

June 24, 1947.

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2,422,695

SUPPRESSION OF PARASITIC OSCILLATIONS IN HIGH FREQUENCY DEVICES

Filed May 7, 1943

2 Sheets-Sheet 1

FIG. 1

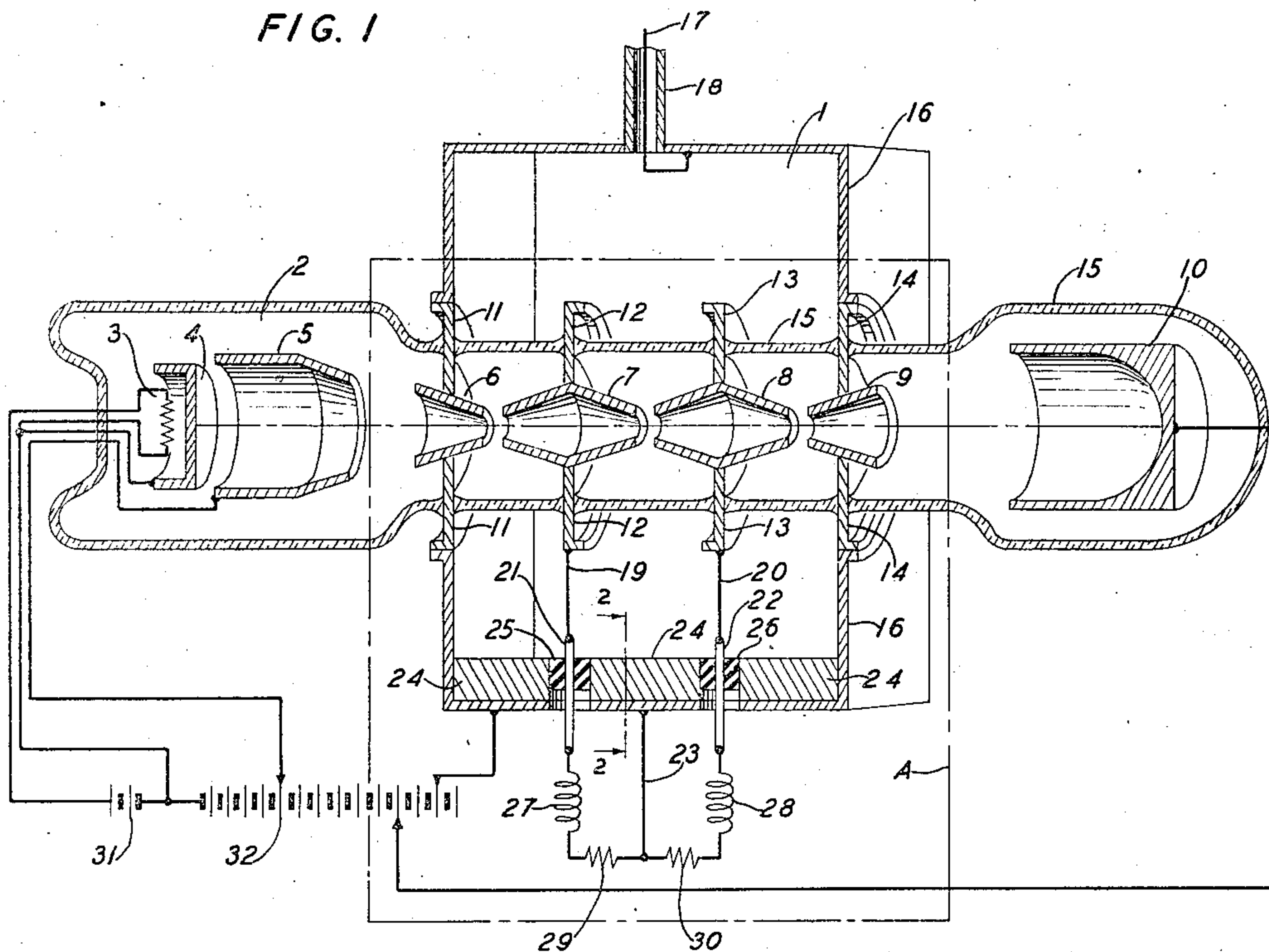
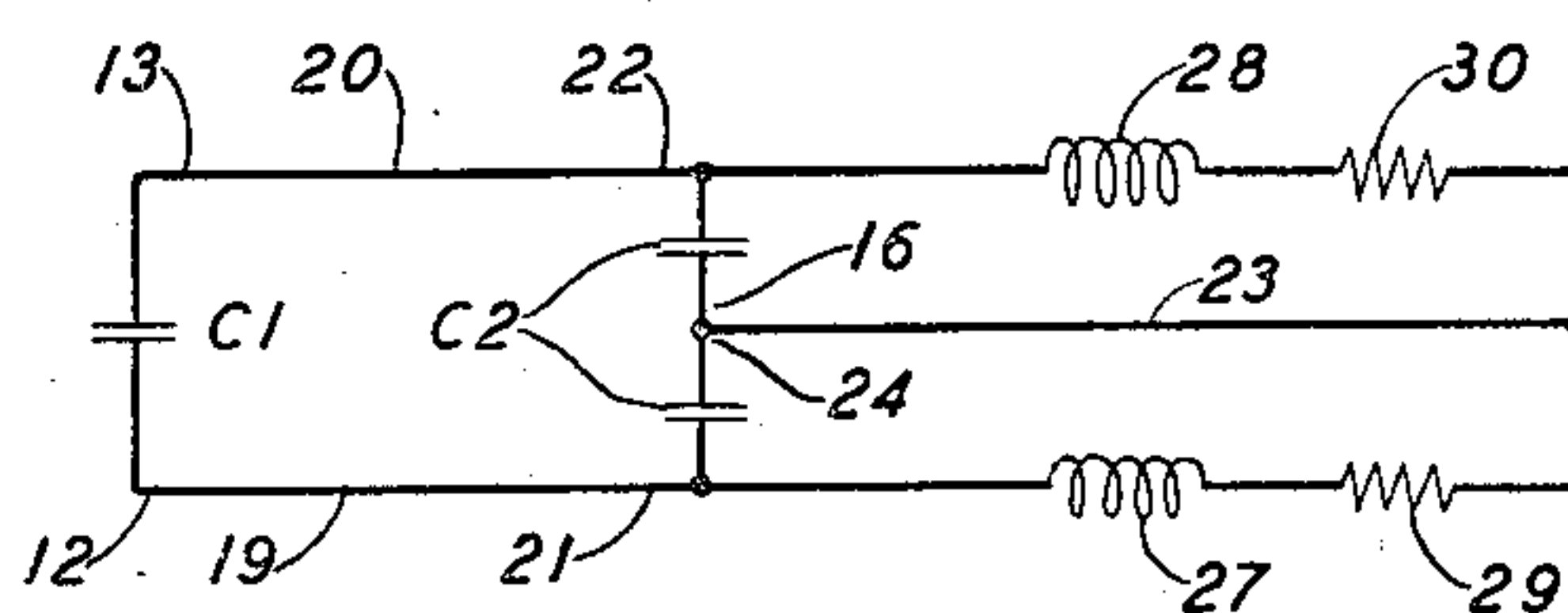
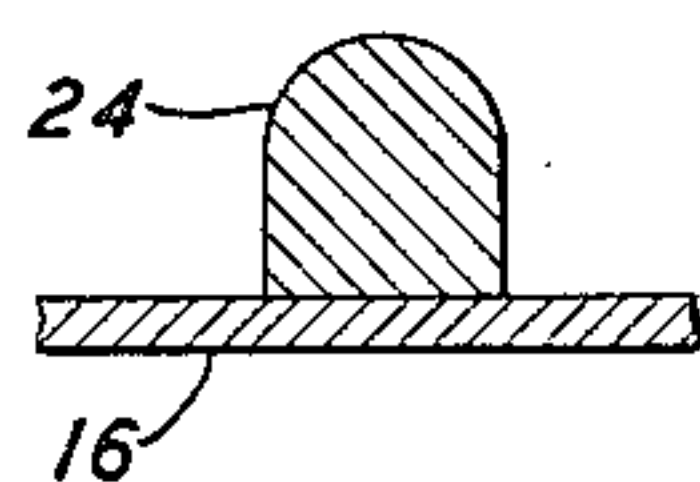


