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W. P. MASON

2,424,576

OSCILLATOR

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FIG. 1.

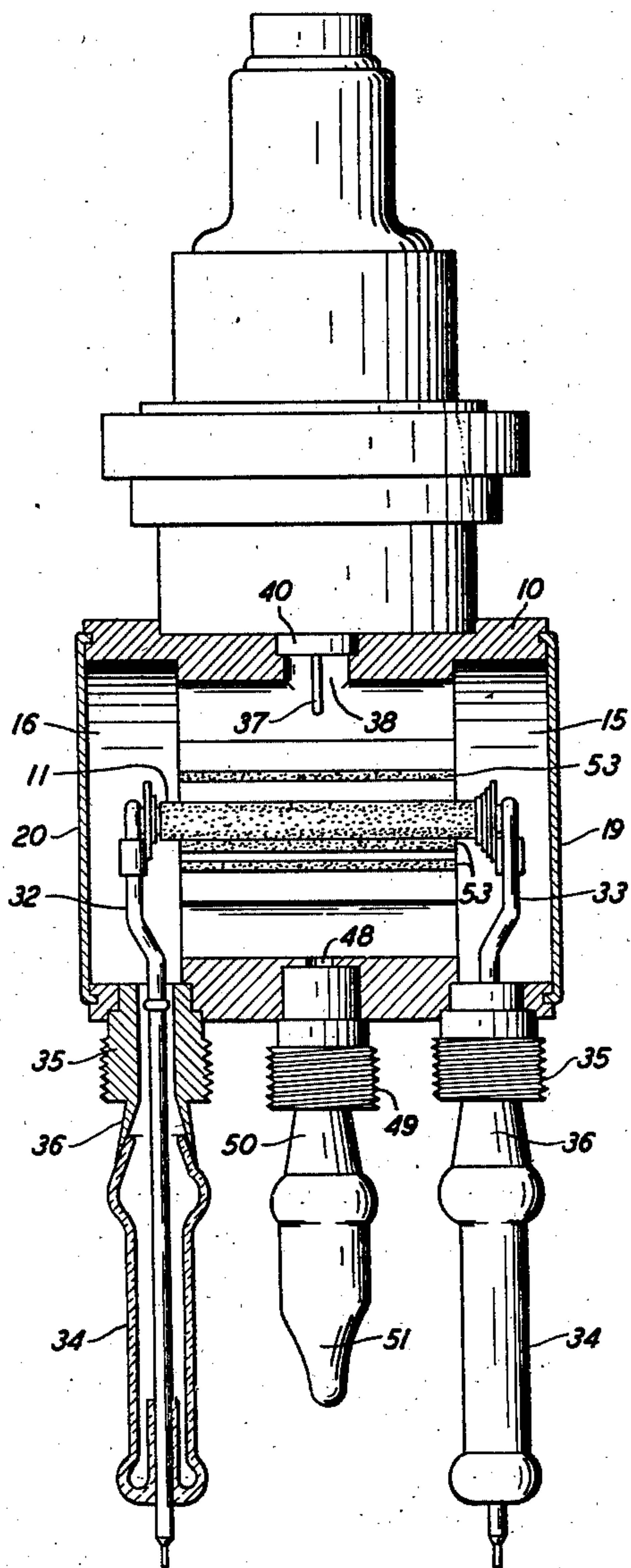


FIG. 2.

