

July 12, 1955

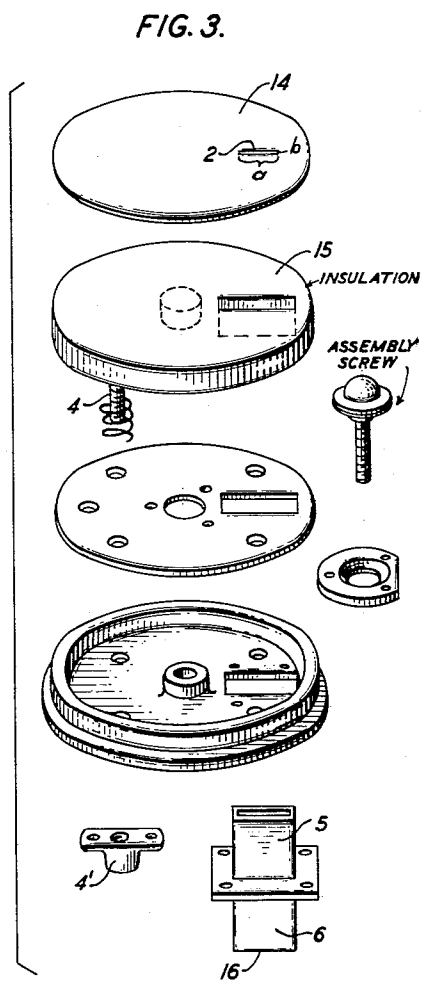
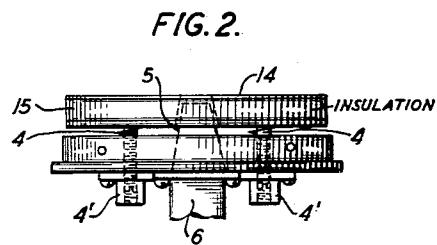
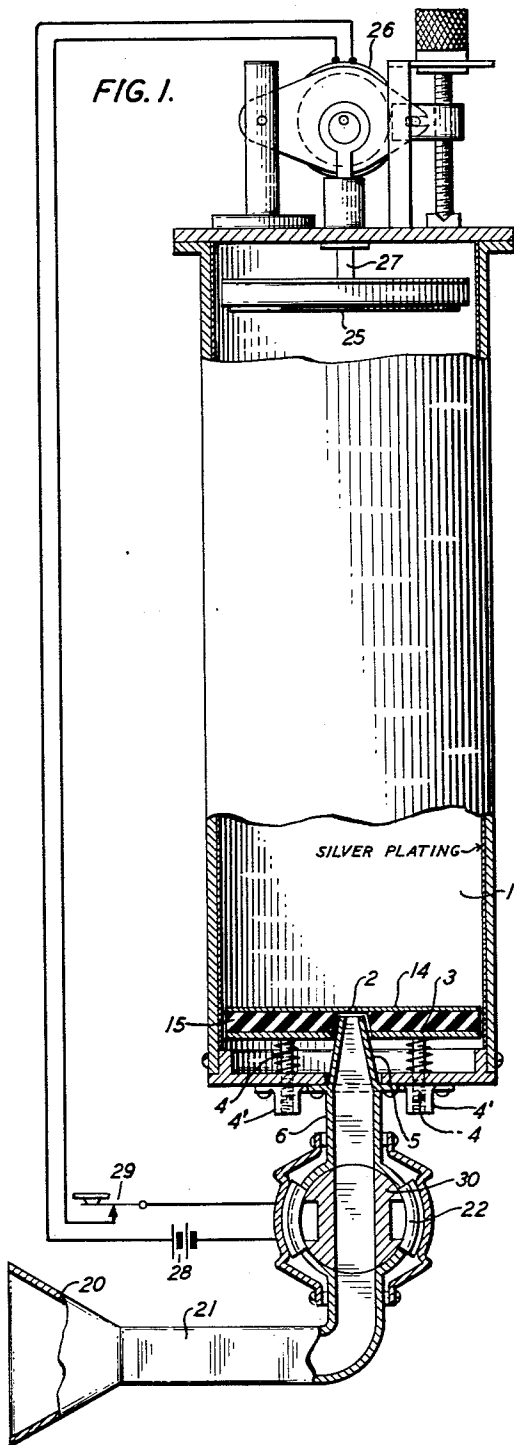
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2,713,153

ORIFICE COUPLING TO RESONANT CAVITIES

Filed Sept. 9, 1947

2 Sheets-Sheet 1



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FIG. 5.