FIG. 3

FIG. 2



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2 Sheets-Sheet 2

FIG. 4

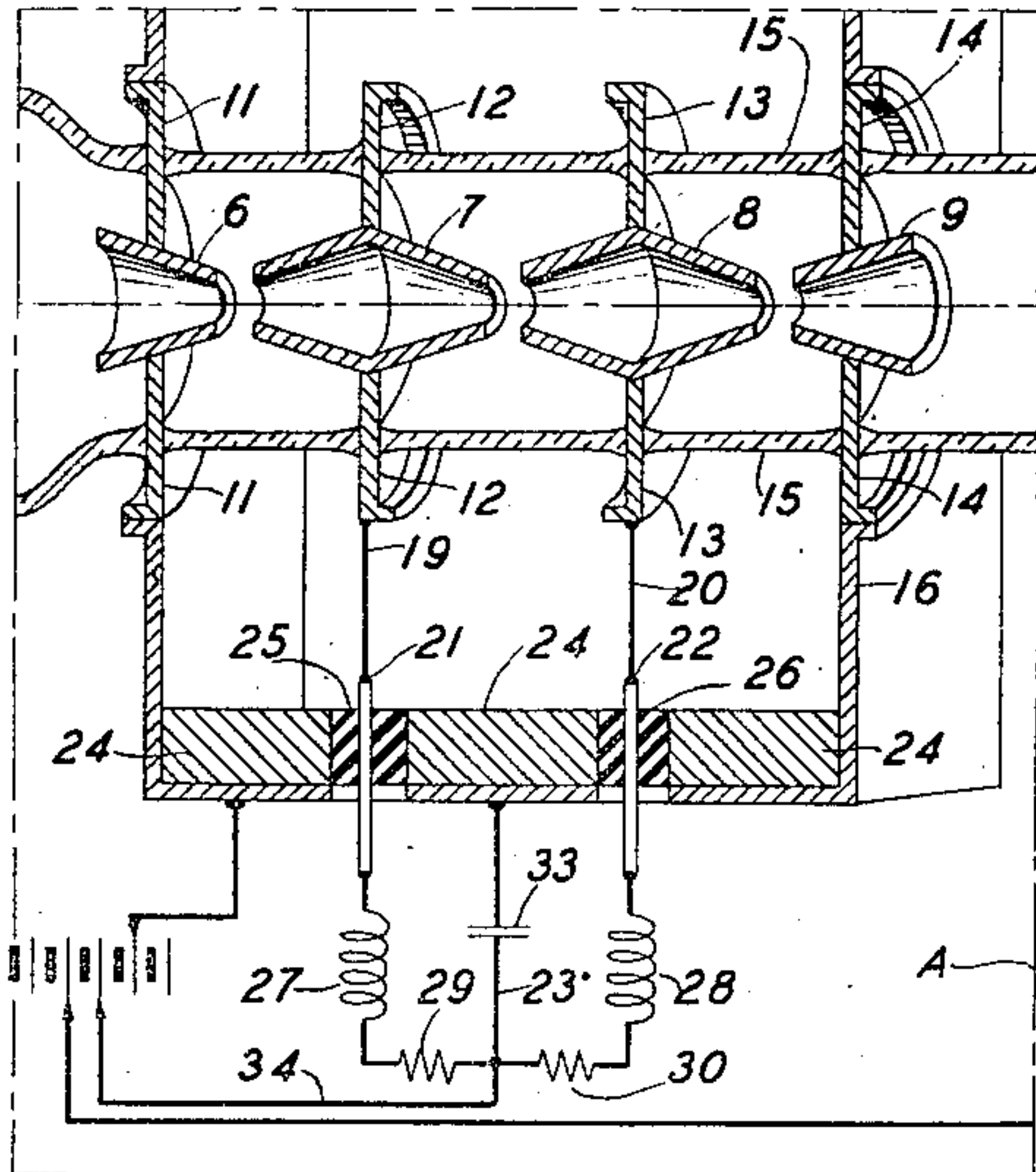


FIG. 5

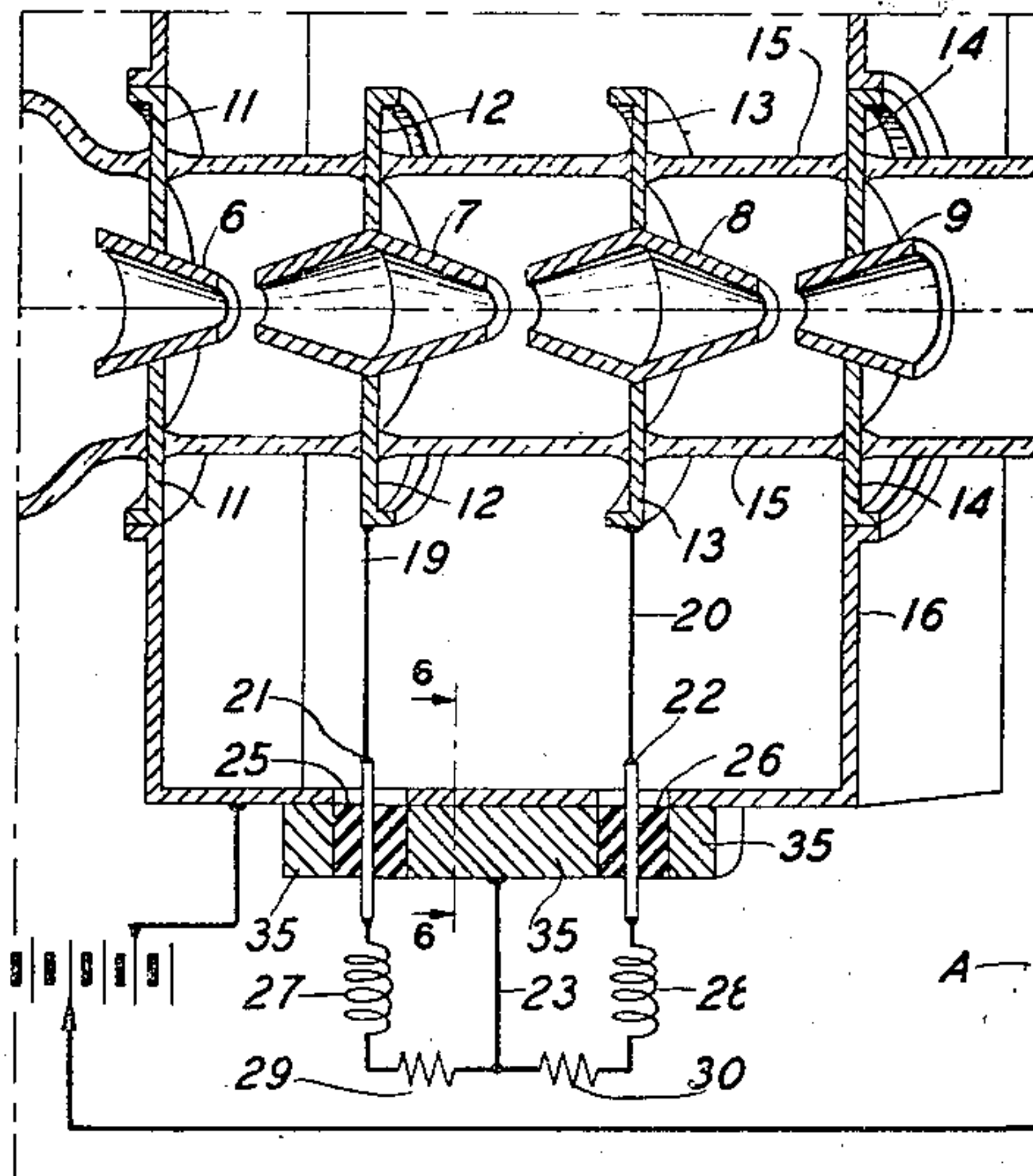


FIG. 7

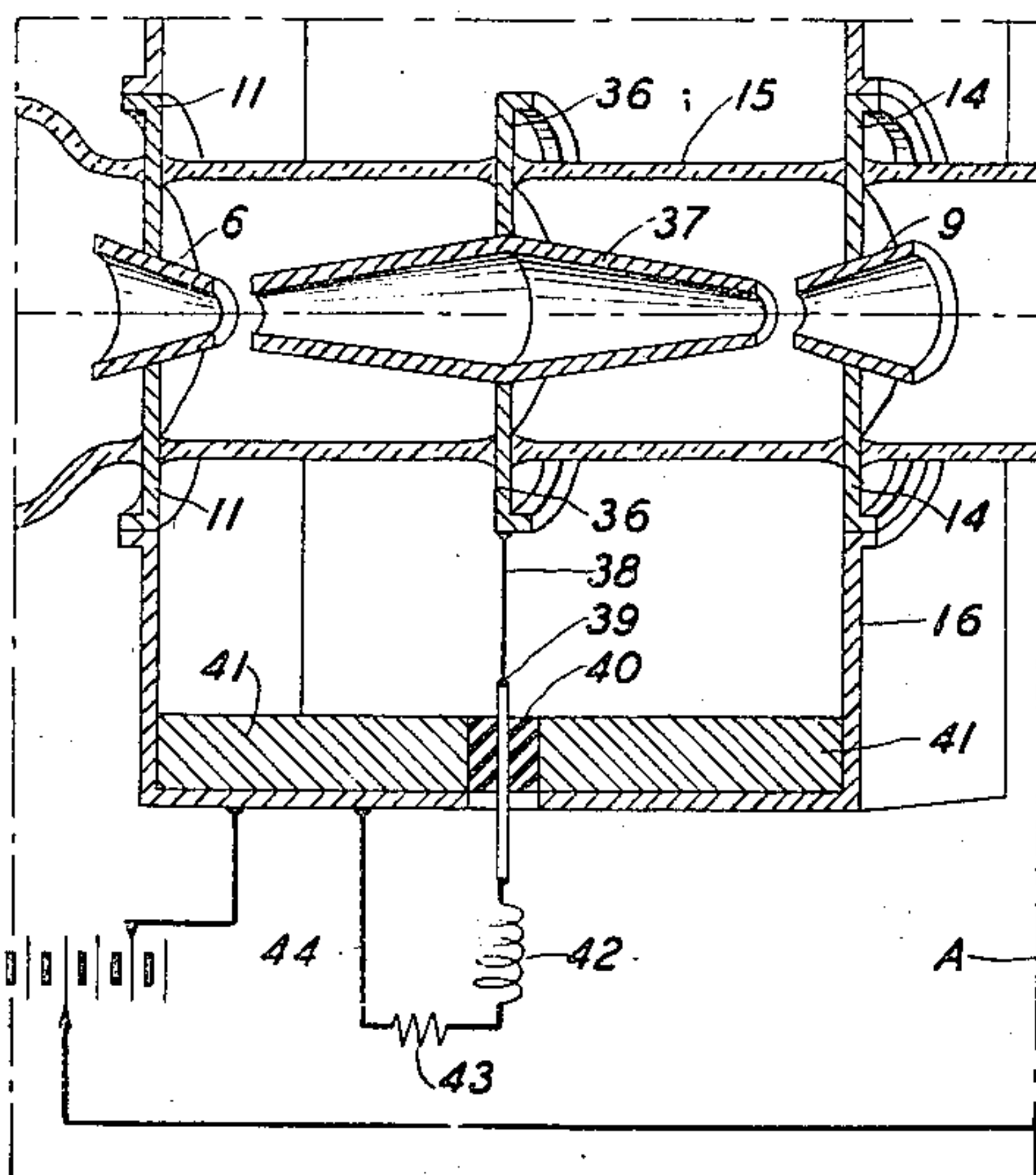


