity dimensions. It depends, in particular, on the length and cross section of the mutual flux path between cavities which path is bounded on one side by the anode structure and on the other by the end plate of the magnetron,

3

its shortest length being the distance separating adjacent portions of the open ends of adjacent cavities. By arranging that these adjacent open cavity ends shall be close together, it has been found possible to produce a large amount of mutual intercavity flux, and therefore a large mutual impedance coupling between adjacent cavities. As long as the intercavity coupling is greater than a certain critical value, increases and reductions in the coupling produce corresponding alterations in the resonant frequency of the magnetron, in accordance with principles which are well known in the coupled circuit art. See, for example, chapter 3 of "High Frequency Alternating Currents," by McIlwain and Brainerd, 1931 edition.

In accordance with a principal aspect of the invention an output power coupling loop is provided which links only the mutual flux which is common to two or more of the cavity resonators. It may extend into the end space of the magnetron through a suitable seal and make contact with the anode block in the vicinity of the central discharge space, in position to link a portion of the flux which is common to two adjacent cavities. Preferably, the loop lies in a plane midway between two adjacent cavities. Evidently a single such coupling loop interacts similarly with the electromagnetic fields within the cavities on each side of it and therefore introduces much less asymmetry into these fields than would be introduced by a loop coupled exclusively to the flux within one cavity. Furthermore, the amount of flux which is linked by the loop and the amount of power abstracted may easily be varied by varying the loop area, for example, by advancing or withdrawing the loop in a radial direction while its end slides over the end of the machined anode block.

If desired, a plurality of such loops may be provided. They may supply energy to a common utilization circuit, phase shifting means being employed to adjust the phases of the currents so withdrawn until they are alike, or, if preferred, the coupling loops may be tuned and employed as trimmers to adjust the oscillation frequency of the magnetron to a desired value.

On the other hand the central cathode may be supplied with operating potential and its heater element with current by way of conductors which extend radially into the magnetron end space in the plane of the axis of one of the cavity resonators, about which plane the flux from each cavity divides substantially equally, half passing to the adjacent cavity on one side and the other half to the adjacent cavity on the other side. With this disposition of the cathode supply conductors the coupling between them and the high frequency fields is reduced to a minimum, with consequent reduction of high frequency power losses in the conductors.

The invention will be fully understood from the following description of a preferred illustrative embodiment thereof taken in conjunction with the appended drawings, in which:

Fig. 1 is a plan view of a cavity-tuned magnetron provided with a plurality of mutual inductance coupling loops and a cathode supply lead disposed in accordance with the invention;

Fig. 2 is a broken vertical cross section of Fig. 1;

Fig. 3 is a plan view of a magnetron similar to that of Fig. 1 but in which the intercavity coupling has been increased by a reduction of the separation distance between cavities;

4

Fig. 4 is a plan view of a magnetron similar to that of Fig. 1 but in which the intercavity coupling has been reduced by the use of elongated cavities;

Fig. 5 is a plan view of a part of a magnetron similar to that of Fig. 1 but in which the intercavity coupling has been further reduced by the employment of narrow parallel-sided slots as tuning cavities; and

Fig. 6 is an end view of a magnetron similar to that of Fig. 1 but in which certain of the coupling loops are arranged to supply energy to a common utilization circuit.

Referring now to Figs. 1 and 2, the body of the magnetron may comprise a comparatively massive block 10 of conductive material such as copper, into which are cut as by drilling, a central discharge space 12 and a plurality of resonant cavities 14 surrounding the same and symmetrically disposed about it. Each of the cavities 14 opens on to the discharge space 12 through a channel or slot 16 which serves as a coupling means between the energy of movement of the electrons in the discharge space 12 and the electromagnetic field within the cavities 14. The cylindrical surfaces 18 between channels 16 serve as anode surfaces.