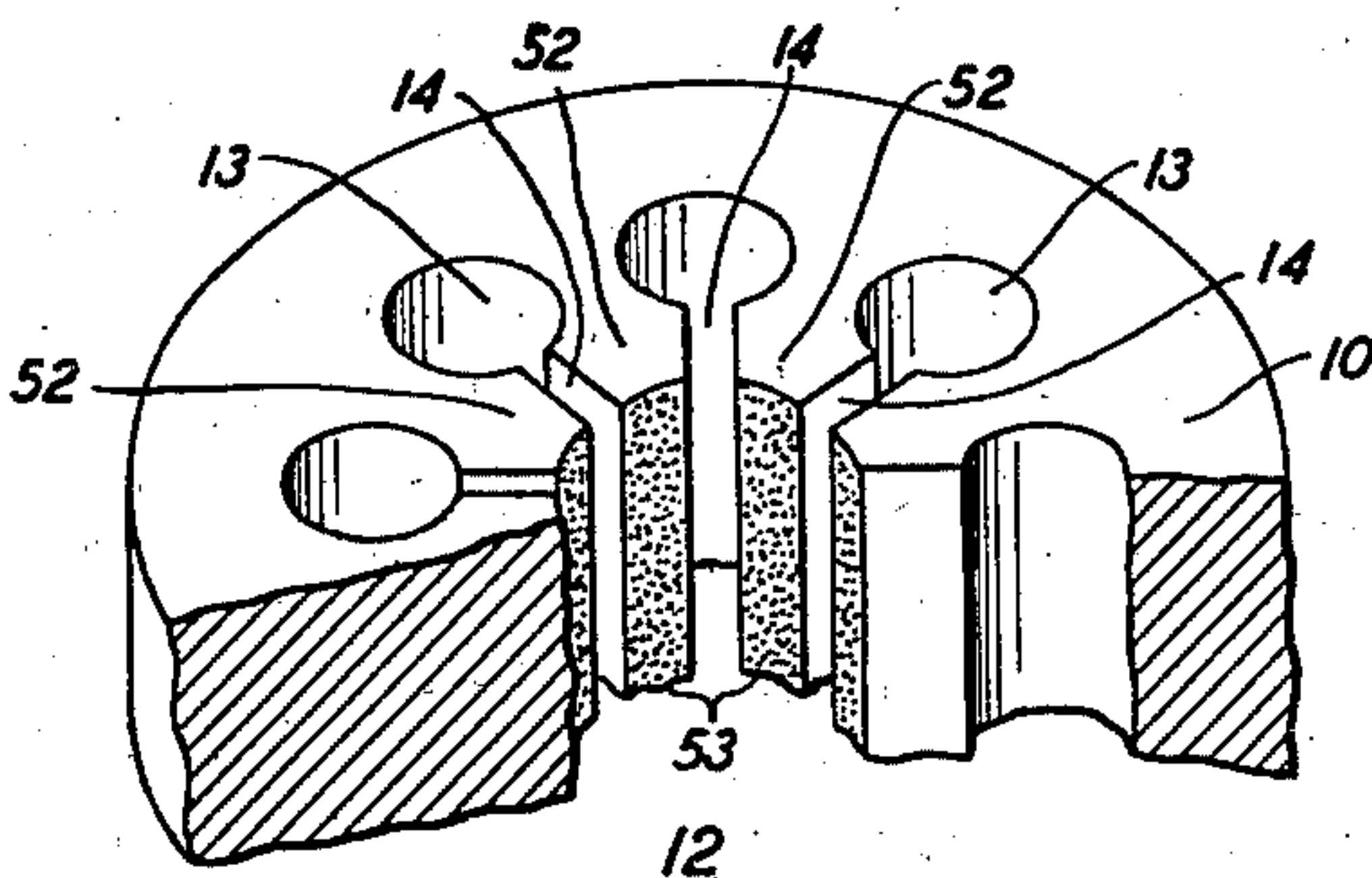


FIG. 4.