FIG. 6

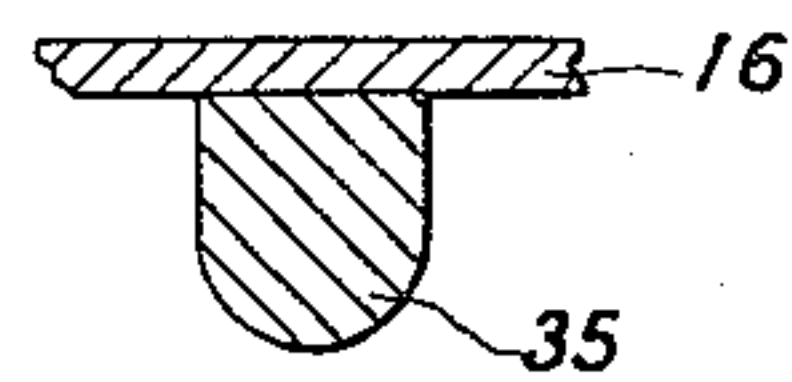
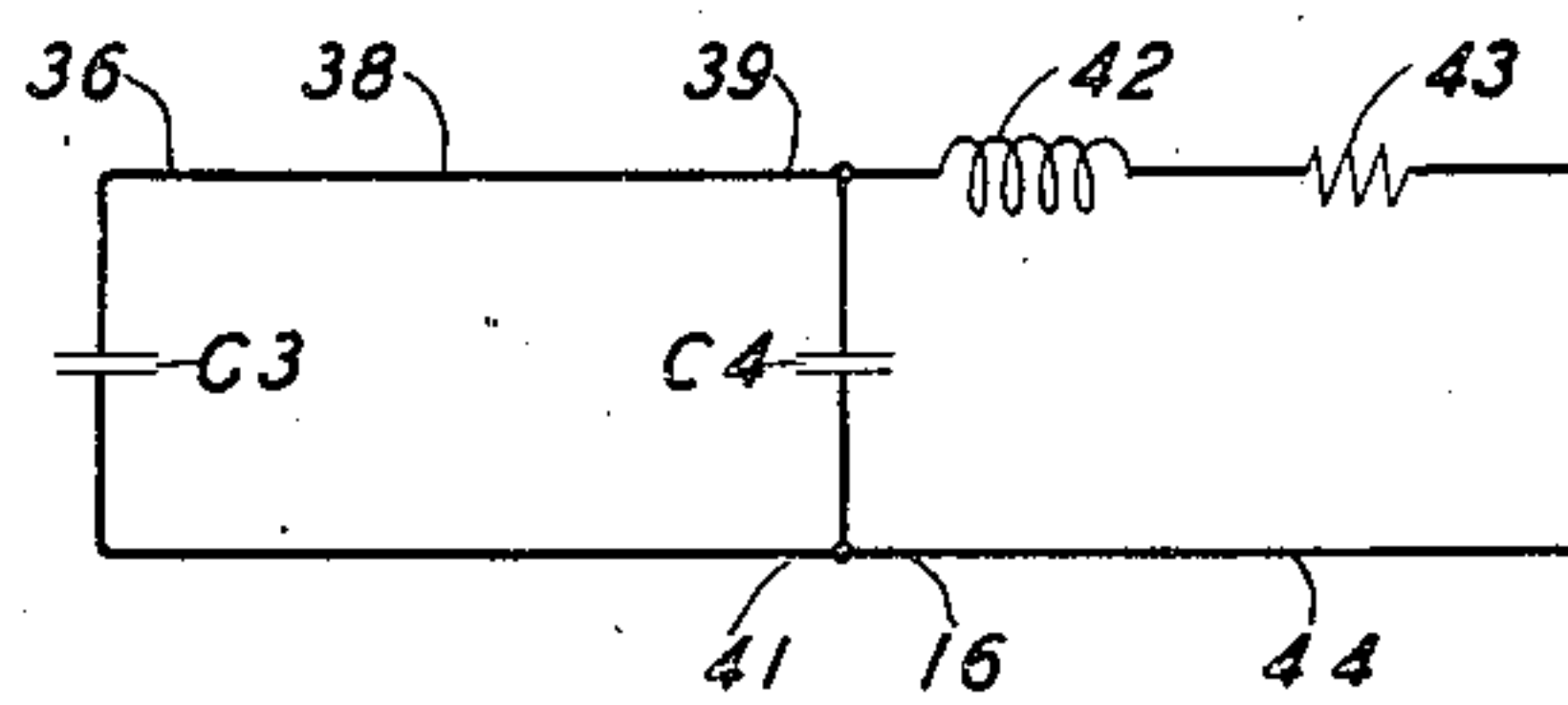


