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RESONANT CAVITY DRIVE

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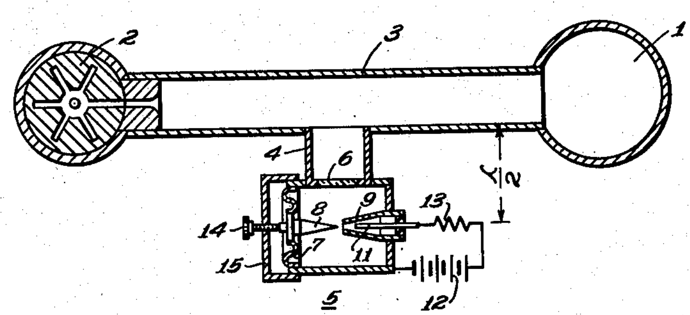
Fig. 1.



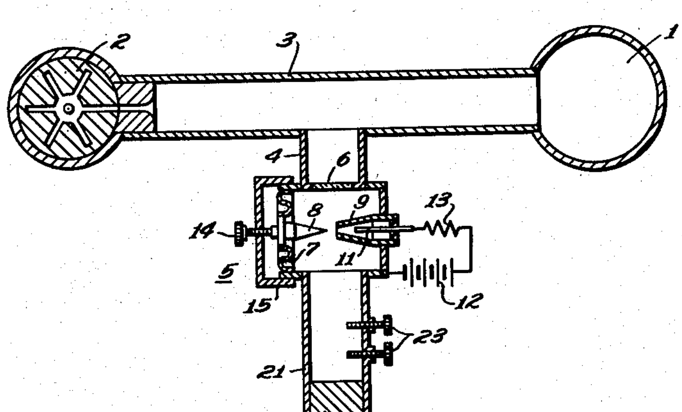


Fig. 2.

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RESONANT CAVITY DRIVE

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Our invention relates to transmission of ultra-high-frequency electromagnetic energy through wave guides and, in particular, relates to a system for supplying power in pulses through a wave guide from an ultra-high-frequency generator to a resonant cavity or the like.

For certain purposes, it is desirable to energize or drive a cavity having conducting walls with ultra-high-frequency electromagnetic energy in successive pulses spaced from each other by substantial time intervals, in order to cause the cavity to resonate electromagnetically with alternating fields of very high intensity. For example, it may be desired to transmit power at a wave length of a few centimeters in pulses lasting for a time of the order of one millionth of a second, the pulses following each other at intervals of the order of a thousandth of a second. Under such circumstances, the electrical and magnetic fields in the resonator may store relatively large amounts of energy, and at the beginning of each pulse this energy must be supplied and built up from the source of high-frequency oscillations supplying the pulses in a small fraction of the pulse duration. With wave lengths of the order of magnitude mentioned, it is usually desirable to transmit the power through wave guides, and at present the best available type of generator for the desired amounts of pulsed power is the magnetron. Such a magnetron is caused to emit the desired pulses by applying anode voltage in the form of pulses of the proper number per second.

Under such circumstances, it is necessary for the magnetron to build up its own stored energy to correspond with the output voltage desired, and also to build up the energy in the resonant cavity at the inception of each of the above-mentioned power pulses. Difficulty has been found to arise in doing this because of the large amount of energy stored in the resonant cavity compared with that stored within the electromagnetic fields of the magnetron, and it is found, in fact, that the mode of vibration of and operating frequency of the system are dependent in some degree on the rate at which the magnetron is able to supply energy to the resonating chamber. In short, the mode of vibration desired for the system in many instances is one in which a rapid draft of energy is required from the magnetron at the inception of the pulse impressed on the resonant cavity, and with the simple arrangement of a magnetron, wave guide and resonant cavity so far described, it is difficult and often impossible to obtain the desired modes of vibration.

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One object of our invention is, accordingly, to provide a transmission system between the magnetron and the resonant cavity in which the magnetron is cut off from the cavity until its power has built up to a predetermined magnitude, at which instant it is switched into communication with the cavity to build up the resonant energy therein.

Another object of our invention is to provide an improved form of transmission system between an oscillation generator and a resonant cavity capable of determining the mode of vibration in which the oscillation generator will build up when energized.

Still another object of our invention is to provide an improved system for supplying power in pulses from an oscillation generator to a load of a type which requires a rapid draft of energy to effectively establish a predetermined condition of operation therein.

A further object of our invention is to provide an improved form of wave guide transmission system in which a magnetron supplies power to a resonant cavity.

Other objects of our invention will become apparent upon reading the following description, taken in connection with the drawing, in which:

Figure 1 is a schematic cross-sectional view showing a magnetron generator connected to a resonating cavity through a wave guide system embodying the principles of our invention; and

Fig. 2 is a similar view of a modified form of the wave guide system of our invention.

Referring in detail to the drawing, a resonant cavity 1, which may be of any desired type, is arranged to be supplied with ultra-high-frequency electromagnetic energy from an oscillation source 2, illustrated as of a magnetron of the cavity type, through a wave guide 3 of any suitable type. It is well known that for best operating conditions in the steady state of magnetron requires a load impedance of given magnitude and phase. It is possible to adjust the length of guide 3 and the degree of coupling into the cavity so that the magnitude and phase of the load which the cavity presents to the magnetron, corresponds to this optimal condition.