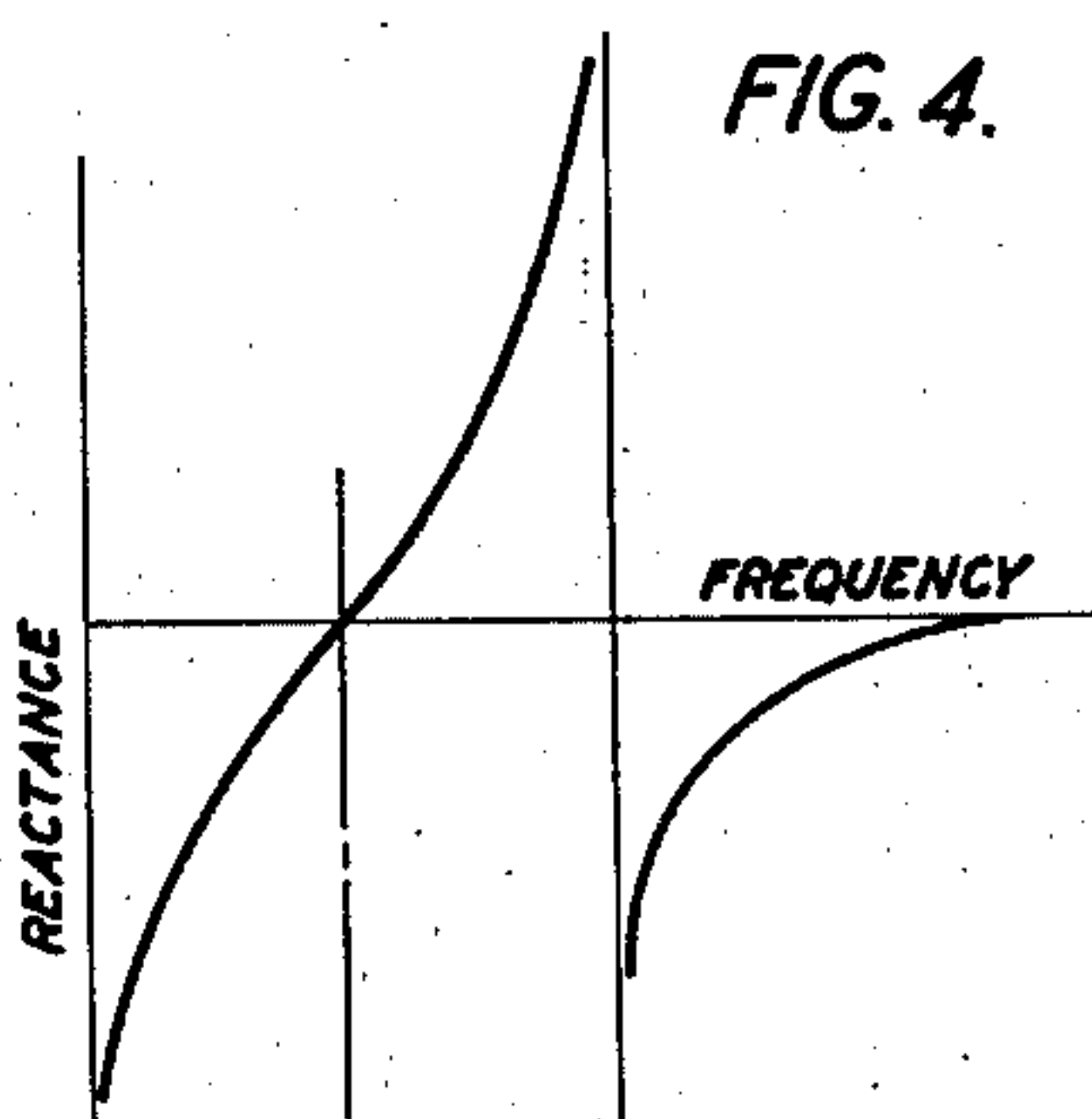


FIG. 5.