FIG. 8



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## UNITED STATES PATENT OFFICE

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SUPPRESSION OF PARASITIC OSCILLATIONS  
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19 Claims. (Cl. 178-44)

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This invention relates to high frequency electronic devices and particularly those comprising space resonators. It relates particularly to the technique of carrying electrical conductors through the space within such a resonator for various purposes as for instance the placing of direct current potentials upon the electrodes of an electron tube located within the resonator.

An object of the invention is to provide such conductors through the space of the resonator without giving rise to unwanted electrical oscillation energy.

Another object is to provide such conductors without allowing thereby excessive leakage or unwanted radiation of the high frequency energy with which the resonator is energized for a desired purpose.

In high frequency electronic devices a common method of exciting resonant cavities or space resonators for the purpose of producing high frequency electrical energy is to pass an electron tube through the enclosed space through apertures in the shell of the cavity or resonator so that an electron stream may be projected to interact with the enclosed high frequency electric field. Sometimes the resonator is included within the evacuated envelope of the electron tube and the electron stream is directed through apertures in the resonator.

In the excitation of a resonator by any such means it is common practice to provide electrodes along the path of the electron stream within the resonator and bias these electrodes suitably to control the electrons in various ways. The control may be to accelerate, decelerate, focus, deflect or otherwise act upon the electron stream. The leads for charging or biasing these electrodes must ordinarily pass through the high frequency field of the resonator. These leads have electrical dimensions of themselves and in combination with other elements of the device they frequently act to set up undesired electrical oscillations which absorb electron energy and may cause damage in their dissipation.

According to this invention these unwanted oscillations are prevented by extending the circuit which tends to support them outside of the resonator and inserting there a damping resistance. At the same time the dissipation through this circuit of useful energy at the operating frequency is prevented by adjustment of the length of the circuit within the resonator and the effective termination of it for the operating frequency at the boundary of the resonator.

The invention is more completely set forth in

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the following description and the associated drawings, of which:

Fig. 1 shows a high frequency oscillator utilizing the invention in one form;

Fig. 2 is a section through a portion of the shell of the resonator of Fig. 1 to show a form of construction;

Fig. 3 is a schematic circuit diagram used in explaining the invention as embodied in Fig. 1;

Fig. 4 illustrates an application of the invention to an oscillator circuit which is a slight modification of Fig. 1;

Fig. 5 illustrates an alternative to the structure of Fig. 1;

Fig. 6 is a section through a portion of the shell of the resonator of Fig. 5 to show a form of construction;

Fig. 7 shows an application of the invention to an oscillator circuit using a tube with one less electrode than the tube of Fig. 1;

Fig. 8 is a schematic circuit diagram used in explaining the invention as embodied in Fig. 7.

Referring now to Fig. 1. This shows as an example a high frequency oscillator circuit incorporating the invention. In the operation of this circuit the resonator 1 is energized at its resonant frequency by the three-gap electron tube 2 utilizing the electron velocity variation method in the following manner. The electrons in passing from the cathode 4 to the collector 10 are exposed to the high frequency electric field within the resonator as they pass through each of the three gaps (between electrodes 6 and 7, 7 and 8, and 8 and 9). In the first gap (between electrodes 6 and 7) the electron velocities are varied in accord with the impressed high frequency electric field. While passing through electrode 7 the electrons, because of the velocity variations, become partially grouped so that the electron stream acquires a degree of electron density variation. In the second gap (between electrodes 7 and 8) the density varied stream delivers energy to the high frequency field and at the same time additional velocity variations are impressed upon the electrons. In passing through electrode 8 further electron grouping takes place so that the electron stream acquires a higher degree of density variation. The electron stream then delivers additional energy to the high frequency field in the third gap (between electrodes 8 and 9). Devices operating on the same general principle may have a number of gaps greater than three or only two. The particular method of operation whereby high frequency energy is derived from the electron stream is not important to an understanding of



the invention and therefore a more detailed discussion of it is not necessary here. The invention as embodied in Fig. 1 has to do with the matter of electrical connections to electrodes such as 7 and 8 within the resonator and incidental electrical effects arising from such connections which may interfere with the proper operation of the device.