The anode block 10 is preferably mounted centrally in a cylindrical shell or casing of conductive material such as copper, connected thereto. If preferred, anode block 10 and shell 20 may be machined from a single solid mass. In either case the shell may be closed at the end by plates 22 which serve both to exclude air and gases and to define the end spaces 24 in which the mutual flux 26 common to adjacent cavities exists. These end plates may be flat, or they may be recessed as shown, the better to concentrate the mutual flux 26 in the vicinity of the coupling loops to be described.

A central cathode, for example an elongated cylindrical element 28, whose surface is rendered electron emissive by suitable treatment may be mounted centrally in the discharge space 12 and supported in place as by conductive rods 30. To bring it to a state of electron emissiveness, heat may be applied thereto as by a heating element 32 which may be embedded in ceramic material within the cathode 28 and electrically connected thereto. The heater 32 may be supplied from any suitable source such as a battery 34, for example, by way of the cathode supports 30 which may be brought into the end spaces 24 through insulating seals 36.

In operation the heater leads 30 will be maintained at or close to the cathode potential which is highly negative with respect to the anode block 10 and the end plates 22 which define the end spaces 24 through which the heater leads 30 reach the cathode 28 and the heater 32. To avoid asymmetry the electromagnetic fields within the end spaces 24 due to the presence of the low potential heater leads and also to prevent high frequency induction therein and consequent power loss, they are preferably brought into the end spaces in the plane of the axis of one of the tuning cavities 14. Thus the mutual flux lines 26 emerging from the cavity 14 pass to either side of the heater leads 30 in such a way that only a negligible quantity of this flux links the heater leads. By this expedient coupling between the heater leads and the electromagnetic fields in the end spaces may be reduced to a negligible value.

Under certain conditions, the operating tem-

5

perature of the cathode may be maintained after the apparatus has been well started merely by bombardment thereof by electrons which originate on the cathode surface, travel into the discharge space and partway through their orbits and return at high velocities to the cathode. The cathode 28 may be provided with end discs 38 to maintain space charge conditions within the discharge space at desired values and reduce losses due to the escape of working electrons into the end spaces of the device.

Operating voltage may be applied between cathode 28 and anode block 10 from a suitable source, for example, a battery 40 whose negative terminal is connected to the cathode 28 and whose positive terminal is connected to the anode block 10 and casing 20 which, since it is external to the cathode and liable to be touched by the hands of an attendant, may be connected to ground. If desired, a varying voltage, e. g., a succession of pulses or a low frequency signal voltage of any desired type, may be applied to the anode 10 to effect modulation of the oscillations.

An axial magnetic field may be supplied in any desired manner, as by a coil 41 carrying a steady current in accordance with known practice.

In accordance with the invention, power may be abstracted by way of a loop which links only the flux 26 which is mutual to two adjacent cavities 14. A loop of a convenient and suitable form may comprise a rod 42 which extends radially inward from the outside through the casing 20 into the end space 24 of the magnetron and there bends over to make contact with the end face of the anode block 10 as at 44. Preferably, its course lies in a plane midway between two adjacent cavities 14. It may be brought into the end space 24 by way of a flexible seal 46 so that the exact position at which its bent tip 44 makes contact with the end face of the anode block 10 may be varied at will simply by advancing or withdrawing the rod 42. Power withdrawn by way of this loop may be led over any suitable transmission path to a suitable load or utilization circuit schematically indicated by the resistor 48.

The figures also illustrate the manner in which the mutual inductance coupling loops of the invention may be applied to the adjustment of the oscillation frequency. To this end, a plurality of mutual inductance coupling loops 50, all of which may be alike and similar to the energy abstraction loop 42 extend radially inward into the end space 24 preferably symmetrically disposed about the same. The outward extension of each of these loops 50 may form the inner conductor of a coaxial line whose conductor is a tube 52 connected to the magnetron casing 20 at one end and coupled to the inner conductor 50 by way of a conductive disc 54 whose axial position is adjustable. A handle 56, for example, of insulating material, may be provided to facilitate adjustment of the coupling disc 54 axially of the tube 52. The inner conductors 50 may be advanced or withdrawn as desired to alter the amount of flux linked by the inwardly bent portion thereof by way of a suitable flexible connection.