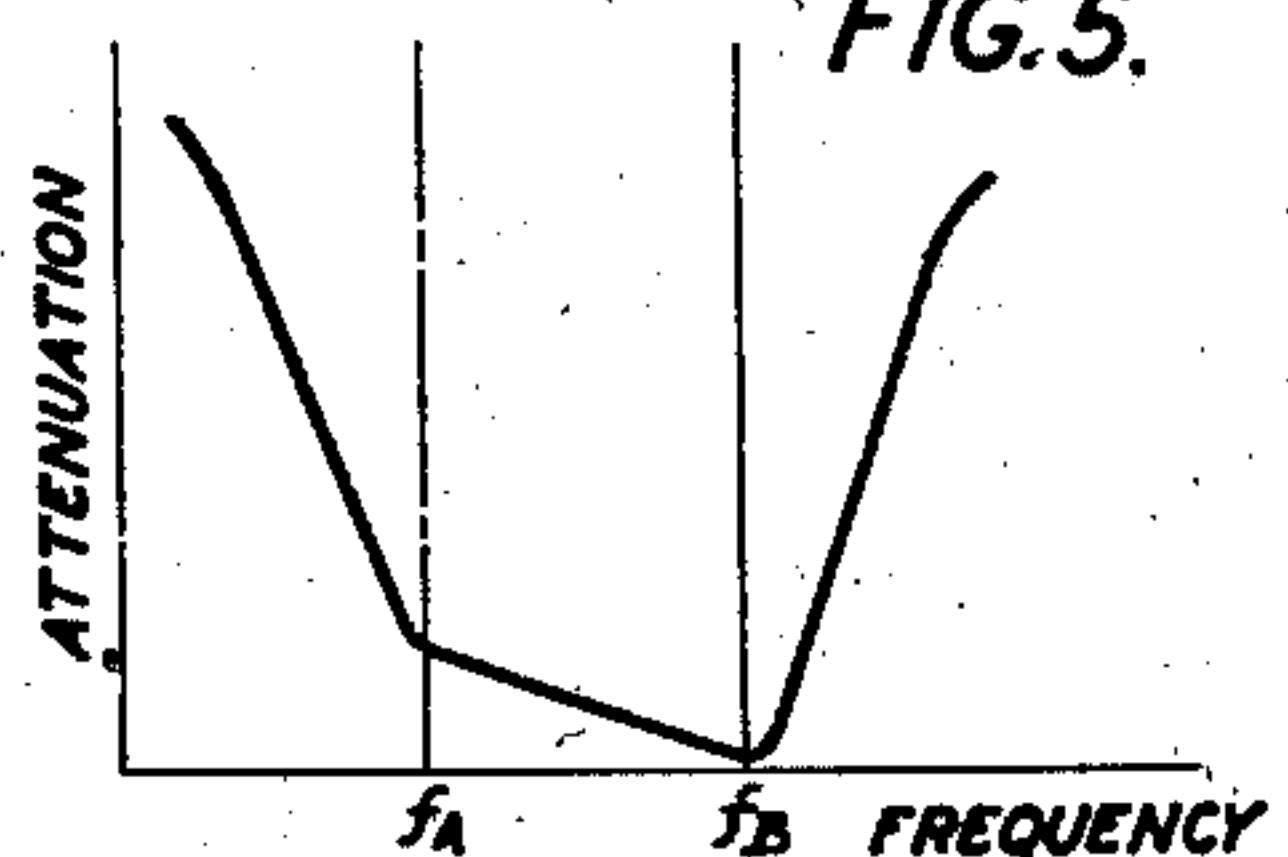
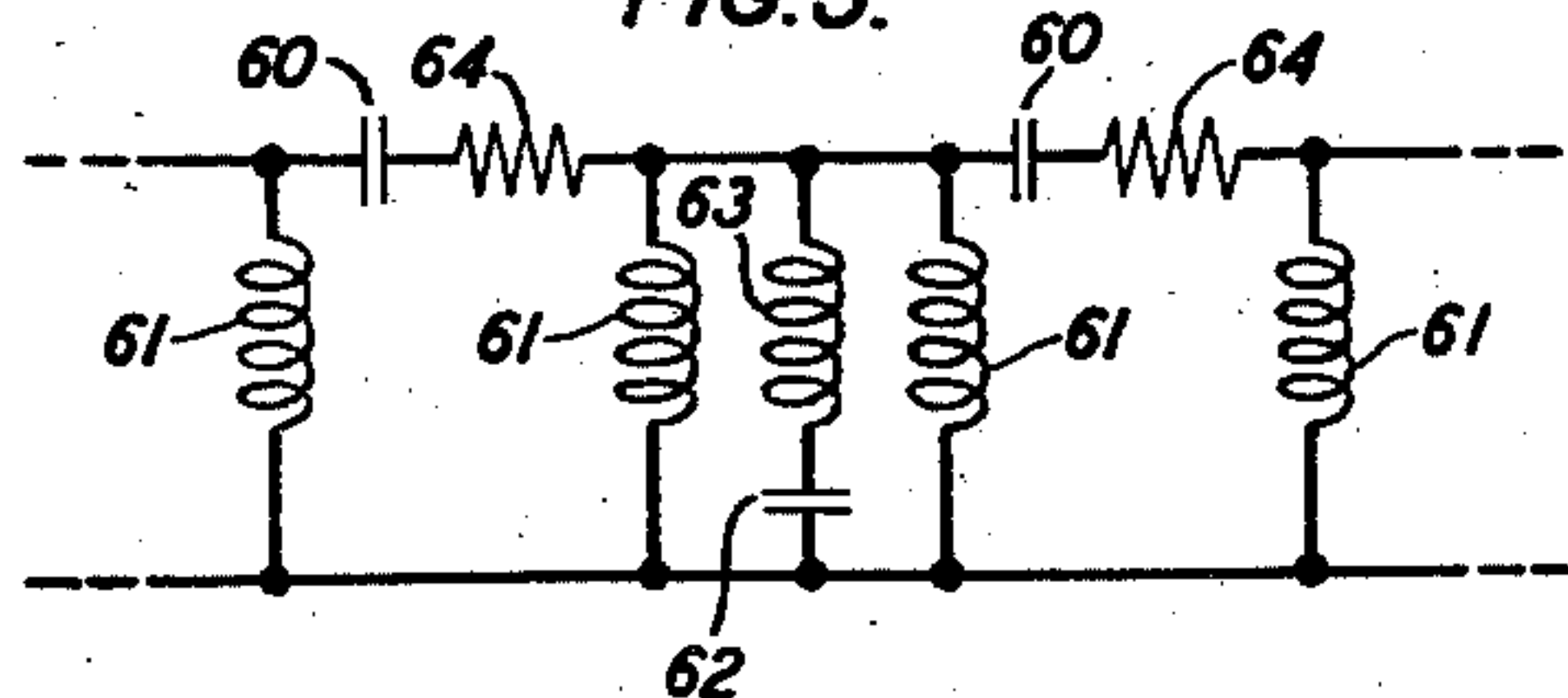