Fig. 1 is schematic in nature. It shows an axial section of the resonator 1 and the electron tube 2 which extends through the resonator along its axis and of which the electrodes 6, 7, 8 and 9 and their supporting rings 11, 12, 13 and 14 form part of the conducting shell of the resonator. The other part of the resonator shell (16) makes contact with the rings 11 and 14 to complete the enclosure of the space within the resonator. The shell portion 16 is shown as rectangular though it could as well be cylindrical about the axis or of some other shape. The rings 11, 12, 13 and 14 are fused into the generally cylindrical evacuated envelope 15 of the electron tube 2. The envelope 15 may be of glass or other suitable insulating material.

The electron emitting cathode 4 is indirectly heated by the heater 3 from the energy source 31. An alternating current source may be substituted for the battery 31 indicated. The electron accelerator 5 and the other electrodes of the tube are maintained at suitable potentials through connections from source 32. A rectifier power supply system or other type of direct current power source may be substituted for the battery 32. Under the influence of the positively charged electrodes 5, 6, 7, 8, 9 and 10 a stream of electrons is caused to flow from the cathode along the axis of the tube (as indicated by the broken line) to the collector 10 thereby producing electrical energy in the resonator 1 at its resonant frequency as described briefly above. For the purpose of focusing the electron stream a unidirectional axial magnetic field may be impressed in the vicinity of the gap between electrodes 5 and 6 in a known manner. Means for such is not shown in order to simplify the drawing. The high frequency energy produced in the resonator may be transmitted to a load circuit through the coaxial line 17, 18.

The electrodes 7 and 8 are maintained at the desired potential by connections to the shell 16 (and thence to the source 32) through the leads 19, 20, 21, 22, the coils 27, 28 and the resistors 29, 30 and the lead 23. The leads 21 and 22 pass through the insulating bushings 25 and 26 in the metallic member 24 which is connected to the shell 16 to become effectively a part of it and reduce appropriately the length of the leads 19 and 20 within the resonator space. The relation of member 24 to the cavity space is indicated in Fig. 2 which shows a section through member 24 and a portion of the shell 16.

The leads 19, 20, 21, 22 and 23, the members 24, 25 and 26, the coils 27 and 28 and the resistors 29 and 30 are involved in this embodiment of the present invention. Apart from the invention, leads such as 19 and 20 could connect directly to the shell 16 or to source 32. With such direct connections, however, it has been found that the leads may undesirably radiate high frequency energy from the resonator if carried outside of the resonator shell or may give rise to parasitic oscillations of a frequency different from that of the resonator. In an actual device of the type illustrated in Fig. 1 in which the operating frequency ranged from 2000 to 3000 megacycles parasitic oscillations at a frequency of

about 750 megacycles were encountered. Such parasitic oscillations may be suppressed according to the invention in the manner illustrated in Fig. 1. By an arrangement of the leads and the use of by-passing condensers, small chokes and resistors the parasitic oscillation circuit comprising the leads 19 and 20 connecting to the discs 12 and 13 is made to include damping resistors as shown in the schematic diagram Fig. 3. In Fig. 3, C1 represents the capacitance between the two discs 12 and 13 which are connected to and support the electrodes 7 and 8. The leads 19 and 20 form a transmission line between C1 and C2. C2 represents a small by-passing capacitance made up of the between leads 21 and 22 and the member 24 separated by the dielectric of the insulating bushings 25 and 26. Thus the line comprising leads 19 and 20 is terminated at the boundary of the resonator by the capacitance C2. In the actual 2000 to 3000-megacycle device referred to this capacitance was approximately one micromicrofarad. Resistors 29 and 30 (100 ohms each in the device mentioned) are connected across the terminating capacitance C2 but are isolated from the resonator oscillations (in the 2000 to 3000-megacycle frequency range in the device mentioned) by the small choke coils 27 and 28 which in the actual device mentioned were 5 turns each on a one-sixteenth inch mandrel. Thus the resistors are effective in preventing the parasitic oscillations such as at the mentioned 750-megacycle frequency but are isolated from the resonator oscillations at 2000 to 3000 megacycles. In order to have a low voltage across the capacitance C2 at the resonator frequency, (though the voltage is high between electrodes 7 and 8 and hence across the capacitance C1) the line length between C1 and C2 is made approximately one-quarter wavelength long with respect to that frequency. This is accomplished in the showing of Fig. 1 by building into the resonator space with the metallic block 24 which shortens the line by effectively moving inwardly the cavity boundary at the position of the leads 19 and 20. When the device is to cover a range of frequencies, as was the actual one referred to (where the range was 2000 to 3000 megacycles), and the length of the line cannot conveniently be varied, it is necessary to compromise upon the length so that at some frequencies it departs from the quarter wavelength. In the actual device referred to the length of the line varied between one-quarter and less than one-half wavelength over the frequency range. Lengths of the order of one-half wavelength should be avoided as then the voltage across C2 would tend to be as high as that across C1. The line can be any odd number of quarter wavelengths long with the same relation between the voltages across C1 and C2. Similarly any number of half wavelengths should be avoided.

In the 2000 to 3000-megacycle device referred to, the arrangement described was effective in removing parasitic oscillations at approximately 750 megacycles without absorbing or permitting the radiation of appreciable power in the 2000 to 3000-megacycle range. The required electrical values of the elements C2, 27, 28, 29 and 30 will vary depending upon the operating frequency. The values are not critical, however, those mentioned in connection with the references to the 2000 to 3000-megacycle device tested are given only as illustrative. While it may be unusual it is possible that under some conditions the isolating choke coils 27 and 28 may not be required.



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In review, the features of the invention which cooperate in preventing leads through a resonator from dissipating useful energy or causing parasitic oscillations are, briefly, lead lengths within the resonator, such, in terms of wavelength, that a low voltage termination at the resonator boundary may be had, termination of the leads at the boundary to by-pass energy at the operating frequency, and termination of the leads external to the boundary to dissipate energy at a parasitic frequency.