Inasmuch as the separate resonant cavities 14 are intercoupled with one another and also with the tuned coaxial lines 50, 52, 54 by way of the mutual flux 26, it will be understood that alteration of the effective electrical length of these coaxial lines alters the frequency to which they are resonant and, when the coupling is greater

6

than a certain critical value, the oscillation frequency of the device as a whole is altered. Such an arrangement provides a convenient means for adjusting the oscillation frequency of the magnetron precisely to a desired value for which it was designed, and so compensating for the effect of minute errors in manufacture.

For a given resonant frequency of the system composed of one resonant cavity and the channel which connects the same with the central interaction space, the length of the mutual flux path between adjacent cavities 14 is most conveniently controlled by alteration in the shape of the cavity section. Thus, as the cross section of the cavity is shortened in the radial direction and elongated in a direction perpendicular thereto, the length of the mutual flux path between adjacent cavities is shortened, thereby increasing the mutual flux and the intercavity coupling. Fig. 3 shows a simplified plan view of a magnetron having cavities 58 of this modified form. They may conveniently have the form of intersecting circles being constructed by drilling two holes on centers which are spaced apart by less than their diameters.

Similarly, the intercavity couplings may be reduced, for a given resonant frequency of the cavities, by the use of cavities of radially elongated cross sections. Such elongated cavities 60 may have radial sides as shown in Fig. 4 or they may be simple parallel-sides slots 62 as shown in Fig. 5. Distribution of cavities in the manner shown in Figs. 4 and 5 by increasing the cavity surfaces, improves the dissipation of heat. In addition, it permits the use of a greater number of cavities, for a given amount of intercavity coupling, than is possible with an arrangement such as that shown in Fig. 3. For example, if the number of cavities of Fig. 3 were changed from 6 to 12 without other alteration, adjacent sides of neighboring cavities would intersect, which would render them wholly inoperative. Thus, in a proper design, the cavity shape is intimately related with the number of cavities to be employed.

In the interests of simplicity, frequency adjusting loops 50, 52, 54 are omitted from Figs. 3, 4 and 5, though they may be employed if desired. The magnetrons here represented may otherwise be similar to that of Figs. 1 and 2, and like parts are designated by like reference characters.

Fig. 6 is a plan view of a modification in which the mutual inductance coupling loops of the invention are arranged for simultaneous supply of oscillation energy to a common load. Four such loops 64 are provided, symmetrically disposed about the periphery of the magnetron discharge space 12. Provision may be made for varying the effective areas of these loops in a manner similar to that hereinabove described in connection with Fig. 1. Means for this purpose have, in the interests of simplicity, been omitted from the drawings.

Inasmuch as the phases of the electromagnetic fields in successive cavities 14 measured around the periphery of the magnetron, differ substantially from each other, the currents withdrawn by these loops 64 are by no means necessarily in phase with each other. Therefore, in order that they may be effectively supplied as by coaxial lines 66 to a common load, symbolically indicated in the figure by a resistor 68, suitable means are preferably provided for bringing these currents into phase. Any suitable means will serve this purpose, the familiar so-called "trombone" slides

7

70 being shown in the figure in series with all but one of the lines 66. Movement of the sliders 70 alters the effective lengths of the lines 66 and therefore enables the operator to bring the currents withdrawn by all of the loops 64 into co-

phasal relation.

Various modifications of the arrangement hereinabove described will suggest themselves to those skilled in the art for utilizing the mutual inductance coupling loops of the invention either for withdrawing power, for tuning adjustment, or otherwise, as desired.