FIG. 3.



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## UNITED STATES PATENT OFFICE

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## OSCILLATOR

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6 Claims. (Cl. 250—27.5)

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This invention relates to oscillators and more particularly to those employing a multiply-resonant structure.

The invention is directed to distinguishing the several resonant frequencies of the multiply-resonant system so that oscillations at a single definite frequency readily may be secured without interference from adjacent resonant frequencies.

The invention is especially applicable to the type of resonator comprising a perforated block structure containing a plurality of individual resonating cavities separated by segments of the block. The segments have faces grouped about a central reaction space. In accordance with the invention a resistive film, coating or outer layer is formed or placed upon the surfaces of the anode segments facing toward the reaction space. A resistance is thus introduced into the multiply-resonant system in such a manner as to affect the several resonant frequencies in different degree, in particular introducing attenuations for waves of various frequencies. The amount of attenuation introduced is greatest for one of the resonant frequencies, least for another and has intermediate values for the remaining resonant frequencies. Oscillations tend to be maintained only at the particular resonant frequency having the least damping as a result of the inserted resistance.

In the drawings:

Fig. 1 shows a longitudinal-sectional view of a magnetron oscillator embodying the invention;

Fig. 2 is a perspective view of the anode block of the oscillator of Fig. 1;

Fig. 3 is a schematic diagram of the equivalent circuit of the resonator involved in the oscillator; and

Figs. 4 and 5 are graphs useful in explaining the principle of operation of the invention.

Referring to the drawings, 10 is an anode structure comprising a perforated cylindrical block of conductive material, 11 is a cathode of cylindrical form concentrically mounted within the anode structure, and 12 (Fig. 2) is a reaction space between the anode and cathode elements.