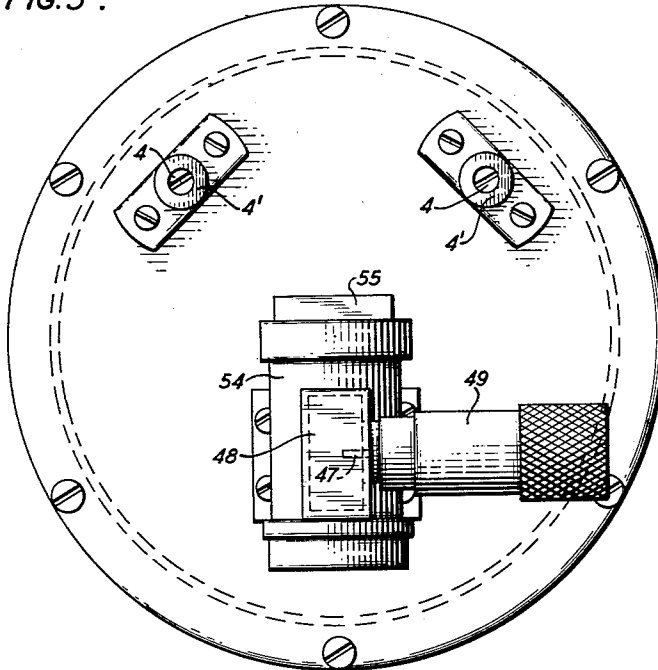
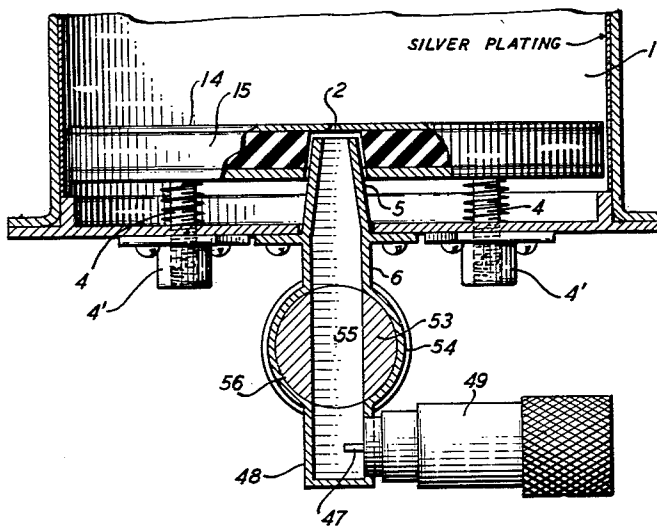


FIG. 4.



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ORIFICE COUPLING TO RESONANT CAVITIES

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Application September 9, 1947, Serial No. 772,987

1 Claim. (Cl. 333—83)

This invention relates to cavity resonators and more particularly to improvements in the wave energy feed connections thereto.

An object of the invention is to excite a cavity resonator by means of a concentrated and polarized electromagnetic field in a manner to intensify the operating mode with respect to extraneous modes.

Another object of the invention is to increase the energy density of the exciting field applied to a cavity resonator by means of a narrowed coupling and polarizing slit, whereby the operating mode of the resonator may be excited with an improved ring-time.

A feature of the invention is a resonant cavity having a tapered wave guide feeding a narrow slit in the wall of the cavity. The feed guide substantially tapers down to the size of the slit, thereby permitting a reduction in slit size for a given degree of coupling.

It has been customary to feed resonant cavities, and more particularly high Q cavities, known as echo boxes, ring boxes and the like, by means of circular or round orifices. Since circular orifices do not per se offer coupling discrimination in contrast to the discrimination achieved with a slit, alignment of the associated wave guide feed system has to be held to a high order of precision to prevent the excitation of certain families of unwanted modes when such orifices are used.