What is claimed is:

1. In a high frequency magnetron device having a plurality of spaced anode surfaces interconnected by a like plurality of open-ended cavity resonators, and in which adjacent anode surfaces and cavities are intercoupled by high frequency electromagnetic fields existing in a region adjacent the open ends of said resonators, means for withdrawing oscillatory energy from said device which comprises a conductor extending into the end space of said device and disposed adjacent said open resonator ends in a plane substantially midway between two adjacent cavities in position to link a part of the magnetic flux which is common to said resonators and to avoid linking flux which is exclusively associated with either one of said resonators singly.

2. The combination, in electromagnetic oscillation apparatus, which comprises at least two frequency-determining cavity resonators, said resonators having openings so juxtaposed as to provide a path from one of said resonators into another of said resonators for the mutual oscillatory magnetic flux which is common to both of said resonators, and means for abstracting energy from said resonators without introducing excessive asymmetry into the field patterns of said resonators, comprising a conductive loop disposed externally of both of said resonators and substantially midway along said path in position to link a portion of said mutual flux.

3. The combination, in electromagnetic oscillation apparatus, which comprises at least two frequency-determining cavity resonators, said resonators having openings so juxtaposed as to provide a path from one of said resonators into another of said resonators for the mutual oscillatory magnetic flux which is common to both of said resonators, said mutual flux providing a coupling between said resonators, and means for adjusting the common oscillation frequency of said coupled resonators to a desired value, comprising an auxiliary resonant device disposed externally of both of said resonators and coupled to said mutual flux, and means for tuning said auxiliary resonant device.

4. The combination, in electromagnetic oscillation apparatus, which comprises at least two frequency-determining cavity resonators, said resonators having openings so juxtaposed as to provide a path from one of said resonators into another of said resonators for the mutual oscillatory magnetic flux which is common to both of said resonators, said mutual flux providing a coupling between said resonators, and means for adjusting the common oscillation frequency of said coupled resonators to a desired value, comprising a conductor disposed externally of both of said resonators in position to link a portion of said mutual flux, an auxiliary resonant device arranged to be excited by currents flowing in said conductor, and means for tuning said auxiliary resonant device.

8

5. The combination, in electromagnetic oscillation apparatus, which comprises a plurality of frequency-determining cavity resonators, said resonators having openings so mutually juxtaposed as to provide a path from each of said resonators into another of said resonators for the mutual oscillatory magnetic flux which is common to both of said resonators, said mutual flux providing a coupling between said resonators, and means for abstracting energy from said resonators without introducing excessive asymmetry into the field patterns of said resonators, comprising a plurality of conductive loops, each disposed externally of said resonators in position to link a portion of the mutual flux existing along one of said paths.

6. The combination, in electromagnetic oscillation apparatus, which comprises a plurality of frequency-determining cavity resonators, said resonators having openings so mutually juxtaposed as to provide a path from each of said resonators into another of said resonators for the mutual oscillatory magnetic flux which is common to both of said resonators, said mutual flux providing a coupling between said resonators, and means for adjusting the common oscillation frequency of all of said intercoupled resonators to a desired value, comprising a plurality of auxiliary resonant devices disposed externally of said resonators and coupled to said mutual flux, and means for tuning each of said auxiliary resonator devices.

7. In combination with an electromagnetic oscillation device having at least two adjacent open-ended frequency-determining cavity resonators arranged substantially parallel to each other and separated by a conductive wall, which resonators, when the device is in operation, support oscillatory electromagnetic fields which are at least partly in antiphase relation, means for abstracting energy from said device which comprises a conductor disposed in the plane of said separating wall and beyond the end thereof which adjoins said open resonator ends in position to link a part of the magnetic flux which is common to said resonators and to avoid linking flux which is exclusively associated with either one of said resonators singly.