To facilitate the mounting of the cathode and the making of electrical connections thereto for heating purposes, the anode 10 may be fashioned to provide end spaces 15 and 16 at either end. The spaces 15 and 16 are preferably closed by end plates 19 and 20 which may, if desired, be of suitable ferromagnetic material to facilitate the application of a strong steady magnetic field to the reaction space 12 by means of an external magnet or magnets in well-known manner.

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The cathode 11 preferably has a coating of thermionically highly emissive material and encloses a heating winding. The cathode assembly may be supported by a pair of heater leads 32 and 33. Each heater lead is in turn supported by a tubular glass seal 34 and a bushing 35. The bushing has a tapered flaring edge 36 to the inner surface of which the glass may readily be sealed.

The central reaction space 12 with the cathode removed is indicated by the corresponding reference character in Fig. 2 and preferably comprises a cylindrical bore coaxial with the block 10. A plurality of resonating cavities are formed in the block 10 as by boring a plurality of cylindrical holes 13 having their axes lying on an imaginary cylinder coaxial with the block 10, the holes 13 being connected with the reaction space 12 by individual slots 14, preferably radial.

An output coupling arrangement may be provided as by means of an inductive loop 37 (shown edgewise in Fig. 1) inserted into a radial bore 38. The two ends of the loops 37 may be connected respectively to the inner and outer conductors of a suitable coaxial output fitting in accordance with known practice. The outer conductor of the coaxial fitting may comprise a tubular member 40 inserted into the hole 38 and the inner conductor may be an extension of the conductor forming the loop 37.

For convenience in pumping out the structure to the desired degree of vacuum, a small hole 48 may be made in the anode block as by drilling and a bushing 49, similar to the bushings 35, may be fitted around the hole 48. The bushing 49, preferably includes a flared and tapered portion 50 to which may be sealed a glass tube for use in pumping. The glass tube may be sealed off after evacuation in the usual manner to form a tip 51.

The anode segments comprise the portions of the material of the block 10 between adjacent slots 14. The anode segments are designated by the reference numeral 52 in Fig. 2, each segment presenting to the reaction space a surface 53. In accordance with the invention, each anode segment surface 53 is formed or coated with matter of relatively high ohmic resistance, as for example by applying a coating of carbon or graphite thereto. Such a coating is indicated by shading in Fig. 2.

The magnetron disclosed is adaptable to being built on any suitable physical scale according to the frequency at which it is desired to operate. In an embodiment suitable for operation in the neighborhood of 3,000 megacycles (10 centimeters wavelength) the anode block 10 may have an



over-all length between the end plates 19 and 20 of some 2.6 inches.

In the conventional magnetron of the type chosen herein to illustrate the application of the invention, the side chambers 13 operate as individual resonant circuits coupled together through the reaction space 12 and, if desired, through the end spaces 15, 16. The resonant system as a whole may be represented by an equivalent circuit as shown in Fig. 3, comprising a network having the operating characteristics of a band-pass filter. In the circuit of Fig. 3, the reaction space 12 is treated as a wave guide or transmission line with a high-pass transmission characteristic represented by series condensers 60 and shunt inductances 61. The side chambers 13 are effectively series resonant branches-parallel connected with respect to the reaction space 12 and each side chamber is represented in Fig. 3 by a condenser 62 and an inductance 63. The resistance coating upon each surface 53 is represented by a resistor 64, this resistance acting as a series impedance to electromagnetic waves traversing the transmission line comprising the condensers 60 and inductances 61. For simplicity, there is assumed to be no coupling through the end spaces, although such coupling may be taken into account with an equivalent circuit of greater complexity. The end result of the addition of resistance is the same in either case.

The reactance characteristic of a recurrent structure of the type depicted in Fig. 3 is shown as a function of frequency in Fig. 4, the reactance of the filter varying from zero reactance at the lower cut-off frequency  $f_A$ , to infinite reactance at the upper cut-off frequency,  $f_B$ , as is well known in the theory of such networks. The resistors 64 being in the series arms of the network have the greatest effect in the portion of the filter band where the reactance is at a minimum, the effect growing less as the frequency approaches the frequency of infinite reactance.