In Figs. 1 and 3 the connections are such that the electrodes 7 and 8 are polarized through the leads 19 and 20 to the same potential as the resonator shell 16 to which they are connected by lead 23. These electrodes may be polarized at a potential different from that of the shell 16 as shown in Fig. 4. Fig. 4 is bounded by the broken line A and may be substituted for the portion of Fig. 1 within the broken line A of that figure. Here a by-pass condenser 33 is interposed between the lead 23 and the shell 16 and lead 23 is connected to the potential source through lead 34 as may be desired. Should it be desired to polarize the electrodes 7 and 8 to different potentials the connection between resistors 29 and 39 may be opened and each resistor connected to the shell through separate by-pass condensers each like condenser 33 and each resistor connected to a desired point on the potential source by a separate lead like lead 34.

In connection with Fig. 1 it was explained that the member 24 is used to shorten the length of the leads 19 and 20 within the resonator and that it also served in conjunction with leads 21 and 22 to form the by-pass capacitance designated C2 in Fig. 3. In case the wavelength requirement of leads 19 and 20 does not require that they be shortened by building into the resonator space as by member 24 in Fig. 1 it will be necessary to provide otherwise the by-pass capacitance C2. One method of doing this is shown in Figs. 5 and 6 where a metallic member 35 is connected to the shell 16 external to it. The leads 21 and 22 pass through member 35 and with it and the dielectric of the insulating bushings 25 and 26 form a by-pass capacitance in the same manner as with member 24 in Fig. 1. Fig. 5 may be substituted in Fig. 1 for the portion of Fig. 1 bounded by the broken line A.

It is obvious that, if rather than the necessity for shortening the length of conductors 19 and 20 by building into the resonator space as shown in Figs. 1 and 4 it is necessary to increase the length of the conductors, the resonator space may be built out by means of a bulge outward of member 16 at the position of the conductors 19 and 20.

Fig. 7 shows the application of the invention when the electron tube of Fig. 1 is a two-gap tube rather than a three-gap tube. It will be noted in Fig. 7 that between electrodes 6 and 9 there is one electrode 37 and two interelectrode gaps rather than two electrodes (7 and 8) and three interelectrode gaps as shown in Figs. 1, 4 and 5. Fig. 7 may be substituted in Fig. 1 for the portion of Fig. 1 bounded by the broken line A. The operation with Fig. 7 substituted in Fig. 1 is the same as explained in connection with Fig. 1 except that the second gap of Fig. 1 does not exist and may be considered as eliminated by the extension of electrodes 7 and 8 toward each other to close it. In operation with Fig. 7 the electron velocities are varied in the gap between electrodes 6 and 37, they are grouped and the electron stream becomes density varied within electrode

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37 and energy is transferred from the electron stream to the high frequency electric field of the resonator in the gap between electrodes 37 and 9. As regards the present invention, the Fig. 7 modification of Fig. 1 alters the situation in that only one lead 38 is required within the resonator space rather than the two 19 and 20. As indicated in Fig. 7 the only effect of this is to eliminate one lead such as 19 and its associated through lead and bushing, choke coil and resistor. That is, it may be seen that in effect it eliminates from Fig. 1 lead 19, lead 21 and bushing 25, choke coil 27 and resistor 29. Correspondingly, it eliminates choke coil 27 and resistor 29 from Fig. 3 leaving the schematic diagram as shown in Fig. 8. The diagram of Fig. 8 applies to Fig. 7 just as the diagram of Fig. 3 applies to Fig. 1. In Fig. 8, C3 represents the capacity of electrode 37 to electrodes 6 and 9 and C4 represents the by-pass capacitance formed by the conductor 39 the dielectric of bushing 40 and member 41. It is obvious that the arrangement of Figs. 7 and 8 functions to prevent parasitic oscillation and the dissipation of energy at the operating frequency in the same manner as the arrangement of Fig. 1. It may be said that Fig. 3 shows a balanced line arrangement while Fig. 8 shows an unbalanced line.

It is obvious that the modifications of Fig. 1 to provide a different bias on the electrodes in the resonator and to provide a by-pass capacity C2 without shortening the leads within the resonator shown in Figs. 4 and 5, respectively, may also apply to the arrangement shown in Fig. 7.

The circuit shown to illustrate the invention is that of an oscillator. However, it should be understood that the utility of the invention is not so limited and that it may be used with amplifiers or any other device wherein it is desired to carry conductors through the space of an electrical resonator and it is necessary to prevent parasitic oscillations which may be produced thereby. Further, it may be applicable to any high frequency circuit where a similar condition exists whether or not a space resonator is involved. For instance, there may be involved the carrying of leads through a non-resonant wave guide or a shielded compartment or even through a region of high frequency influence without a definite boundary.

What is claimed is:

1. A high frequency system comprising means for producing in a region a high frequency electric field, at least one electrical conductor capable of acting as a high frequency transmission line in conjunction with another part of the system serving as a return conductor and extending into the said region from a region in which the high frequency field is substantially less intense than in the first said region, the length of the said electrical conductor within the first said region being substantially a quarter wavelength of the high frequency field, a capacitance connected between the said conductors at the boundary of the first said region, and an inductance and a resistance connected in series between the said conductors in the second said region.

2. A high frequency system comprising means for producing in a region a high frequency electric field, at least one electrical conductor capable of acting as a high frequency transmission line in conjunction with another part of the system serving as a return conductor and extending into the said region from a region in which the high frequency field is substantially less intense than



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in the first said region, the length of the said electrical conductor within the first said region being substantially a quarter wavelength of the high frequency field, a capacitance connected between the said conductors at the boundary of the first said region, and a resistance connected between the said conductors in the second said region.

3. A high frequency system comprising means for producing in a region a high frequency electric field, at least one electrical conductor capable of acting as a high frequency transmission line in conjunction with another part of the system serving as a return conductor and extending into the said region from a region in which the high frequency field is substantially less intense than in the first said region, the length of the said electrical conductor within the first said region being substantially an odd number of quarter wave-lengths of the high frequency field, a capacitance connected between the said conductors, at the boundary of the first said region, and an inductance and a resistance connected in series between the said conductors in the second said region.