8. In combination with a high frequency magnetron device having a plurality of anode surfaces defining a central discharge space and a plurality of intercoupled frequency-determining cavity resonators disposed about said discharge space, means for withdrawing oscillatory energy from said device which comprises a plurality of coupling loops symmetrically disposed with respect to the axis of said device, each arranged to link a part of the oscillatory magnetic field of said resonators without excessive loading, phase adjusting means coupled to certain of said separate coupling loops for bringing currents withdrawn from said device by said loops into co-phasal relation with each other, and common utilization means for said separately withdrawn currents.

9. In combination with a high frequency magnetron device having a plurality of anode surfaces defining a central discharge space and a plurality of open-ended frequency-determining cavity resonators disposed about said discharge space, adjacent ones of said resonators being separated by walls each of which terminates in one of said anode surfaces, means for adjusting the frequency of oscillation of said device to a desired value, which comprises a plurality of con-

ductors each disposed in the plane of one of said separating walls and beyond the end thereof which is adjacent to said open resonator ends in position to link a part of the magnetic flux which is common to said resonators and extending outward of said device to become the inner conductor of a coaxial line, a tubular conductor surrounding each of said outwardly extending parts, connected to an outer boundary wall of said device and constituting the outer conductor of said coaxial line, and adjustable tuning means coupling each of said inner conductors to the tubular member which surrounds it at a desired distance from the axis of said device.

10. In a high frequency magnetron device having a plurality of circularly disposed spaced anode surfaces defining a central discharge space, a plurality of open-ended cavity resonators disposed about said central discharge space, an end plate which, with the ends of said anode surfaces adjacent said open resonator ends defines a region in which there exists a high frequency electromagnetic flux intercoupling said resonators, which flux emerges from one of said open resonator ends and divides substantially evenly about a plane containing the axis of said resonator, the flux portion on each side of said division plane passing to an adjacent resonator on the same side of said plane, an electrode within said discharge space, and means for applying a potential to said last-named electrode which comprises a conductor extending inward of said device from the outside thereof and through said flux-containing region to said last-named electrode, said conductor lying in said division plane substantially throughout its length, whereby coupling between said conductor and said flux is reduced to a minimum.

11. In a high frequency electrical oscillator of the magnetron type comprising a substantially cylindrical anode of conducting material having therein a plurality of electromagnetically coupled cavity resonators each of which opens into a central space within said anode, said central space and resonator cavities opening at their ends into common end spaces defined by said anode, conductive end plates joined to said anode at both ends and providing therewith a substantially complete conducting envelope enclosing said resonator cavities and the chamber formed by said spaces, and adjustable power-output means comprising a hook-ended conductor extending inwardly of one of said end spaces and through its wall, lying in a plane substantially midway between two adjacent cavity resonators in position to link electromagnetic flux which is common to said two resonators, the hooked end of said conductor being in electrical contact with an end of said anode, said conductor being movable to facilitate adjustment of the amount of said flux linked.

12. In a high frequency electrical oscillator of the magnetron type comprising a substantially cylindrical anode of conducting material having therein a plurality of electromagnetically coupled cavity resonators each of which opens into a central space within said anode, said central space and resonator cavities opening at their ends into common end spaces defined by said anode, conductive end plates joined to said anode at both ends and providing therewith a substantially complete conducting envelope enclosing said resonator cavities and the chamber formed by said spaces, and adjustable power-output means comprising a plurality of hook-

ended conductors extending inwardly of one of said end spaces and through its wall, each lying in a plane substantially midway between two adjacent cavity resonators in position to link magnetic flux which is common to said two resonators, the hooked end of each of said conductors being in electrical contact with an end of said anode, each of said conductors being movable to facilitate adjustment of the amount of said flux linked, and tunable means for supplying the outputs of all of said conductors in phase to a common utilization circuit.