In accordance with the invention applicant has determined that a resonant chamber or echo box provided with a properly oriented narrow slit orifice in the wall thereof, fed by a wave guide substantially tapering down to the dimensions of said slit, will provide an improved ring-time and be free of the precise wave guide alignment restriction aforementioned in order to limit the excitation of unwanted modes.

Referring to the figures of the drawing,

Fig. 1 shows a resonance chamber with the improved energy feed connections in accordance with the invention;

Fig. 2 shows the end plate construction thereof with the tapered feed attached thereto;

Fig. 3 is an exploded view of the end plate construction;

Fig. 4 shows the improved resonance chamber with a modified wave guide switch; and

Fig. 5 shows an end view thereof.

Cavity resonators are the microwave analogs of tuned circuits comprising lumped or distributed reactance elements used at lower frequencies as fundamental circuit components. High Q cavity resonators, such as echo boxes have been found difficult to excite into oscillation at a desired operating mode without concomitantly exciting other extraneous or unwanted modes associated with the cavity. Circular and relatively large coupling orifices in the walls of such resonant chambers have frequently been the unsuspected cause of the excitation of unwanted modes.

In the course of experimentation with various types of orifice couplings and energy feed devices thereto, applicant discovered that a narrow, lineal slit fed by a tapered wave guide section or the like, tapering down to the di-

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mensions of the slit, improved the ring time of a resonant cavity, presumably by concentrating and polarizing the wave energy in the operating mode and concomitantly reducing the tendency for simultaneously exciting extraneous modes.

Referring to Fig. 1 of the drawing, a tunable cylindrical cavity resonator 1 designed to operate in the TE_{01n} mode is shown, provided with a single narrow, rectangular slit 2 provided in the end wall 3 thereof. Leveling screws 4 may be provided in the end wall 3, as disclosed in the United States application Serial No. 543,830, filed July 7, 1944, by W. A. Edson and W. F. Kannenberg, now patented as United States Patent 2,471,419, May 31, 1949. Alternatively, leveling may be at the piston end and accomplished by means of curved, orthogonal supporting surfaces independently movable for slight adjustment.

The end wall 3, comprises a thin copper facing 14 glued to plate 15 of phenol formaldehyde condensation product, as shown in Figs. 2 and 3, and described in the aforementioned United States patent of W. A. Edson and W. F. Kannenberg.

The narrow, rectangular coupling slit 2, whose height b is reduced sufficiently to render it lineally dimensioned, is fed by means of a tapering section of wave guide 5, which tapers down at one end thereof to the practically lineal dimension of said slit. At its opposite end, the tapering section 5 has a rectangular cross-section which registers with the corresponding and equal rectangular section 16 of a standard wave guide 6. The length of the tapered section 5 is preferably of the order of a half wavelength or more. The tapered feed section 5 may be formed of copper sheet soldered to the phenol fiber plate 15 in a manner to clear the plate and permit leveling.

Upon exciting the resonance chamber 1 by means of the concentrated electromagnetic field, it is found that the narrow rectangular slit 2 produces less intermode coupling than does an equivalent round orifice. Furthermore, as the size of the slit is reduced, the amount of intermode coupling decreases. The tapered feed section 5 concentrates the electromagnetic field at the lineal slit 2, resulting in improved excitation of the operating mode and reduction of unwanted modes. The slit by a polarization effect also favors the operating mode. Concomitantly the tapering section affords an impedance transformation between the impedance of the wave guide 6 and the impedance at the slit 2, whereby any tendency to set up undesired reflections and standing waves because of impedance mismatch, is thereby considerably reduced.

Due to the concentration of the electromagnetic field at the slit by means of the tapered feed, it becomes possible to use a smaller slit and still maintain a given amount and degree of coupling to the operating mode. Further advantages are derived thereby, such as, (1) the "window" discontinuity in the end plate becomes smaller, reducing the eddy current fringing area, (2) the reflecting surface of the end plate is more homogeneous, (3) the intermode coupling is reduced as a consequence of slit size reduction, ameliorating the mode-crossing problem.