4. A high frequency system comprising means for producing in a region a high frequency electric field, at least one electrical conductor capable of acting as a high frequency transmission line in conjunction with another part of the system serving as a return conductor and extending into the said region from a region in which the high frequency field is substantially less intense than in the first said region, the length of the said electrical conductor within the first said region being substantially an odd number of quarter wavelengths of the high frequency field, a capacitance connected between the said conductors at the boundary of the first said region, and a resistance connected between the said conductors in the second said region.

5. In combination, a hollow electrical resonator, leads extending from points within the resonator to points external to it, means for determining the lengths of the leads within the resonator appropriately with respect to the frequency to which the resonator is tuned, a shunt path of low impedance at the frequency of the resonator between the leads in the region of the resonator boundary, and a resistive load connected between the leads external to the resonator.

6. A high frequency device comprising a hollow electrical resonator, an electron tube at least partially included within the space of the resonator, electrodes of the said tube within the space of the resonator, electrical conductors connected to the said electrodes and extending across the space of the resonator to and beyond the boundary thereof, means for determining the distance required to be traversed by the conductors between the electrodes and the resonator boundary, capacitance means interconnecting the conductors where they leave the resonator space, and inductance and resistance means interconnecting the conductors outside of the resonator space.

7. A device according to claim 6 in which the distance required to be traversed by the conductors between the electrodes and the resonator boundary is made substantially one-quarter wavelength at the resonant frequency of the resonator.

8. A device according to claim 6 in which the distance required to be traversed by the conductors between the electrodes and the resonator boundary is made substantially an odd number

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of quarter wavelengths at the resonant frequency of the resonator.

9. A high frequency device comprising a hollow electrical resonator bounded by a shell of electrically conducting material, an electron tube at least partially included within the space of the resonator, an electrode of the said tube within the space of the resonator, an electrical conductor connected to the said electrode and extending across the space of the resonator to and beyond the boundary thereof, means for determining the distance required to be traversed by the conductor between the electrode and the resonator boundary, capacitance means interconnecting the conductor and the resonator shell where the conductor leaves the resonator space and an electrical connection including inductance and resistance interconnecting the conductor and the resonator shell outside of the resonator space.

10. A device according to claim 9 in which the distance required to be traversed by the conductor between the electrode and the resonator boundary is made substantially one-quarter wavelength at the resonant frequency of the resonator.

11. A device according to claim 9 in which the distance required to be traversed by the conductor between the electrode and the resonator boundary is made substantially an odd number of quarter wavelengths at the resonant frequency of the resonator.

12. A high frequency device comprising a hollow electrical resonator bounded by a shell of electrically conducting material, an electron tube at least partially included within the space of the resonator, an electrode of the said tube within the space of the resonator, an electrical conductor connected to the said electrode and extending across the space of the resonator to and beyond the boundary thereof, means for determining the distance required to be traversed by the conductor between the electrode and the resonator boundary, capacitance means interconnecting the conductor and the resonator shell where the conductor leaves the resonator space and an electrical connection including resistance interconnecting the conductor and the resonator shell outside of the resonator space.

13. A device according to claim 12 in which the distance required to be traversed by the conductor between the electrode and the resonator boundary is made substantially one-quarter wavelength at the resonant frequency of the resonator.

14. A device according to claim 12 in which the distance required to be traversed by the conductor between the electrode and the resonator boundary is made substantially an odd number of quarter wavelengths at the resonant frequency of the resonator.

15. A device according to claim 12 in which the distance required to be traversed by the conductor between the electrode and the resonator boundary is made substantially less than one-half wavelength at the resonant frequency of the resonator.

16. A high frequency device comprising a hollow electrical resonator having a shell of conducting material, an electrical conductor extending from a position within the space of the resonator to the boundary of the resonator, means for determining the distance necessary to be traversed by the conductor within the space of the resonator comprising a conducting member built into the resonator space at the position of



the conductor and connected to the shell at that position to effectively move the shell inwardly to reduce the space in the resonator and the distance required to be traversed by the conductor in reaching the boundary of the resonator.

17. A high frequency oscillator system comprising a hollow resonator serving as a resonant circuit whereby the oscillator is made operative at a given high frequency, an electron discharge device in operative relation to the said resonator, at least one electrical conductor capable of acting as a high frequency transmission line in conjunction with another part of the system serving as a return conductor and extending from without the resonator through the space within the resonator to connect with an electrode of the electron discharge device, the length of the said electrical conductor within the space of the resonator being substantially an odd number of quarter wavelengths of the said given high frequency, a capacitance connected between the said conductors at the boundary of the resonator and a resistance connected between the said conductors external to the resonator.

18. A high frequency system comprising a hollow resonator serving as a resonator circuit whereby the system is made operative at a given high frequency, an electron discharge device in operative relation to the said resonator, at least one electrical conductor capable of acting as a high frequency transmission line in conjunction with another part of the system serving as a return conductor and extending from without the resonator through the space within the resonator to connect with an electrode of the electron dis-

charge device, the length of the said electrical conductor within the space of the resonator being substantially an odd number of quarter wavelengths of the said given high frequency, a capacitance connected between the said conductors at the boundary of the resonator and a resistance connected between the said conductors external to the resonator.

19. A high frequency system comprising a hollow resonator having a shell of conducting material and serving as a resonant circuit whereby the system is made operative at a given high frequency, at least one electrical conductor entering and passing through the space of the resonator, and means for making the length of the said conductor within the space a desired value with respect to the wavelength corresponding to the said high frequency comprising a structure of conducting material designed with respect to the said desired conductor length and the resonator dimensions placed within the shell of the cavity and in contact therewith in the region where the conductor enters, in effect thickening the shell of the cavity in that region.

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