13. In a high frequency electrical oscillator of the magnetron type comprising a substantially cylindrical anode of conducting material having therein a plurality of electromagnetically coupled cavity resonators each of which opens into a central space within said anode, said central space and resonator cavities opening at their ends into common end spaces defined by said anode, conductive end plates joined to said anode at both ends and providing therewith a substantially complete conducting envelope enclosing said resonator cavities and the chamber formed by said spaces, and adjustable power-output means comprising a plurality of hook-ended conductors extending inwardly of one of said end spaces and through its wall, each lying in a plane substantially midway between two adjacent cavity resonators in position to link magnetic flux which is common to said two resonators, the hooked end of each of said conductors being in electrical contact with an end of said anode, each of said conductors being movable to facilitate adjustment of the amount of said flux linked, and being individually connected to the inner conductors of a like plurality of tunable coaxial transmission lines.

14. In a high frequency electrical oscillator of the magnetron type comprising a substantially cylindrical anode of conducting material having therein a plurality of electromagnetically coupled cavity resonators each of which opens into a central space within said anode, said central space and resonator cavities opening at their ends into common end spaces defined by said anode, conductive end plates joined to said anode at both ends and providing therewith a substantially complete conducting envelope enclosing said resonator cavities and the chamber formed by said spaces, said end plates having central, inwardly extending portions for concentrating magnetic flux which is common to two adjacent cavity resonators into the peripheral regions of said end spaces, and adjustable power-output means comprising a conductor extending inwardly of one of said end spaces and through its wall, lying in a plane substantially midway between two adjacent cavity resonators, in position to link a part of the magnetic flux which is common to said two adjacent resonators in said peripheral region of said end space.

15. In a high frequency electrical oscillator of the magnetron type comprising a substantially cylindrical anode of conducting material having therein a plurality of electromagnetically coupled cavity resonators each of which opens into a central space within said anode, said central space and resonator cavities opening at their ends into common end spaces defined by said anode, conductive end plates joined to said anode at both ends and providing therewith a substantially complete conducting envelope enclosing said resonator cavities and the chamber formed by said spaces, said end plates having

11

central, inwardly extending portions for concentrating magnetic flux which is common to two adjacent cavity resonators into the peripheral regions of said end spaces, and adjustable power-output means comprising a plurality of hook-ended conductors extending inwardly of one of said end spaces and through its wall, lying in a plane substantially midway between two adja-

12

cent cavity resonators in position to link magnetic flux in said peripheral region which is common to said two resonators, the hooked end of each of said conductors being in electrical contact with an end of said anode, each of said conductors being movable to facilitate adjustment of the amount of said flux linked.

JAMES B. FISK.

Disclaimer

2,411,151.—*James B. Fisk*, Madison, N. J. OUTPUT COUPLING FOR HIGH-FREQUENCY OSCILLATORS. Patent dated Nov. 19, 1946. Disclaimer filed June 2, 1950, by the assignee, *Bell Telephone Laboratories, Incorporated*.

Hereby enters this disclaimer to claims 1, 2, and 7 of said patent.
[*Official Gazette*, Sept. 5, 1950.]

11

central, inwardly extending portions for concentrating magnetic flux which is common to two adjacent cavity resonators into the peripheral regions of said end spaces, and adjustable power-output means comprising a plurality of hook-ended conductors extending inwardly of one of said end spaces and through its wall, lying in a plane substantially midway between two adja-

12

cent cavity resonators in position to link magnetic flux in said peripheral region which is common to said two resonators, the hooked end of each of said conductors being in electrical contact with an end of said anode, each of said conductors being movable to facilitate adjustment of the amount of said flux linked.

JAMES B. FISK.

Disclaimer

2,411,151.—*James B. Fisk*, Madison, N. J. OUTPUT COUPLING FOR HIGH-FREQUENCY OSCILLATORS. Patent dated Nov. 19, 1946. Disclaimer filed June 2, 1950, by the assignee, *Bell Telephone Laboratories, Incorporated*.

Hereby enters this disclaimer to claims 1, 2, and 7 of said patent.
[*Official Gazette*, Sept. 5, 1950.]