In accordance with the principles of our invention, the wave guide 3 is provided with a branch 4 which is connected to a form of switching device of the type frequently referred to in the microwave art as a T-R switch. While several different types of switch of this type are known, we have shown for purposes of illustrating our invention a switch 5 comprising a resonant chamber having conductive walls, the interior of which is connected to the wave guide 4 through a window 6 of a material such as borosilicate glass which is transparent to the radiation carried by the wave guide, but enables the interior of the cavity 5 to be maintained at any desired pressure different from that existing within the wave guide 4. One wall 7 of the chamber 5 consists of a flexible metallic diaphragm which carries in its central area a conical projection 8 of conducting material long enough to extend substantially to the geometrical central region of the chamber 5. The opposite wall of the chamber 5 is provided with an open-ended conical member 9 which projects likewise into the central region of the chamber 5. Into the interior of the conical member 9 there projects a conducting rod 11 which is sealed through insulating material into the wall of the chamber and which projects nearly to the open end of the member 9. The chamber 5 is exhausted to a pressure in the neighborhood of that at which electrical discharges most readily pass across the gap between the rod 11 and member 9, and such discharges are arranged to be maintained by a suitable voltage source 12 supplying current through a control resistor 13. This arrangement maintains a continual source of free electrons in the region between the ends of the conical projections 8 and 9 and facilitates the production of breakdown discharges between the latter. The flexible diaphragm 7 is arranged to be controlled in position by a thumb screw 14 threaded through a bridge-member 15 attached to the walls of the chamber 5. By adjusting the position of the thumb screw 14, the distance, and hence the capacitance, between the members 8 and 9 can be carried over a considerable range, to tune the cavity 5 into resonance at the operating frequency. The length of branch 4 is so dimensioned as to effectively place the discharge gap of the T-R box in series with the transmission line 3, in accordance with well understood principles of transmission theory. So long as there exists no electrical discharge across this gap, the line is therefore in effect open-circuited and the cavity for all purposes is electrically disconnected from the source of oscillations.

The mode of operation of the foregoing arrangement is as follows: When positive voltage of the right amount is applied to the anode of the magnetron 2, it begins to oscillate and gradually builds up the power of its oscillation. A portion of these oscillations is initially transmitted through the wave guides 3 and 4 to resonant chamber 5, but not to the cavity 1. It is of insufficient intensity to cause a substantial discharge between the members 8 and 9 in chamber 5 and that chamber therefore acts as an open circuit in the wave guide system 4. This open circuit is located at such a distance from the junction of the wave guide 4 with wave guide 3, that it has the effect of an open circuit in the latter and thus prevents the supply of substantial power to the resonant chamber 1. However, when the intensity of the electromagnetic field in the chamber 5 has reached a predetermined value fixed by the characteristics of that chamber, such as the length of the gap between the members 8 and 9 and the strength of the ionizing current between rod 11 and member 9, the gap between members 8 and 9 will suffer electric breakdown so that it becomes freely conductive and acts substantially like a short-circuit across the wave guide branch 4. By reason of its position relative to the wave guide 3, this change

from open- to short-circuit produces a similar change at the junction point of guides 3 and 4, changing the previously existing open-circuit to a short-circuit and thus permitting power now to flow freely along guide 3 toward the cavity 1. In the meantime the magnetron has, under conditions prior to breakdown built up to an operating condition of high stability, owing to the fact that R. F. fields of sufficient intensity for the proper operation have been established in its interaction space; it is now capable of taking on the new load, i. e., the cavity 1, without impairing this stability. By a suitable choice of the distance between the magnetron and the junction point of the guides 3 and 4, one is in a position to vary the effective load impedance presented to the magnetron before the gap breaks down, and thus improve within limits the build-up process in the magnetron, which is a function of the load impedance.

Sometimes we find that a further improvement may be obtained by connecting a dissipative adjustable load through a second window to the T-R switch and thus to branch 4 as is shown in Fig. 2. When this arrangement is used, the load presented to the magnetron during the build-up period can be adjusted over a wider range, sometimes resulting in an appreciable improvement of the build-up process. In Fig. 2 the chamber 5 is provided with a continuation 21 which may be of similar cross-section to branch 4, and which is provided at its remote end with a dissipative load 22 with regulating means of conventional type such as thumb screws 23 projecting into the guide.

It is also found that even where the magnetron has practically no tendency to resonate except in the desired mode of vibration, the total time required for the system to build up to a desired intensity of oscillation can be controlled by proper adjustment of the switch chamber 5. It is found, in fact, that a particular intensity of the electromagnetic field established in the magnetron 2 will produce a minimum time of building up the oscillations in the chamber 1 to a desired strength. If the energy to which the magnetron 2 has built up is either less or greater than this critical value, the total elapsed time to build up the vibrations in the resonant cavity 1 is increased. The employment of our switching system, accordingly, makes it possible to operate the transmission system in a novel way so that it is capable of reducing the build-up time of the vibrations within the cavity 1 to a minimum.

Under certain circumstances, it may be desirable to obtain other optimal conditions than a minimum build-up time in the cavity 1, and when such is the case, the switching system which we have described affords an agency for achieving such desired purposes.

We claim as our invention:

1. In combination with a resonant cavity, a wave guide and an oscillation generator of the cavity type connected to supply energy to said cavity through said wave guide, said cavity being of the type which when connected as aforesaid to said generator tends to cause said generator to oscillate in undesired modes when the electromagnetic energy of said generator is below a predetermined level, and normally open switching means effectively in series in the wave guide path between said generator and said cavity, said switching means comprising elements responsive to the energy flowing from said generator when it exceeds said predetermined level to close said path.

2. The combination according to claim 1 characterized by a branch wave guide connected into said wave guide and by switching means disposed in said branch effectively at a distance from the main guide corresponding to an integral number of half-wave-lengths of the waves produced by the generator.

3. The combination according to claim 2 characterized by means for dissipating the energy in the branch.

4. The combination according to claim 1 characterized by the fact that the switching means is a TR switch.

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