Because of the band-pass type of characteristic, the multiple resonances which appear and which are generally as numerous as the side chambers are all included within the transmission band. In general this means that the resonant frequencies are relatively close together. In the conventional magnetron, trouble often arises due to uncertainty as to which of the several resonant frequencies will be supported in sustained oscillations when the magnetron is operated. Also, it may occur that the magnetron will pass suddenly and unaccountably from one frequency of oscillation to another.

Fig. 5 shows the attenuation characteristic of the filter together with the effect of the resistance added to the anode segment surfaces in accordance with the invention. The attenuation, instead of being uniformly low over the transmission band, as in a normal filter has a relatively high value at the edge of the band corresponding to the frequency  $f_A$  of zero reactance. The attenuation gradually decreases over the band to a minimum at the frequency  $f_B$  of infinite reactance. It has been pointed out that the resonant frequencies of the system are distributed through the transmission band. The resonant frequency having minimum attenuation associated therewith will evidently be favored by the system in the generation of sustained oscillations. In the example shown in Fig. 5, the resonant frequency nearest to the frequency of infinite reactance will be preferred for sustained oscillation. This will be at or close to  $f_B$ . The attenuation

introduced at the remaining resonant frequencies will tend to prevent oscillation at these frequencies. The device described will therefore tend to oscillate at one frequency only and always at the same frequency.

Except for the physical configuration of the resonator, the device disclosed is similar to currently preferred types of magnetrons and it operates on substantially the same principle so that it is thought unnecessary to describe the operation in any further detail, the same being already familiar to those skilled in the art.

It will be evident that the invention is applicable to cavity resonators generally and is not limited to a particular type of cavity resonator. The invention may be employed in any organization including a multiply-resonant structure and is not limited to a magnetron oscillator.

What is claimed is:

1. An oscillator comprising two spaced conductive surfaces in opposing relation forming a wave transmission line, said line having a plurality of side chambers opening out therefrom and dividing one of said surfaces into a plurality of segments, means coupled to said line to excite oscillations in said line and said side chambers, and a damping layer of ohmic resistive material forming the external surface of one of said segments, whereby damping is introduced into said line and oscillations of one particular resonant frequency of the system are favored.
2. An oscillator comprising two spaced parallel cylindrical conductive surfaces in opposing relation forming an endless transmission line, said line having a plurality of side chambers opening out radially therefrom and dividing one of said cylindrical surfaces into a plurality of cylindrical segments, means coupled to said line to excite oscillations in said line and side chambers, and a damping layer of ohmic resistive material forming the external surface of each of said cylindrical segments whereby damping is introduced into said line and oscillations of one particular resonant frequency of the system are favored.
3. An oscillator comprising two spaced conductive surfaces in opposing relation forming a transmission line, said line having a plurality of side chambers opening therefrom and dividing one of said surfaces into a plurality of segments, said side chambers constituting effectively shunt paths for electromagnetic waves traversing said transmission line, whereby said line is multiresonant, and means on the surface of one of said segments to introduce series resistance into said transmission line independently of said shunt paths, whereby one particular resonant frequency of the system is favored.
4. An oscillator comprising two spaced surfaces in opposing relation forming a transmission line, said line having a plurality of side chambers opening therefrom and dividing one of said surfaces into a plurality of segments, and a damping layer of ohmic resistive material forming the external surface of one of said segments, whereby damping is introduced into said line and oscillations of one particular resonant frequency of the system are favored.
5. An oscillator comprising two spaced parallel cylindrical conductive surfaces in opposing relation forming an endless transmission line, said line having a plurality of side chambers opening out radially therefrom and dividing one of said cylindrical surfaces into a plurality of cylindrical segments, and a damping layer of ohmic resistive material forming the external surface



of each of said cylindrical segments whereby damping is introduced into said line and oscillations of one particular resonant frequency of the system are favored.

6. An oscillator comprising two spaced conductive surfaces in opposing relation forming a transmission line, said line having a plurality of side chambers opening therefrom, dividing one of said surfaces into a plurality of segments and rendering the system multiresonant, and means mounted upon said segments to introduce resistance into said transmission line, whereby one particular resonant frequency of the system is favored.

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