In the embodiment disclosed in Fig. 1, a microwave pickup horn 20 is connected to wave guide 21, which leads through a wave guide switch 22 to the taper section 5 connected to the lower end of cavity resonator 1. The slit-like aperture 2 is preferably located at a point in the lower end of the cavity resonator 1 which is about .48 of the radius since it is in that region that the electric vector of TE_{01} mode oscillations is of maximum intensity. The cavity resonator 1 is provided with a tuning piston 25 operated by a motor 26 and reciprocating mechanism 27 of the type disclosed and claimed in Kannenberg et al. application, Serial No. 544,990 filed July 14, 1944, now patented as United States Patent 2,537,139,

January 9, 1951. The motor 26 and the actuator of the wave guide switch 22 are connected in series with a source 28 through a key 29. In the closed position of the key 29, the wave guide switch 22 is open as shown in Fig. 1 and the motor is in operation causing the piston 25 to vary the tuning of resonator 1 over a range of frequencies including that of the transmitter of a radio object locating system in connection with which the apparatus of Fig. 1 is intended to operate. A pulse of oscillation energy picked up by the horn 20 is guided to the interior of the resonator 1 to excite it, and upon cessation of the pulse the resonator returns an outgoing train of decaying oscillations to the wave guide 21 and the horn 20. The tuning cycle of the piston 25 is relatively slow compared to the period of duration of the incoming pulse and of reemission from the resonator 1 so that for any given incoming pulse the piston 25 may be considered as if fixed in position. Consequently when the piston 25 is in the position at which a natural resonance frequency of the resonator corresponds with the frequency of the oscillations of an incoming pulse, the resonator will be strongly excited and will return a relatively long train of oscillations to the receiving apparatus of the radio object locator. It is therefore possible to check up on the tuning of the object locator receiver and the over-all efficiency of the radio object locator by observing the duration of the oscillation train emitted by resonator 1 and received at the object locator receiver.

The modification shown in Fig. 4 includes a modified wave guide switch or valve for opening and closing the path of transmission of wave energy to or from the resonant chamber 1.

The solid cylindrical rotor 53 of the wave guide switch may be mounted in the wave guide feed pipe 6 adjacent to the taper section 5, and if desired, the unit may be cast in one piece.

The rotor 53 has its longitudinal axis transverse to the longitudinal axis of wave guide 48, and is provided with a slot of the same interior cross-section as the wave guide 48 in order to present a smooth through transmission path when the two are aligned. The rotor 53 fits in a bulged out casing 54 with substantially no friction therebetween and is provided with a flat end stub 55.

To prevent the transmission of energy into the resonant chamber 1, the rotor 53 is turned to a position where its walls 56 interrupt and block the transmission path of wave energy between wave guides 6 and 48. A coaxial to wave guide coupling probe 47 may serve to bring the wave energy from a coaxial conductor 49 into the resonant chamber 1 or conversely.

Preferably, the wave guide 48 should be so proportioned as to present an odd multiple of quarter wavelengths to the resonator 1 when the switch is closed to block transmission and an even multiple of quarter wavelengths when the switch is open.

The wave guide switch may also be provided with plural passageways which may be selectively blocked or connected together in the manner disclosed in my aforesaid copending application, whereby a first wave guide transmission line may be alternately connected to a second or third wave guide path at will.

What is claimed is:

In combination, a high Q cavity resonator having a cylindrical side wall and a pair of conductive end walls spaced apart and parallel to each other, one end wall being composite and comprising a pair of metallic discs having a lossy dielectric plate coextensive therewith and sandwiched therebetween, said discs having aligned rectangular slots respectively decreasing in cross-sectional area toward the cavity, the innermost slot being a lineal slit of reduced dimensions, and a rectangular wave-guide feed having a tapered section transforming the impedance of the rectangular wave guide to that of the lineal slit, the tapering end thereof being recessed in said dielectric plate adjacent said lineal slit, said slit being located at one-half the radius of its disc, and a closure plate fastened to said side wall.

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